REPORT

Tailings Management Feasibility Study

Troilus Feasibility Study

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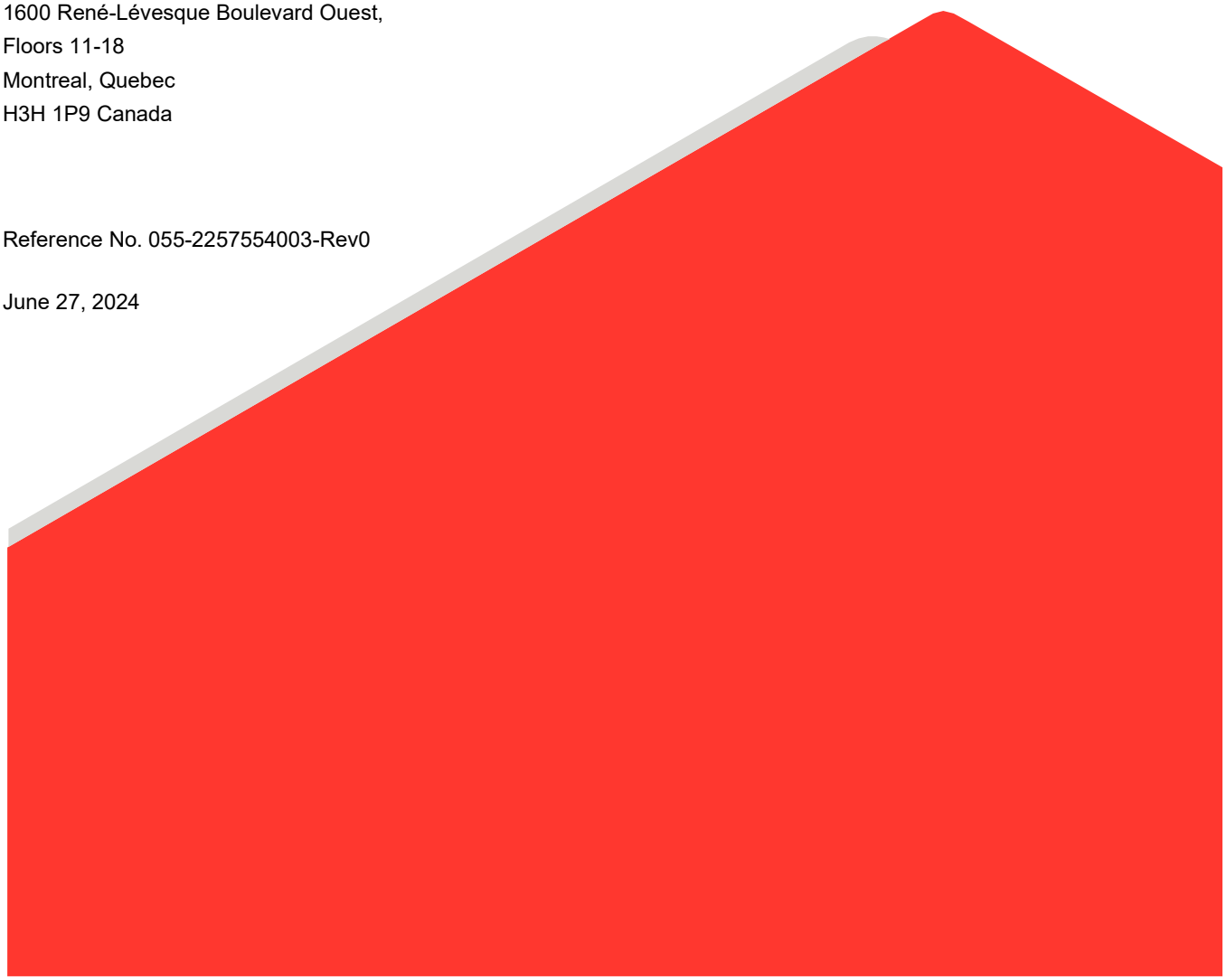

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Executive Summary

This report presents the feasibility study (FS) level design for raising the crest of the existing Tailings Storage Facility (TSF) and in-pit tailings disposal concept at the Troilus Mine Site. Troilus Mine is an inactive open pit gold and copper mine located in the municipality of Baie-James, Quebec, Canada.

Troilus Gold Corp. (Troilus) is undertaking a FS-level assessment to recommence mining operations. To support the tailings generated from the life of mine (LoM) operations, the existing TSF will be raised from the current crest elevation of approximately 399 to 401 masl (dyke height of approximately 30 m), to an ultimate elevation of 435 masl (total dyke height of approximately 64 m). The TSF raise will provide an additional 169 million tonnes (Mt) of storage capacity. The intention of the FS TSF design is to raise the existing TSF while limiting the additional required site footprint.

Existing Facility

There is one existing TSF at the Troilus mine site. The TSF commenced operations in 1996 and was raised annually from 1997 until 2009 when mining operations ceased, and the site entered the care and maintenance phase. In general, the existing facility is an upstream raise construction with a till-core starter embankment located at a minimum elevation of approximately 371 masl. The existing facility has performed well during operations and throughout the care and maintenance phase.

Feasibility Design Concept

The FS design concept of the Main Dyke raise and new East Dyke is for downstream construction. The design assumes a raise of the existing dyke to a final elevation of 435 masl and construction of a new saddle dyke along the low point of the mountain slope on the eastern side of the TSF, also to 435 masl.

For the Main Dyke in particular, measures have been incorporated into the design to migrate from the current upstream structure to downstream construction, resulting in improved geotechnical stability. The downstream construction method provides additional storage capacity and a lower environmental risk of failure than the upstream and centreline construction adopted for the existing TSF.

The TSF embankment will include a zoned run of mine waste rock embankment with upstream sand filter underlain by a layer of geotextile and gravel filter. There will be surplus waste rock produced throughout the LoM operations (i.e., more than what is required for embankment construction), meaning there will be no material balance issues for sourcing construction fill. Filters will be produced on site through crushing and likely screening of locally sourced materials.

Deposition modelling was completed using commercially available Muk3D software in annual or more frequent increments. The rate of rise for the facility is approximately 4 m/yr throughout the life of the facility, based on an annual tonnage of 18.18 Mt.

Design Criteria

The feasibility design was developed using extreme loading conditions per the Global Industry Standard for Tailings Management (GISTM)(GTR, 2020) and the criteria of Directive 019, which outlines applicable controls for the design and the construction and operation of TSFs in Quebec. Canadian Dam Association (CDA) dam safety guidelines are used broadly and depend on a risk-based classification. Consequence classification is determined for a

TSF based on incremental losses that a failure of the TSF may inflict on downstream or upstream areas. As the earthquake and flood criteria will be consistent with GISTM, which presumes an extreme consequence as defined in CDA, the requirements of the CDA and consequence classification were not defined for this study.

Design Assessments

Stability analyses of the dykes were completed using SLOPE/W, a commercially available limit equilibrium analysis software package using the Morgenstern-Price method of analysis, which concurrently satisfies both force and moment equilibrium. The FS embankment designs meet the geotechnical stability requirements under static and extreme seismic loading conditions. Stress-deformation analysis and simplified dynamic displacement analyses were completed and results indicate that the existing embankment filters will experience minor deformation and should perform as per their design intent.

Tailings Storage Facility Water Management

The TSF water management will occur in much the same way as historical operations for the first 10 years. Drainage from the tailings beach and mountain slope will be collected by gravity to the TSF pond. The drainage includes both natural runoff and water exfiltrating from the deposited tailings. Pond water will be pumped for recirculation to the process plant and, if there is surplus, for discharge to the environment after treatment for total suspended solids removal via the existing treatment plant or its eventual replacement. The TSF is required to operate with a minimum 250-m long upstream tailings beach and a minimum 1.5 m pond freeboard, both of which are achievable based on geometric modelling carried out for the study.

The pond and the beach geometry will allow containing the regulatory Directive-019 environmental “project flood.” The emergency spillway will be designed to manage the probable maximum flood (PMF).

In-Pit Tailings Disposal

The TSF will reach its full capacity during year 10 and tailings are planned to be disposed into mined-out pits until the end of Mine Life (year 22). In-pit tailings disposal will progress sequentially into the Southwest pit, J4 pit and then 87 pit. The mine plan was developed with this constraint of concept for migration to in-pit disposal in the later years of mine development.

Closure Considerations

The current concept for TSF closure is expected to resemble the concept which was approved for closure of the existing facility. At the end of operations, a closure spillway channel would be built to connect the TSF Pond to the flooded 87 Pit Lake located north of the TSF. The channel invert will be lowered by several metres to limit the size of the closure pond and to provide a large long-term freeboard to the embankment. The TSF surface will be vegetated to create a closure landscape and to mitigate beach erosion.

A waste rock dump will be developed on the tailings deposited in the Southwest pit. The flooded J4, 87 and X22 pits should form a pit lake that will be connected to the Bibou diversion and the TSF closure spillway. This pit lake discharge shall overflow toward the lake A.

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Abbreviations and Acronyms

Acronym	Definition
2D	two-dimensional
3D	three-dimensional
CDA	Canadian Dam Association
CPT	cone penetration test
D_{50}	the corresponding particle size when the cumulative percentage reaches 50%
ECCC	Environment and Climate Change Canada
EDF	Environmental Design Flood
FoS	Factor of safety
FS	Feasibility Study
GISTM	Global Industry Standard for Tailings Management
HDPE	high density polyethylene
ID	identification
LoM	life of mine
MASW	multichannel analysis of surface waves
Mbgs	metre below ground surface
NBCC	National Building Code of Canada
PGA	peak ground acceleration
PMF	probable maximum flood
PMP	probably maximum precipitation
SNC	SNC-Lavalin
Troilus	Troilus Gold Corp
TSF	Tailings Storage Facility
w/v	weight per volume
w/w	wet weight

Units of Measure

Unit	Definition
%	percent
%wt	percent weight
°C	degrees Celsius
cm	centimetre
h	hour
kg	kilogram
km	kilometre
km/h	kilometres per hour
kW	kilowatt
m	metre
M m^3	million cubic metres
m/s	metres per second
m/yr	metres per year
m^2	square metre
m^3/h	cubic metres per hour
masl	metres above sea level
mbgs	metres below ground surface
mm	millimetre
Mt	million tonnes
t/m^3	tonnes per cubic metre
w/v	weight per volume
tpd	tonnes per day
yr	year

1.0 INTRODUCTION

This report presents a feasibility (FS) assessment for the expansion of the Troilus Gold Corp. (Troilus) Tailings Managements Facilities at Troilus Mine to serve as a proposed plan to re-open the mine. Troilus Mine is an inactive open-pit gold-and-copper mine located in the municipality of Baie-James, Quebec, Canada.

The Tailings Managements Facilities in this report are comprised of the above-ground TSF located at the existing TSF (called TSF in this report) and the tailings disposal in the future mined out pits (in-pit tailings disposal).

Troilus is undertaking a FS-level assessment to recommence mining operations. To support the tailings generated from the life of mine (LoM) operations, the existing TSF will be raised from the current crest elevation of approximately 399 to 401 metres above sea level (masl), to an ultimate elevation of 435 masl. The intention of the FS tailings management strategy is to raise the existing TSF and use mined-out pits to store tailings while limiting the required additional project footprint taken.

The aim of this FS assessment is to identify potential considerations, constraints, or conflicts that may arise from raising the TSF above the current 399 to 401 masl dyke crest elevation to 435 masl, to complete a FS-level assessment of the project and provide recommendations for feasibility study.

The following scope of work has been undertaken for the FS design:

- Elaboration of the design basis and criteria;
- Layout and capacity assessment;
- Design analyses including deposition planning, seepage, stability, deformation analyses, as well as evaluation of filter compatibility and water balance;
- Dyke-raise risk review;
- Determination of material quantities;
- Development of tailings in-pit disposal concept.

2.0 BACKGROUND

Troilus Mine is an inactive open-pit gold-and-copper mine located in the municipality of Baie-James, Quebec, Canada (Figure 1). The mine operated from 1996 until 2009 when mining operations ceased, and the site entered the care and maintenance phase.

Troilus is undertaking a FS-level assessment to recommence mining operations. A mine plan has been developed by AGP Mining Consultants, which consists of mining four open pits with waste stored in several stockpiles (Figure 4). Troilus will construct a new ore processing facility to treat 50,000 tonnes of ore per day from the local resource to produce gold and copper concentrate. The processing plant will include crushing, milling, gravity gold recovery, and flotation. Troilus requires a tailings management strategy for the processing facility.

2.1 Existing Tailings Storage Facility

There is one existing TSF at the Troilus Mine Site (Figure 2 after text). The TSF commenced operations in 1996 and was raised annually from 1997 until 2009 when the site entered the care and maintenance phase.

The initial design for the facility was carried out by SNC-Lavalin Environnement (SNC). The original design report was not available; however, a 1997 report revision elaborated upon the key design assumptions (SNC 1997). The SNC design concept was to construct an embankment initially to the elevation of 381 masl, subsequently to be raised to the elevations of 385 masl and 390 masl. Tailings were intended to be deposited on the upland areas to the northeast of the dyke and the supernatant water would rest against the embankment. WSP understand that the starter dyke for the Main Embankment of the facility was constructed up to the nominal elevation of 381 masl.

In general, the starter embankment, to the elevation of 381 masl, was designed as a till embankment with a sand and gravel toe drain. Upstream slopes of 2H:1V, downstream slopes of 3H:1V, and an 8 m wide crest were proposed. Rock riprap was placed on the upstream face and a thin granular travelling layer was placed on the crest.

The concept for the staged development of the TSF was revised by Golder Associates Ltd. (Golder 1997). The concept that was selected was to raise the tailings facility by constructing upstream raises 2 m to 2.5 m high by using tailings placed on top of the tailings beach. A filter zone was constructed to allow the passage of exfiltrating water, and mine waste was used for erosion protection. The TSF was raised incrementally using this concept, except that the annual raises were typically 1.5 m high.

Whereas the raise construction methodology was successful, issues were experienced with high levels of suspended solids in the TSF water pond, which posed water management challenges. Several iterative adjustments to the dyke raise heights and pond size were considered during the operational phase to manage these challenges.

In 2004, a study was undertaken to assess the potential to construct a toe berm along the Main Embankment using mine waste rock (Golder 2004). The study demonstrated the beneficial effect of the toe berm, and the berm was constructed in 2005. The berm crest elevation varied from 394 to 397 masl, which corresponded to the crest of the 2005 raise.

In 2005 and 2006, the South Dyke was constructed up to a crest elevation of 402 masl (Golder 2006). This dyke is a till-core, rock-shell dyke with a sand and gravel filter between the till core and the downstream rock shell. Upstream and downstream slopes for this structure are 2H:1V and 2.5H:1V, respectively.

Subsequently, the facility was raised annually until 2009. The last raise crest elevation varied between 400 and 403 masl. In 2010, the mine received a certificate of authorization for a closure plan of the facility.

A construction summary of the Main Dyke is presented in Table 1 and a typical cross-section is included in Illustration 1.

Table 1: TSF Construction Summary

Year	Dyke Crest Elevation (masl)
1995-1996	381
1998-1999	383 to 383.8
2000	384.5 to 386
2001	386 to 387.5
2002	388 to 389
2003	389.5 to 392.5
2004	392 to 396
2005	394 to 398
2006	395.5 to 398.5
2007	397 to 400
2008	398.8 to 403
2009	400 to 403

masl = metres above sea level.

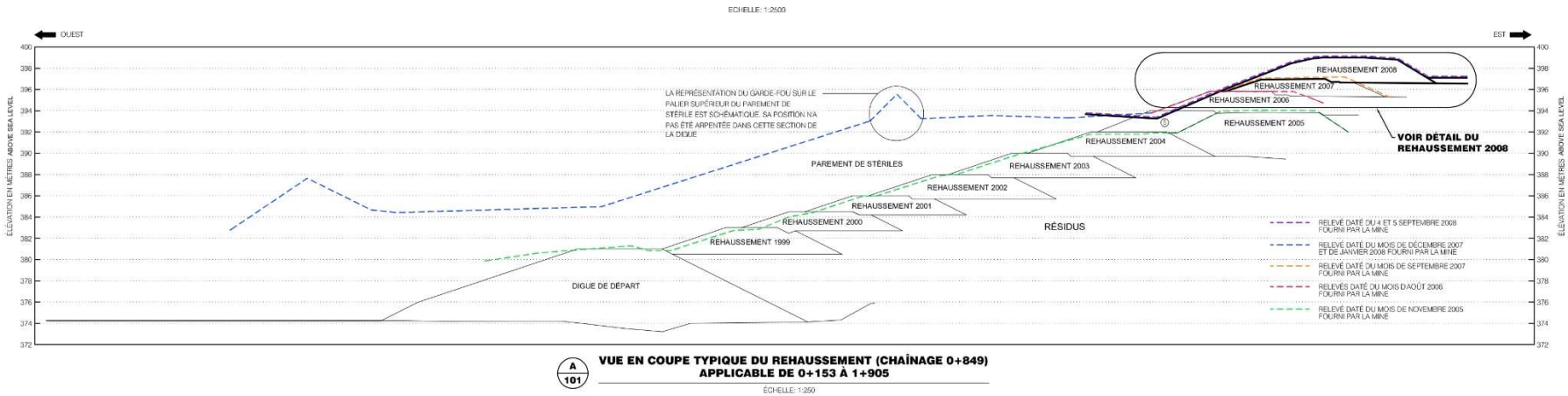

Illustration 1: Typical Cross-section (adapted from Golder 2009)

2.2 Current Performance

Annual inspections have been undertaken by Golder from 2005 until present. The dyke has been performing well and no significant dyke safety issues have been identified since the site went into care and maintenance in 2010.

Five vibrating-wire piezometers are installed in the embankments (Figure 2). Water levels in these instruments showed modest variations during operation and have been relatively stable since the site entered care and maintenance. Water levels have been at elevations of between 381 and 386 masl since 2010 (Illustration 2). In comparison the current TSF crest is at an elevation of about 400 m and the pond is at approximately 396 masl of elevation, indicating that the water table is being drawn down adjacent to the embankment by 10 to 15 m. It is noted that the pre-mining ground surface under the west perimeter embankment was in the order of 380 masl.

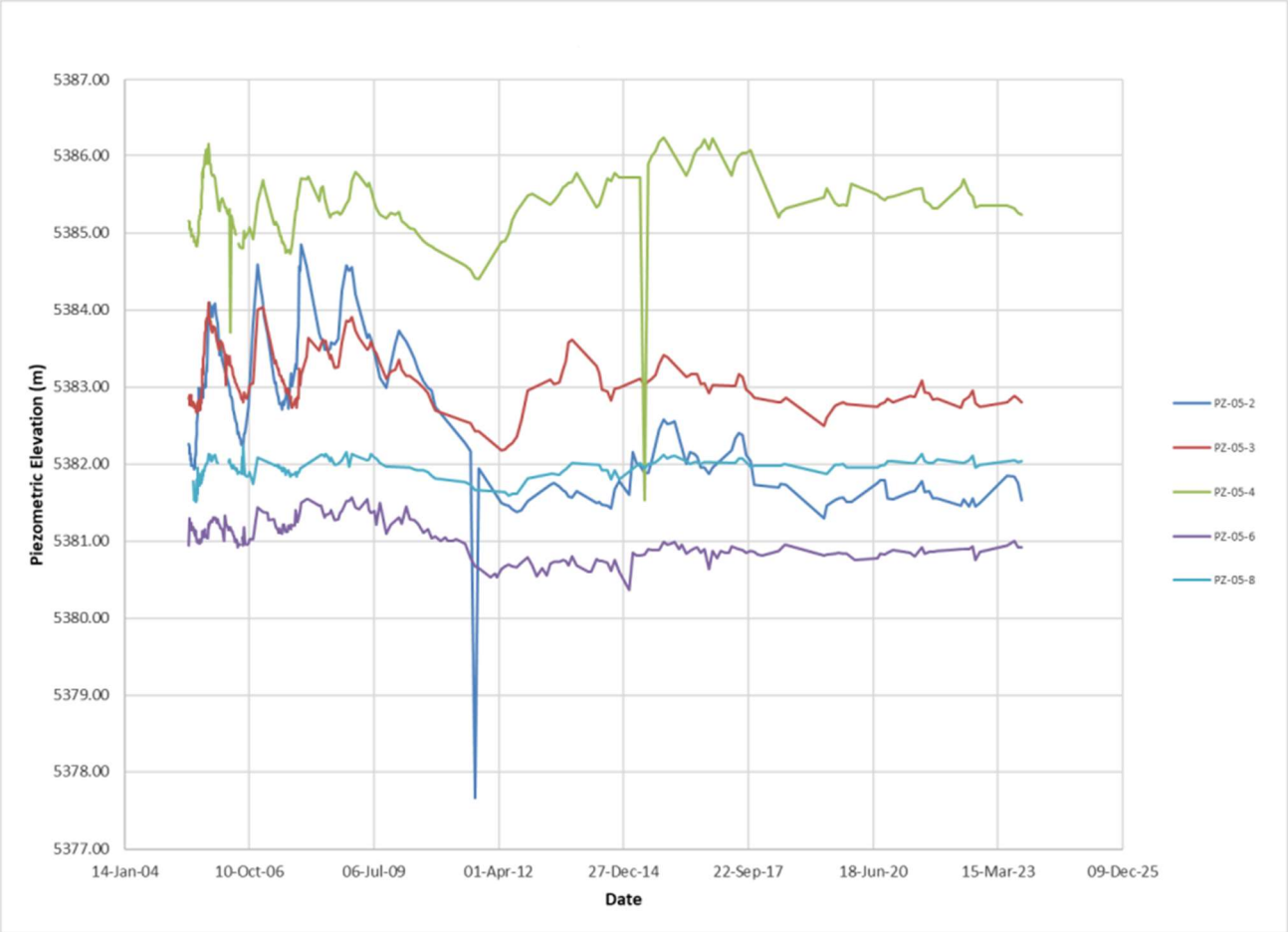

Illustration 2: Piezometric Elevations in Main Dyke 2005 – 2023

2.3 Options Study

In 2018, Golder undertook tailings review and expansion potential assessment to assess the viability of expanding the existing TSF (Golder 2019), and a tailing-option study to evaluate options for tailings management and select a design to carry to the following design phase (Golder 2020). For the FS, WSP considers the decision taken previously as still valid. The Tailings Management Options Study is included in Appendix A.

The tailings review and expansion potential assessment concluded that the re-commissioning of the TSF and further raises were technically feasible, up to an elevation where natural containment along the mountain to the east could be achieved. The option study involved a conceptual trade-off study to evaluate several tailings and water management options for selection of preferred options to advance to the next design phase. Three tailing-preparation options were considered for the option study, including thickened tailings and deep-cone thickened tailings with a centerline-raise construction method, and filtered stackable solids.

A semi-quantitative evaluation of the options was completed considering key attributes such as performance, operability, cost, and closure complexity. Overall ranking of the options resulted in tied scores for the thickened tailings and deep-cone thickened tailings options. The score obtained for filtered tailings was dominated by high operational cost and complexity, resulting in a lower ranking than the slurry options.

The report recommended that the thickened tailings and deep-cone thickened tailings options be advanced to the design phases for further technical study. Following this recommendation tailings characterization was undertaken on a synthetic sample generated from the study pilot plant (section 0). Laboratory tests undertaken as part of this study indicated that increases in the beach slope with additional thickening efforts were likely to be minimal. Based on this, Troilus decided to proceed with the thickened tailings option only for FS design.

Two important parameters have been modified in the project between the previous design phase and FS: the daily tonnage has increased from 35,000 tons to 50,000 tons and the percentage solid of the tailings has decreased from 66% to 54.3%. WSP considers that these two changes do not modify the conclusions of the options study, and that they remain valid.

Additionally, it was decided to proceed with a downstream raise construction method for the TSF raises, rather than a centerline-raise construction method. This decision was made to provide greater storage capacity for the TSF and improve the dyke stability compared to a centreline construction approach as proposed in the tailings management option study.

3.0 BASIS FOR DESIGN AND DESIGN CRITERIA

WSP has developed a Basis of Design and Design Criteria report for this assessment, included in Appendix C and summarized in this section.

3.1 Regulations, Standards and Guidelines

The assessment of the TSF is consistent with applicable regulatory documents, and guidelines from WSP, and national and international organizations, where applicable (e.g., Canadian Dam Association, International Commission of Large Dams). Regulations applicable to this study comprise the following:

- Directive 019 sur l'industrie minière (Government of Quebec, MDDEP 2012)
- The assessment of the TSF is also consistent with the following guidelines, where applicable:
- Global Industry Standard for Tailings Management (GTR, 2020)
- Canadian Dam Association (CDA) Dam Safety Guidelines (2013, 2014)
- CDA Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2019)

- Internal Commission on Large Dams (ICOLD), Tailings Dams Safety, Bulletin No. 194, 2022 (draft)[a]
- Guide de préparation du plan de réaménagement et de restauration des sites miniers au Québec (Closure Guide), (Gouvernement du Quebec, MERN 2022)

Other internationally recognized codes and standards may be used, provided that these codes and standards either meet or exceed the referenced codes herein.

3.2 Basis for Design

Mining dams in Quebec are governed according to Directive 019 (MDDEP, 2012), which outlines applicable controls for the design, construction, and operation of tailings storage facilities. The Directive 019 approach is a proscriptive, standards-based approach to the assessment of design flood events, seismic events, and required factors of safety.

The CDA dam safety guidelines that are used broadly in the mining industry depend on a risk-based classification. A consequence classification is determined for a TSF based on incremental losses that a failure of the TSF may inflict on downstream or upstream areas. Considering the presence of the open pit downstream of the TSF and the absence of a formal consequence classification, it was decided to set the design basis against an "Extreme" consequence classification in accordance with GISTM (GTR, 2020). The earthquake and flood criteria will be consistent with CDA (2013).

While Directive 019 is the legislative requirement for Quebec, the industry standard from the new global standard GISTM (GTR, 2020) has been adopted for the design, such that the potential for the occurrence of extreme environmental loading conditions, exceeding the proscribed load cases from Directive 019, is considered in the design. Consequently, the TSF has been analyzed against ‘extreme’ design loads and the following criteria have been adopted for the design:

Hydrotechnical design basis:

- Designed to manage the probable maximum flood (PMF) without overtopping the containment structure.
- Designed and operated to contain the Directive 019 “project flood” (the environmental design flood) without discharging to the environmental via the emergency spillway.

Geotechnical design basis:

- Designed to withstand a 1:10,000 Annual Exceedance Probability earthquake, after which the TSF will maintain storage integrity.
- Remain geotechnically stable under static conditions and seismic design events during operation.

ESG-related design basis:

- Mitigate impacts to environmental, biological, cultural, and social resources during construction, operation, and post-closure.
- Maintain acceptable operating philosophy and management framework to prevent or restrict contaminant release.

- Construct and operate the TSF in a safe and secure manner that mitigates or eliminates impacts to persons' health, safety, and security.

3.3 Design Criteria

Key design criteria are provided in Table 2.

Table 2: Design Criteria

Criteria	Unit	Value	Source/Comment
Mine Plan			
Life of Mine	Years	24 (pre-production year -2 to year 22)	AGP 2024
Tailings Production rate	tpd	49,800	AGP 2024 & Lycopodium 2024b
Total tailings production	Mt	378.0	AGP 2024 & Lycopodium 2024b
General			
Coordinate system	-	WGS84, UTM Zone 18 (EGM 96 Grid)	Troilus
Design earthquake event	-	1:10,000 Annual Exceedance Probability	GTR 2020
Design earthquake peak ground acceleration	g	0.18 at the surface of the TSF 0.884 at bedrock	Section 4.7
Horizontal acceleration for limit equilibrium analysis	-	½ of the PGA at the bedrock	Adopted
Safety factor static – peak strength	FoS	1.5	Directive 019; CDA 2013, 2014
Safety factor static – post-peak strength [(a)]	FoS	1.3	WSP
Pseudo-static	FoS	1.1	Directive 019
Post-earthquake[(b)]	FoS	1.3	Directive 019
Deformation (only required if pseudo-static criteria not met)	%	≤1-2% Strain	WSP
Embankment Details			
TSF raise construction method	-	Downstream	Adopted
Minimum dyke crest width	m	10	Adopted
Overall downstream slope no steeper than	-	2.5H:1V	Adopted
Tailings Characteristics			
Solids content of tailings slurry discharged to TSF	%wt	54.3	Lycopodium (2024a)
Tailings solids specific gravity	-	2.65	SNC (1997)
Tailings average dry density after deposition	t/m^3	1.5	SNC (1997)
Tailings beach slope	%	0.5% above water; 1.5% below water	WSP (2024f)
Water Management			

Table 2: Design Criteria

Criteria	Unit	Value	Source/Comment
TSF Water Pond and Water Treatment Capacity	-	Manage (contain or discharge after treatment) the Directive 019 'project flood' associated with the 1,000-yr, 24-h rainfall superposed with the melt over 30 days of the 100-yr snowpack. Maintain a freeboard, relative to the crest of the embankment, of minimum 1.5 m during the 'project flood'.	Directive 019.
Freeboard relative to the dyke crest	m	Convey the probable maximum flood (PMF) peak flow with a freeboard, relative to the crest of the embankment, equivalent to the 100-yr extreme wind effect (wind set-up and run-up).	Directive 019, CDA 2013 and 2019.
Minimum operating pond depth at the location of the water intake system	m	3	To avoid solids resuspension or ice effects on pumping, Based on professional experience.
Operational beach width	m	250 min	Adopted
Water reclaim system	-	Barge, per existing	Adopted
Toe Ditch and Sump Design Event	-	Manage the 1:100 yr flood event	Directive 019

PGA = peak ground acceleration; tpd = tonnes per day; Mt = million tonnes; FoS = factor of safety; %wt = percent weight.

Notes:

a) This analysis case considers the post-peak (or residual or liquefied) resistance for materials that are susceptible to strain softening or static liquefaction.

b) This analysis case considers the post-peak (or residual or liquefied) resistance for materials that are susceptible to strain softening, and static and dynamic liquefaction.

3.4 Mine plan

The mine plan provided by AGP (2024) forecasts an ore mill feed of 379.5 Mt and a tailings production of 378.0 Mt over the life of the mine. The final concentrate is 0.4% of the feed and the tailings represented then 99.6% of the mill feed (Lycopodium, 2024b). The tailings will be contained in various mining infrastructures. The following table shows the production of tailings by production year and where it will be deposited.

Table 3 Mine plan (adapted after AGP 2024)

Year	Dry Tailings Production (t)	Dry Tailings* Production (m^3)	Cumulative Dry Tailings Production (t)	Cumulative Dry Tailings Production (m^3)	Tailings deposition location
Pre-Production 2	0	0	0	0	-
Pre-Production 1	711,429	474,286	711,429	474,286	TSF
Y1	12,805,713	8,537,142	13,517,142	9,011,428	TSF
Y2	18,176,996	12,117,997	31,694,138	21,129,426	TSF
Y3	18,177,000	12,118,000	49,871,138	33,247,426	TSF
Y4	18,177,000	12,118,000	68,048,138	45,365,426	TSF
Y5	18,177,000	12,118,000	86,225,138	57,483,426	TSF
Y6	18,177,000	12,118,000	104,402,138	69,601,426	TSF
Y7	18,177,000	12,118,000	122,579,138	81,719,426	TSF
Y8	18,177,000	12,118,000	140,756,138	93,837,426	TSF
Y9	18,177,000	12,118,000	158,933,138	105,955,426	TSF
Y10	18,177,000	12,118,000	177,110,138	118,073,426	TSF/SW pit
Y11	18,177,000	12,118,000	195,287,138	130,191,426	SW pit
Y12	18,177,000	12,118,000	213,464,138	142,309,426	SW pit
Y13	18,177,000	12,118,000	231,641,138	154,427,426	SW pit
Y14	18,177,000	12,118,000	249,818,138	166,545,426	SW pit
Y15	18,177,000	12,118,000	267,995,138	178,663,426	SW pit
Y16	18,177,000	12,118,000	286,172,138	190,781,426	J pit
Y17	18,177,000	12,118,000	304,349,138	202,899,426	J pit
Y18	18,177,000	12,118,000	322,526,138	215,017,426	J pit/ 87 pit
Y19	18,177,000	12,118,000	340,703,138	227,135,426	87 pit
Y20	18,177,000	12,118,000	358,880,138	239,253,426	87 pit
Y21	18,177,000	12,118,000	377,057,138	251,371,426	87 pit
Y22	943,205	628,804	378,000,344	252,000,229	87 pit

* Assuming a dry density of 1.5 t/m^3

4.0 SITE CONDITIONS

4.1 Geology

The bedrock consists mainly of felsic and intermediate metavolcanic rocks in the southern part of the project site, while the central and western parts are composed of intermediate to mafic basalt-type metavolcanic rocks. The eastern part of the project site is crossed by a granitic pluton. This magma thrust introduced dykes into the fractures of the metamorphic rocks and caused alteration of the surrounding rock walls (GEOCON, 1993).

The unconsolidated deposits that cover the bedrock over most of the project site are essentially Quaternary of glacial, fluvio-glacial and alluvial origin. On the bedrock, there is till up to 30 m thick. It is composed of boulders, pebbles, gravel and sand with variable proportions of silt and clay. In the central portion of the project site, a layer

of sand and gravel and fluvio-glacial deposits is found, which is generally loose and up to 15 m thick (GEOCON, 1993).

In the lower parts, under the peat bogs and around the lakes, 2 m thick sand deposits are present. Organic deposits a few meters thick can also sometimes be observed (GEOCON, 1993).

The general stratigraphy encountered in the TSF area consisted of backfill/fill or thin surficial peat and organic silt ranging in gradation from silty sand to silt and sand, with varying amounts of gravel and traces of clay, underlain by alluvium deposits ranging in gradation from silty sand to sandy silt, with traces of clay and gravel, and by compact glacial till deposits, ranging in gradation from silty sand to sandy silt, with varying amounts of gravel, and the presence of cobbles and boulders. Some stratigraphy encountered consisted of an esker deposit of sand with varying amounts of gravel. The bedrock in the area primarily consists of an intermediate volcanic rock with isolated areas of granite, diorite, and mafic volcanic rock. The bedrock was encountered at depths between 0.4 and 23.0 mbgs (WSP, 2024a).

4.2 Topography

The Troilus Mine Site (Site) is part of the Eastmain Lowlands, a division of the James Area physiographic unit. The terrain is rugged. To the south of the Site, there are rocky hills aligned on a northeast/southwest axis with a maximum elevation of 520 masl, while to the north, there is a rocky northeast/southwest with a maximum elevation of 430 masl. Between these two reliefs, the sector forms a valley with an elevation ranging from 365 to 400 masl with an undulating and irregular topography due to the presence of rocky outcrops intersecting the loose deposits (GEOCON, 1993).

A 2019 digital terrain model for the site has been provided by Troilus. The surface was developed from an unmanned aerial photogrammetric survey that utilizes photogrammetry processing methods and ground control points to develop the digital terrain model.

4.3 Terrain and Geohazards

WSP completed a terrain and geohazard map for a 144 km^2 area surrounding the current mine site. The map includes polygons of surficial material types, drainage class and terrain stability. The map and associated technical memorandum are included in Appendix D.

4.4 Climate

The Troilus Mine Site climate baseline conditions, including both historical climate statistics and statistics considering climate change projections are presented in detail the Appendix C of WSP (2024b). This section includes a high-level summary.

As a basis for the analysis, WSP used mainly historical records at two climate stations located approximately 140 km to the south, around the towns of Chibougamau and Chapais:

- The historical observations at the ECCC climate stations around Chibougamau and Chapais provide a reasonable estimate for extracting extreme wet climate statistics as input to the design of the Project surface water management structures. Furthermore, the approach is judged to be mostly conservative as short-term strong precipitation events are expected to be somewhat less intense at the Troilus Site than at the ECCC climate stations (Ouranos 2024).

- The historical observations at the ECCC climate stations around Chibougamau and Chapais provide a reasonable basis for the Project's site-wide water balance model. Before their application, the historical observations were adjusted using multi-annual average, seasonally based differences between the stations' location and the Site; the differences were extracted from the regional 1981–2010 climate normal maps published by Ouranos (2024). Ouranos (2024) regional climate maps suggest that, on average, the climate at the Troilus Site is colder (approximately 1.2 °C in mean annual temperature), with drier winter (approximately 16% less precipitation) and spring (approximately 4% less) seasons, but wetter summer seasons (13% more precipitation) than at the locations of the ECCC climate stations in Chibougamau and Chapais.

Illustration 3, Illustration 4, and Table 4 present average temperature and precipitation statistics:

- The mean annual temperature is -1.0 °C, varying between 16.6 °C in July and -20.6 °C in January (mean monthly daily temperatures). Temperatures stay below zero, on average, between mid-October to mid-April.
- The mean annual precipitation is 960 mm. July and September are the wettest months (130 mm and 120 mm, respectively, mean precipitation) and January and February the driest months (42 mm and 38 mm, respectively, mean precipitation).

Table 4: Average Monthly Climate Statistics for the Troilus Site after Adjustment of Values at Chibougamau-Chapais A, 1982 to 2023

Month	Mean Temperature (°C)	Precipitation (mm)
Jan	-20.6	42
Feb	-18.7	38
Mar	-11.6	50
Apr	-2.1	52
May	5.8	69
Jun	13.9	104
Jul	16.6	130
Aug	15.3	114
Sep	9.0	120
Oct	2.3	95
Nov	-5.9	84
Dec	-16.0	61
Year	*-1.0*	*960*

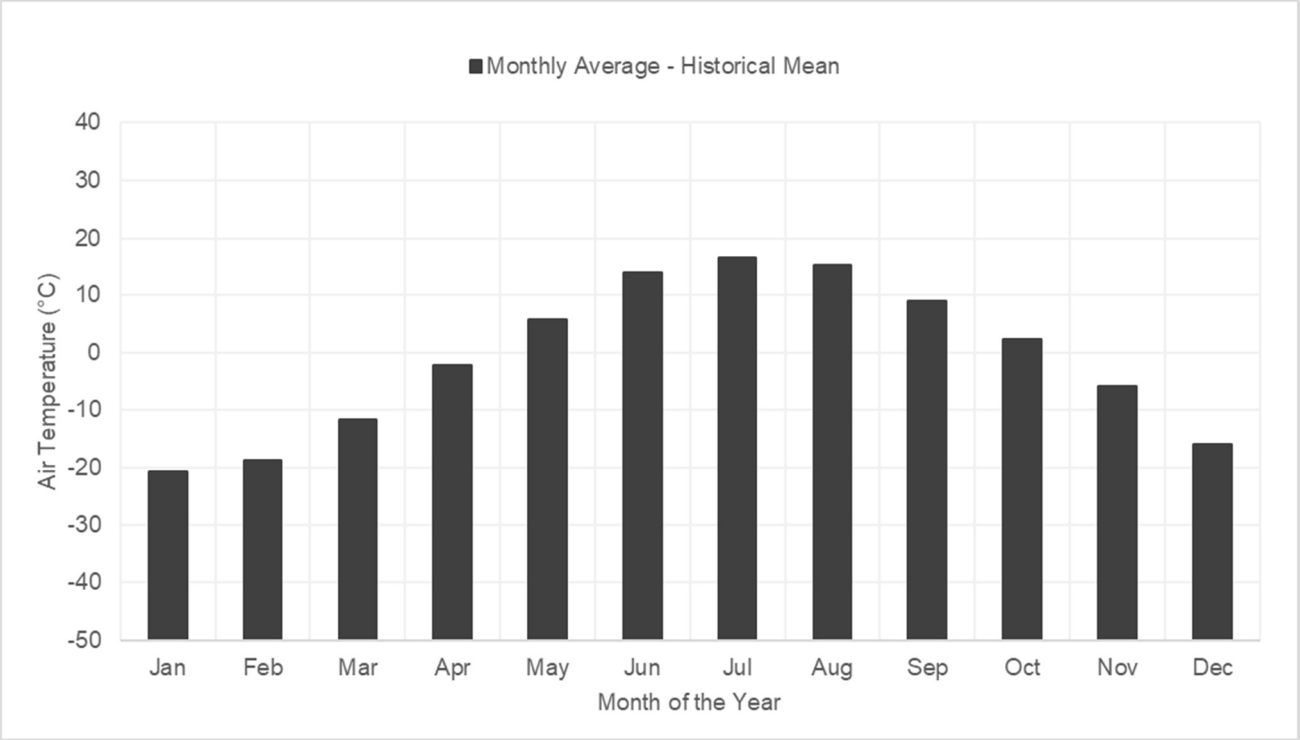

Illustration 3: Air Temperature Statistics for Troilus Site after Adjustment of Values at Chibougamau-Chapais A, 1982 – 2023

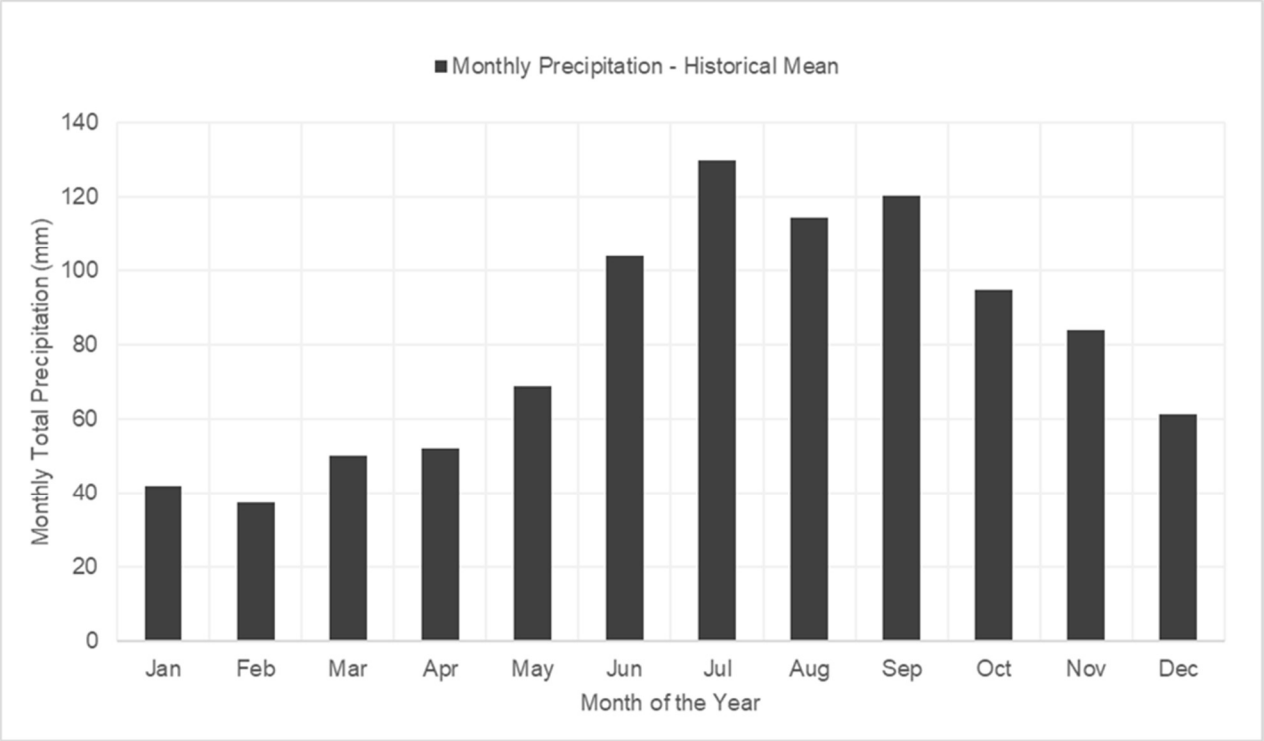

Illustration 4: Total Precipitation Statistics for Troilus Site after Adjustment of Values at Chibougamau-Chapais A, 1982 – 2023

Ouranos (2024) summarizes the projected climate change impact to the average climate conditions. For the current overview, WSP extracted statistics for one greenhouse gas emission scenario (SSP2-4.5 – moderate emissions) and for the 2021-to-2050 time horizon, which includes the Troilus Project's operational life. Generally, scenarios including more emissions cause larger changes relative to historical data, and scenarios including fewer emissions cause smaller changes. Table 5 and the paragraphs below highlight the main points.

- The mean air temperature increases for all scenarios and for all seasons. The changes are largest over the winter months. The median annual projected temperature increase is 1.4 °C.
- The total precipitation is expected to increase over the next decades. Median annual increase is 6%, with the increase over the winter being much larger than those over the summer (11% vs. 4%).
- Even for the same emission scenarios, there is a considerable variability of results among the different projections. The absolute difference between the 10th and the 90th percentile projections is as large as 40% to over 100% of the absolute 50th percentile change to the air temperature and total precipitation. Nevertheless, the overall projected trends – warmer and wetter weather, especially during the winter – appear robust, despite the large uncertainty of the projections.

Table 5: Projected Climate Change Impact to Seasonal Average Precipitation and Temperature for the Troilus Site Region (from Ouranos 2024)

	Changes for the 2021–2050 Period Relative to 1991–2020 *					
	Change to Average Daily Temperature (°C)			Change to Total Precipitation (mm)		
	10%	50%	90%	10%	50%	90%
Dec. to Feb.	1.5	1.9	2.8	10%	11%	15%
Mar. to May	0.6	1.2	1.8	0%	7%	13%
Jun. to Aug.	0.7	1.2	1.7	-1%	4%	4%
Sep. to Nov.	1.1	1.2	1.6	4%	5%	9%
Annual	1.1	1.4	1.8	4%	6%	8%

*The presented changes are statistics (10, 50, and 90 percentiles) over multiple climate projections, they are average over the simulation periods, and they are applicable for one greenhouse gas emission scenario (SSP2-4.5 – moderate emissions). The values are calculated using data extracted from Ouranos (2024).

4.5 Hydrology

The Troilus Mine Site hydrology conditions and data are presented in the Appendix C of WSP (2024b). The same appendix lists hydrological modelling parameters that were used for the design of water management structures and for the site-wide water balance model. The following paragraphs include a few key points from WSP (2024b):

- The Troilus Site, including the TSF, is located within the Bibou Creek valley between Lac Amont (upstream and to the south) and Lac A (downstream and to the north). Lac Amont has a drainage area of 16.5 km^2, the existing Bibou Creek has a drainage area of 31.2 km^2 at its confluence to Lac A, and Lac A has a total drainage area of 48.2 km^2. The TSF, J Pit, 87 Pit and Plant site, which are all part or Lac A's drainage area, have an approximate combined drainage area of 8.1 km^2. Runoff from this area, as well as groundwater seepage to the existing pits, is released to the Lac A watershed following treatment, when required. Other significant water bodies in the vicinity of the site include Lac B, Lac C1, and Lac C2, all within Lac A's watershed. Downstream of Lac A, water flows through Lac A1 and Lac A2 to Lac Boisfort, which has a drainage area of approximately 290 km^2. Further downstream, the area drains west to the Rupert River and to James Bay.

- Based on regional available records (historic streamflow measurement at regional gauging stations), the mean annual runoff for a large natural area over the 1980 to 2010 period was estimated to be 567 mm. Mean monthly values varied between 16 mm in March, before the freshet, and 101 mm in May, the main freshet month.
- Based on available literature and professional judgment, WSP selected hydrological design parameters.
  - In support of the water management structure design, the Soil Conservation Service Curve Number (SCS CN) method was used. Table 6 below presents the land type-dependent selected CN values.
  - For the site-wide water balance, a precipitation-runoff model was developed. Table 7 below presents the resulting mean annual runoff coefficients (ratio between average annual runoff and total precipitation) as they were calculated by the model.

Table 6: Hydrological Design Parameters – Selected SCS CN Values

Land Type	Selected CN Value
Natural area, wooded	60
Natural Area, vegetated	71
Cleared area of the mine site	86
Overburden dumps and built areas (includes plant site)	91
Waste rock dump	72
Tailings Beach	94
Mine Pit Area	93
Pond area (including wetland)	100 (no losses during the short-term events)

Note: Selected CN values account for the material and soil type properties, available literature, and WSP's professional experience.

Table 7: Estimated Annual Runoff Coefficients for the Land Types Used in the Water Balance Model

Land Type	Annual Runoff Coefficient (% of Total Precipitation) [(a)]
Overburden dumps, built areas	68
Cleared area of the mine site	68
Waste rock dumps	60
Natural area, wooded	58
Natural Area, vegetated	58
Tailings Beach	77
Mine Pit Area	86
Pond area (including wetland)	100 – not including evaporation or sublimation losses

Notes:

(a) The annual runoff coefficients are summary results of daily calculations that include evapotranspiration and infiltration losses and that account for antecedent moisture conditions near the surface. The daily effective runoff coefficients vary with the intensity of the rain and snowmelt event.

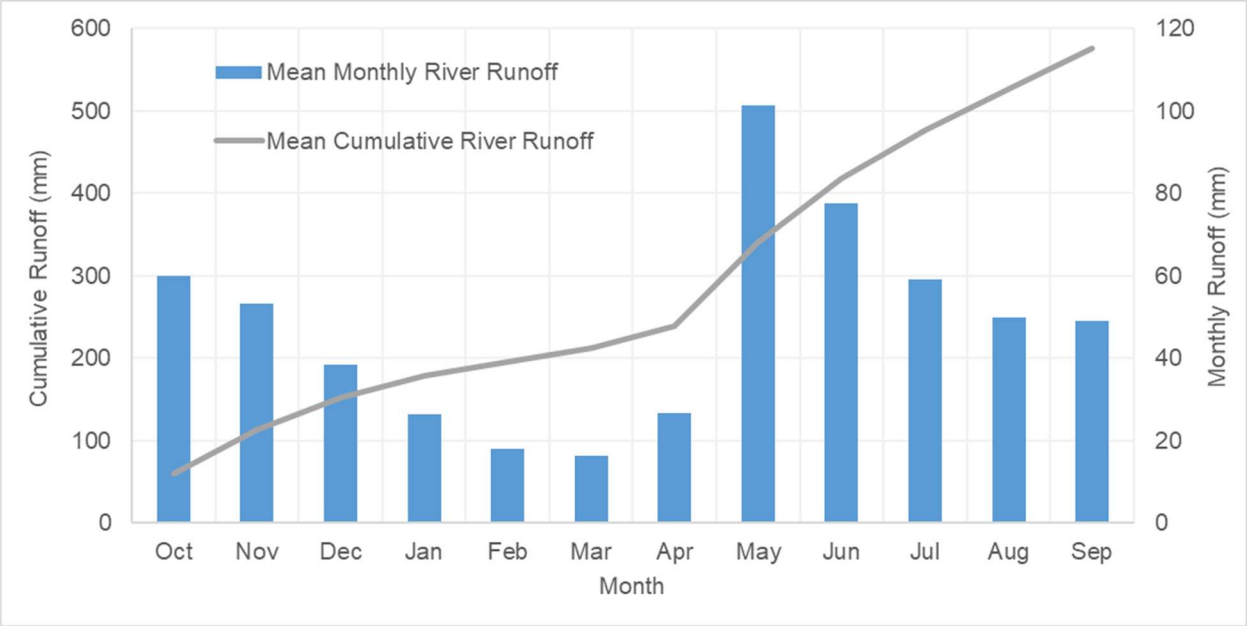

Illustration 5: 1972 to 2021 Mean River Runoff at the Broadback River Station (CEHQ 080809)

Table 8: Frequency Analysis on Annual Runoff at Broadback River Station (CEHQ 080809)

Return Period	Dry Years	Wet Years
2	562	562
10	476	668
25	448	713
50	431	743
100	417	772

4.6 Hydrogeology

A conceptual hydrogeological model was developed at the site scale (WSP, 2024c). The structure of the stratigraphic horizons of the conceptual model is based on all the information obtained during the investigation campaigns (section 6).

4.6.1 Hydrostratigraphy

The hydrogeological characterization works as well as the distribution of surface deposits made it possible to define five natural hydrostratigraphic units and two anthropogenic units:

- Rock outcrop zone.
- Till zone (calibrated hydraulic conductivity of 1 x 10^{-5} m/s and recharge of 128 mm/year).
- Peat zone overlying on till (calibrated hydraulic conductivity of 1 x 10^{-7} m/s and recharge of 35 mm/year).

- Zone of fluvioglacial and juxta-glacial deposits (calibrated hydraulic conductivity of 9 x 10^{-5} m/s and recharge of 219 mm/year).
- Zone of waste rock piles overlying on till (calibrated hydraulic conductivity of 1 x 10^{-3} m/s and recharge of 219 mm/year).
- Mine tailings zone overlying on till (calibrated hydraulic conductivity of 3 x 10^{-6} m/s and recharge of 55 mm/year).
- Rock (calibrated hydraulic conductivity variable from 2 x 10^{-9} m/s to 2 x 10^{-5} m/s which generally decreases with depth and a surface recharge of 55 mm/year).

Groundwater levels are generally near the ground surface and range from -0.6 m (artesian) to 16 m depth. A piezometric map, defined by the measurement of groundwater levels carried out in rock drilling as well as in observation wells screened in sedimentary deposits, is presented in Illustration 6. In general, the direction of groundwater flow is controlled by topography and locally influenced by Pit 87. The well area southeast of the tailings pond shows the highest piezometric levels in the region. From this topographic high, the flows head northwest, toward the mining site. In the area of the southwest projected pit, underground flows follow the direction of Bibou Creek toward the northeast. The current levels of Pit 87 create a local drawdown of nearly 70 m compared to the surrounding piezometric level, while Pit J4 has much less local influence on the groundwater table because the lake water level in the J4 pit is relatively high and the gradient much lower.

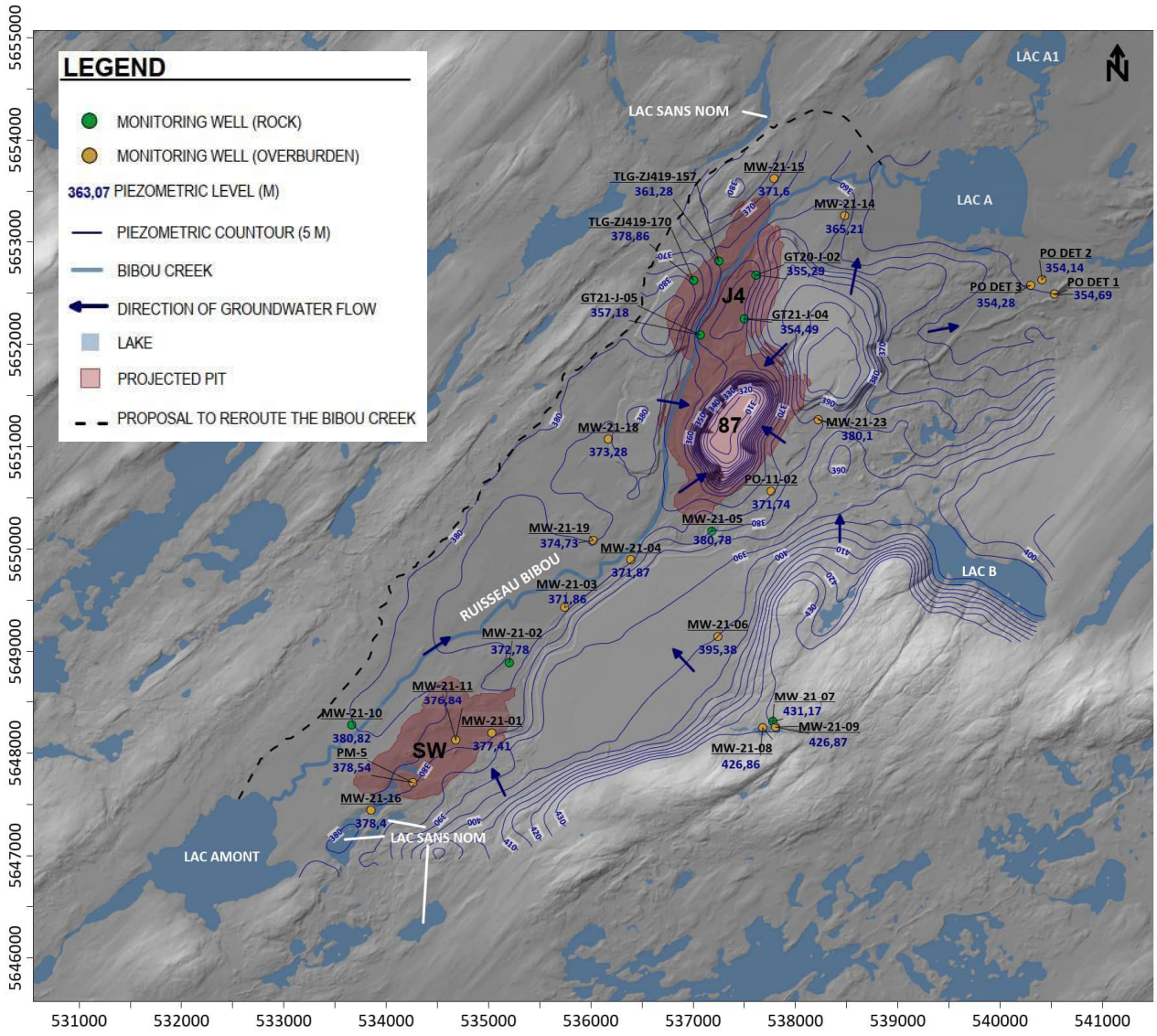

Illustration 6: Piezometric Contours and Flow Direction (after WSP, 2024d)

4.6.2 TSF area

Around and within the TSF, 16 boreholes as presented on Illustration 7 were drilled up to 3 m in the bedrock unit where 9 of them were converted as monitoring wells within different hydrogeological units (Golder, 2022b).

Three main hydrogeological units are observed around the TSF, namely tailings, till and bedrock. Three of the 16 boreholes (BH-21-06, BH-21-07 and MW-21-06) encountered tailings ranging in gradation from sand to silt with a thickness of approximately 20 m and a water level of 3.5 m below ground surface (mbgs) (395.5 masl in elevation) and a hydraulic conductivity of 3 x 10^{-6} m/s at MW-21-06 (Golder, 2022b).

All seven boreholes (BH-21-01 to BH-21-07) and nine monitoring wells (MW-21-01 to MW-21-09) encountered a glacial till deposit at various depths: five at the surface, seven with till overlain by thin layers of topsoil, three with till overlain by tailings and then thin layer of topsoil, and one with till overlain by backfill/fill (Golder, 2022b).

Six monitoring wells (MW-21-01/03/04/07 to 09) were installed within the till with a water level ranging from -0.3 (MW-21-08) to 2.8 (MW-21-04) mbgs (371.5 to 426.8 masl in elevation) and a hydraulic conductivity ranging from 2 x 10^{-5} (MW-21-03 and MW-21-04) to 8 x 10^{-6} m/s (MW-21-09) with a geometric mean of 2 x 10^{-5} m/s (Golder, 2022b).

The bedrock unit was reached for all boreholes excepted for BH-21-07 and MW-21-06, ranging from 0.9 (MW-21-07) to 26.7 (BH-21-04) mbgs (432.5 to 360.8 masl in elevation). Three monitoring wells (MW-21-02, MW-21-05 and MW-21-07) were installed within the bedrock unit with a water level ranging from -0.6 (MW-21-02) to 10.3 mbgs (MW-21-05) (373.0 to 432.2 masl in elevation).

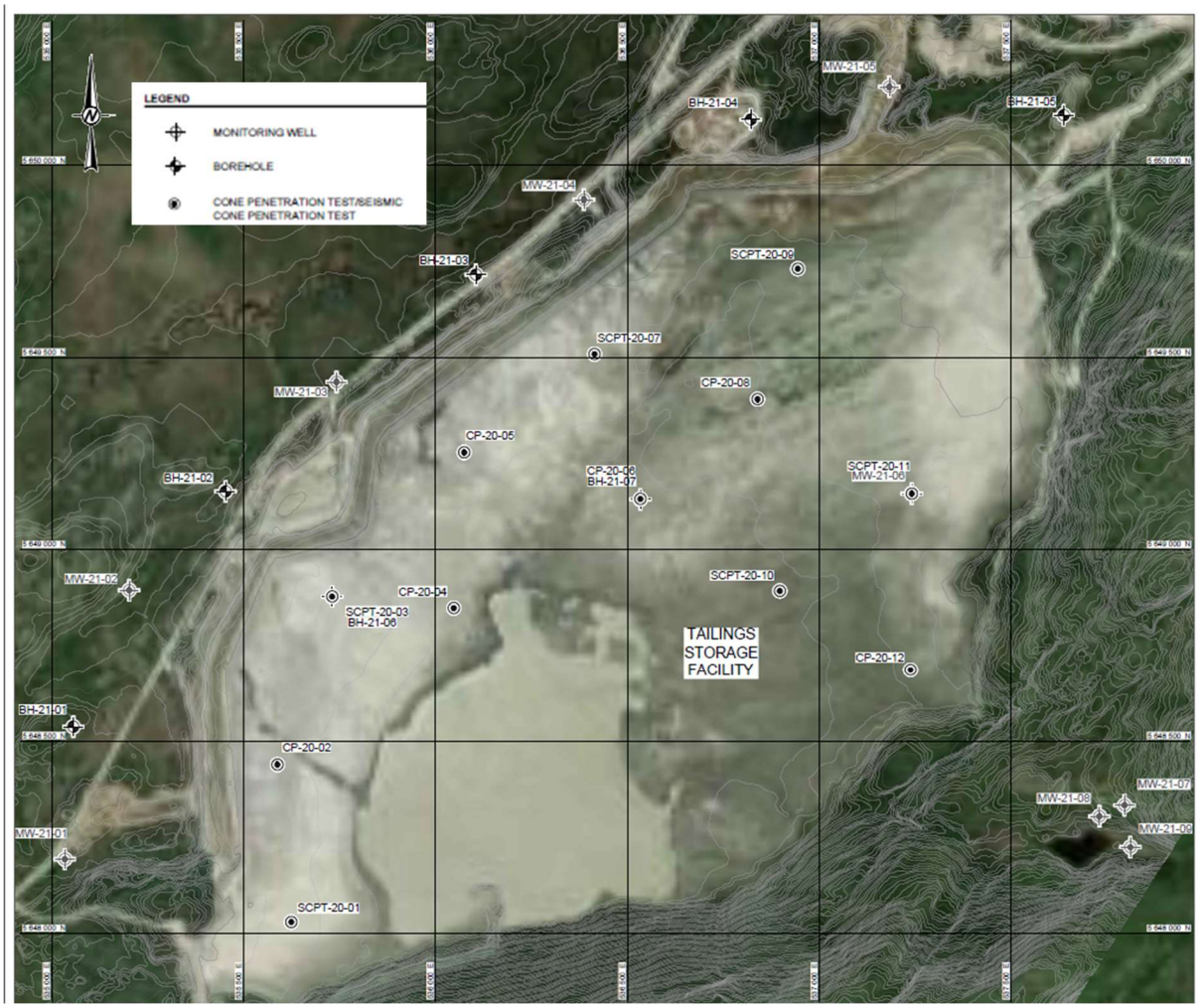

Illustration 7: Tailings Storage Facility Geotechnical Investigation Location

4.6.3 Groundwater quality

Several observation wells have been monitored since the closure of the Troilus mining site. They are located upstream and downstream of the TSF; upstream and downstream of the mining site; in the former industrial sector; as well as downstream from the trench burial site. A water well used by the Awashish family is also monitored to ensure the quality of drinking water. An enhanced monitoring program for the level and quality of groundwater was put in place as part of the impact study (WSP 2024d and 2024e).

Groundwater monitoring at the Troilus mining project site reveals the following main facts (Golder, 2022d, WSP 2024d and 2024e):

- The groundwater upstream of the tailings pond is naturally acidic (generally pH less than 6). The combination of acidic rain, the geology with low buffer capacity and the specific climate of the boreal forest contributes to the acidity of surface waters in this ecosystem.
- The conductivity of the water upstream of the site is less than 100 µmhos/cm while that downstream of the tailings pond is between 100 and 400 µmhos/cm and that in the former industrial sector is between 200 and 450 µmhos/cm.
- The groundwater upstream of the site is of good quality and does not present any contaminants beyond the values established by the groundwater criteria[1].
- The 2023 campaigns show that the Potable Water (EC) comparison criteria (MELCC, 2021) for groundwater were exceeded and observed for Arsenic, Manganese and Ammoniacal Nitrogen for wells that can be used as water supply. Exceedances of the Resurgence in surface water (RES) comparison criteria for groundwater were also observed for Copper and Sulfides (expressed as H_2S and S^{2-}) for wells that can be used as water supplies.
- The 2023 campaigns show that the RES comparison criteria and Appendix V of Règlement sur la protection et la réhabilitation des terrains (MELCC, 2019) for groundwater were exceeded and were observed for Toluene, Sulfides (expressed in H_2S and S^{2-}) and certain metals (Silver, Cadmium, Copper, Manganese, Mercury, Nickel, Zinc) in several observation wells.
- WSP can observe a seasonal fluctuation for copper and zinc concentrations by reviewing the groundwater quality analysis data since 2018 for the various post-closure monitoring wells. Indeed, the concentrations of copper and zinc in groundwater appear to be higher during low flow periods in the fall compared to the results obtained during sampling during spring flood periods.
- All observation wells show values below the detection limit for polycyclic aromatic hydrocarbons (PAHs) during the last sampling campaigns carried out in 2023.

4.7 Site Seismicity

The Troilus site is located within the stable continental region of the North American tectonic plate where the few recorded earthquakes are from ongoing intraplate seismicity within central and eastern North America that is generally characterized by a relatively low historical earthquake occurrence, when compared to western North America.

The WSP Seismic Hazard team undertook probabilistic seismic hazard analysis (PSHA) for the TSF site at Troilus. The analysis was conducted in late 2023 to support the ongoing engineering studies/feasibility-level study of the

[1] MELCCFP : ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (du Québec) since October 2022; formely known as the ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC, from 2018 to 2022), ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (MDDELCC, from 2014 to 2018), ministère du Développement durable, de l'Environnement de la Faune et des Parcs (MDDEFP, from 2012 to 2014), ministère du Développement durable, de l'Environnement et des Parcs (MDDEP, from 2005 to 2012), ministère de l'Environnement (MENV, from 1998 to 2005) and ministère de l'Environnement et de la Faune du Québec (MEF, from 1994 to 1998).

TSF at Troilus. Further details on the PSHA including scope of work, regulatory information, and the models, are provided in Appendix J.

This PSHA uses the 6th-Generation Seismic Hazard Model of Canada (CanadaSHM6) developed to provide seismic hazard values for the 2020 National Building Code of Canada (NBCC). The 2020 NBCC ground motions calculated from CanadaSHM6 are provided by Natural Resources Canada (NRCan) through a web tool. The NRCan web tool provides ground motions for a minimum AEP of 1/2,475.

4.7.1 Methodology

Engineering analyses and design for the Troilus TSF are for an assumed extreme consequence classification for the TSF (Golder, 2022b). PSHA is conducted using OpenQuake software (v3.11.4) developed by Global Earthquake Model (GEM). The methodology and corresponding outputs are summarized below:

Obtain the OpenQuake input files for the CanadaSHM6 SE Canada model as provided in NRCan Open File 8924 (Kolaj et al., 2023).

Validate implementation of CanadaSHM6 in OpenQuake v3.11.4, using the two tests as described below.

Use the CanadaSHM6 SE Canada model and corresponding GMMs (as implemented in the 2020 NBCC) to calculate the 1/10,000 AEP PGA at the Troilus TSF site (50.989ºN, 74.481ºW) for VS30, REF values of 1,500 m/s and 3,000 m/s, and a VS30, SURF value of 180 m/s.

Obtain the average magnitude, distance, and epsilon contributing to the 1/10,000 AEP PGA seismic hazard for each site condition through hazard disaggregation.

4.7.2 Results

The CanadaSHM6 SE Canada model files were validated in OpenQuake v3.11.4 by two tests. The analysis estimated the 1/10,000 annual exceedance probability (AEP) Peak ground acceleration (PGA) at the Troilus TSF site with PSHA using the existing seismic source model (CanadaSHM6) and ground motion models (GMMs) developed for the 2020 National Building Code of Canada (NBCC), with no modifications of the published models (Kolaj et al., 2023). The analysis is undertaken for three site conditions: two $VS30_{,REF}$ values of 1,500 m/s and 3,000 m/s, and one $VS30_{,SURF}$ value of 180 m/s.

The PSHA indicates that 1/10,000 AEP PGA values at the Troilus TSF site are relatively low, with values of 0.0884 g and 0.0800 g for the $VS30_{,REF}$ values of 1,500 m/s and 3,000 m/s, respectively. The 1/10,000 AEP PGA value for the ultimate tailings elevation site condition, $VS30_{,SURF}$= 180 m/s, is 0.180 g.

Assessment of site conditions indicated the greatest contributors to hazard at the site are earthquakes with magnitudes of about Mw 4.8 to 6.0 with source-to-site distances of less than about 60 km. This contribution is likely from distributed shallow crustal earthquakes within the Canadian craton that are not associated with known faults.

At distances greater than 280 km, there is some hazard contribution from larger magnitude earthquakes (i.e., Mw 7.0 to Mw 8.0). These earthquakes likely occur within the Saguenay-Lac-St-Jean region southeast of the Troilus TSF site. Should subsequent seismic analyses require the development of a suite of earthquake acceleration time histories, then period-dependent disaggregation modal distributions will need to be considered.

5.0 TAILINGS CHARACTERIZATION

Golder's archives contain some data on the properties of the tailings within the existing TSF. Based on the Golder (1997) study summary of existing tailings properties is presented in Table 9. Golder undertook a tailings testing program for dewatering, rheological, geotechnical and geochemical testing to support the design, included in Appendix B. Testing was undertaken on samples taken from test work done at COREM on Domain 42 in the J Zone. These samples are thought to be representative of the grind for the various deposits that will be mined over the LoM.

5.1 Existing Tailings Characterization

Typical tailing properties for existing tailings within the TSF are included in Table 9.

Table 9: Typical Existing Tailing Properties

Parameter	Value	Unit	Source
Beach slope (0-500 m)	2	%	Golder 1997
Beach slope (500-1800 m)	0.3	%	Golder 1997
Beach slope (underwater)	3	%	Golder 1997
Specific gravity	2.65	-	SNC (1997)
Water content, deposited tailings	26.3	%	Golder 1997
Dry density, deposited tailings	1.50	t/m^3	Golder 1997
Bulk density, deposited tailings	1.99	t/m^3	Golder 1997

In 2000, samples of the deposited tailings were collected close to, and far away from the point of deposition. These results are summarized in Illustration 8. The data indicates that the tailings are generally classified as silty sands. Near the deposition point (2 to 8 m from the deposition point) an average of 41% of materials pass the #200 sieve, whereas the deposits further from the deposition point (18 to 28 m from the deposition point) have on average 47% passing the #200 sieve. The data indicates moderate segregation with distance from the deposition point. Historically, tailings were deposited without thickening at a solids content of approximately 35%, which is consistent with segregation of the fine material. The materials deposited within the settling pond are assumed to contain mostly fines, considering the likely gradation achieved during the historic milling operation. Frozen layers of tailings of variable thickness have been identified at depths of between 6 m and 14 m below the tailings surface in some central areas of the TSF.

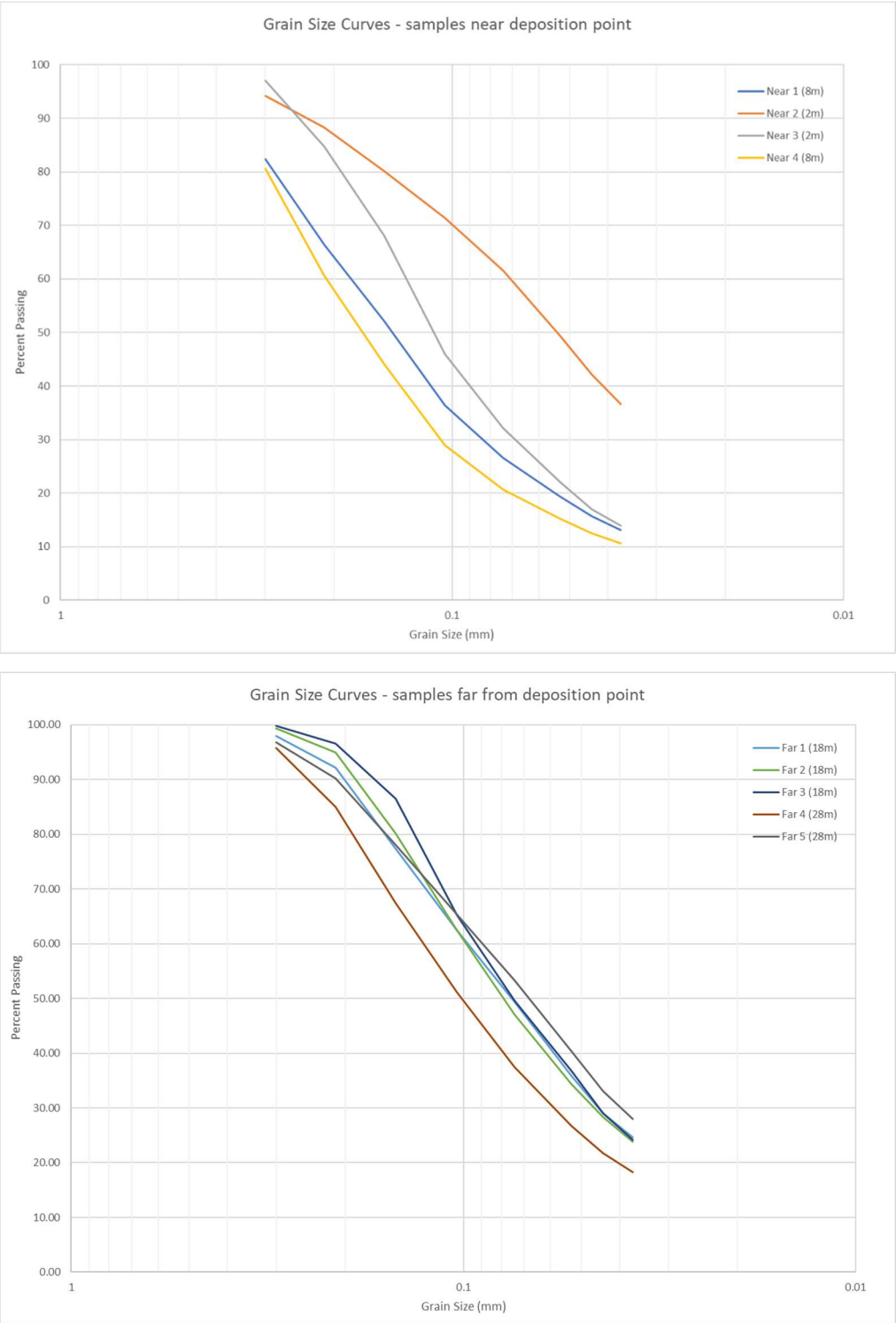

Illustration 8: Tailings Grain Size Curves

5.2 COREM Tailings Sample Characterization

The gradation of the COREM tailings sample received and tested in support of the study is included in Illustration 9. The sample had a specific gravity of 2.84 and P80 (80% passing) of 0.086 mm which is in line with the work performed by Base Metallurgical Laboratories for Troilus. These results are summarized in Table 10.

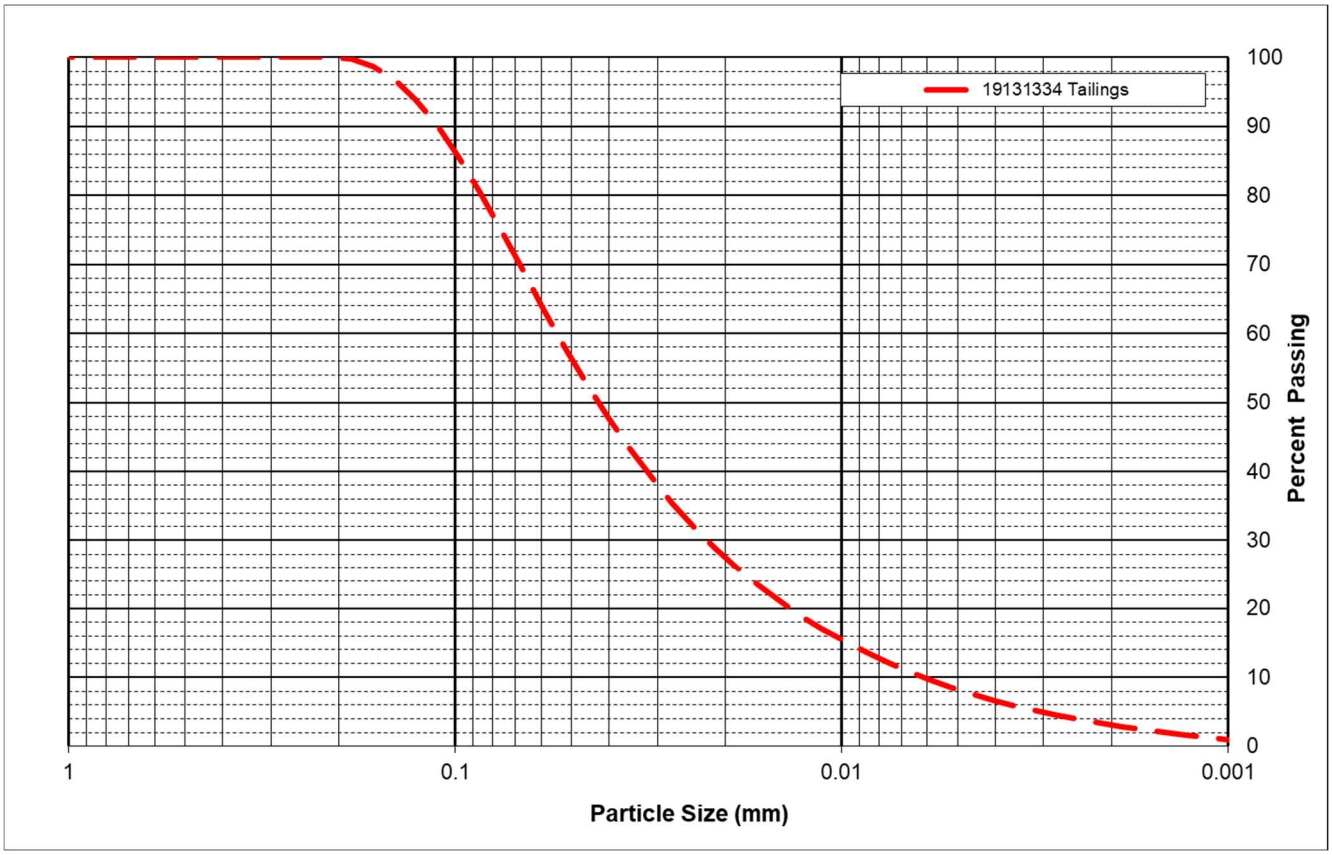

Illustration 9: COREM Tailings Gradation

Table 10: COREM Tailings Properties

Sample	S.G.	P80 (mm)	% Passing 0.011 mm	Tested by
J Zone Tail	2.81	0.080	13.5	Eriez
Southwest Tail Blend	2.89	0.067	18.7	Eriez
87 Zone Tail Blend	2.80	0.081	13.4	Eriez
Golder (Domain 42 & J Zone)	2.84	0.086	16.8	Golder

S.G. = specific gravity; P80 = 80% passing.

Although it is acknowledged that the specific gravity of the tailings may be higher than that used in the original design, it was decided to conserve the value of 2.65 for the FS, to conservatively estimate the airspace requirements of the TSF. This assumption will be reviewed in future design studies.

5.3 Advanced Characterization of Existing Tailings

A detailed analysis was carried out on the CPT tests and laboratory triaxial and direct simple tests (DSS) carried out in the 2020 site investigation program in order to determine the material properties, specifically the peak and post-liquefaction undrained shear strength values used in the stability analysis (see Table 23). Appendix L after the text provides details on the methods used and the results.

5.4 Geochemical Characterization

The historical Troilus tailings predate the current version of Directive 019 in 2012, but were considered to be non-acid generating (SNC, 1997). Data provided by Troilus suggests that seepage from the existing facility supports the fact that the tailings are classified as low-risk as defined by Directive 019. Under the current Directive 019 guidance, there are no specific requirements for seepage management for a TSF for low-risk tailings. Geochemistry testing is still ongoing in support of feasibility design, and design changes could be required if the tailings are reclassified as high-risk tailings.

6.0 FOUNDATION CHARACTERIZATION

A few investigation campaigns were conducted in the TSF area, summarized in Table 11. Studies included laboratory testing programs, including water contents, grain size and hydrometer, Proctor compaction, triaxial permeability and direct shear testing. This geotechnical information formed the database to support the design of the facility.

Table 11: TSF Specific Investigation Campaigns

Year	Responsible	Survey	Reference/ Source	Comment
1994	Techmat	▪ Six boreholes ▪ 20 test pits ▪ 16 mechanical hammer surveys ▪ Six auger surveys ▪ 14 probe tests ▪ Five excavator surveys ▪ 14 standpipe piezometers ▪ Seven piezometers	Techmat. 1995. Projet Troilus, Étude Géotechnique, Campagne 1994, Contrat 795-S-502, Dossier 4189402. March 1995.	-
1995	SNC	▪ 12 test pits	SNC (SNC-Lavalin). 1997. Exploitation minière Troilus, Conception du parc à résidus miniers, Notes techniques, Rapport révisé de SNC Lavalin Environnement. Projet 007595-41ET-401. May 1997.	The records of test pits were not included in the copy of the SNC report provided for review.
1995-1996	SNC	▪ Four boreholes ▪ 12 destructive Boreholes ▪ Seven test pits	SNC (SNC-Lavalin). 1997. Exploitation minière Troilus, Conception du parc à résidus miniers, Notes techniques, Rapport révisé de SNC Lavalin Environnement. Projet 007595-41ET-401. May 1997.	Investigation during construction. The record of borehole sheets and a site plan showing the locations of the various investigation points were not included in the copy of the SNC report provided for review.
2021	Golder	▪ 16 boreholes ▪ 14 cone penetration tests	Golder. 2022b. Factual Geotechnical Investigation	-

Table 11: TSF Specific Investigation Campaigns

Year	Responsible	Survey	Reference/ Source	Comment
			Memorandum for the Existing Tailing Storage Facility – Troilus Mine, Quebec. Golder Doc No 031-19131334-5400-RevA. 4 November 2022.	

The locations of the investigations in the TSF area are shown in the Figure A1 in the report WSP (2024a). The key strata encountered at the Site include:

- Topsoil;
- Peat;
- Glacial till;
- Glaciofluvial – esker;
- Alluvial – spreading plain of silt and fine sand;
- Bedrock.

The geotechnical investigation campaigns conducted outside of the TSF area are summarized in Table 12.

Table 12: General Site Investigation Campaigns

Year	Responsible	Survey	Reference/ Source	Comment
1991	Dupont Desmeules et associés inc.	▪ One borehole ▪ One standpipe piezometer ▪ Nine test pits	Minova Inc. – Projet minier Troilus-Frotet, Site minier. Rapport préliminaire, volume 3. Ref. No 758. December 1991.	Locations of surveys are approximate because they are only presented on a non-georeferenced map.
2020	Golder	▪ Nine seismic refraction lines ▪ 47 MASW test ▪ Six ERI lines	Golder. 2022. Geophysical survey at Troilus mine, Quebec.	Draft report
2021	Golder	▪ 14 boreholes	Golder Associates Ltd. (Golder). 2022c Factual Geotechnical Investigation Memorandum for Proposed Waste Dumps and Mine Infrastructure – Troilus Mine, Quebec. Golder Doc. 014-19131334-Report_STRUCTURES 202108-Rev0. Dated June 9 2022.	-
2023	WSP	▪ 40 (seven for TSF area only) ▪ Three test pits (TSF area only) ▪ 17 manual augers (TSF area only)	WSP (2024a). Factual investigation Report, Troilus Mine Quebec – Feasibility Study, Doc ref. 052-2257554002-Rev0. Dated 13 June April, 2024.	-
2023	BluMetric	▪ 8 test pits ▪ 144 manual augers	BluMetric (2024). Plan de Réhabilitation – Programme de Suivi Environnemental – Plan de Contingence – Zone de Déposition de Poussières	

Year	Responsible	Survey	Reference/ Source	Comment
			Aéroportées. BluMetric Doc. 230138-00. Dated March 29, 2024.	

According to the TSF detailed design by SNC-Lavalin (1997), in general, soils at the existing embankment are comprised of a cover of peat or vegetated soil followed by a till or alluvial (silt) deposit overlaying the bedrock. There are a few peculiarities along the existing dyke: near the northern limit of the existing dyke, a 1- to 3-metre-thick layer of sand overlies the till, and near the southern limit of the existing dyke, a 9-metre-thick esker crosses the axis of the existing dyke. Table 13 summarizes the observed foundation conditions along the chainage of the embankment.

Table 13: Interpreted Foundation Conditions (after SNC 1997)

Stationing along Dyke – SNC 1997 (m)	Corresponding Stationing along Dyke – Figures 9 and 10 (m)	Main Surficial Deposit	Ground Surface Elevation (m)
0+100 – 0+170	3+975 – 3+825	Rock outcrop	378 – 384
0+170 – 0+245	3+825 – 3+750	<1 m peat on silt and sand	378 – 384
0+245 – 0+300	3+750 – 3+700	Esker sand and gravel	378 – 384
0+300 – 0+475	3+700 – 3+525	<2 m peat on silt and sand	376 – 378
0+580 – 1+200	3+425 – 2+750	Till and/or silt	378 – 386
1+200 – 1+300	2+750 – 2+690	Silt and/or till	374 – 376
1+300 – 1+515	2+690 – 2+400	Till	372 – 379
1+515 – 1+615	2+400 – 2+325	Thin till over rock	372 – 374
1+615 – 1+710	2+325 – 2+215	Silt/sand over till	372 – 376
1+710 – 1+825	2+215 – 2+100	>5 m sand over till	376 – 378
1+825 – 1+930	2+100 – 2+000	Till and/or silt	374 – 378
1+930 – 2+210	2+000 – 1+725	Sand over till	374 – 387
2+210 – 2+270	1+725 – 1+650	<2 m sand over till with thin peat	373 – 374
2+270 – 2+940	1+650 – 0+975	<2 m sand over till without thin peat	374 – 390

< = less than; > = greater than.

Below are the observations from the boreholes performed by Golder (2022b) and WSP (2024) in their investigations:

The stratigraphy at the location of the TSF below the dykes or tailings included organic silt and peat at discrete locations from the ground surface to a depth of ± 0.9 m, underlain by glaciofluvial sand from beneath the fill to a depth of up to 3.3 m. This layer is expected to be primarily present through an esker zone that extends to a north-east to south-west trending direction. Till is also present from the ground surface to beneath the surficial soils to depths ranging from ± 1 to ± 27 m. Till is deeper along the northern edge of the TSF and shallows to depths around ± 10 m towards the south end of the TSF and ± 1 m on the mountain slopes.

One borehole was drilled on the tailings beach by Golder in 2009, which extended into the foundation below the tailings. The soils encountered in this borehole consisted of cobbly gravel to gravelly sand (interpreted as glacial till) extending at least 9 m below the contact with the tailings mass.

The groundwater table was observed between 0 and 4 m below ground surface (mbgs) in boreholes drilled at the site, corresponding to the elevations of 365.5 to 368.0 m.

7.0 FEASIBILITY DESIGN DESCRIPTION

7.1 Overview of the TSF Concept

The FS design of the TSF will provide an additional capacity of 169 Mt over the existing TSF. The design assumes a downstream raise of the existing dyke (Main Dyke) to a final elevation of 435 masl and construction of a saddle dyke along the low point of the mountain slope on the eastern side of the TSF, also to 435 masl (Illustration 3). The saddle dyke (East Dyke) is required once the tailings reach an elevation of 428 masl within the TSF, as they can no longer be naturally contained within the TSF sub-catchment by the mountain. It is noted that downstream raises of the facility are constrained by the location and ultimate footprint of the pits adjacent to the toes of the facility. The ultimate configuration of the pits constrains the ultimate elevation and the capacity of the TSF under the selected development methodology.

The FS design of the Main Dyke raise and East Dyke is for downstream construction. For the Main Dyke in particular, measures have been incorporated into the design to migrate from the existing upstream raised facility to downstream construction, resulting in improved geotechnical stability. The downstream construction method provides additional storage capacity and a lower environmental risk than the upstream and centreline construction adopted for the existing TSF. The concept of an internal pond away from the perimeter and draining perimeter embankments is conserved. This concept results in lower pore pressures in the tailings adjacent to the perimeter dykes and has a positive effect on stability.

The western section of the TSF perimeter embankment will be constructed contiguous with the proposed waste rock pile. An integrated waste rock/tailings construction approach will be implemented to promote the quality construction of the tailings containment structure and the long-term performance of the tailings storage facility. It is noted that the waste rock pile will be substantially higher than the TSF embankment. As discussed in section 8.5.2, the stability of the TSF dyke without the waste rock pile was not evaluated. In case the operational restrictions do not allow simultaneous construction of the waste rock pile and the TSF dyke, the stability of the dyke needs to be assessed.

The new starter dyke will be constructed up to the elevation of 403 m. The raise will be constructed in stages of approximately 4 m/yr until Year 8 and 2 m/yr for Year 9 and Year 10. The final elevation will be 435 m. The upstream slope of the future raises will be globally 1.0H:1V, and the ultimate downstream slope of the dyke will vary between 2.5H:1V and 3.0H:1V, depending on the sector.

7.2 Embankment Materials and Zoning

The dyke zoning includes filter and transition zones as illustrated in Figures 12 to 18. The purpose of the filter zone is to prevent migration of the fine-tailing particles into the downstream rockfill zone. The transition zone is located downstream of the filter, between the filter zone and downstream rockfill zone.

Section 7.2.2 presents severable samples meeting the filter zone characteristics. Several sources of sand have been mapped at the site, and this is the preferred source for filter material. A review of potential borrow sources should be undertaken. Depending on the quantity available, screening might be required to meet the gradation limits for the material. The transition zone will be required to be crushed and screened.

The embankments will consist of the components detailed in Table 14.

Table 14: Embankment Zoning

Name	Zone	Description
Embankment Fill	1	The selected embankment (0 – 1000mm) fill is run-of-mine waste rock, placed in 2.0 m maximum lifts and compacted using roller compaction.
Transition Zone	2	1.5 m thick (Main Dyke) and 1 m thick (East dyke), placed in 0.3 m lifts and compacted with bucket; crushed and processed on site.
Separation Layer Between Zone 2 and Zone 3	-	Geotextile fabric (Texel 934)
Filter Zone	3	2 m thick (Main Dyke) and 1 m thick (East dyke), placed in 0.3 m lifts and compacted with bucket; sourced from natural borrow sources possibly with screening on site.
Protection Layer Between Zone 3 and tailings	-	Geotextile fabric (Texel 918) stabilize locally with cobbles to avoid displacement cause by winds.

The following subsections provide details of the materials to be used for the embankment construction. The embankment fill will be run-of-mine waste rock. The transition and filter zones will be screened to fall within the specific gradation envelopes.

7.2.1 Embankment Fill (Zone 1)

The waste rock used for the embankment construction will be directly transported to the TSF through mine operations. Particles larger than 1 m in diameter will be excluded. The fill will be placed and compacted in 1.5 m lifts using civil construction equipment and criteria, to be determined through future work.

7.2.2 Transition Zone (Zone 2)

A transition layer will be placed directly on the embankment fill. The particle size distribution of the transition zone material is consistent with its intended use. The segregation criterion recommended by the USDA (2017) limits the maximum particle size for transition material 2 to 50.8 mm. This criterion is intended to avoid particle segregation during placement, which could lead to a risk of erosion later on. However, for coarse filters, compliance with this criterion often implies defining a very narrow particle size range, which is therefore not very applicable in practice. To overcome this problem, the maximum particle size for transition material 1 has been set at 100 mm. Crushed waste rock could be used as transition material 2. It should be noted that particular attention will have to be paid, during production, to the particle size of the material to ensure that it is well spread out (large particles surrounded by a matrix of finer particles) and that the method of placing the material is adapted to keep segregation to a minimum. Careful quality control monitoring will be required. The particle size envelopes obtained for the transition zone are shown in Illustration 10 and filter grain-size limits are shown in Illustration 10.

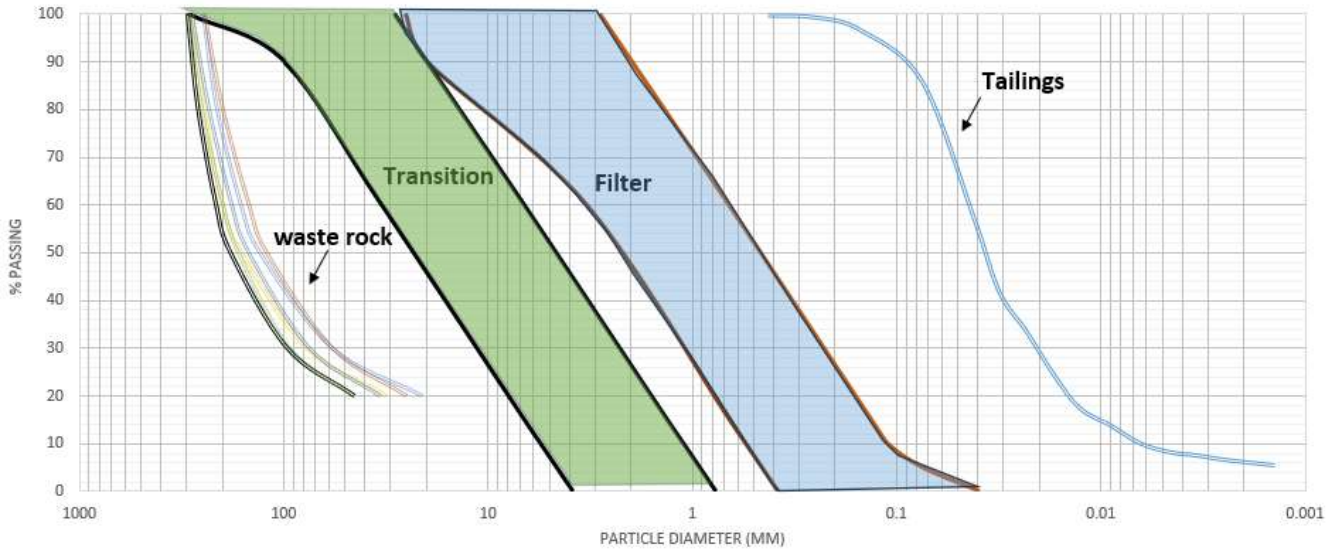

Illustration 10 Transition gradation

Table 15: Filter grain size distribution limit

Grain size distribution (mm)	Maximum percentage passing (%)	Minimum percentage passing (%)
112	92	100
80	86	100
56	75	100
40	65	100
31.5	58	100
20	45	90
14	35	80
10	27	71
5	7	52
2.5	0	32
1.25	0	14
0.630	0	0
0.315	0	0
0.160	0	0
0.08	0	0

7.2.3 Separation Layer

A layer of geotextile, Texel 934 or equivalent, will be installed between the transition zone and the filter zone. The main reason for this geotextile is to prevent the migration of particles into the transition zone. The geotextile will be

placed parallel to the slope direction and anchored at the crest of the successive raises. Appropriate overlap will be provided between adjacent sheets of material.

7.2.4 Filter Zone (Zone 3)

A filter layer will be placed directly on the transition zone. The particle size range of the material planned for the filter zone is consistent with its intended use. The segregation criterion recommended by the USDA (2017) limits the maximum particle size for Transition 1 material to 25.4 mm. This criterion is intended to prevent particle segregation during placement, which could lead to erosion risk. Any granular material present on site that falls within the particle size range of transition zone 1 could be used for the construction of transition 1. The grain sizes of the materials available on site were compared with the grain size classes of the filter zone. Material samples taken in the esker (BH-21-07-SS-18, MW-21-05-SS-9, BH-23-23-SS4, BH-23-59-SS-3, BH-23-16-[SS5, SS-6] and TP-23-92-[02, 02]) conform to the required gradation and can be used as filter material, provided the material is first screened to remove particles larger than 25.4 mm. The particle size envelopes obtained for the filter and compatible material are shown in Illustration 11 and filter grain-size limits are shown in Table 16.

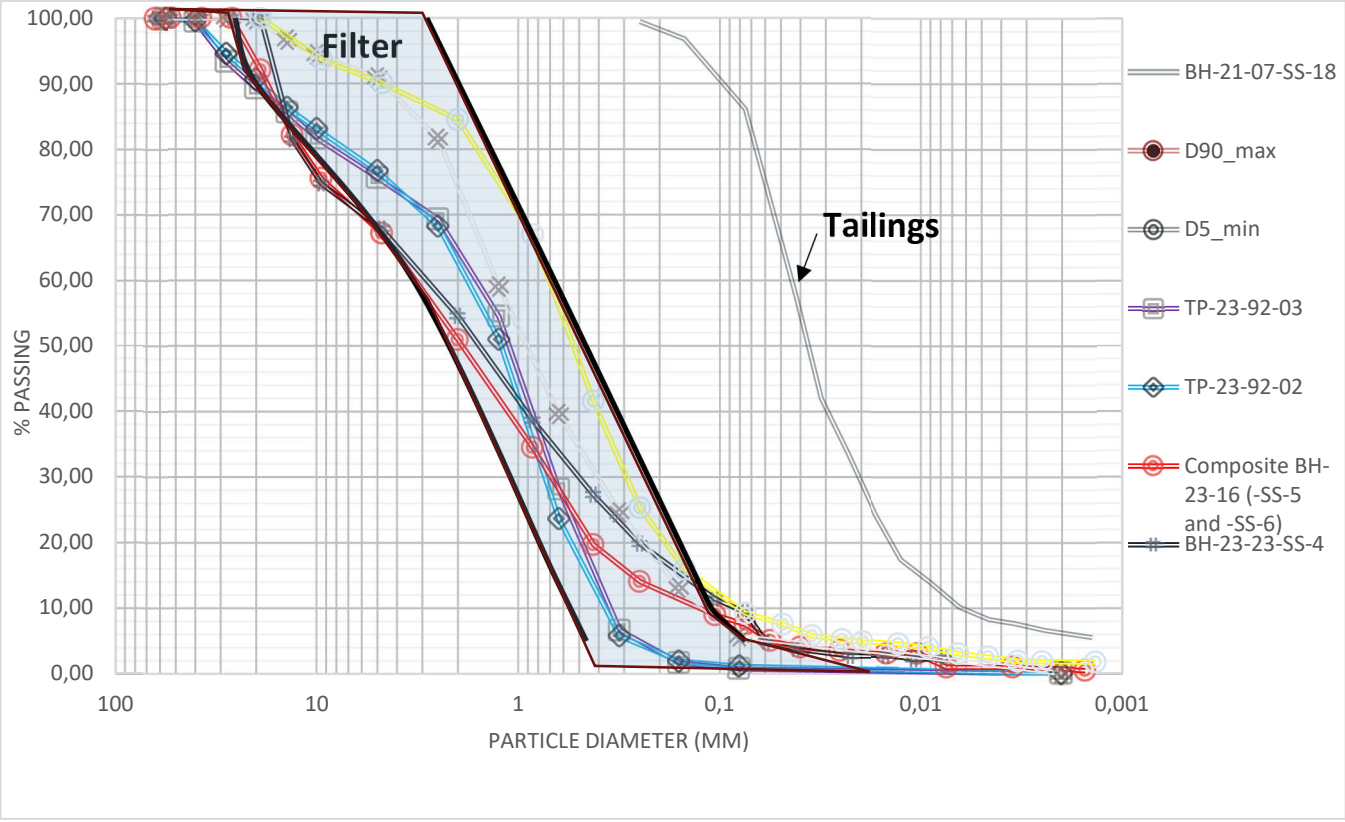

Illustration 11 Filter gradation and material compatibility

Table 16: Filter grain-size distribution limit

Grain size distribution (mm)	Maximum percentage passing (%)	Minimum percentage passing (%)
112	100	100
80	100	100
56	100	100
40	100	100
31.5	100	100
20	90	100
14	84	100
10	79	100
5	68	100
2.5	54	95
1.25	33	78
0.630	13	58
0.315	0	40
0.160	0	19
0.08	0	6

7.2.5 Protection Layer

A layer of geotextile, Texel 918 or equivalent, will be installed between the filter sand and the tailings. The main reason for this geotextile is to prevent the erosion of the sand caused by runoff. The geotextile will be placed parallel to the slope direction and anchored at the crest of the successive raises. Appropriate overlap will be provided between adjacent sheets of material. The geotextile will be stabilized locally with cobbles to avoid displacement caused by winds.

7.3 Initial Construction and Transition to Downstream Construction

The initial raise of the facility will incorporate special features designed to properly transition to the new structure. Prior to the new starter dyke construction, vegetation and organic soil on the downstream face of the TSF will be removed. The existing embankment will be excavated in order to expose the filter zone at the elevation of the 2004 dyke raise and the new filter system (see Sections 7.2.2 to 7.2.5) will be constructed to provide a continuous filter between the old and new construction. The thickness of filtering materials at this connection will be approximately 50% thicker than for subsequent raises in order to accommodate potential differential settlements between old and new construction. Illustration 12 illustrates a conceptual tie in between the existing filter zone of the existing TSF and the new starter dyke (first raise) of the downstream transition. The height of the existing dyke and the construction method varies along the existing alignment and the transition will need to be adjusted along the alignment to ensure there is a suitable tie in with existing filters. In some instances, this may require excavation beyond the final raise of the existing TSF.

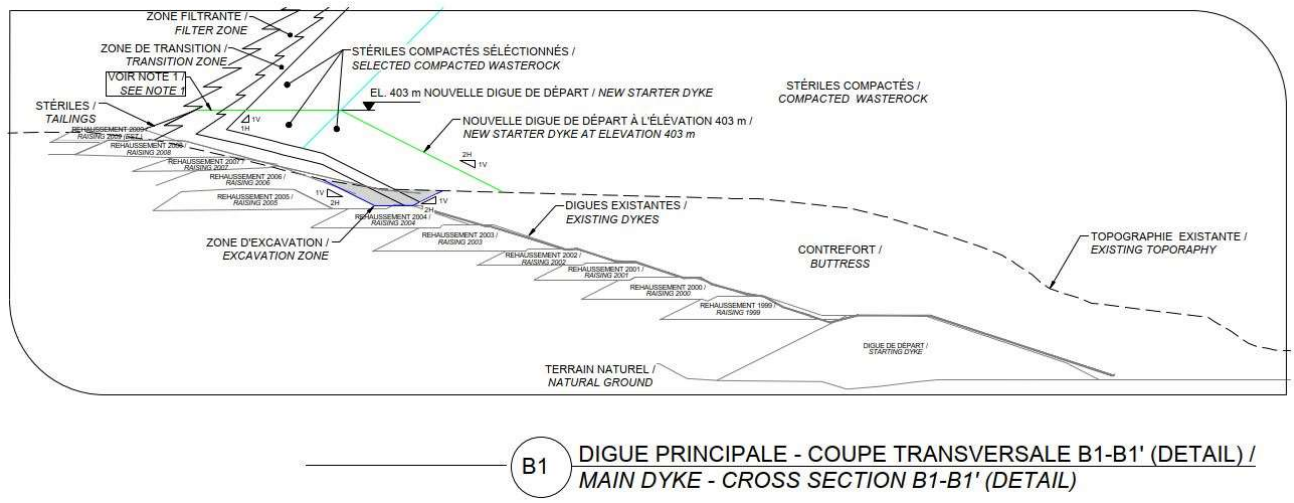

Illustration 12: Conceptual Filter Tie In between Existing TSF and New Starter Dyke

7.4 Embankment Staging

The TSF will be raised annually in 4 m downstream raises. Each raise will be built in 2 steps of 2 m. General embankment fill will either be obtained directly from mining operations or rehandled from adjacent waste rock stockpiles. Specialty construction materials (filter sand, transition gravel and cobbles) will be sourced from existing borrow sources or crushed and screened at the site crushing plant. Once the tailings reach an elevation of 428 masl the East Dyke will be constructed, as tailings can no longer be naturally contained against the mountain.

7.5 Tailings Delivery and Distribution System

The processing plant will include crushing, milling, gravity gold recovery, and flotation (Lycopodium, 2024b). The thickened tailings (approximately 54.3%wt w/w solids) will be pumped to the TSF. At the final stage, the pump system would be required to pump tailings up to an elevation of 435 masl.

The tailings should follow the distribution plan described in section 8.2. The tailings will be distributed with 22 alternating spigots (12 on the west side and 10 on the northeast side) placed along the dykes and natural ground.

7.6 Decant/Reclaim System

The reclaim water system will include a pump system, one barge system and a barge walkway designed by others. The reclaim water pipeline would be approximately 5,100 m from the TSF to the mill.

7.7 Water Management

WSP (2024b) documents the site-wide water management plan as prepared for the Troilus Project FS study; the TSF water management plan is included as well. The following paragraphs repeat some of the content of WSP (2024b).

Tailings deposition in the concave TSF creates a water pond in the southern part of the facility. The pond collects the runoff from the tailings beach and from the upstream mountain slope and, also, the water released from tailings during the consolidation process. Water collected at the toe of the containment dykes may be returned to the TSF Pond as well, if its quality requires it, or it can be pumped to the site's sedimentation ponds for later discharge to the environment. The TSF Pond water is recycled by pumping to the ore processing plant or, when required, to the water treatment plant for treatment before discharge to environment.

The water level in the pond is controlled such that a minimum of 3 m water depth is maintained at all times near the pump intake to prevent resuspension of solids or ice obstructions around the pump intake.

An emergency spillway is constructed with the invert 1.5 m below the dyke crest elevation; the spillway invert is a minimum of 5.5 m above the minimum operating water level, which provides sufficient storage capacity for both normal climate operating variability and for the regulatory environmental design flood. The emergency spillway is a wide, open channel, protected by boulders against surface erosion.

Seepage at the downstream toe of the TSF embankment is collected, at the beginning of the operations, by existing toe ditches and sumps and returned by pumping to the TSF Pond. Later in the operating life, some of the seepage mixes with the runoff from the WD-W-1 Waste Rock Dump and is collected in the SP2 sedimentation pond, upstream of Pit 87.

8.0 FEASIBILITY DESIGN ASSESSMENTS

An assessment of considerations, constraints or conflicts that may restrict or preclude a dyke raise has been undertaken and is presented in this section, including:

- Layout and capacity
- Deposition planning
- Seepage, stability and deformation analyses
- Filter compatibility of materials
- Water balance
- Risk review

8.1 TSF Layout and Capacity Assessment

The TSF is required to permanently store 169 Mt of tailings in the TSF. This involves raising the existing TSF to 435 masl, including a 1.0 m distance between dyke crest and tailings, and converting to a downstream raise construction approach. The LoM stage storage curve is presented in Illustration 13.

An assessment on the impact of raising the TSF on surrounding infrastructure was undertaken. Figure 2 shows the existing mine infrastructure. The impacted areas include the existing polishing basin, mine access road and seepage collection ditches. The polishing ponds and contact water management structure will be required to be replaced with other contact water management structures within the first three years of operations.

Table 17 summarizes the mine infrastructure which would be impacted by TSF raises by approximate elevation and year.

Table 17: Summary of Impacts on Mine Infrastructure

TSF Elevation (masl)	Approximate Year	Infrastructure		
		Polishing Basin	Mine Access Road	Seepage Ditches
403	1	O	O	O
407	2	O [1]	O	X
411	3	O [1]	O	X
415	4	X	O	X
419	5	X	O	X
423	6	X	X	X

Notes: X – infrastructure impacted by TSF raise; O – infrastructure not impacted by TSF raise. 1: station not impacted but pond impacted

Any change of the mine plan and the downstream structures may impact the TSF design due to close proximity. The configuration of the SW or 87 pits and operational structures such as the haul road constrain the ultimate elevation of the Main Dyke and then the TSF capacity following the downstream raise construction.

8.2 TSF Deposition Plan

A deposition plan for the TSF was completed to determine to the crest elevation required to store the LoM tailings, determine construction staging, develop construction material quantities and to inform the spillway design and water management for the TSF.

The objectives of the deposition plan are:

- achieve the conceptual level closure design (Section 9.0)
- form an operational dry beach of at least 250 m against the upstream slope of both the Main Dyke and East Dyke.
- achieve suitable water clarity by having a minimum decant pond depth of 3 m at the position of the pumping station.
- achieve a decant pond location suitable for the plant's process requirements.
- minimize movement of the decant pump barge.

Key considerations for tailings deposition over the LoM are:

- A new starter dyke with a crest of 403 masl is required to start the deposition on the main crest.
- The East Dam needs to be constructed before the tailings reach an elevation of 428 masl.
- For the pre-production deposition, tailings will be predominantly discharged off the natural ground on the east hill. This minimizes the height of the first year of the Main Dyke raise and the requirement to extend the discharge pipe around the entire length of the Main Dyke.
- Beach slopes should be refined after the first year of deposition with the new tailings.
- The barge will be moved upslope as the pond raises, with barge moves to be minimized and deposition.
- For year 10, the deposition should last about 6 months until the TSF reaches its full capacity.

The TSF deposition plan was prepared using the software Muk3D, a three-dimensional modelling software used for planning deposition. Beach slopes were selected based on historical beach slopes and adapted using the tailing characterization work detailed in Section 0. A tailing dry density of 1.5 t/m^3 was selected based on previous work undertaken by SNC (1997). A fixed pond depth was defined for the model of 3 m at the barge location. An annual tailings deposition of 18.25 Mt was considered for the model except for the pre-production year (0.71 Mt) and year one (12.86 Mt).

Tailings deposition modelling has been carried out for each year's production volumes going into the TSF. The results show that the rate of rise of 4 m per year of the embankment is necessary for the first 7 years of production and 2 m for the last 2 years. For the first 5 years, the first half of the 4 m raise might be completed at the end of Q2. For the last 4 years, the raise should be completed before the end of the season of construction, and at mid-year the lift must be half competed (Illustration 13). Quantities per year are included in Table 18 and annual TSF surfaces are included in Appendix I.

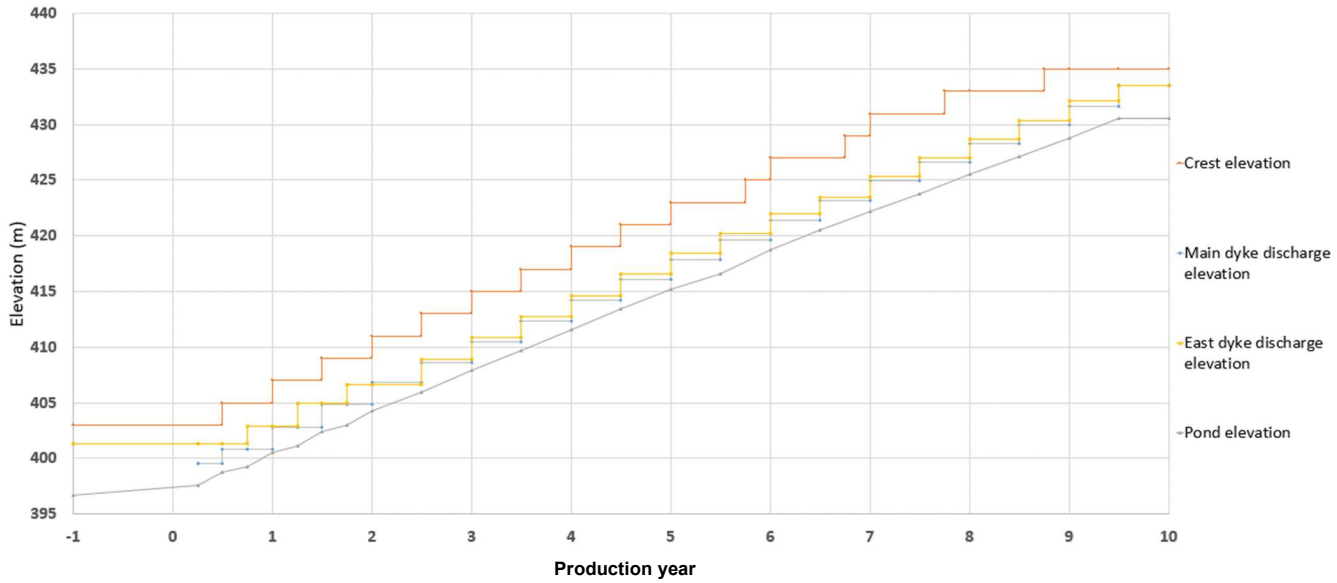

Illustration 13: Capacity of TSF vs. Elevation

Table 18: Tonnage per Discharge Elevation*

Year	Main Crest Elevation (masl)	Maximal Discharge Elevation (masl)		Tonnage (ton)	Cumulative Tonnage (ton)	Pond Elevation (masl)
		Spigot Line Main Dyke	Spigot Line East			
-1	403	-	401.3	728,056	728,056	396.7
1	403-407	402.8	402.9	12,920,00	13,648,060	400.5
2	407-411	406.8	406.6	18,282,640	31,930,700	404.3
3	411-415	410.5	410.8	18,300,251	50,230,951	406.0
4	415-419	414.2	414.6	18,300,605	68,531,556	411.6
5	419-423	417.9	418.4	18,300,895	86,832,451	415.2
6	423-427	421.4	422.0	18,300,984	105,133,435	418.7
7	427-431	424.9	425.4	18,300,229	123,433,664	422.2
8	431-433	428.3	428.7	18,300,916	141,734,580	425.5
9	433-435	431.6	432.1	18,301,238	160,035,818	428.7
10	435	433.5	433.5	9,124,189	169,160,007	430.6
* Assuming a dry density of 1.5 t/m^3						

8.3 Dynamic Liquefaction Potential Analysis

Assessing the liquefaction potential of foundation soils allows to estimate the strength of a soil under seismic loading. Cyclic liquefaction results in a loss of shear strength due to the generation of pore pressures and thus a reduction in effective stresses.

Loose, saturated granular materials are the most likely to show liquefaction potential. Such materials generally exhibit a tendency to contract when submitted to seismic loads. Plastic fine materials do not react in the same way and are more susceptible to cyclic softening.

Analyses to assess the liquefaction potential of the saturated tailings and saturated fine-tailing materials, as well as the alluvial soil in the foundation, were carried out based on data from CPT tests conducted in 2020.

These analyses were carried out by comparing the values of the cyclic stress ratio (CSR), which reflects the shear stress induced in the soil deposit by earthquake, with the values of the cyclic resistance ratio (CRR), which reflects the soil resistance to dynamic loading. Typically, a soil is considered potentially liquefiable or susceptible to cyclic softening when the CSR value is greater than or equal to the CRR value.

8.3.1 CSR and CRR

The CSR profile was established according to the dynamic response of the deposit based on the simplified method of Seed and Idriss (1971), cited by Idriss and Boulanger (2008), as shown in Eq. 1.

$$CSR = 0.65 \frac{a_{max}}{g} \frac{\sigma_{vo}}{\sigma'_{vo}} r_d \quad \textit{Eq. 1a}$$

$$r_{d=} = exp\,[\,\alpha(z) + \beta(z)M)] \quad \textit{Eq. 1b}$$

$$\alpha(z) = -1.012 - 1.126 \sin\left(\frac{z}{11.73} + 5.133\right) \quad \textit{Eq. 1c}$$

$$\beta(z) = 0.106 - 0.118 \sin\left(\frac{z}{11.28} + 5.142\right) \quad \textit{Eq. 1d}$$

where,

a_{max} is the maximum ground surface acceleration.

σ_{vo} is the total vertical stress and σ'_{vo} is the effective vertical stress.

r_d is a shear stress reduction coefficient.

z is depth in meter.

M is moment magnitude.

Two a_{max} values of 0.0884 g and 0.180 g were considered which are associated with the PGA for a Vs_{30REF} =1500 m/s (associated with the foundation level or the bedrock) and Vs_{30REF} =180 m/s (associated with the surface of the TSF), respectively (see section 4.7 for information on the site seismicity). While the dynamic liquefaction assessment for the design is carried out by the PGA related to the surface of the TSF (0.180 g), the PGA considering Vs_{30REF} =1500 m/s was assessed only to provide a comparison and to examine the susceptibility to liquefaction if the amplification of the seismic wave by the tailings pond was neglected. It must be noted that the simplified method of Seed and Idriss (1971) is less accurate for depths greater than 20 m. Therefore, the results for depths below 20 m should be consulted with caution. A seismic shear wave propagation analysis (site response analysis) needs to be carried out to provide a more accurate estimate of the CSR. This can be carried out for the detailed design when the earthquake seismic motions scaled for Troilus site through Site Specific Seismic Hazard Assessment (SSSHA) are available.

The CRR, which is used to quantify the resistance of soils to seismic stress, was evaluated based on data provided by SCPT tests, using the relationship of Idriss and Boulanger (2014), for soils with a soil classification index (Ic) of less than 2.4 (sand-like soil behaviour).

The influence of the static shear bias was not examined. Therefore, the correction factor for static shear stress K_α (as defined by Idriss and Boulanger, 2008) was defined as unity.

8.3.2 Dynamic Liquefaction Analysis Results

The results of the liquefaction and cyclic softening potential analyses are presented in Appendix M, with the main findings summarized in Table 19.

Considering a a_{max} equal to 0.180 g (PGA for a Vs_{30REF} =180 m/s and the design annual exceedance of 1/10,000), the CSR values generally exceed CRR for the saturated tailings and saturated fine tailings, implying that these materials are susceptible to liquefaction. The alluvial soil is susceptible to dynamic liquefaction with the design earthquake for some CPTs and it is not susceptible in other CPTs. The liquefaction of all three materials was considered in the stability assessments (see section 8.5.2).

For CPT-06, CPT-08 and CPT-10B, and CPT-10C the change in the porewater pressure regime associated with the presence of frozen tailings leads to changes in the estimated CSR profiles. The estimation of the CSR with the simplified method of Seed and Idriss (1971) at these locations is highly questionable, as it does not consider the specific case of propagation of the earthquake shear wave in frozen materials. Additionally, the CRR calculation does not consider the dynamic behavior of frozen tailings. Because of these reasons, it is not recommended that these CPTs be considered for the design purposes. The results of liquefaction assessment for these four CPTs are presented in appendix M for comparison with other CPTs.

Considering a a_{max} equal to 0.0884 g, utilising the Seed and Idriss (1971) method, and CPT data, the CRR remains higher than the CSR for almost all CPTs. This emphasizes the importance of the amplification caused by the propagation of the seismic wave in the tailings.

Table 19: Summarized results of liquefaction and cyclic softening potential analyses for saturated tailings, saturated fine tailings, and alluvial soil

a_{max} = 0.180 g (PGA for a Vs_{30REF} =180 m/s)			
CPT test ID	Saturated Tailings	Saturated fine Tailings	Alluvial soil (foundation)
SCPT-01	CRR< CSR	CRR< CSR	CRR< CSR
CPT-02	CRR< CSR	CRR< CSR	Partially[1]
SCPT-03	CRR> CSR	CRR< CSR	CRR< CSR
CPT-04	CRR< CSR	CRR< CSR	CRR> CSR
CPT-05	CRR~ CSR	CRR< CSR	CRR> CSR
CPT-06[3]	CRR< CSR	CRR< CSR	Partially[1]
SCPT-07	Partially[1]	CRR< CSR	Partially[1]
CPT-08[3]	CRR< CSR	CRR< CSR	CRR< CSR
SCPT-09	CRR< CSR	CRR< CSR	CRR> CSR
SCPT-10-B[3]	CRR< CSR	CRR< CSR	Partially[1]
SCPT-10-C[3]	CRR< CSR	-[2]	-[2]
SCPT-11	CRR< CSR	CRR< CSR	-[2]
CPT-12	CRR< CSR	CRR< CSR	-[2]

[1] Partially: about half of the data show CSR>CRR.

[2] The unit was not encountered in the CPT.

[3] For these four CPTs which encountered frozen tailings, the results are provided for comparison only. It is recommended that these CPTs not be considered for design purposes.

In the FS-level study, the liquefaction assessment was carried out merely on CPTs. For the detailed engineering study, liquefaction assessment for the foundation could also be carried out using available SPT results, depending on the needs of the project.

8.4 Seepage Analysis

A seepage analysis was completed to generate a steady state condition pore water pressure distribution and phreatic surface to serve as an input into stability analysis and to estimate and locate expected seepage flows along the TSF. Seepage analysis results are presented in Appendix F and summarized in this section.

8.4.1 Methodology

The SEEP/W module from the Geostudio (2023) suite was used for the analysis. This software uses the finite element method to calculate pore pressures at mesh nodes for saturated and unsaturated conditions. Steady state analysis was carried out for the end of construction and ultimate deposition condition to assess the pore pressure distribution and to estimate the exfiltration rate from the tailings to the foundations and flowing under the dykes.

8.4.2 Material Properties

The saturated hydraulic conductivities of the foundation soil, bedrock, and dyke materials used in the analyses are summarized in Table 20. All materials were modelled with isotropic hydraulic conductivity properties (i.e., equal vertical and horizontal hydraulic conductivity). All materials were modelled by assigning saturated and unsaturated material models and properties, except for the bedrock, which was modelled with a saturated hydraulic conductivity value only. Unsaturated hydraulic conductivity functions, i.e., volumetric water content function, and the hydraulic conductivity function were estimated using functions included in SEEP/W, in a way to satisfy the convergence criteria of the model. For most of the materials, the saturated hydraulic conductivity proposed by SNC (1997) was deemed acceptable and support by experience with similar material. The tailings properties were calibrated in a way that the model provides porewater pressures that match the field data and a reasonably conservative distribution of porewater pressure for the use of stability model.

Table 20: Material Hydraulic Conductivities Used for Seepage Analyses

Material	Material Model	Saturated Hydraulic Conductivity, k (m/s)	Note/Reference
Tailings	Saturated / Unsaturated	3×10^{-6}	Calibrated value and SNC (1997)
Compacted Till Core	Saturated / Unsaturated	8×10^{-7}	Consistent with SNC (1997)
Downstream Filter	Saturated / Unsaturated	1×10^{-4}	Assumed based on WSP's experience with similar materials
Waste Rock / Erosion Protection	Saturated / Unsaturated	1×10^{-1}	Assumed value based on Golder experience with similar material
Foundation Till	Saturated / Unsaturated	8×10^{-7}	Consistent with SNC (1997)
Foundation Glaciofluvial/Alluvial	Saturated / Unsaturated	1×10^{-4}	Assumed based on WSP's experience with similar materials
Bedrock – 0 to 6 m depth	Saturated	1×10^{-6}	Assumed based on WSP's experience with similar materials
Bedrock – > 6 m depth	Saturated	1×10^{-7}	Assumed based on WSP's experience with similar materials

> = greater than.

8.4.3 Model Setup and Boundary Conditions

Four representative cross-sections were selected for seepage and stability analysis (Appendix F and G): two cross-sections on the Main Embankment in front of the pits (cross-sections A and B), one cross-section in front of the West Waste Rock Dump (cross-section D) and one cross-section on the East Dyke (cross-section C). Figures 10 and 11 after the text show the location of the cross-sections.

The models use the ultimate TSF crest elevation of 435 masl with a tailings pond elevation of 434 masl applied to the upper surface of the tailings. Each model was simulated with two assumed beach lengths (distance between the upstream face of the dyke and the ponded water on the tailings pond): 8 m and 200 m. This assumption is

shown in appendix F on Figures F-1, F-7, F-13, and F-19 for the 8 m long beach, and Figures F-2, F-8, F14 and F-20 for the 200 m long beach.

For cross-sections A and B, the model surface between the middle of the downstream slope of the TSF and the open pit has been modelled as a seepage face boundary based on the assumption that the water will exfiltrate from the facility towards the open pit and to let the software compute the phreatic surface. For cross-section C a hydraulic head corresponding to the water elevation of the small pond has been modelled downstream of the dyke and a seepage face boundary where water is expected to exit the facility. For cross-section D, the waste rock dump has been modelled as a seepage face boundary where water is expected to exit the facility.

A 1 m global mesh size was used for the models, with reduced mesh sizes for the zones with smaller thickness (e.g., filter / erosion protection layer), and zones of interface between materials with different properties. The convergence was validated for each model by examining the unconverged pressure head nodes in the model interface, and the conductivity vs. suction plots. Each model has 0 unconverged nodes, and all computed conductivity vs. suction plot data points were equal to input values.

8.4.4 Results of Seepage Analyses

Appendix E presents the results (pore water pressure distribution, total water head distribution and the position of the water table) of the various seepage analyses carried out on cross-section A, B, C and D. The porewater pressures computed for 8 m long beach distances were used for the stability analyses.

Table 21 presents an estimate of potential annual seepage flows for 8 m and 200 m beach distances. The length of the beach will vary during the tailing's deposition. The 8 m beach-length scenario represents a conservative case for the stability analysis while the 200 m beach-length presents a more realistic scenario. The deposition plan shows that the minimum beach length will be 250 m. The analyses were performed for a single profile corresponding to the tailings pond with the highest head of water for each dyke. For comparison purposes, the unit flows obtained from numerical modelling (for a 1 m section of dyke) were multiplied by 100 to present the equivalent for 100 m dyke face.

Table 21: Estimated Potential Seepage Flows

Cross-Section	Exfiltration rates for a 8 m beach along 100 m dyke face (m^3/h)	Exfiltration rates for a 200 m beach along 100 m dyke face (m^3/h)
A	62	8
B	120	44
C	13	0.14
D	99	19

The exfiltration values must be used with care and serve here to qualitative comparison between sectors and scenarios. They are obtained from simplified models. However, the beach length has a significant influence on the tailing's exfiltration flowing under the dyke: where the beach is close to the dyke (8 m), the gradient and the flows increase due to the proximity of permeable materials of the dyke. Where the beach is 200 m long, the gradient and flows decrease, and the water table tends to drop progressively to the level of the old dyke raise. It could be expected that the seepage be closer to those with the 200 m beach than the 8 m beach range.

Cross-section B represents a sector where a 400 meter-wide downstream zone of foundation be excavated and replaced with non-potentially liquefiable material. The exfiltration estimated for the 8 m and 200 m beach scenario for a 400 m dyke length are then estimate to 480 and 176 m^3/h respectively. This area is where exfiltration could be the greater along the TSF.

A sensitivity analysis was carried out to evaluate the impact of different tailing saturated hydraulic conductivities on the exfiltration rate in section B with a 200 m beach. The input parameters were changed as follows:

- Compacted existing tailings decreased from 3 x 10^{-6} m/s to 8 x 10^{-7} m/s.
- Thickened slurry tailings decreased from 3 x 10^{-6} m/s to 1 x 10^{-6} m/s.

By decreasing the saturated hydraulic conductivity, the exfiltration rates were reduced by 16 %. The hydraulic conductivity of tailings has a limited influence on the exfiltration rate but the length of the beach has the greatest influence on the estimated tailings exfiltration for the sensitivity scenarios conducted.

8.5 Stability Analyses

Stability analyses were undertaken for the ultimate TSF elevation. The stability analysis incorporated the porewater pressure distribution predicted by the seepage analyses and the geotechnical properties inferred from previous studies, geotechnical investigations, as well as the technical literature. The geometry modelled in the stability assessment is consistent with the feasibility design concept, as described in section 7.0. Stability analysis results are presented in Appendix G and summarized in this section.

8.5.1 Stability Criteria

The design criteria are elaborated in Appendix C, as well as in section 3.3 of this report. The main points related to the stability analyses are indicated here. The design criteria for slope stability analyses have adopted an ‘’Extreme’’ consequence of failure classification. This is a relatively conservative assumption, which is consistent with the Global Industry Standard on Tailings Management (GTR, 2020), and is adopted in the absence of determination of the consequence of failure for the TSF. Loading conditions and corresponding minimum Factors of Safety (FoS) for the stability analysis are summarized in Table 22.

Table 22: Design Criteria for Slope Stability Analysis

Parameter	Value	Source
Earthquake		
Design earthquake event	1:10,000 Annual Exceedance Probability (AEP)	GTR (2020)
Stability acceptance criteria		
Safety factor static – peak strength	1.5	Directive 019, CDA
Safety factor static – post-peak strength [(a)]	1.3	WSP
Safety factor pseudo-static	1.1	Directive 019
Safety factor post-earthquake [(b)]	1.3	Directive 019
Deformation acceptance criteria		
Deformation (only required if pseudo-static criteria not met)	≤1-2% Strain	WSP

a) This analysis case considers the post-peak (or residual or liquefied) resistance for materials that are susceptible to strain softening or static liquefaction.

b) This analysis case considers the post-peak (or residual or liquefied) resistance for materials that are susceptible to strain softening, and static and dynamic liquefaction.

Stability was assessed using the peak parameters for each material. Stability was also assessed using the post-peak or liquefied (post-liquefaction) parameters of the contracting materials. Post-peak or liquefied parameters are used to study the following failure mechanisms:

- Liquefaction of the tailings caused by static or dynamic loading.
- Liquefaction of contractive granular materials in the foundation (where present), caused by static or dynamic loading.

For mine tailings, as well as sandy foundations (alluvial soil) the state of the materials as well as peak and liquefied undrained shear strength was determined based on CPTs performed in 2020 using different methods, as described in Appendix L.

In order to simplify the reporting and presentation of the analyses, two cases indicated in Table 22, ‘’static – post-peak strength’’, and ‘’post-earthquake’’ are shown with one safety factor, ‘’Post-liquefaction’’, in the results section (Table 24), as the material properties and target safety factors are similar for these two cases.

Analyses under pseudo-static conditions were performed using 50% of the maximum acceleration at rock, AMR, as proposed by Hynes-Griffin & Franklin (1984). The maximum acceleration is taken from the probabilistic seismic hazard analysis (PSHA), presented in Appendix J, for a V_{s30} of 1500 m/s. The peak ground acceleration is 0.0884 g, for a recurrence period of 10,000 years. A horizontal acceleration coefficient of 0.0442g was therefore used. Contrary to the approach described by Hynes-Griffin & Franklin (1984), soil shear strengths have not been reduced (peak strength was used), but a higher target safety factor was considered (Target FoS= 1.1) compared to that proposed by Hynes-Griffin & Franklin (FoS. = 1.0).

8.5.2 Methodology and Studied Scenarios

Two-dimensional limit equilibrium stability analysis was undertaken to assess the geotechnical stability of the TSF at its ultimate proposed elevation. Stability analyses were conducted using GeoStudio SLOPE/W software. The Morgenstern-Price method was employed, which satisfies both force and moment equilibriums to find potential failure surfaces and their corresponding Factors of Safety.

For each analysis, the safety factors of several potential failure surfaces were calculated to determine the minimum safety factor. The safety factor is defined as the ratio of stabilizing forces to driving forces that tend to initiate failure along a given failure surface. The analyses were carried out using a two-dimensional representation, which often represents a conservative simplification of the problem. Four representative cross-sections were selected for stability analysis, shown in a plan view in Figures 10 and 11 after the text:

- **Cross-Section A-A’ (Ch.1+100):** Selected to represent a cross-section of the Main Dyke at the final elevation of the TSF, at the location adjacent to the proposed 87 Pit. Additionally, this cross-section was also selected to represent the sectors where the foundation materials consist mainly of till. The downstream slope at this cross-section is 2.5H:1V. For this section, the distance from the pit to the toe of the dyke is 103 m.
- **Cross-Section B-B’ (Ch. 3+675):** Selected to represent a cross-section of the Main Dyke at the final elevation of the TSF where a relatively thick layer of loose alluvial soil exists under the downstream slope of the dyke when raised to the final design elevation. As will be explained in section 8.5.4, the ultimate downstream slope of the dyke includes a catch bench. The slope facing the Southwest Pit is 2.5H:1V and 3.0H:1V for elevations above and below the bench respectively.

- **Cross-Section C-C': (Ch. 0+550):** This cross section represents the East Dyke. It is selected at a location where the dike is approximately at its maximum height, data on the natural soils exists through adjacent boreholes, and there appears to be a valley in the topography. The downstream slope at this cross-section is 3H:1V.
- **Cross-Section D-D' (Ch. 1+750):** Selected to analyse the potential for a failure of West Waste Rock Dump into the TSF after raised to its final elevation, by simulating the waste rock dump at its highest elevation (500 masl). The cross-section is selected where the existing dyke is at its maximum height across the Main Dyke. The global slope of the waste rock dump was assumed to be 2.5H:1V. Liquefiable soils are up to 7 m thick in this section.

All the cross-sections were analyzed the load conditions described in Table 22 in section 8.5.1.

The following scenarios were assessed:

- A full-height failure, with the slip surface passing through the crest of the embankments for cross-sections A, B and C
- A full height failure, with the slip surface passing through the tailings for cross-sections A, B and C.
- A failure of the West Waste rock Dump into the TSF for cross-section D.

The following assumptions were made for the stability analyses:

- Geometry of the existing dyke was based on Golder (2009) and the tailings facility design report from SNC (1997)
- Different search methods for the critical slip surfaces in Slope/W software were used: Grid and radius, Entry and exit, and Block specified. The lowest FoS was reported in Table 24.
- Both circular and non-circular slip surfaces were considered by using the "Optimized" slip surface option in Slope/W software;
- Frozen tailings were modelled as non-frozen tailings. As frozen tailings are not susceptible to liquefaction, this is a conservative assumption. It is expected that in the long term the tailings would thaw. This aspect needs to be considered in the detailed engineering.
- To be conservative, the phreatic surface for the 8 m beach scenarios was adopted.
- The open pit overburden slope has been considered with a 3H:1V slope.

8.5.3 Material Properties

Numerous slope stability analyses were conducted in the past as the facility evolved. For the FS, the geotechnical parameters for the slope stability analysis were chosen as follows: For the till material, the geotechnical parameters used in the original SNC (1997) report were generally carried forward for effective stress parameters (Table 23). SNC derived these parameters either from laboratory testing (the geotechnical study carried out by SNC, 1997) or from engineering judgment and experience with similar materials. For undrained strength parameters for tailings and alluvial soil in the foundation, parameters were defined based on interpretation of field and laboratory tests

carried out by WSP in 2020-2021 (Appendix L). For the other materials, the input parameters were based on WSP's experience, the technical literature, and knowledge of the site and similar materials.

Recent tailings dyke failures have prompted the evolution of the state of practice for stability assessment to include undrained strength analysis in tailings facility design to account for the contractive nature of slurry deposited tailings. Therefore, the undrained peak and liquefied strength for tailings and alluvial soil in the foundation have been determined to consider in the stability analysis for FS. The parameters were defined based on CPT tests and advanced laboratory test results on the existing tailings.

Appendix L describes the methodology used to interpret the CPT tests and determine the state of materials (contractive vs. dilative), as well as the undrained peak and liquefied strengths. As explained in the appendix, the saturated tailings and the alluvial soil in the foundation are interpreted to be contractive materials that could undergo undrained shearing with porewater pressure generation and strength loss. Therefore, the shear strength of these materials is defined by the undrained shear strength ratio. Additionally, the post-peak analysis case was realized by considering post-liquefaction strength for these materials. The figures at the end of Appendix L show the parameters estimated from each CPT. The parameters adapted for the feasibility design are shown in Table 23 below.

In appendix L, it is explained that two types of tailings were encountered in CPTs. For the feasibility design, only one tailing type was modelled and the lowest strength of the two types of tailings was used. For the detailed design, different properties could be used in the models for different tailings. The peak undrained strength ratio was determined mainly from Sadrekarimi (2014) method. The liquefied undrained strength ratio was adapted mainly from Jefferies and Been (2016), using the state parameter from Plewes et al. (1992), and Robertson (2022) methods.

For the waste rock constituting the dike, the shear strength is defined considering that the rockfill has been mechanically placed and that nominal compaction has taken place. The equation proposed by Leps et al. (1970) was used and corresponds to a conservative function for a rock pile built from the bottom up, as presented by Hawley and Cunning (2017). For the exiting waste rock, as the quality of the material and the construction method is unknown, the lower bound of the values proposed by Leps et al. (1970) is used.

The till and bedrock foundation materials of the facility are not considered to be susceptible to generate porewater pressure when sheared and would act in a dilatant manner under loading (and hence not be susceptible to liquefaction or strain softening). The esker and alluvial sands located in the foundation of the proposed footprint are considered to be susceptible to liquefaction. Where accessible, the loosed granular soil in the foundation must be removed and replaced with waste rock during foundation preparation. Cross section B-B' considers the construction of this shear key under the downstream slope of the future dike.

Table 23: Geotechnical Parameters

Material	Bulk unit weight γt (kN/m3)	Effective Stress Shear Strength		Peak Undrained Shear Strength Ratio	Liquified undrain shear strength Ratio	Reference/Source/ Basis
		C' (kPa)	Φ' (deg)	Su(peak)/σ'v	Su(liq)/σ'v	
Construction material and tailings						
Existing tailings	19.5	0	-	0.20	0.10	Appendix L
Compacted existing tailings	19.5	0	-	0.20	0.10	Appendix L
Thickened slurry tailings	19.5	0	-	0.20	0.10	Assumed*
Compacted till	20.5	0	37	-	-	After SNC (1997)
Existing filter	20.5	0	32	-	-	Assumed*
New filter	20.5	0	32	-	-	Assumed*
Sand and gravel	20.5	0	34	-	-	Assumed*
Transition layer	20.5	0	34	-	-	Assumed*
New waste rock/riprap	20	0	Leps (1970)	-	-	Assumed*
Old waste rock/riprap	20	0	Lower bound of Leps (1970)	-	-	Assumed*
Foundations						
Glacial till	20.5	0	35	-		After SNC (1997)
Glaciofluvial sand/alluvial	18.7	0	-	0.22	0.09	Appendix L
Bedrock (weathered)	Impenetrable					-
Bedrock (fresh)	Impenetrable					-

kN/m^3 = kilonewton per cubic meter; kPa = kilopascal.

* Assumed based on the previous studies, the literature, and knowledge of the site and similar materials.

8.5.4 Results of Geotechnical Stability Analyses

The results of the stability analyses are summarized in Table 24**,** and presented in Appendix G. Table 24 shows the results for different scenarios and failure modes, i.e., slip surfaces that pass through the dyke or in those which reach the tailings beach. Also, for cross-section B-B', FoS values before and after the implementation of mitigation measure are presented. For each case, the ID of figure showing the geometry and the critical slip surface in the appendix is indicated. The findings associated with each cross-section is summarized below.

Cross-section A-A' findings:

All safety factors criteria are met for section A-A' considering the assumptions and the proposed geometry. No berm or excavation is required where the foundation soils consist of till.

Cross-section B-B' findings:

In order to meet the safety factors for section B-B', a catch bench must be considered in the downstream slope of the dyke and liquefiable soils must be excavated and replaced with waste rock (a shear key must be constructed) within the dyke footprint. It is assumed that the shear key can be constructed between the toe of the existing berms and the ultimate toe of the structure.

The catch bench should be at a minimum elevation of 395 masl and a minimum width of 13.5 m. The downstream slope of the dyke is 2.5H:1V and 3.0H:1V for elevations above and below the bench respectively. With the addition of the berm, the distance to the pit is 80.5 m on this section.

On the cross-section, the shear key excavation is 83.5 m long. The excavation extends to the base of the bedrock, i.e., 5 m deep based on the existing boreholes and test pits. Excavation is required only adjacent to the footprint of the new waste rock. The excavation will be filled with waste rock.

Note that, the excavation is modelled with 2H:1V slopes. However, the slopes of the excavation need to be designed for the detailed engineering of the TSF.

Cross-section C-C' findings:

All safety factor criteria are met for section C-C' with the proposed geometry. No berm or excavation is required where the foundation soils are till.

Note that for this location, data on more test pits should be considered for the detailed engineering of the TSF in order to determine the location of the cross section as well as the thickness and properties of the foundation materials.

Cross-section D-D' findings:

All safety factor criteria are met for section D-D' with the proposed geometry. No berm or excavation is required, even if liquefiable soils are present in the foundation. It is important to note that it is assumed that the waste rock pile will be constructed simultaneously with the raise of the TSF at this location. If the TSF is planned to raise before construction of the waste rock pile, the stability at this location must be reassessed and a shear key or a change in the geometry might be required to satisfy the stability criteria.

Table 24 Summary of Stability Results

Profile	Case	Description	Minimum Design Factor of Safety	Calculated Factor of Safety	Figure
Cross-section A-A'	Static	Failure surface in tailings	1.5	2.1	G-1
	Pseudo-static		1.1	1.8	G-3
	Post-liquefaction		1.3	2.0	G-5
	Static	Failure surface in the dyke	1.5	2.1	G-2
	Pseudo-static		1.1	1.9	G-4
	Post-liquefaction		1.3	2.1	G-6
Cross-section B-B'	Static	Failure surface in tailings	1.5	1.1 (without mitigation)	G-7
	Pseudo-static		1.1	0.9 (without mitigation)	G-11
	Post-liquefaction		1.3	0.6 (without mitigation)	G-15
	Static	Failure surface in tailings adding a berm and excavating loose soil	1.5	1.8 (with mitigation)	G-8
	Pseudo-static		1.1	1.5 (with mitigation)	G-12
	Post-liquefaction		1.3	1.3 (with mitigation)	G-16
	Static	Failure surface in the dyke	1.5	1.2 (without mitigation)	G-9
	Pseudo-static		1.1	1.0 (without mitigation)	G-13
	Post-liquefaction		1.3	0.7 (without mitigation)	G-17
	Static	Failure surface in dyke adding a berm and excavating loose soil	1.5	2.3 (with mitigation)	G-10
	Pseudo-static		1.1	2.0 (with mitigation)	G-14
	Post-liquefaction		1.3	2.0 (with mitigation)	G-18
Cross-section C-C'	Static	Failure surface	1.5	2.5	G-19
	Pseudo-static		1.1	2.1	G-20
	Post-liquefaction		1.3	2.5	G-21
Cross-section D-D'	Static	Failure of waste rock dump towards TSF	1.5	2.6	G-22
	Pseudo-static		1.1	2.0	G-23
	Post-liquefaction		1.3	2.0	G-24

8.6 Stress-Deformation Analysis

A stress-deformation analysis was carried out to calculate the stress distribution, horizontal and vertical displacements, as well as the pore water pressure regime. The stress-deformation analysis also allowed to assess the deformation around the transition and filter layers due to the construction and tailings depositions. PLAXIS finite-

element model (FEM) software was used to simulate a time-dependent fully coupled flow-deformation analysis of construction of the dyke and the deposition and consolidation of tailings. The model permitted to estimate the pore water pressure build-up and dissipation, as well as the subsequent settlement through the sequences of staged construction.

8.6.1 Model Setup and Boundary Conditions

The cross-section B-B', as presented in section 8.5.2 and shown on figure 11 after the text was modelled in the FEM software. The full model dimensions were 580 m by 100 m. The model was created large enough to avoid any boundary conditions effects on the results. The left boundary and right boundary of the model are about 300 m away from the main dykes. The bottom boundary of the model is extended 70 m below the alluvial sand. When setting up the geometry of the model, simplifications are applied so that the small elements be merged to their surrounding elements, to enhance the model computation. The simplifications are deemed to have negligible influence on the results. The applied simplifications are presented in Figure H-1.

PLAXIS employs 15-node triangular elements that allow a fourth-order interpolation for displacements (Brinkgreve et al., 2018). The finite element mesh of the stress-deformation model for cross section B-B' was generated in a way that it results in a finer mesh generation in areas of interest and interface between materials with different properties, such as next to the filter and transition layer. Finer elements are also generated near and under the embankments as well as the compacted till key as larger strains are expected for these regions. Then, the meshing becomes courser toward the far-field (boundaries) of the model to reduce the computation time. The generated mesh is presented in Figure H-2.

The model was fully fixed at the bottom, and horizontal displacements were set to zero along the very left and right boundaries. The hydraulic boundary conditions will be discussed in the following subsections along with the stages of the model.

8.6.2 Initial stage

The initial model consisted of an approximately 7.00 m deep alluvial sand underlain by an approximately 6.00 m thick weathered bedrock and an approximately 35 m deep fresh bedrock. Below the starter dyke, the alluvial sand is excavated and replaced with a compacted till. The phreatic surface was interpreted to be at the ground surface before tailings deposition according to the piezometric elevation map of the site (see Illustration 6). Therefore, the hydraulic boundary conditions were set to 380 masl and 377 masl for the left and right boundary conditions, respectively.

The model calculates the initial effective stresses, pore pressures and state parameters using a K_0 procedure. This stage is also coupled by a steady state groundwater flow that allows the model to establish the initial steady state pore pressures and phreatic level according to the defined hydraulic boundary conditions and soil properties. The material properties used for each material are discussed in section 8.6.4.

8.6.3 Construction stages

From the initial stage, several construction stages were simulated to raise the model up to the existing elevations (waste rock El. 400 masl). After reaching the existing elevations, time, displacements, and model state parameters were reset, to consider the actual condition of the TSF as the reference. Then simulations resumed up to reaching the final elevation (waste rock El. 435 masl).

Each stage was mainly composed of waste rock construction, tailing depositions, and consolidations:

- Waste rock construction.
- Tailings deposition.
- Tailings consolidation.

8.6.4 Material Properties and Constitutive Models

Table 25 summarizes the material properties used in the stress-deformation analyses. For most of the materials with expected drained behaviour, the Mohr-Coulomb model is judged to be suitable. For the waste rock and alluvial sand, the Hardening Soil (HS) model was selected, as it considers the effects of a stress increase on the deformation modulus. For state dependent tailings (existing and new), the NorSand (NS) model was used, which is a critical-state based constitutive model. Table 26 shows the properties of the HS model used for alluvial sand and waste rock, as well as the NS model used for tailings.

In WSP's 2020-2021 geotechnical investigation program, a series of undrained and drained isotopically consolidated triaxial tests were performed as part of the laboratory program to characterize the existing tailings. These tests were interpreted to define the critical state line parameters (i.e., Γ, λ_e, and M_{tc}) for the existing tailings, as presented in appendix L. Other NorSand parameters including the hardening and dilatancy were obtained by calibrating the model using a series of simulations against the available laboratory testing. The graphs presenting the NorSand model calibration are shown in figures H-9 to H-16. The characteristic state parameter of the tailings was obtained from interpretation of CPTs. An initial value of -0.05 was considered for the tailings. At the ultimate stage of the model, the state parameter increased to a value of approximately 0.0 and 0.1 for the existing and future tailings, respectively.

Table 25: Material Properties

Parameter	Name	Unit	Materials										
			Alluvial Sand	Existing and future Tailings	Compacted Existing Tailings	Compacted Till	Existing Filter	New Filter	Transition Layer	Sand and Gravel	Waste Rock	Bedrock (fresh)	Bedrock (weathered)
General													
Soil model	-	-	Hardening soil	NorSand	Mohr-Coulomb						Hardening soil	Linear elastic	
Drainage type	-	-	Undrained		Drained						Drained	Drained	
Unsaturated unit weight	γ_{unsat}	kN/m^3	18.0[4]	19.0[4]	19.0[4]	20.0[4]	20.0[4]	20.0[4]	20.0[4]	20.0[4]	20.0[4]	26.5[4]	26.5[4]
Saturated unit weight	γ_{sat}	kN/m^3	18.5	19.5[1]	19.5[1]	20.5[1]	20.5[1]	20.5[1]	20.5[1]	20.5[1]	20.0[1]	26.5[9]	26.5[9]
Initial void ratio	e_{init}	-	0.4[8]	0.7[8]	0.7[8]	0.5[8]	0.4[8]	0.4[8]	0.4[8]	0.4[8]	0.5[8]	< 0.1[8]	
Young's modulus	E'_{ref}	kN/m^2	-	-	36,000[9]	35,000[10]	37,000[9]	37,000[9]	37,000[9]	37,000[9]	-	8.0E9[9]	3.0E9[9]
Poisson's ratio	ν	-	-	-	0.3[9]	0.3[9]	0.3[9]	0.3[9]	0.3[9]	0.3[9]	0.3[9]	0.2[9]	0.2[9]
Cohesion	c'_{ref}	kN/m^2	0.0[1]	-	0.0[1]	0.0[1]	0.0[1]	0.0[1]	0.0[1]	0.0[1]	0.0[1]	-	-
Friction angle	ϕ'	°	26.0[5]	-	35.0[9]	37.0[1]	37.0[9]	32.0[1]	34.0[1]	35.0[9]	35.0[9]	-	-
Dilatancy angle	ψ	°	0.0[3]	-	0.0[3]	0.0[3]	0.0[3]	0.0[3]	0.0[3]	0.0[3]	0.0[3]	-	-
Groundwater													
Model	-	-	Van Genuchten									Saturated	
Horizontal permeability	k_x	m/day	1.0E-4[6]	3.0E-6[6]	3.0E-6[6]	8.0E-7[6]	1.0E-4[6]	1.0E-4[6]	1.0E-4[6]	1.0E-4[6]	0.1[6]	1.0E-7[6]	1.0E-6[6]
Vertical permeability	k_y	m/day	1.0E-4[7]	3.0E-6[7]	3.0E-6[7]	8.0E-6[7]	1.0E-4[7]	1.0E-4[7]	1.0E-4[7]	1.0E-4[7]	0.1[7]	1.0E-7[7]	1.0E-6[7]
Initial													
K_0-determination	-	-	0.6[2]	0.7[9]	0.4[2]	0.4[2]	0.4[2]	0.5[2]	0.4[2]	0.4[2]	0.4[2]	0.5[2]	0.5[2]

[1]=See Table 23.

[2]= K_0 is determined by built-in formulations of PLAXIS 2D, depending on the model being used. It is 0.5 for a linear elastic model. For the Mohr-Coulomb model, PLAXIS 2D uses $1 - \sin(\phi')$ to calculate K_0. For the Hardening Soil model, K_0 is determined using the Poisson's ratio and the over consolidation ratio. OCR is set to 1.00 for the alluvial sand as well as the waste rock.

[3]=Dilatancy angle assumed to be zero for all materials.

[4]=Unsaturated unit weight assumed to be 0.5 kN/m^3 lower than the saturated unit weight for all materials except for the waste rock and bedrock for which it is assumed that $\gamma_{sat} = \gamma_{unsat}$.

[5]= See appendix L.

[6]= From slug tests. See Table 20.

[7]=Horizontal permeability assumed to be equal to the vertical permeability for all materials.

[8]= From Seepage analyses section 8.4.

[9]= Assumed based on experience with similar materials.

[10]=From Hunt (2005).

Table 26: NorSand and HS Model Parameters

Model		NorSand	HS		
Materials		Tailings[1] (Existing and Future)	-	Waste Rock / Rip Rap	Alluvial Sand
Parameters (units)	G_0^{ref} (kN/m^2)	15,000.0	E_{50}^{ref} (kN/m^2)	26,000.0[2]	6,375.0[3]
	p_{ref} (kN/m^2)	100.0	E_{oed}^{ref} (kN/m^2)	26,000.0[4]	6,375.0[4]
	n_G	0.9	E_{ur}^{ref} (kN/m^2)	78,000.0[5]	19,125.0[5]
	ν	0.1	m	0.5[6]	0.5[6]
	Γ	1.17	-	-	-
	λ_e	0.07			
	M_{tc}	1.38			
	N	0.2			
	χ_{tc}	3.5			
	H_0	80.0			
	H_ψ	600.0			
	R	1.00			
	S	0.00			
	ψ_0	-0.05			

[1]=See Appendix H for NorSand calibrations.

[2]= Assumed based on experience.

[3]=Calculated from (Hunt, 2005) for a fine loose sand.

[4]=$E_{oed}^{ref} = E_{oed}^{50}$ (assumed).

[5]=$E_{oed}^{ref} = 3.E_{oed}^{50}$ (assumed).

[6]=Set to default value.

8.6.5 Results of stress-deformation analysis

The results of the stress-deformation analysis are summarized in appendix H in terms of principal total stress, pore water pressure distribution, total head, and horizontal and vertical sum phase displacement for the final stage of the model. In addition, maximum horizontal and vertical displacements at five different corners of the (as illustrated in figure H-8) are summarized in Table 27.

Table 27: Horizontal and Vertical Displacements of the Drain at Points A to E at the final stage of construction and deposition

Point	Point ID		Coordinate (m)		Horizontal Displacement (m)	Vertical Displacement (m)
			X	Y		
A	49,175	176.70	399.70		0.29	-0.62
B	25,765	195.5	428.00		0.02	-0.51
C	2527	212.00	435.00		-0.13	-0.14
D	11,975	203.00	392.20		0.25	-0.64
E	51,033	234.10	380.90		0.20	-0.24

The computed amounts of displacement for pints A, B, and D are generally similar. The difference of 0.4 m between settlements of point D and E, that takes place in a distance of 30 m is judged to be acceptable. Also, the difference of 0.37 m between settlements of point B and C is judged to be acceptable considering the geometry of the embankment. The horizontal displacements remain below 30 cm for all point. In summary, considering the computed displacements in the transition and filter layers (zone 2 and 3), it can be concluded that the thickness of these layers is sufficient, and the integrity of these layers will not be put at risk by the deformation of the embankment and tailings due to construction and deposition.

It is recommended that for the detailed design,

- A sensitivity analysis be carried out, on the compressibility of the waste rock and the existing tailings among other parameters.
- A strength reduction analysis be carried out to compare the factor of safety with the Limit Equilibrium method.
- Depending on the needs of the project, a dynamic stress-deformation analyses be carried out, once the SSSHA is complete.
- Adjusting the construction stages in the model, once the construction sequences are planned.
- Adjusting the model as the construction advances by verifying the results with the instrumentation data (inclinometers, and vibrating wire piezometers, and/or observation wells).

8.7 Simplified Dynamic Displacement

The simplified dynamic displacement analyses were carried out to assess the performance of the main dyke during the design earthquake. These analyses are particularly relevant when materials are not sensitive to dynamic liquefaction or cyclic softening. In the present case, this condition is not met for mine tailings and loose alluvial foundation materials. However, it is considered relevant for failure surfaces in the embankment of the main dyke, where it rests on rock or till. In line with this conclusion, the objective of the seismically induced displacement analyses remains to assess the dynamic performance of the main dyke under the effect of the design earthquake. In particular, these results are intended to support the identification of credible failure modes for the main dyke. For slip surfaces that pass through tailings and liquefiable foundations, the results are shown merely for comparison, and should not be consulted for design purposes.

8.7.1 Methodology

Earthquake-induced permanent displacements were assessed at the Main Dyke by using the Method of Bray and Macedo (2019). This method is derived from the sliding block method of Newmark (1965). According to this method, during an earthquake, a block (representing the failure surface) slides on an inclined plane if $k_y > a_y$ where k_y is the yield coefficient and a_y is the block acceleration induced during the earthquake.

The Bray and Macedo (2019) method is an update of the Bray and Travasarou (2007) method and is a semi-empirical analysis that takes into account the dynamic strength and dynamic stiffness of the structure, as well as the characteristics of the seismic event through the design spectrum. This method is based on the following parameters:

- k_y, the yield seismic coefficient estimated from the stability analysis model. The parameter k_y corresponds to the horizontal seismic coefficient required to obtain a safety factor equal to unity.
- T_s, the natural period of the failure circle estimated from Vs profiles (SCPT or MASW).
- $S_a(1.3T_s)$, the spectral acceleration at the degraded natural period.
- M, the earthquake magnitude (taken from the probabilistic seismic hazard analysis [PSHA]), and
- PGA, peak ground acceleration in units of g of the input base ground motion.

In this method, displacements are calculated on the basis of a database of 6,711 earthquake data from the NGA-West2 database to reduce the uncertainty related to the input seismic motion and thus displacement calculation. It distinguishes ordinary ground motions from those produced near a fault (pulse motions). It, therefore, proposes three sets of equations (for calculation of non-zero displacements as well as for the calculation of displacements), one of which is based on data from ordinary seismic motions, another based on data generated in the vicinity of a fault, and one based on all data. Equation for ordinary and combined ordinary and near fault pulse ground motion have been use for this analysis. According to this method, the probability of a displacement of less than 0.5 cm induced by a seismic event is calculated from Equation 2 for ordinary ground motion and Equation 4 for combined ordinary and near-fault pulse ground motions. Displacement is calculated according to Equation 3 for ordinary ground motion or Equation 5 for combined ordinary and near-fault pulse ground motions if Equation 2 or 4 shows a non-zero probability of displacement (i.e. $P\ (D = 0) \neq 0$) under the application of the design event.

Equations for ordinary ground motion:

$$P\ (D = 0) = 1 - \Phi(-2.48 - 2.97Ln(k_y) - 0.12\left(Ln(k_y))^2 - 0.72T_sLn(k_y) + 1.70T_s + 2.78Ln(S_a(1.3T_s))\right) \quad eq.2a$$

$For\ cases\ where\ T_s \leq 0.7s$

$$P\ (D = 0) = 1 - \Phi(-3.42 - 4.93Ln(k_y) - 0.30\left(Ln(k_y))^2 - 0.35T_sLn(k_y) - 0.62T_s + 2.86Ln(S_a(1.3T_s))\right) \quad eq.2b$$

$For\ cases\ where\ T_s > 0.7s$

Where D = seismic slope displacement and Φ = standard normal cumulative distribution function.

$$Ln\ (D) = -a1 - 2.482Ln(k_y) - 0.244(Ln(k_y))^2 + 0.344Ln(k_y)Ln(S_a(1.3T_s)) + 2.649Ln(S_a(1.3T_s)) - 0.090(Ln(S_a(1.3T_s)))^2 + a2T_s + a3(T_s)^2 + 0.603M_w \pm \epsilon \quad eq.3$$

where a1 = −5.981, a2 = 3.223, and a3 = −0.945 for systems with Ts ⩾ 0.10 s, and a1 =−4.684, a2 = −9.471, and a3 = 0.0 for Ts < 0.10 s.

Equations for combined ordinary and near fault pulse ground motion:

$$P\ (D=0) = 1 - \ \Phi(-2.46 - 2.98Ln(k_y) - 0.12\left(Ln(k_y))^2 - 0.71T_sLn(k_y) + 1.69T_s + 2.76Ln(S_a(1.3T_s))\right)\ eq.4a$$

For cases where $T_s \leq 0.7s$

$$P\ (D=0) = 1 - \ \Phi(-3.40 - 4.95Ln(k_y) - 0.30\left(Ln(k_y))^2 - 0.33T_sLn(k_y) - 0.62T_s + 2.85Ln(S_a(1.3T_s))\right)\ \ eq.4b$$

For cases where $T_s > 0.7s$

$$Ln\ (D) = a1 - 2.491Ln(k_y) - 0.245(Ln(k_y))^2 + 0.344Ln(k_y)Ln(PGA) + 2.703Ln(S_a(1.3T_s)) - 0.089Ln(S_a(1.3T_s)))^2 + a2T_s + a3(T_s)^2 + 0.607M_w + a4 + Ln(PGV) + a5\pm\in \qquad eq.5$$

where,

- When PGV $\leqslant$ 115 cm/s, which is the typical case, a1 =−5.894, a2= 3.152, a3= −0.910, a4 = 0, and a5 = 0 for systems with Ts $\geqslant$ 0.10 s, and a1 =−4.551, a2 = −9.690, a3 =0.0, a4 = 0, and a5 =0 for Ts < 0.10 s.

- When PGV > 115 cm/s, a1 =−5.894, a2 = 3.152, a3 = −0.910, a4 = 1, and a5 =−4.75 for systems with Ts $\geqslant$ 0.10 s, and a1 = −4.551, a2 = −9.690, a3 = 0.0, a4 = 1, and a5 =−4.75 for Ts < 0.10 s.

Two cases on the A-A' and B-B' cross-sections were established for estimating seismic displacements. These cases were selected on the basis of potential slip surfaces that pass through the Main Dyke embankment or in the tailings. The mean Vs profile of the failure circle corresponds to the available profile which is closest to the center of gravity of the sliding mass according to the SLOPE/W stability analyses. The Vs value for tailings is taken from the shear wave velocity tests carried out during CPT, and is the same value as that used in the probabilistic seismic hazard analysis (PSHA) in Appendix J. The Vs for Waste rock was adopted from the MASW profile performed within Golder geophysical investigation (2020). Table *28* and Illustration 14 present the cases studied. It must be recall that case 2 and 4 include slip surfaces that pass through potentially liquefied tailings. Therefore, the application of the simplified displacement method is questionable. These cases are presented merely for comparison with the other two cases.

Table *28: Inputs to seismic displacement analysis*

Case	Cross-Section	Geometry of the potential sliding surface	K_y	$H_{average}$ (m)	$V_{s,\ average}$ (m/s)	T_S (s)
1	A-A'	Failure taking out the entire Main dyke	0.35	20.0	400	0.2
2	A-A'	Failure in the tailings	0.12	44.8	180	1.0
3	B-B'	Failure taking out the entire Main dyke	0.38	34.3	400	0.34
4	B-B'	Failure in the tailings	0.11	57.0	180	1.27

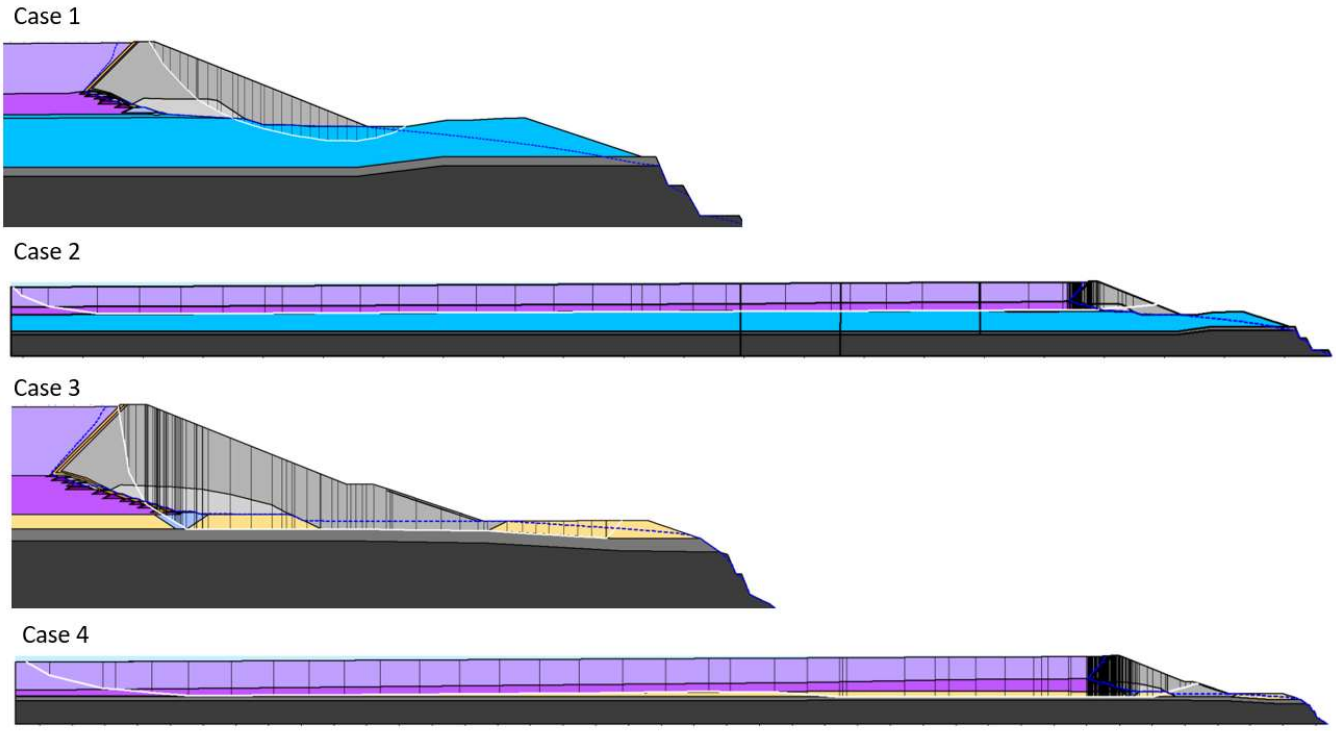

Illustration 14: Geometry of the studied slip surfaces

8.7.2 Results of the simplified dynamic displacement analysis

The results of the analyses, in terms of displacement (in cm) or the probability of negligible displacement are shown in Table 29.

Table 29: Inputs to seismic displacement analysis

Case	Ordinary Ground Motions		Combined (regular and pulse)	
	D (cm)	P (D=0)	D(cm)	P (D=0)
1	0.0	1.00	0.0	1.00
2*	3.0	0.31	3.0	0.29
3*	0.1	1.00	0.1	1.00
4*	2.6	0.48	2.6	0.47

D = Displacement; P (D=0) = Probability of negligible displacement. * Unreliable displacement values because slip surfaces pass through liquifiable tailings or soil

The main conclusions that can be drawn from the results are presented below:

- For cross-section A-A' (case 1), the displacements of the main dyke induced by the design earthquake remain negligible, i.e., less than 3 cm, for a slip surface that passes through the dyke embankment.

- For cross-section B-B' (Case 3), the displacements of the main dyke induced by the design earthquake remain negligible, i.e., less than 3 cm, for a slip surface that passes through the dyke embankment. However, this analysis does not consider the liquefaction of the alluvial soil in the foundation which is liquefiable at some locations based on the liquefaction assessment (see section 8.3).
- For both cross-section A-A' and B-B' (Case 2 and 4 respectively), the displacement of the slip surface that passes through tailings is greater than that of the slip surfaces that pass through the dyke embankment. However, the method does not consider displacement due to liquefaction. The dynamic liquefaction assessment in section 8.3 shows that tailings are liquefiable with the design earthquake. If the tailings do not liquefy, the k_y estimated for a FoS=1 would have been underestimated. If the tailings liquefy, the displacement value in the tailings will be greater than that calculated by the Bray and Macedo (2019) method. Therefore, the results presented in table 29 should not be considered for design purposes.

Two sensitivity analyses were carried out to assess the impact of different parameters on estimated displacements:

- A maximum ground velocity (PGV) of 300 cm/s was considered (instead of 50 cm/s which was used tentatively based on the literature). The displacements in both cross-sections remained as low as 8 cm.
- A yield seismic coefficient, k_y as low as 0.02 was considered. The displacements in both cross-sections remain below 60 cm.

Due to the limitations of the simplified dynamic displacement analyses, it is recommended that for the detailed engineering design, a dynamic stress-deformation analysis be carried out to assess the dynamic behavior of the structure.

8.8 Water Management Analysis

8.8.1 TSF Pond Characteristics

Illustration 15 and Illustration 16 below present the TSF Pond characteristics for the end of Year 1 (dyke raise to 407 masl) and for the last year of operation (final dyke raise to 435 masl):

- For the end of Year 1, the dyke crest is at the elevation of 407.0 masl, the spillway invert at the elevation of 405.5 masl. The minimum operating water level, which is the level maintaining a minimum 3 m water depth near the intake pump location, is at approximately 397.8 masl, or 7.7 m below the spillway invert. The maximum normal operating water level (or the level, on top of which the environmental design flood – the Directive 019 Project Flood – can be stored without discharging via the emergency spillway) is at 404.6 masl. The 15.8 M m^3 of water that can be stored below the emergency spillway invert are equivalent to over three years of precipitation volume over the TSF's direct watershed; this underlines the large safety factor when it comes to water management inside the TSF.
- For the last year of operation, the dyke crest is at the elevation of 435.0 masl, the spillway invert at the elevation of 433.5 masl. The minimum operating water level is at approximately 428 masl, or 7.0 m below the spillway invert. The maximum normal operating water level is at 432.6 masl. The 9.9 M m^3 of water that can be stored below the emergency spillway invert are equivalent to two years of precipitation volume over the TSF's direct watershed.

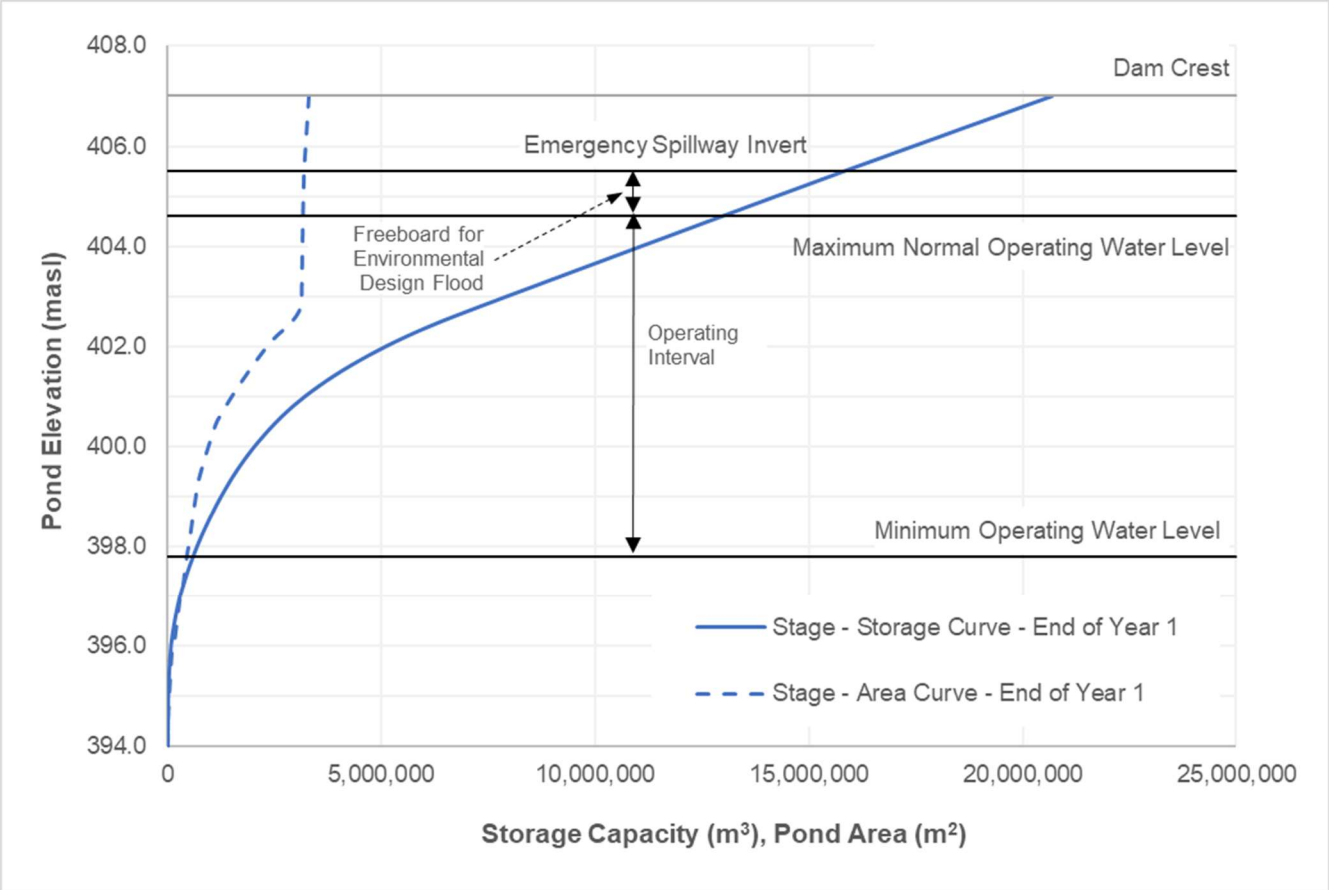

Illustration 15: TSF Pond Stage / Storage / Area Curve – End of Year 1 of Operation

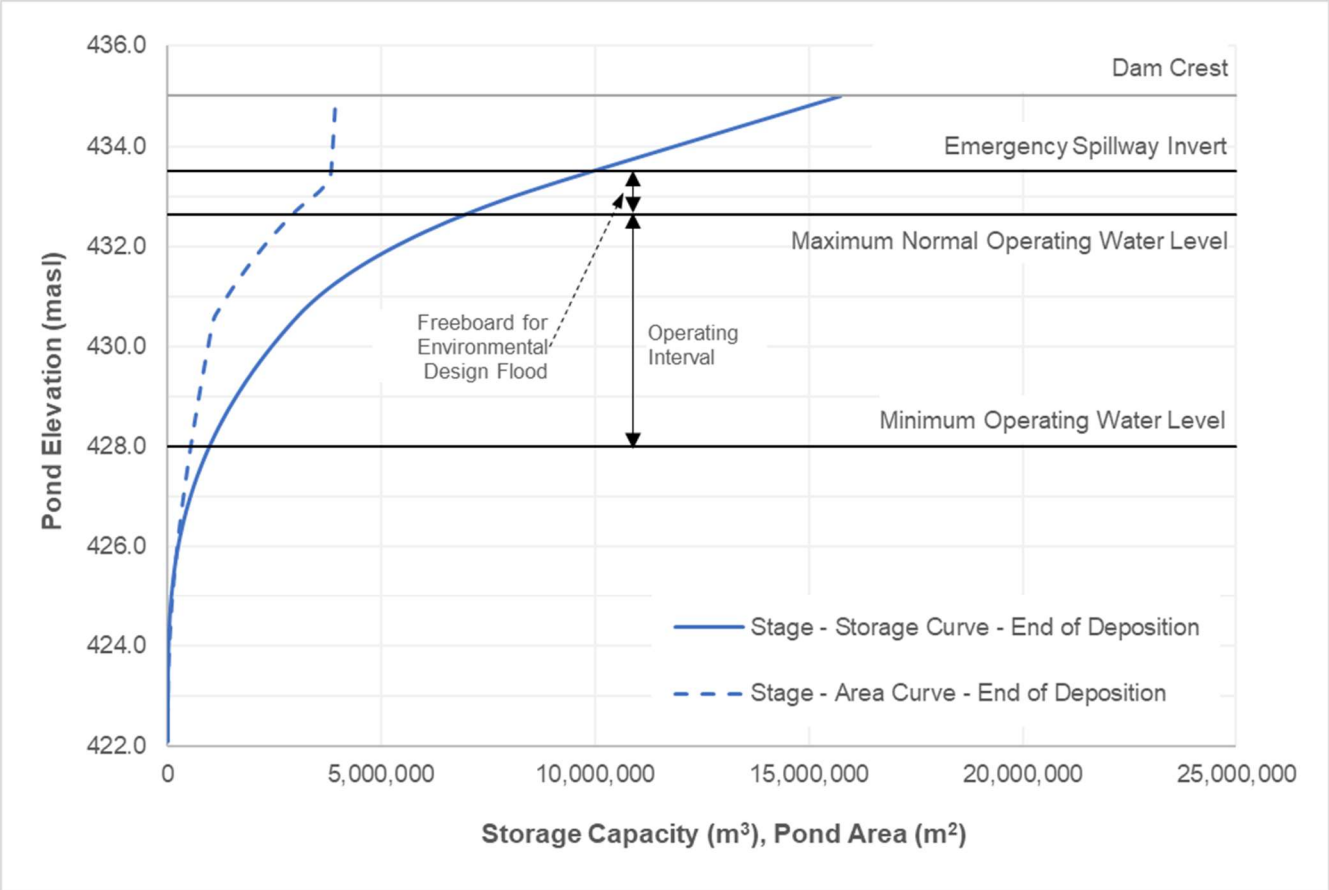

Illustration 16: TSF Pond Stage / Storage / Area Curve – End of Last Year of Operation

8.8.2 Environmental Design Flood

The Directive 019 for the mining industry (MDDEP, 2012) indicates that tailings storage facilities with water retention should be able to contain without uncontrolled discharge to the environment the “project flood event” consisting of the 100-year snow accumulation melting over 30 days superposed to the 1,000-year 24-hour rainfall event. The rainfall event’s return period is 2,000 years for high-risk tailings (5.4), which is not the case for the Troilus TSF (Troilus, 2024).

Based on the climate statistics presented by WSP (2024b), the project flood event has a total depth of 504 mm over 30 days. Cumulated over a 5.9 km^2 watershed and ignoring the losses, as infiltration and evaporation losses would be very small as compared to the size of the event, the TSF Pond must contain a volume of 3.0 million cubic metres (M m^3) water above the maximum operating water level under normal climate conditions. The 5.9 km^2 watershed considers the return to the TSF Pond of water collected by the seepage sumps at the toe of the TSF dyke (S02 and S03 in the southwestern TSF corner and, after the East Dyke construction, S07).

Based on the stage-storage curves in the previous section, the maximum operating water level under normal conditions must be 404.6 masl for the end of Year 1 TSF configuration and 432.6 masl for the final TSF configurations. These two levels are 6.8 m and 4.6 m above the minimum operating water levels, respectively, which allows Troilus the flexibility required to manage the water pond.

8.8.3 Inflow Design Flood and Emergency Spillway Design

Government of Québec (2012) indicates that the TSF emergency spillway should be able to evacuate the PMF safely. Based on CDA (2013) and CDA (2019), the minimum freeboard above the PMF water level was compared to the 100-year-wave runup.

The spillway configurations, required over the TSF operating life, were designed:

- The existing TSF has an emergency spillway in its southwestern corner. For the first dyke raise, to the dyke crest elevation of 403 masl, the existing emergency spillway will be extended upstream, while maintaining its current cross-section (24 m wide, 3H:1V side slope) and a maximum 20% longitudinal slope. The raised spillway invert is 401.5 m.
- For the subsequent dyke raises up to the elevation of 409 masl, a new emergency spillway channel is constructed at the location of the existing emergency spillway, but under consideration for the dyke's downstream raises. The cross-section geometry is maintained as well as the maximum 20% longitudinal slope. The spillway invert is, at all times, 1.5 m below the minimal dyke crest.
- For dyke raises between 411 masl and 435 masl, the emergency spillway is relocated slightly to the south, to take advantage of a location where the natural terrain is at approximately 410 masl, or around 30 m higher than the original location; also the extension of the Southwest Pit footprint does not allow further spillway raises at the original location. The cross-sectional geometry is extended to 30 m base width and 4H:1V; the maximum slope is maintained at 20%.
- Finally, after the end of the deposition, the emergency spillway is relocated to accommodate the backfilling of the South-West Pit, which is immediately downstream of the previous spillway, and the placement of a waste rock dump that covers the spillway footprint. The new location is at the south-most corner of the TSF, at a location where the ultimate TSF dyke is less than 5 m high. This allows the spillway steep segment to be limited to a 4.2% slope. This location will be maintained until the TSF's restauration.

Illustration 17 presents the spillway's rating curves (TSF Pond's water level as a function of the flow discharged from the pond), which considered that the most upstream segment of the spillway channel, along the dyke crest, would have a 1% slope. Due to the large width, flows as high as 21 to 26 m^3/s can be discharged within a 0.5 m water depth for the 24 m and 30 m widths, respectively.

Illustration 18 and Illustration 19 present the hydrological modelling results for the PMF event within the TSF watershed. The calculations were done using the HEC-HMS software, the SCS CN and Unit Hydrograph methods:

- To simulate PMF conditions, WSP made the following assumptions:
  - The initial water level was assumed at the spillway invert, which is extremely conservative when considering the large storage capacity before the spillway invert. This conservatism accounts for possible extreme wet antecedent questions, including potential record snowmelt before the extreme rainfall.
  - The summer-fall 72-hour PMP (see Section 4.4) was simulated to generate the PMF. The summer-fall PMP is a more intense short-term event than its spring counterpart, such that it results in higher short-term flows.
- The PMF pond attenuation in the TSF Pond was modelled using the pond's stage-storage curve and the spillway's stage-discharge curve.
- The results of the assessment are as follows:

- For the end of the Year 1 configuration, the maximum PMF water level is calculated to be 405.89 masl, 1.11 m below the dyke crest. The maximum PMF outflow over the emergency spillway is calculated to be 14.1 m^3/s.
- For the last year of operation, the maximum PMF water level is calculated to be 433.86 masl, 1.14 m below the dyke crest. The maximum PMF outflow over the emergency spillway is calculated to be 15.5 m^3/s.

Wind effects on the water level against the TSF Dyke were calculated using USBR (USBR 2012) and extreme wind speeds as presented in Section 4.4. Maximum fetch lengths are around 2.9 km in the northeast-southwest direction. They correspond to 0.85 m, 0.95 m, 1.1 m, and 1.28 m increases in the water level against the TSF Dyke for the 2-year, 10-metre, 100-metre, and 1,000-year extreme wind speeds respectively. The results are applicable only when the water is high enough for the waves to break against the upstream dyke slopes (1.5H:1V, rock covered upstream slopes were used in the analysis). Under normal operating conditions, the waves would break on the flat tailings slopes and the wind-induced water level increases would be minimal.

The proposed spillway design respects the selected criteria of preventing overtopping during a PMF event superposed to a 100-year wind event.

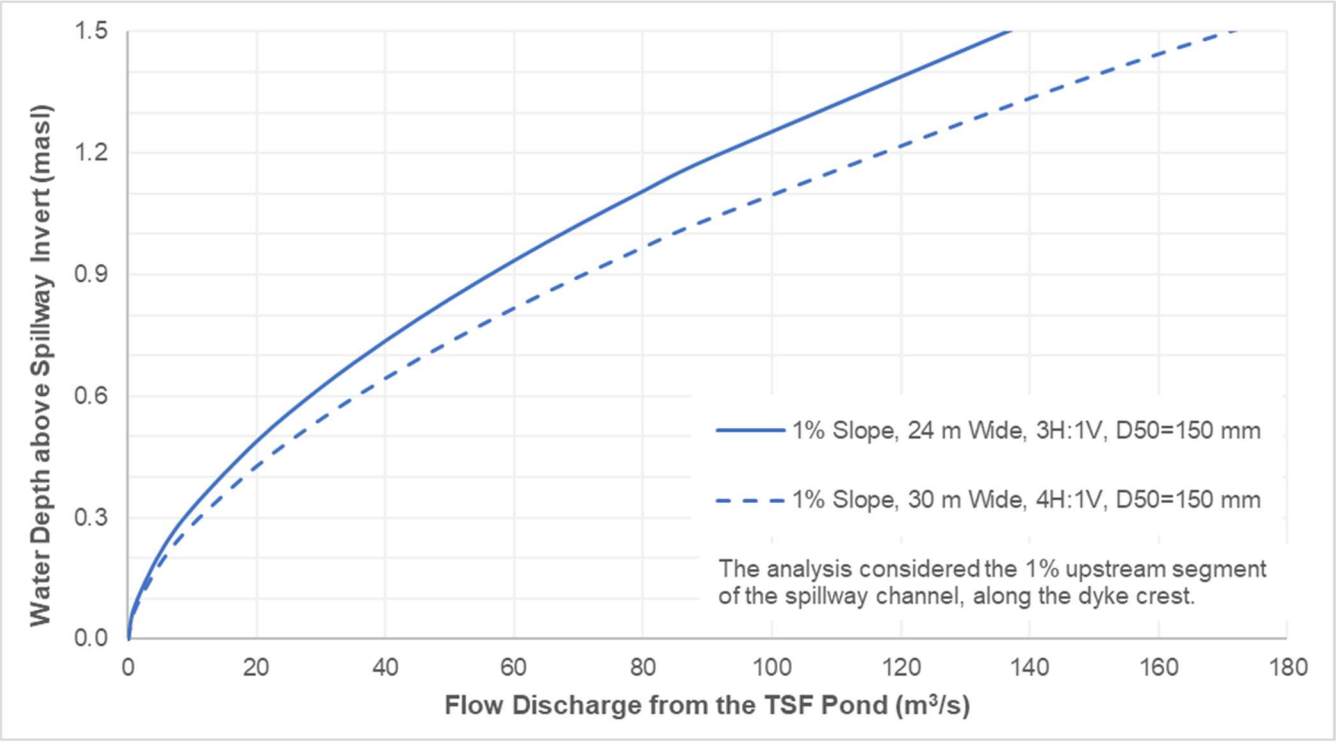

Illustration 17: TSF Emergency Spillway Rating Curves

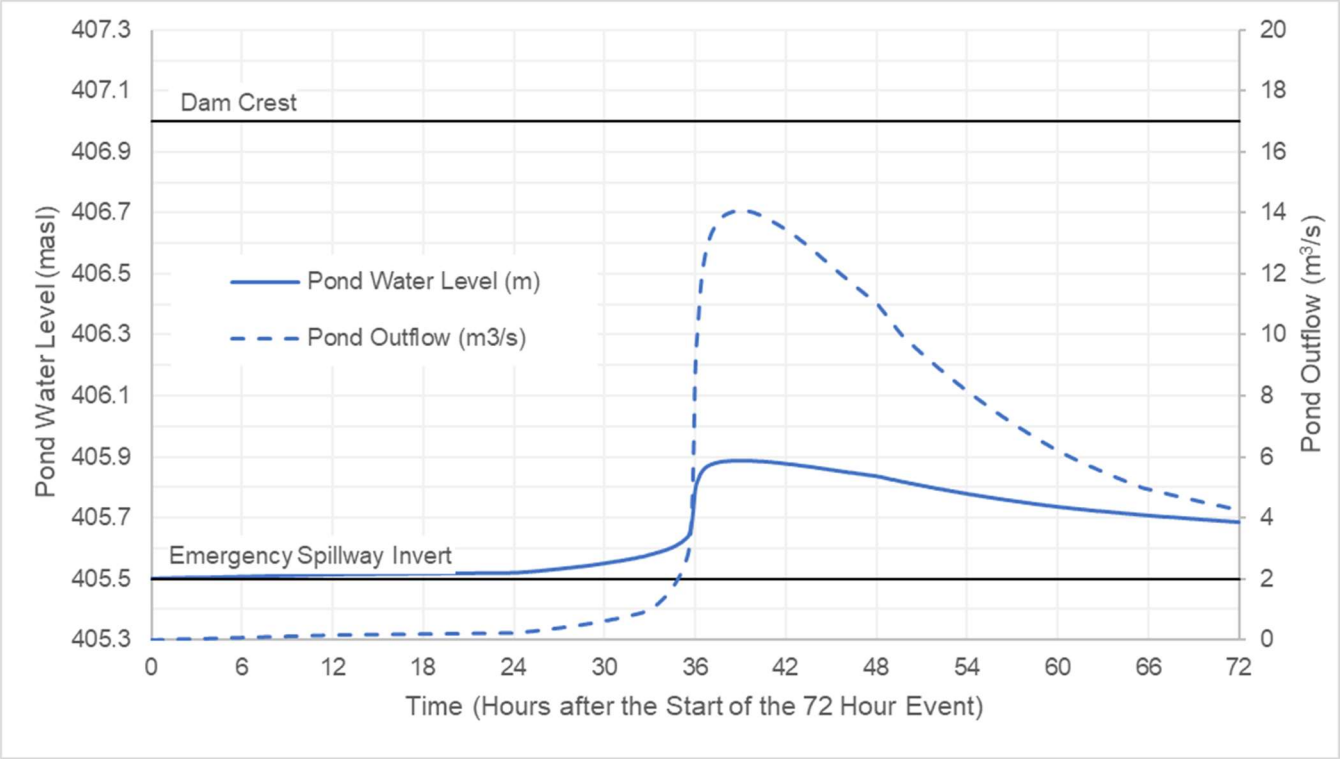

Illustration 18: Simulating the Summer-Fall Probable Maximum Flood in the TSF – End of Year 1 of Operation

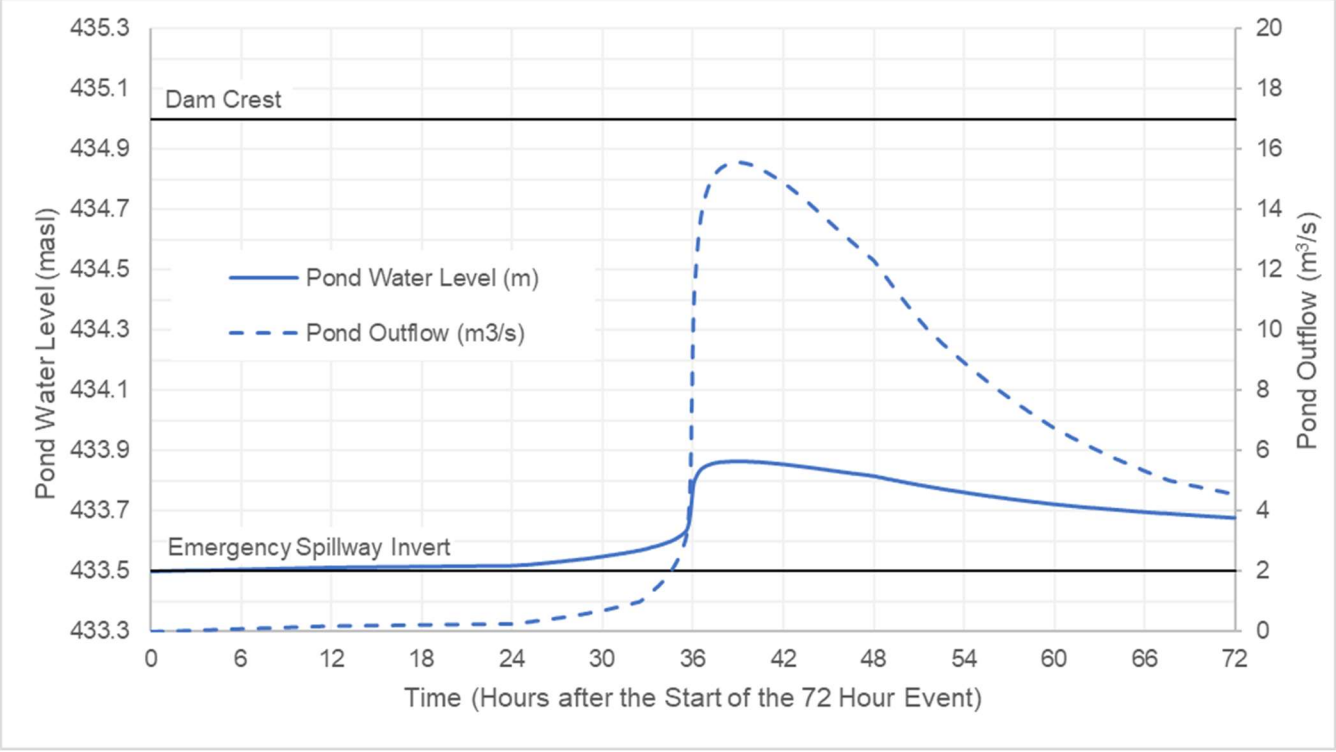

Illustration 19: Simulating the Summer-Fall Probable Maximum Flood in the TSF – Last Year of Operation

The emergency spillway channel will consist of a 1%-sloped segment, near the dyke crest, followed by a 20%-steep chute to the toe of the dyke; the chute slope is limited at 4.2% for the final relocation. Using USACE (1994), the riprap protection against erosion was calculated to be a D_{50} of minimum 400 mm for the 20% segments and 150 mm for the 1% and 4.2% segments.

The recommended minimum riprap thickness is 1.0 m for the 400 mm riprap and 300 mm for the rest; additional transition (bedding) layers should not be required for the underlaying general waste rock. As an exception, for the final relocation, transition layers are recommended to limit infiltration into the dyke. The topography at the base of the dyke is perpendicular to the spillway axis. Spillway discharge would infiltrate in the coarse rock and flow along and within the dyke body, where it may cause internal erosion. To mitigate these issues, WSP proposed placing a 0.3 m till layer surrounded on both sides by 0.3 m gravel as transition to the underlaying waste rock and overlaying riprap.

The initial spillway will be constructed as an upgrade of the upstream segment of the existing spillway. The existing spillway is, for its lower segment, a channel of similar geometry (24 m base width, 3H:1V side slopes) and is protected by a riprap layer with a D_{50} of approximately 1,050 mm (Golder, 2010). No upgrades are required for the lower segment. A dissipation basin is in place as well.

Twenty-metre-long dissipation ponds are included at the toe of the 20% chutes to prevent scour for the remainder of the spillway configurations and alignments.

8.8.4 Water Management Downstream of TSF Dyke

Currently, ditches collect dyke seepage and convey it to three small sumps, where the water quality is monitored and the water is either discharged to the environment or returned to the TSF Pond.

The current operation mode will continue during the initial construction period. Additional collector ditches and sumps (S02 and S03, see WSP, 2024b) will be constructed along southwest and northwest TSF boundaries to accommodate the dyke raises.

Once the TSF Main Dyke extends beyond the existing collector ditches, seepage and runoff from the downstream dyke slope for much of the dyke's length will drain through the WD-W-1 waste rock dump and will be collected in the SP2 sedimentation pond (WSP 2024b). From there, the water will be either returned to the ore processing plant to be used as process water or, after verifying the compliance of the water quality with applicable regulations, it will be pumped to the Main Diversion Channel to be discharged to the environment.

Once the TSF East Dyke is built, collector ditches and a collection sump will be constructed downstream of the dyke.

WSP (2024b) provides additional details on the design of the ditches and sumps.

8.8.5 TSF Pond Water Balance

Appendix L of WSP (2024b) presents the development and the results of a Troilus Project site-wide water balance study, including for the TSF. The following paragraphs present the key points as they are relevant for the TSF design:

- The numerical water balance model simulated, using a daily time step, the site-wide water operations including all sumps and ponds, effluents to the environment, and the process water consumption. Tailings pore water storage and water release after deposition were included; also the partial freezing of the

released water on the tailings beach during winter conditions and melt during the subsequent open-water season.

- The site-wide water balance model was simulated under three separate configurations, all under maximum production capacity at the ore processing plant:
  - Operational Year 1
  - Operational Year 9 (full-site development, the TSF at the maximum elevation)
  - Operational Year 21 (full-site development, tailing deposition in Pit 87).
- Thirty years of historical climate and thirty years for 78 different climate change projections (3 emission scenarios with 26 available projection models for each scenario) were simulated. The results cover a wide range of climate variability.
- For all simulated configurations and for all climate scenarios, the TSF Pond water level was maintained in between the minimum operating water level (established to maintain the operability of the water reclaim system) and the maximum normal operating water level (established to maintain the environmental freeboard). Illustration 20 and Illustration 21 present the typical pond water level variability for Year 1 and Year 9.
- For all simulated configurations and for all climate scenarios, the TSF Pond, the SP2 pond, and, for Year 21, Pit 87 provide the vast majority of the required process water for the ore processing plant. For few, particularly dry, climate conditions and depending on the assumptions regarding ice build-up on the tailings beach, Troilus would recycle water from other site ponds or dewatering volumes from other pits to satisfy the reminder of the demand. Since the overall site-wide system has a large water surplus, there is no risk of a process water deficit.
- Under average historical climate conditions, Troilus could operate the TSF Pond without discharging water from the TSF Pond to the water treatment plant. Under wetter climate conditions, and in particular for climate change scenarios projecting wetter climate, the water treatment plant is required to control the TSF Pond water level. The proposed capacity of 1,200 m^3/h, the same as the capacity of the existing treatment plant, is sufficient for all climate conditions.

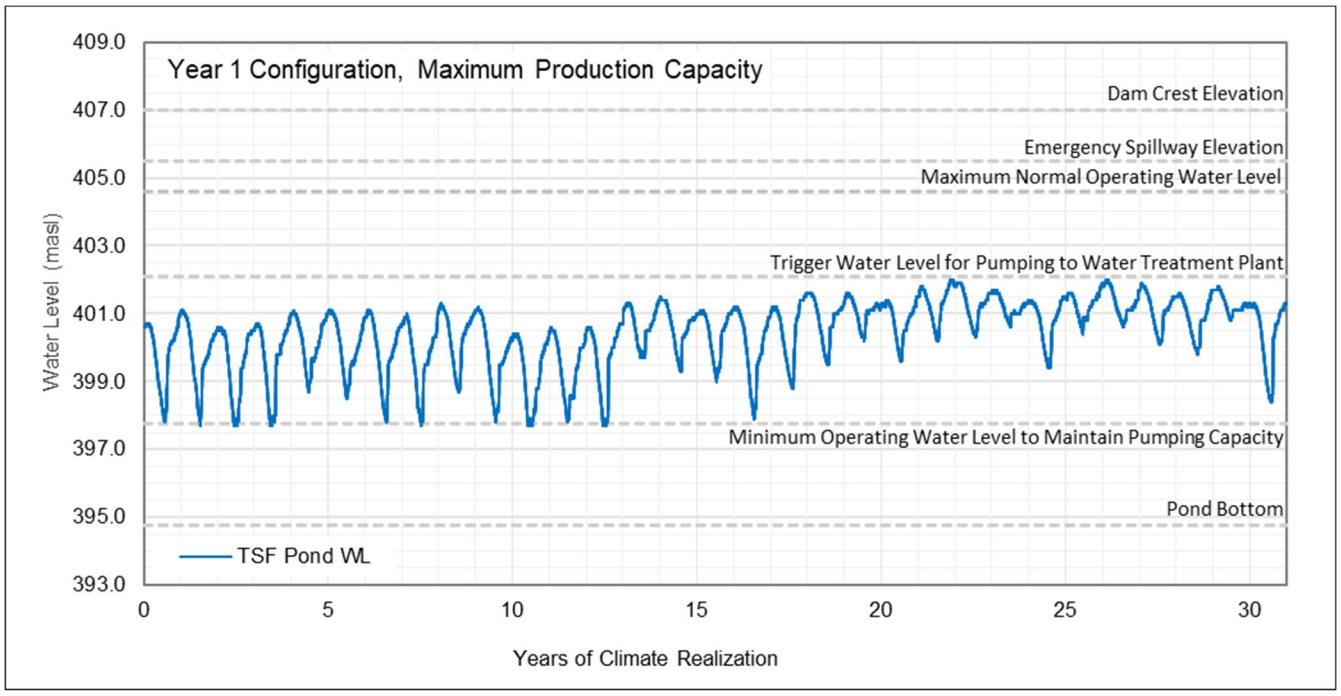

Illustration 20: TSF Pond Water Levels Simulated for the Year 1 Site Configuration under 31 Consecutive Historical Climate Years

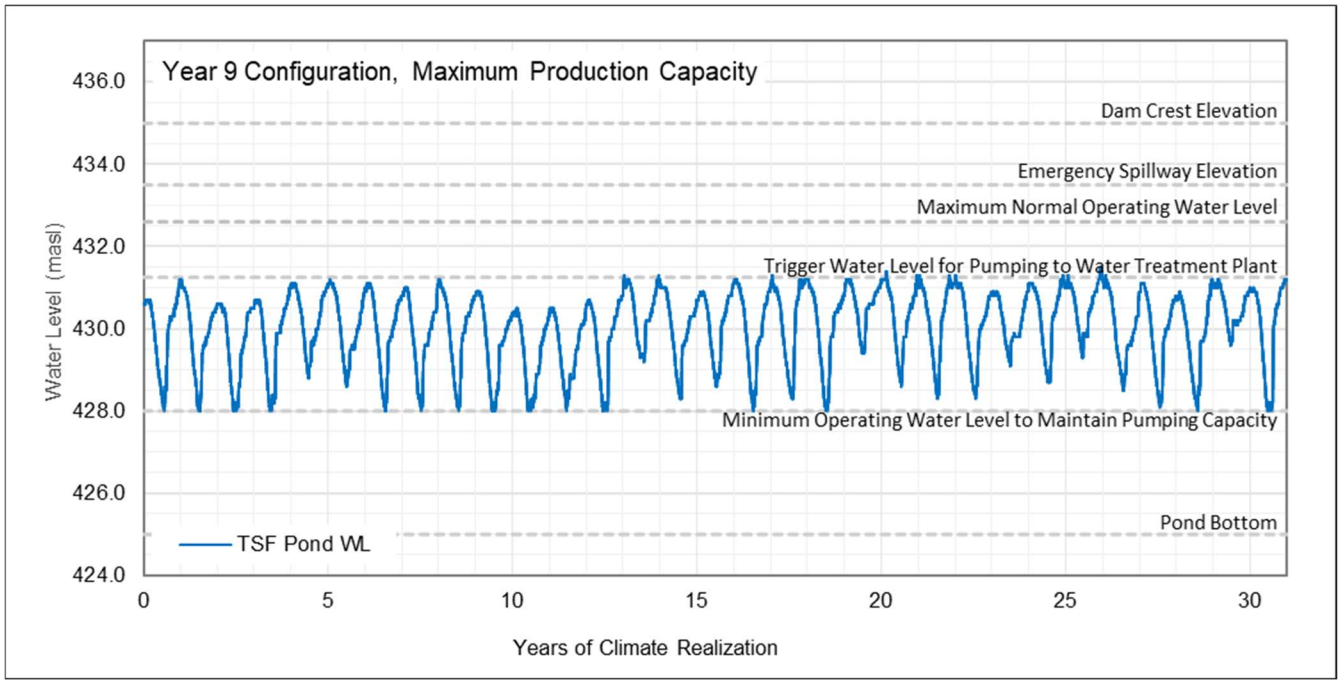

Illustration 21: Simulated Discharge of TSF Pond Surplus Water to the Environment – Last Year of Operation

9.0 TSF CLOSURE CONCEPT

The detailed closure design of the TSF will be developed in the future, as the geometry and final volume of the facility is likely to evolve during mining. The current concept for TSF closure is expected to resemble the concept which was approved for closure of the existing facility and will be integrated into the overall mine closure strategy. Appendix B in WSP (2024b) includes a conceptual closure drainage figure. Also:

- At the end of operations, a closure spillway channel would be built to connect the TSF Pond to the flooded Pit 87 Lake located north of the TSF. The channel would allow lowering the pond water level to increase the long-term freeboard relative to the embankment crest.
- The TSF surface would be reprofiled to allow efficient drainage towards the TSF Pond or the new spillway channel.
- Granular material would be placed on the TSF Pond bottom to avoid the wind resuspension of the tailing fines. The tailings beach would be vegetated to create a closure landscape and to mitigate beach erosion.
- Toe ditches and sumps would be reconfigured and integrated into the overall closure drainage plan.

10.0 INSTRUMENTATION, MONITORING AND SURVEILLANCE

A robust monitoring program should be established as part of the ongoing geotechnical works at the TSF. The monitoring program is intended to both confirm the assumptions made regarding geological interpretations, and to detect unexpected conditions in sufficient time that remedial measures can be adopted. As operations continue and more data is available, assumptions can be monitored, and recommendations can be verified and possibly altered to accommodate actual conditions in the field.

The effectiveness of the monitoring program relies on the efforts of the team to review data, to understand potential instability mechanisms within the TSF and to be observant and responsive to any changes in data trends. The team will also be responsible for:

- Plan safe access routes for data collection;
- Ensure that access routes are maintained, and slopes conditions are respected;
- Ensure compliance with environmental and HSSE guidelines;
- Monitor the instrumentation and verify that the results conform to expectations;
- Carry out monthly inspections, identify anomalies, document them, notify relevant parties and carry out the necessary works;
- Update the Operations, Maintenance and Monitoring Manual monthly/annually.

One responsible person should be appointed to manage the monitoring program, the methods and frequency of data collections, and to manage that data is properly recorded.

The monitoring program, including trigger alarm response plans, will be augmented by a program of regular visual inspection, and will be outlined in a detailed operation, maintenance and surveillance manual, which will be prepared prior to commissioning of the facility.

10.1 Geotechnical Monitoring Instrumentation

Instrumentation data must be reviewed and recorded, in the frequency advised below. A summary table is provided in Table 30. The following instrumentation is proposed in order to confirm the geotechnical performance of the structures associated with the TSF:

- Six to eight inclinometers should be installed progressively in the embankments of the TSF, particularly adjacent to the pits. Inclinometers are integral to monitoring of engineered slopes and provide an angle or measurement of deviation. The data will need to be collected at each instrument on a biweekly (every 2 weeks) basis, if not connected to a wireless acquisition system.
- Fifteen to twenty survey markers should be installed progressively on the embankment to monitor vertical deformations. The survey markers should be placed at the crest, mid slope and near toe of the embankments. Small gradual settlement measurements are expected within the first few months of the dam operation. The site team must assess reasonable settlement measurements, with respect to the speed of settlement and the time of the year (for example, thawing during freshet) and where appropriate, an investigation initiated to determine for the reason for settlement. The markers should be checked biweekly (every 2 weeks).
- Ten to twelve vibrating wire piezometers should be installed progressively in the embankments and the tailings to monitor pore pressures and pore pressure variations. The piezometers will allow monitoring of the phreatic surface within the deposited material and also the foundation of the dam. Piezometers can indicate that drainage systems are not operating as designed and which can destabilize earthworks within the TSF. The vibrating wire piezometers should be checked biweekly (every 2 weeks), if not connected to a wireless acquisition system.
- Eight to ten thermistors should be installed progressively to measure the temperature profile of the tailings. The thermistors should be checked once per calendar month, if not connected to a wireless acquisition system.

The instruments should be installed before the first year of operations.

Table 30 Geotechnical monitoring

Instrument	Number of instruments	Monitoring frequency
Inclinometers	6-8	Biweekly
Survey markers	15-20	Biweekly
Vibrating wire piezometers	10-12	Biweekly
Thermistors	8-10	Once a month

10.2 Groundwater Monitoring

This monitoring program has been developed in accordance with the requirements of Directive 019 of Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MDDEP, 2012) and the Guide to the preparation of the redevelopment and restoration plan for mining sites in Quebec from Ministry of Energy and Natural Resources (MRNF, 2017). The TSF must be constructed and operated using methods to avoid significant degradation of ground water quality. The following instrumentation is proposed in order to monitor groundwater associated with the TSF:

- The existing eight monitoring wells in the TSF area (Illustration 7) located within the expanded TSF footprint should be replaced with new monitoring wells nearby to continue the groundwater water quality monitoring. The monitoring wells should be sampled, and water levels monitored twice a year generally in spring and summer, so as to represent the period of high and low water as prescribed in Directive 019. The configuration of monitoring wells should be aware of the hydrogeological profile of the site, the majority of the wells should be placed in the downstream portion of the dam and on a perpendicular axis to the direction of groundwater flow.
- The parameters to be analyzed for groundwater monitoring are dissolved metals (arsenic, copper, iron, nickel, lead, zinc), hydrocarbons (C10-C50), total cyanides, as well as major ions (Ca+2, HCO3-, K+, Mg+2, Na+, SO4-2), pH and electrical conductivity. This list of parameters may be adjusted according to the results

of geochemical studies on waste rock and tailings. The data obtained will be used to establish local background groundwater levels and to detect changes in groundwater quality during mine operation and closure.

11.0 TSF MATERIAL TAKE OFFS

The quantities were estimated for the TSF, including stripping and construction materials. The quantities were estimated using Civil 3D and construction plans of the existing dykes, the design presented in section 7.2 and the existing ground surface based on 1m provincial LiDAR. The design methodology and quantity estimates result of the accuracy of High (+25%) and Low (-15%) ranges. The estimating the construction or operational costs was not in WSP's scope of work.

Material take offs per year and assumptions are provided in Appendix I. A summary of the quantities is presented in Table 31.

Table 31: TSF Material Take Offs Summary

Structures/Activities	Total	Unit
1. Construction and Site Preparation		
General site preparation (area for clearing and grubbing)	355,600	m^2
2. Excavation volumes		
Topsoil (peat) excavation volume (assume 0.8 m thick)	282,000	m^3
Volume of overburden excavation (liquefaction-sensitive soil)	143,000	m^3
Volume of excavation to reach 2004 raise (potentially reuse as waste rock)	90,000	m^3
Volume of bedrock excavation for emergency spillway	400	m^3
3 Granular Materials		
Crushed rock volume (Transition zone) (1.5 m thick placed in 1.5 m lifts and compacted with bucket at 1:1 slope)	449,700	m^3
Sand and gravel volume (Filter zone) (2.0 m thick placed in 1.5 m lifts and compacted with bucket at 1:1 slope)	555,400	m^3
Selected waste rock volume	1,391,000	m^3
General waste rock volume	17,932,700	m^3
Granular fill "0 – 20 mm" volume (access roads on dykes) assume 20 cm thick	83,400	m^3
Tailings for backfill	20,000	m^3
3. Emergency Spillway		
Boulder for emergency spillway "300 – 1000 mm"	16,700	m^3
4. Lining Material		
Non-woven Geotextile surface area (Texel 918), between filter and tailings material	611,500	m^2
Non-woven Geotextile surface area (Texel 934), between filter and transition material	650,700	m^2

12.0 TAILINGS IN-PIT DISPOSAL

The thickened tailings (approximately 54.3%wt w/w solids) will be produced at the processing plant and pumped for permanent storage. The tailings production is presented in Table 3. The TSF will reach its full capacity during Year 10 and tailings are planned to be disposed into mined out pits until the end of Mine Life (Year 22). In-pit tailings disposal will progress sequentially into the Southwest pit, pit J4 and then pit 87. The mine plan was developed with this constraint of concept for migration to in-pit disposal in the later years of mine development (AGP, 2024).

The in-pit disposal is a practice supported the MELCC to manage tailings and mine waste, but it requires a well-defined study (MELCC, 2021b) to support the permitting process. This section elaborates the concept for in-pit deposition.

12.1 Pits Storage Capacity

The pit capacity to store tailings is limited by geological constraints. At this conceptual design stage, the maximum of tailings is limited by the bedrock surface elevation along the pit rim. This approach simplifies the ground stability considerations by limiting the potential interaction of tailings deposition and the surrounding overburden slopes. Since the current groundwater elevation is above the bedrock surface, the above limitation will allow the disposal concept to operate with groundwater flow into the facility, creating a hydraulic trap and mitigating water seepage from the tailings body toward surrounding groundwater.

The tailings in the SW pit will be placed up to the lowest bedrock elevation (367 masl) along the pit rim. The J4 pit and 87 pit will be connected by a saddle between the pits (at the elevation of 169 masl); therefore, pit J4's storage capacity will be limited to this elevation.

The storage capacity for the SW, J4 and 87 pits are presented in Illustration 22, Illustration 23 and Illustration 24, respectively.

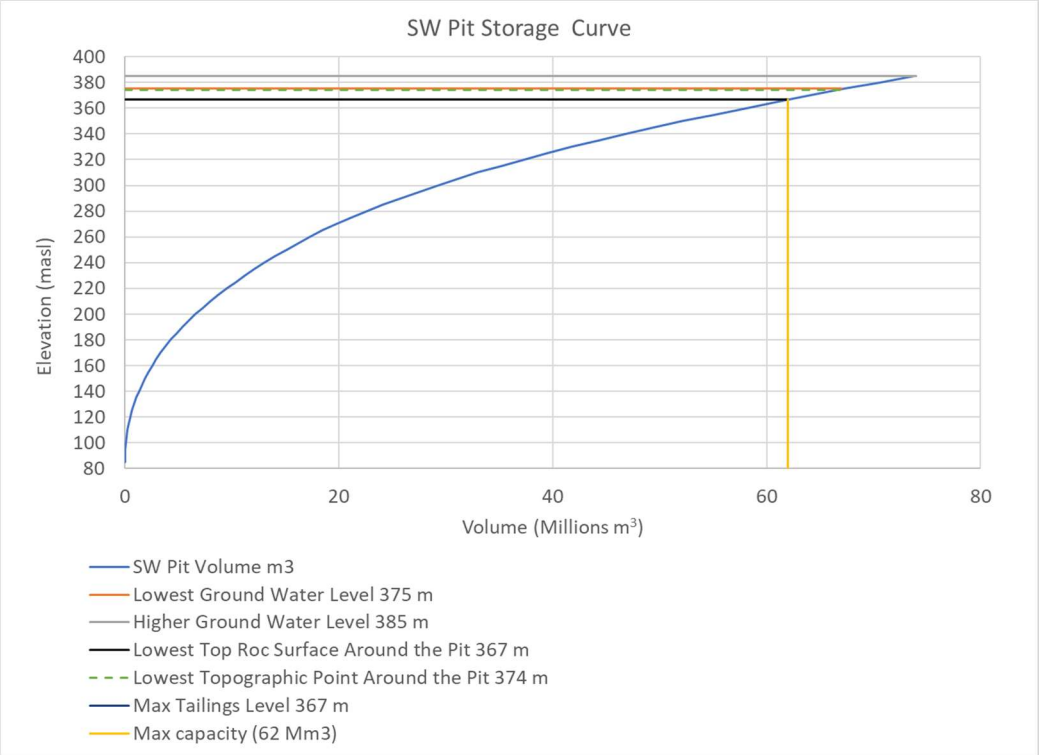

Illustration 22: SW Pit Storage Capacity

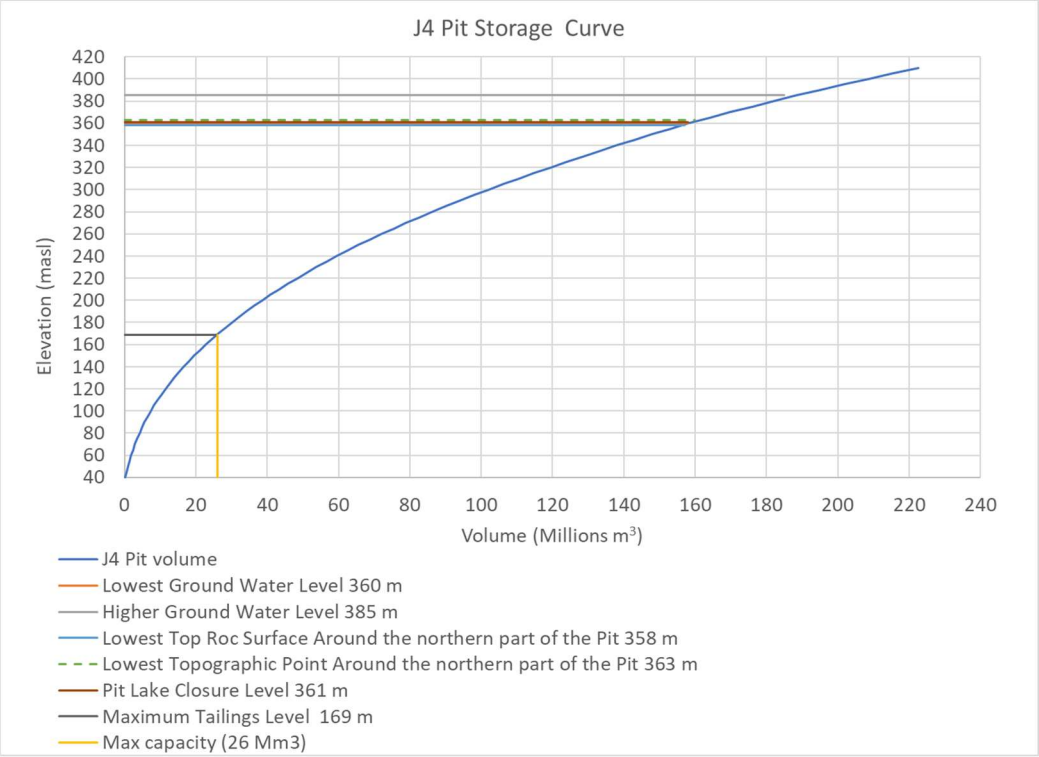

Illustration 23: Pit J4 Storage Capacity

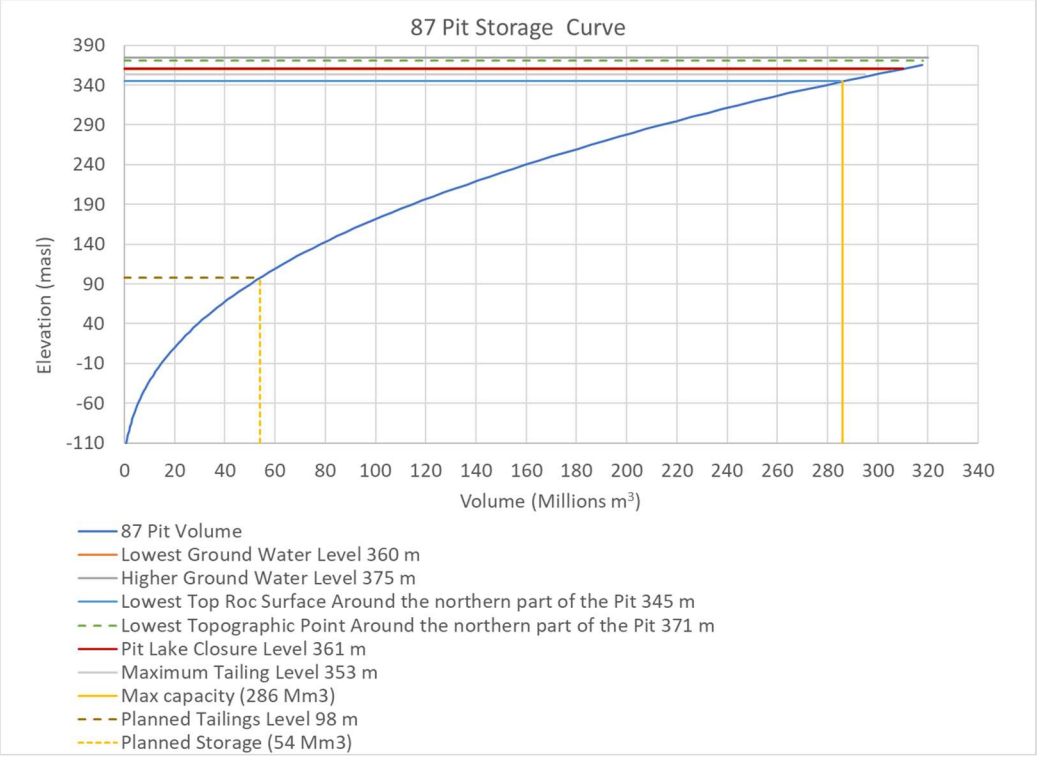

Illustration 24: Pit 87 Storage Capacity

The storage capacities per location and on a cumulative basis are presented in Table 32. The dry tailings mass is based on a dry density of 1.5 t/m^3.

Table 32: Tailings Management Capacity

Tailings Disposal Location	Volume (Mm^3)	Dry Tailings Mass* (Mt)	Cumulative (Mm^3)	Cumulative (Mt)
TSF (dyke elevation 435 masl)	113	169	113	169
SW pit (elevation 367m)	62	93	175	262
Pit J4 (elevation 169 masl to saddle with pit 87)	26	39	201	301
Pit 87 (elevation 98 masl)	52	79	253	380
Total tailings storage	**253**	**380**	**253**	**380**
*Tailings dry density of 1.5 t/m^3				

The tailings storage capacity is sufficient but has some challenge with the current mine plan. Indeed, the pit development, tailings production and tailings storage capacity present a shortage of approximately 15 months (22 Mt) around Year 17. The TSF, SW pit and J4 pits reach their full capacity before pit 87 is ready (mined out) for in-pit tailings disposal. There are a few solutions that need to be advanced to validate their feasibility:

- The SW pit capacity could be increased by building a ring dyke around it. The surrounding waste rock dump and TSF could contribute to the stability of the retainment by acting as stability berm.
- The TSF capacity could be increased with additional upstream raises above the dyke elevation of 435 masl. An increase of approximately 9 m (to the elevation of 444 masl) could be sufficient to accommodate the 22 Mt.
- The tailings deposition planning, tailings consolidation and formation of persistent ice lenses are factors impacting the storage capacity. The tailings management practice can be optimized to maximized tailings storage.

12.2 Disposal Options and Water Management

A technical review was carried out to assess the deposition method, water management practice and tailings discharge considerations for the in-pit disposal. The summary of the findings is presented in Appendix K and three options are presented for each aspect.

1) Deposition Method
    - Subaerial Deposition
    - Subaqueous Deposition
    - Co-disposal with waste rock

1) Tailings Discharge
    - Perimeter spigot discharge
    - Single point discharge
    - Barge discharge

2) Water Management
    - Base drain
    - Sidewall drain
    - Barge decant

Each option was assessed with five parameters:

- Constructability
- Operations
- Hydrogeological
- Geochemical
- Closure

After a review of the different options, the preferred in-pit concept for Troilus consists of a subaerial deposition method with a limited number of points of discharge (2 to 4) on one side of the pit and a barge decant to manage water.

The tailings will be deposited by 2 to 4 spigots from one side of the pit and return water ponds against the opposite site of the pit. A barge will be installed to pump reclaim water back to the mill. A tailings delivery pipeline will need to be constructed to deliver tailings to a few discharge points with limited lateral displacement. The discharge points will be raised, typically along the ramp as the tailings level rises.

The pit water level will be controlled by pumping from a floating barge in the pit. The system will require access to the pit for the floating barge and the reclaim pipeline. This system can continue to operate from operation to closure and allow efficient transition to pit lake closure operation for the J4 and 87 pits. The geochemistry of tailings is assumed to be favourable (section 5.4) but if any issues are identified, the proposed water management permits to create an inward groundwater gradient during operations and mitigate potential groundwater impacts by avoiding potential exfiltration toward groundwater.

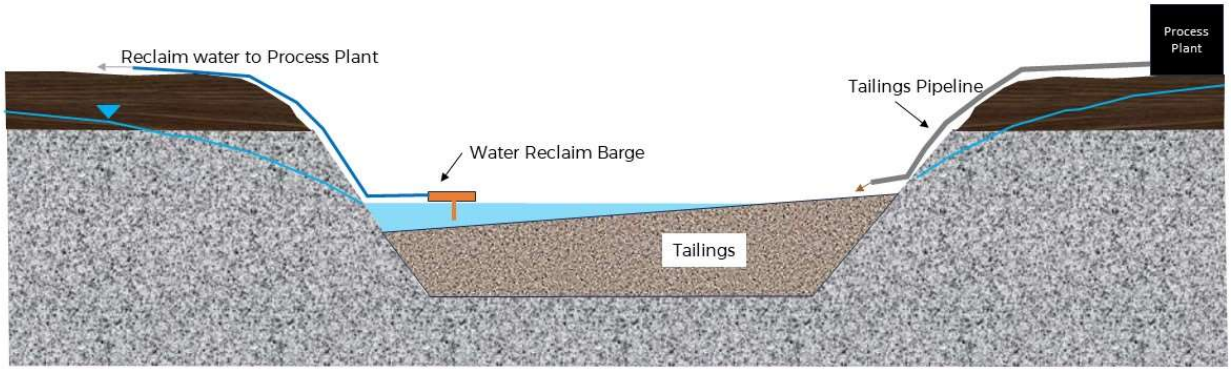

Illustration 25: In-Pit Tailings Disposal Conceptual Cross-Section View (not to scale)

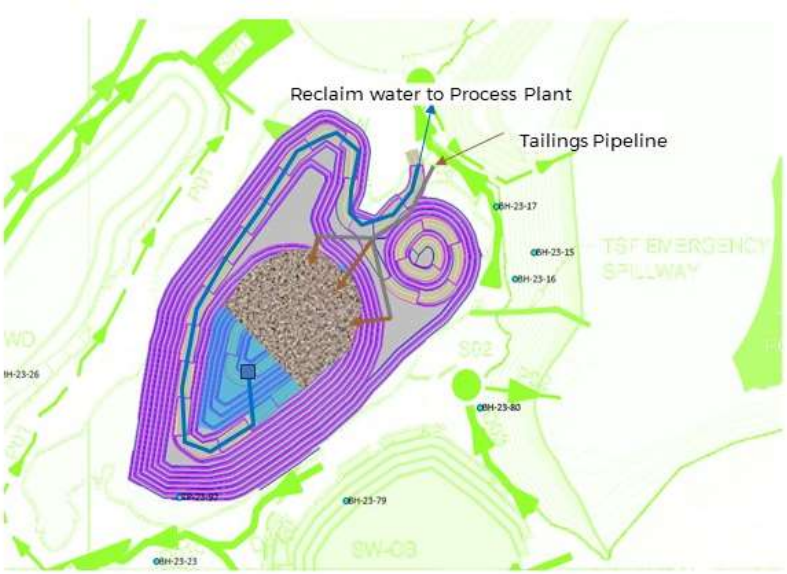

Illustration 26: In-Pit Tailings Disposal Conceptual Plan View (example of the Southwest pit)

The co-disposal with waste rock is not a desirable option for the SW and J4 pits because the tailings storage capacity during operation is limited and any addition of waste rock material would decrease the tailings storage capacity. However, the co-disposal of tailings with waste rock is possible in pit 87 as the storage capacity will not be constrained. The method is amenable to progressive reclamation by judicious placement of waste rock and this can be adapted to dispose of potential acid generating waste rock, if any. Co-disposal will be considered as an option in future phases of study.

12.3 Future of the Troilus Pits

Once the SW tailings storage capacity is reached, waste rock fill will be placed above the tailings. An approximate 216 Mt of waste rock (100 Mm^3) will be placed after year 15 (AGP, 2024). Advancing a waste rock dump over a slurry tailings management facility presents some stability risks (Etezad et al., 2023) but these can be mitigated. Investigations will be undertaken to understand the characteristics of the tailings and assess the impact of potential tailings liquefaction on the stability of the waste rock stockpile. The method of waste rock placement must be adjusted with the site conditions. The first layers of waste rock must typically be thin (1 to 2 m thick over the level of the tailings) with a large deposition front of placement. The thickness of the layer can be increased progressively as the condition are proven to be sufficiently stable by observational and monitoring control. The waste rock dump above the SW pit should be closed using a similar approach to that used for the other waste rock dump at the site.

After operation in Year 22, the northern pits (J4, 87 and X22) will move to the closure phase. The active pumping that controls the water level during the operation phase in the northern pits will be stopped and the water level will rise to form a pit lake. The main Bibou diversion should be connected (WSP, 2024b) with the northern pits to contribute to the pit lake (Illustration 27). The pit lake elevation is expected to be around 361 masl where the overflow will connect with the lowest topographical elevation on the northeast side toward lake A. The maximum depths of water in the pit lake for the J4 and 87 pits are expected to be approximately 190 m and 360 m respectively. These depths could be reduced if waste rock material is placed above the tailings at the bottom of the pit.

The in-pit tailings disposal approach is developed at a conceptual level. The following studies should be advanced during the next engineering phase:

- Develop a basis of design for the in-pit disposal.
- Validate the neutral geochemical behavior of the tailings to be placed into mined out pit and its negligible potential impact on the receiving environment.
- Avance the design of the tailings delivery and water reclaim systems.
- Develop the pit lake closure design concept to facilitate the transition from operations to post-closure.
- Identify sufficient tailings storage that match the mine plan and the tailings production rate.
- Assess pit slope stability during the TSF conversion.

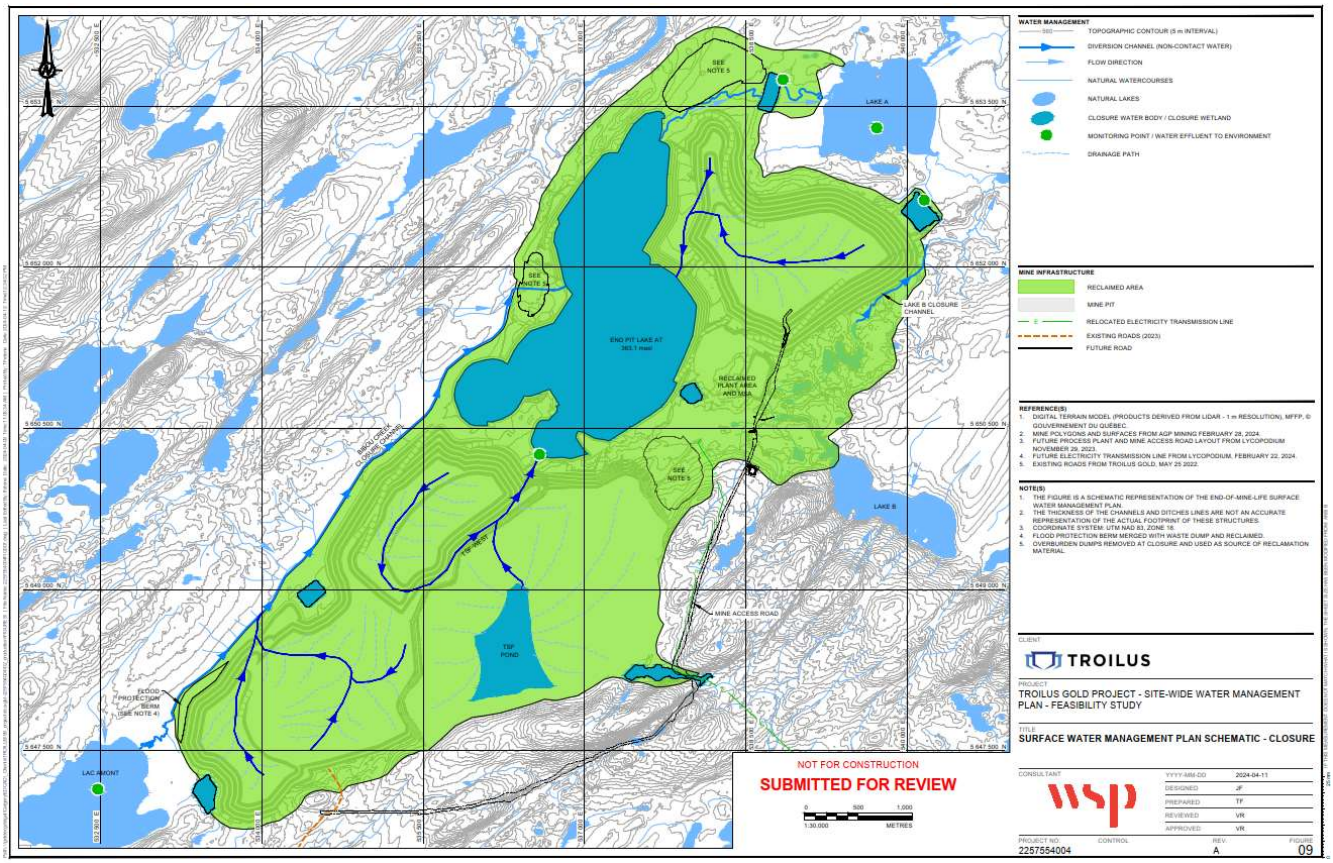

Illustration 27: Conceptual Closure Plan (after WSP, 2024b)

13.0 RISK ASSESSMENT AND FEASIBILTY RECOMMENDATIONS

A design risk assessment was undertaken to identify risks that require additional investigations and/or analysis for future project work. Risks have been categorized into credible or non-credible, and potentially catastrophic or non-catastrophic. The risk and detail design engineering recommendations are included in the following table.

Table 33 Risk Assessment and Detailed Engineering Recommendations

Category	Risk	Discussion	Detailed Engineering Detail Recommendations	Catastrophic/Non-Catastrophic	FS Assessment
Sunny day failure	Static deformation leading to deformation of the filter, increased seepage, erosion of the toe and release of tailings to the environment.	- Filter designed to handle static deformation and in compression. Failure of filter could cause constant release, but waste rock would allow migration of tailings. - Updated deformation analysis using Plaxis 2D shows a maximum settlement of 0.65 m across the existing filter. The differential displacements are deemed to be acceptable.	N/A	Non-Catastrophic	Non-credible
	Static deformation leading to loss of freeboard and overtopping of embankment with run out into pits.	Updated stress-deformation analysis using Plaxis 2D shows 1 m of settlement over the entire height of the dyke. The settlements can be compensated during the construction	The constitutive model should be updated for detailed engineering, complemented by: - A sensitivity analysis be carried out, on the compressibility of the waste rock and the existing tailings among other parameters. - Adjusting the construction stages in the model, once the construction sequences are planned. - Adjusting the model as the construction advances by verifying the results with the instrumentation data (inclinometers, and vibrating wire piezometers, and/or observation wells).	Catastrophic	Credible
	Earthquake induced instability and deformation leading to loss of freeboard and overtopping.	Limit equilibrium show relatively high pseudo-static and post liquefaction factors of safety using a 1 in 10,000-year earthquake event. This failure mode can be assumed to be highly unlikely. However, it needs to be proved out.	- Earthquake peak ground acceleration at site, as well as other seismic hazard parameters, and scaled ground motion time histories should be developed through site-specific seismic hazard assessment (SSSHA). - A liquefaction assessment of the tailings and foundation using seismic site response analysis should be undertaken. Supporting the upstream toe should be undertaken. - Depending on the needs of the project, a dynamic stress-deformation analyses can be carried out on the PLAXIS model already created, once the SSSHA is complete.	Catastrophic	Credible

Table 33 Risk Assessment and Detailed Engineering Recommendations

Category	Risk	Discussion	Detailed Engineering Detail Recommendations	Catastrophic/Non-Catastrophic	FS Assessment
	Earthquake induced liquefaction in the foundation sands leading to loss of freeboard and overtopping.	The susceptibility of liquefaction at some locations is confirmed by the analysis. Current recommendation is to remove all liquefiable sands in the foundation footprint where they are accessible. There is an opportunity to assess the use of these sands as a filter construction material for TSF raises.	- Undertake further investigation to confirm the liquefaction prone zone near the dyke foundation, using SPT data, and using site response analysis when SSSHA is available. - Design the excavation of alluvial soil in the B-B' cross-section area.	Catastrophic	Non-credible
	Excessive seepage through esker leading to a piping failure, deformation of the embankment and run out into the Southwest Pit.	There is a till cut off beneath the starter dyke that appears to extend to bedrock. Assume this failure mode is highly unlikely, however it needs to be proved out.	Design a transition and filter zone between natural esker sand and embankment fill.	Catastrophic	Credible
	Seepage through esker leading to discharge of water into pit.	There is a till cut off beneath the starter dyke that appears to extend to bedrock. No catastrophic loss of contents but could lead to excessive release of tailings contact water to the pit.	Understand potential interaction with adjacent pit.	Non-Catastrophic	Credible
	Failure of waste rock dump into the TSF. Waste rock dump is designed to be a minimum of 50 m above the height of the crest. Run-out into the TSF could lead to wave generation and overtopping of the embankment.	Stability modelling shows high FoS against a multi-bench failure. However, the design is changing regularly, and this should be reassessed at detail engineering.	Updated 2D limit-equilibrium stability analysis accounting for design changes.	Catastrophic	Non-credible
	Piping through incompatible filter zones leading to loss of freeboard and overtopping of the TSF.	Filter and transition zones are required between the natural ground and waste rock in the stability key.	Filter and transition should be designed in detailed engineering to prevent the potential of internal erosion at the contact between the natural sand and the waste rock fill.	Catastrophic	Non-credible
	Failure of upstream hill, to the east of the dyke into the facility. Run-out of a landslide into the TSF could lead to wave generation and overtopping of the embankment.	Upstream hill appears to have a low risk of slope instability based on terrain mapping.	2D limit-equilibrium stability analysis to review sensitivity of slope to changes in phreatic surface.	Catastrophic	Non-credible
	Tailings facility in blast radius for pits leading to liquefaction of foundations/tailings through cyclic loading.	Downstream raise facility and excavation of liquefaction potential material at the toe of the Main Dyke.	Develop operational blasting controls.	Catastrophic	Non-credible
	Foundation failure on low-strength organic silts/peat leading to loss of freeboard and overtopping.	Strip all low-strength/organic materials in the foundation prior to construction.	N/A	Catastrophic	Non-credible
	Foundation failure due to lack of information on stratigraphy in the TSF area.	The east section of the TSF lacks soils data compare to the rest of the area.	Collection of more data should be considered for the detailed engineering of the TSF in order to better understand the thickness and properties of the foundation materials for east section using test pits.	Catastrophic	Credible
Sunny day failure (cont'd)	Change in water level at toe due to dewatering activities at the pits leading to increased pore pressures and decrease in stability.	Stability modelling has conservatively assumed a phreatic surface at ground level.	Transient seepage analysis should be undertaken at detailed engineering, integrated with pits dewatering.	Catastrophic	Non-credible
	Operational interaction between waste rock dump and controlled placement zone, leading to loss of support of the filter and release of tailings through the waste rock.	No loss of containment but release of tailings through waste rock.	Develop operational controls.	Non-Catastrophic	Credible

Table 33 Risk Assessment and Detailed Engineering Recommendations

Category	Risk	Discussion	Detailed Engineering Detail Recommendations	Catastrophic/Non-Catastrophic	FS Assessment
Rainy day / flood-induced failure	Embankment overtopping, during spring freshet or summer storm of the embankment crest due to large storm inflow leading to loss of containment.	TSF emergency spillway designed to evacuate the probable maximum flood peak flow with a freeboard, relative to the crest of the embankment, equivalent to the 2-year extreme wind effect (wind set-up and run-up).	Develop operational controls.	Catastrophic	Credible
	Surface erosion of emergency spillway during an extreme flood event leading to spillway structural damage, loss of tailings containment at the upstream end of the spillway channel and the development of an erosion breach.	TSF emergency spillway designed to withstand without erosion the PMF peak flow. Relocation of the emergency spillway to a lower-risk location	Develop operational controls.	Catastrophic	Credible
Water management	Accumulation of excess water within the TSF pond beyond the pond storage capacity leading to discharge of untreated water to the environment.	Provide sufficient containment capacity for the regulatory environmental design flood (EDF) event. Install water treatment plant to discharge water to the environment if the site-wide water balance points to an overall surplus.	Develop operational controls and/or consider improve the percentage solid of the tailings.	Non-Catastrophic	Credible
	Unexpected poor chemistry of the tailings seepage and runoff leads to potential discharge of untreated water to the environment.	Hypothesis was made based on historical data and planned metallurgic process that water chemistry should be adequate.	Develop operational controls. Verify the tailings pore water chemistry during detailed design and operations.	Non-Catastrophic	Credible
Hazard during construction	Failure of the excavation walls	The design of the excavation of the alluvial soil in the foundation for replacement with waste rock (shear key) was not completed for the FS.	Design the excavation in alluvial soil in the foundation.	Non-Catastrophic	Credible
Dam Consequence Classification	Design was compared to extreme environmental loadings in consideration of GISTM and eventual closure requirements.	Without classification, the dam consequence is assumed as extreme but may lead to tedious permitting process.	Conduct a dam safety review (DSR) and dam breach analysis for detailed engineering design and re-visit the dam consequence classification.	Non-Catastrophic	Credible
Material borrow source	Sources of dyke filter material are not confirmed. Filter zone material would come borrow areas located at the mine site while transition zone would be produced from crush material.	Severable samples meeting the filter zone characteristics are identified among several source of sand mapped at the site.	Review potential borrow sources for the TSF filter zone material and confirms quantity available. Depending on the quality, screening might be required to meet the gradation limits for the material.	Non-Catastrophic	Credible
Tailings management	Lack of storage capacity of the tailings in the first years of operation.	For the first years of operation the annual volume available in the tailing's facility could be tight.	Proceeded with the dykes raise in two steeps of two meters and start the construction early the in the construction season.	Non-Catastrophic	Credible
	Store a large volume of ice in the tailings management facilities.	The design considers a conservative dry density (1.5 t/m^3) for the tailings to take account the presence of ice lens in the facility.	Develop operational controls to minimize the problem	Non-Catastrophic	Credible
	Temporary insufficient tailings storage capacity when mining in 87 pit still occurring and is not available for in-pit tailings disposal.	Based tailings production, mine plan and tailings storage capacity, a shortage of approximately 15 months (22 Mt) is identified around year 17.	Identify alternative tailings storing capacity options.	Non-Catastrophic	Credible
	Underestimated tailings production volumes lead to different storage requirements.	Although it is acknowledged that the specific gravity of the tailings may be higher than that used in the original design, it was decided to conserve the value of 2.65 for the FS, to conservatively estimate the airspace requirements of the TSF. This assumption will be reviewed in future design studies	Review tailings density.	Non-Catastrophic	Credible
	Change in tailings classification leading to a change in tailings management.	Geochemistry testing is still ongoing in support of feasibility design, and design changes could be required if the tailings or waste rock are reclassified as high-risk.	Identify solutions where tailings or waste rock are classified as high-risk	Non-Catastrophic	Credible

14.0 CLOSING

The reader is referred to the Study Limitations section, which precedes the text and forms an integral part of this report.

WSP trust the above meets present requirements of Troilus. In case there is any questions or comments, please contact the undersigned.

Signature Page

WSP Canada Inc.

Original signed	Original signed
Mathieu Gosselin, P.Eng. M.Sc.A., PMP *Geological Engineer*	Carl Pednault, P.Eng. *Tailings Management Engineer*

MG/CP/js

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15.0 CONTRIBUTION

The following table shows the persons responsible for the various sections of the report and those who reviewed them.

Table 34: contributions to the report

Report section	Sub-section /Author	Sub-section /Reviewer
1.Introduction	Mathieu Gosselin	Carl Pednault
2.Background	Mathieu Gosselin	Carl Pednault
3.Basis for design and design criteria	Annyssa Bertrand-Locas	Mohamad Kermani
4.Site condition	Section 4.1 to 4.3: Annyssa Bertrand-Locas Section 4.4 and 4.5: Vlad Rojanschi Section 4.6 Xavier Léveillée-Dallaire Section 4.7: Marie Costello	Mathieu Gosselin
5.Tailings characterization	Mohammad Kermani	Mathieu Gosselin
6. Foundation characterization	Annyssa Bertrand-locas	Mathieu Gosselin
7.Feasibility design description	Annyssa Bertrand-locas	Carl Pednault
8.Feasibility design assessment	Section 8.1 to 8.5 and 8.7: Annyssa Bertrand-Locas Section 8.6: Mohammad Zarrabi Section 8.8: Vlad Rojanschi	Section 8.1: Carl Pednault Section 8.2 to 8.7: Mohammad Kermani Section 8.8: Vlad Rojanschi
9.TSF closure concept	Mathieu Gosselin	Carl Pednault
10. Instrumentation, monitoring, and surveillance	Marie Costello	Carl Pednault
11.TSF material take offs	Mathieu Gosselin	Carl Pednault
12.Tailings in-pit disposal	Mathieu Gosselin	Laurent Gareau
13.Risk assessment and feasibility recommendation	Carl Pednault	Mathieu Gosselin

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APPENDIX A

Tailings Management Options Study

REPORT

Tailings Management Options Study

Troilus Mine, Quebec

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19131334/Doc #003 REV0

October 2020

Distribution List

1 PDF copy: Troilus Gold Corporation

1 PDF copy: Golder Associates Ltd.

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APPENDICES

APPENDIX A
Tailings Dewatering Options

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Troilus Gold Corp. (Troilus) to conduct a feasibility tailings deposition study for their Troilus Gold Project in northwestern Quebec.

Troilus is constructing a new ore processing facility at its existing property to treat 35,000 tonnes of ore per day from the local resource to produce gold and copper concentrate. The life of project will be finalized in parallel with the tailings study, during project execution. The processing plant will include crushing, milling, gravity gold recovery and flotation. Troilus requires a tailings management strategy for the processing facility.

The first stage of study involves a conceptual trade off study to evaluate several tailings and water management options for selection of preferred options to advance to Pre-feasibility Study. This report presents the methods and results of the conceptual trade off study for expansion of the existing Tailings Storage Facility (TSF).

2.0 SCOPE OF WORK

Three tailings preparation options were considered for the conceptual options study including conventional thickened slurry, deep cone thickened slurry, and filtered stackable solids. The following were evaluated for each option:

- Tailings Preparation
  - thickening and filtration dewatering system
  - conveying of tailings to the TSF
  - tie-in design and outline of modifications potentially required to the existing infrastructure
  - Capital Cost Estimate (CAPEX), Operating Cost Estimate (OPEX) (Class 5 AACEI, ± 50%)
  - performance (capacity, environmental, operability and maintainability)
- Tailings and Water Management
  - tailings and water capacity requirements
  - containment infrastructure
  - operational water management plan, water drainage infrastructure
  - tailings stack consolidation modeling and stability assessment
  - operational constraints
  - environmental performance
  - decommissioning approach
  - CAPEX, OPEX (Class 5 AACEI, ± 50%)

3.0 DATA COMPILATION

Golder has been a key contributor to the design, construction and operation of the TSF at Troilus, and as such many of the relevant background data reports exist within our files. We have been informed by the former owner of the site that Troilus may receive the information from Golder's files. The following table summarizes reports that Golder has used in the execution of this project:

Year	Project No.	Deliverable Title	Project Synopsis
1997	SNC-007595-41ET-401	EXPLOITATION MINIÈRE TROILUS, CONCEPTION DU PARC A RÉSIDUS MINIERS. NORD DE CHIBOUGAMOU, QUEBEC.	Initial site characterization and design of starter embankment
1997	971-7088	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE DU PARC À RÉSIDUS	Technical specifications
		EXPLORATION DE BANCS D'EMPRUNT	Borrow search
		RECHERCHE DE BANCS D'EMPRUNT	Borrow search
		MODIFICATION AU SCHÉMA DE DÉVELOPPEMENT DU PARC À RÉSIDUS DE LA MINE TROILUS, MUNICIPALITÉ DE LA BAIE-JAME	Modification of development strategy for TSF
1999	991-7034	ANALYSE DE RISQUES SYSTÈME DE REFOULEMENT DES EAUX DU PARC À RÉSIDUS MINE TROILUS	Water management risk analysis for the TSF.
1999	991-7076	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE DU PARC À RÉSIDUS (1999) PROJET TROILUS	Technical specifications
		RECHERCHE DE BANCS D'EMPRUNT ET AUTRES SONDAGES EXPLORATOIRES	Borrow search
2000	001-7014	MODÉLISATION DES DIFFÉRENTES ÉTAPES DE DÉPOSITION DES RÉSIDUS DANS LE PARC - MARS 2000 À AVRIL 2002, PROJET TROILUS	Deposition modelling - 2000 to 2002
		DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE DU PARC À RÉSIDUS (2000) PROJET TROILUS	Technical specifications
		RAPPORT D'EXPLORATION BANC OUEST ET BANC C AOÛT 200	Borrow search
2001	011-7040	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE DU PARC À RÉSIDUS (2001) PROJET TROILUS	Technical specifications
		PLANS DE RÉFÉRENCE, TRAVAUX DE CONSTRUCTION, ÉTÉ 2001	Drawings for dyke raise
2002	021-7023	PLANS DE RÉFÉRENCE, TRAVAUX DE CONSTRUCTION, ÉTÉ 2002	Drawings for dyke raise
		DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE DU PARC À RÉSIDUS (2002) PROJET TROÏLUS	Technical specifications
		INSPECTION ANNUELLE DU PARC À RÉSIDUS, PROJET TROILUS	Annual inspection report
2002	021-7044	REVUE DU CONCEPT DE REHAUSSEMENT PARC À RÉSIDUS DIVISION TROÏLUS	Review of dam raise concept
2003	03-1221-001	CONSIDÉRATIONS SUR LE REHAUSSEMENT DE LA DIGUE DU PARC À RÉSIDUS À PLUS DE 392,5 M, DIVISION TROILUS	Feasibility for dyke raising
		DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE DU PARC À RÉSIDUS EN 2003 MINE TROÏLUS	Technical specifications
2003	03-1221-009	RECHERCHE DE BANCS D'EMPRUNT MAI 2003	Borrow search
2003	03-1221-016	PLANS DE RÉFÉRENCE TRAVAUX DE CONSTRUCTION 2003 - DIVISION TROILUS REHAUSSEMENT DE LA DIGUE - PARC À RÉSIDUS	Drawings for dyke raise
2003	03-1221-026	OUTIL DE GESTION DE L'EAU PARC À RÉSIDUS DIVISION TROILUS	Water management concept
2003	03-1221-027	INSPECTION ANNUELLE DU PARC À RÉSIDUS, PROJET TROILU	Annual inspection report
2004	04-1221-001	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE ET DE LA DIGUE NORD-EST DU PARC À RÉSIDUS EN 2004 MINE TROÏLUS	Technical specifications
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2004 - DIVISION TROILUS REHAUSSEMENT DE LA DIGUE - PARC À RÉSIDUS	Drawings for dyke raise

Year	Project No.	Deliverable Title	Project Synopsis
2004	04-1221-008	ÉTUDE DE LA MISE EN PLACE D'UN PAREMENT DE STÉRILES EN AVAL DE LADIGUE PRINCIPALE DU PARC À RÉSIDUS DIVISION TROILUS	Assessment of impact to stability for constructing a toe berm on the main dyke
2004	04-1221-016	OPINION TECHNIQUE ET MESURES DE REHABILITATION, DIGUE NORD-EST, PARC À RÉSIDUS, MINE TROÏLUS	Assessment of dyke rupture, northeast dyke.
2005	05-1221-002	PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2005 - DIVISION TROILUS REHAUSSEMENT DE LA DIGUE - PARC À RÉSIDUS	Drawings for dyke raise
		DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE ET DE LA DIGUE NORD-EST DU PARC À RÉSIDUS EN 2005 MINE TROÏLUS	Technical specifications
2005	05-1221-016	INSPECTION ANNUELLE DU PARC À RÉSIDUS, DIVISION TROILUS	Annual inspection report
2005	05-1221-017	OPINION TECHNIQUE AU SUJET DE FAISABILITÉ D'UNE AUGMENTATION DE LA CAPACITÉ D'ENTREPOSAGE DU PARC À RÉSIDUS, DIVISION TROÏLUS	Memo which considered the feasibility of increasing the storage capacity in the TSF
2005	05-1221-018	RAPPORT FACTUEL INSTALLATION DE PIÉZOMÈTRES ÉLECTRIQUES SUR LE SITE DU PARC À RÉSIDUS DE LA MINE TROïLUS	Vibrating wire piezometer installation
2006	06-1221-002	NOUVELLE DIGUE SUD, PARC À RÉSIDUS MINIERS, DIVISION TROÏLU	Stability analysis for the South dyke
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2006 - DIVISION TROILUS Rehaussement de la digue - Parc à résidus	Drawings for dyke raise and new South dyke to El 402 m
		DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE ET CONSTRUCTION DE LA DIGUE SUD DU PARC À RÉSIDUS EN 2006 MINE TROÏLUS	Technical specifications
2006	06-1221-004	ÉVALUATION DE LA CAPACITÉ DE REMPLISSAGE DU PARC À RÉSIDUS, DIVISION TROÏLUS	Assessment of remaining capacity
2006	06-1221-015	INSPECTION ANNUELLE DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS	Annual inspection report
2006	061221-024	PLANS DE RÉFÉRENCE TRAVAUX DE CONSTRUCTION 2006 - DIVISION TROILUS REHAUSSEMENT DE LA DIGUE - PARC À RÉSIDUS	Drawings for dyke raise
2007	07-1221-002	PLAN DE FERMETURE RÉVISION 2007 LES MINES INMET, DIVISION TROILUS	Closure plan update
		PROGRAMME DE CARACTÉRISATION ENVIRONNEMENTALE DES SOLS ET DE L'EAU SOUTERRAINE EN VUE DE LA FERMETURE – PRÉLIMINAIRE	Environmental studies on soils and groundwater in support of closure
2007	07-1221-004	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE DU PARC À RÉSIDUS EN 2007 MINE TROÏLUS	Technical specifications
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2007 - DIVISION TROILUS Rehaussement de la digue - Parc à résidus	Drawings for dyke raise
		INSPECTION ANNUELLE DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS	Annual inspection report
2008	08-1221-010	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE DU PARC À RÉSIDUS EN 2008 MINE TROÏLUS	Technical specifications
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2008 - DIVISION TROILUS Rehaussement de la digue - Parc à résidus	Drawings for dyke raise
		INSPECTION ANNUELLE DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS	Annual inspection report
2008	08-1221-012	OPINION ON THE TAILINGS POND EXPANSION POTENTIAL, TROÏLUS MINE	Opinion on tailings pond expansion potential
2009	09-1221-001	PLANS DE RÉFÉRENCE TRAVAUX DE CONSTRUCTION 2009 - DIVISION TROILUS REHAUSSEMENT DE LA DIGUE - PARC À RÉSIDUS	Drawings for dyke raise
2009	09-1221-002	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE DU PARC À RÉSIDUS EN 2009 MINE TROÏLUS	Technical specifications
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2009 - DIVISION TROILUS REHAUSSEMENT DE LA DIGUE - PARC À RÉSIDUS	Drawings for dyke raise
		INSPECTION ANNUELLE DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS	Annual inspection report

Year	Project No.	Deliverable Title	Project Synopsis
2009	09-1221-011	RÉSULTATS DE L'ÉTUDE D'ÉVALUATION DU POTENTIEL DE LIQUÉFACTION DES RÉSIDUS, PARC À RÉSIDUS, DIVISION TROÏLUS	Liquefaction potential assessment for tailings.
2010	10-1221-005	DEVIS TECHNIQUE - CONSTRUCTION DU SYSTÈME DE GESTION DES EAUX DE SURFACE DU PARC À RÉSIDUS DE LA MINE TROILUS, 2011	Technical specifications for surface water management system
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2007 - DIVISION TROILUS SYSTÈME DE GESTION DES EAUX DE SURFACE	Drawings for surface water management system
		COMPTE RENDU –VISITE DU SITE DU PARC À RÉSIDUS LES 15 ET 16 JUIN 2010, MINE TROÏLU	Site inspection report
		RE: TROILUS MINE - FEASIBILITY STUDY OF A TAILINGS DIVERSION DITCH	Feasibility study for tailings diversion ditch
2010	10-1221-080	DEMANDE DE CERTIFICAT D'AUTORISATION POUR LA RESTAURATION DU PARC À RÉSIDUS	Request for certificate of authorization
2010	10-1221-109	ACTUALISATION DES NIVEAUX ET DÉBITS DE CRUE SUITE AUX CHANGEMENTS AU SYSTÈME DE GESTION DES EAUX -PARC À RÉSIDUS MINIERS TROÏLUS	
		INSPECTION ANNUELLE DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS	Annual inspection report
		ÉTUDE DE FAISABILITÉ DU REGROUPEMENT DES POINTS D'ÉCHANTILLONNAGE DES EFFLUENTS DES EAUX DE SURFACE DU PARC À RÉSIDUS VERS L'ENVIRONNEMENT	Feasibility study for combining sampling points for surface water at the TSF
2012	12-1221-114	CONCEPTUAL STUDY OF EROSION PROCESSES AND EROSION PROTECTION SOLUTIONS ON THE TROILUS STORAGE FACILITY FOLLOWING THE END OF OPERATIONS	Erosion study
2013	13-1221-060	INSPECTION ANNUELLE 2013 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS	Annual inspection report
2014	1405806	INSPECTION ANNUELLE 2014 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS	Annual inspection report
2014	1410952	DEVIS TECHNIQUE - AMÉNAGEMENT D'UN FOSSÉ POUR LE REGROUPEMENT DES EFFLUENTS PR6 ET PR5, MINE TROÏLUS	Technical specifications for changes to surface water management system
		VUE EN PLAN ET COUPES DU FOSSÉ PR5-PR6	Detailed design
2015	1531075	INSPECTION ANNUELLE 2015 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS	Annual inspection report
2016	1655060	INSPECTION ANNUELLE 2016 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS	Annual inspection report
2017	1787327	INSPECTION ANNUELLE 2017 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS	Annual inspection report

TSF = Tailings Storage Facility.

4.0 HISTORY

The initial design for the facility was carried out by SNC Lavalin Inc. (SNC-Lavalin). The original design report was not available, however in a 1997 report revision, the key design assumptions were elaborated:

« Exploitation minière Troilus, conception du parc à résidus miniers », notes techniques, rapport révisé de SNC-Lavalin Environnement, projet 007595-41ET-401, mai 1997.

The design concept proposed by SNC was to construct a dam initially to elevation 381 m, subsequently to be raised to elevation 385 m and 390 m. Tailings were intended to be deposited on the upland areas to the northeast of the dyke and that the supernatant water would rest against the embankment. We understand that the starter dyke for the main embankment of the facility was constructed up to nominal elevation 381 m (9 m maximum height) on the basis of this report.

The concept for the development of the TSF was revised by Golder in 1997 (971-7088). The concept selected was to raise the tailings facility by constructing upstream raises 2 to 2.5 m high using tailings placed on top of the tailings beach. A filter zone was constructed to allow the passage of exfiltrating water, and mine waste was used for erosion protection. The TSF was raised incrementally using this concept, except that the annual raises were typically 1.5 m high.

Whereas the raise construction methodology was largely successful, issues were experienced with high levels of suspended solids in the water pond, which had implications in terms of water management. Several iterations of dyke raise heights and pond size were considered during the operational phase to manage water quality issues.

In 2004, a study was undertaken (04-1221-008) to assess the potential to construct a toe berm along the main embankment using mine waste rock. This study demonstrated the beneficial effect of the toe berm, and the berm was constructed in 2005. The berm crest elevation varied from 394 m to 397 m, which corresponded to the crest of the 2005 raise.

In 2006, the South Dyke was constructed up to a crest elevation of 402 m. This dyke is a till core, rock shell dam with a sand and gravel filter between the till core and the downstream rock shell. Upstream and downstream slopes for this structure are 2H:1V and 2.5H:1V respectively.

Subsequently, the facility was raised annually until 2009. The crest elevation varied between 400 m and 402 m. This was the last raise for the facility, resulting in a maximum dam height of 28 m to 30 m above original ground surface. In 2010, the mine applied for, and received a certificate of authorization for a closure plan of the facility.

5.0 SITE CLASSIFICATION AND DESIGN BASIS

Mining dams in Quebec are governed according to Directive 019, which outlines applicable controls for the design, construction and operation of tailings storage facilities. The Directive 019 approach is a proscriptive, standards-based approach to the assessment of design flood events, seismic events and required factors of safety.

Many operators, and particularly operators who have investments in jurisdictions outside of Quebec, choose to further consider their structures within the framework of the Canadian Dam Association (CDA), Dam Safety Guidelines 2007 (2013 Edition) – (Guideline; CDA 2013). The Guideline proposes a risk-informed approach to dam management. Within this approach, the consequences of failure are analyzed and then the basis of design is developed for a particular risk category for the structures. A formal classification according to the Guideline has not been undertaken for this facility. In 2019, the CDA published an update to the Guideline focussing specifically on tailings dams (CDA 2019). It is recommended that the mine implement the risk-informed approach in the CDA Guidelines, although it may in certain cases be more rigorous than Directive 019.

Table 1 provides a summary of the design basis applied to the conceptual designs.

Table 1: Basis of Design

Item		Description	Source
Technical References & Guidelines			

1	Dam Safety Guidelines 2007 (Revised 2013)	▪ defines a dam as a structure of at least:
		  ▪ 2.5 m in height
		  ▪ 30,000 m^3 in capacity
		▪ prescribes the requirements for:
		  ▪ selection of the inflow design flood
		  ▪ spillway design
		  ▪ minimum freeboard
			Canadian Dam Association (CDA 2013)

2	Technical Memorandum – Application of Dam Safety Guidelines to Mining Dams (2014)	▪ Affirms design criteria ▪ Provides guidance for post-operational management of tailings dams	Canadian Dam Association (CDA 2019)
3	Directive 019 (2012)	▪ defines the environmental design flood (EDF) and minimum freeboard ▪ defines dam safety inflow design flood (IDF).	Gouvernement du Quebec (2012)
Tailings Preparation			
1	Tailings Production Rate	▪ 35,000 tonnes per day	Troilus
2	Tailings Density - mill	▪ 45% solids by weight	Troilus
3	Tailings Density – high rate thickener	▪ 60% solids by weight	Pocock (2020) and Golder database
4	Tailings Density – deep cone thickener	▪ 70% solids by weight	Golder database
5	Tailings Density – filtered tailings	▪ 85-90% solids by weight	Golder database

Table 1: Basis of Design

Item		Description	Source
Water Management			
1	TSF Environmental Design Flood (EDF) – to contain without untreated discharge to the environment	▪ The superposition of a 1000-Year 24-Hour rainfall and the 100-Year snowpack melting over 30 days.	Gouvernement du Quebec (2012)
2	Minimum freeboard between the dyke crest and the maximum EDF water level	▪ 1 m	Gouvernement du Quebec (2012)
3	TSF Inflow Design Flood (IDF) – to discharge from the TSF without compromising the dykes' safety	▪ Probable maximum flood	Gouvernement du Quebec (2012)
4	Minimum freeboard between the dyke crest and the maximum IDF water level	▪ 2-Year wave run-up	CDA (2013)
5	Design flood for the perimeter seepage collection and conveyance system	▪ 100-Year	Gouvernement du Quebec (2012)
Geotechnical			
1	Embankment Slopes	▪ per geotechnical requirements ▪ maximum external slope 4:1 (H:V) ▪ maximum internal slope 2.5:1 (H:V)	Golder
2	Dam Raise Configuration	▪ Centreline Raise	Troilus
3	Tailings Placement Method	▪ Option 1 – perimeter spigotting ▪ Option 2 – east wall spigotting ▪ Option 3 – conveyor, dozer, compactor	Golder
4	Placed Tailings Density	▪ Option 1 – 1.5 t/m^3 dry density ▪ Option 2 – 1.5 t/m^3 dry density ▪ Option 3 – 1.8 t/m^3 dry density	Golder
5	Tailings Beach Slope	▪ Option 1 – 1% BAW, 3% BBW ▪ Option 2 – Range 5% to 10% ▪ Option 3 – N/A	Golder

% = percent; BAW = Beach Above Water; BBW = Beach Below Water, H:V = Horizontal: Vertical, m = metre; m^3 = cubic metre; N/A = not available; TSF = Tailings Storage Facility; t/m^3 = tonnes per cubic metre.

6.0 GEOTECHNICAL DATA REVIEW

6.1 Foundation Conditions

The SNC report (SNC-007595-41ET-401) reported that a total of 8 standard boreholes, 32 exploration wells, 16 dynamic penetration testholes, 6 hollow stem auger holes, 14 coreholes and 5 test pits were advanced at the site. A program of laboratory testing including water contents, grain size and hydrometer, Proctor compaction, triaxial permeability and direct shear testing was carried out. This geotechnical information formed the database to support the design of the facility.

The record of borehole sheets, and a site plan showing the locations of the various investigation points, were not included in the copy of the SNC report provided for review. The key strata encountered at the site include:

- topsoil layer
- peat bog
- glacial till – generally silty sand and gravel containing cobbles and boulders
- glaciofluvial sand and gravel (esker)
- alluvial silt to silty sand
- bedrock outcrop (limited)

In general, the embankment is founded on glacial till, and Table 2 summarizes the observed foundation conditions along the chainage of the embankment:

Table 2: Interpreted Foundation Conditions (after SNC)

Stationing Along Dyke (m)	Main Surficial Deposit	Ground Surface Elevation (m)
0+100 – 0+170	Rock outcrop	378 - 384
0+170 – 0+245	<1 m peat on silt and sand	378 – 384
0+245 – 0+300	Esker sand and gravel	378 – 384
0+300 – 0+475	<2 m peat on silt and sand	376 – 378
0+580 – 1+200	Till and/or silt	378 - 386
1+200 – 1+300	Silt and/or till	374 – 376
1+300 – 1+515	Till	372 - 379
1+515 – 1+615	Thin till over rock	372 – 374
1+615 – 1+710	Silt/sand over till	372 – 376
1+710 – 1+825	>5 m sand over till	376 – 378
1+825 – 1+930	Till and/or silt	374 – 378
1+930 – 2+210	Sand over till	374 – 387
2+210 – 2+270	<2 m sand over till with thin peat	373 – 374
2+270 – 2+940	<2 m sand over till without thin peat	374 – 390

< = less than; > = greater than; m = metre.

The groundwater table was observed between 0 and 4 m below ground in boreholes drilled at the site, corresponding to elevation 365.5 to 368.0 m.

One borehole was drilled on the tailings beach by Golder in 2009, which extended into the foundation below the tailings. The soils encountered in this borehole consisted of cobbly gravel to gravelly sand (interpreted to be glacial till) extending at least 9 m below the contact with the tailings mass.

6.2 Tailings Properties

Golder's archives contain some data on the properties of the tailings within the existing TSF. Based on a 1997 study summary of existing tailings properties is presented in Table 3.

Table 3: Typical Existing Tailings Properties

Parameter	Value	Source
Beach slope (0-500 m)	2%	971-7088
Beach slope (500-1800 m)	0.3%	971-7088
Beach slope (underwater)	3%	971-7088
Specific gravity	2.7	Mine
Water content, deposited tailings	26.3%	971-7088
Dry density, deposited tailings	1.58 t/m^3	971-7088
Bulk density, deposited tailings	1.99 t/m^3	971-7088

% = percent; m = metre; t/m^3 = tonnes per cubic metre.

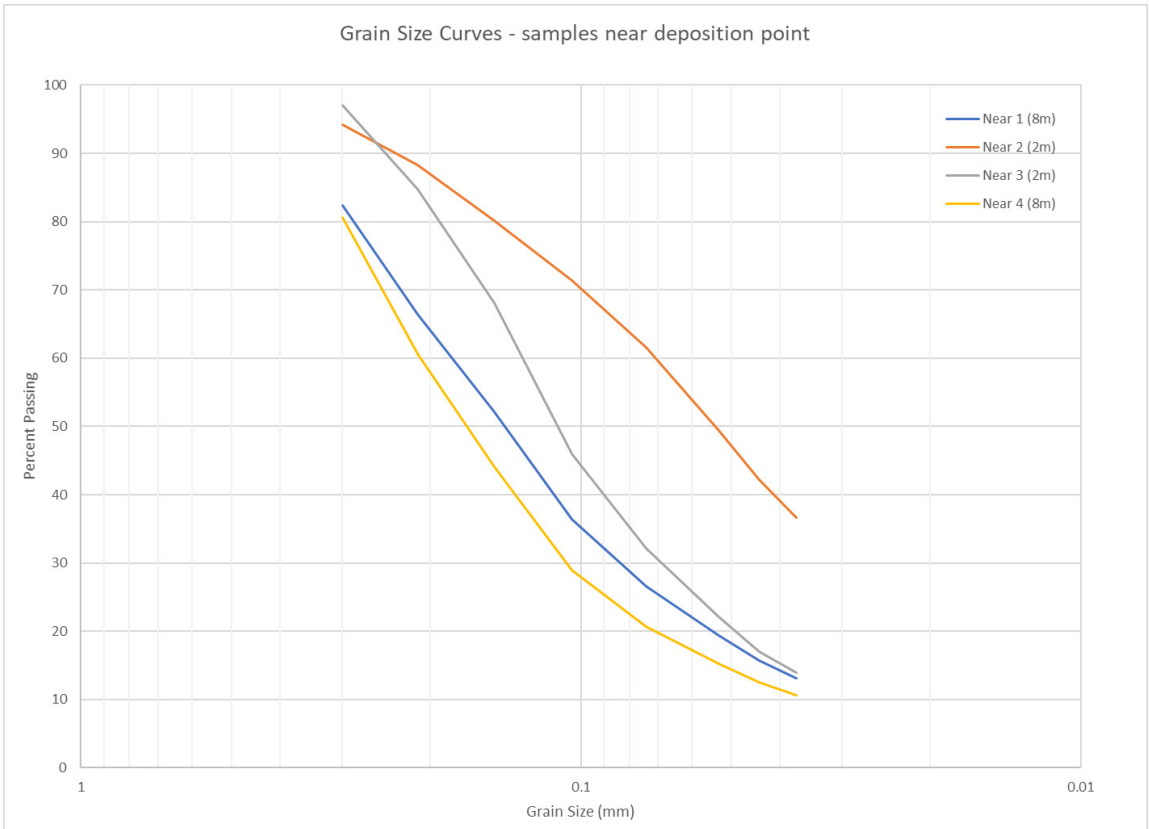
A study in 2000 presented grain size curves for deposited tailings deposited close to, and far away from the point of deposition. These results are summarized in Figure 1. The data indicates that the tailings are generally classified as silty sands. Near the deposition point (2 m to 8 m from the deposition point) the materials average 41% passing the #200 sieve, whereas the deposits further from the deposition point (18 m to 28 m from the deposition point) have on average 47% passing the #200 sieve. The data indicates moderate segregation with distance from the deposition point. The material deposited within the settling pond are assumed to contain mostly fines, considering the likely gradation achieved during the historic milling operation.

The most comprehensive assessment of the properties of the tailings is contained in the 2009 report (09-1221-0011 RF Rev0). A series of five cone penetration tests with pore pressure measurement (CPTu) and one borehole with standard penetration test (SPT) were carried out on the tailings near the crest of the main embankment. Some conclusions of this study were:

- The tailings exhibited behaviour generally of clean sands, silty sands and sandy silts. Thin bands exhibiting behaviour of silty clay were observed randomly.
- The phreatic surface was observed at a depth between 10.0 and 14.6 m below the tailings beach.
- SPT N values (blows per 0.3 m of penetration) varied between 4 and 24.
- Calculated against a seismic event corresponding to a 1:476 year return period, the tailings were calculated to be non-liquefiable.

Mining records indicate that a total of 75 million tonnes (Mt) of tailings were produced over the life of mine.

The liquefaction assessment will have to be updated in conjunction with the feasibility study of the TSF expansion, as the regulatory framework has evolved since the closure of the mine



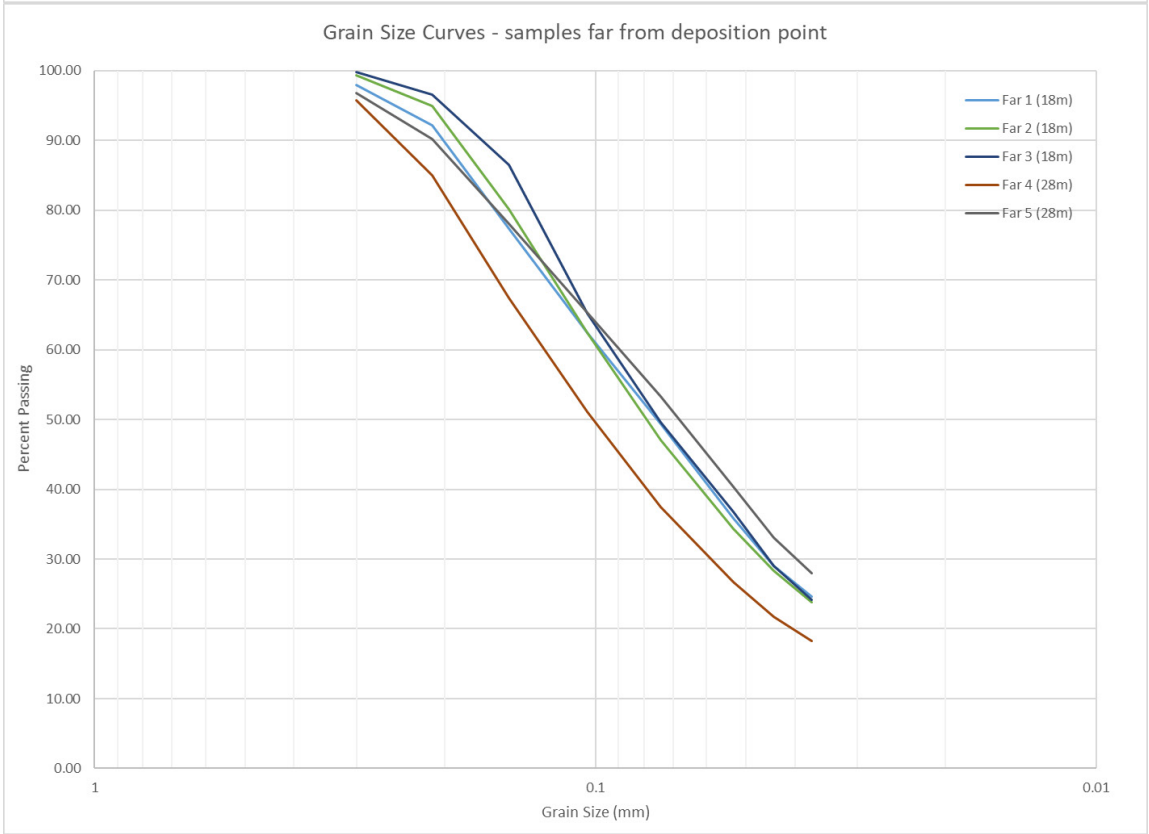


Figure 1: Tailings Grain Size Curves

7.0 EXISTING FACILITIES

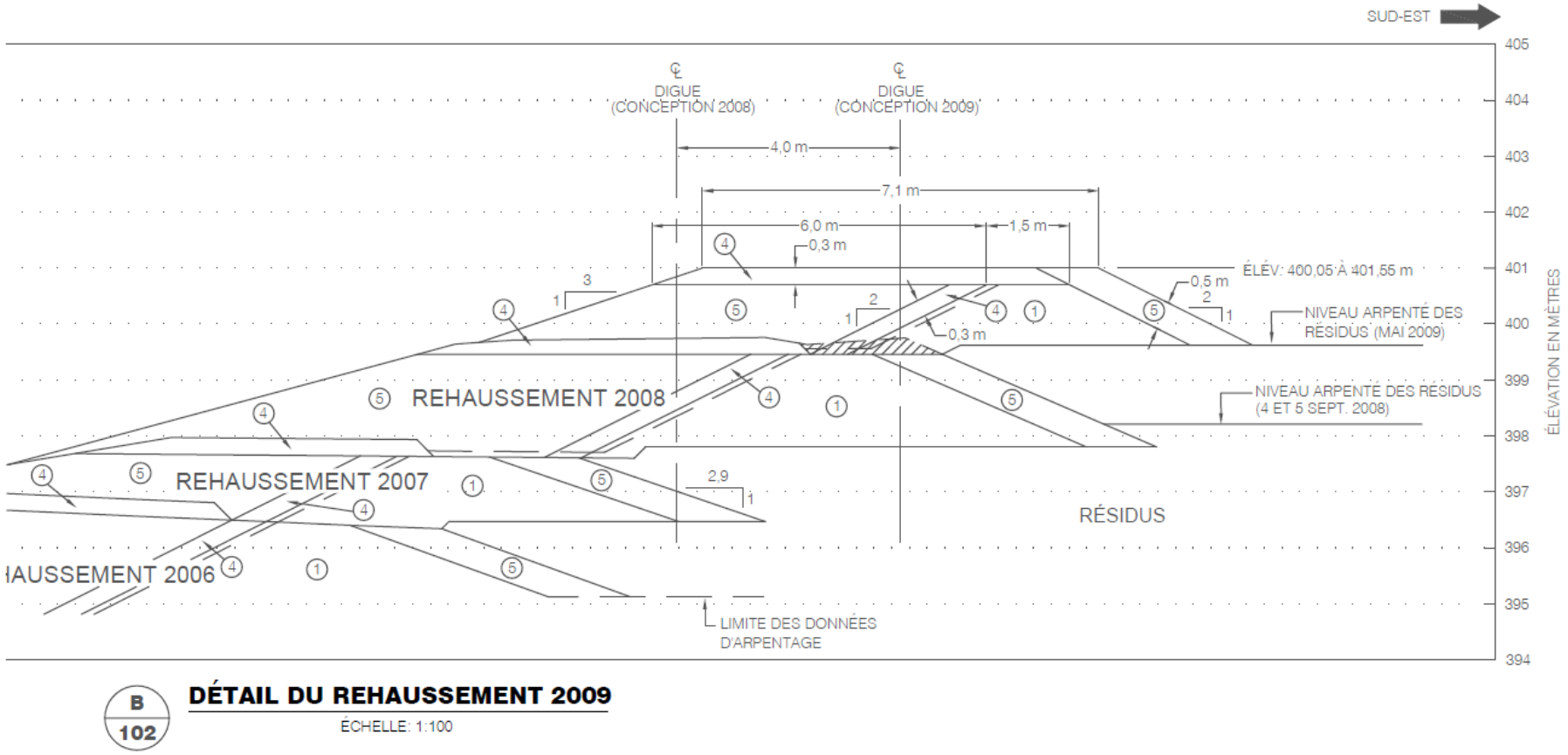
7.1 Design of Starter Embankment

The design of the starter embankment varied depending on the inferred foundation conditions listed in Table 2. In general, the starter embankment, to elevation 381 m, was designed as a till embankment with a sand and gravel toe drain. Upstream slopes of 2H:1V and downstream slopes of 3H:1V, and an 8 m wide crest were proposed. Rock rip rap was placed on the upstream face and a thin granular traveling layer was placed on the crest. Key differences in the starter embankment related to the key-in measures into the foundation, as follows:

- Where the foundation was comprised of rock or till, the dyke was keyed in a minimum of 0.5 m.
- Where the foundation was comprised of peat, the peat was excavated completely.
- Where the foundation was comprised of thin alluvial sand or silt over till, the dyke was keyed in through the sand/silt and at least 0.5 m into the till.
- Where the foundation was comprised of thick alluvial sand or silt over or rock, the dyke was not keyed in, but a cement-bentonite cutoff wall was constructed under the embankment, and keyed into competent foundation.
- Where the foundation was through the esker sands and gravels, a till cutoff was excavated at 1.5H:1V slopes, through the esker materials and into the competent foundation (inferred as rock).
- The sand hill which was observed at chainage 1+930 – 2+210 was at an elevation greater than 381 m. In this location, a till cutoff was proposed at 1.5H:1V slopes, through the sand and keyed in 1 m into the till foundation. The cutoff was to be constructed up to elevation 381 m in preparation for future raises.

7.2 Upstream Raise Design

After construction of the starter embankment, the design concept for the facility was revised, outlined in Golder report (971-7088) and consisted of raising in an upstream direction instead of downstream. The concept included constructing bi-annual compacted embankments, approximately 2.0 to 2.5 m high directly on the sub-aerially deposited tailings beach. In reality, the mine opted to construct approximate 1.5 m high raises annually. The raises were proposed for construction using compacted tailings, with a mine rock protective layer upstream and downstream, and sand filter zone/geotextile between the tailings and the mine rock. A typical sketch from the 2009 raise design is in Figure 2.



1: Compacted Till
4: Granular Filter
5: Rock Fill

Figure 2: Sketch of Typical Raise Design – 2009

Stability analyses carried out in connection with the design were referenced to the geotechnical parameters in the initial SNC Lavalin report. No new investigations were carried out in support of this concept.

7.3 Toe Berm Design

In 2004, the Mine expressed an interest to dispose of mine waste rock at the toe of the main embankment. This had a dual objective to stabilize the embankment and to economically dispose of waste rock. Under the original concept, it was proposed that the 30 m wide buttress would be constructed up to the elevation of the crest of the 2005-era main embankment and then raised in 2 m increments as the main embankment was raised. Golder assessed the stability of this concept (04-1221-008) and found that even for a conservative assumption of complete liquefaction of the tailings, that the revised embankment section met or exceeded the regulatory objectives for stability in place at that time.

The toe berm was constructed in 2005, up to the current dam crest elevation, however the toe buttress was not raised in subsequent years. In subsequent years, a smaller buttress constructed mainly of mine waste rock was added to flatten the downstream slope of the embankment.

7.4 Stability Analysis

7.4.1 Static and Seismic Analysis

Numerous slope stability analyses were conducted as the facility evolved. The geotechnical parameters used in the original SNC Lavalin report were generally carried forward in all subsequent analyses (Table 4). These parameters were derived by SNC Lavalin either from laboratory testing or from engineering judgment and experience with similar materials.

Table 4: Soil Geotechnical Parameters (After SNC 007595-41ET-401)

Soil	Description	Saturated Unit Weight (kN/m^3)	Moist Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (deg)	Pore Pressure Coefficient, r_u
1	Tailings	22.0	22.0	0	25	0.45
2	Compacted till	20.5	20.0	0	37	0.4
3	Granular	20.5	20.0	0	37	0
4	Glacial till	20.0	19.5	0	35	0.2
4’	Alluvial silt	18.5	18.0	0	30	0.2

deg = degree; kN/m^3 = kilonewton per cubic metre; kPa = kilopascal; r_u = Pore Pressure Coefficient.

The seismic criteria applied for analysis of the structures was a horizontal ground acceleration of 0.05 g, which corresponded to an earthquake with a 10% probability of exceedance in 50 years based on the seismic hazard map of Canada. Seismic hazard maps provide peak ground acceleration for a given return period and location. The peak ground acceleration resulting from a given seismic event is affected by many factors including the magnitude, distance to and depth of the epicentre, length of fault, site ground conditions, and event duration.

The analyses generally confirmed that the structures demonstrated factors of safety meeting or exceeding the regulatory minimums.

The stability analyses will have to be redone in conjunction with the feasibility study of the TSF expansion because the regulatory framework has evolved since the closure of the facility.

7.4.2 Liquefaction Susceptibility

A liquefaction susceptibility assessment was carried out in 2009 (09-1221-0011), to support the closure of the facility. Five cone penetration tests (CPT) were advanced within the tailings. The resistance to liquefaction is interpreted as a cyclic resistance ratio (CRR) based on the results of the CPT testing. The cyclic susceptibility ratio (CSR) is calculated based on the designated earthquake acceleration and stress state within the tailings. The CSR for this study was calculated based on a seismic event with a 10% probability of exceedance in 50 years (1:476 year event).

The CPT profiles thus generated showed that generally the CRR was well above the CSR, indicating an acceptable factor of safety against liquefaction. A sensitivity analysis was carried out to assess liquefaction potential in the event that the tailings became saturated, and again the CRR generally exceeded the CSR.

The closure stability analyses therefore considered the intact strength of the tailings, and both static and seismic stability were re-evaluated. The calculated factors of safety exceeded regulatory requirements on this basis.

Current regulatory and industry guidelines will require a re-analysis of seismic and static stability in conjunction with the feasibility study of the TSF expansion of operations. The provided data does not account for any improvements in density (and cyclic resistance) which may have occurred since 2009.

8.0 HYDROTECHNICAL DATA REVIEW

8.1 Climate Context

Figure 3 presents the 1981-2010 climate normal for the Environment Canada's Chapais climate station, approximately 140 km to the south of the Troilus Site (Environment Canada 2020):

- The mean annual temperature is 0.2 °C, varying between 16.4 °C in July and -18.8°C in January (mean monthly daily temperatures). The historical minimum temperature is -43.3 °C (January 1965) and the historical maximum temperature is 35.0 °C (July 1995). Below zero temperatures cover, on average, the mid-October to mid-April period winter period.
- The mean annual precipitation is 996 mm, 685 mm of which falls as rainfall and 311 mm as snowfall. July and September are the wettest months (124 mm and 130 mm, respectively, mean precipitation) and February and March the driest months (39 mm and 50 mm, respectively, mean precipitation).

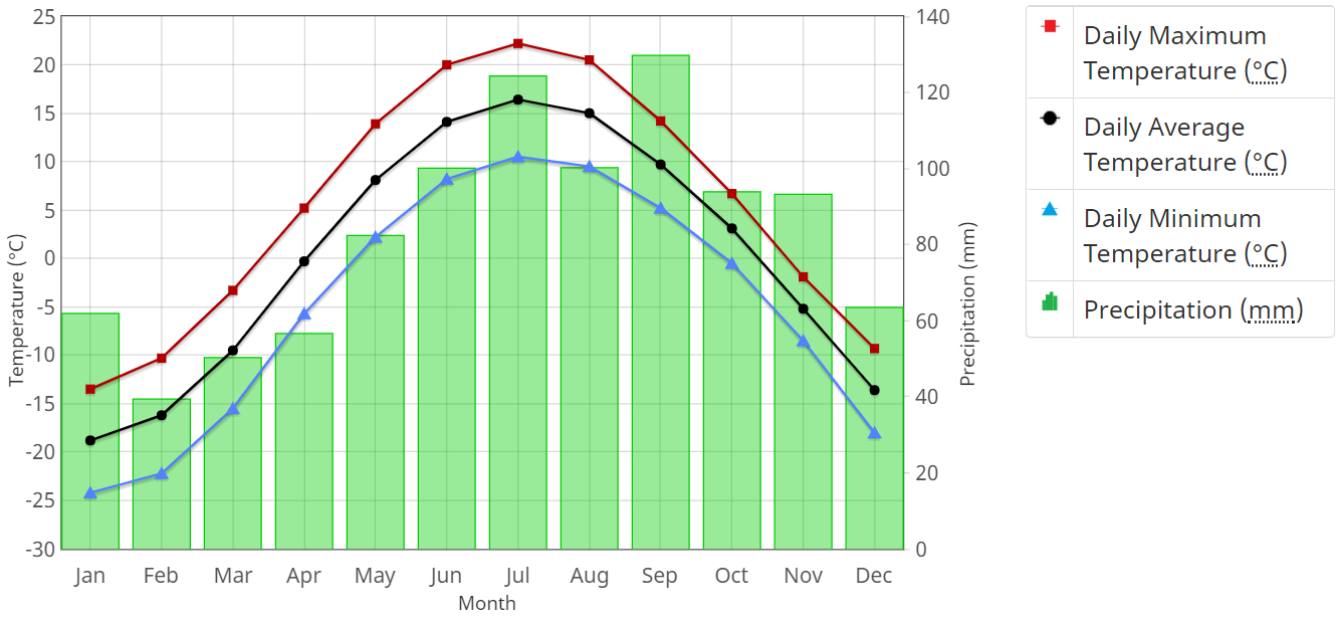


Figure 3: 1981- 2010 Climate Normals for the Chapais Climate Station, Approximately 140 km to the South of the Troilus Site (Environment Canada 2020)

Table 5 documents extreme rainfall and snow cover statistics based on Golder (2010) and SNC-Lavalin (2004). The latest document is a study prepared for the Centre d'expertise hydrique du Québec regarding probable maximum floods for the entire Québec province:

- 100-Year 24-Hour rainfall intensities were estimated to 90 mm for the summer/fall season and 40 mm for the spring season. 1,000-Year 24-Hour summer/fall rainfall was estimated to 125 mm.
- The probable maximum precipitation was estimated to 340 mm (summer, fall) and 180 mm (spring).
- 100-Year maximum annual snow cover thickness was estimated to 464 mm snow water equivalent (Golder 2010) or 375 mm snow water equivalent (SNC-Lavalin 2004).
- The probable maximum snow accumulation was estimated to 800 mm.

Table 5: Extreme Rainfall and Snow Cover Statistics for the Troilus Site

Return Period (Years)	Summer / Fall Rainfall (mm / 24 Hour)	Spring Rainfall (mm / 24 hour)	Maximum Annual Snow Cover (mm water equivalent)
2	41[(a)]		264[(a)]
10	61[(a)]		348[(a)]
50	81[(a)]		429[(a)]
100	90[(a)]	40 [(b)]	464[(a)] 375[(b)]
1,000	125[(a)]		595[(a)]
Probable Maximum Precipitation / Probable Maximum Snow Accumulation	340[(b)]	180 [(b)]	800[(b)]

Extracted from Golder (2010).

Extracted from SNC-Lavalin (2004).

Based on the estimates in Table 5, the Directive 019 “project flood” event (Gouvernement du Quebec 2012) is the sum of a 125 mm 1,000-Year 24-Hour rainfall (assuming that the tailings are not classified as being of high-risk) and 375 mm 100-Year snow cover for a total of 500 mm. As per Gouvernement du Quebec (2012), a duration of 30 days should be considered for this event.

The statistics above do not account for any climate change impacts. Adjustments may be required to account for potential increases in the extreme event intensities and for an overall change to the climate regime. This should be considered in future engineering phases.

8.2 Tailings Storage Facility Water Management Aspects

During the previous operation of the current TSF, the internal water pond on the TSF beach contained the water released from tailings, precipitation runoff from the TSF beach, the upstream mountain slope, and the seepage and runoff collected at the toe of the dyke. Figure 4 below presents the stage-storage curve for the current internal pond, based on the available TSF topography. The total storage capacity below the 399.0 m invert of the emergency spillway is 3.4 Mm^3.

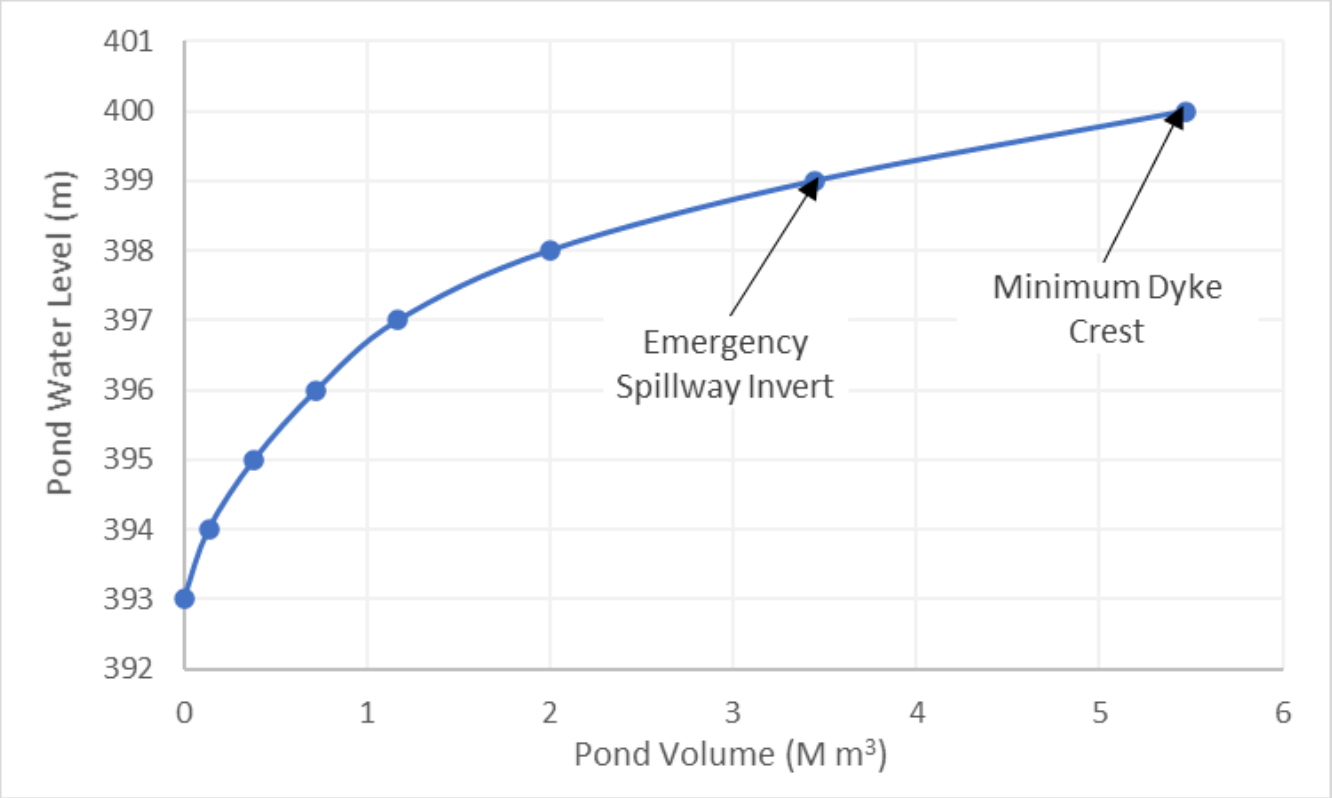


Figure 4: Stage-Storage Curve of the Tailings Storage Facility Internal Pond (Extracted from Golder 2010)

The drainage area reporting to the internal pond include approximately 2.8 km^2 of tailings beach, 2.3 km^2 of upstream mountain slope, and 0.4 km^2 of downstream dyke slope reporting to the collection sump, for a total of 5.5 km^2.

The collected water was recirculated as process water to the ore processing plant. Water surplus was treated at the existing ActiFlo plant for total suspended solids removal before discharge to the environment; the installed treatment rate is 800 m^3/hour.

Five seepage collection points (PR1, PR2, PR5, PR6, and PR7) at the toe of the dyke have been operated in the past. After the end of the mine operations, consolidation works centralized water collected at PR1 and PR6 to PR5; works were also done around the PR2 point. The current status of these collection points (available water storage and pumping capacity) is not known, but it is assumed that update works would be required before the new start of the TSF operation.

The 399 m invert emergency spillway is located in the southeast corner of the TSF; the spillway has a 25 m width and 5H:1V side slopes. In 2013, in preparation for the closure of the TSF, a new spillway chanel was constructed on the downstream slope of the dyke below approximately the elevation 394 m. The spillway channel has a 24 m width, 3H:1V side slopes and was designed for a 20.6 m^3/s peak flow (10,000-Year peak flow under a specific TSF closure configuration). The closure plan was to breach the dyke above the elevation 394 m to connect the internal pond with the spillway channel via an outlet channel; this hasn't happened to date.

9.0 MINE PLAN AND PROJECTED PRODUCTION

Mine production is planned to be 35,000 tonnes per day. For the purpose of this study a linear production rate with no ramp up was assumed for a mine life of 20 years. The total tailings production after 20 years was found to be 255.5 MT.

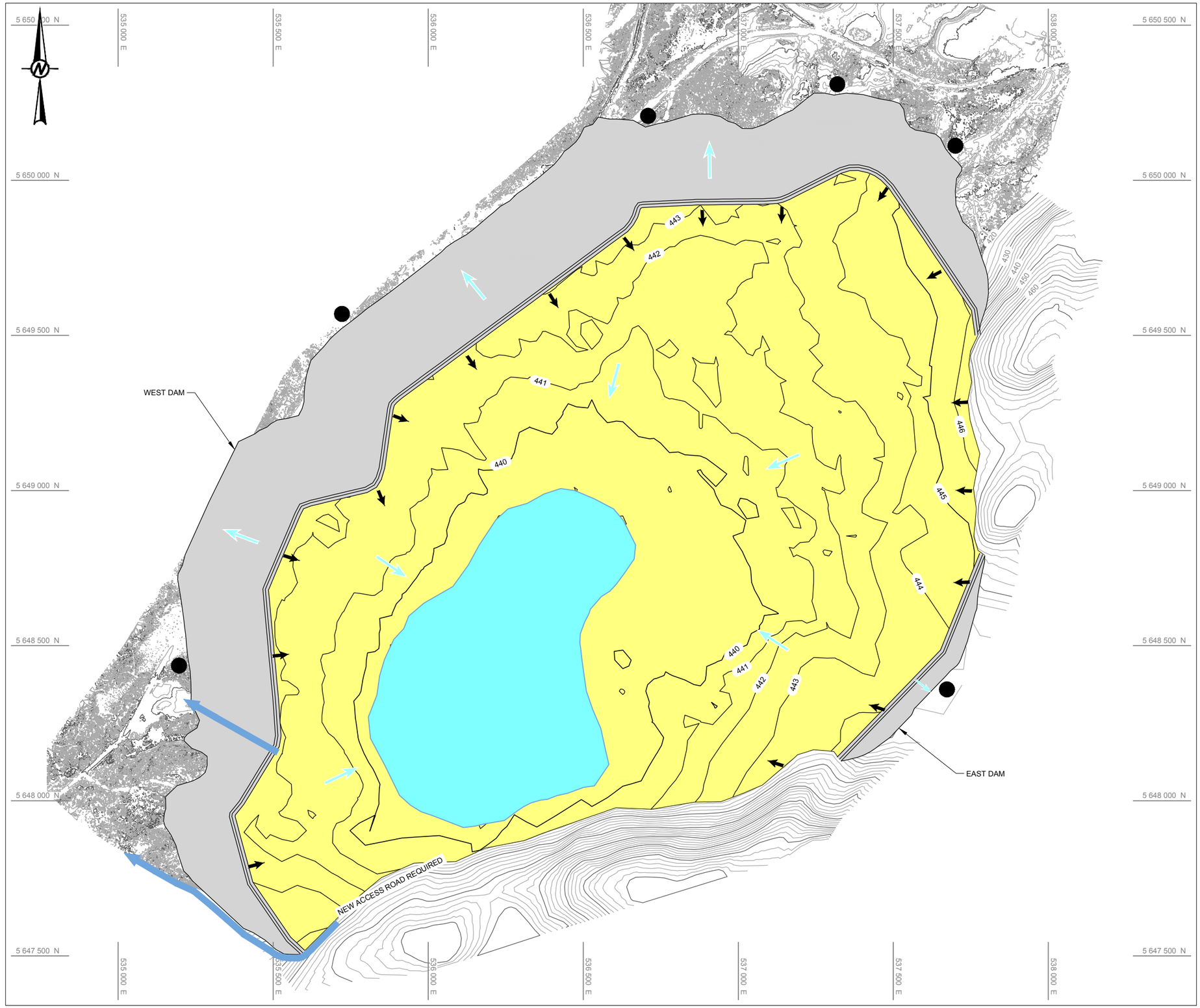
10.0 OPTIONS FOR TAILINGS MANAGEMENT

10.1.1 Depositional Modeling

A deposition model was created to demonstrate conditions within the ultimate TSF. This option represents an extension of historical operating practices in which tailings would be spiggoted from the perimeter of the TSF forming a beach sloped toward the centre of the tailings basin. Beach slopes were selected consistent with those currently observed in the TSF as set out in Section 5.0.

The model was used to estimate the ultimate storage capacity of the TSF, the required annual rate of rise for the proposed production rates and the available capacity of each raise.

Figure 5 presents a plan view of the ultimate tailings basin. The ultimate tailings surface was modelled to be approximately 42 m above the existing tailings surface to provide approximately 218 Mt of tailings storage capacity. This equates to approximately 17 years of storage at projected tailings production rates. The annual rate of rise would be in the range of 2 m to 3 m per year.



LEGEND

- DEPOSITION BEACH
- APPROXIMATE POND AREA
- EXISTING GROUND CONTOUR (2m INTERVAL)
- DEPOSITION SURFACE CONTOUR (1m INTERVAL FOR CLARITY)
- DEPOSITION LOCATION
- SURFACE RUNOFF DIRECTION / DRAINAGE PATH
- EMERGENCY SPILLWAY
- SEEPAGE COLLECTION SUMP

NOTE(S)

1. THIS FIGURE PRESENTS HIGH-LEVEL TAILINGS DEPOSITION AND WATER MANAGEMENT CONCEPTS. ALL PRESENTED DETAILS ARE SUBJECT TO CHANGE DURING THE NEXT ENGINEERING PHASES.
2. ADDITIONAL WATER MANAGEMENT STRUCTURES WILL BE REQUIRED BEYOND THOSE REPRESENTED ON THE FIGURE, INCLUDING MULTIPLE COLLECTION DITCHES, DISSIPATION PONDS, AND OTHERS.

NOT FOR CONSTRUCTION

0 250 500
1:12,500 METRES

CLIENT
TROILUS GOLD CORPORATION

PROJECT
TROILUS GOLD
CONCEPTUAL DEPOSITION PLAN

TITLE
DEPOSITION PLAN - OPTION 1: THICKENED SLURRY

CONSULTANT
GOLDER

YYYY-MM-DD	2020-10-22
DESIGNED	JDS
PREPARED	JDS
REVIEWED	MAT
APPROVED	LFG

PROJECT NO. 19131334 REV. 0 FIGURE 5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

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10.2 Overview

At the outset of the study all available tailings preparation methods were identified including:

- unthickened tailings slurry
- thickened tailings slurry
- deep cone thickened tailings slurry
- paste tailings
- filtered tailings

The unthickened tailings slurry option was screened out based on water management and regulatory perception considerations. The paste tailings option was screened out based on deposition challenges within the TSF related to efficiently placing tailings with limited flow capability and with pumping material with a measurable slump several kilometres to the TSF. In addition, as indicated in Section 6.2 the grain size curve (Figure 1) the tailings deposited in the TSF in slurry form did not show excessive segregation such that depositing thickened tailings would achieve a paste consistency soon after deposition, due to water bleed.

The following three options were evaluated for this study:

Option 1 - Thickened Slurry Tailings

This option represents an extension of historical deposition practices with improved tailings dewatering within a High Rate Thickener located at the process plant. Tailings would be spigotted from the perimeter of the TSF. The existing main (west) and south tailings dams would be raised to form a single dam to derive storage for the required capacity. Natural containment will be provided by the topographic ridge east of the facility to approximately 423 m, above which a saddle dam will be constructed across the east drainage swale for the ultimate TSF configuration. Water will be managed within the tailings basin.

Option 2 - Deep Cone Thickened Slurry Tailings

A deep cone thickener will be used to produce a more viscous slurry tailings. Tailings will be deposited by spiggoting from the topographic high along the east side of the facility to produce a high sloping beach toward the west dam. The existing west dam will be buttressed to produce a 4:1 downstream slope and maintained at its current height. Natural containment will be provided by the topographic ridge east of the facility to approximately 423 m, above which a saddle dam will be constructed across the east drainage swale for the ultimate TSF configuration. Water will be managed within an external pond for the ultimate TSF configuration.

Option 3 - Filtered Tailings

A filter plant will be used to produce stackable tailings at a moisture content suitable to achieve optimal compaction density. Tailings will be transported to the TSF by conveyor, spread with dozers, and compacted in place with rollers to produce a tailings stack. The existing west dam will be buttressed to produce a 4:1 downstream slope and maintained at its current height. Natural containment will be provided by the topographic ridge east of the facility to approximately 423 m, above which a saddle dam will be constructed across the east drainage swale for the ultimate TSF configuration. Water will be managed within an internal pond for the ultimate TSF configuration.

The following sections describe the conceptual designs of each option. The basis of design for each of the options is presented in Section 5.0.

10.3 Thickened Slurry Tailings Management

10.3.1 Tailings Preparation

In this option the tailings from the mining process are collected in a pump box at the mill and directed to a High Rate Thickener (HRT) for dewatering. Thickener underflow is pumped to an agitated storage tank. Operating pump trains of centrifugal pumps are used to deliver the tailings to the entire perimeter of the TSF. Thickener overflow is returned to the mill for re-use and/or treated and discharged.

10.3.2 Tailings Dams

The existing main and south tailings dams would be raised to form a single dam (West Dam) to derive storage for the required capacity. Natural containment will be provided by the topographic ridge east of the facility to approximately 423 m, above which a saddle dam (East Dam) will be constructed across the east drainage swale to an elevation of approximately 445 m for the ultimate TSF configuration.

A center line raise configuration is proposed to mitigate the required rate of rise for the projected tailings production rate. Figure 6 presents conceptual typical dam sections for the west and east dams considering 2 m raise increments to their ultimate height.

The sectional geometry of the dams is similar in concept to the current west dam with a till core and rock fill shell. Modifications from the current dam configuration include transition to centre line raises and buttressing of the downstream slope by flattening the slope to 4:1 to provide additional stability against high foundation and embankment pore water pressures and potential seismic loading. Placement of rock fill for the outer shell in this concept will require close coordination with mining operations, as the rock shell must be constructed in harmony with the core and filter zones.

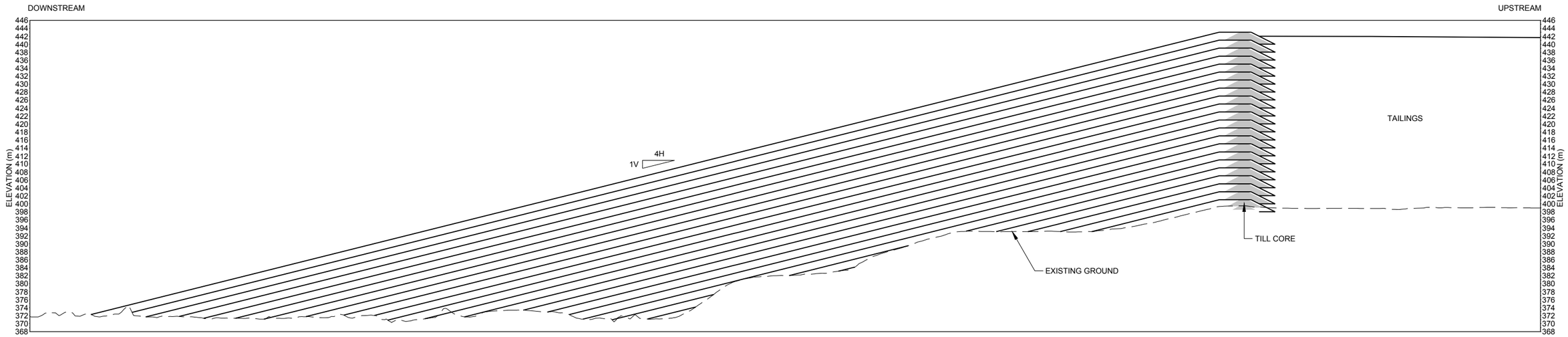
A granular filter zone has been incorporated separating the till core from the rock shell to provide resistance to internal erosion due to deepage. The upstream slope of the dam will be armored with rock fill. Rock fill for erosion protection and the dam shell will be derived from run-of-mine waste rock with oversize material removed. Till will be sourced from an on-site borrow area or mine overburden waste. Granular filter material can be derived from processed waste rock or local natural aggregate source.

Site characterization will be required to define foundation soil and tailings properties to support seepage, stability and deformation analyses in subsequent engineering studies. Seepage analyses will be required to evaluate seepage control requirements and expected pore water pressure conditions that may develop during dam construction and TSF operation.

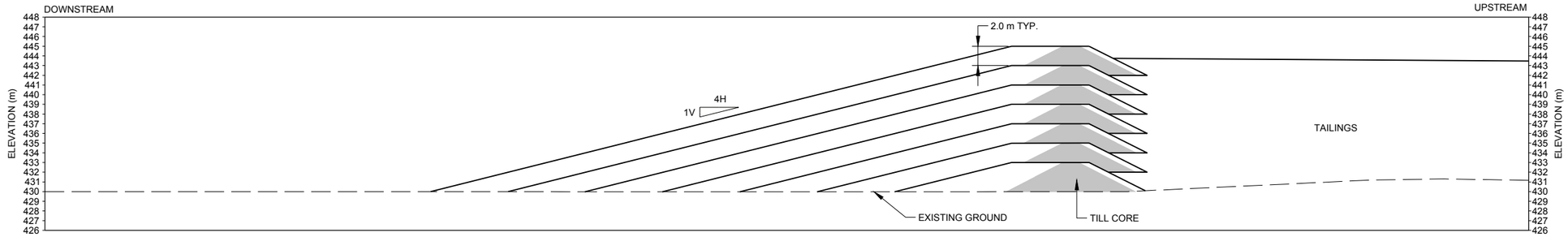
An estimated material take off for the ultimate east and west dams is provided in Table 6

Table 6: Tailings Dams Material Take Off - Option 1

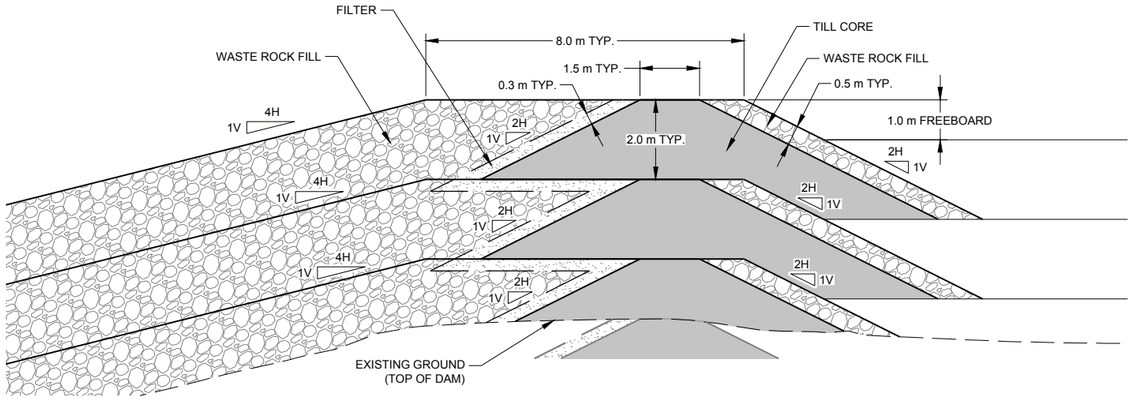
Structure	Material	Quantity	Unit	Source
West Dam	Compacted Till	1,255,000	Cubic metres	Typical Section
	Rock Fill	26,745,000	Cubic metres	Typical Section
	Filter Granular	228,000	Cubic metres	Typical Section
	Stripping and Subgrade Preparation	718,000	Square metres	Conceptual Plan
East Dam	Compacted Till	75,000	Cubic metres	Typical Section
	Rock Fill	313,000	Cubic metres	Typical Section
	Filter Granular	12,000	Cubic metres	Typical Section
	Stripping and Subgrade Preparation	51,000	Square metres	Conceptual Plan



OPTION 1: THICKENED SLURRY
TYPICAL DAM CROSS SECTION
SCALE 1:1000



OPTION 1: THICKENED SLURRY
TYPICAL EAST DAM CROSS SECTION
SCALE 1:500



TYPICAL DAM RAISE DETAIL
SCALE 1:150

0 25 50
1:1,000 METRES

0 10 20
1:500 METRES

0 2.5 5
1:150 METRES

NOT FOR CONSTRUCTION

CLIENT
TROILUS GOLD CORPORATION

PROJECT
TROILUS GOLD
CONCEPTUAL DEPOSITION PLAN

TITLE
TYPICAL DAM SECTIONS - OPTION 1: THICKENED SLURRY

CONSULTANT
GOLDER

YYYY-MM-DD	2020-10-22
DESIGNED	JDS
PREPARED	JDS
REVIEWED	MAT
APPROVED	LFG

PROJECT NO. 19131334 | REV. 0 | FIGURE 6

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25 mm

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10.3.3 Water Management Plan

Consistent with the deposition plan, the water management plan for the thickened slurry tailings option will follow the operational and closure plan that has been implemented for the current TSF. Figure 5 presents the proposed operational water management concepts.

Operational Period

- The internal water pond in the southern part of the TSF will contain the tailings release water, the precipitation runoff on the TSF and upstream areas, as well as the water (seepage and dyke slope runoff) collected at the toe of the TSF dykes. The water will be recirculated to the ore processing plant. In the event of a site-wide water surplus, some of the water may be discharged to the environment after treatment, if required to reach the applicable water quality discharge guidelines.
- The deposition plan and the dyke raise schedule will maintain sufficient pond storage capacity such that the environmental design flood (EDF) volume can be contained or managed (for example, via treatment) without the water level exceeding the crest of the emergency spillway.
- The current emergency spillway will be relocated from the current location, in the southwestern corner of the TSF dyke, further south at the point where the dyke intersects the steep mountain slope. The relocation is required to limit the risk associated with an emergency spillway built on a 55 m high dyke. The new location will allow a flatter spillway channel and one that is built partially on in-situ material in a way that decreases the consequences of a potential erosion. The timing of the relocation will be decided during a future design stage.
- The existing toe ditches and seepage collection sumps will be relocated to alignments that are compatible with the final dyke footprint. The relocation may take place from the beginning or may occur in stages. The details will be decided in the next design stage. Water collected at the sumps would be pumped to the TSF pond.
- The design of the dyke raises will include a downstream slope rock cover of sufficient size to provide long-term erosion resistance of the dyke slope, including under passive closure conditions.

Closure Period

- The operational emergency spillway channel will be modified to serve as a closure drainage channel. The channel invert will be lowered by several meters to limit the size of the closure pond and to provide a large long-term freeboard to the crest of the dykes. The channel will be connected to the natural stream network (the Unnamed Creek to the west of the TSF).
- The TSF surface will be vegetated to create a closure landscape and to avoid beach erosion. A layer of granular material will be placed over the operational pond area to prevent resuspension of fine particles.
- The toe ditches and sumps will be configured to remain functional under passive closure conditions and to allow discharge to the environment.

Water Management Risks and Mitigation Measures

The main identified risks and associated mitigation measures for the water management plan for the thickened slurry option are summarized in Table 7.

Table 7: Principal Water Management Risks and Mitigation Measures for the Thickened Slurry Option

Risk	Consequence	Mitigation Measure	Residual Risk
Accumulation of excess water within the TSF pond beyond the pond storage capacity	Discharge of untreated water to the environment	Provide sufficient containment capacity for the regulatory EDF event. Install water treatment plant to discharge water to the environment if the site-wide water balance points to an overall surplus	Low
Dyke erosion during the activation of the emergency spillway	Structural damage to the dyke	Adequate erosion protection of the spillway channel Relocation of the emergency spillway to a lower-risk location	Low
Resuspension of fine tailings particles under closure conditions	TSF water quality not meeting discharge guidelines	Revegetation of the tailings surface Rock protection of main drainage pathways Placing granular layer over the operational pond area	High in the first years after closure Low on the long-term

EDF = environmental design flood; TSF = Tailings Storage Facility.

10.4 Deep Cone Thickened Tailings

10.4.1 Tailings Preparation

This option is similar to the thickened slurry option; however, a greater degree of dewatering of the tailings is incorporated using paste or deep cone thickeners (DCT) where increased bed depth provides higher compression of the settled solids to achieve a non-segregating slurry having near-paste consistency. Additional settling and rheological testing would be needed to determine the yield stress and viscosity of the thickened material out of a DCT and if piston diaphragm (PD) pumps would be required. However, based on the information currently available and past project experience the thickened the tailings can be pumped to the TSF using a train of centrifugal pumps to one side of the TSF where the tailings having a yield stress result in a higher deposition beach slope compared to the lower solids obtained using a HRT. Thickener overflow is returned to the mill for re-use and/or treated and discharged.

10.4.2 Depositional Modeling

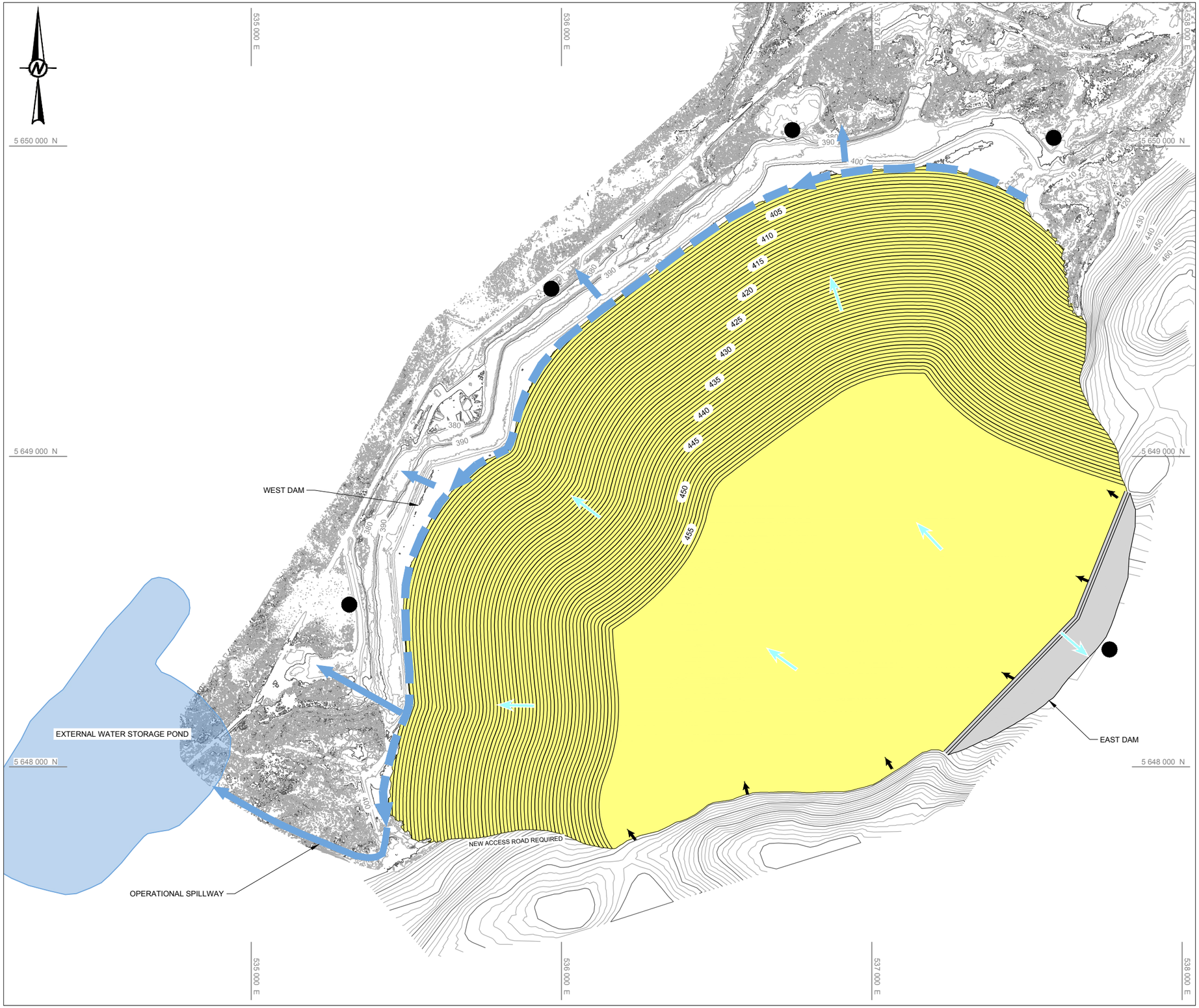
A deposition model was created to demonstrate conditions within the ultimate TSF. Tailings will be deposited by spiggoting from the topographic high along the east side of the facility to produce a high sloping beach toward the west dam. Beach slopes were selected based on a possible range that could be achieved but are dependent on tailings properties as set out in Section 5.0. Additional testing is required to determine an achievable beach angle.

The model was used to estimate the ultimate storage capacity of the TSF, the required annual rate of rise for the proposed production rates and the available capacity of each raise.

Figure 7 presents a plan view of the ultimate tailings basin for a 10% beach slope. The ultimate tailings surface was modelled to be approximately 60 m above the existing tailings surface in the eastern portion of the TSF to provide approximately 204 Mt of tailings storage capacity. This equates to approximately 16 years of storage at projected tailings production rates.

The ultimate TSF capacity was estimated for a 5% beach slope to be approximately 132 Mt, which equates to 10 years of storage at projected tailings production rates.

An assessment of the need for internal drainage at the base of the stack will be required in subsequent design stages. Further, an assessment of the global tailings stability and expected deformation within the currently existing foundation tailings will be required.



LEGEND

- DEPOSITION BEACH
- EXISTING GROUND CONTOUR (2m INTERVAL)
- DEPOSITION SURFACE CONTOUR (1m INTERVAL FOR CLARITY)
- DEPOSITION LOCATION
- SURFACE RUNOFF DIRECTION
- EMERGENCY / OPERATIONAL SPILLWAY
- SURFACE RUNOFF DRAINAGE PATH
- SEEPAGE COLLECTION SUMP

NOTE(S)

1. THIS FIGURE PRESENTS HIGH-LEVEL TAILINGS DEPOSITION AND WATER MANAGEMENT CONCEPTS. ALL PRESENTED DETAILS ARE SUBJECT TO CHANGE DURING THE NEXT ENGINEERING PHASES.
2. ADDITIONAL WATER MANAGEMENT STRUCTURES WILL BE REQUIRED BEYOND THOSE REPRESENTED ON THE FIGURE, INCLUDING MULTIPLE COLLECTION DITCHES, DISSIPATION PONDS, AND OTHERS.

NOT FOR CONSTRUCTION

0 250 500
1:12,500 METRES

CLIENT
TROILUS GOLD CORPORATION

PROJECT
TROILUS GOLD
CONCEPTUAL DEPOSITION PLAN

TITLE
DEPOSITION PLAN - OPTION 2: DEEP CONE THICKENED SLURRY

CONSULTANT
GOLDER

YYYY-MM-DD	2020-10-22
DESIGNED	JDS
PREPARED	JDS
REVIEWED	MAT
APPROVED	LFG

PROJECT NO. 19131334 | REV. 0 | FIGURE 7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

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10.4.3 Tailings Dams

The existing main and south dams will be buttressed to produce a 4:1 downstream slope and maintained at its current height (collectively referred to as the West Dam). Natural containment will be provided by the topographic ridge east of the facility to approximately 423 m, above which a saddle dam (East Dam) will be constructed across the east drainage swale to an elevation of approximately 459 m for the ultimate TSF configuration.

Figure 8 presents conceptual typical dam sections for the west and east dams. Staging of the east dam considered 2 m raise increments to its ultimate height.

The sectional geometry of the dams is similar in concept to the current main dam with a till core and rock fill shell. Modifications from the current dam configuration include transition to centre line raises and buttressing of the downstream slope by flattening the slope of 4:1 to provide additional stability against high foundation and embankment pore water pressures and potential seismic loading.

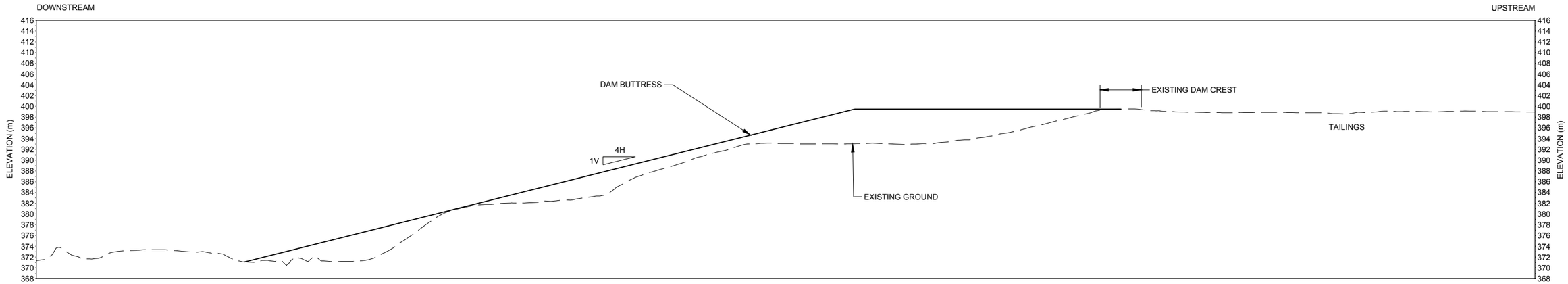
A granular filter zone has been incorporated separating the till core from the rock shell to provide resistance to internal erosion due to seepage. The upstream slope of the dam will be armored with rock fill. Rock fill for erosion protection and the dam shell will be derived from run-of-mine waste rock with oversize material removed. Till will be sourced from a on-site borrow area or mine overburden waste. Granular filter material can be derived from processed waste rock or local natural aggregate source.

Site characterization will be required to define foundation soil and tailings properties to support seepage, stability and deformation analyses in subsequent engineering studies. Seepage analyses will be required to evaluate seepage control requirements and expected pore water pressure conditions that may develop during dam construction and TSF operation.

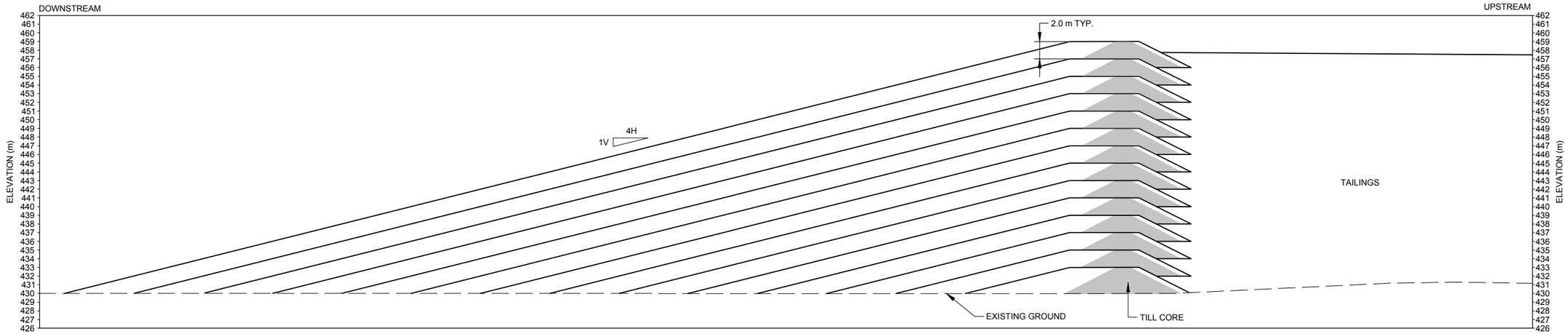
An estimated material take off for the ultimate east and west dams is provided in Table 8

Table 8: Tailings Dams Material Take Off - Option 2

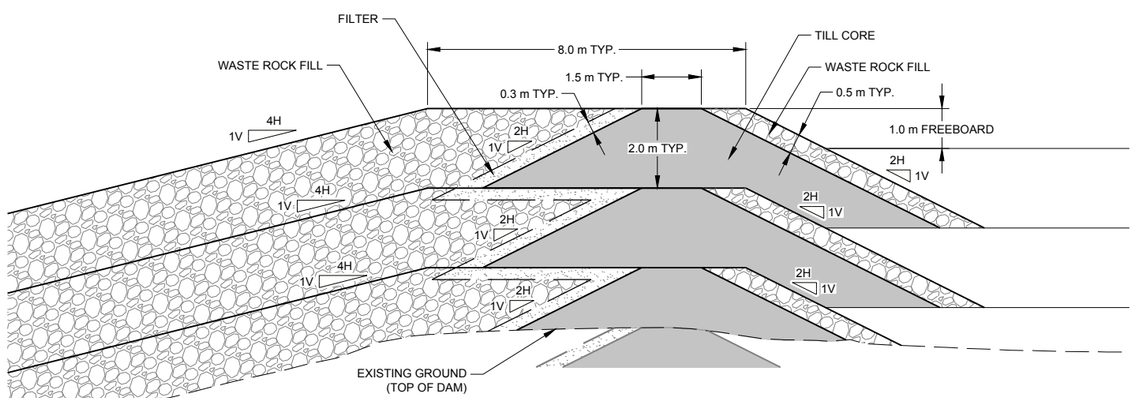
Structure	Material	Quantity	Unit	Source
West Dam	Rock Fill	1,113,000	Cubic metres	Typical Section
	Stripping and Subgrade Preparation	35,000	Square metres	Conceptual Plan
East Dam	Compacted Till	160,000	Cubic metres	Typical Section
	Rock Fill	1,260,000	Cubic metres	Typical Section
	Filter Granular	30,000	Cubic metres	Typical Section
	Stripping and Subgrade Preparation	105,000	Square metres	Conceptual Plan



OPTION 2: DEEP CONE THICKENED SLURRY
TYPICAL WEST DAM BUTTRESS CROSS SECTION
SCALE 1:750



OPTION 2: DEEP CONE THICKENED SLURRY
TYPICAL EAST DAM CROSS SECTION
SCALE 1:500



TYPICAL DAM RAISE DETAIL
SCALE 1:150

0 12.5 25
1:750 METRES

0 10 20
1:500 METRES

0 2.5 5
1:150 METRES

NOT FOR CONSTRUCTION

CLIENT
TROILUS GOLD CORPORATION

PROJECT
TROILUS GOLD
CONCEPTUAL DEPOSITION PLAN

TITLE
TYPICAL DAM SECTIONS - OPTION 2: DEEP CONE THICKENED SLURRY

CONSULTANT
GOLDER

YYYY-MM-DD	2020-10-22
DESIGNED	JDS
PREPARED	JDS
REVIEWED	MAT
APPROVED	LFG

PROJECT NO. 19131334
REV. 0
FIGURE 8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm

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10.4.4 Water Management Strategy

Operational Period

The operational water management plan for the deep cone thickened slurry tailings deposition will include two separate phases:

- In a first phase, the internal water pond will continue to contain all water fluxes related to the TSF operation. The dyke crest will be raised by 0.5 m to 1.0 m at the beginning of the project to provide sufficient water storage capacity.
- In a second phase, as the internal water storage capacity is eliminated by the tailings deposition, an external water pond will be required. For the purpose of this study and following discussions with Troilus Gold, Golder assumed that the Southwest Pit would be available to serve as a water storage pond after its mining. The Southwest Pit is located southwest of the TSF (see Figure 7) and initial verifications indicated that it would have sufficient storage capacity for the TSF EDF.
- The duration of the first phase will depend on the tailings deposition plan and the Southwest Pit mining schedule. The tailings deposition plan in the next engineering phase will be adjusted such that the internal pond has sufficient water storage capacity until the external Southwest Pit becomes available.

During the first phase, the emergency spillway will preserve its current location. In preparation for the second phase, the spillway will be relocated to the southern extremity of the TSF and will transition from an emergency spillway to an operational spillway that will discharge TSF water to the external water pond. The relocated spillway channel will be designed to accommodate on-going operational flows and to withstand the probable maximum flood without damage.

In the later stages of the second phase, the tailings deposition will limit the available space for runoff drainage on the TSF beach towards the operational spillway. Mitigation measures include:

- Maintaining a minimum off-set (for example 50 m, to be decided during future engineering phases and to be adjusted during the operations based on actual performance observations) between the dyke crest and the toe of the new deposition.
- Controlling the accumulation of eroded tailings at the toe of the new deposition by operational removal of accumulated tailings and by the installation of small rock berms for trapping eroded solids.
- Installing additional emergency spillways along the crest of the dyke. During extreme flood events, tailings erosion could limit hydraulic conveyance capacity on the reduced beach width and trigger the overtopping of the dyke. The emergency spillways would allow for a controlled discharge and would protect the overall dyke safety. The emergency spillways will be configured to serve as long-term closure channels too.

The existing toe ditches and seepage collection sumps will be maintained with some adjustments. An additional collection sump and new toe ditches will be required for the new east dyke.

Closure Period

The proposed closure water management plan includes:

- Reprofiling (recontouring) the top plateau of the tailings deposition to direct surface drainage towards a closure channel along the mountain slope.
- Recontouring and armoring of the tailings slopes to avoid long-term erosion.
- Using the operational spillway and the emergency spillways as closure drainage channels.
- Configuring the toe ditches and sumps to remain functional under passive closure conditions and to allow discharge to the environment.

Water Management Risks and Mitigation Measures

The main principal identified risks and associated mitigation measures for the water management plan for the deep cone thickened slurry option are summarized in Table 9.

Table 9: Principal Water Management Risks and Mitigation Measures for the Deep Cone Thickened Option

Risk	Consequence	Mitigation Measure	Residual Risk
Accumulation of excess water within the TSF pond or within external Water Pond beyond the pond storage capacity	Discharge of untreated water to the environment	Provide sufficient containment capacity for the regulatory EDF event at all times. Install water treatment plant to discharge water to the environment if the site-wide water balance points to an overall surplus	Low
Dyke erosion during the activation of the operational or emergency spillway	Structural damage to the dyke	Adequate erosion protection of the spillway channels Relocation of the operational spillway to a lower-risk location	Low
Significant erosion of the tailings slope leading to accumulation of solids between the dyke crest and the deposition slope	Decrease in water storage and conveyance capacity on the TSF ⇒ Risk of discharge of untreated water to the environment, risk of dyke overtopping with consequences to the dyke safety	Maintain sufficient off-set between the dyke crest and the toe of the new deposition Remove eroded tailings on a continuous basis Install structural measures (rock berms) to trap eroded tailings at the toe of the deposition Install additional emergency spillways	Moderate, especially during the later stages of operation
Resuspension of fine tailings particles under closure conditions	TSF water quality not meeting discharge guidelines	Revegetation of the tailings surface Rock protection of main drainage pathways	High in the first years after closure Low to moderate on the long-term

EDF = environmental design flood; TSF = Tailings Storage Facility.

10.5 Filtered Tailings (Dry Stack)

10.5.1 Tailings Preparation

This option is also similar to the thickened slurry option, in that a high rate thickener is added to the process with the thickener underflow discharging into an agitated storage tank. The final degree of dewatering in this option is accomplished via pressure filters. The resulting filter cake could be transported by haul trucks or an overland conveyor to the TSF. Due to the high tonnage and the large fleet of trucks needed, conveyors likely offer some advantages.

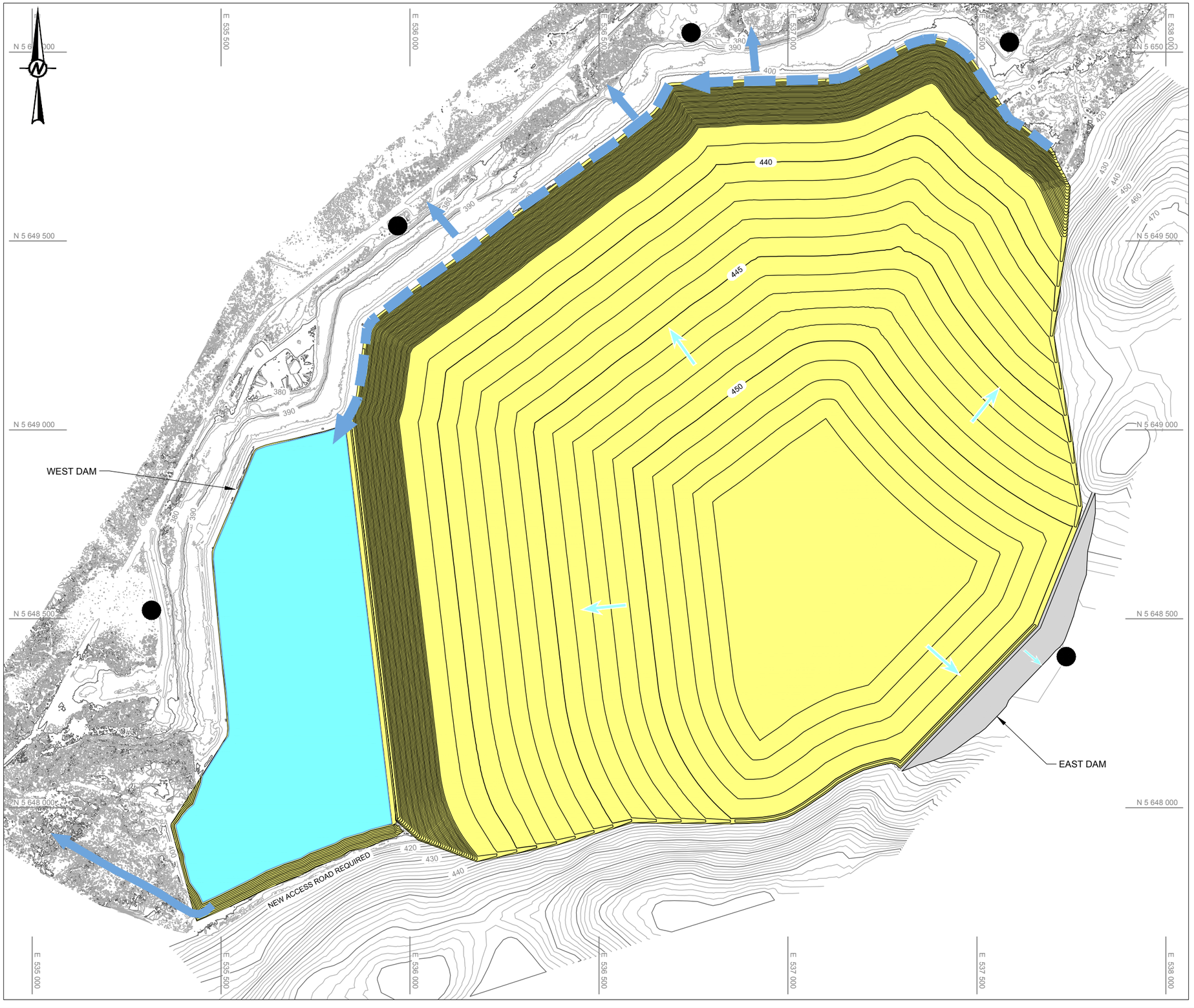
10.5.2 Depositional Modeling

A deposition model was created to demonstrate conditions within the ultimate TSF. Tailings will be pressure filtered to achieve an optimum water content for compaction. Tailings will be deposited on the stack, pushed by dozer in lifts of 300 mm and compacted to 95% of standard Proctor maximum dry density. The geometry of the tailings stack slopes will have slopes no greater than 4 horizontal to 1 vertical (4H:1V). Additional testing is required to determine stable side slopes.

The model was used to estimate the ultimate storage capacity of the TSF, the required annual rate of rise for the proposed production rates and the available capacity of each raise.

Figure 9 presents a plan view of the ultimate tailings stack. The ultimate tailings surface was modelled to be approximately 55 m above the existing tailings surface in the centre of the stack to provide approximately 216 Mt of tailings storage capacity. This equates to approximately 17 years of storage at projected tailings production rates.

The tailings deposition plan will be created for optimum placement of tailings on the stack. Portions of the stack are more critical to the overall stability. The structurally significant shell will need to strictly follow compaction requirements. Non-structurally important areas can be reserved for deposition under non ideal conditions such as winter or heavy rain when compaction targets are difficult to achieve, or during process upsets. At all stages of deposition, the surface of the stack requires proper grading to convey precipitation off the stack to the drainage ditching. An assessment of the need for internal drainage at the base of the stack will be required in subsequent design stages. Further, an assessment of the global stack stability and expected deformation within the currently existing foundation tailings will be required.



LEGEND

- DEPOSITION BEACH
- APPROXIMATE POND AREA
- EXISTING GROUND CONTOUR (2m INTERVAL)
- DEPOSITION SURFACE CONTOUR (1m INTERVAL FOR CLARITY)
- SURFACE RUNOFF DIRECTION
- EMERGENCY SPILLWAY
- SURFACE RUNOFF DRAINAGE PATH
- SEEPAGE COLLECTION SUMP

NOTE(S)

1. THIS FIGURE PRESENTS HIGH-LEVEL TAILINGS DEPOSITION AND WATER MANAGEMENT CONCEPTS. ALL PRESENTED DETAILS ARE SUBJECT TO CHANGE DURING THE NEXT ENGINEERING PHASES.
2. ADDITIONAL WATER MANAGEMENT STRUCTURES WILL BE REQUIRED BEYOND THOSE REPRESENTED ON THE FIGURE, INCLUDING MULTIPLE COLLECTION DITCHES, DISSIPATION PONDS, AND OTHERS.

NOT FOR CONSTRUCTION

0 250 500
1:10,000 METRES

CLIENT
TROILUS GOLD CORPORATION

PROJECT
TROILUS GOLD
CONCEPTUAL DEPOSITION PLAN

TITLE
DEPOSITION PLAN - OPTION 3: FILTERED TAILINGS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-10-22
DESIGNED	JDS
PREPARED	JDS
REVIEWED	MAT
APPROVED	LFG

PROJECT NO. 19131334 | REV. 0 | FIGURE 9

Path: \\golder.gd\gal\saskatoon\gis_Clients\Troilus\Gold\TroilusMine\99_PROJECTS\19131334_TailingsDesFS\1000_OptionsStudy\02_PRODUCTION\DWG\ | File Name: 19131334-1000-Dry Stack Option.dwg | Last Edited By: jskkorsky Date: 2020-09-04 Time:1:15:18 PM | Printed By: JSkkorsky Date: 2020-10-22 Time:9:28:12 AM
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
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10.5.3 Tailings Dams

The existing main and south dams will be buttressed to produce a 4:1 downstream slope and maintained at its current height (collectively referred to as the West Dam). Natural containment will be provided by the topographic ridge east of the facility to approximately 423 m, above which a saddle dam (referred to as the East Dam) will be constructed across the east drainage swale to an elevation of approximately 450 m for the ultimate TSF configuration.

Figure 10 presents conceptual typical dam sections for the west and east dams. Staging of the east dam considered 2 m raise increments to its ultimate height.

The sectional geometry of the dams is similar in concept to the current main dam with a till core and rock fill shell. Modifications from the current dam configuration include transition to centre line raises and buttressing of the downstream slope by flattening the slope of 4:1 to provide additional stability against high foundation and embankment pore water pressures and potential seismic loading.

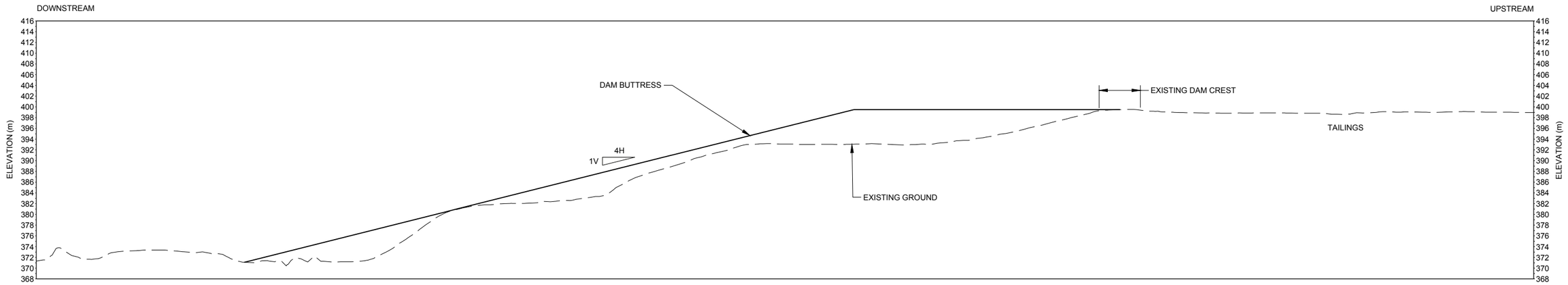
A granular filter zone has been incorporated separating the till core from the rock shell to provide resistance to internal erosion due to deepage. The upstream slope of the dam will be armored with rock fill. Rock fill for erosion protection and the dam shell will be derived from run-of-mine waste rock with oversize material removed. Till will be sourced from a on-site borrow area or mine overburden waste. Granular filter material can be derived from processed waste rock or local natural aggregate source.

Site characterization will be required to define foundation soil and tailings properties to support seepage, stability and deformation analyses in subsequent engineering studies. Seepage analyses will be required to evaluate seepage control requirements and expected pore water pressure conditions that may develop during dam construction and operation.

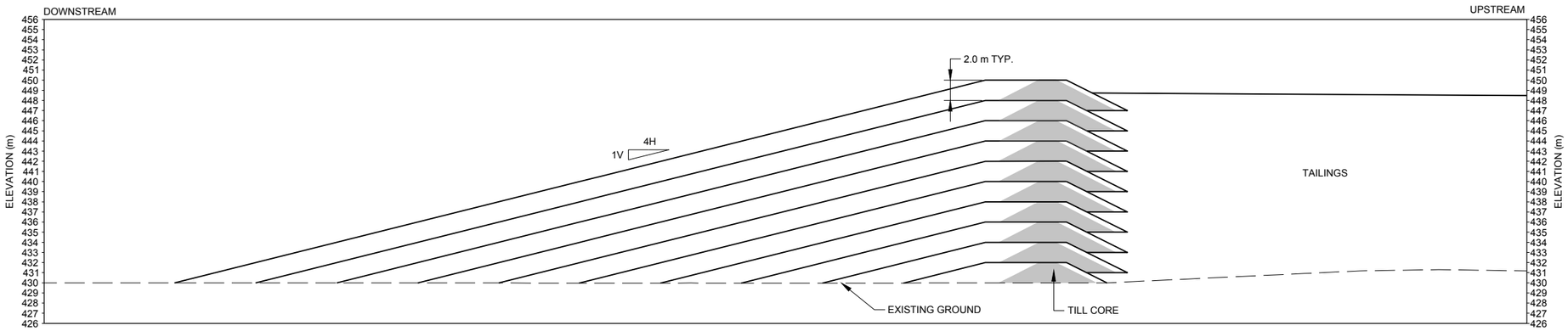
An estimated material take off for the ultimate east and west dams is provided in Table 10.

Table 10: Tailings Dams Material Take Off - Option 3

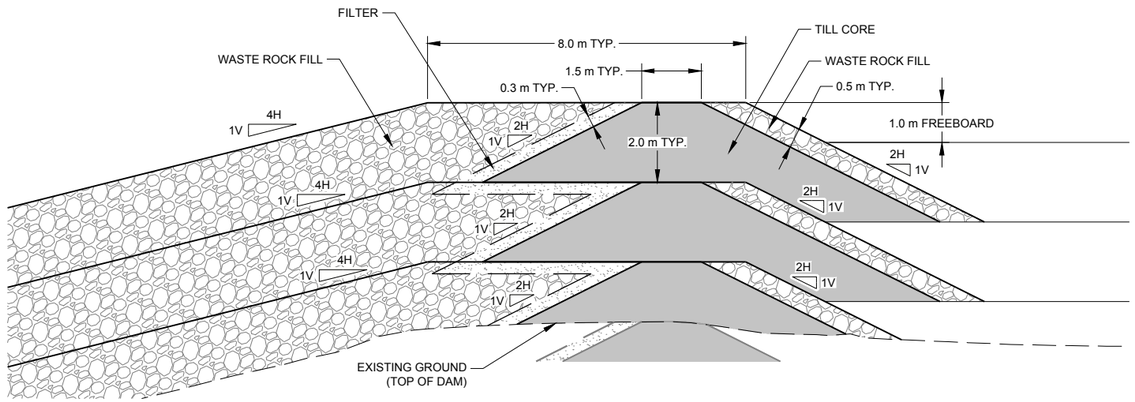
Structure	Material	Quantity	Unit	Source
West Dam	Rock Fill	1,113,000	Cubic metres	Typical Section
	Stripping and Subgrade Preparation	35,000	Square metres	Conceptual Plan
East Dam	Compacted Till	100,000	Cubic metres	Typical Section
	Rock Fill	552,000	Cubic metres	Typical Section
	Filter Granular	18,000	Cubic metres	Typical Section
	Stripping and Subgrade Preparation	67,000	Square metres	Conceptual Plan



OPTION 3: FILTERED TAILINGS
TYPICAL WEST DAM BUTTRESS CROSS SECTION
SCALE 1:750



OPTION 3: FILTERED TAILINGS
TYPICAL EAST DAM CROSS SECTION
SCALE 1:500



TYPICAL DAM RAISE DETAIL
SCALE 1:150

NOT FOR CONSTRUCTION

0 12.5 25
1:750 METRES

0 10 20
1:500 METRES

0 2.5 5
1:150 METRES

CLIENT
TROILUS GOLD CORPORATION

PROJECT
TROILUS GOLD
CONCEPTUAL DEPOSITION PLAN

TITLE
TYPICAL DAM SECTIONS - OPTION 3: FILTERED TAILINGS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-10-22
DESIGNED	JDS
PREPARED	JDS
REVIEWED	MAT
APPROVED	LFG

PROJECT NO. 19131334
REV. 0
FIGURE 10

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

0

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10.5.4 Water Management Strategy

Operational Period

The operational water management plan for the filtered tailings option includes the following main concepts (see Figure 9):

- Initially, the internal water pond has an adequate storage capacity. As the tailings deposition gradually decreases the pond footprint, additional storage capacity will be created by removing currently stored tailings and depositing them elsewhere within the tailings basin. Some tailings volume would need to be removed to create a 4.4Mm3 storage capacity pond, which will consist in a 400,000 m^2 with an average 12 m depth below the crest of the emergency spillway.
- Similar to the deep cone thickened tailings option, the filtered tailings deposition plan will limit the available space for runoff conveyance. Mitigation measures will include:
  - Maintaining a minimum off-set (for example 50 m, to be decided during future engineering phases and to be adjusted during the operations based on actual performance observations) between the dyke crest and the toe of the new deposition.
  - Controlling the accumulation of eroded tailings at the toe of the new deposition by operational removal of accumulated tailings and by the installation of small rock berms for trapping eroded solids. Also, by the progressive reclamation of the tailings slopes with an erosion resistant rock cover.
  - Installing additional emergency spillways along the crest of the dyke. During extreme flood events, tailings erosion could limit hydraulic conveyance capacity on the reduced beach width and trigger the overtopping of the dyke. The emergency spillways would allow for a controlled discharge and would protect the overall dyke safety. The emergency spillways will be configured to serve as long-term closure channels too.

Drainage channels will be constructed at the contact between the tailings stack and the mountain slope.

The existing toe ditches and seepage collection sumps will be maintained with some adjustments. An additional collection sump and new toe ditches will be required for the new east dyke.

Closure Period

The proposed closure water management plan includes

- Armoring and reprofiling (recontouring) the top plateau of the tailings stack to direct surface drainage towards south, where the slope height is smallest.
- Lowering the invert of the emergency spillway near the internal water pond sufficiently to avoid a permanent water pond or to limit its size and to provide adequate long-term freeboard.
- Adapting the reminder of the emergency spillways as closure drainage channels.
- Configuring the toe ditches and sumps to remain functional under passive closure conditions and to allow discharge to the environment.

Water Management Risks and Mitigation Measures

The main principal identified risks and associated mitigation measures for the water management plan for the filtered tailings are summarized in Table 11.

Table 11: Principal Water Management Risks and Mitigation Measures for the Filtered Tailings Option

Risk	Consequence	Mitigation Measure	Residual Risk
Accumulation of excess water within the TSF pond or within external Water Pond beyond the pond storage capacity	Discharge of untreated water to the environment	Provide sufficient containment capacity for the regulatory EDF event at all times. Install water treatment plant to discharge water to the environment if the site-wide water balance points to an overall surplus	Low
Dyke erosion during the activation of the emergency spillway	Structural damage to the dyke	Adequate erosion protection of the spillway channels. Relocation of the operational spillway to a lower-risk location	Low
Significant erosion of the tailings slope leading to accumulation of solids between the dyke crest and the deposition slope	Decrease in water storage and conveyance capacity on the TSF ⇒ Risk of discharge of untreated water to the environment, risk of dyke overtopping with consequences to the dyke safety	Maintain sufficient off-set between the dyke crest and the toe of the new deposition Remove eroded tailings on a continuous basis. Implement rock-cover progressive reclamation of the tailings slopes to limit the erosion extent. Install additional emergency spillways	Moderate, especially during the later stages of operation
Resuspension of fine tailings particles under closure conditions	TSF water quality not meeting discharge guidelines	Revegetation of the tailings surface Rock protection of main drainage pathways	High in the first years after closure Low to moderate on the long-term

EDF = environmental design flood; TSF = Tailings Storage Facility.

11.0 CAPITAL AND OPERATING COSTS

11.1 Tailings Dewatering

The design criteria and simplified flow sheets for the different tailings dewatering options are presented in Appendix A. The three tailings dewatering flow sheets are similar. The tailings from the mill are pumped to the thickeners where flocculent is added to help settle the material. The required thickener diameter to handle the design throughput was estimated from the settling tests (Procock 2020) performed on the Troilus tailings and from Golder's database of gold projects. The required surface area for both types of thickeners was estimated to be the same; what changes is the rake drives as well as the tank geometry including side wall height and floor slope.

The resulting thickener underflows have been estimated for the HRTs at 60 weight percent (wt%) solids or slightly better and at 70 wt% solids or greater for the DCTs. The length of pipeline for the deposition was adjusted to reflect the deposition plan. To properly evaluate the dewatering and pumping requirement additional settling tests and rheological data would be needed, especially since each material have their unique properties based on particle size distribution and mineralogy.

For the filter cake option plate and frame type filter presses were considered to achieve a cake with low moisture content suitable for placement and compaction at the TSF. The final moisture of the cakes is affected by slurry feed densities, operating pressure and the length of the air drying cycle. These operating parameters along with the tailings properties determine the size and number of filters required. Both filtration and modified proctor tests would be needed to properly assess the dewatering requirements for filter cake production. Based on Golder's database of gold projects a filtration rate was used to estimate the filtration requirements to produce a cake with a 15% moisture content. Major dewatering equipment requirements for each option are summarized in Table 12.

Table 12: Major Dewatering Equipment for the Various Options

Component	Thickened Tailings High Rate Thickeners (HRT)	Thickened Tailings Deep Cone Thickeners (DCT)	Filter Cake Plate and Frame Filter Press
Approximate wt% Solids	60 wt% solids	70 wt% solids	85 wt% solids
Dewatering Equipment	One (1) 60 m diameter High Rate Thickener	Two (2) 40 m diameter Deep Cone Thickeners	One (1) 60 m diameter High Rate Thickener + Six (6) 2.5 m x 2.5 m Plate Pressure Filters
Dewatered Tailings Transportation	Two (2) Stages Centrifugal Pumps	Two (2) Stages Centrifugal Pumps	Overland Conveyors
Slurry Transport to TSF	610 mm (24") HDPE DR9 ~ 19000 m Pipeline	560 mm (22") HDPE DR9 ~ 9400 m Pipeline	Not Applicable
Filter Cake Transport to TSF	Not Applicable	Not Applicable	4500 m total length Four (4) Conveyors with Three (3) Transfer Towers

DCT = deep cone thickeners; DR = Diameter Ratio, HDPE = High Density Polyethylene, HRT = High Rate Thickener; m = metres; mm = millimetres; TSF = Tailings Storage Facility; wt% = weight percent.

The basis for the capital cost estimates (CAPEX) with expected accuracy of ± 50% are as follows:

- The dewatering plant will be located adjacent to the metallurgical plant.
- The sizing of the dewatering equipment was determined based on testing performed by Golder on gold tailings with similar particle size distribution. Actual dewatering and rheological test work would be needed to ascertain these values.
- The capital cost of the equipment used in this study were derived from Golder's cost database based on work performed by Golder on past projects where quotes were obtained from equipment vendors.
- The capital costs are based on preliminary equipment sizing and using factored estimate from other projects for buildings size to allow the thickeners, filters, etc. to be enclosed but without developing general arrangements drawings. Factors were also used for direct and indirect costs.

Table 13 provides capital and operating cost estimates for each option.

Table 13: Class 5 CAPEX and OPEX Cost Estimates ($US)

Component	Thickened Tailings High Rate Thickeners (HRT)	Thickened Tailings Deep Cone Thickeners (DCT)	Filter Cake Plate and Frame Filter Press
Plant Equipment	9,281,900	17,030,000	51,200,000
Tailings Transport	12,850,000	6,869,000	40,667,000
Direct Costs	19,860,000	26,810,000	122,380,000
Indirect Costs	2,940,000	2,970,000	12,690,000
TOTAL	**44,931,900**	**53,679,000**	**226,937,000**
OPEX[(a)] ($/tonne)	**0.30 to 0.60**	**0.45 to 0.75**	**6.00 to 7.50**

(a) The operating cost estimate (OPEX) were obtained from other similar projects carried out by Golder. They include power, reagents, maintenance and manpower. They are provided to give an indication of the expected operating cost to dewater the tailings, transport and place them within the tailings facility and for overall water management collection.

DCT = deep cone thickeners; HRT = High Rate Thickener.

11.2 Tailings and Water Management Structures

Cost estimates were prepared for tailings and water management structures for each option. It is noted that Troilus have indicated a preference to include costs associated with waste rock transport and placement within the mining scope. It is noted that due to the limited rate of rise of the tailings facility, and the interaction between the waste rock and filter/core materials, additional costs will be realized above those normally associated with waste dump construction. At the option study phase, limited interactions were held between mining and tailings teams, and for this reason an indicative cost for the specialized placement of waste rock is include in our estimates. At later stages of study, it is important that mining and tailings teams have greater interaction to verify that this additional effort is adequately costed in the mining plan. The following summarizes the basis of the Class 5 capital cost estimates (± 50%):

- take off quantities were based conceptual designs for bulk earthworks
- allowances were provided for discrete water management structures
- unit rates are based on typical values obtained from experience on other projects
- rock fill unit rates consider material provided by mine operations at no cost
- cost associated with typical dozer productivity for in-station pushing and grading to design lines are provided for reference
- estimates are provided of initial CAPEX outlay (year 0) and sustaining capital over the life of mine

Table 14 presents capital cost estimates for each option.

Table 14: Class 5 CAPEX Cost Estimate - Tailings and Water Management Structures

Structure	Component	Quantity	Unit	Unit Cost	Source	Total
Option 1 –Thickened Tailings						
East Dam	Rock Fill	313,000	CUBIC METRES	$ 2.50	Typical Section	$ 782,500
East Dam	Till Core	75,000	CUBIC METRES	$ 15.00	Typical Section	$ 1,125,000
East Dam	Filter Granular	12,000	CUBIC METRES	$ 20.00	Typical Section	$ 240,000
East Dam	Stripping & Subgrade Preparation	51,000	SQUARE METRES	$ 1.50	Conceptual Plan	$ 76,500
West Dam	Rock Fill[(a)]	26,745,000	CUBIC METRES	$ 2.50	Typical Section	$ 66,862,500
West Dam	Till Core	1,255,000	CUBIC METRES	$ 15.00	Typical Section	$ 18,825,000
West Dam	Filter Granular	228,000	CUBIC METRES	$ 20.00	Typical Section	$ 4,560,000
West Dam	Stripping & Subgrade Preparation	718,000	SQUARE METRES	$ 1.50	Conceptual Plan	$ 1,077,000
Toe Ditches	Rock Fill Armor	40,725	CUBIC METRES	$ 5.00	Typical Section	$ 203,625
Toe Ditches	Excavation	97,740	CUBIC METRES	$ 10.00	Typical Section	$ 977,400
Return Water Channels	Rock Fill Armor	20,500	CUBIC METRES	$ 5.00	Typical Section	$ 102,500
Return Water Channels	Excavation	30,750	CUBIC METRES	$ 10.00	Typical Section	$ 307,500
Toe Sumps	Rock Fill Armor	31,500	CUBIC METRES	$ 5.00	Typical Section	$ 157,500
Toe Sumps	Excavation	100,000	CUBIC METRES	$ 10.00	Typical Section	$ 1,000,000
Existing Emergency Spillway Upgrade		1	EACH	$ 1,000,000	Allowance	$ 1,000,000
New Emergency Spillway		22	EACH	$ 250,000	Allowance	$ 5,500,000
Energy Dissipators		2	EACH	$ 200,000	Allowance	$ 400,000
Toe Sump Pumps		6	EACH	$ 250,000	Allowance	$ 1,500,000
TSF Pond Return Pump Station		1	EACH	$ 10,000,000	Allowance	$ 10,000,000
					Total	**$ 115,479,525**
					Initial CAPEX	**$ 17,084,775**
					Sustaining CAPEX	**$ 31,532,250**
					Indicative Incremental Waste Rock Placement Cost	**$66,862,500**
Option 2 – Deep Cone Thickened Tailings						
East Dam	Rock Fill	1,260,000	CUBIC METRES	$ 5.00	Typical Section	$ 3,150,000
East Dam	Till Core	160,000	CUBIC METRES	$ 15.00	Typical Section	$ 2,400,000
East Dam	Filter Granular	30,000	CUBIC METRES	$ 20.00	Typical Section	$ 600,000
East Dam	Stripping & Subgrade Preparation	105,000	SQUARE METRES	$ 1.50	Conceptual Plan	$ 157,500
West Dam	Rock Fill[(a)]	1,113,000	CUBIC METRES	$ 2.50	Typical Section	$ 2,782,500
West Dam	Stripping & Subgrade Preparation	35,000	SQUARE METRES	$ 1.50	Conceptual Plan	$ 52,500
Toe Ditches	Rock Fill Armor	45,000	CUBIC METRES	$ 5.00	Typical Section	$ 225,000
Toe Ditches	Excavation	108,000	CUBIC METRES	$ 10.00	Typical Section	$ 1,080,000
Return Water Channels	Rock Fill Armor	106,100	CUBIC METRES	$ 5.00	Typical Section	$ 530,500
Return Water Channels	Excavation	159,150	CUBIC METRES	$ 10.00	Typical Section	$ 1,591,500
Toe Sump Upgrades	Excavation	50,000	CUBIC METRES	$ 10.00	Typical Section	$ 500,000

Table 14: Class 5 CAPEX Cost Estimate - Tailings and Water Management Structures

Structure	Component	Quantity	Unit	Unit Cost	Source	Total
Existing Emergency Spillway Upgrade		1	EACH	$ 500,000	Allowance	$ 500,000
New Emergency Spillway		4	EACH	$ 350,000	Allowance	$ 1,400,000
Energy Dissipators		4	EACH	$ 200,000	Allowance	$ 800,000
Toe Sump Pumps		5	EACH	$ 250,000	Allowance	$ 1,250,000
External Water Storage Pond		1	EACH	$ 1,000,000	Allowance	$ 1,000,000
TSF Pond Return Pump Station		1	EACH	$ 10,000,000	Allowance	$ 10,000,000
					Total	**$ 31,169,500**
					Initial CAPEX	**$ 12,955,000**
					Sustaining CAPEX	**$ 15,432,000**
					Indicative Incremental Waste Rock Placement Cost	**$2,782,500**
Option 3 – Filtered Tailings						
East Dam	Rock Fill	552,000	CUBIC METRES	$ 5.00	Typical Section	$ 1,380,000
East Dam	Till Core	100,000	CUBIC METRES	$ 15.00	Typical Section	$ 1,500,000
East Dam	Filter Granular	18,000	CUBIC METRES	$ 20.00	Typical Section	$ 360,000
East Dam	Stripping & Subgrade Preparation	67,000	SQUARE METRES	$ 1.50	Conceptual Plan	$ 100,500
West Dam	Rock Fill[(a)]	1,113,000	CUBIC METRES	$ 2.50	Typical Section	$ 2,782,500
West Dam	Stripping & Subgrade Preparation	35,000	SQUARE METRES	$ 1.50	Conceptual Plan	$ 52,500
Toe Ditches	Rock Fill Armor	45,000	CUBIC METRES	$ 5.00	Typical Section	$ 225,000
Toe Ditches	Excavation	108,000	CUBIC METRES	$ 10.00	Typical Section	$ 1,080,000
Return Water Channels	Rock Fill Armor	132,500	CUBIC METRES	$ 5.00	Typical Section	$ 662,500
Return Water Channels	Excavation	198,750	CUBIC METRES	$ 10.00	Typical Section	$ 1,987,500
Toe Sump Upgrades	Excavation	50,000	CUBIC METRES	$ 10.00	Typical Section	$ 500,000
Existing Emergency Spillway Upgrade		1	EACH	$ 500,000	Allowance	$ 500,000
New Emergency Spillway		3	EACH	$ 350,000	Allowance	$ 1,050,000
Energy Dissipators		4	EACH	$ 200,000	Allowance	$ 800,000
Toe Sump Pumps		5	EACH	$ 250,000	Allowance	$ 1,250,000
TSF Pond Return Pump Station		1	EACH	$ 10,000,000	Allowance	$ 10,000,000
					Total	**$ 25,610,500**
					Initial CAPEX	**$ 12,955,500**
					Sustaining CAPEX	**$ 9,873,000**
					Indicative Incremental Waste Rock Placement Cost	**$2,782,500**

(a) Cost to be borne by mine operations.

CAPEX = Capital Cost Estimate; TSF = Tailings Storage Facility.

12.0 OPTION EVALUATIONS

A semi-quantitative evaluation of the options was completed considering key attributes discussed in the preceding sections, such as performance, operability, cost, and others were incorporated within a ranked matrix structure to allow the comparison of various opportunities and constraints for each of the alternatives. For purposes of this evaluation, the reference costs estimated for bulk rock fill placement on the west embankment (see Table 14) were included in the comparison. This is intended to remove potential bias towards one particular option or other. The summary matrix is presented in Table 15.

Table 15: Matrix of the Results of the Options Comparison

Criteria \ Alternative[(a)]	Thickened Slurry Tailings	Deep Cone Thickened Slurry Tailings	Filtered Tailings
Capacity	218 Mt	132-204 Mt	216 Mt
Storage Capacity years	~ 17	~ 10-16	~ 17
Tailings Preparation CAPEX	$44,900,000	$53,700,000	$226,900,000
Earthworks Initial CAPEX	$17,100,000	$15,700,000	$15,700,000
Earthworks Sustaining CAPEX	$98,400,000	$15,400,000	$9,900,000
OPEX (Median $/tonne x Capacity)	$98,000,000	$125,000,000	$1,500,000,000
Capacity Rank	1	3	1
Capex Costs Rank	2	1	3
Opex Costs Rank	1	2	5
Operability	1	1	5
Closure Complexity	2	2	1
Dam Safety and Environmental Risks	3	1	2
Overall	**10**	**10**	**17**

(a) Throughout the options and criteria a rank was selected, i.e., 1 (light green) most favorable, 2 (light yellow) less favorable, and 3 (light red) least favorable among the 3 alternatives. A rank of 5 (dark red) was given where a very significant difference existed between options.

Capacity

Options 1 and 3 were ranked most favourable as they are expected to provide the greatest capacity. Option 2 was ranked least favorable due to capacity risk associated with uncertainty related to achievable beach slope grades.

CAPEX

Options were evaluated based on overall CAPEX. The ability to defer capital expenditure was not factored into the assigned ranking. Option 2 was ranked most favorable owing to lowest equipment and earthworks costs of the options. Option 3 was ranked least favorable, with equipment costs of approximately 4 times those of the other options.

OPEX

Options were evaluated based on expected total OPEX considering the capacity of the facility for each option. Option 1 was ranked most favorable, and Option 3 was ranked least favorable with a value of 5 due to an order of magnitude cost difference from the other options.

Operability

Options 1 and 2 were ranked most favourable due to simple spigotting of tailings and passible water management practices. Option 3 was ranked least favorable with a value of 5 due to complex stack construction considerations, with known precedent known for the projected tailings generation rate in a cold climate.

Closure Complexity

Option 3 was ranked most favorable owing to the ability to progressively decommission the stack. Options 1 and 2 were ranked less favorable, with no clear advantage to either.

Dam Safety and Environmental Risks

Option 2 was ranked most favorable due to low tailings dam embankment heights and gentle tailings slopes. Option 1 was ranked least favorable due to high dam embankment heights and saturated tailings and foundation conditions.

13.0 CONCLUSIONS AND PATH FORWARD

Overall ranking of the options resulted in tied scores for the thickened tailings and deep cone thickened tailings options. The score obtained for filtered tailings was dominated by high operational cost and complexity, resulting in a markedly lower ranking than the slurry options.

It is recommended that the thickened slurry and deep cone thickened slurry options be advanced to pre-feasibility study for further technical study. A net present value analysis considering the LOM and the closure cost is also recommended for the next phases of the project to provide a better understanding of cost implications to the project.

Validation of the capital costs associated with the waste rock shell construction, based on discussions between the mining and tailings designers is recommended for the next stage of design.

14.0 CLOSURE

We trust that this report is consistent with the objectives Set out for the Project and meets the present requirements of Troilus. We thank you for the opportunity to be of service and welcome and comments or questions that you may have.

Signature Page

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https://golderassociates.sharepoint.com/sites/117654/project files/5 technical work/options study/report/003-19131334 tailings options study rev0.docx

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APPENDIX A

Tailings Dewatering Options

Project No.	19131334	**Troilus Gold Project**	GOLDER
Date:	2020-09-01	**Tailings Disposal Options Trade off Study**	
Revision Number:	A	**Design Basis**	

General Information

Level of Study	Trade-off
UG Backfill or Surface Disposal	Surface Disposal
Mineral(s):	Gold

Disclaimer

The process design criteria have been developed by Golder for the purpose of equipment selection and sizing and shall not be interpreted as a guarantee of plant performance. All units are metric unless otherwise indicated.

Process Explanation

Tailings from the mill will be delivered in the TSF with one of three tailings discharge solids densith (conventional tails, thickened tails or filtered tails).

the tailings storage facility (TSF)

Data Source

Provided by Troilus	Troilus
Calculated from other criteria	C
Estimated	E
Typical value or industry standard	T
Assumed value	A
Vendor catalogue or vendor supplied data	V
Golder Associates	Golder

		Value	Units	Source	Remarks
Mill Production					
Operating Weeks per Year		51.0	wk/yr	A	One week major shutdown per year
Scheduled Days per Week		6.5	day/wk	A	Half a day per week for maintenance
Operating Days per Year		332	day/yr	A	
Mill Operating Hours per Day		24.0	h/day	C	
Design Annual Production	Tailings:	35,000	tonne/day	Troilus	
Tailings Production					
Tailings Solids SG		2.65		Troilus	
Design Tailings Production Rate		35,000	tonne/day	Troilus	
Estimated Tailings Produced (Solid)		1,458	tonne/h	C	
Estimated Annual Tailings Production		11,602,500	tonne/yr	C	
Equipment Design Factor		1.15		A	
Tailings Nominal Mass Flow rate		1,458	tonne/h	C	Input to mass balance
Tailings Design Volumetric Flow rate		2,333	m^3/h	C	
Tailings Slurry Discharge Solids Content from the Mill		45	wt%	Troilus	
Thickened Tailings Solids Content		55	wt%	Troilus	
Thickener Underflow Solids Content - Hight Rate		60	wt%	Pocock	In line with Golder data on gold tailings
Thickener Underflow Solids Content - Deep Bed		70	wt%	E, Golder	Estimated based on Golder data
Settling Rate		0.075	$m^2/t/day$	E, Golder	Estimated based on Golder data
Filtered Tailings Solids Content		85	wt%	Troilus	
Pressure Filtration Rate		200	$kg/m^2/hr$	Golder	Based on other Golder gold projects

Troilus Gold Project
Tailings Disposal - Trade-off
Project #: 19131334
Date: August 2020
Revision: A

Cost Estimate (Order of Magnitude +/- 50%)
Thickened Tailings - High Rate Thickener Option

Description	Filtered Tailings					
	Qty	Unit Cost	Labour Rate	Hours	Total Cost ($US)	Description
Equipment						
Flocculant system	1	$ 380,000	$ 80.00	210	$ 396,800	-
High rate thickener	1	$ 4,541,000	$ 80.00	5040	$ 4,944,200	60m D
Thickened tailings tank	2	$ 382,000	$ 80.00	1500	$ 1,004,000	8m D x 10m H with rubber lining, 18 min retention time for each tank
Thickened tailings tank agitator	2	$ 84,000	$ 80.00	80	$ 180,800	cost database
Thickener feed box	1	$ 237,700	$ 80.00	360	$ 266,500	4.5m D x 6m H, tank and supporting structure, interior coating
Fresh water tank	1	$ 61,700	$ 80.00	360	$ 90,500	4m D x 6m H, 30 min retention time
Process water tank	1	$ 125,700	$ 80.00	600	$ 173,700	6m D x 8m H, 13 min retention time
Thickener underflow pumps	2	$ 103,000	$ 80.00	360	$ 263,600	762 m3/hr for each pump, 1 operating, 1 standby
Tailings pumps	2	$ 260,000	$ 80.00	600	$ 616,000	2333 m3/hr, 1 operating, 1 standby
Gland water pumps	2	$ 24,000	$ 80.00	120	$ 67,200	15m3/hr
Fresh water pumps	2	$ 16,000	$ 80.00	120	$ 51,200	102m3/hr
Process water pumps	2	$ 44,000	$ 80.00	500	$ 168,000	908m^3/hr
Flush water pumps	2	$ 79,000	$ 80.00	600	$ 254,000	1950 m3/hr 2-Stage system
Thickener area sump pump	1	$ 14,000	$ 80.00	120	$ 23,600	70m3/hr
Tank area sump pump	1	$ 14,000	$ 80.00	120	$ 23,600	70m3/hr
Air system	1	$ 276,200	$ 80.00	500	$ 316,200	Including air compressor, instrument air receiver and instrument air dryer
Misc. equipment	1	$ 442,000	$ -	0	$ 442,000	5% of total Equipment
Sub Total Major Equipment		**$ 8,076,300**			**$ 9,281,900**	
Tailings disposal to TSF						
Thickened tailings pumps - 1st stage	2	$ 201,000	$ 80.00	600	$ 498,000	1523 m3/hr, 1 operating, 1 standby
Thickened tailings pumps - 2nd stage	2	$ 261,300	$ 80.00	600	$ 618,600	1523 m3/hr, 1 operating, 1 standby
Thickened tailings pipeline to TSF	19,008 m	$ 617 /m	$ -	-	$ 11,732,464	24" DR9 with heat trace and insulation
Total Tailings Disposal Cost					**$ 12,850,000**	
Plant Direct Costs						
Allowance for Earthworks	31%				$ 2,877,400	31% of total equipment cost
Allowance for Concrete	45%				$ 4,176,900	45% of total equipment cost
Allowance for Structural Steel	58%				$ 5,383,600	58% of total equipment cost
Allowance for HVAC	4%				$ 371,300	4% of total equipment cost
Allowance for Electrical	7,204	$ 720 /kW			$ 5,186,655	
Allowance for Instrumentation	2%				$ 185,700	2% of total equipment cost
Allowance for DCS and programming	1 lot	45000			$ 45,000	database
Allowance for manual valves	11%				$ 1,021,100	11% of total equipment cost
Allowance for plant piping	6%				$ 557,000	6% of total equipment cost
Allowance for fire suppression	1 lot	55000			$ 55,000	database
Sub Total Direct Allowances					**$ 19,860,000**	
Total Plant Direct Costs (TPDC)					**$ 41,991,900**	
Plant Indirect Costs						
Project Indirects						
Project Indirects - detailed engineering	2%				$ 839,838	2% of the TPDC
Project Indirects - construction management	1%				$ 419,919	1% of the TPDC
Construction Indirects - commissioning	1.0%				$ 207,334	1% of the total equipment material cost
Construction Indirects - vendor reps	0.3%				$ 104,980	0.25% of the TPDC
Construction Indirects - temporary construction facilities	0.3%				$ 104,980	0.25% of the TPDC
Construction Indirects - capital spares	0.5%				$ 209,960	0.5% of the TPDC
Construction Indirects - owners costs	0.5%				$ 209,960	0.5% of the TPDC
Project Indirects - Freight	4%				$ 829,335	4% of the equipment material cost
Total Project Indirects					**$ 2,930,000**	
TOTAL PLANT CAPITAL COSTS					**$ 44,922,000**	
Total Capital Cost ($US)					**$ 44,922,000**	

Troilus Gold Project
Tailings Disposal - Trade-off
Project #: 19131334
Date: August 2020
Revision: A

Cost Estimate (Order of Magnitude +/- 50%)
Thickened Tailings - Deep Cone Thickener Option

Description	Filtered Tailings					
	Qty	Unit Cost	Labour Rate	Hours	Total Cost ($US)	Description
Equipment						
Flocculant system	1	$ 380,000	$ 80.00	210	$ 396,800	-
Deep Cone Thickener	2	$ 5,724,000	$ 80.00	5040	$ 12,254,400	40m D
Thickened Tailings Tank	1	$ 382,000	$ 80.00	1500	$ 502,000	8m D x 10m H with rubber lining, 25 min retention time for each tank
Thickened Tailings Tank Agitator	1	$ 109,200	$ 80.00	80	$ 115,600	cost database
Thickener feed box	2	$ 237,700	$ 80.00	360	$ 533,000	4.5m D x 6m H, tank and supporting structure, interior coating
Fresh water tank	1	$ 61,700	$ 80.00	360	$ 90,500	4m D x 6m H, 30 min retention time
Process water tank	1	$ 211,700	$ 80.00	1200	$ 307,700	8m D x 10m H, 19 min retention time
Thickener underflow pumps	4	$ 89,000	$ 80.00	360	$ 471,200	590m3/hr for each pump, 2 operating, 2 standby
Tailings pumps	3	$ 172,000	$ 80.00	600	$ 660,000	1166 m^3/hr, 2 operating, 1 standby
Gland water pumps	2	$ 24,000	$ 80.00	120	$ 67,200	15m3/hr
Fresh water pumps	2	$ 16,000	$ 80.00	120	$ 51,200	102m3/hr
Process water pumps	2	$ 56,000	$ 80.00	180	$ 140,800	1367m^3/hr
Flush water pumps	2	$ 72,000	$ 80.00	600	$ 240,000	1650 m3/hr 2-Stage system
Thickener area sump pump	2	$ 14,000	$ 80.00	120	$ 47,200	70m3/hr
Tank area sump pump	1	$ 14,000	$ 80.00	120	$ 23,600	70m3/hr
Air system	1	$ 276,200	$ 80.00	500	$ 316,200	Including air compressor, instrument air receiver and instrument air dryer
Misc. equipment	1	$ 811,000	$ -	0	$ 811,000	5% of total Equipment
Sub Total Major Equipment		**$15,405,200**		**11,470**	**$ 17,030,000**	
Tailings disposal to TSF						
Thickened tailings pumps - 1st stage	2	$ 190,000	$ 80.00	600	$ 476,000	1175 m3/hr, 1 operating, 1 standby
Thickened tailings pumps - 2nd stage	2	$ 247,000	$ 80.00	600	$ 590,000	1175 m3/hr, 1 operating, 1 standby
Thickened tailings pipeline to TSF	9,400 m	$ 617 /m	$ -	-	$ 5,802,039	22" DR9 with heat trace and insulation
Total Tailings Disposal Cost					**$ 6,869,000**	
Plant Direct Costs						
Allowance for Earthworks	31%				$ 5,279,300	31% of total equipment cost
Allowance for Concrete	25%				$ 4,257,500	25% of total equipment cost
Allowance for Structural Steel	40%				$ 6,812,000	40% of total equipment cost
Allowance for HVAC	4%				$ 681,200	4% of total equipment cost
Allowance for Electrical	8,957	$ 720 /kW			$ 6,449,000	
Allowance for Instrumentation	2%				$ 340,600	2% of total equipment cost
Allowance for DCS and programming	1 lot	45000			$ 45,000	database
Allowance for manual valves	11%				$ 1,873,300	11% of total equipment cost
Allowance for plant piping	6%				$ 1,021,800	6% of total equipment cost
Allowance for fire suppression	1 lot	55000			$ 55,000	database
Sub Total Direct Allowances					**$ 26,810,000**	
Total Plant Direct Costs (TPDC)					**$ 50,709,000**	
Plant Indirect Costs						
Project Indirects						
Project Indirects - detailed engineering	2%				$ 1,014,180	2% of the TPDC
Project Indirects - construction management	1%				$ 507,090	1% of the TPDC
Construction Indirects - commissioning	1.0%				$ 154,052.00	1% of the total equipment cost
Construction Indirects - vendor reps	0.3%				$ 67,025	0.25% of the TPDC
Construction Indirects - temporary construction facilities	0.3%				$ 67,025	0.25% of the TPDC
Construction Indirects - capital spares	0.5%				$ 134,050	0.5% of the TPDC
Construction Indirects - owners costs	0.5%				$ 134,050	0.5% of the TPDC
Project Indirects - Freight	4%				$ 890,968	4% of the equipment cost
Total Project Indirects					**$ 2,970,000**	
TOTAL PLANT CAPITAL COSTS					**$ 53,679,000**	
Total Capital Cost ($US)					**$ 53,679,000**	

Troilus Gold Project
Tailings Disposal - Trade-off
Project #: 19131334
Date: August 2020
Revision: A

Cost Estimate (Order of Magnitude +/- 50%)
Filter Cake - Pressure Filter Option

Description	Filtered Tailings					
	Qty	Unit Cost	Labour Rate	Hours	Total Cost ($US)	Description
Equipment						
Flocculant system	1	$ 380,000	$ 80.00	210	$ 396,800	-
Thickener	1	$ 4,541,000	$ 80.00	5040	$ 4,944,200	60m D
Pressure filter pack	6	$ 4,500,000	$ 80.00	2160	$ 28,036,800	2.5m plate, 5 operating, 1 standby
Filter cake conveyor	3	$ 502,000	$ 80.00	1800	$ 1,938,000	80m
Filter cake collecting conveyor	2	$ 213,000	$ 80.00	900	$ 570,000	35m
Filter feed tank	2	$ 382,000	$ 80.00	1500	$ 1,004,000	8m D x 10m H with rubber lining, 18 min retention time for each tank
Filter feed tank agitator	2	$ 84,000	$ 80.00	80	$ 180,800	cost database
Filtrate receiver	1	$ 126,000	$ 80.00	600	$ 174,000	6m D x 8m H, 16 min retention time
Thickener feed box	1	$ 237,700	$ 80.00	360	$ 266,500	4.5m D x 6m H, tank and supporting structure, interior coating
Fresh water tank	1	$ 61,700	$ 80.00	360	$ 90,500	4m D x 6m H, 30 min retention time
Process water tank	1	$ 211,700	$ 80.00	1200	$ 307,700	8m D x 10m H, 14 min retention time
Thickener underflow pumps	2	$ 103,000	$ 80.00	360	$ 263,600	762 m^3/hr for each pump, 1 operating, 1 standby
Filter feed pumps	10	$ 287,000	$ 80.00	120	$ 2,966,000	6 operating, 4 standby
Tailings pumps	2	$ 260,000	$ 80.00	600	$ 616,000	2333 m^3/hr, 1 operating, 1 standby
Gland water pumps	2	$ 64,000	$ 80.00	120	$ 147,200	40m^3/hr
Fresh water pumps	2	$ 13,000	$ 80.00	120	$ 45,200	127m^3/hr
Process water pumps	2	$ 73,000	$ 80.00	600	$ 242,000	1653m^3/hr
Cloth wash pumps	2	$ 127,000	$ 80.00	120	$ 273,200	-
Filtrate pumps	2	$ 45,000	$ 80.00	360	$ 147,600	715m^3/hr
Thickener area sump pump	1	$ 14,000	$ 80.00	120	$ 23,600	70m^3/hr
Tank area sump pump	1	$ 14,000	$ 80.00	120	$ 23,600	70m^3/hr
Filter area sump pump	2	$ 14,000	$ 80.00	120	$ 47,200	70m^3/hr
Filter air compressor	24	$ 174,000	$ 80.00	500	$ 5,136,000	
Air system	1	$ 276,200	$ 80.00	500	$ 316,200	Including air compressor, instrument air receiver and instrument air dryer
Plant air receiver	6	$ 45,000	$ 80.00	120	$ 327,600	
Crane	3	$ 54,000	$ 80.00	480	$ 277,200	5 Ton, 41m runway, 9.7m span
Misc. equipment	1	$ 2,439,000	$ -	0	$ 2,439,000	5% of total Equipment
Sub Total Major Equipment		**$ 47,041,300**			**$ 51,200,000**	
Surface Pipeline						
Tailings pipeline from mill to dewatering plant	200 m	$ 404 /m	$ -	-	$ 80,881	30" DR9
Process water pipeline from dewatering plant to mill	200 m	$ 259 /m	$ -	-	$ 51,768	24" DR9
Fresh water pipeline from mill to dewatering plant	200 m	$ 23 /m	$ -	-	$ 4,655	6" DR9
Total surface pipeline cost					**$ -**	
Tailings disposal to TSF						
Filter cake overland conveyor	1	$ 35,307,000	$ 80.00	67000	**$ 40,667,000**	4500m total - 4 conveyors open conveyor gallery and 3 transfer towers
Plant Direct Costs						
Allowance for Earthworks	35%				$ 17,920,000	35% of total equipment cost
Allowance for Concrete	35%				$ 17,920,000	35% of total equipment cost
Allowance for Structural Steel and cladding	60%				$ 30,720,000	60% of total equipment cost
Allowance for HVAC	20%				$ 10,240,000	20% of total equipment cost
Allowance for Electrical	21,259	$ 1200 /kW			$ 25,510,920	
Allowance for Instrumentation	6%				$ 3,072,000	6% of total equipment cost
Allowance for DCS and programming	1 lot	45000			$ 45,000	database
Allowance for manual valves	15%				$ 7,680,000	15% of total equipment cost
Allowance for plant piping	18%				$ 9,216,000	18% of total equipment cost
Allowance for fire suppression	1 lot	55000			$ 55,000	database
Sub Total Direct Allowances					**$ 122,380,000**	
Total Plant Direct Costs (TPDC)					**$ 214,247,000**	
Plant Indirect Costs						
Project Indirects						
Project Indirects - detailed engineering	2%				$ 3,213,705	1.5% of the TPDC
Project Indirects - construction management	1%				$ 2,142,470	1% of the TPDC
Construction Indirects - commissioning	1%				$ 823,483	1% of the total equipment material cost
Construction Indirects - vendor reps	0.25%				$ 535,618	0.25% of the TPDC
Construction Indirects - temporary construction facilities	0.25%				$ 535,618	0.25% of the TPDC
Construction Indirects - capital spares	0.5%				$ 1,071,235	0.5% of the TPDC
Construction Indirects - owners costs	0.5%				$ 1,071,235	0.5% of the TPDC
Project Indirects - Freight	4%				$ 3,293,932	4% of the equipment cost
Total Project Indirects					**$ 12,690,000**	
TOTAL PLANT CAPITAL COSTS					**$ 226,937,000**	
Total Capital Cost ($US)					**$ 226,937,000**	

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APPENDIX B

Tailings Characterization Report

GOLDER
MEMBER OF WSP

REPORT

Laboratory Test Results

Troilus Thickened Tailings Assessment

Submitted to:

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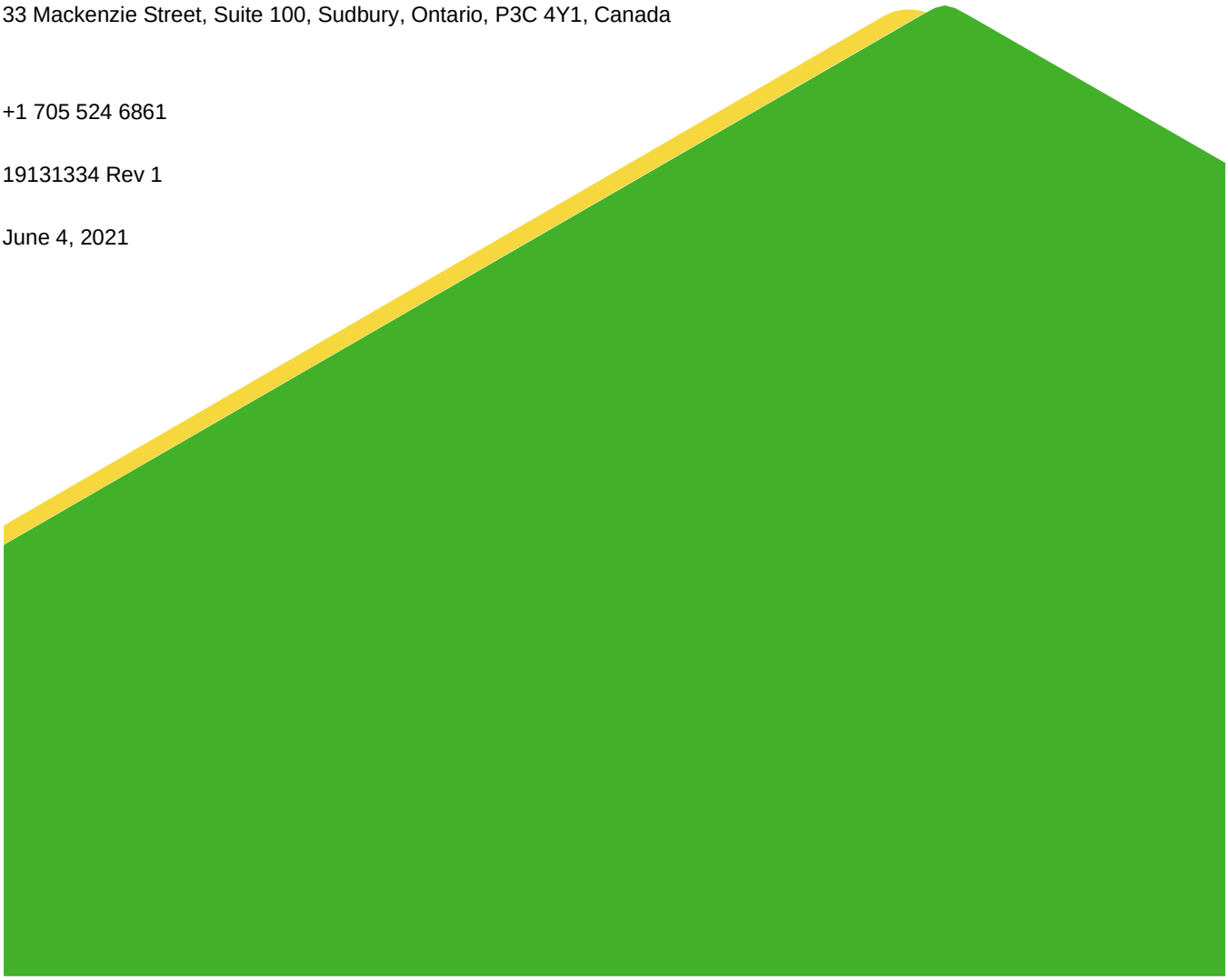
19131334 Rev 1

June 4, 2021



Distribution List

1 PDF copy: Troilus Gold Corp., Toronto, ON

1 PDF copy: Golder Associates Ltd., Sudbury, ON

Study Limitations

This report was prepared for the exclusive use of Troilus Gold Corp. (Troilus) on the Troilus Gold Project. The report, which specifically includes all tables, figures and appendices, is based on measurements and observations made and data and information collected during the laboratory studies conducted by Golder Associates Ltd. (Golder) for Troilus. The test results are based solely on the ambient conditions of the laboratory at the time the measurements and tests were conducted.

The services performed, as described in this report, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

The sample(s) provided for the tests are assumed to be representative of material found at the site. The test data given herein pertains to the sample(s) provided and may not be applicable to material from other production periods or zones. Assessment of the sample environmental conditions and possible hazards associated with the material composition is based on the results of chemical analysis of samples which are possibly from a limited number of locations. However, it is never possible, even with exhaustive sampling and testing, to dismiss the possibility that part of a site or a production line may remain undetected. The results found from the tests may not be reproducible under the field conditions.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by Troilus, communications between Golder and Troilus, and to any other reports prepared by Golder for Troilus relative to the specific site described in the report, tables, drawings, figures, and appendices. ***In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.***

No other party may use or rely on this report or any portion thereof without Golder's express written consent. Any use, which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, Golder should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

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1.0 INTRODUCTION

Troilus Gold Corp. (Troilus) has retained Golder Associates Ltd. (Golder) to carry out laboratory testing on a tailings sample of flotation tailings from test work done at COREM on Domain 42 in the J Zone. The samples are thought to be representative of the grind for the various deposits that will be mined over the life of mine of the Troilus Gold Project to assess dewatering and rheological properties to support a pre-feasibility level study for the production and transportation of thickened tailings.

2.0 SAMPLE RECEIPT AND PREPARATION

2.1 Sample Receipt

Samples received by Golder's Sudbury laboratory are summarized in Table 1. All samples were received in good condition with all seals intact. The total weight of the shipment was 54 kg. The samples were shipped via Purolator.

Table 1: Sample Receipt Summary

Date	Amount/Container	Label as Received	Golder Sample ID
February 25, 2021	54 kg / 4x 20 L pails	Tailings	19131334 Tailings

All samples received by Golder are subjected to material property characterization tests to establish properties and allow for comparison should future testing be required.

2.2 Hazard Assessment

Prior to handling the 19131334 Tailings, each pail was assessed separately for hazardous gases. The gas analysis results are presented in Table 2.

Table 2: Sample Hazard Assessment

Date	Label as Received	Golder Sample ID	VOC (ppm)	HCN (ppm)	H_2S (ppm)
March 5, 2021	Tailings	19131134 Tailings	0	0	0

VOC: Volatile Organic Compounds

HCN: Hydrogen Cyanide gas

H_2S: Hydrogen Sulphide gas

Metals analysis using Inductively Coupled Plasma with a Mass Spectrometer detector (ICP-MS) was performed on a composite sample obtained via individual pipe samples from each pail. In addition, cyanide levels were also examined. This testing helps to identify health and safety hazards such as heavy metals or cyanide which may be present. The sample was sent to an external laboratory for ICP-MS analysis. Table 3 and Appendix A present the results.

Table 3: Cyanide Analysis Results

Sample	Result (µg/L)
19131334 Tailings	<0.040

No hazardous gases were detected in any of the samples. The concentrations of heavy metals and cyanide present in the samples were considered to be acceptable to handle according to Golder's established protocols.

2.3 Sample Preparation

Proper sample preparation technique is a critical first step to ensure proper homogenization of solids, representative sub-sampling and reproducibility of results.

The solids were combined, homogenized with tap water and treated as one sample for the remainder of the test program.

2.4 Sample Shipping / External Testing

Sub-samples of the bulk sample(s) were collected and sent to AGAT, XPS Centre, SGS, and SGS for the purpose of material property characteristics. Table 4 summarizes the shipping and external testing.

Table 4: Sample Shipping

Date	Amount/Container	Golder Sample ID	Shipped To	Purpose
March 5, 2021	200 g / 250 mL jar	19131334 Tailings	AGAT	ICP-MS / Free CN
March 19, 2021	150 g / 500 mL jar	19131334 Tailings	XPS Centre	XRD / WRA / S
March 30, 2021	500 g / 500 mL jar	19131334 Tailings	SGS	Trace Metals / Total Metals Scan / ABA Modified Sobek

3.0 MATERIAL CHARACTERIZATION

3.1 pH Analysis

Table 5 presents the pH of each sample and the temperature at which it was measured.

Table 5: pH Analysis

Sample	pH	Temperature (°Celsius)
19131334 Tailings	8.2	20

3.2 Particle Size Distribution

Particle size distribution (PSD) was determined using a Malvern Mastersizer 3000 laser particle size analyzer according to ASTM D4464.

Specific values are presented in Table 6. The gradation parameter DXX, tabulated in microns, refers to the average particle diameter that XX% by weight of material is smaller than.

Table 6: Particle Size Distribution

Sample	D10 (µm)	D30 (µm)	D50 (µm)	D60 (µm)	D80 (µm)
19131334 Tailings	6	22	43	55	86

Figure 1 presents the results.

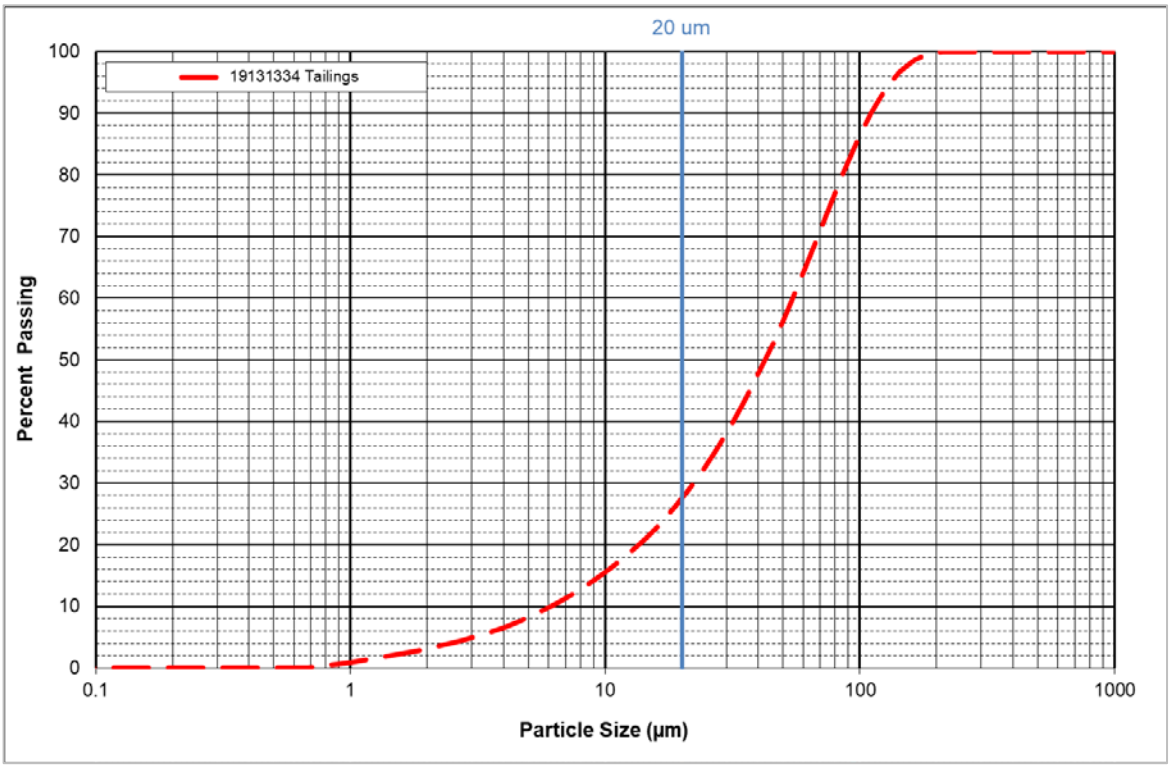

Figure 1: PSD Results

3.3 Specific Gravity

The specific gravity (SG) of the sample was determined using vacuum de-aired water. Each slurry sample was also vacuum de-aired prior to SG measurement. The results are presented in Table 7.

Table 7: Specific Gravity Results

Sample	Trial 1	Trial 2	Average
19131334 Tailings	2.84	2.83	2.84

3.4 Chemistry and Mineralogy

Chemical and mineralogical analyses were performed using whole rock analysis (WRA) by inductively coupled plasma (ICP) and X-ray diffraction (XRD) via semi-quantitative analysis by Rietveld Method, respectively whereas sulphur analysis was performed by LECO method. The results are presented in Table 8 to Table 10 as well as Figure 2 and Figure 3.

Table 8: Chemical Composition (wt%)

SAMPLE	19131334 Tailings
Al_2O_3	14.3
BaO	0.017
CaO	4.24
Cr_2O_3	0.036
Fe_2O_3	6.68
K_2O	1.82
LOI	0.79
MgO	4.03
MnO	0.043
Na_2O	3.61
P_2O_5	0.129
SiO_2	62.2
SrO	0.031
TiO_2	0.549
Total	98.5

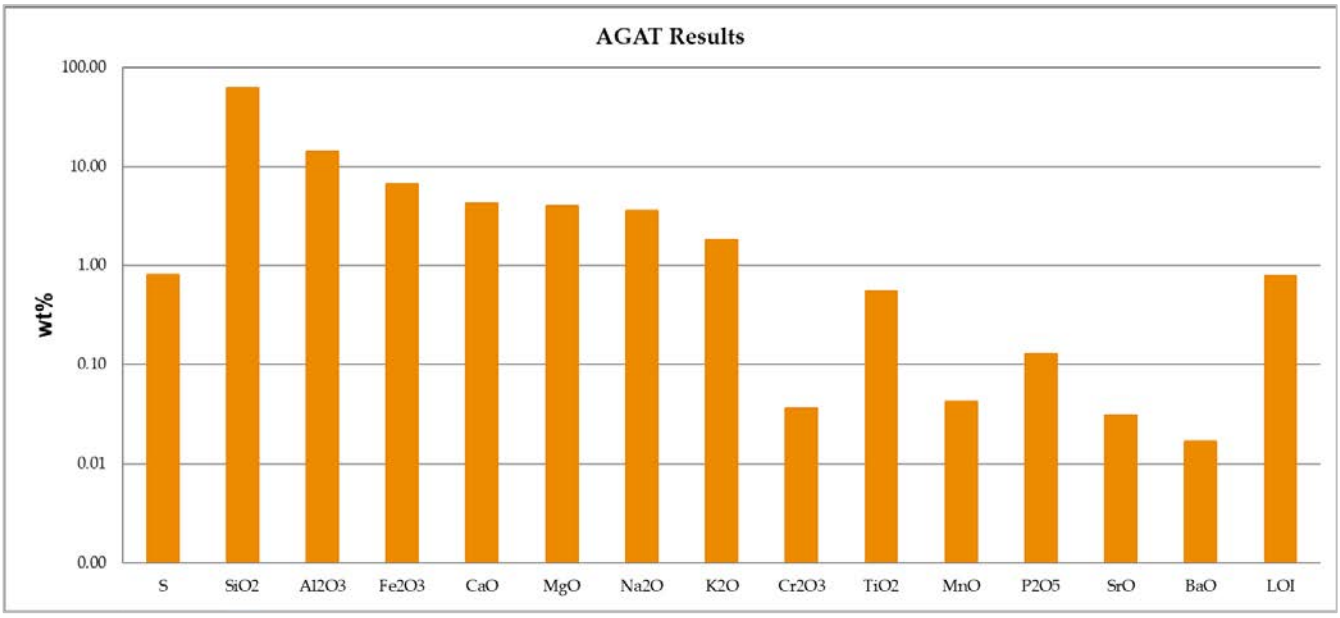

Figure 2: Chemical Composition

Table 9: Semi-quantitative Mineralogical Composition - 19131334 Tailings

Mineral SQ-XRD	Chemical Formula	Wt%
Albite	$(Na,Ca)Al(Si,Al)_3O_8$	28.86
Quartz	SiO_2	23.02
Anorthite	$CaAl_2Si_2O_8$	20.51
Phlogopite	$K_2Mg_6(Al_2Si_6O_{20})(OH)_4$	11.73
Actinolite	$Ca_2(Mg,Fe^{+2})_5Si_8O_{22}(OH)_2$	11.46
Chlorite	$Mg_2Al_3(Si_3Al)O_{10}(O)_8$	2.25
Orthoclase	$K(AlSi_3O_8)$	2.17
	Total	**100.00**

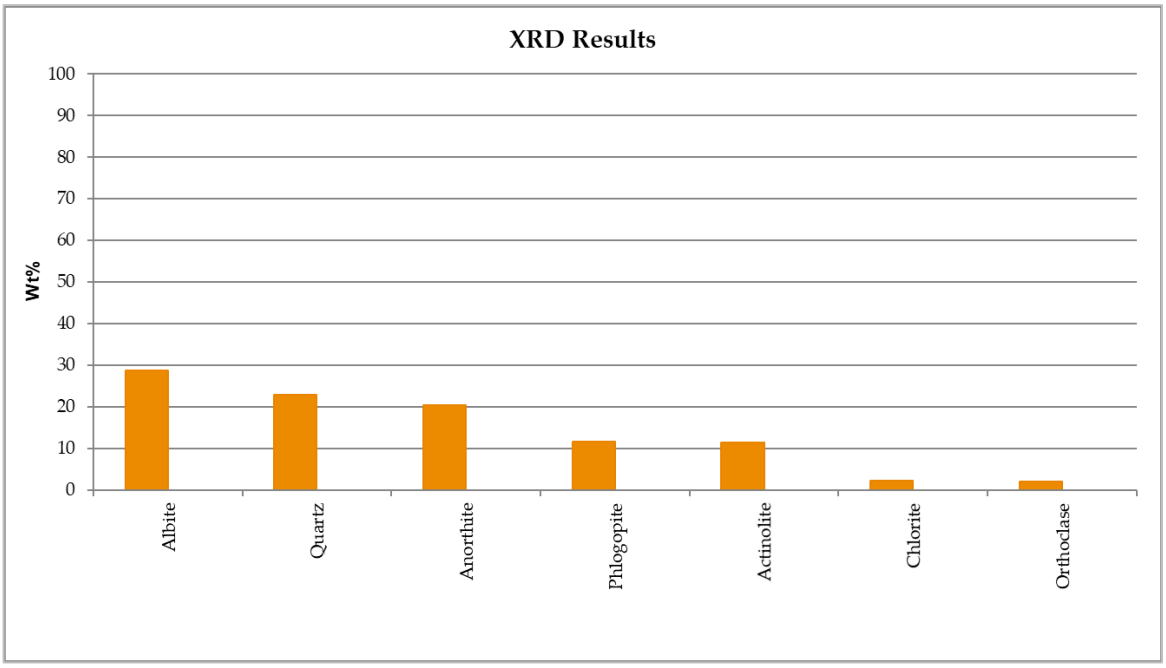

Figure 3: Semi-quantitative Mineralogical Composition

Table 10: LECO Sulphur Analysis

Sample	Sulphur (wt%)
19131334 Tailings	0.806

3.5 Environmental Analysis

Environmental analyses were performed using multi-acid digestions, modified Sobek method, and MA200-Met 1.2 Digest. The results are presented in Appendix B.

4.0 DEWATERING TESTING

4.1 Settling Tests

The first stage of settling tests usually consists of an assessment of the potential for thickening through use of synthetic polymers. Several types of flocculants were screened in order to test a range of parameters such as charge density and molecular weight. The typical types of flocculants considered are the anionic and non-ionic polymers. Table 11 shows the flocculants which were examined and their properties.

Table 11: Flocculant Properties

Flocculant	Manufacturer	Type	Ionicity (mole %)	Molecular Weight
AN 920 VHM	SNF	Non - ionic	0	Very High
AN 905 VHM	SNF	Anionic	5	Very High
AN 926 VHM	SNF	Anionic	25	Very High
AN 945 SH	SNF	Anionic	40	High
AN 977 SH	SNF	Anionic	70	High
MF 919	BASF	Anionic	46	Very High

To select the most effective flocculant, several factors were examined, such as initial settling velocity, overflow clarity, flocculant size and structure, as well as underflow density. The overflow clarity was measured in NTU (Nephelometric Turbidity Unit) where lower numbers indicate clearer water. The screening results are presented in Table 12 as well as Figure 4 and Figure 5. All screening tests were performed in 500 mL vessels. The pH was adjusted to 10 for all settling trials.

Table 12: Flocculant Screening Results

Flocculant	Dosage (g/tonne)	Feed Solids (wt% solids)	Overflow Clarity after 45 minutes (NTU)	Initial Settling Rate (m/hour)	Calculated Underflow Density (wt% solids)	Floc Size	Floc Structure
AN 920 VHM	25	25	19	6.9	62	Medium	Normal
AN 905 VHM			22	10.9	60	Medium	Fluffy
AN 926 VHM			15	5.6	59	Medium	Fluffy
AN 945 SH			13	6.6	58	Small	Fluffy
AN 977 SH			12	3.3	59	Small	Normal
MF 919			13	5.6	59	Small	Normal

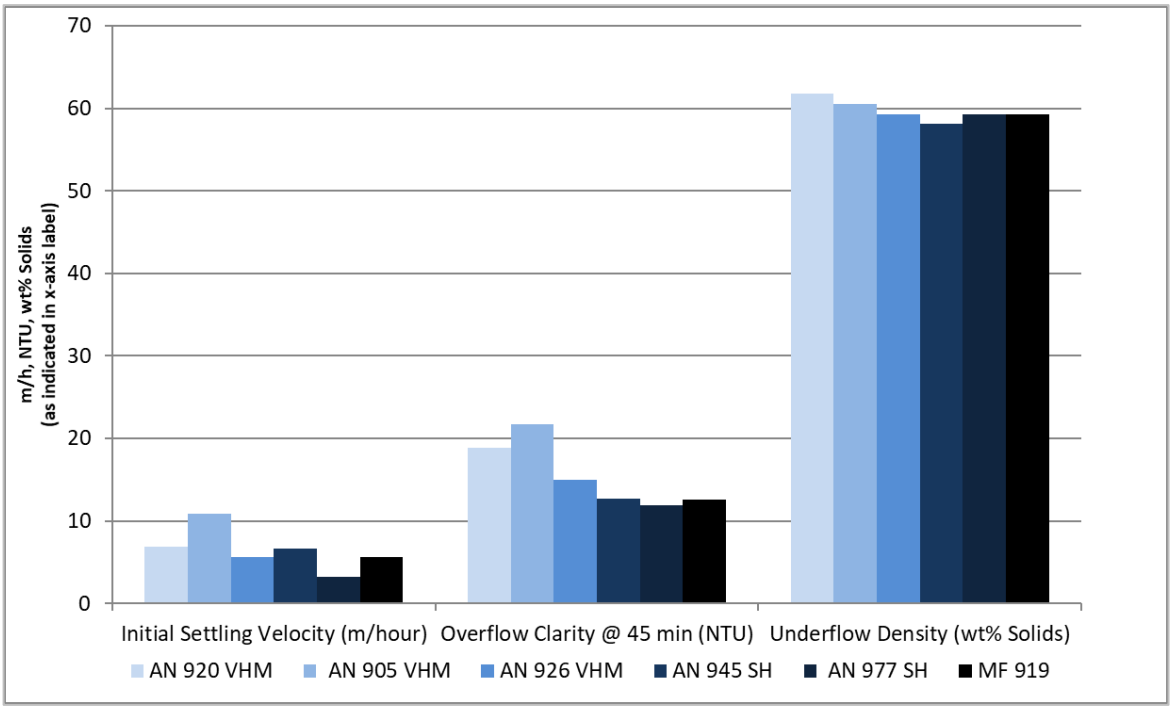

Figure 4: Flocculant Screening Results

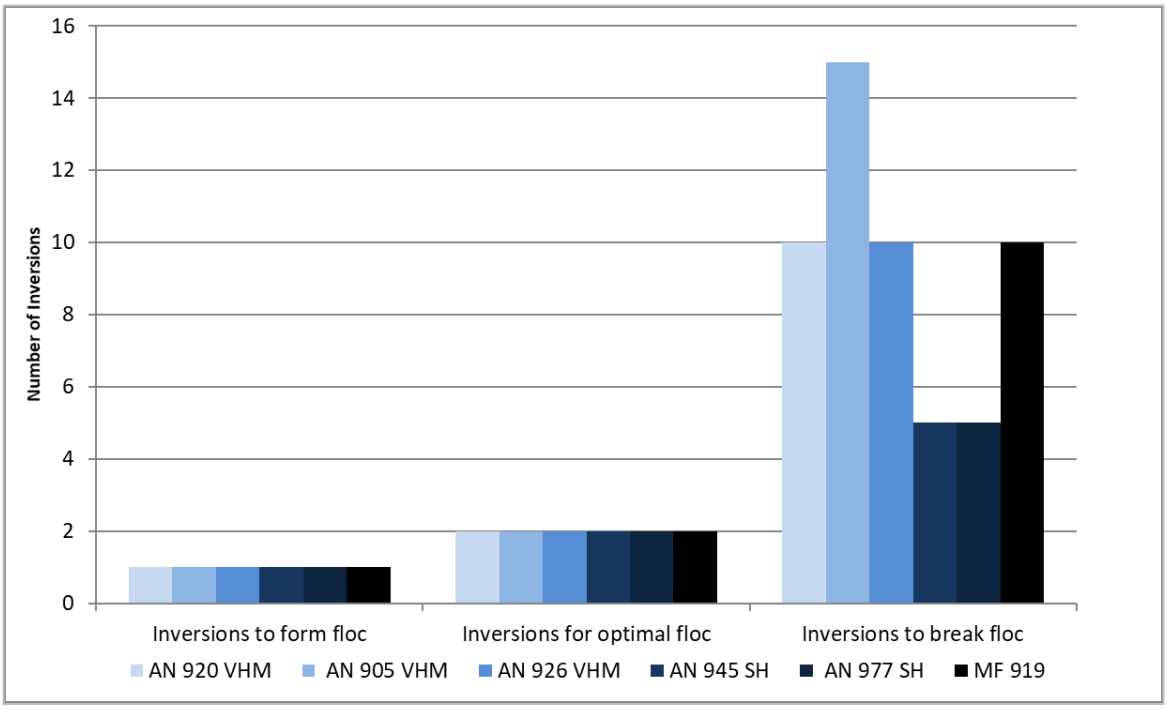

Figure 5: Flocculant Strength Results

Based on the screening results, AN 920 VHM was chosen as the best flocculant for dewatering the 19131334 Tailings sample. The next step in the settling tests was to optimize flocculant dosage and feed solids. The dosage represents the amount of flocculant (polymer) in grams for each tonne of material. These tests were carried out in 1 L vessels. Underflow solids were raked after settling for 45 minutes. The results are summarized on Figure 6, Figure 7 and Figure 8.

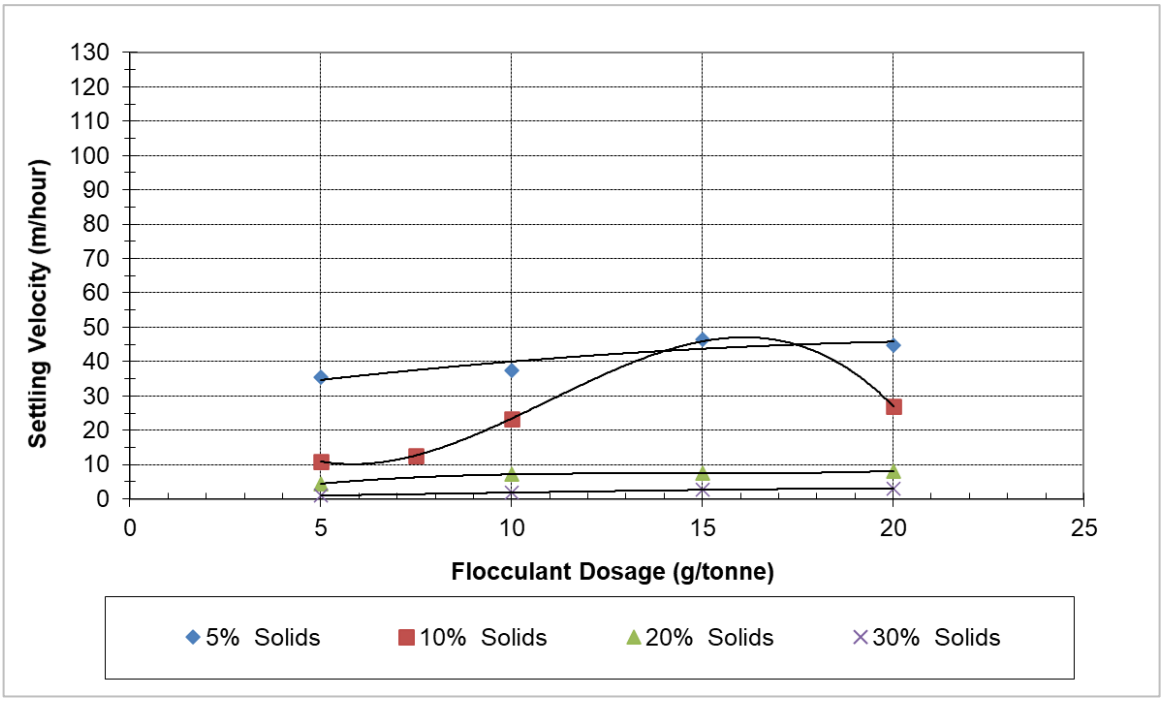

Figure 6: Settling Velocity vs. Flocculant Dosage at Varying Feed Solids

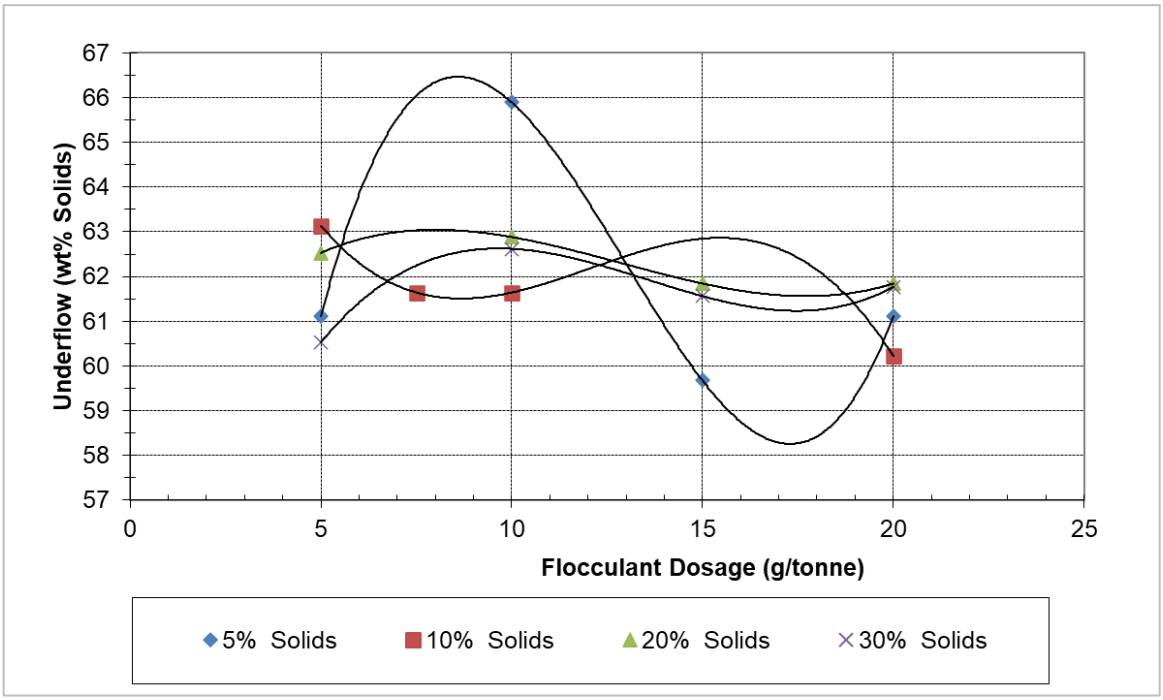

Figure 7: Underflow wt% Solids vs. Flocculant Dosage at Varying Feed Solids

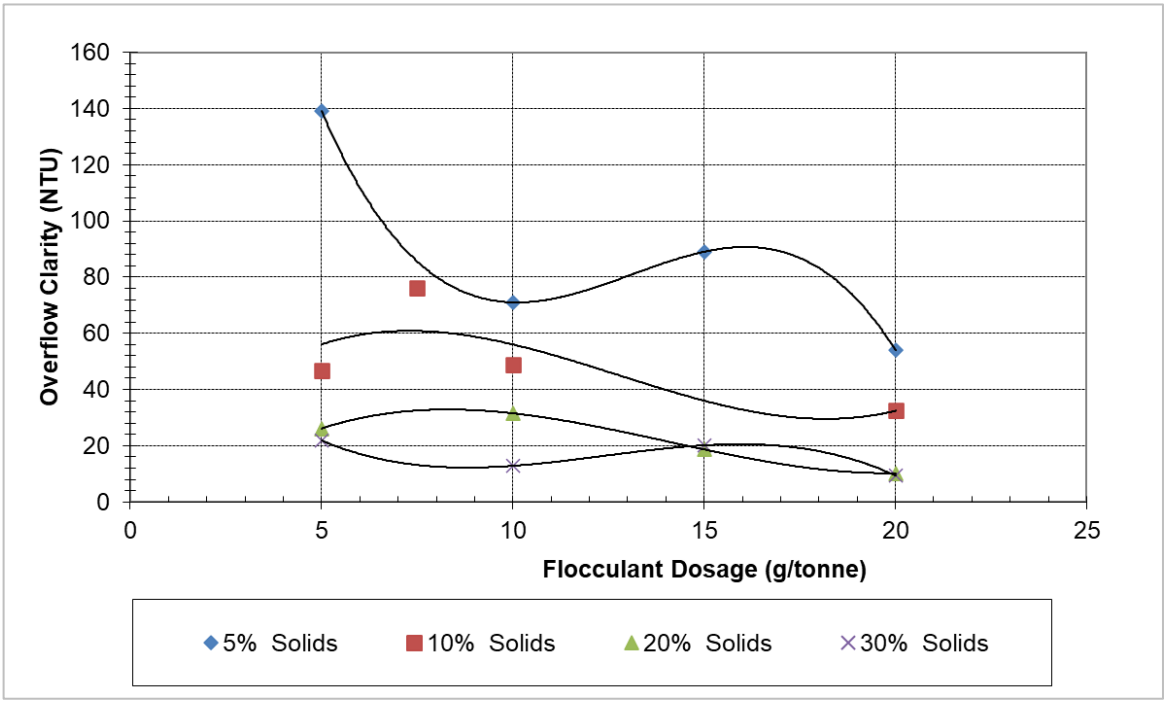

Figure 8: Overflow Clarity vs. Flocculant Dosage at Varying Feed Solids

The optimal conditions from the screening results were carried forward to larger scale 4L tests to more accurately determine the underflow density. These tests are considered static, bench scale and actual underflow solids, depending on thickener technology, may differ.

Based on the results obtained during the screening process, it was determined that a feed density of 5 wt% solids and a flocculant dosage of 10 g/tonne would provide good settling characteristics for the 19131334 Tailings sample. Figure 9 present the settling curves whereas Table 13 provides a summary.

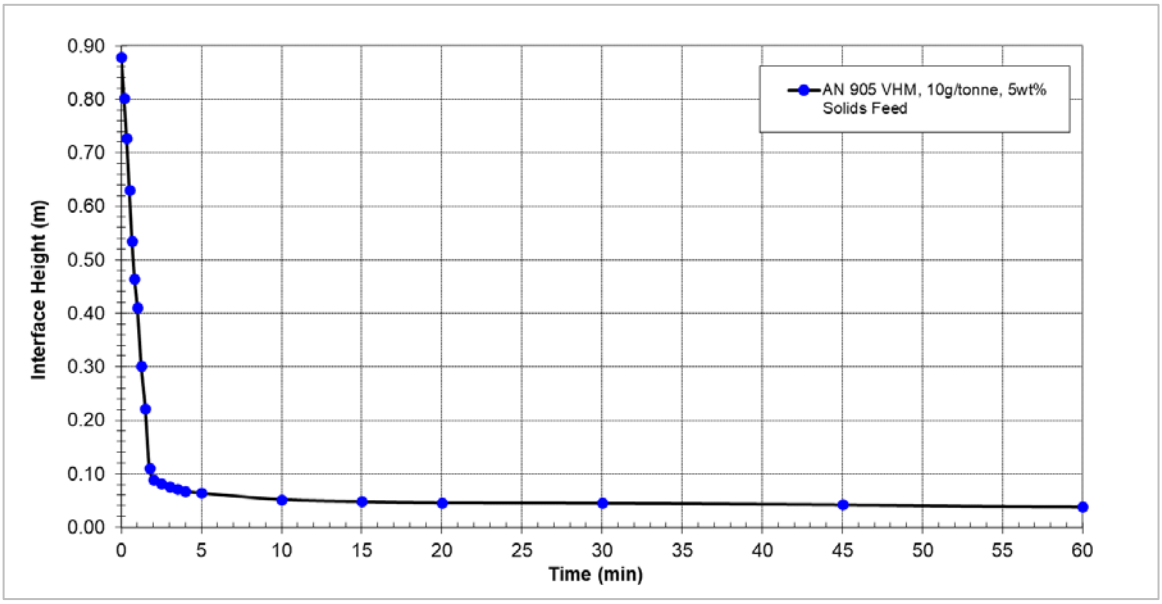

Figure 9: Settling Curve, 5% Solids Feed, 10 g/tonne

Table 13: 4L Settling Summary

Flocculant Dosage (g/tonne)	Feed Solids (wt% solids)	Overflow Clarity after 45 minutes (NTU)	Calculated Underflow Density after 1 hour (wt% solids)	Calculated Underflow Density after 2 hours (wt% solids)	Calculated Underflow Density after 24 hours (wt% solids)	Measured Underflow Density after 24 hours (wt% solids)
10	5	22	67	68	68	65

4.2 Centrifuge Testing

Samples of the underflow solids from the 4L settling tests were centrifuged until no further change in density was observed. This testing provided the ‘phi max’ value, which related to the maximum density achievable by use of high compression gravimetric settling methods. Table 14 presents the results.

Table 14: Centrifuge Results

Flocculant Dosage (g/tonne)	Feed Solids (wt% solids)	Measured Underflow Density from 4L Settling (wt% solids)	Calculated Underflow Density from Centrifuge (wt% solids)
10	5	76	65

4.3 Compression Settling

Additional dewatering testing was performed at a larger scale in order to investigate the effect of bed depth. This test is classified as semi-continuous since flocculated sample is added until a predetermined bed height is achieved while withdrawing excess overflow. Also, when samples are collected from the underflow, additional material is added to the column until the bed depth returns to the original height. The continuously raked bed in the tube was approximately 0.8 m in height. After the test, samples of the underflow were collected at the various depths where wt% solids and yield stress were measured. The results are presented in Table 15 as well as Figure 10.

Table 15: Compression Settling Results

Sample	Flocculant	Feed Solids	Overflow TSS	Settling Test Underflow Density at 4 Hours	Yield Stress before Shearing	Yield Stress after Shearing
		(wt% solids)	(ppm)	(wt% solids)	(Pa)	(Pa)
1st (0-11.2 cm)	10 g/tonne AN 905 VHM	5	15 min – 1021 45 min - 887	79	1947	851
2nd (11.2-24.3 cm)				78	1189	617
3rd (24.3-37.0 cm)				74	275	215
4th (37.0-50.0 cm)				73	249	165

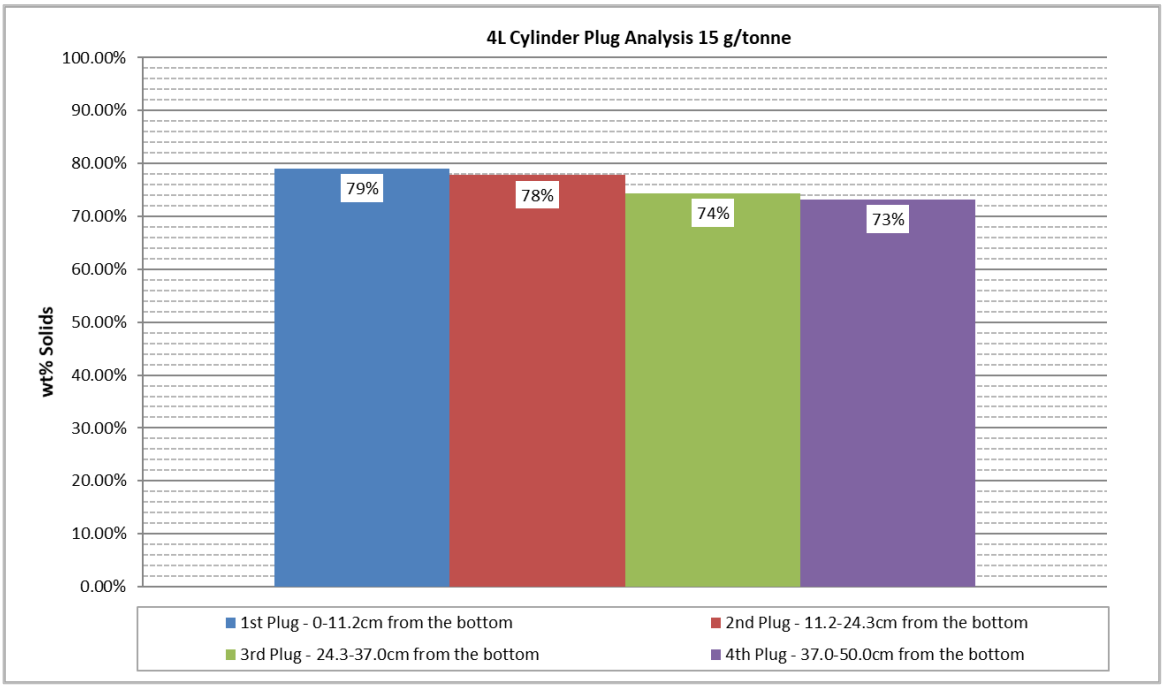

Figure 10: 4L Plug Analysis – 19131334 Tailings

5.0 RHEOLOGICAL CHARACTERIZATION

Rheological testing was carried out to evaluate flow and handling properties. These tests provide an indication regarding the material's behaviour in the course of mixing, slump adjustment, pumping, flowing and also while sitting idle. Rheological characterization provides data for the selection of process equipment such as mixers, pumps and pipelines.

5.1 Slump vs. Solids Content

To gauge sensitivity to water additions, small increments of water were added to the bulk sample. After each addition, slump and solids content was determined. This generates a relationship between slump and solids content which is typically used to determine the degree of process control required to maintain slump control of the final product. The results are presented on Figure 11.

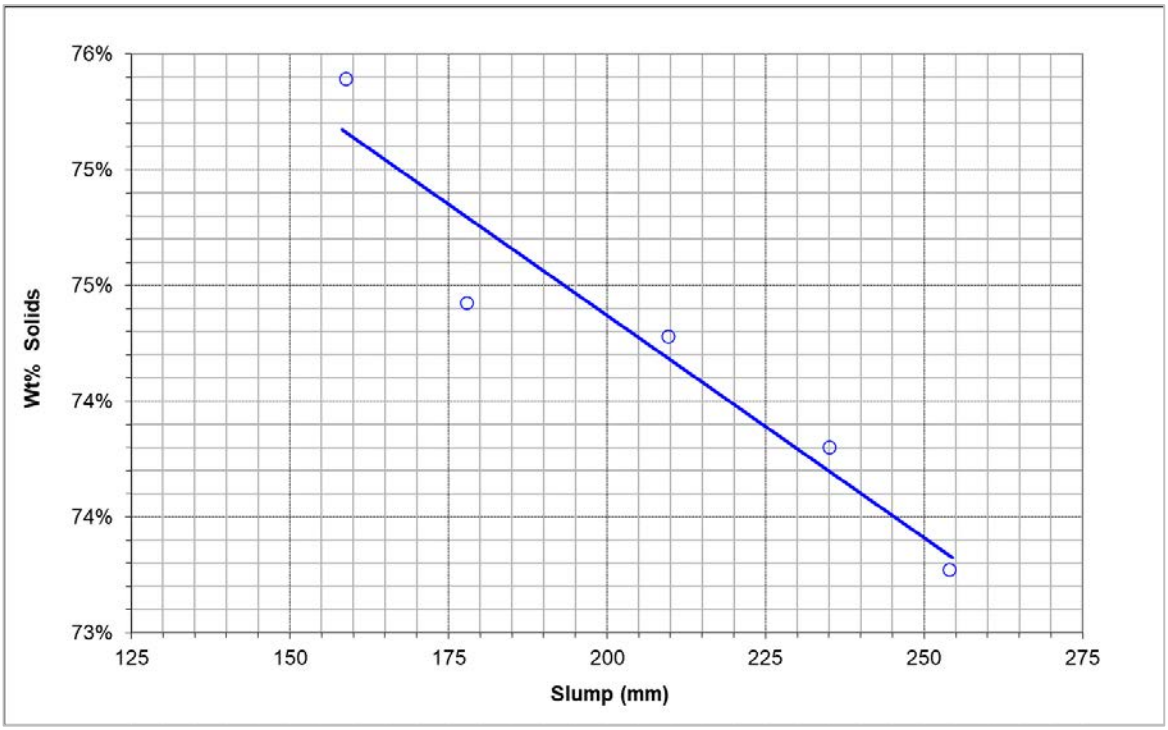

Figure 11: Solids Content vs. Slump

5.2 Static Yield Stress Testing

Yield stress is defined as the minimum force required to initiate flow. Static yield stress was determined by using a very slow moving (0.2 RPM) vane spindle attached to a torque spring. The spindle was immersed in the sample and measurements were taken at various solids contents. There are different test methods to determine yield stress, one termed ‘static’ and the other ‘dynamic’. Figure 12 presents the static yield stress testing results.

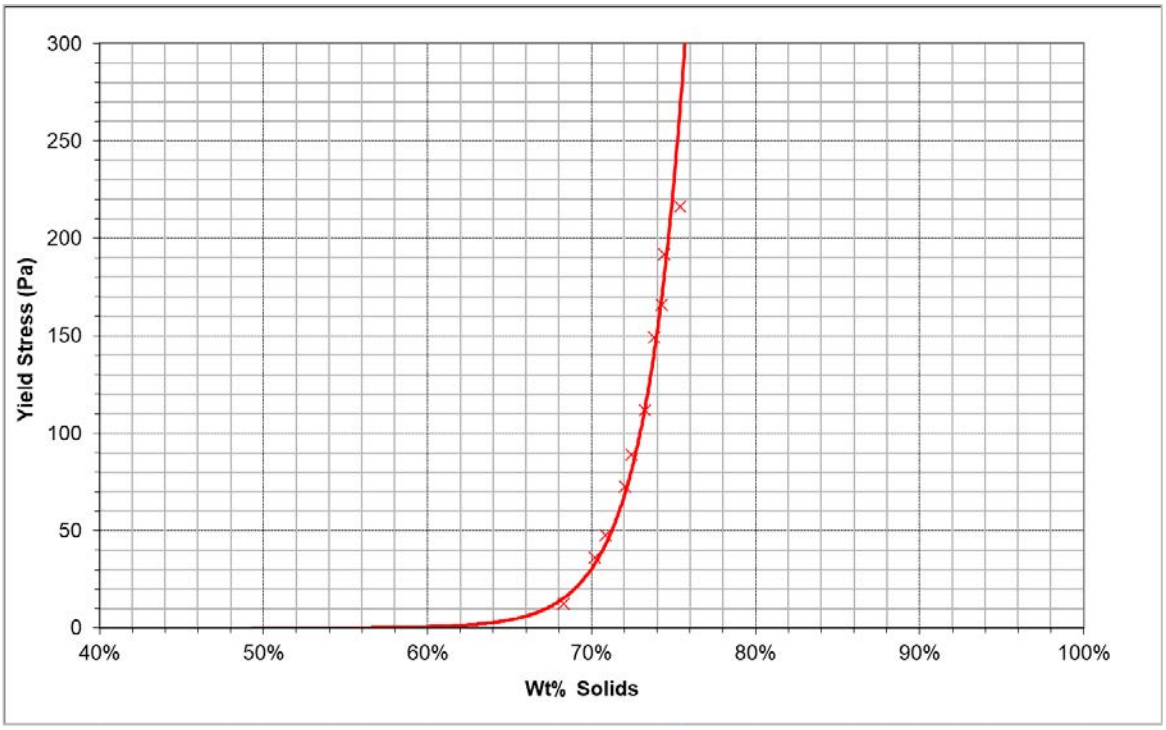

Figure 12: Static Yield Stress vs. wt% Solids

5.3 Water Bleed and Yield Stress vs. Time

Moisture retention testing was carried out to assess the water bleed properties of the paste while sitting idle in test beakers. Two slump consistencies were tested at four time intervals. At each time interval the water bleed and yield stress were measured. Figure 13 presents the results.

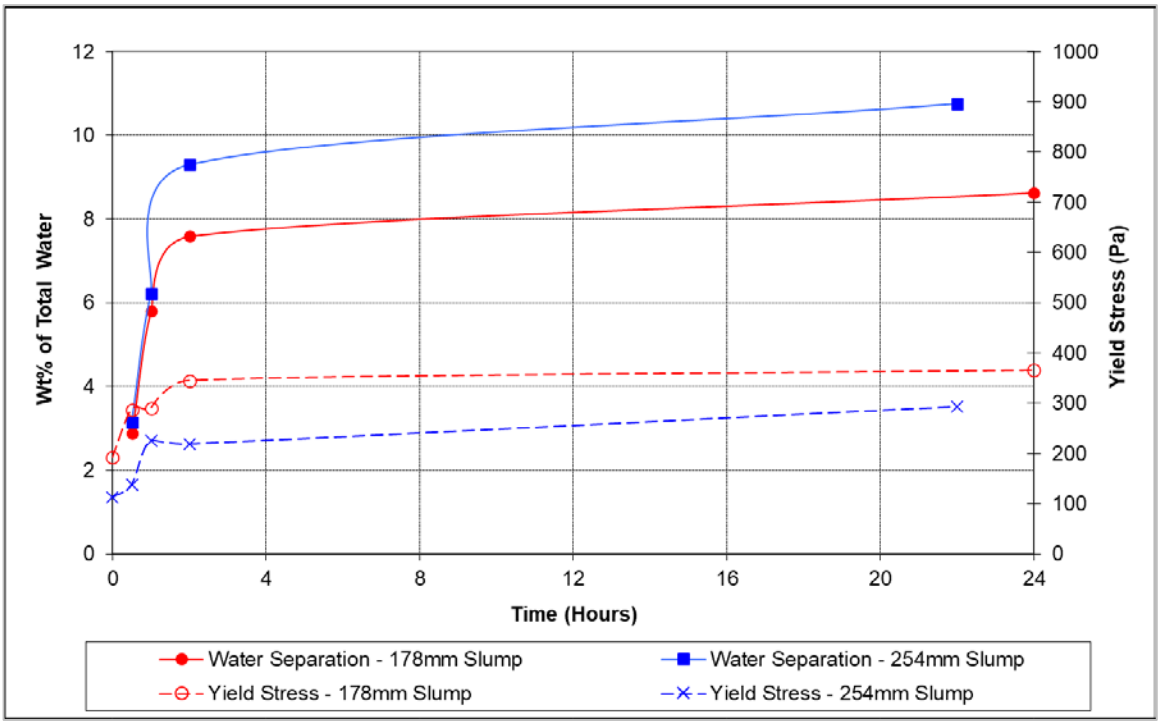

Figure 13: Water Bleed and Yield Stress vs. Time

5.4 Plug Yield Stress

Plug yield stress analysis was performed to determine if consolidation has occurred throughout a cross-section of idle paste material, as may be present in a pipeline's cross-section. Two slump consistencies of material were allowed to sit idle for two hours, and a specially designed vane spindle was immersed at three depths to measure yield stress. Figure 14 presents the results.

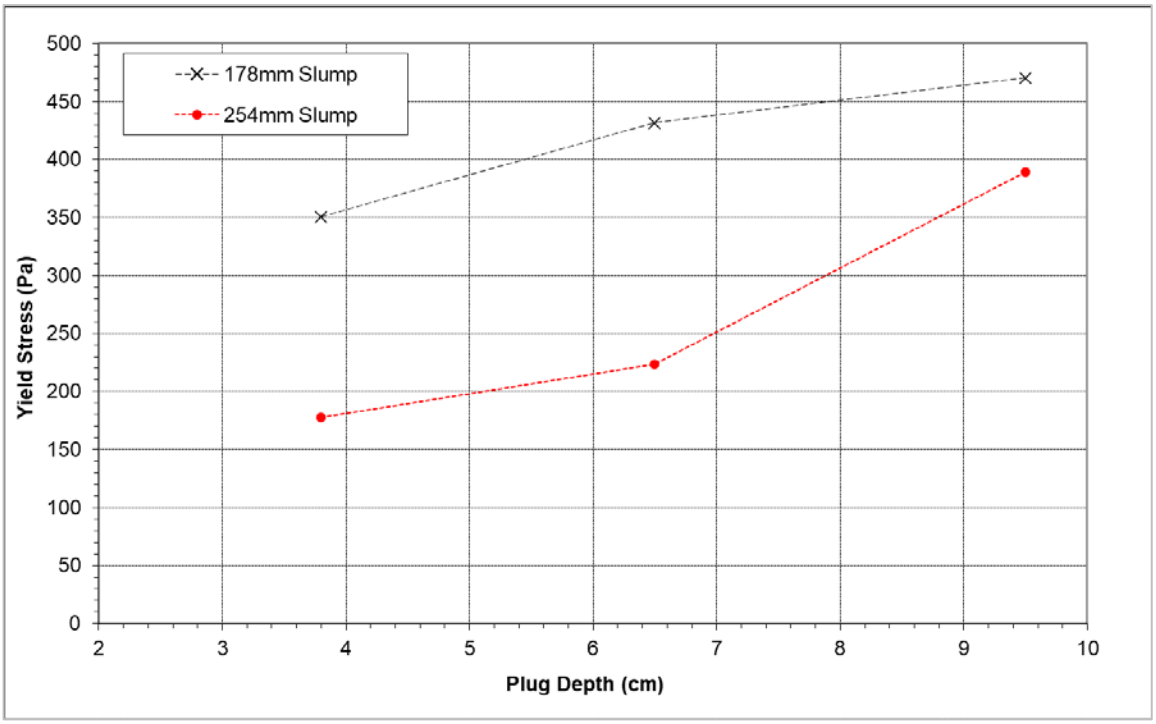

Figure 14: Plug Yield Stress Results

5.5 Viscosity and Dynamic Yield Stress Determination

Viscosity testing provides bench scale flow properties and fluid characterization. Dynamic viscosity and yield stress data is essential for mixer, pump and pipeline design. In order to compare or duplicate viscosity results of non-Newtonian fluids, it is important to test according to the same conditions. Test conditions and parameters such as cycle time and instrument sensor configuration are critical to producing usable data from bench scale viscometers.

The yield stress determined through this testing is referred to as dynamic yield stress since it is extrapolated from dynamic shear stress data to zero shear. The instrument sensor or bob rotated inside the cup which contained the sample and torque measurements were recorded at several incremental speeds or shear rates.

Viscosity testing was completed at two temperatures to determine the effects temperature has on the flow properties and fluid characteristics. The temperatures the testing was completed at was 20°C and 6°C.

The rheograms are presented in Appendix C and summarized test results are presented in Table 16 and Table 17 as well as on Figure 15 through Figure 18.

Table 16: Bingham Viscosity and Yield Stress Summary – 19131334 Tailings at 20°C

Wt% Solids	Bingham Yield Stress (Pa)		Bingham Viscosity (PaS)	
	Ramp Up	Ramp Down	Ramp Up	Ramp Down
74.8	254	140	0.830	0.929
73.5	145	103	0.674	0.697
73.0	138	93	0.586	0.610
72.5	92	65	0.395	0.419
71.5	71	56	0.374	0.369
69.9	37	28	0.143	0.145
68.2	22	18	0.075	0.310

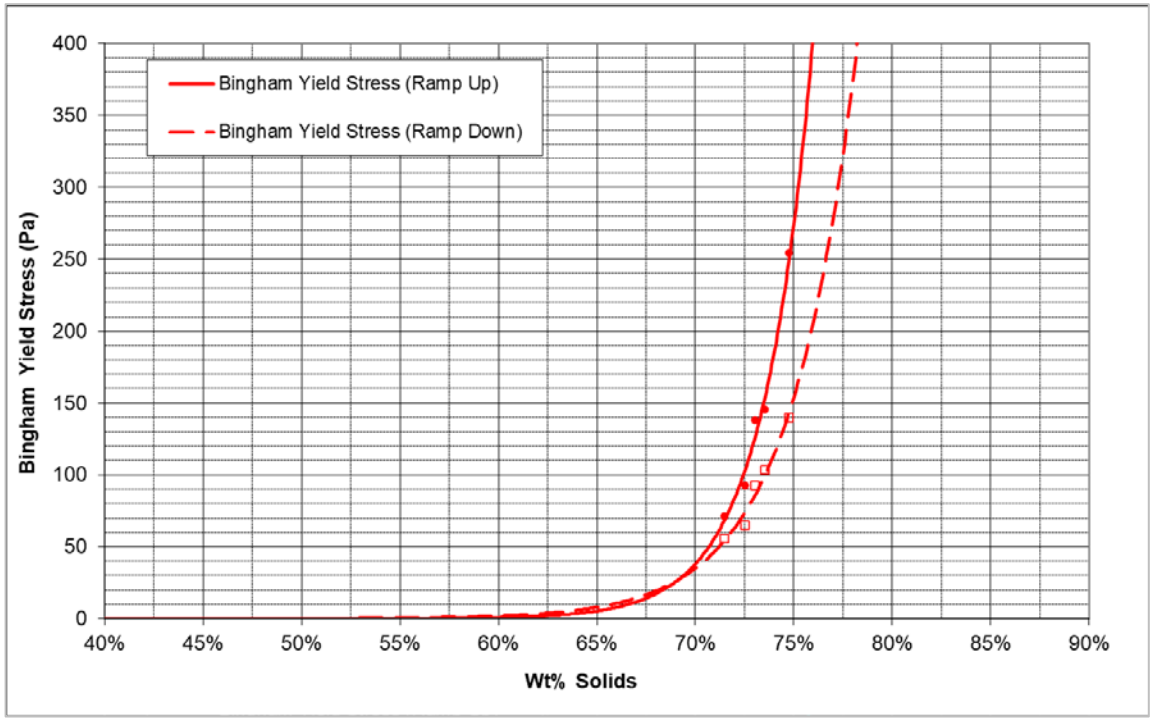

Figure 15: Bingham Yield Stress Results – 19131334 Tailings at 20°C

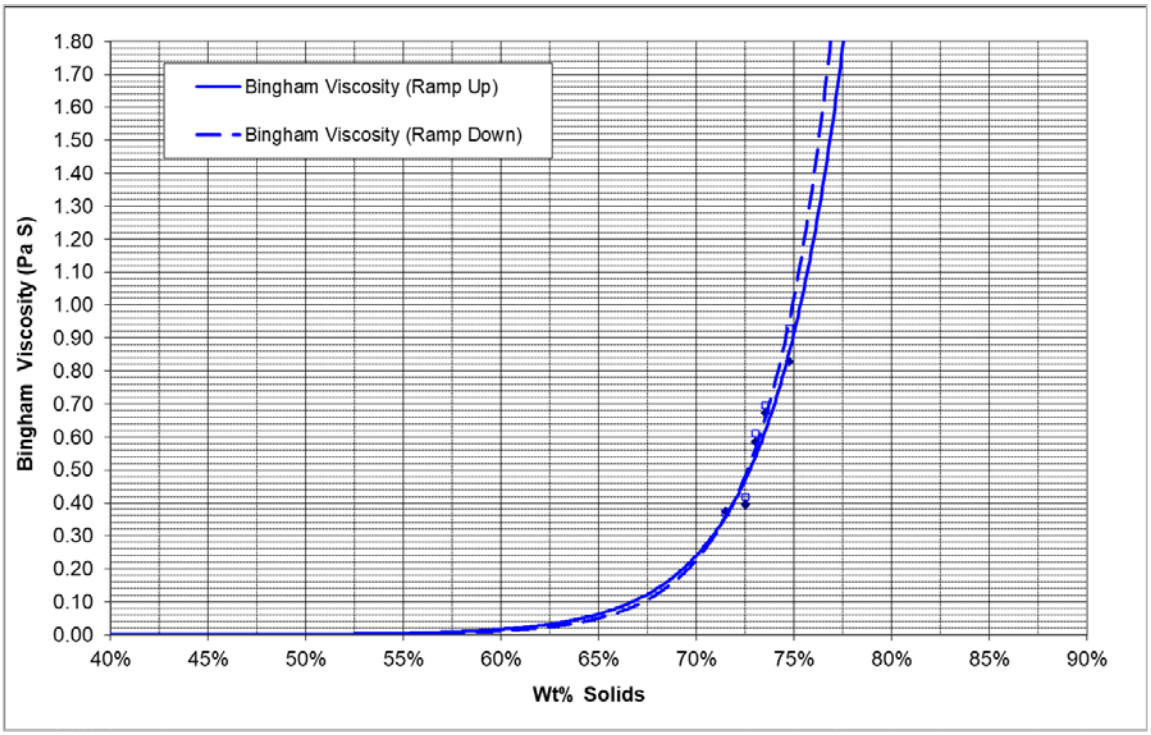

Figure 16: Bingham Viscosity Results – 19131334 Tailings at 20°C

Table 17: Bingham Viscosity and Yield Stress Summary – Tailings at 6°C

Wt% Solids	Bingham Yield Stress (Pa)		Bingham Viscosity (PaS)	
	Ramp Up	Ramp Down	Ramp Up	Ramp Down
75	319	170	1.134	1.275
74	254	136	0.853	0.964
73	163	103	0.643	0.691
72	92	70	0.437	0.454
71	66	50	0.288	0.297
70	68	30	0.147	0.151
68	23	18	0.325	0.087

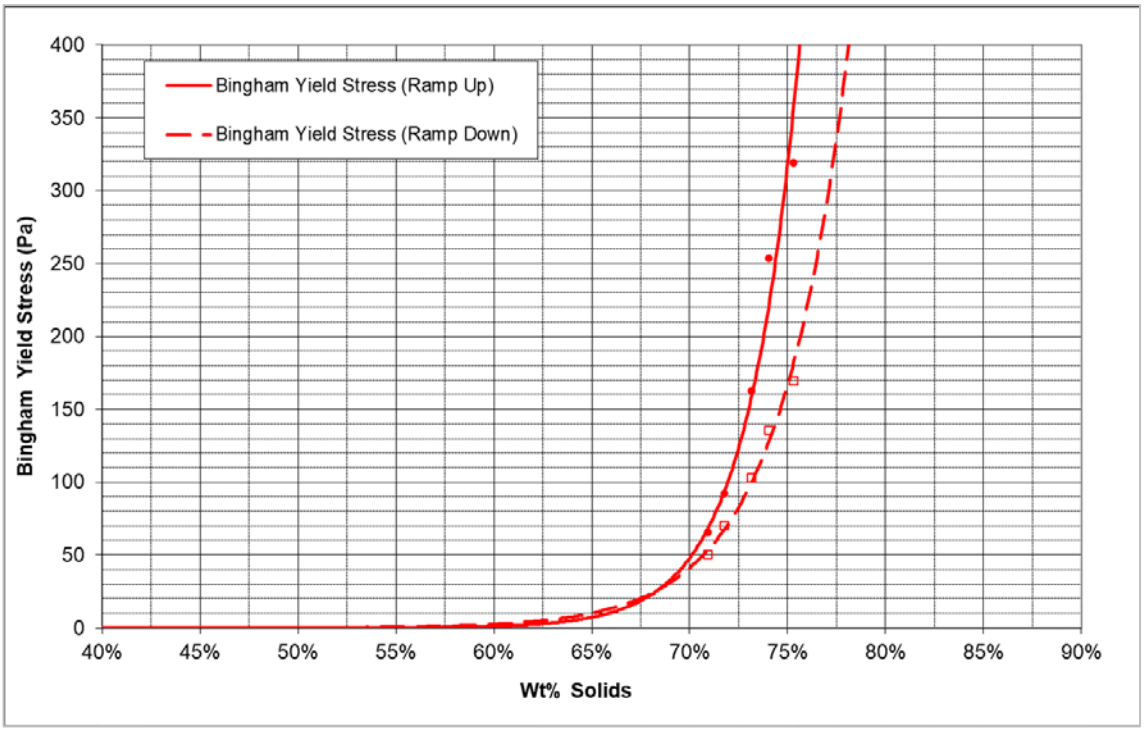

Figure 17: Bingham Yield Stress Results – Tailings at 6°C

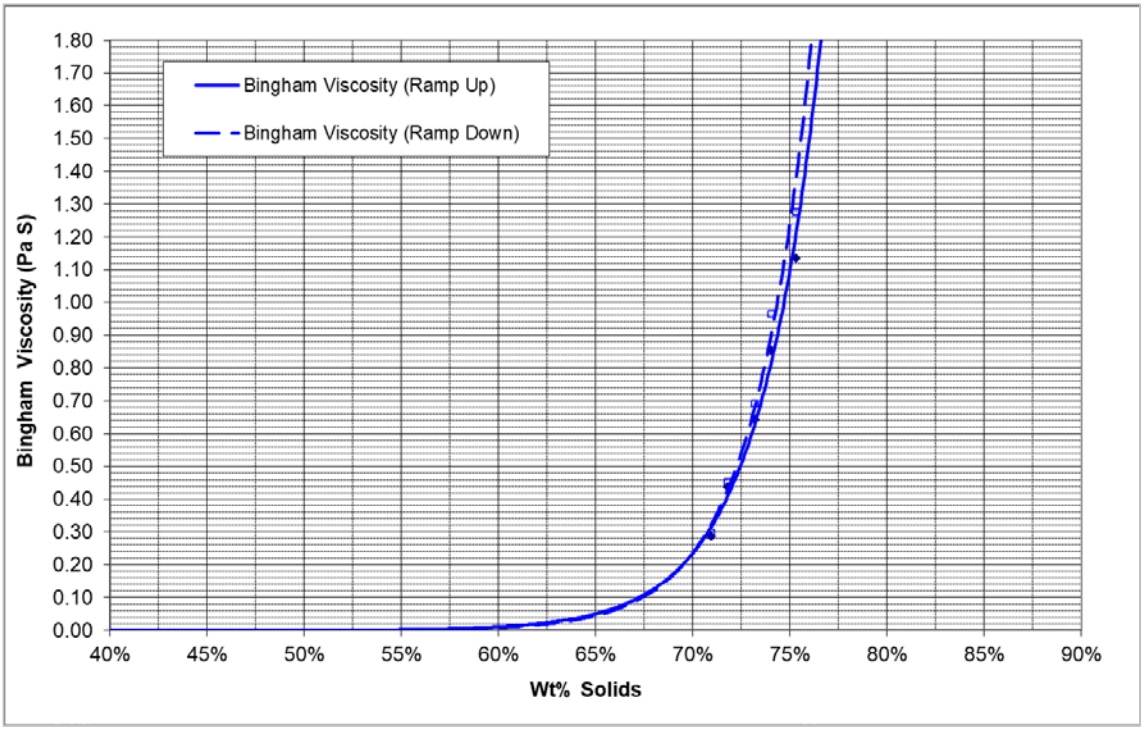

Figure 18: Bingham Viscosity Results – Tailings at 6°C

6.0 CLOSURE

If there are any questions regarding this report, please do not hesitate to contact the undersigned.

Golder Associates Ltd.

<Original signed by>

Victoria Newman
Laboratory Supervisor

<Original signed by>

Pierre Primeau, P. Eng.
Senior Process Engineer

VN/PP/mc

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https://golderassociates.sharepoint.com/sites/117654/project files/6 deliverables/012 - tailings characterization/19131334 troilus lab report - june 3, 2021.docx

APPENDIX A

ICPMS

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: GOLDER ASSOCIATES
33 MACKENZIE STREET SUITE 100
SUDBURY, ON P3C4Y1
(705) 524-6861
ATTENTION TO: Mark Labelle
PROJECT: 19131334
AGAT WORK ORDER: 21U718813
SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Lab Manager
DATE REPORTED: Mar 10, 2021
PAGES (INCLUDING COVER): 9
VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*Notes

Disclaimer:

- *All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.*
- *All samples will be disposed of within 30 days following analysis, unless expressly agreed otherwise in writing. Please contact your Client Project Manager if you require additional sample storage time.*
- *AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.*
- *This Certificate shall not be reproduced except in full, without the written approval of the laboratory.*
- *The test results reported herewith relate only to the samples as received by the laboratory.*
- *Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, warranties of merchantability, fitness for a particular purpose, or non-infringement. AGAT assumes no responsibility for any errors or omissions in the guidelines contained in this document.*
- *All reportable information as specified by ISO/IEC 17025:2017 is available from AGAT Laboratories upon request.*

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Western Enviro-Agricultural Laboratory Association (WEALA)
Environmental Services Association of Alberta (ESAA)

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AGAT Laboratories

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http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 21U718813

PROJECT: 19131334

CLIENT NAME: GOLDER ASSOCIATES

ATTENTION TO: Mark Labelle

SAMPLING SITE:

SAMPLED BY:

Free CN (Soil)

DATE RECEIVED: 2021-03-05

DATE REPORTED: 2021-03-10

				SAMPLE DESCRIPTION:	**19131334 Tailings**
				SAMPLE TYPE:	**Soil**
				DATE SAMPLED:	**2021-03-05 14:45**
Parameter	**Unit**	**G / S**	**RDL**	**2189552**	
Cyanide, Free	µg/g		0.040	<0.040	

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Analysis performed at AGAT Toronto (unless marked by *)

<Original signed by>

Certified By:

Results relate only to the items tested. Results apply to samples as received.

AGAT Laboratories

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Certificate of Analysis

AGAT WORK ORDER: 21U718813

PROJECT: 19131334

CLIENT NAME: GOLDER ASSOCIATES

ATTENTION TO: Mark Labelle

SAMPLING SITE:

SAMPLED BY:

Metals Scan (Soil)

DATE RECEIVED: 2021-03-05

DATE REPORTED: 2021-03-10

				19131334
		SAMPLE DESCRIPTION:		Tailings
		SAMPLE TYPE:		Soil
		DATE SAMPLED:		2021-03-05 14:45
Parameter	Unit	G / S	RDL	2189552
Aluminum	µg/g		100	13100
Antimony	µg/g		0.8	<0.8
Arsenic	µg/g		1	5
Barium	µg/g		2.0	86.3
Beryllium	µg/g		0.4	<0.4
Bismuth	µg/g		0.1	1.0
Boron	µg/g		5	<5
Cadmium	µg/g		0.5	<0.5
Calcium	µg/g		10	3410
Cerium	µg/g		0.01	29.1
Cesium	µg/g		0.01	2.97
Chromium	µg/g		5	143
Cobalt	µg/g		0.5	29.7
Copper	µg/g		1.0	334
Europium	µg/g		1	<1
Gallium	µg/g		0.50	7.60
Iron	µg/g		500	33700
Lanthanum	µg/g		0.1	13.4
Lead	µg/g		1	1
Lithium	µg/g		0.5	17.6
Magnesium	µg/g		10	15800
Manganese	µg/g		5.0	159
Mercury	µg/g		0.10	<0.10
Molybdenum	µg/g		0.5	2.4
Nickel	µg/g		1	74
Niobium	µg/g		0.05	0.20
Phosphorus	µg/g		10	445
Potassium	µg/g		10	12500

<Original signed by>

Certified By:

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Certificate of Analysis

AGAT WORK ORDER: 21U718813

PROJECT: 19131334

CLIENT NAME: GOLDER ASSOCIATES

ATTENTION TO: Mark Labelle

SAMPLING SITE:

SAMPLED BY:

Metals Scan (Soil)

DATE RECEIVED: 2021-03-05

DATE REPORTED: 2021-03-10

			SAMPLE DESCRIPTION:	19131334 Tailings
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	2021-03-05 14:45
Parameter	Unit	G / S	RDL	2189552
Rubidium	µg/g		0.10	96.3
Scandium	µg/g		0.50	4.99
Selenium	µg/g		0.8	<0.8
Silicon	µg/g		20	250
Silver	µg/g		0.5	0.6
Sodium	µg/g		10	369
Strontium	µg/g		5	6
Sulfur	µg/g		20	8190
Tellurium	µg/g		0.01	513
Thallium	µg/g		0.5	<0.5
Thorium	µg/g		0.4	1.8
Tin	µg/g		1	<1
Titanium	µg/g		10	1640
Tungsten	µg/g		0.50	1.31
Uranium	µg/g		0.50	<0.50
Vanadium	µg/g		0.4	74.9
Yttrium	µg/g		0.05	3.21
Zinc	µg/g		5	29
Zirconium	µg/g		1.0	7.2

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

2189552 Dilution required, RDL has been increased accordingly.

Analysis performed at AGAT Toronto (unless marked by *)

<Original signed by>

Certified By:

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Quality Assurance

CLIENT NAME: GOLDER ASSOCIATES

AGAT WORK ORDER: 21U718813

PROJECT: 19131334

ATTENTION TO: Mark Labelle

SAMPLING SITE:

SAMPLED BY:

Soil Analysis

RPT Date: Mar 10, 2021			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Free CN (Soil)															
Cyanide, Free	2171976		<0.040	<0.040	NA	< 0.040	95%	70%	130%	103%	80%	120%	101%	70%	130%
Metals Scan (Soil)															
Aluminum	2176412		22400	22500	0.4%	< 10.0	95%	70%	130%	100%	80%	120%	NA	70%	130%
Antimony	2176412		<0.8	<0.8	NA	< 0.8	117%	70%	130%	96%	80%	120%	92%	70%	130%
Arsenic	2176412		6	5	18.2%	< 1	118%	70%	130%	92%	80%	120%	97%	70%	130%
Barium	2176412		98.4	93.7	4.9%	< 2.0	99%	70%	130%	99%	80%	120%	97%	70%	130%
Beryllium	2176412		0.8	0.8	NA	< 0.4	86%	70%	130%	95%	80%	120%	82%	70%	130%
Bismuth	2176412		0.2	0.2	NA	< 0.1	92%	70%	130%	90%	80%	120%	82%	70%	130%
Boron	2176412		10	10	NA	< 5	78%	70%	130%	98%	80%	120%	71%	70%	130%
Cadmium	2176412		<0.5	<0.5	NA	< 0.5	108%	70%	130%	100%	80%	120%	95%	70%	130%
Calcium	2176412		36100	36900	2.2%	< 10	97%	70%	130%	97%	80%	120%	95%	70%	130%
Cerium	2176412		46.7	47.0	0.6%	< 0.01	104%	70%	130%	102%	80%	120%	108%	70%	130%
Cesium	2176412		1.54	1.51	2.0%	< 0.01	104%	70%	130%	102%	80%	120%	106%	70%	130%
Chromium	2176412		33	31	6.3%	< 5	110%	70%	130%	99%	80%	120%	102%	70%	130%
Cobalt	2176412		13.4	12.6	6.2%	< 0.5	108%	70%	130%	97%	80%	120%	99%	70%	130%
Copper	2176412		28.8	27.2	5.7%	< 1.0	96%	70%	130%	100%	80%	120%	99%	70%	130%
Europium	2176412		1	1	NA	< 1	106%	70%	130%	101%	80%	120%	103%	70%	130%
Gallium	2176412		6.48	6.50	0.3%	< 0.50	96%	70%	130%	96%	80%	120%	93%	70%	130%
Iron	2176412		33400	33200	0.6%	< 50	113%	70%	130%	93%	80%	120%	NA	70%	130%
Lanthanum	2176412		19.9	19.3	3.1%	< 0.1	104%	70%	130%	102%	80%	120%	110%	70%	130%
Lead	2176412		18	17	5.7%	< 1	101%	70%	130%	93%	80%	120%	88%	70%	130%
Lithium	2176412		25.0	23.6	5.8%	< 0.5	88%	70%	130%	97%	80%	120%	101%	70%	130%
Magnesium	2176412		9850	10100	2.5%	< 10	103%	70%	130%	101%	80%	120%	103%	70%	130%
Manganese	2176412		860	810	6.0%	< 5.0	114%	70%	130%	96%	80%	120%	90%	70%	130%
Mercury	2176412		0.10	<0.10	NA	< 0.10	101%	70%	130%	92%	80%	120%	85%	70%	130%
Molybdenum	2176412		<0.5	<0.5	NA	< 0.5	114%	70%	130%	101%	80%	120%	100%	70%	130%
Nickel	2176412		28	27	3.6%	< 1	109%	70%	130%	99%	80%	120%	96%	70%	130%
Niobium	2176412		0.526	0.460	13.4%	< 0.05	98%	70%	130%	89%	80%	120%	100%	70%	130%
Phosphorus	2176412		695	651	6.5%	< 10	92%	70%	130%	94%	80%	120%	100%	70%	130%
Potassium	2176412		3520	3560	1.1%	< 10	121%	70%	130%	100%	80%	120%	100%	70%	130%
Rubidium	2176412		23.2	24.3	4.6%	< 0.10	104%	70%	130%	100%	80%	120%	101%	70%	130%
Scandium	2176412		5.77	5.62	2.6%	< 0.50	98%	70%	130%	97%	80%	120%	93%	70%	130%
Selenium	2176412		<0.8	<0.8	NA	< 0.8	113%	70%	130%	97%	80%	120%	99%	70%	130%
Silicon	2176412		433	404	6.9%	< 20	95%	70%	130%	89%	80%	120%	95%	70%	130%
Silver	2176412		<0.5	<0.5	NA	< 0.5	98%	70%	130%	97%	80%	120%	91%	70%	130%
Sodium	2176412		259	263	1.5%	< 10	108%	70%	130%	99%	80%	120%	100%	70%	130%
Strontium	2176412		70	66	5.9%	< 5	105%	70%	130%	95%	80%	120%	89%	70%	130%
Sulfur	2176412		540	496	8.5%	< 20	100%	70%	130%	89%	80%	120%	100%	70%	130%

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Results relate only to the items tested. Results apply to samples as received.

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http://www.agatlabs.com

Quality Assurance

CLIENT NAME: GOLDER ASSOCIATES

AGAT WORK ORDER: 21U718813

PROJECT: 19131334

ATTENTION TO: Mark Labelle

SAMPLING SITE:

SAMPLED BY:

Soil Analysis (Continued)

RPT Date: Mar 10, 2021			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Tellurium	2176412		< 0.01	< 0.01	NA	< 0.01	104%	70%	130%	107%	80%	120%	102%	70%	130%
Thallium	2176412		<0.5	<0.5	NA	< 0.5	105%	70%	130%	95%	80%	120%	94%	70%	130%
Thorium	2176412		4.96	4.85	2.2%	< 0.4	104%	70%	130%	101%	80%	120%	107%	70%	130%
Tin	2176412		1	1	NA	< 1	112%	70%	130%	92%	80%	120%	89%	70%	130%
Titanium	2176412		198	172	14.1%	< 1.0	104%	70%	130%	95%	80%	120%	115%	70%	130%
Tungsten	2176412		< 0.50	< 0.50	NA	< 0.50	102%	70%	130%	93%	80%	120%	95%	70%	130%
Uranium	2176412		0.65	0.59	NA	< 0.50	101%	70%	130%	92%	80%	120%	91%	70%	130%
Vanadium	2176412		46.2	43.0	7.2%	< 0.4	122%	70%	130%	100%	80%	120%	102%	70%	130%
Yttrium	2176412		16.0	16.4	2.5%	< 0.05	104%	70%	130%	101%	80%	120%	113%	70%	130%
Zinc	2176412		90	84	6.9%	< 5	108%	70%	130%	103%	80%	120%	104%	70%	130%
Zirconium	2176412		3.9	3.7	NA	< 1.0	98%	70%	130%	93%	80%	120%	94%	70%	130%

Comments: NA Signifies Not Applicable
Duplicate NA: results are under 5X the RDL and will not be calculated.
Matrix spike NA: Spike level < native concentration. Matrix spike acceptance limits do not apply and are not calculated.

Certified By: <Original signed by>

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http://www.agatlabs.com

Method Summary

CLIENT NAME: GOLDER ASSOCIATES

AGAT WORK ORDER: 21U718813

PROJECT: 19131334

ATTENTION TO: Mark Labelle

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Cyanide, Free	INOR-93-6052	modified from ON MOECC E3015, SM 4500-CN- I, G-387	TECHNICON AUTO ANALYZER
Aluminum	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Antimony	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Arsenic	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Barium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Beryllium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Bismuth	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Boron	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Cadmium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Calcium	MET-93-6105	modified from EPA 6010D	ICP/OES
Cerium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Cesium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Chromium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Cobalt	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Copper	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Europium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Gallium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Iron	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Lanthanum	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Lead	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Lithium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Magnesium	MET-93-6105	modified from EPA 6010D	ICP/OES
Manganese	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Mercury	MET-93-6103	modified from EPA 7471B and SM 3112 B	ICP-MS
Molybdenum	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Nickel	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Niobium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Phosphorus	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Potassium	MET-93-6105	modified from EPA 6010D	ICP/OES

Results relate only to the items tested. Results apply to samples as received.

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TEL (905)712-5100
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http://www.agatlabs.com

Method Summary

CLIENT NAME: GOLDER ASSOCIATES

AGAT WORK ORDER: 21U718813

PROJECT: 19131334

ATTENTION TO: Mark Labelle

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Rubidium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Scandium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Selenium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Silicon	MET-93-6105	modified from EPA 6010D	ICP/OES
Silver	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Sodium	MET-93-6105	modified from EPA 6010D	ICP/OES
Strontium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Sulfur	MET-93-6105	modified from EPA 6010D	ICP/OES
Tellurium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Thallium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Thorium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Tin	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Titanium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Tungsten	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Uranium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Vanadium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Yttrium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Zinc	MET 93 -6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Zirconium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS

Results relate only to the items tested. Results apply to samples as received.

AGAT Laboratories

8:5/8:6/8:7 on ice

5835 Coopers Avenue
Mississauga, Ontario
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com

Laboratory Use Only
Arrival Temperature: 12.0, 12.1, 12.0
AGAT WO #: 21U718813
Lab Temperature:
Notes: no ice / packs

Chain of Custody Record

Ph.: 905.712.5100 · Fax: 905.712.5122 · Toll Free: 800.856.6261

Client Information:

Company: Golder Associates
Contact: PED Laboratory
Address: 33 Mackenzie, Suite 100
Sudbury, ON P3C 4Y1
Phone: 705-524-6861 Fax: 705-524-1984
Project: 19131334 PO: 881900
AGAT Quotation #:

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements:

☐ Regulation 153/09 (reg. 511 Amend.)
Table ____ Indicate one
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture (check one)
☐ Coarse ☐ Fine

☐ Sewer Use
Region ____ Indicate one
☐ Sanitary
☐ Storm

☐ Regulation 558
☐ CCME
☐ Other (specify)
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*

Regular TAT
☐ 5 to 7 Working Days

Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☑ 1 Working Day

OR
Date Required (Rush surcharges may apply):

*TAT is exclusive of weekends and statutory holidays

Invoice To:

Same: Yes ☑ No ☐
Company:
Contact:
Address:

Is this a drinking water sample? (potable water intended for human consumption) ☐ Yes ☑ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition?** ☐ Yes ☑ No

Legend Matrix

GW Ground Water O Oil
SW Surface Water P Paint
SD Sediment S Soil

Report Information – reports to be sent to:

1. Name: Mark Labelle
   Email: mlabelle@golder.com
2. Name: Vicki Newman
   Email: vnewman@golder.com

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6- ☐ SAR ☐ NO_3/NO_2 ☐ N-Total ☐ Hg ☐ pH	Nutients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_3	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	TCLP:	Sewer Use	WADCN
19131334 Tailings	05/03/2021	2:45pm	S	1			X														X

Samples Relinquished by (print name & sign): Matt Johnston Matt
Date/Time: 05/03/21 4:45pm
Samples Received by (Print name & sign): Jeremy Runshaw
Date/Time: 05/03/21
Samples Relinquished by (print name & sign): To ProCatter
Date/Time: 21/03/08 3:00pm
Samples Received by (Print name & sign):
Date/Time: Mar-9 9:09. 4:45

Pink Copy – Client
Yellow + Golden Copy – AGAT
White Copy – AGAT

Page 1 of 1
NO:

APPENDIX B

Environmental Analysis

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Strong 4-acid Digest

Project : CA20M-00000-110-18115-02

27-April-2021

SGS Lakefield Internal Met-Min
Attn : John Patsias

Date Rec. : 20 April 2021
LR Report: **CA11005-APR21**

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: 19131334 Trolus Tailings
Silver [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	0.7
Aluminum [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	85000
Arsenic [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	4.8
Barium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	150
Beryllium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	0.60
Bismuth [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	2
Calcium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	28000
Cadmium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	0.10
Cobalt [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	50
Chromium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	240
Copper [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	340
Iron [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	45000
Potassium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	14000
Lithium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	23
Magnesium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	22000
Manganese [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	320
Molybdenum [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	3.9
Nickel [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	93
Lead [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	4
Antimony [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	< 0.8
Selenium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	< 0.7
Tin [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	< 6
Strontium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	250
Titanium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	3100
Thallium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	0.63
Uranium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	0.75
Vanadium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	120
Yttrium [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	9.77
Zinc [µg/g]	26-Apr-21	16:34	27-Apr-21	10:10	36

OnLine LIMS

00024753 74

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Test method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples. SGS Canada Inc. Environment-Health & Safety statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : CA20M-00000-110-18115-02
LR Report : **CA11005-APR21**

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<Original signed by>

Chris Sullivan, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

OnLine LIMS

0002475374

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SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

ABA - Modified Sobek

Project : CA20M-00000-110-18115-02

29-April-2021

SGS Lakefield Internal Met-Min
Attn : John Patsias

Date Rec. : 20 April 2021
LR Report: **CA11004-APR21**

,

Copy: #1

Phone:
Fax:

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: 19131334 Trolus Tailings
Paste pH [no unit]	27-Apr-21	14:05	29-Apr-21	09:06	9.07
Fizz Rate [no unit]	27-Apr-21	14:05	29-Apr-21	09:06	2
Sample weight [g]	27-Apr-21	14:05	29-Apr-21	09:06	2.02
HCl Added [mL]	28-Apr-21	12:08	29-Apr-21	09:06	23.10
HCl [Normality]	27-Apr-21	14:05	29-Apr-21	09:06	0.10
NaOH [Normality]	27-Apr-21	14:05	29-Apr-21	09:06	0.10
NaOH to pH=8.3 [mL]	28-Apr-21	14:08	29-Apr-21	09:06	16.78
Final pH [no unit]	28-Apr-21	14:08	29-Apr-21	09:06	1.73
NP [t CaCO3/1000 t]	28-Apr-21	14:08	29-Apr-21	09:06	15.6
AP [t CaCO3/1000 t]	29-Apr-21	16:59	29-Apr-21	16:59	22.8
Net NP [t CaCO3/1000 t]	29-Apr-21	16:59	29-Apr-21	16:59	-7.21
NP/AP [ratio]	29-Apr-21	16:59	29-Apr-21	16:59	0.68
Sulphur (total) [%]	28-Apr-21	06:40	29-Apr-21	16:59	0.887
Acid Leachable SO4-S [%]	29-Apr-21	16:59	29-Apr-21	16:59	0.16
Sulphide [%]	29-Apr-21	12:21	29-Apr-21	16:59	0.73
Carbon (total) [%]	28-Apr-21	06:40	28-Apr-21	18:28	0.040
Carbonate [%]	28-Apr-21	11:54	28-Apr-21	18:28	< 0.025

<Original signed by>

Chris Sullivan, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

OnLine LIMS

0002479206

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SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : CA20M-00000-110-18115-02
LR Report : **CA11004-APR21**

*NP (Neutralization Potential)

$$= \frac{50 \times (N \text{ of HCL} \times \text{Total HCL added} - N \text{ NaOH} \times \text{NaOH added})}{\text{Weight of Sample}}$$

*AP (Acid Potential) = % Sulphide Sulphur x 31.25
*Net NP (Net Neutralization Potential) = NP-AP
NP/AP Ratio = NP/AP
*Results expressed as tonnes CaCO3 equivalent/1000 tonnes of material
Samples with a % Sulphide value of <0.02 will be calculated using a 0.02 value.

OnLine LIMS

0002479206

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SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Quebec MA200-Met 1.2 Digest

Project : CA20M-00000-110-18115-02

28-April-2021

SGS Lakefield Internal Met-Min
Attn : John Patsias

Date Rec. : 20 April 2021
LR Report: **CA11006-APR21**

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Completed Date	4: Analysis Completed Time	5: 19131334 Trolus Tailings
Silver [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	0.7
Aluminum [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	19000
Arsenic [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	4.9
Boron [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	1
Barium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	110
Beryllium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	0.06
Bismuth [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	1.8
Calcium [µg/g]	26-Apr-21	12:04	26-Apr-21	13:02	4400
Cadmium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	0.08
Cobalt [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	25
Chromium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	130
Copper [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	340
Iron [µg/g]	26-Apr-21	12:04	26-Apr-21	13:02	35000
Potassium [µg/g]	26-Apr-21	12:04	26-Apr-21	13:02	14000
Lithium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	21
Magnesium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	15000
Manganese [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	170
Molybdenum [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	2.0
Sodium [µg/g]	26-Apr-21	12:04	26-Apr-21	13:02	750
Nickel [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	71
Phosphorus [µg/g]	26-Apr-21	12:04	26-Apr-21	13:02	540
Lead [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	1.6
Antimony [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	< 0.8
Selenium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	< 0.7
Tin [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	< 6
Strontium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	11
Titanium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	1400
Thallium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	0.45
Uranium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	0.30
Vanadium [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	74
Zinc [µg/g]	27-Apr-21	14:30	27-Apr-21	20:04	28

OnLine LIMS

0002477133

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SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : CA20M-00000-110-18115-02
LR Report : **CA11006-APR21**

<Original signed by>

Chris Sullivan, B.Sc., C.Chem
Project Specialist,
Environment, Health & Safety

OnLine LIMS

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Test method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples. SGS Canada Inc. Environment-Health & Safety statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

APPENDIX C

Rheograms

Golder

Viscosity / Flow Curve Testing R/S Plus Rheometer

Client:	Troilus
Project Number:	19131334
Date:	2021-03-24
Technologist	CA

		Status	Reviewer	Date Complete
Data Entry		**Complete**	**CA**	**2021-03-26**
Data Review	**1st Review**	**Complete**	**CA**	**2021-03-26**
	2nd Review	**Complete**	**VN**	**2021-03-26**

Sample ID:	19131334 Tailings
Sample Description:	Grey Paste
Water:	Tap Water
pH Adjustment:	N/A
Bob:	CC25 Manufacturer's Bob
Additional Info:	
Specific Gravity	2.84

VISCOSITY DATA

Ramp Up

REF	Trial 1	Trial 2	Trial 3	AVG
1	0.8963	0.7555	0.8378	0.830
2	0.6827	0.7319	0.6074	0.674
3	0.5721	0.5969	0.5904	0.586
4	0.4277	0.3663	0.3896	0.395
5	0.3704	0.3874	0.3655	0.374
6	0.1470	0.1398	0.1414	0.143
7	0.0757	0.0734	0.0770	0.075

Ramp Down

Trial 1	Trial 2	Trial 3	AVG
0.9876	0.8841	0.9167	0.929
0.7118	0.7189	0.6610	0.697
0.6051	0.6241	0.6007	0.610
0.4351	0.4154	0.4051	0.419
0.3637	0.3831	0.3602	0.369
0.1499	0.1409	0.1438	0.145
0.7730	0.0782	0.0798	0.310

YIELD STRESS DATA

Ramp Up

REF	Trial 1	Trial 2	Trial 3	AVG
1	241.0397	269.2715	252.7620	254.358
2	139.7277	127.4387	169.0816	145.416
3	140.3767	133.6274	140.7004	138.235
4	91.9067	97.2633	88.0461	92.405
5	69.8865	69.7823	73.4992	71.056
6	36.5698	36.9764	37.4309	36.992
7	21.3497	22.2330	21.0746	21.552

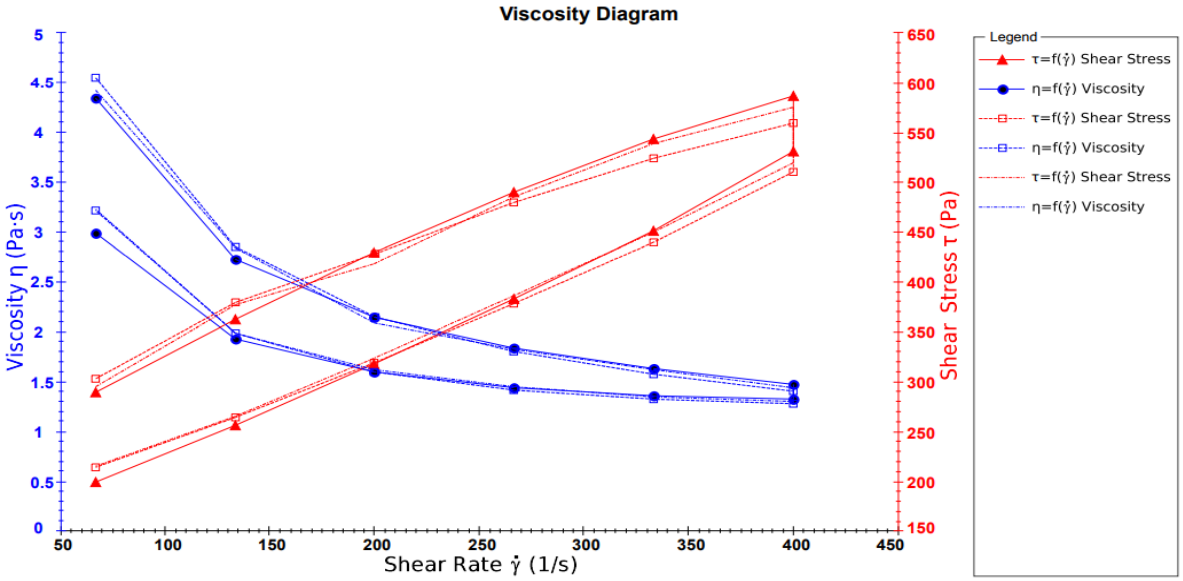
Ramp Down

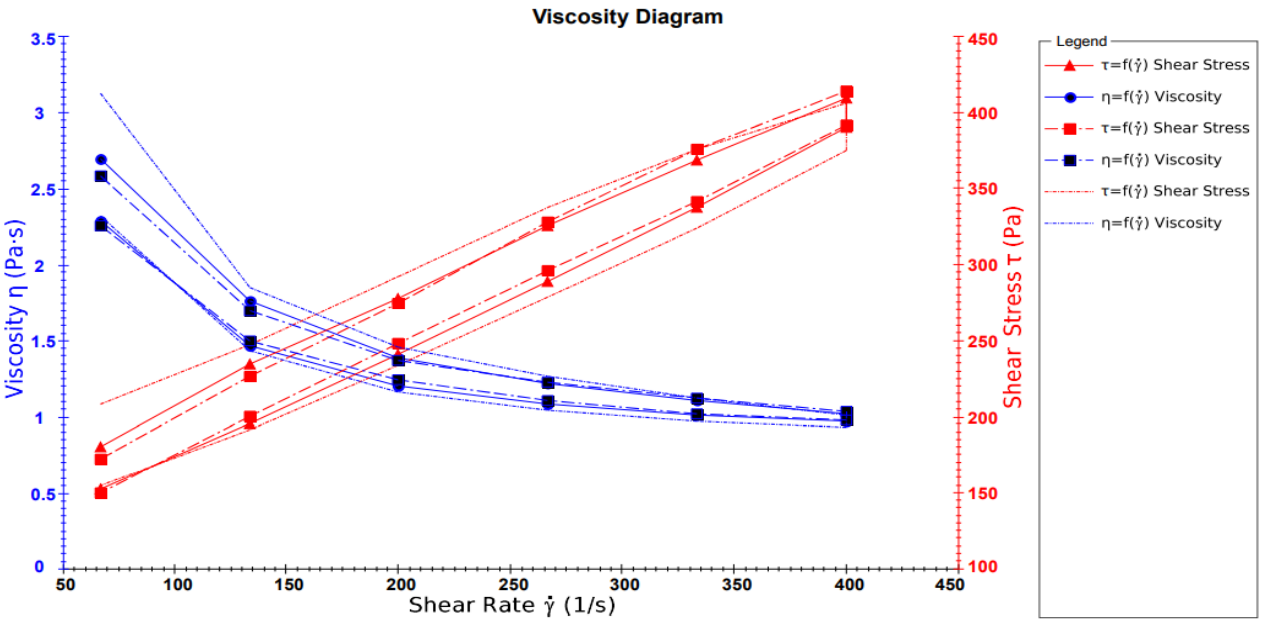
Trial 1	Trial 2	Trial 3	AVG
125.9646	148.0497	145.8536	139.956
101.3686	103.3586	105.1057	103.278
93.7334	91.9715	92.8277	92.844
69.7334	59.3514	66.3402	65.142
55.5014	56.5542	54.8853	55.647
29.2033	27.0703	27.3290	27.868
17.9088	18.2770	17.9219	18.036

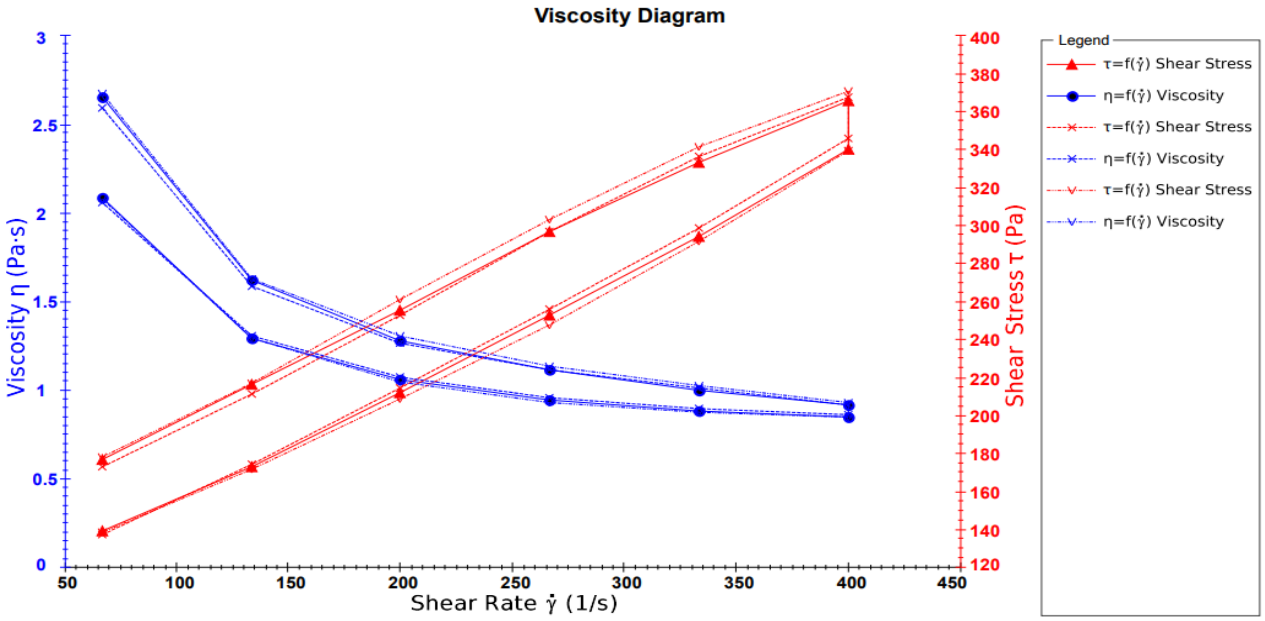
WEIGHT PERCENT SOLIDS

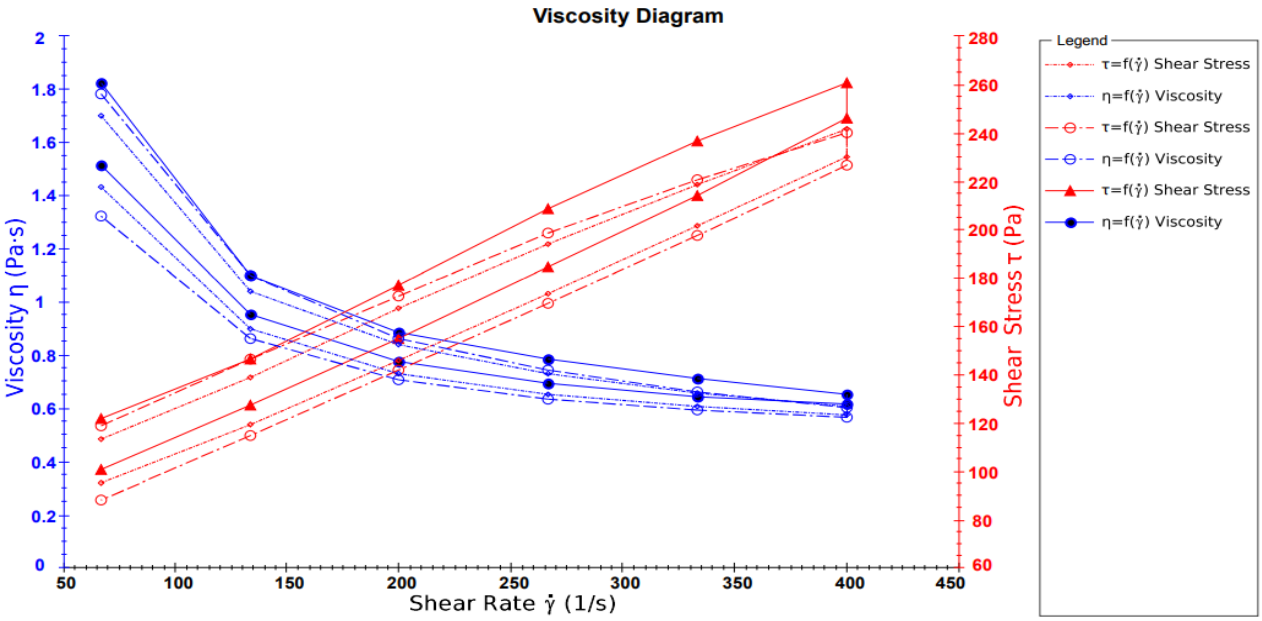
REF	Pan #	Pan Wt. (g)	Wet (g)	Dry (g)	Wt% Solids	SVF (Φ)
1	CA	6.1300	17.6600	14.7500	74.76%	0.51
2	N13	6.2100	20.9400	17.0400	73.52%	0.49
3	Q14	6.2500	21.5900	17.4500	73.01%	0.49
4	N12	6.2400	26.1100	20.6500	72.52%	0.48
5	X6	6.0000	19.5700	15.7000	71.48%	0.47
6	Z17	31.3800	54.9300	47.8500	69.94%	0.45
7	N26	30.6300	47.9900	42.4700	68.20%	0.43

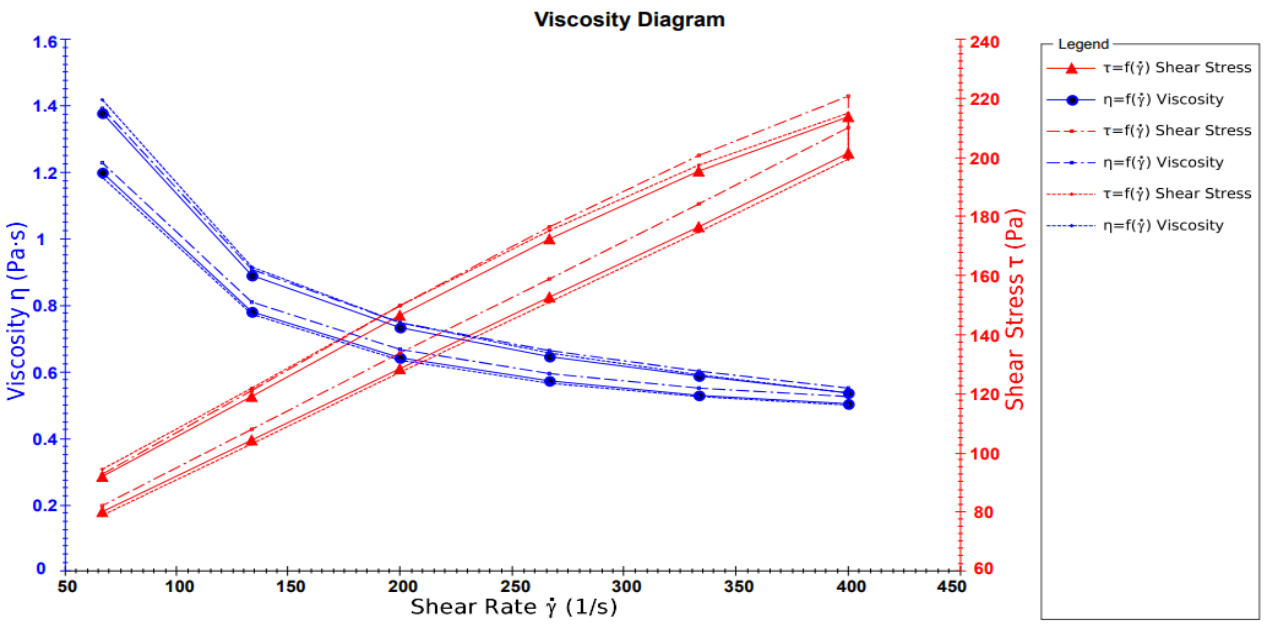
Additional Notes:

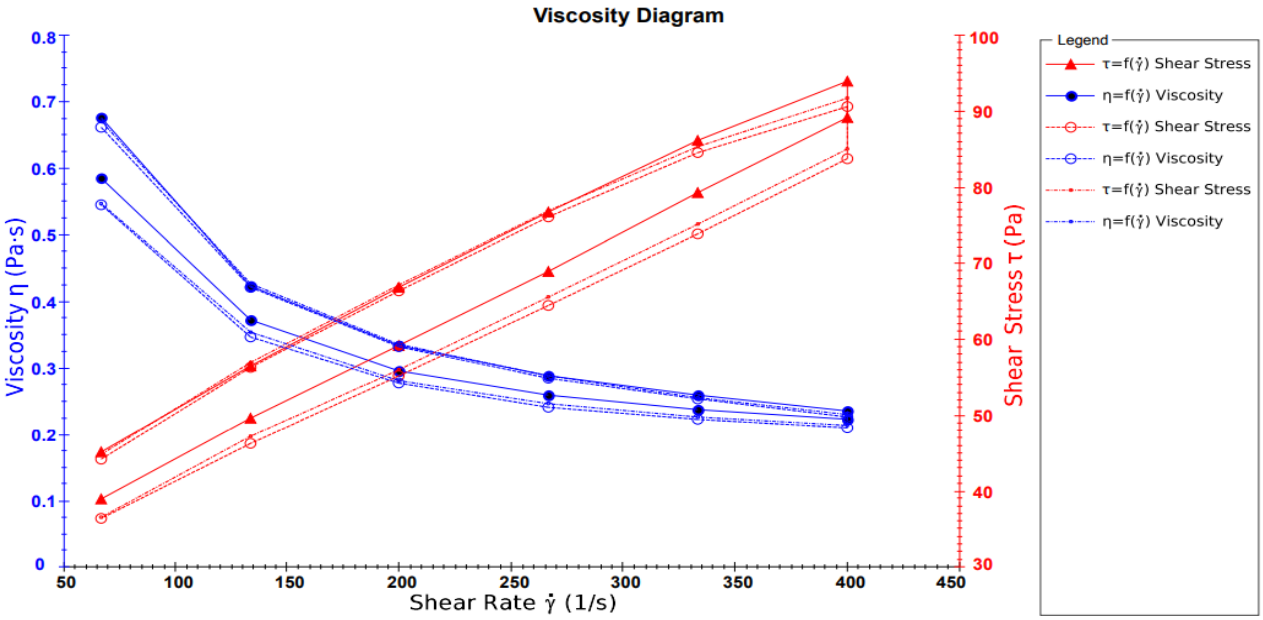

Viscosity Diagram
Viscosity η (Pa·s)
Shear Stress τ (Pa)
Shear Rate γ̇ (1/s)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
150
200
250
300
350
400
450
500
550
600
650
50
100
150
200
250
300
350
400
450
Legend
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity

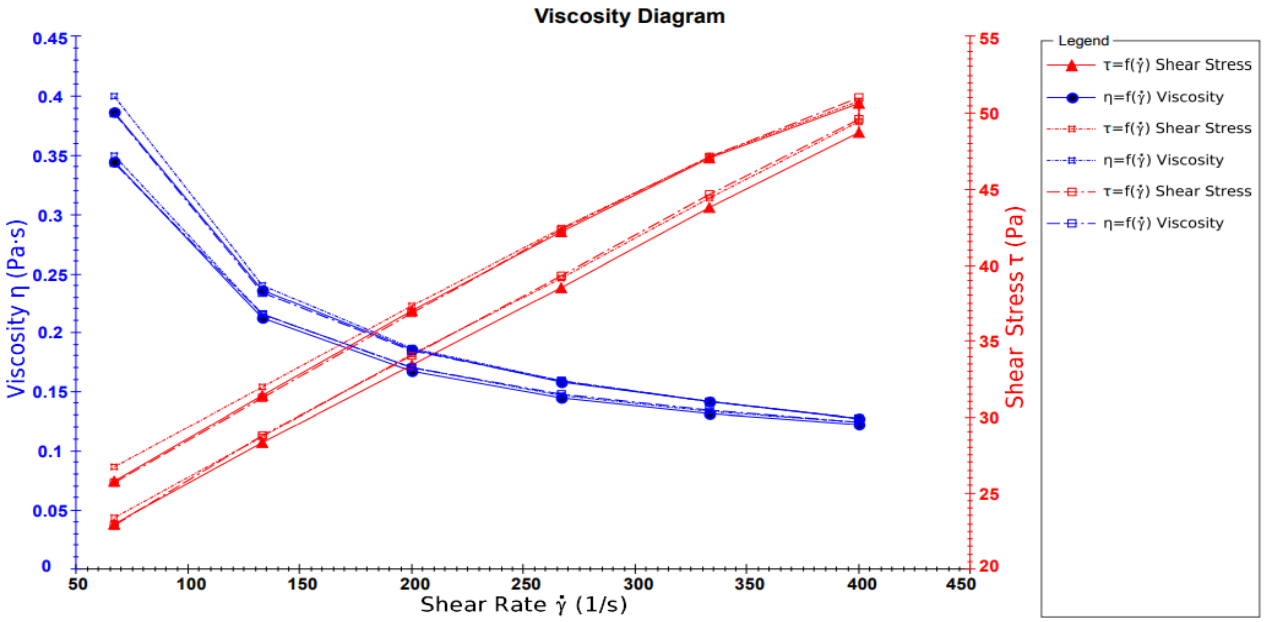

Viscosity Diagram
Viscosity η (Pa·s)
Shear Stress τ (Pa)
Shear Rate γ̇ (1/s)
3.5
3
2.5
2
1.5
1
0.5
0
450
400
350
300
250
200
150
100
50
100
150
200
250
300
350
400
450
Legend
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity


Viscosity Diagram
Viscosity η (Pa·s)
Shear Stress τ (Pa)
Shear Rate γ̇ (1/s)
0
0.5
1
1.5
2
2.5
3
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
50
100
150
200
250
300
350
400
450
Legend
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity


Viscosity Diagram
Viscosity η (Pa·s)
Shear Stress τ (Pa)
Shear Rate γ̇ (1/s)
Legend
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity


Viscosity Diagram
Viscosity η (Pa·s)
Shear Stress τ (Pa)
Shear Rate γ̇ (1/s)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
240
220
200
180
160
140
120
100
80
60
50
100
150
200
250
300
350
400
450
Legend
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity


Viscosity Diagram
Viscosity η (Pa·s)
Shear Stress τ (Pa)
Shear Rate γ̇ (1/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
30
40
50
60
70
80
90
100
50
100
150
200
250
300
350
400
450
Legend
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity


Viscosity Diagram
Viscosity η (Pa·s)
Shear Stress τ (Pa)
Shear Rate γ̇ (1/s)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
55
50
45
40
35
30
25
20
50
100
150
200
250
300
350
400
450
Legend
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity
τ=f(γ̇) Shear Stress
η=f(γ̇) Viscosity

Report

Measuring DataSet Identifications

[794] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-668]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	794
Execution Date:	3/23/2021
UID:	668
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[798] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-672]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	798
Execution Date:	3/23/2021
UID:	672
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[799] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-673]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	799
Execution Date:	3/23/2021
UID:	673
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

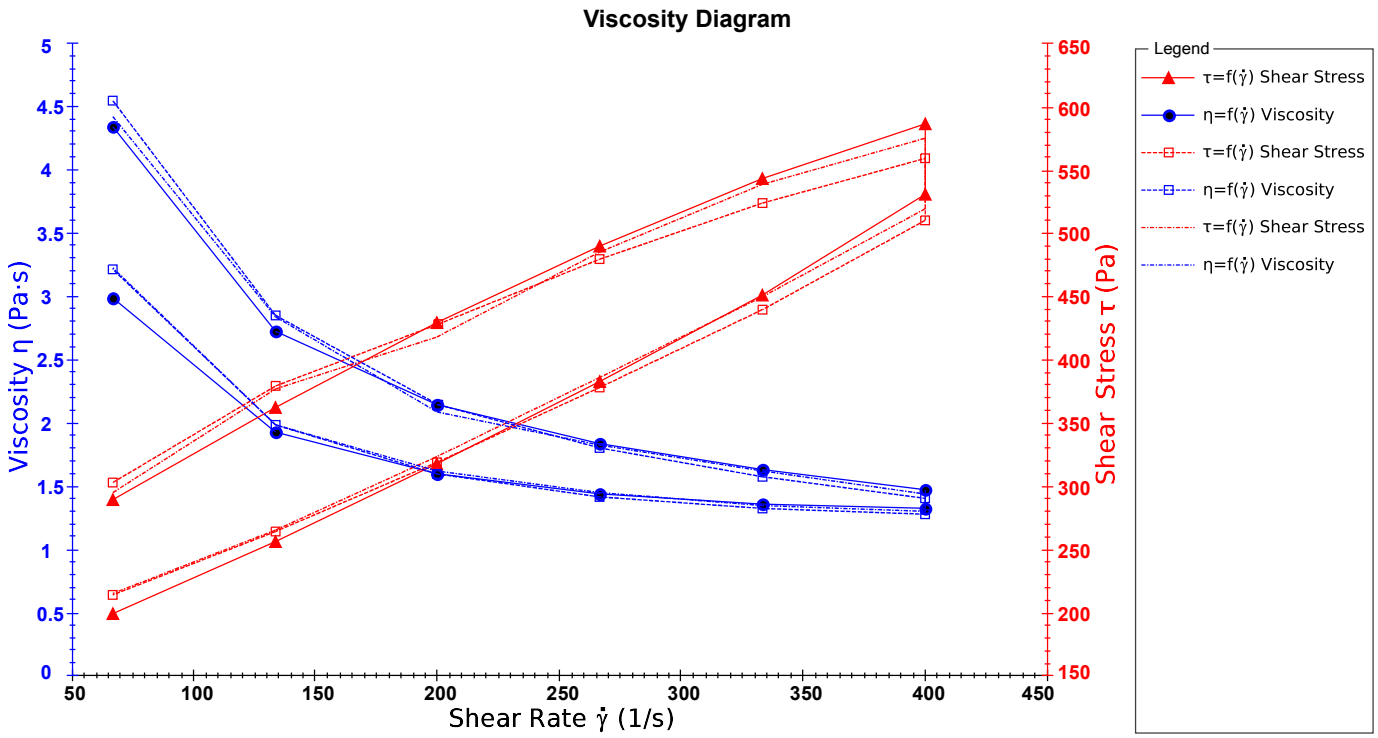
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	294.958	66.675	4.4238
3	13	377.434	133.350	2.8304
4	17	417.561	199.999	2.0878
5	21	485.183	266.661	1.8195
6	26	538.796	333.336	1.6164
7	30	575.585	400.011	1.4389
1	34	519.077	400.011	1.2977
2	39	449.688	333.336	1.3491
3	43	386.586	266.661	1.4497
4	47	323.596	199.999	1.6180
5	51	264.807	133.337	1.9860
6	56	214.787	66.662	3.2220

[799] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-673]

Main Diagram



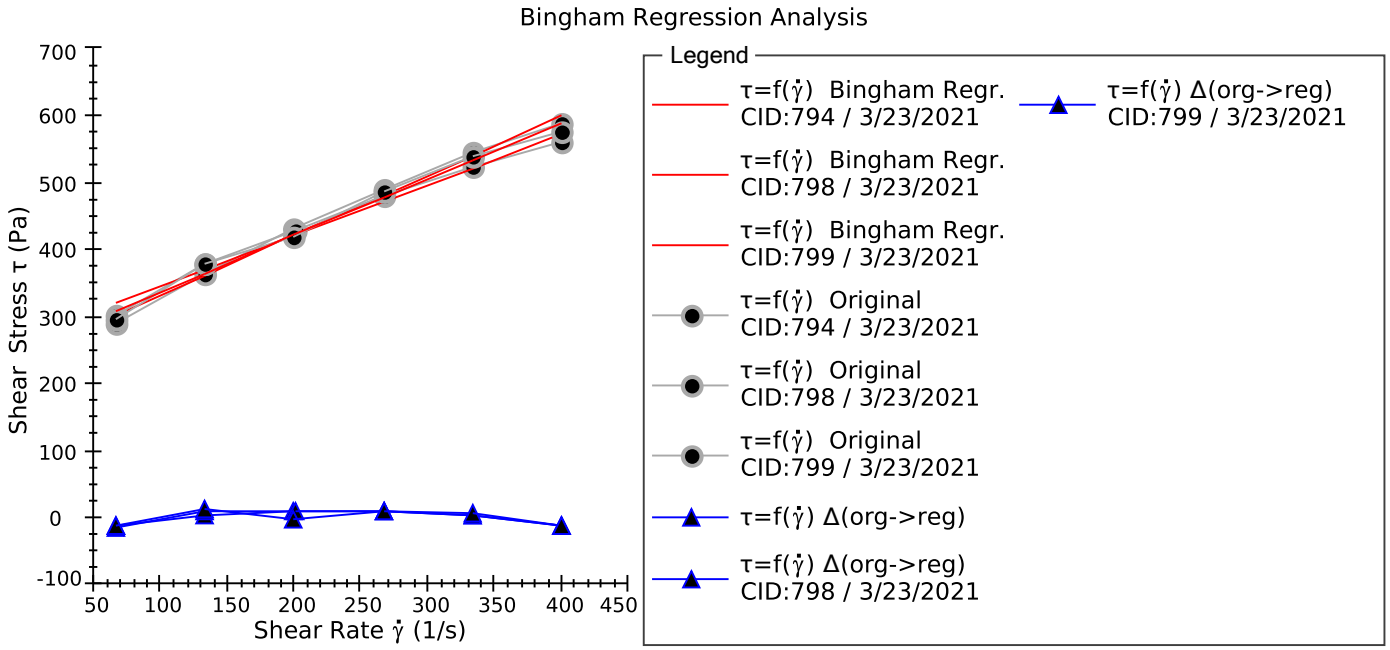
For all DataSets

Regression Analysis

Configuration:

[794] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-668]
[798] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-672]
[799] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-673]

Bingham Regression
Included blocks(numbers):



Result:

[794] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-668]

Bingham Regression y = mx + n
y = 0.8963 * x + 241.0397
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.8963 Pas
Bingham Yield Stress τ(B)
241.0397 Pa
Standard Deviation:
11.1775052960
Stability Index R^2:
0.9920663510
Valid data pairs:
6
Constants:
[0] 241.039746567208
[1] 0.896345648505964
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[798] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-672]

Bingham Regression y = mx + n
y = 0.7555 * x + 269.2715
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.7555 Pas
Bingham Yield Stress τ(B)
269.2715 Pa
Standard Deviation:
13.1207604347
Stability Index R²:
0.9847230858
Valid data pairs:
6
Constants:
[0] 269.271530925445
[1] 0.75545640368787
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[799] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-673]

Bingham Regression y = mx + n
y = 0.8378 * x + 252.762
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

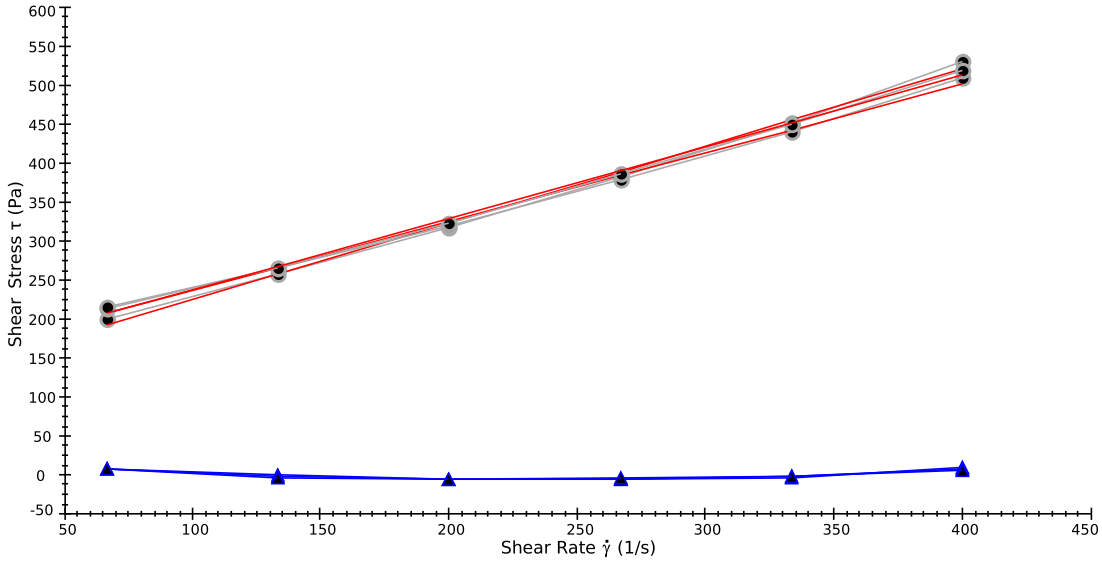
Bingham Viscosity η(B)
0.8378 Pas
Bingham Yield Stress τ(B)
252.7620 Pa
Standard Deviation:
12.6541402129
Stability Index R²:
0.9884032644
Valid data pairs:
6
Constants:
[0] 252.761992317285
[1] 0.837800491660916
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[794] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-668]
[798] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-672]
[799] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-673]

Bingham Regression
Included blocks(numbers):



Result:

[794] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-668]

Bingham Regression y = mx + n
y = 0.9876 * x + 125.9646
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.9876 Pas
Bingham Yield Stress τ(B)
125.9646 Pa
Standard Deviation:
7.4719743303
Stability Index R^2:
0.9970645842
Valid data pairs:
6
Constants:
[0] 125.964608363199
[1] 0.987555165169405
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[798] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-672]

Bingham Regression y = mx + n
y = 0.8841 * x + 148.0497
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.8841 Pas
Bingham Yield Stress τ(B)
148.0497 Pa
Standard Deviation:
6.9142922272
Stability Index R²:
0.9968641735
Valid data pairs:
6
Constants:
[0] 148.049665694294
[1] 0.88405497527578
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[799] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-673]

Bingham Regression y = mx + n
y = 0.9167 * x + 145.8536
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.9167 Pas
Bingham Yield Stress τ(B)
145.8536 Pa
Standard Deviation:
6.3792289867
Stability Index R²:
0.9975159648
Valid data pairs:
6
Constants:
[0] 145.853645367059
[1] 0.916724436612579
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ẏ	Viscosity (Pa·s) η
2	9	302.929	66.675	4.5434
3	13	379.709	133.350	2.8475
4	17	428.303	200.012	2.1414
5	21	479.926	266.661	1.7998
6	26	523.663	333.336	1.5710
7	30	558.772	400.011	1.3969
1	34	509.886	400.011	1.2747
2	39	439.872	333.336	1.3196
3	43	377.948	266.661	1.4173
4	47	319.448	199.999	1.5972
5	51	264.715	133.337	1.9853
6	56	214.110	66.662	3.2119

[798] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-672]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	289.174	66.662	4.3379
3	13	362.385	133.350	2.7176
4	17	429.334	199.999	2.1467
5	21	490.163	266.661	1.8382
6	26	543.357	333.336	1.6301
7	30	586.725	400.011	1.4668
1	34	530.185	400.011	1.3254
2	39	451.502	333.336	1.3545
3	43	382.708	266.674	1.4351
4	47	318.169	199.999	1.5909
5	51	256.748	133.337	1.9256
6	56	199.083	66.675	2.9859

[794] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-668]

Report

Measuring DataSet Identifications

[800] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-674]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	800
Execution Date:	3/23/2021
UID:	674
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[801] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-675]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	801
Execution Date:	3/23/2021
UID:	675
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[802] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-676]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	802
Execution Date:	3/23/2021
UID:	676
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

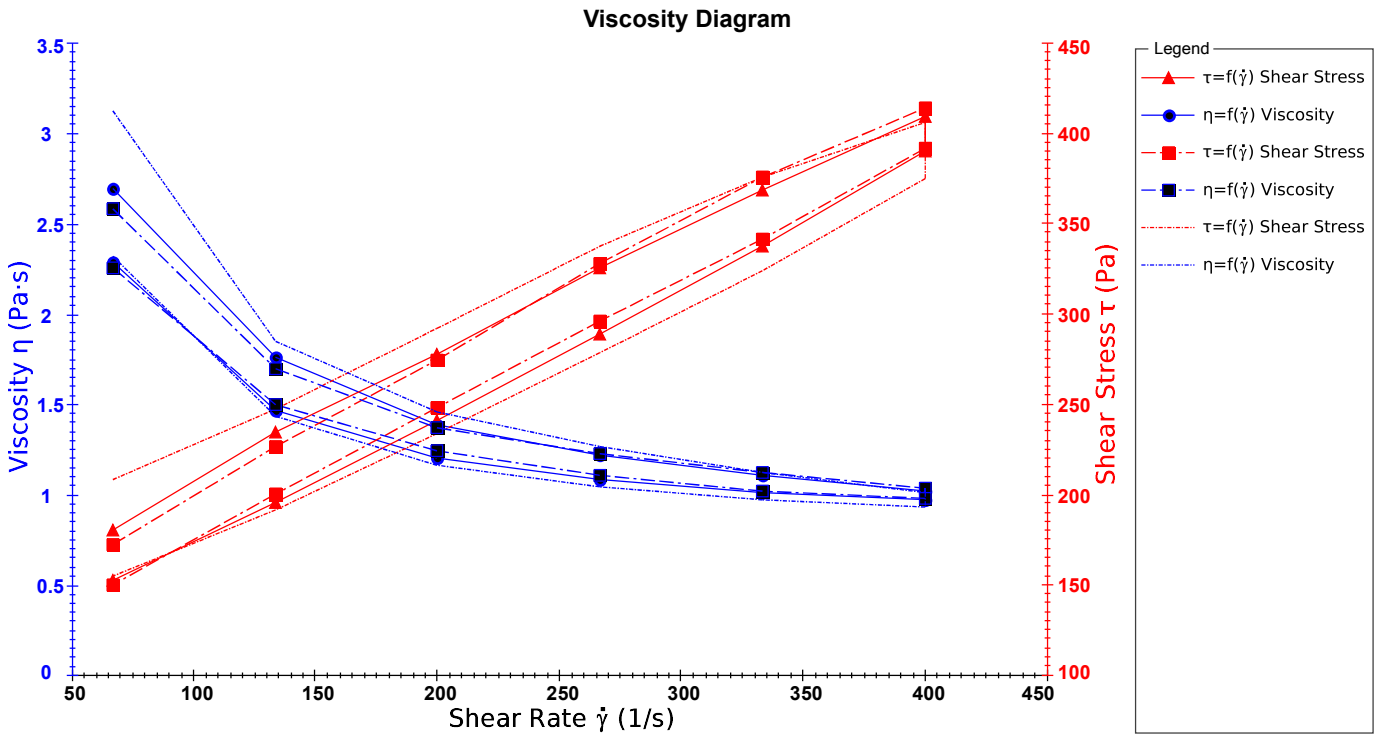
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	208.132	66.662	3.1222
3	13	246.984	133.337	1.8523
4	17	291.609	199.999	1.4581
5	21	337.497	266.661	1.2656
6	26	375.131	333.336	1.1254
7	30	405.542	400.011	1.0138
1	34	374.615	399.998	0.9365
2	39	323.990	333.336	0.9720
3	43	277.901	266.661	1.0422
4	47	233.332	199.999	1.1667
5	51	191.637	133.337	1.4372
6	56	154.493	66.662	2.3176

[802] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-676]

Main Diagram



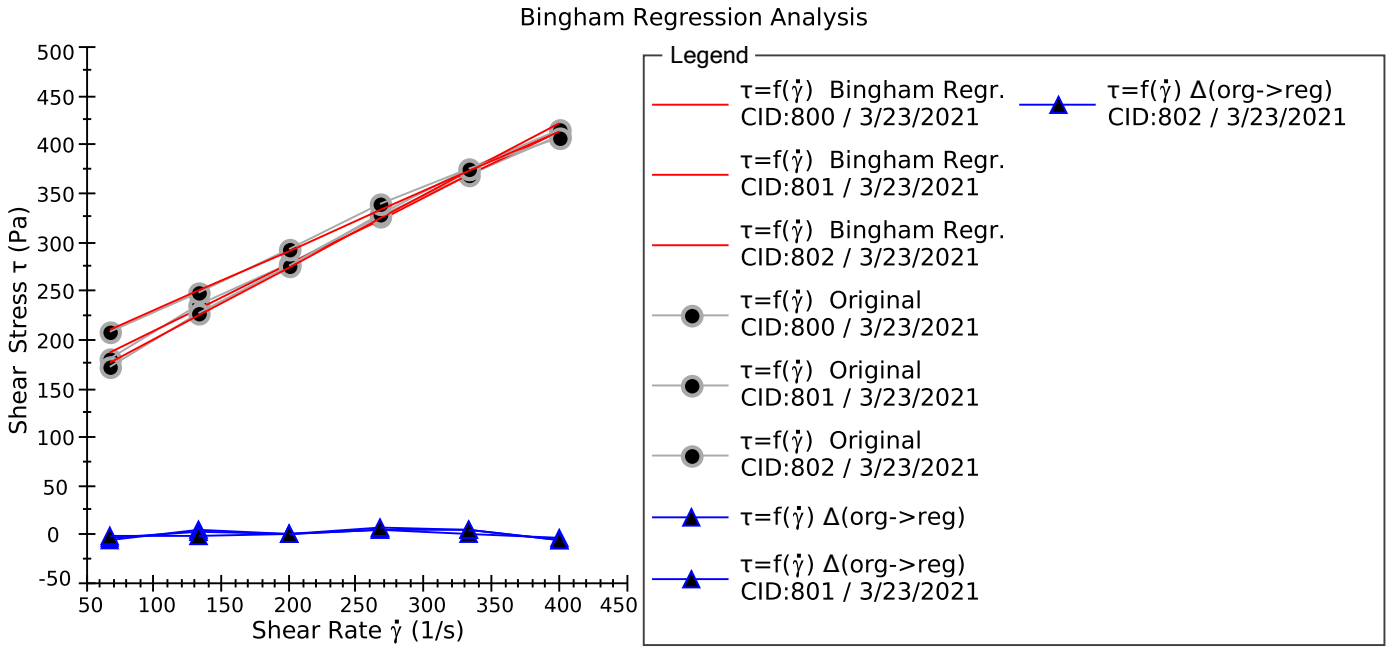
For all DataSets

Regression Analysis

Configuration:

[800] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-674]
[801] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-675]
[802] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-676]

Bingham Regression
Included blocks(numbers):



Result:

[800] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-674]

Bingham Regression y = mx + n
y = 0.6827 * x + 139.7277
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.6827 Pas
Bingham Yield Stress τ(B)
139.7277 Pa
Standard Deviation:
4.3545373615
Stability Index R^2:
0.9979116359
Valid data pairs:
6
Constants:
[0] 139.727673490734
[1] 0.6826506622519
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[801] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-675]

Bingham Regression y = mx + n
y = 0.7319 * x + 127.4387
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.7319 Pas
Bingham Yield Stress τ(B)
127.4387 Pa
Standard Deviation:
5.0915277538
Stability Index R²:
0.9975169214
Valid data pairs:
6
Constants:
[0] 127.438684678162
[1] 0.731877809394827
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[802] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-676]

Bingham Regression y = mx + n
y = 0.6074 * x + 169.0816
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

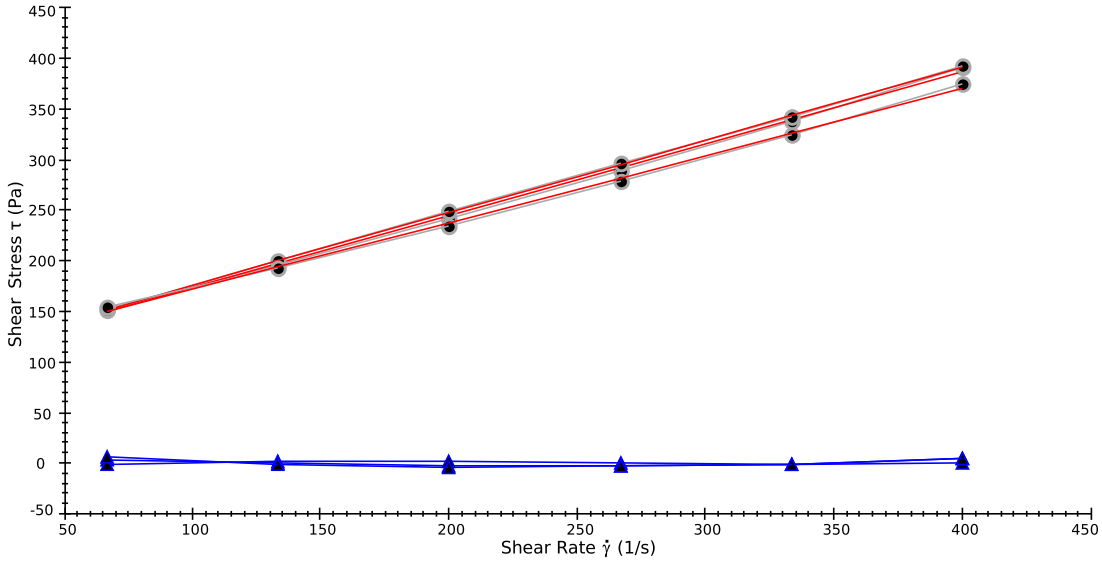
Bingham Viscosity η(B)
0.6074 Pas
Bingham Yield Stress τ(B)
169.0816 Pa
Standard Deviation:
5.2295168977
Stability Index R²:
0.9962028576
Valid data pairs:
6
Constants:
[0] 169.08159653207
[1] 0.607430480961817
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[800] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-674]
[801] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-675]
[802] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-676]

Bingham Regression
Included blocks(numbers):



Result:

[800] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-674]

Bingham Regression y = mx + n
y = 0.7118 * x + 101.3686
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.7118 Pas
Bingham Yield Stress τ(B)
101.3686 Pa
Standard Deviation:
3.4630483352
Stability Index R^2:
0.9987841830
Valid data pairs:
6
Constants:
[0] 101.368647489842
[1] 0.711806309160029
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[801] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-675]

Bingham Regression y = mx + n
y = 0.7189 * x + 103.3586
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.7189 Pas
Bingham Yield Stress τ(B)
103.3586 Pa
Standard Deviation:
1.2067654401
Stability Index R²:
0.9998551164
Valid data pairs:
6
Constants:
[0] 103.358589811139
[1] 0.718904831839646
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[802] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-676]

Bingham Regression y = mx + n
y = 0.661 * x + 105.1057
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.6610 Pas
Bingham Yield Stress τ(B)
105.1057 Pa
Standard Deviation:
4.6623692845
Stability Index R²:
0.9974475346
Valid data pairs:
6
Constants:
[0] 105.105710281305
[1] 0.660957185460512
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	172.014	66.688	2.5794
3	13	226.450	133.337	1.6983
4	17	274.392	199.999	1.3720
5	21	327.476	266.661	1.2281
6	26	375.376	333.336	1.1261
7	30	413.566	399.998	1.0339
1	34	391.398	400.011	0.9785
2	39	341.406	333.336	1.0242
3	43	295.537	266.661	1.1083
4	47	247.949	199.999	1.2398
5	51	200.177	133.337	1.5013
6	56	150.154	66.662	2.2525

[801] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-675]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	179.905	66.675	2.6982
3	13	234.769	133.337	1.7607
4	17	277.060	199.999	1.3853
5	21	325.391	266.661	1.2202
6	26	368.230	333.336	1.1047
7	30	408.725	399.998	1.0218
1	34	390.252	399.998	0.9756
2	39	336.848	333.336	1.0105
3	43	288.776	266.661	1.0829
4	47	240.851	199.999	1.2043
5	51	195.596	133.337	1.4669
6	56	152.412	66.662	2.2863

[800] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-674]

Report

Measuring DataSet Identifications

[803] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-677]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	803
Execution Date:	3/23/2021
UID:	677
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[804] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-678]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	804
Execution Date:	3/23/2021
UID:	678
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[805] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-679]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	805
Execution Date:	3/23/2021
UID:	679
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

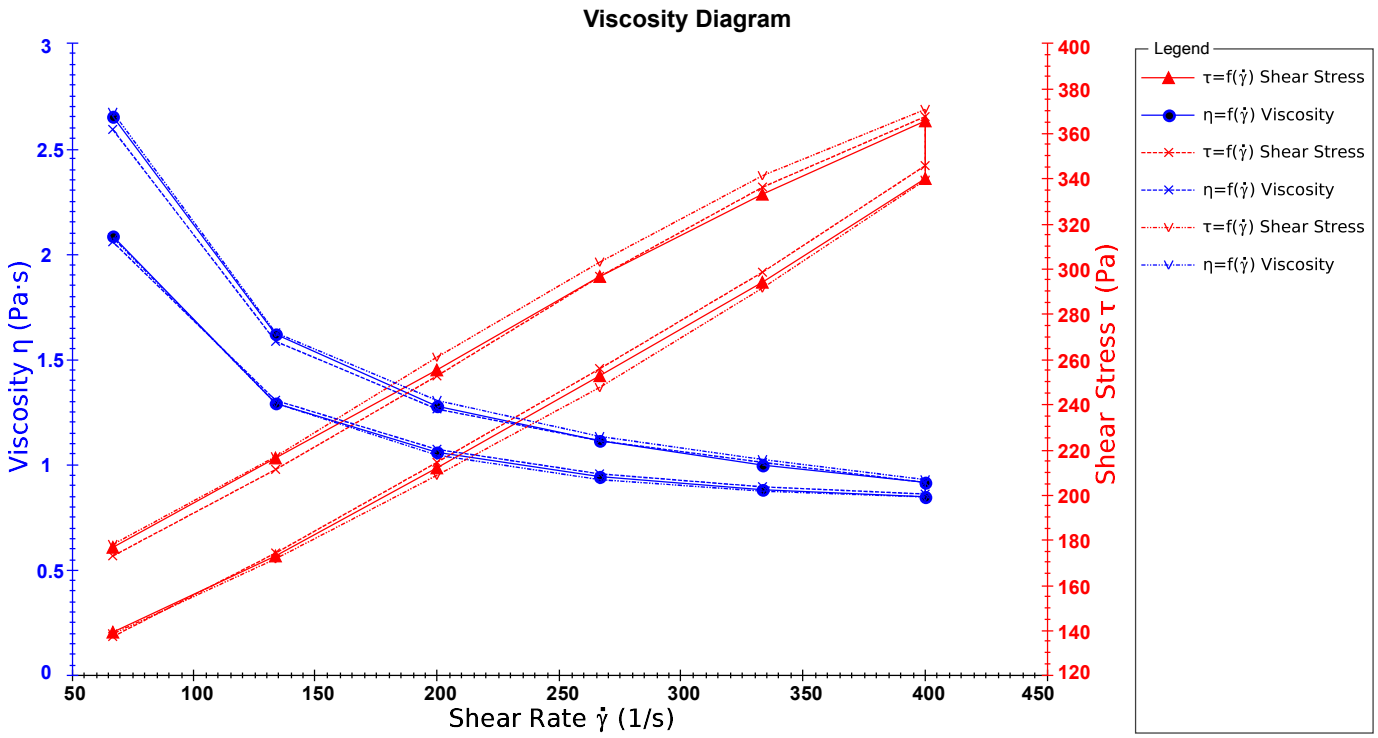
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	178.125	66.662	2.6721
3	13	217.060	133.337	1.6279
4	17	260.656	199.999	1.3033
5	21	302.856	266.661	1.1357
6	26	341.438	333.336	1.0243
7	30	370.557	399.998	0.9264
1	34	339.279	399.998	0.8482
2	39	291.714	333.336	0.8751
3	43	247.666	266.661	0.9288
4	47	208.842	199.999	1.0442
5	51	171.833	133.337	1.2887
6	56	138.636	66.662	2.0797

[805] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-679]

Main Diagram



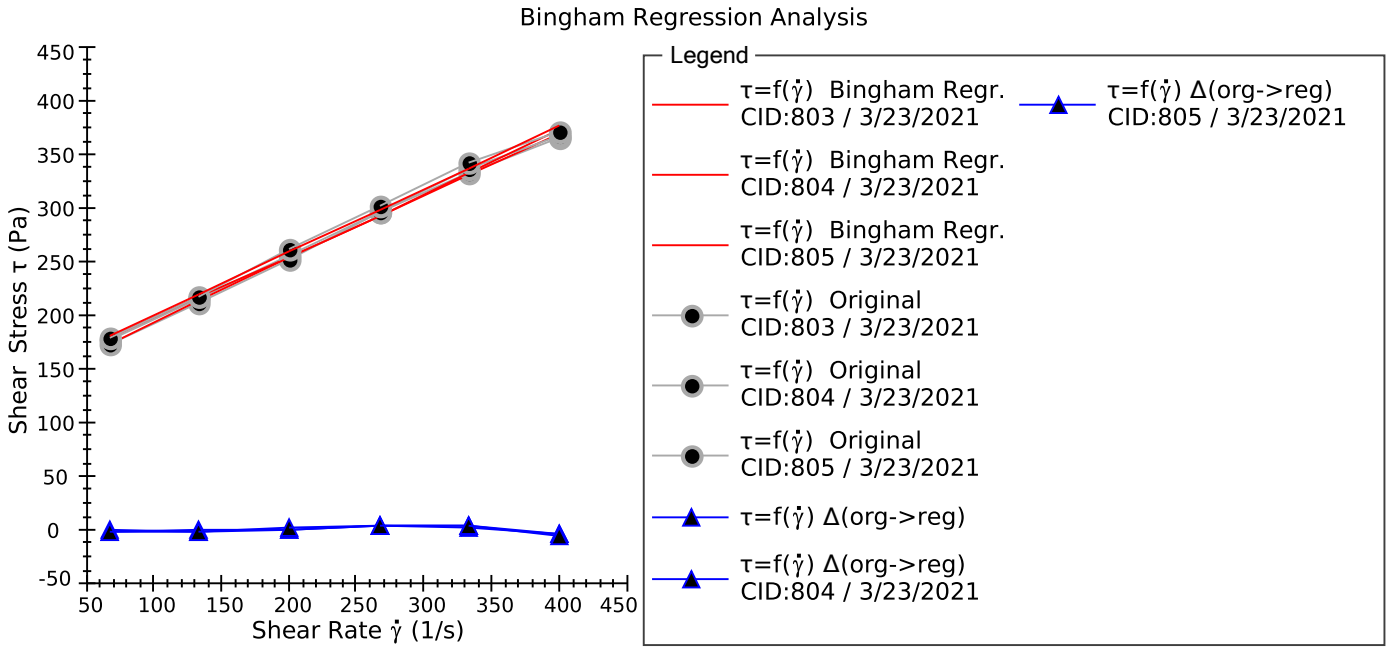
For all DataSets

Regression Analysis

Configuration:

[803] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-677]
[804] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-678]
[805] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-679]

Bingham Regression
Included blocks(numbers):



Result:

[803] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-677]

Bingham Regression y = mx + n
y = 0.5721 * x + 140.3767
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.5721 Pas
Bingham Yield Stress τ(B)
140.3767 Pa
Standard Deviation:
2.8805078489
Stability Index R^2:
0.9986978642
Valid data pairs:
6
Constants:
[0] 140.376659085623
[1] 0.572083656237903
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[804] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-678]

Bingham Regression y = mx + n
y = 0.5969 * x + 133.6274
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.5969 Pas
Bingham Yield Stress τ(B)
133.6274 Pa
Standard Deviation:
3.7319184882
Stability Index R²:
0.9979937885
Valid data pairs:
6
Constants:
[0] 133.627403003471
[1] 0.596910578830943
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[805] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-679]

Bingham Regression y = mx + n
y = 0.5904 * x + 140.7004
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

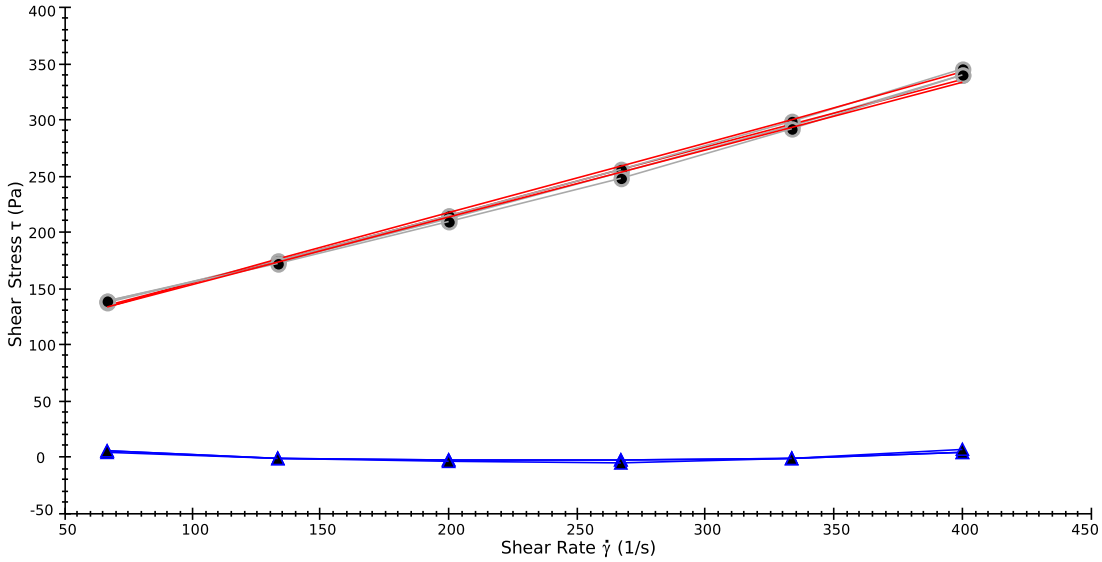
Bingham Viscosity η(B)
0.5904 Pas
Bingham Yield Stress τ(B)
140.7004 Pa
Standard Deviation:
4.7517420503
Stability Index R²:
0.9966792192
Valid data pairs:
6
Constants:
[0] 140.700391233706
[1] 0.590353332115472
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[803] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-677]
[804] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-678]
[805] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-679]

Bingham Regression
Included blocks(numbers):



Result:

[803] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-677]

Bingham Regression y = mx + n
y = 0.6051 * x + 93.7334
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.6051 Pas
Bingham Yield Stress τ(B)
93.7334 Pa
Standard Deviation:
3.9823679934
Stability Index R^2:
0.9977775985
Valid data pairs:
6
Constants:
[0] 93.7333549224872
[1] 0.605113119335569
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[804] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-678]

Bingham Regression y = mx + n
y = 0.6241 * x + 91.9715
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.6241 Pas
Bingham Yield Stress τ(B)
91.9715 Pa
Standard Deviation:
3.3291857652
Stability Index R²:
0.9985385943
Valid data pairs:
6
Constants:
[0] 91.9714959775015
[1] 0.624074761095136
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[805] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-679]

Bingham Regression y = mx + n
y = 0.6007 * x + 92.8277
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.6007 Pas
Bingham Yield Stress τ(B)
92.8277 Pa
Standard Deviation:
5.4754408756
Stability Index R²:
0.9957455350
Valid data pairs:
6
Constants:
[0] 92.8277192929509
[1] 0.600720371729978
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	172.661	66.662	2.5901
3	13	211.408	133.337	1.5855
4	17	252.808	199.999	1.2640
5	21	296.863	266.661	1.1133
6	26	336.103	333.336	1.0083
7	30	367.591	399.998	0.9190
1	34	345.441	399.998	0.8636
2	39	298.640	333.336	0.8959
3	43	255.903	266.661	0.9597
4	47	214.142	199.999	1.0707
5	51	174.153	133.337	1.3061
6	56	137.250	66.662	2.0589

[804] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-678]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	176.758	66.662	2.6516
3	13	216.253	133.337	1.6219
4	17	255.271	199.999	1.2764
5	21	296.503	266.661	1.1119
6	26	332.878	333.336	0.9986
7	30	365.510	399.998	0.9138
1	34	340.089	400.011	0.8502
2	39	294.192	333.336	0.8826
3	43	252.319	266.661	0.9462
4	47	211.538	199.999	1.0577
5	51	172.644	133.337	1.2948
6	56	138.780	66.662	2.0818

[803] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-677]

Report

Measuring DataSet Identifications

[809] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-683]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	809
Execution Date:	3/23/2021
UID:	683
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[808] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-682]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	808
Execution Date:	3/23/2021
UID:	682
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[807] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-681]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	807
Execution Date:	3/23/2021
UID:	681
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

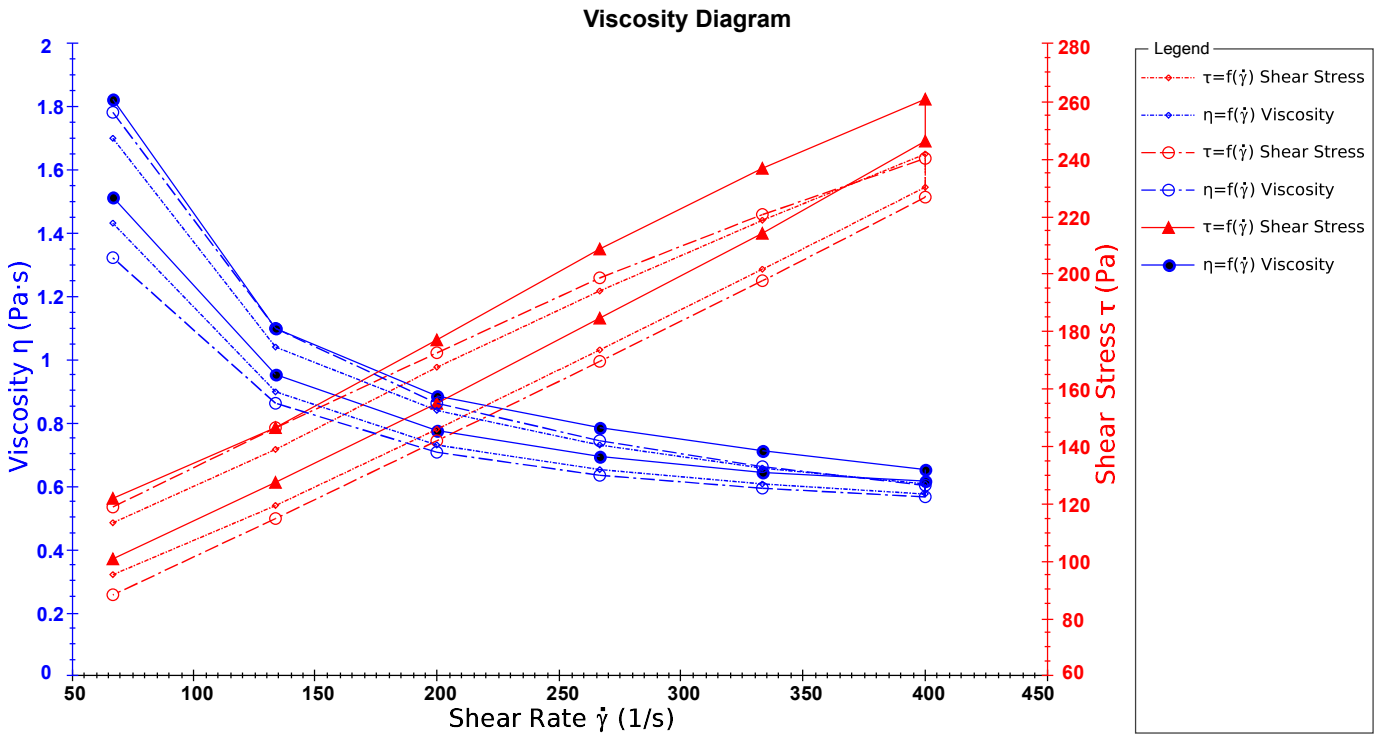
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	113.153	66.662	1.6974
3	13	138.643	133.337	1.0398
4	17	167.524	199.999	0.8376
5	21	194.176	266.661	0.7282
6	26	218.442	333.336	0.6553
7	30	241.747	399.998	0.6044
1	34	229.801	399.998	0.5745
2	39	201.237	333.336	0.6037
3	43	173.524	266.661	0.6507
4	47	145.776	199.999	0.7289
5	51	119.500	133.337	0.8962
6	56	95.344	66.662	1.4303

[807] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-681]

Main Diagram



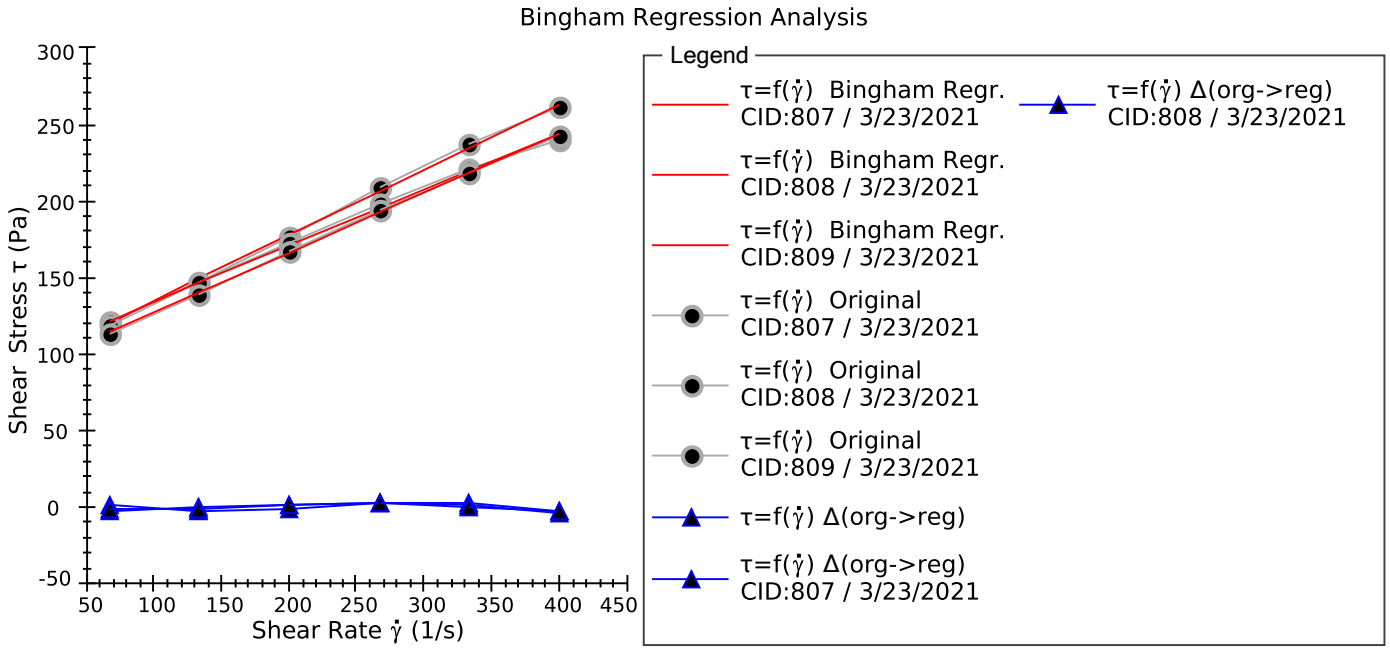
For all DataSets

Regression Analysis

Configuration:

[809] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-683]
[808] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-682]
[807] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-681]

Bingham Regression
Included blocks(numbers):



Result:

[809] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-683]

Bingham Regression y = mx + n
y = 0.4277 * x + 91.9067
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.4277 Pas
Bingham Yield Stress τ(B)
91.9067 Pa
Standard Deviation:
2.5729027045
Stability Index R^2:
0.9981422289
Valid data pairs:
6
Constants:
[0] 91.9066894535011
[1] 0.427685999608658
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[808] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-682]

Bingham Regression y = mx + n
y = 0.3663 * x + 97.2633
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.3663 Pas
Bingham Yield Stress τ(B)
97.2633 Pa
Standard Deviation:
3.0135044472
Stability Index R²:
0.9965314847
Valid data pairs:
6
Constants:
[0] 97.2633253096825
[1] 0.366308589823296
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[807] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-681]

Bingham Regression y = mx + n
y = 0.3896 * x + 88.0461
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

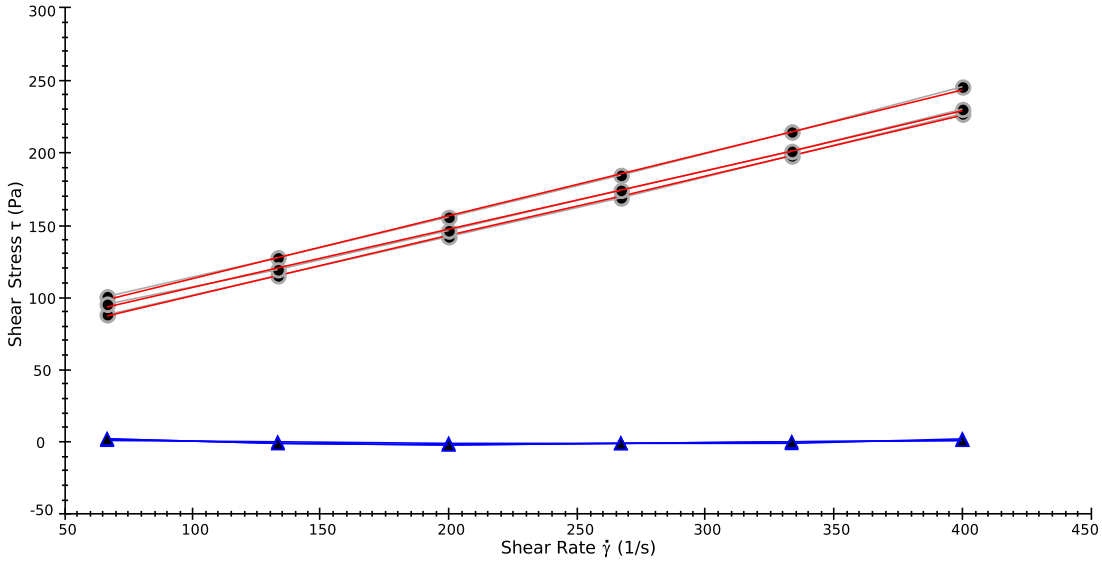
Bingham Viscosity η(B)
0.3896 Pas
Bingham Yield Stress τ(B)
88.0461 Pa
Standard Deviation:
1.9275497812
Stability Index R²:
0.9987425914
Valid data pairs:
6
Constants:
[0] 88.0460601643691
[1] 0.389579181899334
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[809] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-683]
[808] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-682]
[807] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-681]

Bingham Regression
Included blocks(numbers):



Result:

[809] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-683]

Bingham Regression y = mx + n
y = 0.4351 * x + 69.7334
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.4351 Pas
Bingham Yield Stress τ(B)
69.7334 Pa
Standard Deviation:
1.8919375409
Stability Index R^2:
0.9990286302
Valid data pairs:
6
Constants:
[0] 69.7334119175282
[1] 0.435115963650947
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[808] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-682]

Bingham Regression y = mx + n
y = 0.4154 * x + 59.3514
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.4154 Pas
Bingham Yield Stress τ(B)
59.3514 Pa
Standard Deviation:
0.9841762284
Stability Index R²:
0.9997113565
Valid data pairs:
6
Constants:
[0] 59.3514334568385
[1] 0.415365932268363
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[807] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-681]

Bingham Regression y = mx + n
y = 0.4051 * x + 66.3402
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.4051 Pas
Bingham Yield Stress τ(B)
66.3402 Pa
Standard Deviation:
1.5795936640
Stability Index R²:
0.9992186896
Valid data pairs:
6
Constants:
[0] 66.3401659658575
[1] 0.405102964610894
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	118.873	66.662	1.7832
3	13	146.258	133.337	1.0969
4	17	172.470	199.999	0.8624
5	21	198.277	266.661	0.7436
6	26	220.300	333.336	0.6609
7	30	240.231	399.998	0.6006
1	34	226.692	399.998	0.5667
2	39	197.336	333.336	0.5920
3	43	169.300	266.661	0.6349
4	47	141.668	199.999	0.7083
5	51	114.595	133.337	0.8594
6	56	88.026	66.662	1.3205

[808] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-682]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	121.588	66.662	1.8240
3	13	146.185	133.337	1.0964
4	17	176.722	199.999	0.8836
5	21	208.543	266.661	0.7821
6	26	236.593	333.336	0.7098
7	30	260.567	399.998	0.6514
1	34	245.842	399.998	0.6146
2	39	214.162	333.336	0.6425
3	43	184.489	266.661	0.6918
4	47	155.063	199.999	0.7753
5	51	127.083	133.337	0.9531
6	56	100.920	66.662	1.5139

[809] 3/23/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-683]

Report

Measuring DataSet Identifications

[814] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-687]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	814
Execution Date:	3/24/2021
UID:	687
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[815] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-688]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	815
Execution Date:	3/24/2021
UID:	688
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[817] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-690]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	817
Execution Date:	3/24/2021
UID:	690
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

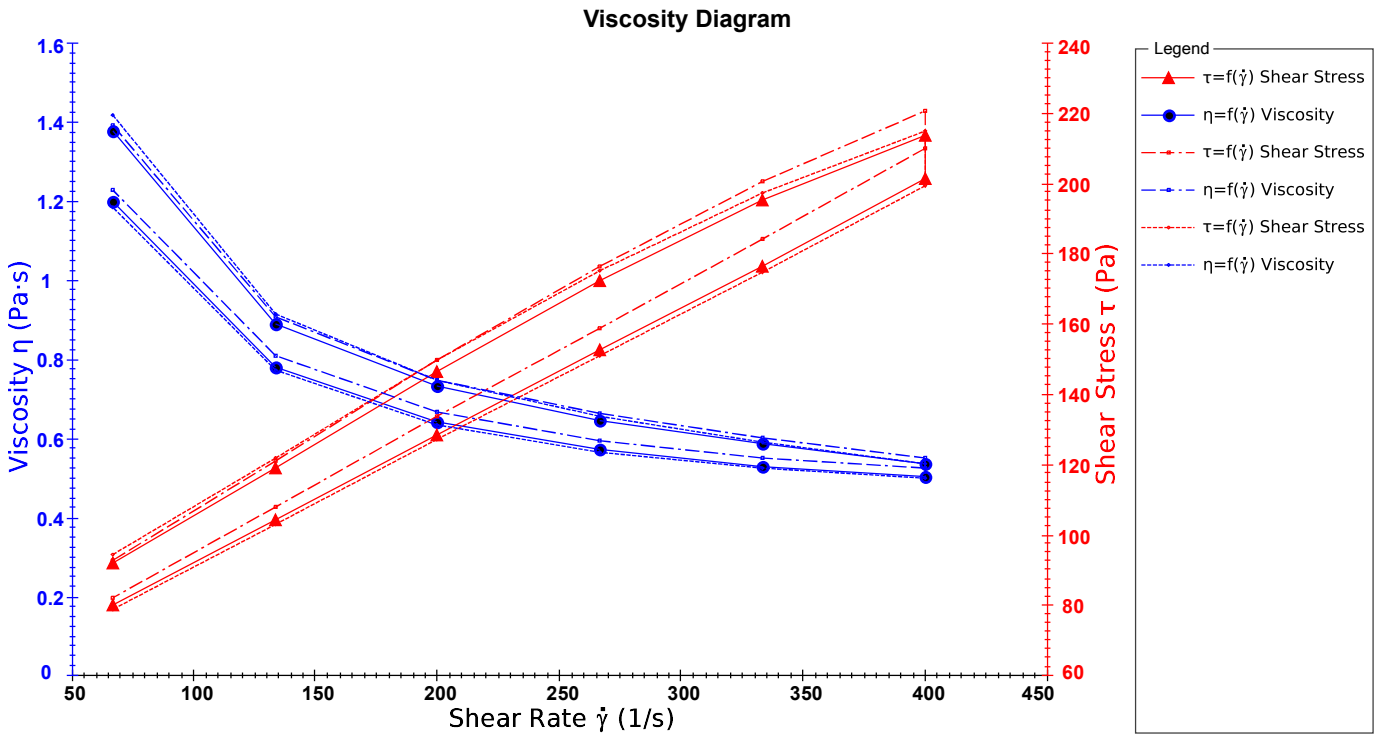
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ẏ	Viscosity (Pa·s) η
2	9	94.432	66.662	1.4166
3	13	121.870	133.337	0.9140
4	17	149.571	199.999	0.7479
5	21	174.903	266.661	0.6559
6	26	197.245	333.336	0.5917
7	30	214.725	399.998	0.5368
1	34	199.288	399.998	0.4982
2	39	174.618	333.336	0.5239
3	43	150.734	266.661	0.5653
4	47	126.934	199.999	0.6347
5	51	103.051	133.337	0.7729
6	56	78.912	66.662	1.1838

[817] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-690]

Main Diagram



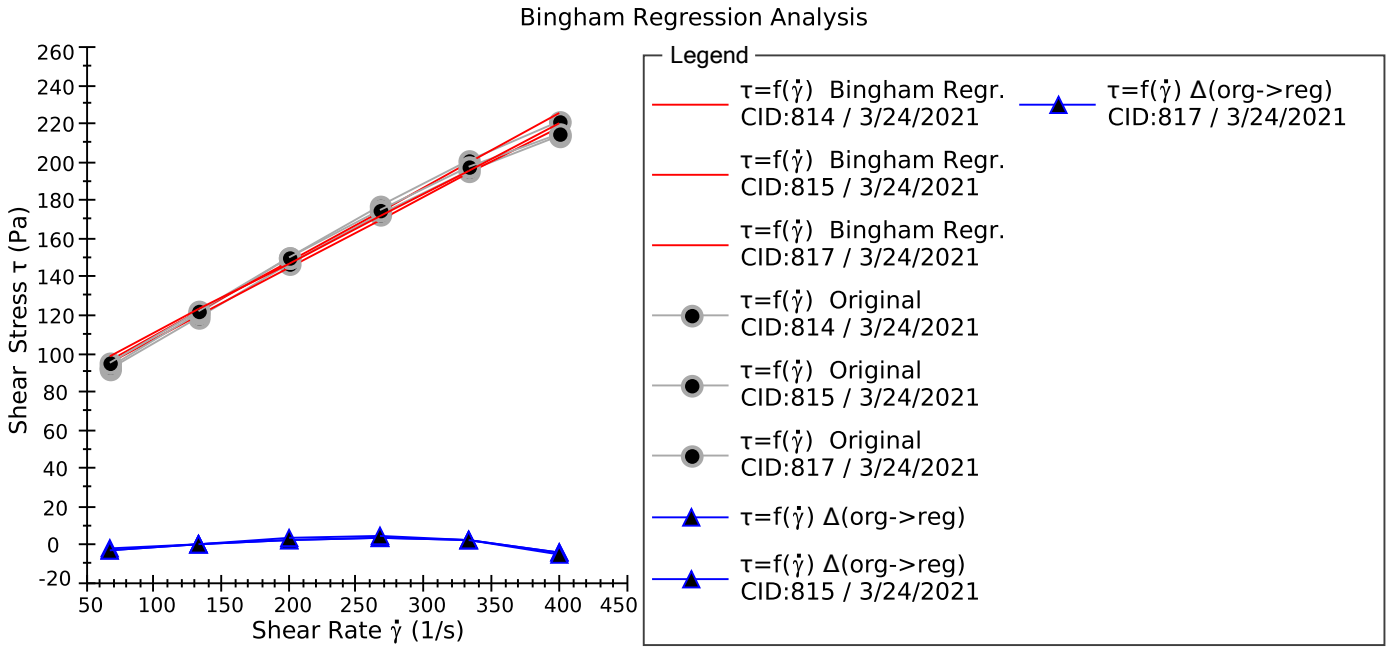
For all DataSets

Regression Analysis

Configuration:

[814] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-687]
[815] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-688]
[817] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-690]

Bingham Regression
Included blocks(numbers):



Result:

[814] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-687]

Bingham Regression y = mx + n
y = 0.3704 * x + 69.8865
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.3704 Pas
Bingham Yield Stress τ(B)
69.8865 Pa
Standard Deviation:
3.3939463043
Stability Index R^2:
0.9957005393
Valid data pairs:
6
Constants:
[0] 69.886509112687
[1] 0.370393971628196
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[815] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-688]

Bingham Regression y = mx + n
y = 0.3874 * x + 69.7823
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.3874 Pas
Bingham Yield Stress τ(B)
69.7823 Pa
Standard Deviation:
3.4364195309
Stability Index R²:
0.9959706801
Valid data pairs:
6
Constants:
[0] 69.7823189626297
[1] 0.387449535776666
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[817] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-690]

Bingham Regression y = mx + n
y = 0.3655 * x + 73.4992
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

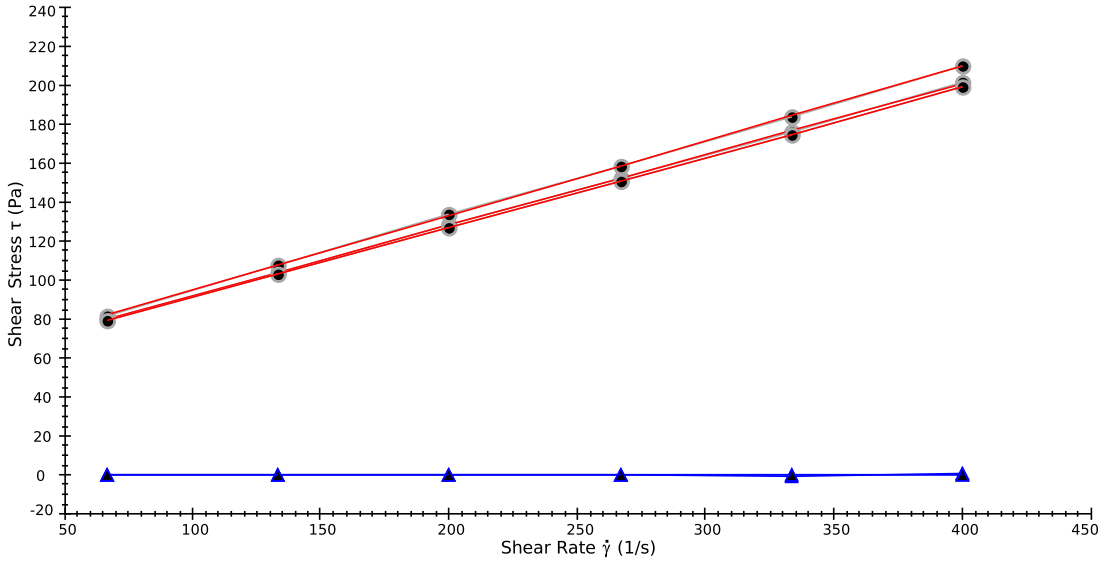
Bingham Viscosity η(B)
0.3655 Pas
Bingham Yield Stress τ(B)
73.4992 Pa
Standard Deviation:
4.0201371789
Stability Index R²:
0.9938180275
Valid data pairs:
6
Constants:
[0] 73.4992369446831
[1] 0.365537834822649
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[814] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-687]
[815] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-688]
[817] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-690]

Bingham Regression
Included blocks(numbers):



Result:

[814] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-687]

Bingham Regression y = mx + n
y = 0.3637 * x + 55.5014
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.3637 Pas
Bingham Yield Stress τ(B)
55.5014 Pa
Standard Deviation:
0.3139688961
Stability Index R^2:
0.9999616753
Valid data pairs:
6
Constants:
[0] 55.5013874944402
[1] 0.363697660595474
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[815] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-688]

Bingham Regression y = mx + n
y = 0.3831 * x + 56.5542
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.3831 Pas
Bingham Yield Stress τ(B)
56.5542 Pa
Standard Deviation:
0.2957305257
Stability Index R²:
0.9999693625
Valid data pairs:
6
Constants:
[0] 56.554246430006
[1] 0.383145845968828
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[817] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-690]

Bingham Regression y = mx + n
y = 0.3602 * x + 54.8853
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.3602 Pas
Bingham Yield Stress τ(B)
54.8853 Pa
Standard Deviation:
0.2627297446
Stability Index R²:
0.9999726340
Valid data pairs:
6
Constants:
[0] 54.8852814900855
[1] 0.360162862220549
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	92.798	66.662	1.3921
3	13	120.960	133.337	0.9072
4	17	149.784	199.999	0.7489
5	21	176.480	266.661	0.6618
6	26	200.634	333.336	0.6019
7	30	220.464	399.998	0.5512
1	34	209.898	399.998	0.5247
2	39	183.905	333.336	0.5517
3	43	158.795	266.661	0.5955
4	47	133.527	199.999	0.6676
5	51	107.769	133.337	0.8082
6	56	81.832	66.662	1.2276

[815] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-688]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	91.890	66.662	1.3784
3	13	118.739	133.337	0.8905
4	17	146.289	199.999	0.7314
5	21	172.079	266.661	0.6453
6	26	195.112	333.336	0.5853
7	30	213.759	399.998	0.5344
1	34	201.398	399.998	0.5035
2	39	176.320	333.336	0.5290
3	43	152.404	266.661	0.5715
4	47	128.157	199.999	0.6408
5	51	103.977	133.337	0.7798
6	56	79.927	66.662	1.1990

[814] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-687]

Report

Measuring DataSet Identifications

[819] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-692]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	819
Execution Date:	3/24/2021
UID:	692
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[820] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-693]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	820
Execution Date:	3/24/2021
UID:	693
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[821] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-694]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	821
Execution Date:	3/24/2021
UID:	694
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

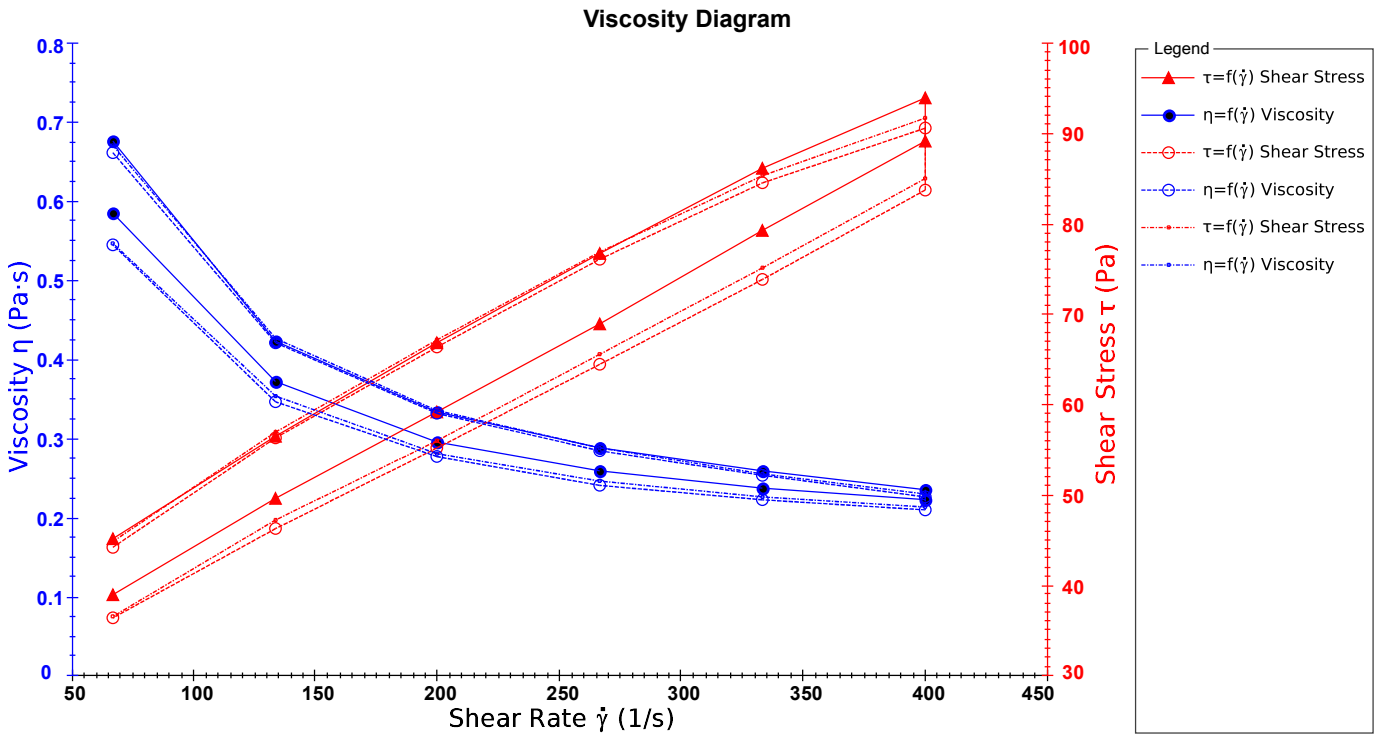
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	44.748	66.662	0.6713
3	13	56.854	133.337	0.4264
4	17	67.096	199.999	0.3355
5	21	76.838	266.661	0.2882
6	26	85.266	333.336	0.2558
7	30	91.737	399.998	0.2293
1	34	84.935	399.998	0.2123
2	39	75.147	333.336	0.2254
3	43	65.506	266.661	0.2457
4	47	56.002	199.999	0.2800
5	51	47.210	133.337	0.3541
6	56	36.492	66.662	0.5474

[821] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-694]

Main Diagram



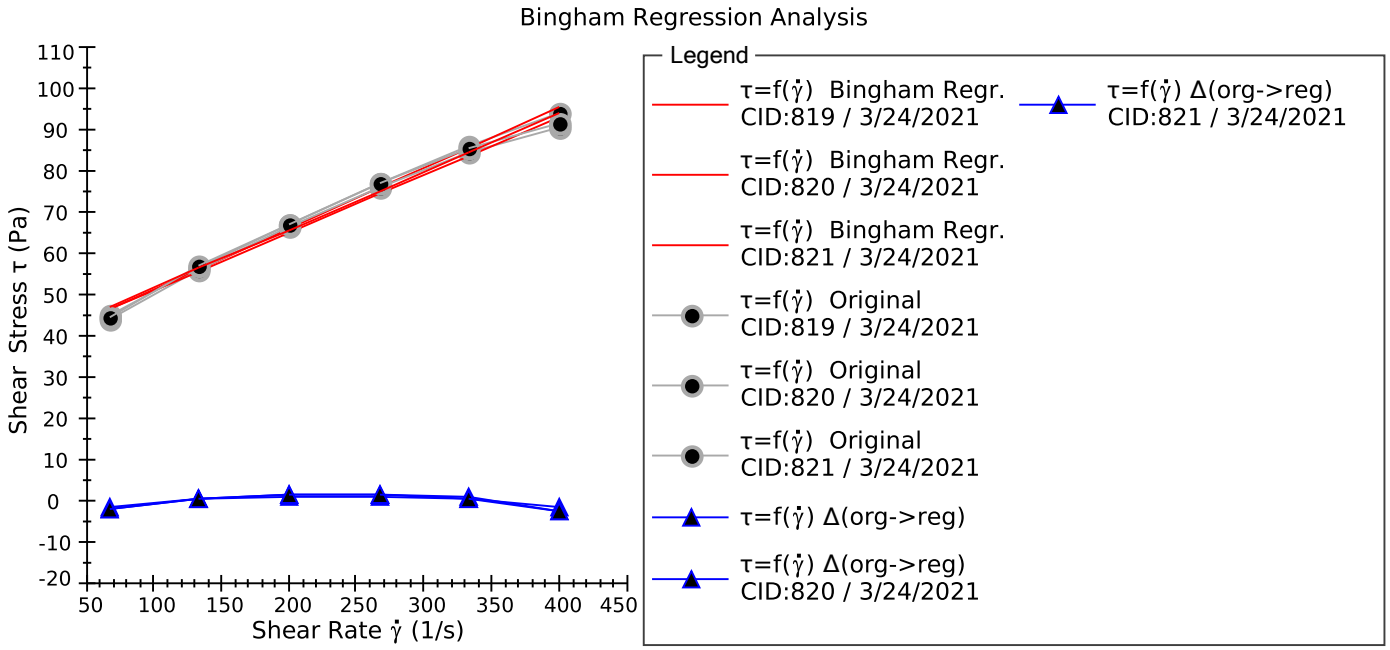
For all DataSets

Regression Analysis

Configuration:

[819] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-692]
[820] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-693]
[821] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-694]

Bingham Regression
Included blocks(numbers):



Result:

[819] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-692]

Bingham Regression y = mx + n
y = 0.147 * x + 36.5698
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.1470 Pas
Bingham Yield Stress τ(B)
36.5698 Pa
Standard Deviation:
1.2313315455
Stability Index R^2:
0.9964042109
Valid data pairs:
6
Constants:
[0] 36.5698139655211
[1] 0.146993197903825
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[820] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-693]

Bingham Regression y = mx + n
y = 0.1398 * x + 36.9764
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.1398 Pas
Bingham Yield Stress τ(B)
36.9764 Pa
Standard Deviation:
2.0321288841
Stability Index R²:
0.9892543314
Valid data pairs:
6
Constants:
[0] 36.9763841020033
[1] 0.139826687681003
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[821] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-694]

Bingham Regression y = mx + n
y = 0.1414 * x + 37.4309
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

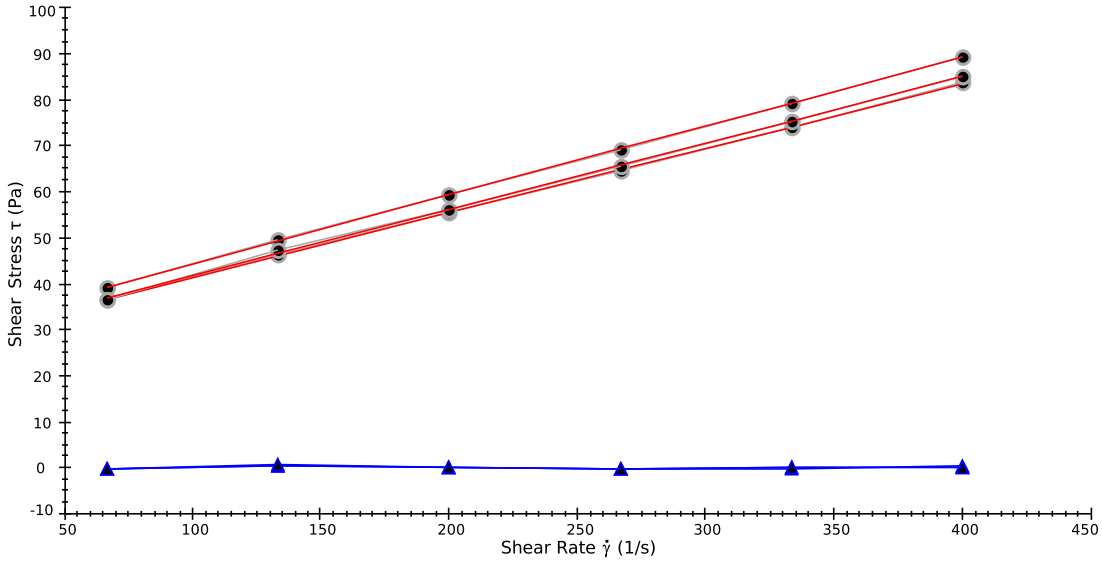
Bingham Viscosity η(B)
0.1414 Pas
Bingham Yield Stress τ(B)
37.4309 Pa
Standard Deviation:
1.9466765779
Stability Index R²:
0.9903460366
Valid data pairs:
6
Constants:
[0] 37.4309421770828
[1] 0.141395642791957
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[819] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-692]
[820] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-693]
[821] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-694]

Bingham Regression
Included blocks(numbers):



Result:

[819] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-692]

Bingham Regression y = mx + n
y = 0.1499 * x + 29.2033
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.1499 Pas
Bingham Yield Stress τ(B)
29.2033 Pa
Standard Deviation:
0.2543436006
Stability Index R^2:
0.9998520073
Valid data pairs:
6
Constants:
[0] 29.2032727538667
[1] 0.149923622609577
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[820] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-693]

Bingham Regression y = mx + n
y = 0.1409 * x + 27.0703
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.1409 Pas
Bingham Yield Stress τ(B)
27.0703 Pa
Standard Deviation:
0.2834962715
Stability Index R²:
0.9997917526
Valid data pairs:
6
Constants:
[0] 27.0703438846042
[1] 0.140868517043722
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[821] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-694]

Bingham Regression y = mx + n
y = 0.1438 * x + 27.329
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.1438 Pas
Bingham Yield Stress τ(B)
27.3290 Pa
Standard Deviation:
0.4287360009
Stability Index R²:
0.9995430456
Valid data pairs:
6
Constants:
[0] 27.3290201540003
[1] 0.143798984973796
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	44.136	66.662	0.6621
3	13	56.211	133.337	0.4216
4	17	66.306	199.999	0.3315
5	21	75.993	266.661	0.2850
6	26	84.479	333.336	0.2534
7	30	90.490	399.998	0.2262
1	34	83.637	399.998	0.2091
2	39	73.846	333.336	0.2215
3	43	64.379	266.661	0.2414
4	47	55.249	199.999	0.2762
5	51	46.236	133.337	0.3468
6	56	36.291	66.662	0.5444

[820] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-693]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	45.082	66.662	0.6763
3	13	56.457	133.337	0.4234
4	17	66.869	199.999	0.3343
5	21	76.775	266.661	0.2879
6	26	86.136	333.336	0.2584
7	30	93.890	399.998	0.2347
1	34	89.179	399.998	0.2229
2	39	79.238	333.336	0.2377
3	43	68.949	266.661	0.2586
4	47	59.212	199.999	0.2961
5	51	49.573	133.337	0.3718
6	56	38.960	66.662	0.5844

[819] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-692]

Report

Measuring DataSet Identifications

[823] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-696]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	823
Execution Date:	3/24/2021
UID:	696
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[824] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-697]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	824
Execution Date:	3/24/2021
UID:	697
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[825] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-698]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	825
Execution Date:	3/24/2021
UID:	698
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

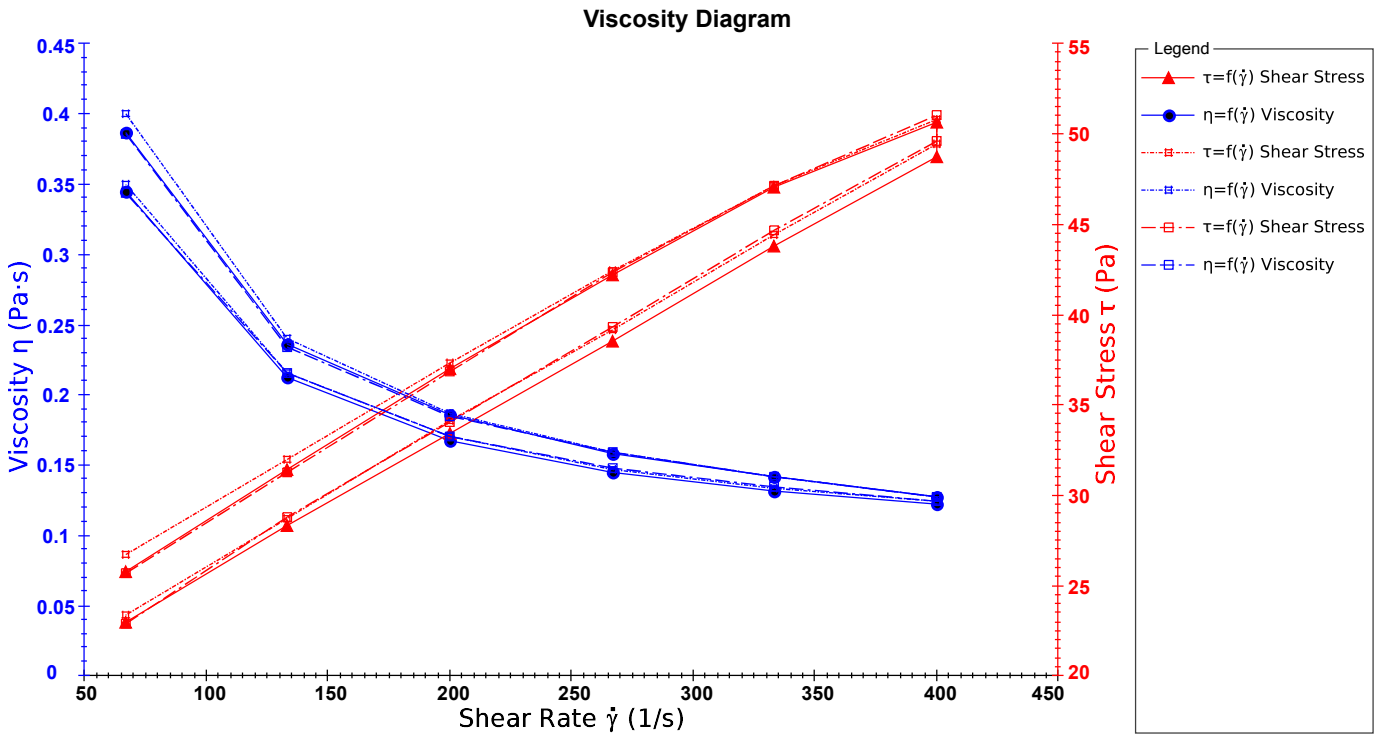
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	25.710	66.662	0.3857
3	13	31.228	133.337	0.2342
4	17	36.862	199.999	0.1843
5	21	42.338	266.661	0.1588
6	26	47.113	333.336	0.1413
7	30	51.027	399.998	0.1276
1	34	49.578	399.998	0.1239
2	39	44.641	333.336	0.1339
3	43	39.297	266.661	0.1474
4	47	34.075	199.999	0.1704
5	51	28.762	133.337	0.2157
6	56	22.907	66.662	0.3436

[825] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-698]

Main Diagram



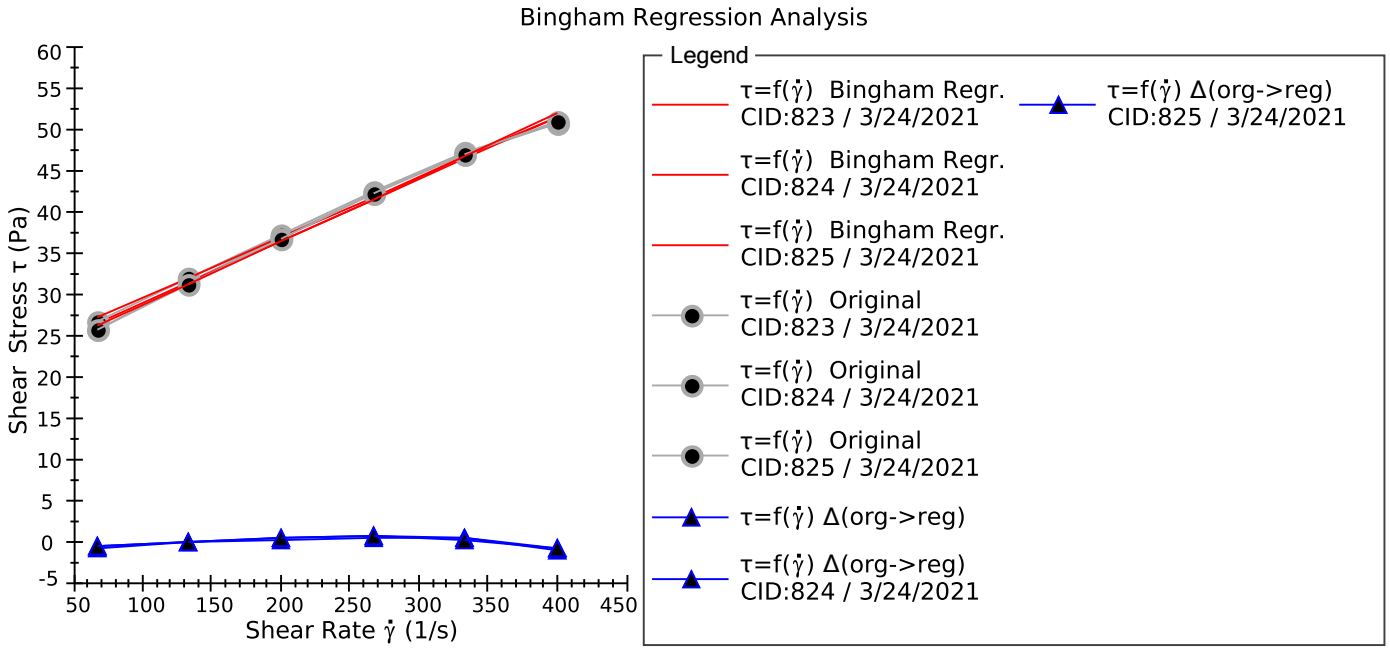
For all DataSets

Regression Analysis

Configuration:

[823] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-696]
[824] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-697]
[825] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-698]

Bingham Regression
Included blocks(numbers):



Result:

[823] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-696]

Bingham Regression y = mx + n
y = 0.0757 * x + 21.3497
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.0757 Pas
Bingham Yield Stress τ(B)
21.3497 Pa
Standard Deviation:
0.7525450190
Stability Index R^2:
0.9949385977
Valid data pairs:
6
Constants:
[0] 21.3496961097781
[1] 0.0756653001582221
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[824] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-697]

Bingham Regression y = mx + n
y = 0.0734 * x + 22.233
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.0734 Pas
Bingham Yield Stress τ(B)
22.2330 Pa
Standard Deviation:
0.6031170862
Stability Index R²:
0.9965437288
Valid data pairs:
6
Constants:
[0] 22.2329925109628
[1] 0.0734425029085228
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[825] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-698]

Bingham Regression y = mx + n
y = 0.077 * x + 21.0746
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

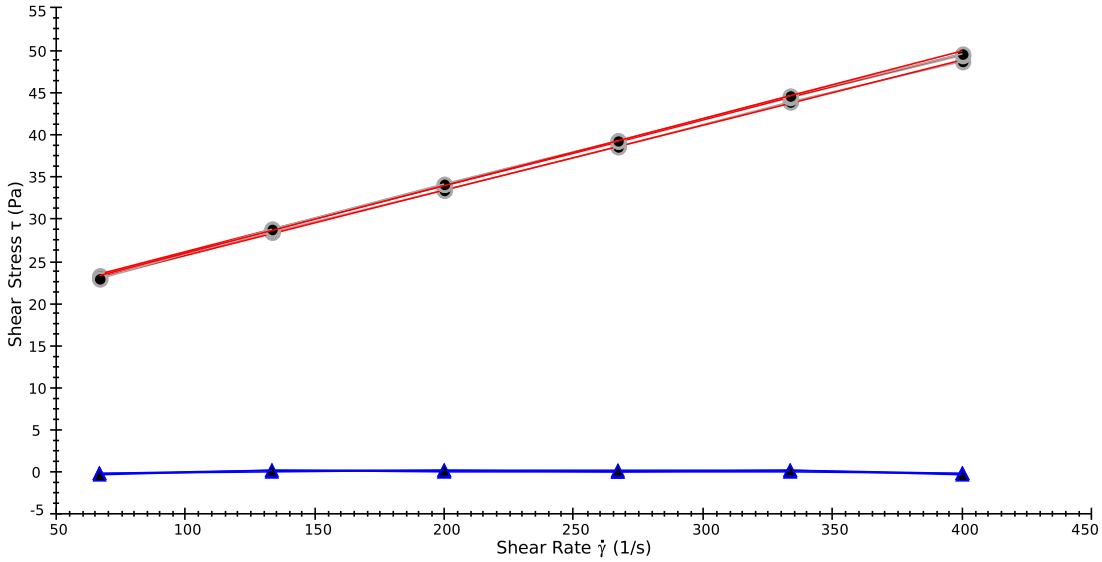
Bingham Viscosity η(B)
0.0770 Pas
Bingham Yield Stress τ(B)
21.0746 Pa
Standard Deviation:
0.6708758972
Stability Index R²:
0.9961133641
Valid data pairs:
6
Constants:
[0] 21.0745817822229
[1] 0.0770213639678822
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[823] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-696]
[824] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-697]
[825] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-698]

Bingham Regression
Included blocks(numbers):



Result:

[823] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-696]

Bingham Regression y = mx + n
y = 0.0773 * x + 17.9088
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.0773 Pas
Bingham Yield Stress τ(B)
17.9088 Pa
Standard Deviation:
0.1275001886
Stability Index R^2:
0.9998599529
Valid data pairs:
6
Constants:
[0] 17.9087737215034
[1] 0.0772582473234243
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[824] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-697]

Bingham Regression y = mx + n
y = 0.0782 * x + 18.277
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.0782 Pas
Bingham Yield Stress τ(B)
18.2770 Pa
Standard Deviation:
0.1576619475
Stability Index R²:
0.9997911606
Valid data pairs:
6
Constants:
[0] 18.2770018991237
[1] 0.0782306474455731
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[825] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-698]

Bingham Regression y = mx + n
y = 0.0798 * x + 17.9219
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.0798 Pas
Bingham Yield Stress τ(B)
17.9219 Pa
Standard Deviation:
0.2658760618
Stability Index R²:
0.9994295309
Valid data pairs:
6
Constants:
[0] 17.9219460088344
[1] 0.0798069728082185
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ẏ	Viscosity (Pa·s) η
2	9	26.677	66.662	0.4002
3	13	31.940	133.337	0.2395
4	17	37.276	199.999	0.1864
5	21	42.377	266.661	0.1589
6	26	47.131	333.336	0.1414
7	30	50.816	399.998	0.1270
1	34	49.418	399.998	0.1235
2	39	44.428	333.336	0.1333
3	43	39.143	266.661	0.1468
4	47	34.131	199.999	0.1707
5	51	28.736	133.337	0.2155
6	56	23.328	66.662	0.3499

[824] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-697]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	25.756	66.662	0.3864
3	13	31.399	133.337	0.2355
4	17	37.010	199.999	0.1851
5	21	42.176	266.661	0.1582
6	26	47.041	333.336	0.1411
7	30	50.648	399.998	0.1266
1	34	48.686	399.998	0.1217
2	39	43.793	333.336	0.1314
3	43	38.488	266.661	0.1443
4	47	33.387	199.999	0.1669
5	51	28.329	133.337	0.2125
6	56	22.930	66.662	0.3440

[823] 3/24/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-696]

Golder

Viscosity / Flow Curve Testing R/S Plus Rheometer

Client:	Troilus
Project Number:	19131334
Date:	2021-04-12
Technologist	CA

		Status	Reviewer	Date Complete
Data Entry		**Complete**	**CA**	**2021-04-12**
Data Review	**1st Review**	**Complete**	**CA**	**2021-04-12**
	2nd Review	**Complete**	**VN**	**2021-04-13**

Sample ID:	19131334 Tailings
Sample Description:	Brown Paste
Water:	Tap Water
pH Adjustment:	N/A
Bob:	CC25 Manufacturer's Bob
Additional Info:	Testing completed at 6°C, sample stored in fridge and temp maintained in waterbath
Specific Gravity	2.84

VISCOSITY DATA

Ramp Up

REF	Trial 1	Trial 2	Trial 3	AVG
1	1.1448	1.0417	1.2163	1.134
2	0.9042	0.8473	0.8089	0.853
3	0.6421	0.6304	0.6561	0.643
4	0.4433	0.4309	0.4376	0.437
5	0.2783	0.2852	0.3002	0.288
6	0.1450	0.1452	0.1494	0.147
7	0.0808	0.8120	0.0836	0.325

Ramp Down

Trial 1	Trial 2	Trial 3	AVG
1.2748	1.2300	1.3202	1.275
0.9895	0.9783	0.9252	0.964
0.6821	0.6973	0.6949	0.691
0.4559	0.4633	0.4423	0.454
0.2880	0.2999	0.3025	0.297
0.1530	0.1474	0.1520	0.151
0.0879	0.0865	0.0866	0.087

YIELD STRESS DATA

Ramp Up

REF	Trial 1	Trial 2	Trial 3	AVG
1	326.4620	330.2170	301.0132	319.231
2	232.2722	265.8837	262.9252	253.694
3	162.2546	167.7589	158.3837	162.799
4	89.2229	91.3448	96.4447	92.337
5	65.9932	69.4338	62.0793	65.835
6	39.2756	36.6722	37.1436	37.697
7	24.8885	23.0886	22.0464	23.341

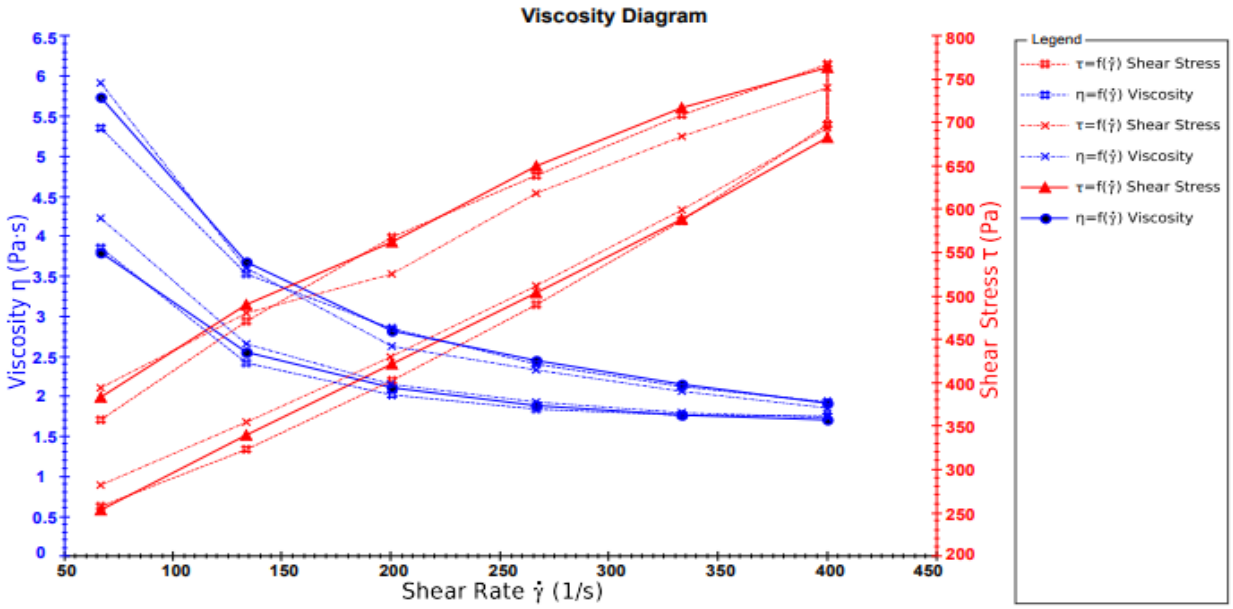
Ramp Down

Trial 1	Trial 2	Trial 3	AVG
167.1001	190.8094	150.8365	169.582
130.6542	132.7336	143.3294	135.572
99.8042	107.0665	102.3937	103.088
68.3720	67.0745	74.3594	69.935
49.5375	50.6282	50.9924	50.386
30.9596	29.2291	29.5959	29.928
18.4680	18.3318	18.0960	18.299

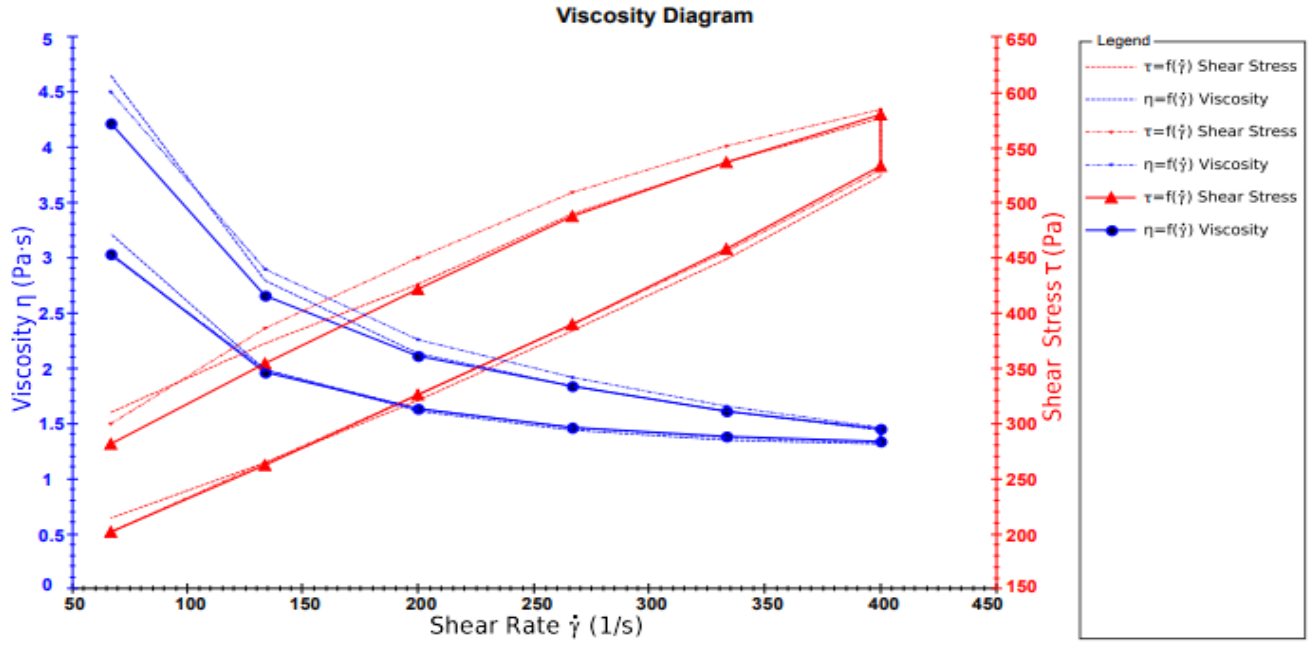
WEIGHT PERCENT SOLIDS

REF	Pan #	Pan Wt. (g)	Wet (g)	Dry (g)	Wt% Solids	SVF (Φ)
1	CA	6.1400	22.0500	18.1200	75.30%	0.52
2	Q25	6.2200	25.1600	20.2400	74.02%	0.50
3	41	6.7700	22.0900	17.9800	73.17%	0.49
4	X36	6.2400	23.8200	18.8600	71.79%	0.47
5	25	6.2700	22.8500	18.0300	70.93%	0.46
6	X6	6.0200	18.7800	14.9000	69.59%	0.45
7	14	29.9600	49.2200	43.1000	68.22%	0.43

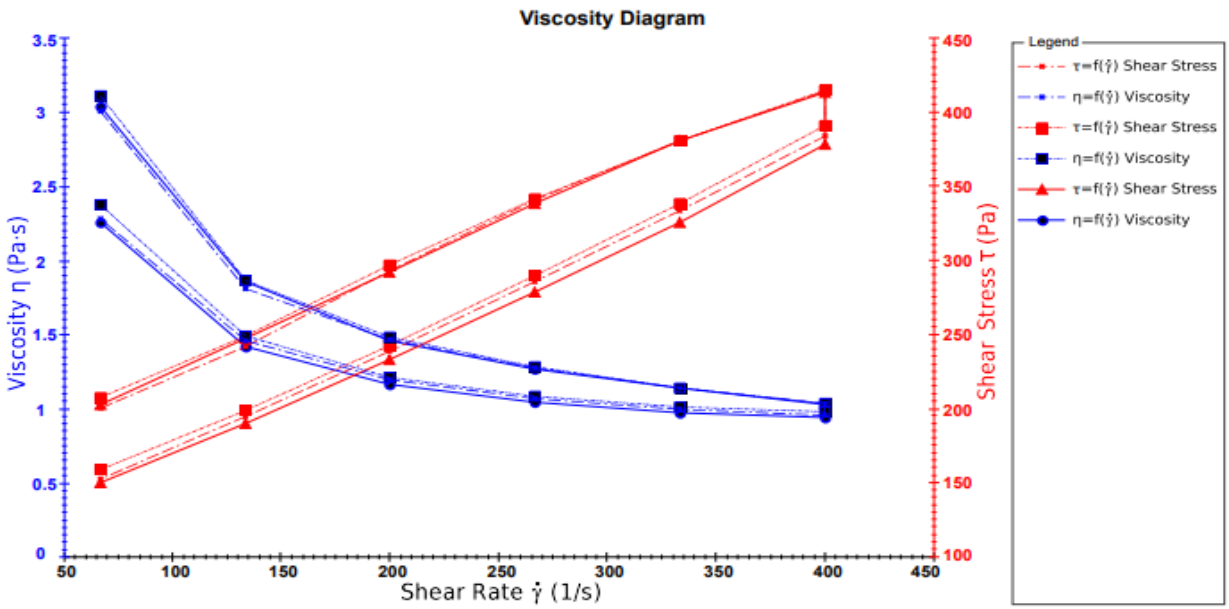
Additional Notes:



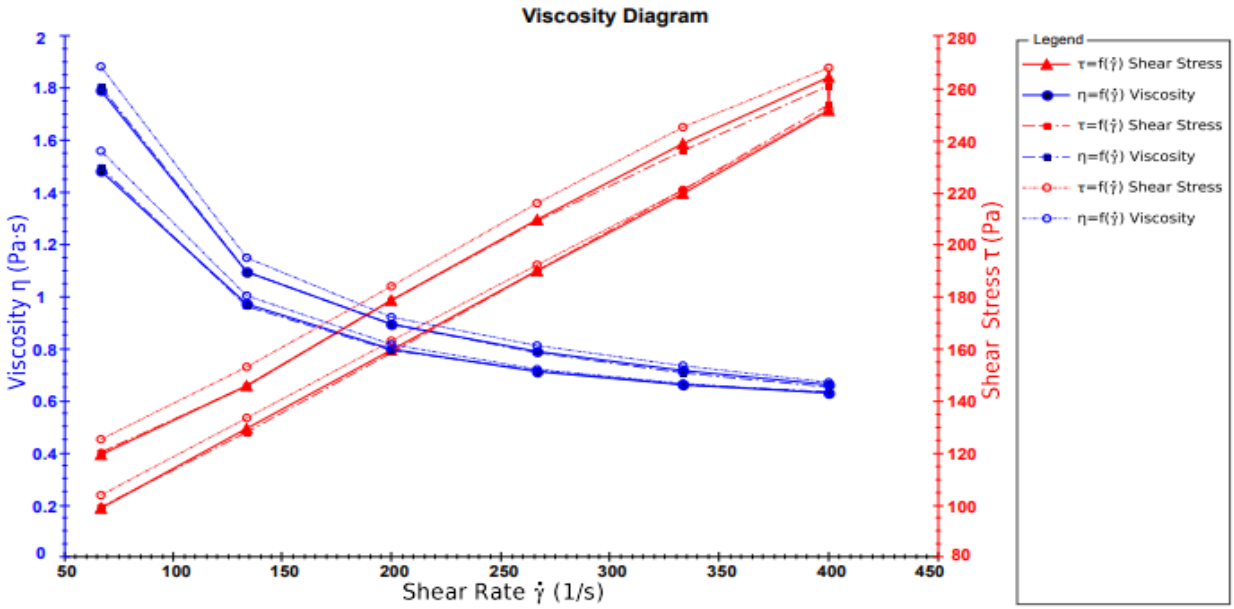
For all DataSets



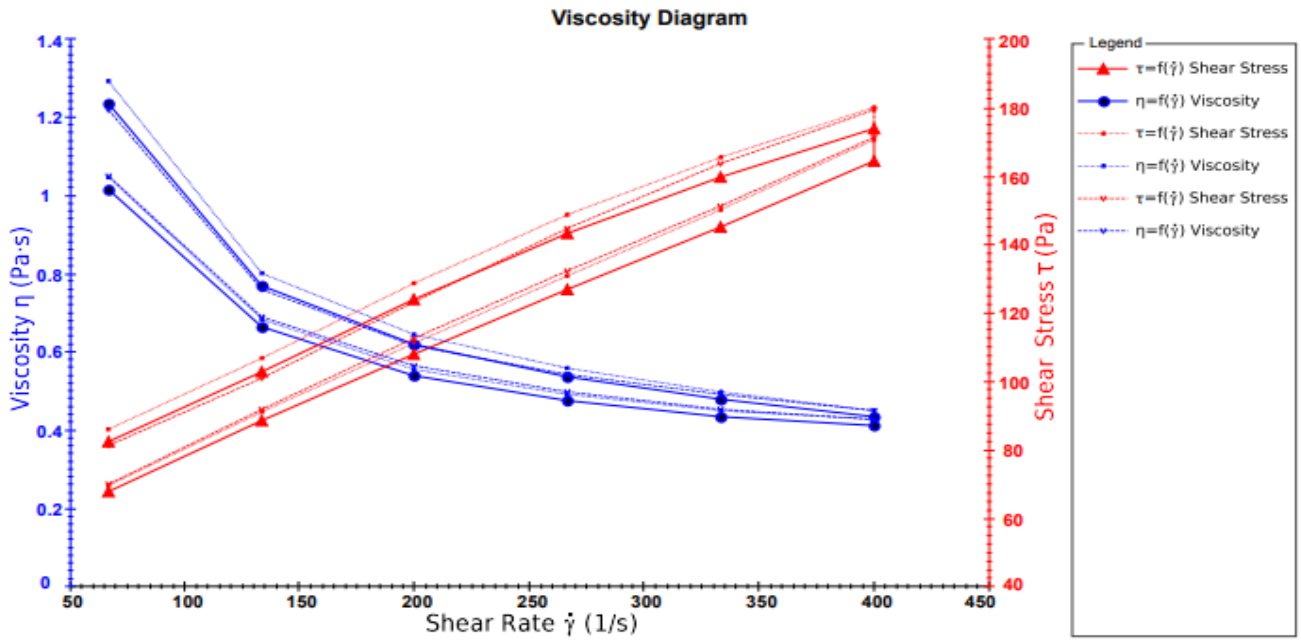
For all DataSets



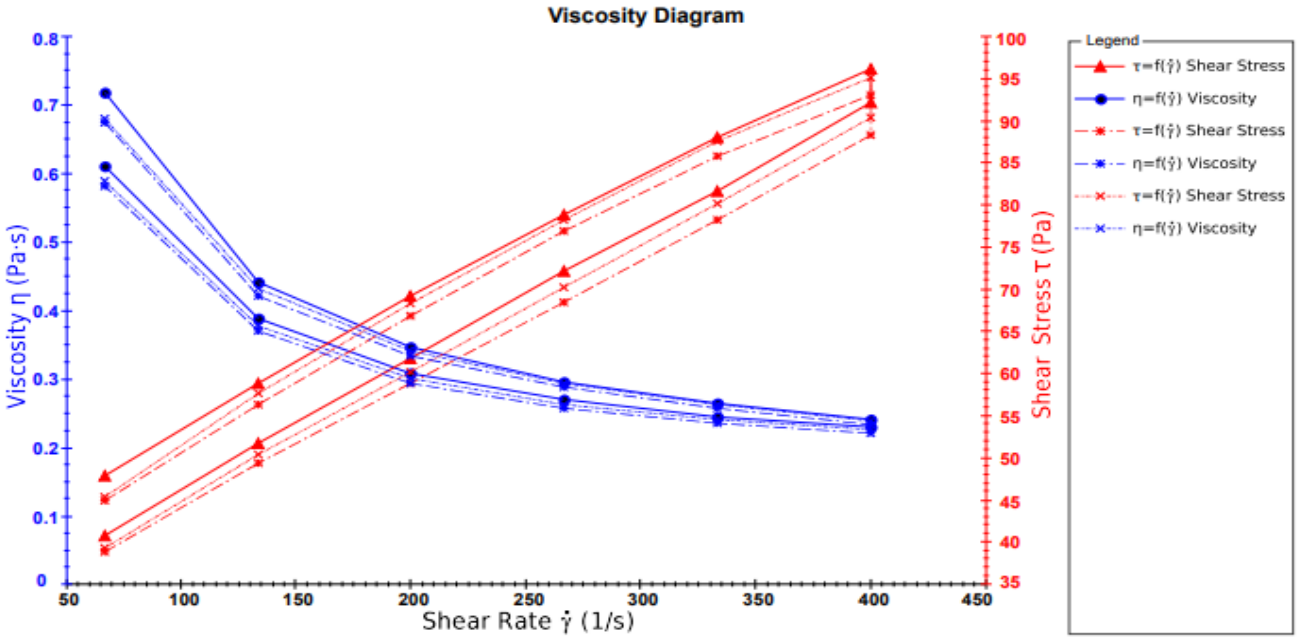
For all DataSets



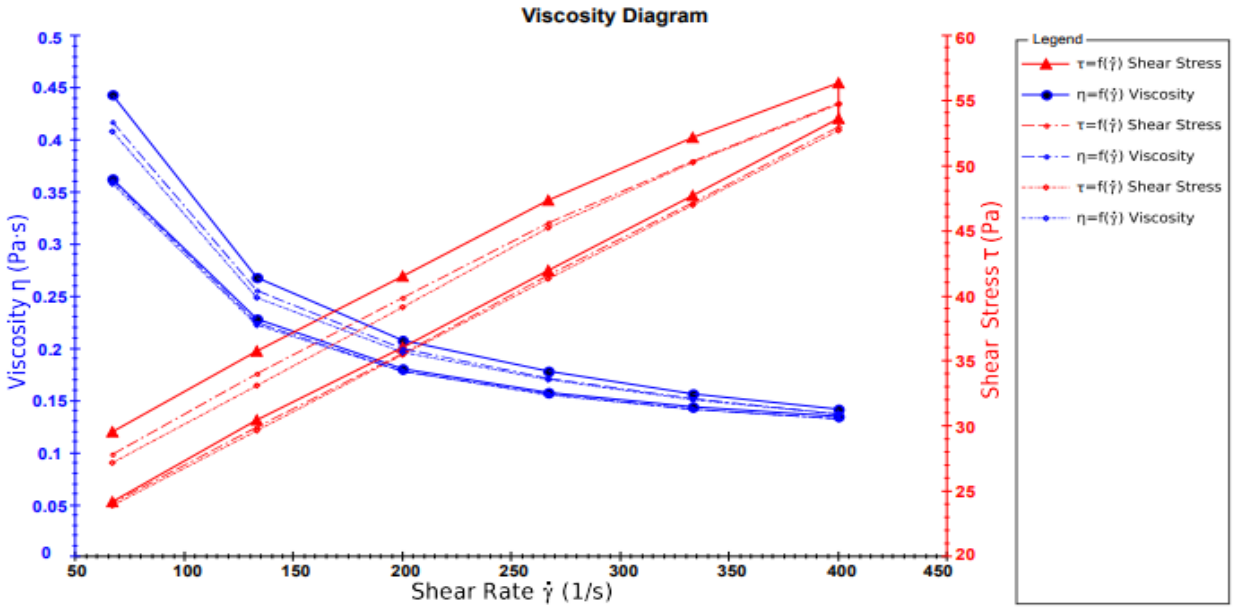
For all DataSets



For all DataSets



For all DataSets



For all DataSets

Report

Measuring DataSet Identifications

[711i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-4]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	711
Execution Date:	4/9/2021
UID:	4
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[710i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-3]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	710
Execution Date:	4/9/2021
UID:	3
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[707i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-2]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	707
Execution Date:	4/9/2021
UID:	2
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

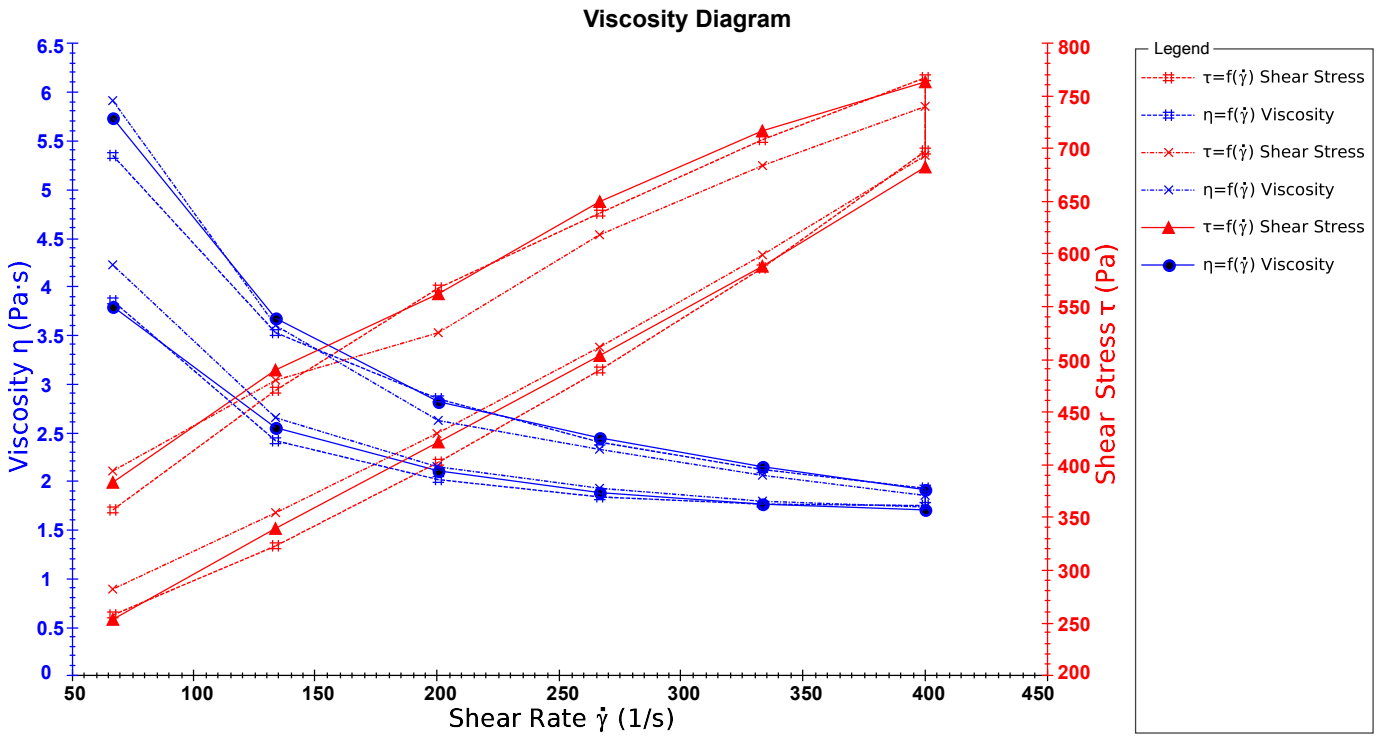
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	356.441	66.701	5.3439
3	13	470.764	133.337	3.5306
4	17	567.557	200.012	2.8376
5	21	638.651	266.661	2.3950
6	26	708.242	333.336	2.1247
7	30	767.296	399.998	1.9183
1	34	696.754	400.011	1.7418
2	39	586.208	333.349	1.7585
3	43	489.606	266.674	1.8360
4	47	402.149	200.012	2.0106
5	51	321.953	133.337	2.4146
6	56	256.679	66.662	3.8504

[707i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-2]

Main Diagram



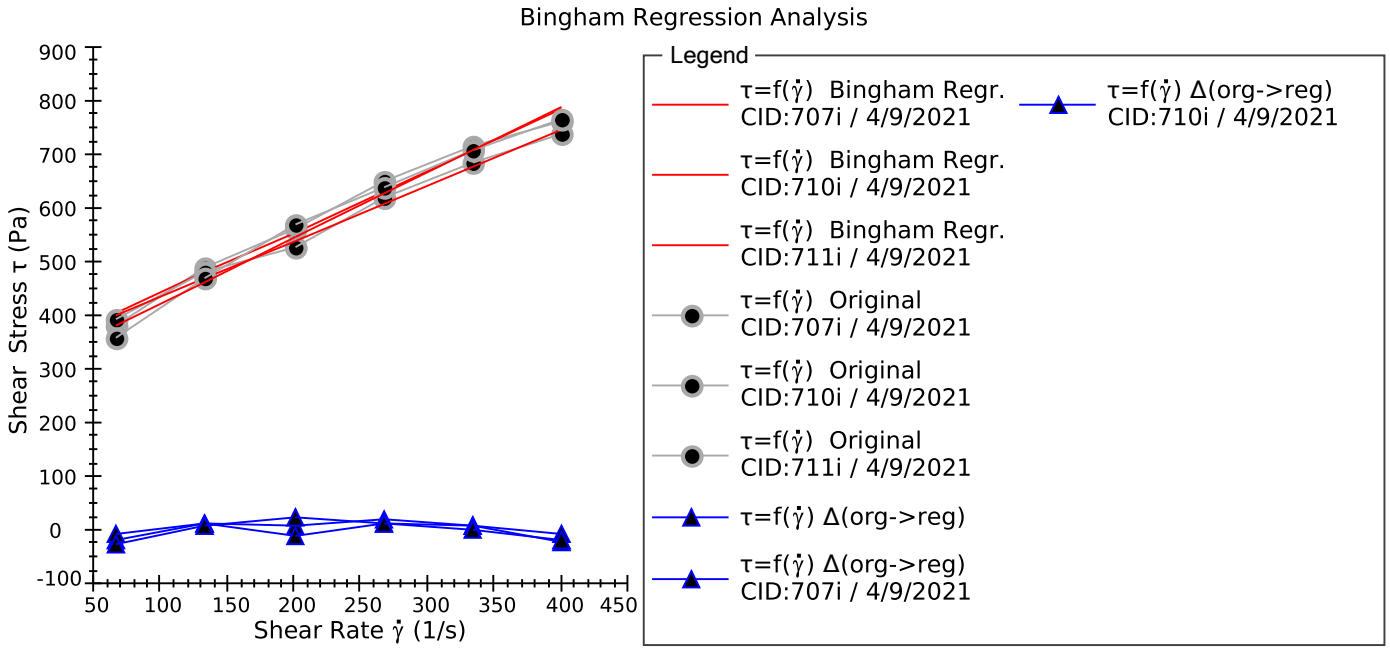
For all DataSets

Regression Analysis

Configuration:

[711i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-4]
[710i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-3]
[707i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-2]

Bingham Regression
Included blocks(numbers):



Result:

[711i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-4]

Bingham Regression y = mx + n
y = 1.1448 * x + 326.462
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
1.1448 Pas
Bingham Yield Stress τ(B)
326.4620 Pa
Standard Deviation:
18.5563300760
Stability Index R²:
0.9866667168
Valid data pairs:
6
Constants:
[0] 326.461953182741
[1] 1.14483774181582
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[710i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-3]

Bingham Regression y = mx + n
y = 1.0417 * x + 330.217
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
1.0417 Pas
Bingham Yield Stress τ(B)
330.2170 Pa
Standard Deviation:
11.6225885271
Stability Index R²:
0.9936382377
Valid data pairs:
6
Constants:
[0] 330.217035011167
[1] 1.04172107879464
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[707i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-2]

Bingham Regression y = mx + n
y = 1.2163 * x + 301.0132
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

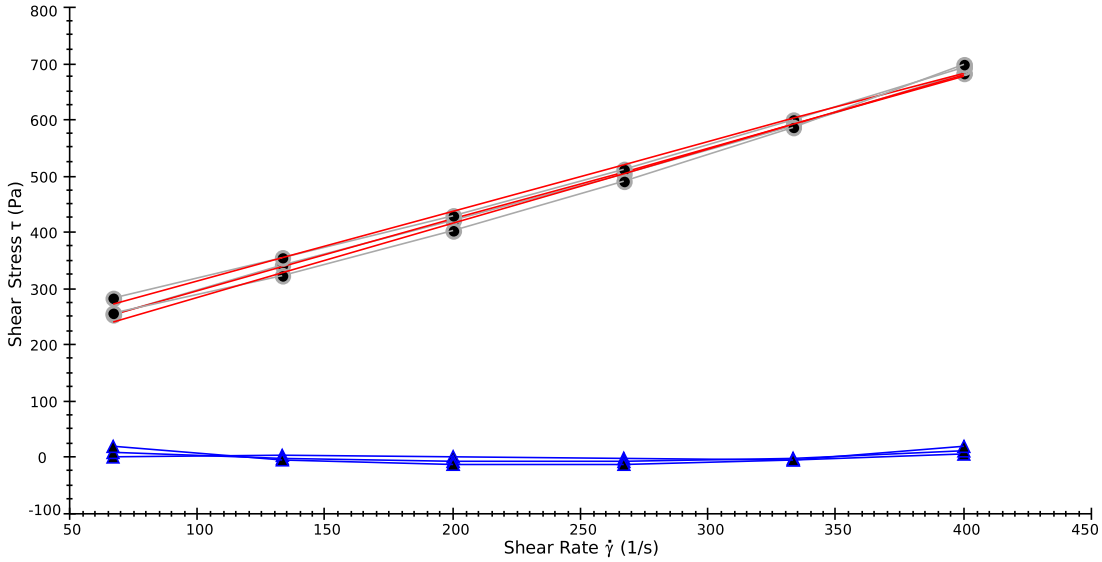
Bingham Viscosity η(B)
1.2163 Pas
Bingham Yield Stress τ(B)
301.0132 Pa
Standard Deviation:
21.4990678744
Stability Index R²:
0.9841833694
Valid data pairs:
6
Constants:
[0] 301.013151137938
[1] 1.21629975009644
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[711i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-4]
[710i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-3]
[707i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-2]

Bingham Regression
Included blocks(numbers):



Result:

[711i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-4]

Bingham Regression y = mx + n
y = 1.2748 * x + 167.1001
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
1.2748 Pas
Bingham Yield Stress τ(B)
167.1001 Pa
Standard Deviation:
4.2715538975
Stability Index R^2:
0.9994229042
Valid data pairs:
6
Constants:
[0] 167.100125172568
[1] 1.27476033567065
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[710i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-3]

Bingham Regression y = mx + n
y = 1.23 * x + 190.8094
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
1.2300 Pas
Bingham Yield Stress τ(B)
190.8094 Pa
Standard Deviation:
8.5028350014
Stability Index R²:
0.9975483933
Valid data pairs:
6
Constants:
[0] 190.809364894485
[1] 1.22996429113035
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[707i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-2]

Bingham Regression y = mx + n
y = 1.3202 * x + 150.8365
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
1.3202 Pas
Bingham Yield Stress τ(B)
150.8365 Pa
Standard Deviation:
15.9786763305
Stability Index R²:
0.9925232745
Valid data pairs:
6
Constants:
[0] 150.836509096144
[1] 1.32019412043971
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	393.542	66.688	5.9013
3	13	480.078	133.350	3.6001
4	17	525.347	200.012	2.6266
5	21	618.137	266.661	2.3181
6	26	683.804	333.336	2.0514
7	30	738.863	400.011	1.8471
1	34	692.621	400.011	1.7315
2	39	597.951	333.336	1.7938
3	43	511.394	266.674	1.9177
4	47	429.804	199.999	2.1490
5	51	353.378	133.337	2.6503
6	56	281.679	66.662	4.2255

[710i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-3]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	382.461	66.701	5.7340
3	13	488.869	133.350	3.6661
4	17	562.015	200.012	2.8099
5	21	649.568	266.661	2.4359
6	26	715.544	333.336	2.1466
7	30	763.167	400.011	1.9079
1	34	682.626	400.011	1.7065
2	39	587.470	333.336	1.7624
3	43	503.313	266.661	1.8875
4	47	421.495	200.012	2.1073
5	51	339.538	133.337	2.5465
6	56	252.846	66.662	3.7930

[711i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-4]

Report

Measuring DataSet Identifications

[720i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-7]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	720
Execution Date:	4/9/2021
UID:	7
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[719i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-6]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	719
Execution Date:	4/9/2021
UID:	6
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[717i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-5]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	717
Execution Date:	4/9/2021
UID:	5
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

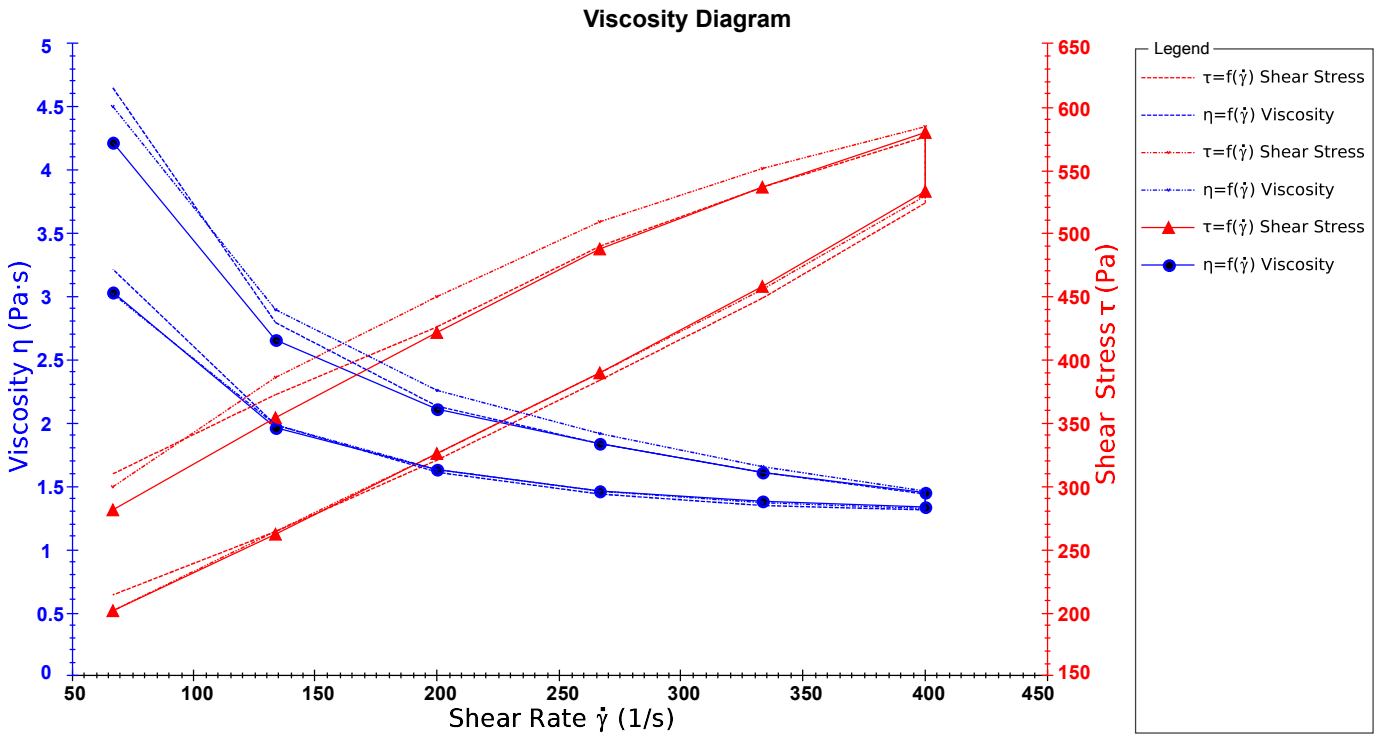
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	310.067	66.662	4.6513
3	13	372.135	133.363	2.7904
4	17	425.703	199.999	2.1285
5	21	489.458	266.661	1.8355
6	26	536.564	333.336	1.6097
7	30	576.162	400.011	1.4404
1	34	523.388	400.011	1.3084
2	39	448.254	333.336	1.3448
3	43	383.626	266.661	1.4386
4	47	321.180	200.012	1.6058
5	51	264.475	133.337	1.9835
6	56	214.368	66.662	3.2157

[717i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-5]

Main Diagram



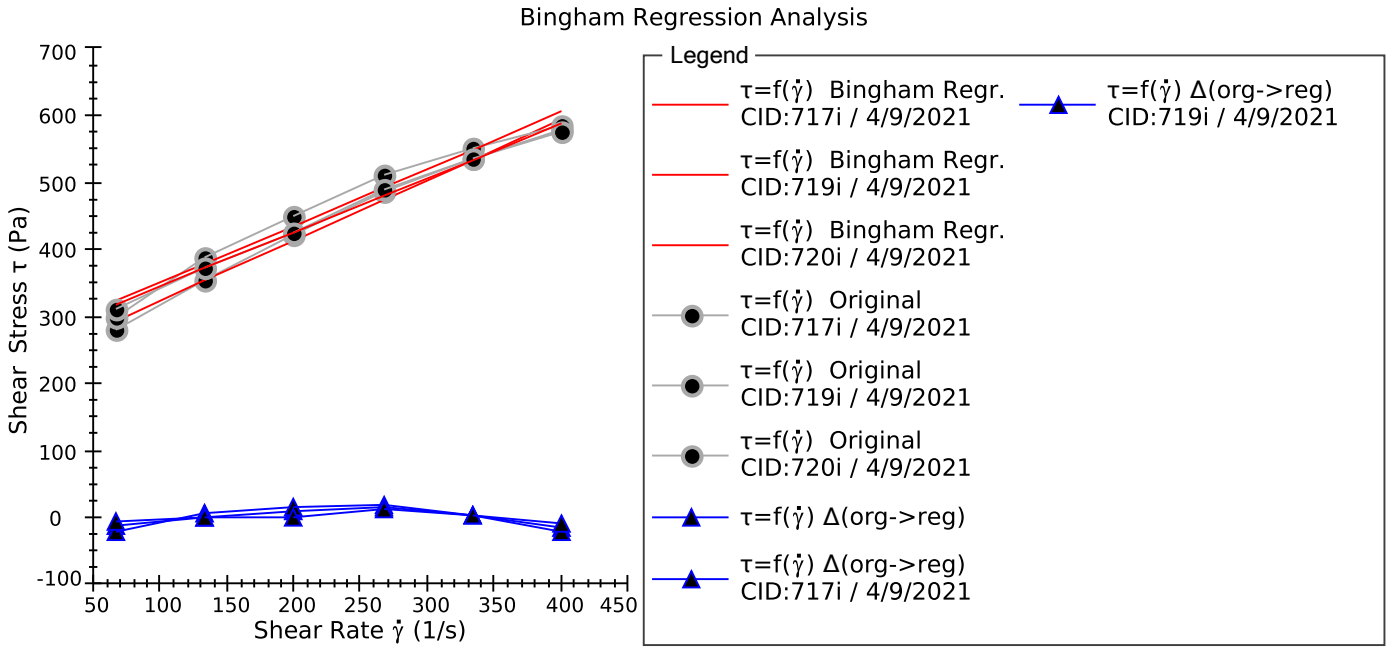
For all DataSets

Regression Analysis

Configuration:

[720i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-7]
[719i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-6]
[717i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-5]

Bingham Regression
Included blocks(numbers):



Result:

[720i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-7]

Bingham Regression y = mx + n
y = 0.9042 * x + 232.2722
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.9042 Pas
Bingham Yield Stress τ(B)
232.2722 Pa
Standard Deviation:
12.4509654828
Stability Index R^2:
0.9903428302
Valid data pairs:
6
Constants:
[0] 232.272155815015
[1] 0.904201531020191
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[719i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-6]

Bingham Regression y = mx + n
y = 0.8473 * x + 265.8837
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.8473 Pas
Bingham Yield Stress τ(B)
265.8837 Pa
Standard Deviation:
19.5783840724
Stability Index R²:
0.9732750142
Valid data pairs:
6
Constants:
[0] 265.883663528258
[1] 0.847272386933826
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[717i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-5]

Bingham Regression y = mx + n
y = 0.8089 * x + 262.9252
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

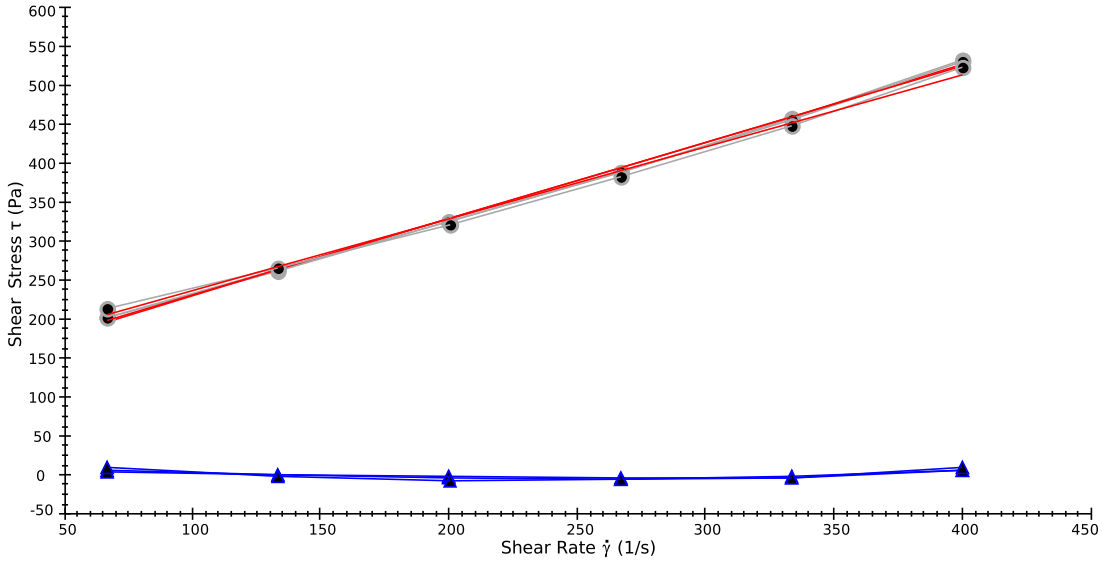
Bingham Viscosity η(B)
0.8089 Pas
Bingham Yield Stress τ(B)
262.9252 Pa
Standard Deviation:
8.4978062800
Stability Index R²:
0.9943566912
Valid data pairs:
6
Constants:
[0] 262.925196635237
[1] 0.808937521368163
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[720i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-7]
[719i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-6]
[717i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-5]

Bingham Regression
Included blocks(numbers):



Result:

[720i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-7]

Bingham Regression y = mx + n
y = 0.9895 * x + 130.6542
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.9895 Pas
Bingham Yield Stress τ(B)
130.6542 Pa
Standard Deviation:
5.1921452581
Stability Index R^2:
0.9985860027
Valid data pairs:
6
Constants:
[0] 130.65415714511
[1] 0.989502392900115
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[719i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-6]

Bingham Regression y = mx + n
y = 0.9783 * x + 132.7336
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.9783 Pas
Bingham Yield Stress τ(B)
132.7336 Pa
Standard Deviation:
4.6753629784
Stability Index R²:
0.9988267568
Valid data pairs:
6
Constants:
[0] 132.733575487339
[1] 0.978263750165642
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[717i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-5]

Bingham Regression y = mx + n
y = 0.9252 * x + 143.3294
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.9252 Pas
Bingham Yield Stress τ(B)
143.3294 Pa
Standard Deviation:
8.6179366280
Stability Index R²:
0.9955580472
Valid data pairs:
6
Constants:
[0] 143.329415483597
[1] 0.925212695213894
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ẏ	Viscosity (Pa·s) η
2	9	299.745	66.662	4.4965
3	13	386.291	133.337	2.8971
4	17	450.307	199.999	2.2515
5	21	509.641	266.674	1.9111
6	26	551.132	333.336	1.6534
7	30	584.381	400.011	1.4609
1	34	530.160	400.011	1.3254
2	39	455.759	333.336	1.3673
3	43	389.125	266.661	1.4593
4	47	325.551	199.999	1.6278
5	51	263.965	133.337	1.9797
6	56	201.415	66.662	3.0214

[719i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-6]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	280.752	66.662	4.2116
3	13	353.806	133.350	2.6532
4	17	420.945	199.986	2.1049
5	21	487.672	266.661	1.8288
6	26	536.707	333.336	1.6101
7	30	579.636	400.011	1.4491
1	34	532.800	400.011	1.3320
2	39	458.230	333.336	1.3747
3	43	389.381	266.661	1.4602
4	47	325.263	199.999	1.6263
5	51	261.944	133.337	1.9645
6	56	201.628	66.675	3.0240

[720i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-7]

Report

Measuring DataSet Identifications

[725i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-11]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	725
Execution Date:	4/9/2021
UID:	11
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[724i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-10]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	724
Execution Date:	4/9/2021
UID:	10
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[721i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-9]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	721
Execution Date:	4/9/2021
UID:	9
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

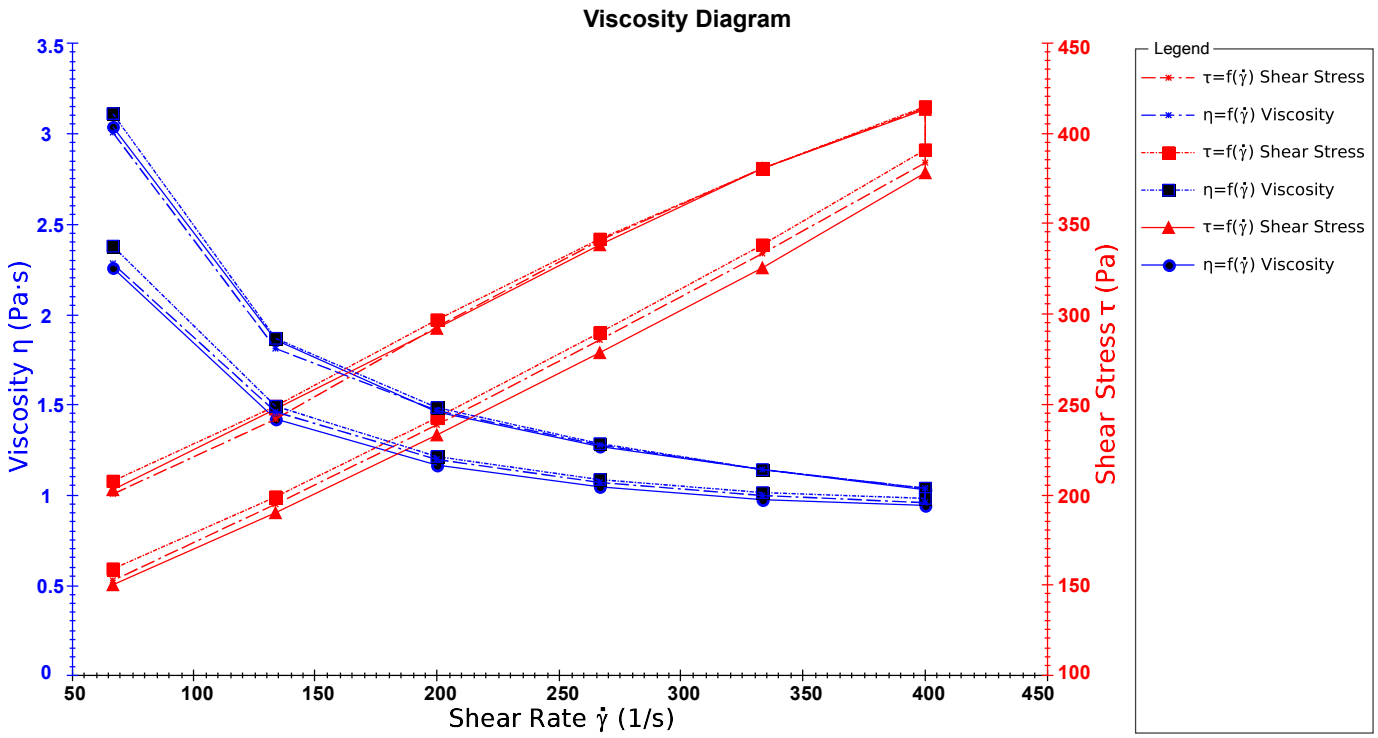
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	200.173	66.662	3.0028
3	13	241.563	133.337	1.8117
4	17	292.663	199.999	1.4633
5	21	340.565	266.661	1.2771
6	26	380.473	333.336	1.1414
7	30	413.441	399.998	1.0336
1	34	383.584	399.998	0.9590
2	39	333.248	333.336	0.9997
3	43	285.458	266.661	1.0705
4	47	238.551	199.999	1.1928
5	51	194.415	133.337	1.4581
6	56	151.973	66.662	2.2798

[721i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-9]

Main Diagram



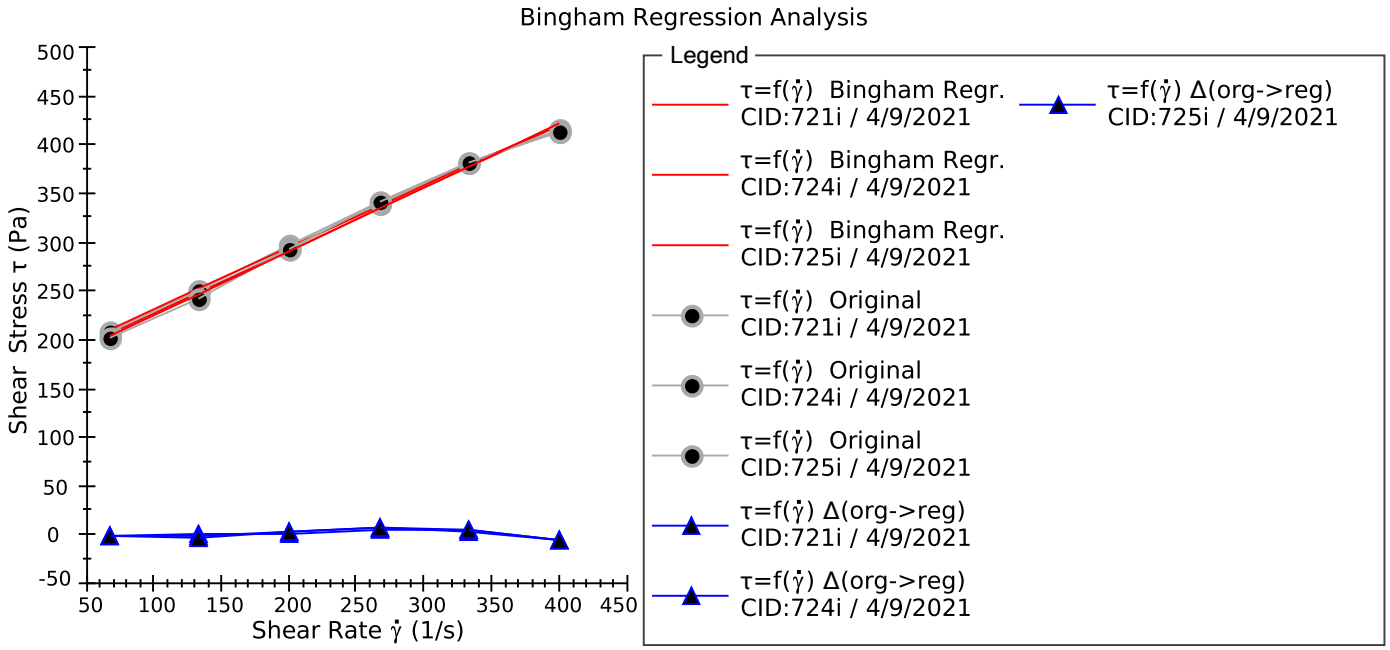
For all DataSets

Regression Analysis

Configuration:

[725i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-11]
[724i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-10]
[721i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-9]

Bingham Regression
Included blocks(numbers): 1



Result:

[725i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-11]

Bingham Regression y = mx + n
y = 0.6421 * x + 162.2546
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.6421 Pas
Bingham Yield Stress τ(B)
162.2546 Pa
Standard Deviation:
4.6670839625
Stability Index R²:
0.9972906055
Valid data pairs:
6
Constants:
[0] 162.254643141594
[1] 0.642128462073529
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[724i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-10]

Bingham Regression y = mx + n
y = 0.6304 * x + 167.7589
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.6304 Pas
Bingham Yield Stress τ(B)
167.7589 Pa
Standard Deviation:
4.7659160730
Stability Index R²:
0.9970687200
Valid data pairs:
6
Constants:
[0] 167.758880955416
[1] 0.630350126989455
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[721i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-9]

Bingham Regression y = mx + n
y = 0.6561 * x + 158.3837
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

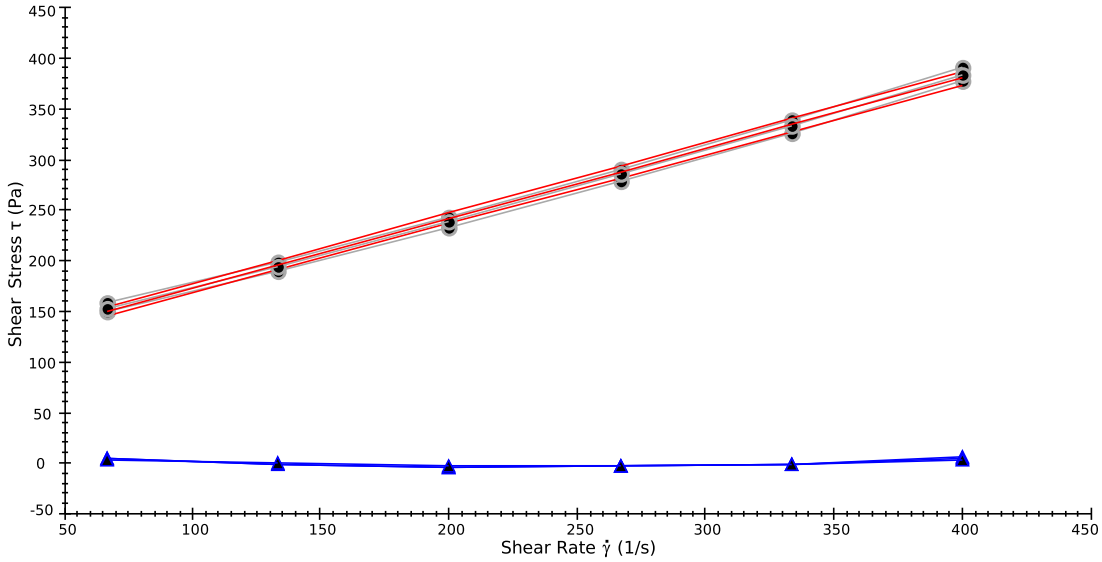
Bingham Viscosity η(B)
0.6561 Pas
Bingham Yield Stress τ(B)
158.3837 Pa
Standard Deviation:
6.1203385152
Stability Index R²:
0.9955451196
Valid data pairs:
6
Constants:
[0] 158.383727555499
[1] 0.656129331496152
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[725i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-11]
[724i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-10]
[721i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-9]

Bingham Regression
Included blocks(numbers): 2



Result:

[725i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-11]

Bingham Regression y = mx + n
y = 0.6821 * x + 99.8042
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.6821 Pas
Bingham Yield Stress τ(B)
99.8042 Pa
Standard Deviation:
4.5156906629
Stability Index R^2:
0.9977511801
Valid data pairs:
6
Constants:
[0] 99.804191114708
[1] 0.68209542842695
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[724i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-10]

Bingham Regression y = mx + n
y = 0.6973 * x + 107.0665
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.6973 Pas
Bingham Yield Stress τ(B)
107.0665 Pa
Standard Deviation:
4.4819739320
Stability Index R²:
0.9978799996
Valid data pairs:
6
Constants:
[0] 107.066473397126
[1] 0.697316709796122
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[721i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-9]

Bingham Regression y = mx + n
y = 0.6949 * x + 102.3937
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.6949 Pas
Bingham Yield Stress τ(B)
102.3937 Pa
Standard Deviation:
2.9593656152
Stability Index R²:
0.9990681621
Valid data pairs:
6
Constants:
[0] 102.39372428487
[1] 0.694908403737978
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ẏ	Viscosity (Pa·s) η
2	9	207.404	66.662	3.1113
3	13	249.145	133.337	1.8685
4	17	296.888	199.999	1.4845
5	21	341.499	266.661	1.2806
6	26	379.919	333.336	1.1397
7	30	414.182	399.998	1.0355
1	34	390.896	400.011	0.9772
2	39	338.274	333.336	1.0148
3	43	289.572	266.661	1.0859
4	47	242.597	199.999	1.2130
5	51	198.685	133.337	1.4901
6	56	158.621	66.662	2.3795

[724i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-10]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ẏ	Viscosity (Pa·s) η
2	9	202.298	66.662	3.0347
3	13	247.382	133.337	1.8553
4	17	291.437	199.999	1.4572
5	21	338.190	266.661	1.2682
6	26	380.397	333.336	1.1412
7	30	412.799	399.998	1.0320
1	34	377.914	400.011	0.9448
2	39	325.223	333.336	0.9757
3	43	278.419	266.674	1.0440
4	47	232.442	199.999	1.1622
5	51	189.627	133.337	1.4222
6	56	150.145	66.662	2.2523

[725i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-11]

Report

Measuring DataSet Identifications

[726i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-12]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	726
Execution Date:	4/9/2021
UID:	12
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[727i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-13]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	727
Execution Date:	4/9/2021
UID:	13
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[728i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-14]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	728
Execution Date:	4/9/2021
UID:	14
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

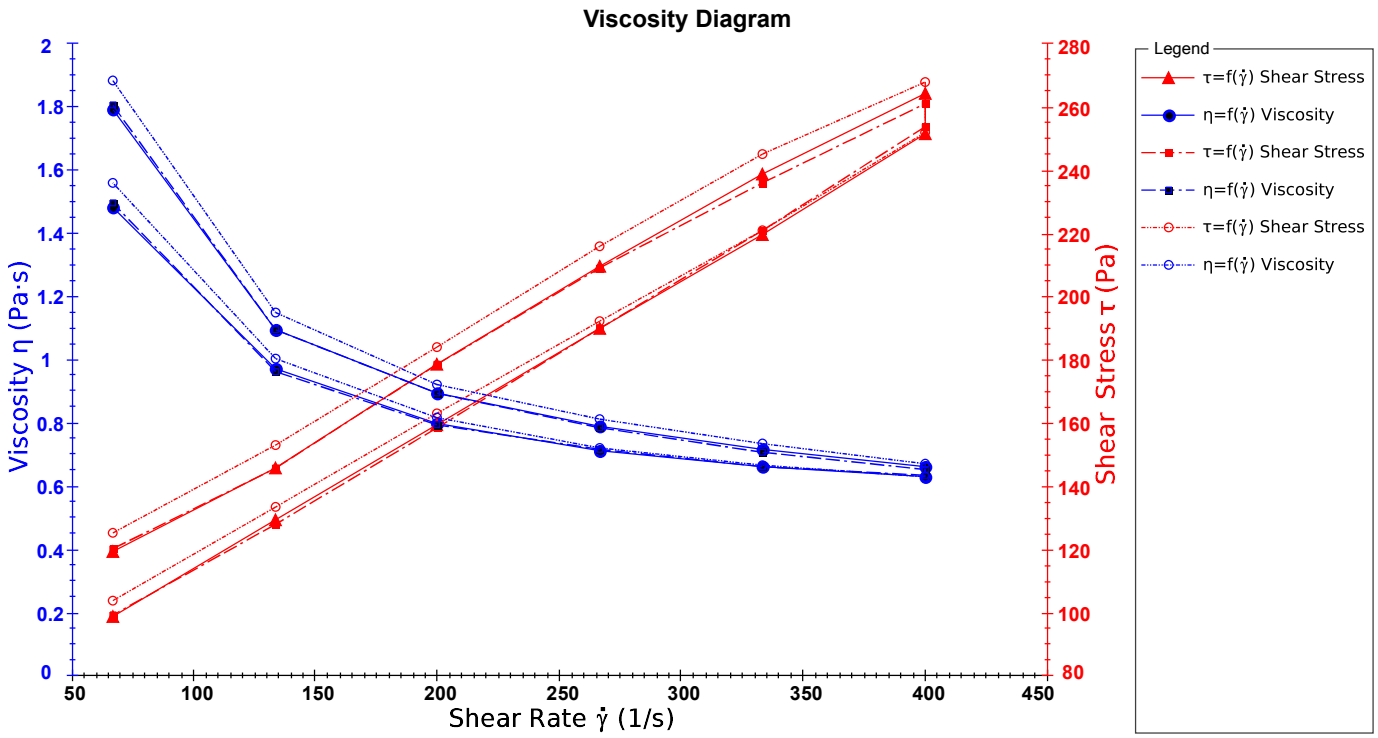
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	125.304	66.662	1.8797
3	13	152.951	133.337	1.1471
4	17	184.086	199.999	0.9204
5	21	215.995	266.661	0.8100
6	26	245.094	333.336	0.7353
7	30	267.837	399.998	0.6696
1	34	251.840	399.998	0.6296
2	39	220.972	333.336	0.6629
3	43	192.314	266.661	0.7212
4	47	163.021	199.999	0.8151
5	51	133.561	133.337	1.0017
6	56	103.720	66.662	1.5559

[728i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-14]

Main Diagram



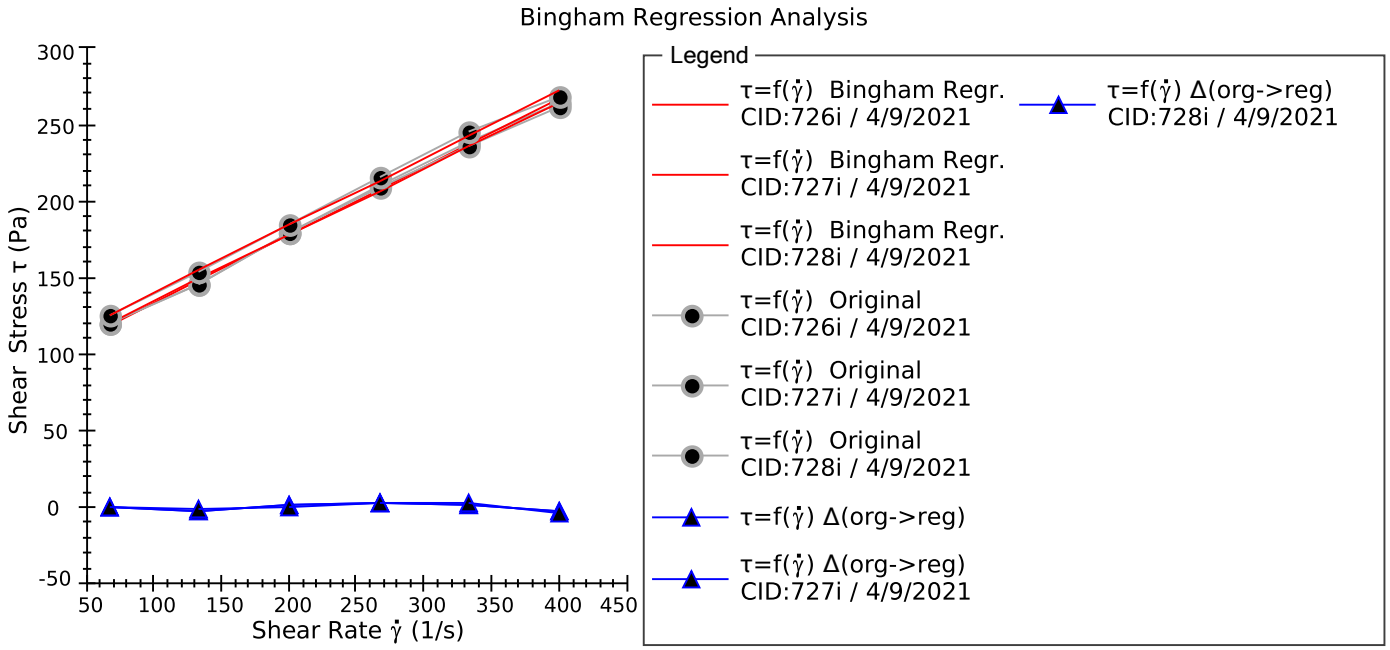
For all DataSets

Regression Analysis

Configuration:

[726i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-12]
[727i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-13]
[728i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-14]

Bingham Regression
Included blocks(numbers):



Result:

[726i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-12]

Bingham Regression y = mx + n
y = 0.4433 * x + 89.2229
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.4433 Pas
Bingham Yield Stress τ(B)
89.2229 Pa
Standard Deviation:
2.2982281301
Stability Index R^2:
0.9986195761
Valid data pairs:
6
Constants:
[0] 89.2229344104805
[1] 0.443290581482031
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

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[727i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-13]

Bingham Regression y = mx + n
y = 0.4309 * x + 91.3448
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.4309 Pas
Bingham Yield Stress τ(B)
91.3448 Pa
Standard Deviation:
2.5175542828
Stability Index R²:
0.9982473557
Valid data pairs:
6
Constants:
[0] 91.3448074798674
[1] 0.430876285309312
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[728i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-14]

Bingham Regression y = mx + n
y = 0.4376 * x + 96.4447
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

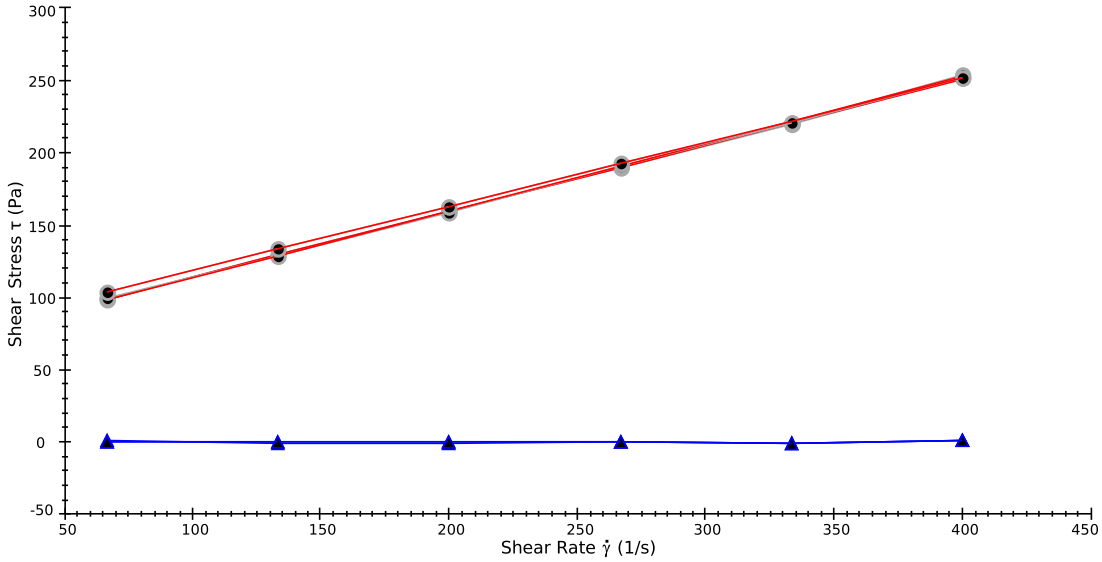
Bingham Viscosity η(B)
0.4376 Pas
Bingham Yield Stress τ(B)
96.4447 Pa
Standard Deviation:
2.8599054738
Stability Index R²:
0.9978079372
Valid data pairs:
6
Constants:
[0] 96.4447334452431
[1] 0.437572708283562
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[726i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-12]
[727i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-13]
[728i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-14]

Bingham Regression
Included blocks(numbers):



Result:

[726i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-12]

Bingham Regression y = mx + n
y = 0.4559 * x + 68.372
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.4559 Pas
Bingham Yield Stress τ(B)
68.3720 Pa
Standard Deviation:
0.5289165290
Stability Index R^2:
0.9999307958
Valid data pairs:
6
Constants:
[0] 68.3719743938789
[1] 0.455939886084341
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[727i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-13]

Bingham Regression y = mx + n
y = 0.4633 * x + 67.0745
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.4633 Pas
Bingham Yield Stress τ(B)
67.0745 Pa
Standard Deviation:
1.2405330691
Stability Index R²:
0.9996314648
Valid data pairs:
6
Constants:
[0] 67.0745107098034
[1] 0.463329974743167
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[728i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-14]

Bingham Regression y = mx + n
y = 0.4423 * x + 74.3594
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.4423 Pas
Bingham Yield Stress τ(B)
74.3594 Pa
Standard Deviation:
0.5238137257
Stability Index R²:
0.9999278872
Valid data pairs:
6
Constants:
[0] 74.3593915770495
[1] 0.44234035837122
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ẏ	Viscosity (Pa·s) η
2	9	120.159	66.662	1.8025
3	13	146.012	133.337	1.0951
4	17	178.802	199.999	0.8940
5	21	209.114	266.661	0.7842
6	26	236.063	333.336	0.7082
7	30	261.142	399.998	0.6529
1	34	253.721	399.998	0.6343
2	39	220.911	333.336	0.6627
3	43	190.179	266.661	0.7132
4	47	158.698	199.999	0.7935
5	51	128.135	133.337	0.9610
6	56	99.462	66.662	1.4920

[727i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-13]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	119.222	66.662	1.7885
3	13	145.735	133.337	1.0930
4	17	178.577	199.999	0.8929
5	21	209.574	266.661	0.7859
6	26	238.747	333.336	0.7162
7	30	264.085	399.998	0.6602
1	34	251.392	399.998	0.6285
2	39	219.601	333.336	0.6588
3	43	189.858	266.661	0.7120
4	47	159.428	199.999	0.7971
5	51	129.499	133.337	0.9712
6	56	98.766	66.662	1.4816

[726i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-12]

Report

Measuring DataSet Identifications

[729i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-16]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	729
Execution Date:	4/9/2021
UID:	16
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[730i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-17]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	730
Execution Date:	4/9/2021
UID:	17
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[731i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-18]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	731
Execution Date:	4/9/2021
UID:	18
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

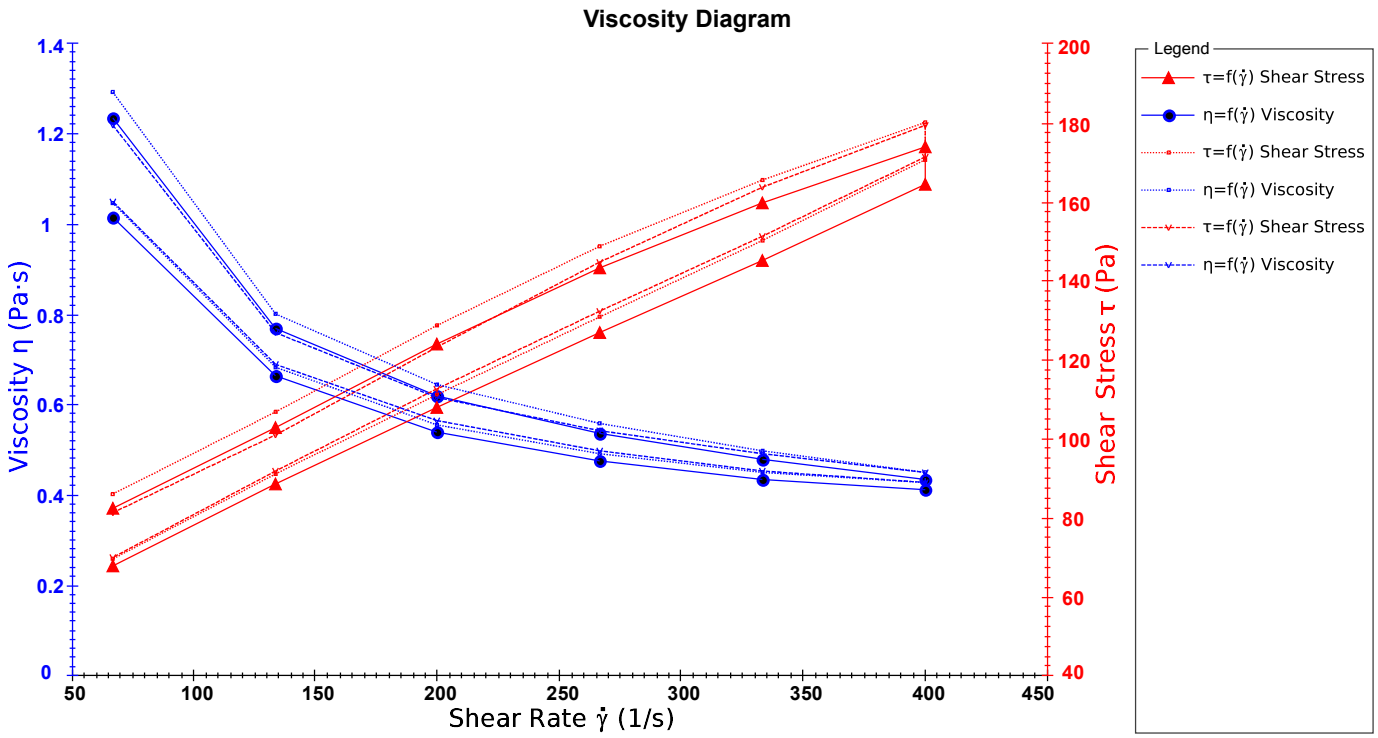
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	81.123	66.662	1.2169
3	13	100.999	133.337	0.7575
4	17	123.018	199.999	0.6151
5	21	144.704	266.661	0.5427
6	26	163.514	333.336	0.4905
7	30	179.357	399.998	0.4484
1	34	171.401	399.998	0.4285
2	39	151.353	333.336	0.4541
3	43	132.409	266.661	0.4965
4	47	112.600	199.999	0.5630
5	51	91.770	133.337	0.6883
6	56	69.939	66.662	1.0492

[731i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-18]

Main Diagram



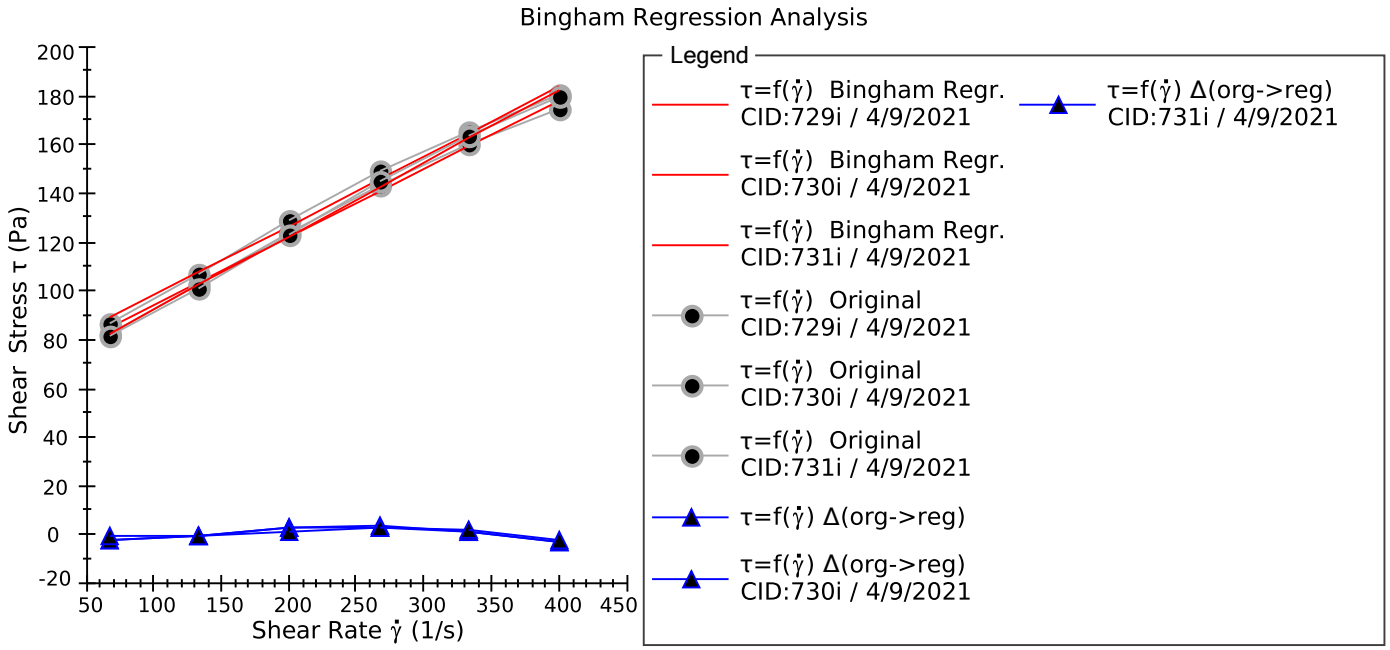
For all DataSets

Regression Analysis

Configuration:

[729i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-16]
[730i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-17]
[731i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-18]

Bingham Regression
Included blocks(numbers):



Result:

[729i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-16]

Bingham Regression y = mx + n
y = 0.2783 * x + 65.9932
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.2783 Pas
Bingham Yield Stress τ(B)
65.9932 Pa
Standard Deviation:
2.7486553549
Stability Index R²:
0.9950067264
Valid data pairs:
6
Constants:
[0] 65.9931662116547
[1] 0.278254488459433
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[730i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-17]

Bingham Regression y = mx + n
y = 0.2852 * x + 69.4338
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.2852 Pas
Bingham Yield Stress τ(B)
69.4338 Pa
Standard Deviation:
2.8116194784
Stability Index R²:
0.9950262547
Valid data pairs:
6
Constants:
[0] 69.4338024486611
[1] 0.285189547803659
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[731i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-18]

Bingham Regression y = mx + n
y = 0.3002 * x + 62.0793
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

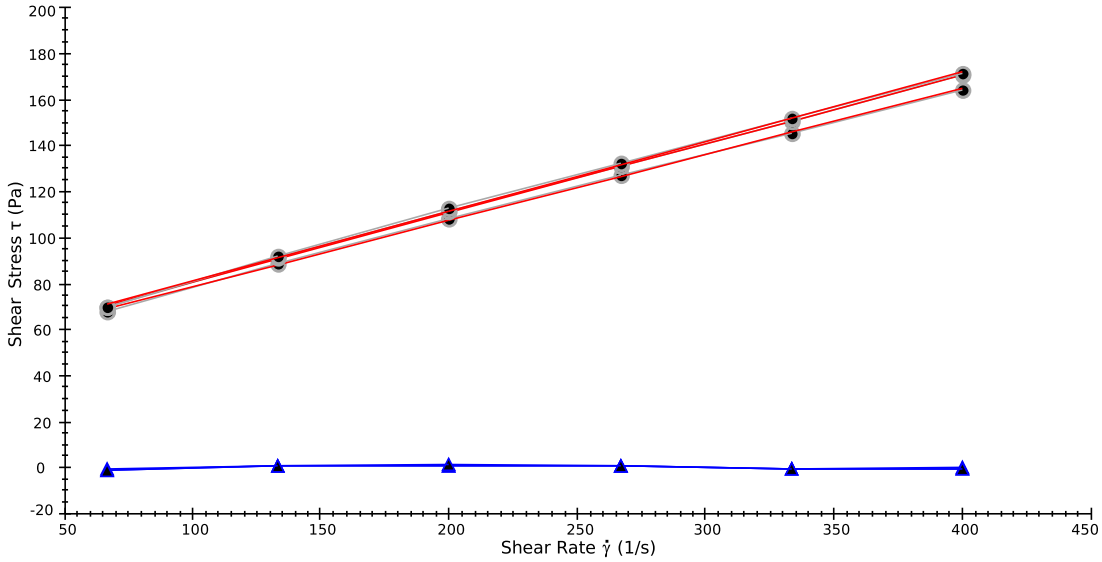
Bingham Viscosity η(B)
0.3002 Pas
Bingham Yield Stress τ(B)
62.0793 Pa
Standard Deviation:
2.1973418718
Stability Index R²:
0.9972517177
Valid data pairs:
6
Constants:
[0] 62.0793178406335
[1] 0.300172511617313
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[729i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-16]
[730i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-17]
[731i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-18]

Bingham Regression
Included blocks(numbers):



Result:

[729i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-16]

Bingham Regression y = mx + n
y = 0.288 * x + 49.5375
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.2880 Pas
Bingham Yield Stress τ(B)
49.5375 Pa
Standard Deviation:
0.8662564865
Stability Index R^2:
0.9995349625
Valid data pairs:
6
Constants:
[0] 49.5374774260205
[1] 0.288007007826482
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[730i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-17]

Bingham Regression y = mx + n
y = 0.2999 * x + 50.6282
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.2999 Pas
Bingham Yield Stress τ(B)
50.6282 Pa
Standard Deviation:
0.6654888414
Stability Index R²:
0.9997468501
Valid data pairs:
6
Constants:
[0] 50.6282452637772
[1] 0.2999151928751
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[731i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-18]

Bingham Regression y = mx + n
y = 0.3025 * x + 50.9924
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.3025 Pas
Bingham Yield Stress τ(B)
50.9924 Pa
Standard Deviation:
1.0058871959
Stability Index R²:
0.9994317229
Valid data pairs:
6
Constants:
[0] 50.9923634868527
[1] 0.302515295577662
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ẏ	Viscosity (Pa·s) η
2	9	86.152	66.662	1.2924
3	13	106.900	133.337	0.8017
4	17	128.712	199.999	0.6436
5	21	148.558	266.661	0.5571
6	26	165.333	333.336	0.4960
7	30	180.211	399.998	0.4505
1	34	170.397	399.998	0.4260
2	39	150.110	333.336	0.4503
3	43	130.996	266.661	0.4912
4	47	111.256	199.999	0.5563
5	51	91.098	133.337	0.6832
6	56	69.791	66.662	1.0469

[730i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-17]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	82.276	66.662	1.2342
3	13	102.613	133.337	0.7696
4	17	123.788	199.999	0.6189
5	21	143.141	266.661	0.5368
6	26	159.673	333.336	0.4790
7	30	174.022	399.998	0.4351
1	34	164.322	399.998	0.4108
2	39	145.090	333.336	0.4353
3	43	126.894	266.661	0.4759
4	47	107.923	199.999	0.5396
5	51	88.594	133.337	0.6644
6	56	67.610	66.662	1.0142

[729i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-16]

Report

Measuring DataSet Identifications

[733i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-19]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	733
Execution Date:	4/9/2021
UID:	19
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[734i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-20]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	734
Execution Date:	4/9/2021
UID:	20
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[735i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-21]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	735
Execution Date:	4/9/2021
UID:	21
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

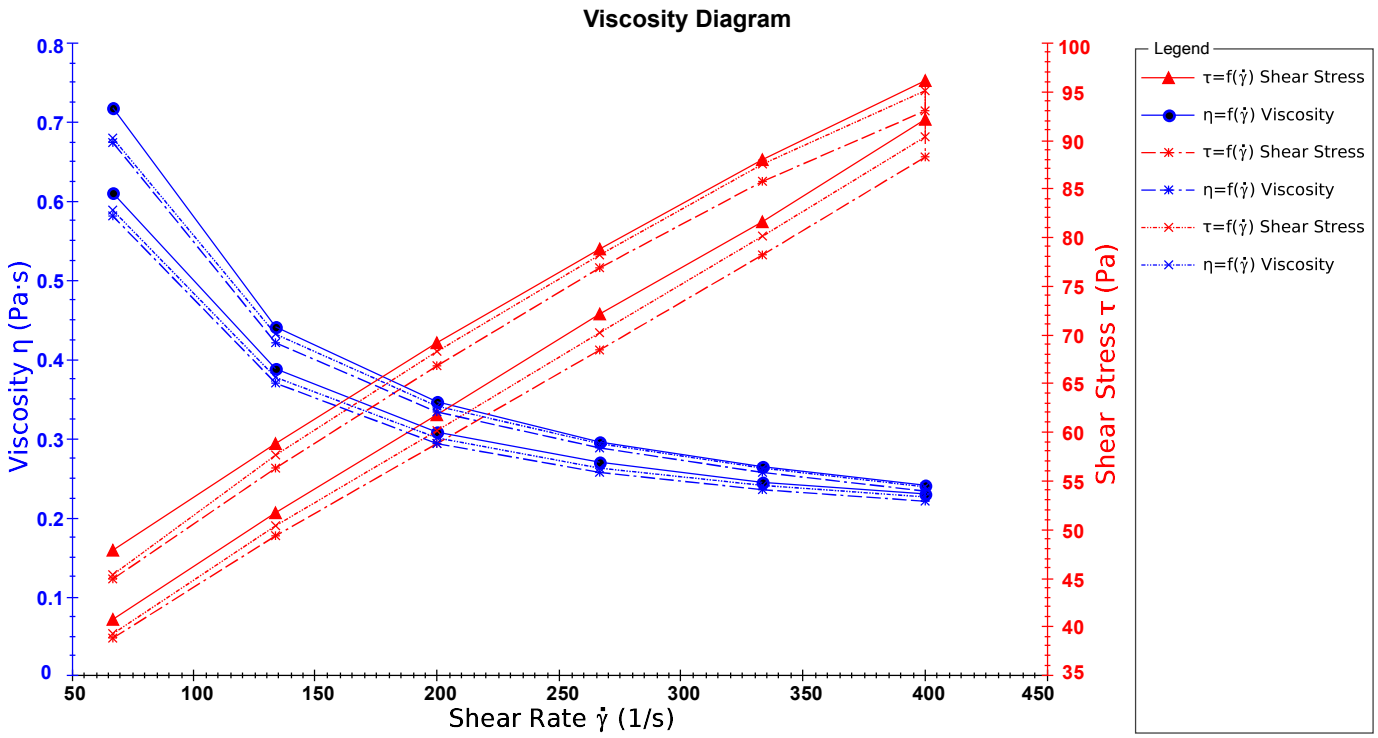
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	45.345	66.662	0.6802
3	13	57.556	133.337	0.4317
4	17	68.302	199.999	0.3415
5	21	78.221	266.661	0.2933
6	26	87.498	333.336	0.2625
7	30	95.125	399.998	0.2378
1	34	90.352	399.998	0.2259
2	39	80.040	333.336	0.2401
3	43	70.191	266.661	0.2632
4	47	60.126	199.999	0.3006
5	51	50.365	133.337	0.3777
6	56	39.253	66.662	0.5888

[735i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-21]

Main Diagram



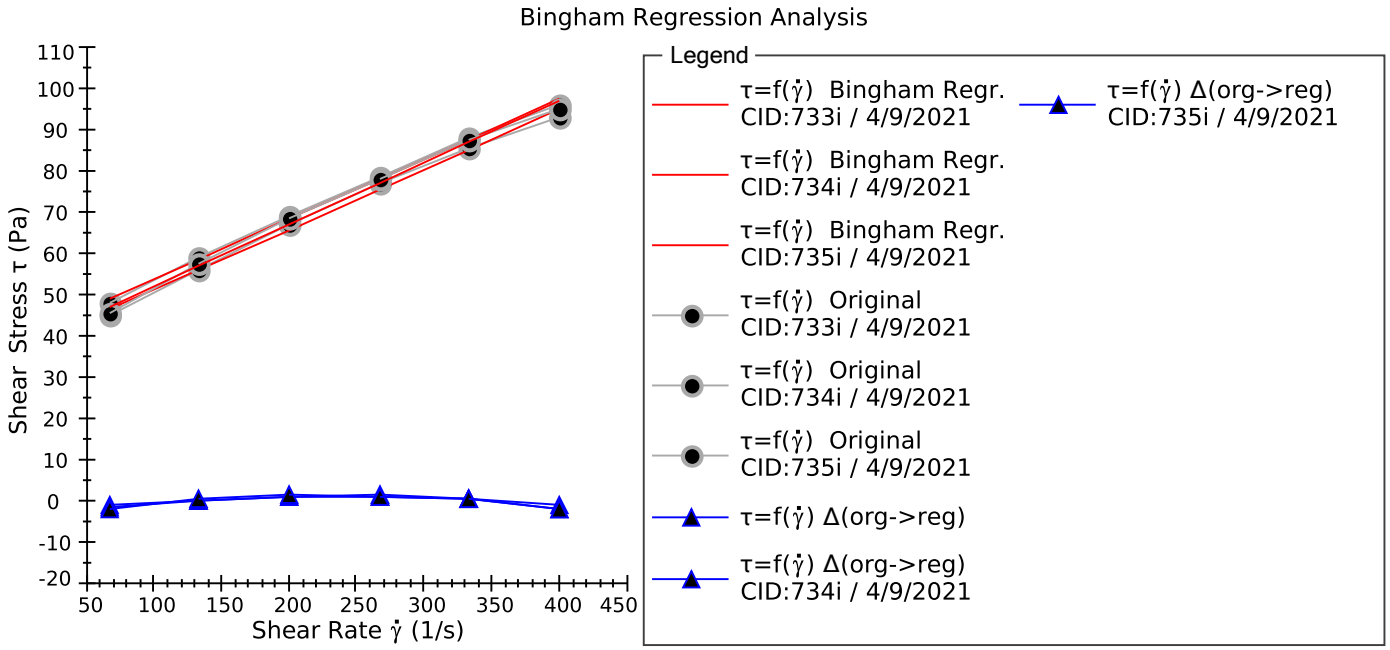
For all DataSets

Regression Analysis

Configuration:

[733i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-19]
[734i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-20]
[735i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-21]

Bingham Regression
Included blocks(numbers):



Result:

[733i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-19]

Bingham Regression y = mx + n
y = 0.145 * x + 39.2756
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.1450 Pas
Bingham Yield Stress τ(B)
39.2756 Pa
Standard Deviation:
1.0269942786
Stability Index R^2:
0.9974274443
Valid data pairs:
6
Constants:
[0] 39.2755842433206
[1] 0.145019982495124
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[734i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-20]

Bingham Regression y = mx + n
y = 0.1452 * x + 36.6722
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.1452 Pas
Bingham Yield Stress τ(B)
36.6722 Pa
Standard Deviation:
1.5017987741
Stability Index R²:
0.9945298829
Valid data pairs:
6
Constants:
[0] 36.6722056968758
[1] 0.145219158498226
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[735i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-21]

Bingham Regression y = mx + n
y = 0.1494 * x + 37.1436
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

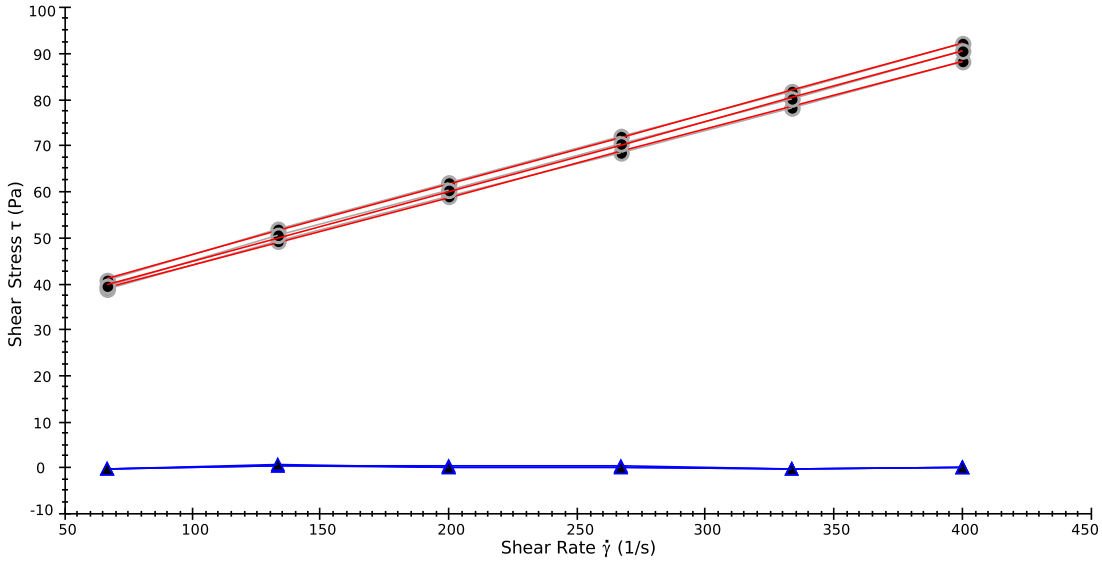
Bingham Viscosity η(B)
0.1494 Pas
Bingham Yield Stress τ(B)
37.1436 Pa
Standard Deviation:
1.5788028654
Stability Index R²:
0.9942909980
Valid data pairs:
6
Constants:
[0] 37.1435792910096
[1] 0.149419102866186
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[733i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-19]
[734i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-20]
[735i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-21]

Bingham Regression
Included blocks(numbers):



Result:

[733i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-19]

Bingham Regression y = mx + n
y = 0.153 * x + 30.9596
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.1530 Pas
Bingham Yield Stress τ(B)
30.9596 Pa
Standard Deviation:
0.3722268663
Stability Index R^2:
0.9996955328
Valid data pairs:
6
Constants:
[0] 30.9596059178944
[1] 0.152958257527094
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[734i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-20]

Bingham Regression y = mx + n
y = 0.1474 * x + 29.2291
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.1474 Pas
Bingham Yield Stress τ(B)
29.2291 Pa
Standard Deviation:
0.2709139909
Stability Index R²:
0.9998263255
Valid data pairs:
6
Constants:
[0] 29.229080326842
[1] 0.147410120214535
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[735i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-21]

Bingham Regression y = mx + n
y = 0.152 * x + 29.5959
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.1520 Pas
Bingham Yield Stress τ(B)
29.5959 Pa
Standard Deviation:
0.3707055247
Stability Index R²:
0.9996940598
Valid data pairs:
6
Constants:
[0] 29.5959403572231
[1] 0.151965814286884
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	44.887	66.662	0.6734
3	13	56.191	133.337	0.4214
4	17	66.794	199.999	0.3340
5	21	76.830	266.661	0.2881
6	26	85.684	333.336	0.2570
7	30	92.953	399.998	0.2324
1	34	88.307	399.998	0.2208
2	39	78.150	333.336	0.2344
3	43	68.451	266.661	0.2567
4	47	58.799	199.999	0.2940
5	51	49.262	133.337	0.3695
6	56	38.779	66.662	0.5817

[734i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-20]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ẏ	Viscosity (Pa·s) η
2	9	47.859	66.662	0.7179
3	13	58.788	133.337	0.4409
4	17	69.196	199.999	0.3460
5	21	78.735	266.661	0.2953
6	26	88.003	333.336	0.2640
7	30	96.099	399.998	0.2402
1	34	92.095	399.998	0.2302
2	39	81.606	333.336	0.2448
3	43	72.034	266.661	0.2701
4	47	61.745	199.999	0.3087
5	51	51.703	133.337	0.3878
6	56	40.714	66.662	0.6108

[733i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-19]

Report

Measuring DataSet Identifications

[736i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-22]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	736
Execution Date:	4/9/2021
UID:	22
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[737i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-23]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	737
Execution Date:	4/9/2021
UID:	23
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control

Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

[738i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-24]

Measurement Program:	Golder-CC25 - bingham report R1.rpf
Number of blocks:	4
Measurement points count:	14
Execution ID(custom):	738
Execution Date:	4/9/2021
UID:	24
Data source:	DB
Measuring system:	CC25
Rheometer:	R/S Rheometer (302437)
RheometerFirmware:	8.01 10/21/2002 00:00:00
Measuring system gap[mm]:	1
Thermostat:	
Company:	
Excecuting Operator:	SystemUser
Final Comment:	
Notice:	
Substance Charge:	
Substance Description:	
Substance Name:	
SubstanceNumber:	

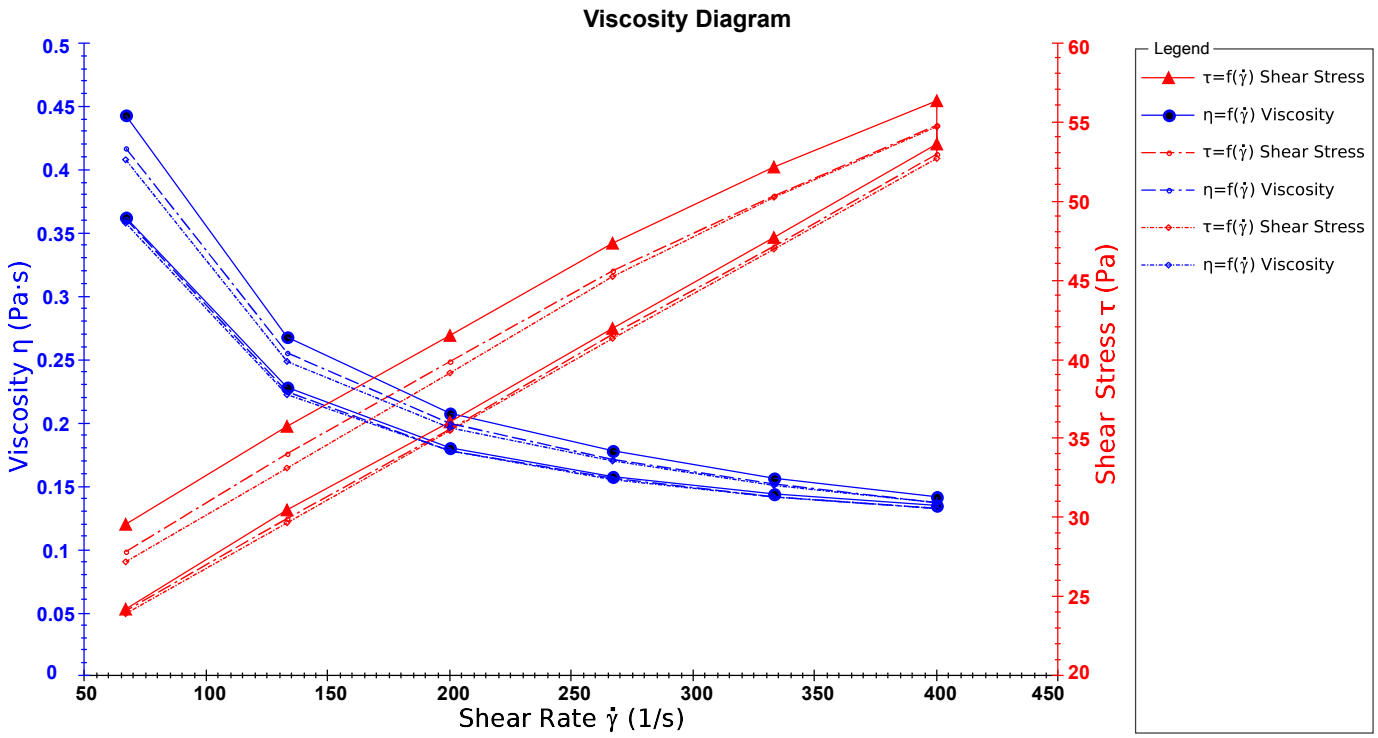
Block 1	Rotation Ramp Measuring Block, CSR, lin, 30 s, 0 -> 400 1/s, 7 MPoints No Temperature control
Block 2	Rotation Ramp Measuring Block, CSR, lin, 30 s, previous Value -> 0 1/s, 7 MPoints No Temperature control
Block 3	Bingham Regression Included blocks(numbers): 1
Block 4	Bingham Regression Included blocks(numbers): 2

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	27.153	66.662	0.4073
3	13	33.048	133.337	0.2479
4	17	39.072	199.999	0.1954
5	21	45.219	266.661	0.1696
6	26	50.161	333.336	0.1505
7	30	54.672	399.998	0.1367
1	34	52.678	399.998	0.1317
2	39	46.923	333.336	0.1408
3	43	41.283	266.661	0.1548
4	47	35.451	199.999	0.1773
5	51	29.589	133.337	0.2219
6	56	23.846	66.662	0.3577

[738i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-24]

Main Diagram



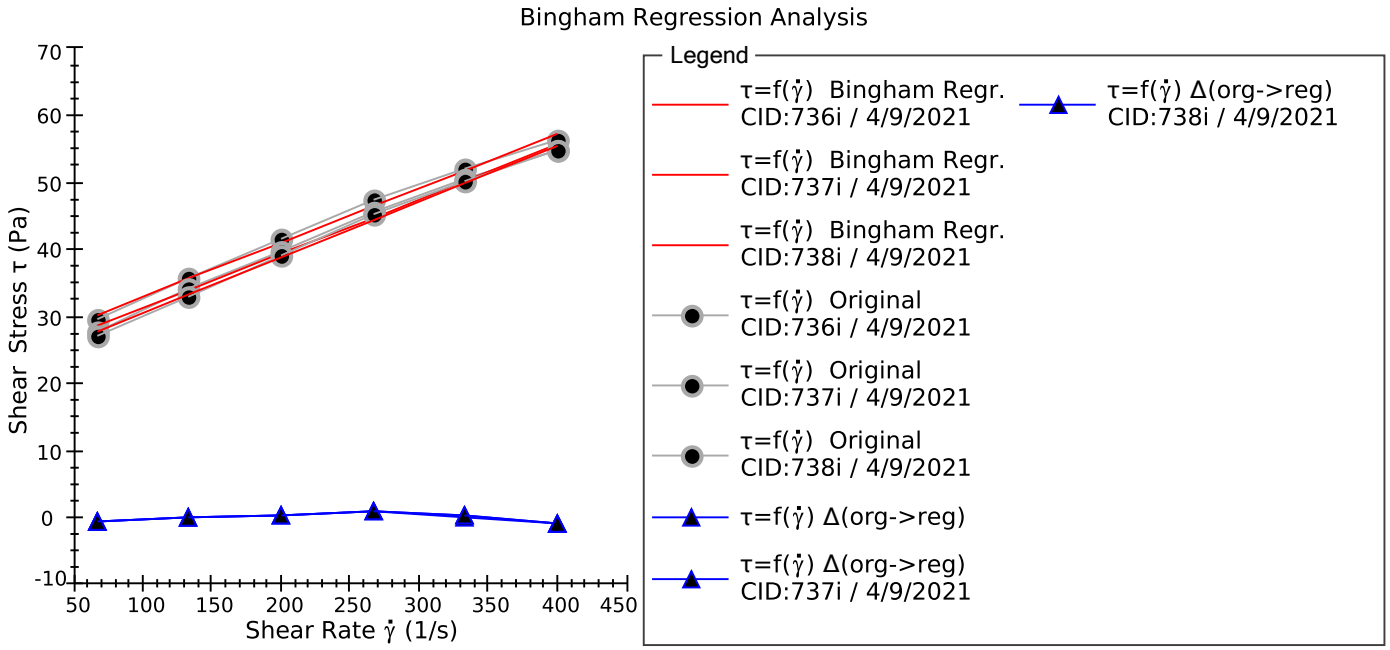
For all DataSets

Regression Analysis

Configuration:

[736i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-22]
[737i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-23]
[738i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-24]

Bingham Regression
Included blocks(numbers):



Result:

[736i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-22]

Bingham Regression y = mx + n
y = 0.0808 * x + 24.8885
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.0808 Pas
Bingham Yield Stress τ(B)
24.8885 Pa
Standard Deviation:
0.7588498273
Stability Index R²:
0.9954808982
Valid data pairs:
6
Constants:
[0] 24.8884550621494
[1] 0.0807695764059901
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[737i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-23]

Bingham Regression y = mx + n
y = 0.0812 * x + 23.0886
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.0812 Pas
Bingham Yield Stress τ(B)
23.0886 Pa
Standard Deviation:
0.7132051341
Stability Index R²:
0.9960504023
Valid data pairs:
6
Constants:
[0] 23.0885947255142
[1] 0.081223229136365
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========

[738i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-24]

Bingham Regression y = mx + n
y = 0.0836 * x + 22.0464
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

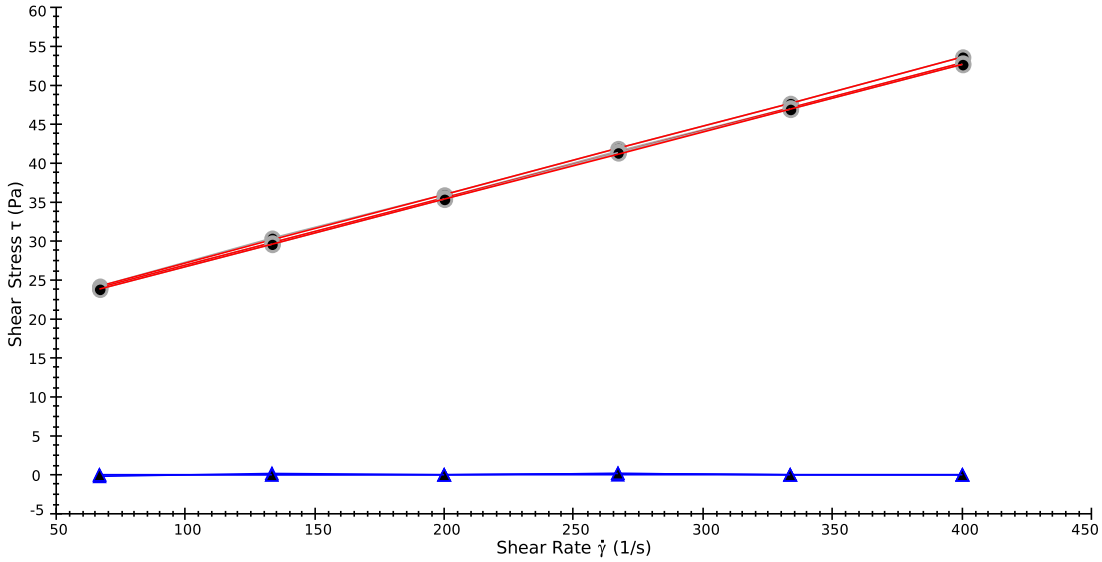
Bingham Viscosity η(B)
0.0836 Pas
Bingham Yield Stress τ(B)
22.0464 Pa
Standard Deviation:
0.6766100729
Stability Index R²:
0.9966430522
Valid data pairs:
6
Constants:
[0] 22.0463543011385
[1] 0.0836060202039326
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Regression Analysis

Configuration:

[736i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-22]
[737i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-23]
[738i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-24]

Bingham Regression
Included blocks(numbers):



Result:

[736i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-22]

Bingham Regression y = mx + n
y = 0.0879 * x + 18.468
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.0879 Pas
Bingham Yield Stress τ(B)
18.4680 Pa
Standard Deviation:
0.1609293670
Stability Index R^2:
0.9998274749
Valid data pairs:
6
Constants:
[0] 18.4680199021217
[1] 0.0878563617649248
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[737i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-23]

Bingham Regression y = mx + n
y = 0.0865 * x + 18.3318
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.0865 Pas
Bingham Yield Stress τ(B)
18.3318 Pa
Standard Deviation:
0.1108974966
Stability Index R²:
0.9999155687
Valid data pairs:
6
Constants:
[0] 18.3317576486572
[1] 0.0865472281475237
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

==========
[738i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-24]

Bingham Regression y = mx + n
y = 0.0866 * x + 18.096
x ... Shear Rate[1/s]
y ... Shear Stress[Pa]

Bingham Viscosity η(B)
0.0866 Pas
Bingham Yield Stress τ(B)
18.0960 Pa
Standard Deviation:
0.0672631073
Stability Index R²:
0.9999689525
Valid data pairs:
6
Constants:
[0] 18.095992462598
[1] 0.0865682757104844
[2] 0
[3] 0
[4] 0
[5] 0
[6] 0
[7] 0
[8] 0
[9] 0

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	27.802	66.662	0.4171
3	13	34.010	133.337	0.2551
4	17	39.791	199.999	0.1990
5	21	45.558	266.661	0.1708
6	26	50.309	333.336	0.1509
7	30	54.774	399.998	0.1369
1	34	52.941	399.998	0.1324
2	39	47.094	333.336	0.1413
3	43	41.594	266.661	0.1560
4	47	35.555	199.999	0.1778
5	51	29.889	133.337	0.2242
6	56	24.083	66.662	0.3613

[737i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-23]

Main Data Table(s)

Number Nr.	Time (s) t	Shear Stress (Pa) τ	Shear Rate (1/s) Ÿ	Viscosity (Pa·s) η
2	9	29.566	66.662	0.4435
3	13	35.738	133.337	0.2680
4	17	41.461	199.999	0.2073
5	21	47.255	266.661	0.1772
6	26	52.111	333.336	0.1563
7	30	56.276	399.998	0.1407
1	34	53.613	399.998	0.1340
2	39	47.659	333.336	0.1430
3	43	41.941	266.661	0.1573
4	47	36.033	199.999	0.1802
5	51	30.422	133.337	0.2282
6	56	24.137	66.662	0.3621

[736i] 4/9/2021, from DB, created by Golder-CC25 - bingham report R1.rpf, 14 MP in 4 Blocks [UID-22]

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APPENDIX C

Basis for Design and Design Criteria

TECHNICAL MEMORANDUM

DATE May 6, 2024 **Reference No.** 024-22575574003-TM-Rev0

TO Ian Prichard, Senior Vice-President, Technical Services
Troilus Gold Corporation

FROM Carl Pednault and Laurent Gareau **EMAIL Carl Pednault@wsp.com; Laurent.Gareau@wsp.com**

TAILINGS MANAGEMENT FACILITY – FEASIBILITY DESIGN BASIS MEMORANDUM
TROILUS MINE, QUÉBEC – DRAFT

1.0 REVISION RECORD

Table 1: Revision Record

Revision				Areas Revised	Remarks
No.	By	Approved	Date YYYY-MM-DD		
19131334-007-TM-Rev1	Mathieu Gosselin	Laurent Gareau	2022-04-07	-	First Release
024-2257554003-TM-RevA	Mathieu Gosselin	Laurent Gareau	2023-08-28	all	First Revision
024-2257554003-TM-RevB	Mathieu Gosselin	Carl Pednault	2024-04-26	all	Second Revision
024-2257554003-TM-Rev0	Mathieu Gosselin	Carl Pednault	2024-05-03	all	Final Revision

2.0 INTRODUCTION

WSP Canada Inc. (WSP) has been retained by Troilus Gold Corp. (Troilus) to conduct a feasibility tailings deposition study for their Troilus Gold Project in northwestern Quebec.

Troilus is constructing a new ore processing facility at its existing property to treat 50,000 tonnes of ore per day from the local resource to produce doré and a gold bearing copper concentrate. Ore processing will include crushing, milling, gravity gold recovery, and flotation. Troilus requires a tailings management strategy for the processing facility.

The first stage of the study involved a conceptual trade-off study to evaluate several tailings and water management options for selecting a preferred alternative to advance to the next design phase (Golder 2020a). The chosen option is the Thickened Tailings using High-Rate Thickeners (HRT), presented as option one in the options study report.

Following the previous design phase and a geotechnical characterization (WSP, 2024) of the existing Tailing Storage Facility (TSF), a Design Basis Memo (DBM) has been created to establish design criteria and methodologies for the feasibility study (FS) of the expansion of the existing TSF.

The TSF will reach its full capacity during the first half of the Life of Mine (LoM) and tailings are planned to be disposed into mined-out pits until the end of Mine Life. The design basis for in-pit disposal of a portion of the tailings will be developed in a later stage of design.

As this is a working document, it will be updated as new information becomes available throughout the execution of the Project.

3.0 PROJECT DESCRIPTION

3.1 Existing TSF

There is one existing TSF at the Troilus Mine Site (Figure 1), and it is constrained by dykes to the North and West and natural topography to the East and South. The TSF commenced operations in 1996 and was raised annually from 1997 until 2009, when the Site entered the care and maintenance phase.

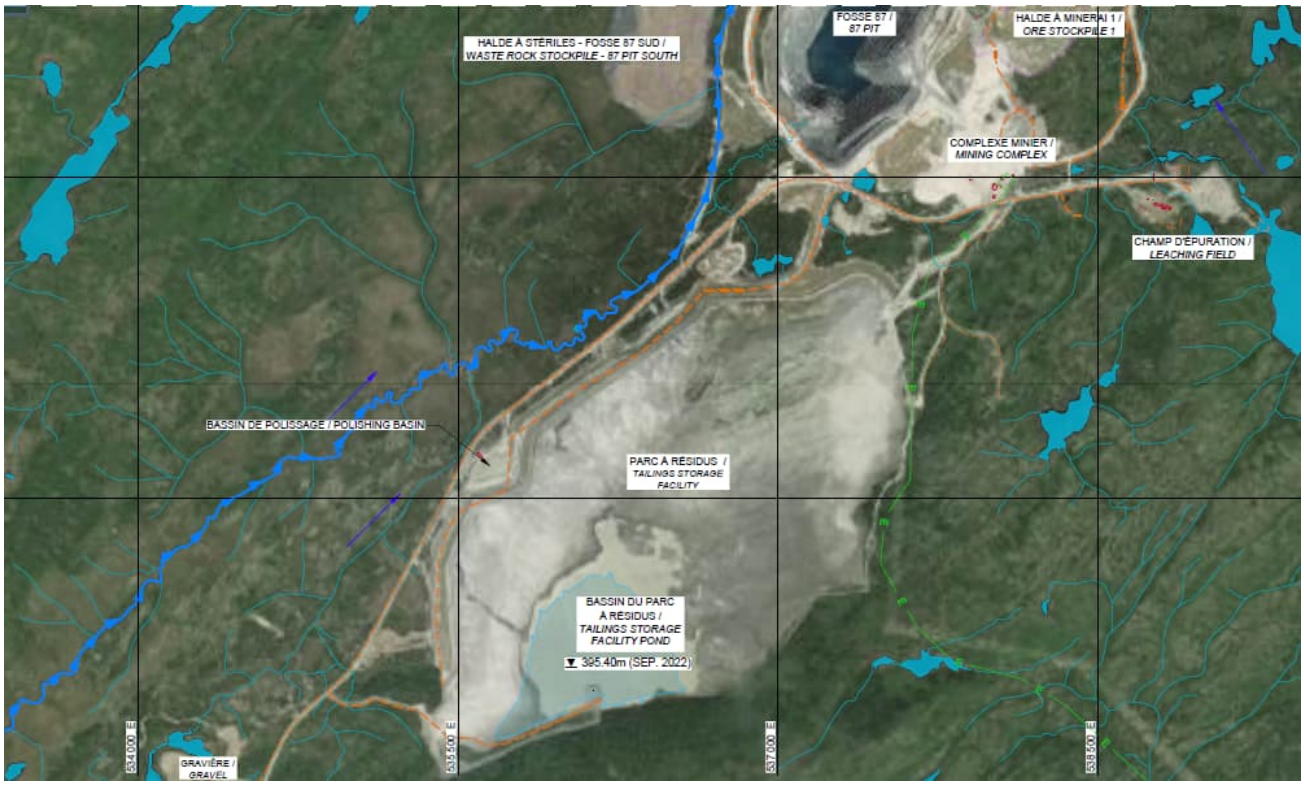


Figure 1: Current TSF Aerial Photo

SNC Lavalin Inc. (SLI) carried out the initial design for the facility. The original design report is not available. However, the critical design assumptions are elaborated in a 1997 report on the design revision (SLI, 1997). The SLI design concept was to construct a dyke initially to elevation 381 metres above seal level (masl),

subsequently to be raised to 385 masl and 390 masl using the upstream construction method. Tailings were intended to be deposited on the upland areas northeast of the dyke, and supernatant water would rest against the embankment. WSP understands that the starter dyke for the main embankment of the facility was constructed to a nominal elevation of 381 masl (SLI 1997).

The starter embankment to elevation 381 masl was designed as a till embankment with sand and gravel toe drain. Upstream slopes of 2H:1V, downstream slopes of 3H:1V, and an 8 m wide crest were proposed. Rock rip rap was placed on the upstream face, and a thin granular travelling layer was placed on the crest.

The concept for the development of the TSF was revised by Golder in 1997 (Golder 1997). The idea was to raise the tailings facility by constructing upstream raises 2 to 2.5 m high annually, using tailings placed on top of the tailings beach. A filter zone was built to allow the passage of exfiltrating water, and mine waste was used for erosion protection. The TSF was raised incrementally utilizing this concept, and the annual raises were typically 1.5 m high.

Although the raised construction methodology was largely successful, issues with high levels of suspended solids in the TSF water pond posed water management challenges. Several iterative adjustments to the dyke raise-heights and pond size were considered during the operational phase to manage these challenges.

In 2004, a study was undertaken (Golder 2004) to assess the potential to construct a toe berm along the main embankment using mine waste rock. The study demonstrated the benefits of the toe berm, and it was built in 2005. The berm crest elevation varied from 394 to 397 masl, corresponding toto crest of the 2005 raise for the main Dyke.

In 2005 and 2006, a small dyke (south dyke) was built in the south part of the TSF. This dyke is not connected to the main dyke and was built at a crest elevation of 402 masl (Golder 2006). The south dyke is a till core, a rock-shell dyke with sand and gravel filter between the till core and the downstream rock shell. Upstream and downstream slopes for this structure are 2H:1V and 2.5H:1V, respectively.

The facility was raised annually until 2009. The last raise crest elevation varied between 400 masl and 403 masl. In 2010, the mine received a certificate of authorization for a closure plan of the facility.

A construction summary of the main dyke is presented in Table 2, and a typical cross-section is included in Figure 2.

Table 2: Main Dyke TSF Construction Summary

Year	Dyke Crest Elevation (masl)
1995-1996	381
1998-1999	383 to 383.8
2000	384.5 to 386
2001	386 to 387.5
2002	388 to 389
2003	389.5 to 392.5
2004	392 to 396
2005	394 to 398
2006	395.5 to 398.5
2007	397 to 400
2008	398.8 to 403
2009	400 to 403

masl = metres above sea level.

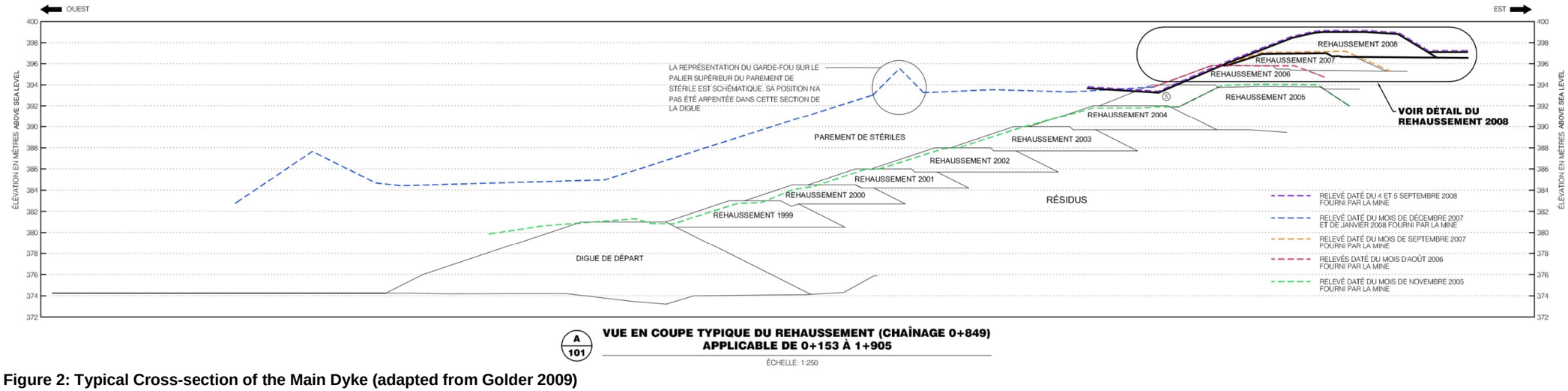


Figure 2: Typical Cross-section of the Main Dyke (adapted from Golder 2009)

3.2 FS TSF design

The FS design is to raise the Main Dyke using the downstream construction method and eventually to construct an East Dyke, also using downstream construction. The design assumes to increase the existing dyke to a final elevation of 435 masl and construct the Saddle dyke along the low point of the mountain slope on the eastern side of the TSF to 435 m.

For the Main Dyke, in particular, measures have been incorporated into the design to migrate from upstream to downstream construction, resulting in improved geotechnical stability. The downstream construction method provides additional storage capacity and lower environmental risk than the upstream and centreline construction adopted in the existing TSF.

The TSF embankment will be a zoned run of mine waste rock with upstream sand and gravel filters underlain by a geotextile layer. More waste rock will be produced throughout the LoM operations than needed for embankment construction, so there will be no material balance issues for sourcing construction fill. Filters will be produced on Site through crushing and screening of locally sourced materials.

For the FS design, the geometry of the dykes will be adjusted with the new data presented in this DBM and analysis.

4.0 FEASIBILITY STUDY SCOPE OF WORK

The design concept selected from the Tailings Management Options Study (Golder 2020a) for the previous design phase is the thickened slurry tailings, using thickeners. This option represents an extension of historical deposition practices with improved tailings dewatering within a thickener inin the process plant. Tailings would be spigotted from the perimeter of the TSF.

The existing main (west) and south tailings dykes would be raised to form a single dyke to derive storage for the first half of the LoM. Natural containment will be provided by the topographic ridge east of the facility to approximately 427 masl, above which a saddle dyke will be constructed across the east drainage swale for the ultimate TSF configuration. Water will be managed within a tailings pond within the facility. A pump station shall be installed to control pond water.

The following scope of work will be undertaken for the FS TSF design:

- Tailings and Water Management.
- Geotechnical stability of the retaining structure of TSF.
- Geotechnical instrumentation monitoring plan.
- Filter design and construction

- MaterialMaterial analysis and design.
- Tailings and water capacity requirements.
- Emergency spillway design.
- Containment structures.
- Elaboration of the deposition plan.
- Operational constraints.
- Environmental performance.
- Closure approach.
- Estimation of quantities for Capital Cost Estimate (CAPEX), Operating Cost Estimate (OPEX)

5.0 BATTERY LIMITS

The battery limits for the study are assumed as:

- Discharge of tailings in the TSF (end of the discharge pipe).
- Return water at the existing TSF.
- The footprint boundaries of the ultimate TSF.
- The TSF will be designed to be contiguous with the proposed adjacent West Waste Rock Dump (WRD). The battery limit of the WRD and TSF interface will be defined in conjunction with the mine designer.

6.0 DATA COMPLITATION

WSP has been a pivotal contributor to the design, construction and operation of the TSF at Troilus through its now wholly owned subsidiary, Golder Associés Ltée (Golder). Table 3 summarizes reports Golder and WSP used in the options study and will be referred to throughout the FS design.

Table 3: Historical Report Summary

Year	Project No.	Deliverable Title	Project Synopsis
1997	SNC-007595-41ET-401	EXPLOITATION MINIÈRE TROILUS, CONCEPTION DU PARC A RÉSIDUS MINIERS. NORD DE CHIBOUGAMOU, QUEBEC.	Initial site characterization and design of starter embankment
1997	971-7088	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE DU PARC À RÉSIDUS.	Technical specifications
		EXPLORATION DE BANCS D'EMPRUNT.	Borrow search
		RECHERCHE DE BANCS D'EMPRUNT.	Borrow search
		MODIFICATION AU SCHÉMA DE DÉVELOPPEMENT DU PARC À RÉSIDUS DE LA MINE TROILUS, MUNICIPALITÉ DE LA BAIE-JAME.	Modification of development strategy for TSF

Table 3: Historical Report Summary

Year	Project No.	Deliverable Title	Project Synopsis
1999	991-7034	ANALYSE DE RISQUES SYSTÈME DE REFOULEMENT DES EAUX DU PARC À RÉSIDUS MINE TROILUS.	Water management risk analysis for the TSF
1999	991-7076	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE DU PARC À RÉSIDUS (1999) PROJET TROILUS.	Technical specifications
		RECHERCHE DE BANCS D'EMPRUNT ET AUTRES SONDAGES EXPLORATOIRES.	Borrow search
2000	001-7014	MODÉLISATION DES DIFFÉRENTES ÉTAPES DE DÉPOSITION DES RÉSIDUS DANS LE PARC - MARS 2000 À AVRIL 2002, PROJET TROILUS.	Deposition modelling – 2000 to 2002
		DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE DU PARC À RÉSIDUS (2000) PROJET TROILUS.	Technical specifications
		RAPPORT D'EXPLORATION BANC OUEST ET BANC C AOÛT 2000.	Borrow search
2001	011-7040	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE DU PARC À RÉSIDUS (2001) PROJET TROILUS.	Technical specifications
		PLANS DE RÉFÉRENCE, TRAVAUX DE CONSTRUCTION, ÉTÉ 2001.	Drawings for dyke raise
2002	021-7023	PLANS DE RÉFÉRENCE, TRAVAUX DE CONSTRUCTION, ÉTÉ 2002.	Drawings for dyke raise
		DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE DU PARC À RÉSIDUS (2002) PROJET TROÏLUS.	Technical specifications
		INSPECTION ANNUELLE DU PARC À RÉSIDUS, PROJET TROILUS.	Annual inspection report
2002	021-7044	REVUE DU CONCEPT DE REHAUSSEMENT PARC À RÉSIDUS DIVISION TROÏLUS.	Review of dam raise concept
2003	03-1221-001	CONSIDÉRATIONS SUR LE REHAUSSEMENT DE LA DIGUE DU PARC À RÉSIDUS À PLUS DE 392,5 M, DIVISION TROILUS.	Feasibility for dyke raising
		DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE DU PARC À RÉSIDUS EN 2003 MINE TROÏLUS.	Technical specifications
2003	03-1221-009	RECHERCHE DE BANCS D'EMPRUNT MAI 2003.	Borrow search
2003	03-1221-016	PLANS DE RÉFÉRENCE TRAVAUX DE CONSTRUCTION 2003 – DIVISION TROILUS REHAUSSEMENT DE LA DIGUE – PARC À RÉSIDUS.	Drawings for dyke raise
2003	03-1221-026	OUTIL DE GESTION DE L'EAU PARC À RÉSIDUS DIVISION TROILUS.	Water management concept
2003	03-1221-027	INSPECTION ANNUELLE DU PARC À RÉSIDUS, PROJET TROILU.	Annual inspection report
2004	04-1221-001	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE ET DE LA DIGUE NORD-EST DU PARC À RÉSIDUS EN 2004 MINE TROÏLUS.	Technical specifications
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2004 – DIVISION TROILUS REHAUSSEMENT DE LA DIGUE - PARC À RÉSIDUS.	Drawings for dyke raise

Table 3: Historical Report Summary

Year	Project No.	Deliverable Title	Project Synopsis
2004	04-1221-008	ÉTUDE DE LA MISE EN PLACE D'UN PAREMENT DE STÉRILES EN AVAL DE LA DIGUE PRINCIPALE DU PARC À RÉSIDUS DIVISION TROILUS.	Assessment of impact to stability for constructing a toe berm on the main dyke
2004	04-1221-016	OPINION TECHNIQUE ET MESURES DE RÉHABILITATIONRÉHABILITATION, DIGUE NORD-EST, PARC À RÉSIDUS, MINE TROÏLUS.	Assessment of dyke rupture, northeast dyke
2005	05-1221-002	PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2005 – DIVISION TROILUS REHAUSSEMENT DE LA DIGUE – PARC À RÉSIDUS.	Drawings for dyke raise
		DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE ET DE LA DIGUE NORD-EST DU PARC À RÉSIDUS EN 2005 MINE TROÏLUS.	Technical specifications
2005	05-1221-016	INSPECTION ANNUELLE DU PARC À RÉSIDUS, DIVISION TROILUS.	Annual inspection report
2005	05-1221-017	OPINION TECHNIQUE AU SUJET DE FAISABILITÉ D'UNE AUGMENTATION DE LA CAPACITÉ D'ENTREPOSAGE DU PARC À RÉSIDUS, DIVISION TROÏLUS.	Memo which considered the feasibility of increasing the storage capacity in the TSF
2005	05-1221-018	RAPPORT FACTUEL INSTALLATION DE PIÉZOMÈTRES ÉLECTRIQUES SUR LE SITE DU PARC À RÉSIDUS DE LA MINE TROÏLUS.	Vibrating wire piezometer installation
2006	06-1221-002	NOUVELLE DIGUE SUD, PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Stability analysis for the South dyke
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2006 – DIVISION TROILUS REHAUSSEMENT DE LA DIGUE – PARC À RÉSIDUS.	Drawings for dyke raise and new South dyke to El 402 m
		DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE ET CONSTRUCTION DE LA DIGUE SUD DU PARC À RÉSIDUS EN 2006 MINE TROÏLUS.	Technical specifications
2006	06-1221-004	ÉVALUATION DE LA CAPACITÉ DE REMPLISSAGE DU PARC À RÉSIDUS, DIVISION TROÏLUS.	Assessment of remaining capacity
2006	06-1221-015	INSPECTION ANNUELLE DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
2006	061221-024	PLANS DE RÉFÉRENCE TRAVAUX DE CONSTRUCTION 2006 – DIVISION TROILUS REHAUSSEMENT DE LA DIGUE – PARC À RÉSIDUS.	Drawings for dyke raise
2007	07-1221-002	PLAN DE FERMETURE RÉVISION 2007 LES MINES INMET, DIVISION TROILUS.	Closure plan update
		PROGRAMME DE CARACTÉRISATION ENVIRONNEMENTALE DES SOLS ET DE L'EAU SOUTERRAINE EN VUE DE LA FERMETURE – PRÉLIMINAIRE.	Environmental studies on soils and groundwater in support of closure
2007	07-1221-004	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE DU PARC À RÉSIDUS EN 2007 MINE TROÏLUS.	Technical specifications
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2007 – DIVISION TROILUS REHAUSSEMENT DE LA DIGUE – PARC À RÉSIDUS.	Drawings for dyke raise

Table 3: Historical Report Summary

Year	Project No.	Deliverable Title	Project Synopsis
		INSPECTION ANNUELLE DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
2008	08-1221-010	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE DU PARC À RÉSIDUS EN 2008 MINE TROÏLUS.	Technical specifications
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2008 – DIVISION TROILUS REHAUSSEMENT DE LA DIGUE – PARC À RÉSIDUS.	Drawings for dyke raise
		INSPECTION ANNUELLE DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
2008	08-1221-012	OPINION ON THE TAILINGS POND EXPANSION POTENTIAL, TROÏLUS MINE.	Opinion on tailings pond expansion potential
2009	09-1221-001	PLANS DE RÉFÉRENCE TRAVAUX DE CONSTRUCTION 2009 – DIVISION TROILUS REHAUSSEMENT DE LA DIGUE – PARC À RÉSIDUS.	Drawings for dyke raise
2009	09-1221-002	DEVIS TECHNIQUE REHAUSSEMENT DE LA DIGUE PRINCIPALE DU PARC À RÉSIDUS EN 2009 MINE TROÏLUS.	Technical specifications
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2009 – DIVISION TROILUS REHAUSSEMENT DE LA DIGUE – PARC À RÉSIDUS.	Drawings for dyke raise
		INSPECTION ANNUELLE DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
2009	09-1221-011	RÉSULTATS DE L'ÉTUDE D'ÉVALUATION DU POTENTIEL DE LIQUÉFACTION DES RÉSIDUS, PARC À RÉSIDUS, DIVISION TROÏLUS.	Liquefaction potential assessment for tailings.
2010	10-1221-005	DEVIS TECHNIQUE – CONSTRUCTION DU SYSTÈME DE GESTION DES EAUX DE SURFACE DU PARC À RÉSIDUS DE LA MINE TROILUS, 2011.	Technical specifications for surface water management system
		PLANS POUR CONSTRUCTION, TRAVAUX DE CONSTRUCTION 2007 – DIVISION TROILUS SYSTÈME DE GESTION DES EAUX DE SURFACE.	Drawings for surface water management system
		COMPTE RENDU –VISITE DU SITE DU PARC À RÉSIDUS LES 15 ET 16 JUIN 2010, MINE TROÏLU.	Site inspection report
		RE: TROILUS MINE – FEASIBILITY STUDY OF A TAILINGS DIVERSION DITCH.	Feasibility study for tailings diversion ditch
2010	10-1221-080	DEMANDE DE CERTIFICAT D'AUTORISATION POUR LA RESTAURATION DU PARC À RÉSIDUS.	Request for certificate of authorization
2010	10-1221-109	ACTUALISATION DES NIVEAUX ET DÉBITS DE CRUE SUITE AUX CHANGEMENTS AU SYSTÈME DE GESTION DES EAUX – PARC À RÉSIDUS MINIERS TROÏLUS.	Update to the design of the TSF closure spillway
		INSPECTION ANNUELLE DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
		ÉTUDE DE FAISABILITÉ DU REGROUPEMENT DES POINTS D'ÉCHANTILLONNAGE DES EFFLUENTS DES EAUX DE SURFACE DU PARC À RÉSIDUS VERS L'ENVIRONNEMENT.	Feasibility study for combining surface water effluent points downstream of the TSF

Table 3: Historical Report Summary

Year	Project No.	Deliverable Title	Project Synopsis
2012	12-1221-114	CONCEPTUAL STUDY OF EROSION PROCESSES AND EROSION PROTECTION SOLUTIONS ON THE TROILUS STORAGE FACILITY FOLLOWING THE END OF OPERATIONS.	Tailings beach erosion study
2013	13-1221-060	INSPECTION ANNUELLE 2013 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
2014	1405806	INSPECTION ANNUELLE 2014 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
2014	1410952	DEVIS TECHNIQUE - AMÉNAGEMENT D'UN FOSSÉ POUR LE REGROUPEMENT DES EFFLUENTS PR6 ET PR5, MINE TROÏLUS.	Technical specifications for changes to surface water management system
		VUE EN PLAN ET COUPES DU FOSSÉ PR5-PR6.	Detailed design
2015	1531075	INSPECTION ANNUELLE 2015 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
2016	1655060	INSPECTION ANNUELLE 2016 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
2017	1787327	INSPECTION ANNUELLE 2017 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
2019	19125303	INSPECTION ANNUELLE 2019 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
2020	20145228	INSPECTION ANNUELLE 2020 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report
2022	21468036	INSPECTION ANNUELLE 2022 DU PARC À RÉSIDUS MINIERS, DIVISION TROÏLUS.	Annual inspection report

7.0 TECHNICAL ACRONYMS AND ABBREVIATIONS

Below is a list of units, abbreviations, and acronyms that will be used in this design basis report.

Table 4: List of System of Units, Abbreviations, and Acronyms

Project System of Units: Metric			
Mass/Density		**Other**	
kg	Kilograms	%	percent
t	tonnes (1,000 kg)	G	gravitational acceleration (9.8 m/s^2)
Mt	Million tonnes (1,000 kg)	°C	degrees Celsius
kg/m^3	kilograms per cubic metre	Pa s	Pascal-second (viscosity)
Mtpa	Million tonnes per annum	masl	Meters above sea level
tpd	Tonnes per day		
Length		**Seismic/Hydrologic**	
mm	Millimetre	PGA	Peak Ground Acceleration
m	Metre	PMP	Probable Maximum Precipitation
km	Kilometre	AEP	Annual Exceedance Probability

Table 4: List of System of Units, Abbreviations, and Acronyms

Project System of Units: Metric			
Area			
m^2	square metre		
Volume		**Slurry Concentration**	
m^3	cubic metre	wt%	percentage per solid weight
Mm^3	Million cubic metre		
Pressure/Stress		**Flow**	
Pa	Pascal	L/s	Litre per second
kPa	Kilopascal	m^3/hr	cubic metre per hour
Other Naming Conventions		**Time**	
FoS	Factor of Safety	Yr	year
NA	Not Applicable	D	day
TBD	To Be Determined	H	hour
TSF	Tailings Storage Facility	Min	minute
FS	Feasibility Study	S	second
LoM	Life of Mine		

8.0 GUIDELINES AND REGULATIONS

Table 5 provides a brief description of the guidelines used in Québec for the design, operation, and closure of tailings storage facilities. Some of these guidelines will be consulted for the feasibility study and stability assessment of the TSF, as explained in section 9.1.

Table 5: Referenced Guidelines

Guideline	Description
Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP; English: Québec Ministry of Sustainable Development, Environment and Parks), Directive 019 sur l'industrie minière (D019), 2012, 3rd edition	Guidance was first published in 1989 and re-edited in 2005 and 2012. Used in Québec to assess any mining project that requires issuance of a CofA per the *Loi sur la qualité de l'environnement*. This document includes classification and environmental and geotechnical management of mine waste in Québec and recommended stability criteria.
Ministère de l'Énergie et des Ressources naturelles (MERN; English: Québec Ministry of Energy and Natural Resources), Guide de préparation du plan de réaménagement et de restauration des sites miniers au Québec (Closure Guide), 2022, 3rd édition	First published in 1997 and re-edited in 2017 and 2022. The document provides recommendations on requirements for all aspects of closure planning and implementation. Appendix 1, "Complementary Information on Stability," addresses geotechnical stability considerations.
CDA, Dam Safety Guidelines, 2013, 2014, and Application of Dam Safety Guidelines to Mining Dams, 2019	Provides classification based on the consequence of failure and recommendations for seismic loading conditions, slope stability factors of safety, and hydrological criteria.

Guideline	Description
GTR, Global Industry Standard on Tailings Management (GISTM), Topic III, 2020	Provides principles regarding design, construction, operation, and monitoring of tailings facilities.
ICOLD, Tailings Dams Safety, Bulletin No. 194, 2022 (draft)[(a)]	Technical guidance consolidating leading international practice for tailings dams' design.

a) Reference will be updated upon issuance of the final version of the bulletin.

C of A = Certificate of Authorization; CDA = Canadian Dam Association; ICOLD = Internal Commission on Large Dams; GTR = Global Tailings Review.

9.0 DESIGN BASIS

This section summarizes the basis retained for the feasibility study of the TSF at Troilus site.

9.1 Adopted Standards and Guidelines

Mining dams in Québec are governed according to Directive 019, which outlines applicable controls for tailings storage facility design, construction and operation. The Directive 019 approach is a proscriptive, standards-based approach to the assessment of design flood events, seismic events and required factors of safety.

Whilst Directive 019 is the legislative requirement for Quebec, the industry standard from the new Global Industry Standard for Tailings Management – GISTM (GTR 2020) is recommended for the feasibility design criteria.

Other internationally recognized codes and standards may be used, provided that they either meet or exceed the referenced codes herein.

9.2 Key Design Considerations

Key design considerations for the feasibility design are:

- Remain geotechnically stable under static conditions and seismic design events during operation and closure.
- Mitigate impacts to environmental, biological, cultural, and social resources during construction, operation, and post-closure.
- Maintain acceptable operating philosophy and management framework to prevent or restrict contaminant release.
- Construct and operate the TSF in a safe and secure manner that mitigates or eliminates impacts to persons' health, safety, and security.

9.3 Site Data

This section includes a summary of the input parameters that will be used for design. It presents the actual values that will be uniformly applied / utilized throughout design, linked to the criteria summarized in section 10.0. Table 6 shows the site location.

Table 6: Site Location

Description	Criteria/Value	Units	Reference/ Source
Site Coordinate System	WGS84 UTM NAD 83 Zone 18	-	-
Site Location	Latitude: 50.989ºN Longitude: -74.481ºW	Degree	Golder, 2022. Projet Minier Troilus – Description initiale du projet, Reference 001-21497249-rev0, Dated April 29, 2022.
	Easting: 536 401 m E Northing: 5 648 765 m N	m	
Site Elevation Range	352 to 430	masl	Google Earth, Dated August 23, 2023

9.3.1 Topographic Data

Troilus has provided a topographic surface for the Site from an unmanned aerial photogrammetric survey using photogrammetry processing methods and ground control points to develop the digital surface model. The Site is generally undulating terrain with a significant north-east south-west topographical ridge to the south-east of the existing TSF.

9.3.2 Stratigraphic Data

A few investigation campaigns were conducted in the TSF area, summarized in Table 7. Studies included laboratory testing programs, including water contents, grain size and hydrometer, Proctor compaction, triaxial permeability and direct shear testing. This geotechnical information formed the database to support the design of the facility.

Table 7: TSF Investigation Campaigns

Year	Responsible	Survey	Reference/ Source	Comment
1991	Dupont Desmeules et associés inc.	▪ One borehole ▪ One standpipe piezometer ▪ Nine Test Pits	Minova Inc. – Projet minier Troilus-Frotet, Site minier. Rapport préliminaire, volume 3. Ref. No 758. December 1991.	Locations of the survey are approximate because they are only presented on a non-georeferenced map.
1994	Techmat	▪ Six boreholes ▪ 20 test pits ▪ 16 mechanical hammer surveys ▪ Six auger surveys ▪ 14 probe tests ▪ Five excavator surveys ▪ 14 standpipe piezometers ▪ Seven piezometers	Techmat. 1995. Projet Troilus, Étude Géotechnique, Campagne 1994, Contrat 795-S-502, Dossier 4189402. March 1995.	-
1995	SLI	▪ 12 test pits	SLI (SNC-Lavalin Inc.). 1997. Exploitation minière Troilus, Conception du parc à résidus miniers, Notes techniques, Rapport révisé de SNC Lavalin Environnement. Projet 007595-41ET-401. May 1997.	The records of test pits were not included in the copy of the SLI report provided for review.
1995-1996	SLI	▪ Four boreholes ▪ 12 destructive Boreholes ▪ Seven test pits	SLI (SNC-Lavalin Inc.). 1997. Exploitation minière Troilus, Conception du parc à résidus	Investigation during construction. The record of borehole sheets and a site

Table 7: TSF Investigation Campaigns

Year	Responsible	Survey	Reference/ Source	Comment
			miniers, Notes techniques, Rapport révisé de SNC Lavalin Environnement. Projet 007595-41ET-401. May1997.	plan showing the locations of the various investigation points were not included in the copy of the SLI report provided for review.
2021	Golder	▪ 16 boreholes ▪ 14 cone penetration tests	Golder. 2022a. Factual Geotechnical Investigation Memorandum for the Existing Tailing Storage Facility – Troilus Mine, Quebec. Golder Doc No 031-19131334-5400-RevA. 4 November 2022.	-
2023	WSP	▪ Seven boreholes (TSF area only) ▪ Three test pits ▪ 17 manual augers	2023 winter and summer investigation. WSP (2024). Factual investigation Report, Troilus Mine Quebec – Feasibility Study, Doc ref. 052-2257554002-RevA. Dated 19 April, 2024.	

The key strata encountered at the Site include:

- Topsoil layer (organic matter)
- Peat
- Till – generally silty sand and gravel containing cobbles and boulders.
- Glaciofluvial sand and gravel (esker)
- Alluvial silt to silty sand
- Bedrock outcrop (limited)

In general, the embankment is found on glacial till. Table 8 summarizes the observed foundation conditions along the chainage of the embankment. Drawing 7595-0100-4102-450 (not included in this deliverable, SLI, 1997) includes a plan view of the dyke that shows the chainages indicated in Table 8.

Table 8: Interpreted Foundation Conditions (After SLI, 1997)

Stationing Along Dyke (m)	Main Surficial Deposit	Ground Surface Elevation (masl)
0+100 – 0+170	Rock outcrop	378 – 384
0+170 – 0+245	<1 m peat on silt and sand	378 – 384
0+245 – 0+300	Esker sand and gravel	378 – 384
0+300 – 0+475	<2 m peat on silt and sand	376 – 378
0+580 – 1+200	Till and/or silt	378 – 386
1+200 – 1+300	Silt and/or till	374 – 376
1+300 – 1+515	Till	372 – 379
1+515 – 1+615	Thin till over rock	372 – 374
1+615 – 1+710	Silt/sand over till	372 – 376
1+710 – 1+825	>5 m sand over till	376 – 378
1+825 – 1+930	Till and/or silt	374 – 378
1+930 – 2+210	Sand over till	374 – 387
2+210 – 2+270	<2 m sand over till with thin peat	373 – 374
2+270 – 2+940	<2 m sand over till without thin peat	374 – 390

The groundwater table was observed between 0 m and 4 m below ground in boreholes drilled at the Site, corresponding to elevation 365.5 to 368.0 masl.

Below are the observations from the boreholes performed by Golder (2022a) and WSP (2023a) investigation:

- The stratigraphy at the location of the TSF below the dykes or tailings included organic silt and peat at discrete locations from the ground surface to a depth of ± 0.9 m, underlain by glaciofluvial sand from beneath fill to a depth of up to 3.3 m. This layer is expected to be primarily present through an esker zone that extends to a north-east to south-west trending direction. Till is also present from the ground surface to beneath the surficial soils to depths ranging from ± 1 to ± 27 m. Till is deeper along the northern edge of the TSF and shallows to depths around ± 10 m towards the south end of the TSF and ± 1 m on the mountain slopes.
- One borehole was drilled on the tailings beach by Golder in 2009, which extended into the foundation below the tailings. The soils encountered in this borehole consisted of cobbly gravel to gravelly sand (interpreted as glacial till) extending at least 9 m below the contact with the tailings mass.

9.3.3 Climate Data

The Troilus Site climate conditions are specific for its location in northwestern Québec. The closest climate stations with available, both recent and long-term climate records, are approximately 140 km to the south, around the towns of Chibougamau and Chapais, where Environment and Climate Change Canada (ECCC) has operated over time eight different climate stations (ECCC, 2023a). The ground elevations of the Environment and Climate Change Canada (ECCC) stations are comparable (387 masl for Chibougamau Chapais A, 396 masl for Chapais) with the heights at the Troilus Site (generally 370 to 470 masl within the local watershed). Acknowledging that there are no historical climate observations near the Project Site, WSP estimated that:

- The historical observation at the ECCC climate stations around Chibougamau and Chapais provides a reasonable estimate for extracting extreme wet climate statistics as input to the design of the Project surface water management structures. Furthermore, the approach is considered mostly conservative as short-term vital precipitation events are expected to be less intense at the Troilus Site than at the ECCC climate stations (Ouranos, 2023).
- The historical observations at the ECCC climate stations around Chibougamau and Chapais provide a reasonable basis for the Project's site-wide water balance model. Before their application, the historical observations were adjusted using multi-annual average, seasonally-based differences between the stations' location and the Site; the differences were extracted from the regional 1981 to 2010 climate normal maps published by Ouranos (2023). Ouranos (2023) regional climate maps suggest that, on average, the climate at the Troilus Site is colder (approximately 1.2°C in mean annual temperature), with drier winter (approximately 16% less precipitation) and spring (approximately 4% less) seasons, but wetter summer seasons (13% more precipitation) than at the locations of the ECCC climate stations in Chibougamau and Chapais.
- For all applications, the potential impact of climate change on the relevant climate statistics should be considered.

The climate baseline results and other pertinent information will be presented in another document (WSP 2023b).

9.3.4 Seismic Data

Table 9 presents the seismic data considered for the TSF design.

Table 9 Seismic data input values

Description	Criteria/ Value	Reference/ Source	Comment
Geological Survey of Canada	NBC 2020	Geological Survey of Canada	-
Approach	Extrapolation of spectral accelerations for 1: 475 years and 1: 1 000 years to 1: 10 000 years	Geological Survey of Canada	-
Seismic Response spectra	6th generation seismic hazard model	Based on the 2020 seismic motion models	-
Design Earthquake (ultimate height, Operation, and Closure)	1:10 000 years	-	-
PGA Reduction Factor	½ of the PGA value	Hynes-Griffin, M.E., and Franklin, A. G. (1984)	A 20% reduction in strength parameters will be applied if the materials are deemed to be susceptible to strength reduction.

Table 10 compares the design ground motions return periods proposed by different guidelines. It is shown that CDA and GISTM both offer return periods for earthquake events based on on-site operation and dam classification. D019

stipulates that the selected return period should not be less than 2,475 years and should reflect the risks associated with the structure. The Québec Closure Guide (MERN 2022) recommends that dams be designed to withstand critical events with a 10,000-year return period.

WSP recommends evaluating the facilities against GISTM standards (GTR, 2020). Considering the presence of the open pit downstream of the TSF, it was decided to set the design basis against an "Extreme" consequence classification. An earthquake ground motion with an annual exceedance probability (AEP) of 1 in 10,000 or the maximum credible earthquake (MCE) was considered for this significance level. Without site-specific seismic hazard assessment and a lack of knowledge of the MCE, a return period of 1 in 10,000 was adopted for this DBM.

Table 10: Minimum Return Periods of Design Ground Motions Proposed by Guidelines for Active and Passive Care Closure Phases

	Guidelines with Criteria Independent of Classification and Closure Phase		Guidelines with Criteria Specific to Classification and Closure Phase				
Closure Phase	**N/A**		**Active Care**			**Passive Care**	
Guideline Classification	**D019 (MDDEP 2012)**	**MERN (2022)**	**CDA (2013, 2019)**	**GISTM (GTR, 2020)**	**ICOLD (2022)[a]**	**CDA (2013, 2019)**	**GISTM (GTR, 2020)**
Low	2,475[b]	10,000	100	200 or MCE[c]	200	1,000	10,000 or MCE
Significant			between 100 and 1,000	1,000 or MCE	1,000	2,475	
High			2,475	2,475 or MCE	2,475	½ between 2,475 and 10,000 or MCE	
Very high			½ between 2,475 and 10,000 or MCE	5,000 or MCE	5,000 or 50th percentile MCE	10,000 or MCE	
Extreme			10,000 or MCE	10,000 or MCE	10,000 or 84th percentile MCE	10,000 or MCE	

a) ICOLD (2022) proposes the same seismic design criteria for operations and active care phases and states that "higher criteria should be considered for the passive care closure phase."

b) D019 stipulates that the design earthquake return period should not be inferior to 2,475 years and should reflect the risks associated to the structure.

c) Maximum Credible Earthquake

N/A = not applicable; CDA = Canadian Dam Association.

Earthquake ground motions for Troilus will be developed from an office-based study using the OpenQuake platform, an integrated earthquake risk assessment tool. Ground motions will be based on the seismic setting, site ground conditions, and extrapolation of the 2020 National Building Code of Canada (NBCC) earthquake ground motions from the 6th Generation National Seismic Hazard Model developed by the Geological Survey of Canada.

10.0 DESIGN CRITERIACRITERIA

10.1 Deposition Schedule

The mine plan provided by AGP details the expected tailings production throughout the planned life of the mine. The table below will form the basis of the deposition modelling.

Table 11: Tailings Schedule (AGP, 2023 and Lycopodium 2024)

Year	Period	Tailings* Production (t)
Pre-Production 2	1	0
Pre-Production 1	2	711,429
Y1	3	12,805,713
Y2	4	18,176,996
Y3	5	18,177,000
Y4	6	18,177,000
Y5	7	18,177,000
Y6	8	18,177,000
Y7	9	18,177,000
Y8	10	18,177,000
Y9	11	18,177,000
Y10	12	18,177,000
Y11	13	18,177,000
Y12	14	18,177,000
Y13	15	18,177,000
Y14	16	18,177,000
Y15	17	18,177,000
Y16	18	18,177,000
Y17	19	18,177,000
Y18	20	18,177,000
Y19	21	18,177,000
Y20	22	18,177,000
Y21	23	18,177,000
Y22	24	943,205
Total		378,000,344

*Assumed dry

10.2 General Design Criteria

The general tailings production design criteria are detailed in Table 12.

Table 12: General Design Criteria

Parameter	Value	Units	Source
Coordinate System			
Coordinate system	WGS84, UTM Zone 18 (EGM 96 Grid)	-	Troilus
Mine Plan			
Assumed mine life	22	Years	AGP 2024
Mill nominal tailings production rate	49,800	tpd	AGP 2024 & Lycopodium 2024b
Total tailings production	378.0	Mt	AGP 2024 & Lycopodium 2024b
Total tailings to be deposited in the TSF	169	Mt	WSP
Deposition Method	Deposition by multiple spigots	-	-

Note that from total tailings production of 378.0 Mt, 169 Mt will be in the existing TSF, and the rest will be deposited in-pit. The basis for the concept development for the in-pit deposition will be presented in the main FS TMF report..

10.3 Loading Conditions and Geotechnical Strength Properties

The stability analyses would be conducted for static, seismic, and post liquefaction conditions. For static and seismic analyses, shear strength properties would be defined according to material response to shearing (ICOLD 2022) following a nomenclature consistent with Ladd and DeGroot (2004):

- Undrained strength analysis (USA) parameters for saturated contractive material, such as contractive tailings or sand in the foundation. Characterization efforts focus mainly on these materials as they are more critical to dam stability.
- Effective stress analysis (ESA) parameters for dilative soils, unsaturated soils, and controlled fill materials.

Strength parameters are defined based on interpretation of data presented in SLI (1997) and collected during the Golder's 2020 to 2021 investigation (Golder 2022) or, in the absence of any new information, from WSP's experience with similar projects and geological contexts. Spatial variability in properties will be recognized when deemed appropriate using statistical approaches to parameter selection. Guidance is provided in the following subsections on the methods used to assess shear strength properties.

Table 13: Methods Used to Assess Peak Shear Strength

Material	USA or ESA parameters	Methods
Tailings	USA	Based on either of ▪ In-situ tests: characteristic percentile of undrained shear strength ratios obtained using the CPT using empirical equations of Sadrekarimi (2014) and Riveros and Sadrekarimi 2020. ▪ Laboratory tests: constant volume DSS tests and triaxial test results compared to Riveros and Sadrekarimi (2021).
	ESA (for partially saturated tailings only)	▪ Peak effective friction angle based on a combination of laboratory testing results and/or CPT-based relationships.
Other contractive soils	USA	▪ CPT or SPT empirical correlations (Sadrekarimi 2014)
Other dilative soils	ESA	▪ CPT or SPT empirical correlations previous studies and literature
Waste rock	ESA	▪ Leps (1970): Non-linear shear strength function from Hawley and Cunning (2017)

The liquefied strength for the post-peak and post-seismic analyses for tailings and foundation sand will be determined using CPT and SPT test results. More details can be found in section 10.5.1.

10.4 Tailings Properties

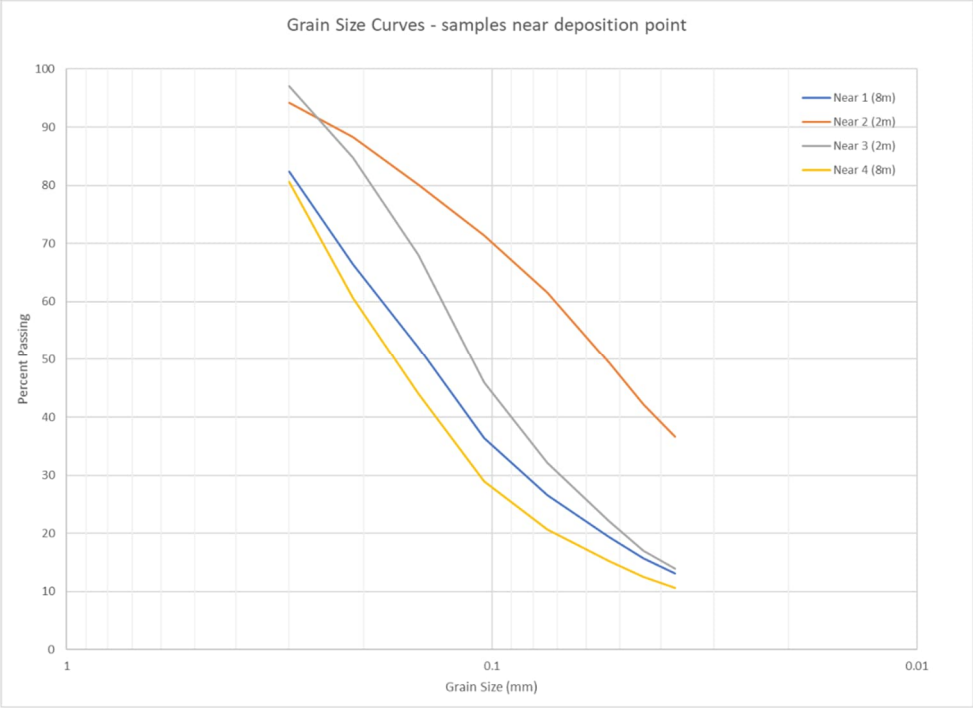
WSP's archives contain data on the properties of the tailings within the existing TSF. Based on a 1997 study, a summary of existing tailings properties is presented in Table 14.

Table 14: Typical Existing Tailings Properties

Parameter	Value	Unit	Source
Tailings classification	-	Non-acid generating, non-metal leaching	Troilus
Beach slope (0-500 m)	2	%	Golder 1997
Beach slope (500-1800 m)	0.3	%	Golder 1997
Beach slope (underwater)	3	%	Golder 1997
Specific gravity	2.65	-	SLI 1997
Dry density, deposited tailings	1.50	t/m^3	Golder 1997
Bulk density, deposited tailings	1.99	t/m^3	Golder 1997

A study in 2000 (Golder, 2000) presented grain size curves for deposited tailings close to and far away from the point of deposition. These results are summarized in Figure 3. The data indicates that the tailings are generally classified as silty sands. Near the deposition point (2 to 8 m from the deposition point), the materials average 41% passing the #200 sieve, whereas the deposits further from the deposition point (18 to 28 m from the deposition

point) have an average of 47% passing the #200 sieve. The data indicates moderate segregation with distance from the deposition point. Historically, tailings were deposited without thickening with with a solid content of approximately 35%, which is consistent with segregation of the fine material. The material deposited within the settling pond is assumed to contain mostly fines, considering the likely gradation achieved during the historic milling operation. Frozen layers of tailings or variable thickness have been identified at depths between 6 to 14 m below the tailings surface.



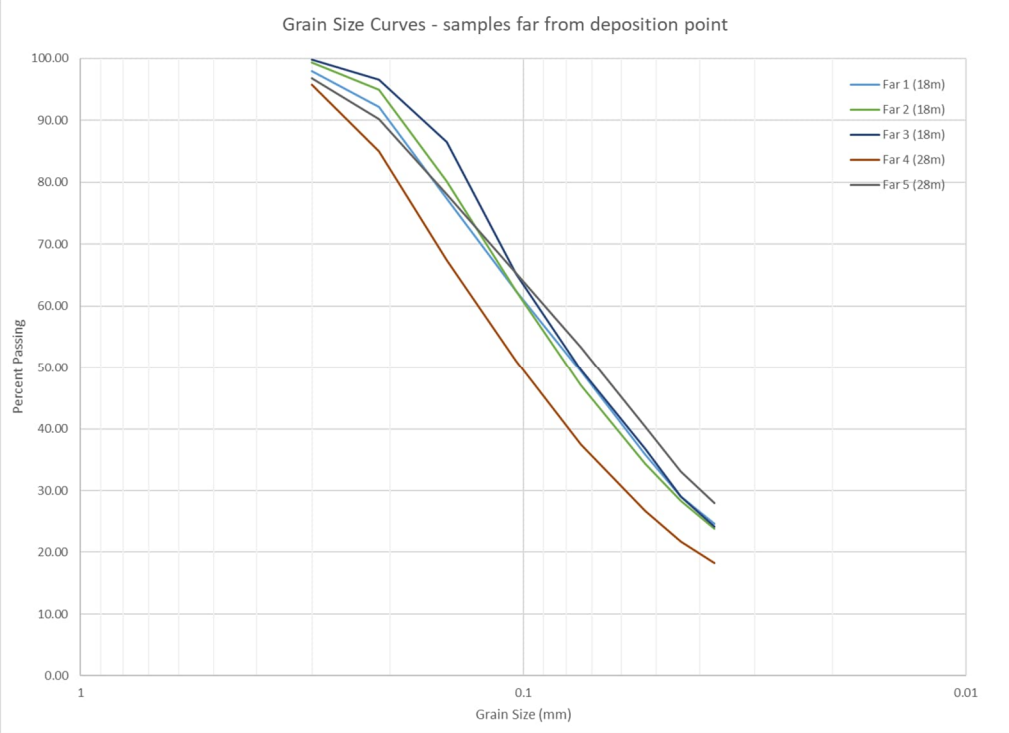


Figure 3: Tailings Grain Size Curves

Golder prepared a tailings testing program for dewatering, rheological, geotechnical and geochemical testing to support the previous engineering phase (Golder 2020b). The tailings properties used for the FS deposition model are in Table 15.

Table 15: Future Tailings Properties

Parameter	Value	Unit	Source
Tailings classification	-	Non-acid generating, non-metal leaching	Troilus
Beach slope (above water)	0.5	%	Adopted
Beach slope (underwater)	1.5	%	Adopted
Specific gravity	2.84	-	Golder, 2021a
Solid content end of pipe	54.3	Weight % solid	Golder, 2021a
Dry density, deposited	1.50	t/m^3	Estimate
Bulk density, deposited	1.99	t/m^3	Estimate

10.4.1 Additional Characterization Data

Golder undertook a geotechnical and geophysical investigation program in 2020 and 2021, for future feasibility design work. The geophysical program included high-resolution seismic refraction data with MASW testing to

assess compressional and shear wave velocities of the subsurface materials and delineate depth to bedrock (Golder, 2022b).

10.5 Geotechnical Parameters for FS Study

Numerous slope stability analyses were conducted as the facility evolved. The proposed geotechnical parameters derived from laboratory testing, from engineering judgment and experience with similar materials used for FS are presented in Table 16.

Table 16: Geotechnical Parameters

Description	Dry Unit Weight	Bulk Unit Weight	Effective Stress Shear Strength[a]		Undrained Shear Strength Ratio	Liquified undrain shear strength Ratio	Saturated Hydraulic Conductivity [b]	Reference/Source/Basis
	γ_t (kN/m^3)	γ_t (kN/m^3)	C' (kPa)	Φ' (deg)	Su(peak)/σ'v	Su(liq)/σ'v	m/s	
	Tailings Storage Facility							
Existing tailings	14.5	19.5	0	26	0.20	0.1	3.0×10^{-6}	After SLI 1997
Thickened slurry tailings	14.5	19.5	0	26	0.20	0.1	3.0×10^{-6}	Assumed
Compacted till	20.0	20.5	0	37			8.0×10^{-7}	After SLI 1997
Existing Filter	20.5	20.5	0	32	-		1.0×10^{-4}	Assumed
New Waste rock/ Rip Rap	20.0	20.0	0	Leps (1970)	-	-	1.0×10^{-1}	Assumed
Old Waste rock/ Riprap	20.0	20.0	0	Lower Leps (1970)	-	-	1.0×10^{-1}	Assumed
	Foundations							
Glacial till	19.5	20.5	0	35	-	-	8.0×10^{-7}	After SLI 1997
Glaciofluvial Sand	17.7	18.7	0	-	0.22	0.09	1.0×10^{-4}	Assumed
Bedrock (weathered)	Impenetrable						1.0×10^{-6}	Assumed
Bedrock (fresh)	Impenetrable						1.0×10^{-7}	Assumed

a) A strength reduction factor of 20% will be applied to the effective shear strength parameters for the post-liquefaction stability modelling scenario or adjusted according to ongoing analysis.

b) No anisotropy will be applied to the hydraulic conductivities for seepage modelling (ky/kx = 1).

10.5.1 Advanced Characterization of Tailings

The data from the latest geotechnical investigation (Golder, 2022a) is the basis for determining the tailings engineering parameters such as in-situ state and peak and liquefied undrained shear strength. The design undrained shear strength is determined by considering both CPT and Laboratory testing values.

Shearing Response Assessment

The shearing response (contractive/dilative) of materials refers to the reaction to shearing: A contractive material could experience strength loss due to the build-up of porewater pressure. In this case, USA parameters are recommended. In contrast, a dilative material does not exhibit positive porewater pressure build-up when sheared, and ESA parameters are recommended.

It is broadly accepted that the shearing response of clays, silts, and sands (tailings) depends on the state of the material in terms of density and effective stress level, i.e., whether the in-situ void ratio is found above (contractive) or below (dilative) the critical state line. The shearing response is typically assessed with the in-situ state parameter (ψ): contractive materials have positive state parameters, whereas dilative materials have negative state parameters. Shuttle and Cunning (2008) proposed a limit state parameter of -0.05 to distinguish between contractive or dilative shearing response, to account notably for strain localization and/or porewater pressure migration during undrained shear. This limit was adopted for the current DBM.

Engineered fill materials are assumed to be dilative from WSP's understanding of site conditions and design information. Judgement on the shearing response of other materials relies mainly on CPT-based screening methods:

- screening charts of Jefferies and Been (2006) adapted by Shuttle and Cunning (2007, 2008)
- screening charts based on soil behaviour type classification of Robertson (2016)
- state parameter based on Been and Jefferies (1992)
- state parameter based on Plewes et al. (1992)

The shearing response is also determined based on laboratory direct simple shear (DSS) tests performed on reconstituted samples.

Undrained Shear Strength

The peak undrained shear strength of tailings is determined using two methods:

- In-situ tests: uses the characteristic percentile of undrained shear strength ratios obtained using the empirical equations using CPT data.
- Laboratory tests: uses peak undrained strengths measured in a laboratory during constant volume DSS tests and undrained triaxial tests. The obtained values are also compared to Riveros and Sadrekarimi (2021). Golder (2022a) performed advanced laboratory testing on a mixed sample of existing tailings. A critical state line will be determined using the triaxial tests. This will allow the determination of state parameters at the beginning of shear tests. The undrained shear strength ratios, $S_{u(peak)}/\sigma'_v$, form triaxial and DSS tests will be then correlated with the state parameter. This will provide a complementary method of determination of undrained shear strength that will be used for the design along with CPT data.

The liquefied strength of tailings will be determined using empirical methods that are regularly used in tailings characterization practice. These methods are presented in the table below. The design parameters will be chosen by consulting values from these methods and exercising engineering judgment.

Table 14: Summary of Cone Penetration Test-Based Methods Used to Assess Engineering Parameters

Parameter	Method
Stratigraphy	▪ adjacent boreholes and normalized CPT results
Total and effective vertical overburden stress, σ_{v0} and σ'_{v0}	▪ specific gravity, water content, and fines content as reported in SLI (1997) and Golder (2020b), and porewater pressure profile inferred from porewater pressure dissipation tests.

In situ state and shearing response	▪ screening charts:
	  ▪ Jefferies and Been (2006) adapted by Shuttle and Cunning (2007, 2008).
	  ▪ Robertson (2016) based on soil behaviour type classification.
	▪ state parameter[(a)] based on screening methods:
	  ▪ Been and Jefferies (1992).
	  ▪ Plewes et al. (1992).

Peak undrained shear strength ratio, $S_{u(peak)}/\sigma'_v$	▪ Sadrekarimi[(a)] (2014) ▪ Riveros and Sadrekarimi (2021)

Liquefied undrained shear strength ratio[(a)], $S_{u(liq)}/\sigma'_v$	▪ Figures 6.47 and 6.48 of Jefferies and Been (2016) using the characteristic state parameter estimated using two screening methods:
	  ▪ Been and Jefferies (1992)
	  ▪ Plewes et al. (1992)
	▪ Sadrekarimi (2014)
	▪ Robertson (2010)
	▪ Robertson (2022)

a) Methods not applied to cohesive soils.

CPT = cone penetration test; FVT = field vane test.

Where phreatic surface is relatively low relative to the tailings surface, partially saturated tailings are either treated as dry dilative materials with ESA parameters, or as saturated contractive materials with USA parameters. These two behaviours are differentiated using two methods:

1) The first method involves using particle size distribution curves of tailings to estimate its soil-water characteristic curve, as shown by Aubertin et al. (2003). The evaluated air-entry value then acts as a boundary between partially saturated materials that behave as dry materials and materials with non-continuous air voids that behave as fully saturated soils. In stability models, this boundary is inferred from coupled seepage analyses.

2) The second method uses 85% degree saturation as the boundary between dry and fully saturated behaviour. InIn situ degree saturation is interpreted from CPT measurements of compression wave velocities based on an empirical correlation presented in Valle-Molina (2006) developed on sand specimens with 86% to 100% degree saturation. This method is adapted from ICOLD (2022), which recommends that soils with degrees of saturation higher than 85% be treated as being fully saturated and that soils with 70% to 85% degree saturation "be carefully evaluated." For this basis memorandum, due to uncertainties associated with determining degree saturation within the 70% to 85% range, the boundary between dry and saturated materials was set at 85%.

10.6 Load conditions and target safety factors

Slope stability for the TSF will be evaluated under the loading conditions and corresponding minimum factors of safety (FoS) summarized in Table 17.

Table 17: Design Criteria for Slope Stability Analysis

Parameter	Value	Source
Earthquake		
Design earthquake event	1:10,000 Annual Exceedance Probability (AEP)	GTR (2020)
Stability acceptance criteria		
Safety factor static – peak strength	1.5	Directive 019, CDA
Safety factor static – post-peak strength [(a)]	1.3	WSP
Safety factor Pseudo-static	1.1	Directive 019
Safety factor post-earthquake [(b)]	1.3	Directive 019
Deformation (only required if pseudo-static criteria not met)	≤1-2% Strain	WSP

a) This analysis case considers the post-peak (or residual or liquefied) resistance for materials that are susceptible to strain softening or static liquefaction.

b) This analysis case considers the post-peak (or residual or liquefied) resistance for materials that are susceptible to strain softening, and static and dynamic liquefaction.

10.7 Dynamic deformation analysis

Earthquake-induced permanent deformations analysis will be assessed for a critical cross section using methods that are widely used in the practice in dynamic deformation assessment of retaining structures. These methods, often referred to as sliding block analyses, are based on Newmark's (1965) sliding block method for evaluating lateral spreading. In these analyses, the sliding mass (e.g., a non-liquefied soil layer) is modelled as a rigid block resting on a plane subjected to an earthquake motion described by an accelerogram. The block and plane initially move together with no relative displacement. When the inertia and gravity forces on the block exceed the sliding resistance between the block and the plane, the block begins to slide in relation to the plane. The acceleration at which the block begins to move relative to the plane is referred to as the yield acceleration (k_y). The sliding of the block does not stop immediately when the acceleration of the plane drops below k_y because the inertia of the moving block must be dissipated by the contact shearing resistance. So, the block continues to move at a decreasing velocity until the block's velocity equals that of the plane, at which time the block and the plane once again move together. For any set of acceleration-time history and sliding resistance, the result of the sliding block analysis is the cumulative displacement over the entire record. (NASEM 2021). Among the methods generally used in tailings management practice, the following two methods will be used for theFS. For next phases of the Project, when earthquake time histories are available via Site Specific Seismic Hazard Assessment, other methods could also be used.

1) Semi-empirical method by Bray and Travasarou (2007) which is developed around a database of 688 seismic movements recorded worldwide. It considers the dynamic resistance and the dynamic rigidity of the structure, as well as the characteristics of the seismic event through the design spectrum. This method is based on ground motion parameters including the critical seismic coefficient, k_y, the natural period of the potential sliding mass, T_s, the spectral acceleration at the degraded natural period, $S_a(1.5T_s)$, and M, the magnitude of the earthquake.

2) Bray and Macedo (2019) Method, which it is an update of the method of Bray and Travasarou (2007) including:

   (a) The use of a much larger database including 6,711 earthquake data to reduce the uncertainty related to the seismic input movement and therefore improve the displacement calculation.
   (b) Distinguishing ordinary seismic movements (ordinary ground motions) from those produced near a fault (pulse motions). So, it proposes three series of equations (for the zero displacement probability calculation as well as for the displacement calculation) including one based on ordinary seismic motion data, one based on data produced near a fault, and one based on the data set.
   (c) The threshold for null displacements was reduced to 0.5 cm instead of 1.0 cm in Bray and Travasarou (2007). Thus, a spectral acceleration corresponds to a period of 1.3 times the natural period, $S_a(1.3T_s)$ was applied in all calculations since this value is more representative of site degradation according to the new database.

11.0 WATER MANAGEMENT DESIGN CRITERIA

A separate document (WSP 2023b) presents the design criteria for water management for the Troilus Project. Table 18 presents the relevant standards for water management at and around the TSF. They are based primarily on the (MELCC 2012) provincial government's Directive 019 for the mining industry, on the Canadian Dam Association's dam safety recommendations (CDA 2013 and 2019), and the 2020 Global Industry Standard on Tailings Management (GTR 2020).

Table 18: Water Management Structures Design Criteria

Structure	Design Criteria	Source and Comments
TSF water pond normal operating levels	Manage the pond water levels, such as the minimum pond depth is approximately 3 m, to avoid resuspension of fine particles due to pumping.	Operational recommendation
TSF water pond and water treatment capacity	Manage the Directive 019 "project flood" associated with the 1,000-year 24-hour rainfall superimposed with the melt over 30 days of the 100-year snowpack. Maintain a freeboard, relative to the crest of the dyke, of minimum 1 m during the "project flood."	Directive 019 (MELCC, 2012).
TSF emergency spillway	Convey the PMF peak flow with a freeboard, relative to the crest of the dyke, equivalent to the 100-year extreme wind effect (wind set-up and run-up). Design the spillway channel to be non-erodible during the PMF event unless the channel erosion would not impact the dam (e.g., at sufficient distance downstream of the dam).	Directive 019 (MELCC, 2012) and Canadian Dam Association (2013, 2019) recommendations.
Design of drainage structures (ditches and sumps) around the TSF, at the toe of the TSF dykes	Contain the 1:100-year flood event with a minimum of 0.3 m freeboard and without structural damage.	Directive 019 (MELCC, 2012).
General	Consider the impact of climate change on design storm events by using available median projections for the planned Project LoM.	Current standards including Global Industry Standard on Tailings Management (GTR 2020) and Strategic Assessment of Climate Change (ECCC 2020b)

12.0 CLOSURE PHILOSOPHY

The detailed closure design of the TSF will be elaborated in the future, as the geometry and final volume of the facility are likely to evolve during mining. The current concept for TSF closure is expected to resemble the concept which was approved for closure of the existing facility. At the end of operations, a closure spillway channel would be built to connect the TSF Pond to the flooded 87 Pit Lake located north of the TSF. The channel invert will be lowered by several metres to limit the size of the closure pond and to provide a large long-term freeboard to the embankment. The TSF surface will be vegetated to create a closure landscape and to mitigate beach erosion.

13.0 CAPITAL AND OPERATING COSTS APPROACH

For feasibility, only design and construction quantities (+30% to -20%) will be developed by WSP to support the TSF CAPEX prepared by others. For comparison, the capital and operation cost estimative (i.e., CAPEX and OPEX) for the Options Study have used the Class 5 estimates with a contingency of ±50%.

14.0 CLOSURE

We trust that this memorandum is consistent with the objectives set out for the Project and meets the present requirements of Troilus. We thank you for the opportunity to be of service and welcome any comments or questions you may have.

WSP Canada Inc.

<Original signed by>

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MK/MG/CP/LG/jr

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APPENDIX D

Terrain Mapping

TECHNICAL MEMORANDUM

DATE 4 May 2021 **Project No.** 19131334

TO Laurent Gareau and Mike Tremblay

FROM Anne Sommerville and Dennis O'Leary **EMAIL anne_sommerville@golder.com**

TROILUS GOLD MINE TERRAIN AND GEOHAZARD MAPPING

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was requested by Troilus Gold Incorporated (Troilus) to complete terrain and geohazard mapping for a 144 km^2 area (8 km by 18 km) surrounding its current mine site located approximately 125 km northwest of Chibougamau, Quebec. The extent of the area to be mapped was determined based on consultation with Troilus Gold to ensure the study area proposed met their requirements. The following provides details on the methods used for the terrain and geohazard mapping and the results of the terrain analysis.

2.0 METHODS

Methods used to complete the terrain analysis for Troilus Gold Mine Project included a review of available published data including Fraser and Martin (1988), Vincent (1989) and Chinn and Corrivaux (2006). In addition, the drilling database (SIGÉOM 2021) was accessed to determine drilling locations within the general study area. Although the drill logs did not provide details on the type of surficial material, they did provide an indication of the thickness of the overburden overlying the bedrock.

Following the collection and review of the background data, 30 cm digital stereo aerial photographs acquired 24 August 2013 were obtained from La Géomathèque (a provider of digital aerial imagery based in Quebec). These digital images were subsequently merged with provincial 1 metre LiDAR data to produce digital imagery that could be viewed in 3D on a computer monitor with the aid of specialised 3D glasses. The imagery was loaded into Golder's softcopy mapping system, a system that incorporates both ArcGIS and PurVIEW. This combination of software packages allows mappers the ability to zoom down from the initial capture resolution of 30 cm to resolutions as large as 1 cm larger.

Relatively homogeneous terrain polygons were delineated within the study area at scales ranging from 1:3,000 (3 cm resolution) to 1:1,000 (1 cm resolution). Each terrain polygon was delineated based on parent materials/soil types[1], surface expression, depth to bedrock, slope class, drainage, and geological modifying processes. Each terrain unit was also rated for terrain stability[2, 3].

All mapping adhered to Terrain Classification System for British Columbia, Version 2.0 (Howes and Kenk 1997), and Mapping and Assessing Terrain Stability Guidebook, 2nd Edition (B.C. Ministry of Environment 1999); both

[1] The term 'soil types' is used here from an engineering perspective; they are synonymous with surficial materials and are not intended to imply soils from the Canadian System of Soil Classification (Soil Classification Working Group 1998).
[2]Adapated from Mapping and Assessing Terrain Stability Guidebook (B.C. Ministry of Environment 1999).; modified from Land Management Handbook 18 (Chatwin et al. 1994). The classification address landslides greater than 0.05 ha in size using conventional forest clearing practices and sidecast road construction.
[3]Terrain units classed as I, II or III may contain minor amounts of Class IV or V terrain. These areas may not have been delineated due to mapping scale and scope of work.

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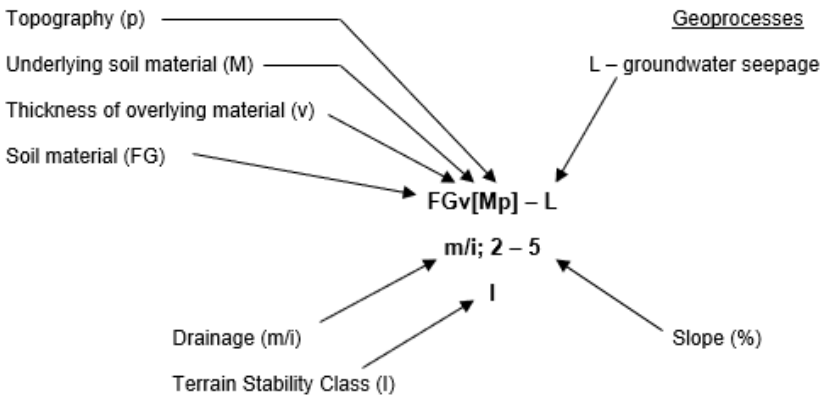
these documents provide general frameworks for terrain and terrain stability classification, respectively, and are used by Golder for all terrain mapping projects worldwide. Table 1 provides the five-class terrain stability classification system (B.C. Ministry of Environment 1999) that was used to support this project.

Table 1: Terrain Stability Classification (from B.C. Environment 1999)[2,3]

Terrain Stability Class	Interpretation
I	No significant stability problems exist.
II	There is very low likelihood of landslides following timber harvesting or road construction; minor slumping is expected along road cuts, especially for 1 or 2 years following construction.
III	Minor stability problems can develop. Timber harvesting should not significantly reduce terrain stability. There is a low likelihood of landslide initiation following timber harvesting. Minor slumping is expected along road cuts, especially for 1 or 2 years following construction. There is a low likelihood of landslide initiation following road construction.
IV	Expected to contain areas with a moderate likelihood of landslide initiation following timber harvesting or road construction.
V	Expected to contain areas with a high likelihood of landslide initiation following timber harvesting or road construction.

No field investigations were completed to support the mapping or the application of the terrain stability classification system.

A series of 1:10,000 scale map figures are found in Appendix A of this technical memorandum. Parent materials/soil types are colour coded based on surficial materials (e.g., green represents till; orange represents glaciofluvial, etc.). It should be noted that the colour representing the subsurface soil material is used where overlying sediments are less than 1 m in thickness (e.g., a terrain polygon mapped as organic veneers overlying till materials is colour coded as green (colour used for till materials). The maps also show the spatial extent of all terrain units, labels for each terrain polygon, and contours. A typical terrain polygon label is as follows:



In the example above, the terrain unit is characterised by glaciofluvial (FG) veneers (v; < 1 m thick) overlying a morainal (M) plain (p). The soils are moderately well to imperfectly drained with slopes of 2% to 5%. Groundwater seepage (L) is found within this unit and terrain stability has been rated as stable (TSC Class1).

3.0 TERRAIN ANALYSIS

3.1 Background

The study area is located within the southeastern section of the Canadian Shield. The topography of the southeastern section of the Canadian Shield is the result of a long series of events culminating in the modification of old erosion surfaces by glaciers during the Quaternary[2] period (Vincent 1989). As a result, this part of the Canadian Shield generally has low local relief, rarely exceeding 100 metres, with isolated hills standing above the plateau surface (Vincent 1989). Bostock (1970) describes the area as a vast, undulating lake-studded plateau. During the last glaciation (Late Wisconsinan) this part of the Canadian Shield was covered by ice of the Labrador Sector; one of several ice domes which were components of the Laurentide Ice Sheet (Dyke 2009). The Late Wisconsinan ice reached its maximum extent approximately 24,000 to 23,000 years ago and by approximately 8,000 to 7,000 years ago the southeastern section of the Canadian Shield was thought to be ice-free (Dyke 2009).

The modern topographic features of the Canadian Shield relate to the presence or absence of Quaternary deposits. In the central part of the southeastern shield (where the study area is located) there are thick till (morainal) deposits that have been moulded by ice into streamlined landforms (Vincent 1989). Although the texture, structure, composition and morphology of the till is variable it is generally derived from metamorphic and igneous rocks resulting in till which is sandy, stony and non-calcareous (Vincent 1989). The structure of the till varies depending on the type of till and how it was deposited. For example, till which has been moulded into streamlined landforms tends to be massive (a mixture of unsorted material with no structure), whereas hummocky moraine which is also massive is interstratified with sand and gravel (Vincent 1989) reflecting the movement of water within the till as it melts. The streamlined features were formed underneath the ice and the hummocky moraine or stagnation moraine is thought to form at the margin of the glacier as it melts (Vincent 1989). Glaciofluvial sediments are widespread in the southeastern Canadian Shield occurring as eskers and outwash deposits, both of which are composed of stratified sands and gravels (Vincent 1989). There is also evidence of glacial lake deposits in the southeastern section of the Canadian Shield. Glacial Lake Ojibway was the largest and is thought to have extended north to include the Lac Mistassini area which is approximately 50 km east of the study area. More recent deposits like eolian or fluvial sediments are formed by the modification of glacial sediments by wind and water, respectively. Organic soils are accumulating in wetlands on glacial lake deposits, low relief till areas and depressions on bedrock surfaces (Vincent 1989).

There are numerous mining exploration reports available through SIGÉOM (2021) all of which describe the bedrock geology in this area. The Troilus mine site is located within the eastern segment of the Frotet-Evans greenstone belt, within the Opatica Subprovince of the Superior Province (Chinn and Corrivaux 2006). The belt is composed of two Archean volcanic piles separated by a sedimentary basin. The volcanic belts consist of submarine basalt and andesite interbedded with minor amounts of the rhyolite, intermediate to felsic volcaniclastics, pyroclasitcs, siltstone, argillite and greeywacke (Chinn and Corrivaux 2006). The regional metamorphic grade ranges from lower greenschist to lower amphibolite facies (Chinn and Corrivaux 2006). The eastern volcanic pile is referred to as the Troilus-Frotet greenstone belt which is divided into four structural and lithostratigraphic dominates separated a by major regional fault (Chinn and Corrivaux 2006). For further details on the bedrock geology in this area, refer to Chinn and Corrivaux (2006).

[2] Quaternary defined as occurring in past 2.588 ± 0.005 million years ago to the present

Despite the mining activity in this area there is very little information available from a surficial geology and soils perspective. The mining exploration reports concentrate on the resources below the ground surface associated with the bedrock geology rather than surficial sediments, however many of the reports do include a brief description of the landscape and provide some details on surficial sediments. Chinn and Corrivaux (2006) describe the topography in the area as low and rolling and expressed as north-east trending drumlins. They indicate that higher areas have little or no overburden, but low lying areas around lakes have thick overburden composed of till and sandy glaciofluvial sediments.

Fraser and Martin (1988) suggest the overburden is variable in thickness and nature but is assumed to be generally less than 15 m with a few remnant rocky exposures. The material they suggest is predominantly ablation (stagnation) till with localised areas of lodgement (basal) till, and some fairly extensive areas of glaciofluvial sediments. Fraser and Martin (1988) also note that no lacustrine clay deposits are known in the area. A sandy boulder till is dominant in the area and has formed broad, gentle to moderately steep ridges with their long axes parallel or subparallel to the presumed ice flow direction (Fraser and Martin 1988). This till is composed of a coarse sandy matrix, which is poorly sorted, with subangular to subrounded boulders commonly between 40 cm and 100 cm in dimension. The boulders are often of the same rock type as the local bedrock geology suggesting a short transport distance. Lodgement or basal till is rare in the area, but it is hard, poorly sorted and has a fine grained silty texture (Fraser and Martin 1988). Glaciofluvial sediments are either flat to gently undulating elevated plains with gentle to moderately sloping edges or esker ridges (Fraser and Martin 1988). The planar deposits are moderately sorted and consist of a medium to coarse sand. The eskers are well defined, between 50 and 150 meters in width and between 10 and 30 metres in height. Although small cobbles are found within the esker deposits they are mainly composed of medium to coarse grained sand (Fraser and Martin 1988). Fraser and Martin (1988) also note that bog occurs throughout the area in flat low-lying areas.

3.2 Results

A total of 3,259 polygons were delineated within the study area, resulting in an average polygon size of 4.4 ha. These polygons ranged in size from 0.03 ha (glaciofluvial sediments at the edge of the study area) to 376.3 ha (a lake southeast of the mine site).

3.2.1 Soil Material Types and Distribution

Table 2 provides a summary of the surficial materials mapped within the study area and the spatial distribution is provided in Appendix A. Moraine (till) is the dominant surficial material within the study area (60.3%) followed by organic soils (13.7%) and then glaciofluvial sediments (7.2%). Lakes account for almost 12% of the study area and areas of anthropogenic disturbance (e.g., the Troilus mine site) accounts for just over 6% of the study area.

Table 2: Surficial Material Types within the Study Area

Surficial Material Type	Map Symbol	Surficial Materials within the Study Area	
		Area (ha)	Percent (%)
Anthropogenic	A	885.6	6.2
Colluvium	C	5.5	<0.1
Fluvial	F	54.8	0.4
Glaciofluvial	FG	1,042.3	7.2
Moraine (till)	M	8,687.2	60.3
Organic	O	1,979.6	13.7
Water	N	1,681.4	11.7
Bedrock	R	63.6	0.4
Total[(a)]		14,400.0	100.0

(a) Numbers may not add up due to rounding

Moraine (till) – Till is the most common surficial material mapped within the study area accounting for approximately 60.3% (8,687.2 ha) of materials mapped. Approximately 56.5% of the till is considered to be greater than 3 m in thickness, with the remaining 43.5% less than 3 m in thickness and overlying bedrock. The thicker deposits are represented by two different landforms within the study area: streamlined and undulating/hummocky. The streamlined features (drumlins) are mainly located northeast of the mine site and were formed at the base of the ice. Their long axes are parallel to the ice flow direction which in this area is from the northeast to the southwest, and they were formed as the ice moved across the landscape (Figure 1). In comparison, the undulating/hummocky topography was likely formed during deglaciation as the sediments collapsed due to the melting of buried stagnant ice near the glacial margin (Figure 2). Within the study area the largest extent of undulating/hummocky topography is in the northeast although some has been mapped immediately north of the mine site. The thicker till deposits are mainly located in a central belt within the study area extending from the northeast to the southwest between bedrock ridges. Elsewhere the till is thinner (less than 3 m thick) and the topography is controlled by the underlying bedrock ridges. Drainage in areas mapped as till ranges from rapidly to poor and this is dependent on location within the landscape, texture and coarse fragment content. Higher areas tend to have better drainage, with lower areas and thinner till in bedrock depressions imperfectly to poorly drained.

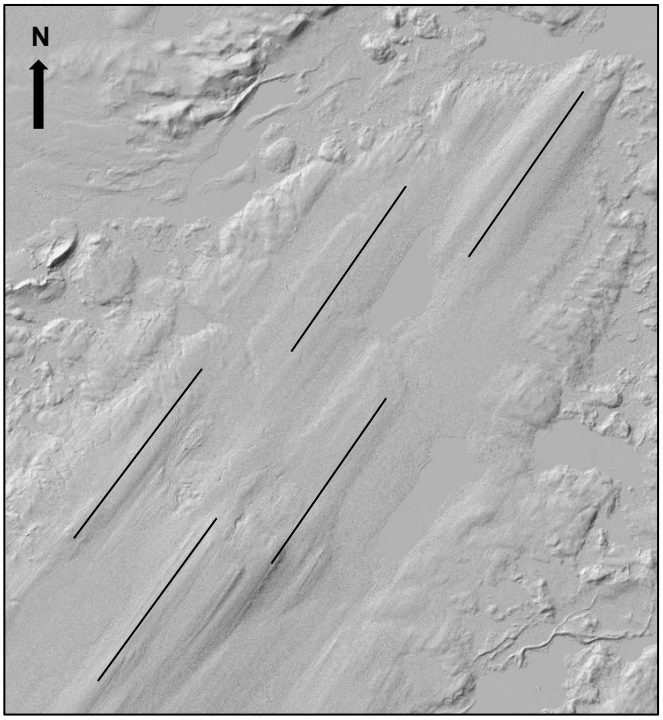


Figure 1: Streamlined topography extending northeast to southwest and parallel to the former ice flow direction.

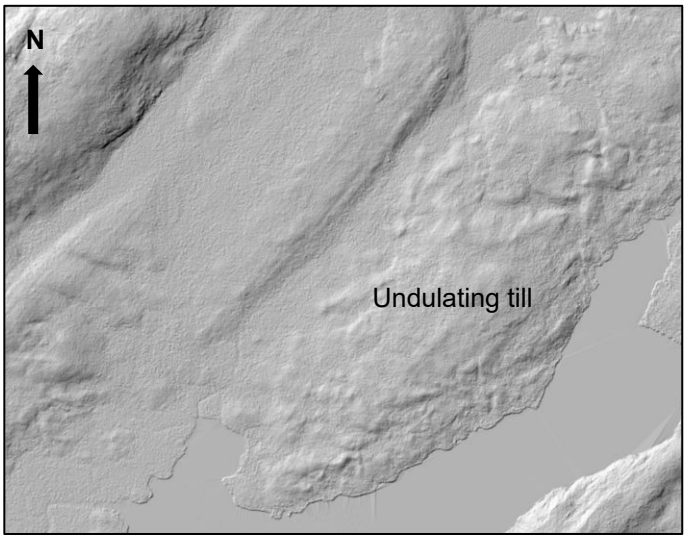


Figure 2: Thick, undulating till deposits formed by the melting of buried ice during deglaciation

Organics – Very poorly drained organic soils account for approximately 13.7% (1,979.6 ha) of surficial materials mapped within the study area. They are generally found within a central belt that extends from the northeast to the southwest through the study area. Approximately 40% of the organic soils are thought to be greater than 3 m in thickness (organic plains, Op), a further 40% is considered to be dominated by blankets (between 1 m and 3 m in thickness, Ob) of organic material and the remaining 20% by veneers (less than 1 m in thickness, Ov). One of the largest areas of thick organic soils is located east of the mine site with other large extents in the northwest part of the study area. In some of these areas, patterned fens (string bogs) have developed with the ridges (strings) and

hollows (flarks) oriented parallel to the slope of the landform and perpendicular to the flow of groundwater (Cohen et al. 2020) (Figure 3). Where the organic soils are considered to be less than 3 m in thickness they have been mapped as overlying till. It is possible that small glacial lakes formed as the ice retreated and melted and therefore the underlying sediments may be glaciolacustrine in nature rather than till in some areas. Glaciolacustrine sediments tend to be finer grained (silt and clay) with few coarse fragments (clasts), however given the bedrock geology in this area the glaciolacustrine sediments, if they exist, may include fine grained sands and silt rather than clay.

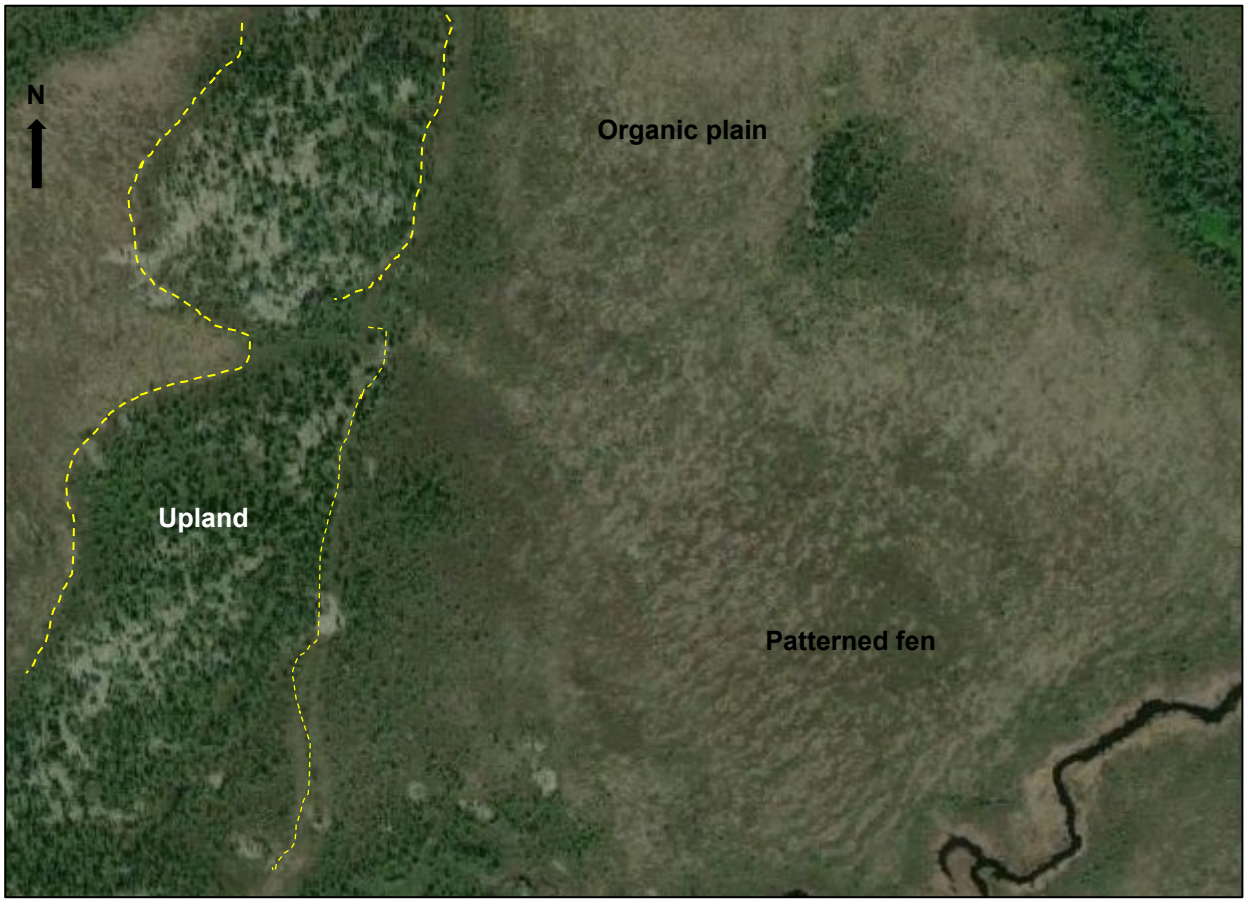


Figure 3: Thick accumulations of organic soils (organic plain) with patterned fen

Glaciofluvial – Glaciofluvial sediments account for 7.2% (1,042.3 ha) of the study area. The highest concentration of glaciofluvial sediments extends in a northeast direction from the north end of the mine site, but other smaller areas of these glacial meltwater sediments are found within the study area especially southwest of the mine site. Approximately 72% of the glaciofluvial sediments are considered to be more than 3 m in thickness and are represented by eskers, planar to gently undulating topography or terraces (Figure 4). The sediments less than 3 m in thickness have been mapped overlying till. The eskers are well developed and extend up to 700 m in length, are up to 100 m wide and up to 20 m in height. Eskers are formed by the deposition of glaciofluvial sediments within subglacial tunnels created by meltwater at the base of the ice. The preservation of the eskers is an indication that the ice likely stagnated and melted *in situ*, preserving the mounds of glaciofluvial material deposited underneath the ice. The northeast part of the study area also has extensive areas of undulating to hummocky stagnation moraine, as discussed above, supporting the idea of a large block of ice breaking off from

the main ice front and stagnating *in situ*. Areas of planar to gently undulating topography and terraces were likely deposited by meltwater at the front of the ice as outwash and may have been subsequently eroded. Undulating to hummocky topography forms when buried ice within the glaciofluvial sediments melts and the surrounding sediments collapse into the holes. The glaciofluvial sediments are likely composed of beds of sand and gravel and given the coarse nature of these sediments, drainage is generally well to rapid with moderate to imperfect drainage in lower areas or depressions.

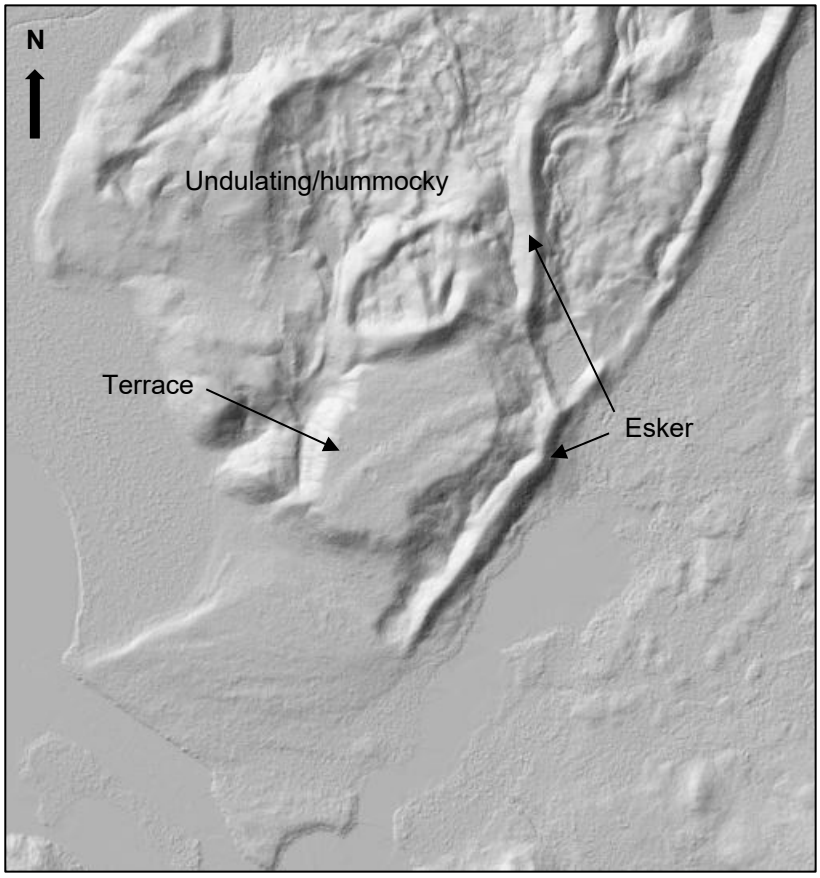


Figure 4: Glaciofluvial sediments represented by undulating to hummocky topography, a terrace and eskers

Fluvial – Modern fluvial systems within the study area are quite rare and account for only 0.4% (54.8 ha) of the study area. Those that have been mapped either link areas of organic accumulation or lakes. There is likely little deposition within these systems and the aerial photography suggests that any fine grained material has been washed away leaving coarse material (cobbles, boulders etc.) on the surface and the main riverbed material. Smaller creeks were noted in the areas of organic accumulation suggesting that water flow is mainly through the wetlands.

3.2.2 Drainage

Table 3 provides a summary of drainage within the study area and suggests that 61.2% (8,803.8 ha) of the surficial materials within the study area are considered to be moderately well to rapidly drained. Rapidly drained surficial materials are found mainly associated with glaciofluvial sediments or exposed bedrock throughout the study area. The glaciofluvial sediments are composed of sand and gravel and therefore even in areas of flatter topography these sediments tend to be rapidly to well drained. Well and moderately well drained surficial

materials are distributed throughout the study area and are mainly associated with till, either as thick till deposits or thinner deposits overlying bedrock.

The topography has an influence on the drainage throughout the study area and therefore lower areas of the landscape tend to have wetter conditions. Imperfectly and poorly drained surficial materials account for approximately 5.8% and 1.6%, respectively, of the study area and these drainage classes are characterised by fluctuating water tables. Lower areas of till adjacent to fluvial or organic areas are imperfectly and/or poorly drained.

Very poorly drained sediments account for approximately 13.7% of the study area and these are associated with areas of organic accumulation. They are concentrated in low-lying areas especially east and north of the mine site.

Table 3: Drainage Classes within the Study Area

Drainage Class	Map Symbol	Surficial Materials within the Study Area	
		Area (ha)	Percent (%)
Rapidly	r	297.9	2.1
Well	w	5,686.7	39.5
Moderately well	m	2,819.2	19.6
Imperfect	i	834.7	5.8
Poor	p	235.1	1.6
Very poor	v	1,966.2	13.7
Null[(a)]		2,560.3	17.8
Total[(b)]		14,400.0	100.0

(a) Null includes water (N) and anthropogenic area (A)
(b) Numbers may not add up due to rounding

3.2.3 Terrain Stability

Table 4 provides a summary of the terrain stability statistics for the study area. Approximately 99.7% of the study area is considered to be stable (Terrain Stability Class I, II, III or Null) with only 0.3% potentially unstable or unstable. The landscape is quite subdued with slopes generally between 0% and 20% grade. Although there are areas of steeper slopes mainly associated with bedrock highs in the study area, the metamorphic and igneous nature of the bedrock is not prone to failure. The areas of potential instability are generally associated with veneers and blankets of till overlying steeper bedrock slopes with slopes ranging from 23% to 104% grade. In areas where bedrock is exposed at the surface there is some evidence of rockfall on steeper slopes and this is likely the result of freeze-thaw activity. Only one area of unstable terrain was identified within the study area and this is located at the south end of the mine site near the tailings pond. The slope is composed of thick till and the toe of the slope appears to have been eroded likely by fluctuations in the level of the tailings pond resulting in shallow landslide activity.

Table 4: Terrain Stability Classes within the Study Area

Terrain Stability Class	Terrain Stability within the Study Area	
	Area (ha)	Percent (%)
I	6,938.4	48.2
II	3,983.9	27.7
III	872.7	6.1
IV	44.5	0.3
V	0.1	<0.1
Null[(a)]	2,560.3	17.8
Total[(b)]	14,400.0	100.0

(a) Null includes water (N) and anthropogenic area (A)
(b) Numbers may not add up due to rounding

4.0 CLOSURE

We trust that this report provides the information that you require at this time. Please do not hesitate to contact the undersigned if you have any questions or need clarification. Golder appreciates the opportunity to be of service on this project.

Yours Truly,

Golder Associates Ltd.

<Original signed by>

<Original signed by>

Anne Sommerville
Senior Terrain Scientist

Dennis O'Leary
Senior Terrain Scientist, Principal

https://golderassociates.sharepoint.com/sites/117654/project files/5 technical work/terrain and geohazard mapping/tech_memo_troilus_terrain_draft.docx

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APPENDIX A

Terrain Mapping

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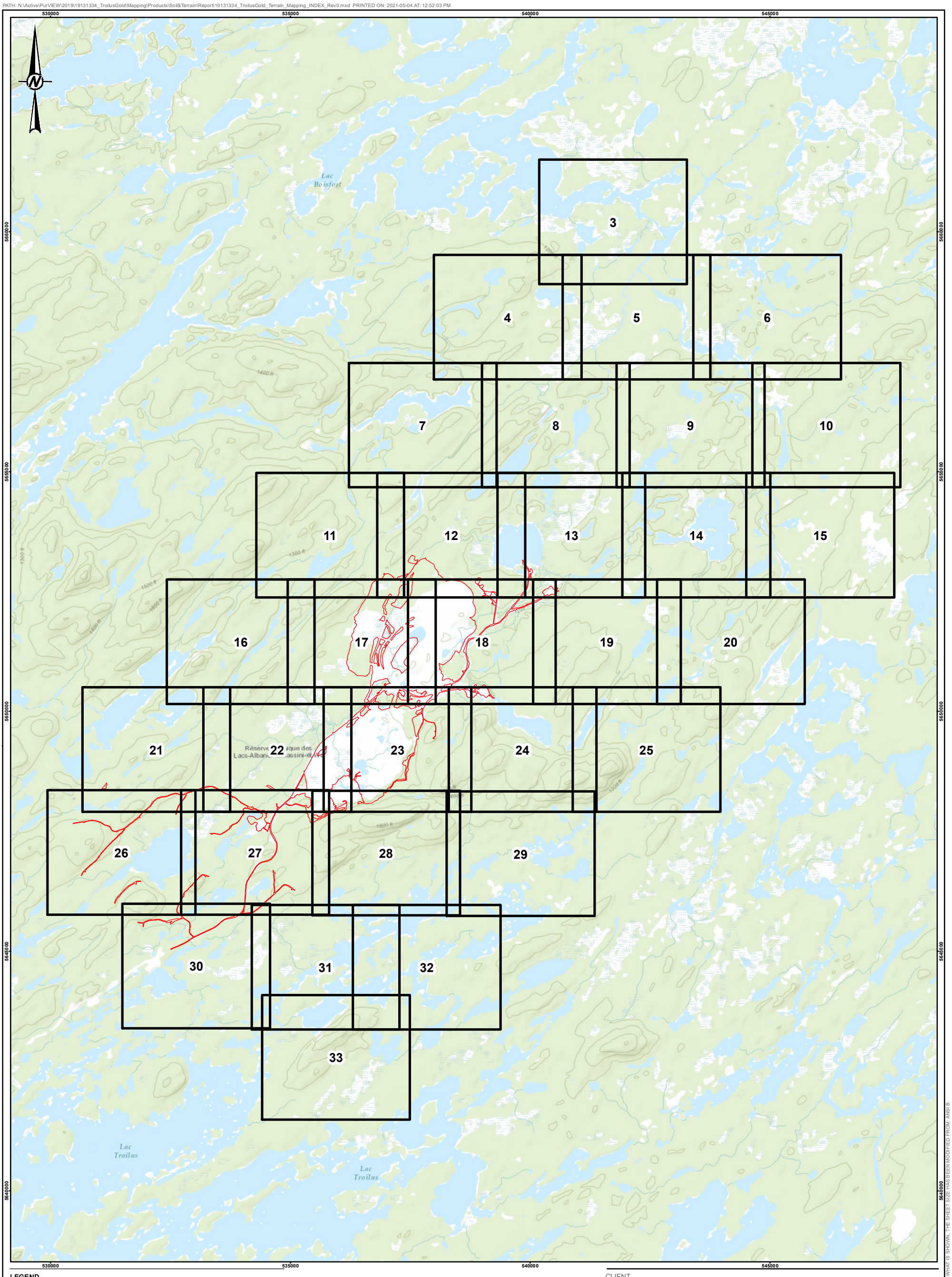

LEGEND

- MAP WINDOW
- MINE SITE

0 1,500 3,000

1:75,000 METRES

REFERENCE(S)

TOPOGRAPHIC MAP © ESRI AND ITS LICENSORS. USED UNDER LICENSE, ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 18 DATUM: NAD 83

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
INDEX MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	1

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Terrain Symbol Legend

Surficial Material

A	Anthropogenic
C	Colluvium
D	Weathered Bedrock (in situ)
E	Loess\Eolian
F	Fluvial
FG	Glaciofluvial
I	Ice
L	Lacustrine
LG	Glaciolacustrine
M	Morainal/Till
N	Waterbody
O	Organic
PG	Preglacial Gravels
R	Bedrock
PA	Pleistocene Alluvium

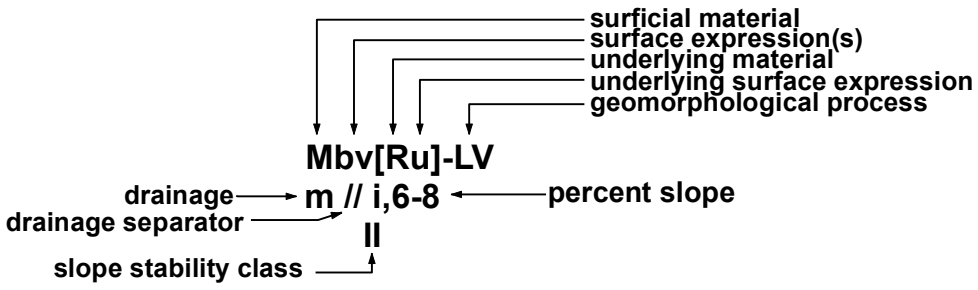
Texture

a	Blocks
b	Boulders
c	Clay
d	Mixed fragments
e	Fibric organic
g	Gravel
h	Humic organic
k	Cobble
m	Mud
p	Pebbles
r	Rubble
s	Sand
u	Mesic organic
x	Angular fragments
y	Shells
z	Silt

Terrain Stability Classification

Terrain Stability Class	Interpretation
I	No significant stability problems exist
II	Very low likelihood of landslide initiation following land clearing or road/pipeline construction
III	Low likelihood of landslide initiation following land clearing or road/pipeline construction
IV	Moderate likelihood of landslide initiation following land clearing or road/pipeline construction (may include areas of existing potentially unstable terrain)
V	High likelihood of landslide initiation following land clearing or road/pipeline construction (may include areas of existing unstable terrain)

Terrain Polygon Label



Drainage Code Separator

,	no intermediate classes
-	all intermediate classes
/	first drainage dominant
//	first drainage significantly dominant

Drainage

r	rapid
w	well
m	moderate
i	imperfect
p	poor
v	very poor

Surface Expression

a	Moderate Slope
b	Blanket (1 - 3 m)
c	Cone(s)
d	Depression(s)
f	Fan(s)
h	Hummock(s)
j	Gentle Slope
k	Moderately Steep Slope
m	Rolling
p	Plain (> 3 m)
r	Ridge(s)
s	Steep Slope
t	Terrace(s)
u	Undulating
v	Veneer (0.2 - 1 m)
x	Thin Veneer (< 0.2 m)

Geomorphological Process Subclasses

Mass Movement Processes	
s	Debris slide
t	Debris torrent
u	Slump in surficial material
Fluvial Processes	
b	Backchannels
u	Progressive bank erosion
Permafrost Processes	
e	Thermokarst: thermal erosion by water

Qualifiers

A	Active
I	Intermittant

Geomorphological Process

"	Initiation Zone
D	Deflation
K	Karst Processes
X	Permafrost Processes
V	Gully Erosion
W	Washing
B	Braiding Channel
I	Irregularly Sinuous Channel
J	Anastomosing Channel
M	Meandering Channel
A	Snow Avalanches
F	Slow Mass Movements
R	Rapid Mass Movements
E	Eroded
H	Kettled
U	Inundated
L	Surface Seepage

NOTE(S)

1. THIS DRAWING MUST BE READ IN CONJUNCTION WITH GOLDER ASSOCIATES LIMITED'S REPORT.

REFERENCE(S)

1. TERRAIN SYMBOL LEGEND ANNOTATED LIST FROM HOWES & KENK (1997).
2. TERRAIN STABILITY CLASSIFICATION ADAPTED FROM APEGBC (2002 AND MINISTRY OF FORESTS (1999)).

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

TITLE
TERRAIN LEGEND

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	**2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25mm

350
345
360
355
365
370
375
380
5660000
Ovb[Mvb] v,0-1 I
Mb[Ru] i,0-3 I
Mp i,0-2 I
Obv[Mp] v,0-1 I
Mu m-i,0-2 I
Op v,0-1 I
Ov[Mp] v,0-1 I
Ob[Mp] v,0-1 I
Mu m-w,0-4 I
Mu w,2-15 I
Mu w,3-17 I
FGvb[Mb] m-i,0-2 I
Ovb[Mp] v,0-1 I
Mu w,0-7 I
Obv[Mp] v,0-1 I
Op v,0-1 I
Obv[Mp] v,0-1 I
N
Mv[Mb] p,0-1 I
Mu w/m,0-13 I
Op v,0-1 I
Mp w-r,0-2 I
Mbv[Rh] m-w,5-21 II
Mp m/i,1-3 I
Mbv[Ru] w//r,3-15 II
Mp m-i,0-2 I
Ru r,1-24 II
Mp p,0-2 I
Op v,0-1 I
Ovb[Mp] v,0-2 I
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Mu w//m,1-7 I
Mp p,0-1 II
Mj m//i,8-18 II
Mj m,13-26 II
Mpj w,1-14 I
Op v,0-1 I
Mbv[Rj] w//m,1-20 II
Mbv[Raj] w,17-38 III
Mu w//m,2-15 I
Mp i-p,0-1 I
Mp m,0-1 I
Mu m//i,0-5 I
Maj[Raj] w-m,16-35 III
Mp i//p,0-3 I
Ov[Mp] v,0-1 I
Mu w/m,0-8 I
Mp m,1-5 I
Ob[Mp] v,0-1 I
Mp i,0-2 I
Mb[Ru] m,1-12 II
Obv[Mp] v,0-1 I
Mv[Rks] w,45-82 III
Mbv[Rh] w-r,6-39 II
Obv[Mp] v,0-1 I
Mpu w,4-18 I
Md i-p,1-3 I
Mp i//p,0-5 I
Mbv[Rja] w-m,6-36 II
Mp i-p,0-2 I
Mpj i//m,3-9 II
Mb[Ru] i,1-3 I
Mup w/m,0-14 I
Mp p,0-1 I
Mp i-p,0-2 I
Mpj w//m,1-16 I
Mp i//p,0-1 I
Mp i,0-4 I
Obv[Mp] v,0-1 I
Mvb[Rd] m,9-50 III
Mbv[Rh] m,2-26 II
Mbv[Rjp] w-m,2-15 II
Mbv[Ru] w-m,0-5 I
Mbv[Ru] w,1-9 I
Mp p,0-2 I
Mp i-p,0-2 I
Obv[Mp] v,0-2 I
Mp m//i,1-4 I
Mb[Rd] i,1-3 I
Mu w//m,1-23 II
Ovb[Mb] v,0-1 I
Mp m//i,0-2 I
Obv[Mp] v,0-1 I
Mp p,0-1 I
Mp w,0-4 I
Mj w,7-25 II
Mpj w,3-16 I
Mpj m//i,1-12 I
Mvx[Ru] w-r,5-26 I
Obv[Mp] v,0-1 I
Op v,0-1 I
Mbv[Ru] w/m,1-12 I
Mbv[Rj] m,8-17 II
Mbv[Rj] w-m,1-20 II
Mbv[Raj] w,17-38 III
Mp i-p,0-1 I
Mp m,0-1 I
Mu m//i,0-5 I
Maj[Raj] w-m,16-35 III
Mb[Ru] m,1-12 II
Obv[Mp] v,0-1 I
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Mbv[Rh] w-r,6-39 II
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Mp i-p,0-2 I
Mpj i//m,3-9 II
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Mbv[Rh] m,2-26 II
Mvb[Rd] m,9-50 III
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Mu w//m,1-23 II
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Mbv[Rj] m,8-17 II
Mvx[Ru] w-r,5-26 I
Mp w-r,0-2 I
Mp p,0-1 II
Op v,0-1 I
Mu w/m,3-10 I
Mu w//m,1-7 I
Mbv[Rj] w-m,1-20 II
Mbv[Raj] w,17-38 III
Mp i-p,0-1 I
Mp m,0-1 I
Mu m//i,0-5 I
Maj[Raj] w-m,16-35 III
Mb[Ru] m,1-12 II
Obv[Mp] v,0-1 I
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Mbv[Rh] w-r,6-39 II
Md i-p,1-3 I
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Mpj i//m,3-9 II
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Mb[Ru] i,1-3 I
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Mvb[Rd] m,9-50 III
Mbv[Ru] w-m,0-5 I
Mu w//m,1-23 II
Mb[Rd] i,1-3 I
Mbv[Rj] m,8-17 II
Mvx[Ru] w-r,5-26 I
Mp w-r,0-2 I
Mp p,0-1 II
Op v,0-1 I
Mu w/m,3-10 I
Mu w//m,1-7 I
Mj m//i,8-18 II
Mj m,13-26 II
Mbv[Rj] w-m,1-20 II
Mbv[Raj] w,17-38 III
Mp i-p,0-1 I
Mp m,0-1 I
Mu m//i,0-5 I
Maj[Raj] w-m,16-35 III
Mb[Ru] m,1-12 II
Obv[Mp] v,0-1 I
Mv[Rks] w,45-82 III
Mbv[Rh] w-r,6-39 II
Md i-p,1-3 I
Mp i-p,0-2 I
Mpj i//m,3-9 II
Mbv[Rja] w-m,6-36 II
Mb[Ru] i,1-3 I
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Mbv[Rh] m,2-26 II
Mvb[Rd] m,9-50 III
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Mu w//m,1-23 II
Mb[Rd] i,1-3 I
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Ru r,1-24 II
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Mu w//m,1-7 I
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Mp p,0-2 I
Op v,0-1 I
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Op v,0-1 I
Mp p,0-2 I
Ov[Mp] v,0-1 I
Op v,0-1 I
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Mp i//p,0-3 I
Mp i-p,0-2 I
Mp i//p,0-1 I
Mp i,0-4 I
Obv[Mp] v,0-2 I
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Mp w,0-4 I
Mj w,7-25 II
Mpj w,3-16 I
Mpj m//i,1-12 I
Obv[Mp] v,0-1 I
Op v,0-1 I
Mbv[Ru] w/m,1-12 I
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Mp p,0-1 I
Mp m//i,0-2 I
Obv[Mp] v,0-1 I
Mp p,0-1 I
Obv[Mp] v,0-1 I
Op v,0-1 I
Mj w,7-25 II
Mp i,0-2 I
Mpu w,4-18 I
Obv[Mp] v,0-1 I
Mp i//p,0-1 I
Mp i,0-4 I
Mpj w//m,1-16 I
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Mp m//i,1-4 I
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N
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Mp p,0-2 I
Ov[Mp] v,0-1 I
Ob[Mp] v,0-1 I
Mp m,1-5 I
Mp i,0-2 I
Mu w/m,0-8 I
Mp i//p,0-5 I
Obv[Mp] v,0-1 I
Mp i-p,0-2 I
Mp i-p,0-2 I
Mp i//p,0-1 I
Mp i,0-4 I
Obv[Mp] v,0-1 I
Mp m//i,1-4 I
Mp w,0-4 I
Mj w,7-25 II
Mpj w,3-16 I
Mpj m//i,1-12 I
Mp i-p,0-2 I
Mp i-p,0-2 I
Mp p,0-1 I
Mp m//i,0-2 I
Obv[Mp] v,0-1 I
Mp p,0-1 I
Obv[Mp] v,0-1 I
Op v,0-1 I
Mj w,7-25 II
Mp i,0-2 I
Mpu w,4-18 I
Obv[Mp] v,0-1 I
Mp i//p,0-1 I
Mp i,0-4 I
Mpj w//m,1-16 I
Obv[Mp] v,0-2

540000

540000

LEGEND

CONTOUR (5 m INTERVAL)

TERRAIN POLYGON BOUNDARY (APPROXIMATE)

SITE SYMBOLOGY

ESKER

DOMINANT SURFICIAL MATERIAL

BEDROCK (R)

FLUVIAL (F)

GLACIOFLUVIAL (FG)

MORAINAL (TILL)(M)

WATERBODY (N)

ORGANIC (O)

Terrain Polygon Label

surficial material
surface expression(s)
underlying material
underlying surface expression
geomorphological process

Mbv[Ru]-LV

drainage → m // i,6-8 ← percent slope
drainage separator →
slope stability class → II

INDEX MAP

N

5 km

0 250 500

1:10,000 METRES

REFERENCE(S)

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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

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Ma[Ra] w-m,16-35 III
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Mu w//m,0-8
Mp i//p,0-5
Mp m,1-5
Ob[Mp] v,0-1
Mp i,0-2
Mpu w,4-18
Mp i//p,0-1
Obv[Mp] v,0-1
Mp m-i,0-2
Obv[Md] v,0-1
Mp i,0-1
Mv[Rks] w,45-82 III
Mb[Ru] i,1-6
Mbv[Rjp] w-m,2-15 II
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Mup w/m,0-14
Mp p,0-1
Mp i-p,0-2
Mpj w//m,1-16
Obv[Mp] v,0-2
Ovb[Mp] v,0-1
Mpj i//m,3-9 II
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Mbv[Ru] w,1-9
Ovb[Mb] v,0-1
Mp i-p,0-2
Mp w,0-4
Mpu w,3-18 II
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Mj w,7-25 II
Mvx[Ru] w-r,5-26
Mp i,0-1
Op v,0-1
Mp m//i,0-2
Mp p,0-1
Mjp w,3-16
Mpj m//i,1-12
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Mp i,0-1
Mpu w//m,1-11
Mp i,0-2
FGbv[Mp] w,0-3
Obv[Mp] v,0-1
Ob[Mp] v,0-1
Mu w-m,0-17 II
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Obv[Mp] v,0-1
Ovb[Mb] v,0-1
Obv[Mp] v,0-1
FGv[Mp] i,0-3
Mp i,0-1
FGv[Mp] w/m,0-3
Mp i//m,0-3
Mu w,1-12
Op v,0-1
Mp p,0-2
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Obv[Mp] v,0-2
Mp m-i,0-5
Ov[Mp] v,0-2
Mpu w//m,0-12
Ovb[Mp] v,0-1
Ob[Mp] v,0-1
Mp i//m,1-4
Mbv[Ru] w,5-13 II
Mp-L i-p,0-6 II
Mvx[Rh] w,8-45 III
Mvx[Ru] w,6-32 II
FGbv[Mp] w,0-5
Mvb[Rj] w,2-18 II
FGbv[Mu] w,6-20 II
FGbv[Mp] w,1-4
Mp m//i,0-5
Ovb[Mp] v,0-1
Op v,0-1
Mp w,0-6
Mp m,0-3
Mu w,5-25 II
Mb[Ra] w,26-34 III
Mp i-p,0-3
FGbv[Mp] w//m,0-3
Op v,0-1
Mb[Ru] i,0-2
Mbv[Rj] w,4-12 II
Mpu w-m,1-12
Md p,0-2
Obv[Mp] v,0-1
Mbv[Ru] w//m,0-9
Op v,0-1
FGbv[Mp] w,0-2
Mpu w,0-7
Mpu m//i,1-7
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Mpu w/m,1-8
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Ovb[Mp] v,0-1
Mp m,2-5
Mb[Ru] i,0-2
Mbv[Ru] w,1-13 II
Mp m//i,0-5
Op v,0-1
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Mpj w,0-9
Mp i//m,0-2
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Mpj w,1-10
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Mp i//p,0-2
Mpu m,3-7
Obv[Mp] v,0-1
Mj m//i,4-10 II
Mb[Ru] m//i,1-12
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Obv[Mp] v,0-2
Mpu m-i,1-6
Mb[Rj] m-i,7-18 II
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Mja-L m-i,8-36 III
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Mp p-i,0-2
Mp p,0-2
Mb[Rj] i,5-10 II
Mb[Rjp] w//m,1-10 II
Op v,0-1
Mbv[Rjp] w//m,1-26 II
Mj w,5-25 II
Mp w//m,0-5
Mp w//m,2-5
Mbv[Rja] w,10-30 II
Mp i//p,0-3
Mp w,0-3
Mja w,10-29 II
Mb[Rj] i//p,0-6
Mp w,0-5
Mp m-i,0-5
Mp m,0-5
Mpu w,0-5
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Mpu w,0-7
Mbv[Rj] w,7-19 II
Mb[Rj] w,6-22 II
Mbv[Rj] m//p,3-8
Mpj i,2-7 II
Mpu w,0-7
Mp w,0-5
Mjp w,2-9 II
Ov[Mp] v,0-1
Mj w,5-25 II
Mj w,6-16 II
Mpj m,0-7
Mb[Ru] i,0-2
Mp w,0-4
Mp i,0-1
Mp i/m,0-2
Mp m,1-5
Mpu m,3-7
Mp i/p,0-2
Mb[Ru] m//i,1-12
Mb[Rj]-L m-i,11-19 III
Obv[Mp] v,0-2
Ovb[Mp] v,0-2
Mja-L m-i,8-36 III
Mp m//i,1-4
Mbv[Ru] w,5-13 II
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Mu w,1-12
Mp i//p,0-1
Mpj w,1-12
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Mpu w,3-18 II
Mpu w-m,1-12
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Mp i/m,0-2
Mp m,1-5
Mpu m//i,1-7
Mp m//i,0-5
Op v,0-1
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Mj w,5-25 II
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Mp i,0-1
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Mp p,0-2
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Mp p-i,0-2
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Op v,0-1
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Mb[Rj] i,5-10 II
Mb[Rjp] w//m,1-10 II
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Mpj m,0-7
Mb[Rj] w,6-22 II
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Mpj i,2-7 II
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Mp w,0-5
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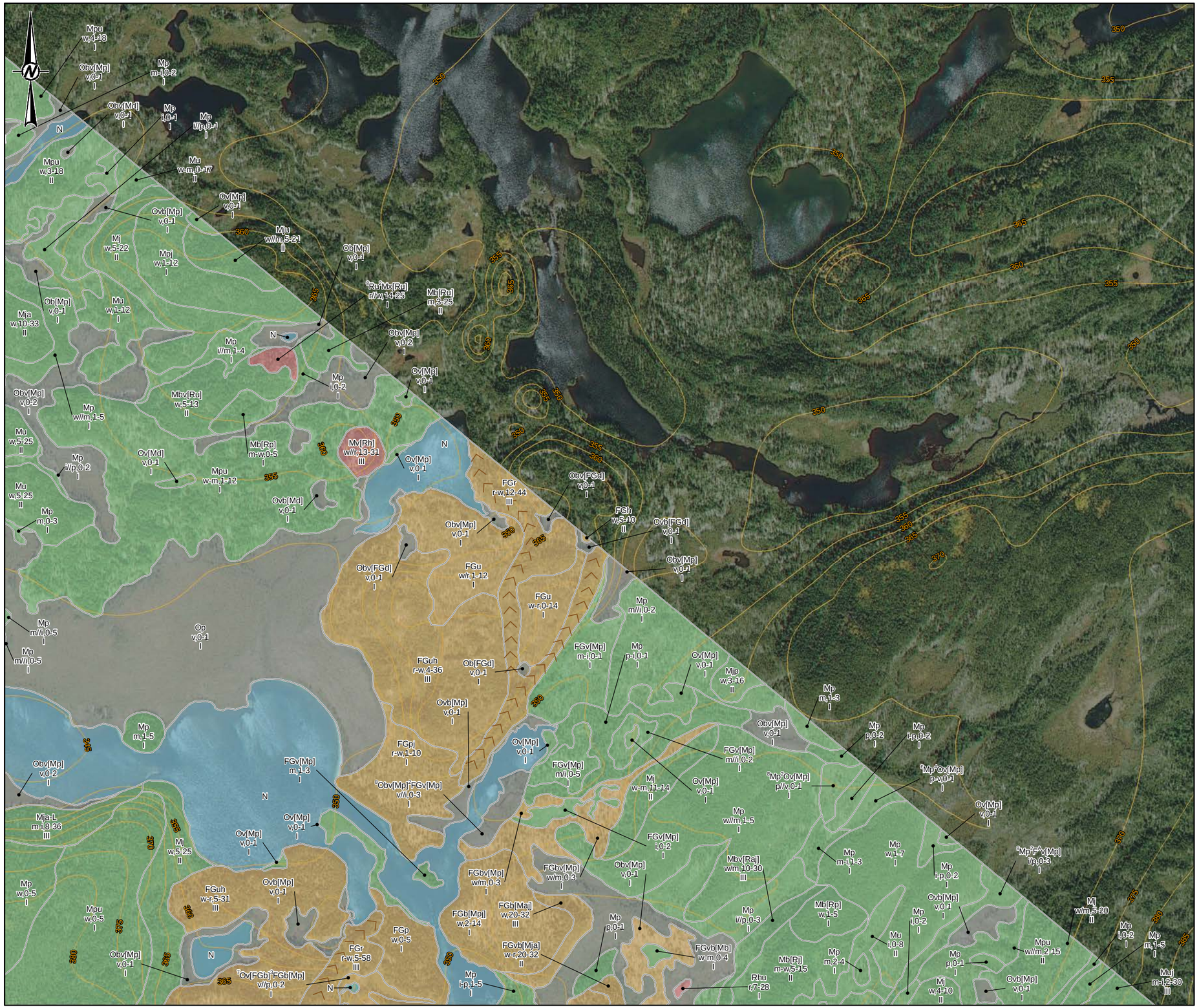

LEGEND

- CONTOUR (5 m INTERVAL)
- TERRAIN POLYGON BOUNDARY (APPROXIMATE)

SITE SYMBOLOGY

- ESKER

DOMINANT SURFICIAL MATERIAL

- BEDROCK (R)
- GLACIOFLUVIAL (FG)
- MORAINAL (TILL)(M)
- WATERBODY (N)
- ORGANIC (O)

Terrain Polygon Label

surficial material
surface expression(s)
underlying material
underlying surface expression
geomorphological process

Mbv[Ru]-LV

drainage
drainage separator
m // i,6-8 — percent slope
II
slope stability class

REFERENCE(S)

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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

PATH: N:\Active\Pur\VIEW\19131334_TroiluGoldMapping\Products\Soil&TerrainReport\19131334_TroiluGold_Terrain_Mapping_Rev0.mxd PRINTED ON: 2021-05-04 AT 1:20:59 PM

LEGEND

CONTOUR (5 m INTERVAL)

TERRAIN POLYGON BOUNDARY (APPROXIMATE)

SITE SYMBOLOGY

ESKER

DOMINANT SURFICIAL MATERIAL

- BEDROCK (R)
- FLUVIAL (F)
- GLACIOFLUVIAL (FG)
- MORAINAL (TILL)(M)
- WATERBODY (N)
- ORGANIC (O)

Terrain Polygon Label

surficial material
surface expression(s)
underlying material
underlying surface expression
geomorphological process

Mbv[Ru]-LV
m // i,6-8
II

drainage
drainage separator
slope stability class
percent slope

INDEX MAP

N

5 km

0 250 500

1:10,000 METRES

REFERENCE(S)

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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT

GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

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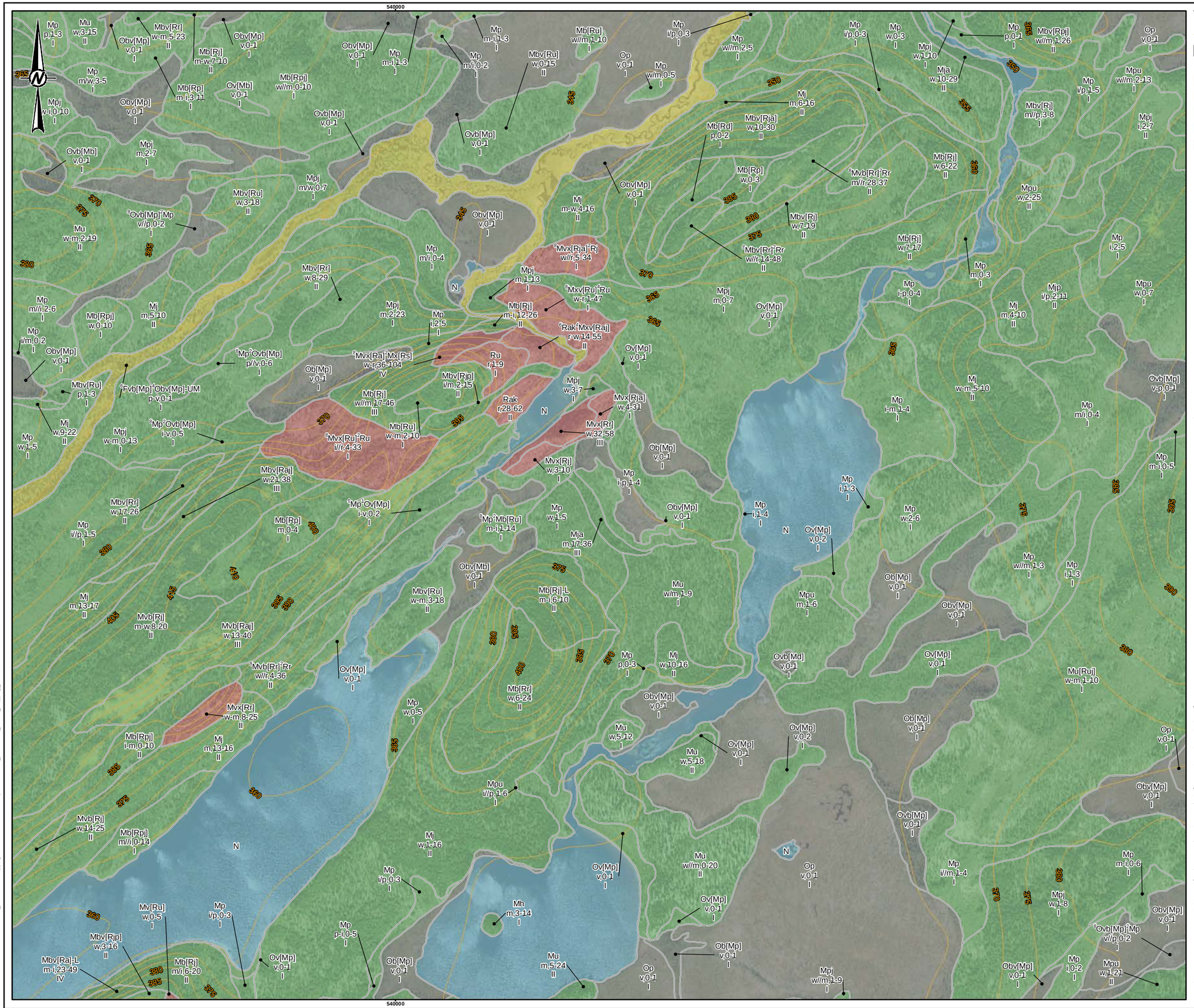
540000
N
Mp p,1-3 I
Mu w,3-15 II
Obv[Mp] v,0-1 I
Mbv[Rj] w-m,5-23 II
Mb[Rj] m-w,7-10 II
Mp m/w,3-5 I
Mb[Rp] m-i,3-11 I
Mpj v-i,0-10 I
Ov[Mb] v,0-1 I
Mb[Rpj] w//m,0-10 I
Ovb[Mp] v,0-1 I
Mpj m,2-7 I
Ovb[Mb] v,0-1 I
Mbv[Ru] w,3-18 II
Mpj m/w,0-7 I
Mu w-m,2-19 II
°Ovb[Mp]-Mp v//p,0-2 I
Mp m/i,0-4 I
Mbv[Rj] w,8-29 II
Mp m/i,2-6 I
Mj m,5-10 II
Mb[Rpj] w,0-10 I
Mp i//m,0-2 I
Obv[Mp] v,0-1 I
Mbv[Ru] p,1-3 I
°Fvb[Mp]-°Obv[Mp]-UM p-v,0-1 I
Mj w,9-22 II
Mp w,1-5 I
°Mp-°Ovb[Mp] i-v,0-5 I
Mpj w-m,0-13 I
Mbv[Raj] w,21-38 III
Mbv[Rj] w,17-26 II
Mp i//p,1-5 I
Mb[Rp] m,0-4 I
°Mp-°Ov[Mp] i-v,0-2 I
Mj m,13-17 II
Mvb[Rj] m-w,8-20 II
Mvb[Raj] w,13-40 III
Mbv[Ru] w-m,3-18 II
Mb[Rj]-L m-i,6-10 II
Obv[Mb] v,0-1 I
°Mvb[Rj]-Rr w//r,4-36 II
Ov[Mp] v,0-1 I
Mbv[Raj]-L m-i,23-49 IV
Mb[Rj] m//i,6-20 II
Mv[Ru] w,0-5 I
Mbv[Rjp] w,3-16 II
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Ov[Mp] v,0-1 I
Ob[Mp] v,0-1 I
Mp p-i,0-5 I
Mu m,5-24 II
Op v,0-1 I
Mh m,3-14 I
Ov[Mp] v,0-1 I
Mp i-m,1-3 I
Mp m/i,0-2 I
Mb[Ru] w//m,1-10 I
Mp i/p,0-3 I
Mp w//m,2-5 I
Mbv[Ru] w,0-15 II
Op v,0-1 I
Mp w//m,0-5 I
Mj m,6-16 II
Mbv[Rjp] w//m,1-26 II
Mp i/p,0-3 I
Mp w,0-3 I
Mpj w,1-10 I
Mja w,10-29 II
Mp p,0-1 I
Op v,0-1 I
Mp i/p,1-5 I
Mpu w//m,2-13 I
Mbv[Rj] m//p,3-8 I
Mpj i,2-7 II
Mbv[Rja] w,10-30 II
Mb[Rd] p,0-2 I
°Mvb[Rj]-°Rr m//r,28-37 II
Mb[Rj] w,6-22 II
Mb[Rp] w,0-3 I
Mpu w,2-25 II
Mbv[Rj] w,7-19 II
Mb[Rj] w,7-17 II
Mp m,0-3 I
Mp i,2-5 I
Mp i-p,0-4 I
Mpj m,0-7 I
Mp i/p,2-11 II
Mj m,4-10 II
Mpu w,0-7 I
Ov[Mp] v,0-1 I
°Mvx[Raj]-°Rj w//r,5-34 I
°Mvx[Ru]-°Ru w-r,1-47 I
Mb[Rj] m-i,12-26 II
°Rak-°Mxv[Raj] r-w,14-55 II
Mpj m,1-13 I
Mp i,2-5 I
°Mvx[Ra]-°Mx[Rs] w-r,36-104 IV
°Mp-°Ovb[Mp] p/v,0-6 I
Ob[Mp] v,0-1 I
Mbv[Rjp] i/m,2-15 II
Ru r,1-9 I
Rak r,28-62 II
Mb[Rj] w//m,17-46 III
°Mvx[Ru]-°Ru i//r,4-33 I
Mb[Ru] w-m,2-10 I
Mpj w,3-7 I
Mvx[Rja] w,4-31 I
Mvx[Rj] w,32-58 III
Mvx[Rj] w,3-10 I
Mp i-p,1-4 I
Mp w,1-5 I
Mja m,17-36 III
Mb[Rj]-L m-i,6-10 II
Mu w//m,1-9 I
Mpu m,1-6 I
Ovb[Md] v,0-1 I
Mp p,0-3 I
Mj w,10-16 II
Obv[Mp] v,0-1 I
Mb[Rr] w,6-24 II
Mp w,0-5 I
Mu w,5-12 I
Mu w,5-18 II
Mpu i//p,1-6 I
Ov[Mp] v,0-2 I
Ov[Mp] v,0-1 I
Mj w,1-16 II
Mu w//m,0-20 II
Ov[Mp] v,0-1 I
Op v,0-1 I
Mp i,1-4 I
Mp i,1-3 I
Mp w,2-6 I
Ov[Mp] v,0-2 I
Ob[Mp] v,0-1 I
Mpu w,1-21 II
Mp i,0-2 I
Mp w//m,1-3 I
Mp i,1-3 I
Mu[Ruj] w-m,1-10 I
Op v,0-1 I
Obv[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Mp m-i,0-5 I
Mp m-i,0-6 I
Mpj w,1-8 I
°Ovb[Mp]-°Mp v//p,0-2 I
Obv[Mp] v,0-1 I
Ovb[Mp] v-p,0-1 I
Mj w-m,5-10 II
Mp i-m,1-4 I
Mp m/i,0-4 I
Mp i,1-3 I
Mp i,1-5 I
Mpj i,2-7 II
Mpu w,0-7 I
Mp i,2-5 I
Mp i/m,1-4 I
Mp i-p,0-4 I
Mp m,0-3 I
Mb[Rj] w,7-17 II
Mpj m,0-7 I
Mj m,4-10 II
Mp i/p,2-11 II
Mpu w,0-7 I
Mp i,2-5 I
Mp m/i,0-4 I
Mp m-i,0-5 I
Mp m-i,0-6 I
Mpj w,1-8 I
°Ovb[Mp]-°Mp v//p,0-2 I
Obv[Mp] v,0-1 I
Mpu w,1-21 II
Mp i,0-2 I
Obv[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Op v,0-1 I
Obv[Mp] v,0-1 I
Mp i,1-3 I
Mp w,2-6 I
Ov[Mp] v,0-2 I
Ob[Mp] v,0-1 I
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Obv[Mp] v,0-1 I
Ov[Mp] v,0-1 I
Mu[Ruj] w-m,1-10 I
Ovb[Mp] v,0-1 I
Ob[Mp] v,0-1 I
Op v,0-1 I
Obv[Mp] v,0-1 I
Mu w,5-18 II
Ov[Mp] v,0-2 I
Ov[Mp] v,0-1 I
Mu w//m,1-9 I
Mpj w//m,1-9 I
Op v,0-1 I
Ob[Mp] v,0-1 I
Mp i,1-4 I
Mp i/m,1-4 I
Ov[Mp] v,0-1 I
Ov[Mp] v,0-1 I
Mp i,1-3 I
Mp w,1-5 I
Mp i/p,0-3 I
Mp p-i,0-5 I
Mu m,5-24 II
Op v,0-1 I
Mh m,3-14 I
Ov[Mp] v,0-1 I
Mp i-p,1-4 I
Mp w,1-5 I
Mja m,17-36 III
Mp i/p,0-3 I
Mp i/p,0-3 I
Mp i,1-3 I
Mp w,0-3 I
Mpj w,1-10 I
Mja w,10-29 II
Mp p,0-1 I
Mbv[Rpj] w//m,1-26 II
Op v,0-1 I
Mp i/p,1-5 I
Mpu w//m,2-13 I
Mbv[Rj] m//p,3-8 I
Mpj i,2-7 II
Mbv[Rja] w,10-30 II
Mb[Rd] p,0-2 I
°Mvb[Rj]-°Rr m//r,28-37 II
Mb[Rj] w,6-22 II
Mb[Rp] w,0-3 I
Mpu w,2-25 II
Mbv[Rj] w,7-19 II
Mb[Rj] w,7-17 II
Mp m,0-3 I
Mp i,2-5 I
Mp i-p,0-4 I
Mpj m,0-7 I
Mp i/p,2-11 II
Mj m,4-10 II
Mpu w,0-7 I
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Mp i,2-5 I
°Mvx[Ra]-°Mx[Rs] w-r,36-104 IV
°Mp-°Ovb[Mp] p/v,0-6 I
Ob[Mp] v,0-1 I
Mbv[Rjp] i/m,2-15 II
Ru r,1-9 I
Rak r,28-62 II
Mb[Rj] w//m,17-46 III
°Mvx[Ru]-°Ru i//r,4-33 I
Mb[Ru] w-m,2-10 I
Mpj w,3-7 I
Mvx[Rja] w,4-31 I
Mvx[Rj] w,32-58 III
Mvx[Rj] w,3-10 I
Mp i-p,1-4 I
Mp w,1-5 I
Mja m,17-36 III
Mb[Rj]-L m-i,6-10 II
Mu w//m,1-9 I
Mpu m,1-6 I
Ovb[Md] v,0-1 I
Mp p,0-3 I
Mj w,10-16 II
Obv[Mp] v,0-1 I
Mb[Rr] w,6-24 II
Mp w,0-5 I
Mu w,5-12 I
Mu w,5-18 II
Mpu i//p,1-6 I
Ov[Mp] v,0-2 I
Ov[Mp] v,0-1 I
Mj w,1-16 II
Mu w//m,0-20 II
Ov[Mp] v,0-1 I
Op v,0-1 I
Mp i,1-4 I
Mp i,1-3 I
Mp w,2-6 I
Ov[Mp] v,0-2 I
Ob[Mp] v,0-1 I
Mpu w,1-21 II
Mp i,0-2 I
Mp w//m,1-3 I
Mp i,1-3 I
Mu[Ruj] w-m,1-10 I
Op v,0-1 I
Obv[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Mp m-i,0-5 I
Mp m-i,0-6 I
Mpj w,1-8 I
°Ovb[Mp]-°Mp v//p,0-2 I
Obv[Mp] v,0-1 I
Ovb[Mp] v-p,0-1 I
Mj w-m,5-10 II
Mp i-m,1-4 I
Mp m/i,0-4 I
Mp i,1-3 I
Mp i,1-5 I
Mpj i,2-7 II
Mpu w,0-7 I
Mp i,2-5 I
Mp i/m,1-4 I
Mp i-p,0-4 I
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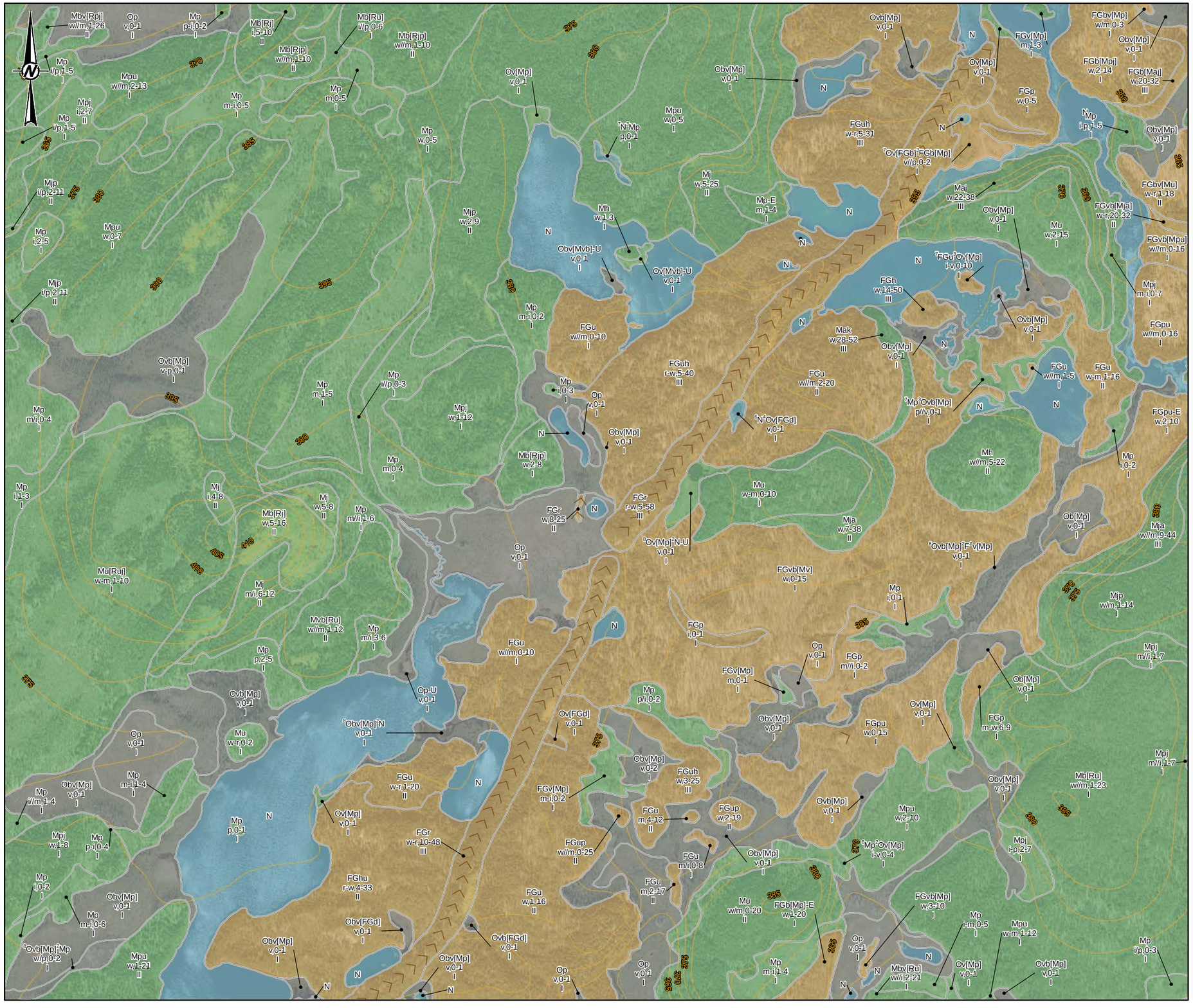
Mpj m,0-7 I
Mj m,4-10 II
Mp i/p,2-11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p-i,0-2
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i,5-10
II
Mb[Ru]
i/p,0-6
I
Mb[Rjp]
w//m,1-10
II
Mb[Rjp]
w//m,1-10
II
Mp
i/p,1-5
I
Mpu
w//m,2-13
I
Mpj
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Mp
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Mp
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Mpu
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Obv[Mp]
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Ovb[Mp]
v,0-1
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FGbv[Mp]
w/m,0-3
I
Obv[Mp]
v,0-1
I
FGb[Mpj]
w,2-14
I
FGb[Maj]
w,20-32
III
Ov[Mp]
v,0-1
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m,1-3
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FGp
w,0-5
I
FGuh
w-r,5-31
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v,0-1
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Mjp
i/p,2-11
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Mp
i,2-5
I
Mpu
w,0-7
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Mjp
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Mp
i,2-5
I
Mjp
w,2-9
II
Mh
w,1-3
I
Obv[Mvb]-U
v,0-1
I
Ov[Mvb]-U
v,0-1
I
Mp-E
m,1-4
I
Mj
w,5-25
II
Maj
w,22-38
III
Obv[Mp]
v,0-1
I
Mu
w,2-15
I
FGvb[Mja]
w-r,20-32
II
FGbv[Mu]
w-r,1-18
II
FGvb[Mpu]
w//m,0-16
I
FGu
w//m,0-10
I
Mp
m-i,0-2
I
FGh
w,14-50
III
FGu
w//m,2-20
II
Mak
w,28-52
III
Obv[Mp]
v,0-1
I
Ovb[Mp]
v,0-1
I
Mpj
m-i,0-7
I
FGpu
w//m,0-16
I
Ovb[Mp]
v-p,0-1
I
Mp
m/i,0-4
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Mp
m,1-5
I
Mp
i/p,0-3
I
Mpj
w,1-12
I
Mp
i,0-3
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v,0-1
I
Obv[Mp]
v,0-1
I
Mb[Rjp]
w,2-8
I
Mp
m,0-4
I
FGr
r-w,5-58
III
FGr
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II
Mu
w-m,0-10
I
Mja
w,7-38
II
Mp
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I
Mj
i,4-8
II
Mj
w,5-8
II
Mb[Rj]
w,5-16
II
Mp
m//i,1-6
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Mu[Ruj]
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Mj
m/i,6-12
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Ob[Mp]
v,0-1
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Mvb[Ru]
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I
Mjp
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Mp
p,2-5
I
FGu
w//m,0-10
I
Op
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I
FGp
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I
Mpj
m/i,1-7
I
Op-U
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I
Ob[Mp]
v,0-1
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III
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Mp
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II
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v,0-1
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Mpj
i-p,2-7
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Mp
i,0-2
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FGhu
r-w,4-33
II
FGu
m,2-17
II
FGu
w,1-16
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Mu
w/m,0-20
II
FGb[Mp]-E
w,1-20
I
FGvb[Mp]
w,3-10
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Mp
i-m,0-5
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Mpu
w-m,1-12
I
Mp
m-i,0-6
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Obv[Mp]
v,0-1
I
Obv[FGd]
v,0-1
I
Ovb[FGd]
v,0-1
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Obv[Mp]
v,0-1
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Obv[Mp]
v,0-1
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Mpu
w,1-21
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Op
v,0-1
I
Mp
m-i,1-4
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Mbv[Ru]
w//i,2-21
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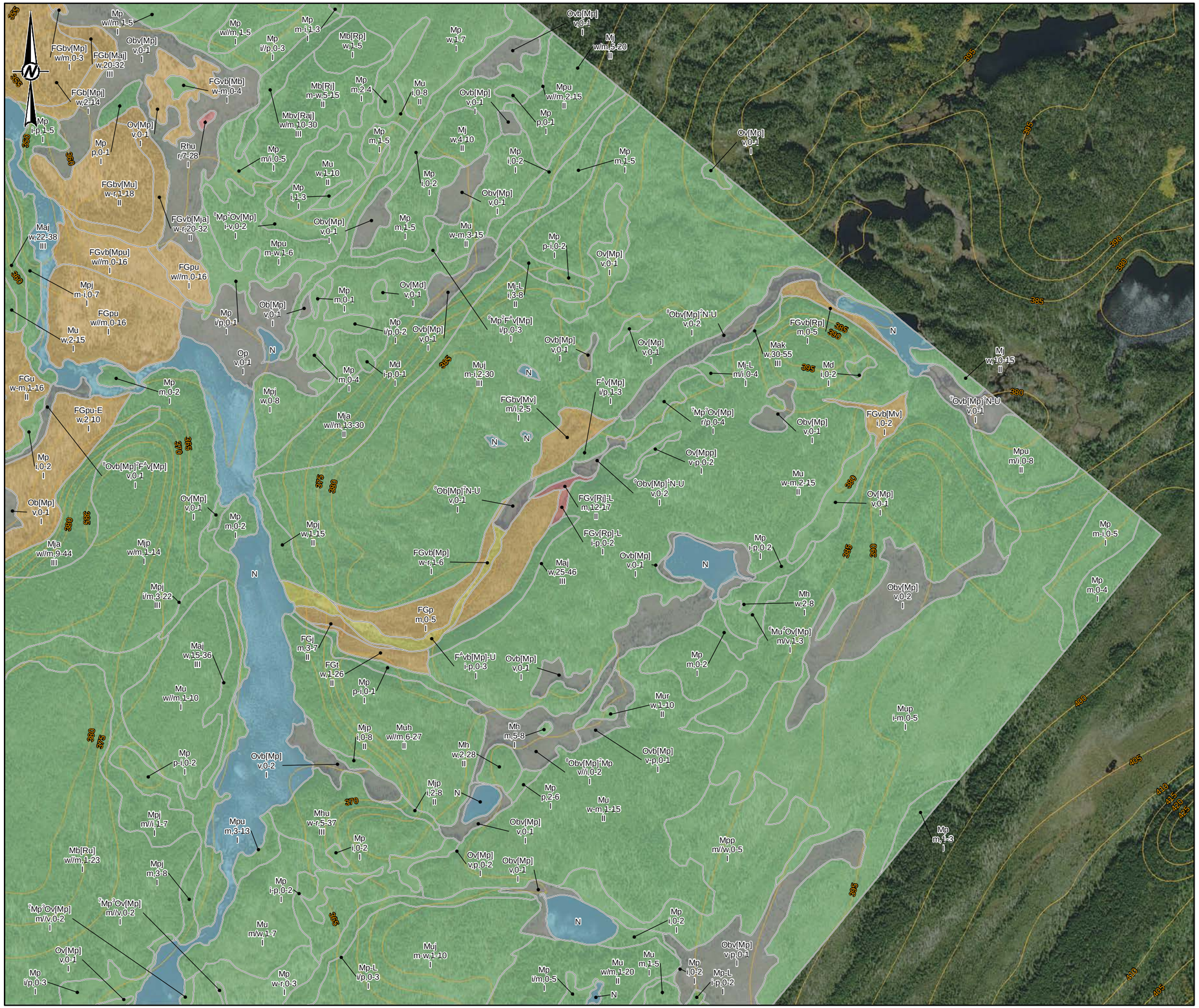
Ov[Mp]
v,0-1
I
Ovb[Mp]
v,0-1
I
Mp
i/p,0-3
I
Ovb[Mp]
v/p,0-2
I
Op-U
v,0-1
I
Ov[FGd]
v,0-1
I
Obv[Mp]
v,0-1
I
Obv[Mp]
v,0-1
I
Mp
p,i,0-2
I
Op
v,0-1
I
Obv[Mp]
v,0-1
I
Ov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Obv[Mp] v,0-1 I
FGbv[Mp] w/m,0-3 I
FGb[Maj] w,20-32 III
Mp m,1-5 I
Mb[Rp] w,1-5 I
Mp w,1-7 I
Ovb[Mp] v,0-1 I
Mj w/m,5-20 II
FGvb[Mb] w-m,0-4 I
FGb[Mp] w,2-14 I
Mb[Rj] m-w,5-15 II
Mp m,2-4 I
Mu i,0-8 II
Mbv[Raj] w/m,10-30 III
Mpu w/m,2-15 II
Mp i-p,1-5 I
Ov[Mp] v,0-1 I
Mp p,0-1 I
Mj w,4-10 II
Rhu r,7-28 I
Mp m/i,0-5 I
Mp i,0-2 I
Mu w,1-10 II
Mp i,1-3 I
FGbv[Mu] w-r,1-18 II
Obv[Mp] v,0-1 I
FGvb[Mja] w-r,20-32 II
Maj w,22-38 III
FGvb[Mpu] w/m,0-16 I
Mpu m-w,1-6 I
Mp p-i,0-2 I
FGpu w/m,0-16 I
Mpj m-i,0-7 I
Ov[Md] v,0-1 I
Mj-L i,3-8 II
Ob[Mp] v,0-1 I
Mp i/p,0-1 I
Mp i/p,0-2 I
Ovb[Mp] v,0-1 I
Mu w,2-15 I
Op v,0-1 I
Mp m,0-4 I
Md i-p,0-1 I
Mpj w,0-8 I
Mja w/m,13-30 III
FGbv[Mv] m/i,2-5 I
Mp m,0-2 I
FGpu-E w,2-10 I
FGu w-m,1-16 II
Mp i,0-2 I
Ov[Mp] v,0-1 I
Ob[Mp] v,0-1 I
Mp m,0-2 I
Mpj w,1-15 II
Mja w/m,9-44 III
Mpj w/m,1-14 I
Mpj i/m,3-22 III
FGvb[Mp] w-r,1-6 I
Maj w,25-46 III
FGp m,0-5 I
FGj m,3-7 II
FGt w,1-26 II
Maj w,15-36 III
Mu w/m,1-10 I
Mp p-i,0-1 I
Mp i,0-2 I
Mjp i,0-8 II
Muh w/m,6-27 II
Mh w,2-28 II
Mh m,5-8 I
Mp p-i,0-2 I
Ovb[Mp] v,0-2 I
Mjp i,2-8 II
Mp p,2-6 I
Mpj m/i,1-7 I
Mpu m,3-13 I
Mhu w-r,5-37 III
Mp i,0-2 I
Mb[Ru] w/m,1-23 I
Mpj m,3-8 I
Mp i-p,0-2 I
Ov[Mp] v,p,0-2 I
Obv[Mp] v,0-1 I
Mpp m/w,0-5 I
Mu m/w,1-7 I
Mp w-r,0-3 I
Mp-L i/p,0-3 I
Muj m-w,1-10 I
Mp i/m,0-5 I
Mu w/m,1-20 II
Mu m,1-5 I
Mp i,0-2 I
Mp-L i-p,0-2 I
Obv[Mp] v-p,0-1 I
Ovb[Mp] v,0-1 I
Mp i-p,0-2 I
Mp m,0-4 I
Mp m-i,0-5 I
Mh w,2-8 I
Obv[Mp] v,0-2 I
Mup i-m,0-5 I
Mp m,1-3 I
Mur w,1-10 II
Ovb[Mp] v-p,0-1 I
Mu w-m,1-15 II
Mpu m/i,0-8 II
Mu w-m,2-15 II
Ov[Mp] v,0-1 I
Mj w,10-13 II
FGvb[Mv] i,0-2 I
Obv[Mp] v,0-1 I
Mak w,30-55 III
Mj-L m/i,0-4 I
Md i,0-2 I
FGvb[Rp] m,0-5 I
Ov[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Mj-L i-p,0-2 I
Mp i,0-2 I
Ov[Mp] v,0-1 I
Mp i,0-2 I
Mp m,0-2 I
Mp i,0-2 I
Mp i,0-2 I
Mp i

LEGEND

- CONTOUR (5 m INTERVAL)
- TERRAIN POLYGON BOUNDARY (APPROXIMATE)

DOMINANT SURFICIAL MATERIAL

- ANTHROPOGENIC (A)
- BEDROCK (R)
- GLACIOFLUVIAL (FG)
- MORAINAL (TILL)(M)
- WATERBODY (N)
- ORGANIC (O)

Terrain Polygon Label

surficial material
surface expression(s)
underlying material
underlying surface expression
geomorphological process

Mbv[Ru]-LV
drainage → m // i,6-8 ← percent slope
drainage separator → II
slope stability class

REFERENCE(S)

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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	11

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm
0

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Obv[Mp] v,0-1 I
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FGb[Mp] w,0-6 I
FGvb[Mp] w/m,0-4 I
Mja m-w,14-32 II
Mp m//i,1-4 I
Mpj w/m,0-10 I
Mp w/m,0-4 I
Mvx[Rj] m,6-8 II
Mbv[Rja] m,7-42 III
Mp m//i,1-6 I
Ov[Mp] v,0-1 I
Mp i//p,1-5 I
Mja m,11-38 II
Mbv[Rj] w,5-39 III
Mp i,1-4 I
Mj m,13-16 II
Mvb[Rj] w,14-25 II
Mb[Rj] m,5-18 II
Mb[Rpj] i-m,0-10 II
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Mb[Rd] p,0-1 I
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Mb[Rj] m,4-14 II
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Mj m,5-12 II
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Mbv[Raj] w,22-40 III
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Mvx[Rja] w//r,8-34 II
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Mu w/m,1-16 II
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Mp p-i,0-2 I
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Mb[Rj] m-w,4-26 II
Mb[Rja] w,14-44 III
Mj m/w,8-13 II
Obv[Mb] v,0-1 I
Mbv[Rh] w,10-42 III
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Mb[Rr] m,4-18 II
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Ru r,4-27 I
Mpu w/m,0-8 II
Mbv[Rr] w/m,15-31 III
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Mp w-m,1-5 I
Obv[Mb] v,0-1 I
Rr4 Mxv[Rr] r//i,0-36 I
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Mp m,0-5 I
Mp m-i,0-5 I
Mp m,0-1 I
Mp i,0-2 I
Ovb[Mp] v,0-1 I
Mp w,2-6 I
Mj m-i,1-4 I
Mj w,7-12 II
Op v,0-1 I
Mp i,2-4 I
Mp i,0-3 I
Mp m//i,2-4 I
Mp i,0-4 I
Mj m,2-16 II
Mp p,2-4 I
Mp i//p,0-3 I
Ovb[Mp] v,0-1 I
Mp i//p,1-4 I
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Ov[Mp] v,0-1 I
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Mu w,1-20 II
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Ov[Mp] v,0-1 I
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Mp i,1-5 I
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Mp i,2-4 I
Mp i,0-4 I
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Mp i,0-2 I
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Mp p,0-1 I
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Mp i,0-2 I
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Mu w/m,1-16 II
Mj m,7-12 II
Mbv[Rr] w,13-34 III
Mp m-w,1-4 I
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FGv[Mb] w/m,0-3 I
Ovb[Mp] v,0-1 I
Mp m-i,0-3 I
Mp p-i,0-2 I
FGvb[Mb] w/m,0-4 I
Mxv[Rp] r/r,1-63 I
Mb[Rj] m-w,4-26 II
Mb[Rja] w,14-44 III
Mj m/w,8-13 II
Obv[Mb] v,0-1 I
Mbv[Rh] w,10-42 III
Mp m//i,1-5 I
Mb[Rp] w,1-5 I
Obv[Mp] v,0-1 I
Mb[Rr] w-m,8-27 II
Ovb[Mb] Mp v-p,0-4 I
Mv[Rj] Rk w/r,9-68 I
Mb[Rr] m,4-18 II
Mp m-i,1-5 I
Mbv[Rjp] m,8-19 I
Mv[Rak] w,23-56 III
Mp w-m,1-3 I
Mp p/i,0-1 I
Mb[Rr] w,10-27 II
Mv[Rp] w,0-21 I
Mb[Rj] w,5-11 II
Mj m/w,8-12 II
Ov[Mb] v,0-2 I
Mj m,6-17 II
Mp i//p,0-3 I
Mb[Rj] w,12-16 II
Ru r,4-27 I
Mpu w/m,0-8 II
Mbv[Rr] w/m,15-31 III
Mp m,1-3 I
Mp w-m,1-5 I
Obv[Mb] v,0-1 I
Rr4 Mxv[Rr] r//i,0-36 I
Mp4 Mb[Ru] w/m,0-10 I
Mp m,0-5 I
Mp m-i,0-5 I
Mp m,0-1 I
Mp i,0-2 I
Ovb[Mp] v,0-1 I
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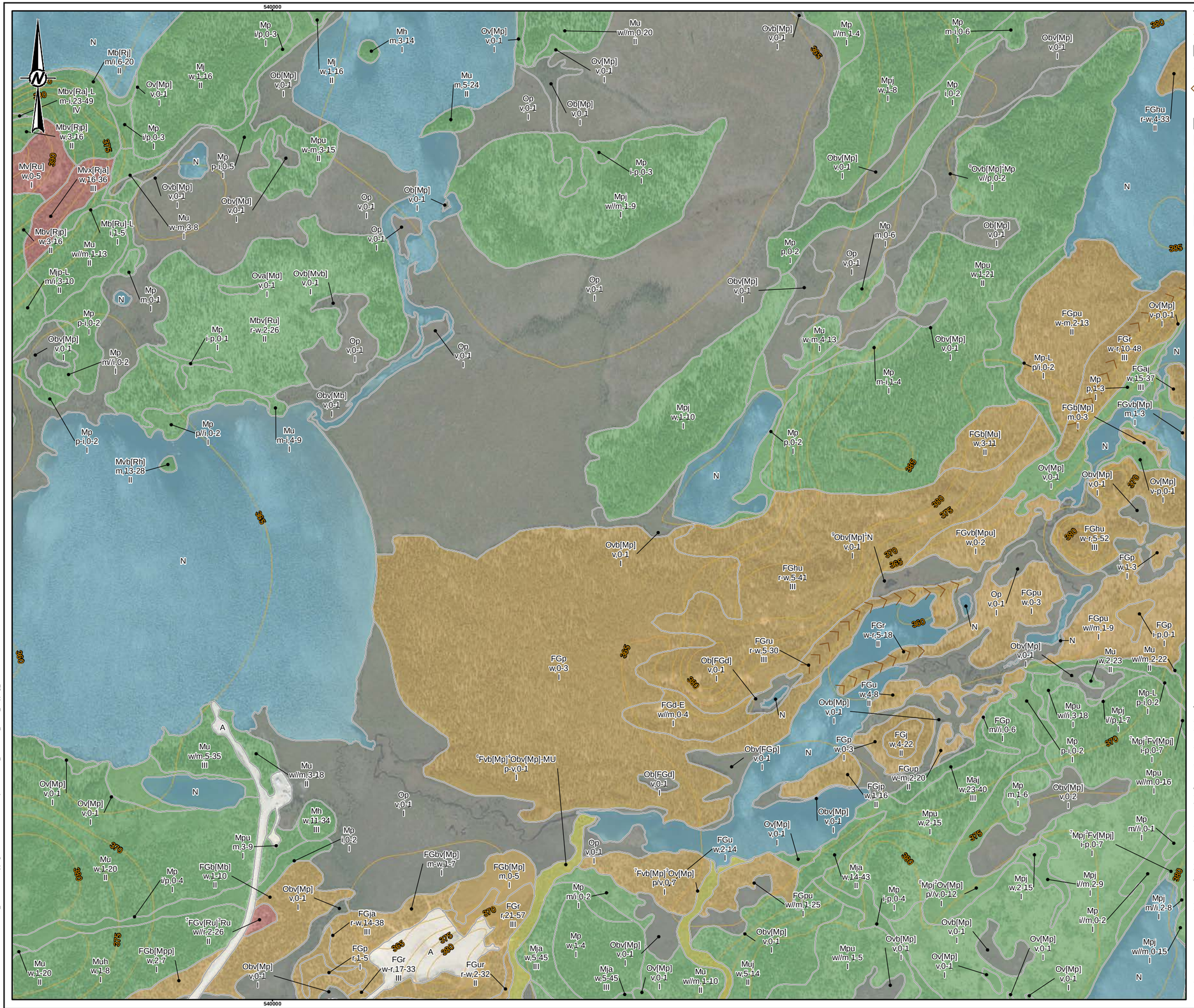


LEGEND

- CONTOUR (5 m INTERVAL)
- TERRAIN POLYGON BOUNDARY (APPROXIMATE)

SITE SYMBOLOGY

- ESKER

DOMINANT SURFICIAL MATERIAL

- ANTHROPOGENIC (A)
- BEDROCK (R)
- FLUVIAL (F)
- GLACIOFLUVIAL (FG)
- MORAINAL (TILL)(M)
- WATERBODY (N)
- ORGANIC (O)

Terrain Polygon Label

surficial material
surface expression(s)
underlying material
underlying surface expression
geomorphological process

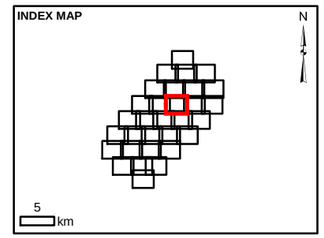
Mbv[Ru]-LV

drainage → m // i,6-8 ← percent slope
drainage separator

II

slope stability class

INDEX MAP



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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	13

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

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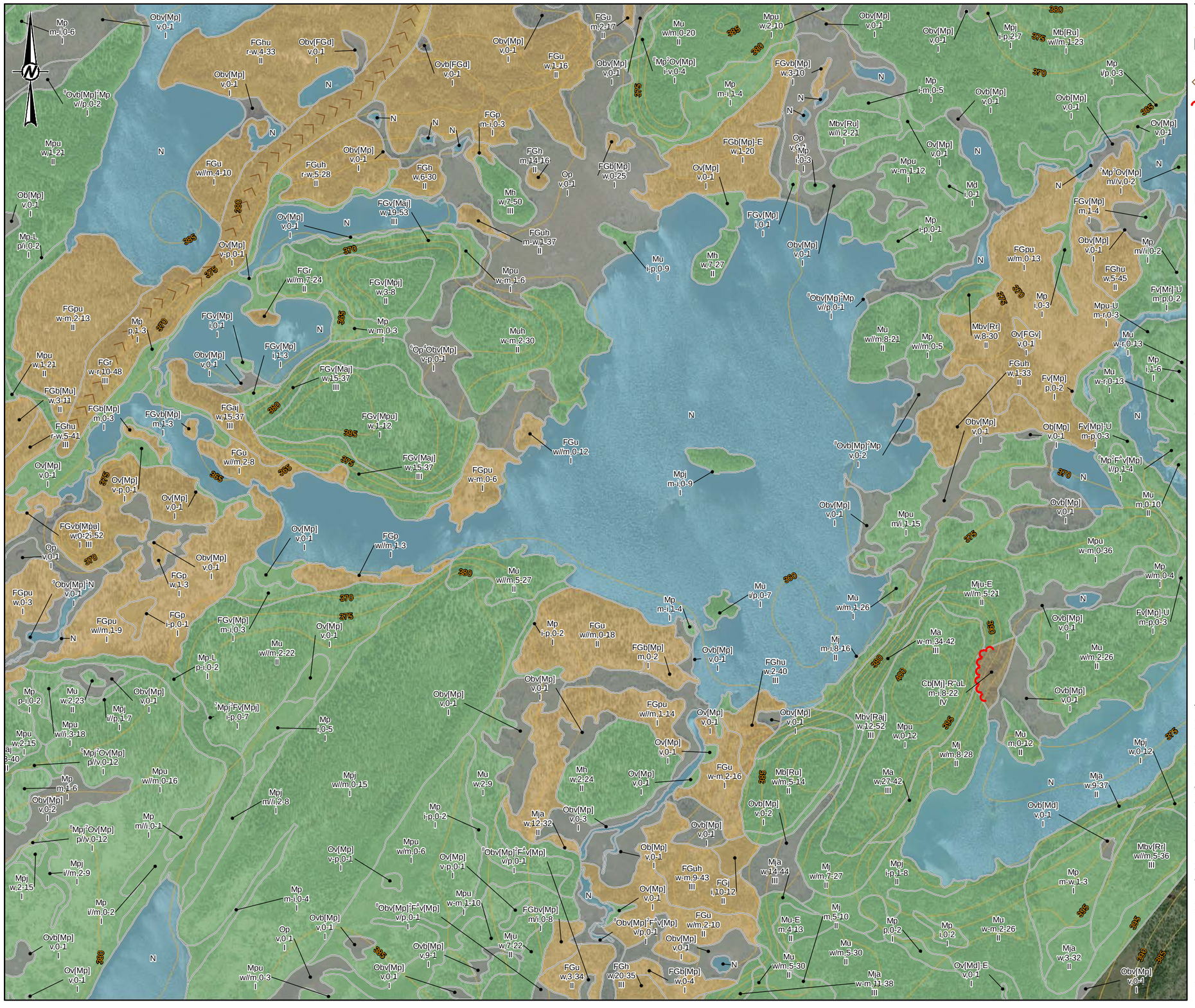
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Obv[Mp] v,0-1 I
FGu w,1-16 II
FGu m,2-17 II
Mu w/m,0-20 II
Mpu w,2-10 I
Obv[Mp] v,0-1 I
Mpj i-p,2-7 I
Mb[Ru] w//m,1-23 I
FGvb[Mp] w,3-10 I
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Op v,0-1
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Ov[Mp] v,0-1 I
Mpu w-m,1-12 I
Md i,0-1 I
FGv[Mp] m,1-4 I
Mp m//i,0-2 I
FGhu w,5-45 II
Fv[Mp]-U m-p,0-2 I
Mpu-U m-r,0-3 I
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Mu w-r,0-13 I
Fv[Mp] p,0-2 I
Mu w-r,0-13 I
FGuh w,1-33 II
Ov[FGv] v,0-1 I
Mbv[Rr] w,8-30 II
Mp i,0-3 I
FGpu w/m,0-13 I
Obv[Mp] v,0-1 I
Mp i-p,0-1 I
FGv[Mp] i,0-1 I
Mu i-p,0-9 I
Mh w,7-27 II
Mu w//m,8-21 II
Mp w/m,0-5 I
Mpj i-p,2-7 I
Mb[Ru] w//m,1-23 I
Mp i-p,0-3 I
Ovb[Mp] v,0-1 I
Ov[Mp] v,0-1 I
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Mpu w,2-10 I
Obv[Mp] v,0-1 I
Mu w/m,0-20 II
Mp m-i,0-3 I
Mpu w,1-21 II
FGu w//m,4-10 I
FGuh r-w,5-28 II
Obv[Mp] v,0-1 I
FGh w,6-30 II
FGp m-i,0-3 I
FGh m,14-16 II
Op v,0-1 I
Mh w,7-50 III
FGb[Mp] w,0-25 I
FGb[Mp]-E w,1-20 I
Ov[Mp] v,0-1 I
Op v,0-1 I
Mp i-p,0-3 I
Mpu w-m,1-12 I
Md i,0-1 I
Mp²Ov[Mp] m/v,0-2 I
Ob[Mp] v,0-1 I
Mp-L p/i,0-2 I
Ov[Mp] v,0-1 I
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Ov[Mp] v-p,0-1 I
FGr w//m,7-24 II
FGv[Mpj] w,3-8 II
Mpu w-m,1-6 I
Mu i-p,0-9 I
Mh w,7-27 II
FGpu w-m,2-13 II
Mp p,1-3 I
FGv[Mp] i,0-1 I
Mp w-m,0-3 I
Muh w-m,2-30 II
Mpu w,1-21 II
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FGv[Mp] i,1-3 I
FGv[Maj] w,15-37 III
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FGb[Mp] m,0-3 I
FGvb[Mp] m,1-3 I
FGaj w,15-37 III
FGv[Mpu] w,1-12 I
FGu w//m,0-12 I
FGu w//m,2-8 I
FGpu w-m,0-6 I
FGhu r-w,5-41 III
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Ov[Mp] v,0-1 I
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Op v,0-1 I
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FGp w,1-3 I
FGp i-p,0-1 I
FGpu w//m,1-9 I
FGpu w,0-3 I
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Mp-L p-i,0-2 I
Mu w//m,2-22 II
Ov[Mp] v,0-1 I
FGv[Mp] m-i,0-3 I
FGp w//m,1-3 I
Ov[Mp] v,0-1 I
Mu w//m,5-27 II
Mp i-p,0-2 I
FGu w//m,0-18 II
Mp m-i,1-4 I
Mu i/p,0-7 I
Mu w/m,1-26 I
Mj m-i,8-16 II
FGb[Mp] m,0-2 I
Ovb[Mp] v,0-1 I
Ma w-m,34-42 III
FChu w,2-40 III
Cb[Mj]-R-uL m-i,8-22 IV
Mju-E w//m,5-21 II
Ovb[Mp] v,0-1 I
Fv[Mp]-U m-p,0-3 I
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Mpu w-m,0-36 I
Mp w/m,0-4 I
Mu m,0-10 II
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Mp i,1-6 I
Mu w-r,0-13 I
Fv[Mp] p,0-2 I
Mu w-r,0-13 I
FGuh w,1-33 II
Mbv[Rr] w/m,5-36 III
Mp m-w,1-3 I
Mpj i-p,1-8 II
Mj w/m,7-27 II
Mja w,14-44 III
Obv[Mp] v,0-1 I
Ob[Mp] v,0-1 I
Fv[Mp]-U m-p,0-3 I
°Mp²Fv[Mp] i//p,1-4 I
Mu m,0-10 II
Ovb[Mp] v,0-1 I
Mpu m/i,1-15 I
Mpu w-m,0-36 I
Mp w/m,0-4 I
Fv[Mp]-U m-p,0-3 I
Mu w/m,2-26 II
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Mu w/m,1-26 I
Mj m-i,8-16 II
Ma w-m,34-42 III
Cb[Mj]-R-uL m-i,8-22 IV
Ovb[Mp] v,0-1 I
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Mbv[Rr] w/m,5-36 III
Mp m-w,1-3 I
Mu m,0-10 II
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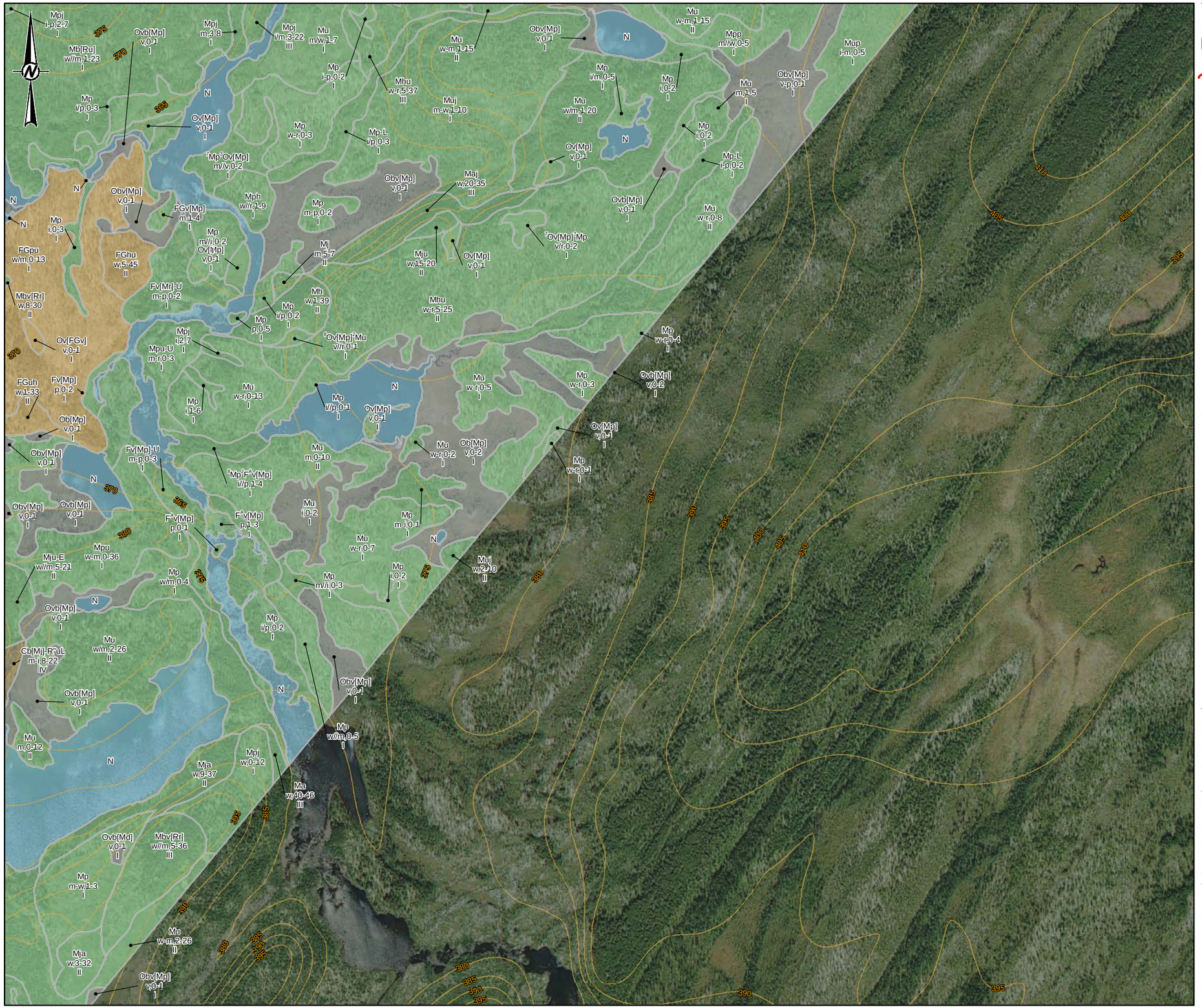


LEGEND

- CONTOUR (5 m INTERVAL)
- TERRAIN POLYGON BOUNDARY (APPROXIMATE)

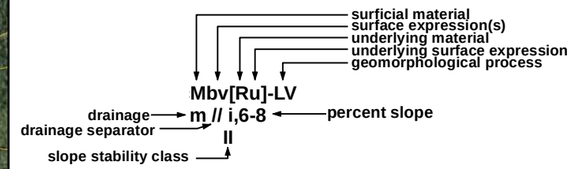
SITE SYMBOLOGY

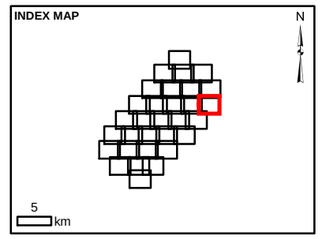
- LANDSLIDE HEAD WALL SCARP

DOMINANT SURFICIAL MATERIAL

- COLLUVIUM (C)
- GLACIOFLUVIAL (FG)
- MORAINAL (TILL)(M)
- WATERBODY (N)
- ORGANIC (O)

Terrain Polygon Label





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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	15

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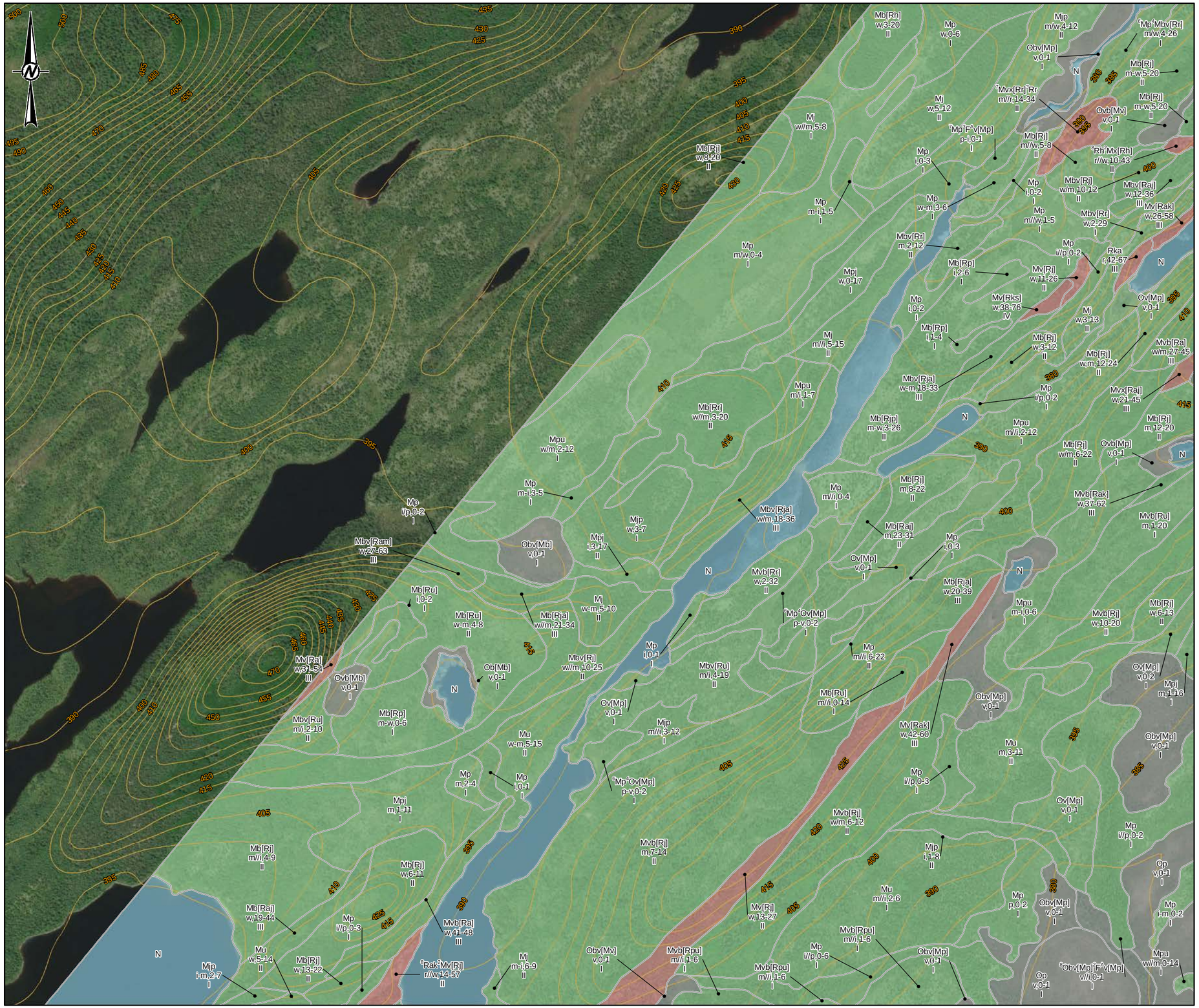
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
0 25mm



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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

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TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	16

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

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Mj w,5-12 II
Mp m,0-4 I
Mb[Ru] m-i,0-5 I
Mp m-i,0-5 I
Mb[Rj] m,15-22 II
Mb[Rj] m/i,1-6 I
Mb[Rj] m,15-22 II
Mp i,1-5 I
Mb[Ru] w-m,5-18 II
Mbv[Rja] w,17-35 III
Mpj w-m,0-16 I
Mb[Rj] w-m,12-24 II
Mp m,0-4 I
Mp m,0-4 I
Ovb[Mb] v,0-1 I
Ovb[Mb] v,0-1 I
Ovb[Mv] v,0-1 I
Mb[Rj] w,m,12-24 II
Rak r,29-69 III
Mp i/p,0-1 I
Mp i-p,0-1 I
Mb[Rj] m/i,7-18 II
Mvb[Rj] w,2-18 I
Mvb[Raj] w,31-44 III
Rak r,29-64 III
Mb[Rj] m/w,5-8 II
Mp i,0-2 I
Mb[Rp] m,1-4 I
Mbv[Ru] w-m,5-29 II
Mpu m,1-6 I
Mbv[Raj] w,12-36 III
Mbv[Rj] w/m,10-12 II
Mp w-m,3-6 I
Mp i/p,0-2 I
Mb[Rj] m,5-20 II
Mbv[Rf] m,2-12 II
Mp m/w,1-5 I
Mv[Rj] w,11-26 II
Mbv[Rf] w,2-29 I
Mv[Rak] w,26-58 III
Mvx[Raj] w,21-45 III
Obv[Mb] v,0-1 I
Mp m,0-5 I
Mb[Rp] i,2-6 I
Mb[Rjp] m-w,3-26 II
Rka r,42-67 III
Mvb[Raj] w-m,24-45 III
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Mj w,3-13 II
Mb[Rp] i,1-4 I
Mb[Ru] m,4-11 II
Ov[Mp] v,0-1 I
Ov[Mp] v,0-1 I
Mv[Rks] w,38-76 IV
Mp i,0-2 I
Mb[Rj] m,10-15 II
Mb[Rj] w/m,6-18 II
Mbv[Rja] w-m,18-33 III
Ovb[Mb] v,0-2 I
Mb[Rj] w,3-12 II
Ovb[Mp] v,0-1 I
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Mpu m/i,2-12 I
Mb[Rj] m,12-20 II
Ovb[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Mvb[Ru] m,1-20 I
Mb[Rj] w/m,6-22 II
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Ov[Mp] v,0-1 I
Mvb[Rak] w,37-62 III
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Mpj m,1-16 I
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Mvb[Rj] w,10-20 II
Mb[Rj] w,6-13 II
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Obv[Mp] v,0-1 I
Ov[Mp] v,0-2 I
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Mh m/i,3-16 I
Op v,0-1 I
Mp p,0-2 I
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Obv[Mp] v,0-1 I
Ov[Mp] v,0-1 I
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Mu m/i,2-6 I
Mp i-m,0-2 I
Mp p,0-2 I
Obv[Mp] v,0-1 I
Mpu w,0-5 I
Ob[Mp] v,0-1 I
Ovb[Md] v,0-1 I
Ovb[Mp] v,0-1 I
Ov[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Ob[Mp] v,0-1 I
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Mu w,3-8 I
Op v,0-1 I
Obv[Md] v,0-1 I
Mp i/p,0-6 I
Op v,0-1 I
Obv[Mp] v,0-1 I
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Mj m,7-15 II
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Mh m,2-14 I
Mp p,0-2 I
Mpj m,1-8 I
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Mh m/w,19-40 II
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Mu m,5-10 II
Mbv[Ru] m-i,0-26 I
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Ov[Mp] v,0-1 I
Mp m,3-5 I
Ov[Mp] v,0-1 I
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Obv[Mp] v,0-1 I
Obv[Mp] v,0-1 I
Fv[Mp] p,0-2 I
Obv[Mp] v,0-1 I
Ov[Mp] p,0-1 I
Obv[Mp] v,0-1 I
Mp m/i,0-3 I
Ov[Mp] v,0-1 I
Mp p,0-2 I
Mpu w/m,0-10 I
Mbv[Ru] m-i,0-15 I
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Mp i-p,0-2 I
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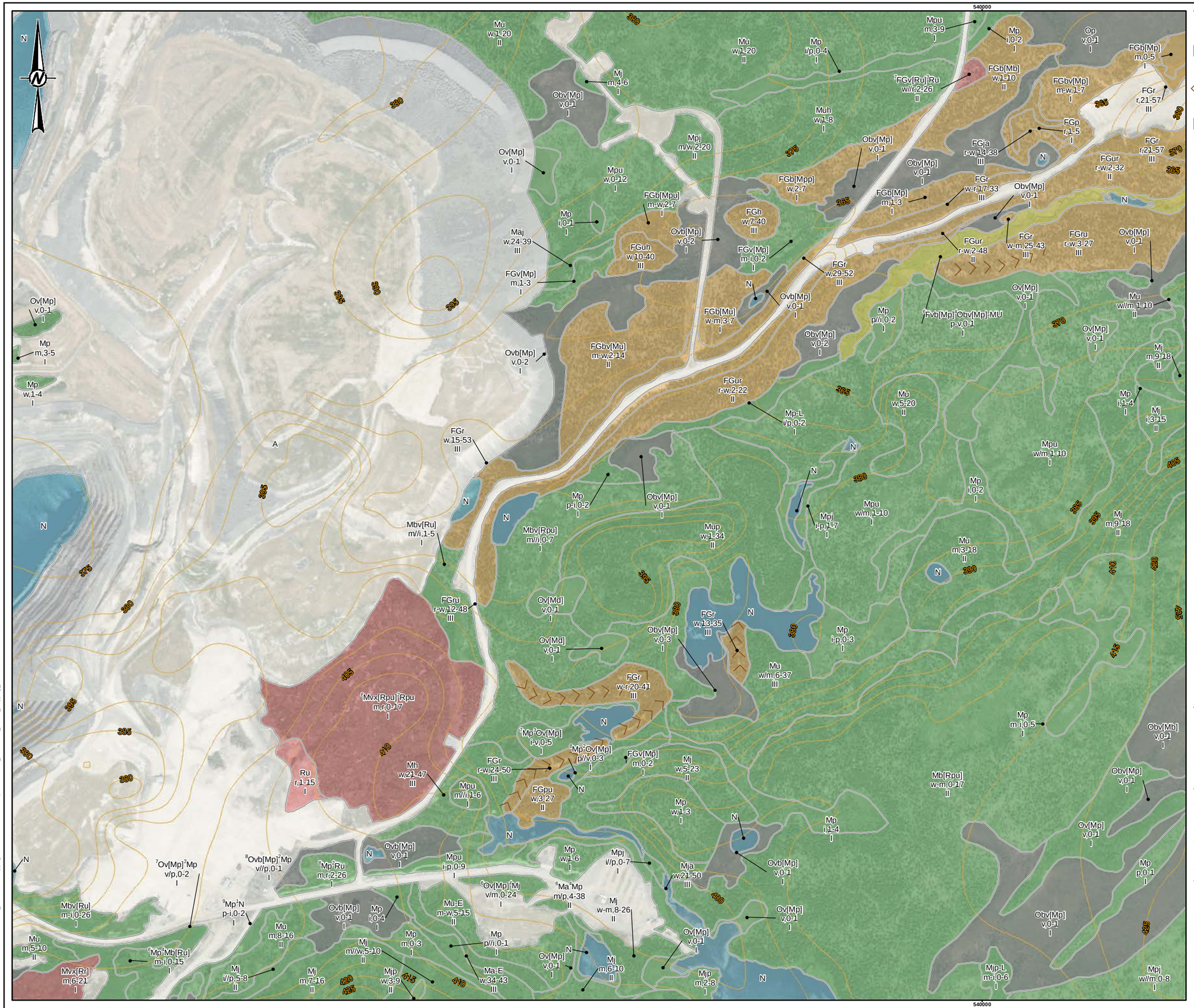
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Mp i,0-2 I
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FGb[Mp] m,0-5 I
FGb[Mb] w,1-10 II
FGv[Ru]-Ru w//r,2-26 II
FGbv[Mp] m-w,1-7 I
FGr r,21-57 III
Mj m,4-6 I
Obv[Mp] v,0-1 I
Muh w,1-8 I
FGp r,1-5 I
Ov[Mp] v,0-1 I
Mpj m/w,2-20 II
Obv[Mp] v,0-1 I
FGja r-w,14-38 III
FGr r,21-57 III
Mpu w,0-12 I
Obv[Mp] v,0-1 I
FGur r-w,2-32 II
FGb[Mpp] w,2-7 I
FGb[Mpu] m-w,2-7 I
FGb[Mp] m,1-3 I
FGr w-r,17-33 III
Obv[Mp] v,0-1 I
Mp i,0-1 I
FGh w,7-40 III
Maj w,24-39 III
Ovb[Mp] v,0-2 I
FGv[Mp] m-i,0-2 I
FGuh w,10-40 III
FGur r-w,2-48 II
FGr w-m,25-43 III
FGru r-w,3-27 III
Ovb[Mp] v,0-1 I
FGv[Mp] m,1-3 I
FGr w,29-52 III
Ov[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
FGb[Mu] w-m,3-7 I
Mp p/i,0-2 I
FVb[Mp]-Obv[Mp]-MU p-v,0-1 I
Mu w//m,1-10 II
Ov[Mp] v,0-1 I
Mp m,3-5 I
Obv[Mp] v,0-2 I
Ov[Mp] v,0-1 I
Mj m,9-18 II
Mp w,1-4 I
FGbv[Mu] m-w,2-14 II
Ovb[Mp] v,0-2 I
FGur r-w,2-22 II
Mu w,5-20 II
Mp i,1-4 I
Mj i,3-15 II
Mp-L i/p,0-2 I
FGr w,15-53 III
Mpu w/m,1-10 I
Mp i,0-2 I
Mbv[Ru] m/i,1-5 I
Mbv[Rpu] m/i,0-7 I
Mup w,1-34 II
Mpj i-p,1-7 I
Mj m,9-18 II
Mu m,3-18 II
Mp p-i,0-2 I
Obv[Mp] v,0-1 I
Ov[Md] v,0-1 I
FGru r-w,12-48 III
FGr w,13-35 III
Obv[Mp] v,0-3 I
Mp i-p,0-3 I
Ov[Md] v,0-1 I
FGr w-r,20-41 III
Mu w/m,6-37 III
Mp m-i,0-5 I
Obv[Mb] v,0-1 I
Obv[Mp] v,0-1 I
Mb[Rpu] w-m,0-17 II
Ru r,1-15 I
Mh w,21-47 III
FGr r-w,24-50 III
FGv[Mp] m,0-2 I
Mj w,5-23 II
FGpu w,3-27 II
Mpu m//i,1-6 I
Mp w,1-3 I
Mp i,1-4 I
Ov[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Mpu i-p,0-9 I
Mp w,1-6 I
Mpj i//p,0-7 I
Mja w,21-50 III
Ovb[Mp] v,0-1 I
Mp p,0-1 I
Ov[Mp] v,0-1 I
Obv[Mp] v,0-1 I
Mu m,8-16 II
Mp m,0-3 I
Mp p/i,0-1 I
Mj m//w,5-10 II
Mu-E m-w,5-15 II
Ma-E w,34-43 III
Mj m,6-10 II
Mjp m,2-8 I
Mjp-L m-i,0-6 I
Mj w//m,0-8 I
Mu m,5-10 II
Mv[Rr] m,6-21 I
Mj i//p,5-8 II
Mj m,7-16 II
Mjp w,3-9 II
Mu-E w,34-43 III
Mp i,0-2 I
Mpu w/m,1-10 I
Mj i-p,1-7 I
Mu m,3-18 II
Mp i-p,0-3 I
Mu w/m,6-37 III
Mp m-i,0-5 I
Obv[Mb] v,0-1 I
Obv[Mp] v,0-1 I
Mb[Rpu] w-m,0-17 II
Mp i,1-4 I
Ov[Mp] v,0-1 I
Mp p,0-1 I
Obv[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Mp i,1-4 I
Mj i,3-15 II
Mpu w/m,1-10 I
Mp i,0-2 I
Mj m,9-18 II
Mj w//m,0-8 I
Mp m,3-5 I
Mp w,1-4 I
Mbv[Ru] m-i,0-26 I
Mu m,5-10 II
Mv[Rr] m,6-21 I
Mj i//p,5-8 II
Mj m,7-16 II
Mjp w,3-9 II
Mu-E w,34-43 III
Mjp m,2-8 I
Mjp-L m-i,0-6 I
Mj w//m,0-8 I
FGr w,15-53 III
FGru r-w,12-48 III
Mh w,21-47 III
Ru r,1-15 I
Mpu m/i,1-6 I
FGr w-r,20-41 III
Mu w/m,6-37 III
Mb[Rpu] w-m,0-17 II
Mp i,1-4 I
Ov[Mp] v,0-1 I
Mp p,0-1 I
Mja w,21-50 III
Ovb[Mp] v,0-1 I
Ov[Mp] v,0-1 I
Obv[Mp] v,0-1 I
Mj w-m,8-26 II
Mp i,0-4 I
Mp m,0-3 I
Mp p/i,0-1 I
Mj m//w,5-10 II
Mu-E m-w,5-15 II
Ma-E w,34-43 III
Mj m,6-10 II
Mjp m,2-8 I
Mjp-L m-i,0-6 I
Mj w//m,0-8 I
Mbv[Ru] m/i,1-5 I
Mbv[Rpu] m/i,0-7 I
Mup w,1-34 II
Mpj i-p,1-7 I
Mu m,3-18 II
Mp p-i,0-2 I
Obv[Mp] v,0-1 I
Ov[Md] v,0-1 I
FGru r-w,12-48 III
FGr w,13-35 III
Obv[Mp] v,0-3 I
Mp i-p,0-3 I
Ov[Md] v,0-1 I
FGr w-r,20-41 III
Mu w/m,6-37 III
Mp m-i,0-5 I
Obv[Mb] v,0-1 I
Obv[Mp] v,0-1 I
Mb[Rpu] w-m,0-17 II
Ru r,1-15 I
Mh w,21-47 III
FGr r-w,24-50 III
FGv[Mp] m,0-2 I
Mj w,5-23 II
FGpu w,3-27 II
Mpu m/i,1-6 I
Mp w,1-3 I
Mp i,1-4 I
Ov[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Mpu i-p,0-9 I
Mp w,1-6 I
Mpj i//p,0-7 I
Mja w,21-50 III
Ovb[Mp] v,0-1 I
Mp p,0-1 I
Ov[Mp] v,0-1 I
Obv[Mp] v,0-1 I
Mu m,8-16 II
Mp m,0-3 I
Mp p/i,0-1 I
Mj m//w,5-10 II
Mu-E m-w,5-15 II
Ma-E w,34-43 III
Mj m,6-10 II
Mjp m,2-8 I
Mjp-L m-i,0-6 I
Mj w//m,0-8 I
Mu m,5-10 II
Mv[Rr] m,6-21 I
Mj i//p,5-8 II
Mj m,7-16 II
Mjp w,3-9 II
FGr w,15-53 III
FGru r-w,12-48 III
Mh w,21-47 III
Ru r,1-15 I
Mpu m/i,1-6 I
FGr w-r,20-41 III
Mu w/m,6-37 III
Mb[Rpu] w-m,0-17 II
Mp i,1-4 I
Ov[Mp] v,0-1 I
Mp p,0-1 I
Mja w,21-50 III
Ovb[Mp] v,0-1 I
Ov[Mp] v,0-1 I
Obv[Mp] v,0-1 I
Mj w-m,8-26 II
Mp i,0-4 I

N
A
FGb[Mb] w,1-10 II
Op v,0-1 I
Obv[Mp] v,0-1 I
FGb[Mp] m,0-5 I
Mp m/i,0-2 I
FGu w,2-14 I
Ov[Mp] v,0-1 I
Mpu w,2-15 I
Mja w,14-43 II
Mpj w,2-15 I
Mp i/m,0-2 I
Mp m/i,0-1 I
Mpj w/m,0-15 I
Ov[Mp] v,0-1 I
Mpu w/m,0-6 I
FGbv[Mp] m-w,1-7 I
FGp r,1-5 I
FGja r-w,14-38 III
Mp w,1-4 I
Obv[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Mpj i/m,2-9 I
Mp m-i,0-4 I
Ovb[Mp] v,0-1 I
Mp i-p,0-2 I
Mpu w-m,1-10 I
FGr r,21-57 III
Mja w,5-45 III
Mpu w/m,1-5 I
Mp i-p,0-4 I
Obv[Mp] v,0-1 I
Mpj w/m,0-15 I
Obv[Mp] v,0-1 I
Ov[Mp] v,0-1 I
Fvb[Mp]-Obv[Mp]-MU p-v,0-1 I
Fvb[Mp]-Ov[Mp] p/v,0-7 I
Ovb[Mp] v,0-1 I
Mpu w//m,0-16 I
Obv[Mp] v,0-1 I
Mpu w//m,0-3 I
FGr w-r,17-33 III
FGur r-w,2-32 II
Muj w,5-14 II
Obv[Mp] v,0-1 I
FGur r-w,2-48 II
Ov[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Mp-W r,1-3 I
Obv[Mp] v,0-1 I
FGu i-m,0-6 I
Obv[Mp] v,0-1 I
Mp i,1-3 I
Mp-Ov[Mp] m-v,0-4 I
Mpj i/m,1-7 I
Mu w/m,1-10 II
Mp p,0-1 I
Mu w,0-15 I
Mju w,7-22 II
Obv[Mp] v,0-1 I
FGr w-m,25-43 III
Op v,0-1 I
Ovb[Mp] v,0-1 I
FGru r-w,3-27 III
Mp m/i,0-2 I
Mp i/p,0-3 I
Mp w,0-5 I
Mp i/p,0-1 I
Ov[Mp] v,0-1 I
Mp-L i/p,0-4 I
Mpj m,2-7 I
Mp p//,0-1 I
Mu w,0-20 II
Ov[Mp] v,0-1 I
FGu w,1-24 I
Ov[Mp] v,0-1 I
Mp i,1-4 I
Mp m/i,0-3 I
Mp i/p,0-2 I
Mpu w/m,1-10 I
Mpj w,1-7 I
Mp i,0-1 I
Mj i,3-15 II
Mj m,9-18 II
Mp w/m,0-2 I
Mpj w/m,3-8 II
Ov[Mp] v,0-1 I
Mp-N p,0-5 I
Mpu w/m,1-10 I
Obv[Mp] v/p,0-1 I
Mp m/i,3-5 I
Obv[Mp] v,0-1 I
Mp m-i,1-3 I
Mp-L i/p,1-6 II
Mu w,7-18 I
Mp i,0-2 I
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Mp i,0-2 I
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Mp-Ov[Mp] p/v,0-1 I
FGpu w,2-16 II
Mu m,3-18 II
Mb[Rpu] w-m,0-17 II
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Mp i,0-2 I
Ov[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Mp i,1-2 I
Obv[Mp] v,0-1 I
Obv[Mp] v,0-1 I
FGhu w-r,1-38 II
Mj w-m,8-20 II
Mp i-p,0-1 I
Obv[Mp] v,0-1 I
FGhu w,3-36 III
FGb[Mpu] w,2-16 I
Obv[Mb] v,0-1 I
Mp m,1-3 I
Mpu w,2-15 II
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Mpj w//m,0-8 I
Mp i,0-2 I
Mpu w/m,2-18 I
Mp i-p,0-2 I
Obv[Mp] v,0-1 I
Ob[Mp] v,0-1 I
Mp i-p,1-5 I
Ovb[Mp] v,0-1 I
FGru r-w,4-38 II
Mp i,0-1 I
FV[Mp]-MU i-p,1-3 I
Mp m,1-3 I
Mp i//p,1-5 I
Ov[Mp] v,0-1 I
Mpu m-i,0-5 I
Obv[Mp] v,0-1 I
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Ovb[Mp] v,0-3 I
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Mp m/i,1-5 I
FGr w//m,4-20 II
Mu i,3-9 II
Muh w/m,3-42 II
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Mp i-p,0-5 I
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Ob[Mp] v,0-1 I
Mh w,9-24 II
Op v,0-1 I
Ov[Mp] v,0-1 I
Mjp w/m,3-10 II
Mp i//p,0-2 I
Mp w/m,1-4 I
Obv[Mp] v,0-1 I
Mpu w//m,1-7 I
Mjp-L m-i,0-6 I
Obv[Mp] v,0-1 I
Mp i,0-2 I
Mp i,3-5 I
Mp i,4-8 II
Mp i,0-2 I
Mp i-p,0-2 I
Mp i-p,0-1 I
Mu w//m,0-10 II
Mp i,0-2 I
Ov[Mp] v,0-1 I
Obv[Mp] v,0-1 I
FGhu w-r,1-38 II
Mp i-p,0-1 I
Obv[Mp] v,0-1 I
FGb[Mpu] w,2-16 I
N
Mpu w,2-15 II
Obv[Mp] v,0-1 I
Mp i,0-2 I
Mpu w/m,2-18 I
Mp i-p,0-2 I
Obv[Mp] v,0-1 I
Ob[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
Mp i/p,1-5 I
FGru r-w,4-38 II
Ov[Mp] v,0-1 I
Mpu m-i,0-5 I
Mj m-w,14-26 III
Mp p,1-5 I
Mu w/m,3-32 II
Mp i,0-3 I
Obv[Mp] v,0-2 I
Mu i,3-9 II
Muh w/m,3-42 II
FGr w//m,4-20 II
Mh w,9-24 II
Ob[Mp] v,0-1 I
Op v,0-1 I
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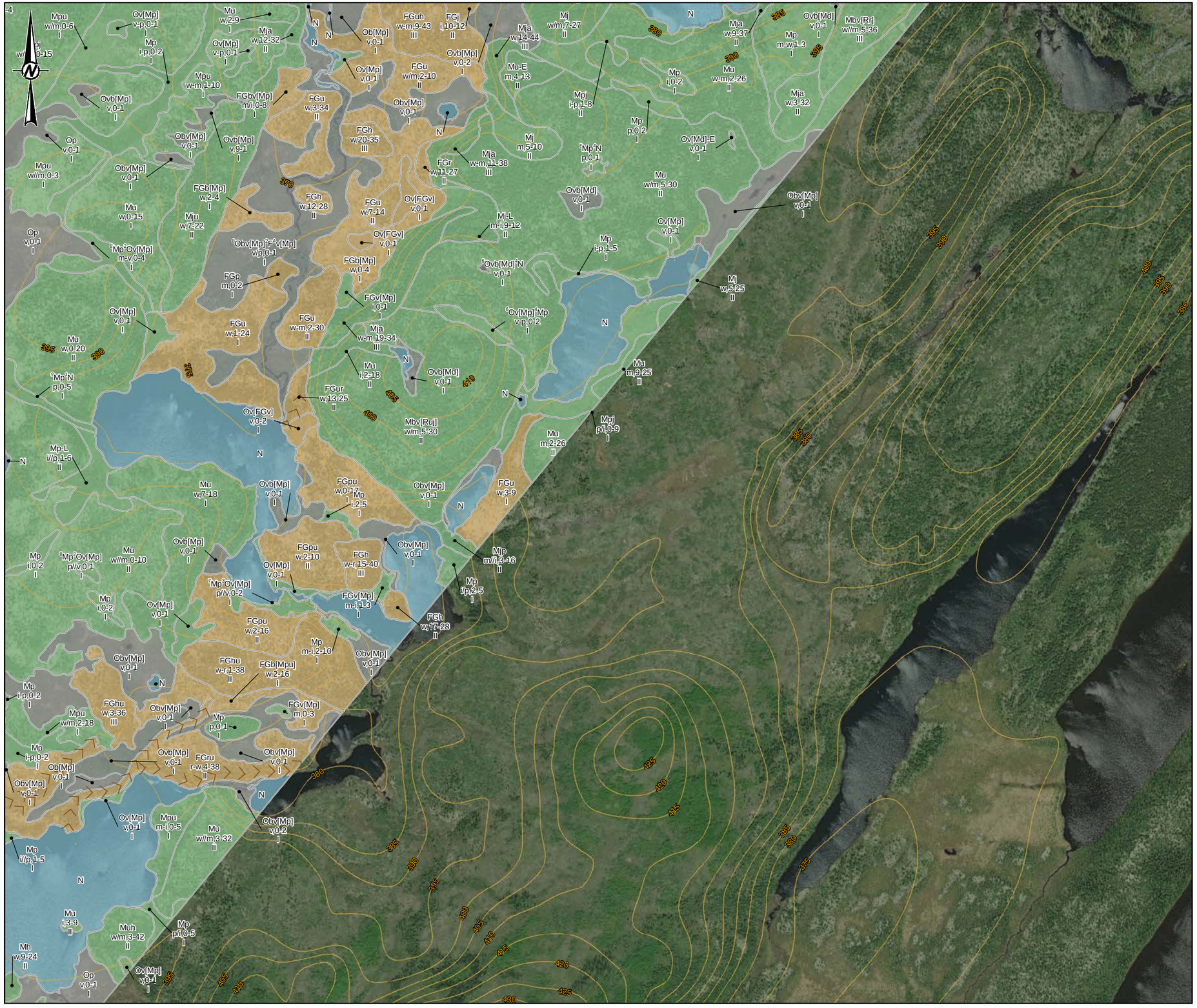


LEGEND

CONTOUR (5 m INTERVAL)

TERRAIN POLYGON BOUNDARY (APPROXIMATE)

SITE SYMBOLOGY

ESKER

DOMINANT SURFICIAL MATERIAL

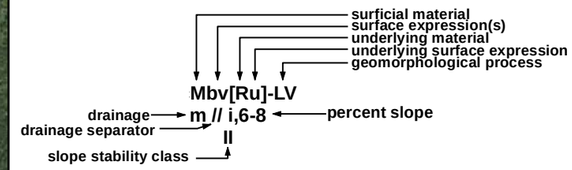
GLACIOFLUVIAL (FG)

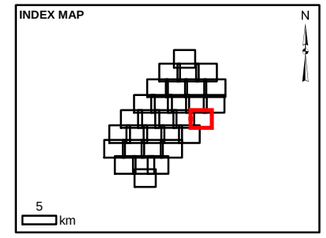
MORAINAL (TILL)(M)

WATERBODY (N)

ORGANIC (O)

Terrain Polygon Label





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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	20

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© THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
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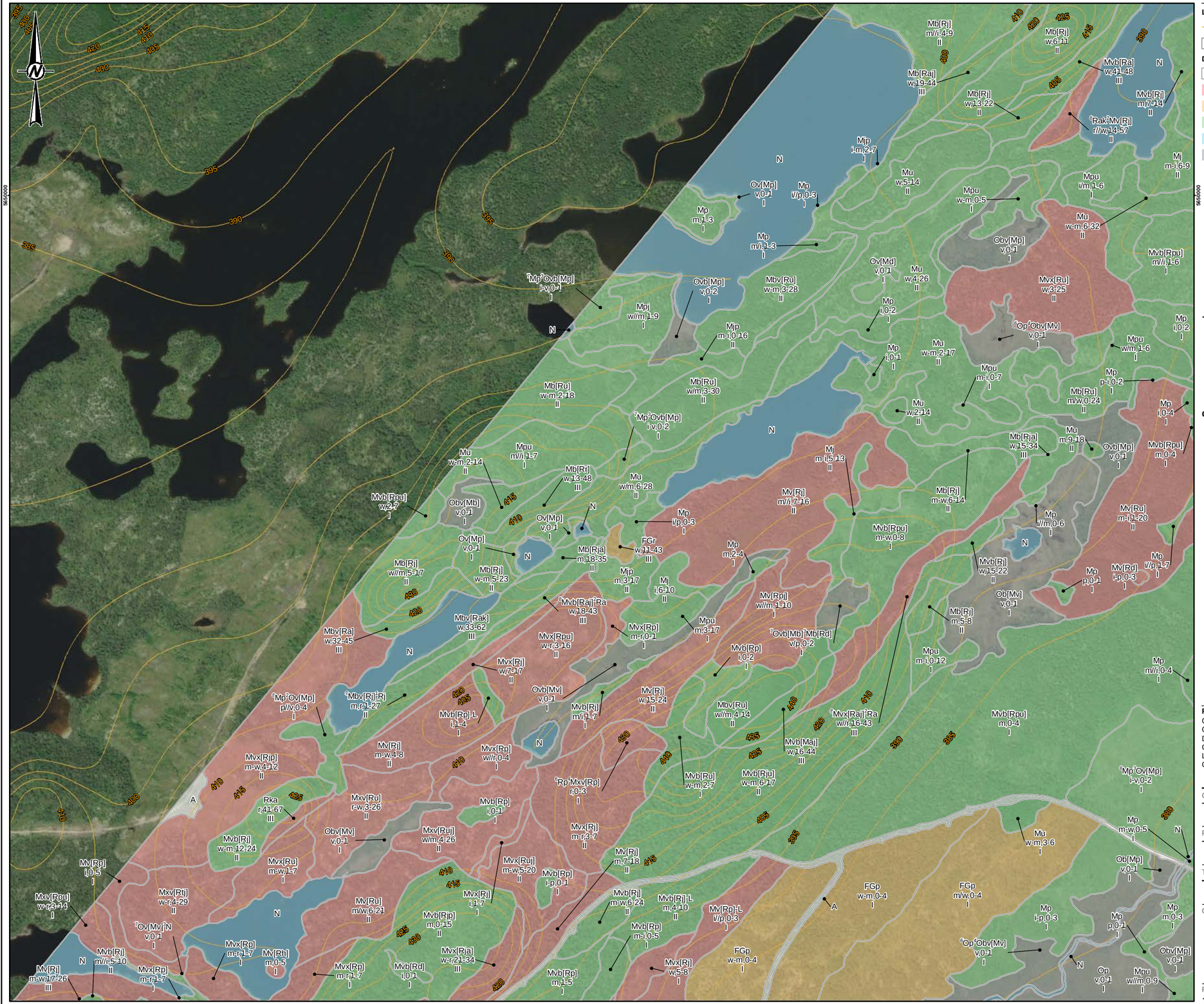


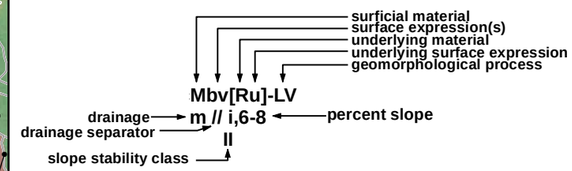
LEGEND

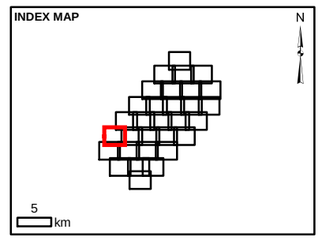
- CONTOUR (5 m INTERVAL)
- TERRAIN POLYGON BOUNDARY (APPROXIMATE)

DOMINANT SURFICIAL MATERIAL

- ANTHROPOGENIC (A)
- BEDROCK (R)
- GLACIOFLUVIAL (FG)
- MORAINAL (TILL)(M)
- WATERBODY (N)
- ORGANIC (O)

Terrain Polygon Label





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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	21

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
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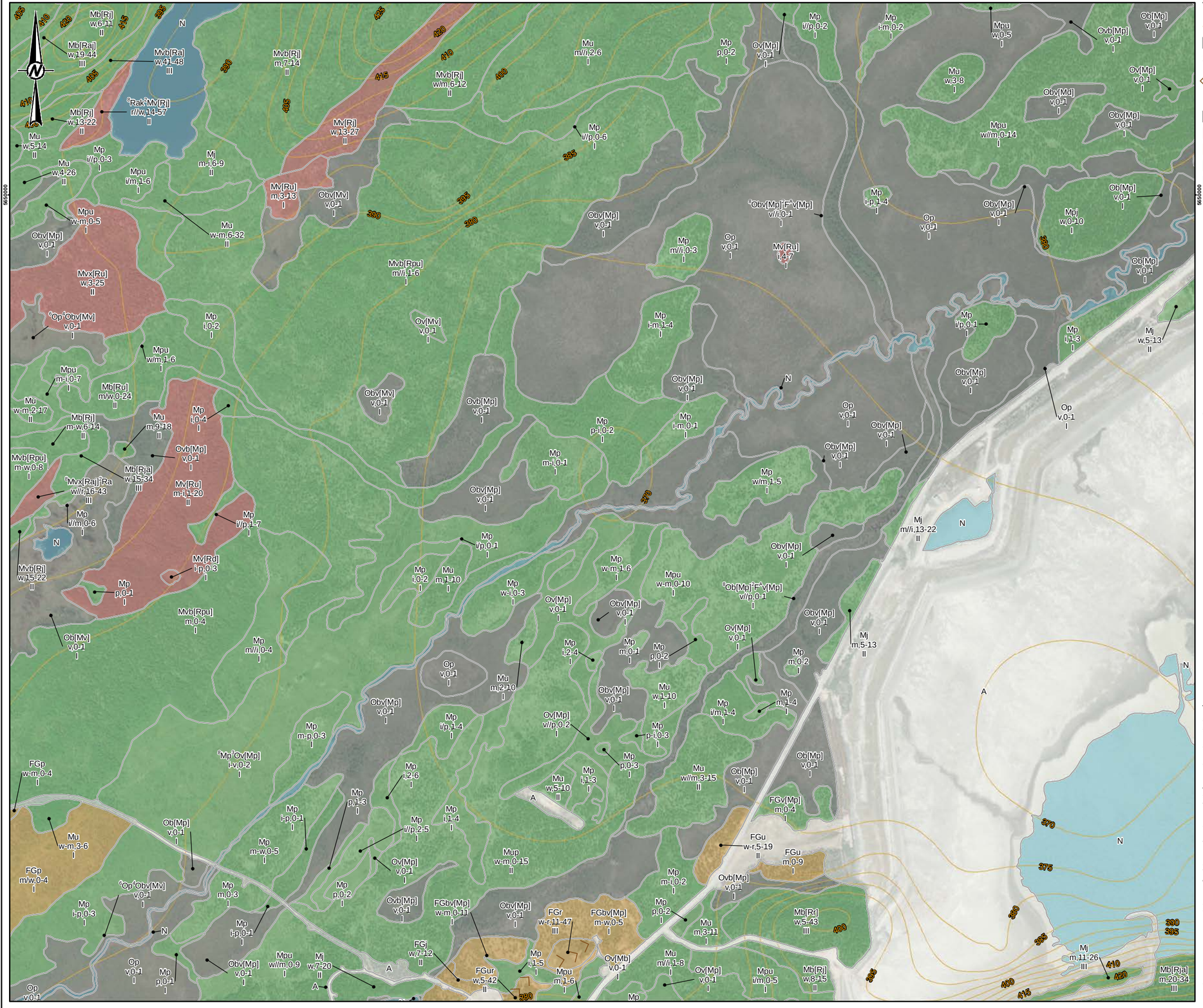
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Mu w,5-14 II
Mu w,4-26 II
Mp i//p,0-3 I
Mpu i'm,1-6 I
Mpu w-m,0-5 I
Obv[Mp] v,0-1 I
Mu w-m,6-32 II
Mvx[Ru] w,3-25 II
°Op⁴Obv[Mv] v,0-1 I
Mpu w/m,1-6 I
Mpu m-i,0-7 I
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Mu w-m,2-17 II
Mb[Rj] m-w,6-14 II
Mu m,9-18 II
Mvb[Rpu] m-w,0-8 I
Mb[Rja] w,15-34 III
°Mvx[Raj²Ra w//r,16-43 III
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Mp i'/p,1-7 I
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Mvb[Rpu] m,0-4 I
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Mvb[Rj] w,15-22 II
Mvb[Rj] m,7-14 II
Mv[Rj] w,13-27 II
Mv[Ru] m,3-13 I
Obv[Mv] v,0-1 I
Mj m-i,6-9 II
Mvb[Rj] w/m,6-12 II
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Mp i//p,0-6 I
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Mp i,0-2 I
Mp i,0-4 I
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Mu w,3-8 I
Mpu w//m,0-14 I
Mpu w,0-5 I
Ovb[Mp] v,0-1 I
Obv[Md] v,0-1 I
Obv[Mp] v,0-1 I
Ob[Mp] v,0-1 I
Mp i-p,1-4 I
°Obv[Mp]²F^v[Mp] v//i,0-1 I
Op v,0-1 I
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Mu w,1-10 I
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Obv[Mp] v,0-1 I
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FGbv[Mp] m-w,0-5 I
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Mpu m,1-6 I
Mp w-m,1-6 I
Mpu w-m,0-10 I
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Obv[Mp] v,0-1 I
Obv[Mp] v,0-1 I
Mj m,5-13 II
Mp m,0-2 I
Mp i'/m,1-4 I
Ob[Mp] v,0-1 I
Mu w//m,3-15 II
FGv[Mp] m,0-4 I
FGu w-r,5-19 II
FGu m,0-9 I
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Mp p,0-2 I
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Mu m/i,1-8 I
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Mb[Rja] m,20-34 III
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FGv[Mp] m,0-4 I
Mp i'/p,0-1 I
Mp i,1-3 I
Mj w,5-13 II
Obv[Mp] v,0-1 I
Op v,0-1 I
Ovb[Mp] v,0-1 I
Mp m-i,0-2 I
Mp p,0-2 I
Mu m,3-11 I
Mb[Rj] w,5-43 III
Mj m,11-26 III
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Mj m,5-13 II
Mp m,0-2 I
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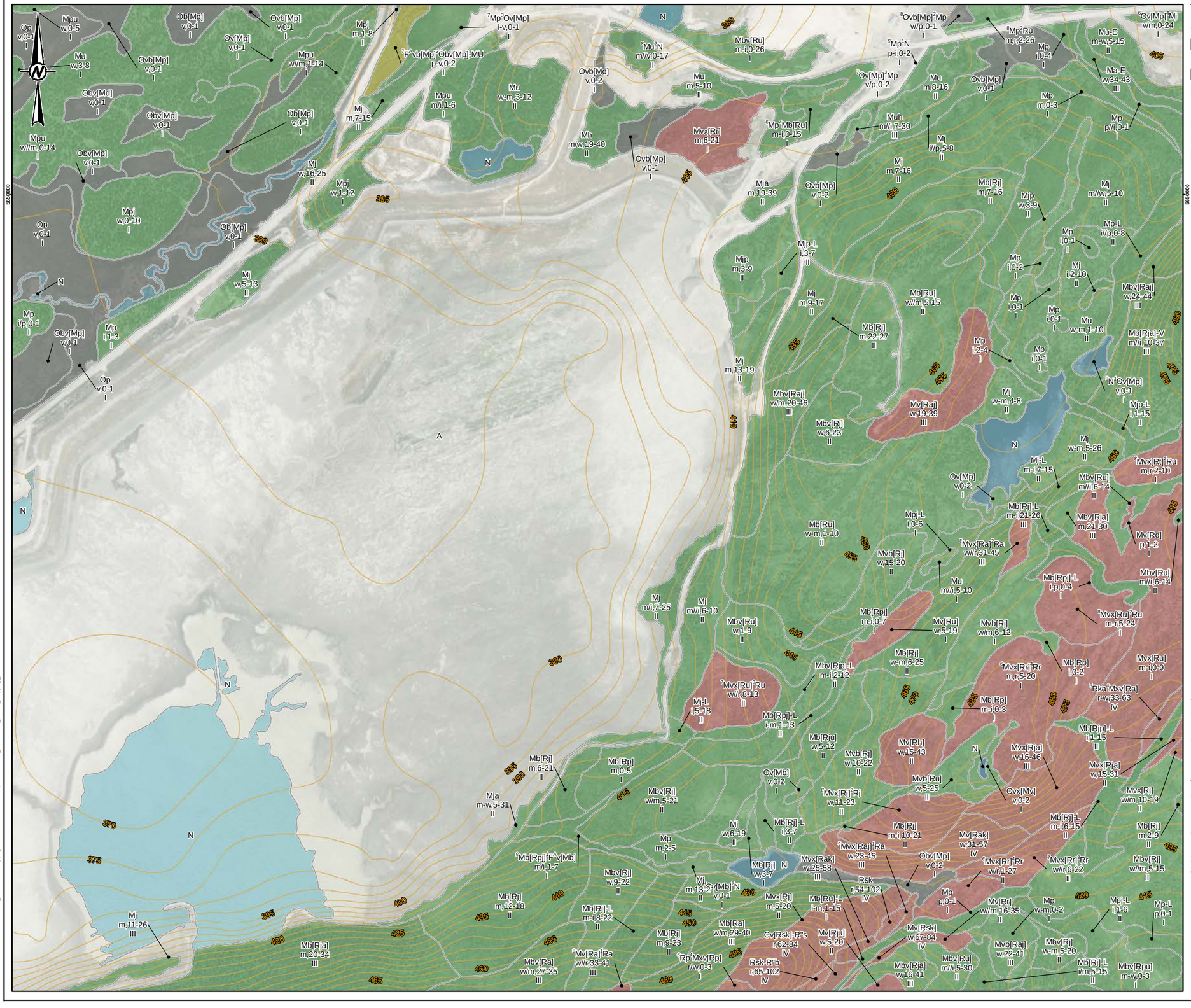
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Mj m,7-15 II
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Mjp-L i,1-15 II
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Cv[Rsk]-R's r,62-84 IV
Rsk-R'b r,65-102 IV
Mv[Rsk] w,67-84 IV
Mv[Rr] w//m,16-35 II
Mp w-m,0-2 I
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Mbv[Rj] w-m,5-20 II
Mbv[Rj]-L i/m,5-15 II
Mbv[Rpu] m-w,0-3 I
Mbv[Rja] w,16-41 III
Mbv[Ru] m//i,5-30 II
Mpj-L i,1-6 II
Mp-L p,0-1 I
Mv[Rpj] m-w,0-3 I
Mv[Rj] w-m,5-20 II
Mvx[Rj]-Ru m-r,5-24 I
Mvx[Rj]-Rr m,r,5-20 I
Mvx[Ru] m-i,0-9 I
Mvx[Ru]-Ru w//r,8-13 II
Mvx[Rj]-Ra w//r,31-45 III
Mvx[Rj]-Ru m,r,2-10 I
Mvx[Ru]-Ru m,r,2-26 I
Mvx[Rj]-Ra w//r,33-41 III
Rka-Mvx[Ra] r-w,33-63 IV
Mvx[Rj]-Rr w/r,2-10 I
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Mvb[Rj] w,16-41 III
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Mvb[Rj] w,5-12 II
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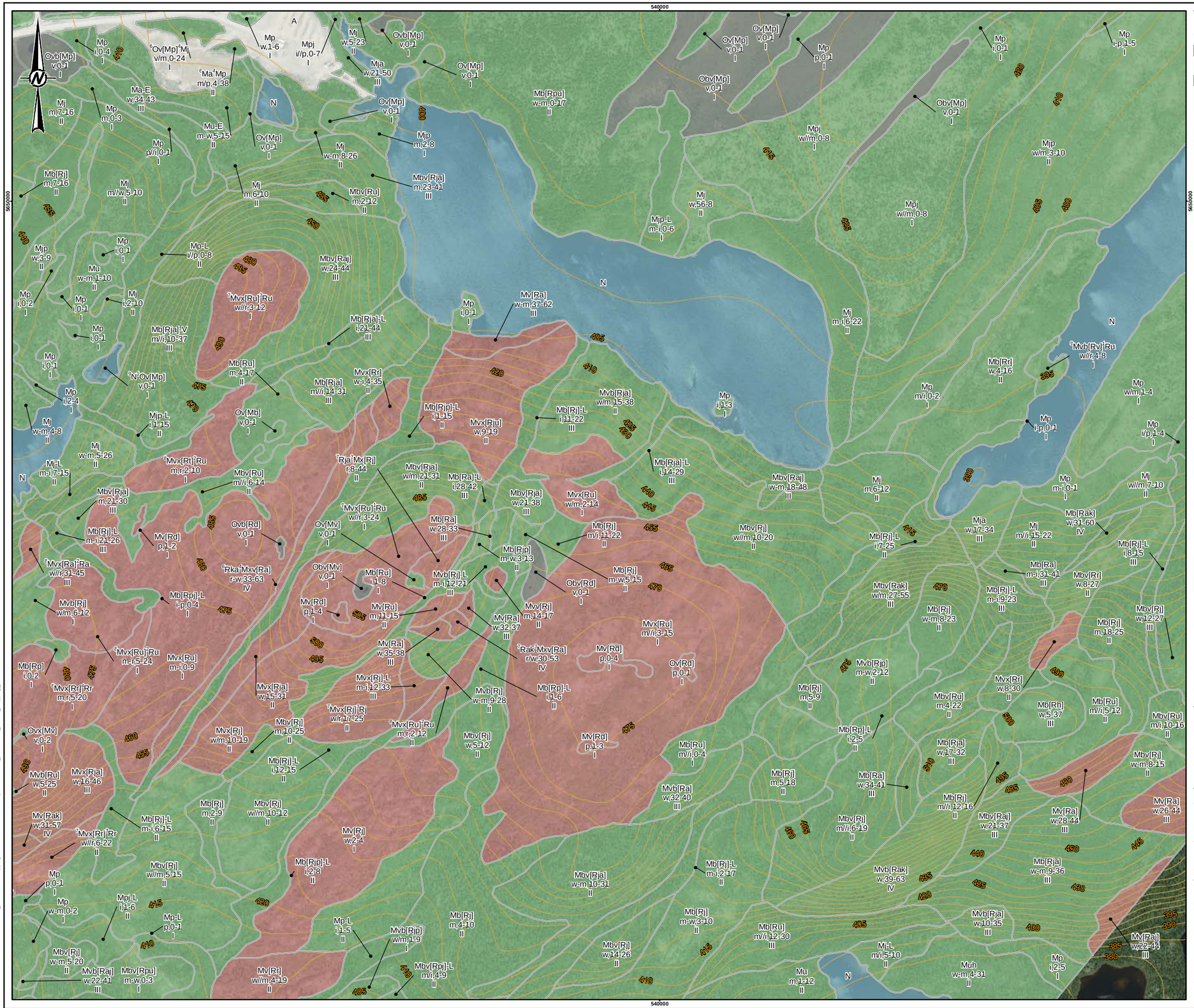


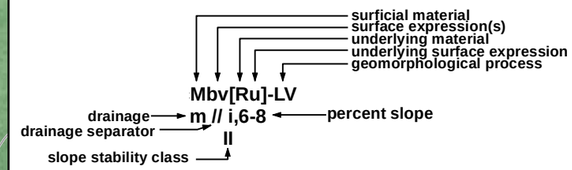
LEGEND

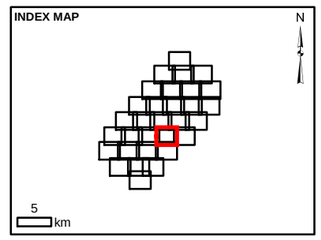
- CONTOUR (5 m INTERVAL)
- TERRAIN POLYGON BOUNDARY (APPROXIMATE)

DOMINANT SURFICIAL MATERIAL

- ANTHROPOGENIC (A)
- BEDROCK (R)
- MORAINAL (TILL)(M)
- WATERBODY (N)
- ORGANIC (O)

Terrain Polygon Label





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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	24

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

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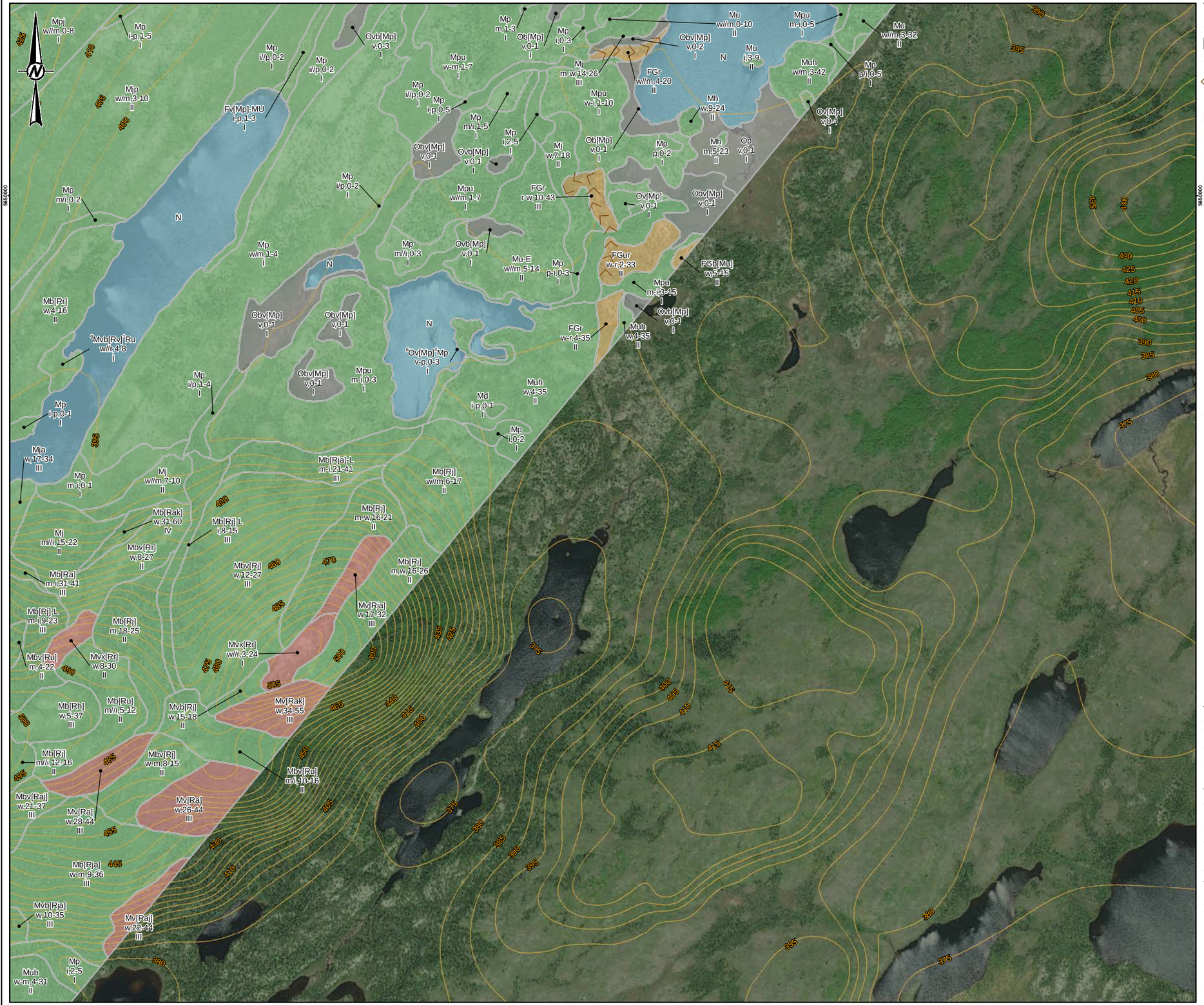


LEGEND

- CONTOUR (5 m INTERVAL)
- TERRAIN POLYGON BOUNDARY (APPROXIMATE)

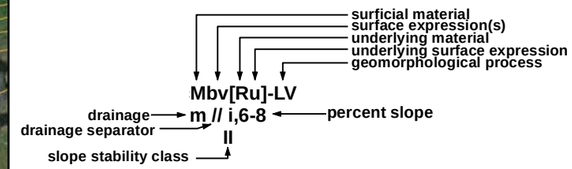
SITE SYMBOLOGY

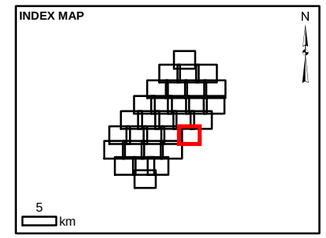
- ESKER

DOMINANT SURFICIAL MATERIAL

- BEDROCK (R)
- GLACIOFLUVIAL (FG)
- MORAINAL (TILL)(M)
- WATERBODY (N)
- ORGANIC (O)

Terrain Polygon Label





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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	25

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
25mm
0

530000

LEGEND

CONTOUR (5 m INTERVAL)

TERRAIN POLYGON BOUNDARY (APPROXIMATE)

SITE SYMBOLOGY

ESKER

DOMINANT SURFICIAL MATERIAL

ANTHROPOGENIC (A)

BEDROCK (R)

GLACIOFLUVIAL (FG)

MORAINAL (TILL)(M)

WATERBODY (N)

ORGANIC (O)

Terrain Polygon Label

surficial material
surface expression(s)
underlying material
underlying surface expression
geomorphological process

Mbv[Ru]-LV

drainage → m // i,6-8 ← percent slope

drainage separator → II

slope stability class →

INDEX MAP

N

5 km

0 250 500

1:10,000 METRES

REFERENCE(S)

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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

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TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	26

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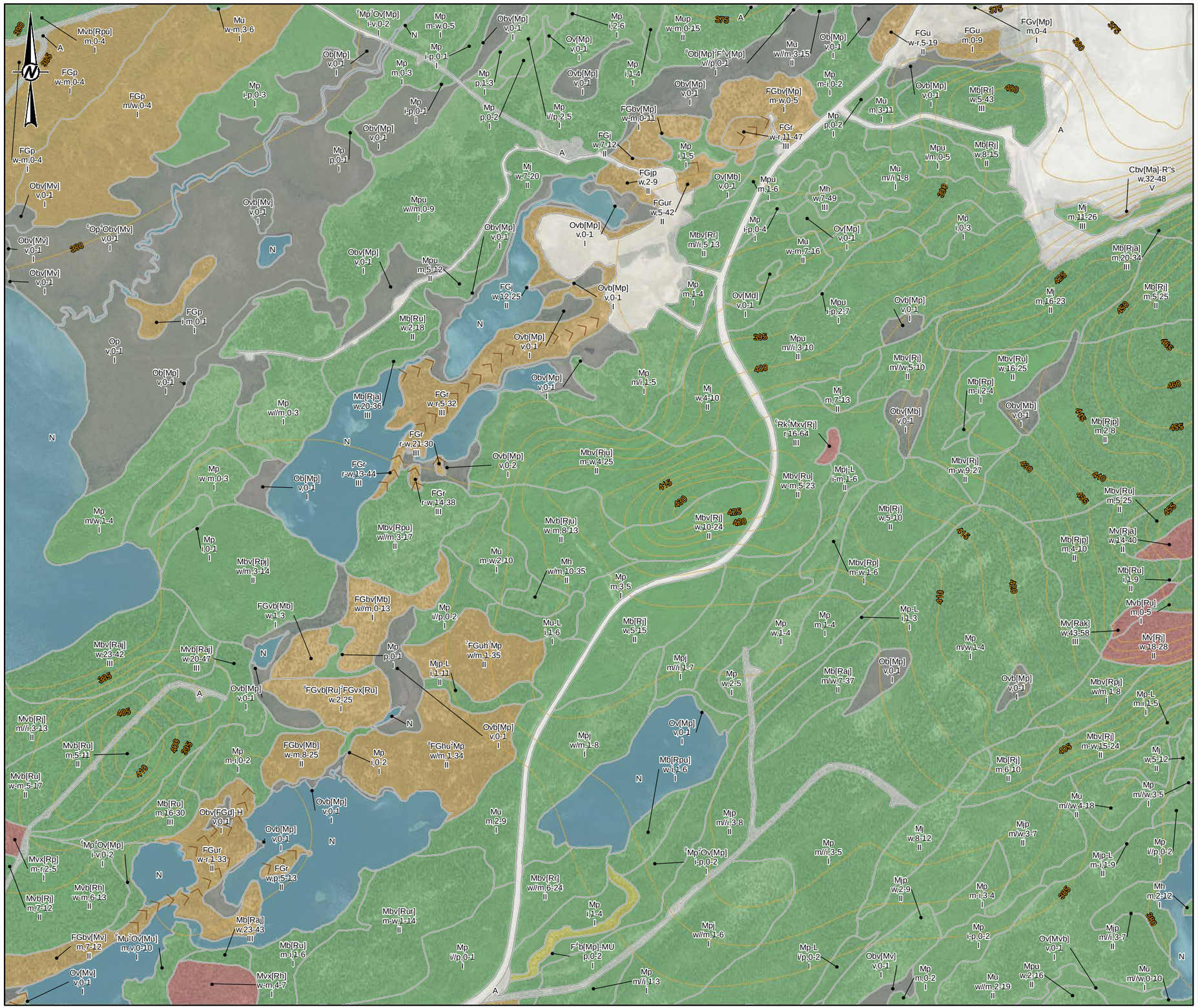
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Mp i,1-4 I
Mup w-m,0-15 II
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Ob[Mp] v,0-1 I
FGu w-r,5-19 II
FGu m,0-9 I
FGv[Mp] m,0-4 I
FGp w-m,0-4 I
FGp m/w,0-4 I
Mp i-p,0-3 I
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Mp i-p,0-1 I
Mp p,1-3 I
Mp p,0-2 I
Mp i//p,2-5 I
Obv[Mp] v,0-1 I
Ovb[Mp] v,0-1 I
FGbv[Mp] m-w,0-5 I
Mp m-i,0-2 I
Ovb[Mp] v,0-1 I
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Mu m,3-11 I
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Mj w,7-20 II
FGjp w,2-9 II
FGur w,5-42 II
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Mb[Rj] w,8-15 II
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Mp m-i,0-2 I
FGbv[Mb] w-m,8-25 II
Mp i,0-2 I
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Mpj w/m,1-8 I
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Mb[Rpu] w,1-6 I
Mvb[Rj] m//i,3-13 II
Mvb[Raj] w,23-42 III
Mvb[Raj] w,20-47 III
FGuh Mp w/m,1-35 II
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Mpj-L i,1-11 II
Ovb[Mp] v,0-1 I
FGvb[Ru] FGvx[Ru] w,2-25 I
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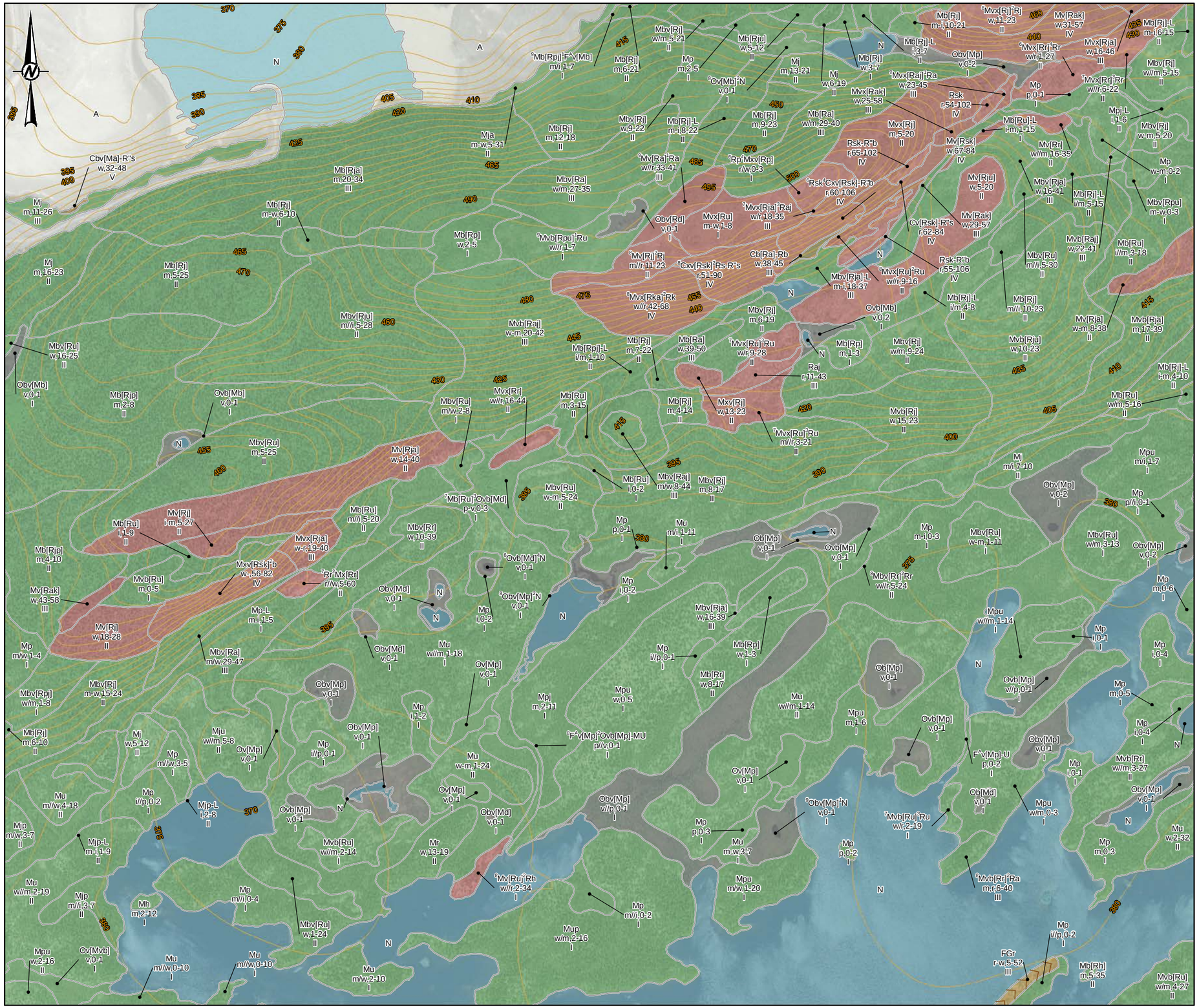
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Mbv[Ru] m,5-25 II
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Mb[Ru] i,1-9 II
Mb[Rjp] m,4-10 II
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Mjp-L m-i,1-9 II
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Mp i,0-2 I
Mp i,0-2 I

540000

540000

LEGEND

CONTOUR (5 m INTERVAL)

TERRAIN POLYGON BOUNDARY (APPROXIMATE)

SITE SYMBOLOGY

ESKER

DOMINANT SURFICIAL MATERIAL

BEDROCK (R)

FLUVIAL (F)

GLACIOFLUVIAL (FG)

MORAINAL (TILL)(M)

WATERBODY (N)

ORGANIC (O)

Terrain Polygon Label

surficial material
surface expression(s)
underlying material
underlying surface expression
geomorphological process

Mbv[Ru]-LV

drainage → m // i,6-8 ← percent slope
drainage separator → II
slope stability class →

INDEX MAP

N

5 km

0 250 500

1:10,000 METRES

REFERENCE(S)

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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT

GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	29

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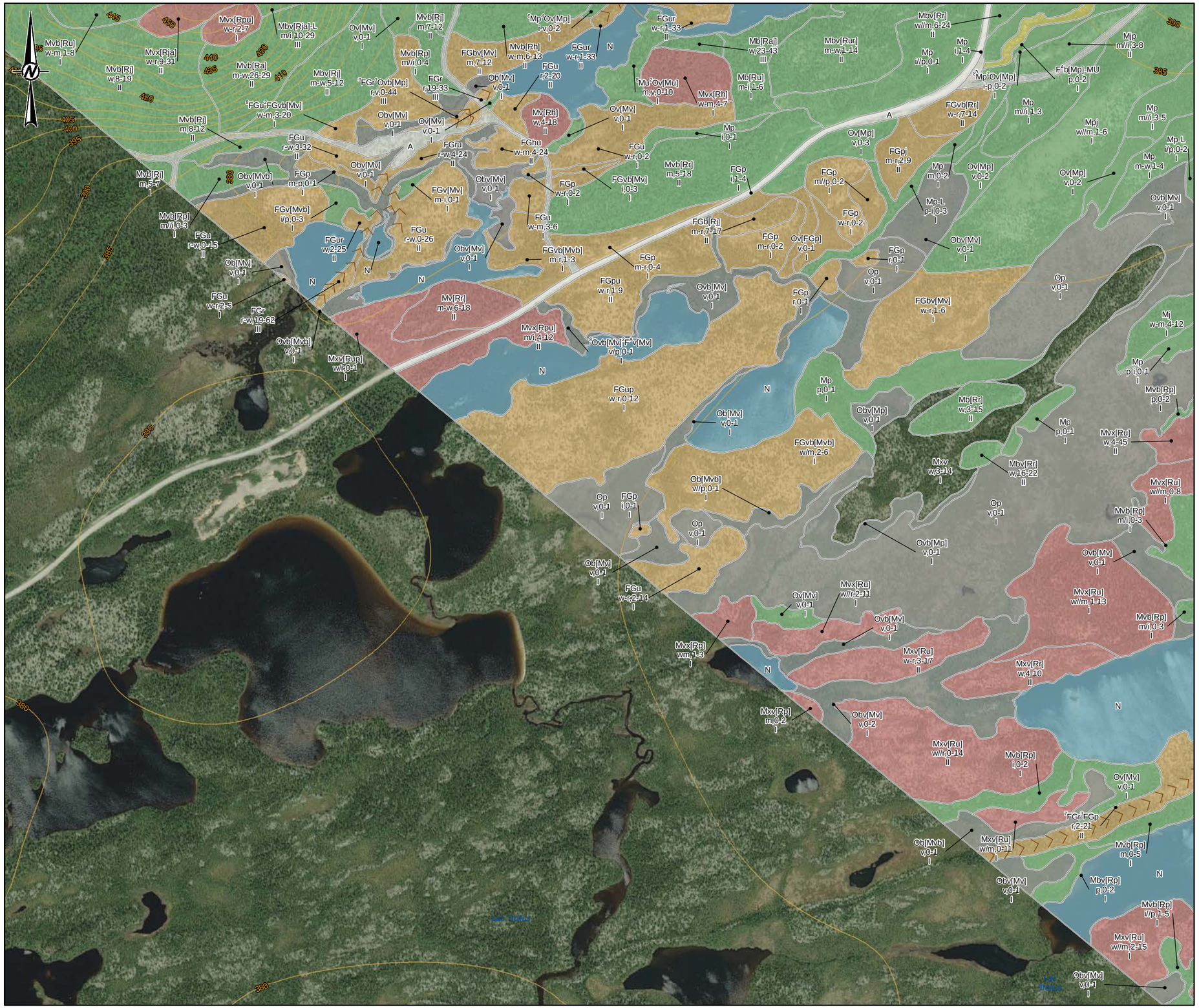
© THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0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Mvb[Rj] w,8-19 II
Mvb[Ra] m-w,26-29 II
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Ov[Mv] v,0-1 I
Mvb[Rj] m,7-12 II
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Ov[Mv] v,0-1 I
Mvb[Rj] m,8-12 II
FGu r-w,3-32 II
FGu r-w,0-15 II
Mvb[Rp] m/i,0-3 I
Obv[Mvb] v,0-1 I
FGp m-p,0-1 I
FGv[Mv] m-i,0-1 I
FGv[Mvb] r/p,0-3 I
Ob[Mv] v,0-1 I
FGu r-w,2-5 I
FGr r-w,19-62 III
Ovb[Mvb] v,0-1 I
Mxv[Rup] w/r,0-1 I
FGu r-w,4-24 II
FGur w,2-25 II
FGu r-w,0-26 II
Obv[Mv] v,0-1 I
FGu w-m,3-6 I
FGvb[Mvb] m-r,1-3 I
FGp m-r,0-4 I
FGpu w-r,1-9 II
Mv[Rf] m-w,6-18 II
Mvx[Rpu] m/i,4-12 II
Ovb[Mv] f-v[Mv] v/p,0-1 I
FGup w-r,0-12 I
Ob[Mv] v,0-1 I
Op v,0-1 I
FGp i,0-1 I
Ob[Mv] v,0-1 I
FCu w-r,2-14 I
Mvx[Rp] w/m,1-3 I
Mp[2]Ov[Mp] i-v,0-2 I
Mvb[Rh] w-m,6-13 II
FGur w-r,1-33 II
FGu r,2-20 II
Ob[Mv] v,0-1 I
FGr[2]Ovb[Mp] r,v,0-44 III
FGu[2]FGvb[Mv] w-m,3-20 I
Mv[Rh] w,4-18 II
FGhu w-m,4-24 II
Ov[Mv] v,0-1 I
FGu w-r,0-2 I
FGp w-r,0-2 I
FGvb[Mv] i,0-3 I
FGur w-r,1-33 II
Mu[2]Ov[Mu] m,v,0-10 I
Mvx[Rh] w-m,4-7 I
Mb[Ru] m-i,1-6 I
Mb[Raj] w,23-43 III
Mbv[Rur] m-w,1-14 II
FGCr[2]Ovb[Mp] r,v,0-44 III
Mbv[Rf] w//m,6-24 II
Mp i,1-4 I
Mp i//p,0-1 I
Mp[2]Ov[Mp] i-p,0-2 I
F[2]b[Mp]-MU p,0-2 I
Mp m/i,1-3 I
FGvb[Rr] w-r,7-14 II
Ov[Mp] v,0-3 I
FGpj m-r,2-9 II
Mp m/i,3-8 II
Mp m/i,3-5 I
Mpj w//m,1-6 I
Mp-L i/p,0-2 I
Mp m-w,1-4 I
Ov[Mp] v,0-2 I
Ovb[Mv] v,0-1 I
Mp-L p-i,0-3 I
Ov[Mp] v,0-2 I
FGp m//p,0-2 I
FGp w-r,0-2 I
Mp m/i,0-2 I
Ov[Mv] v,0-1 I
FGb[Rj] m-r,7-17 II
FGp m-r,0-2 I
Ov[FGp] v,0-1 I
FGp r,0-1 I
Op v,0-1 I
Obv[Mv] v,0-1 I
FGbv[Mv] w-r,1-6 I
Op v,0-1 I
Mj w-m,4-12 I
Mp p-i,0-1 I
Mvb[Rp] p,0-2 I
Mb[Rf] w,3-15 II
Mp p,0-1 I
Mvx[Ru] w,4-45 II
Mvx[Ru] w//m,0-8 I
Mvb[Rp] m/i,0-3 I
Mp p,0-1 I
Obv[Mp] v,0-1 I
FGvb[Mvb] w/m,2-6 I
Mxv w,3-14 I
Mbv[Rf] w,16-22 II
Ob[Mvb] v//p,0-1 I
Op v,0-1 I
FGp i,0-1 I
Op v,0-1 I
Ovb[Mp] v,0-1 I
Op v,0-1 I
Ob[Mv] v,0-1 I
Ov[Mv] v,0-1 I
Mvx[Ru] w//r,2-11 I
Ovb[Mv] v,0-1 I
Mvx[Ru] w-r,3-17 II
Mvx[Ru] w//m,1-13 I
Ovb[Mv] v,0-1 I
Mvb[Rp] m/i,0-3 I
Mxv[Rf] w,4-10 II
Mvx[Rp] m,0-2 I
Obv[Mv] v,0-2 I
Mvx[Ru] w//r,0-14 II
Mvb[Rp] i,0-2 I
Ov[Mv] v,0-1 I
FGr[2]FGp r,2-21 II
Ob[Mvb] v,0-1 I
Mxv[Ru] w/m,0-11 I
Mvb[Rp] m,0-5 I
Mbv[Rp] p,0-2 I
Obv[Mv] v,0-1 I
Mvb[Rp] i//p,1-5 I
Mxv[Ru] w//m,2-15 I
Obv[Mv] v,0-1 I
Mvb[Rj] m,5-7 I
Mvb[Rj] m,5-18 II
Mbv[Rj] m-w,5-12 II
Mvb[Rj] w-m,1-8 I
Mvx[Rja] w-r,9-31 II
Mvb[Rj] w,8-19 II
Mvb[Ra] m-w,26-29 II
Mbv[Rja]-L m/i,10-29 III
Mvx[Rpu] w-r,2-7 I
Mvb[Rj] m,7-12 II
FGbv[Mv] m,7-12 II
FGur w-r,1-33 II
FGu r,2-20 II
FGr r,19-33 III
Mv[Rh] w,4-18 II
Ov[Mv] v,0-1 I
FGu w-r,0-2 I
Mvb[Rj] m,5-18 II
FGp i,1-4 I
FGp w-r,0-2 I
FGvb[Mv] i,0-3 I
Mp i,0-1 I
Mb[Ru] m-i,1-6 I
Mvx[Rh] w-m,4-7 I
Mb[Raj] w,23-43 III
Mbv[Rur] m-w,1-14 II
Mp i//p,0-1 I
Mp[2]Ov[Mp] i-p,0-2 I
Mp m/i,1-4 I
F[2]b[Mp]-MU p,0-2 I
Mp m/i,1-3 I
FGvb[Rr] w-r,7-14 II
Mp m/i,3-5 I
Mpj w//m,1-6 I
Mp-L i/p,0-2 I
Mp m-w,1-4 I
Ov[Mp] v,0-2 I
Ovb[Mv] v,0-1 I
Ov[Mp] v,0-3 I
FGpj m-r,2-9 II
Mp m,0-2 I
Ov[Mp] v,0-2 I
FGp m//p,0-2 I
Mp-L p-i,0-3 I
FGp w-r,0-2 I
Ov[FGp] v,0-1 I
FGp r,0-1 I
Op v,0-1 I
Obv[Mv] v,0-1 I
Op v,0-1 I
Mj w-m,4-12 I
Mp p-i,0-1 I
Mvb[Rp] p,0-2 I
Mb[Rf] w,3-15 II
Mp p,0-1 I
Mvx[Ru] w,4-45 II
Mvx[Ru] w//m,0-8 I
Mvb[Rp] m/i,0-3 I
Mp p,0-1 I
Obv[Mp] v,0-1 I
FGvb[Mvb] w/m,2-6 I
Mxv w,3-14 I
Mbv[Rf] w,16-22 II
Ob[Mvb] v//p,0-1 I
Op v,0-1 I
FGp i,0-1 I
Op v,0-1 I
Ovb[Mp] v,0-1 I
Op v,0-1 I
Ob[Mv] v,0-1 I
Ov[Mv] v,0-1 I
Mvx[Ru] w//r,2-11 I
Ovb[Mv] v,0-1 I
Mvx[Ru] w-r,3-17 II
Mvx[Ru] w//m,1-13 I
Ovb[Mv] v,0-1 I
Mvb[Rp] m/i,0-3 I
Mxv[Rf] w,4-10 II
Mvx[Rp] m,0-2 I
Obv[Mv] v,0-2 I
Mvx[Ru] w//r,0-14 II
Mvb[Rp] i,0-2 I
Ov[Mv] v,0-1 I
FGr[2]FGp r,2-21 II
Ob[Mvb] v,0-1 I
Mxv[Ru] w/m,0-11 I
Mvb[Rp] m,0-5 I
Mbv[Rp] p,0-2 I
Obv[Mv] v,0-1 I
Mvb[Rp] i//p,1-5 I
Mxv[Ru] w//m,2-15 I
Obv[Mv] v,0-1 I
Mvb[Rj] m,5-7 I
Mvb[Rp] m/i,0-3 I
FGu r-w,0-15 II
Ob[Mv] v,0-1 I
FGu r-w,2-5 I
FGr r-w,19-62 III
Ovb[Mvb] v,0-1 I
Mxv[Rup] w/r,0-1 I
FGu r-w,4-24 II
FGur w,2-25 II
FGu r-w,0-26 II
Obv[Mv] v,0-1 I
FGu w-m,3-6 I
FGvb[Mvb] m-r,1-3 I
FGp m-r,0-4 I
FGpu w-r,1-9 II
Mv[Rf] m-w,6-18 II
Mvx[Rpu] m/i,4-12 II
Ovb[Mv] f-v[Mv] v/p,0-1 I
FGup w-r,0-12 I
Ob[Mv] v,0-1 I
Op v,0-1 I
FGp i,0-1 I
Ob[Mv] v,0-1 I
FCu w-r,2-14 I
Mvx[Rp] w/m,1-3 I
Mp[2]Ov[Mp] i-v,0-2 I
Mvb[Rh] w-m,6-13 II
FGur w-r,1-33 II
FGu r,2-20 II
Ob[Mv] v,0-1 I
FGr[2]Ovb[Mp] r,v,0-44 III
FGu[2]FGvb[Mv] w-m,3-20 I
Mv[Rh] w,4-18 II
FGhu w-m,4-24 II
Ov[Mv] v,0-1 I
FGu w-r,0-2 I
FGp w-r,0-2 I
FGvb[Mv] i,0-3 I
FGur w-r,1-33 II
Mu[2]Ov[Mu] m,v,0-10 I
Mvx[Rh] w-m,4-7 I
Mb[Ru] m-i,1-6 I
Mb[Raj] w,23-43 III
Mbv[Rur] m-w,1-14 II
Mbv[Rf] w//m,6-24 II
Mp i,1-4 I
Mp i//p,0-1 I
Mp[2]Ov[Mp] i-p,0-2 I
Mp m/i,1-4 I
F[2]b[Mp]-MU p,0-2 I
Mp m/i,1-3 I
FGvb[Rr] w-r,7-14 II
Mp m/i,3-5 I
Mpj w//m,1-6 I
Mp-L i/p,0-2 I
Mp m-w,1-4 I
Ov[Mp] v,0-2 I
Ovb[Mv] v,0-1 I
Ov[Mp] v,0-3 I
FGpj m-r,2-9 II
Mp m,0-2 I
Ov[Mp] v,0-2 I
FGp m//p,0-2 I
Mp-L p-i,0-3 I
FGp w-r,0-2 I
Ov[FGp] v,0-1 I
FGp r,0-1 I
Op v,0-1 I
Obv[Mv] v,0-1 I
Op v,0-1 I
Mj w-m,4-12 I
Mp p-i,0-1 I
Mvb[Rp] p,0-2 I
Mb[Rf] w,3-15 II
Mp p,0-1 I
Mvx[Ru] w,4-45 II
Mvx[Ru] w//m,0-8 I
Mvb[Rp] m/i,0-3 I
Mp p,0-1 I
Obv[Mp] v,0-1 I
FGvb[Mvb] w/m,2-6 I
Mxv w,3-14 I
Mbv[Rf] w,16-22 II
Ob[Mvb] v//p,0-1 I
Op v,0-1 I
FGp i,0-1 I
Op v,0-1 I
Ovb[Mp] v,0-1 I
Op v,0-1 I
Ob[Mv] v,0-1 I
Ov[Mv] v,0-1 I
Mvx[Ru] w//r,2-11 I
Ovb[Mv] v,0-1 I
Mvx[Ru] w-r,3-17 II
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Ovb[Mv] v,0-1 I
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Obv[Mv] v,0-2 I
Mvx[Ru] w//r,0-14 II
Mvb[Rp] i,0-2 I
Ov[Mv] v,0-1 I
FGr[2]FGp r,2-21 II
Ob[Mvb] v,0-1 I
Mxv[Ru] w/m,0-11 I
Mvb[Rp] m,0-5 I
Mbv[Rp] p,0-2 I
Obv[Mv] v,0-1 I
Mvb[Rp] i//p,1-5 I
Mxv[Ru] w//m,2-15 I
Obv[Mv] v,0-1 I
Mvb[Rj] m,5-7 I
Mvb[Rj] m,5-18 II
Mbv[Rj] m-w,5-12 II
Mvb[Rj] w-m,1-8 I
Mvx[Rja] w-r,9-31 II
Mvb[Rj] w,8-19 II
Mvb[Ra] m-w,26-29 II
Mbv[Rja]-L m/i,10-29 III
Mvx[Rpu] w-r,2-7 I
Mvb[Rj] m,7-12 II
FGbv[Mv] m,7-12 II
FGur w-r,1-33 II
FGu r,2-20 II
FGr r,19-33 III
Mv[Rh] w,4-18 II
Ov[Mv] v,0-1 I
FGu w-r,0-2 I
Mvb[Rj] m,5-18 II
FGp i,1-4 I
FGp w-r,0-2 I
FGvb[Mv] i,0-3 I
Mp i,0-1 I
Mb[Ru] m-i,1-6 I
Mvx[Rh] w-m,4-7 I
Mb[Raj] w,23-43 III
Mbv[Rur] m-w,1-14 II
Mbv[Rf] w//m,6-24 II
Mp i,1-4 I
Mp i//p,0-1 I
Mp[2]Ov[Mp] i-p,0-2 I
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F[2]b[Mp]-MU p,0-2 I
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FGvb[Rr] w-r,7-14 II
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Mpj w//m,1-6 I
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Mp m-w,1-4 I
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Ovb[Mv] v,0-1 I
Ov[Mp] v,0-3 I
FGpj m-r,2-9 II
Mp m,0-2 I
Ov[Mp] v,0-2 I
FGp m//p,0-2 I
Mp-L p-i,0-3 I
FGp w-r,0-2 I
Ov[FGp] v,0-1 I
FGp r,0-1 I
Op v,0-1 I
Obv[Mv] v,0-1 I
Op v,0-1 I
Mj w-m,4-12 I
Mp p-i,0-1 I
Mvb[Rp] p,0-2 I
Mb[Rf] w,3-15 II
Mp p,0-1 I
Mvx[Ru] w,4-45 II
Mvx[Ru] w//m,0-8 I
Mvb[Rp] m/i,0-3 I
Mp p,0-1 I
Obv[Mp] v,0-1 I
FGvb[Mvb] w/m,2-6 I
Mxv w,3-14 I
Mbv[Rf] w,16-22 II
Ob[Mvb] v//p,0-1 I
Op v,0-1 I
FGp i,0-1 I
Op v,0-1 I
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Op v,0-1 I
Ob[Mv] v,0-1 I
Ov[Mv] v,0-1 I
Mvx[Ru] w//r,2-11 I
Ovb[Mv] v,0-1 I
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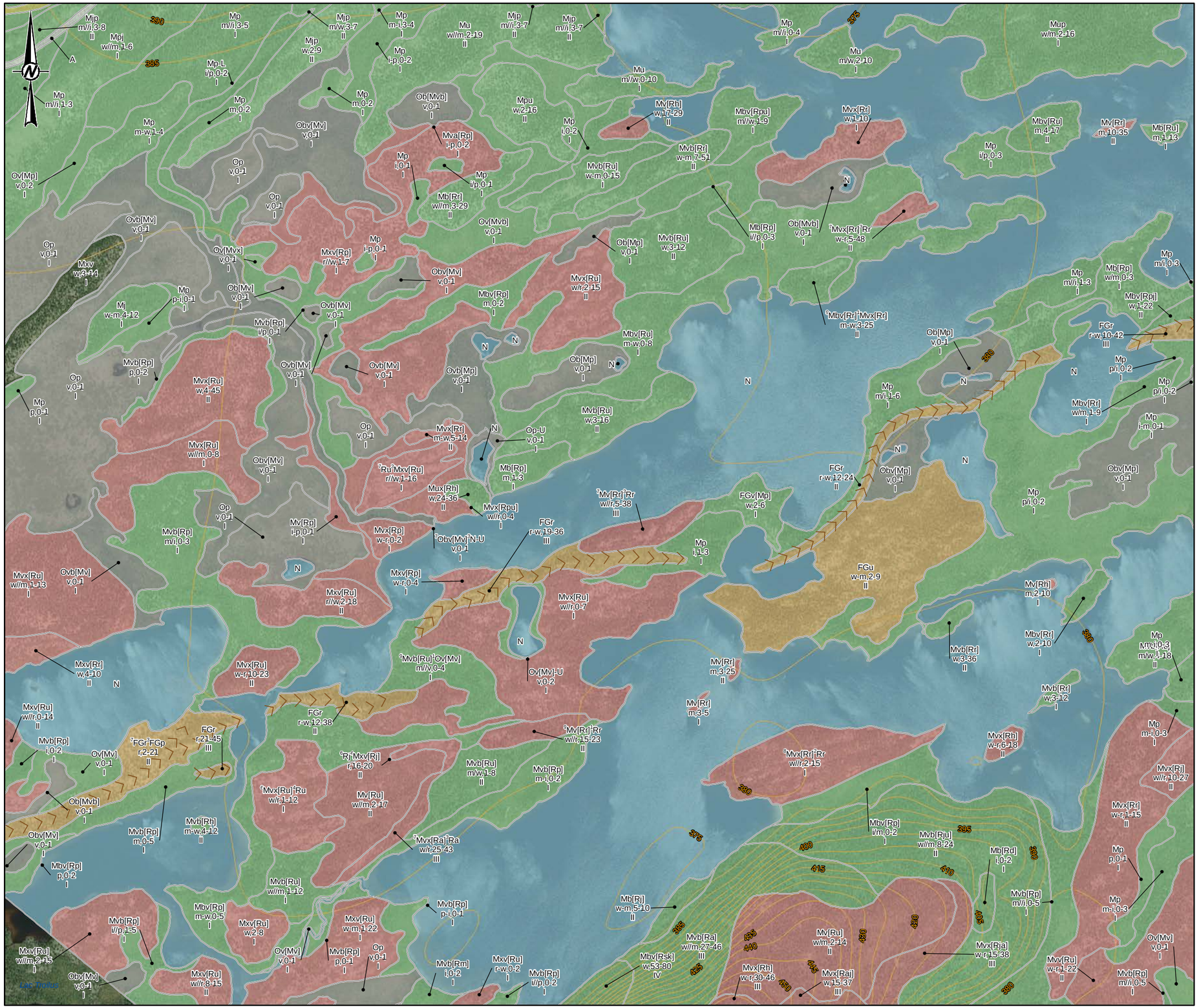
Mvx[Ru] w//m,1-13 I
Ovb[Mv] v,0-1 I
Mvb[Rp] m/i,0-3 I
Mxv[Rf] w,4-10 II
Mvx[Rp] m,0-2 I
Obv[Mv] v,0-2 I
Mvx[Ru] w//r,0-14 II
Mvb[Rp] i,0-2 I
Ov[Mv] v,0-1 I
FGr[2]FGp r,2-21 II
Ob[Mvb] v,0-1 I
Mxv[Ru] w/m,0-11 I
Mvb[Rp] m,0-5 I
Mbv[Rp] p,0-2 I
Obv[Mv] v,0-1 I
Mvb[Rp] i//p,1-5 I
Mxv[Ru] w//m,2-15 I
Obv[Mv] v,0-1 I
Mvb[Rj] m,5-7 I
Mvb[Rp] m/i,0-3 I
FGu r-w,0-15 II
Ob[Mv] v,0-1 I
FGu r-w,2-5 I
FGr r-w,19-62 III
Ovb[Mvb] v,0-1 I
Mxv[Rup] w/r,0-1 I
FGu r-w,4-24 II
FGur w,2-25 II
FGu r-w,0-26 II
Obv[Mv] v,0-1 I
FGu w-m,3-6 I
FGvb[Mvb] m-r,1-3 I
FGp m-r,0-4 I
FGpu w-r,1-9 II
Mv[Rf] m-w,6-18 II
Mvx[Rpu] m/i,4-12 II
Ovb[Mv] f-v[Mv] v/p,0-1 I
FGup w-r,0-12 I
Ob[Mv] v,0-1 I
Op v,0-1 I
FGp i,0-1 I
Ob[Mv] v,0-1 I
FCu w-r,2-14 I
Mvx[Rp] w/m,1-3 I
Mp[2]Ov[Mp] i-v,0-2 I
Mvb[Rh] w-m,6-13 II
FGur w-r,1-33 II
FGu r,2-20 II
Ob[Mv] v,0-1 I
FGr[2]Ovb[Mp] r,v,0-44 III
FGu[2]FGvb[Mv] w-m,3-20 I
Mv[Rh] w,4-18 II
FGhu w-m,4-24 II
Ov[Mv] v,0-1 I
FGu w-r,0-2 I
FGp w-r,0-2 I
FGvb[Mv] i,0-3 I
FGur w-r,1-33 II
Mu[2]Ov[Mu] m,v,0-10 I
Mvx[Rh] w-m,4-7 I
Mb[Ru] m-i,1-6



LEGEND

CONTOUR (5 m INTERVAL)

TERRAIN POLYGON BOUNDARY (APPROXIMATE)

SITE SYMBOLOGY

ESKER

DOMINANT SURFICIAL MATERIAL

- ANTHROPOGENIC (A)
- BEDROCK (R)
- FLUVIAL (F)
- GLACIOFLUVIAL (FG)
- MORAINAL (TILL)(M)
- WATERBODY (N)
- ORGANIC (O)

Terrain Polygon Label

surficial material
surface expression(s)
underlying material
underlying surface expression
geomorphological process

Mbv[Ru]-LV
drainage → m // i,6-8 ← percent slope
drainage separator → II
slope stability class

INDEX MAP

N

5 km

0 250 500

1:10,000 METRES

REFERENCE(S)

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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT

GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
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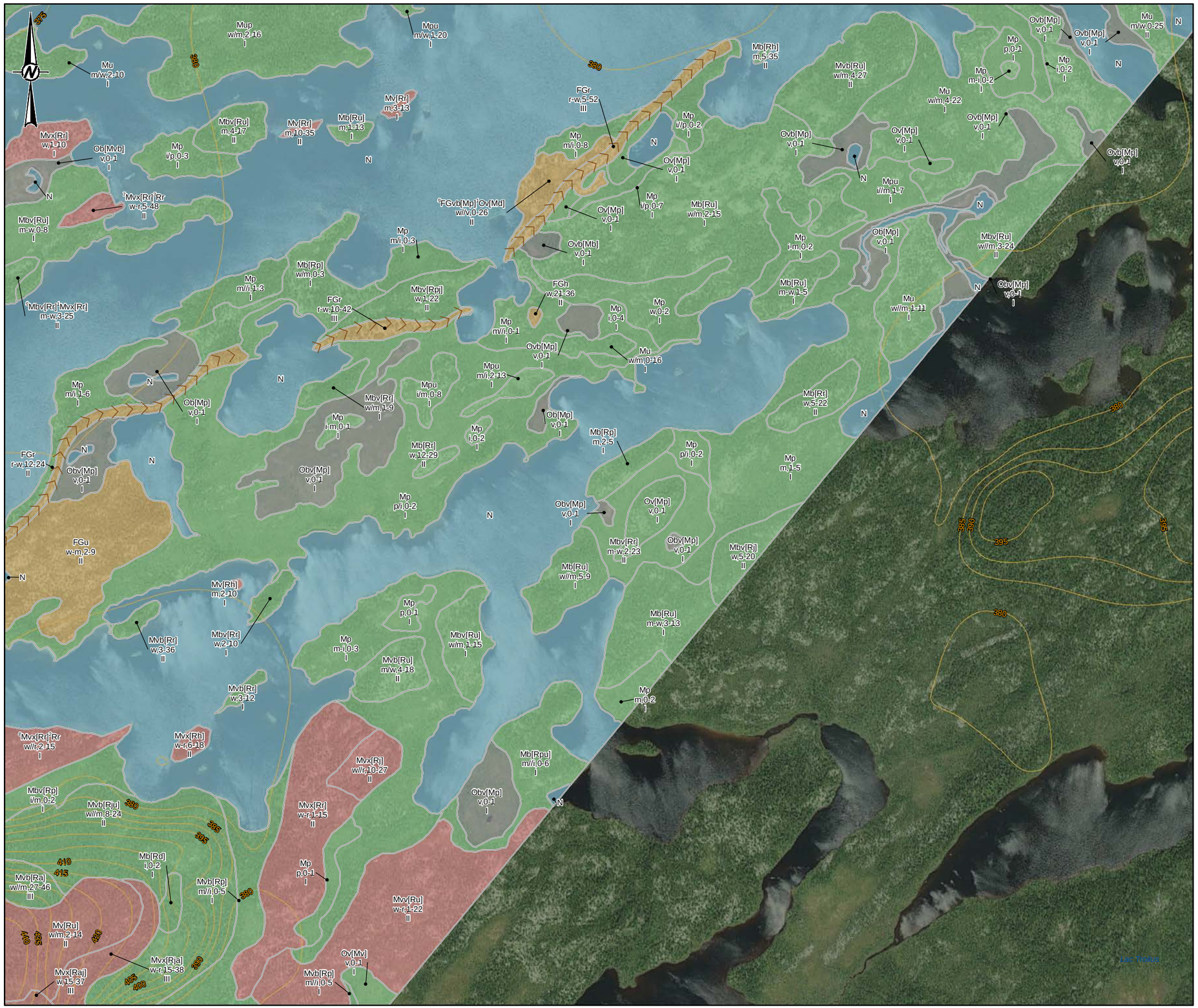

LEGEND

CONTOUR (5 m INTERVAL)

TERRAIN POLYGON BOUNDARY (APPROXIMATE)

SITE SYMBOLOGY

ESKER

DOMINANT SURFICIAL MATERIAL

- BEDROCK (R)
- GLACIOFLUVIAL (FG)
- MORAINAL (TILL)(M)
- WATERBODY (N)
- ORGANIC (O)

Terrain Polygon Label

surficial material
surface expression(s)
underlying material
underlying surface expression
geomorphological process

Mbv[Ru]-LV

drainage → m // i,6-8 ← percent slope
drainage separator → II
slope stability class

INDEX MAP

N

5 km

0 250 500

1:10,000 METRES

REFERENCE(S)

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COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	32

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25mm

0

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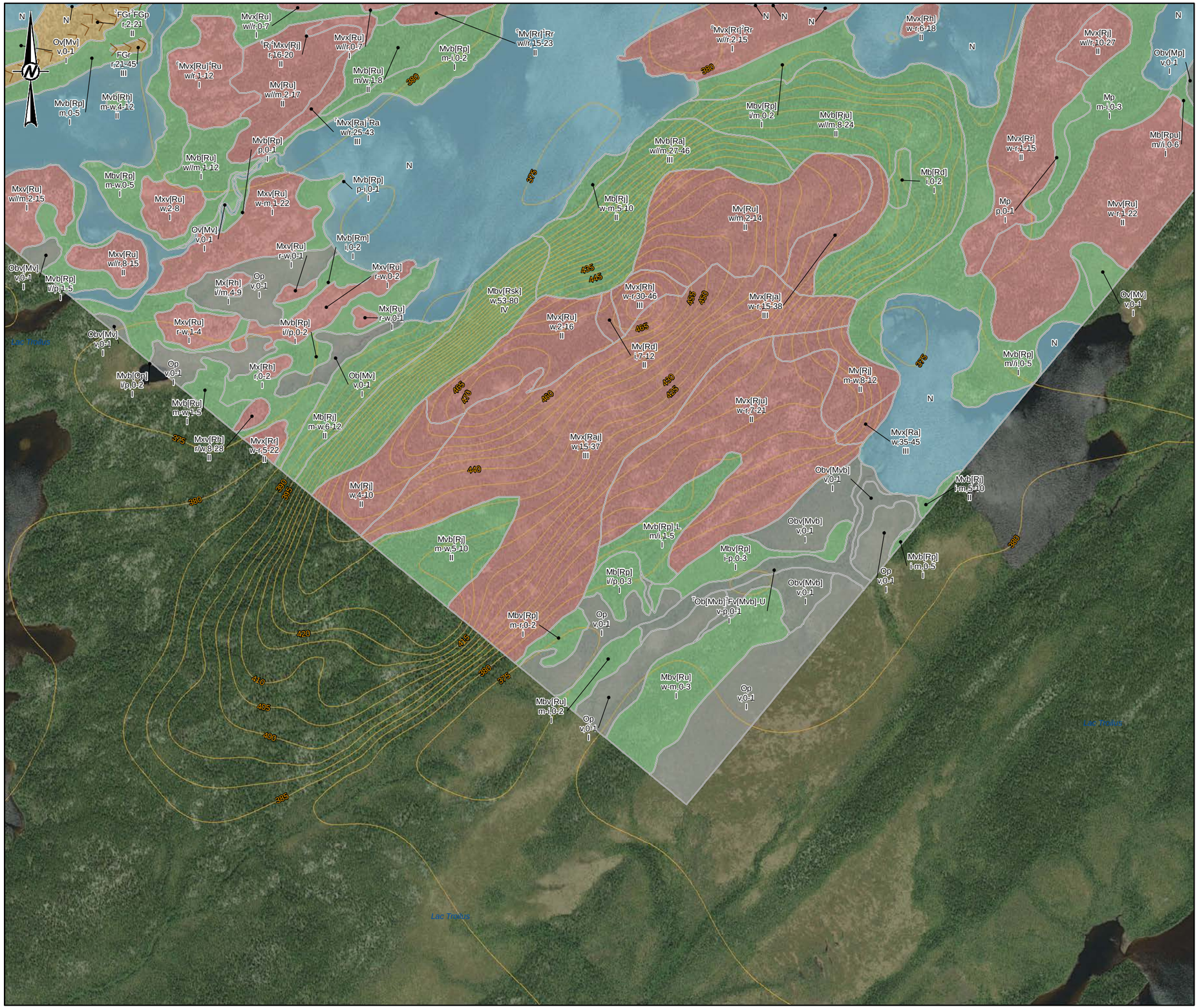


LEGEND

- CONTOUR (5 m INTERVAL)
- TERRAIN POLYGON BOUNDARY (APPROXIMATE)

SITE SYMBOLOGY

- ESKER

DOMINANT SURFICIAL MATERIAL

- BEDROCK (R)
- GLACIOFLUVIAL (FG)
- MORAINAL (TILL)(M)
- WATERBODY (N)
- ORGANIC (O)

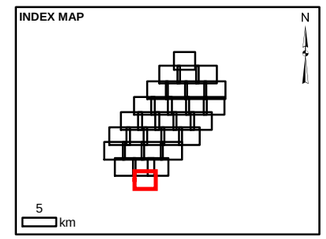
Terrain Polygon Label

surficial material
surface expression(s)
underlying material
underlying surface expression
geomorphological process

Mbv[Ru]-LV

drainage → m // i,6-8 ← percent slope
drainage separator → II
slope stability class →

INDEX MAP



0 250 500
1:10,000 METRES

REFERENCE(S)

CONTOUR DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. HYDROGRAPHY OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. IMAGERY COPYRIGHT © 20180605 ESRI AND ITS LICENSORS. SOURCE: DIGITALGLOBE. USED UNDER LICENSE, ALL RIGHTS RESERVED.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
TROILUS GOLD

PROJECT
TROILUS GOLD PROJECT

TITLE
TERRAIN MAPPING

CONSULTANT
GOLDER

YYYY-MM-DD	2021-05-04
DESIGNED	DOL
PREPARED	PMT
REVIEWED	AS
APPROVED	DOL

PROJECT NO.	CONTROL	REV.	FIGURE
19131334	9000	0	33

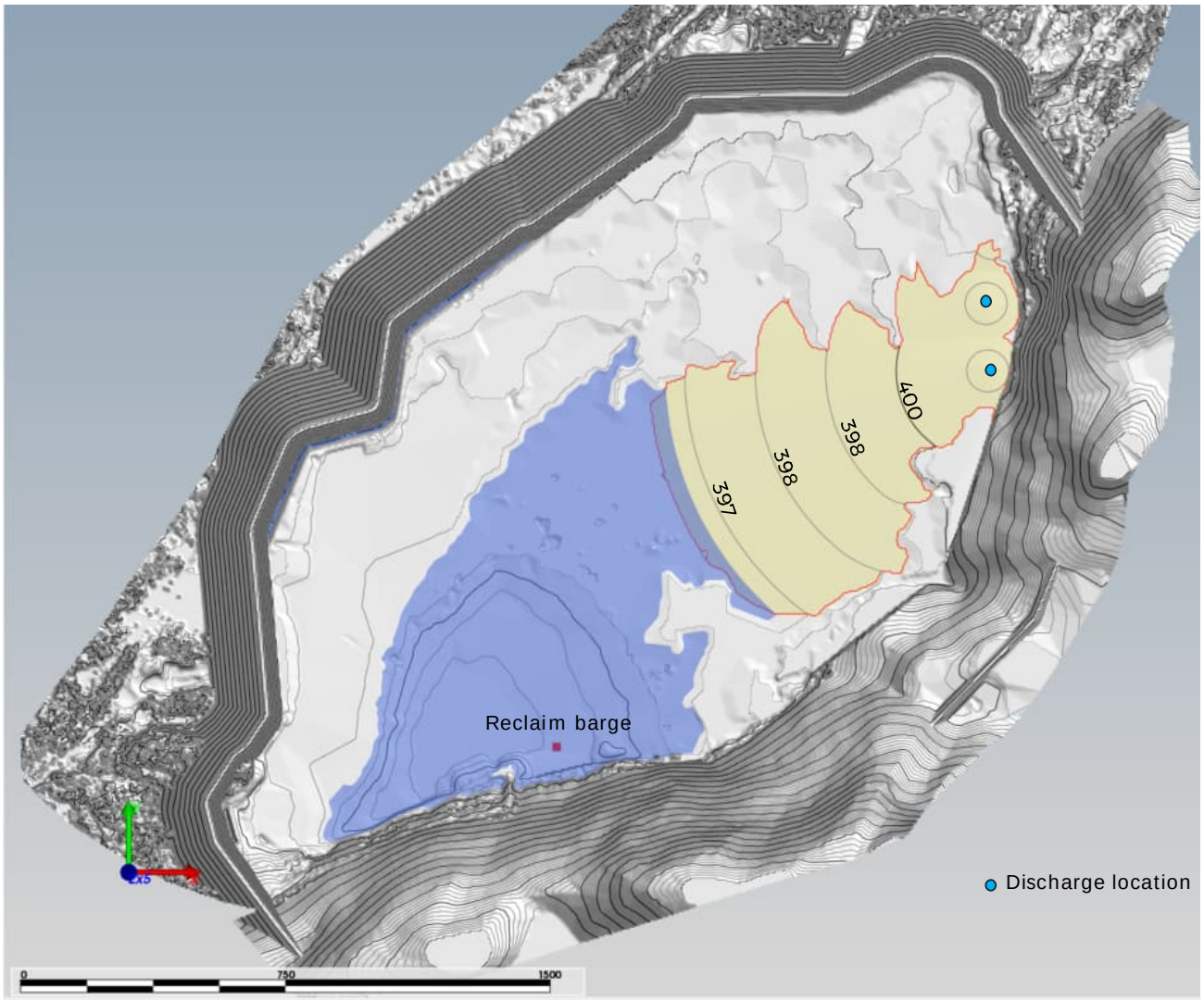
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm
0

PATH: N:\Active\Pur\VIEW\2019\19131334_TroiluGold\Mapping\Products\Soil&Terrain\Report\19131334_TroiluGold_Terrain_Mapping_Rev0.mxd PRINTED ON: 2021-05-04 AT: 1:45:48 PM

APPENDIX E

Deposition Modelling

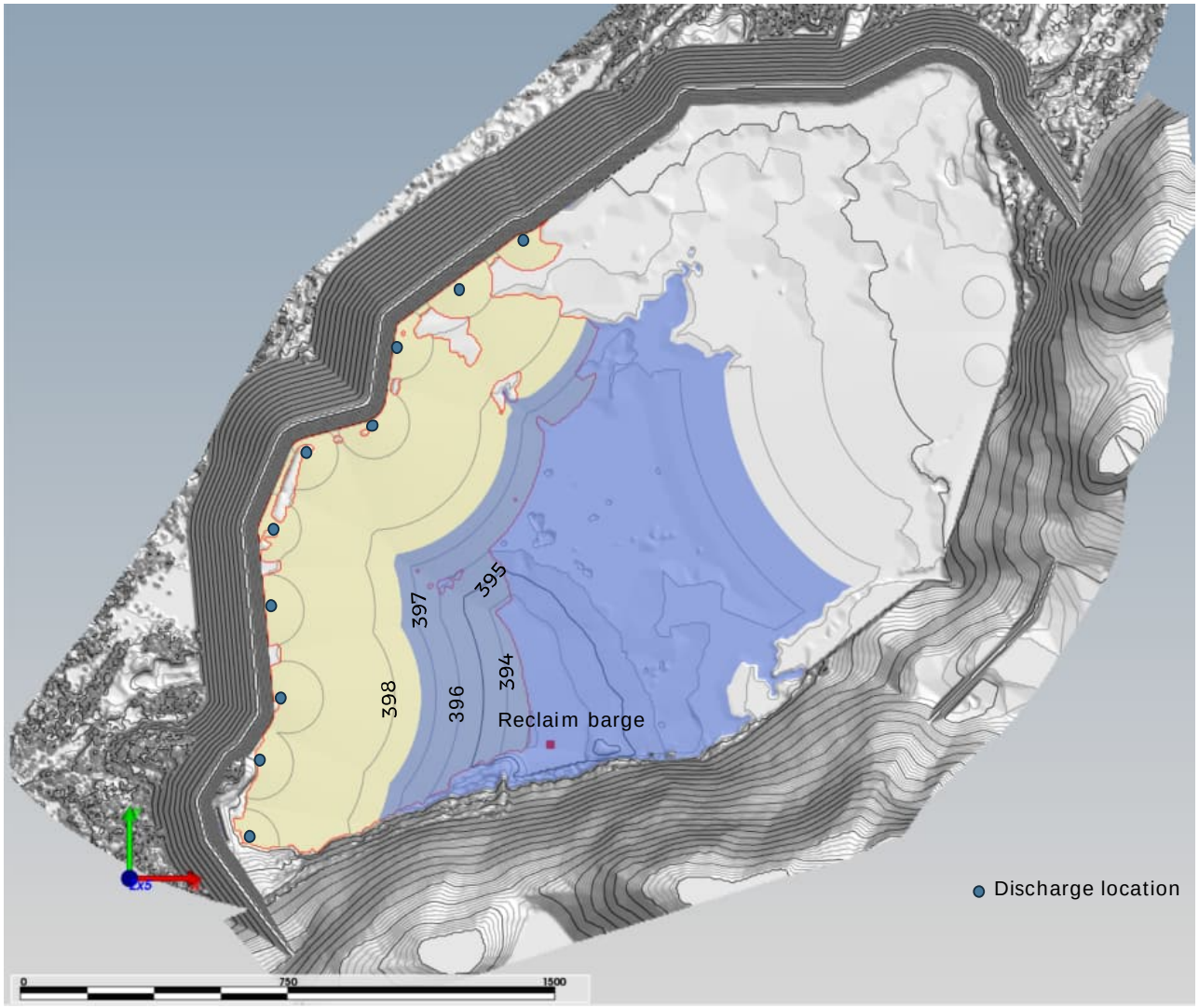


Production year : -1

Discharge elevation: 401.3 masl

Main Dyke elevation: 403.0 masl

Pond elevation: 396.7 masl

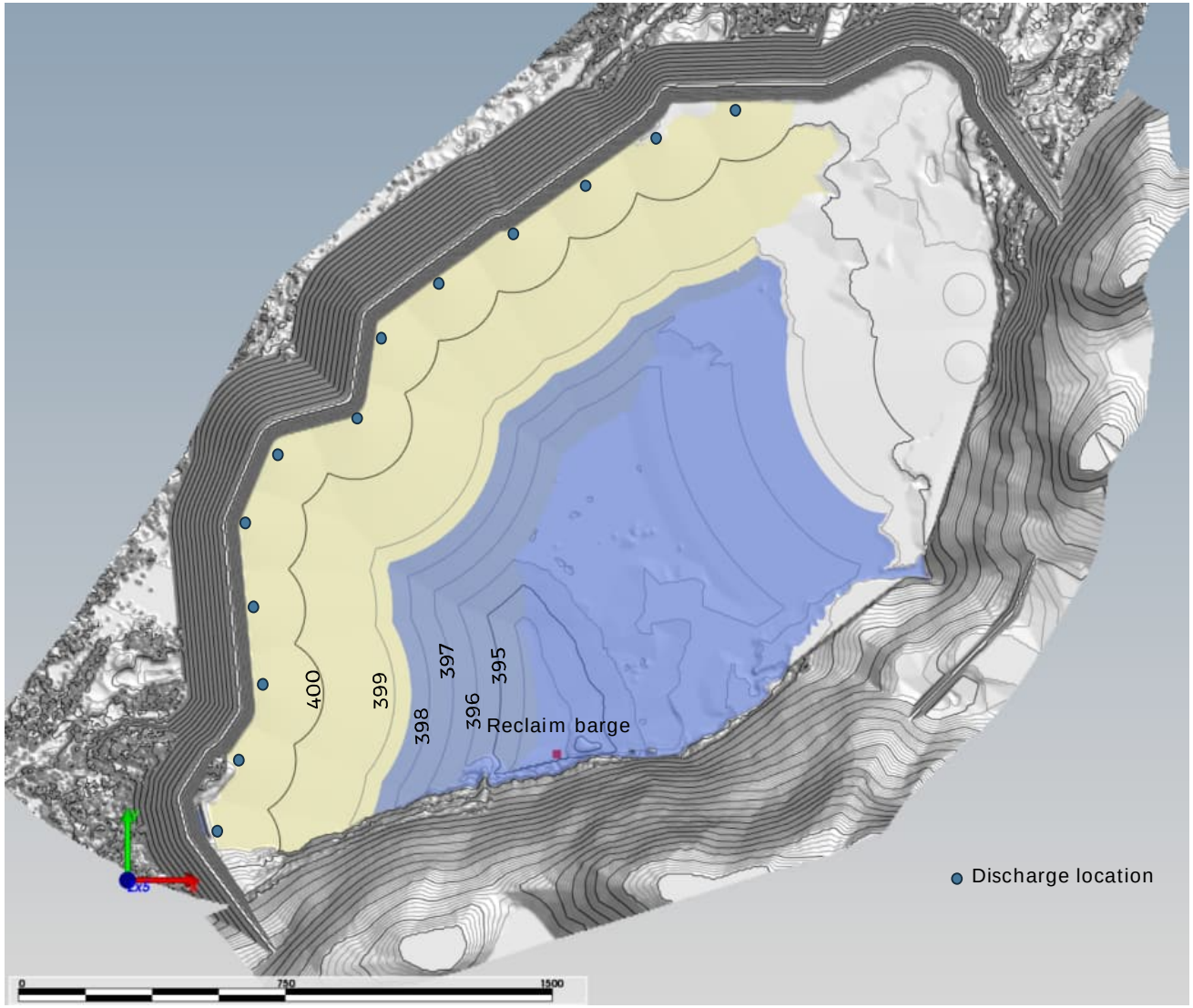


Production year : 1 (Q1)

Discharge elevation: 399.5 masl

Main Dyke elevation: 403.0-407.0 masl

Pond elevation: 397.6 masl

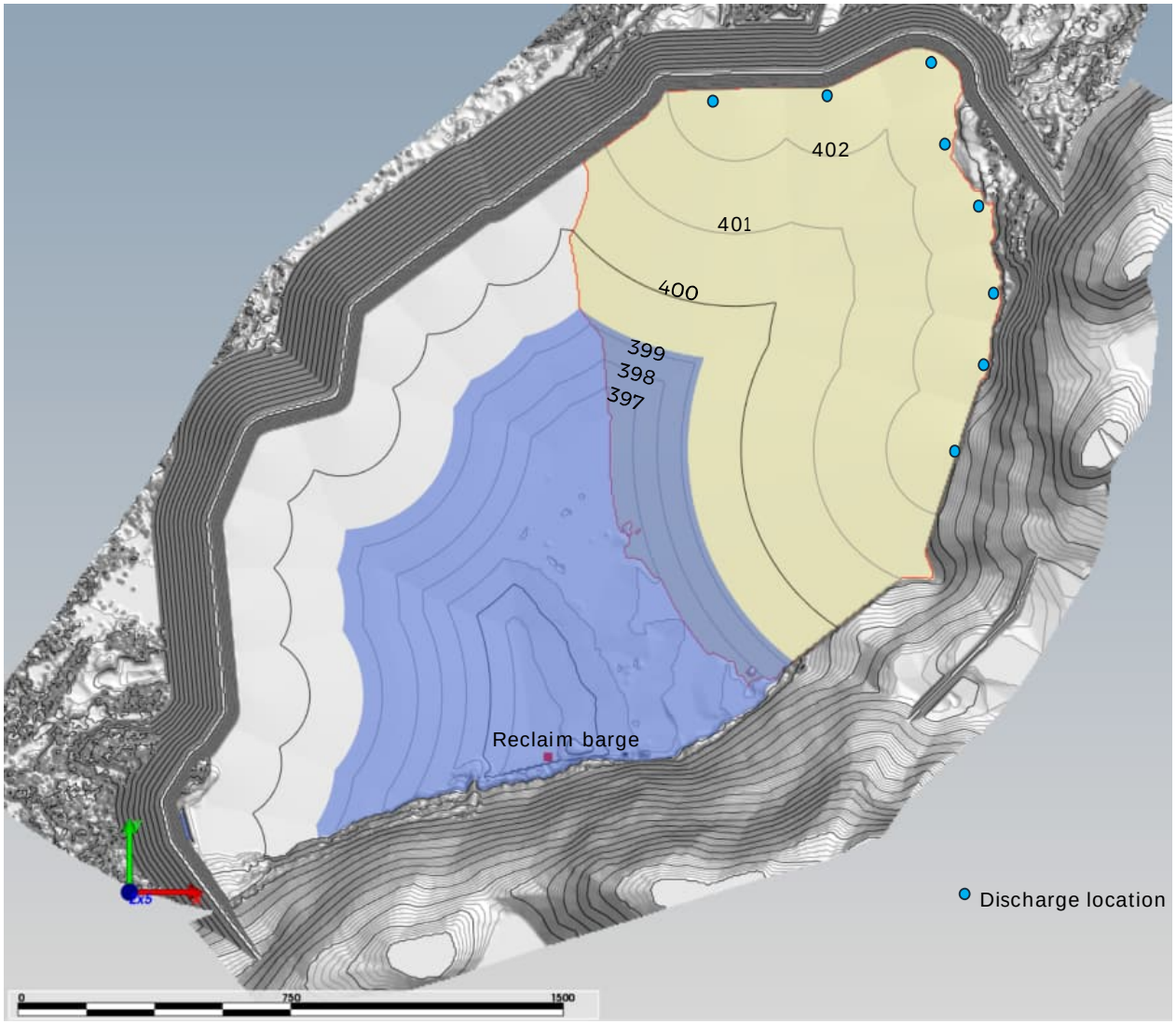


Production year : 1 (Q2)

Discharge elevation: 400.8 masl

Main Dyke elevation: 403.0-407.0 masl

Pond elevation: 398.8 masl

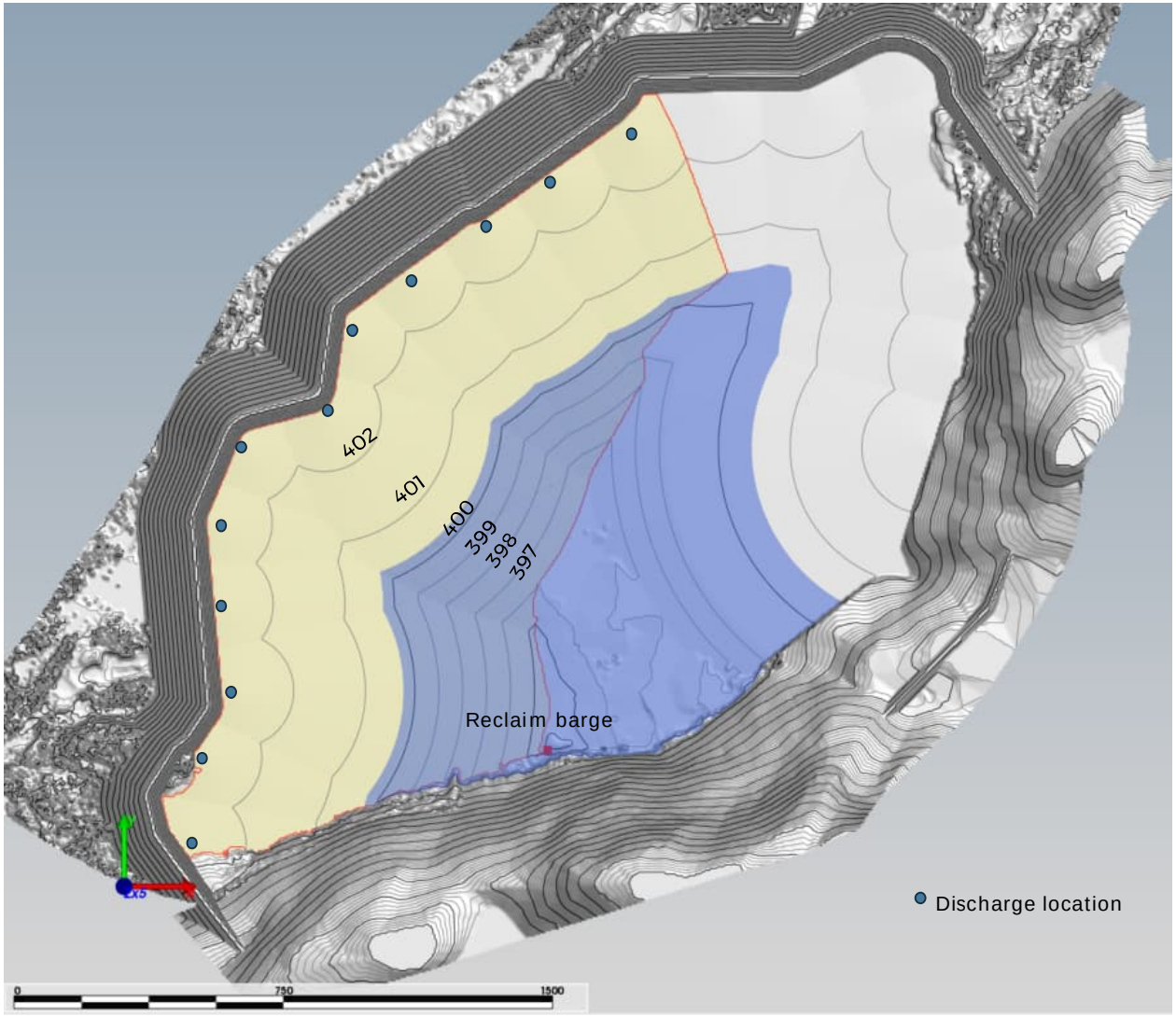


Production year : 1 (Q3)

Discharge elevation: 402.9 masl

Main Dyke elevation: 403.0-407.0 masl

Pond elevation: 399.3 masl

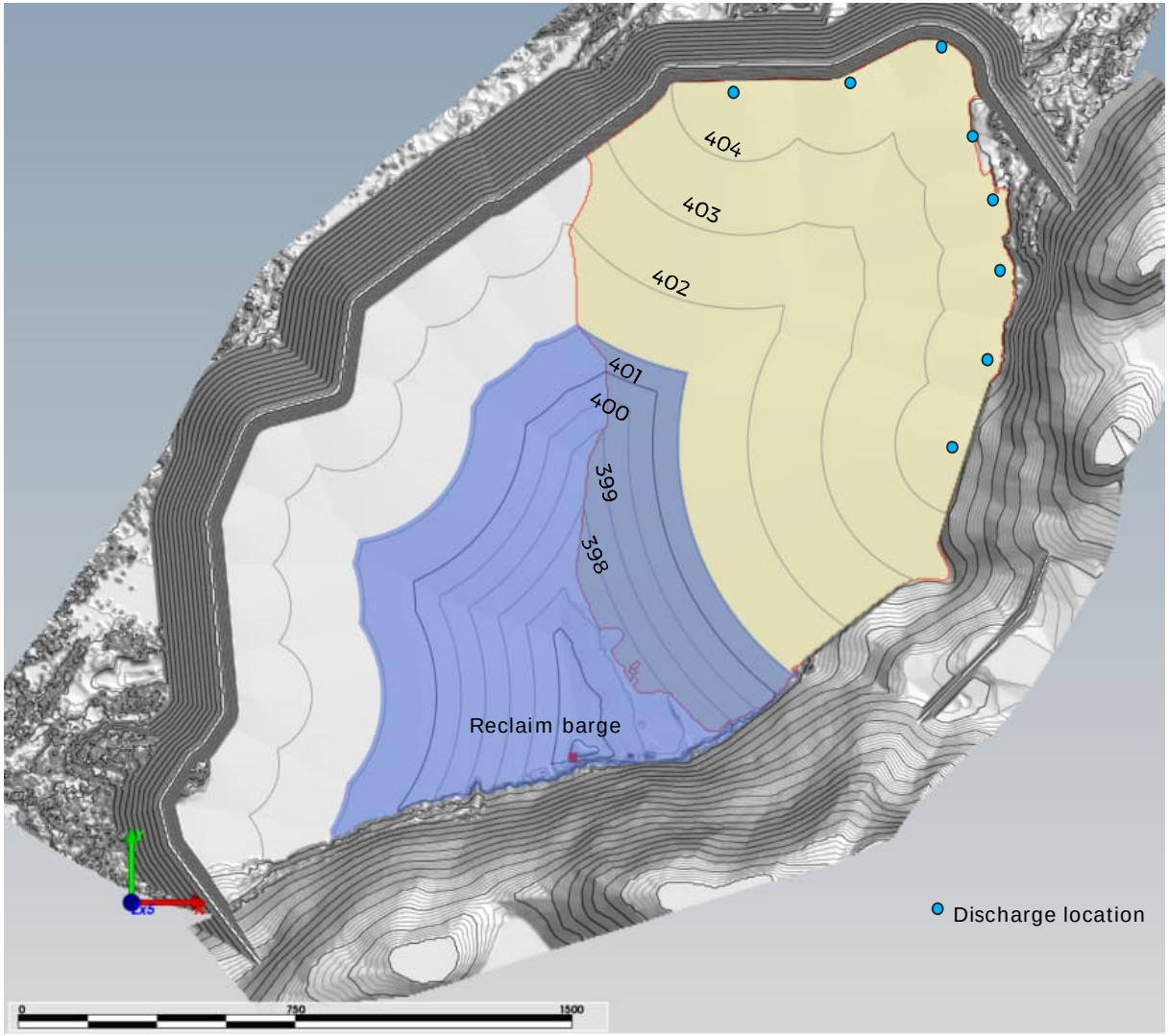


Production year : 1 (Q4)

Discharge elevation: 402.8 masl

Main Dyke elevation: 403.0-407.0 masl

Pond elevation: 400.5 masl

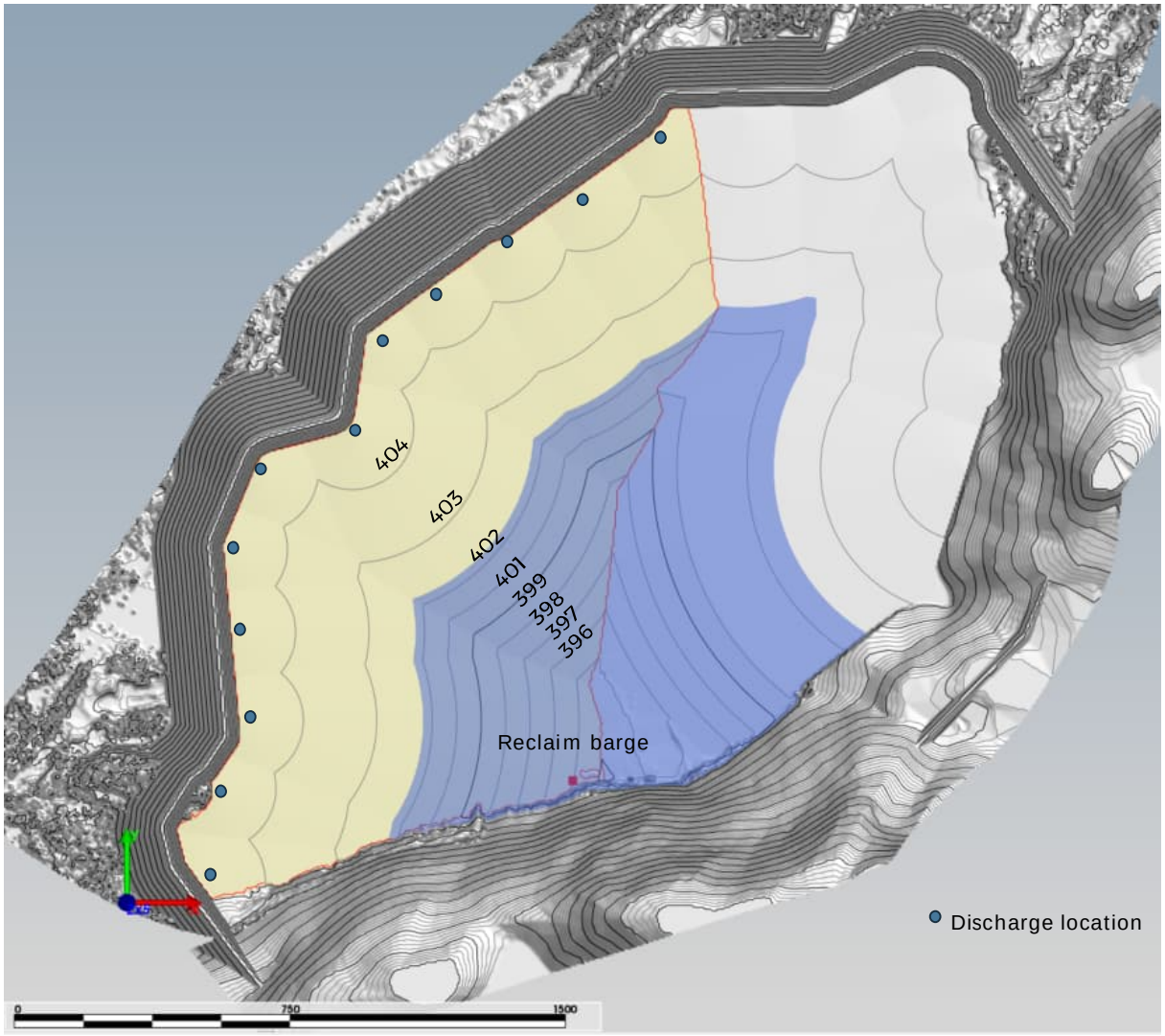


Production year : 2 (Q1)

Discharge elevation: 405.0 masl

Main Dyke elevation: 407.0-411.0 masl

Pond elevation: 401.1 masl

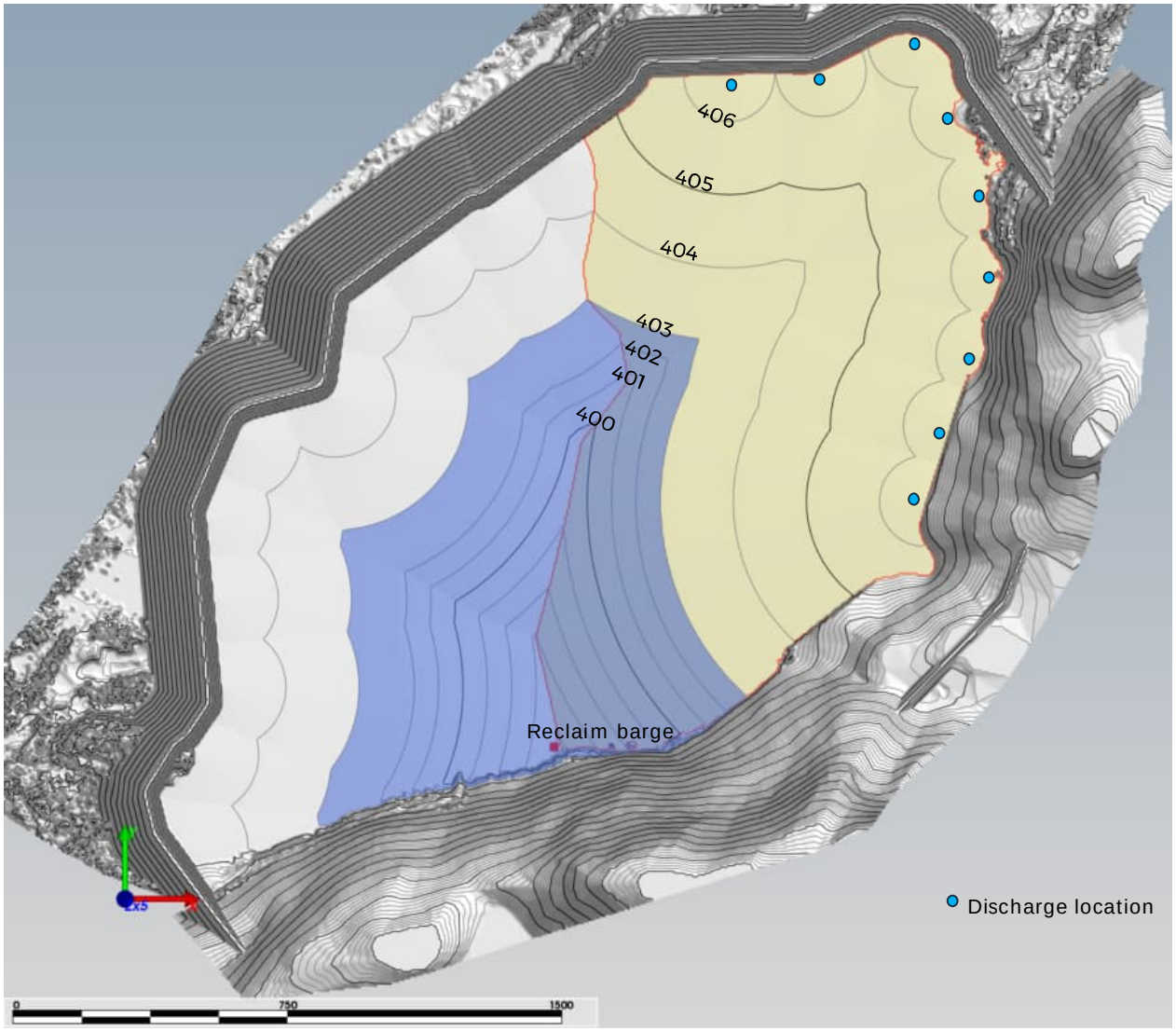


Production year : 2 (Q2)

Discharge elevation: 404.8 masl

Main Dyke elevation: 407.0-411.0 masl

Pond elevation: 402.4 masl

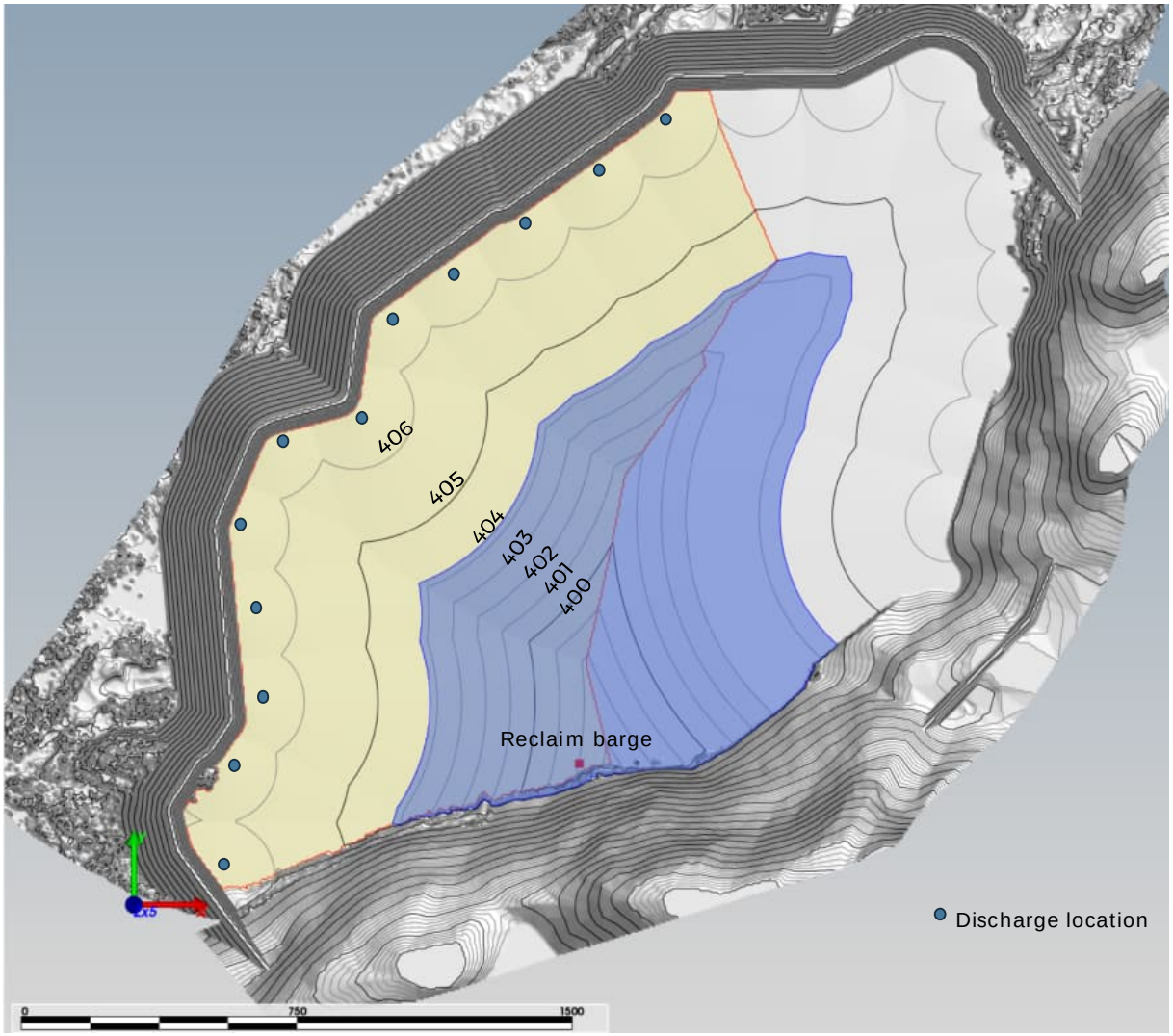


Production year : 2 (Q3)

Discharge elevation: 406.6 masl

Main Dyke elevation: 407.0-411.0 masl

Pond elevation: 403.0 masl

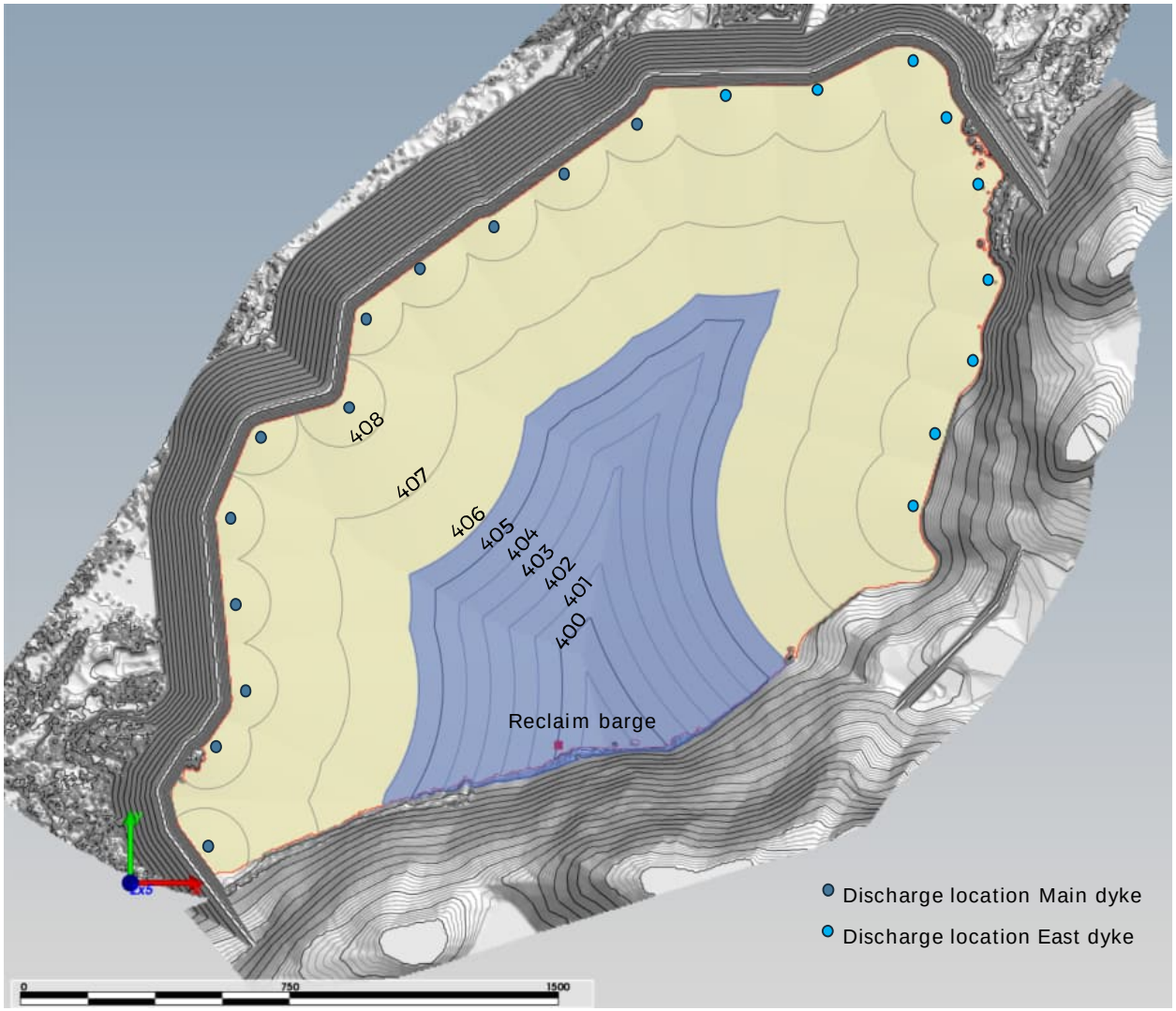


Production year: 2 (Q4)

Discharge elevation: 406.8 masl

Main Dyke elevation: 407.0-411.0 masl

Pond elevation: 404.3 masl



Production year: 3 (Q1-Q2)

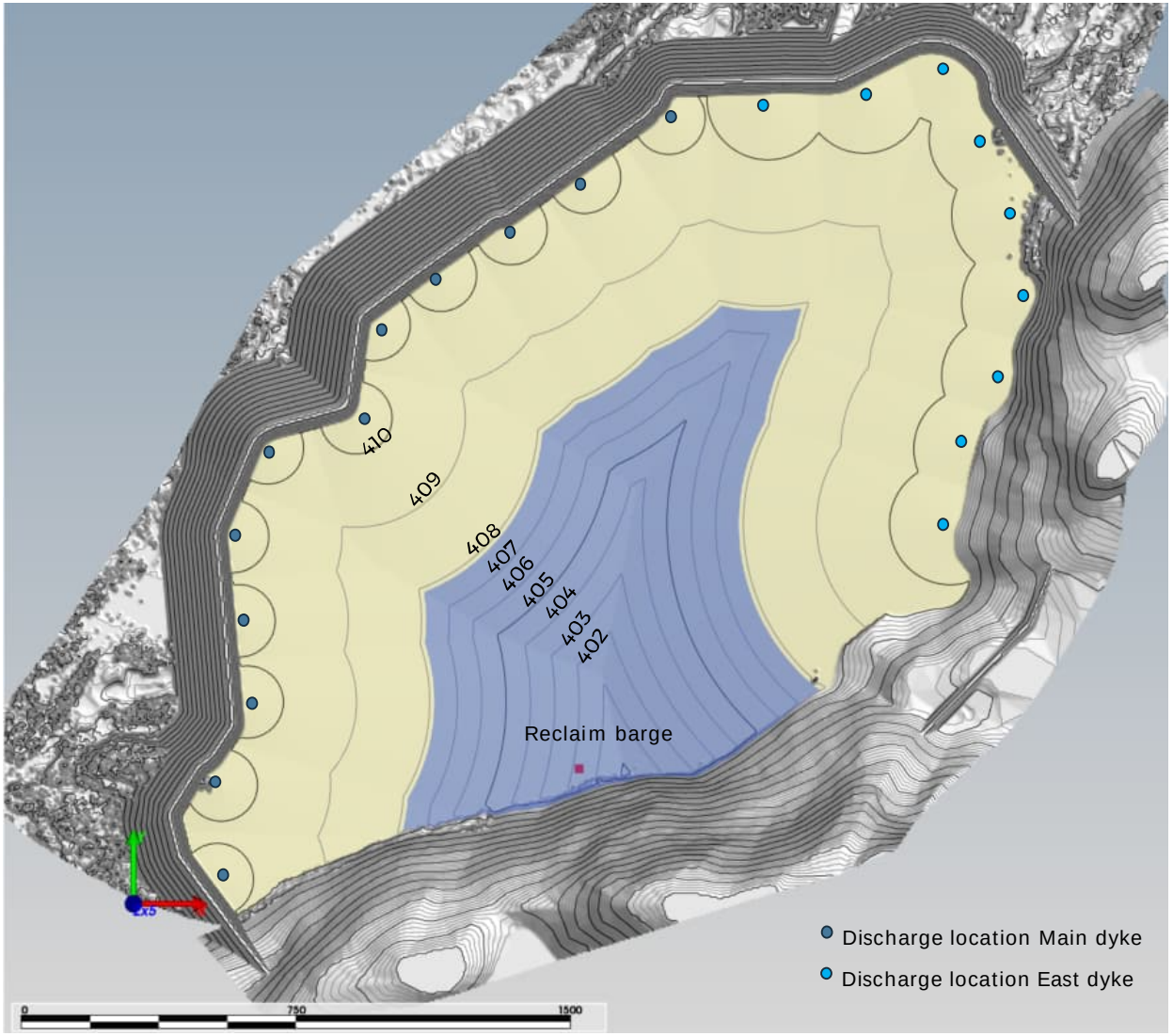
Discharge elevation:

East dyke: 408.8 masl

Main dyke: 408.6 masl

Main Dyke elevation: 411.0-415.0 masl

Pond elevation: 406.0 masl



Production year : 3 (Q2-Q3)

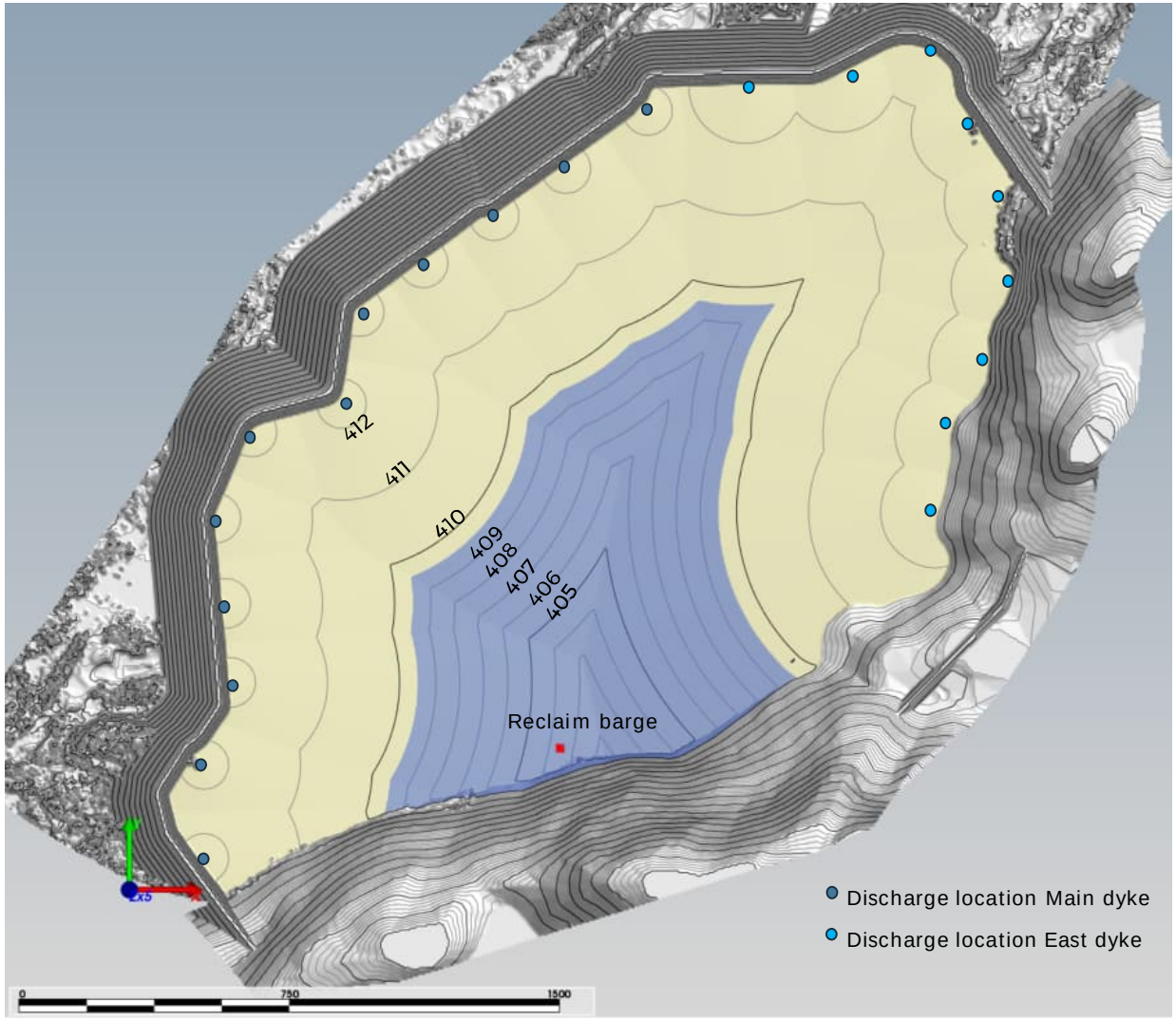
Discharge elevation:

East dyke: 410.8 masl

Main dyke: 410.5 masl

Main Dyke elevation: 411.0-415.0 masl

Pond elevation: 407.9 masl



Production year : 4 (Q1-Q2)

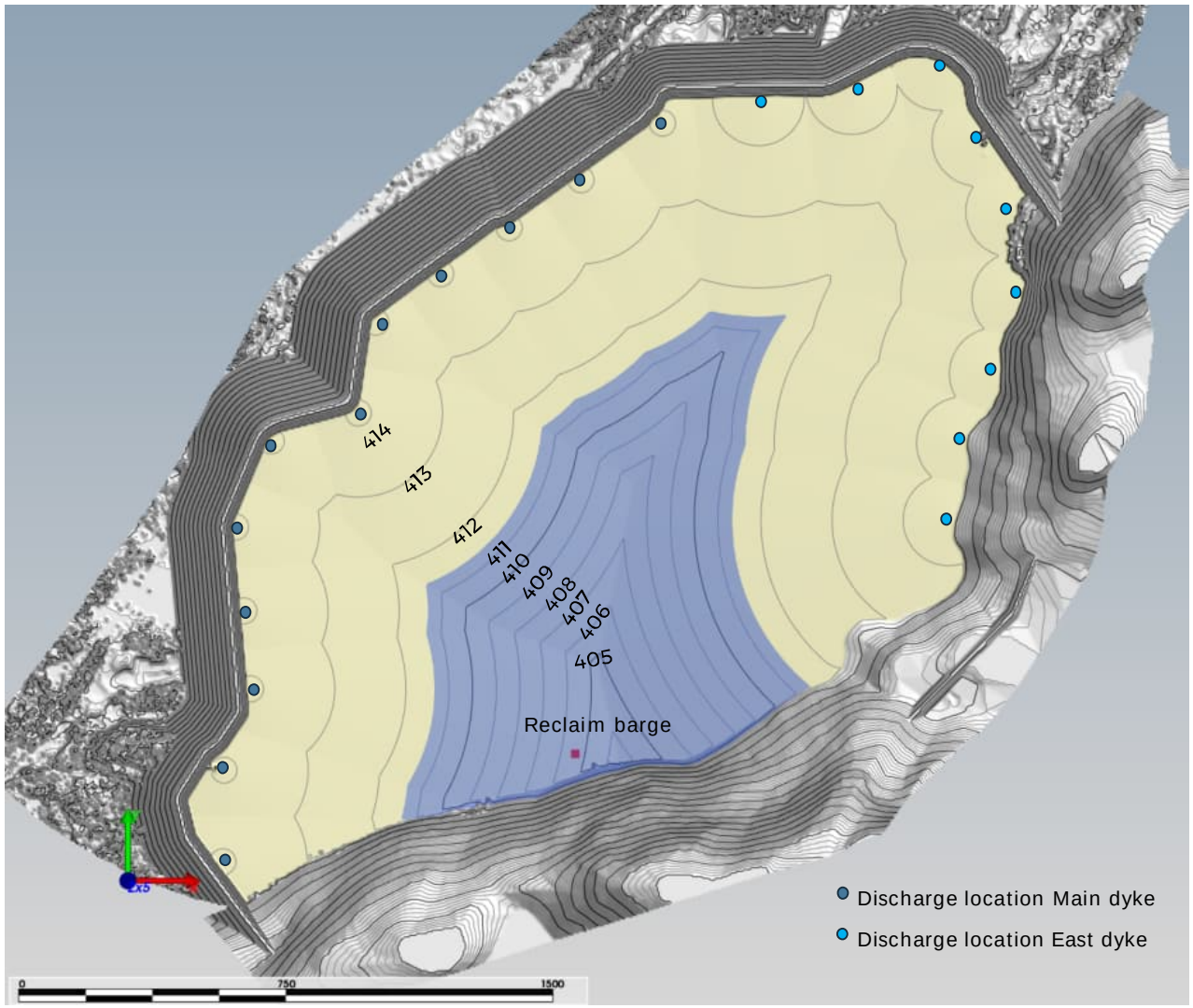
Discharge elevation:

East dyke: 412.8 masl

Main dyke: 412.3 masl

Main Dyke elevation: 411.0-417.0 masl

Pond elevation: 409.7 masl



Production year : 4 (Q2-Q3)

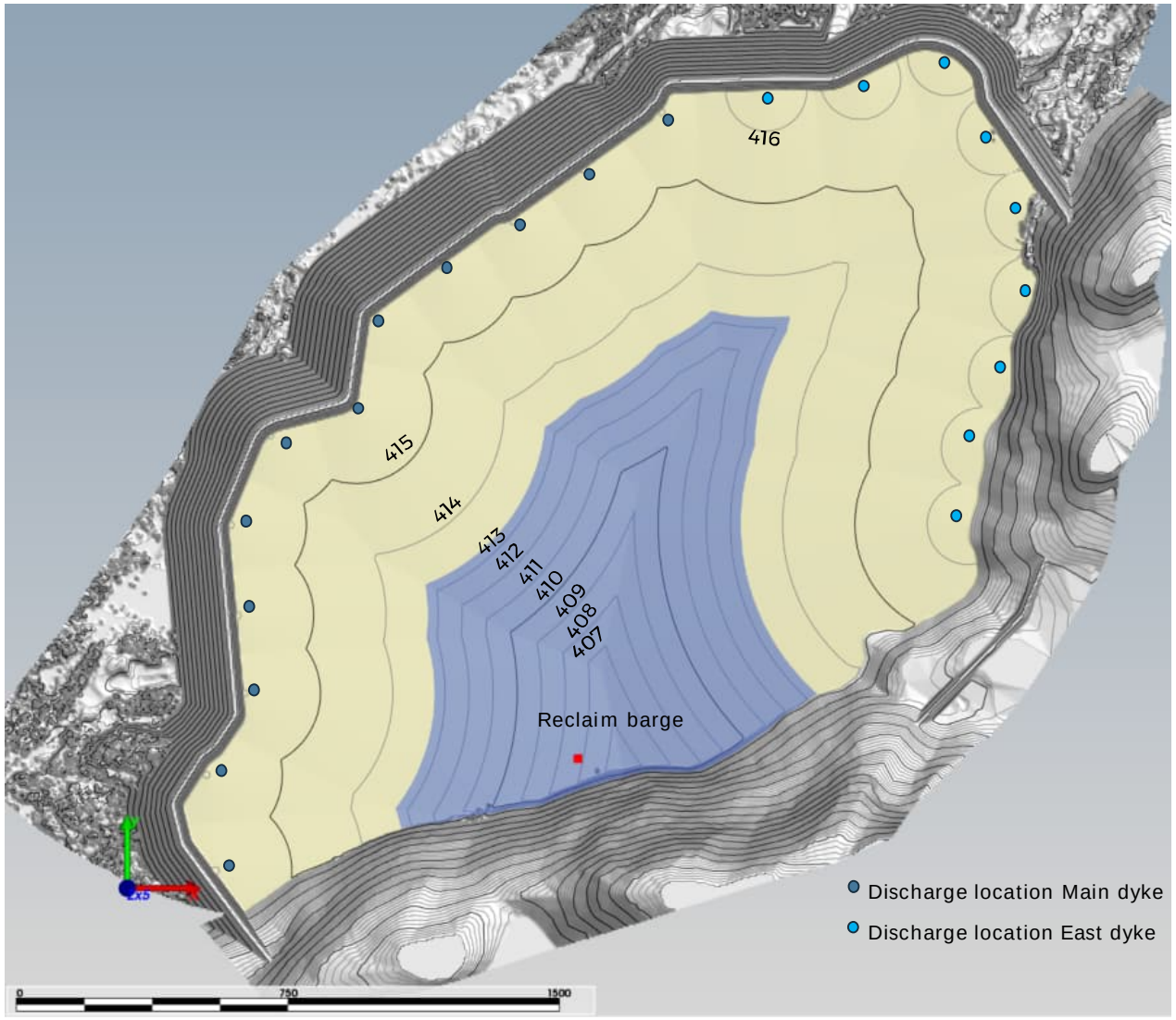
Discharge elevation:

East dyke: 414.6 masl

Main dyke: 414.2 masl

Main Dyke elevation: 417.0-421.0 masl

Pond elevation: 411.6 masl



Production year : 5 (Q1-Q2)

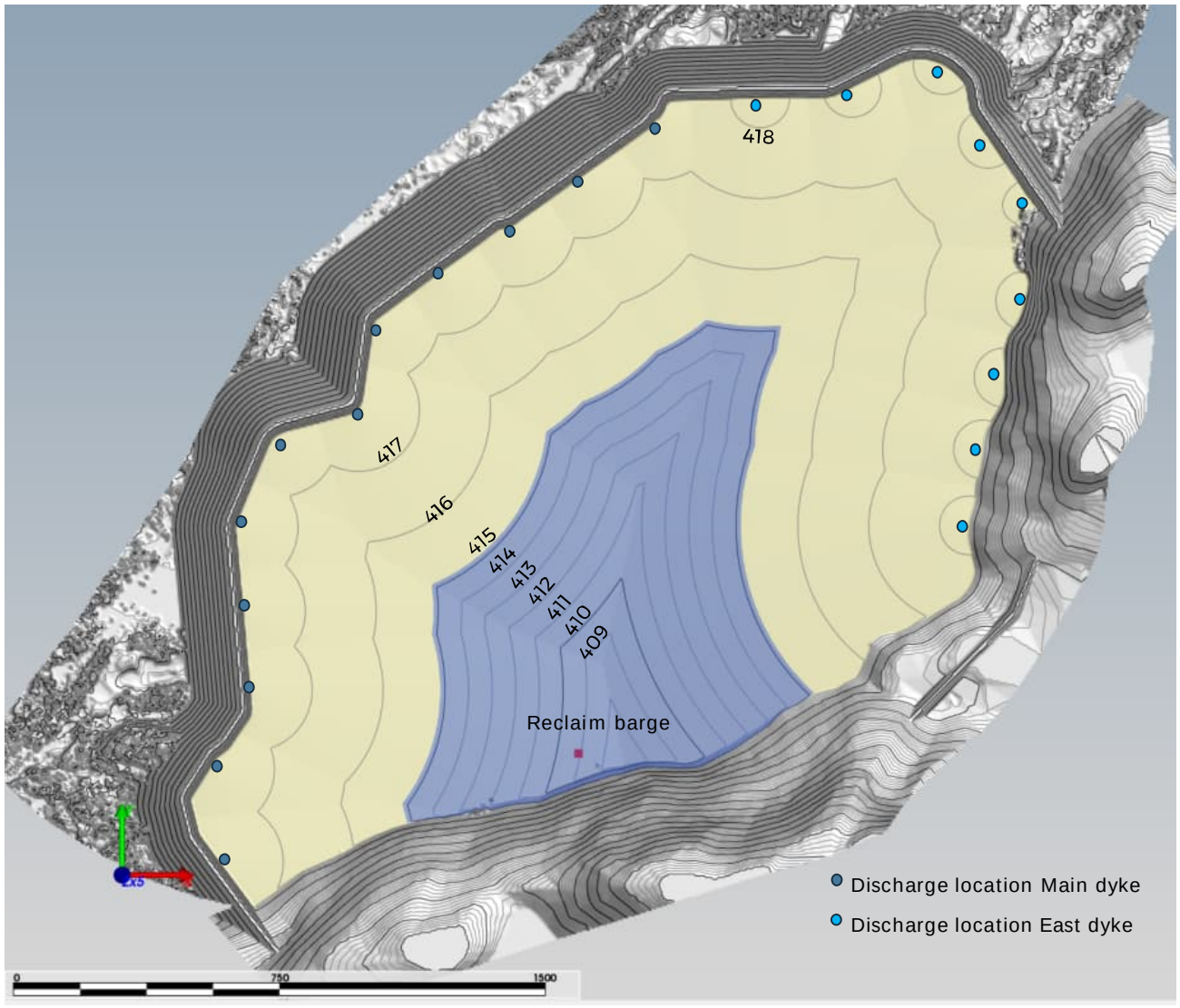
Discharge elevation:

East dyke : 416.6 masl PC0

Main dyke : 416.1 masl

Dyke elevation: 417.0-421.0 masl

Pond elevation: 413.4 masl



Production year : 5 (Q3-Q4)

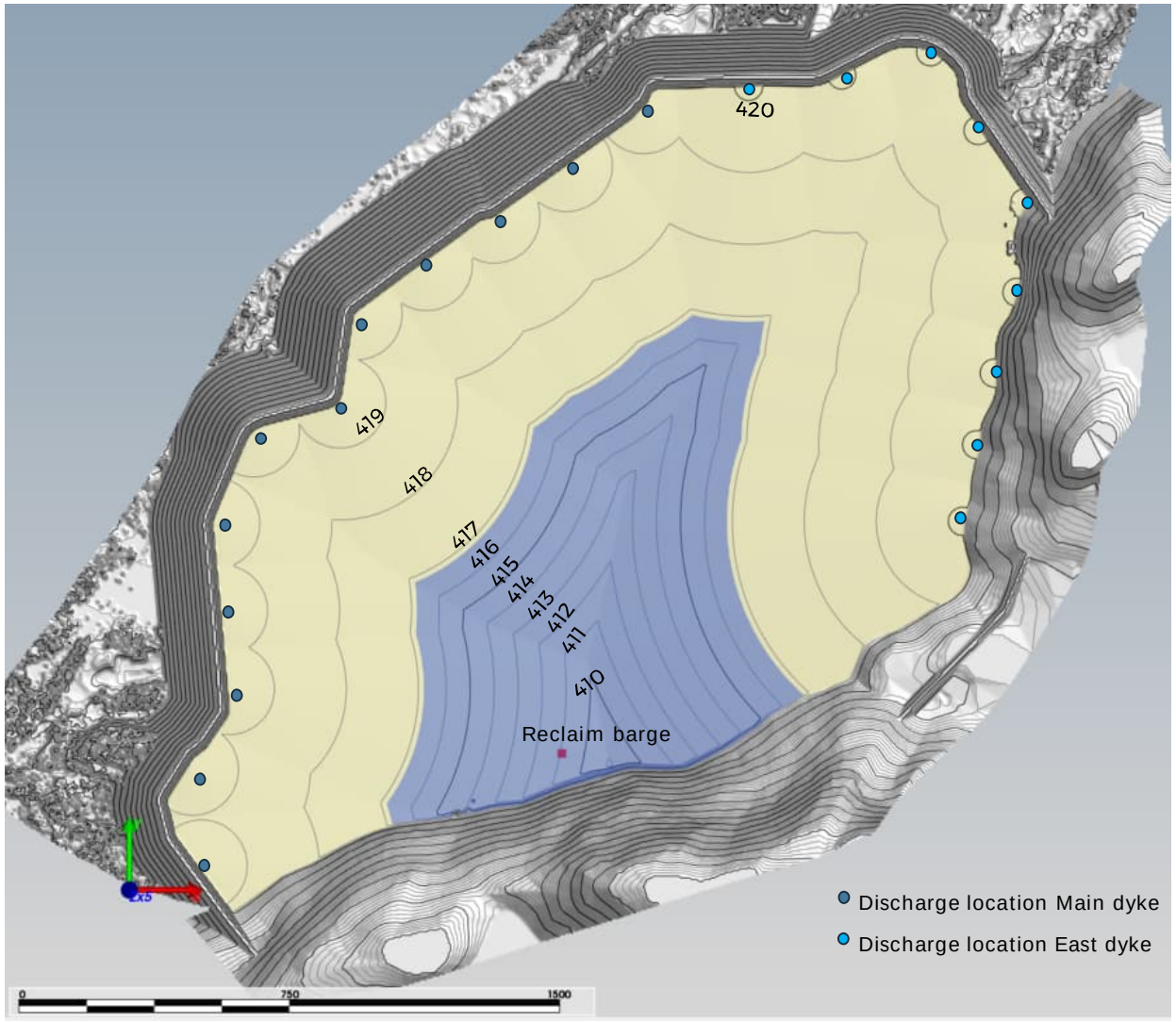
Discharge elevation:

East dyke: 418.4 masl

Main dyke: 417.8 masl

Main Dyke elevation: 419.0-423.0 masl

Pond elevation: 415.2 masl



Production year : 6 (Q1-Q2)

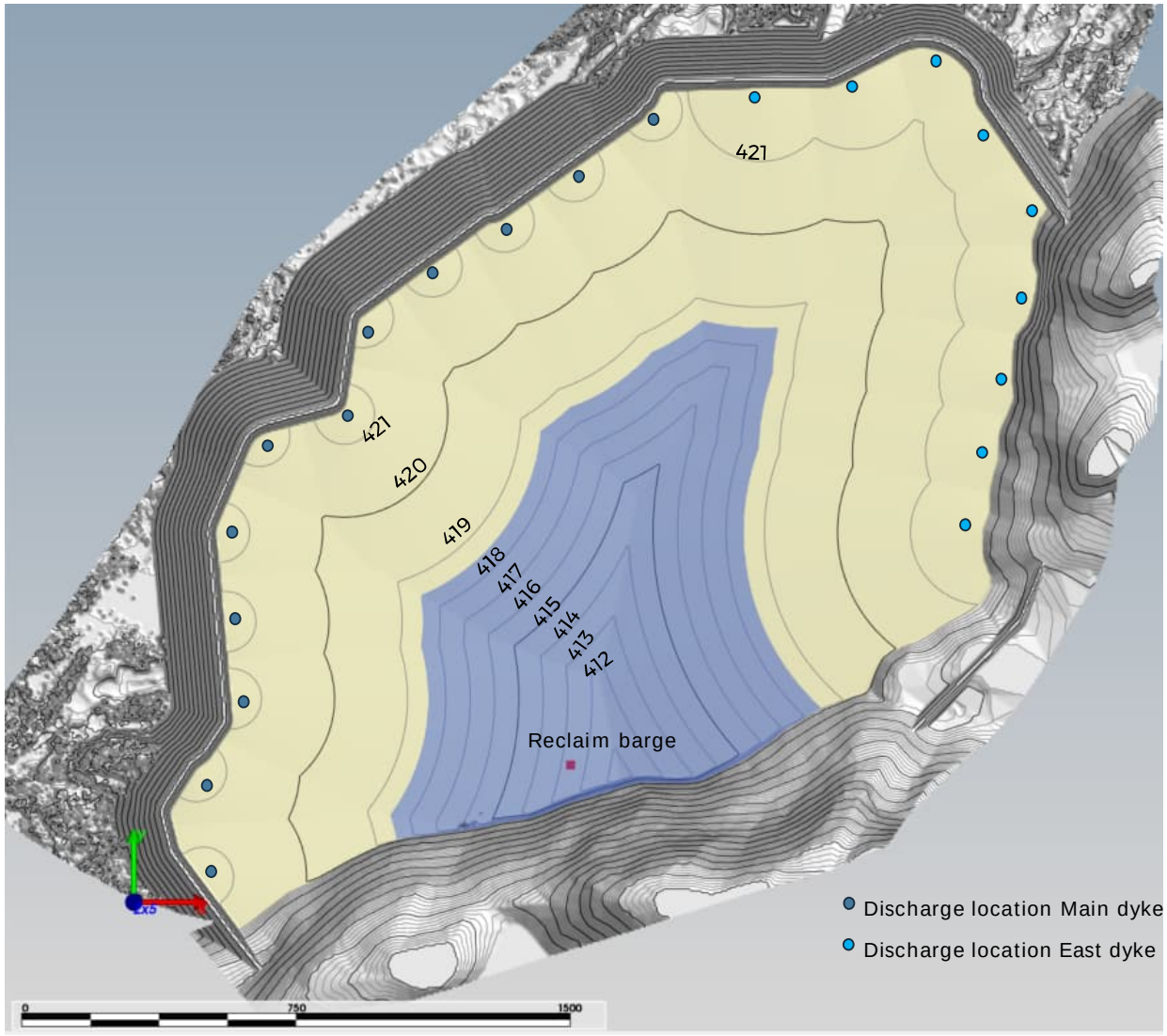
Discharge elevation:

East dyke: 420.2masl

Main dyke: 419.6 masl

Main Dyke elevation: 423.0-427.0 masl

Pond elevation: 416.6 masl



Production year : 6 (Q3-Q4)

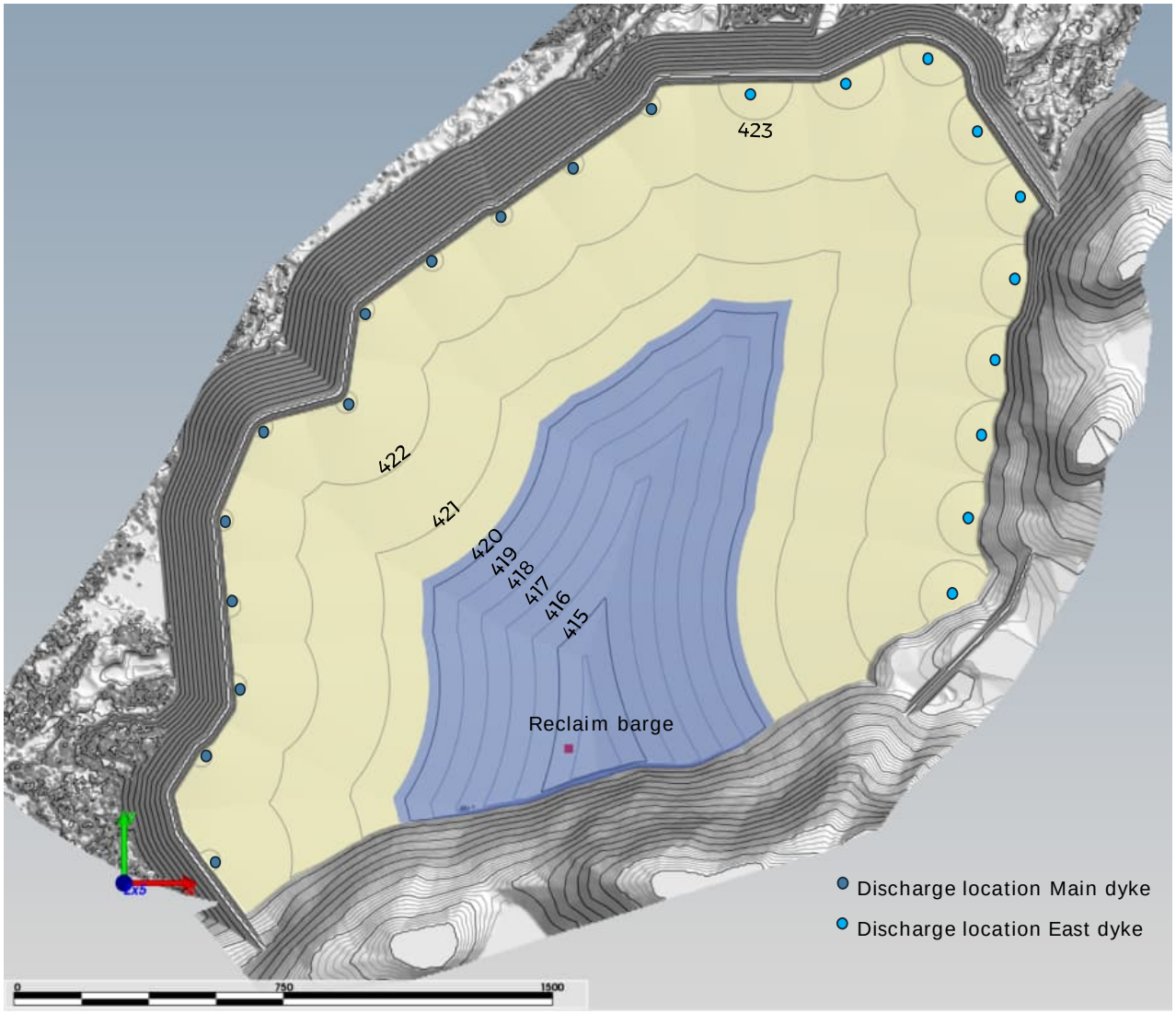
Discharge elevation:

East dyke: 422.0 masl

Main dyke: 421.4 masl

Main Dyke elevation: 423.0-427.0 masl

Pond elevation: 418.7 masl



Production year : 7 (Q1-Q2)

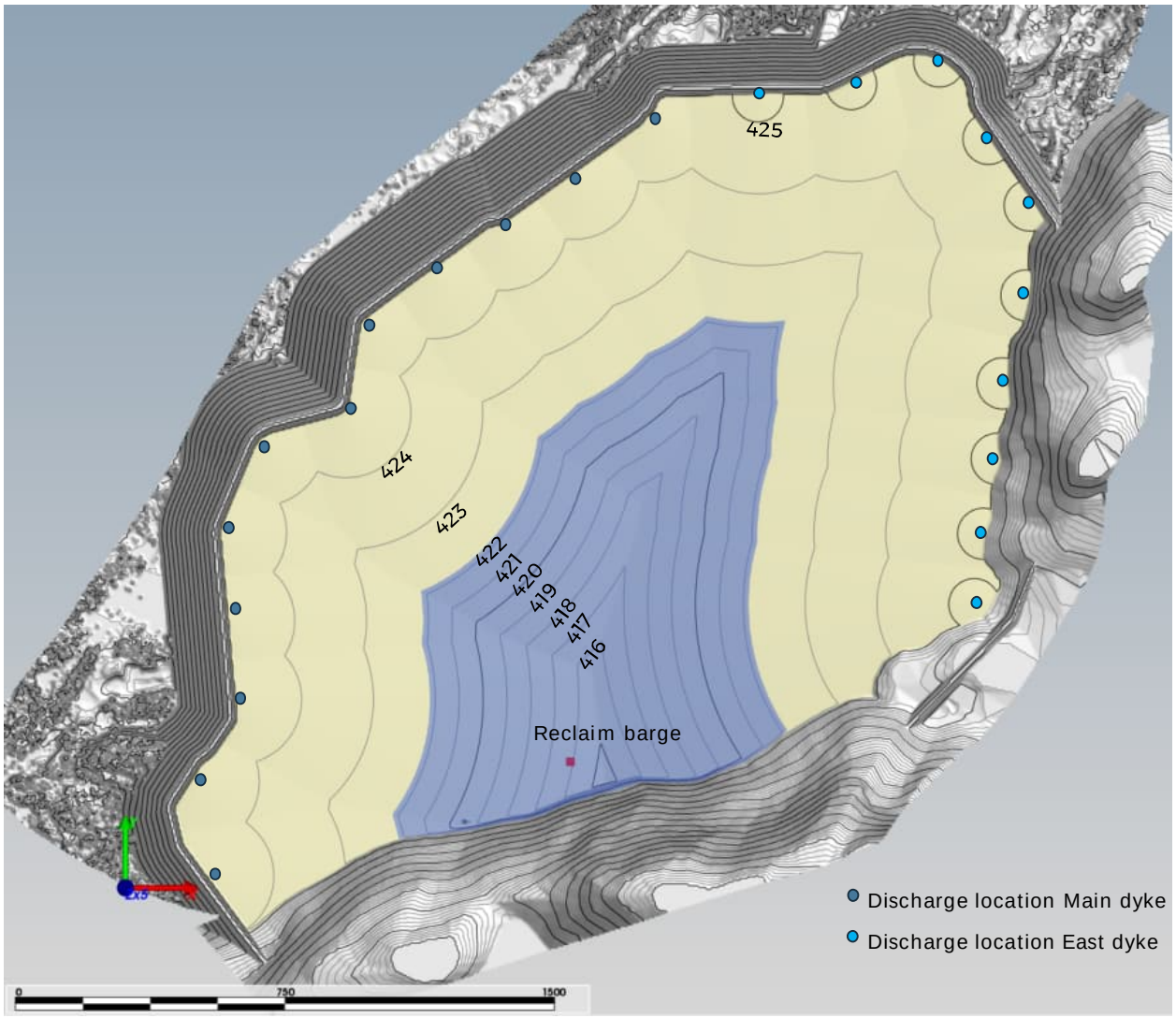
Discharge elevation:

East dyke: 423.5 masl

Main dyke: 423.2 masl

Main Dyke elevation: 427.0-431.0 masl

Pond elevation: 420.5 masl



Production year : 7 (Q3-Q4)

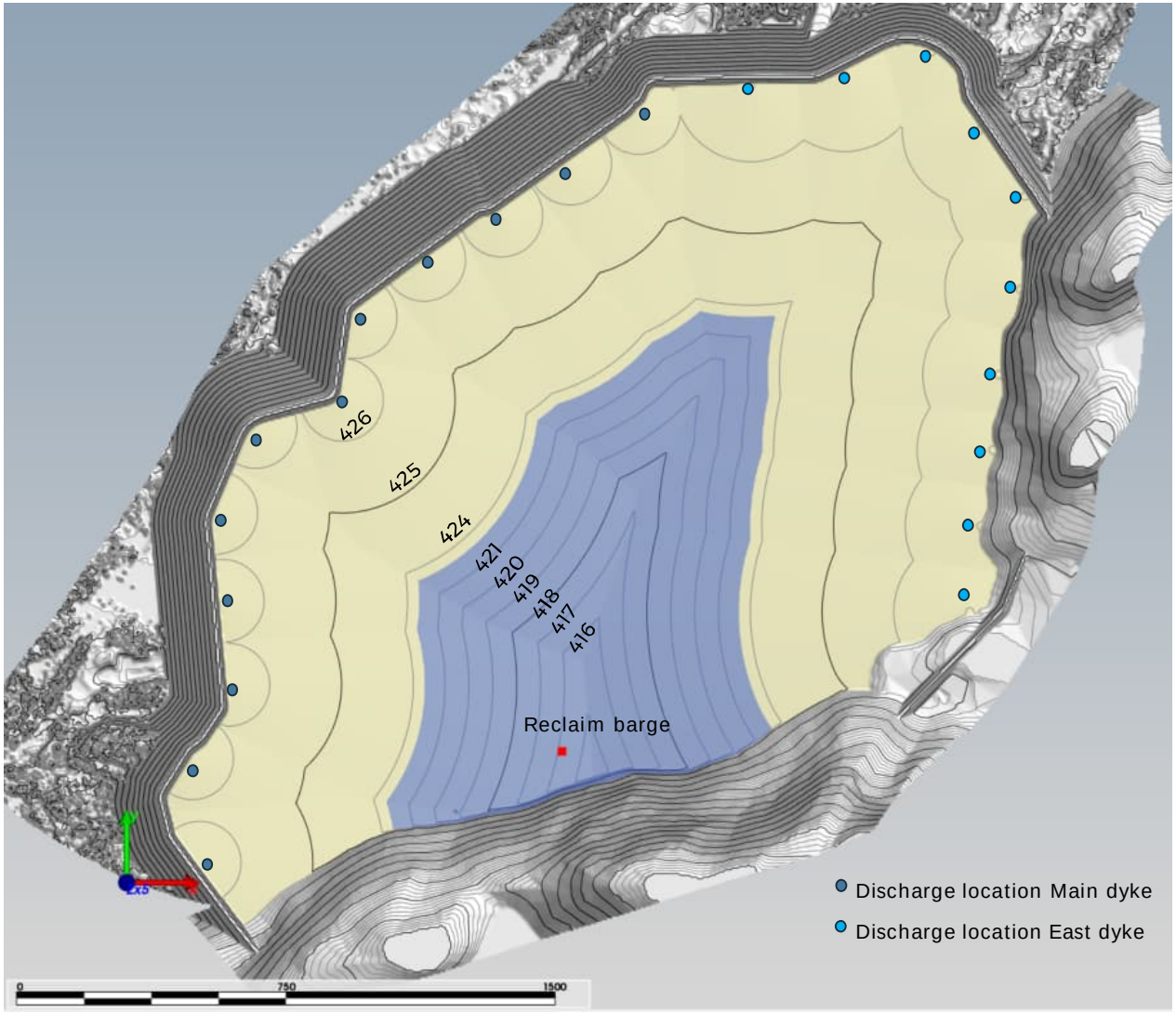
Discharge elevation:

East dyke: 425.4 masl

Main dyke: 424.9 masl

Main Dyke elevation: 427.0-431.0 masl

Pond elevation: 422.2 masl



Production year : 8 (Q1-Q2)

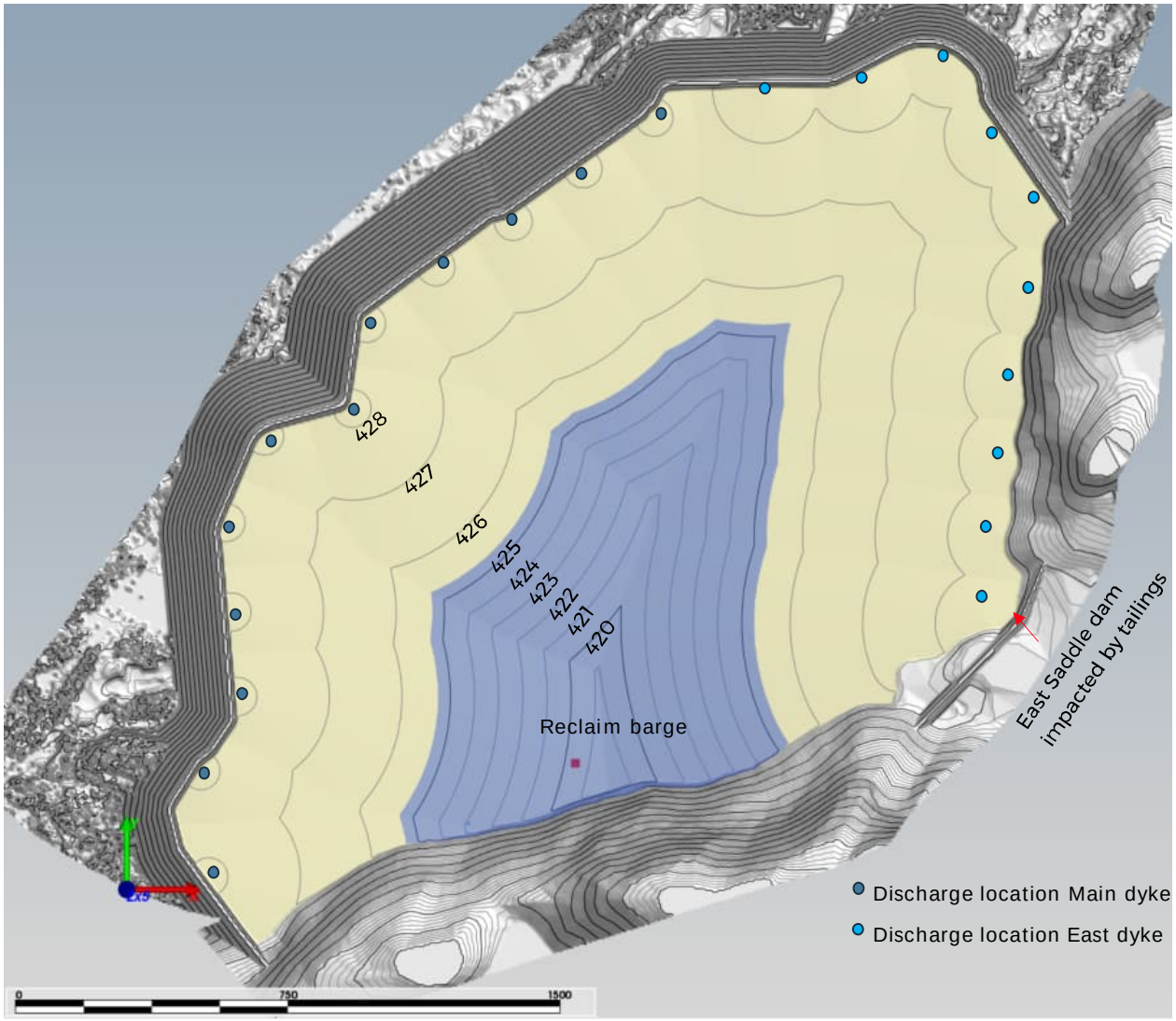
Discharge elevation:

East dyke: 427.1 masl

Main dyke: 426.6 masl

Main Dyke elevation: 431.0-433.0 masl

Pond elevation: 423.8 masl



Production year : 8 (Q3-Q4)

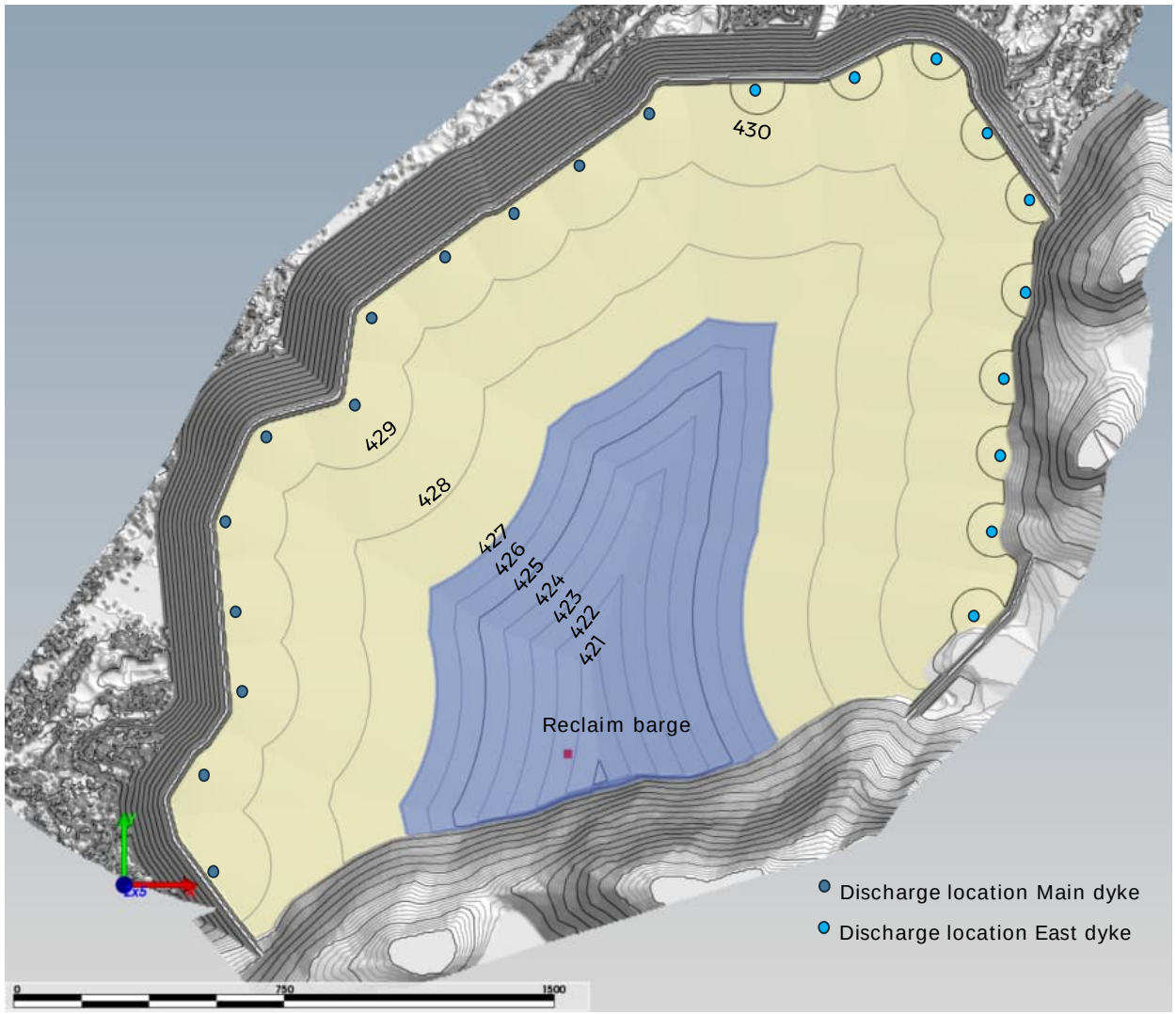
Discharge elevation:

East dyke: 428.7masl

Main dyke: 428.3 masl

Main Dyke elevation: 431.0-433.0 masl

Pond elevation: 425.5 masl



Production year : 9 (Q1-Q2)

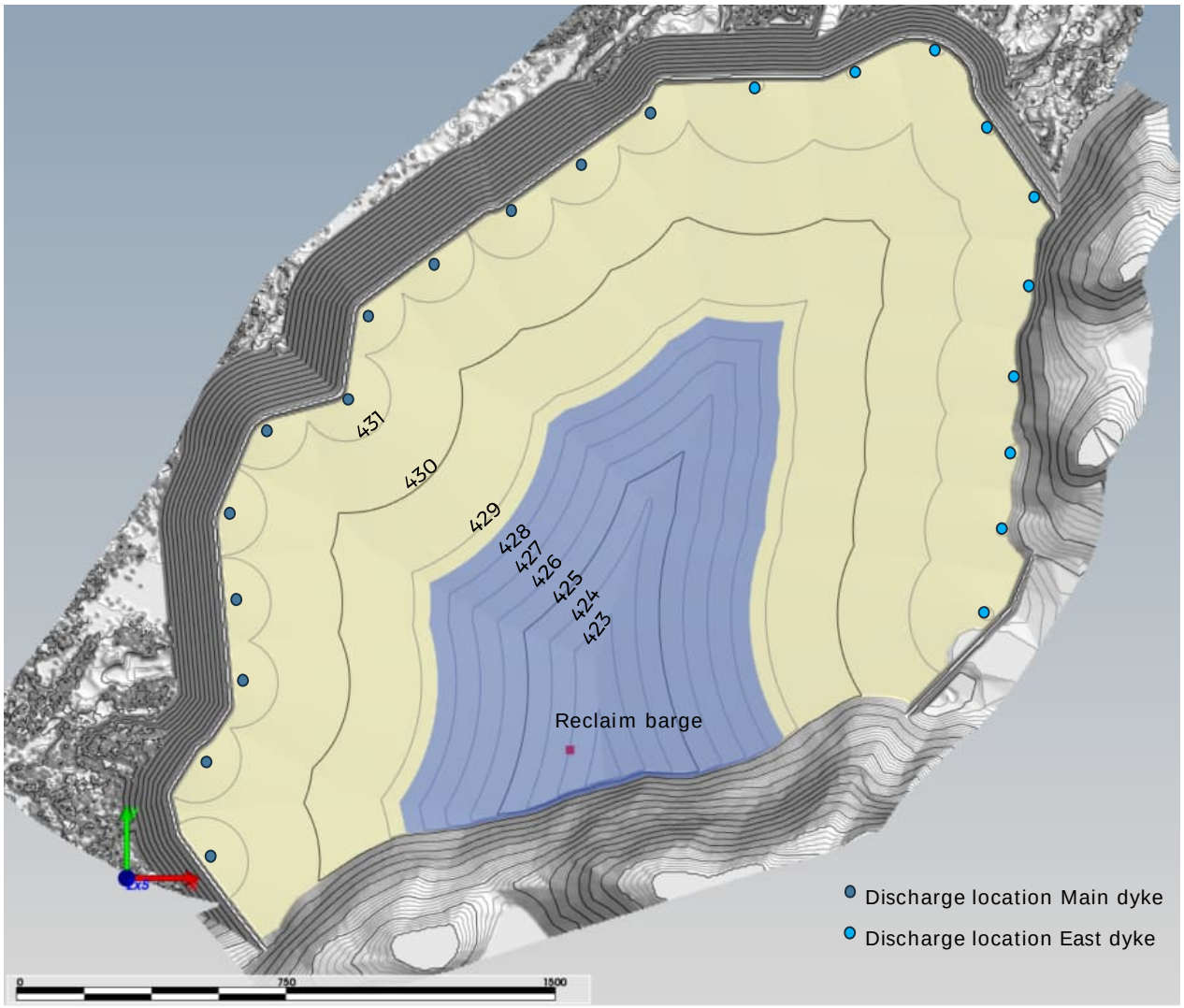
Discharge elevation:

East dyke: 430.4 masl

Main dyke: 429.9 masl

Main Dyke elevation: 433.0-435.0 masl

Pond elevation: 427.1 masl



Production year : 9 (Q3-Q4)

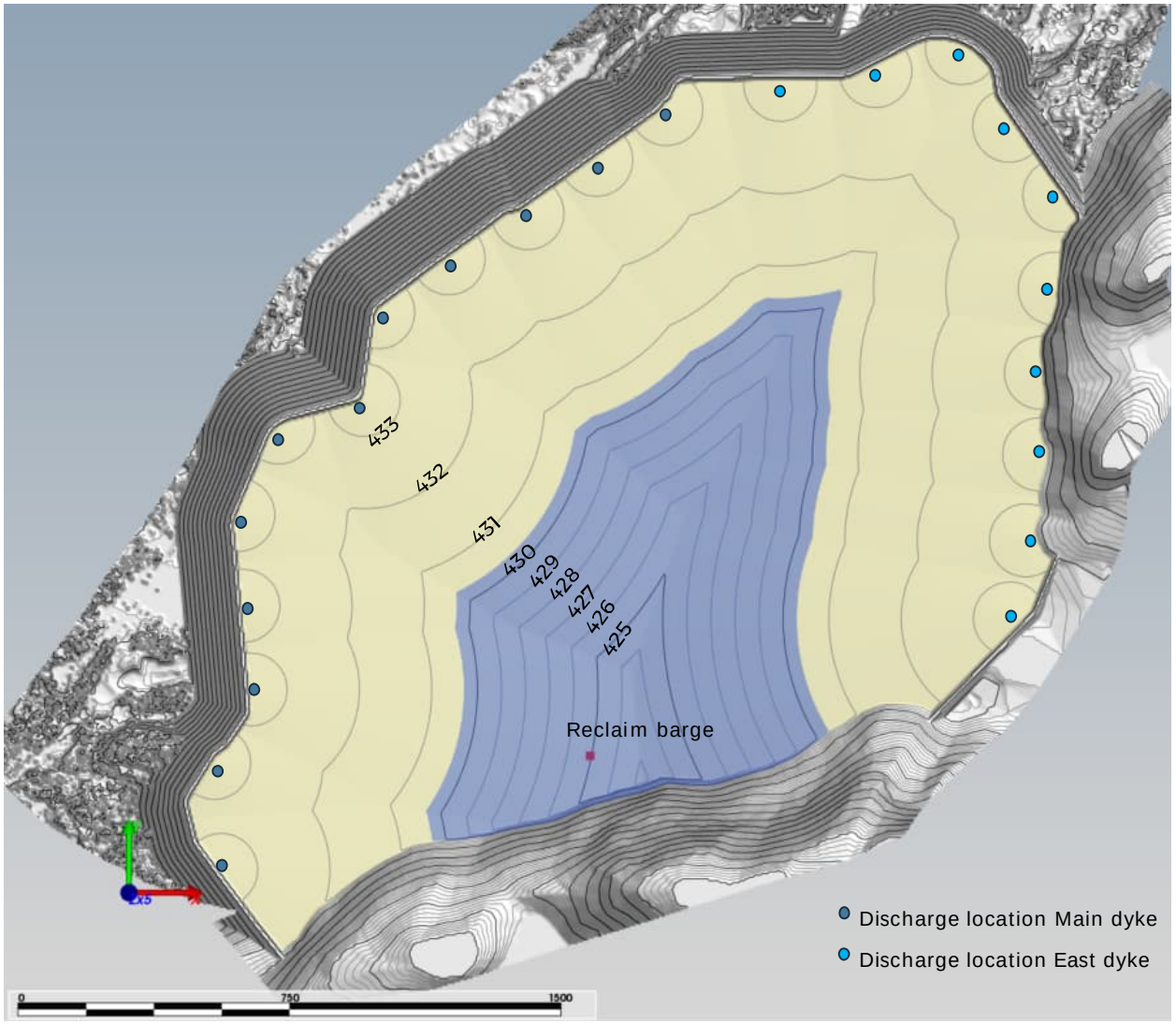
Discharge elevation:

East dyke: 432.1 masl

Main dyke: 431.6 masl

Main Dyke elevation: 433.0-435.0 masl

Pond elevation: 428.8 masl



Production year : 10 (Q1-Q2)

Discharge elevation:

East dyke: 433.5 masl

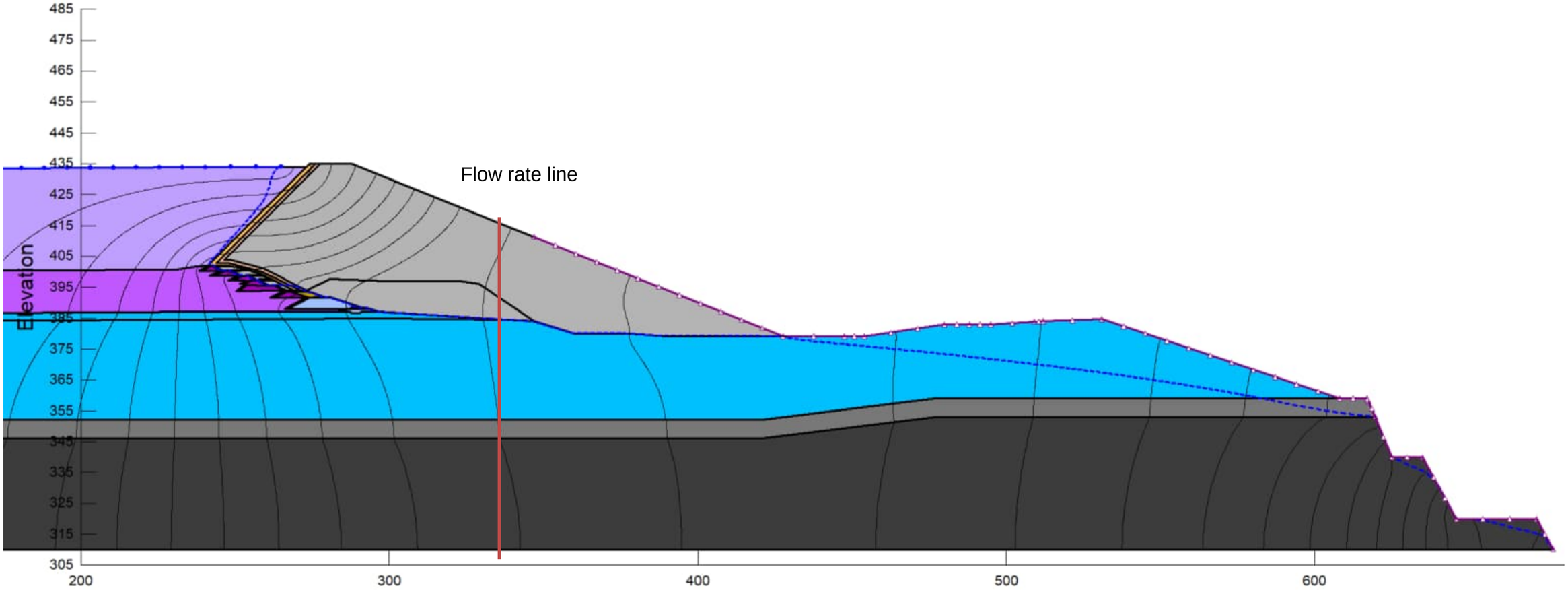
Main dyke: 433.5 masl

Main Dyke elevation: 435.0 masl

Pond elevation: 430.6 masl

APPENDIX F

Seepage Analysis



Color	Name	Hydraulic Material Model	Sat Kx (m/sec)	Ky'/Kx' Ratio
	Bedrock (fresh)	Saturated Only	1e-07	1
	Bedrock (Weathered)	Saturated Only	1e-06	1
	Compacted existing tailings	Saturated / Unsaturated	3e-06	1
	Compacted Till	Saturated / Unsaturated	8e-07	1
	Existing filter	Saturated / Unsaturated	1e-04	1
	Existing tailings	Saturated / Unsaturated	3e-06	1
	Glacial till	Saturated / Unsaturated	8e-07	1
	New filter	Saturated / Unsaturated	1e-04	1
	Sand and gravel	Saturated / Unsaturated	1e-04	1
	Thickened slurry tailings	Saturated / Unsaturated	3e-06	1
	Transition layer	Saturated / Unsaturated	1e-04	1
	Waste rock / Rip rap	Saturated / Unsaturated	1e-01	1

Color	Name	Category	Kind	Parameters
	Seepage face	Hydraulic	Water Rate	Hydraulic head = elevation
	8 m Beach	Hydraulic	Water Total Head	433,959 m

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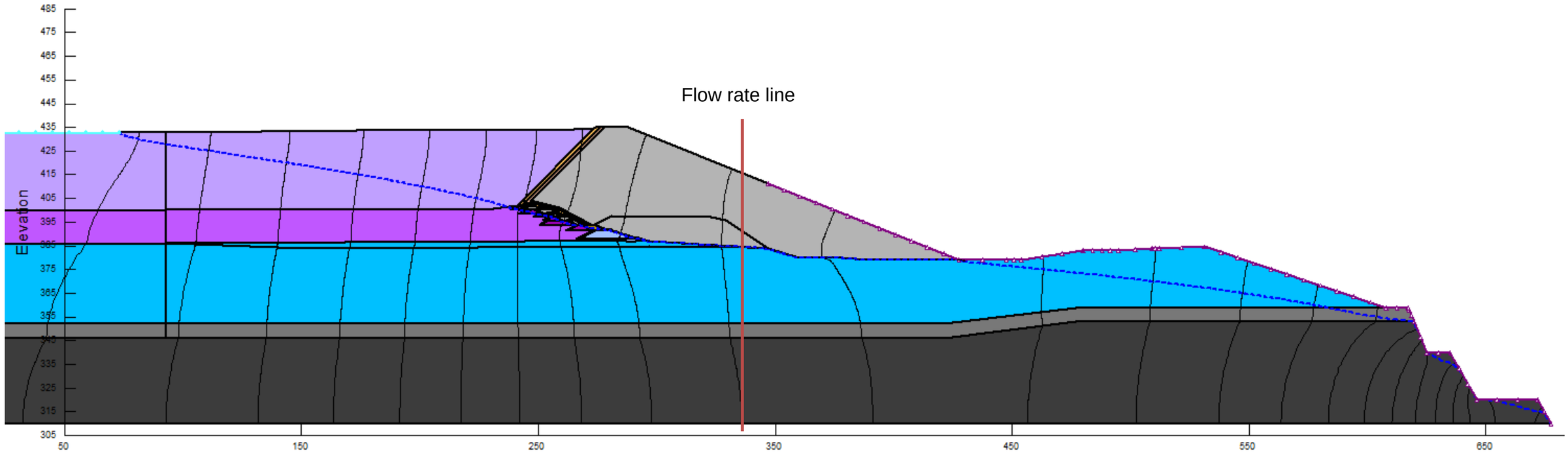
H3H 1P9 Canada

PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION A-A'- 8 METERS BEACH

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-1**

0 25 mm



Color	Name	Hydraulic Material Model	Sat Kx (m/sec)	Ky'/Kx' Ratio
	Bedrock (fresh)	Saturated Only	1e-07	1
	Bedrock (Weathered)	Saturated Only	1e-06	1
	Compacted existing tailings	Saturated / Unsaturated	3e-06	1
	Compacted Till	Saturated / Unsaturated	8e-07	1
	Existing filter	Saturated / Unsaturated	1e-04	1
	Existing tailings	Saturated / Unsaturated	3e-06	1
	Glacial till	Saturated / Unsaturated	8e-07	1
	New filter	Saturated / Unsaturated	1e-04	1
	Sand and gravel	Saturated / Unsaturated	1e-04	1
	Thickened slurry tailings	Saturated / Unsaturated	3e-06	1
	Transition layer	Saturated / Unsaturated	1e-04	1
	Waste rock / Rip rap	Saturated / Unsaturated	1e-01	1

Color	Name	Category	Kind	Parameters
	200 m Beach	Hydraulic	Water Total Head	433 m
	Seepage face	Hydraulic	Water Rate	Hydraulic head = elevation

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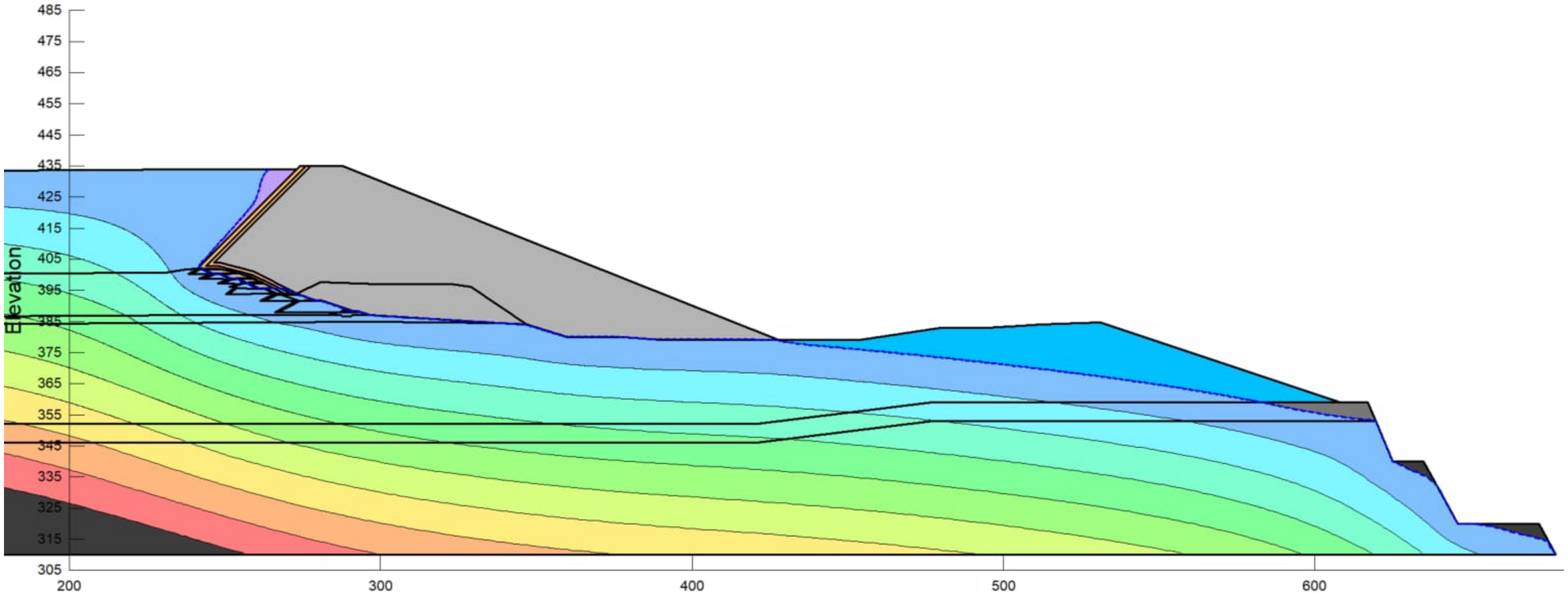
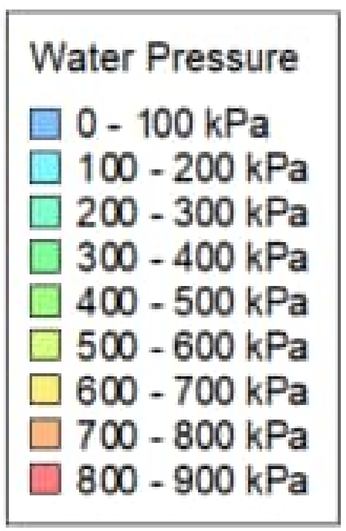
PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION A-A'-200 METERS BEACH

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-2**





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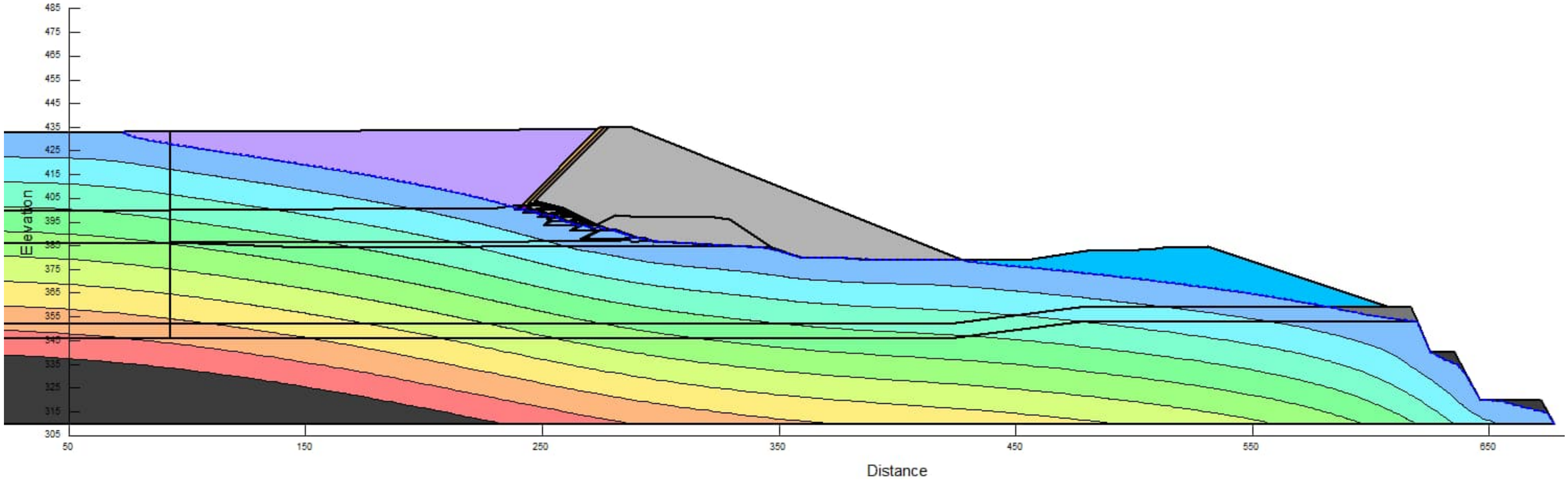
PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION A-A'- 8 METERS BEACH-WATER PRESSURE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-3**

0 25 mm



Water Pressure

- 0 - 100 kPa
- 100 - 200 kPa
- 200 - 300 kPa
- 300 - 400 kPa
- 400 - 500 kPa
- 500 - 600 kPa
- 600 - 700 kPa
- 700 - 800 kPa
- 800 - 900 kPa

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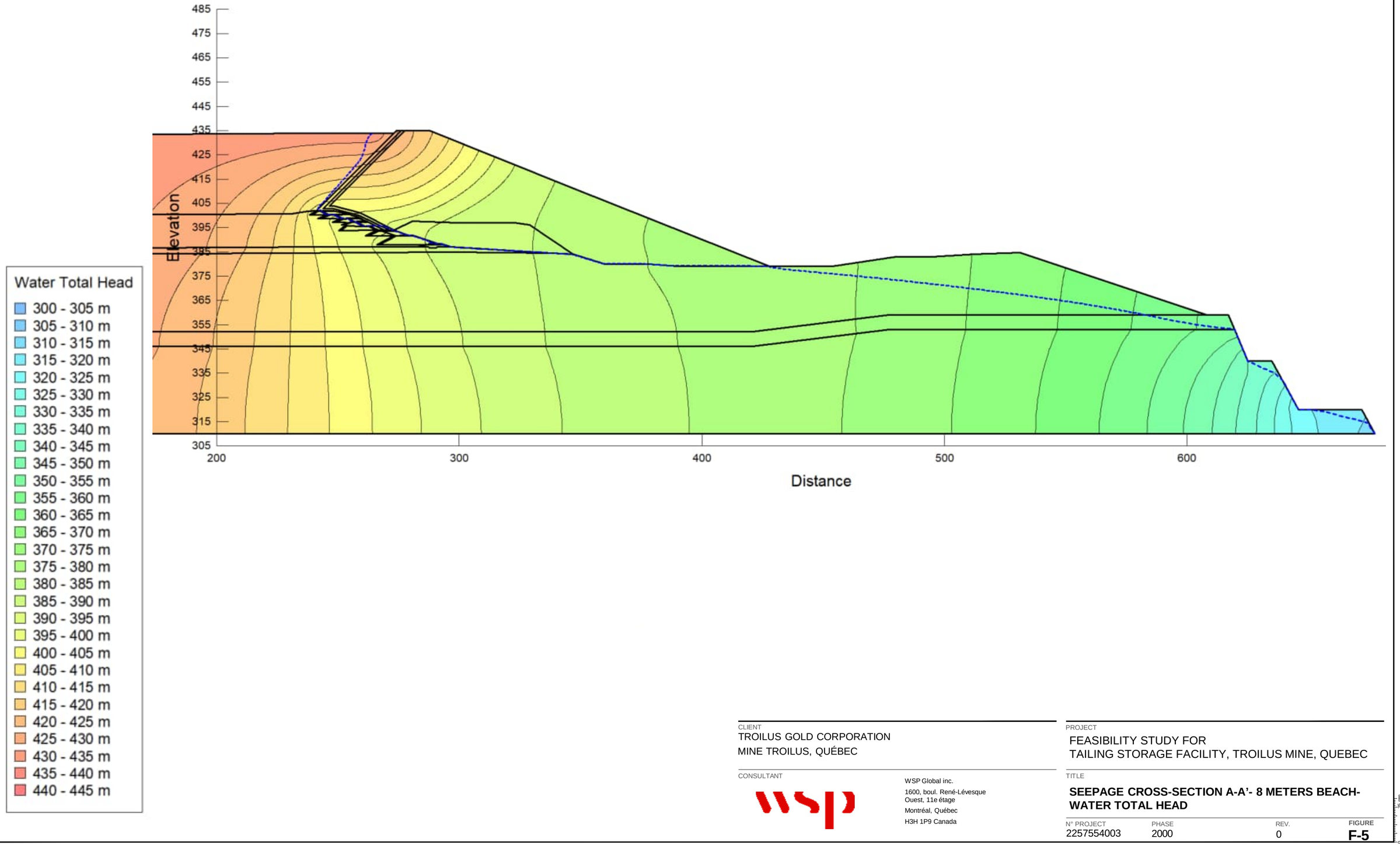
PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION A-A'- 200 METERS BEACH-WATER PRESSURE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-4**

0 25 m



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PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION A-A'- 8 METERS BEACH-WATER TOTAL HEAD

N° PROJECT	PHASE	REV.	FIGURE
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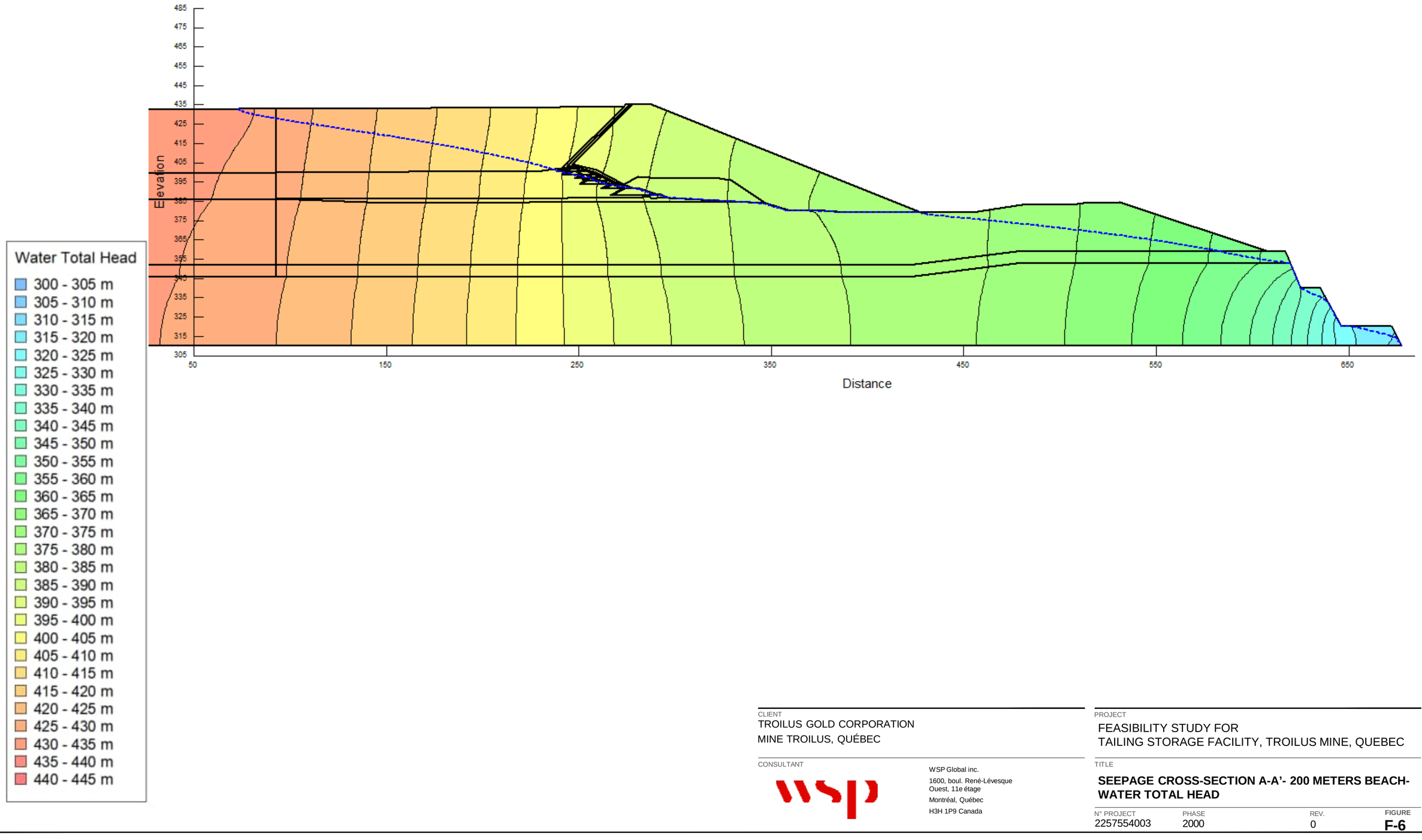
0 25 mm



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TROILUS GOLD CORPORATION
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CONSULTANT

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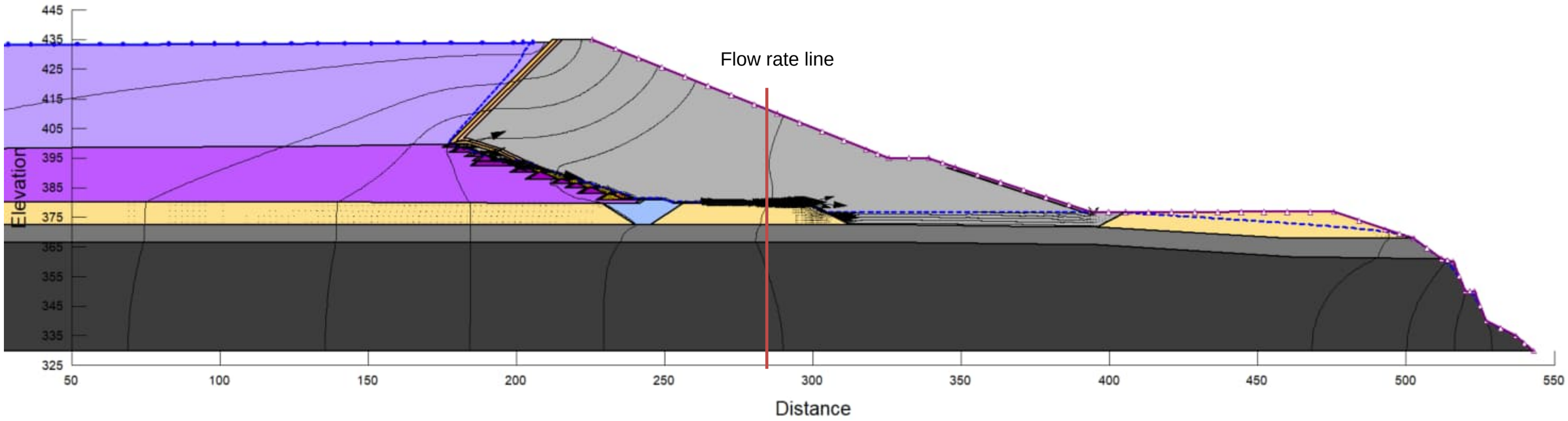
1600, boul. René-Lévesque Ouest, 11e étage
Montréal, Québec
H3H 1P9 Canada

PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION A-A'- 200 METERS BEACH-WATER TOTAL HEAD

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-6**

0 25 mm



Color	Name	Hydraulic Material Model	Sat Kx (m/sec)	Ky'/Kx' Ratio
	Alluvial	Saturated / Unsaturated	1e-04	1
	Bedrock (fresh)	Saturated Only	1e-07	1
	Bedrock (Weathered)	Saturated Only	1e-06	1
	Compacted existing tailings	Saturated / Unsaturated	3e-06	1
	Compacted Till	Saturated / Unsaturated	8e-07	1
	Existing filter	Saturated / Unsaturated	1e-04	1
	Existing tailings	Saturated / Unsaturated	3e-06	1
	New filter	Saturated / Unsaturated	1e-04	1
	Sand and gravel	Saturated / Unsaturated	1e-04	1
	Thickened slurry tailings	Saturated / Unsaturated	3e-06	1
	Transition layer	Saturated / Unsaturated	1e-04	1
	Waste rock / Rip rap	Saturated / Unsaturated	1e-01	1

Color	Name	Category	Kind	Parameters
	Seepage face	Hydraulic	Water Rate	Hydraulic head = elevation
	8 m Beach	Hydraulic	Water Total Head	433,95036 m

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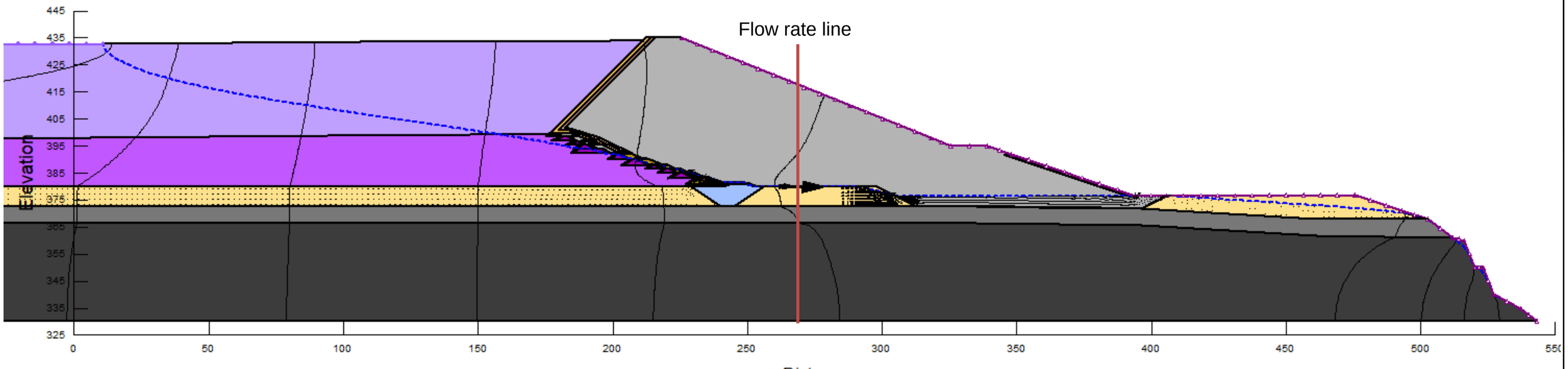
PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION B-B'- 8 METERS BEACH

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-7**

0 25 mm



Color	Name	Hydraulic Material Model	Sat Kx (m/sec)	Ky'/Kx' Ratio
	Alluvial	Saturated / Unsaturated	1e-04	1
	Bedrock (fresh)	Saturated Only	1e-07	1
	Bedrock (Weathered)	Saturated Only	1e-06	1
	Compacted existing tailings	Saturated / Unsaturated	3e-06	1
	Compacted Till	Saturated / Unsaturated	8e-07	1
	Existing filter	Saturated / Unsaturated	1e-04	1
	Existing tailings	Saturated / Unsaturated	3e-06	1
	New filter	Saturated / Unsaturated	1e-04	1
	Sand and gravel	Saturated / Unsaturated	1e-04	1
	Thickened slurry tailings	Saturated / Unsaturated	3e-06	1
	Transition layer	Saturated / Unsaturated	1e-04	1
	Waste rock / Rip rap	Saturated / Unsaturated	1e-01	1

Color	Name	Category	Kind	Parameters
	200 m Beach	Hydraulic	Water Total Head	433 m
	Seepage face	Hydraulic	Water Rate	Hydraulic head = elevation

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FEASIBILITY STUDY FOR
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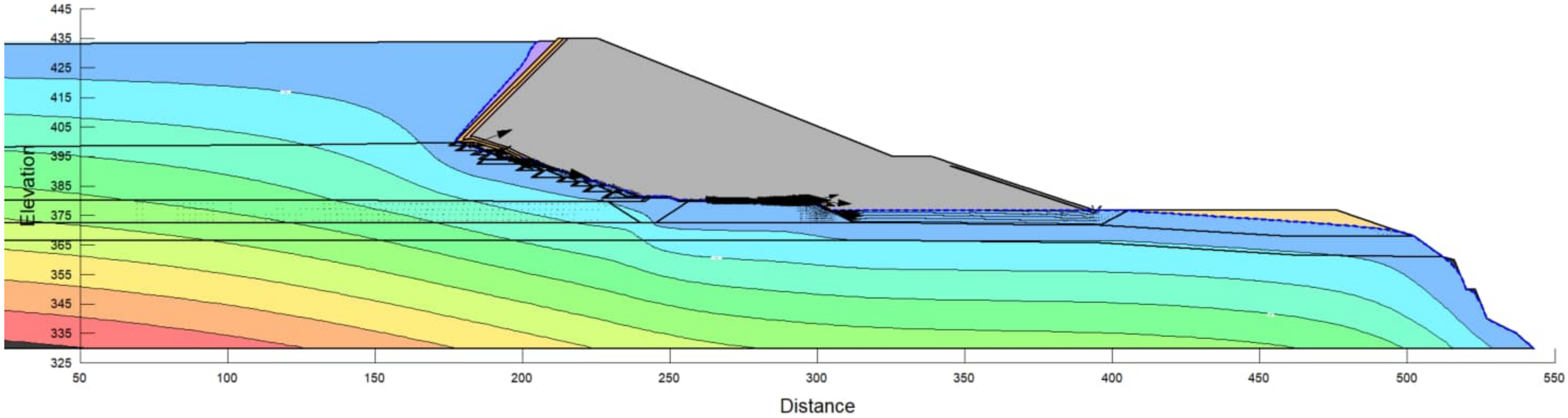
TITLE
SEEPAGE CROSS-SECTION B-B'- 200 METERS BEACH

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-8**

0 25 mm



Water Pressure

- 0 - 100 kPa
- 100 - 200 kPa
- 200 - 300 kPa
- 300 - 400 kPa
- 400 - 500 kPa
- 500 - 600 kPa
- 600 - 700 kPa
- 700 - 800 kPa
- 800 - 900 kPa

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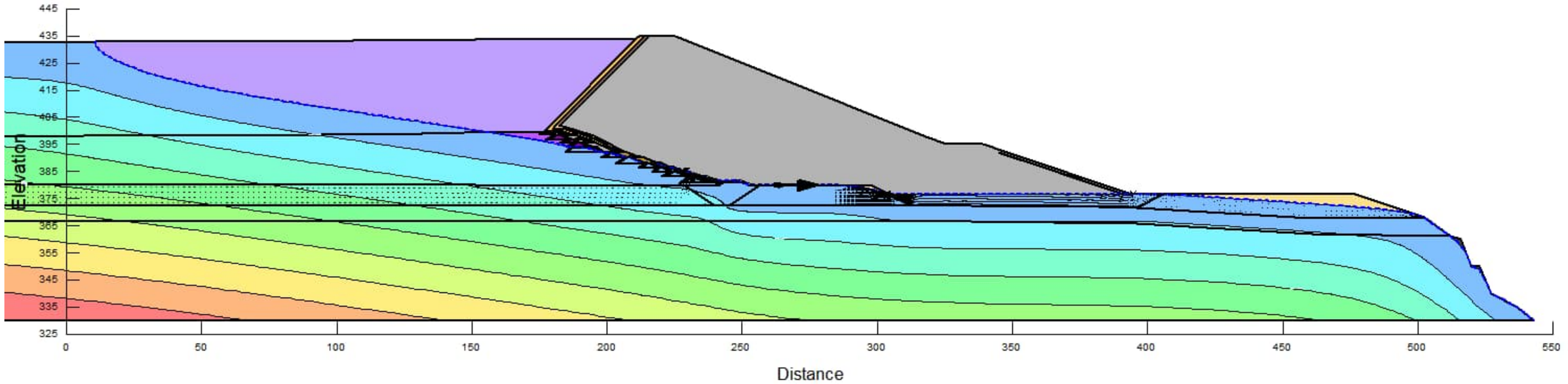
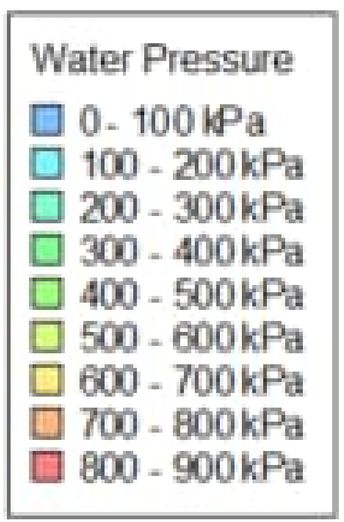
PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION B-B'- 8 METERS BEACH-WATER PRESSURE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-9**

0 25 mm





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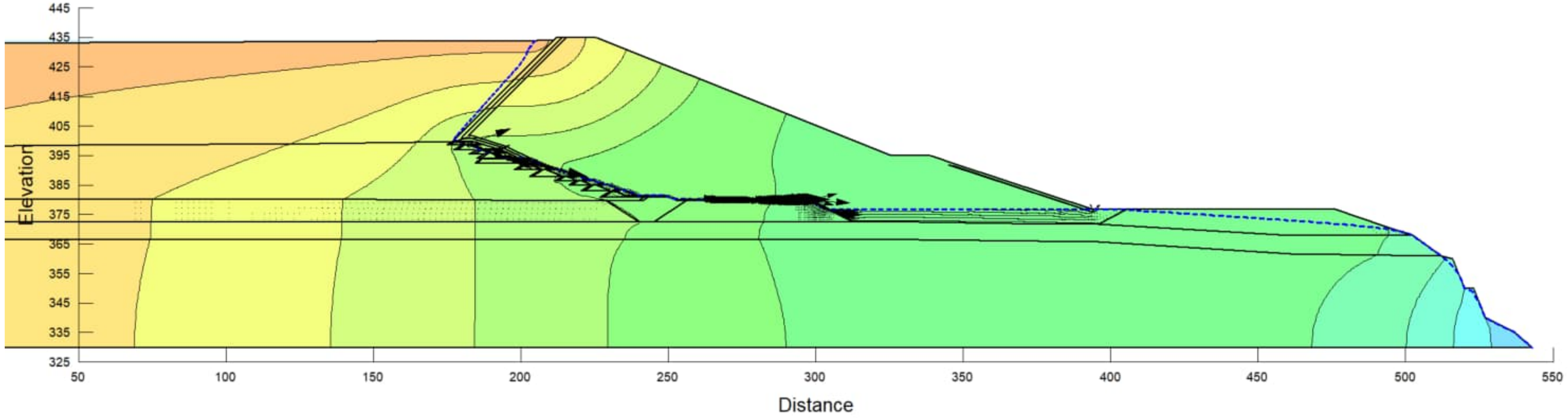
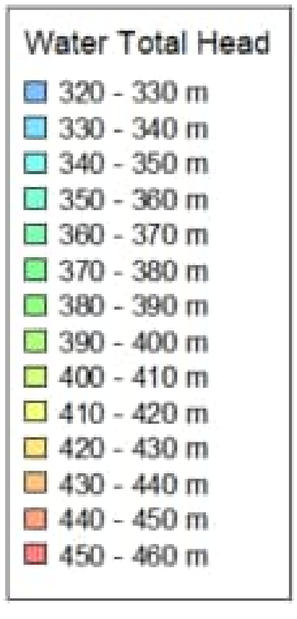
TITLE
SEEPAGE CROSS-SECTION B-B'- 200 METERS BEACH-WATER PRESSURE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-10**

0 25 mm





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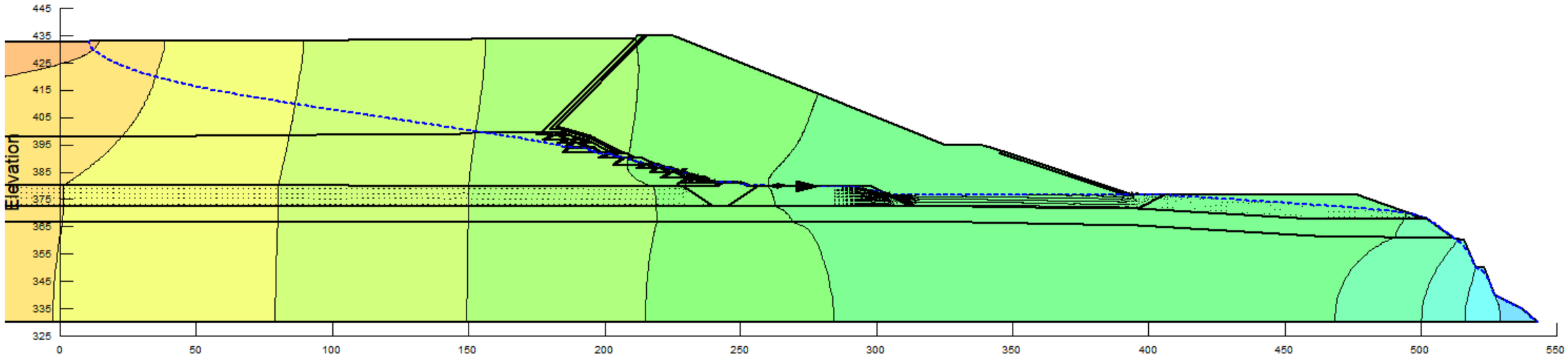
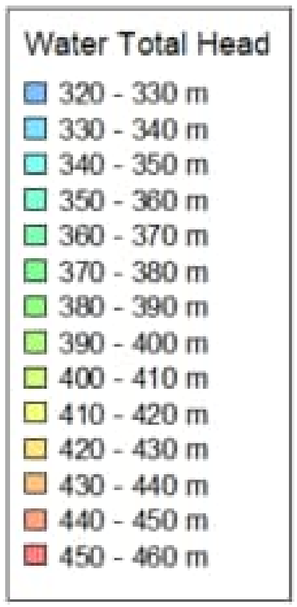
PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION B-B'- 8 METERS BEACH-TOTAL WATER HEAD

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-11**

0 25 mm





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FEASIBILITY STUDY FOR
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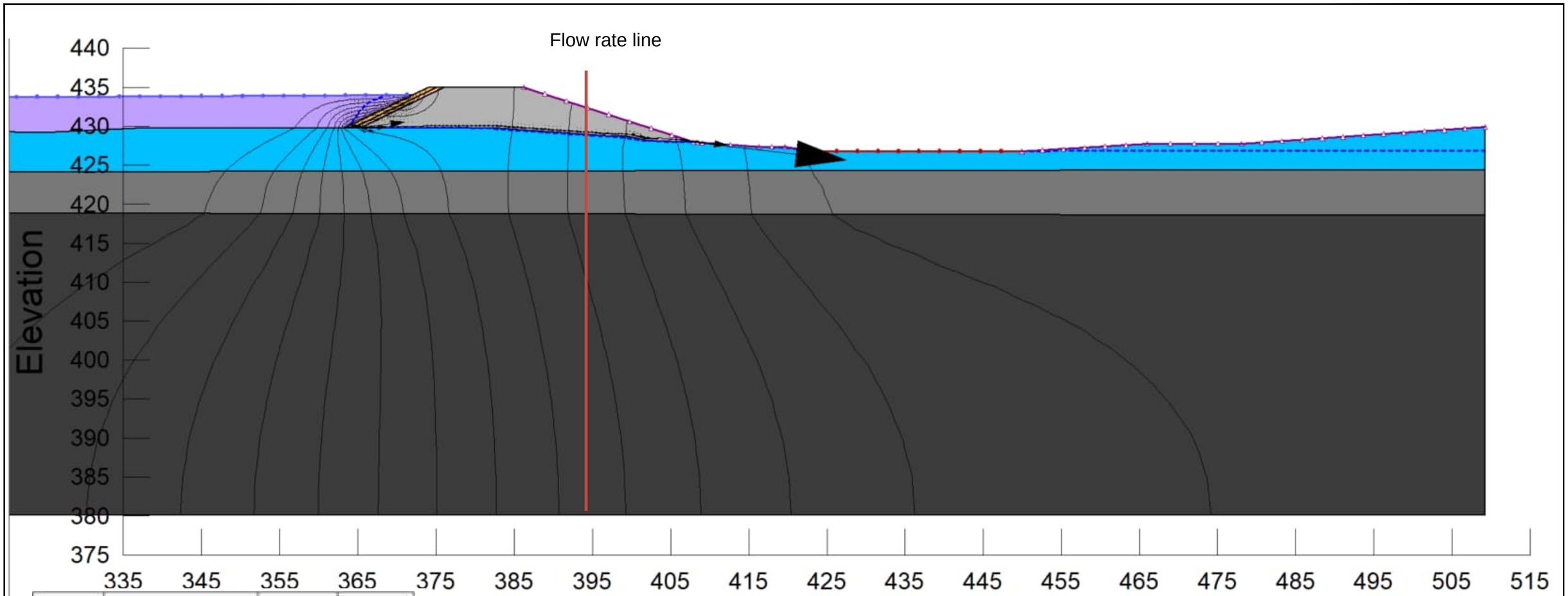
TITLE
SEEPAGE CROSS-SECTION B-B'- 200 METERS BEACH-TOTAL WATER HEAD

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-12**

0 25 mm



Color	Name	Sat Kx (m/sec)	Ky'/Kx' Ratio
	Bedrock (fresh)	1e-07	1
	Bedrock (Weathered)	1e-06	1
	Glacial till	8e-07	1
	New filter	1e-04	1
	Thickened slurry tailings	3e-06	1
	Transition layer	1e-04	1
	Waste rock / Rip rap	1e-01	1

Color	Name	Category	Kind	Parameters
	Seepage face	Hydraulic	Water Rate	Hydraulic head = elevation
	8 m Beach	Hydraulic	Water Total Head	433,99697 m
	Zero Pressure	Hydraulic	Water Pressure Head	0 m

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PROJECT
FEASIBILITY STUDY FOR
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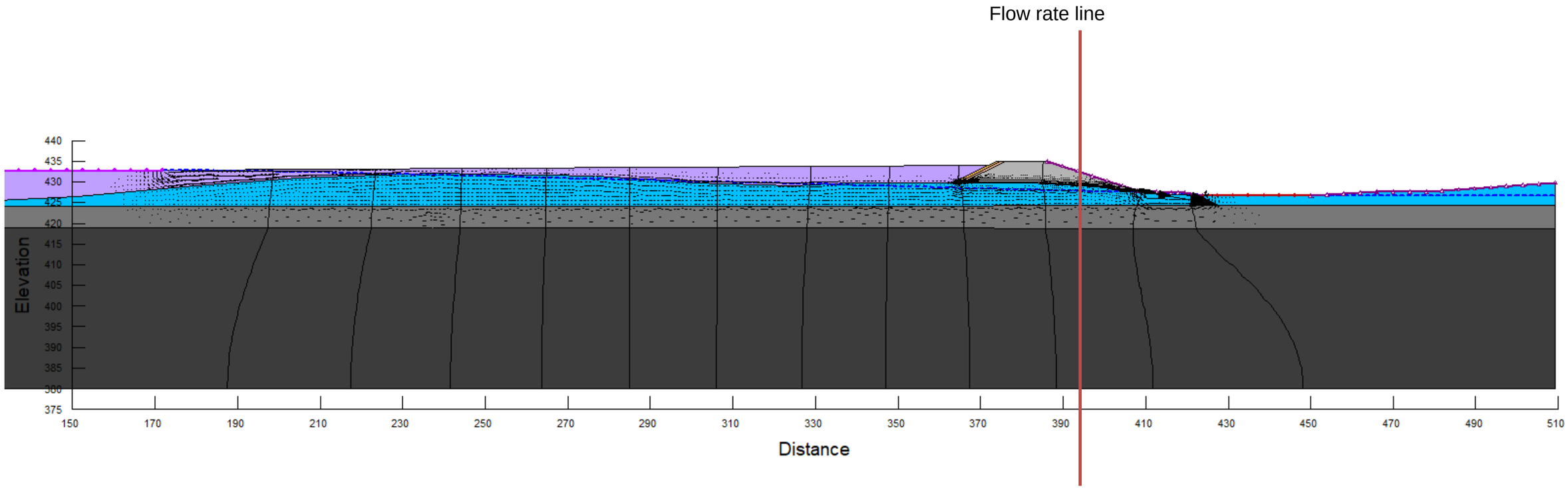
TITLE
SEEPAGE CROSS-SECTION C-C'- 0 METERS BEACH

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-13**



Color	Name	Sat Kx (m/sec)	Ky'/Kx' Ratio
	Bedrock (fresh)	1e-07	1
	Bedrock (Weathered)	1e-06	1
	Glacial till	8e-07	1
	New filter	1e-04	1
	Thickened slurry tailings	3e-06	1
	Transition layer	1e-04	1
	Waste rock / Rip rap	1e-01	1

Color	Name	Category	Kind	Parameters
	200 m beach	Hydraulic	Water Total Head	433 m
	Seepage face	Hydraulic	Water Rate	Hydraulic head = elevation
	Zero Pressure	Hydraulic	Water Pressure Head	0 m

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PROJECT
FEASIBILITY STUDY FOR
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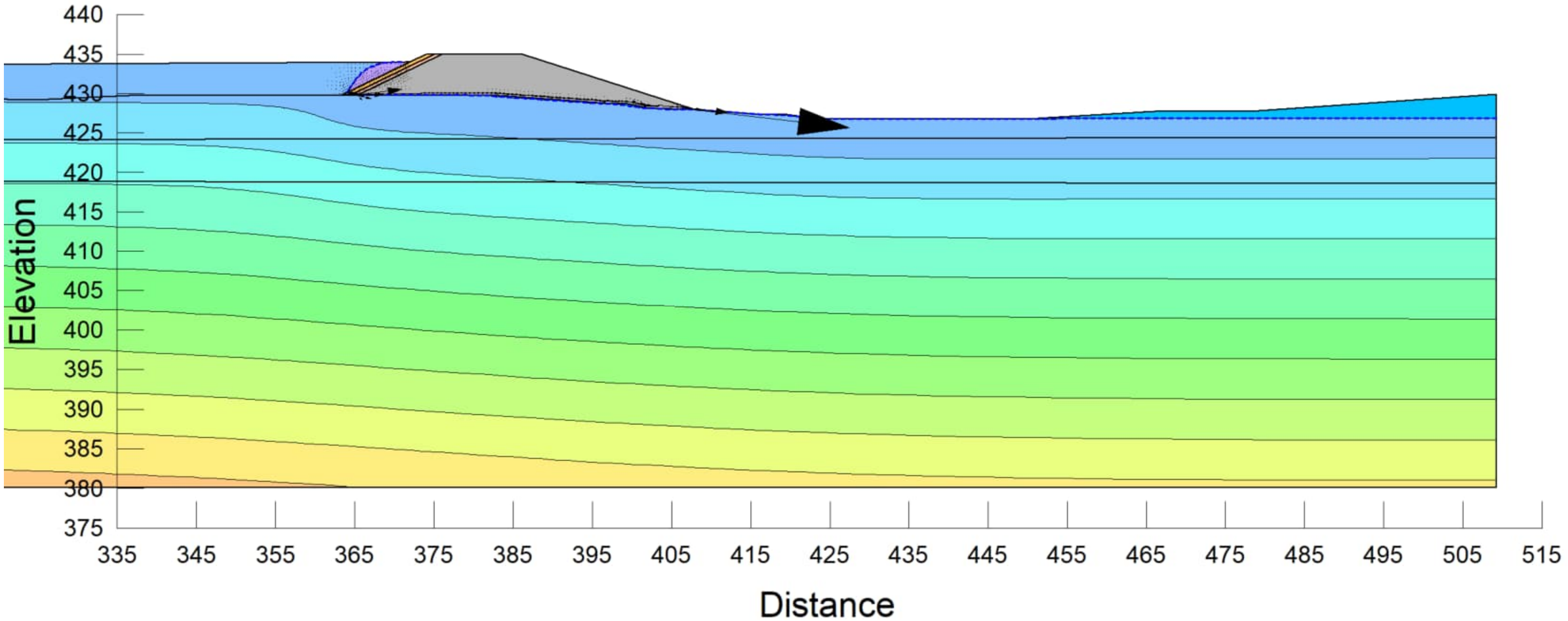
TITLE
SEEPAGE CROSS-SECTION C-C'- 200 METERS BEACH

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-14**

0 5 10 15 20 25 m



Water Pressure

- 0 - 50 kPa
- 50 - 100 kPa
- 100 - 150 kPa
- 150 - 200 kPa
- 200 - 250 kPa
- 250 - 300 kPa
- 300 - 350 kPa
- 350 - 400 kPa
- 400 - 450 kPa
- 450 - 500 kPa
- 500 - 550 kPa
- 550 - 600 kPa
- 600 - 650 kPa

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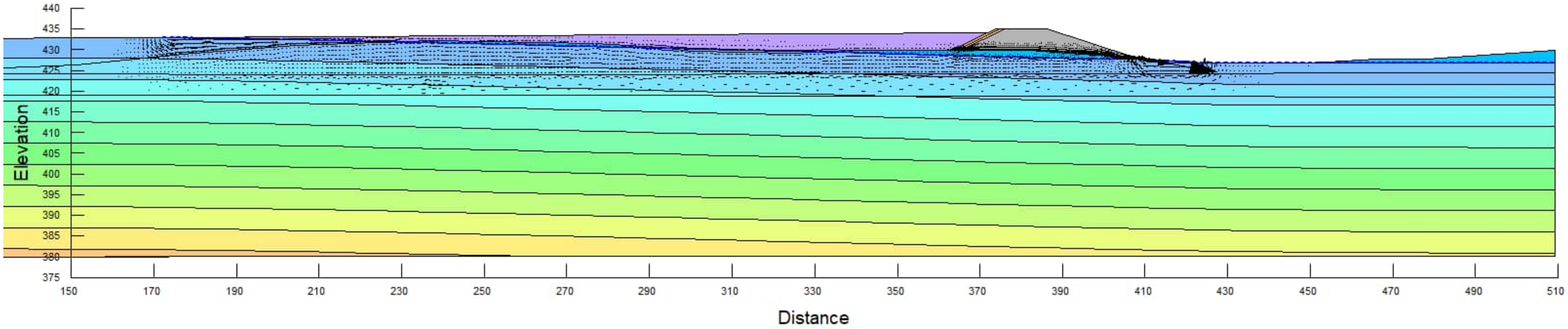
PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION C-C'- 8 METERS BEACH-WATER RESSURE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-15**

0 25 mm



Water Pressure

- 0 - 50 kPa
- 50 - 100 kPa
- 100 - 150 kPa
- 150 - 200 kPa
- 200 - 250 kPa
- 250 - 300 kPa
- 300 - 350 kPa
- 350 - 400 kPa
- 400 - 450 kPa
- 450 - 500 kPa
- 500 - 550 kPa
- 550 - 600 kPa
- 600 - 650 kPa

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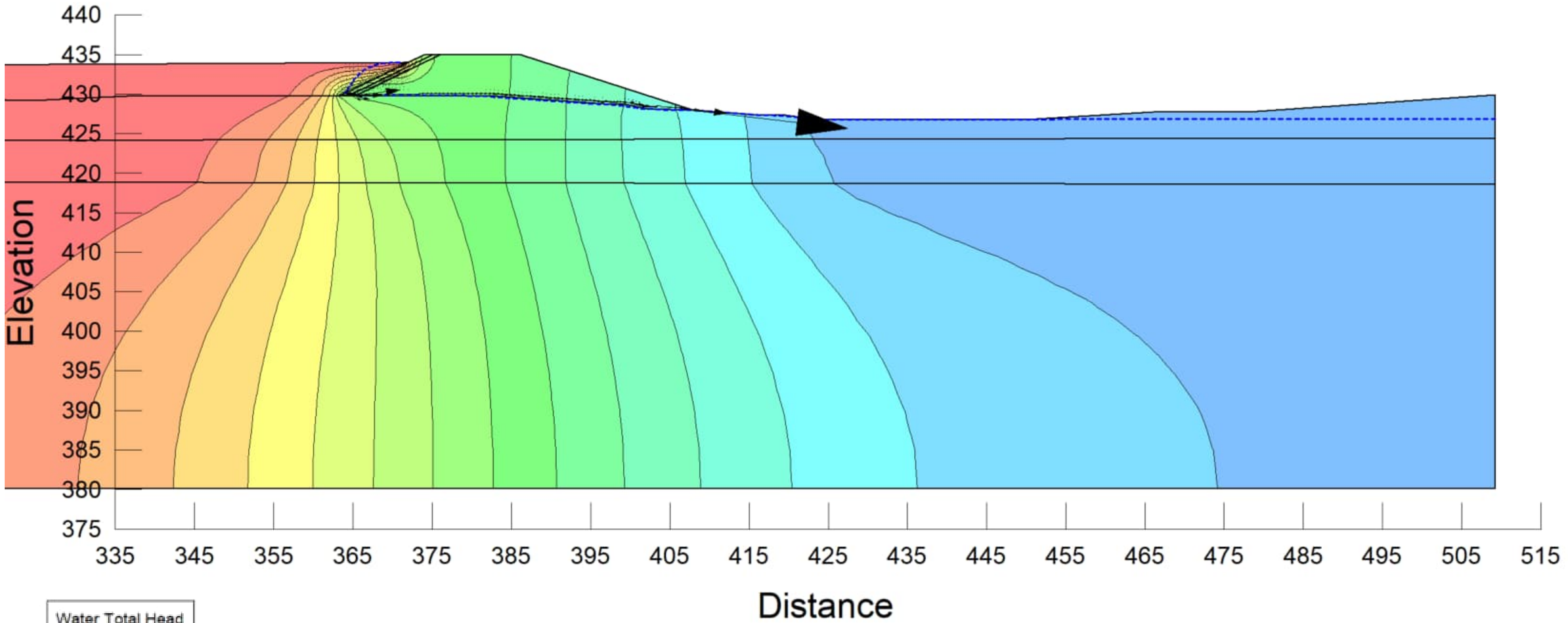
TITLE
SEEPAGE CROSS-SECTION C-C'- 200 METERS BEACH-WATER RESSURE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-16**

0 25 m



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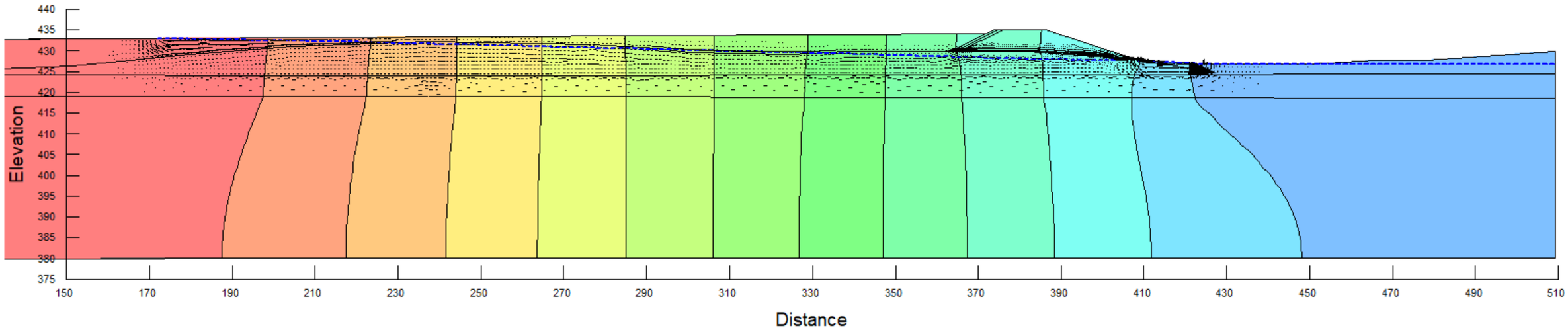
PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION C-C'- 8 METERS BEACH-WATER TOTAL HEAD

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-17**

0 25 mm



Water Total Head

- 426,5 - 427 m
- 427 - 427,5 m
- 427,5 - 428 m
- 428 - 428,5 m
- 428,5 - 429 m
- 429 - 429,5 m
- 429,5 - 430 m
- 430 - 430,5 m
- 430,5 - 431 m
- 431 - 431,5 m
- 431,5 - 432 m
- 432 - 432,5 m
- 432,5 - 433 m
- 433 - 433,5 m
- 433,5 - 434 m

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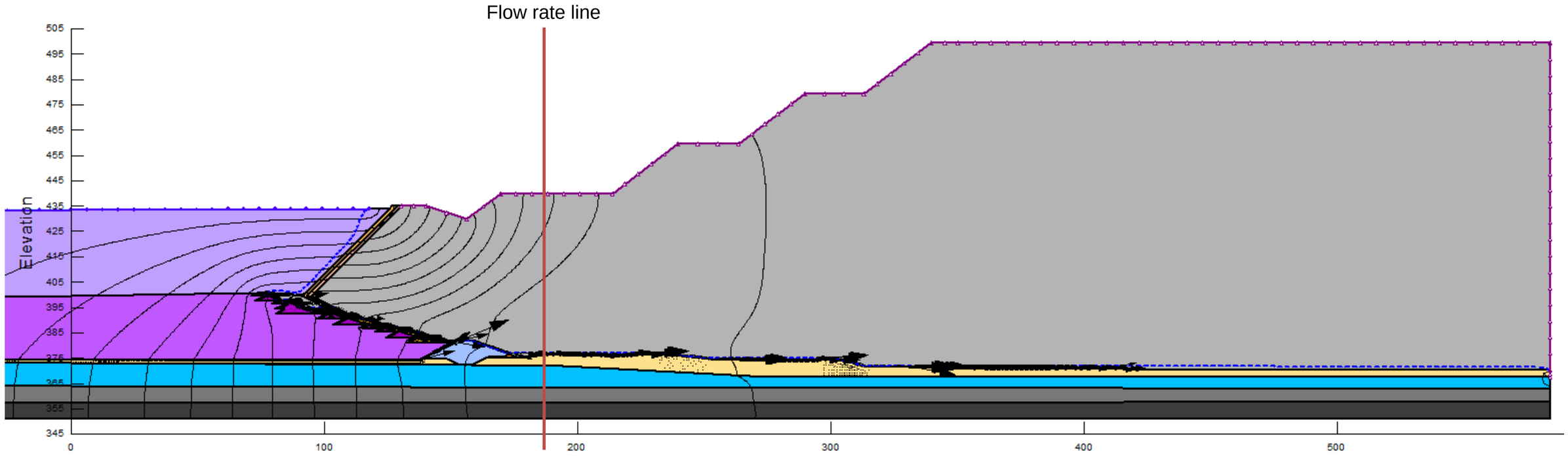
TITLE
SEEPAGE CROSS-SECTION C-C'- 200 METERS BEACH-WATER TOTAL HEAD

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-18**

0 25 m



Color	Name	Sat Kx (m/sec)	Ky'/Kx' Ratio
	Alluvial	1e-04	1
	Bedrock (fresh)	1e-07	1
	Bedrock (Weathered)	1e-06	1
	Compacted existing tailings	3e-06	1
	Compacted Till	8e-07	1
	Existing filter	1e-04	1
	Existing tailings	3e-06	1
	Glacial till	8e-07	1
	New filter	1e-04	1
	Sand and gravel	1e-04	1
	Thickened slurry tailings	3e-06	1
	Transition layer	1e-04	1
	Waste rock / Rip rap	1e-01	1

Color	Name	Category	Kind	Parameters
	Seepage face	Hydraulic	Water Rate	Hydraulic head = elevation
	8 m Beach	Hydraulic	Water Total Head	433,95996 m

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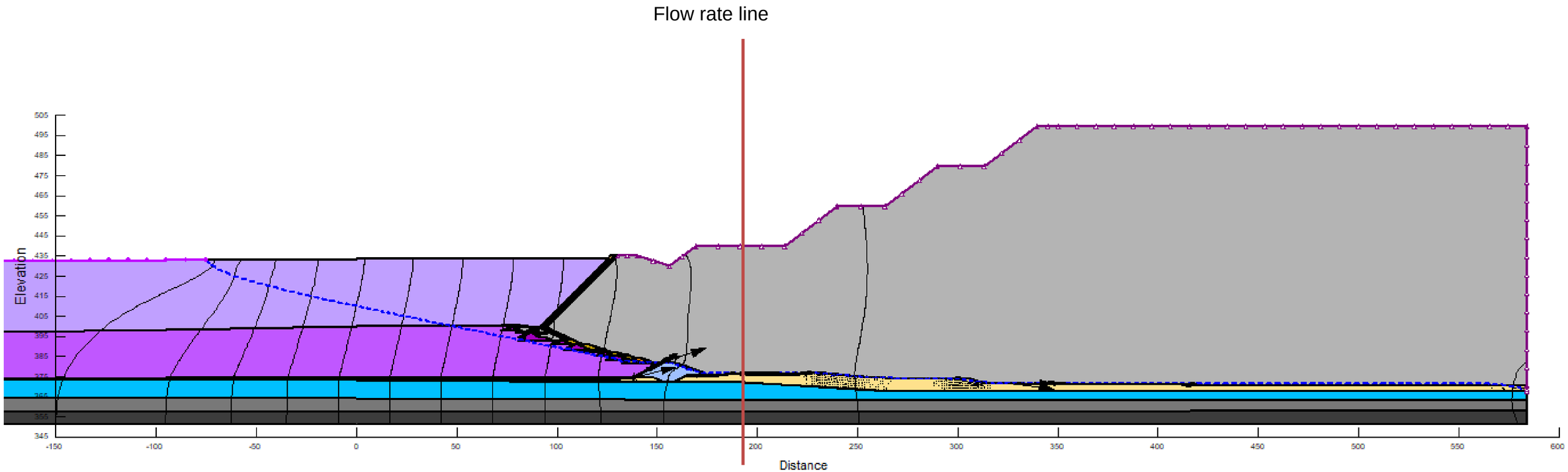
PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SEEPAGE CROSS-SECTION D-D'- 8 METERS BEACH

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-19**

0 5 10 15 20 25 m



Color	Name	Sat Kx (m/sec)	Ky'/Kx' Ratio
	Alluvial	1e-04	1
	Bedrock (fresh)	1e-07	1
	Bedrock (Weathered)	1e-06	1
	Compacted existing tailings	3e-06	1
	Compacted Till	8e-07	1
	Existing filter	1e-04	1
	Existing tailings	3e-06	1
	Glacial till	8e-07	1
	New filter	1e-04	1
	Sand and gravel	1e-04	1
	Thickened slurry tailings	3e-06	1
	Transition layer	1e-04	1
	Waste rock / Rip rap	1e-01	1

Color	Name	Category	Kind	Parameters
	200 m Beach	Hydraulic	Water Total Head	433 m
	Seepage face	Hydraulic	Water Rate	Hydraulic head = elevation

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PROJECT
FEASIBILITY STUDY FOR
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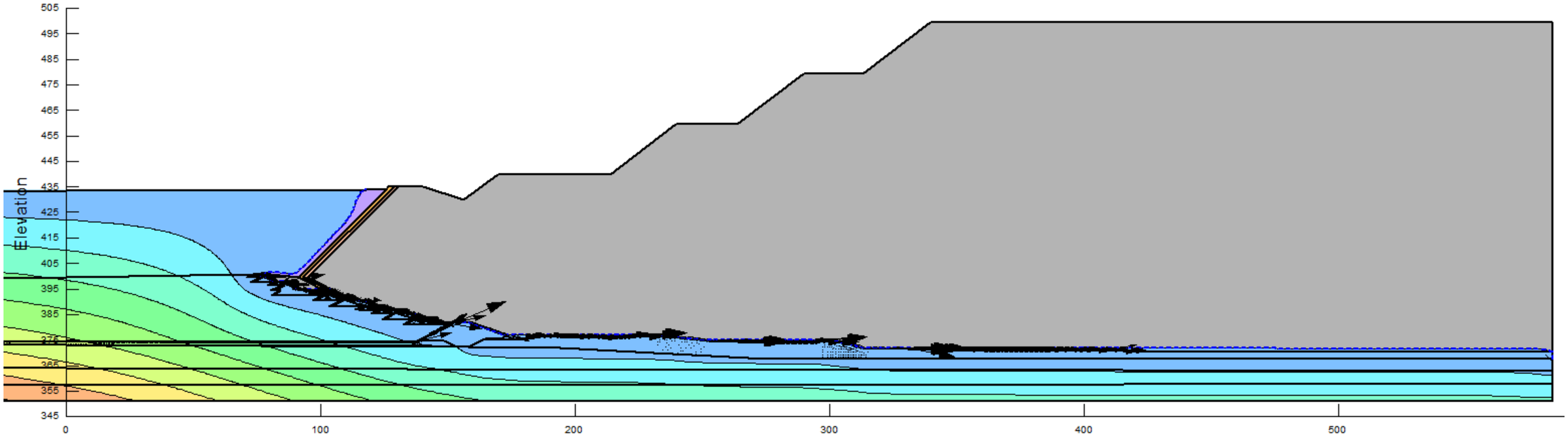
TITLE
SEEPAGE CROSS-SECTION D-D'- 200 METERS BEACH

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-20**

0 mm 25 mm



Water Pressure

- 0 - 90 kPa
- 90 - 180 kPa
- 180 - 270 kPa
- 270 - 360 kPa
- 360 - 450 kPa
- 450 - 540 kPa
- 540 - 630 kPa
- 630 - 720 kPa
- 720 - 810 kPa

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PROJECT
FEASIBILITY STUDY FOR
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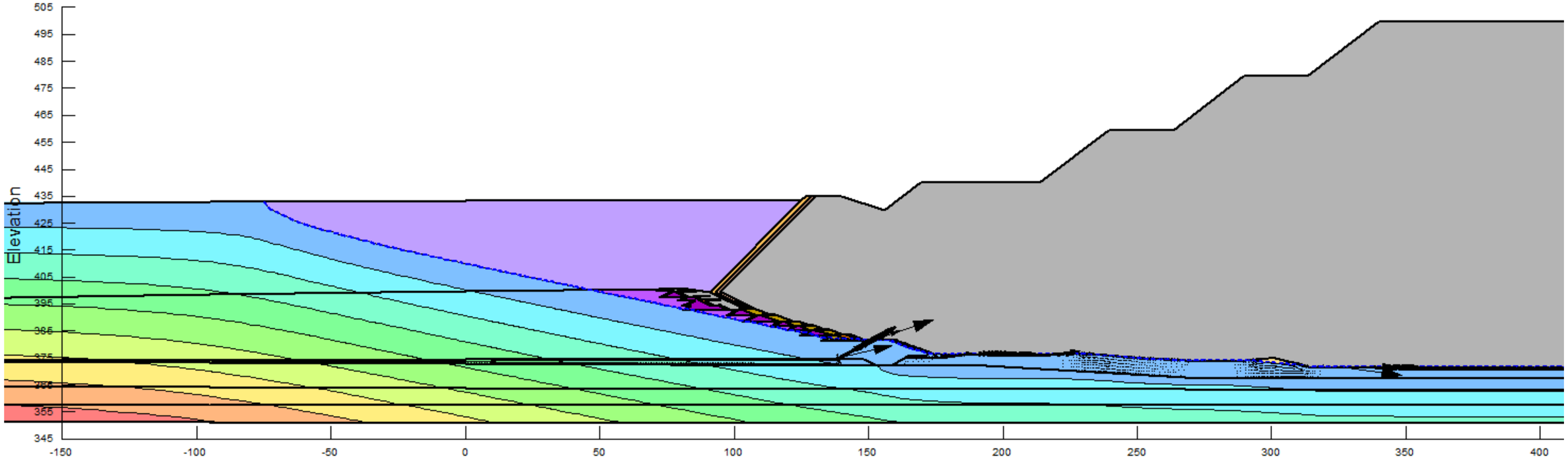
TITLE
SEEPAGE CROSS-SECTION D-D'- 8 METERS BEACH-WATER PRESSURE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-21**

0 25 mm



Water Pressure

- 0 - 90 kPa
- 90 - 180 kPa
- 180 - 270 kPa
- 270 - 360 kPa
- 360 - 450 kPa
- 450 - 540 kPa
- 540 - 630 kPa
- 630 - 720 kPa
- 720 - 810 kPa

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PROJECT
FEASIBILITY STUDY FOR
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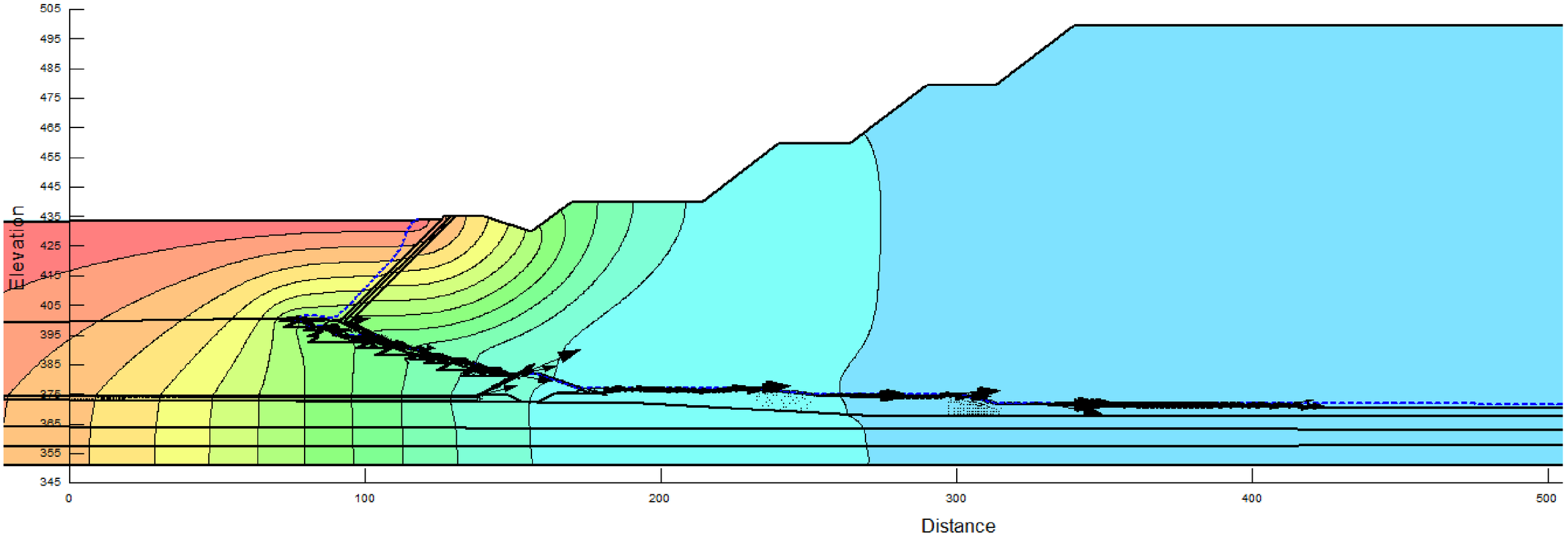
TITLE
SEEPAGE CROSS-SECTION D-D'- 200 METERS BEACH-WATER PRESSURE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-22**

0 25 mm



Water Total Head

- 365 - 370 m
- 370 - 375 m
- 375 - 380 m
- 380 - 385 m
- 385 - 390 m
- 390 - 395 m
- 395 - 400 m
- 400 - 405 m
- 405 - 410 m
- 410 - 415 m
- 415 - 420 m
- 420 - 425 m
- 425 - 430 m
- 430 - 435 m

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PROJECT
FEASIBILITY STUDY FOR
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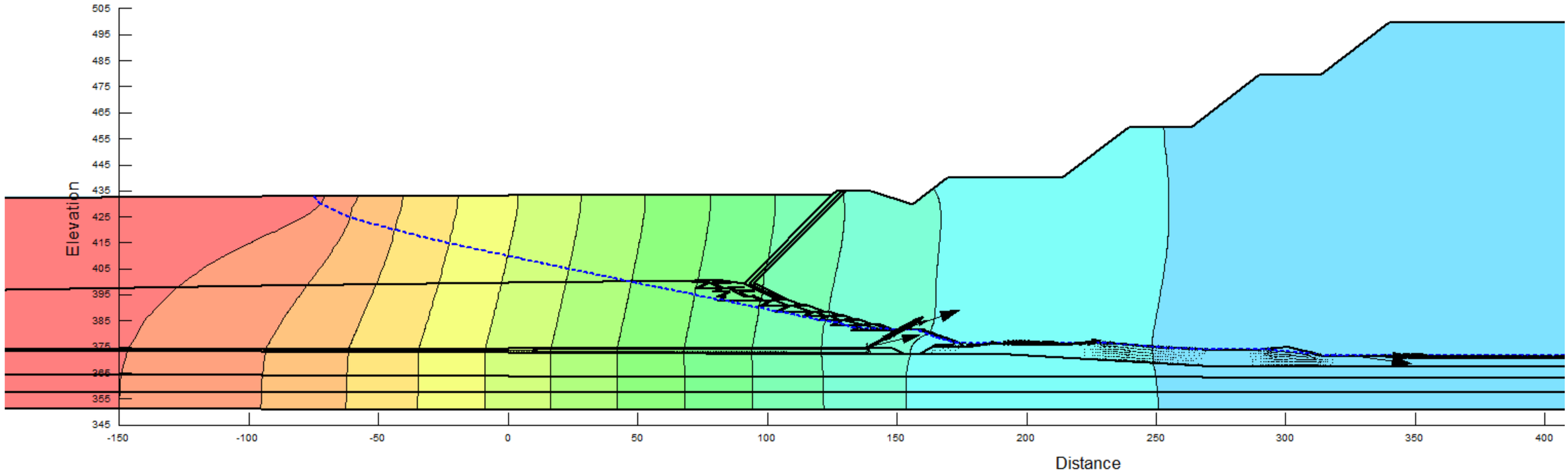
TITLE
SEEPAGE CROSS-SECTION D-D'- 8 METERS BEACH-WATER TOTAL HEAD

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-23**

0 25 mm



Water Total Head

- 365 - 370 m
- 370 - 375 m
- 375 - 380 m
- 380 - 385 m
- 385 - 390 m
- 390 - 395 m
- 395 - 400 m
- 400 - 405 m
- 405 - 410 m
- 410 - 415 m
- 415 - 420 m
- 420 - 425 m
- 425 - 430 m
- 430 - 435 m

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FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

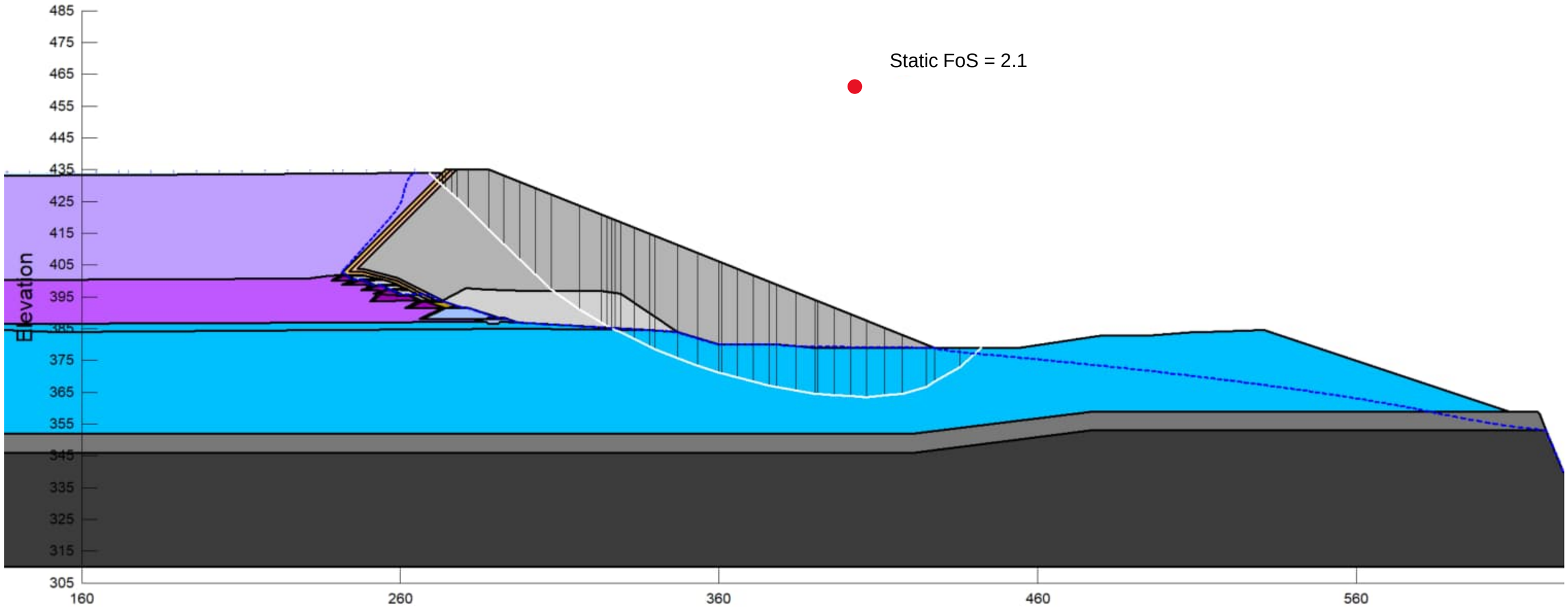
TITLE
SEEPAGE CROSS-SECTION D-D'- 200 METERS BEACH-WATER TOTAL HEAD

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**F-24**

0 25 mm

APPENDIX G

Stability Modelling



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	Glacial till	Mohr-Coulomb	20,5		35	
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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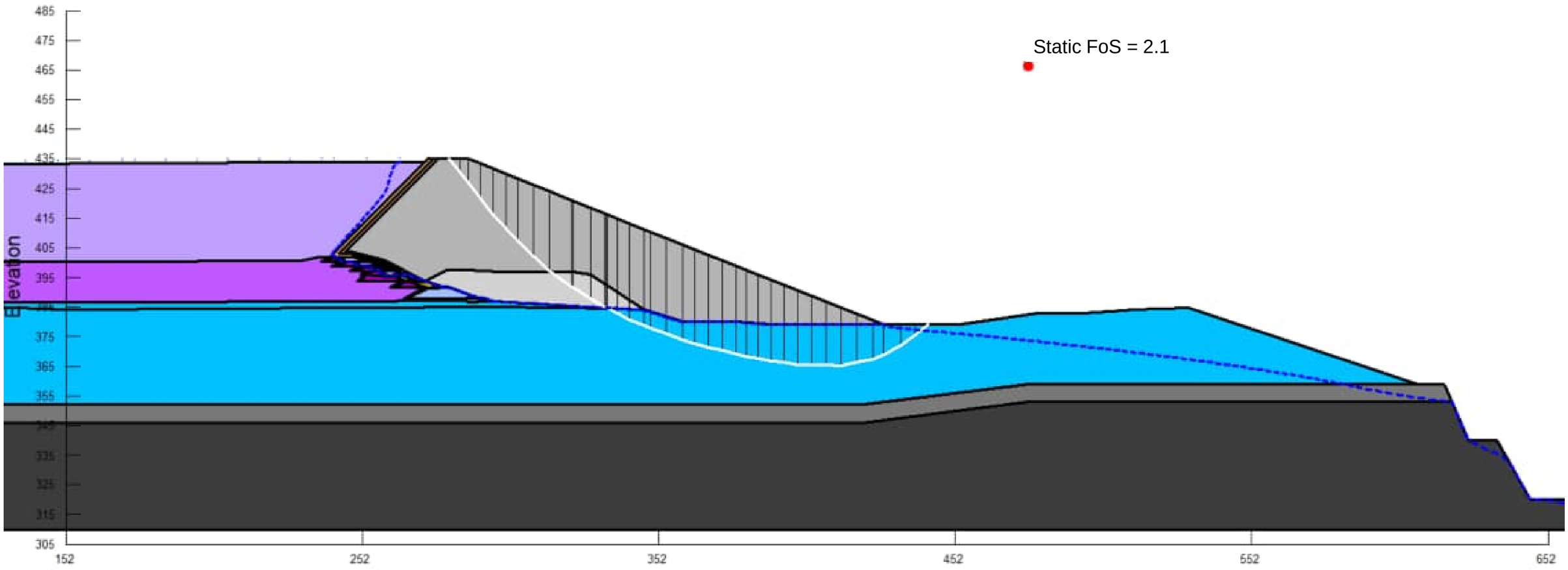
TITLE
SECTION A-A' –STATIC FULL BREACH FAILURE SURFACE IN TAILINGS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-1**

0 5 10 15 20 25 m



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	Glacial till	Mohr-Coulomb	20,5		35	
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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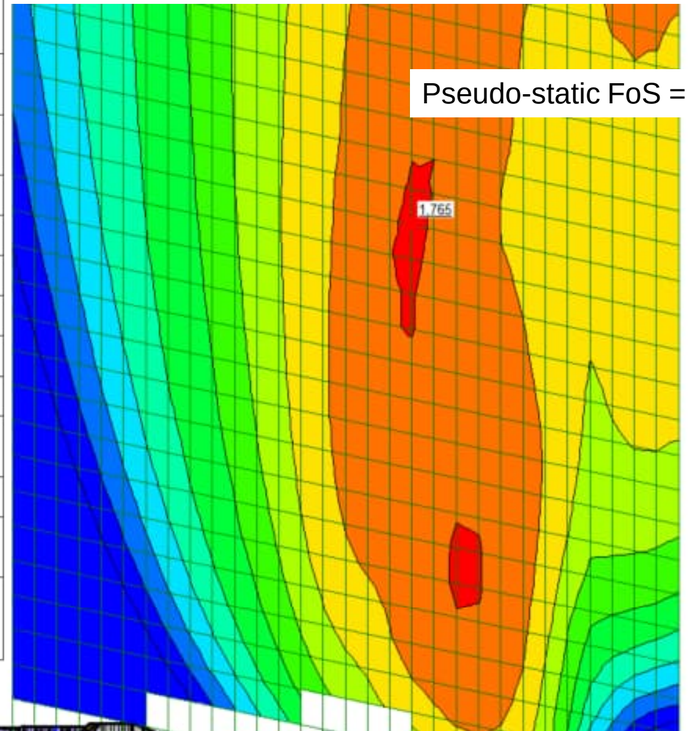
TITLE
SECTION A-A' –STATIC FULL BREACH FAILURE SURFACE IN DYKE

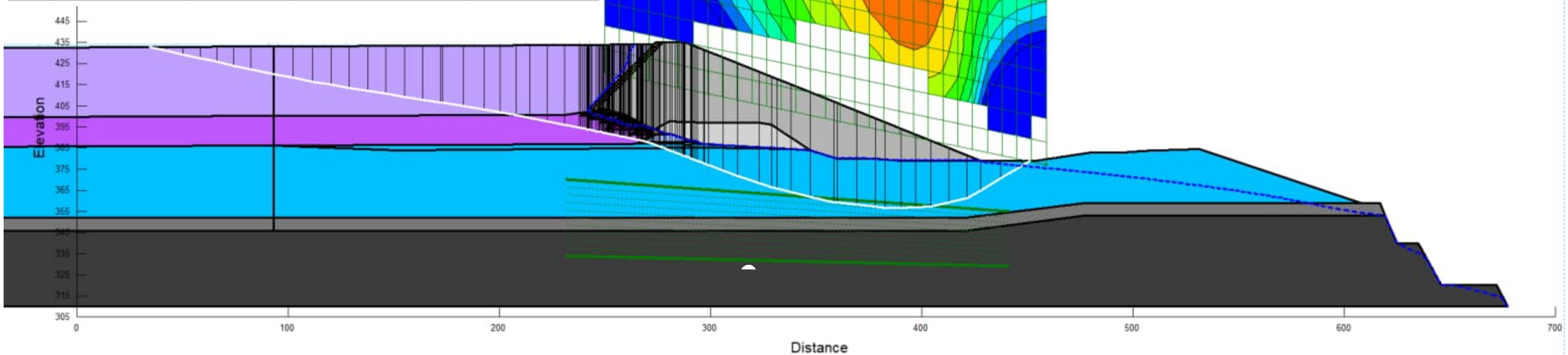
N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-2**

0 25 mm

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Saturated glacial till	Mohr-Coulomb	20,5		35	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		



Pseudo-static FoS = 1.8



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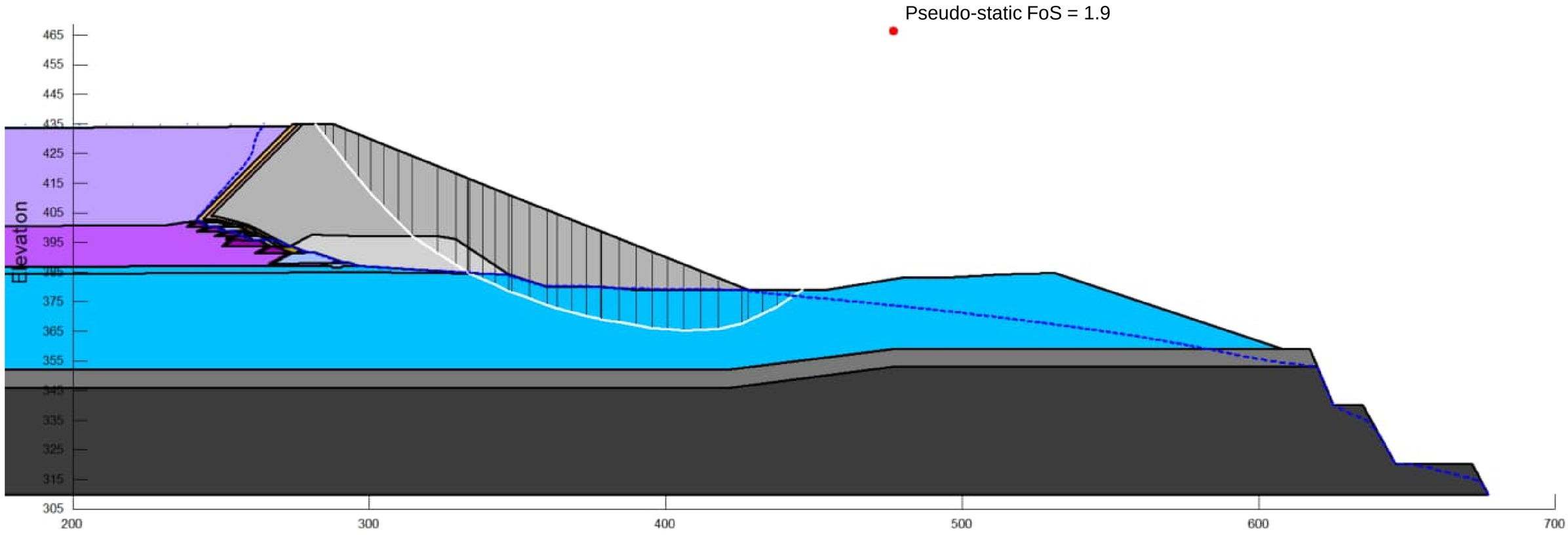
TITLE
SECTION A-A' –PSEUDO-STATIC FULL BREACH FAILURE SURFACE IN TAILINGS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-3**

0 mm 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 mm



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Saturated glacial till	Mohr-Coulomb	20,5		35	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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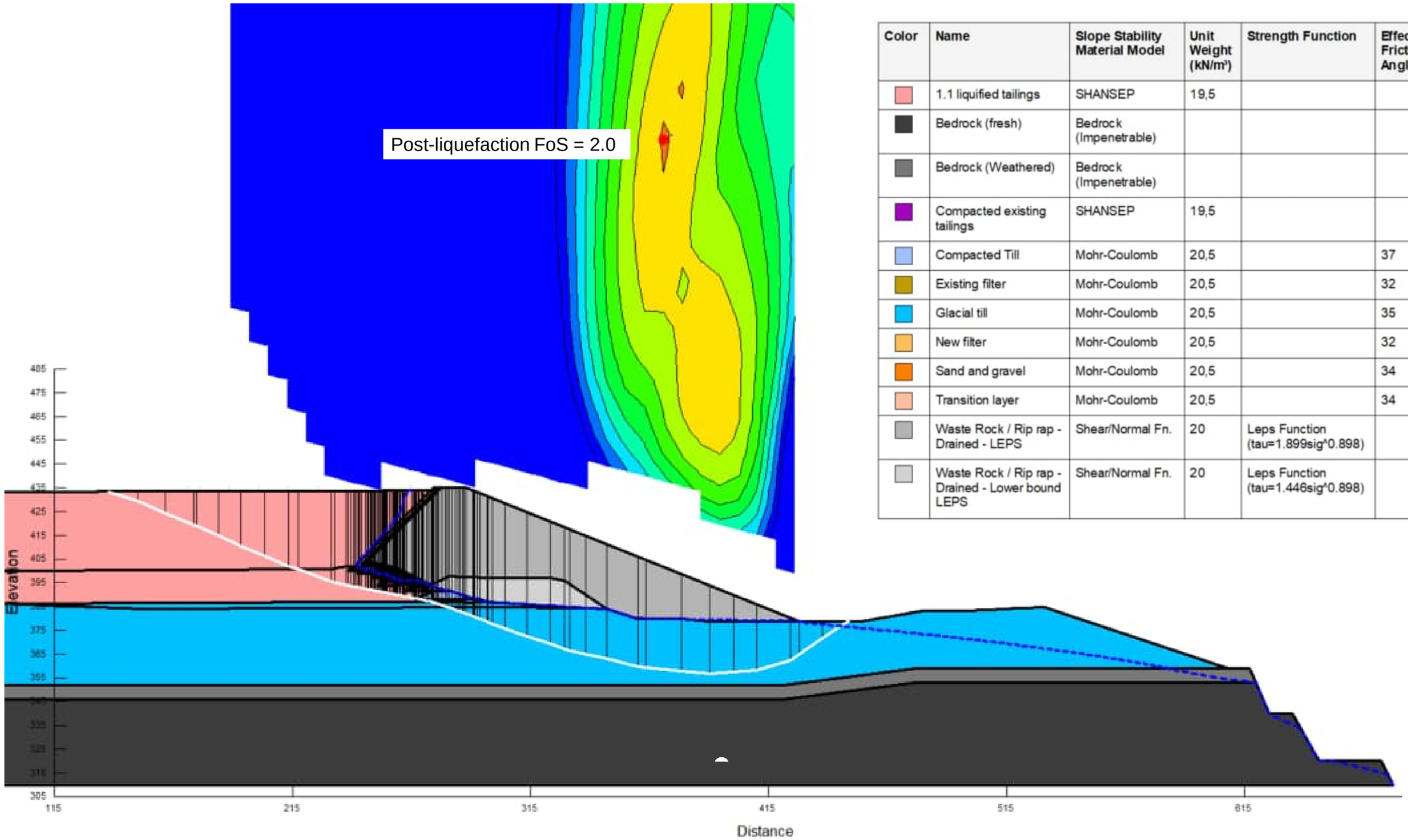
TITLE
SECTION A-A' –PSEUDO-STATIC FULL BREACH FAILURE SURFACE IN DYKE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-4**

0 25 mm



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	1.1 liquified tailings	SHANSEP	19,5			0,1
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Glacial till	Mohr-Coulomb	20,5		35	
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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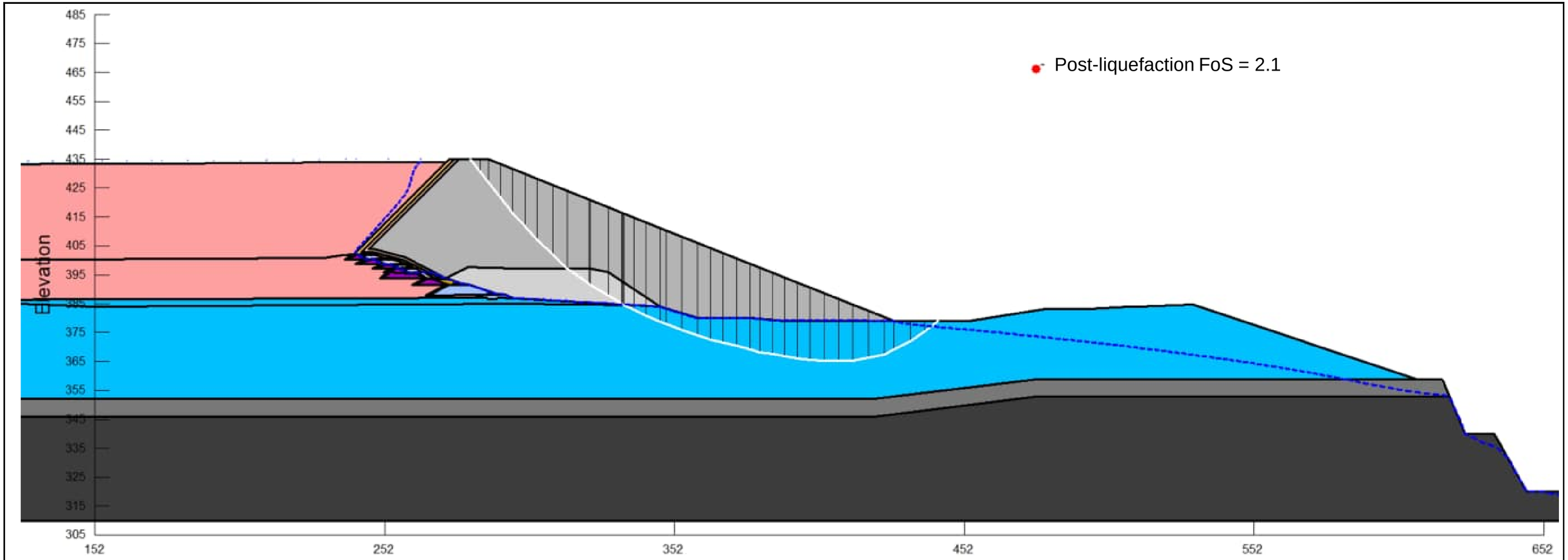
TITLE
SECTION A-A' –POST-LIQUEFACTION FULL BREACH FAILURE SURFACE IN TAILINGS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-5**

0 25 mm



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	1.1 liquified tailings	SHANSEP	19,5			0,1
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Glacial till	Mohr-Coulomb	20,5		35	
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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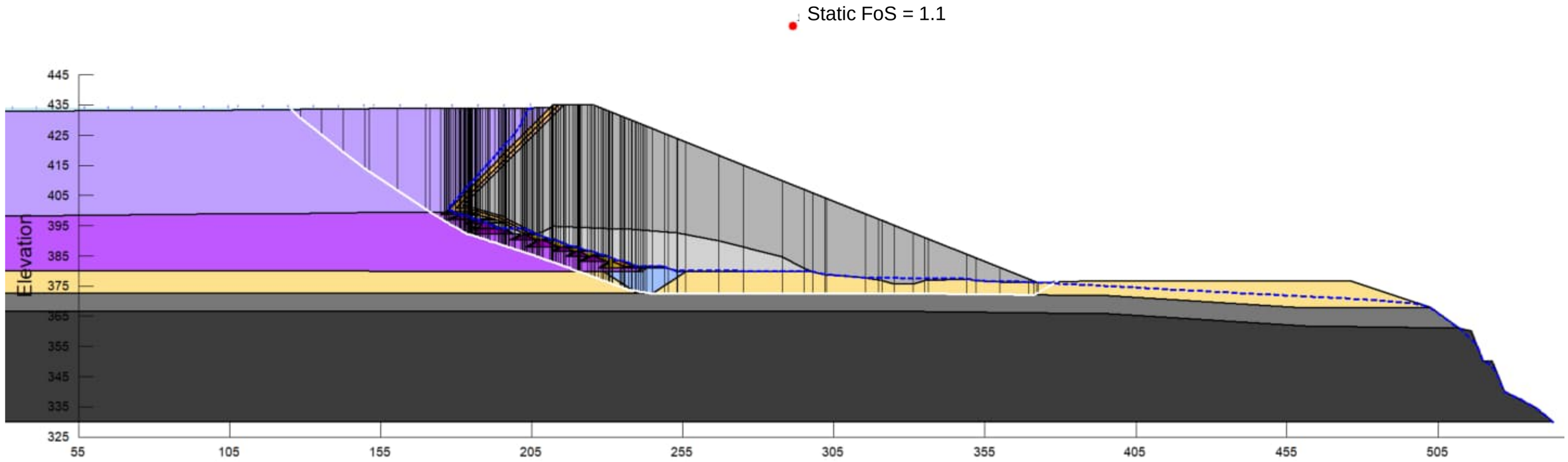
TITLE
SECTION A-A' –POST-LIQUEFACTION FULL BREACH FAILURE SURFACE IN DYKE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	G-6

0 25 mm



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Alluvial	SHANSEP	18,7			0,22
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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FEASIBILITY STUDY FOR
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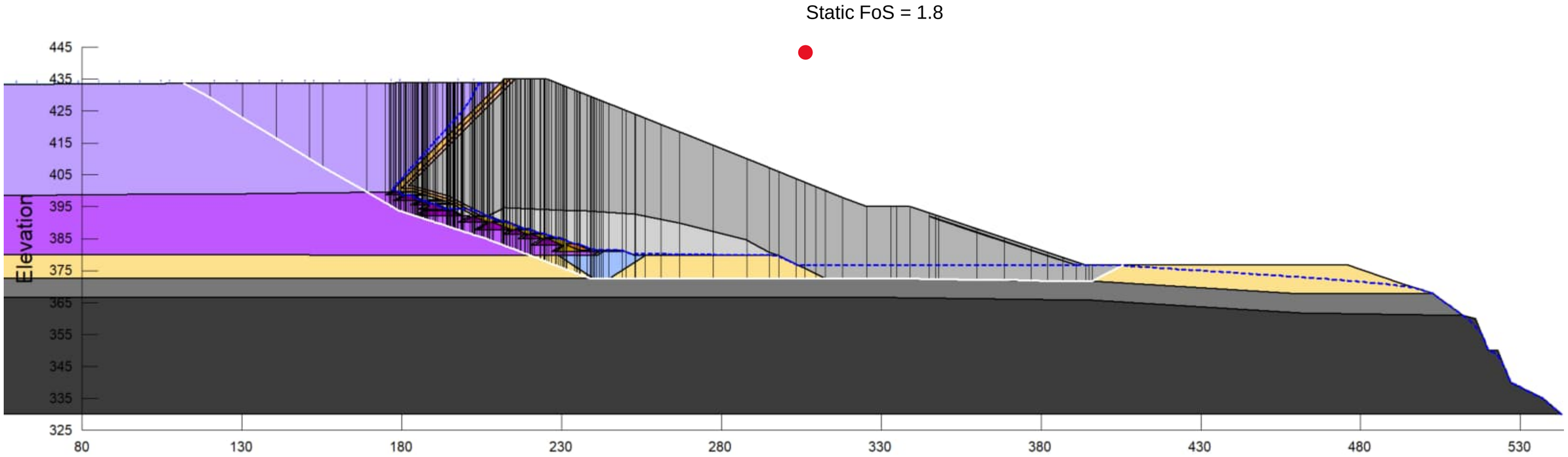
TITLE
SECTION B-B' –STATIC FULL BREACH FAILURE SURFACE IN TAILINGS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	G-7

0 25 mm



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Alluvial	SHANSEP	18,7			0,22
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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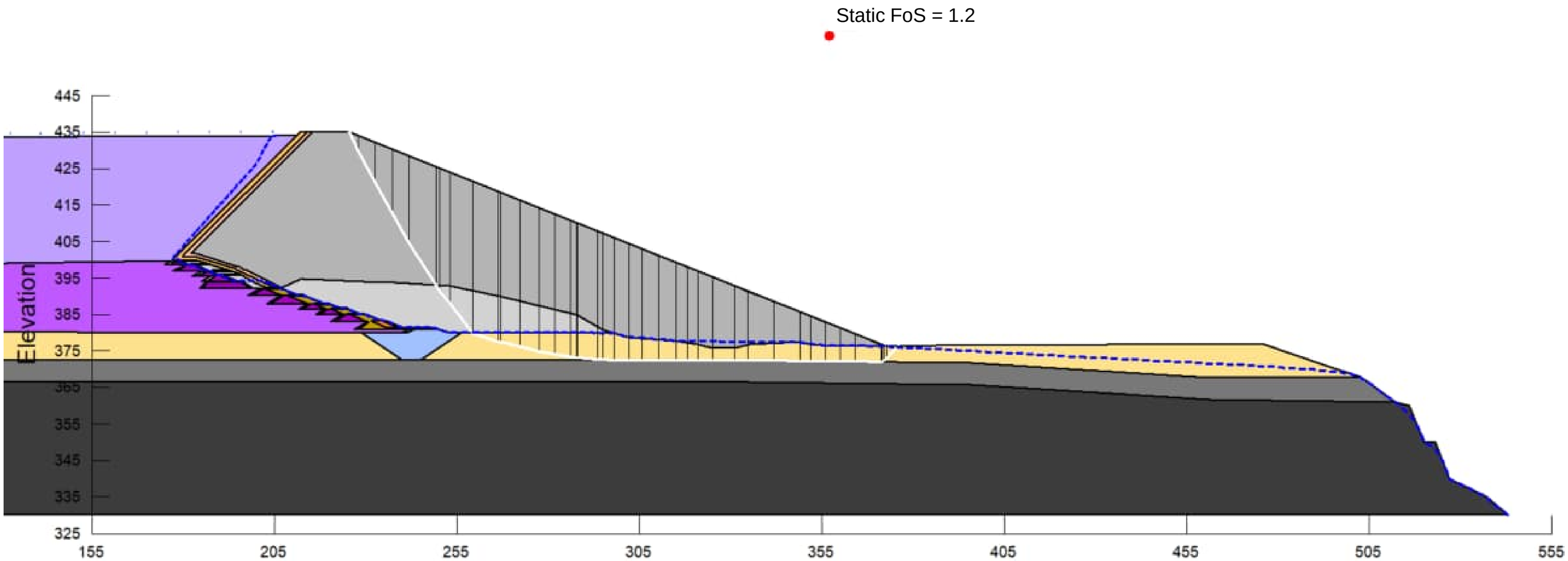
TITLE
SECTION B-B' –STATIC FULL BREACH FAILURE SURFACE IN TAILINGS-ADDING BERM AND EXCAVATION

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-8**

0 5 10 15 20 25 m



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Alluvial	SHANSEP	18,7			0,22
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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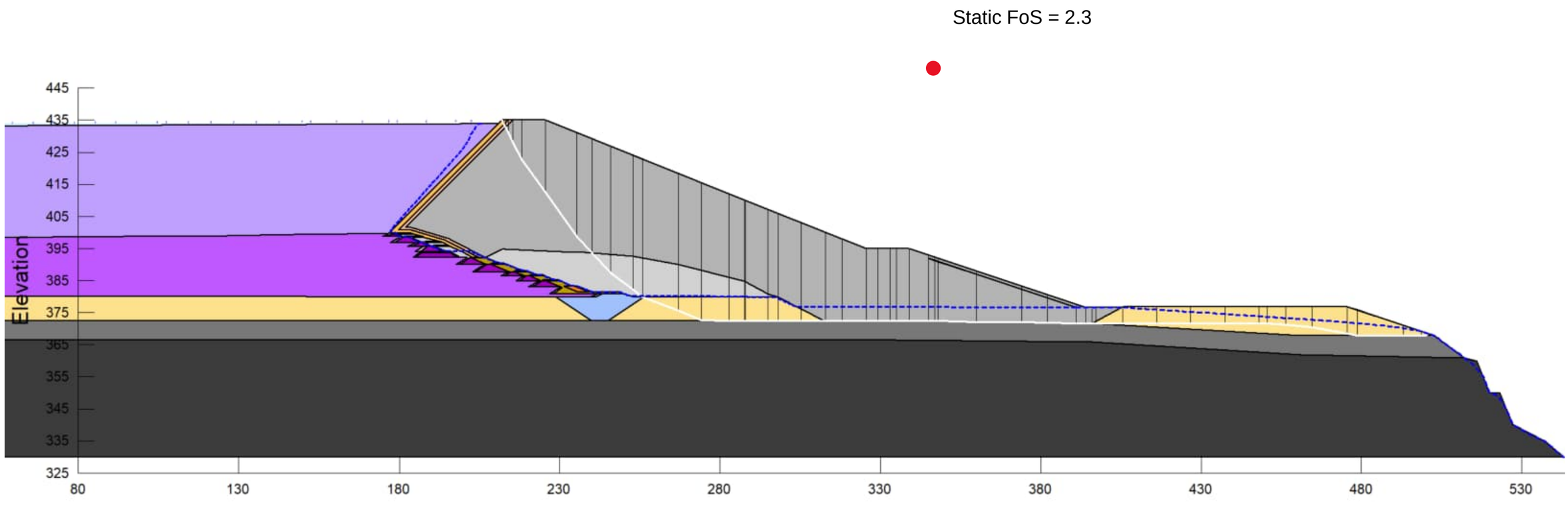
TITLE
SECTION B-B' –STATIC FULL BREACH FAILURE SURFACE IN DIKE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-9**

0 25 mm



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Alluvial	SHANSEP	18,7			0,22
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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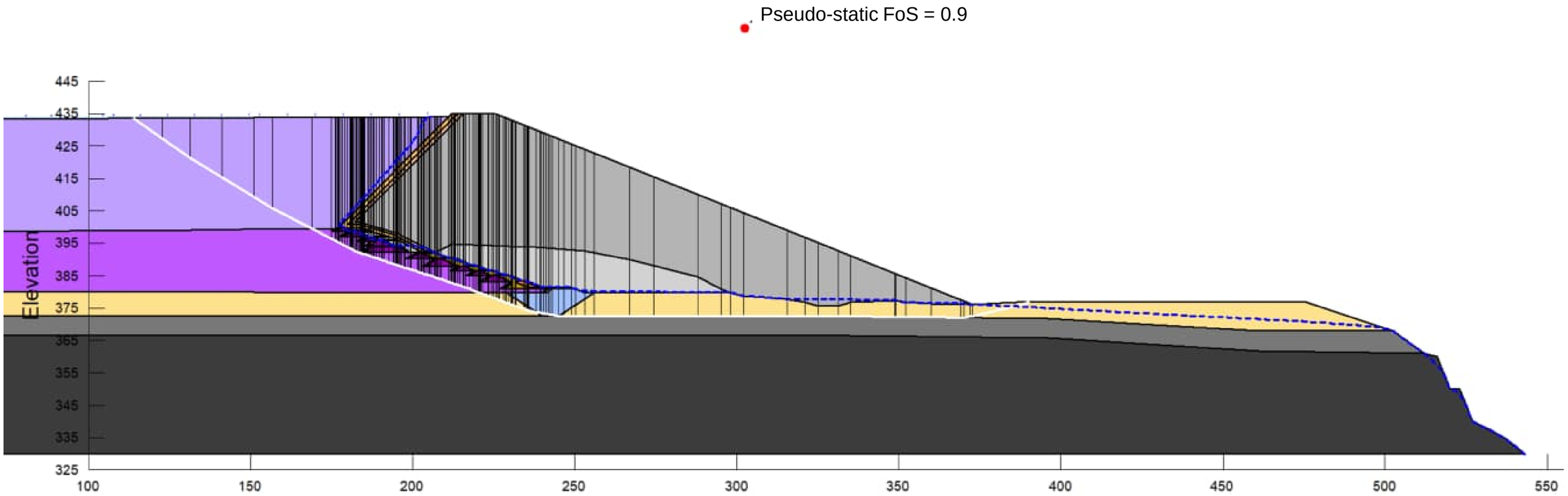
TITLE
SECTION B-B' –STATIC FULL BREACH FAILURE SURFACE IN DIKE -ADDING BERM AND EXCAVATION

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-10**

0 5 10 15 20 25 m



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Alluvial	SHANSEP	18,7			0,22
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Riprap - Drained - LEPS	SheanNormalFn.	20	Leps Function (tau=1.099sig^0.898)		
	Waste Rock / Riprap - Drained - Lowerbound LEPS	SheanNormalFn.	20	Leps Function (tau=1.446sig^0.898)		

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PROJECT
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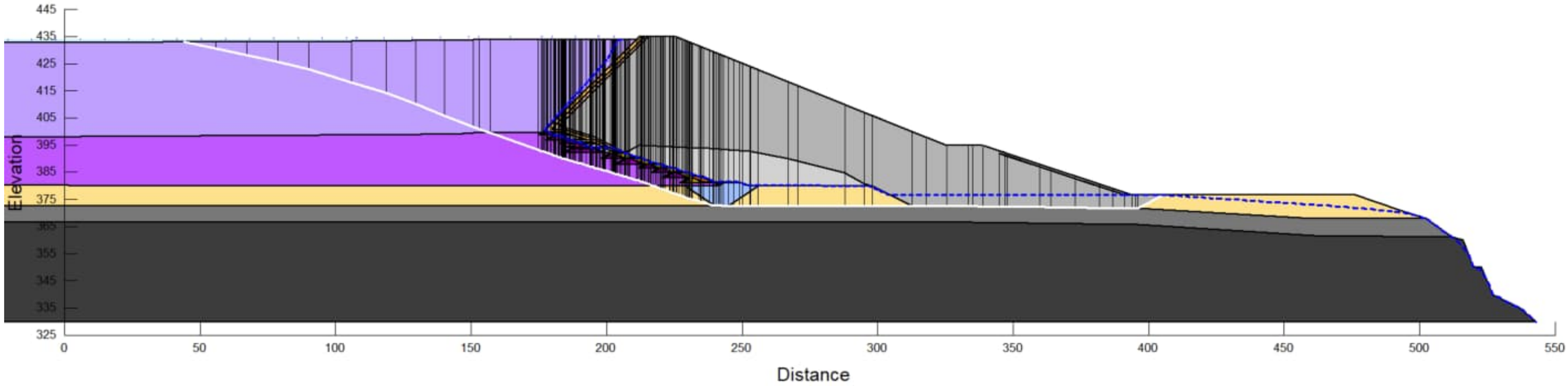
TITLE
SECTION B-B' –PSEUDO-STATIC FULL BREACH FAILURE SURFACE IN TAILINGS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-11**

0 5 10 15 20 25 mm

Pseudo-static FoS = 1.5



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Alluvial	SHANSEP	18,7			0,22
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Riprap - Drained - LEPS	ShearNormalFn	20	Leps Function (tau=1.099sig^0.898)		
	Waste Rock / Riprap - Drained - Lowerbound LEPS	ShearNormalFn	20	Leps Function (tau=1.446sig^0.898)		

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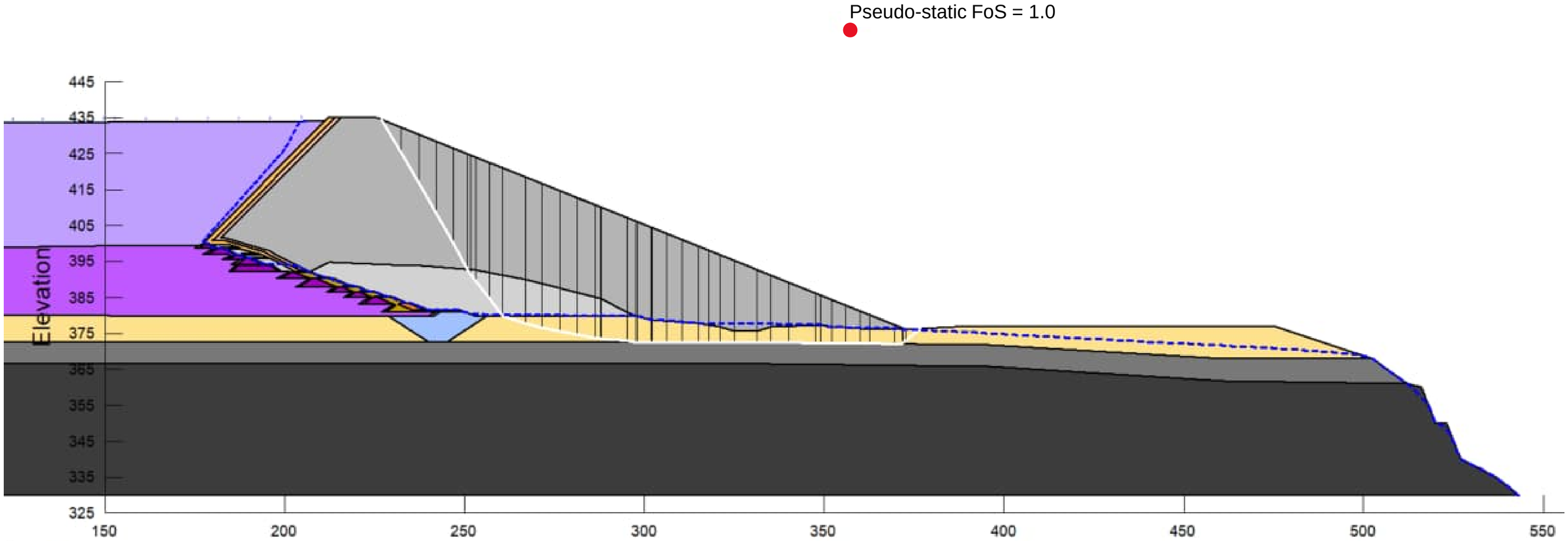
PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SECTION B-B' –PSEUDO-STATIC FULL BREACH FAILURE SURFACE IN TAILINGS-ADDING BERM AND EXCAVATION

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-12**

0 5 10 15 20 25 m



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Alluvial	SHANSEP	18,7			0,22
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	SheanNormalFn.	20	Leps Function (tau=1.099sig^0.898)		
	Waste Rock / Rip rap - Drained - Lowerbound LEPS	SheanNormalFn.	20	Leps Function (tau=1.446sig^0.898)		

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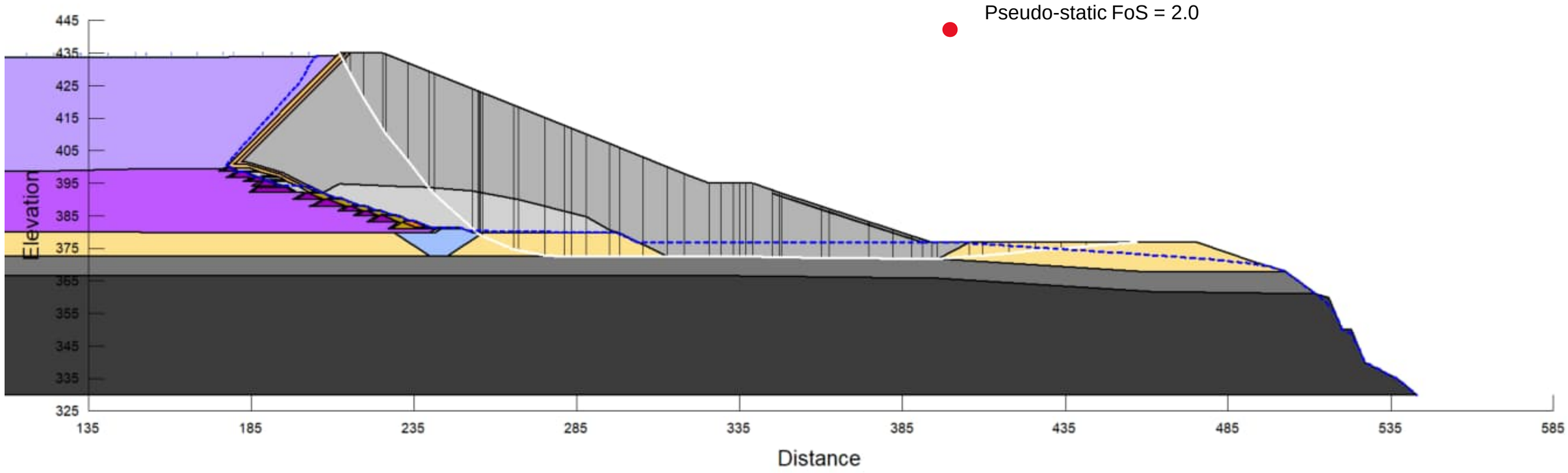
TITLE
SECTION B-B' –PSEUDO-STATIC FULL BREACH FAILURE SURFACE IN DYKE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-13**

0 25 mm



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Alluvial	SHANSEP	18,7			0,22
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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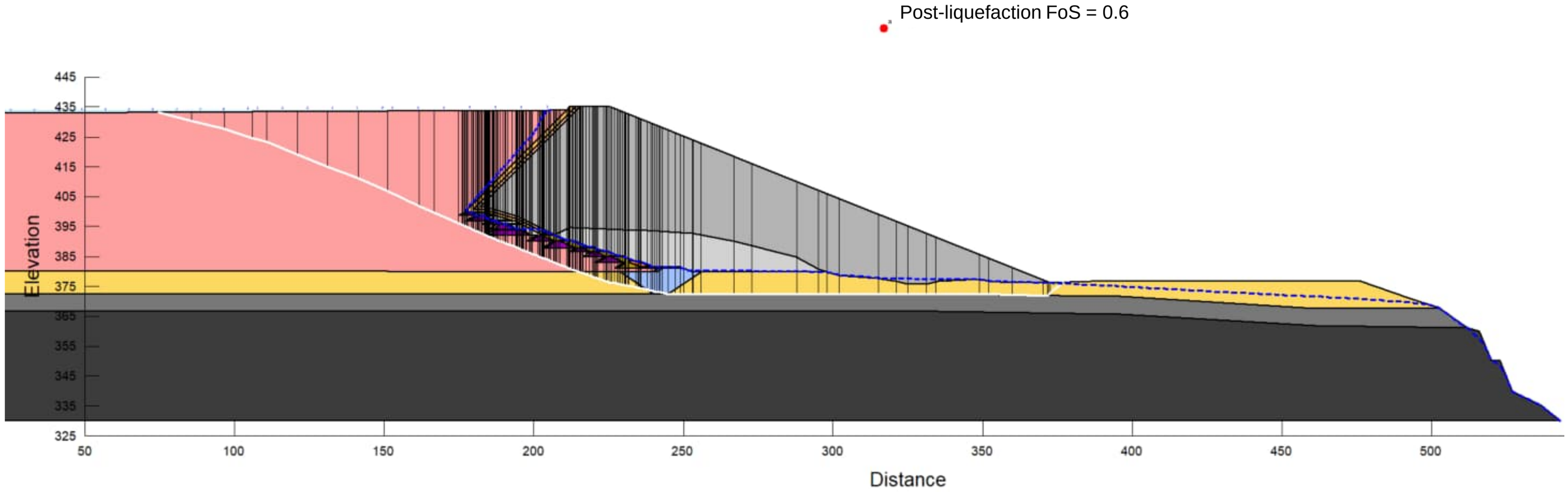
TITLE
SECTION B-B' –PSEUDO-STATIC FULL BREACH FAILURE SURFACE IN DYKE-ADDING BERM AND EXCAVATION

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-14**

0 5 10 15 20 25 m



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	1.1 Liquified Alluvial	SHANSEP	18,7			0,09
	1.1 liquified tailings	SHANSEP	19,5			0,1
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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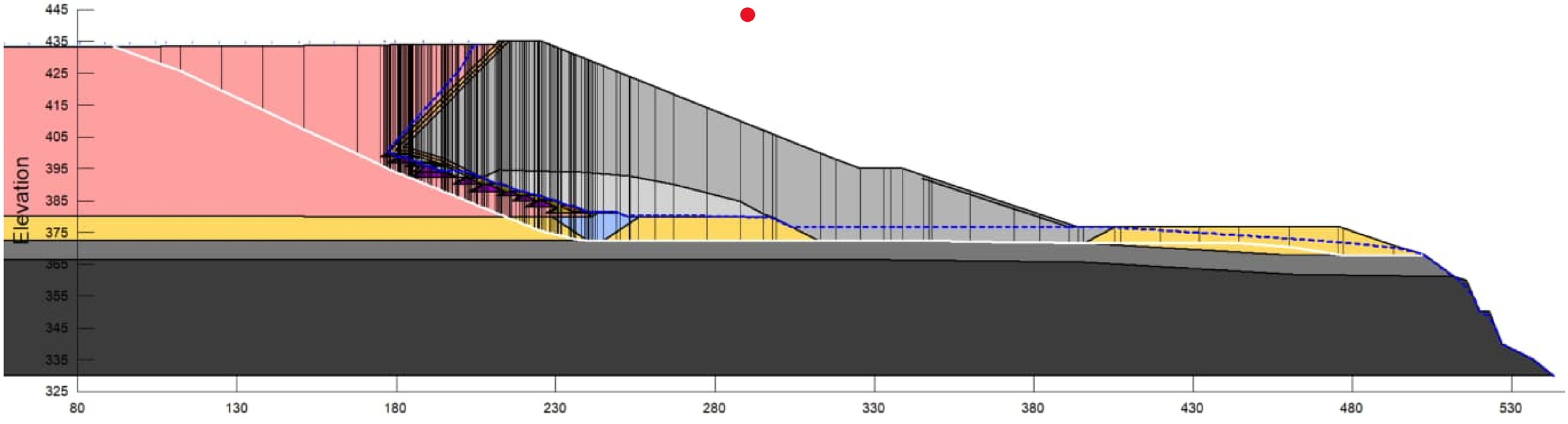
TITLE
SECTION B-B' –POST-LIQUEFACTION FULL BREACH FAILURE SURFACE IN TAILINGS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-15**

0 25 m

Post-liquefaction FoS = 1.3



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	1.1 Liquified Alluvial	SHANSEP	18,7			0,09
	1.1 liquified tailings	SHANSEP	19,5			0,1
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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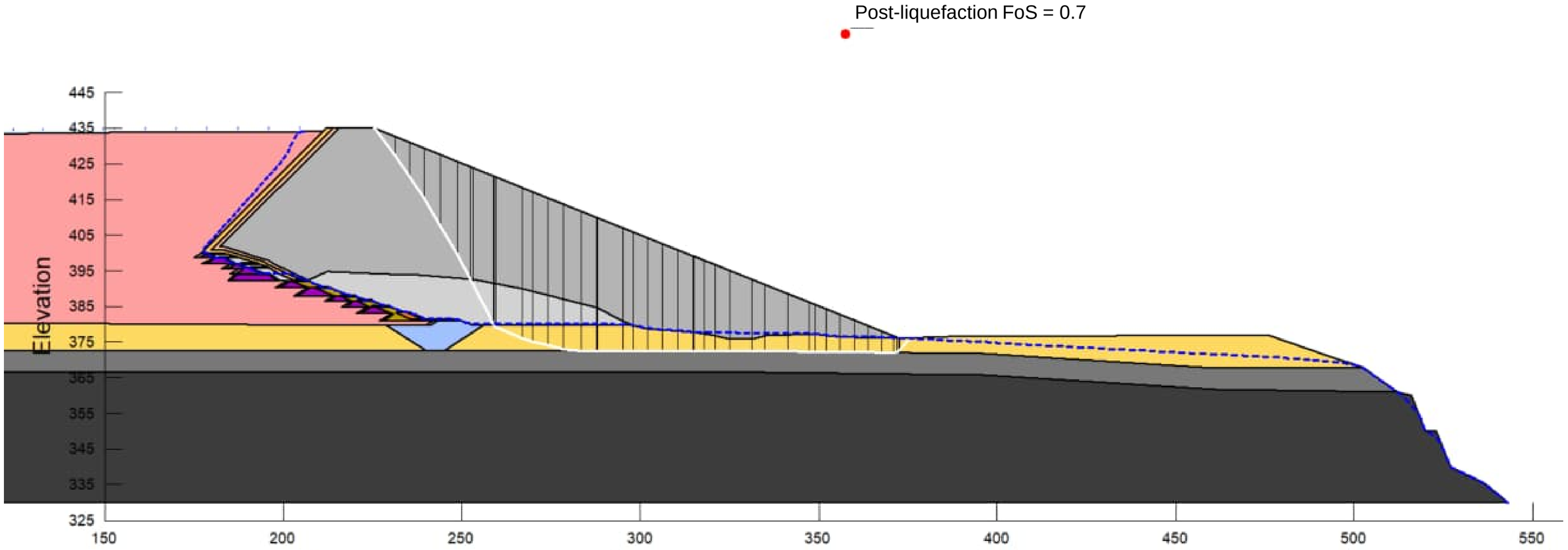
TITLE
SECTION B-B' –POST-LIQUEFACTION FULL BREACH FAILURE SURFACE IN TAILINGS-ADDING BERM AND EXCAVATION

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-16**

0 5 10 15 20 25 m



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	1.1 Liquified Alluvial	SHANSEP	18,7			0,09
	1.1 liquified tailings	SHANSEP	19,5			0,1
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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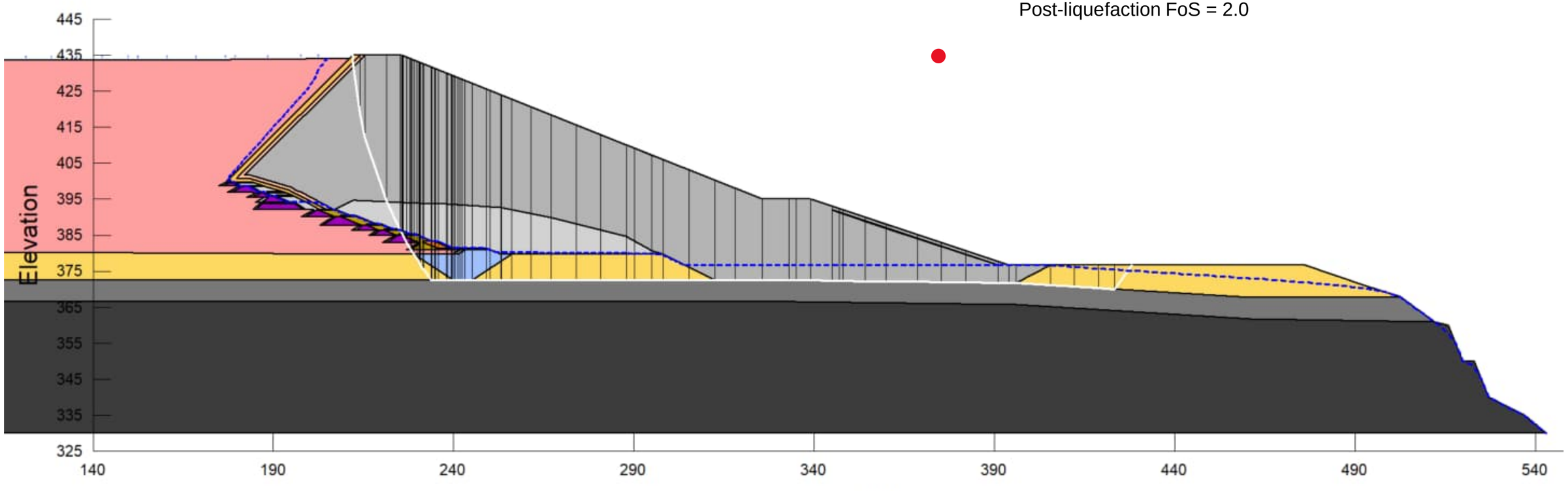
TITLE
SECTION B-B' –POST-LIQUEFACTION FULL BREACH FAILURE SURFACE IN DIKE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-17**

0 25 mm



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	1.1 Liquified Aluvial	SHANSEP	18,7			0,09
	1.1 liquified tailings	SHANSEP	19,5			0,1
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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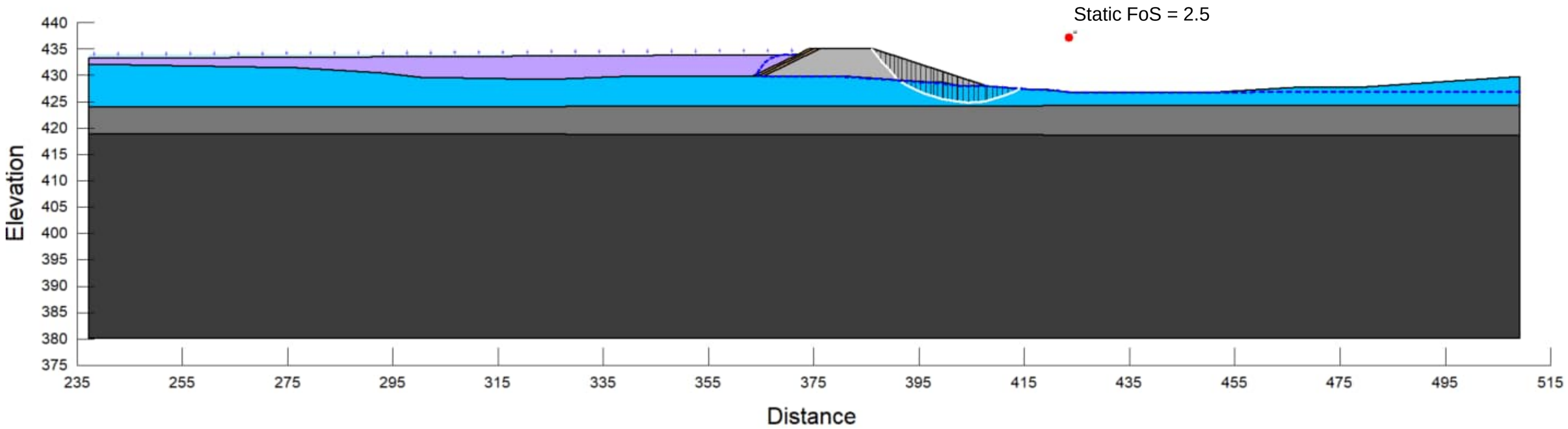
TITLE
SECTION B-B' –POST-LIQUEFACTION FULL BREACH FAILURE SURFACE IN DIKE-ADDING BERM AND EXCAVATION

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-18**

0 5 10 15 20 25 m



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Tau/Sigma Ratio	Effective Friction Angle (°)
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Glacial till	Mohr-Coulomb	20,5			35
	New filter	Mohr-Coulomb	20,5			32
	Thickened slurry tailings	SHANSEP	19,5		0,2	
	Transition layer	Mohr-Coulomb	20,5			34
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		

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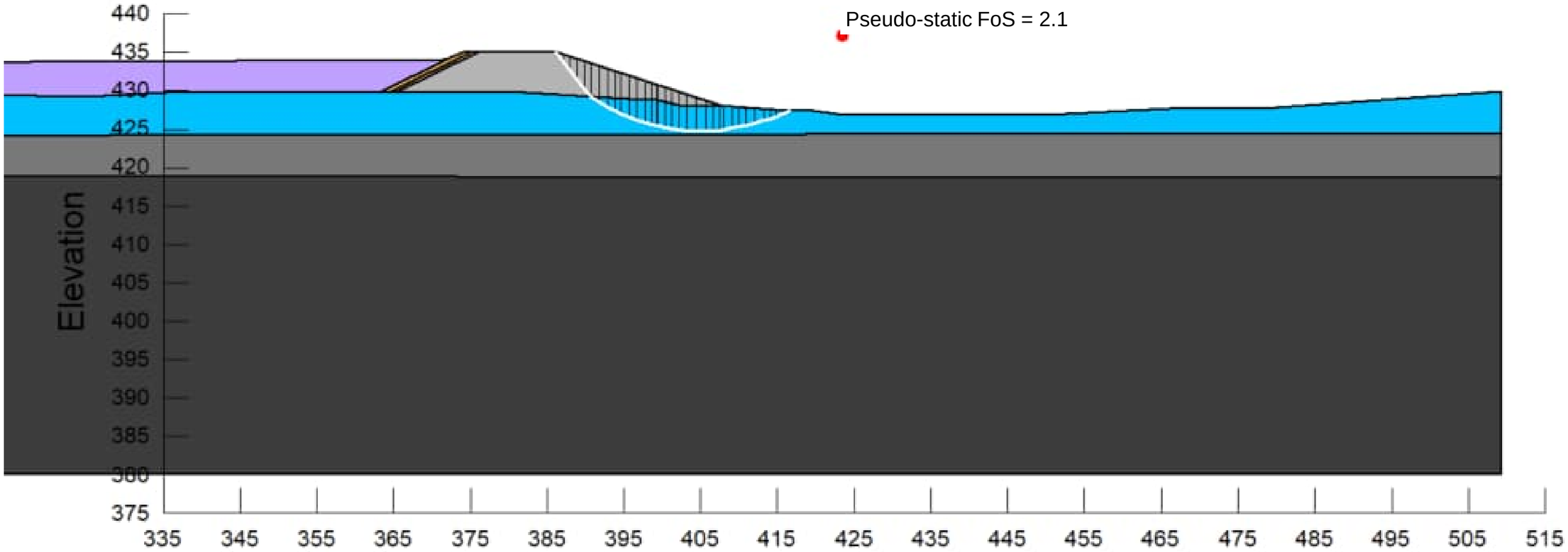
TITLE
SECTION C-C' –STATIC FULL BREACH FAILURE SURFACE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-19**

0 5 10 15 20 25 m



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Tau/Sigma Ratio	Effective Friction Angle (°)
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Glacial till	Mohr-Coulomb	20,5			35
	New filter	Mohr-Coulomb	20,5			32
	Thickened slurry tailings	SHANSEP	19,5		0,2	
	Transition layer	Mohr-Coulomb	20,5			34
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		

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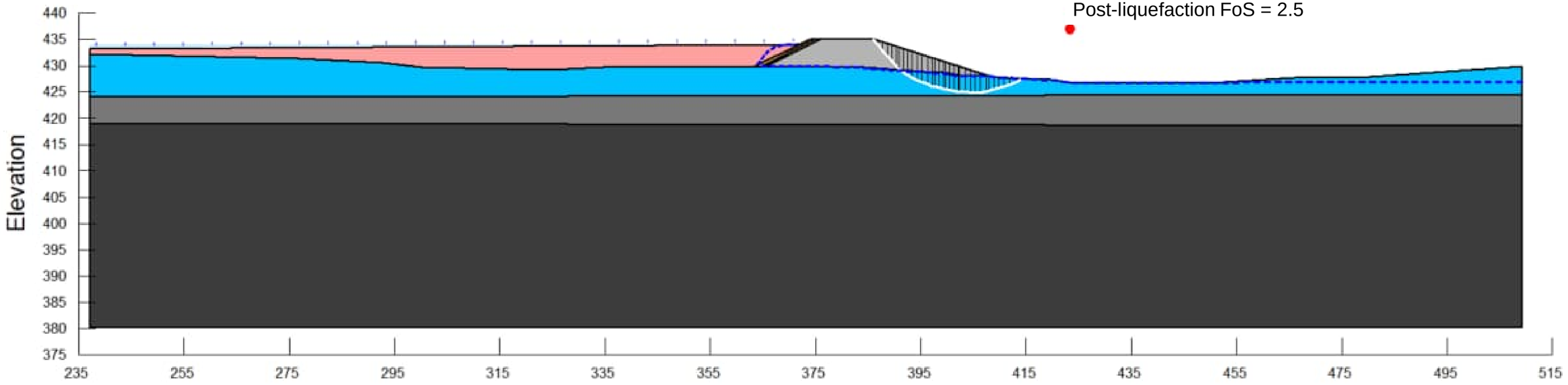
TITLE
SECTION C-C' –PSEUDO-STATIC FULL BREACH FAILURE SURFACE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-20**

0 5 10 15 20 25 m



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	1.1 liquified tailings	SHANSEP	19,5			0,1
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Glacial till	Mohr-Coulomb	20,5		35	
	New filter	Mohr-Coulomb	20,5		32	
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		

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FEASIBILITY STUDY FOR
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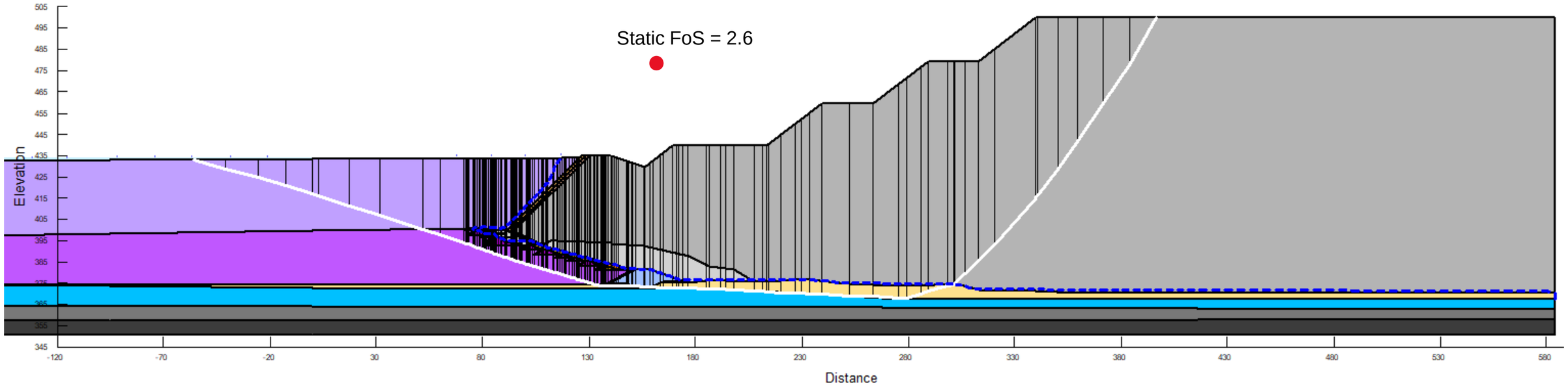
TITLE
SECTION C-C' –POST-LIQUEFACTION FULL BREACH FAILURE SURFACE

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-21**

0 5 10 15 20 25 m



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Alluvial	SHANSEP	18,7			0,22
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	Glacial till	Mohr-Coulomb	20,5		35	
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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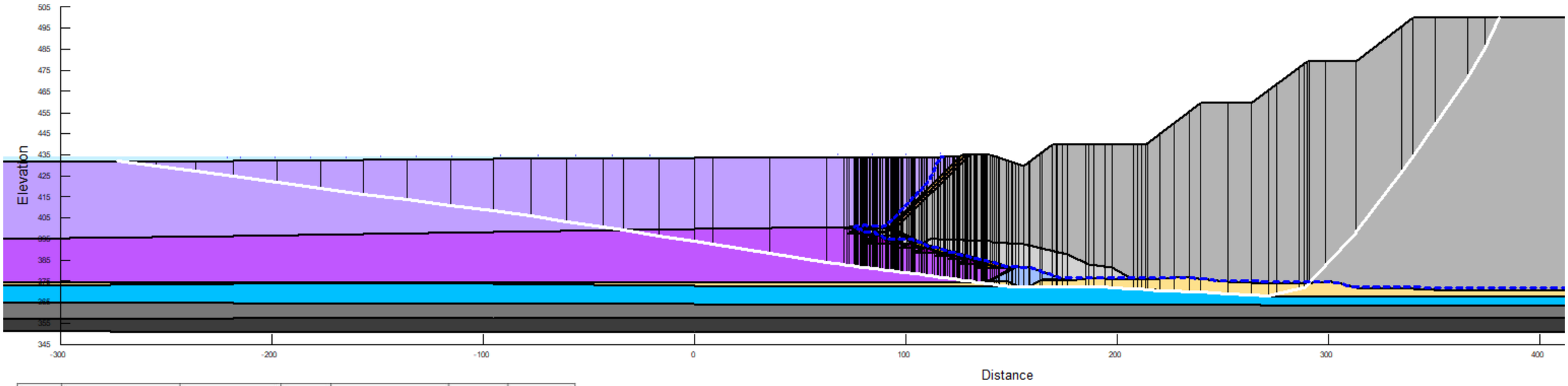
PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SECTION D-D' -STATIC FAILURE OF WASTE DUMP TOWARDS TSF

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-22**

0 25 mm

Pseudo-static FoS = 2.0



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	Alluvial	SHANSEP	18,7			0,22
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Existing tailings	SHANSEP	19,5			0,2
	Glacial till	Mohr-Coulomb	20,5		35	
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Thickened slurry tailings	SHANSEP	19,5			0,2
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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PROJECT
FEASIBILITY STUDY FOR
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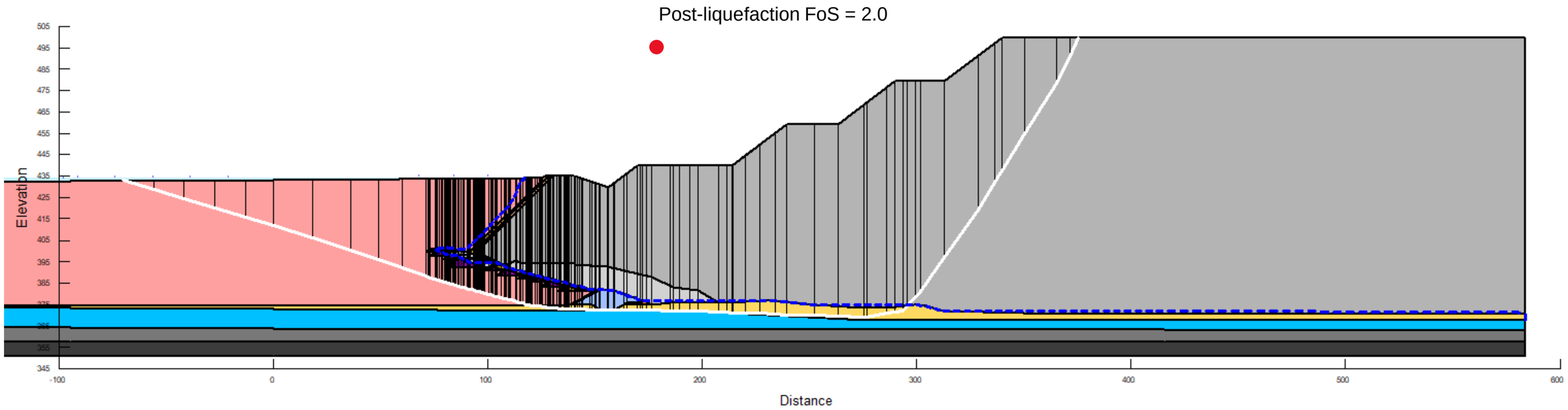
TITLE
SECTION D-D' –PSEUDO-STATIC FAILURE OF WASTE DUMP TOWARDS TSF

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-23**

0 25 mm



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Friction Angle (°)	Tau/Sigma Ratio
	1.1 Liquified Alluvial	SHANSEP	18,7			0,09
	1.1 liquified tailings	SHANSEP	19,5			0,1
	Bedrock (fresh)	Bedrock (Impenetrable)				
	Bedrock (Weathered)	Bedrock (Impenetrable)				
	Compacted existing tailings	SHANSEP	19,5			0,2
	Compacted Till	Mohr-Coulomb	20,5		37	
	Existing filter	Mohr-Coulomb	20,5		32	
	Glacial till	Mohr-Coulomb	20,5		35	
	New filter	Mohr-Coulomb	20,5		32	
	Sand and gravel	Mohr-Coulomb	20,5		34	
	Transition layer	Mohr-Coulomb	20,5		34	
	Waste Rock / Rip rap - Drained - LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.899sig^0.898)		
	Waste Rock / Rip rap - Drained - Lower bound LEPS	Shear/Normal Fn.	20	Leps Function (tau=1.446sig^0.898)		

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PROJECT
FEASIBILITY STUDY FOR
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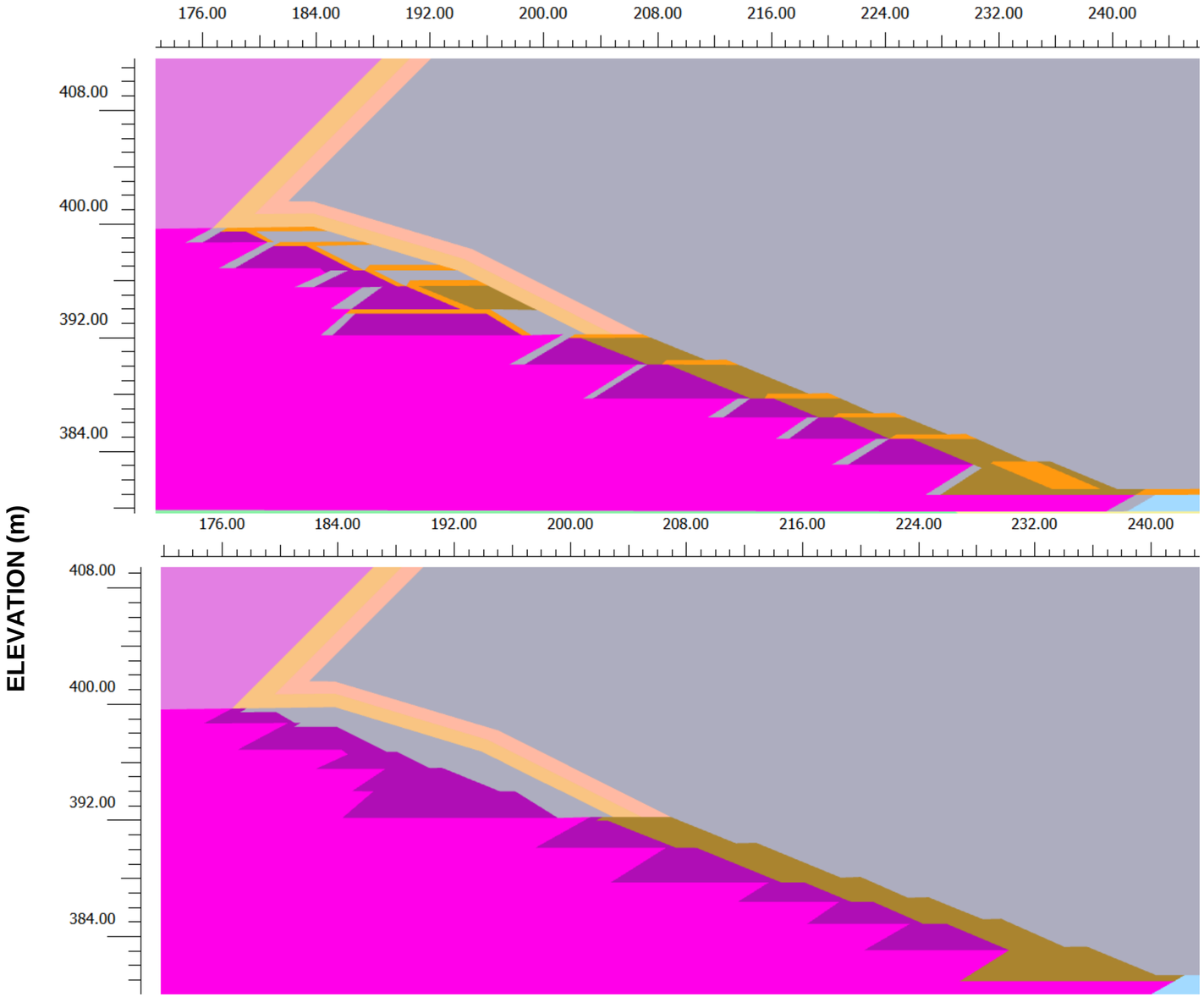
TITLE
SECTION D-D' –POST-LIQUEFACTION FAILURE OF WASTE DUMP TOWARDS TSF

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**G-24**

0 5 10 15 20 25 m

APPENDIX H

Deformation Analysis



Materials

- Alluvial
- Bedrock (fresh)
- Bedrock (Weathered)
- Compacted existing tailings
- Compacted Till
- Existing filter
- Existing tailings
- New filter
- Sand and gravel
- Thickened slurry tailings
- Transition layer
- Waste Rock / Rip rap
- Waste Rock / Rip rap

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FEASIBILITY STUDY FOR
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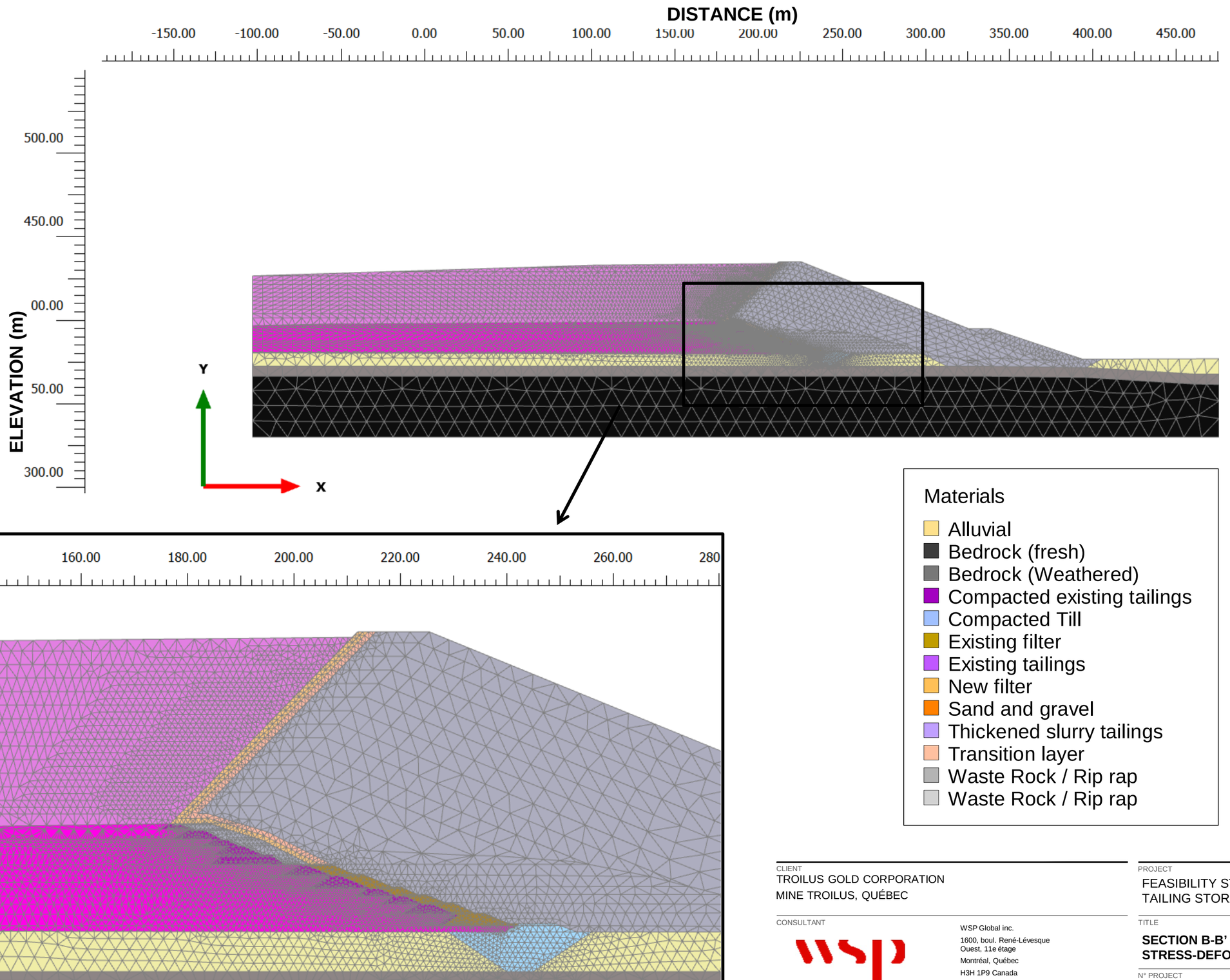
TITLE
SECTION B-B'-ORIGINAL (ABOVE) AND SIMPLIFIED (BOTTOM) GEOMETRY OF THE STRESS-DEFORMATION MODEL

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	H-1

0 25 mm



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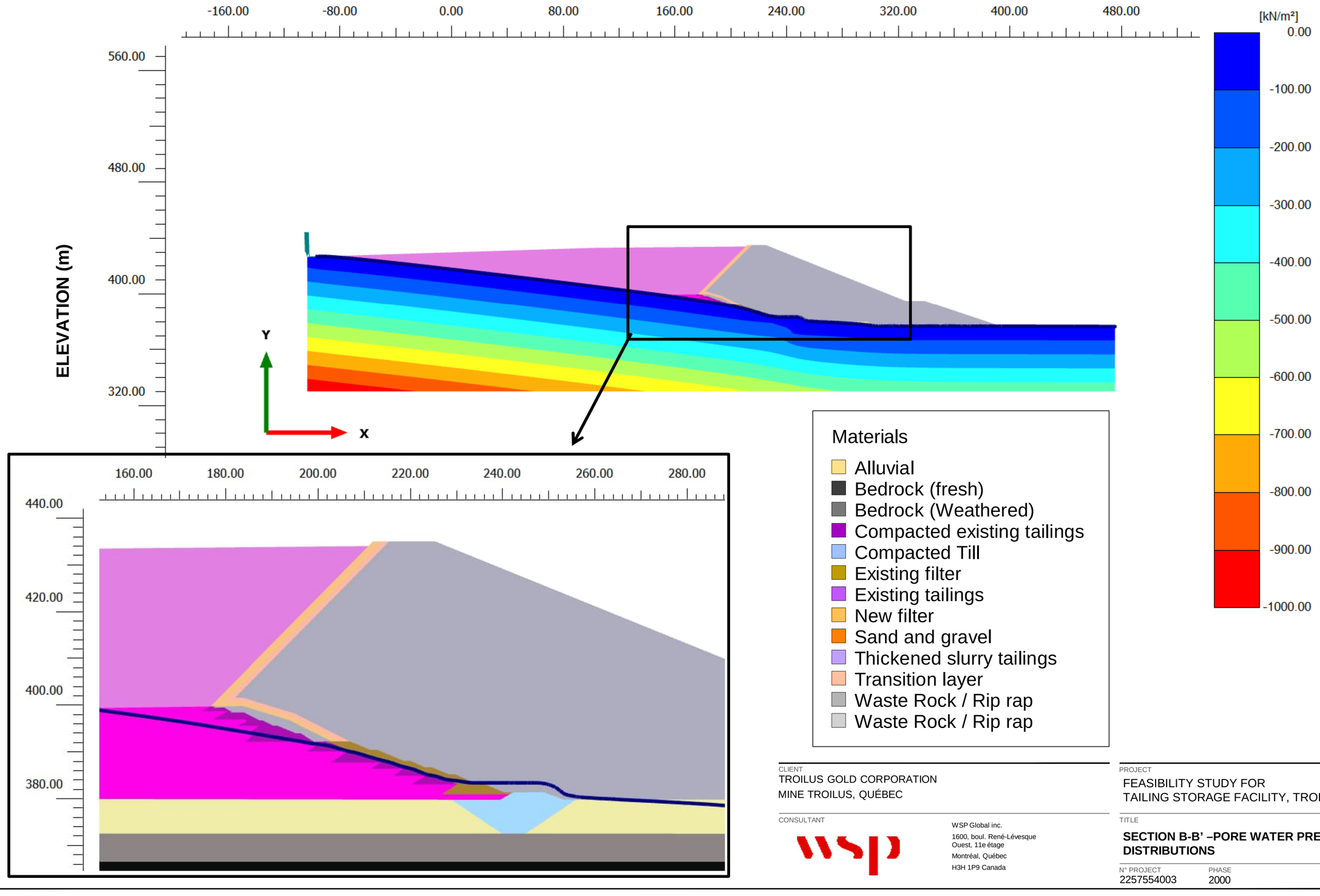
TITLE
SECTION B-B' –FINITE ELEMENT MESH OF THE STRESS-DEFORMATION MODEL

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-2**

0 5 10 15 20 25 mm

DISTANCE (m)



[kN/m²]
0.00
-100.00
-200.00
-300.00
-400.00
-500.00
-600.00
-700.00
-800.00
-900.00
-1000.00

Materials

- Alluvial
- Bedrock (fresh)
- Bedrock (Weathered)
- Compacted existing tailings
- Compacted Till
- Existing filter
- Existing tailings
- New filter
- Sand and gravel
- Thickened slurry tailings
- Transition layer
- Waste Rock / Rip rap
- Waste Rock / Rip rap

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FEASIBILITY STUDY FOR
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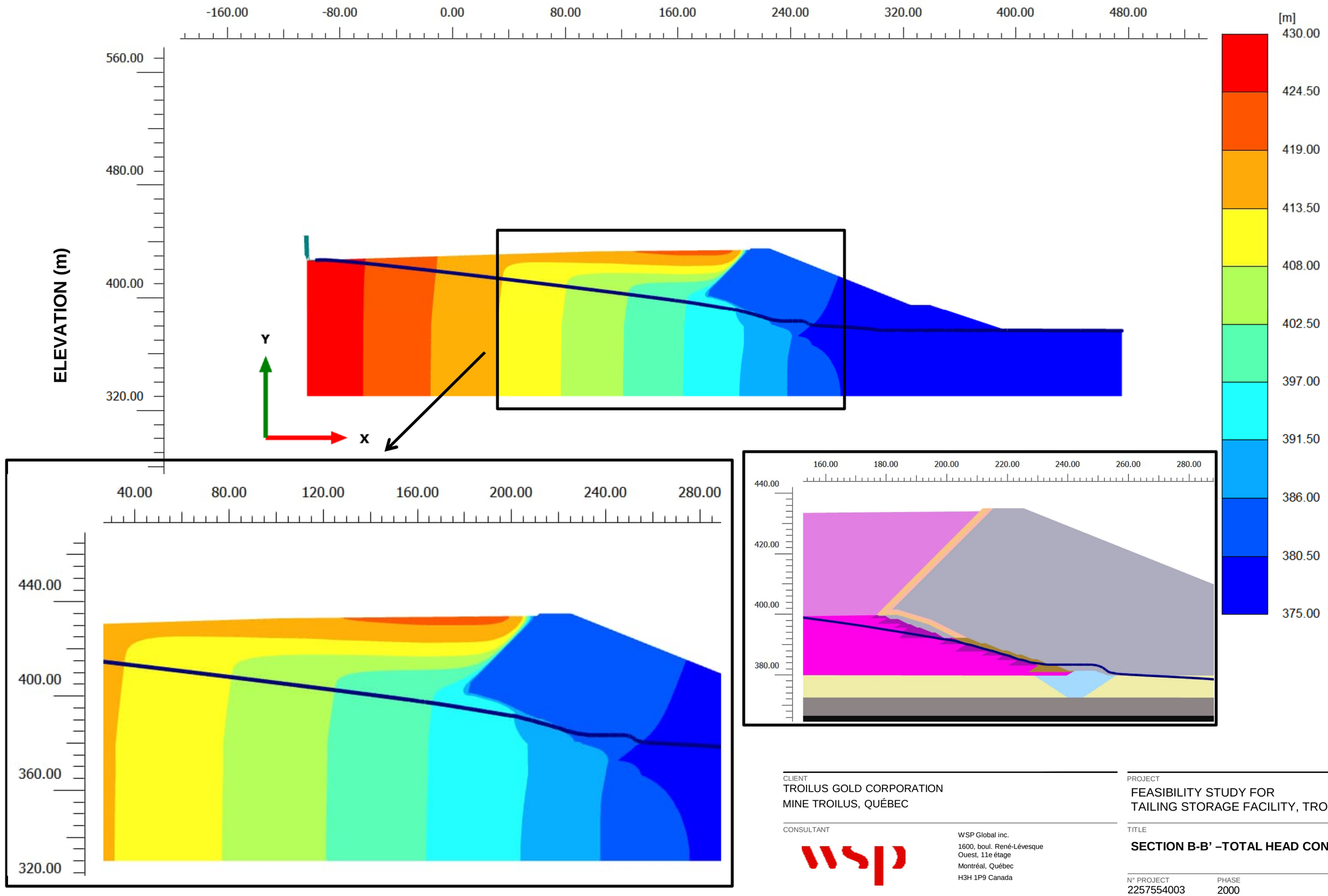
TITLE
SECTION B-B' –PORE WATER PRESSURE DISTRIBUTIONS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-3**

0 5 10 15 20 25 mm

DISTANCE (m)

ELEVATION (m)



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FEASIBILITY STUDY FOR
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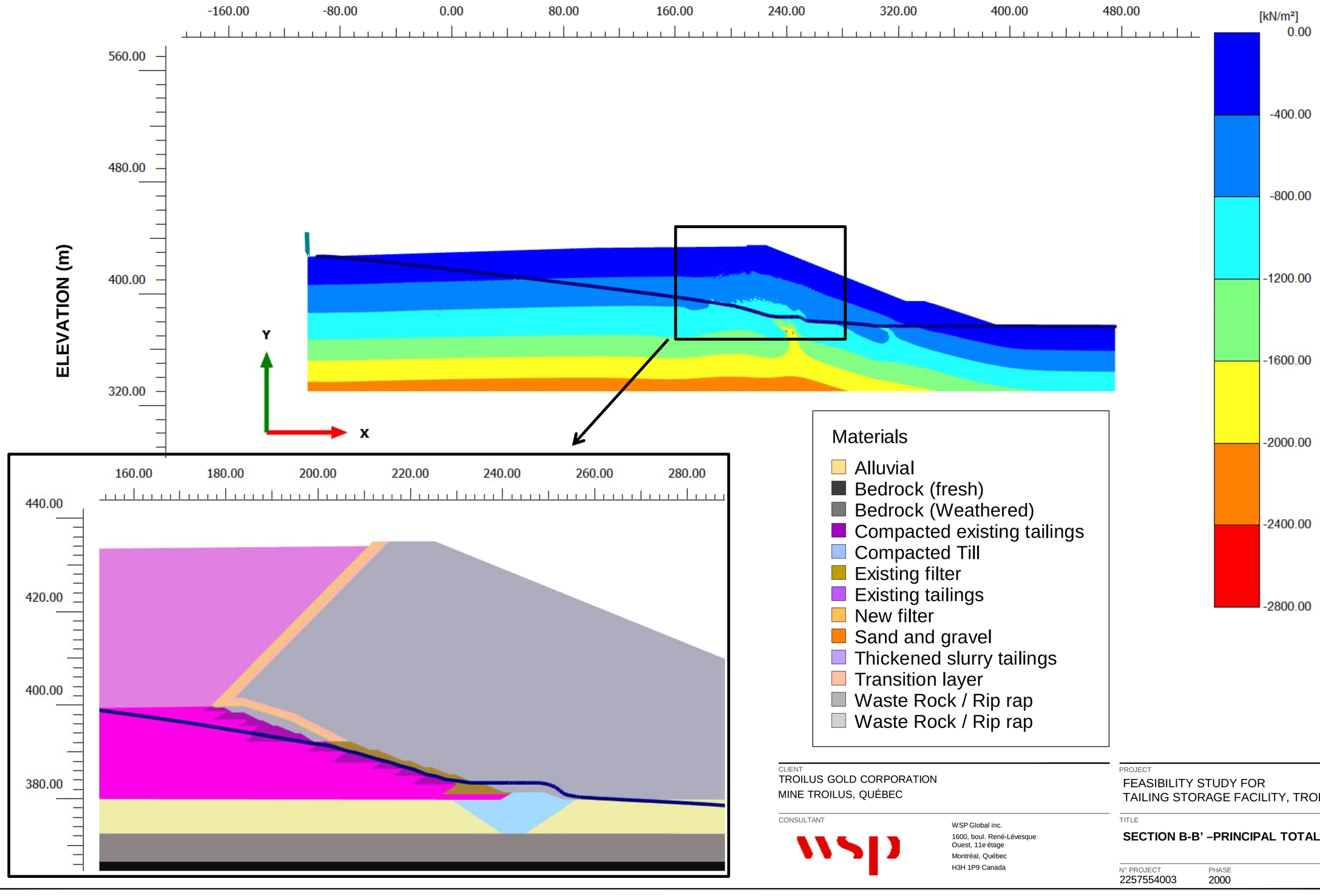
TITLE
SECTION B-B' –TOTAL HEAD CONTOURS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-4**

0 mm 12.5 mm 25 mm

DISTANCE (m)



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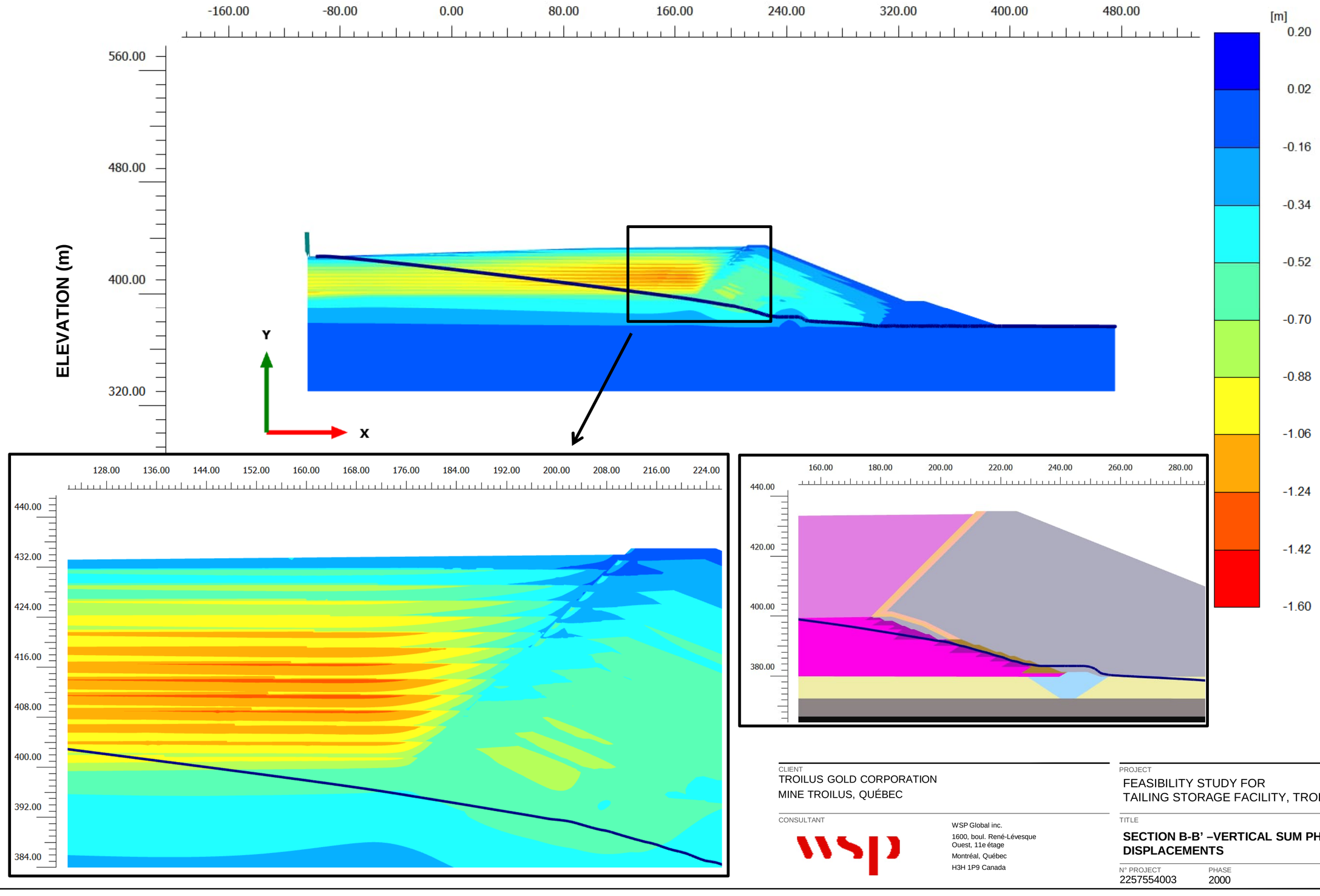
TITLE
SECTION B-B' –PRINCIPAL TOTAL STRESS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-5**

DISTANCE (m)



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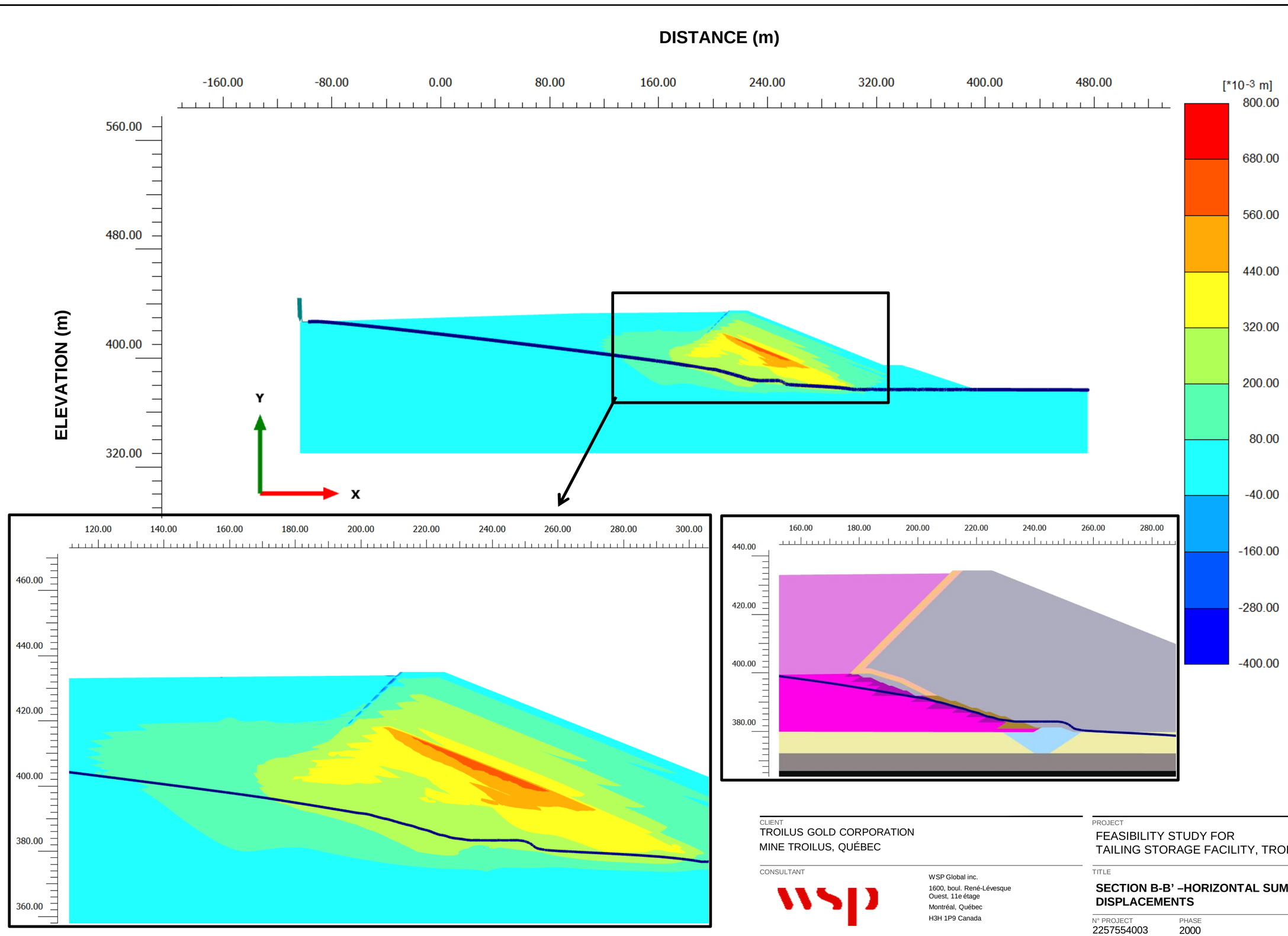
TITLE
SECTION B-B' –VERTICAL SUM PHASE DISPLACEMENTS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-6**

0 25 mm



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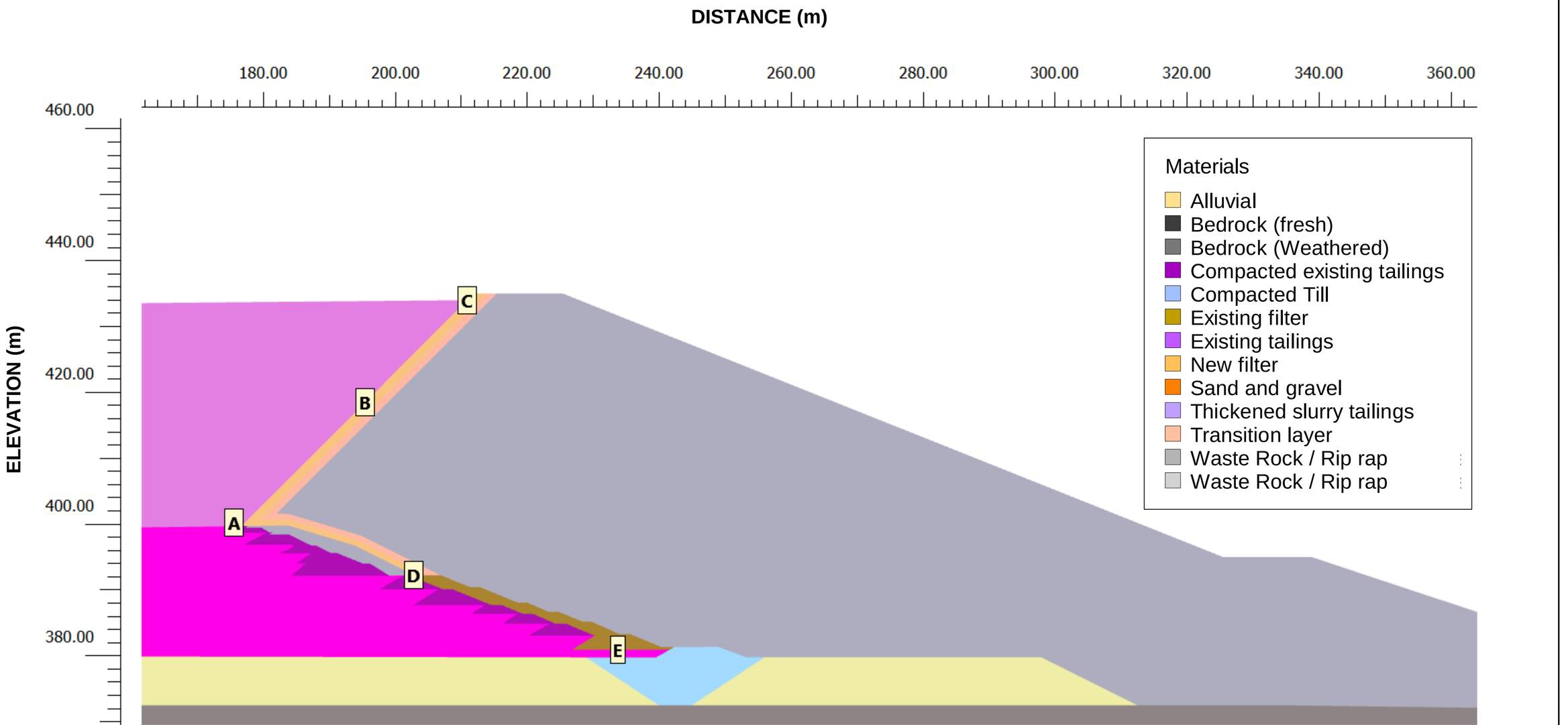
TITLE
SECTION B-B' –HORIZONTAL SUM PHASE DISPLACEMENTS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-7**



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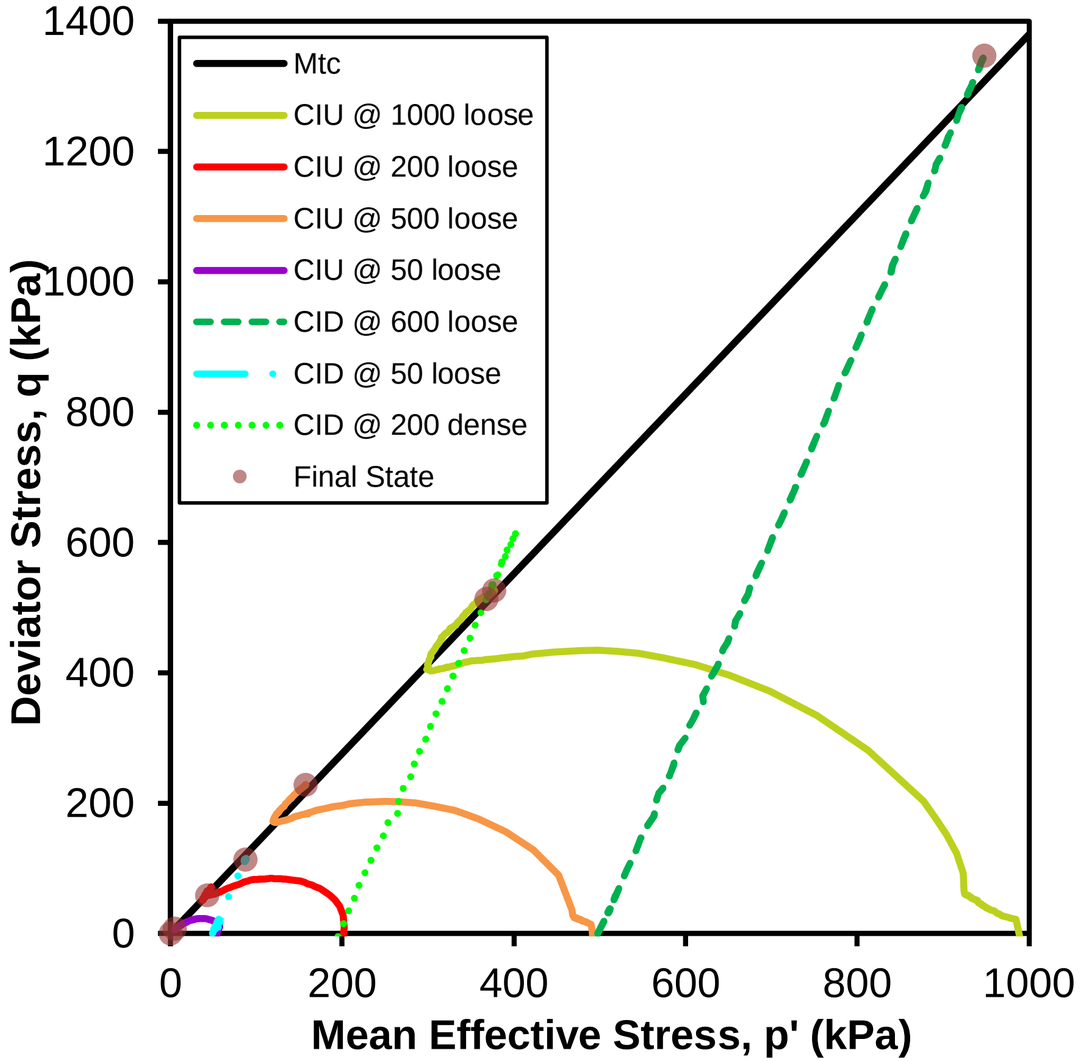
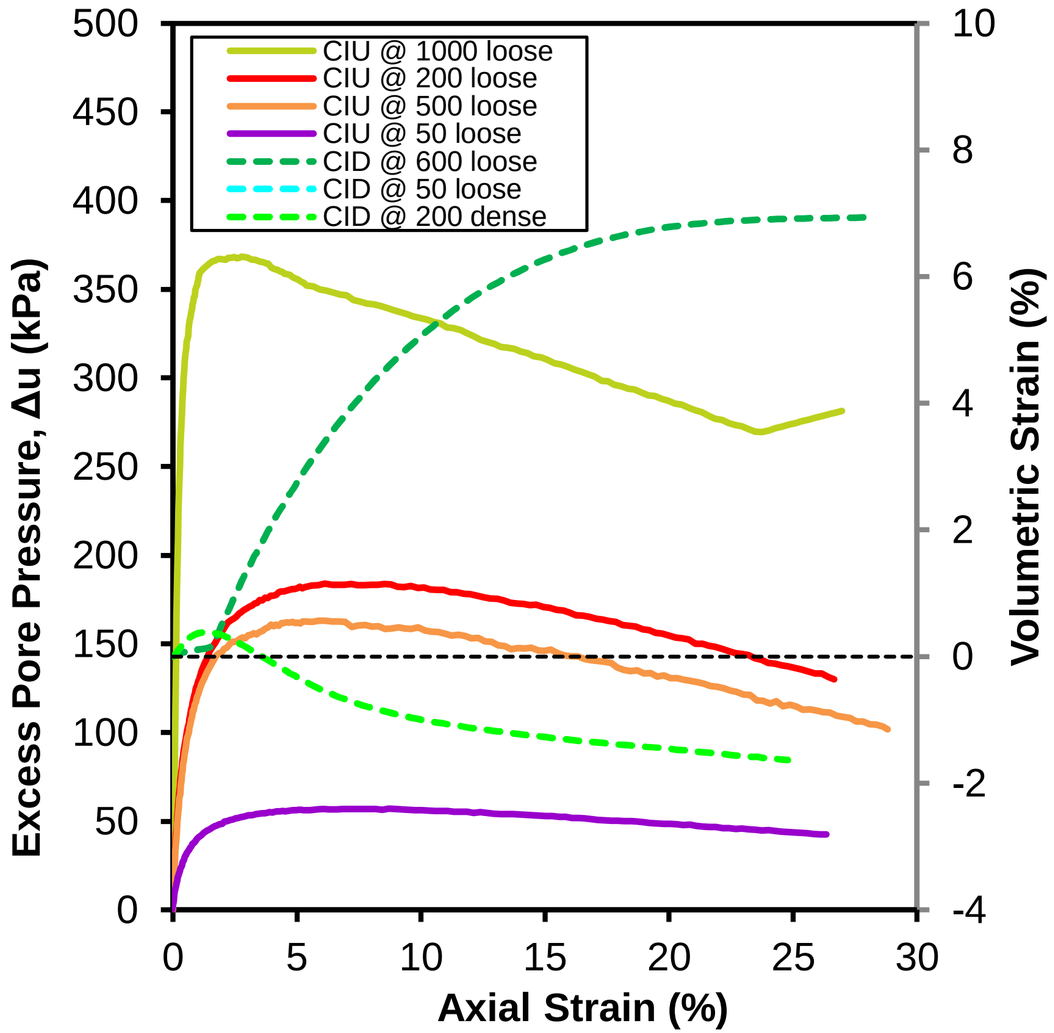
TITLE
SECTION B-B' –DRAIN DISPLACEMENT CHECK POINTS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-8**





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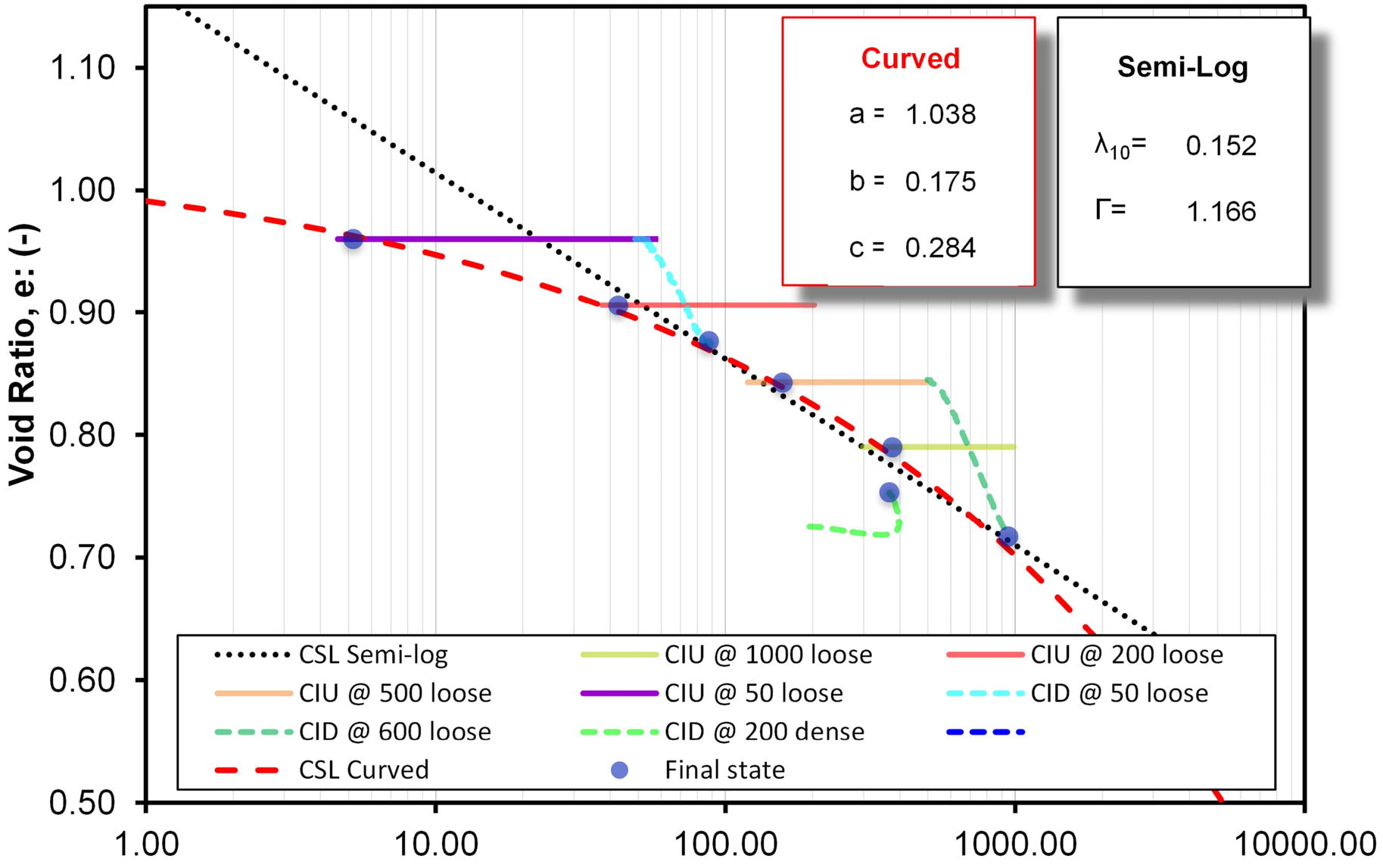
TITLE
STRESS PATH AND AXIAL STRAIN-VOLUMETRIC STRAIN (EXCESS PORE WATER PRESSURE) CURVES FOR CIU AND CID TESTS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-9**



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PROJECT
FEASIBILITY STUDY FOR
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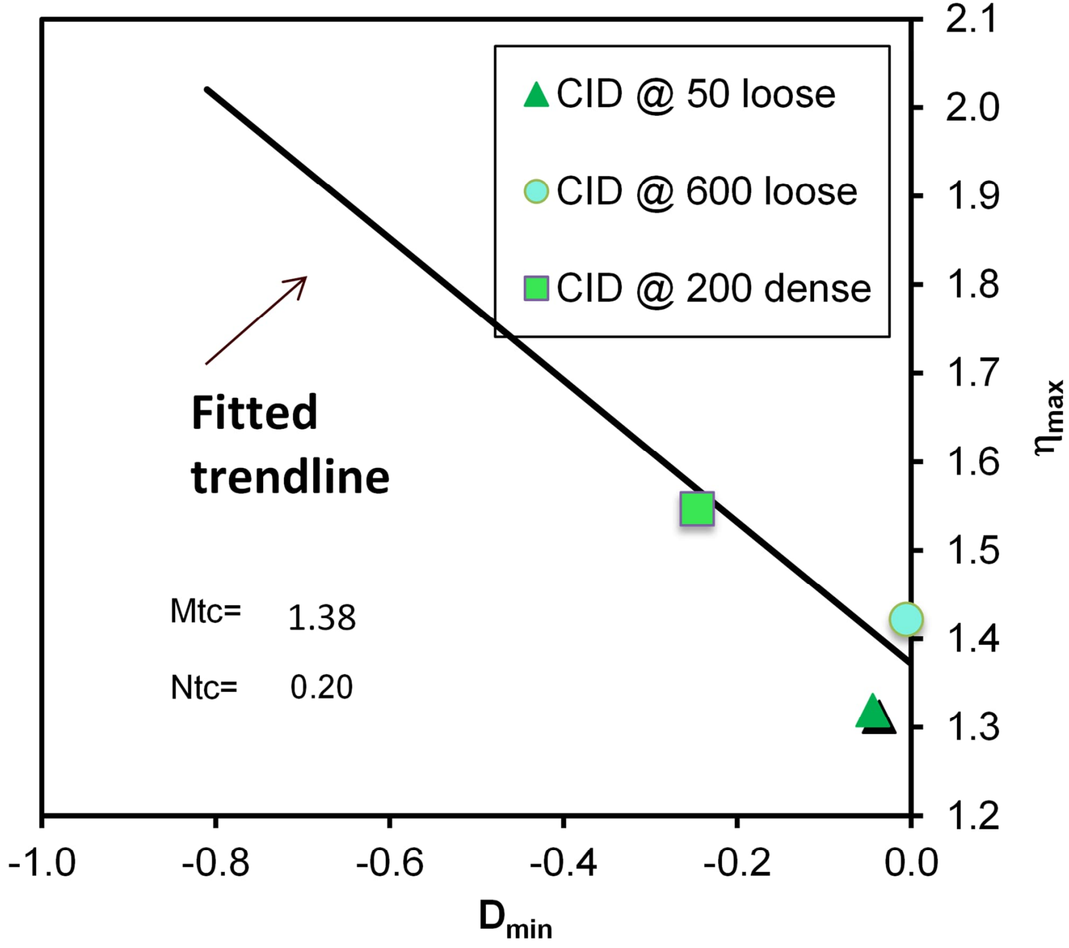
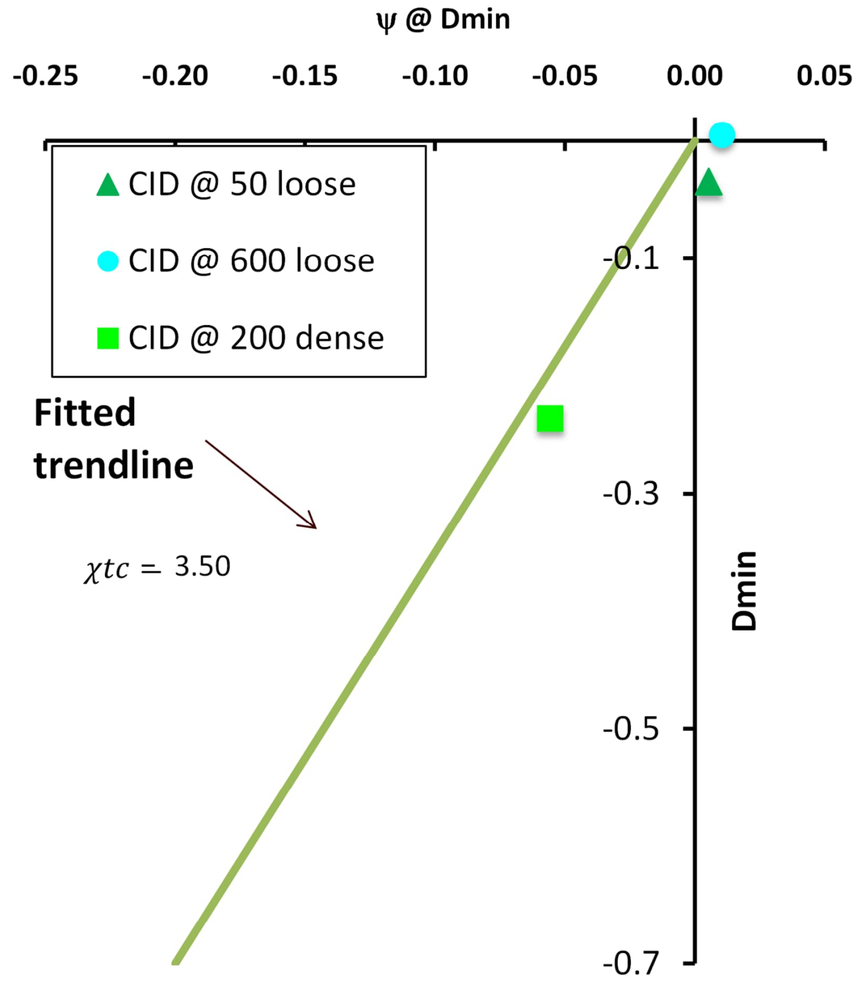
TITLE
CRITICAL STATE LINE OBTAINED FROM CID AND CIU TESTS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-10**

0 25 mm





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PROJECT
FEASIBILITY STUDY FOR
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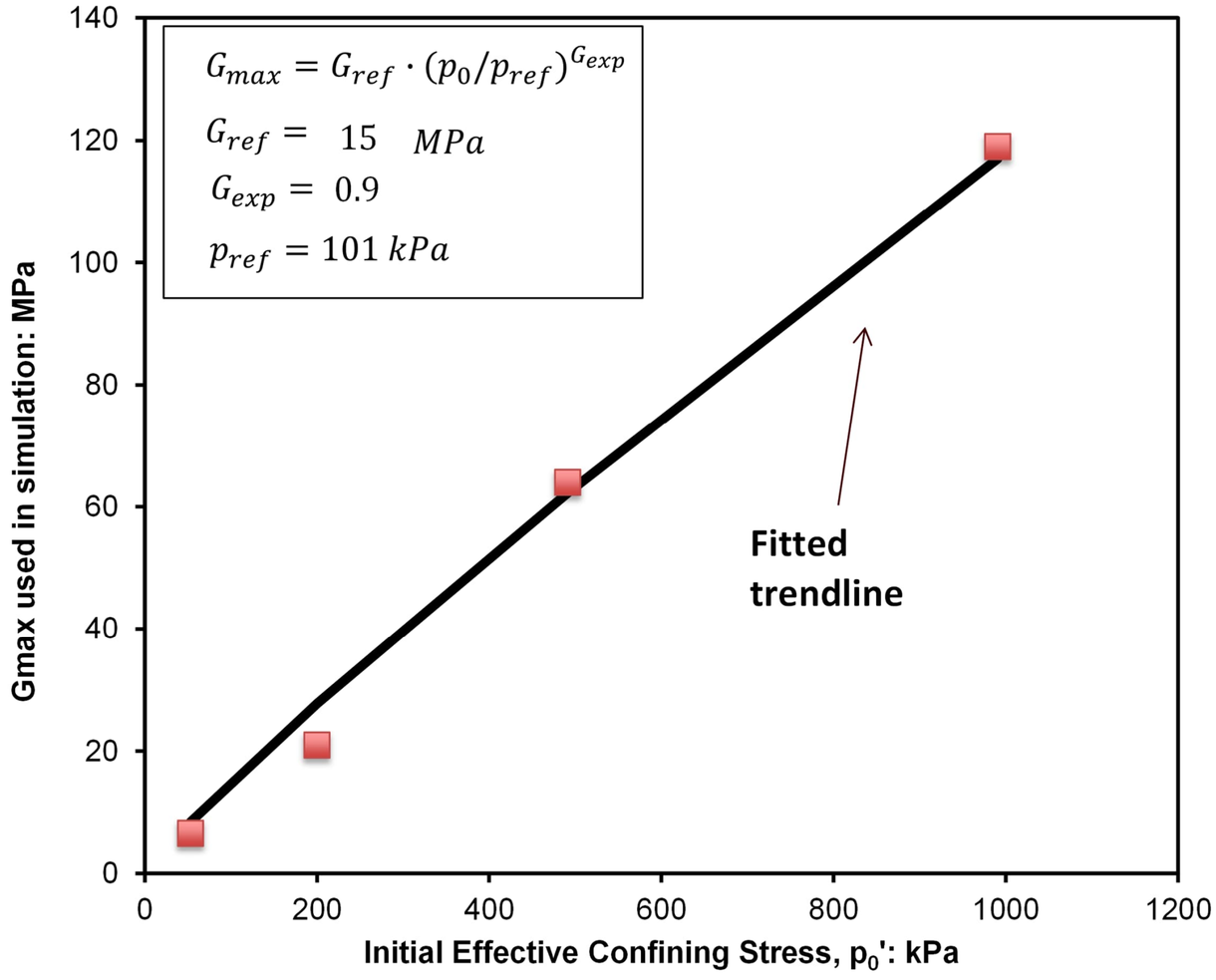
TITLE
NORSAND DILATANCY AND CRITICAL STATE PARAMETERS OBTAINED FROM CID TESTS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-11**

0 25 mm



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PROJECT
FEASIBILITY STUDY FOR
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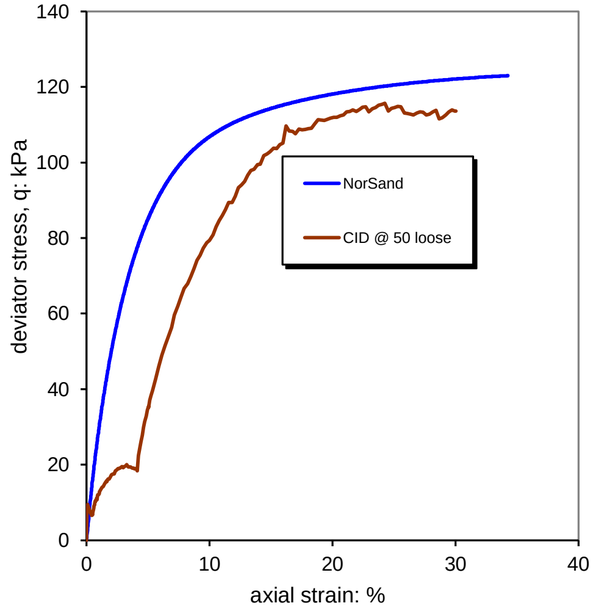
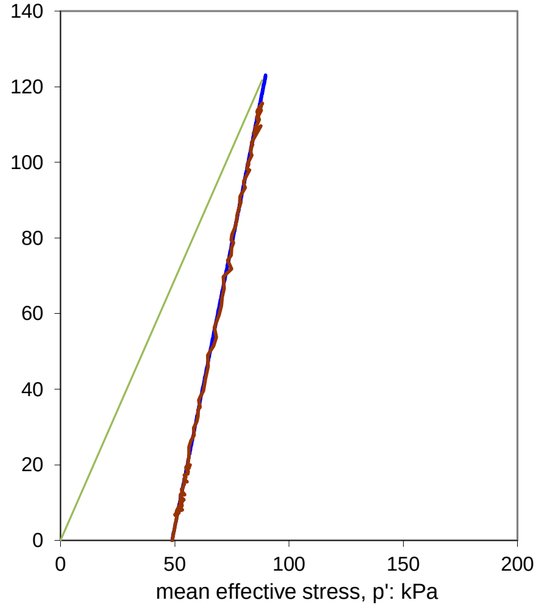
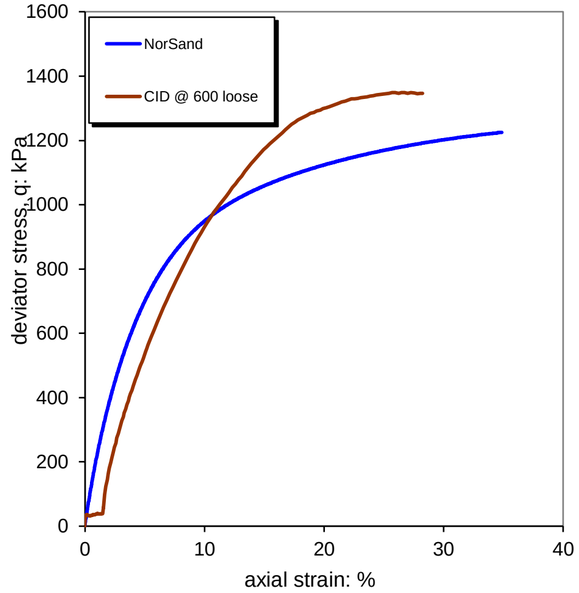
TITLE
MAXIMUM SHEAR MODULUS OBTAINED FROM NORSAND SIMULATIONS

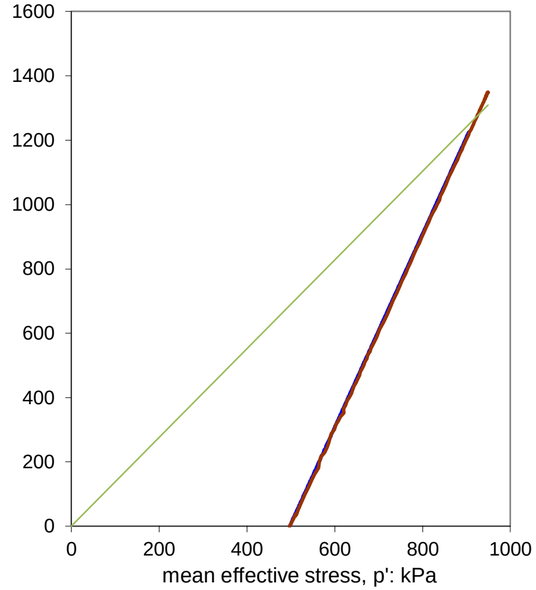
N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-12**

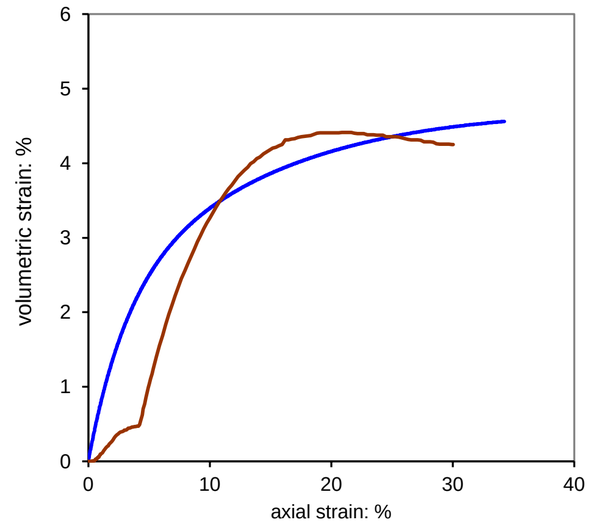
0 25 mm

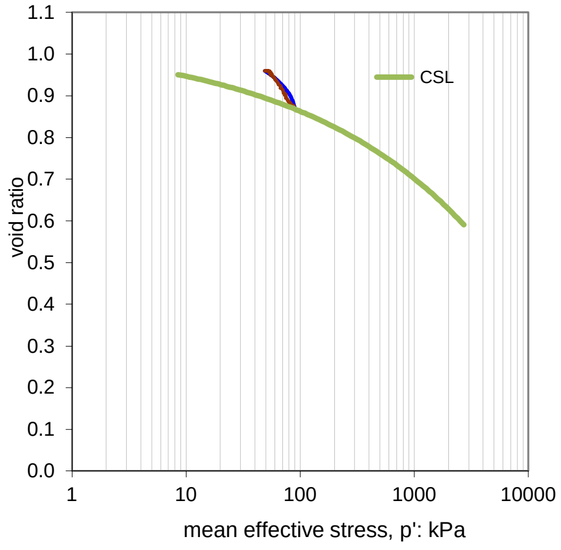


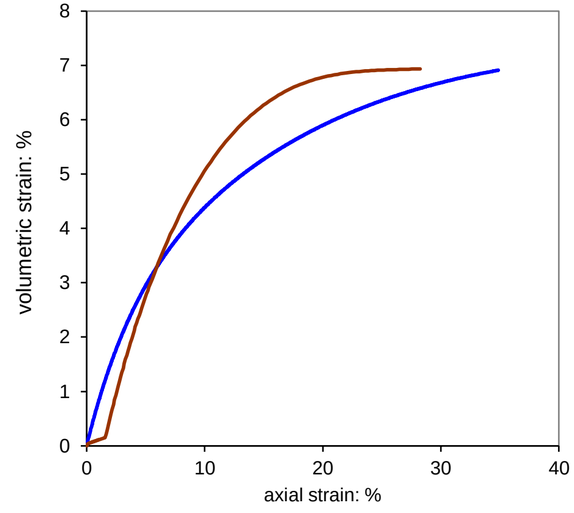


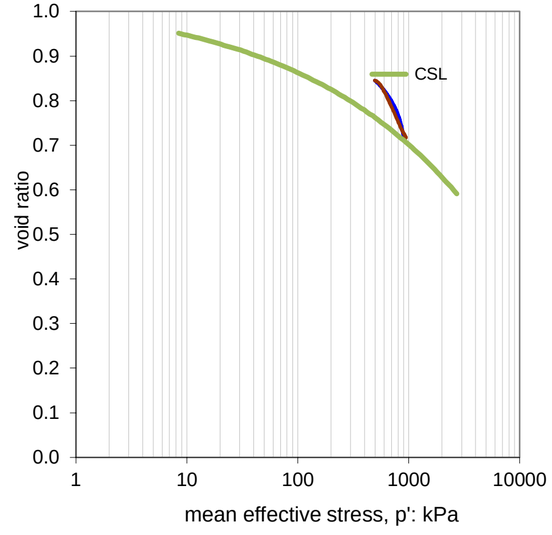












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PROJECT
FEASIBILITY STUDY FOR
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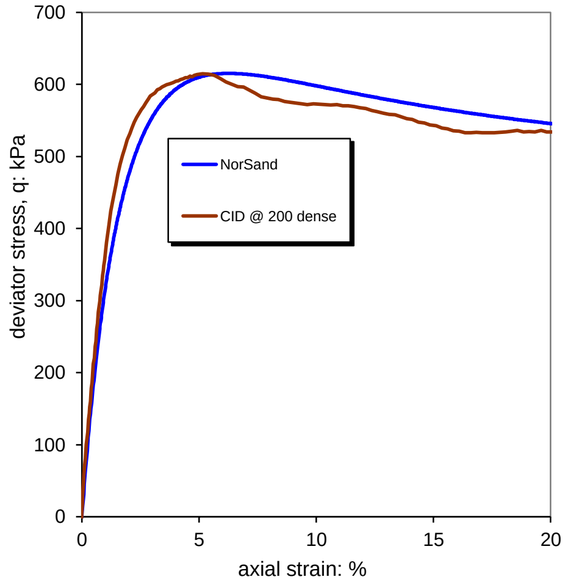
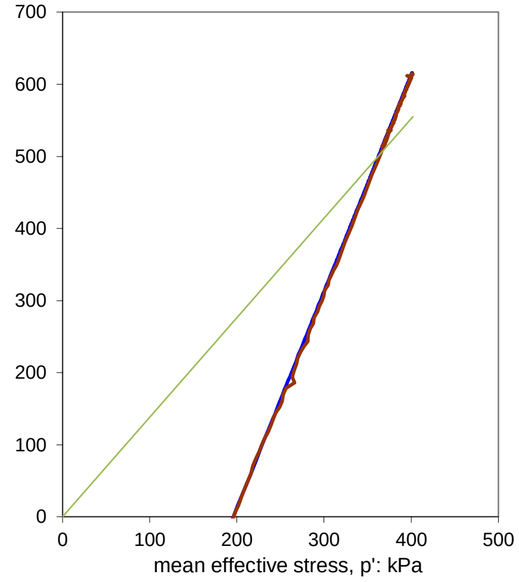
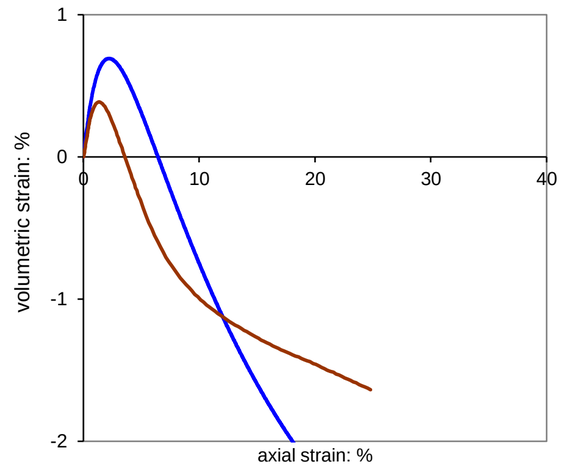
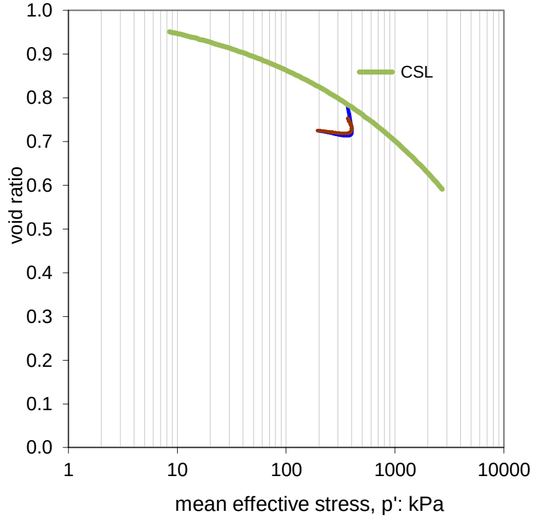
TITLE
SECTION B-B' –NorSand SIMULATIONS- CID TESTS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-13**









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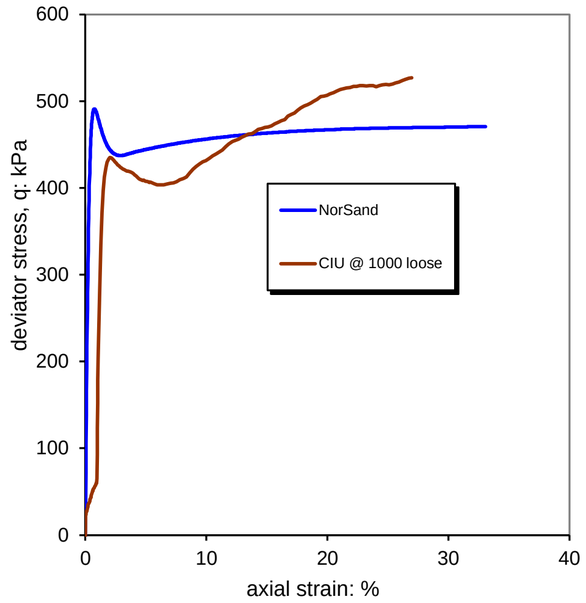
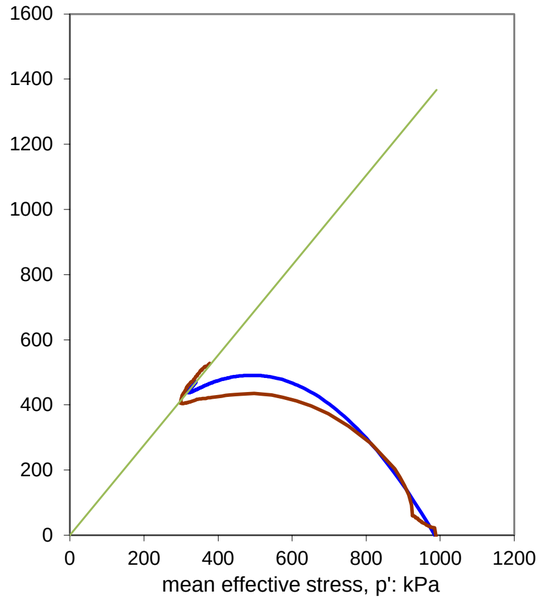
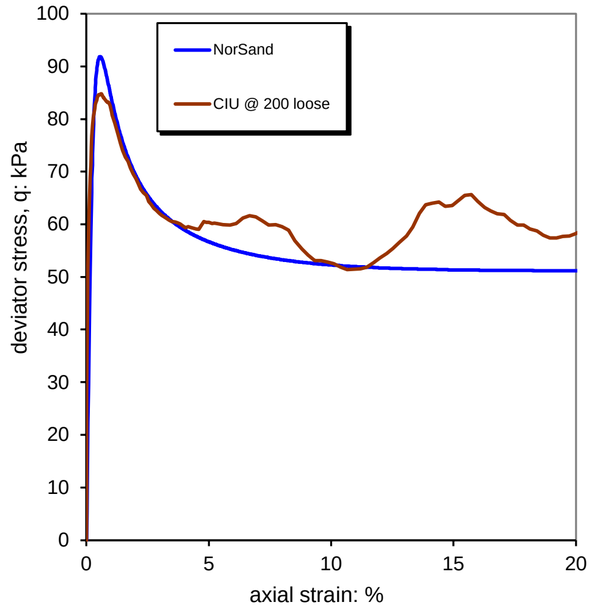
TITLE
SECTION B-B' –NorSand SIMULATIONS- CID TESTS

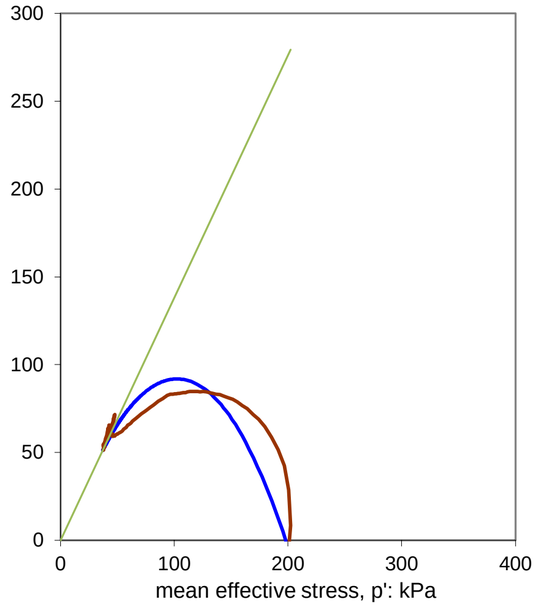
N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-14**

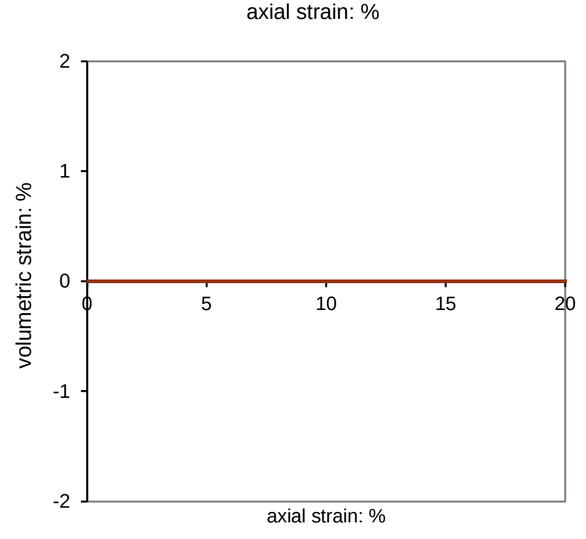
0 25 mm

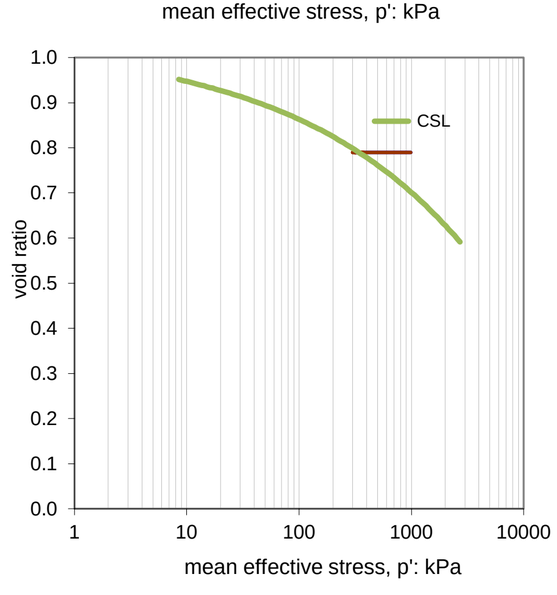


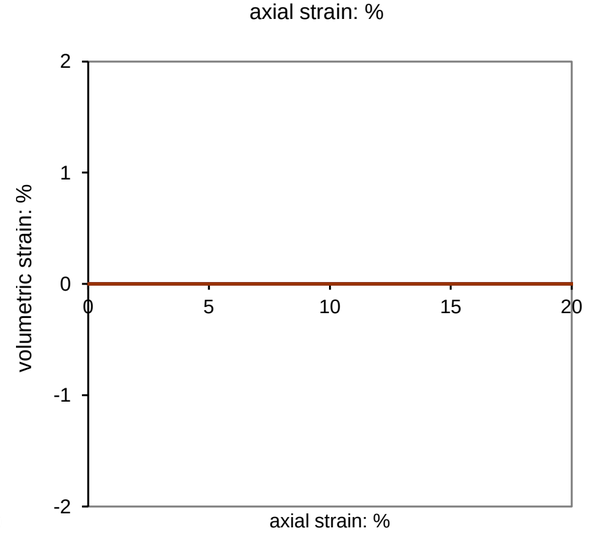


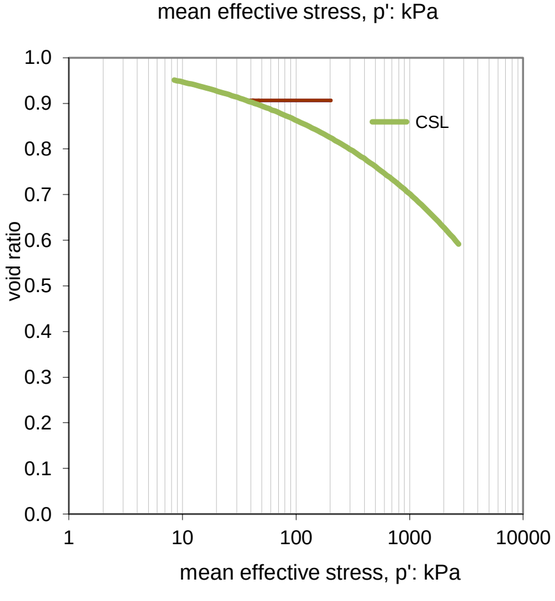












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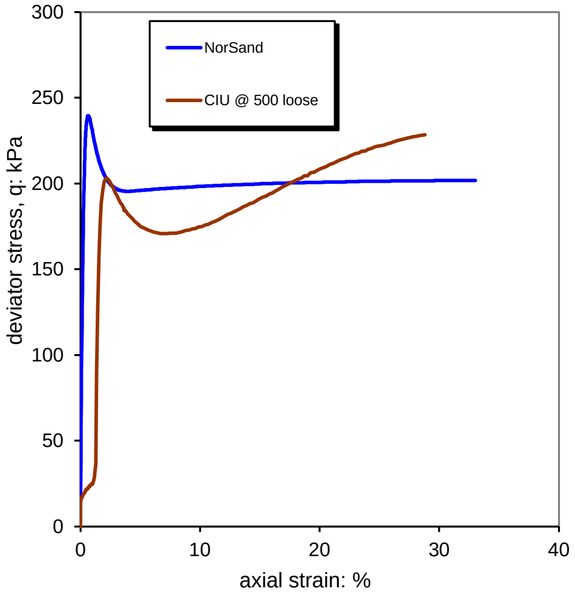
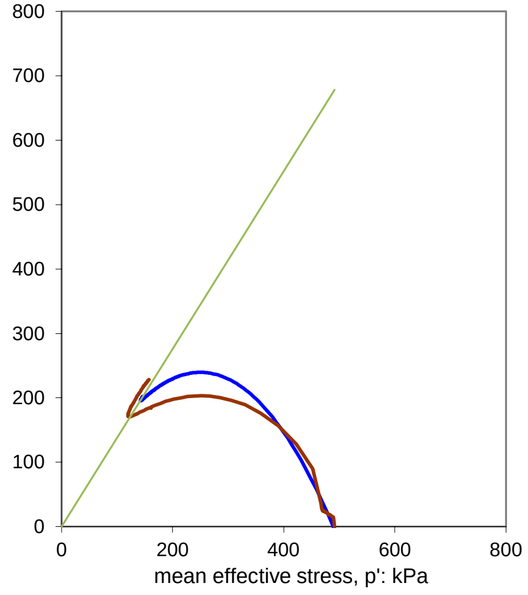
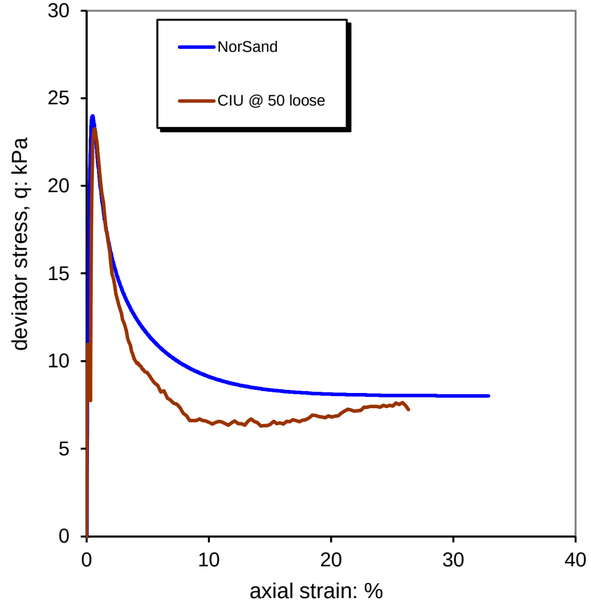
TITLE
SECTION B-B' –NorSand SIMULATIONS- CIU TESTS

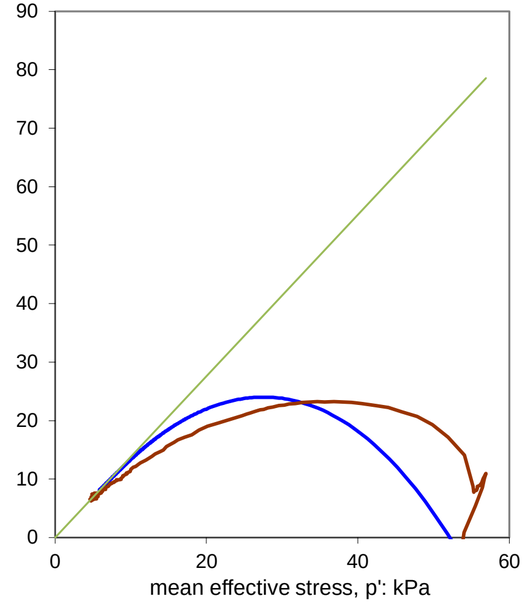
N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-15**

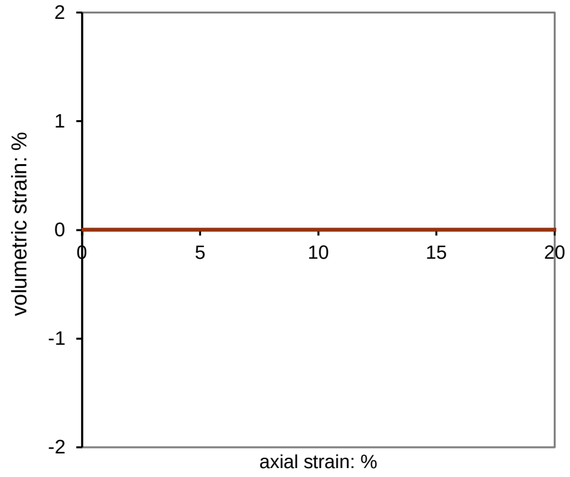
0 25 mm

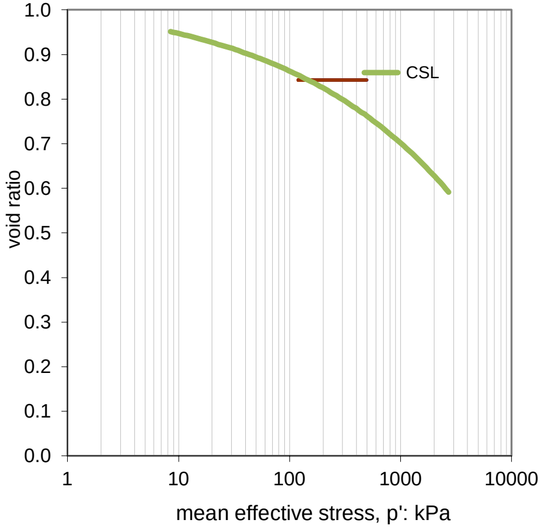


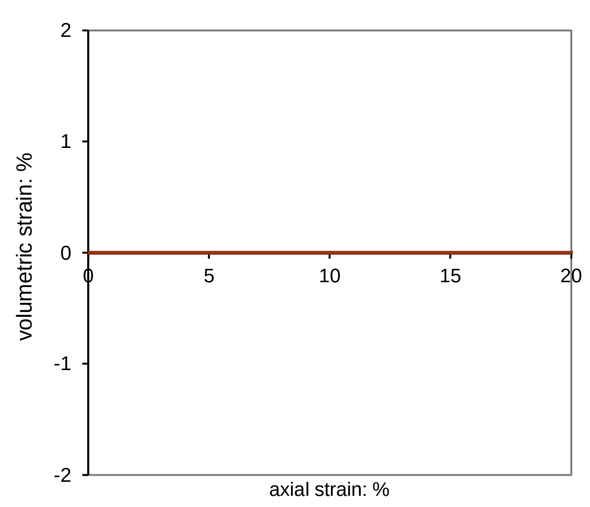












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PROJECT
FEASIBILITY STUDY FOR
TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
SECTION B-B' –NorSand SIMULATIONS- CIU TESTS

N° PROJECT	PHASE	REV.	FIGURE
2257554003	2000	0	**H-16**

APPENDIX I

Material Take Offs

Calculation Cover Sheet

Customer	Troilus Gold Corp.	**Proj No**	2257554003		
Project Title	Troilus Support -TSF - FS	**Calc No**	-		
Calculation Title	tailings storage facilities Plan - MTOs and Operational Requirements, LOM	**Phase/Task**			
Elec File Location		**Date**	30-avr-24		
Project File Location	https://golderassociates.sharepoint.com/:f:/r/sites/169483/Project%20Files/6%20Deliverables/047-22	**Page**	1	**of**	3

Purpose

Quantities for the Troilus Feasibility Study of the tailing management facilities

Limitations: Unprotected digital files are able to be modified after issue. WSP does not take responsibility for issues that may arise following the use of modified digital content.

Calculation Method

CAD calculations supplemented by area-based and geometry-based calculations for volumes of dyke material.

Assumptions and Limitations

General Assumptions

1. The quantities provided herein are for the Troilus Gold tailings storage facilities Plan, including stripping and construction materials.
2. No contingency is included in the calculated quantities.
3. Quantities were estimated using Civil 3D and construction plan of the actual dykes. The existing ground surface was based on 1m provincial LiDAR.
4. The accuracy of the calculations is +/-30% when it comes to total excavation and fill volumes.
5. Available borehole data was used to estimate peat thickness within stripping footprints. Boreholes were selected based on proximity the TSF structure.
6. No bulking factor was accounted for in bulk excavation volumes.
7. Quantities do not include quantities associated with the maintenance of future emergency spillways.
8. Quantities associated with mine closure are not included.
9. Quantities associated with access to the dyke are not included.
10. Quantities associated with operation and maintenance are not included.

Assumptions for the East Dyke

1. The access road is assumed to be located on top of the dyke crest.
2. Granular material for access roads on the dam is assumed to be 10 m wide and 0.1m deep on the entire length of the dyke for each raise.
3. Granular material for access road estimates are classified as "0-20mm".
4. Transition layer where required are comprised of 1 m thick "0-100mm" material on non-woven geotextile.
5. Filter layers where required are comprised of 1m thick sandy gravel.
6. It is assumed that the saddle dyke will not be required for before the 428m raise (year 10) .
7. It's assumed that the dyke should be raised by 4m per year to a final elevation of 435 meters.
8. Seeding and topsoil quantities are note included since it's closure quantities.
9. Selected waste rock is classified as "0-1000mm" 2.5m thick layer and 10m wide compacted with roller.
10. Non-woven Geotextile quantity include 10% for overlaping during installation.

Assumptions for the Main Dyke

1. The access road is assumed to be located on top of the dyke crest.
2. Granular material for access roads on the dyke is assumed to be 10 m wide and 0.1m deep on the entire length of the dyke for each raise
3. Granular material estimates are classified as "0-20mm".
4. Transition layer where required are comprised of 2 m thick "0-100mm" material on non-woven geotextile.
5. Filter layers where required are comprised of 1.5 to 2 m thick sandy gravel.
6. The starting dyke (capex) is assumed to be at an altitude of 403 masl.
7. It's assumed that the dyke should be raised from new starter dyke by 4 m per year (except years 8 and 9 for 2m) to a final elevation of 435 meters.
8. Seeding and topsoil quantities are note included since it's closure quantities.
9. Selected waste rock is classified as "0-1000mm" 2.5m thick layer and 10m wide compacted with roller.
10. Non-woven Geotextile quantity include 10% for overlaping during installation.

Assumptions for excavation and stripping

1. All excavation side slopes are assumed to be 2H:1V.
2. Peat is assumed to be removed within the dyke footprint.
3. Peat thickness depth was assumed to be constant within the striping area.
4. Potential liquefiable soil will be remove at the foot of the future dyke. Available borehole data was used to estimate the depht of the excavation.
5. The Filter layer on the 2004 dyke raise is expected to be found at the elevation shown on the constrution plan.

Assumptions for Construction Timing

1. New starter dyke will be required at year -1 for deposition on year 1. and so on.

Software Used

Excel				**Microsoft 365**					
Civil 3D	*x*			**AutoCAD 2021**					

References

Data			**File Link**
Mine Plan			Mine Plan
Dykes - typical sections			
CAD files (Dykes)			Design
Borehole summary			

Conclusions

Rev	Date	Description	By	Checked	Approved
4	30-04-2024	Troilus Feasibility Study Tailing Storage Facility Plan - Material Take Off Tables	CP, MG	MG	CP
3	26-04-2024	Troilus Feasibility Study Tailing Storage Facility Plan - Material Take Off Tables	CP, MG	MG	CP
2	1-03-2024	Troilus Feasibility Study Tailing Storage Facility Plan - Material Take Off Tables	CP, MG	MG	CP
1	24-01-2024	Troilus Feasibility Study Tailing Storage Facility Plan - Material Take Off Tables	CP, MG	MG	CP
0	21-12-2023	Troilus Feasibility Study Tailing Storage Facility Plan - Material Take Off Tables	CP, MG	MG	CP
A	17-11-2023	Troilus Feasibility Study Tailing Storage Facility Plan - Material Take Off Tables	CP,MG	MG	CP

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TSF Quantities

Structures/Activities		Unit	Total	Dyke elevation (m)/Year											
					403	407	411	415	419	423	427	431	433	435	435
				-2	-1	1	2	3	4	5	6	7	8	9	10
1. Construction and Site Prep															
1.1	General site preparation (area for clearing and grubbing)	m^2	335 800	-	-	167 900	-	167 900	-	-	-	-	-	-	-
1.2	East dyke preparation (area for clearing and grubbing)	m^2	19 800	-	-	-	-	-	-	-	9 900	9 900	-	-	-
2. Excavation volumes															
2.1 Main Dyke															
2.1.1	Top soil (peat) excavation volume (assume 0.8m thick)	m^3	270 000	-	-	135 000	-	135 000	-	-	-	-	-		-
2.1.2	Volume of overburden excavation (liquefaction-sensitive soil)	m^3	143 000	-	-	143 000	-	-	-	-	-	-	-		-
2.1.3	Volume of excavation to reach 2004 raise (potentielly reuse as waste rock)	m^3	90 000	-	90 000	-	-	-	-	-	-	-	-		-
2.1.4	Volume of bedrock excavation for emergency spillway	m^3	400	-	-	200	-	200	-	-	-	-	-		-
2.2 East Saddle Dam															
2.2	Top soil (peat) excavation volume (assume 0.5m thick)	m^3	12 000	-	-	-	-	-	-	-	6 000	6 000	-		-
3 Granular Materials															
3.1 Main Dyke															
3.1.1	Crushed rock volume (Transition zone) (1.5 m thick placed in 1.5 m lifts and compacted with bucket at 1:1 slope)	m^3	446 000	-	142 000	33 000	35 000	36 000	37 000	39 000	40 000	41 000	21 000	22 000	-
3.1.2	Sand and gravel volume (Filter zone) (2 m thick placed in 1.5 m lifts and compacted with bucket at 1:1 slope)	m^3	552 000	-	189 000	40 000	41 000	43 000	45 000	46 000	48 000	49 000	25 000	26 000	-
3.1.3	Selected waste rock volume	m^3	1 337 000	-	300 000	114 000	118 000	123 000	127 000	132 000	137 000	141 000	72 000	73 000	-
3.1.4	General waste rock volume	m^3	17 919 000	-	-	2 650 000	2 650 000	2 500 000	2 500 000	2 500 000	2 500 000	2 500 000	109 000	10 000	-
3.1.5	Granular fill "0-20mm" volume (access roads on dykes) assume 20 cm thick	m^3	80 800	-	6 800	7 100	7 400	7 700	8 000	8 300	8 600	8 800	9 000	9 100	-
3.1.6	Tailings for backfill	m^3	20 000	-	20 000	-	-	-	-	-	-	-	-		-
3.2 East Dyke															
3.2.1	Crushed rock volume (Transition zone) (1 m thick placed in 1.5 m lifts and compacted with bucket at 2:1 slope)	m^3	3 700	-	-	-	-	-	-	-	400	1 500	1 800	-	-
3.2.2	Sand and gravel volume (Filter zone)(1 m thick placed in 1.5 m lifts and compacted with bucket at 2:1 slope)	m^3	3 400	-	-	-	-	-	-	-	400	1 300	1 700	-	-
3.2.3	Selected waste rock volume	m^3	54 000	-	-	-	-	-	-	-	10 200	22 800	21 000	-	-
3.2.4	General waste rock volume	m^3	13 700	-	-	-	-	-	-	-	1 300	6 200	6 200	-	-
3.2.5	Granular fill "0-20mm" volume (access roads on dykes) assume 20 cm thick	m^3	2 600	-	-	-	-	-	-	-	400	1 080	1 120	-	-
3.3 Emergency Spillway															
3.3.1	Boulder for emergency spillway "300-1000mm"	m^3	16 700	-	4 100	5 800	850	850	850	850	850	850	850	850	-
3.3.2	General waste rock volume (include in item 3.1.4)	m^3	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Lining Material															
4.1.1	Non-woven Geotextile surface area (Texel 918), between filter and tailings material	m^2	601 000	-	56 000	60 000	62 000	65 000	67 000	69 000	72 000	74 000	37 500	38 500	-
4.1.2	Non-woven Geotextile surface area (Texel 934), between filter and transition material	m^2	640 300	-	138 300	55 000	57 000	60 000	62 000	64 000	66 000	68 000	34 500	35 500	-
4.2.1	East dyke non-woven Geotextile (Texel 918), between filter and tailings material	m^2	10 500	-	-	-	-	-	-	-	1 100	4 200	5 200	-	-
4.2.2	East dyke non-woven Geotextile (Texel 934) surface area, between filter and transition material	m^2	10 400	-	-	-	-	-	-	-	1 100	4 100	5 200	-	-
5. Geotechnical Instrumentation															
5.1	Drilling, geotechnical instrumentation and installation	$ CAD	650 000	-	-	350 000	-	-	200 000	-	100 000	-	-	-	-

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APPENDIX J

PSHA

MEMO

TO: Mohammad Kermani, P.Eng.

FROM: Nathan Clarke

CC: Annyssa Bertrand-Locas, Mathieu Gosselin, Alan Hull

SUBJECT: **Troilus TSF**
Probabilistic Seismic Hazard Analysis – Rev1

DATE: 08 December 2023

REF: CA-GLD-2257554003 / 2000.2002

1 INTRODUCTION

The WSP Canada Mining team requested the WSP Seismic Hazard team to undertake probabilistic seismic hazard analysis (PSHA) for the tailings storage facility (TSF) site at Troilus Gold Mine in Québec, Canada. The PSHA results will assist ongoing engineering for Troilus Gold Corporation (Troilus).

This technical memorandum presents the methodology and findings of the PSHA.

2 SCOPE OF WORK

The work scope undertaken is based on an email sent by Sophie Bainbridge of the WSP Mining team, dated 30 August 2023.

- Estimate the horizontal peak ground acceleration (PGA) ground motion with an annual exceedance probability (AEP) of 1/10,000 for the Troilus TSF site located at 50.989ºN and 74.481ºW ('Troilus TSF site'), using the 6th-Generation Seismic Hazard Model of Canada (CanadaSHM6).
- Conduct the PSHA for a site condition representative of the TSF foundation. This site condition is represented by the time-averaged shear-wave velocity (V_S) in the 30 m below a reference depth ($V_{S30,REF}$). Two $V_{S30,REF}$ values are used in this assessment; one lower $V_{S30,REF}$ of 1,500 m/s, and one upper $V_{S30,REF}$ of 3,000 m/s. These values reflect the range of V_S values measured for the TSF foundations by WSP Golder (2022a) and the range of V_{S30} values associated with the National Building Code of Canada (NBCC) Site Class A.
- Conduct the PSHA for a V_{S30} representative of the ultimate tailings surface elevation, i.e., $V_{S30,SURF}$. A $V_{S30,SURF}$ of 180 m/s is used in this assessment. This value was calculated based on V_S data measured in seismic cone penetration tests (SCPTs) undertaken within the TSF in 2020 (WSP Golder, 2022b). This calculation is described in Attachment A.
- Provide an earthquake magnitude associated with the PGA at 1/10,000 AEP for input to liquefaction analyses.
- Summarise the methodology and findings of the analysis in this technical memorandum.

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3 REGULATORY CONTEXT

The relevant regulations and guidelines applicable to tailings dams in Québec are:

- Directive 019 sur l'industrie minière (Gouvernement du Québec, 2012)
- Global Industry Standard for Tailings Management (GISTM; Global Tailings Review [GTR], 2020)
- Canadian Dam Association (CDA) Dam Safety Guidelines (2013)
- CDA Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2014, revised 2019)

This PSHA uses the 6th-Generation Seismic Hazard Model of Canada (CanadaSHM6) developed to provide seismic hazard values for the 2020 National Building Code of Canada (NBCC). The 2020 NBCC ground motions calculated from CanadaSHM6 are provided by Natural Resources Canada (NRCan) through a web tool[1]. The NRCan webtool provides ground motions for a minimum AEP of 1/2,475.

Engineering analyses and design for the Troilus TSF are for an assumed Extreme consequence classification for the TSF (WSP Golder, 2022c). As per the 2013 and 2019 CDA guidelines and 2020 GISTM, seismic design for Extreme classification facilities should be based on ground motions with a 1/10,000 AEP. These low probability ground motions are not provided by the NRCan webtool. This analysis estimates the 1/10,000 AEP earthquake ground motions for the Troilus TSF site.

4 SEISMIC SOURCE MODEL

We adopt the CanadaSHM6 seismic source models as described by Kolaj et al. (2023; NRCan Open File 8924) to estimate the site-specific PGA with an AEP of 1/10,000. CanadaSHM6 is the latest national consensus seismic hazard model for Canada and was the basis of the 2020 NBCC. CanadaSHM6 consists of three regional models based on their location:

- Southeastern Canada
- Western Canada
- Eastern Arctic Canada

The Troilus TSF site is located within the southeastern (SE) Canada model. The SE Canada model comprises three alternative sub-models: the Historical (H2), Regional (R2), and Hybrid (HY) sub-models (Figure 1). Source parameters in the H2 sub-model are based on historical earthquake locations and magnitudes. The R2 sub-model was developed using the regional geological criteria as the basis for selection of the seismic source parameters, and the HY sub-model was developed using both historical earthquake data and regional geological parameters. Each of the sub-models contains several seismic source zones. These are uniform-area source zones where the rate of earthquake activity is assumed to be uniform across each zone.

The Troilus TSF site is located within the Stable Cratonic Core of Eastern Canada (prefixed 'SCCE' in Figure 2) uniform-area source zone, which models the eastern portion of the stable cratonic core in CanadaSHM6. In general, the stable cratonic core comprises ancient (> 1 Ga) continental crust that has not undergone major post-Precambrian (i.e., <542 Ma) deformation. Earthquake activity rates in the cratonic core of North America are generally low compared to

[1] 2020 National Building Code of Canada Seismic Hazard Tool, available at: https://earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/nbc2020-cnb2020-en.php

geologically younger areas of the continental crust typical of western regions of North America. Within about 600 km of the Troilus TSF site there are, however, some more historically seismically active areas of SE Canada, including parts of the St. Lawrence Valley, western Québec, and eastern Ontario. These regions have experienced several moderate to larger historical and pre-historical earthquakes including an estimated moment magnitude (Mw) 7.0 earthquake in 1663 near Charlevoix, QC (Kolaj et al., 2020).

5 GROUND MOTION MODELS

We apply the same combination of ground motion models (GMMs) used in the 2020 NBCC in our PSHA for the Troilus TSF site. The GMMs are used to model the source-to-site attenuation of earthquake accelerations. The following two suites of GMMs were applied with the CanadaSHM6 seismic source models to calculate the 2020 NBCC seismic hazard values, each weighted 50% (Kolaj et al., 2019):

- The Atkinson and Adams (2013; AA13) median and standard deviation GMMs as developed for implementation with the previous national seismic hazard model, CanadaSHM5.
- The preliminary 13 NGA-East median GMMs (PEER Report 2017-03 [Goulet et al., 2017a,b]) with the standard deviation model from the CanadaSHM5 AA13 GMMs.

The AA13 GMMs comprise five models developed for eastern North America. These GMMs were developed for reference hard-rock site conditions represented by a V_{S30} of 2,000 m/s. The GMMs are applicable for earthquake magnitudes ranging from Mw 4.8 to Mw 8.0 and source-to-site distances up to 600 km. The AA13 standard deviation (sigma) model is a spectral period-dependent model intended to capture the natural variability of hypothetical future earthquakes (i.e., aleatory variability).

The preliminary NGA-East GMMs comprise 13 models developed as part of the Next Generation Attenuation (NGA) project for central and eastern North America (CENA). These GMMs were developed for reference hard-rock site conditions represented by a V_{S30} of 3,000 m/s. They are applicable for earthquake magnitudes ranging from Mw 4.0 to Mw 8.2 and source-to-site distances up to 1,500 km. The NGA-East GMMs were developed from the CENA ground motion database that is relatively limited compared to other more active regions (such as western United States [WUS]). Therefore, standard deviation models from other tectonic regions, including the WUS and Japan, were used to inform the NGA-East standard deviation models. The resulting NGA-East standard deviation models have high sigma values, leading to large differences between median and mean ground motions. For CanadaSHM6, the AA13 standard deviation model is applied with the NGA-East median GMMs, instead of the NGA-East standard deviation models.

Site terms are applied to the AA13 and NGA-East GMMs to account for the amplification or deamplification of seismic energy by the ground conditions beneath a site. These site amplification models are based on the V_{S30} conditions at the site (i.e., $V_{S30,REF}$ = 1,500 m/s and 3,000 m/s, and $V_{S30,SURF}$ = 180 m/s for the Troilus TSF site in this analysis) compared to the reference V_{S30} value for which the GMMs were developed. Kolaj et al. (2019) describes the site amplification models implemented with the AA13 and NGA-East GMMs.

The preliminary 13 NGA-East GMMs have been superseded by a final suite of 17 GMMs (Goulet et al., 2018), as noted in the addendum to PEER Report 2017-03 (Goulet et al. 2017a,b). However, in this analysis we apply the CanadaSHM6 source model and corresponding GMMs as implemented for the 2020 NBCC, i.e., we do not use the final suite of 17 NGA-East GMMs.

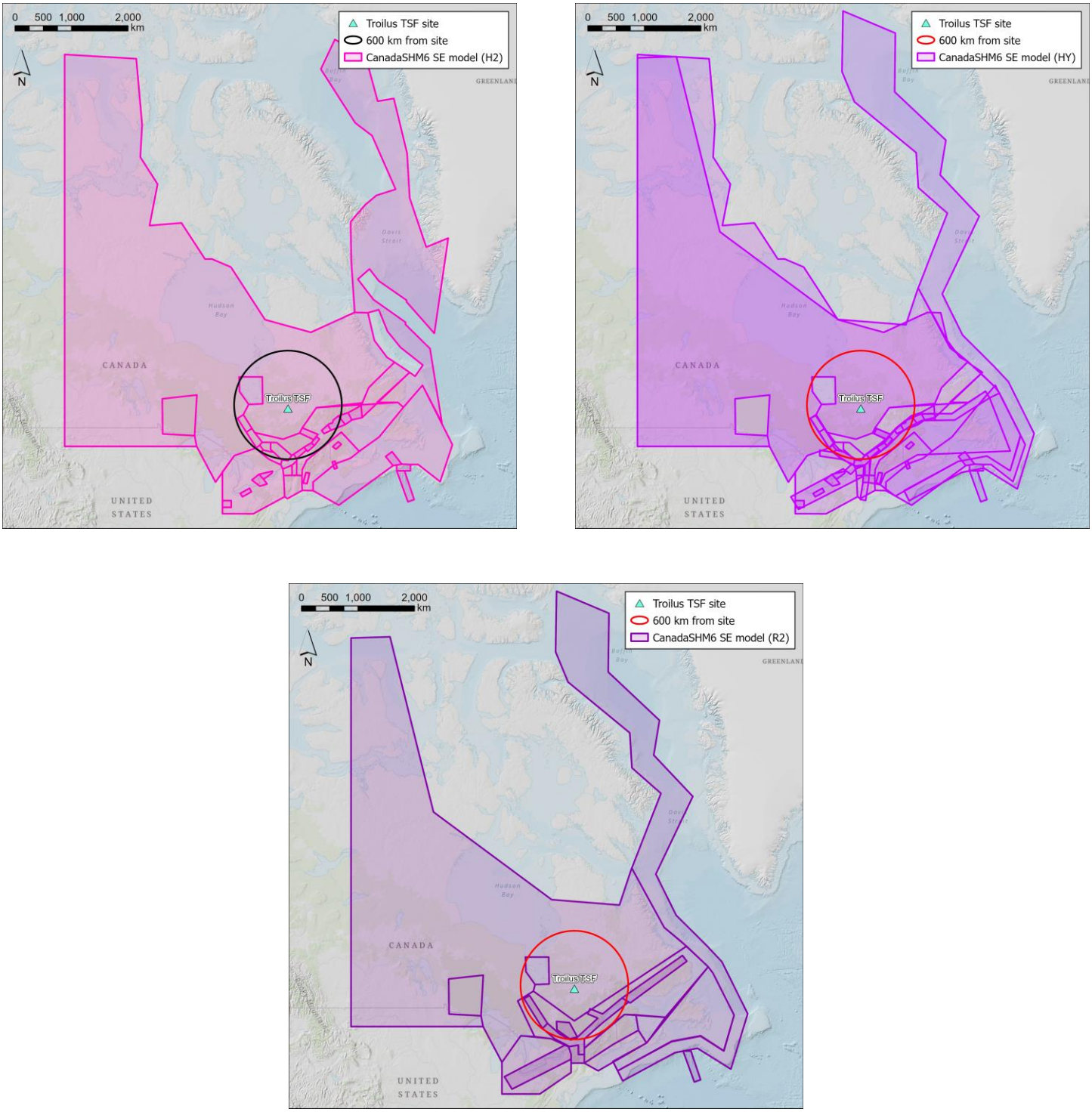

Figure 1: Top left: CanadaSHM6 SE Canada Historical (H2) source model. Top right: CanadaSHM6 SE Canada Hybrid (HY) source model. Bottom: CanadaSHM6 SE Canada Regional (R2) source model. Model data from Kolaj et al. (2023).

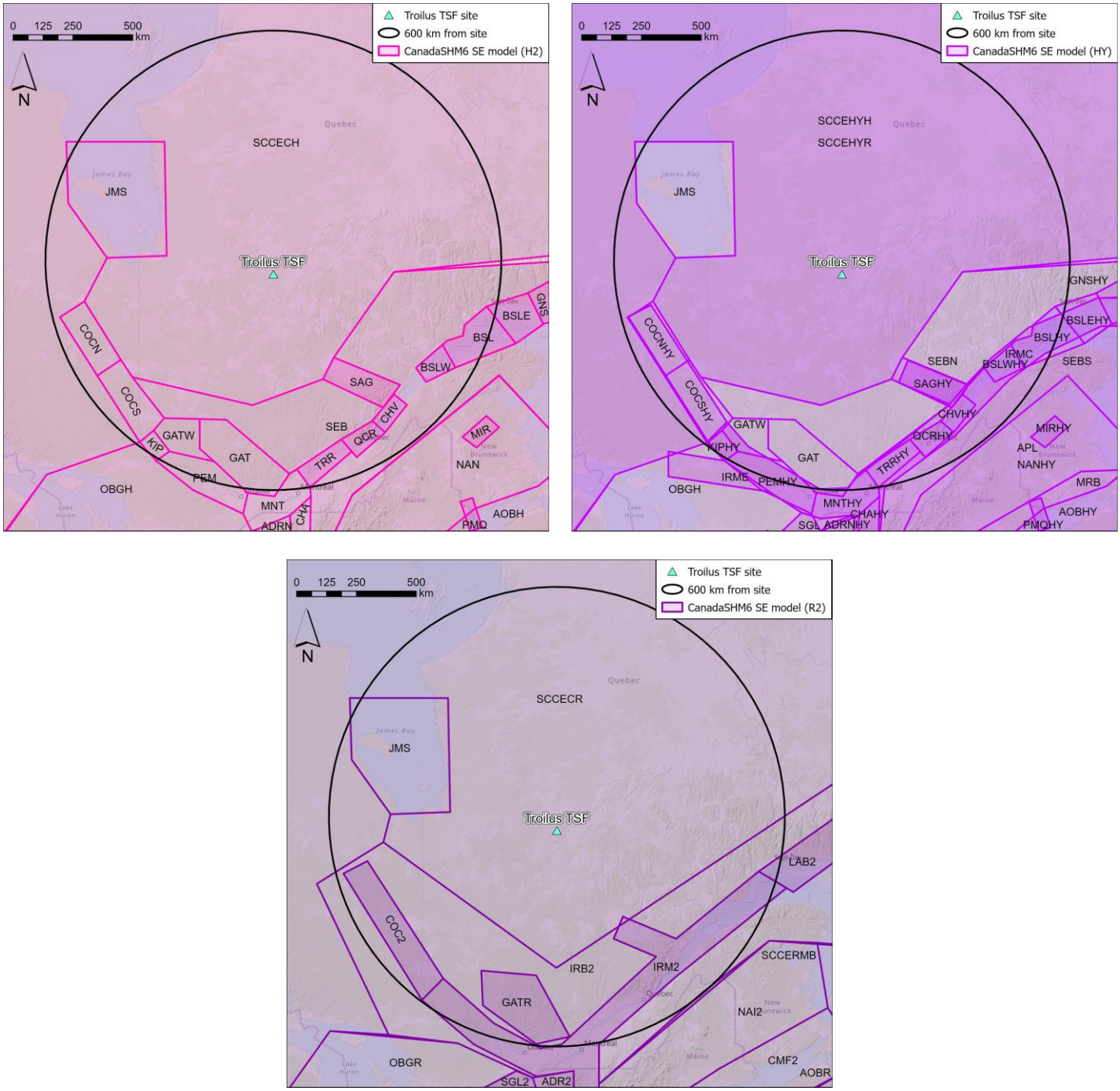

Figure 2: Uniform-area seismic sources in the CanadaSHM6 SE Canada source models: Historical (top left), Hybrid (top right), and Regional (bottom). Labels indicate source zone names as per Kolaj et al. (2023). Key sources are referenced in text.

6 METHODOLOGY

We conduct the PSHA using the OpenQuake software (v3.11.4) developed by Global Earthquake Model (GEM). Our methodology and the corresponding outputs are summarised below:

- Obtain the OpenQuake input files for the CanadaSHM6 SE Canada model as provided in NRCan Open File 8924 (Kolaj et al., 2023).
- Validate our implementation of CanadaSHM6 in OpenQuake v3.11.4, using the two tests as described below.
- Use the CanadaSHM6 SE Canada model and corresponding GMMs (as implemented in the 2020 NBCC) to calculate the 1/10,000 AEP PGA at the Troilus TSF site (50.989ºN, 74.481ºW) for $V_{S30,REF}$ values of 1,500 m/s and 3,000 m/s, and a $V_{S30,SURF}$ value of 180 m/s.
- Obtain the average magnitude, distance, and epsilon contributing to the 1/10,000 AEP PGA seismic hazard for each site condition through hazard disaggregation.

7 MODEL VALIDATION

We ran two tests to validate our implementation of the CanadaSHM6 SE Canada model files in OpenQuake v3.11.4:

1. Run CanadaSHM6 SE Canada model and corresponding GMMs unadjusted for the closest example city (La Malbaie) to the Troilus TSF site at 1/2,475 AEP and V_{S30} = 450 m/s. The results are then compared to the sample hazard values supplied in NRCan Open File 8924 (Kolaj et al., 2023).

2. Run CanadaSHM6 SE Canada model and corresponding GMMs unadjusted for the Troilus TSF site at 1/2,475 AEP for a V_{S30} = 1,500 m/s. Results are then compared to the NRCan 2020 NBCC Seismic Hazard Tool results.

Table 1 lists the test results, indicating that they are less than 0.4% different from those from the online seismic hazard tool. The small difference is attributed to minor differences in the OpenQuake software versions (that is, v3.11.4 [this assessment] and v3.3.2 [2020 NBCC results]).

Table 1: Mean Uniform Hazard Spectra for CanadaSHM6 Validation Tests, 1/2,475 AEP.

Spectral Period (s)	Test 1: La Malbaie (V_{S30} = 450 m/s)		Test 2: Troilus TSF (V_{S30} = 1,500 m/s)	
	5%-damped, RotD50, Mean Spectral Acceleration (g), 1/2,475 AEP	% difference compared to 2020 NBCC results (Open File 8924, Kolaj et al., 2023)	5%-damped, RotD50, Mean Spectral Acceleration (g), 1/2,475 AEP	% difference compared to 2020 NBCC results (NRCan Seismic Hazard Tool)
PGA	1.15	-0.17%	0.0418	-0.11%
0.2	2.22	0.08%	0.0734	-0.05%
0.5	1.21	-0.39%	0.0574	-0.08%
1.0	0.613	0.04%	0.0358	-0.04%
5.0	0.0604	-0.04%	0.00558	0.05%
10.0	0.0177	0.16%	0.00227	-0.07%

Notes:
1. Validation tests completed using OpenQuake v3.11.4, 2020 NBCC results calculated using OpenQuake v3.3.2.

8 RESULTS

We estimate the 1/10,000 AEP PGA for at the Troilus TSF site with PSHA using the existing seismic source model (CanadaSHM6) and GMMs developed for the 2020 NBCC, with no modifications of the published models (Kolaj et al., 2023). The analysis is undertaken for three site conditions: two $V_{S30,REF}$ values of 1,500 m/s and 3,000 m/s, and one $V_{S30,SURF}$ value of 180 m/s. Tables and figures below present the results of our PSHA.

8.1 1/10,000 AEP peak ground acceleration

Table 2 lists the 1/10,000 AEP PGA for each site condition. Figure 3 shows the 1/10,000 AEP PGA for each site condition compared to PGA with greater annual exceedance probabilities derived from the NRCan 2020 NBCC Seismic Hazard Tool.

Table 2: Mean 1/10,000 AEP PGA for the $V_{S30,REF}$ values of 1,500 m/s and 3,000 m/s and the $V_{S30,SURF}$ value of 180 m/s.

Spectral Period	5%-damped, RotD50, Mean Spectral Acceleration (g), 1/10,000 AEP		
	$V_{S30,REF}$ = 1,500 m/s	$V_{S30,REF}$ = 3,000 m/s	$V_{S30,SURF}$ = 180 m/s
PGA	0.0884	0.0800	0.180

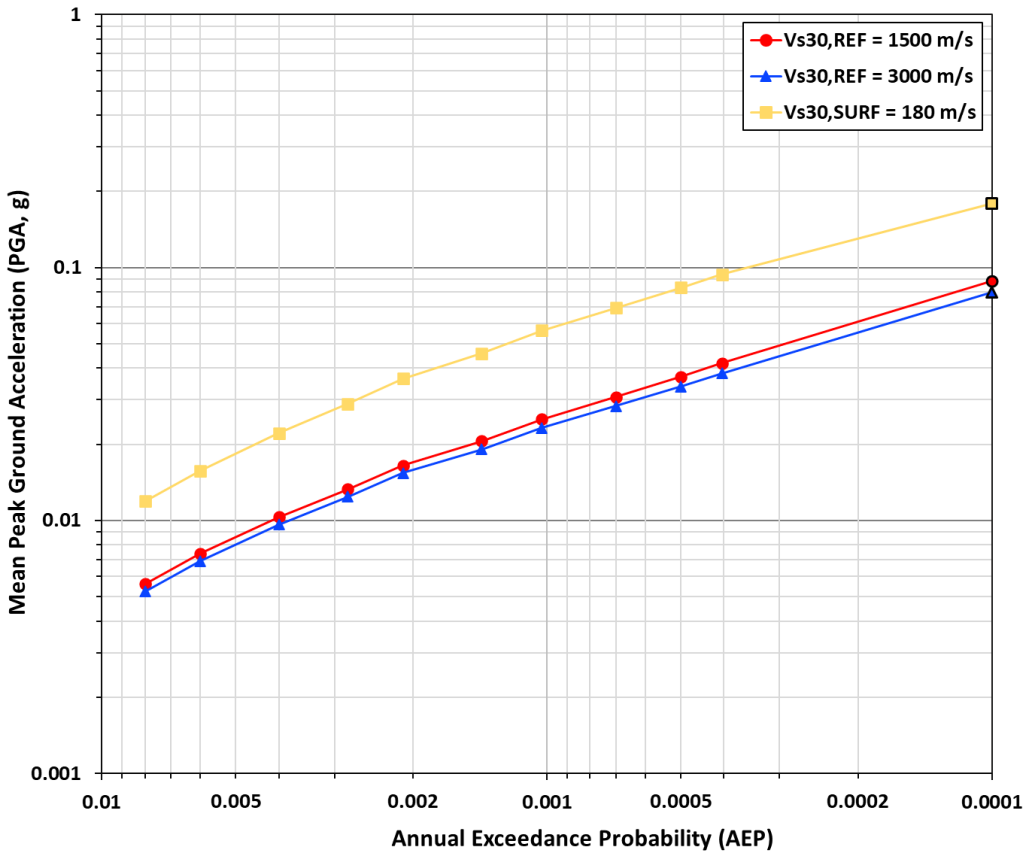

Figure 3: Mean PGA for 1/10,000 AEP (black outlined symbols, this study) and for larger AEPs (non-outlined symbols, from NRCan 2020 NBCC Seismic Hazard Tool). Red: $V_{S30,REF}$ = 1,500 m/s, blue: $V_{S30,REF}$ = 3,000 m/s, yellow: $V_{S30,SURF}$ = 180 m/s.

8.2 Magnitude, distance, and epsilon disaggregation

Figure 4, Figure 5, and Figure 6 show the relative contribution of earthquakes, by magnitude and source-to-site distance, to the 1/10,000 AEP PGA hazard for the V_{S30} values of 1,500 m/s, 3,000 m/s, and 180 m/s, respectively. The disaggregations plot the distribution of epsilon for each combination of distance and magnitude. Epsilon is the number of standard deviations away from the median in the GMMs. Epsilon informs the earthquake scenarios in the PSHA that contribute to the earthquake intensity at the given spectral period and likelihood (AEP). In the CanadaSHM6 model, a maximum of five standard deviations above and below the mean are included in the calculation (i.e., epsilon ± 5).

Table 3 summarises the mean, median, and modal values of magnitude, distance, and epsilon derived from the PGA hazard disaggregations (Figure 4, Figure 5, and Figure 6).

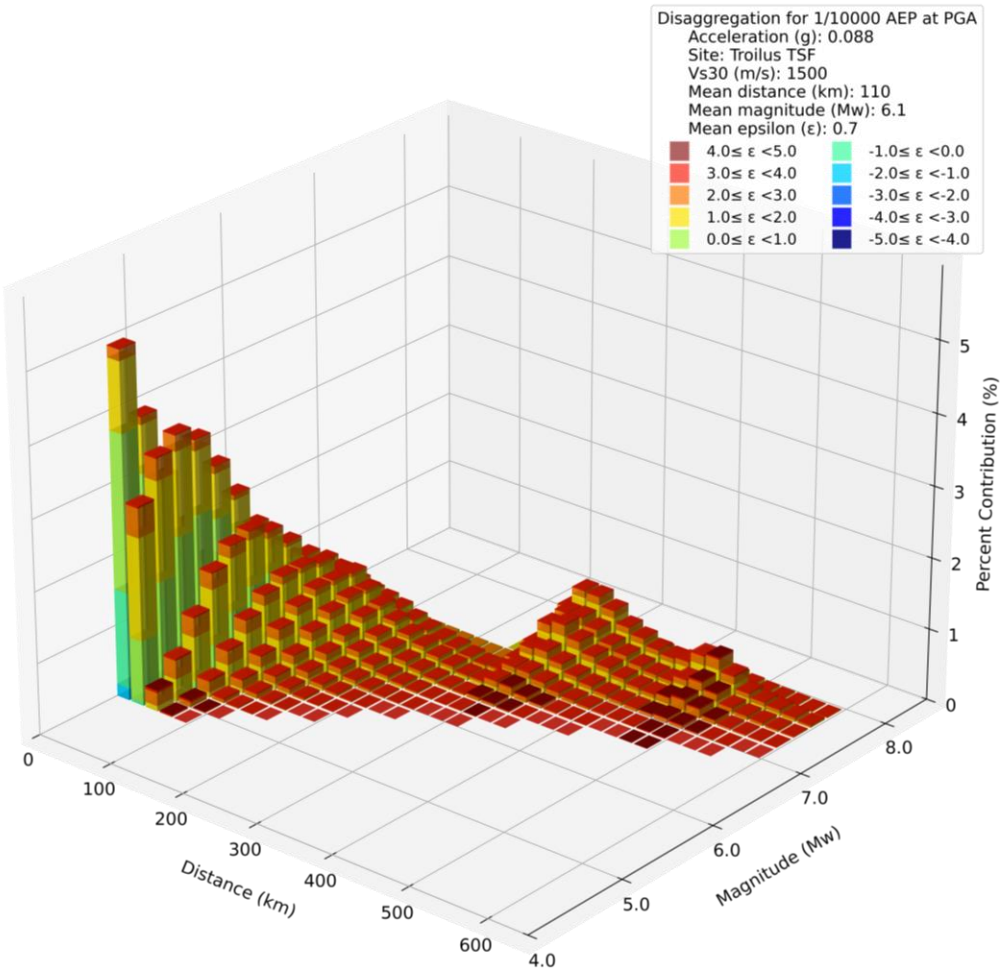

Figure 4: Magnitude, distance, and epsilon disaggregation of the 1/10,000 AEP PGA hazard ($V_{S30,REF}$ = 1,500 m/s).

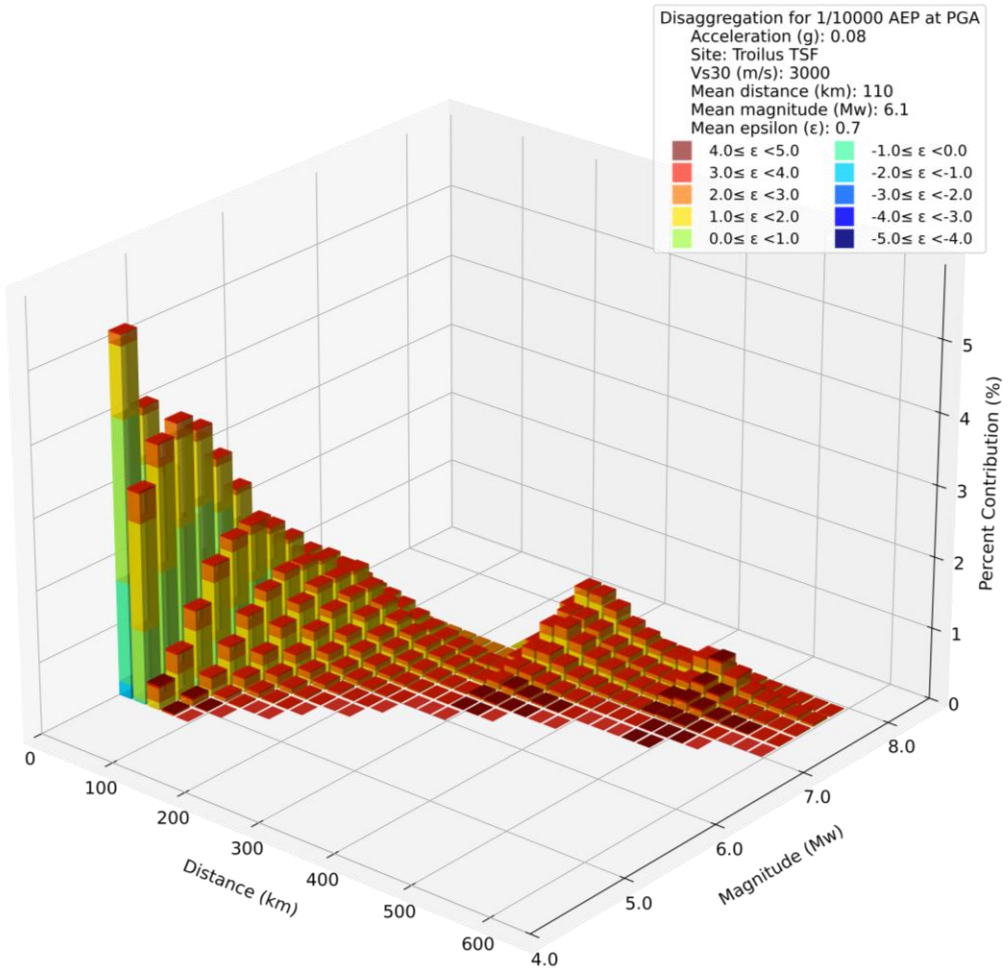

Figure 5: Magnitude, distance, and epsilon disaggregation of the 1/10,000 AEP PGA hazard ($V_{S30,REF}$ = 3,000 m/s).

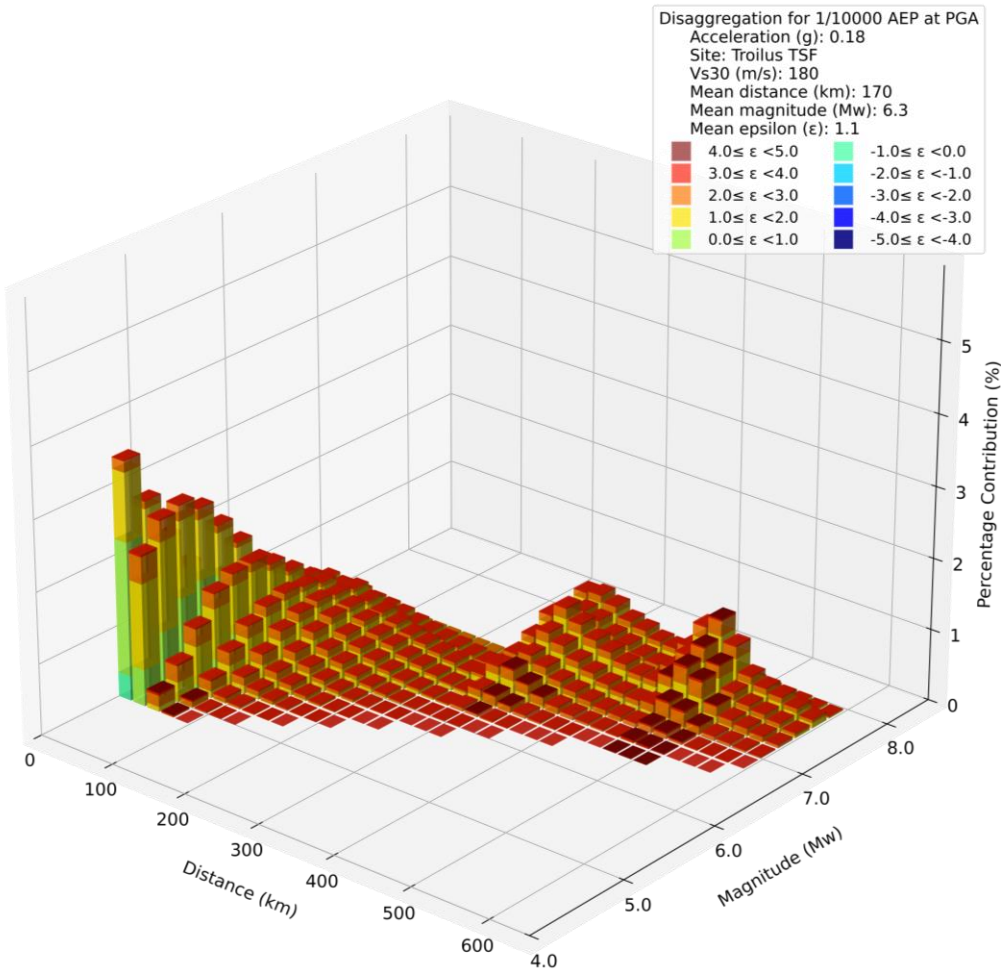

Figure 6: Magnitude, distance, and epsilon disaggregation of the 1/10,000 AEP PGA hazard ($V_{S30,REF}$ = 180 m/s).

Table 3: Mean, median, and modal magnitude, distance, and epsilon contributing to the 1/10,000 AEP PGA at the Troilus TSF site for $V_{S30,REF}$ = 1,500 m/s and 3,000 m/s and $V_{S30,SURF}$ = 180 m/s.

V_{S30} (m/s)	Distance (km)			Magnitude (Mw)			Epsilon		
	Mean	Median	Mode	Mean	Median	Mode	Mean	Median	Mode
1,500	100 - 120	40 - 60	0 - 20	6.0 - 6.2	6.0 - 6.2	4.8 - 5.0	0.7	0.5	0.5
3,000	100 - 120	40 - 60	0 - 20	6.0 - 6.2	6.0 - 6.2	4.8 - 5.0	0.7	0.5	0.5
180	100 - 120	80 - 100	0 - 20	6.0 - 6.2	6.4 - 6.6	4.8 - 5.0	1.1	1.5	0.5

Notes:

1. Values obtained through disaggregation of the 1/10,000 AEP PGA hazard.

8.3 Discussion

The PSHA indicates that 1/10,000 AEP PGA values at the Troilus TSF site are relatively low, with values of 0.0884 g and 0.0800 g for the $V_{S30,REF}$ values of 1,500 m/s and 3,000 m/s, respectively (Table 2 and Figure 3). The 1/10,000 AEP PGA value for the ultimate tailings elevation site condition, $V_{S30,SURF}$ = 180 m/s, is 0.180 g.

Disaggregation of the 1/10,000 AEP PGA indicates that at all site conditions analyzed the greatest contributors to hazard at the site are earthquakes with magnitudes of about Mw 4.8 to 6.0 with source-to-site distances of less than about 60 km. This contribution is likely from distributed shallow crustal earthquakes within the Canadian craton (source zones prefixed 'SCCE' in Figure 2) that are not associated with known faults. At source-to-site distances greater than about 280 km, there is some hazard contribution from larger magnitude earthquakes (i.e., Mw 7.0 to Mw 8.0). These earthquakes likely occur within the Saguenay-Lac-St-Jean region ('SAG' in H2 model, see Figure 2) southeast of the Troilus TSF site.

Table 3 lists mean, median, and modal magnitude and source-to-site distance of the earthquakes contributing to the 1/10,000 AEP PGA hazard. These results show differences between the three types of average because the Troilus TSF site disaggregation results are multi-modal. Selection of mean, median, or modal values depends on the types of analyses proposed, but in general, use of the mean magnitude-distance pair is inappropriate for sites with multi-modal disaggregations such as the Troilus TSF site. We suggest instead that multiple magnitude-distance combinations be considered for seismic analyses at sites with multiple modes. For example, liquefaction analyses could consider the PGA result (e.g., 0.08 g for $V_{S30,REF}$ = 1,500 m/s) with both an Mw ~5.5 earthquake (dominant mode) and an Mw ~7.5 earthquake (second mode). Such an analysis reflects the possible sources of earthquake ground motions at the 1/10,000 AEP – a moderate-magnitude earthquake relatively close to the site and a large-magnitude earthquake at a greater distance.

Similarly, if subsequent seismic analyses require the development of a suite of earthquake acceleration time histories, then period-dependent disaggregation modal distributions will need to be considered. The PSHA results provided here, however, are insufficient for any acceleration time history analyses.

9 CONCLUSIONS AND RECOMMENDATIONS

The 1/10,000 AEP PGA results presented here are suitable for geotechnical analyses at the Troilus TSF site because they are based on the CanadaSHM6 seismic source model and GMMs (AA13 and preliminary NGA-East) without adjustment. This conclusion is subject to confirmation by WSP Canada that the Troilus TSF foundation ground conditions have V_{S30} values of 1,500 m/s and 3,000 m/s, and the Troilus TSF ultimate tailings surface elevation ground condition has a V_{S30} value of 180 m/s. If the site V_{S30} conditions are different than assumed as indicated by site investigations, then we recommend that these seismic hazard analyses are updated and revised, if necessary.

As noted in Section 5, the preliminary 13 NGA-East GMMs have been superseded by the final suite of 17 NGA-East GMMs (Goulet et al., 2018) that post-date the development of CanadaSHM6. A potential refinement of the analyses presented here could include the implementation of CanadaSHM6 with the 17 NGA-East GMMs, along with more recent site amplification models developed for central and eastern North America by Stewart et al. (2020) and Hashash et al. (2020).

CLOSING

We trust that this technical memorandum provides the necessary methodology and result of the PSHA completed for the Troilus TSF site in Québec, Canada.

Please address any questions to Nathan Clarke.

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Junior Geoscientist

Reviewed by Alan Hull, Ph.D., CEG (CA)
Senior Vice President
WSP USA Inc.

Attachments:

Attachment A – Calculation of $V_{S30,SURF}$ for the Ultimate Tailings Surface Elevation.

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TROILUS TSF PSHA – ATTACHMENT A

CALCULATION OF $V_{S30,SURF}$ FOR THE ULTIMATE TAILINGS SURFACE ELEVATION

Overview:

To undertake probabilistic seismic hazard analysis (PSHA) for the surface elevation of the tailings storage facility (TSF) at Troilus Mine requires the time-averaged shear-wave velocity (V_S) over the upper 30 m below the surface (i.e., $V_{S30,SURF}$). For this analysis, $V_{S30,SURF}$ is calculated using shear-wave measurement collected during seismic cone penetration tests (SCPTs) pushed within the tailings at Troilus Mine.

This Attachment describes the approach used to calculate $V_{S30,SURF}$ for input to the PSHA, and the result of the calculation.

Methodology:

The following approach was implemented to calculate a V_{S30} representative of the tailings surface elevation:

- Identify SCPTs pushed within the tailings and review the associated shear-wave velocity depth profiles (data for the SCPT completed in 2020 is provided in WSP Golder, 2022b).
- With reference to inferred stratigraphic units for each layer in the V_S depth profiles (as provided by colleagues in the WSP Mining team), identify all units inferred to be non-frozen tailings (i.e., excluding underlying soils and frozen tailings).
- Calculate the time-average shear-wave velocity for all units inferred to be non-frozen tailings, for each SCPT pushed within tailings.
- Take the mean of the time-averaged shear-wave velocities to the base of non-frozen tailings, as calculated in the above step.
- Adopt the mean value calculated in the above step as the $V_{S30,SURF}$ to be used for PSHA.

Assumptions:

The approach described above includes some key assumptions, described further here:

- We understand that the ultimate tailings elevation within the Troilus TSF is to be higher than the existing elevation, by approximately 35 m. Therefore, it was agreed by the WSP Seismic Hazard team and WSP Mining team that a representative $V_{S30,SURF}$ for the ultimate tailings surface elevation should be estimated based on the existing V_S measurements within tailings. V_S measurements associated with the underlying soils were excluded on the basis that when the ultimate tailings elevation is achieved, the tailings thickness would be greater than 30 m.
- It was also assumed that the $V_{S30,SURF}$ value representative of the ultimate tailings surface elevation excludes frozen tailings (which have higher shear-wave velocity compared to non-frozen tailings, as indicated in the 2020 SCPT data).

Results:

Eight SCPTs were pushed within the tailings: SCPTs 20-01, 20-03, 20-07, 20-09, 20-10, 20-10B, 20-10C, and 20-11. The locations of these SCPTs within the TSF are shown on Figure A1. SCPT 20-10 was excluded from the calculation because the termination depth

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was only 2.8 m below ground surface. V_S data from the remaining seven SCPTs were considered in the $V_{S30,SURF}$ calculation (Table A1). The completion depths of these seven SCPTs were between 13.8 m and 21.8 m below ground surface.

Table A1 presents the time-averaged V_S to the base of the tailings (excluding frozen tailings) for each of the seven SCPTs considered. The results range from 144 m/s to 214 m/s.

Using these seven values of time-averaged V_S, a mean value of time-averaged V_S to the base of the tailings was calculated to be 180 m/s. This value was adopted as the $V_{S30,SURF}$ value representative of the ultimate tailings surface elevation.

Table A1: Completion depth, maximum tailings depth, and time-averaged shear-wave velocity to the base of non-frozen tailings for the SCPTs considered in the $V_{S30,SURF}$ calculation.

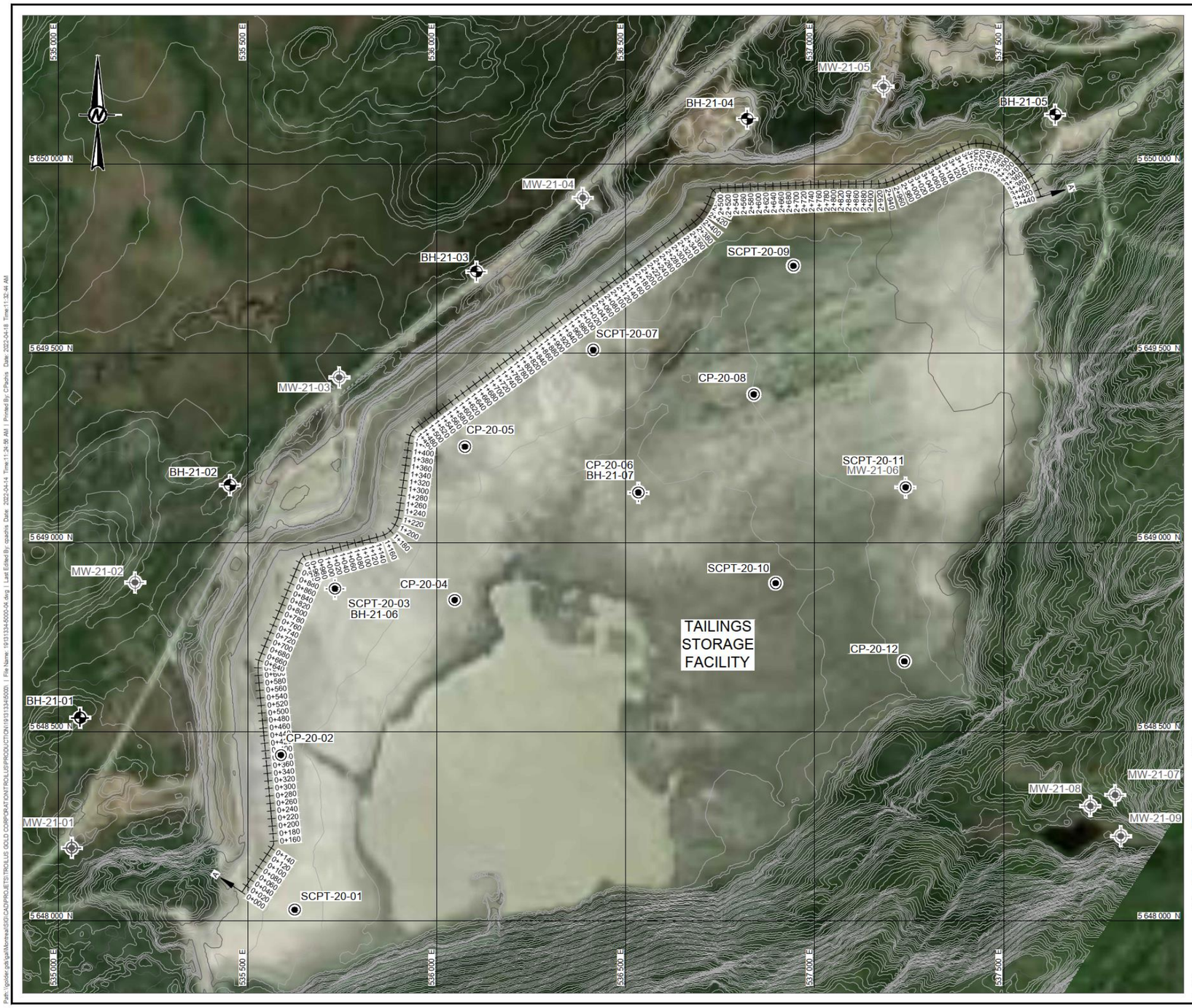
SCPT ID	SCPT Completion Depth (m)	Maximum Tailings Depth (m)	Time-averaged V_S to Base of Non-Frozen Tailings (m/s)
20-01	13.80	13.80	144.4
20-03	19.80	19.80	211.3
20-07	22.80	18.80	214.9
20-09	22.80	21.80	185.9
20-10B	18.80	18.80	200.6
20-10C	14.80	14.80	129.3
20-11	19.35	19.35	173.6
			Mean = 180.0

Notes:

1. $V_{S30,SURF}$ calculation excludes frozen tailings.
2. $V_{S30,SURF}$ calculation excludes SCPT 20-10 due to shallow termination at 2.8 m below ground surface.

References:

WSP Golder, 2022b. *Factual Geotechnical Investigation Memorandum for the Existing Tailing Storage Facility – Troilus Mine, Québec* (031-19131334-5400-RevA). Golder Associates Ltd.



SITE LOCATION VIEW
NOT IN SCALE

LEGEND

- MONITORING WELL
- BOREHOLE
- CONE PENETRATION TEST / SEISMIC CONE PENETRATING TEST

REFERENCES

- TOPOGRAPHY FROM DRAWING "Topo-CNT-1m-near-pits-UTM.dxf" PROVIDED BY CLIENT.
- AERIAL IMAGE PROVIDED BY ESRI (2021).
- DRAWINGS # "0812210010-101.dwg", "0812210010-102.dwg", "0812210010-103.dwg" DESIGNED BY GOLDER, MAY 2008
- COORDINATES SYSTEM : UTM NAD 83, ZONE 18

CONFIDENTIAL

DRAFT

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1:10 000 METRES

CLIENT
TROILUS GOLD CORPORATION

PROJECT
GEOTECHNICAL INVESTIGATION FOR TAILING STORAGE FACILITY, TROILUS MINE, QUEBEC

TITLE
TAILING STORAGE FACILITY GEOTECHNICAL INVESTIGATION LOCATIONS

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-04-18
DESIGNED	C. Pachis
PREPARED	A. Bertand-Locas
REVIEWED	S. Bainbridge
APPROVED	L. Gareau

PROJECT NO.	PHASE	REV.	FIGURE
19131334	5000	A	A1

THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

Figure A1: Plan of Geotechnical Investigation Locations at the Troilus TSF (from WSP Golder, 2022b).

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APPENDIX K

In-Pit Disposal Options

APPENDIX K

In-pit Disposal Options

Table K-1: Deposition Method Options

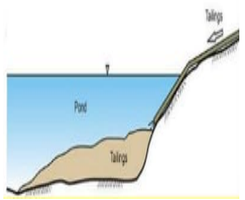
Method/Consideration	Concept Description	Constructability Considerations	Operational Considerations	Hydrogeological Considerations	Geochemical Considerations	Closure Considerations
Subaerial Deposition	Pit water level is maintained below the tailings beach by pumping. Tailings are deposited by spigot or open pipe from one side of the facility and return water ponds against a perimeter wall. A barge or perimeter/base drain is installed to pump reclaim water back to the mill.	Requires access to at least both sides of the pit, likely can be managed via the production ramps. No specialist construction required.	Well established operational scenario. Exposed tailings are susceptible to formation of ice lenses.	Operational dewatering results in inward gradients during operation, mitigating potential groundwater impacts due to seepage. Continual base drain pumping required for hydraulic containment.	Exposed tailings are susceptible to oxidation, leading to acid generation and metals leaching if tailings have such potential.	Amenable to waste rock cover (if required) and pit flooding formation of pit lake at closure. Closure pit lake level could be below or above tailings/waste rock surface. Formation of ice lenses during operations greatly lengthen closure period to produce stable tailings surface to accept a dry cover.
Subaqueous Deposition 	Pit water level is controlled above the tailings beach level by pumping. Tailings are deposited into the water directly from floating barges below frozen layer in winter. Barges can be displaced to promote an even tailings surface and efficient airspace usage. Water level is maintained by pumping either from barge or perimeter/base drain and increases as the tailings surface rises.	Requires access to the pit pond for tailings disposal and water reclaim. Requires significant investment in movable floating infrastructure.	Established operational scenario. Moving deposition infrastructure may be challenging in winter months due to freezing of the water cover.	Operational dewatering results in inward gradients during operation, mitigating potential groundwater impacts due to seepage. Inward gradient may reduce during late stage deposition. Continual base drain pumping required for hydraulic containment	Best solution for mitigating geochemical issues.	Subaqueous tailings may present special challenges with construction of a closure dry cover (if required). Amenable to pit flooding and pit lake formation at closure.
Co-disposal with waste rock	Pit water level is maintained below the tailings beach by pumping. Tailings are deposited by spigot or open pipe from one side of the facility while waste rock is end-dumped from the opposite end of the facility. Excess water is pumped via barge or perimeter/base drain back to the mill.	Requires multiple access points to the pit for both waste rock and tailings disposal in order to prevent interference.	Has been implemented at other sites, but not as common as subaqueous or subaerial deposition. Most efficient use of pit airspace. Requires interdepartmental coordination for co-management of tailings and waste rock.	Similar to subaerial deposition.	Similar to subaerial deposition.	Amenable to progressive reclamation by judicious placement of waste rock. Solution can be adapted to dispose of PAG waste rock if any. Most amenable to establishment of habitat for post-closure pit lake solutions.

Table K-2: Tailings Discharge Options

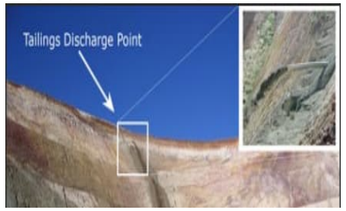
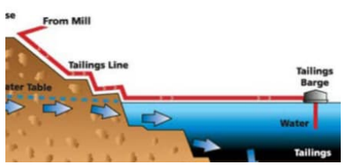
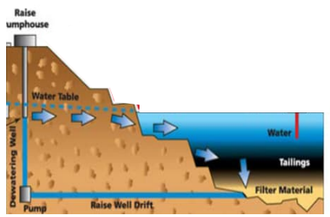
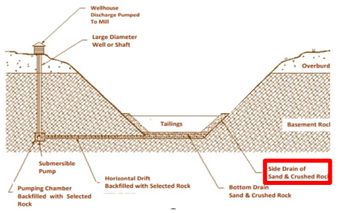
Method/Consideration	Concept Description	Constructability Considerations	Operational Considerations	Hydrogeological Considerations	Geochemical Considerations	Closure Considerations
Perimeter spigot discharge	A pipeline is constructed around the perimeter of the pit and small diameter spigots are evenly spaced and sequentially operated. Pipeline is raised as the tailings level rises.	Requires access to the entire perimeter, at multiple levels. Difficult and expensive to implement.	Efficient use of airspace, due to more complete filling. Spigot discharge systems are routinely utilized in winter conditions. Typically used with subaerial deposition to promote flatter beach slopes.	Similar to subaerial deposition.	Similar to subaerial deposition.	Similar to subaerial deposition. Difficult to shape the final surface for post-closure.
Single point discharge 	A tailings delivery pipeline is constructed to deliver tailings to a single discharge point with limited lateral displacement. The pipeline is raised, typically along the ramp as the tailings level rises.	Simple and inexpensive construction.	Less efficient use of airspace, due to long beaches. Single point discharge systems are routinely used in winter conditions. Typically used with subaerial deposition to promote flatter slopes. Requires access to the opposite side of the pit for water reclaim infrastructure.	Similar to subaerial deposition.	Similar to subaerial deposition.	Similar to subaerial deposition. Difficult to shape the final surface for post-closure.
Barge discharge 	Tailings are discharged from a floating barge which can be moved around the pit periodically. A floaging pipeline is required from the ramp to the barge.	Moderately expensive to implement, but is used successfully in other operations.	Labor intensive to operate. A single point discharge is typically required for winter operation, as moving the barge is not possible. Only compatible with subaqueous deposition.	Similar to subaqueous deposition.	Similar to subaqueous deposition.	The shape of the final TSF surface can be modified to accommodate construction of post-closure features to enhance environmental performance post-closure.

Table K-3: Water Management Options

Method/Consideration	Concept Description	Constructability Considerations	Operational Considerations	Hydrogeological Considerations	Geochemical Considerations	Closure Considerations
Base drain 	A filter compatible drain is constructed at the base of the pit prior to tailings deposition. A drainage gallery is extended laterally into the pit walls and connected to a vertical wet well which is pumped to draw water from the base drain.	No access to operational in-pit TSF is required for dewatering. System is easily automated. Somewhat capital intensive.	Established operational scenario. Less susceptible to freezing during winter operation.	Establishes a negative gradient in the tailings which mitigates outward flow to the environment and promotes consolidation. May, or may not be sufficient for pit water level control, depending on the permeability of the tailings. Compatible with subaqueous deposition.	Best solution for mitigating geochemical issues.	Base drain can continue to operate post-closure. Tailings density may be slightly higher than subaqueous deposition.
Sidewall drain 	A filter compatible drain is constructed at the side of the pit prior to tailings deposition and raised sequentially as the tailings surface rises. Sidewall drain may be allowed to flow into the pit water cover or be managed via a drainage gallery and wet well.	Requires periodic placement of filter material inside the pit. Not ideal for large pits where filter construction becomes a critical path constraint.	Established operational scenario. Less common than basal drain or barge decant systems.	Permits controlling gradients out of the tailings mass which mitigates outflow to the environment and promotes consolidation. Difficult to implement with subaqueous deposition.	Similar to subaerial deposition.	Can continue to operate post-closure. Tailings density may be slightly higher than subaqueous deposition.
Decant barge	Pit water levels are controlled by pumping from a floating barge in the pit.	Requires access to the pit for the floating barge and reclaim pipeline.	Established operational scenario. Simple operation, requires special considerations for winter conditions.	Permits controlling gradients out of the tailings mass which mitigates outflow to the environment and promotes consolidation. Compatible with subaqueous deposition.	Similar to subaqueous deposition.	Can continue to operate post-closure. Permits efficient transition to pit lake option.

APPENDIX L

Advanced Interpretation of Field and Laboratory Testing on Tailings

DRAFT

APPENDIX L

Advanced Interpretation of Field and Laboratory Tests

Troilus Operation Tailings Storage Facility

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1.0 INTRODUCTION

A site investigation program was carried out by WSP/Golder in 2020 and 2021 for the existing Tailings Storage Facility (TSF). The factual investigation data were presented in a memorandum (WSP/Golder 2022). The investigation included advanced laboratory testing and CPTu (cone penetration testing) and SCPTu (cone penetration testing with measurement of shear wave velocities). The interpretation of these tests was done to a certain extent for the pre-feasibility-level study. For the feasibility study, a more comprehensive and in-depth interpretation of the results was conducted. The objective was to determine the material properties such as in situ state parameters, as well as peak and post-liquefaction undrained shear strength values. A summary of the interpretation is presented herein. The interpretation of the CPTs and Advanced Laboratory Testing is presented in Sections 2.0 and 3.0 respectively.

2.0 CONE PENETRATION TESTING (CPT)

ConeTec (ConeTec Investigations Ltd.) provided the raw CPT data including the tip resistance and sleeve friction, porewater pressure dissipation test, and shear wave velocity measurements to Troilus in electronic format. WSP Canada Inc. (WSP) then analysed the data using an in-house spreadsheet to interpret the stratigraphy, assess porewater pressure regime, and estimate engineering parameters. Table 1 presents a summary of the analysis methods used for all twelve CPTs to evaluate parameters with respect to the shearing response and strength of selected materials. The methods are further described in the following subsections.

Table 1: Summary of Cone Penetration Test-Based Methods Used to Assess Engineering Parameters

Parameter	Methods
In situ state and shearing response (Section 2.3)	▪ Screening charts: – Jefferies and Been (2006) adapted by Shuttle and Cunning (2007, 2008) – Robertson (2016) based on soil behaviour type classification. ▪ State parameter[(a)] based on screening methods: – Been and Jefferies (1992) – Plewes et al. (1992), Reid (2015)
Peak undrained shear strength ratio, $S_{u(peak)}/\sigma'_v$ (Section 2.4) [(b)]	▪ Sadrekarimi[(a)] (2014) ▪ Riveros and Sadrekarimi (2021)
Liquefied undrained shear strength ratio(a), $Su(liq)/\sigma'_v$ (Section 2.5)	▪ Figures 6.47 and 6.48 of Jefferies and Been (2016) using the characteristic state parameter estimated with two screening methods: Been and Jefferies (1992), and Plewes et al. (1992) ▪ Sadrekarimi (2014) ▪ Robertson (2010) ▪ Robertson (2022)

(a) Methods not applicable to cohesive soils.

(b) Since tailings were found to be relatively stiff on the site, no field vane test was conducted. Therefore, a cone factor calibrated on field vane test results was not carried out.

2.1 Stratigraphic units encountered in CPT

The stratigraphic units of interest encountered in the CPT (recognized based on the CPT signature), the porewater pressure response, and the findings in adjacent boreholes, were, from top to bottom, unsaturated tailings, saturated tailings, frozen tailings, and fine saturated tailings, as well as the alluvial soil in the foundation. As the interpretation methods developed around cone penetration testing mostly consider a saturated medium, data points on the unsaturated tailings and frozen tailings were not interpreted for determination of the parameters listed in Table 1.

2.2 Statistical approach

CPT tests typically generate a substantial amount of data, making it a favorable tool to investigate the spatial variability of geotechnical units. For instance, a CPT pushed through a 10 m thick unit using a 0.025 m reading interval would generate 400 data points. To account for the considerable amount of data gathered during the investigation, a statistical approach was used when interpreting data collected.

The stability of the structure is generally governed by the loosest foundation layers that present a higher in situ state parameter (Section 2.3.2). For design purposes, Jefferies and Been (2016) recommend selecting a characteristic value of the state parameter (ψ_k) that lies between the 80th percentile and 90th percentile values. In this study, the ψ_k corresponds to the 90th percentile of the estimated in situ state parameter values.

A similar approach was used with some assessment methods when estimating the peak undrained shear strength (Section 2.4) and liquefied shear strength (Section 2.5) of contractive materials susceptible to liquefaction. The 10th percentile of shear strength values was selected for all materials with methods relying on the assessed ψ_k.

The characteristic values for each material of interest are summarized in Table 5, Table 6 and Table 7, as well as Figure 6, Figure 7, and Figure 8 in Appendix L-1 at the end of this memorandum. In addition, frequency histograms displaying the distribution of the following parameters are presented in Appendix L-2 after the text for each CPT.

2.3 In situ state and shearing response

The *in situ* state of cohesionless materials refers to whether in situ void ratios are above (contractive material) or below (dilative material) the critical state line (CSL), considering the effective confining stress. A contractive material could experience strength loss when sheared due to shear-induced porewater pressure build-up. In this case, undrained shear strength parameters are proposed. If the peak undrained shear strength is exceeded under monotonic or cyclic loading, then the liquefied undrained shear strength would be mobilized. In contrast, a dilative material would not exhibit positive excess porewater pressure or strength loss when sheared and effective stress shear strength parameters are recommended (i.e., effective friction angle).

The state parameter (ψ) is typically used to assess the in situ state; contractive materials have positive state parameters, whereas dilative materials have negative state parameters. Shuttle and Cunning (2008) proposed a limit state parameter of -0.05 to distinguish between contractive or dilative materials to account notably for strain localization and/or porewater pressure migration during undrained shear. This limit which is generally accepted in engineering applications was adopted for this report.

According to the current state-of-the-art, the CPT is the most reliable in situ test to assess the in situ state of fine-grained cohesionless materials. This is achieved through empirical or material-specific methods. The present study estimates the in situ state using two screening charts, as shown in section 2.3.1, that are based on the soil behaviour type classification, and two empirical methods embedded within the critical state soil mechanics (CSSM) framework. These methods are described in the following subsections. The results and characteristic state parameters are summarized in Table 5, Table 6 and Table 7 and in Figure 6 Figure 7 and Figure 8 at the end of this memorandum.

The determination of state parameter using CPT data is based on Shuttle & Cunning (2007) (see Eq. 1), who relate the in situ state parameter (ψ) to in situ normalized CPT parameters (normalized cone tip resistance, Q_p; dynamic porewater pressure ratio, B_q; material-specific coefficient, $\bar{k}$ or k; and $\bar{m}$ or m. $\bar{k}$ and $\bar{m}$ are determined using the CSSM methods through Eq. 2 and Eq. 3 respectively (Been et al., 1988). For simplification purposes, Eq. 1 to Eq. 3 are shown with undrained material-specific coefficients.

$$\psi = -\frac{\ln\left[\left(Q_p(1 - B_q) + 1\right)/\bar{k}\right]}{\bar{m}} \quad \text{Eq. 1}$$

$$\bar{k} = 3M_{tc} + \left(\frac{0.85}{\lambda_{10}}\right)M_{tc} \quad \text{Eq. 2}$$

$$\bar{m} = 11.9 - 13.3\,\lambda_{10} \quad \text{Eq. 3}$$

where,

ψ : in situ state, where $\psi \geq -0.05$ is the accepted demarcation between contractive and dilative materials.

$Q_p = {(q_t - p_0)}/{p_0'}$: normalized cone tip resistance from CPT.

$B_{q=} {(u_2 - u_0)}/{(q_t - \sigma_{v0})}$: normalized dynamic porewater pressure from CPT.

$\bar{k}\ or\ k$: material-specific coefficient – apply to undrained or drained CPT penetration, respectively.

$\bar{m}\ or\ m$: material-specific coefficient – apply to undrained or drained CPT penetration, respectively.

λ_{10}: compressibility of the CSL.

M_{tc}: principal stress ratio at critical state, with triaxial compression as a reference.

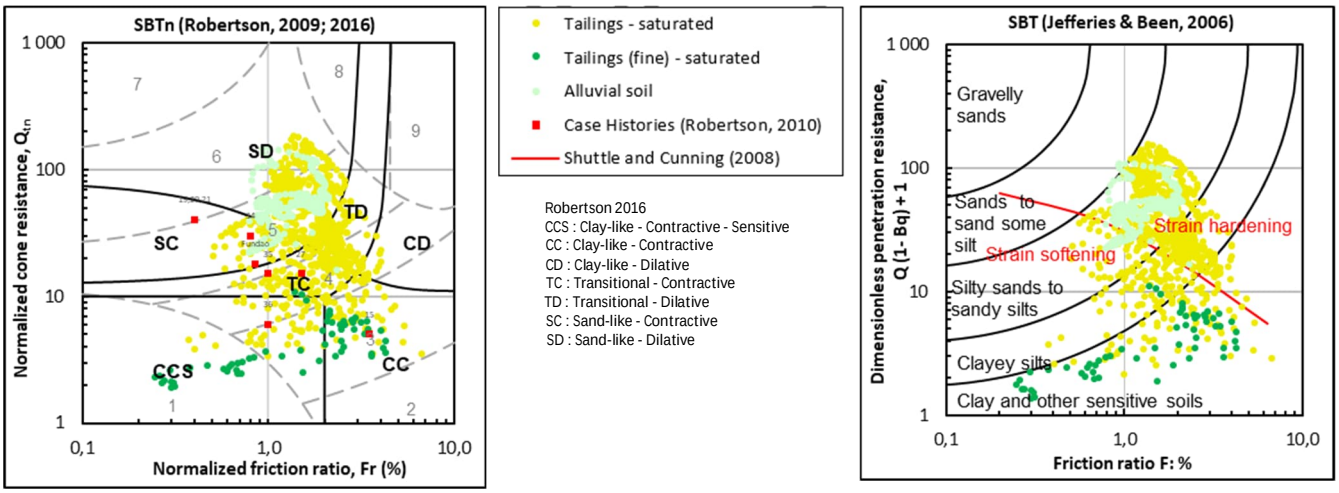
Equations 1 to 3 are basis for determination of state parameter using screening methods described in section 2.3.2.

2.3.1 Screening charts

Shuttle and Cunning (2007, 2008) and Robertson (2016) propose screening methods based on plots of normalized cone tip resistance versus normalized friction ratio to evaluate whether CPT data predominantly lie above or below the ψ = -0.05 line.

Figure 1 shows an example of these screening methods applied to CPT-20-04 data. In the Robertson chart (Figure 1a; 2016), the pseudo-horizontal black line is associated with a state parameter of -0.05. The Shuttle and Cunning chart (Figure 1b; 2008), which was adapted from the normalized soil behaviour plot of Jefferies and Been (2006), presents a red line corresponding to ψ = -0.05.

Saturated tailings data are represented on the two charts by yellow circles, fine saturated tailings by green circles, and the alluvial soil in the foundation are shown by cyan. Both screening methods are in agreement; with tailings data generally plotting below the ψ = -0.05 line for the fine saturated tailings. This suggests a predominantly positive in situ state parameter or contractive shearing response. Data on saturated tailings and alluvial soil are on the two sides of the limit, which signifies the importance of statistics. For both cases, when the 90th percentile of the data is looked at, the materials are contractive. The same general distribution was observed in other CPTs as well. The screening charts for each CPT can be found in the Appendix L-2 after the text.



a) **b)**

Figure 1: Example of screening chart (CPT-21-04 Data) plotted on the (a) Robertson Screening Chart and the (b) Jefferies and Been Screening Chart

Source: Jefferies and Been screening chart adapted by Shuttle and Cunning (2007, 2008).

SBTn = normalized soil behaviour type; SBT = soil behaviour type;

2.3.2 In Situ State-Based Screening Methods

The Plewes et al. (1992) and Been and Jefferies (1992) screening methods were also used to estimate the in-situ state of cohesionless materials. Both methods were assessed through additional data by Reid (2015). These methods are embedded within the CSSM framework, more specifically through the empirical estimation of the compressibility of the CSL (λ_{10}). The Plewes et al. (1992) method relates the λ_{10} to the friction ratio (F_r) through Eq. 4, while the Been and Jefferies (1992) relies on the soil classification index ($I_{c,BJ}$) as shown in Eq. 5. The λ_{10} obtained from either method can be applied to Eq. 1 to Eq. 3.

It is worth highlighting that Jefferies and Been (2016) prefer Eq. 4 over Eq. 5 as they consider the F_r to be a better indicator of λ_{10} than $I_{c,BJ}$. In contrast, Torres-Cruz (2021) cautions against relying on $F_r - \lambda_{10}$ correlations, noting the potential unreliability of friction sleeve measurements in intermediate loose soils such as tailings.

$$\lambda_{10} = \frac{F_r}{10} \qquad \text{Eq. 4}$$

$$\lambda_{10} = 34 - 10 I_{c,BJ} \qquad \text{Eq. 5}$$

The figures after the text in Appendix L-2 include the state parameters calculated for each CPT. Table 5, Table 6, Table 7 and Figure 6 to Figure 8 in Appendix L-1 after the text include the characteristic (90th percentile) in situ state parameters for saturated tailings, fine saturated tailings and alluvial soil in the foundation. They also include the $Q_{tn,cs}$ parameter based on Robertson (2022). Based on the screening charts, the characteristic state parameters, as well as $Q_{tn,cs}$ values, both two types of tailings and alluvial soil are considered as contractive materials. Therefore, the shear strength of these materials needs to be defined in terms of undrained shear strength ratio, as explained in the following sections.

2.4 Peak Undrained Shear Strength Ratio

The peak undrained shear strength ratio, $S_{u(peak)}/\sigma'_v$, was defined using two methods, described below.

Note that in the 2020–2021 site investigation no field vane tests were performed, as the tailings were found to be too coarse, so undrained shearing was impossible. Also, the tailings were found to be too stiff, which made it impossible at most locations to push and turn the vane.

It should be noted that all methods have unique features that can affect reliability in specific cases and, therefore, should be employed with caution.

2.4.1 Sadrekarimi (2014)

The screening method of Sadrekarimi (2014) was developed on sand specimens with varying proportion of fine particles. It relates the CPT stress-normalized cone tip resistance to back-calculated undrained shear strengths (Eq. 6). This method was applied to tailings and the alluvial soil in the foundation but should be used with caution owing to the finer-grained characteristics of Selbaie materials.

$$\frac{S_{u(peak)}}{\sigma'_v} = 0.189 + 0.008 q_{c1} \qquad \text{Eq. 6}$$

where,

q_{c1}: stress-normalized cone tip resistance.

2.4.2 Riveros and Sadrekarimi (2021)

Riveros and Sadrekarimi (2021) present a screening method developed on gold sand tailings. It relates *in situ* shear wave velocity measurements with the undrained shear strength obtained from laboratory constant volume direct simple shear tests (Eq. 7) performed on reconstituted samples. This method was only applied to tailings and alluvial soil.

$$\frac{S_{u(peak)}}{\sigma'_v} = (0.46 V_{s1} + 68.84) x 10^{-3} \qquad \text{Eq. 7}$$

where,

V_{s1}: stress-normalized shear wave velocity

Note that Riveros and Sadrekarimi (2021) method is developed based on a limited number of laboratory testing data, and is expected to provide a lower range for the peak undrained strength values. In some CPTs, less than 5 test measurements were obtained for the average shown in Table 5, Table 6 and Table 7. Samples with less than 5 values are indicated in these tables with footnotes. In this memorandum, this method is used merely to provide a comparison for Sadrekarimi (2014) method.

The shear strength ratio profiles and variability at each CPT location are presented in the Appendix L-2 after the text. The average $S_{u(peak)}/\sigma'_v$ obtained from the two methods are summarized for each CPT in Appendix L-1 in Table 5, Table 6 and Table 7, as well as Figure 6, Figure 7, and Figure 8 for saturated tailing, saturated fine tailings, and alluvial soil, respectively.

2.5 Liquefied Undrained Shear Strength Ratio

Upon shearing, a contractive material eventually reaches its critical state at large strain and the liquefied undrained shear strength ($S_{u(liq.)}$) controls the resistance of the material to flow failure. This strength is often normalized over the vertical effective stress (σ'_v) to obtain the liquefied undrained shear strength ratio $S_{u(liq.)}/\sigma'_v$. The methods used to assess this parameter are described below.

2.5.1 Jefferies and Been (2016)

The Jefferies and Been (2016) method is based on the in situ state parameter and Eq. 8a, which was developed from case histories along with the application of the CSSM framework. Eq. 8b is applicable to very loose soils where ψ is greater than λ_{10}. The in situ state parameters used in these equations were estimated in the present study using the Been and Jefferies (1992) and Plewes et al. (1992), described in section 2.3.2.

$$\frac{S_{u(liq.)}}{\sigma'_v} = 0.0501 \cdot \left(\frac{1 + 2 \cdot K_0}{3}\right) \cdot M_{tc} + 0.8 \cdot (\lambda_{10} - \psi) \quad \text{Eq. 8a}$$

$$For\ very\ loose\ soils: if\ \psi > \lambda_{10}\ then\ \frac{S_{u(liq.)}}{\sigma'_v} = \left(\frac{1 + 2 \cdot K_0}{3}\right) \cdot \frac{M_{tc}}{2} \cdot e^{(-\psi/\lambda_e)} \quad \text{Eq. 8b}$$

where,

$K_0 = \sigma'_h/\sigma'_v$: geostatic stress ratio (was assumed to equal 0.7 in the analyses)

λ_e = Compressibility of the CSL in natural logarithmic scale

The other variables are presented in previous sections.

2.5.2 Sadrekarimi (2014)

By evaluating the most reliable field-liquefaction data from past cases of liquefaction flow failures and soil shearing behavior observed in a large database of laboratory shear tests for different modes of shear, Sadrekarimi (2014) proposes Eq. 9 to relate the stress-normalized cone tip resistance to liquefied undrained strength ratios for simple shear conditions. Sadrekarimi (2014) specifies that the method should only be applied when q_{c1} < 8.

$$\frac{S_{u(liq.)}}{\sigma'_v} = 0.017 + 0.015 q_{c1} \quad \text{Eq. 9}$$

2.5.3 Robertson (2010, 2022)

Robertson indicates that the normalized cone resistance, Q_{tn} can be linked to the state parameter using a clean sand equivalent normalized cone resistance, $Q_{tn,cs}$. $Q_{tn,cs}$ is an index to determine the behavior of tailings and soil. According to Robertson (2022), the soils having $Q_{tn,cs}$ > 80 show dilative behavior at large strains. Sand-like soils having $Q_{tn,cs}$ < 70 are contractive at large strains. Between 70 < $Q_{tn,cs}$ < 80, the soils can be initially contractive but become dilative with increasing strains.

Robertson (2022) method is represented by **Erreur ! Source du renvoi introuvable.** to Eq. 13b:

$$\frac{S_{u(liq.)}}{\sigma_v^{'}} = 0.0007^{0.084Q_{tn,cs}} + \frac{0.3}{Q_{tn,cs}} \quad \text{Eq. 10}$$

$$Q_{tn} = [(q_t - \sigma_{v0})/p_a](p_a/\sigma'_{v0})^n \quad \text{Eq. 11}$$

$$Q_{tn,cs} = K_c Q_{tn} \quad \text{Eq. 12}$$

$$1.7 < I_c \leq 3.0 \;:\; K_c = 1.8346{I_c}^5 - 23.673{I_c}^4 + 124.02{I_c}^3 - 320.616{I_c}^2 + 405.821I_c - 199.97 \quad \text{Eq. 13a}$$

$$I_c \leq 1.7 \;:\; K_c = 1.0 \quad \text{Eq. 13b}$$

where $(q_t - \sigma_{v0})/p_a$ = dimensionless net cone resistance; $(p_a/\sigma'_{v0})^n$ = stress normalization factor; n = stress exponent that varies with the soil behavior type (SBT); p_a= atmospheric pressure; K_c = a correction factor that is a function of grain characteristics; and, I_c is the SBT index as defined by Robertson and Wride (1998). Robertson (2022) specifies that **Erreur ! Source du renvoi introuvable.** is applicable when $Q_{tn,cs} \leq 80$ and that $0{,}02 \leq \frac{S_{u(liq.)}}{\sigma_v^{'}} \leq \tan\varphi'$.

The liquefied shear strength ratio profiles and variability at each CPT location are presented in Appendix L-2 after the text. The post-liquefaction undrained shear strength ratios (associated with the 90th percentile of state parameters) are summarized in Appendix L-1 for saturated tailings, saturated fine tailings, and alluvial soil. Note that Robertson (2022) suggests using the average value for design purposes. Therefore, for this method, the average value of the liquefied strength is presented in the table and figures of Appendix L-1.

It is important to emphasize some distinctions between the methods used in this study to assess the liquefied undrained shear strength. The Robertson (2010) method was developed on the experience of case histories involving mostly sand deposits that were back-analysed and subsequently characterized using $Q_{tn,cs}$. The latter was empirically normalized to represent the behaviour of clean sands. The Robertson (2022) method presents an update to Robertson (2010). It incorporates insights from more recent case histories and accounts for partial drainage that occurs in intermediate soils during CPT. The liquefied undrained shear strength ratios based on Robertson (2010) are presented in the appendix merely for comparison. Sadrekarimi (2014) provides a simple method developed on the same case histories that were characterized using the parameter q_{c1}.

The method of Jefferies and Been (2016) was developed based on the CSSM framework accounting for field scale effects. They consider material-specific parameters such as compressibility (λ_{10}) and the slope of principal stress ratio at critical state (M_{tc}). Typically, these two parameters differ in mine tailings as compared to natural soils, hence a material-specific analysis is generally preferred. In this study, screening methods of Plewes et al. (1992) and Been and Jefferies (1992) were used to define λ_{10}. On the other hand, M_{tc} was determined based on triaxial laboratory testing carried out on the tailings in 2021.

Considering the points mentioned above, more consideration is given to the Jefferies and Been (2016) and Robertson (2022) methods when evaluating the liquefied undrained shear strength of tailings and alluvial soils.

In the case of the future phases of the project, the liquefied strength of tailings controls the design, and the Shuttle & Jefferies (2016) method can be used to have a more precise value for the state parameter and liquefied undrained shear strength.

3.0 ADVANCED LABORATORY TESTING

In the 2020–2021 geotechnical investigation, advanced testing was performed on tailings to gather information on strength parameters and determine the critical state line (CSL) of the tailings. The test methodology and results are presented in the factual geotechnical investigation report (WSP/Golder 2022). To establish the critical state line (CSL) of the existing tailings, a combination of undrained (CIU) and drained (CID) triaxial tests were

performed. The geotechnical laboratory testing program also included Direct Simple Shear (DSS) tests. Note that the geotechnical investigation program also included tests on synthesized tailings. In this memorandum, only the tests on the existing tailings are reassessed.

In this memorandum, the results of these tests are interpreted in a more detailed manner. Interpretation of triaxial tests for CSL provided material specific inputs for CPT interpretation (Section 3.1). Interpretation of DSS tests and the undrained triaxial tests (CIU), served for finding a correlation between the peak undrained shear strength ratio ($S_{u\ peak}/\sigma'_v$) and the state parameter (ψ) (Section 3.2).

3.1 Triaxial Compression Tests for Critical State Line Determination

To determine the CSL of the existing tailings, triaxial compression tests (drained and undrained) were conducted on the combined sample of existing tailings collected from within the existing TSF (see Figure 2 for the gradation of the samples). The fines content (% passing Nº. 200 sieve) was around 70% for samples. All triaxial tests were carried out following recommendations in Bishop & Henkel (1969), Jeffries and Been (2016) and ASTM D7181 and D4767.

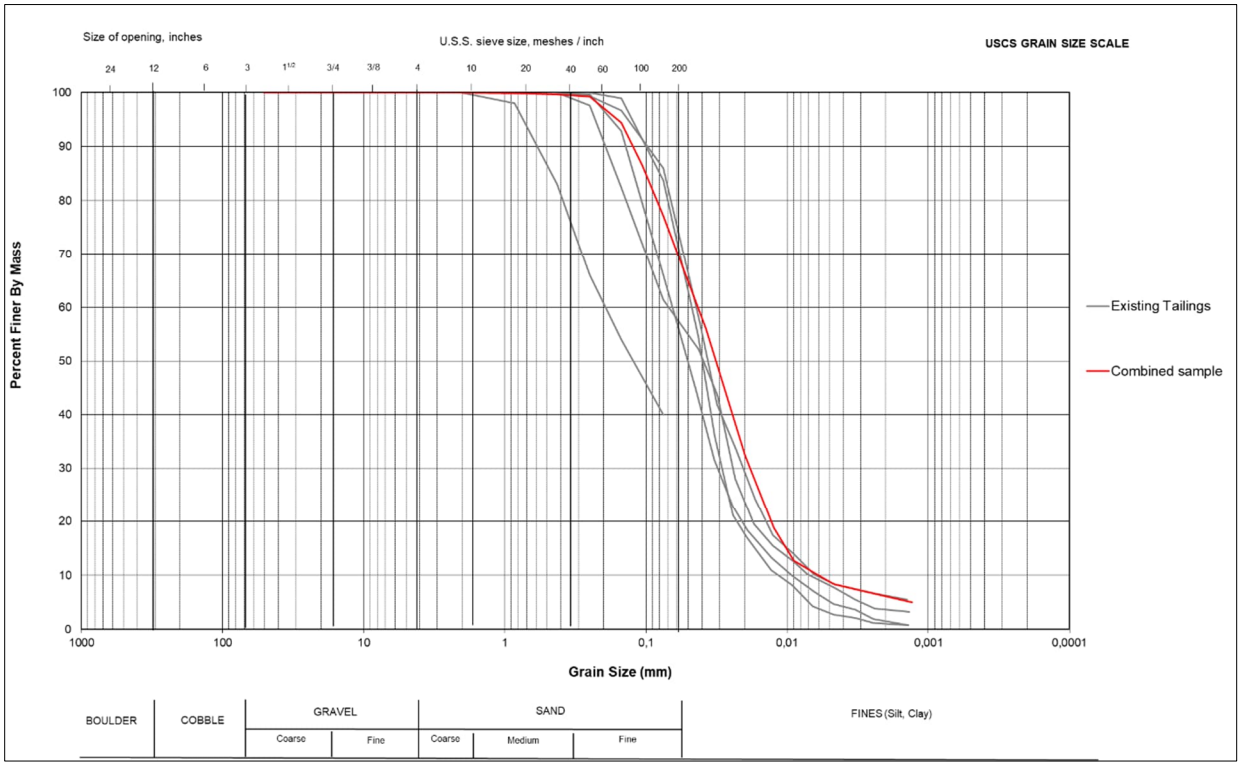


Figure 2: Gradation of Combined Tailings Sample

A summary of the tests conducted including the void ratio and mean effective stress at different stages of testing is presented in Table 2.

Table 2: Summary of triaxial testing program for critical state line determination.

Material	Test Type	Test ID	Void Ratio		State Parameter Prior to Shear	Mean Effective Stress p'	
			Prior to Shear	After Shear		Prior to Shear	After Shear
Combined sample of	CIU	CSL-1	0.79	0.79	0.08	990.3	377.3
	CIU	CSL-2	0.91	0.91	0.09	188.6	34.2

Material	Test Type	Test ID	Void Ratio		State Parameter Prior to Shear	Mean Effective Stress p'	
			Prior to Shear	After Shear		Prior to Shear	After Shear
existing tailings	CIU	CSL-3	0.84	0.84	0.09	491.5	157.6
	CIU	CSL-4	0.96	0.96	0.04	43.3	-5.1*
	CID	CSL-5	0.96	0.88	0.05	48.8	87.3
	CID	CSL-6	0.85	0.72	0.09	497.2	948.3
	CID	CSL-7	0.73	0.75	-0.09	194.9	368.0

* This test was performed in a low confining pressure. At low confining pressures, the porewater pressure reading is not accurate. As a negative mean effective stress is physically impossible, for interpretation of the test, this value was set to zero and the porewater pressures during the whole shearing phase were modified accordingly.

Figure 3 shows the stress paths for the seven triaxial tests. The envelope of the critical state p'-q points provides the critical state stress ratio, M_{tc} = 1.42.

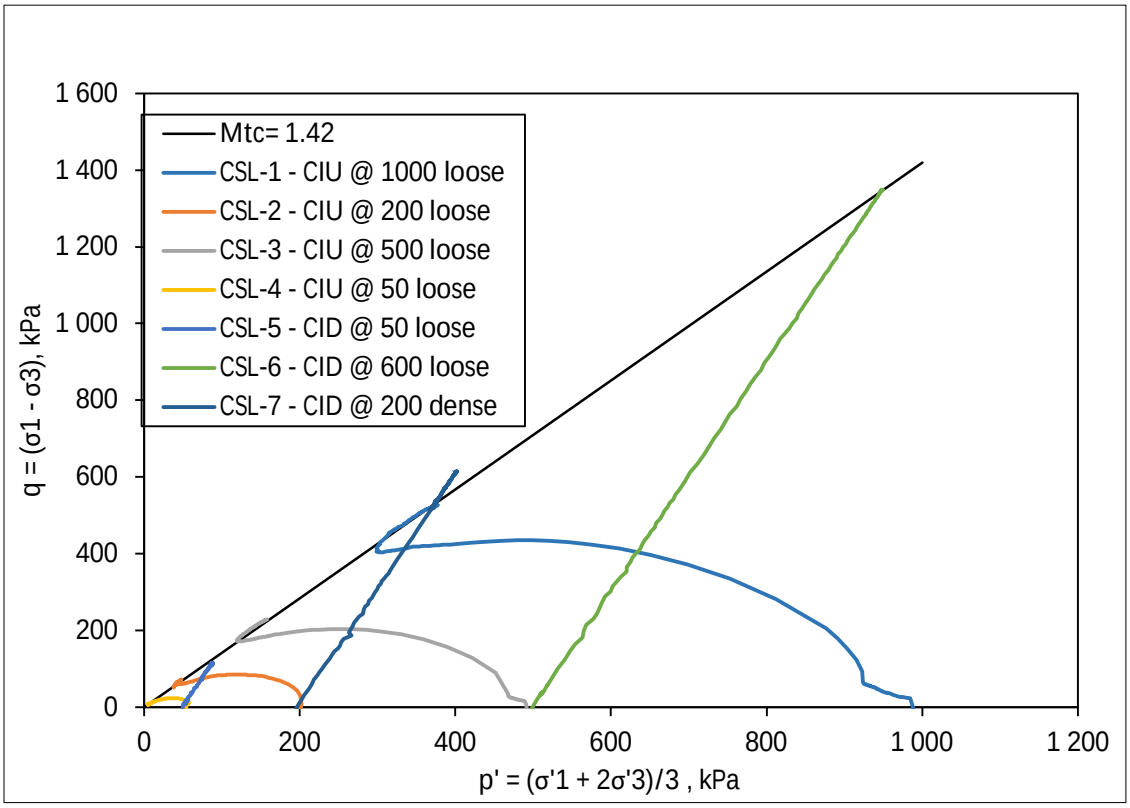


Figure 3- Stress paths obtained from triaxial tests (CID and CIU) on combined sample of existing tailings.

Figure 4 shows the CSL, as well as the void ratio of each of the triaxial test samples before and after shear and the path during the test. The complete information regarding the triaxial tests can be found in the WSP/Golder (2022). Two CSLs were obtained considering two approaches: a straight line in semi-logarithmic scale (called CSL Approach A, Eq. 12) and a curve model (CSL Approach B, Eq. 13). Below are the equations associated with each method.

Eq. 14

$$e_c = \Gamma + \lambda_{10} \log (p')$$

Eq. 15

$$e_c = a + b\left(\frac{p'}{P_{ref}}\right)^c$$

The parameters calibrated for the linear (on semi-logarithmic scale) CSL, Eq.1 is: Γ = 1.166, λ_{10} = 0.152. The parameters obtained from calibration based on the B approach, Eq. 2, are: $a = 1.038$, $b = 0.175, c = 0.284$. These parameters were used for calibration of numerical models for the stress-deformation analysis. The CSL was also used to determine the state parameters at the end of the consolidation phase of the laboratory shear tests, as will be explained in the next section.

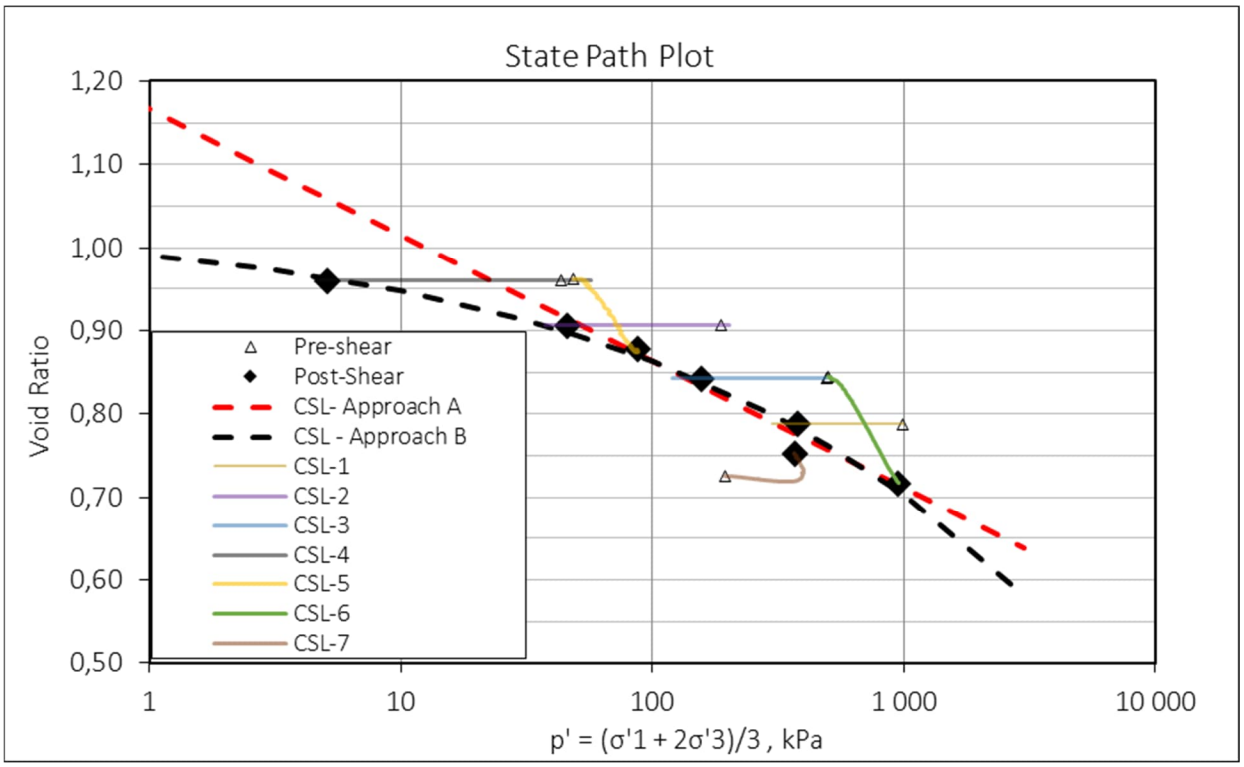


Figure 4- Critical state line obtained from triaxial tests (CID and CIU) on a combined sample of existing tailings.

3.2 Direct Simple Shear (DSS) test

Direct simple shear (DSS) tests were conducted on three specimens from a sample of existing tailings (BH-21-06 T07), as well as three specimens of a combined sample of existing tailings (the same material that was used for triaxial CSL tests). Vertical loads were selected to represent the stresses that will be imposed on the tailings as the TSF is raised. Table 3 shows the results from the existing tailings sample, and Table 4 shows the results from the combined sample.

Table 3: Summary of Direct Simple Shear (DSS) Test results on existing tailings sample BH-21-06 T07 (the same sample as CSL sample).

Material	Dry Density	Initial Vertical Stress	Void Ration Prior to Shear	State parameter Prior to Shear	Peak Shear Stress (kPa)	Peak Shear Stress Ratio
Sample of existing tailings (BH-21-06 07)	1592	200.0	0.65	-0.18	149	0.74
		499.8	0.66	-0.11	167	0.33
		800.3	0.66	-0.08	274	0.34

* Calculated using the CSL defined by the combined sample.

Table 4: Summary of Direct Simple Shear (DSS) Test results on the combined existing tailings sample (the same sample as CSL sample).

Material	Dry Density	Initial Vertical Stress	Void Ration Prior to Shear	State parameter Prior to Shear	Peak Shear Stress (kPa)	Peak Shear Stress Ratio
Combined sample of existing tailings	1481	200.60	0.80	-0.03	63	0.31
		499.87	0.74	-0.03	103	0.21
		800.0	0.65	-0.09	211	0.26

For the DSS tests and the undrained triaxial tests (CIU), the state parameter was calculated based on the void ratio and an estimation of the confining pressure, p' at the end of consolidation, and the CSL (linear in a semi-logarithmic space, Approach A). Figure 5 shows the data from the DSS and triaxial tests. Note that the state parameters for BH-21-06 T07 are not accurate as the CSL determined for the combined sample that was used to calculate the state parameters for this sample. The two samples showed different behaviors in the DSS tests and are expected to have different characteristics.

In Figure 5, in order for the triaxial test data to be comparable to the DSS tests, a reduction factor of 0.75 was applied to the undrained shear strength ratios from triaxial tests. This ratio is generally what is observed in gold mine tailings projects when comparing DSS and triaxial tests on the same material and the same state. This graph provides a lower bound for the peak undrained shear strength ratio ($S_{u\ peak}/\sigma'_v$) for the range of the state parameters (ψ) reconstituted in the laboratory. This figure can be used to determine the shear strength of tailings for the stability assessments.

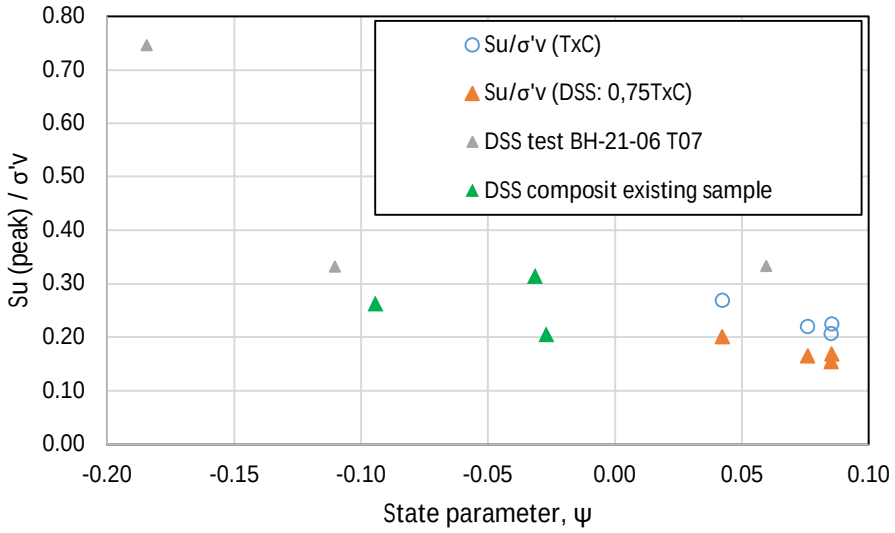


Figure 5- Correlation between (S_{upeak}/σ'_v) and state parameter (ψ) for combined samples of existing tailings.

Signature Page

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APPENDIX L-1 - SUMMARY OF CHARACTERISTIC VALUES OF SATURATED TAILINGS, FINE SATURATED TAILINGS AND ALLUVIAL SOIL (FOUNDATION)

Table 5: Summary of characteristic values of Saturated tailings

CPT ID	Saturated tailings									
	Bq 90th perc.	Characteristic State Parameter, ψk (-)		Peak Undrained Shear Strength Ratio, Su(peak)/σ'vo		Liquefied Undrained Shear Strength Ratio, Su(liq)/σ'vo				
		Been and Jefferies (1992) 90th perc.	Plewes et al. (1992), Reid (2015) 90th perc.	Sadrekarimi-(2014) Average (Peak)	Riveros and Sadrekarimi (2021) Average (Peak)[1]	Fig.6.47 J & B (2016) – Ψk from Been and Jefferies (1992) 10th perc.	Fig.6.47 J & B (2016) – Ψk from Plewes et al. (1992) 10th perc.	Robertson (2010) Average	Robertson (2022) Average	Sadrekarimi (2014) Average
SCPT-20-01	0.01	-0.05	-0.07	0.22	0.14	0.17	Dilative	0.10	0.10	0.07
CPT-20-02	0.01	-0.04	-0.08	0.22	-	0.18	Dilative	0.16	0.46	0.07
SCPT-20-03	0.01	-0.04	-0.08	0.22	0.15	0.17	Dilative	0.14	0.41	0.08
CPT-20-04	0.11	0.01	0.00	0.22	-	0.16	0.17	0.08	0.21	0.08
CPT-20-05	0.01	-0.04	-0.08	0.22	-	0.17	Dilative	0.12	0.39	0.08
CPT-20-06	0.02	-0.07	-0.07	0.23	-	Dilative	Dilative	Dilative	Dilative	Dilative
SCPT-20-07	0.01	-0.04	-0.07	0.22	0.15	0.17	Dilative	0.14	0.36	0.08
CPT-20-08	0.03	0.00	0.02	0.21	-	0.13	0.09	0.06	0.06	0.05
SCPT-20-09	0.02	-0.06	-0.08	0.23	0.15	Dilative	Dilative	Dilative	Dilative	Dilative
SCPT-20-10-B	0.02	-0.01	0.01	0.22	0.13[2]	0.13	0.10	0.06	0.07	0.07
SCPT-20-10-C	0.02	-0.07	-0.07	0.22	0.12[2]	Dilative	Dilative	Dilative	Dilative	Dilative
SCPT-20-11	0.00	-0.07	-0.09	0.23	0.14	Dilative	Dilative	Dilative	Dilative	Dilative
CPT-20-12	0.03	-0.04	-0.03	0.21	-	0.15	0.14	0.08	0.13	0.06

[1] This method is used merely to provide a comparison for Sadrekarimi (2014) method.
[2] Less than 5 test values were obtained to calculate the average value.

NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

Table 6: Summary of characteristic values of Fine saturated tailings

CPT ID	Fine saturated tailings									
	Bq 90th perc.	Characteristic State Parameter, ψk (-)		Peak Undrained Shear Strength Ratio, Su(peak)/σ'vo		Liquefied Undrained Shear Strength Ratio, Su(liq)/σ'vo				
		Been and Jefferies (1992) 90th perc.	Plewes et al. (1992), Reid (2015) 90th perc.	Sadrekarimi-(2014) Average (Peak)	Riveros and Sadrekarimi (2021) Average (Peak)[1]	Fig.6.47 J & B (2016) - Ψk from Been and Jefferies (1992) 10th perc.	Fig.6.47 J & B (2016) - Ψk from Plewes et al. (1992) 10th perc.	Robertson (2010) Average	Robertson (2022) Average	Sadrekarimi (2014) Average
SCPT-20-01	0.42	0.10	0.11	0.20	0.13[2]	0.14	0.14	0.08	0.08	0.03
CPT-20-02	0.31	0.08	0.10	0.20	-	0.16	0.14	0.10	0.30	0.05
SCPT-20-03	0.07	-0.02	-0.05	0.22	-	0.19	Dilative	0.16	0.36	0.07
CPT-20-04	0.67	0.19	0.28	0.20	-	0.07	0.00	0.05	0.11	0.03
CPT-20-05	0.19	0.06	0.08	0.21	-	0.15	0.10	0.10	0.32	0.05
CPT-20-06	0.08	0.01	0.00	0.21	-	0.16	0.19	0.10	0.30	0.07
SCPT-20-07	0.17	0.05	0.07	0.21	-	0.11	0.06	0.07	0.17	0.05
CPT-20-08	0.12	0.02	0.02	0.20	-	0.14	0.13	0.07	0.20	0.05
SCPT-20-09	0.43	0.01	0.26	0.20	-	0.16	0.18	0.08	0.17	0.04
SCPT-20-10-B	0.02	-0.04	-0.07	0.22	-	0.17	Dilative	0.14	0.36	0.36
SCPT-20-10-C	-	-	-	-	-	-	-	-	-	-
SCPT-20-11	0.08	-0.01	-0.01	0.21	0.16	0.15	0.09	0.10	0.26	0.06
CPT-20-12	0.04	-0.02	0.05	0.21	-	0.14	0.15	0.08	0.18	0.06

[1] This method is used merely to provide a comparison for Sadrekarimi (2014) method.
[2] Less than 5 test values were obtained to calculate the average value.

NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

Table 7: Summary of characteristic values of Alluvial soil (foundation)

CPT ID	Alluvial soil (foundation)									
	Bq 90th perc.	Characteristic State Parameter, ψk (-)		Peak Undrained Shear Strength Ratio, Su(peak)/σ'vo		Liquefied Undrained Shear Strength Ratio, Su(liq)/σ'vo				
		Been and Jefferies (1992) 90th perc.	Plewes et al. (1992), Reid (2015) 90th perc.	Sadrekarimi-(2014) Average (Peak)	Riveros and Sadrekarimi (2021) Average (Peak)[1]	Fig.6.47 J & B (2016) - Ψk from Been and Jefferies (1992) 10th perc.	Fig.6.47 J & B (2016) - Ψk from Plewes et al. (1992) 10th perc.	Robertson (2010) Average	Robertson (2022) Average	Sadrekarimi (2014) Average
SCPT-20-01	-	-	-	-	-	-	-	-	-	-
CPT-20-02	0.00	-0.06	-0.02	0.24	-	Dilative	0.10	Dilative	Dilative	Dilative
SCPT-20-03	0.00	-0.05	-0.07	0.23	0.18[2]	Dilative	Dilative	Dilative	Dilative	Dilative
CPT-20-04	0.00	-0.08	-0.10	0.24	-	Dilative	Dilative	Dilative	Dilative	Dilative
CPT-20-05	0.01	-0.09	-0.12	0.24	-	Dilative	Dilative	Dilative	Dilative	Dilative
CPT-20-06	0.00	-0.08	-0.08	0.24	-	Dilative	Dilative	Dilative	Dilative	Dilative
SCPT-20-07	0.00	-0.01	0.02	0.22	0.14[2]	0.12	0.09	0.07	0.10	0.08
CPT-20-08	0.19	0.03	0.04	0.23	-	0.19	0.09	0.08	0.25	0.09
SCPT-20-09	0.00	-0.10	-0.09	0.25	0.14[2]	Dilative	Dilative	Dilative	Dilative	Dilative
SCPT-20-10-B	0.00	-0.10	-0.11	0.25	0.14[2]	Dilative	Dilative	Dilative	Dilative	Dilative
SCPT-20-10-C	-	-	-	-	-	-	-	-	-	-
SCPT-20-11	-	-	-	-	-	-	-	-	-	-
CPT-20-12	-	-	-	-	-	-	-	-	-	-

[1] This method is used merely to provide a comparison for Sadrekarimi (2014) method.
[2] Less than 5 test values were obtained to calculate the average value.

NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

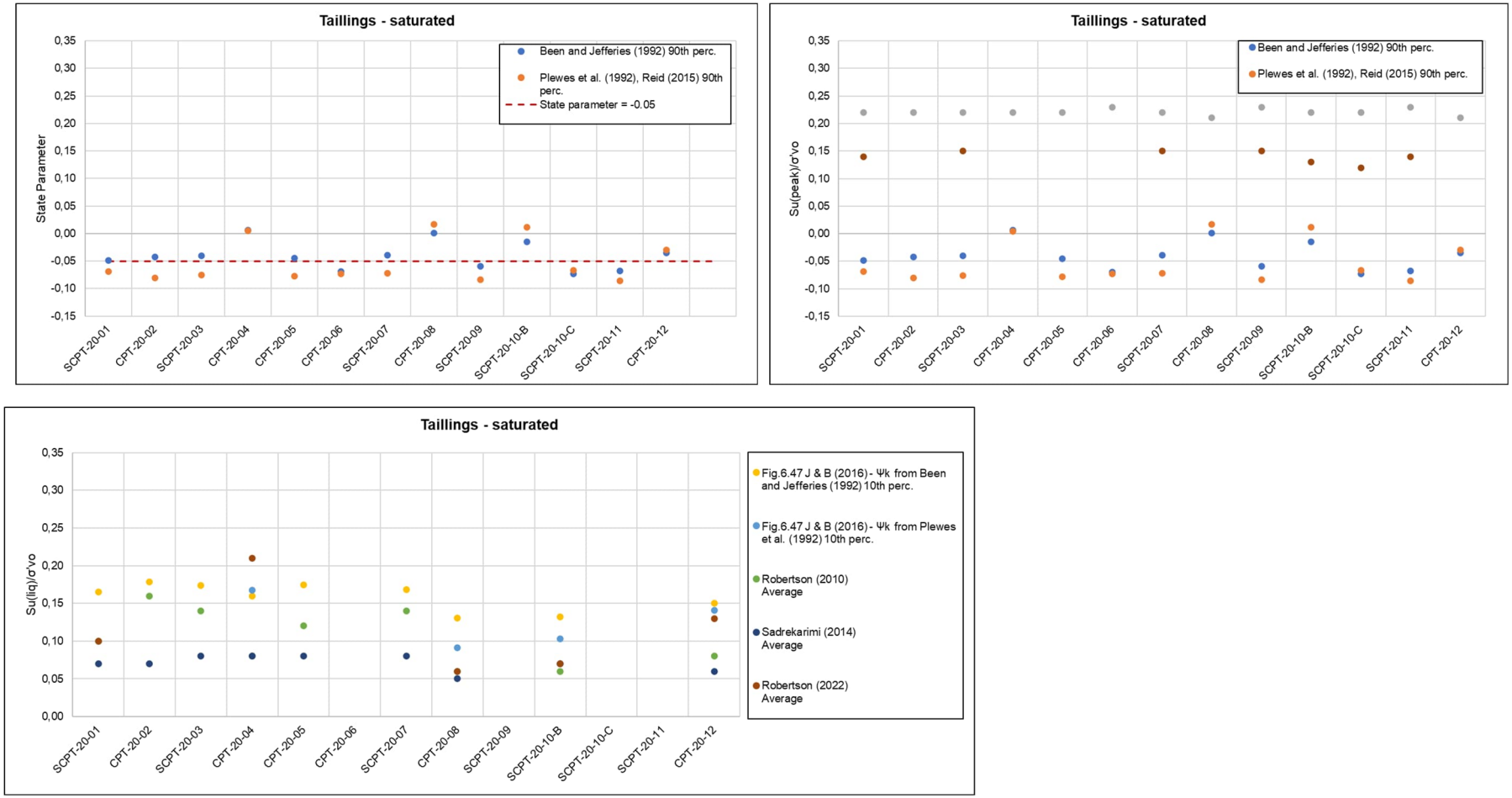


Figure 6: Summary of characteristic values of saturated tailings

Notes:

1.The liquefied undrained shear strength values, $S_{u(liq)}/\sigma'_{v0}$ are presented only for the methods (CPTs ?) in which the material is interpreted to be contractive.

2. Riveros and Sadrekarimi (2021) method is used merely to provide a comparison for Sadrekarimi (2014) method.

NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

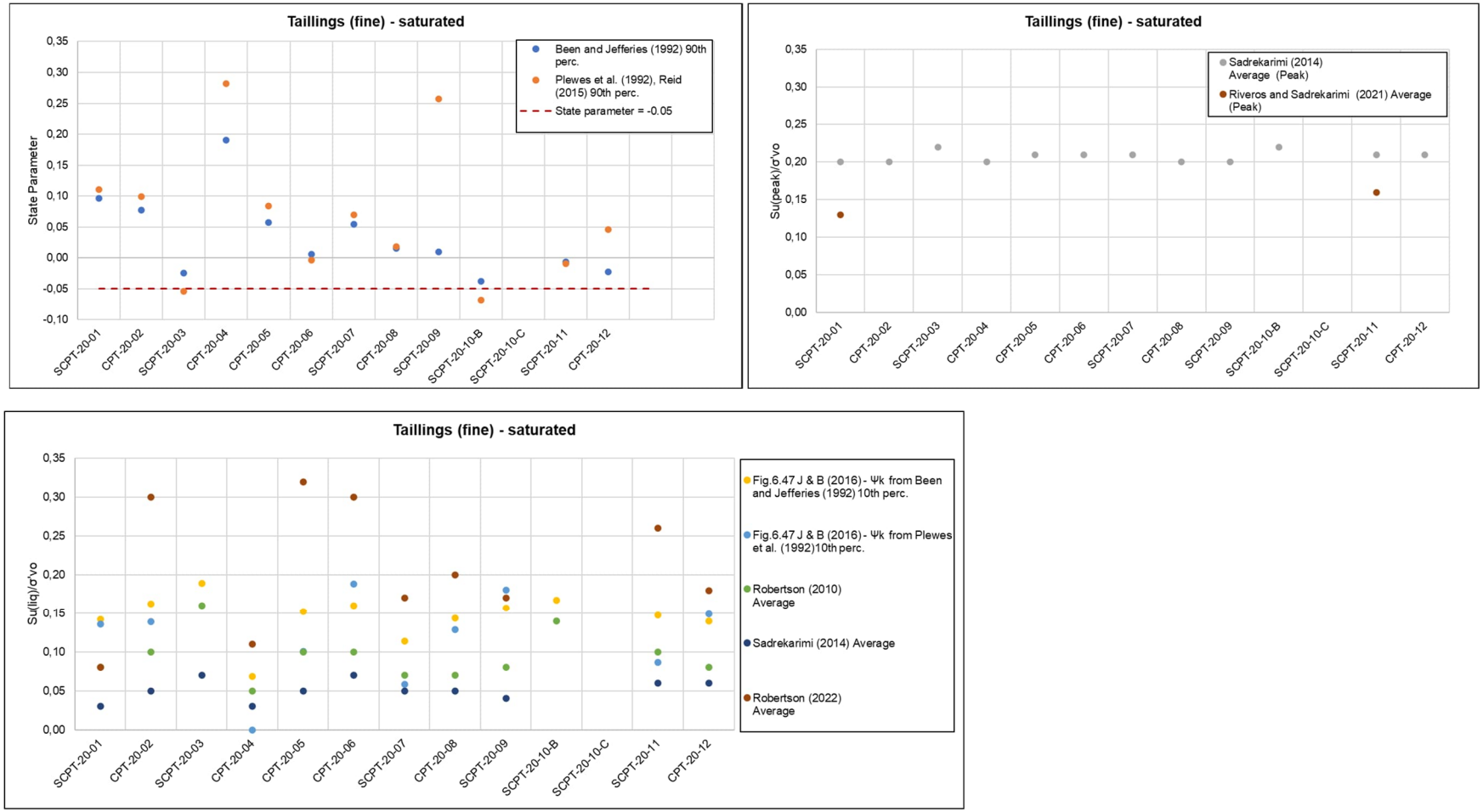


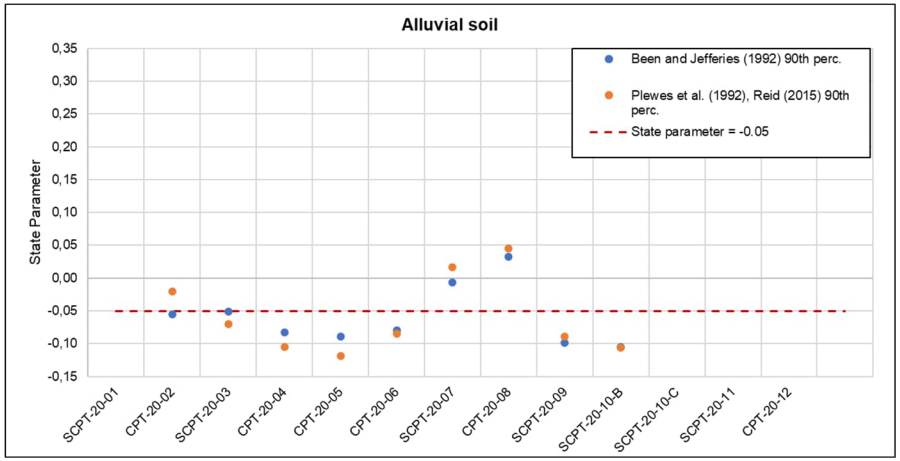
Figure 7: Summary of characteristic values of fine saturated tailings

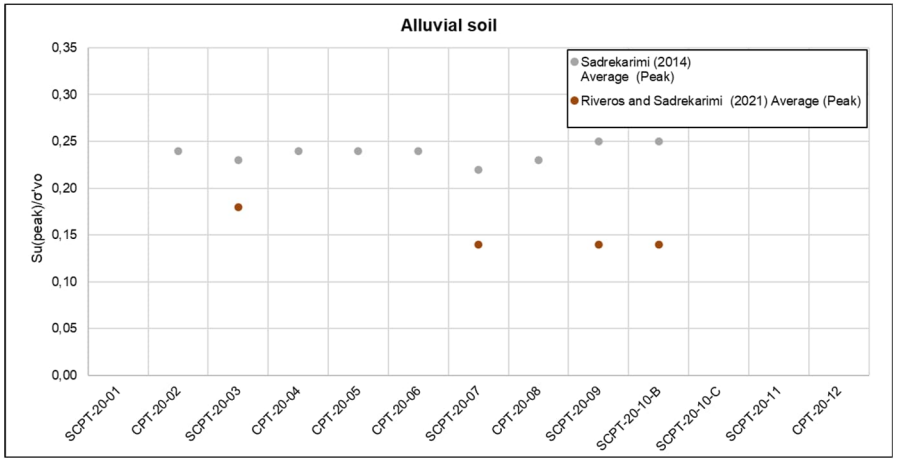
Notes:

1.The liquefied undrained shear strength values, $S_{u(liq)}/\sigma'_{v0}$ are presented only for the methods (CPTs ?) in which the material is interpreted to be contractive.

2. Riveros and Sadrekarimi (2021) method is used merely to provide a comparison for Sadrekarimi (2014) method.

NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.





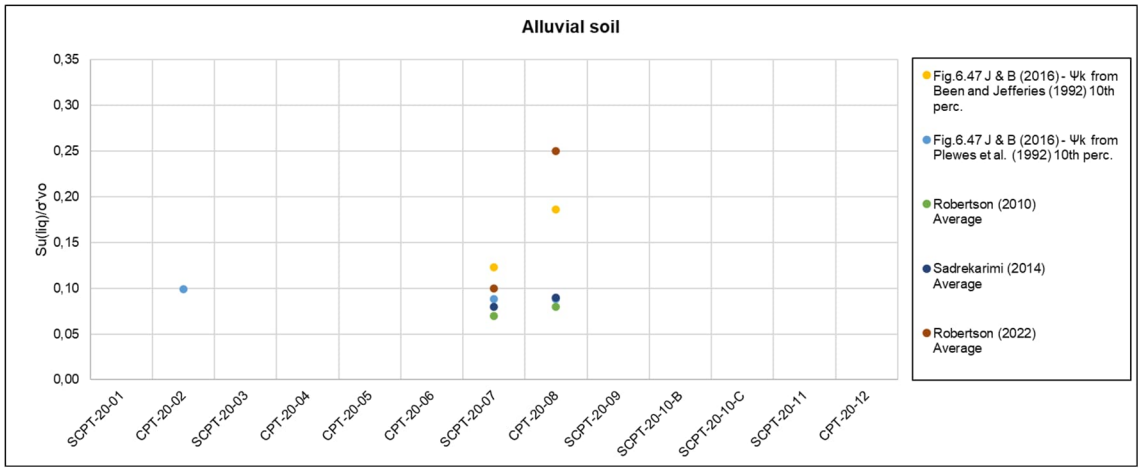


Figure 8: Summary of characteristic values of alluvial soil (foundation)

Notes:

1.The liquefied undrained shear strength values, $S_{u(liq)}/\sigma'_{v0}$ are presented only for the methods (CPTs ?) in which the material is interpreted to be contractive.

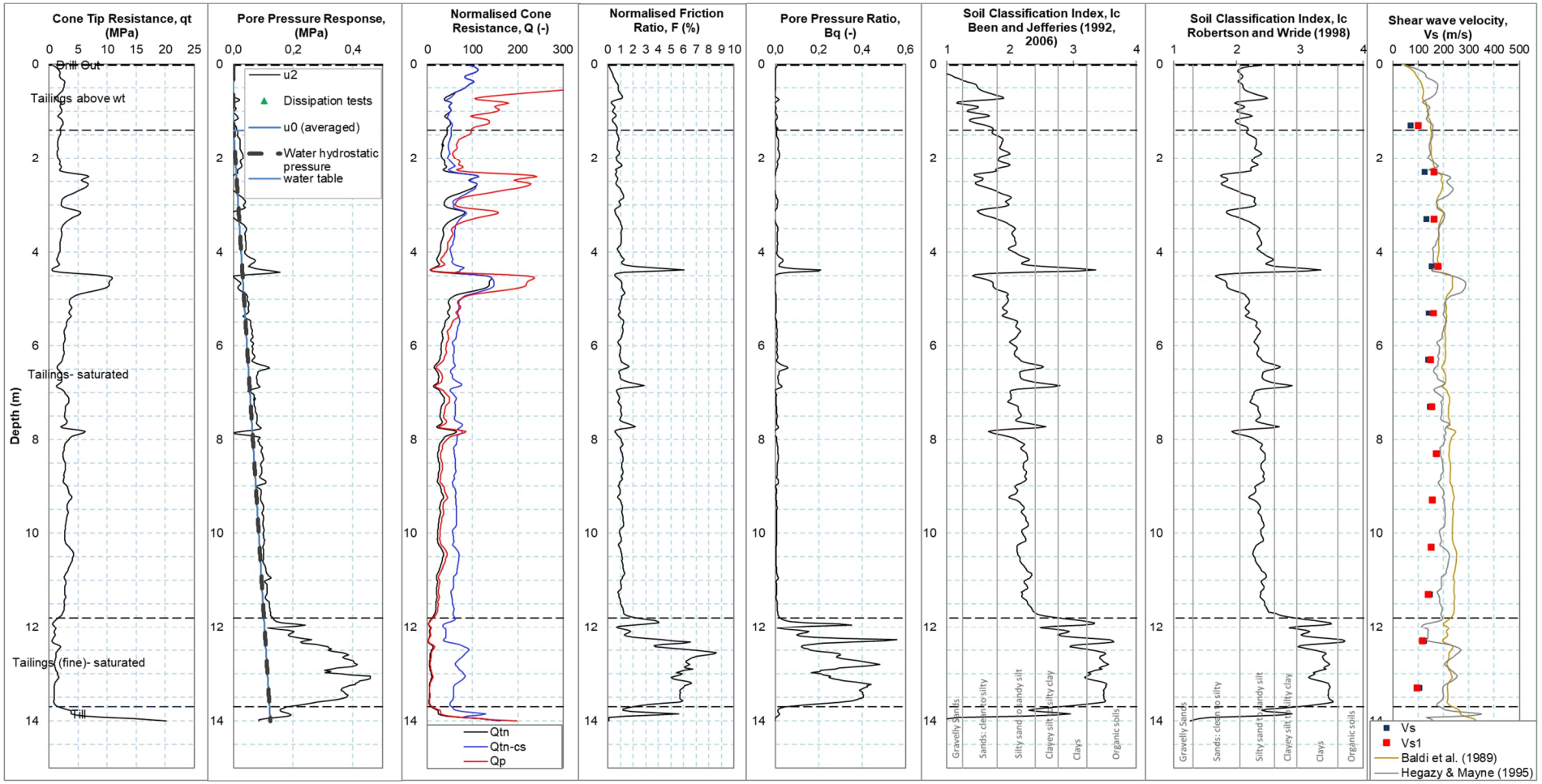
2. Riveros and Sadrekarimi (2021) method is used merely to provide a comparison for Sadrekarimi (2014) method.

NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

APPENDIX L-2 – INTERPRETATION OF CPT TESTS

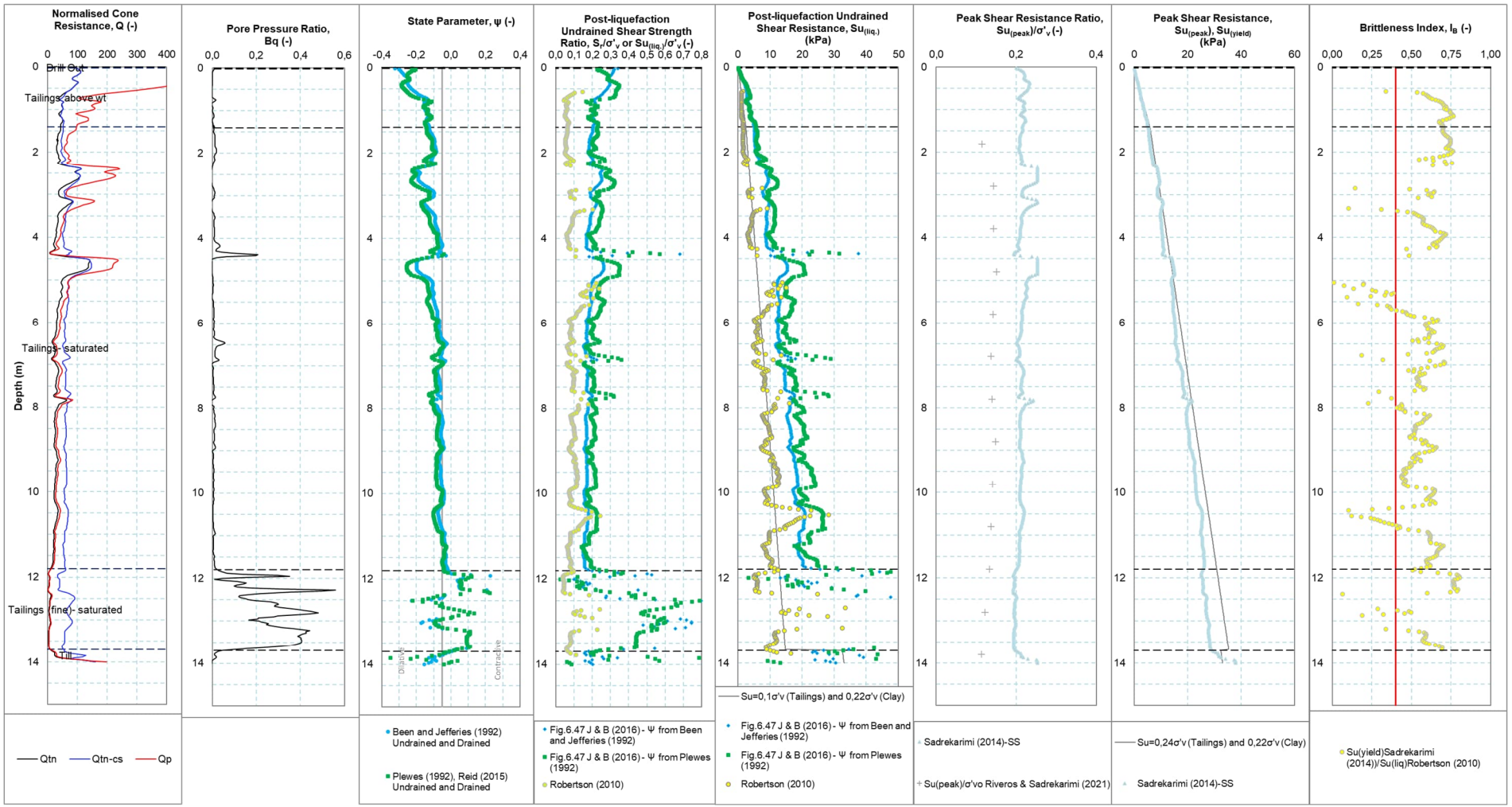
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-01



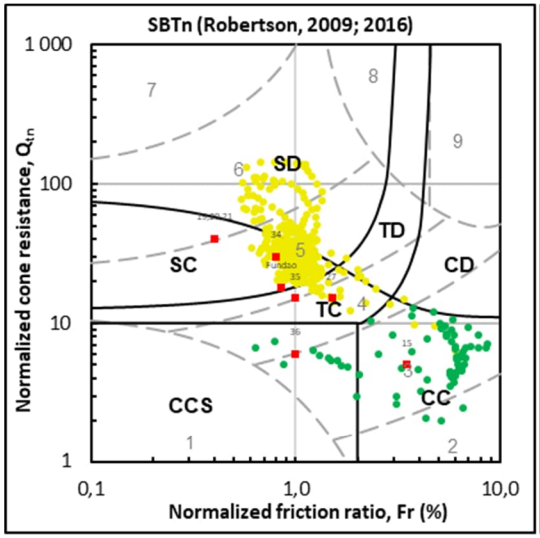
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

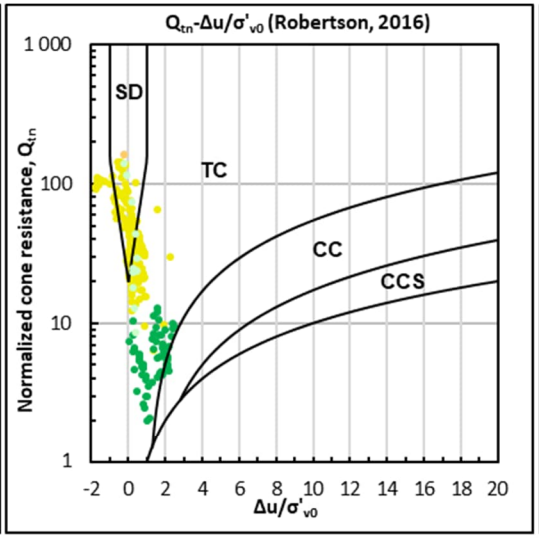
SCPT-01

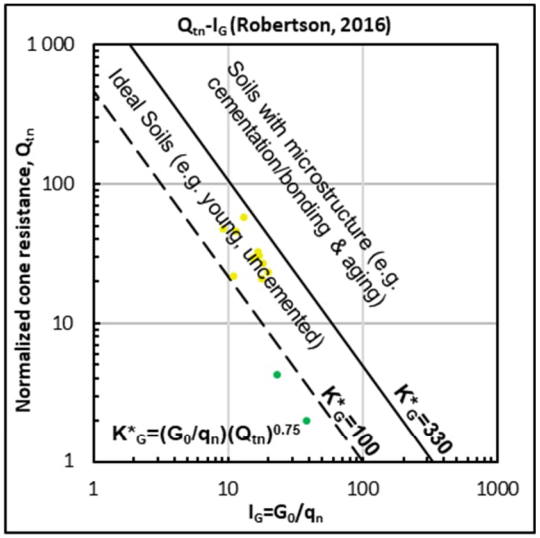


NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-01

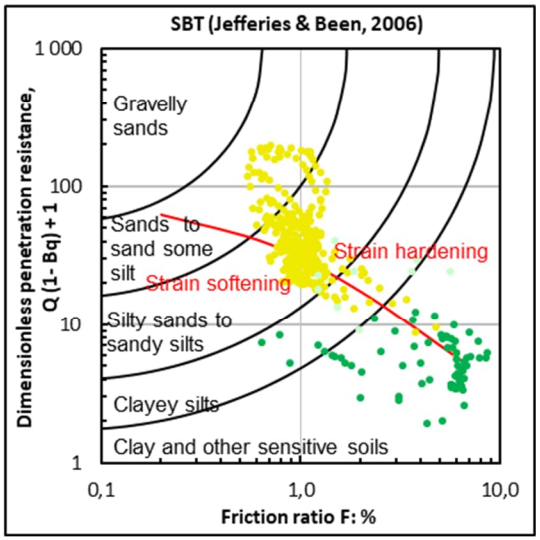






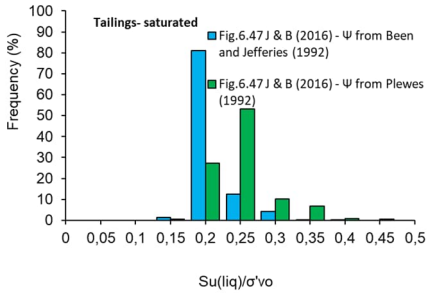
Robertson 2009	**Robertson 2016**
1 : Sensitive Clays and Silts	**CCS : Clay-like - Contractive - Sensitive**
2 : Organic Soils	**CC : Clay-like - Contractive**
3 : Clays	**CD : Clay-like - Dilative**
4 : Silt Mix	**TC : Transitional - Contractive**
5 : Sandy Mix	**TD : Transitional - Dilative**
6 : Sands	**SC : Sand-like - Contractive**
7 : Gravelly Sands	**SD : Sand-like - Dilative**
8 : Stiff Sands to Clayed Sands	
9 : Stiff Clays and Silts	

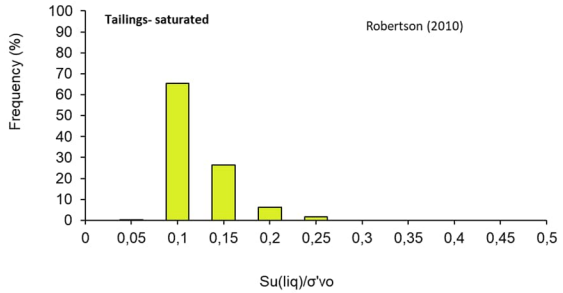
- Tailings- saturated
- Tailings (fine)- saturated
- Case Histories (Robertson, 2010)
- Shuttle and Cunning (2008)

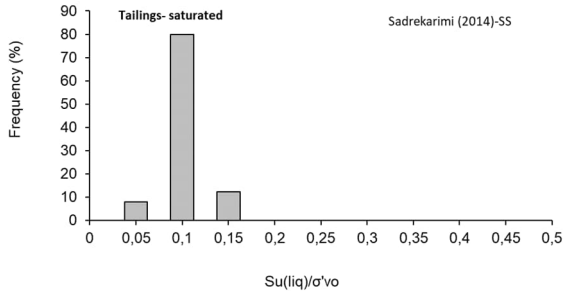


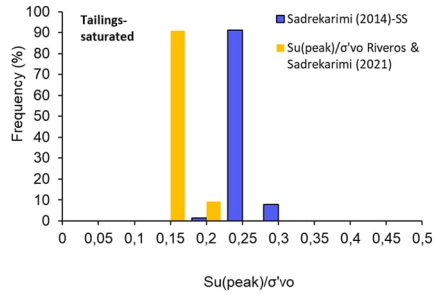
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

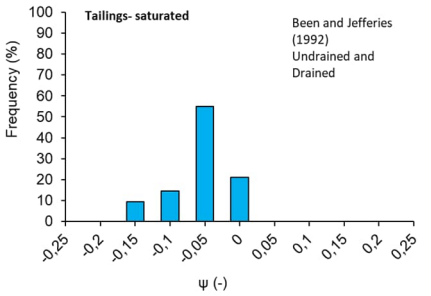
SCPT-01
Saturated tailings

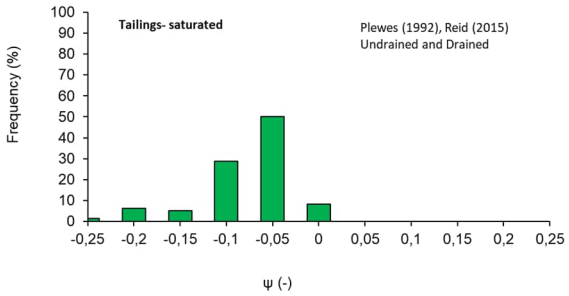






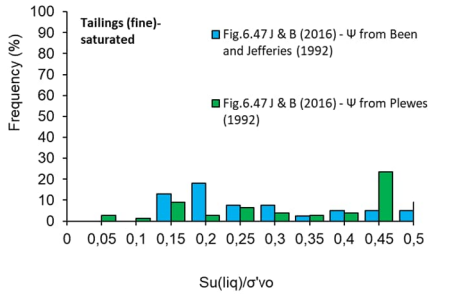


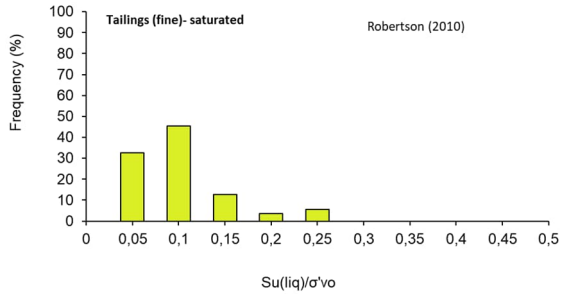


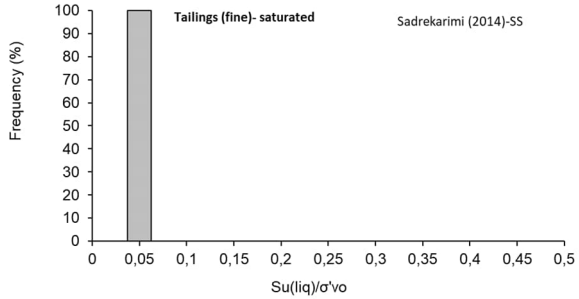


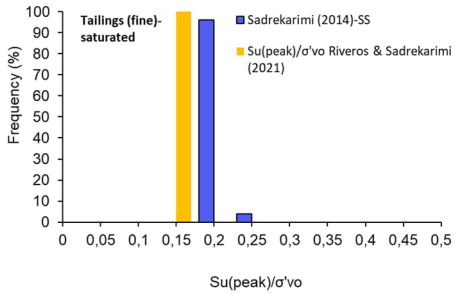
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

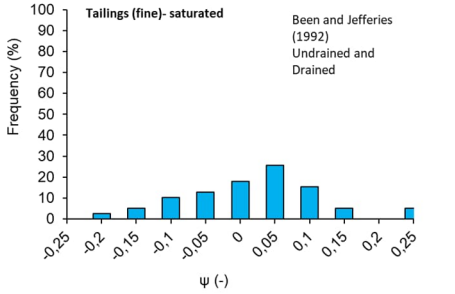
SCPT-01
Fine saturated tailings

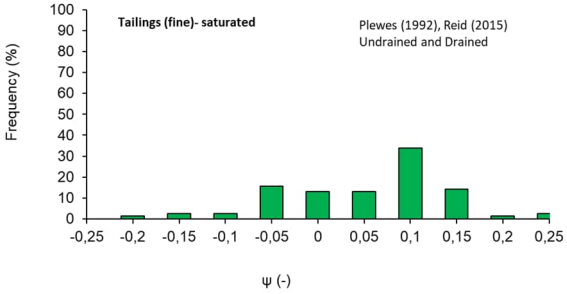






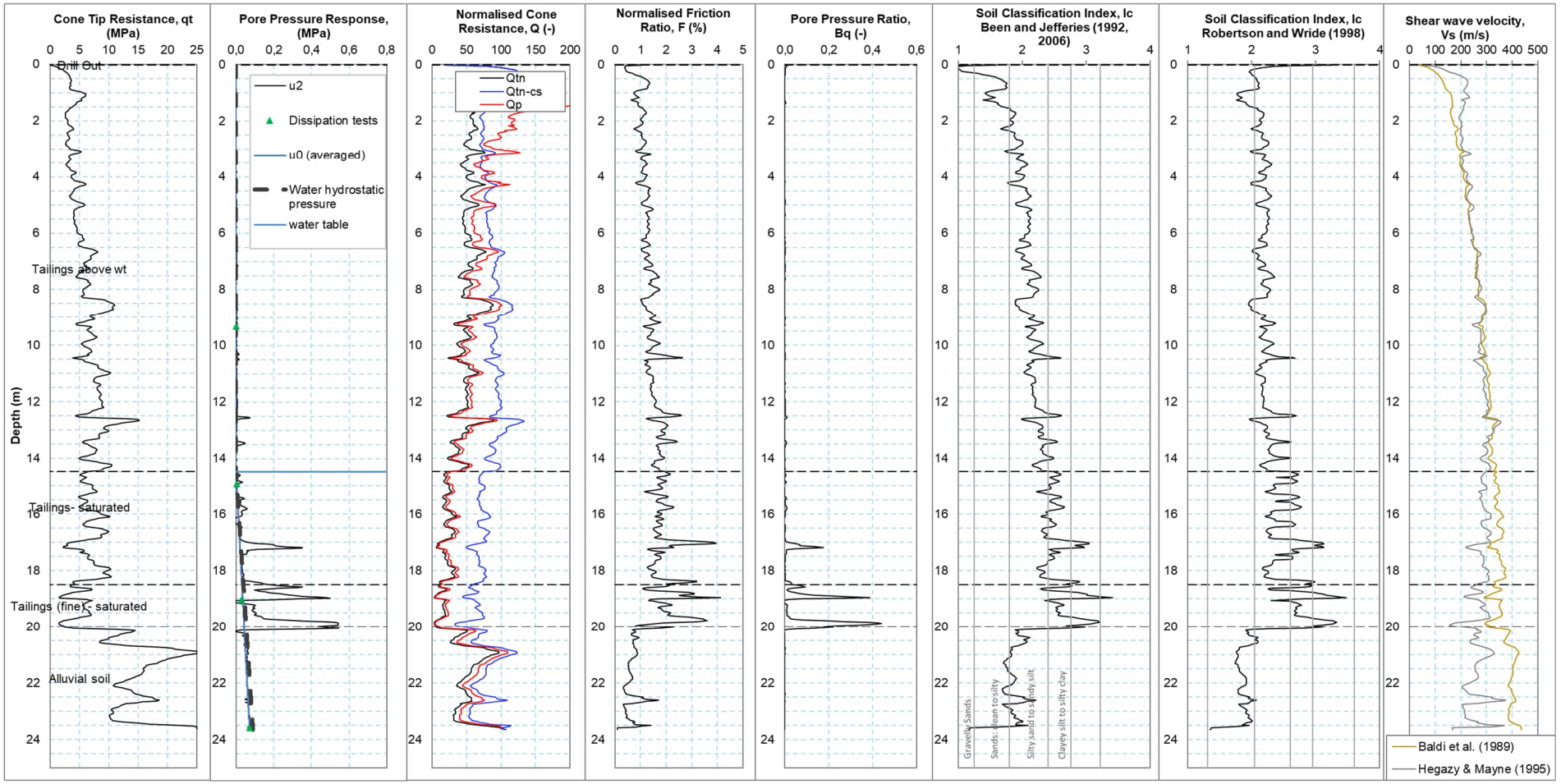






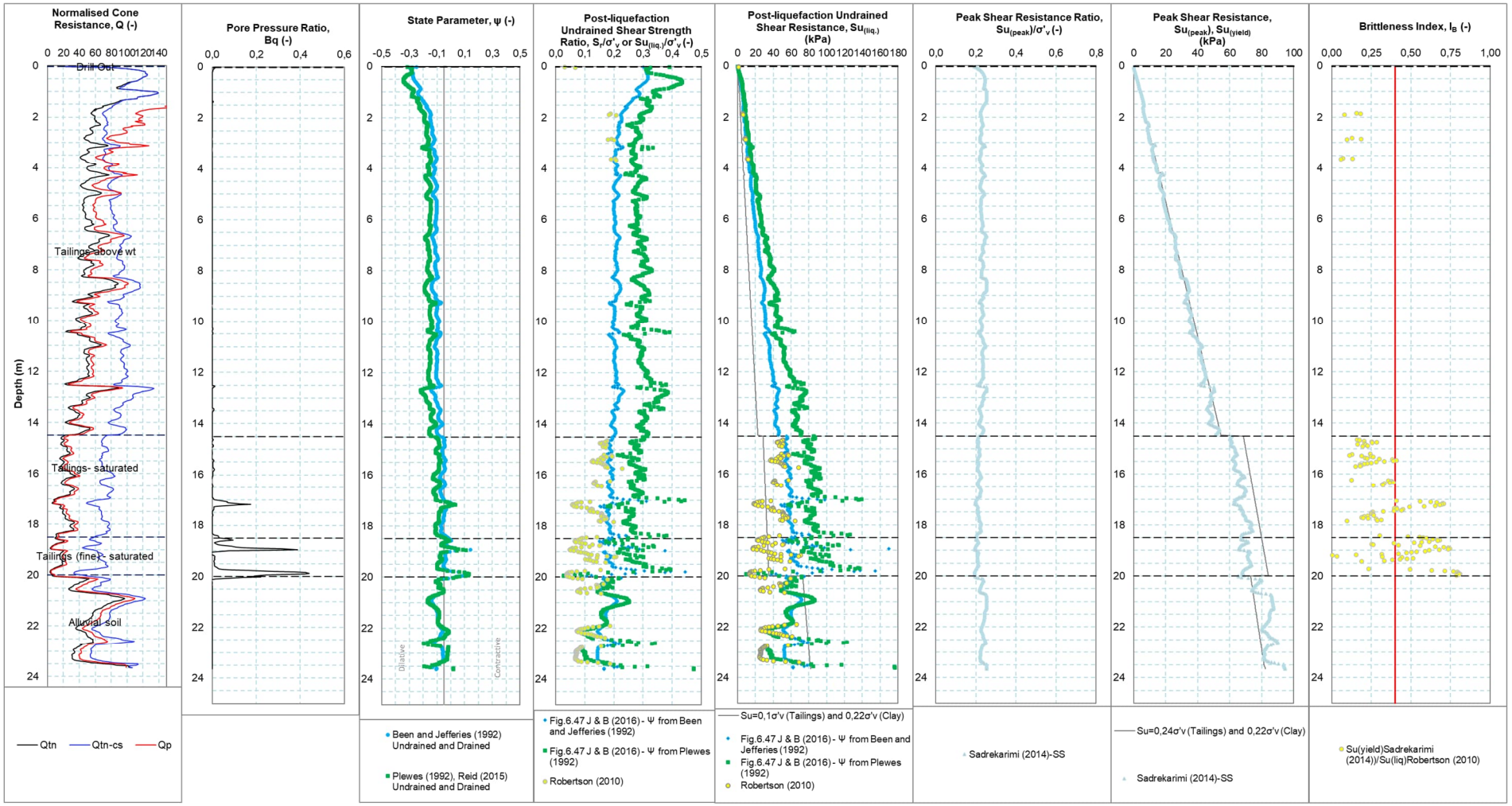
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

CPT-02



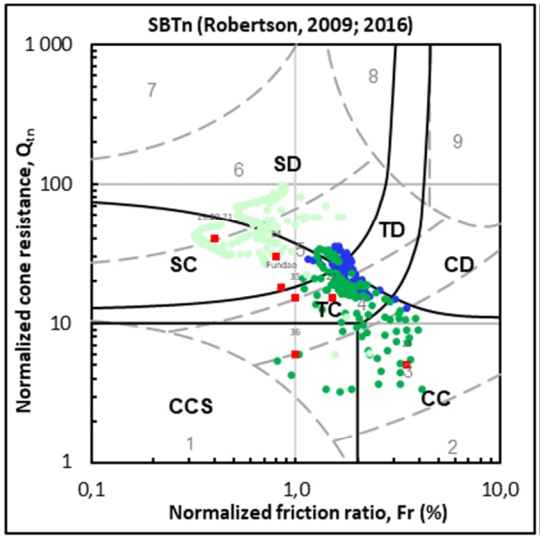
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

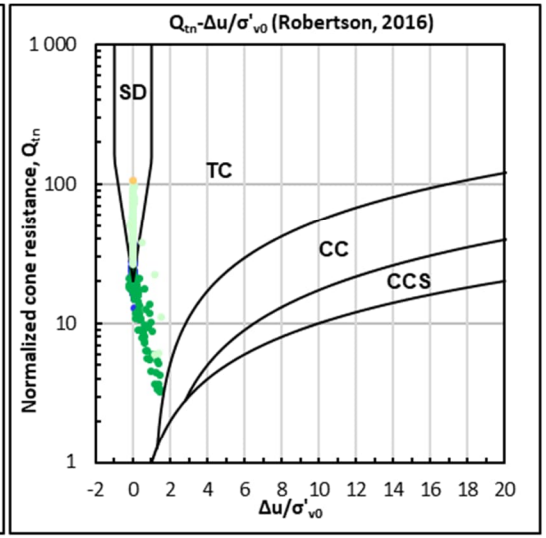
CPT-02



NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

CPT-02





Robertson 2009	Robertson 2016
1 : Sensitive Clays and Silts	CCS : Clay-like - Contractive - Sensitive
2 : Organic Soils	CC : Clay-like - Contractive
3 : Clays	CD : Clay-like - Dilative
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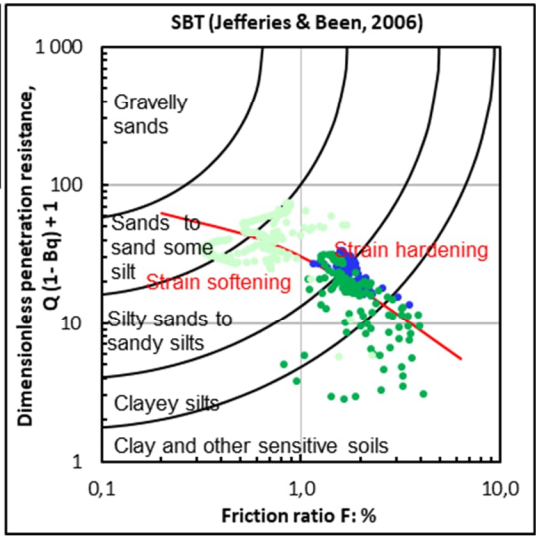
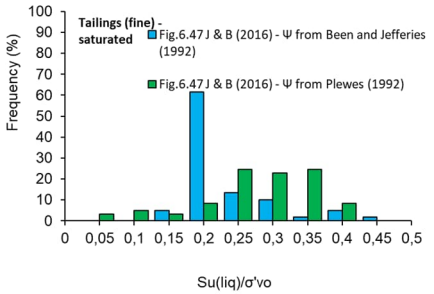
6 : Sands	SC : Sand-like - Contractive
7 : Gravelly Sands	SD : Sand-like - Dilative
8 : Stiff Sands to Clayed Sands	
9 : Stiff Clays and Silts	

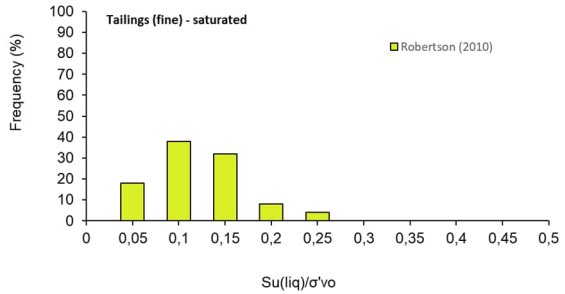
- Tailings- saturated
- Tailings (fine) - saturated
- Alluvial soil
- Case Histories (Robertson, 2010)
- Shuttle and Cunning (2008)

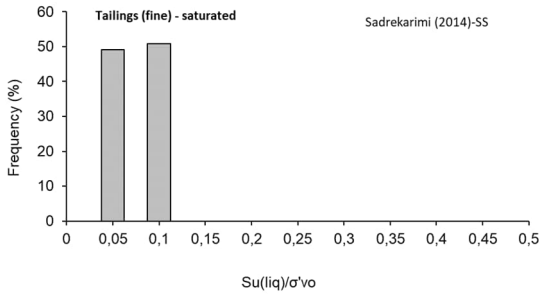


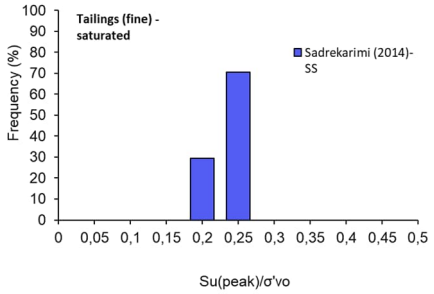
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

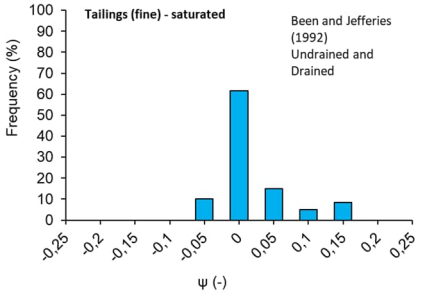
CPT-02
Fine saturated tailings

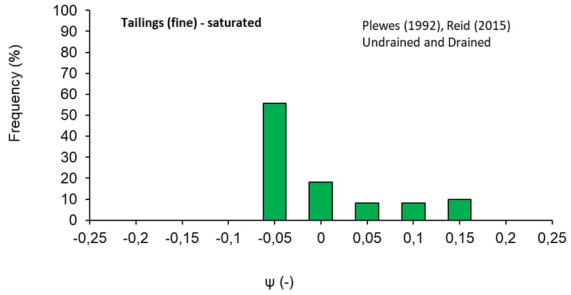






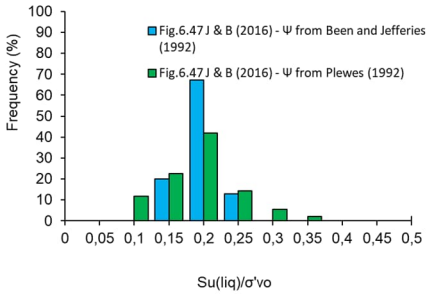


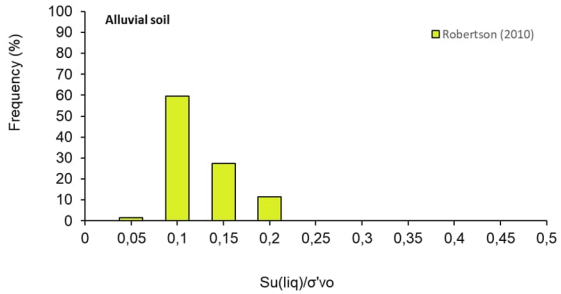


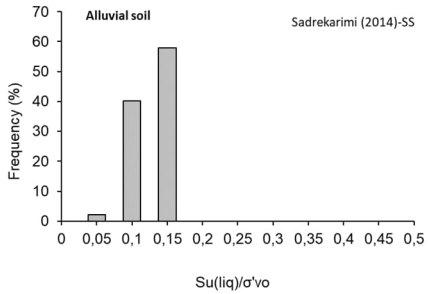


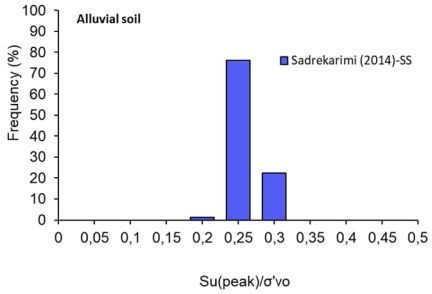
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

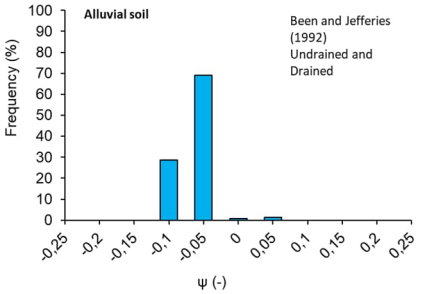
CPT-02
Alluvial soil (foundation)

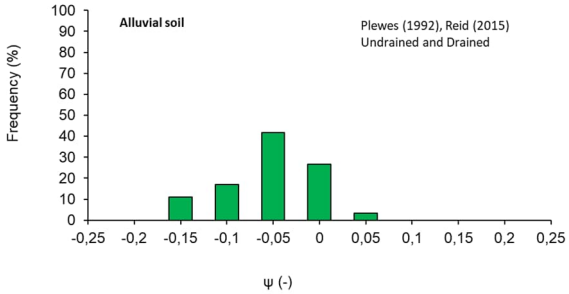






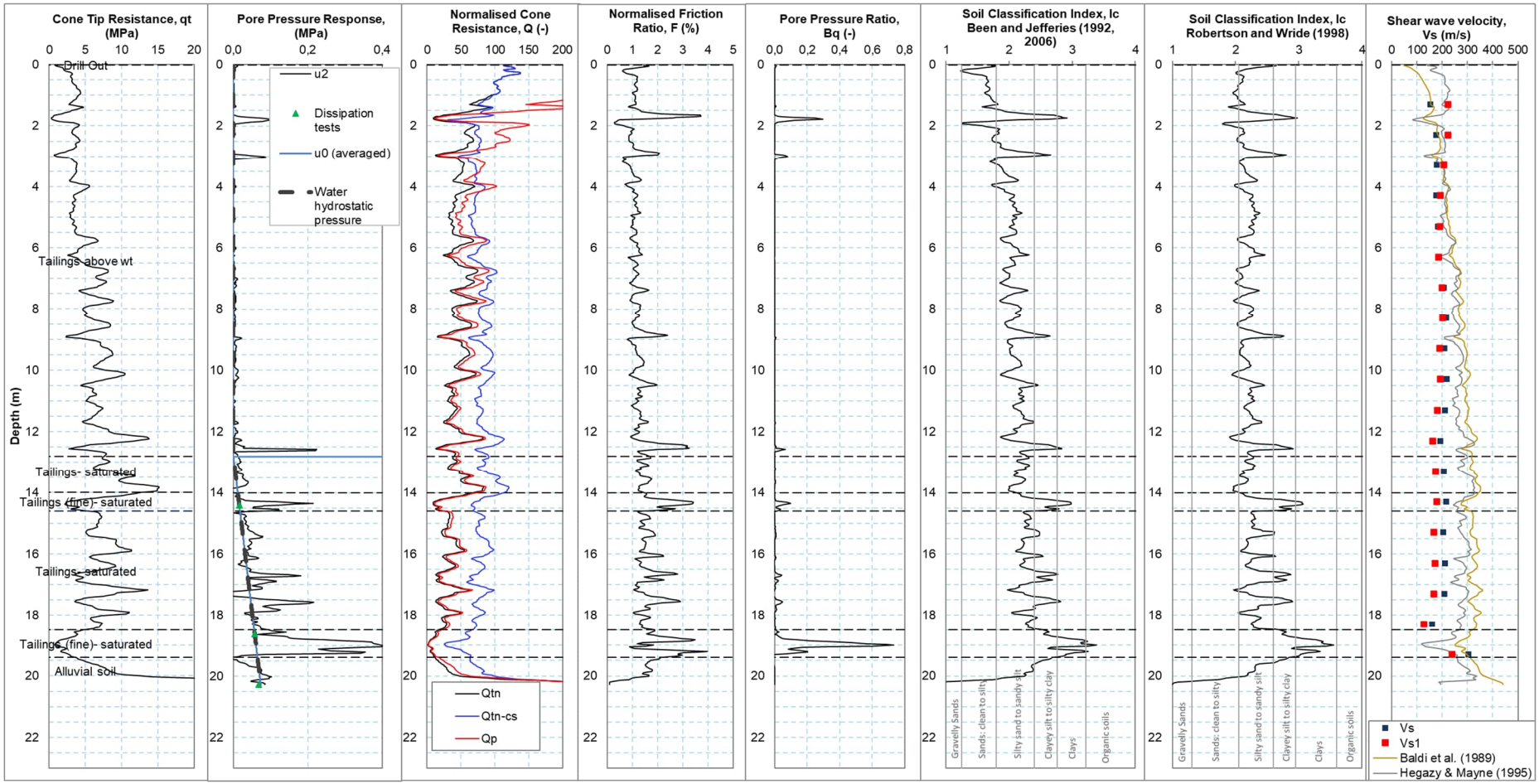






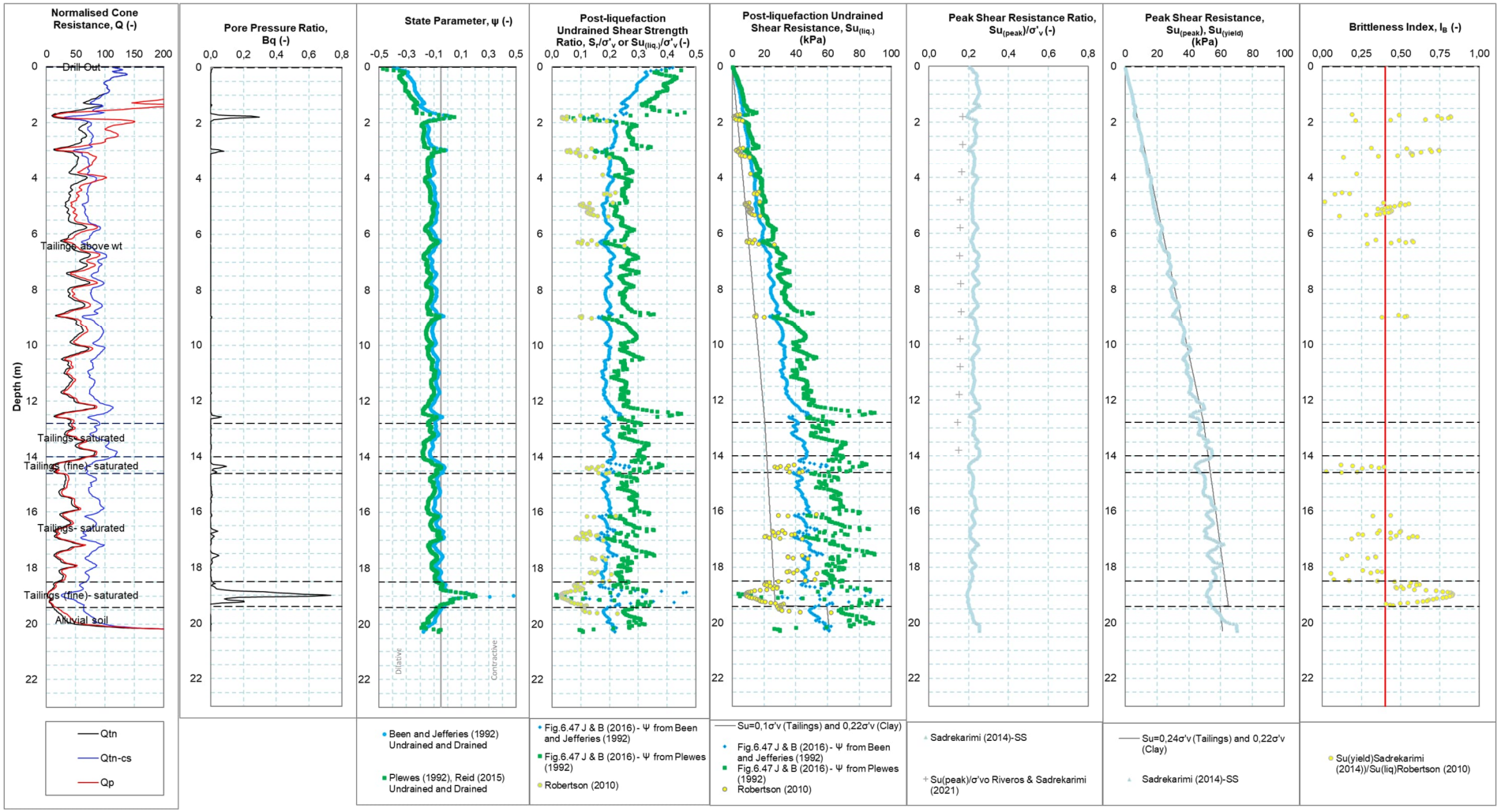
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-03



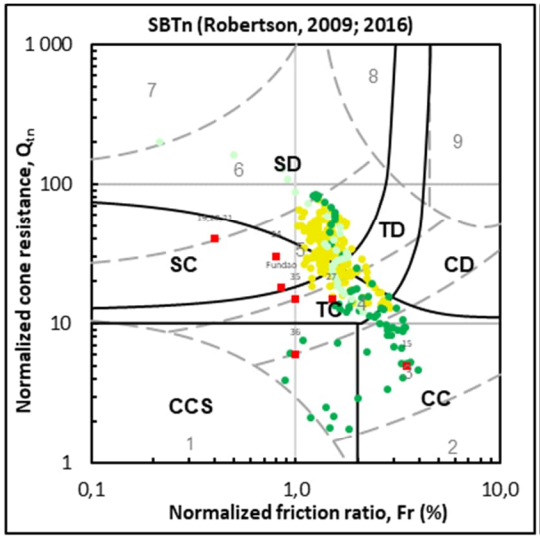
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

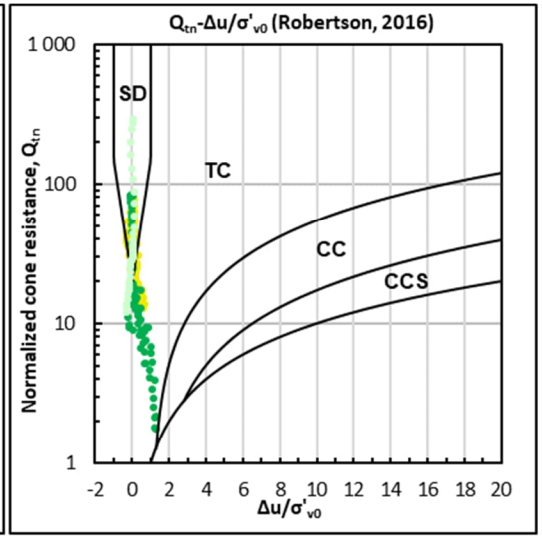
SCPT-03

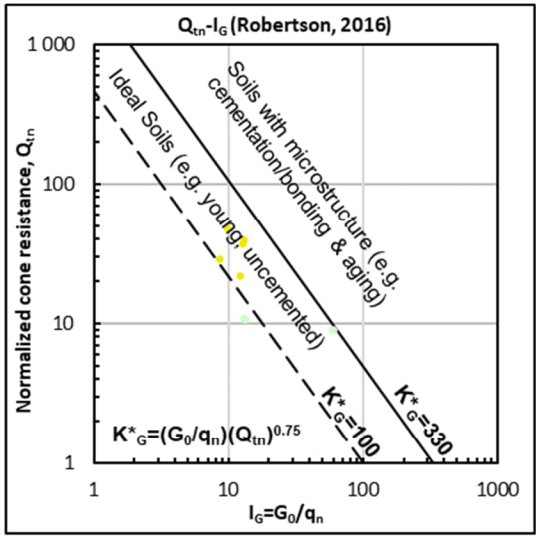


NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-03







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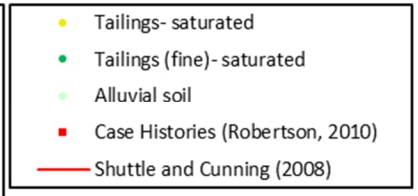
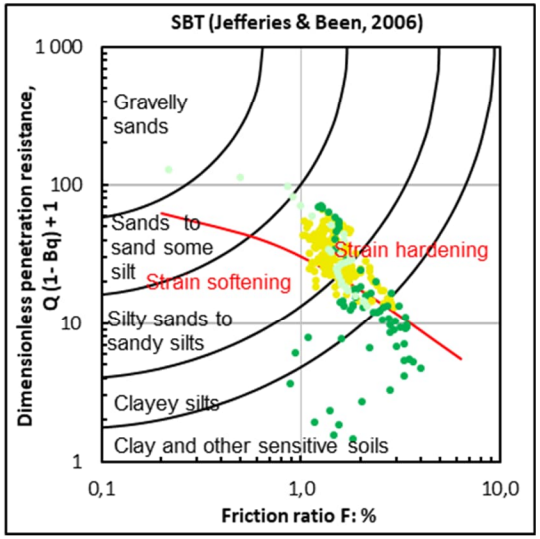
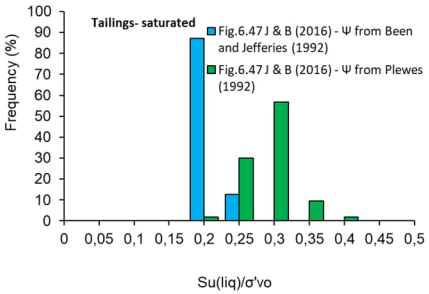
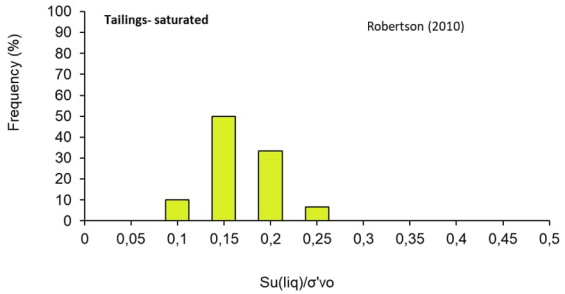


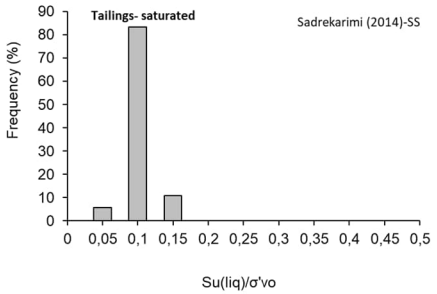


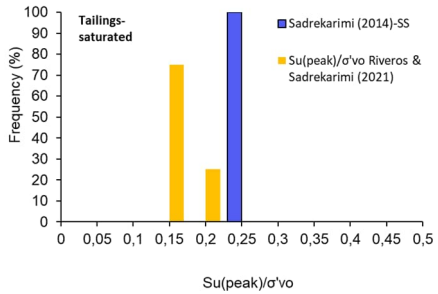
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

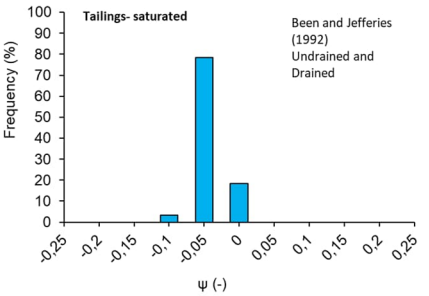
SCPT-03
Saturated tailings

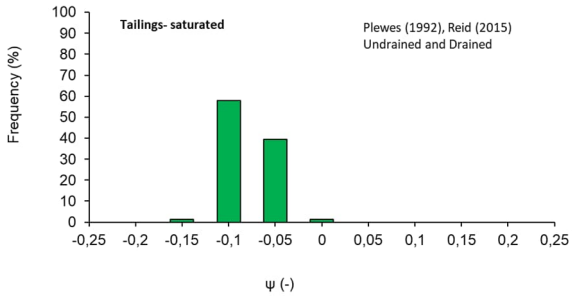






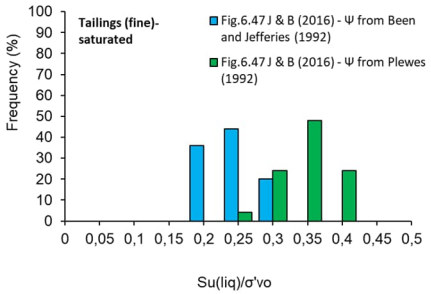


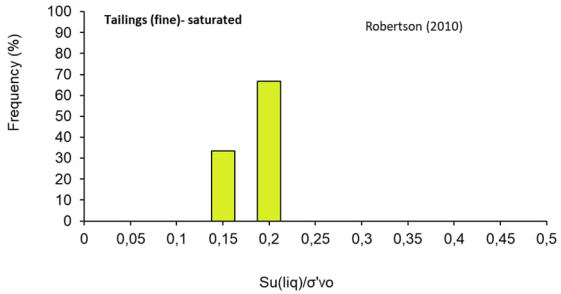


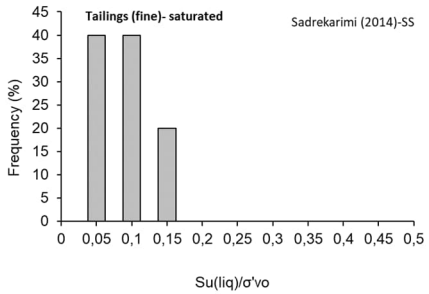


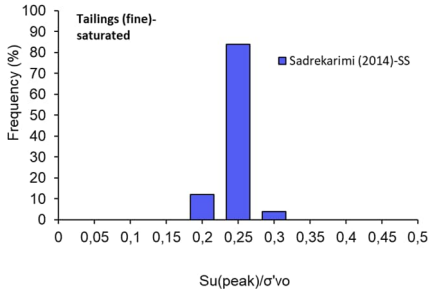
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

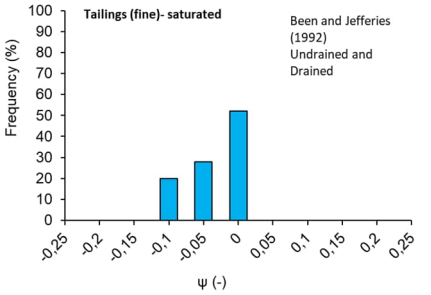
SCPT-03
Fine saturated tailings

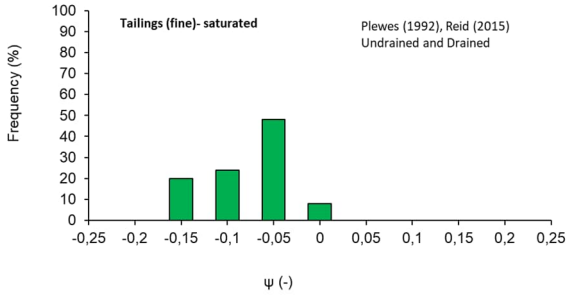






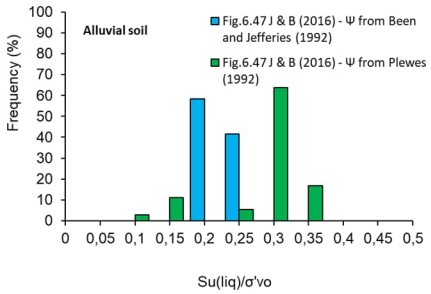


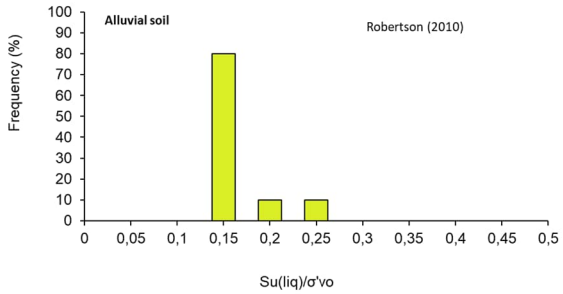


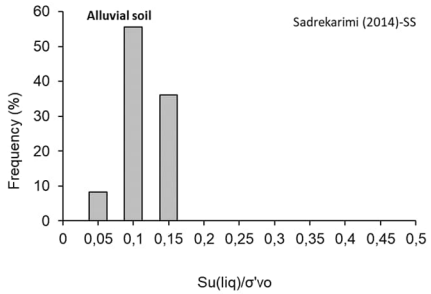


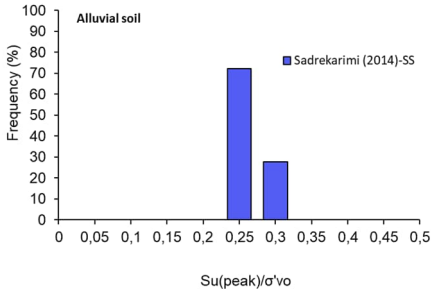
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

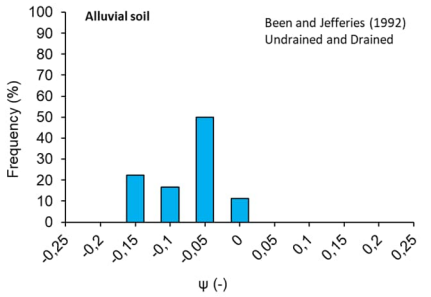
SCPT-03
Alluvial soil (foundation)

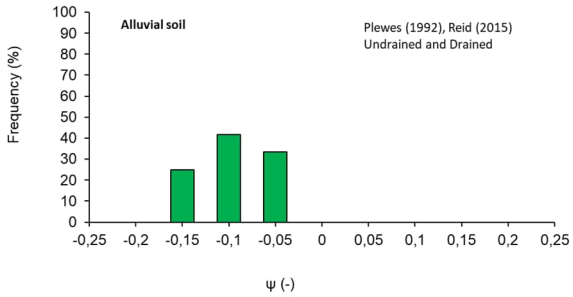






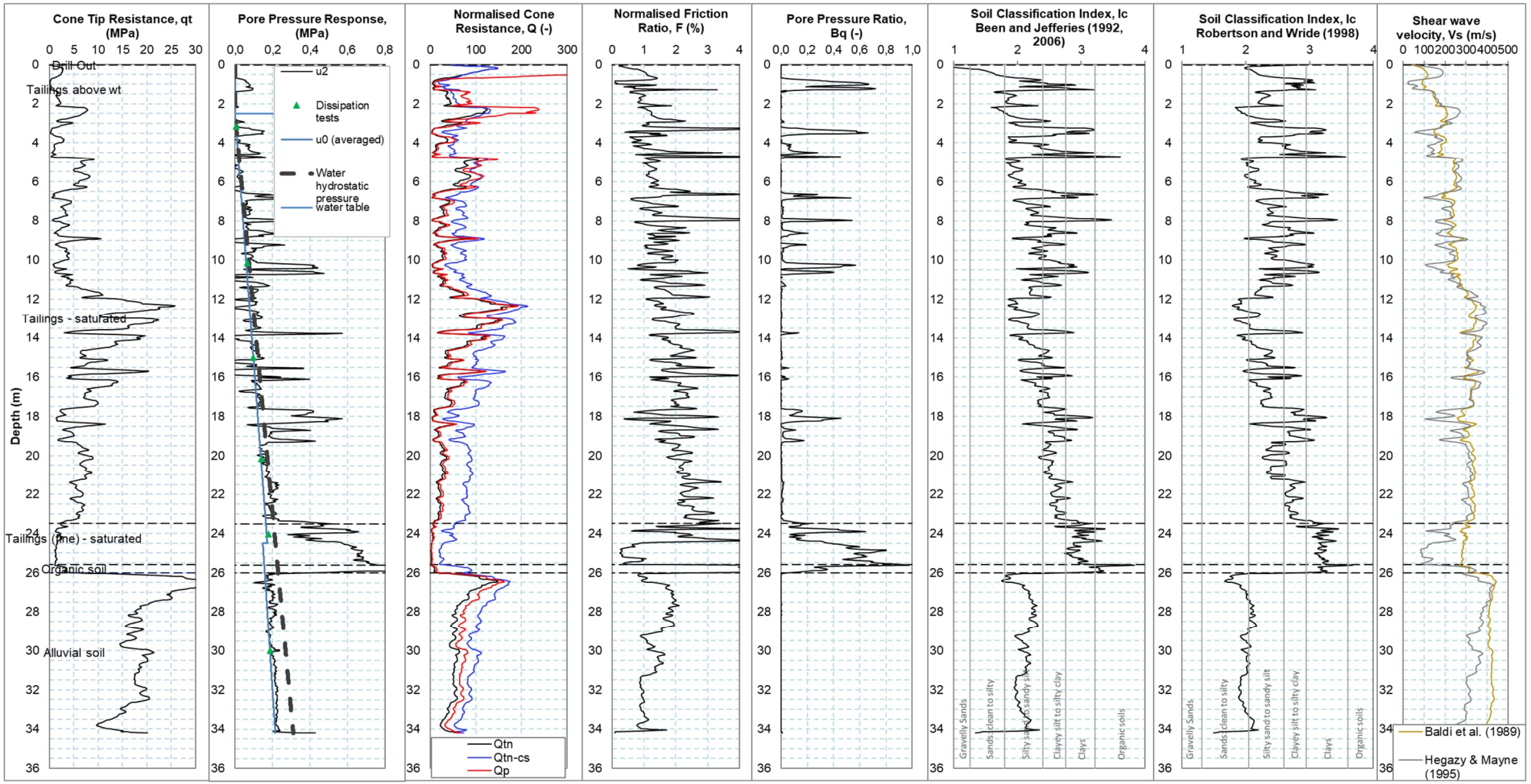






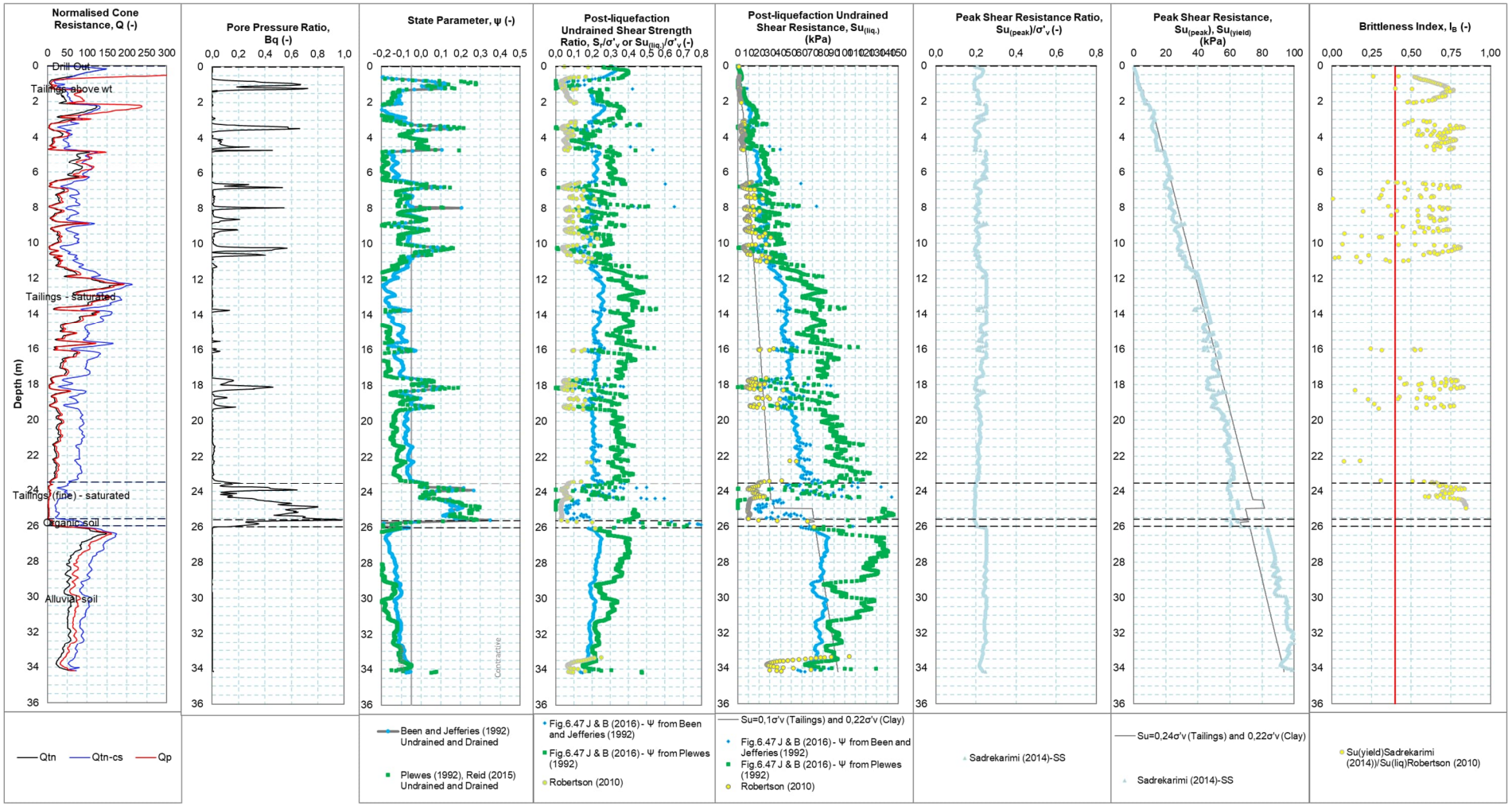
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

CPT-04



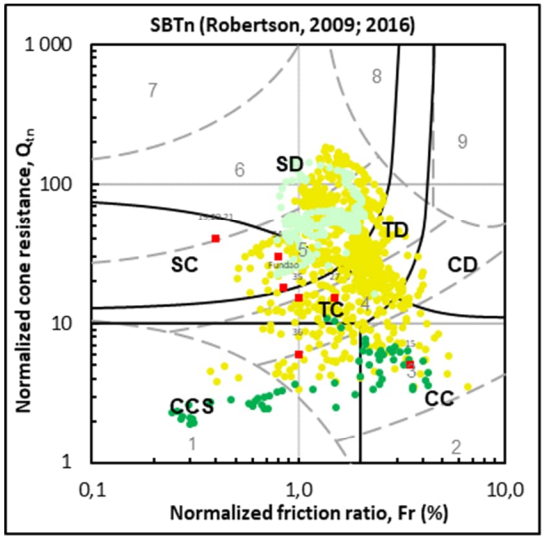
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

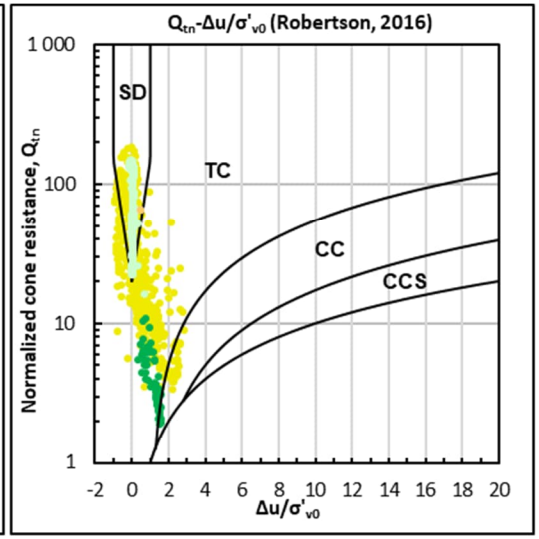
CPT-04



CPT-04

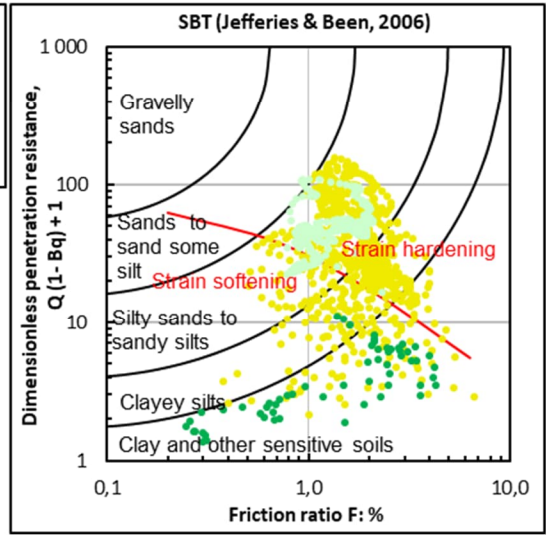
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.





Robertson 2009	Robertson 2016
1 : Sensitive Clays and Silts	CCS : Clay-like - Contractive - Sensitive
2 : Organic Soils	CC : Clay-like - Contractive
3 : Clays	CD : Clay-like - Dilative
4 : Silt Mix	TC : Transitional - Contractive
5 : Sandy Mix	TD : Transitional - Dilative
6 : Sands	SC : Sand-like - Contractive
7 : Gravelly Sands	SD : Sand-like - Dilative
8 : Stiff Sands to Clayed Sands	
9 : Stiff Clays and Silts	

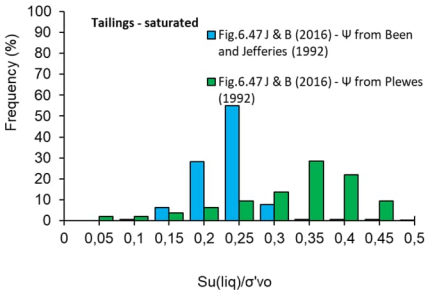
- Tailings - saturated
- Tailings (fine) - saturated
- Alluvial soil
- Case Histories (Robertson, 2010)
- Shuttle and Cunning (2008)

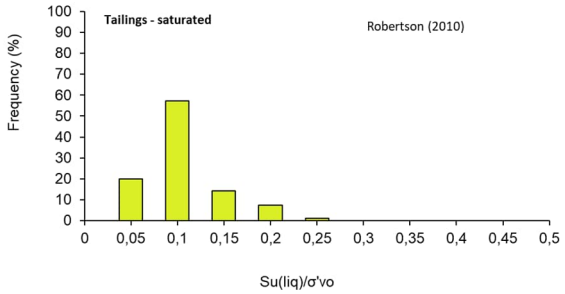


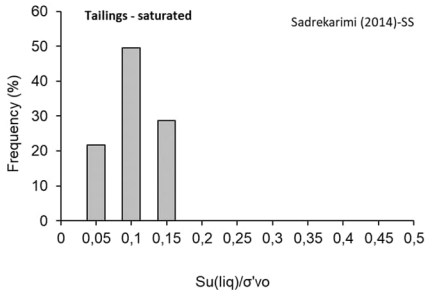
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

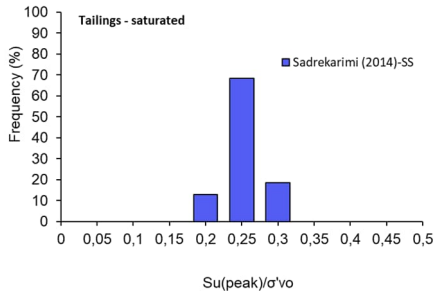
CPT-04

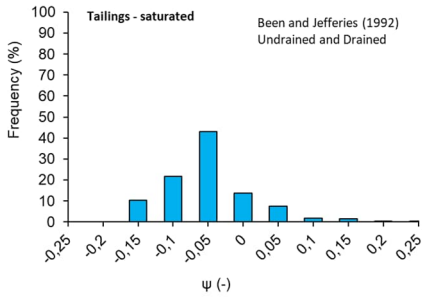
Saturated tailings

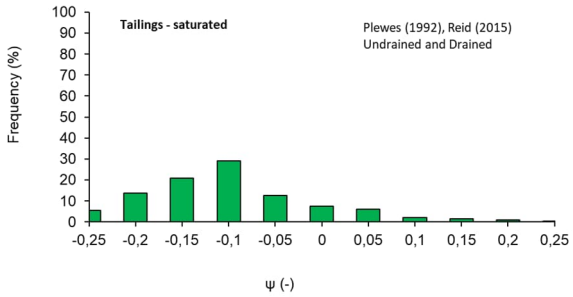






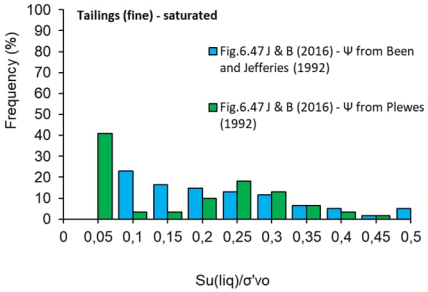


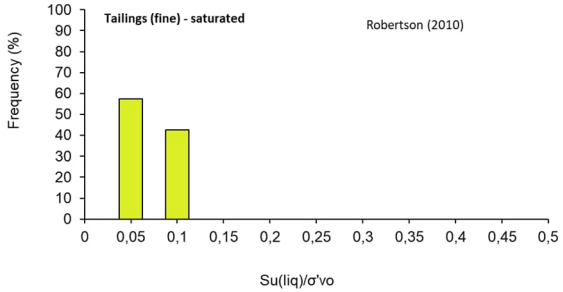


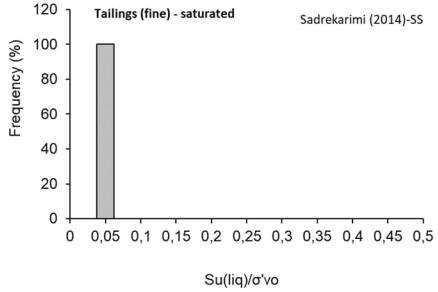


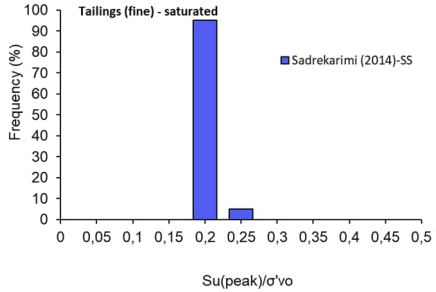
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

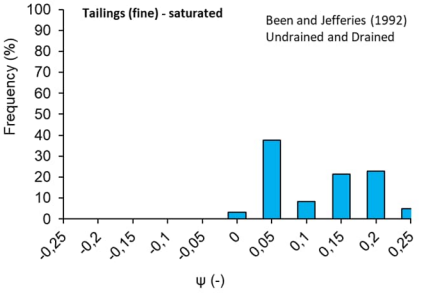
CPT-04
Fine saturated tailings

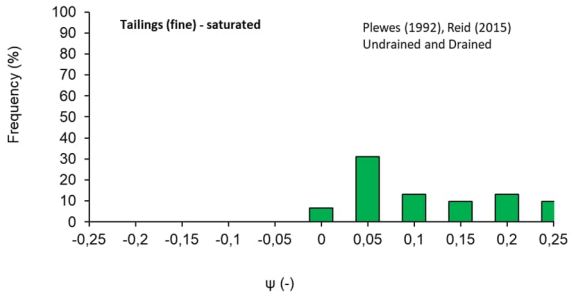






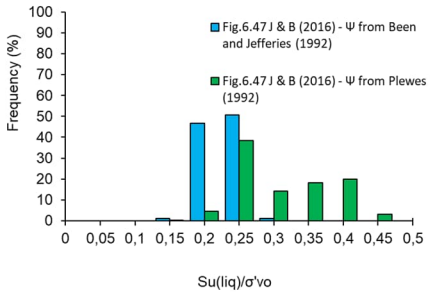


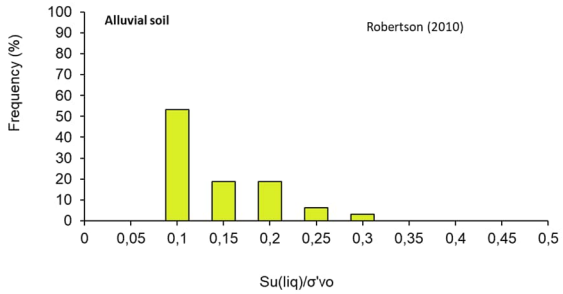


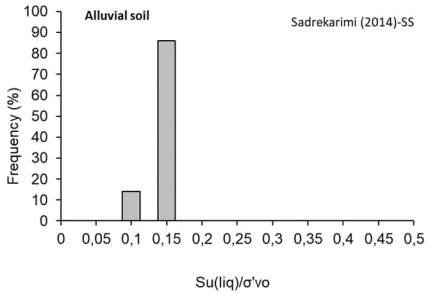


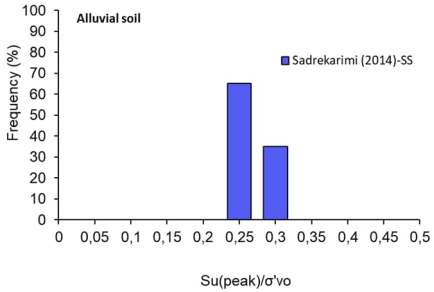
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

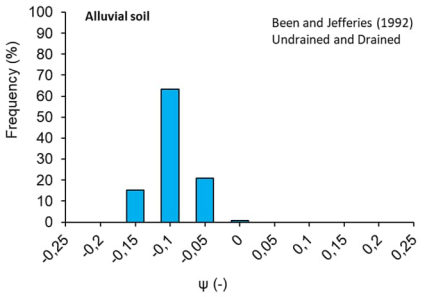
CPT-04
Alluvial soil (foundation)

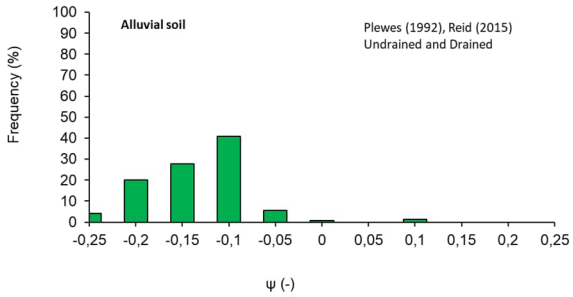






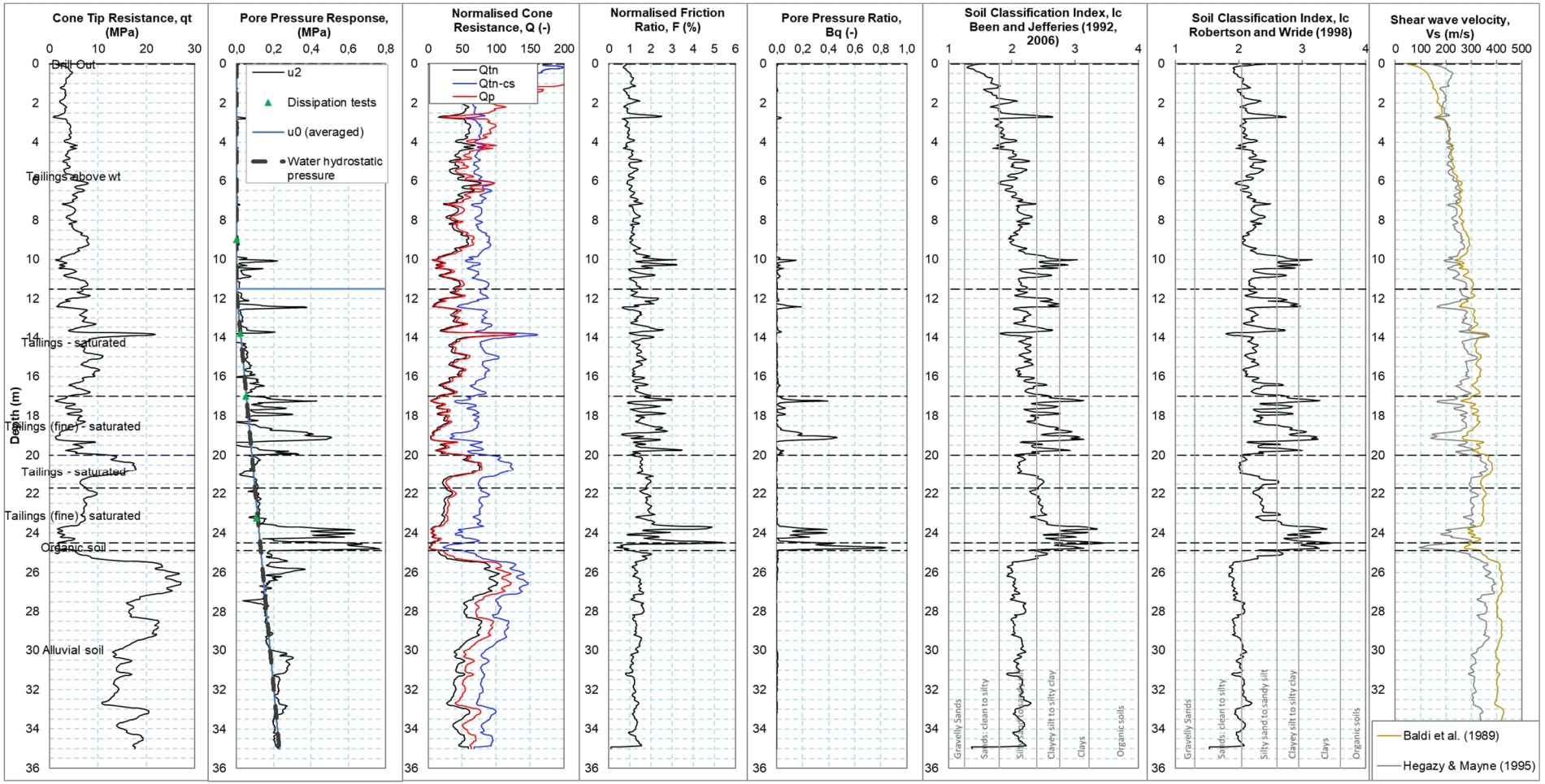






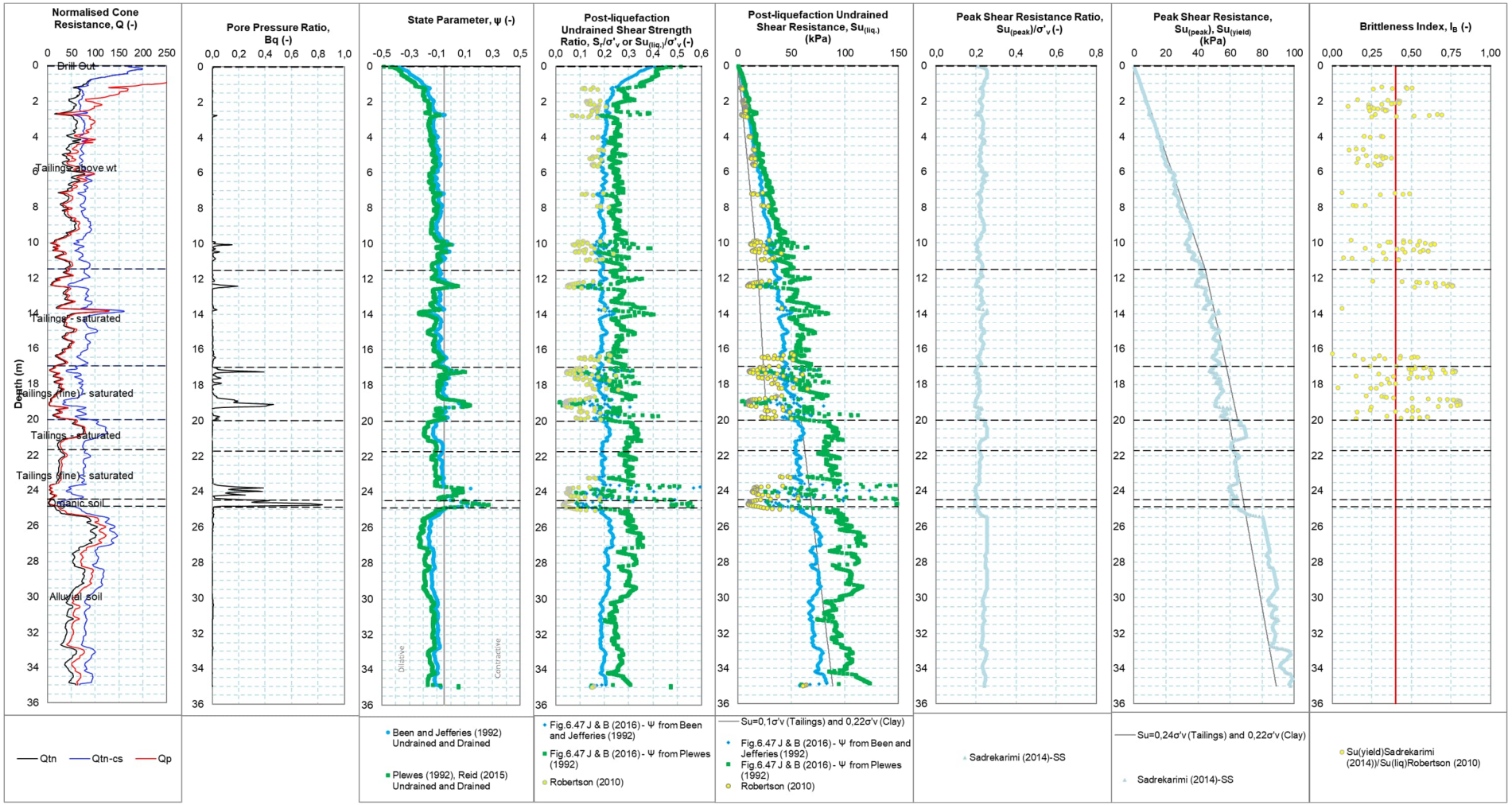
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

CPT-05



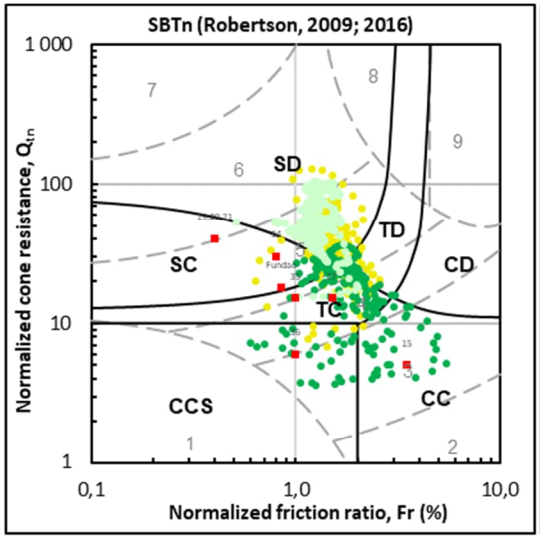
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

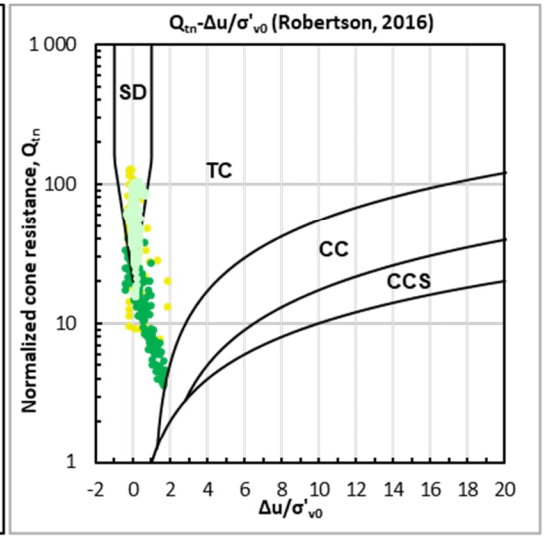
CPT-05



NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

CPT-05





Robertson 2009	Robertson 2016
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- Tailings - saturated
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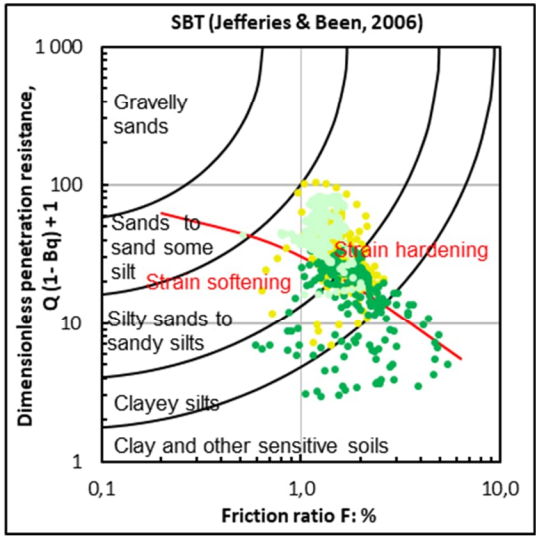
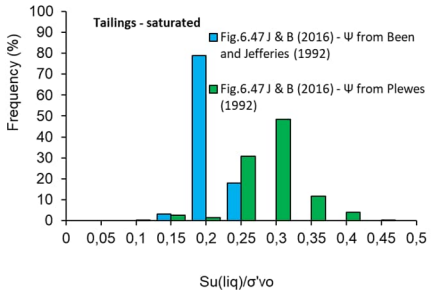
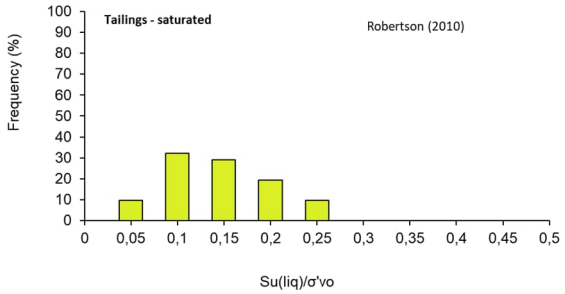
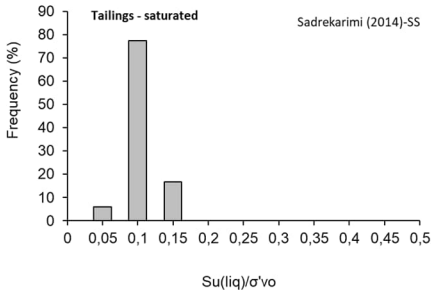


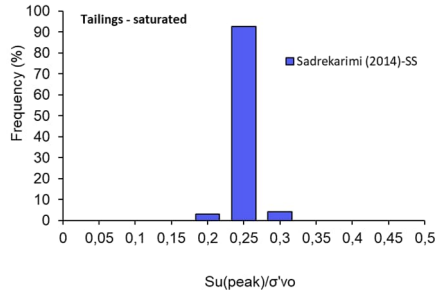
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

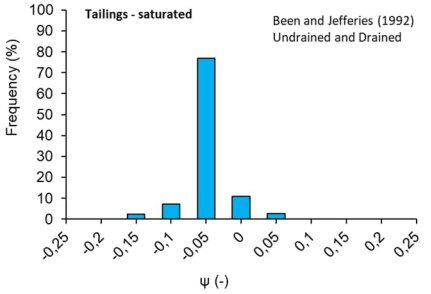
CPT-05
Saturated tailings

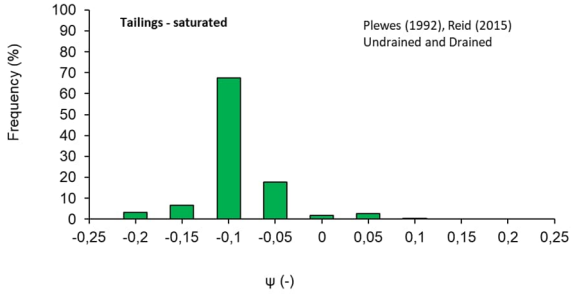






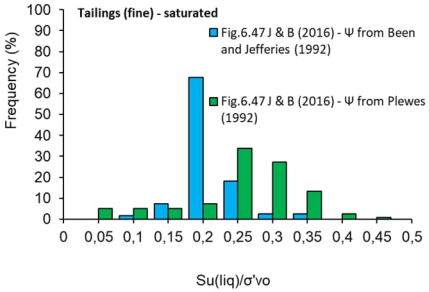


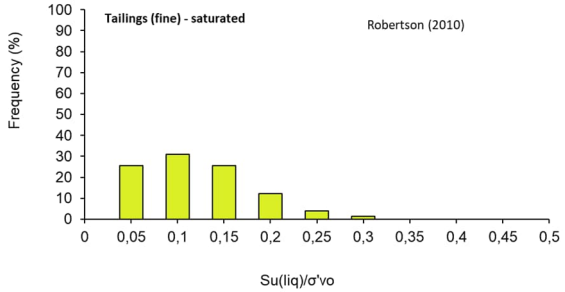


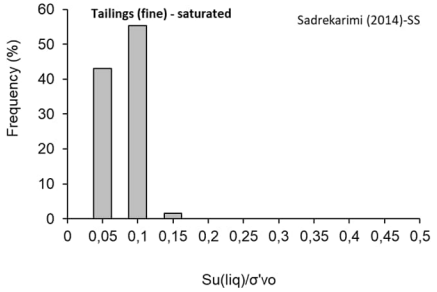


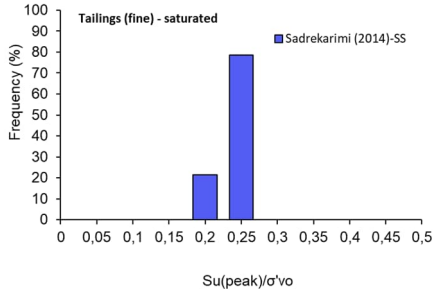
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

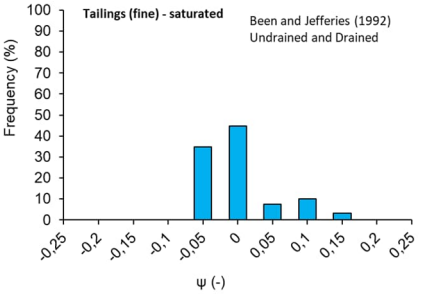
CPT-05
Fine saturated tailings

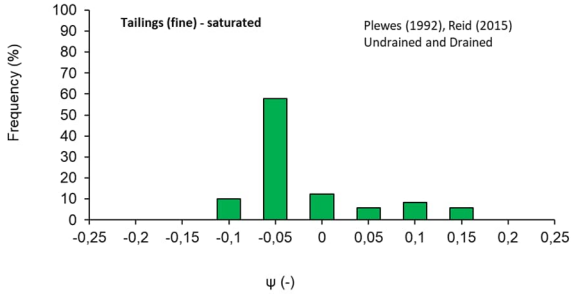






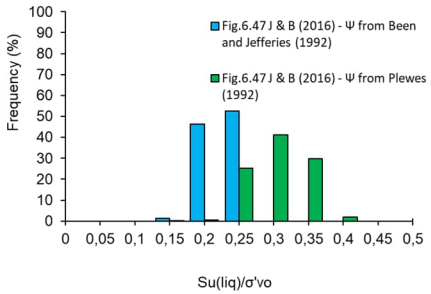


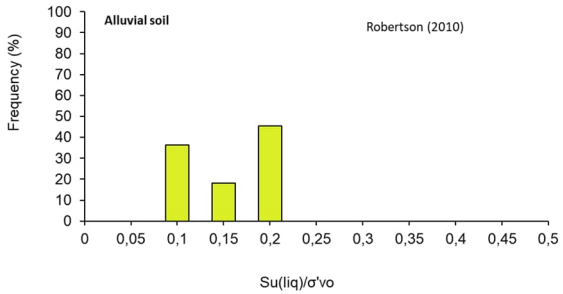


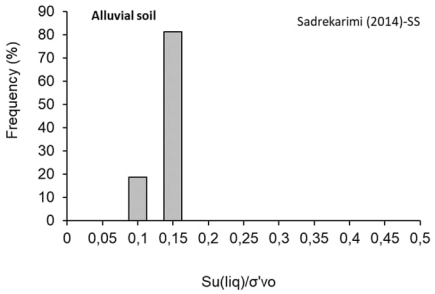


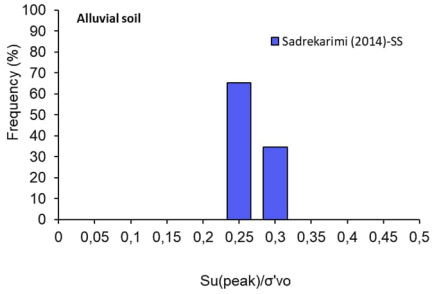
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

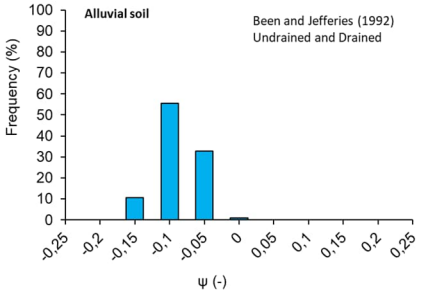
CPT-05
Alluvial soil (foundation)

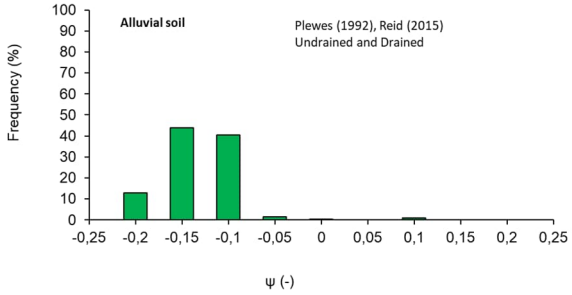






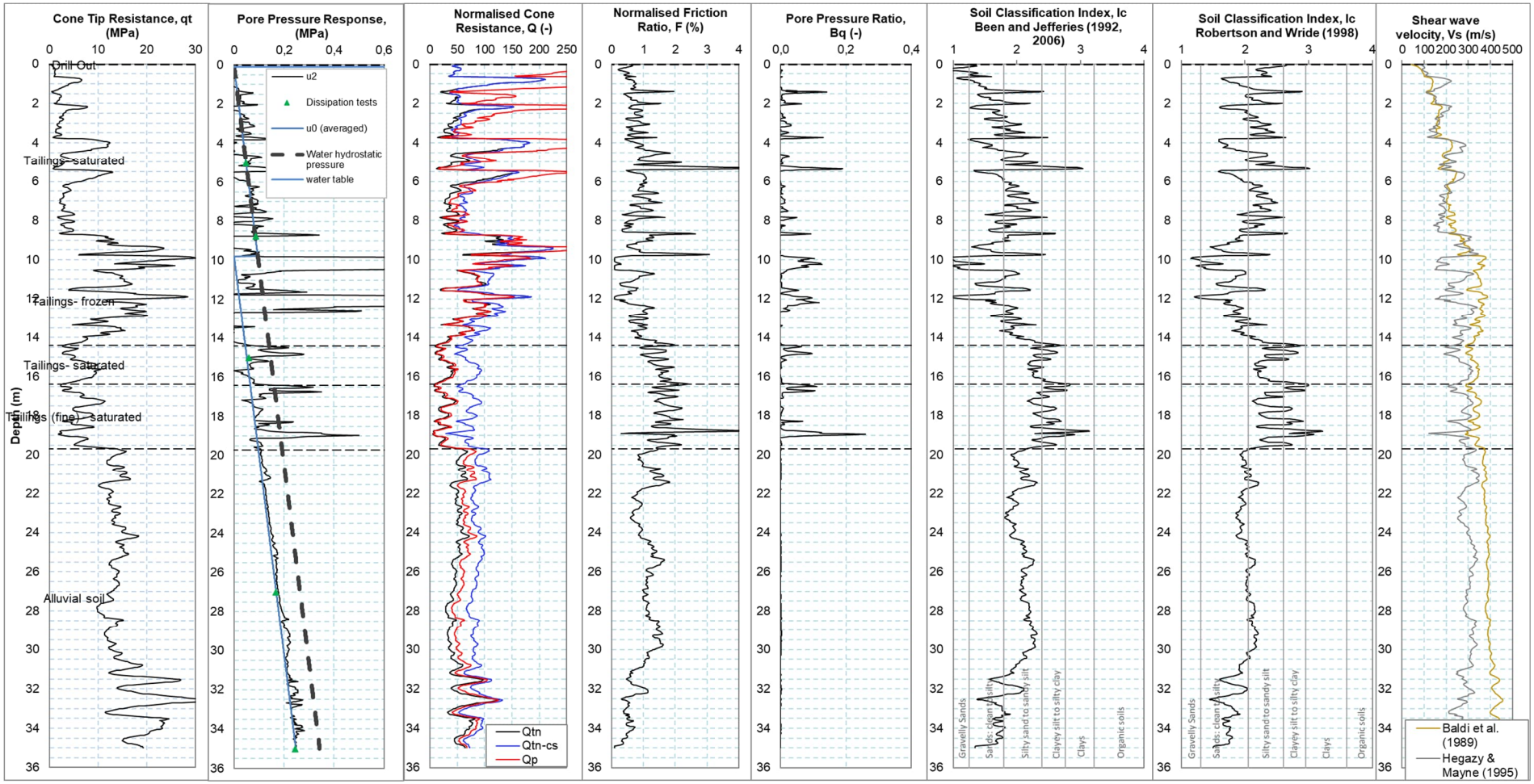






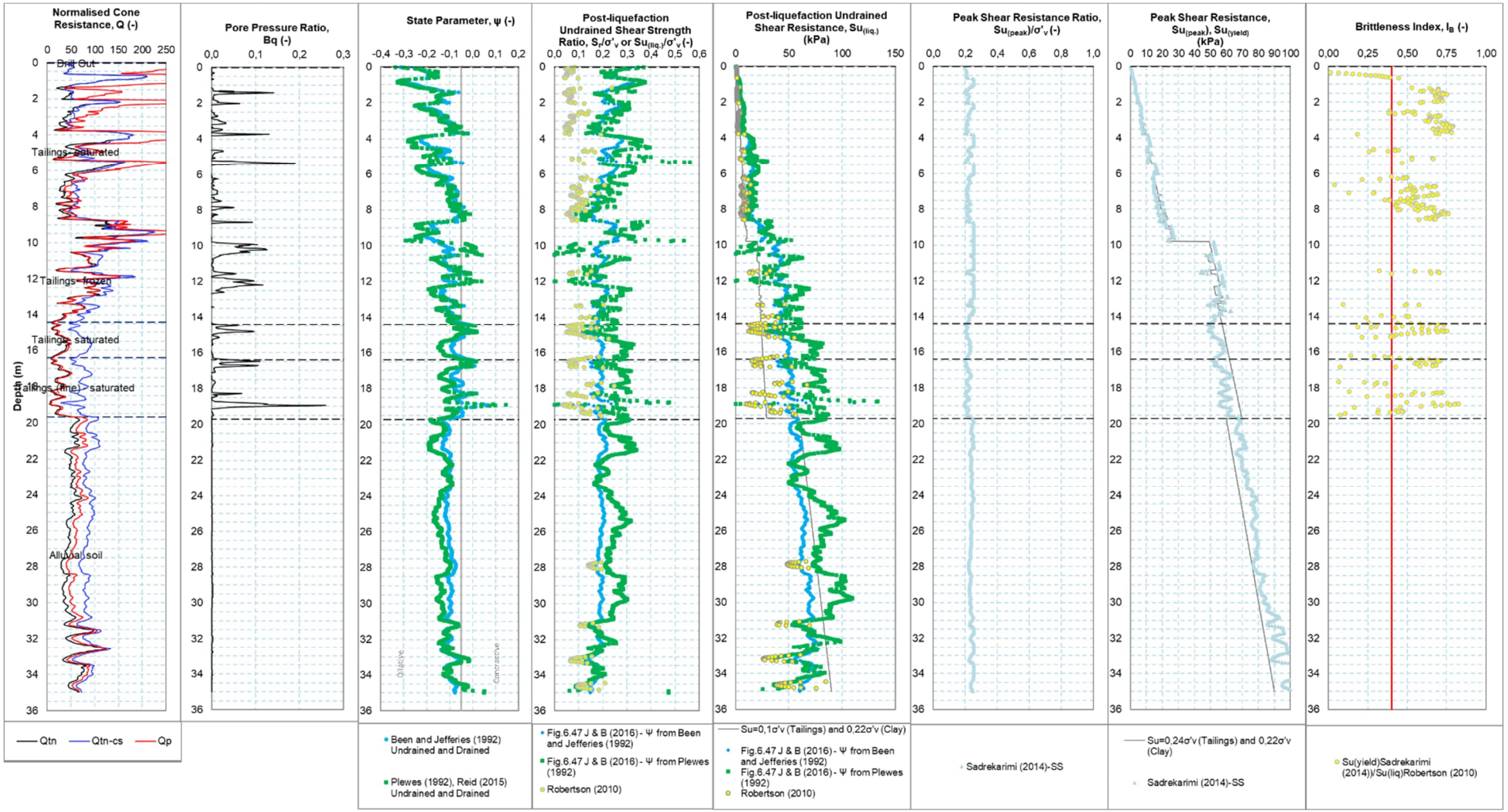
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

CPT-06



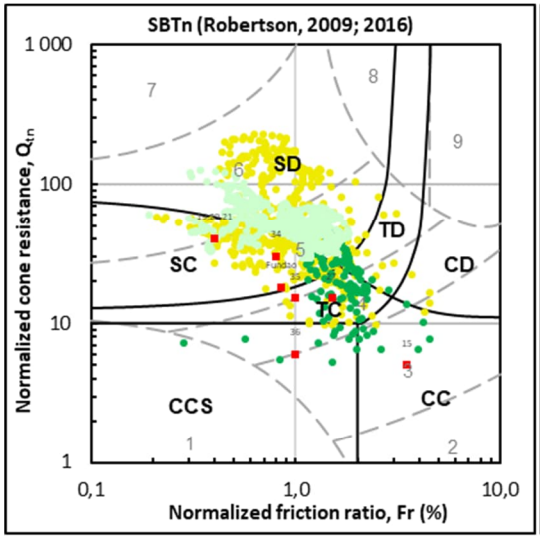
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

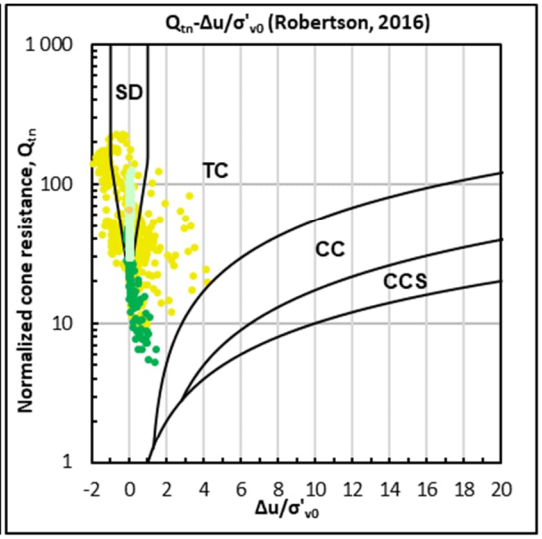
CPT-06



NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

CPT-06





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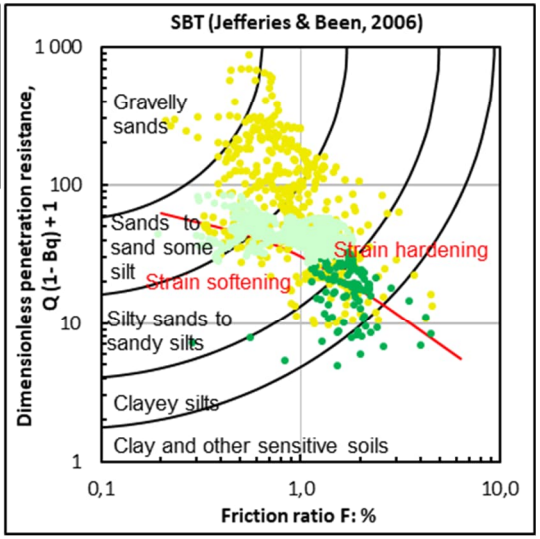
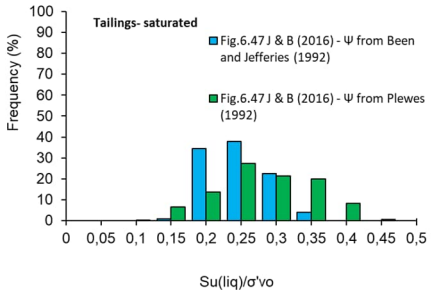
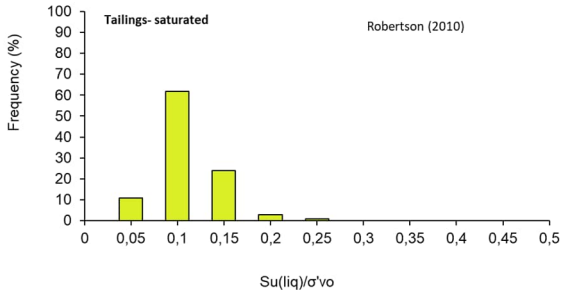
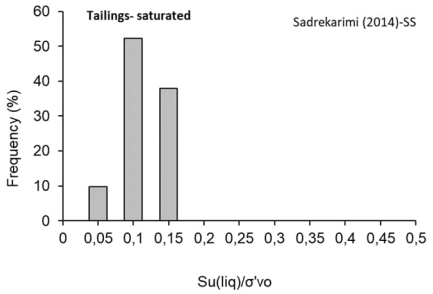


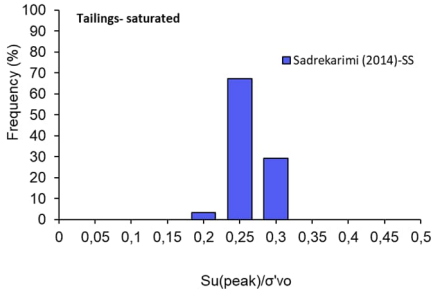
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

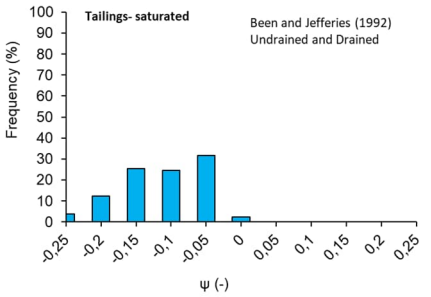
CPT-06
Saturated tailings

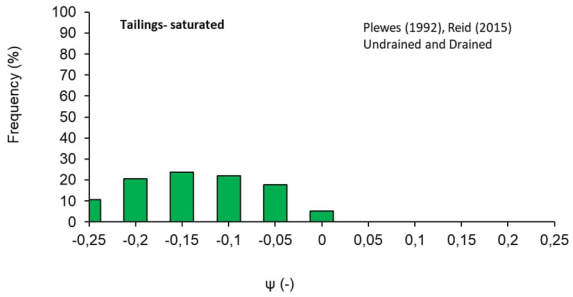






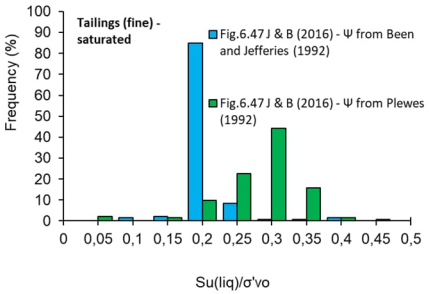


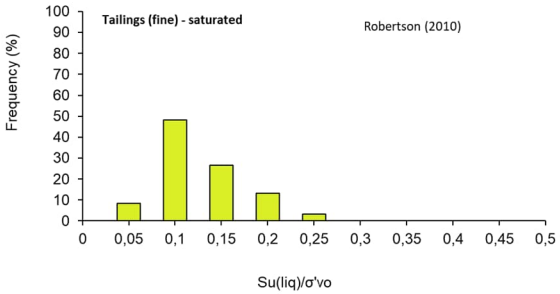


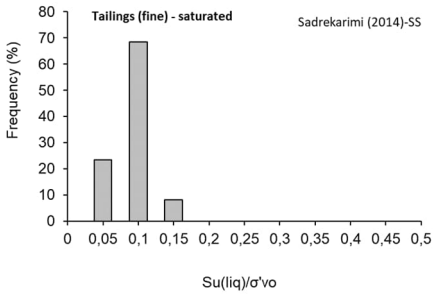


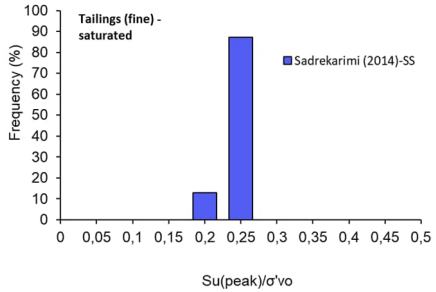
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

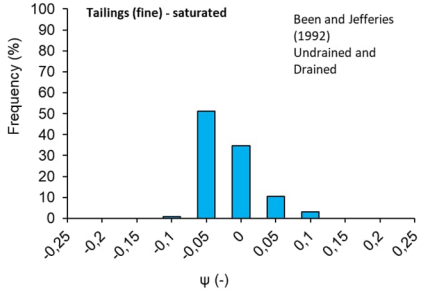
CPT-06
Fine saturated tailings

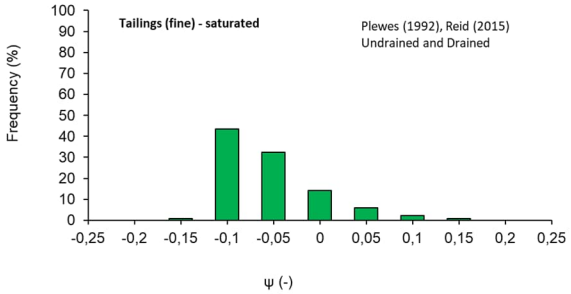






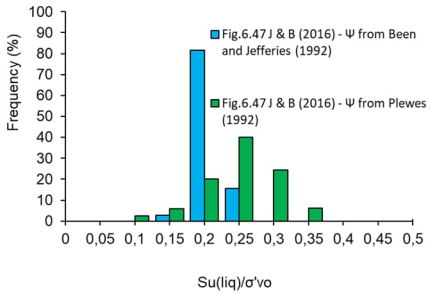


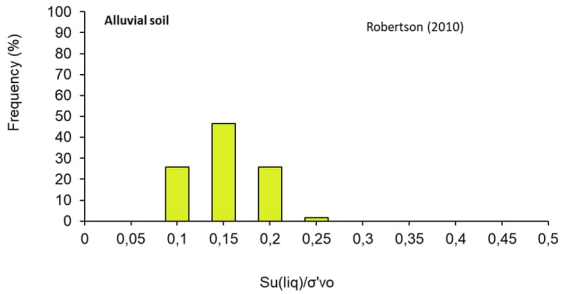


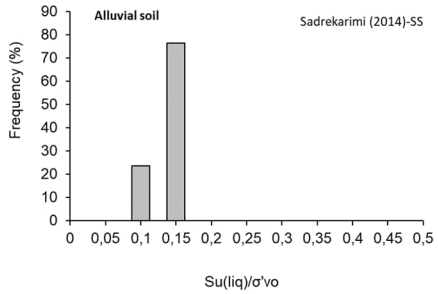


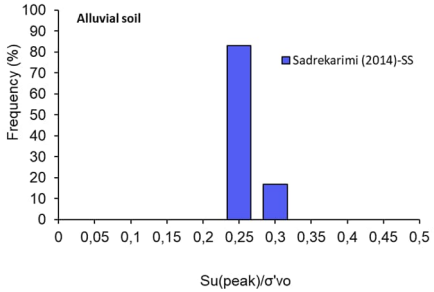
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

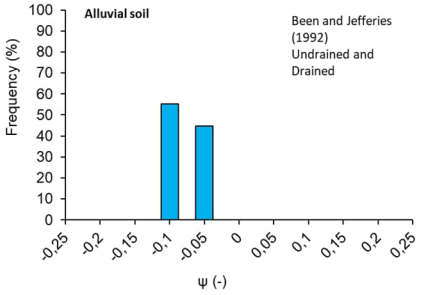
CPT-06
Alluvial soil (foundation)

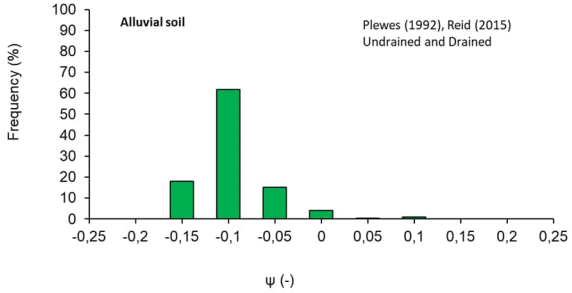






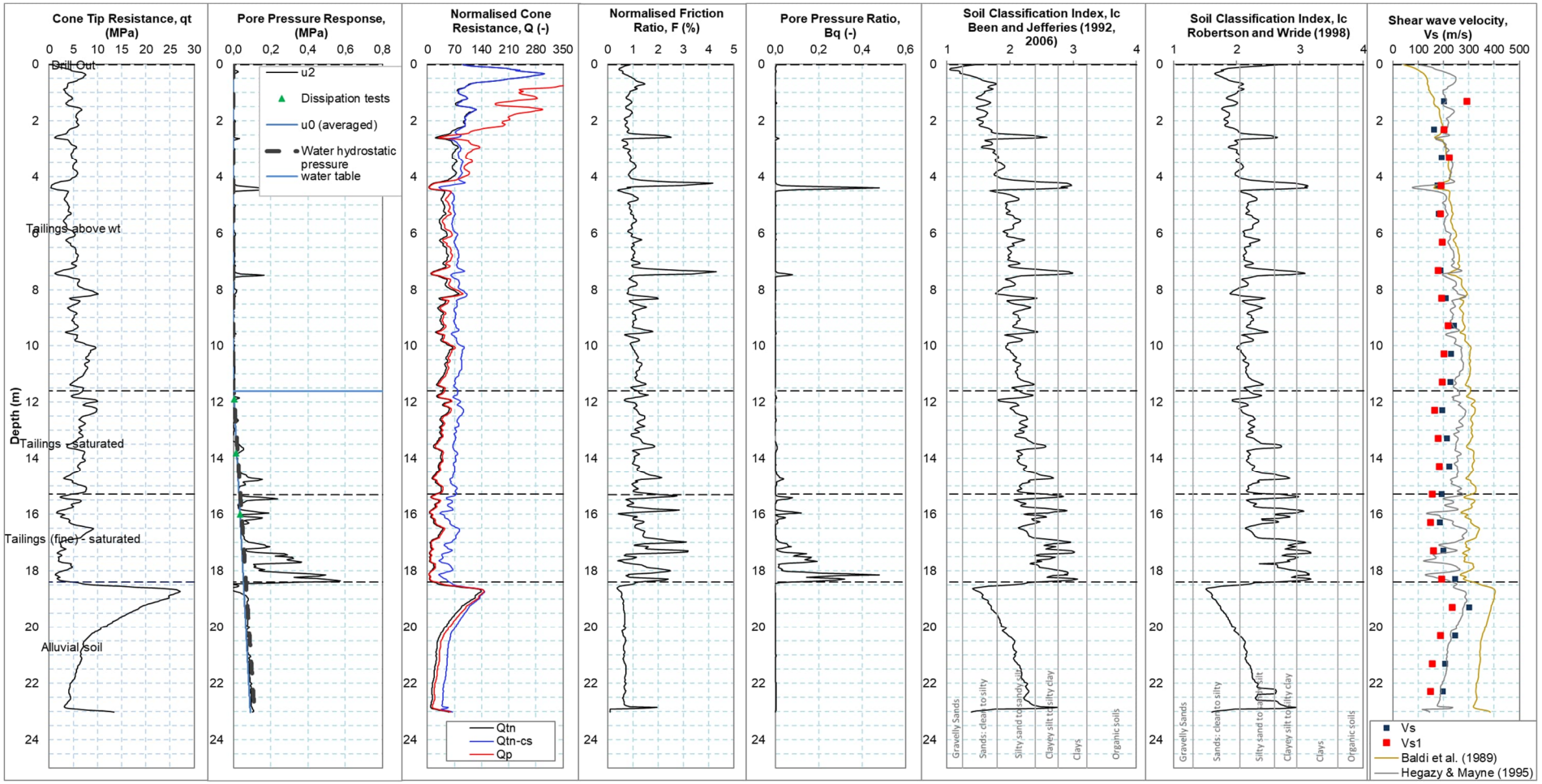






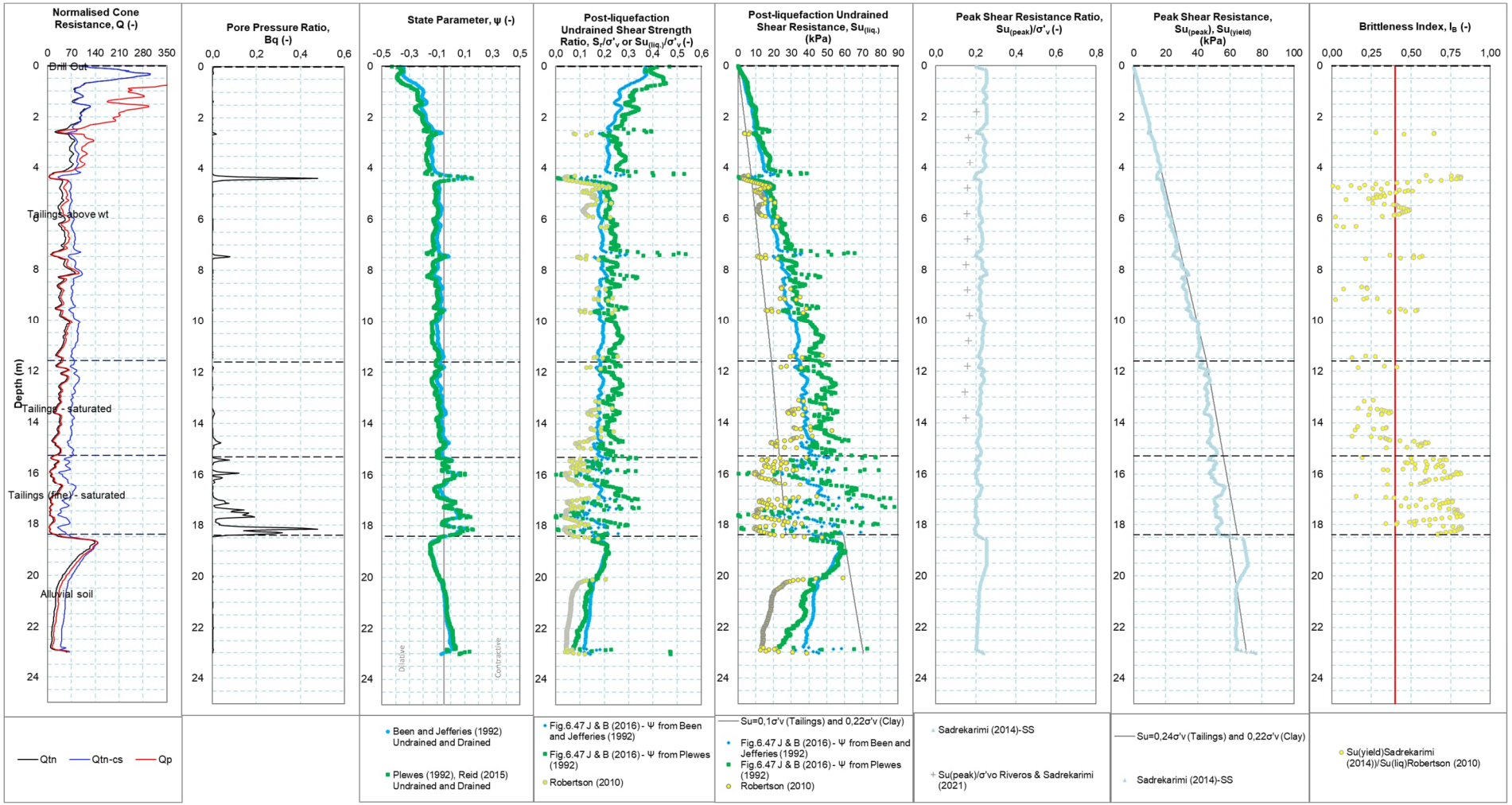
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-07



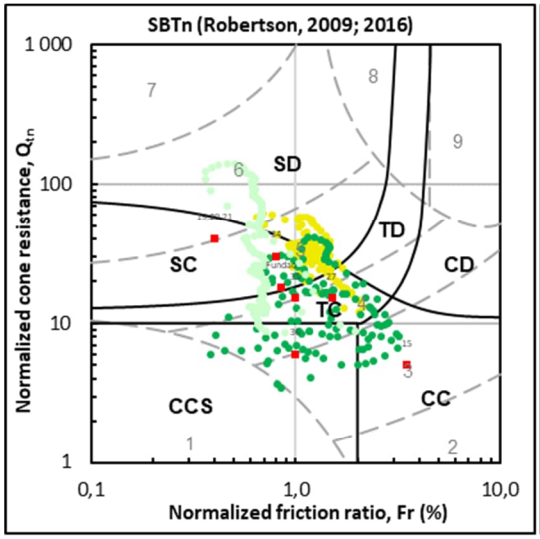
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

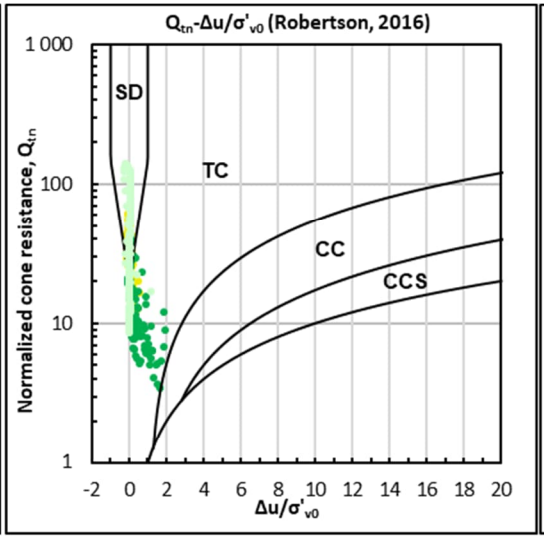
SCPT-07

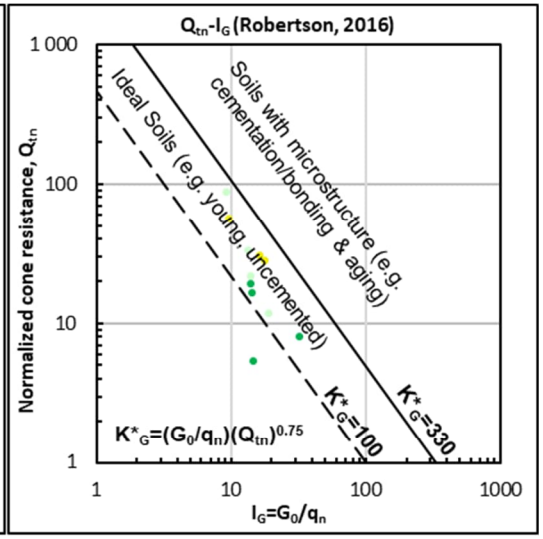


NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-07







Robertson 2009	Robertson 2016
1 : Sensitive Clays and Silts	CCS : Clay-like - Contractive - Sensitive
2 : Organic Soils	CC : Clay-like - Contractive
3 : Clays	CD : Clay-like - Dilative
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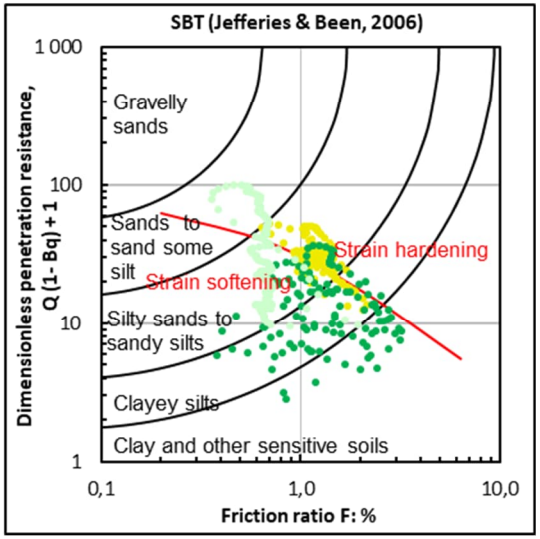
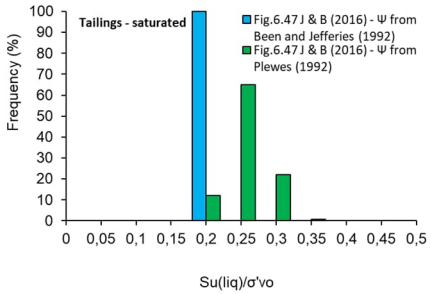
6 : Sands	SC : Sand-like - Contractive
7 : Gravelly Sands	SD : Sand-like - Dilative
8 : Stiff Sands to Clayed Sands	
9 : Stiff Clays and Silts	

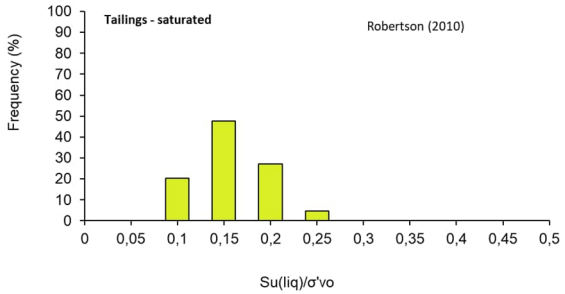
- Tailings - saturated
- Tailings (fine) - saturated
- Alluvial soil
- Case Histories (Robertson, 2010)
- Shuttle and Cunning (2008)

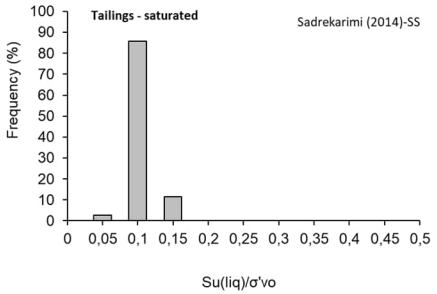


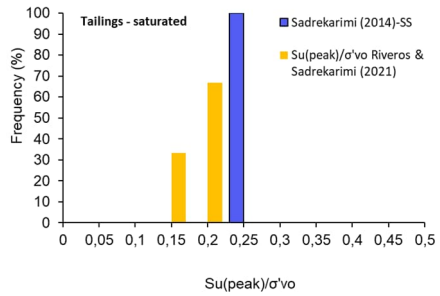
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

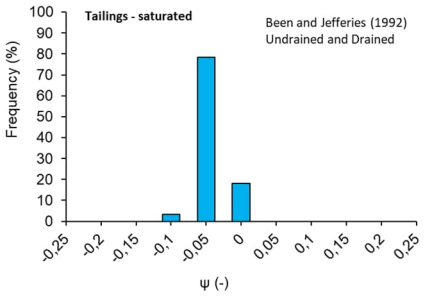
SCPT-07
Saturated tailings

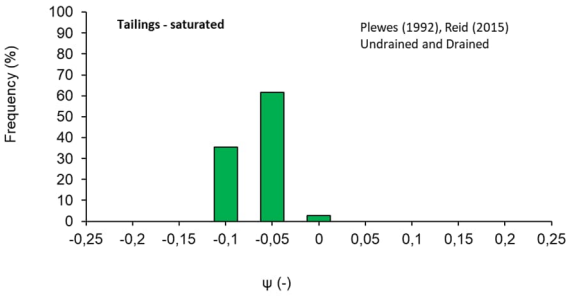






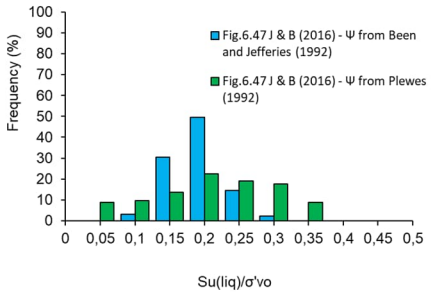


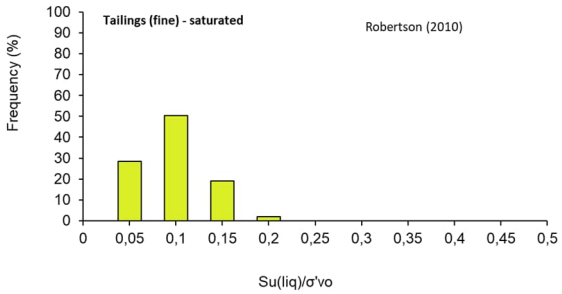


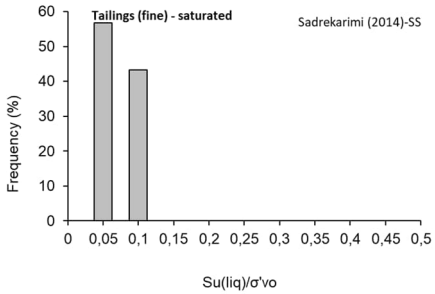


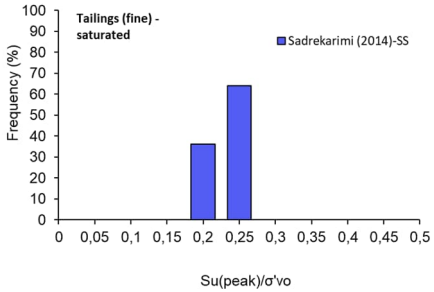
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

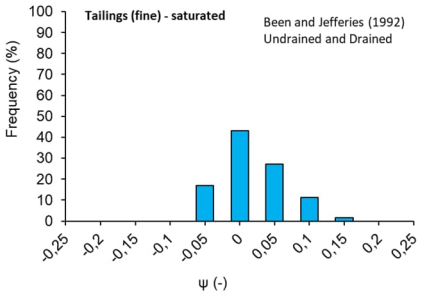
SCPT-07
Fine saturated tailings

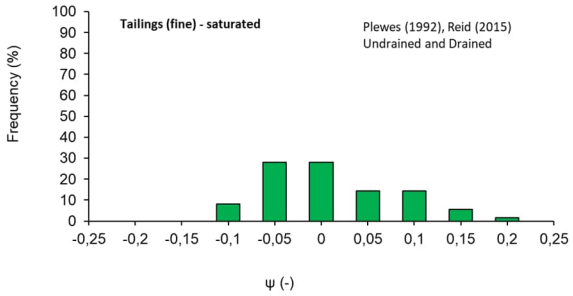






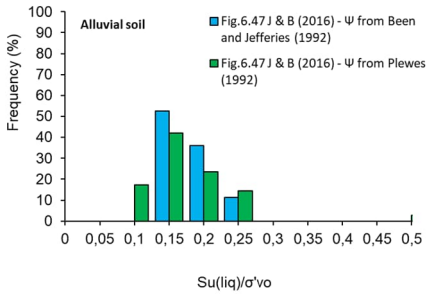


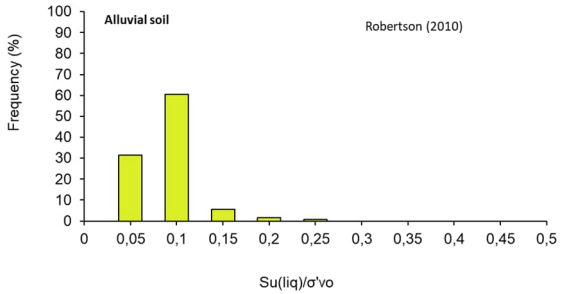


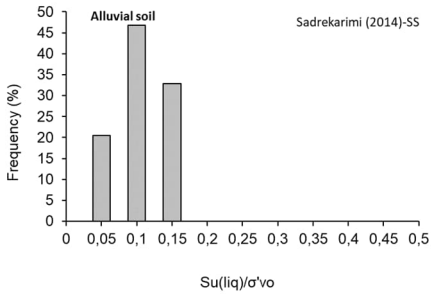


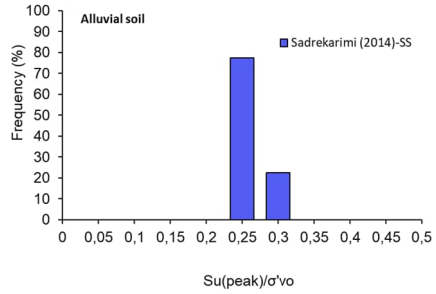
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

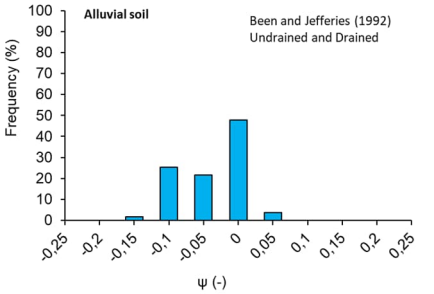
SCPT-07
Alluvial soil (foundation)

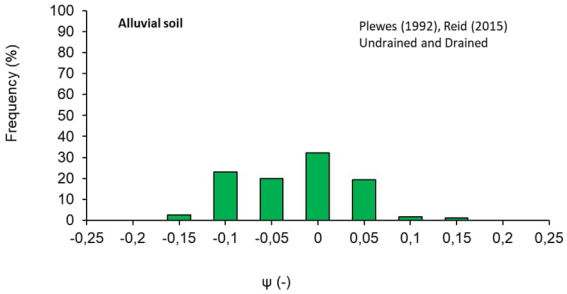






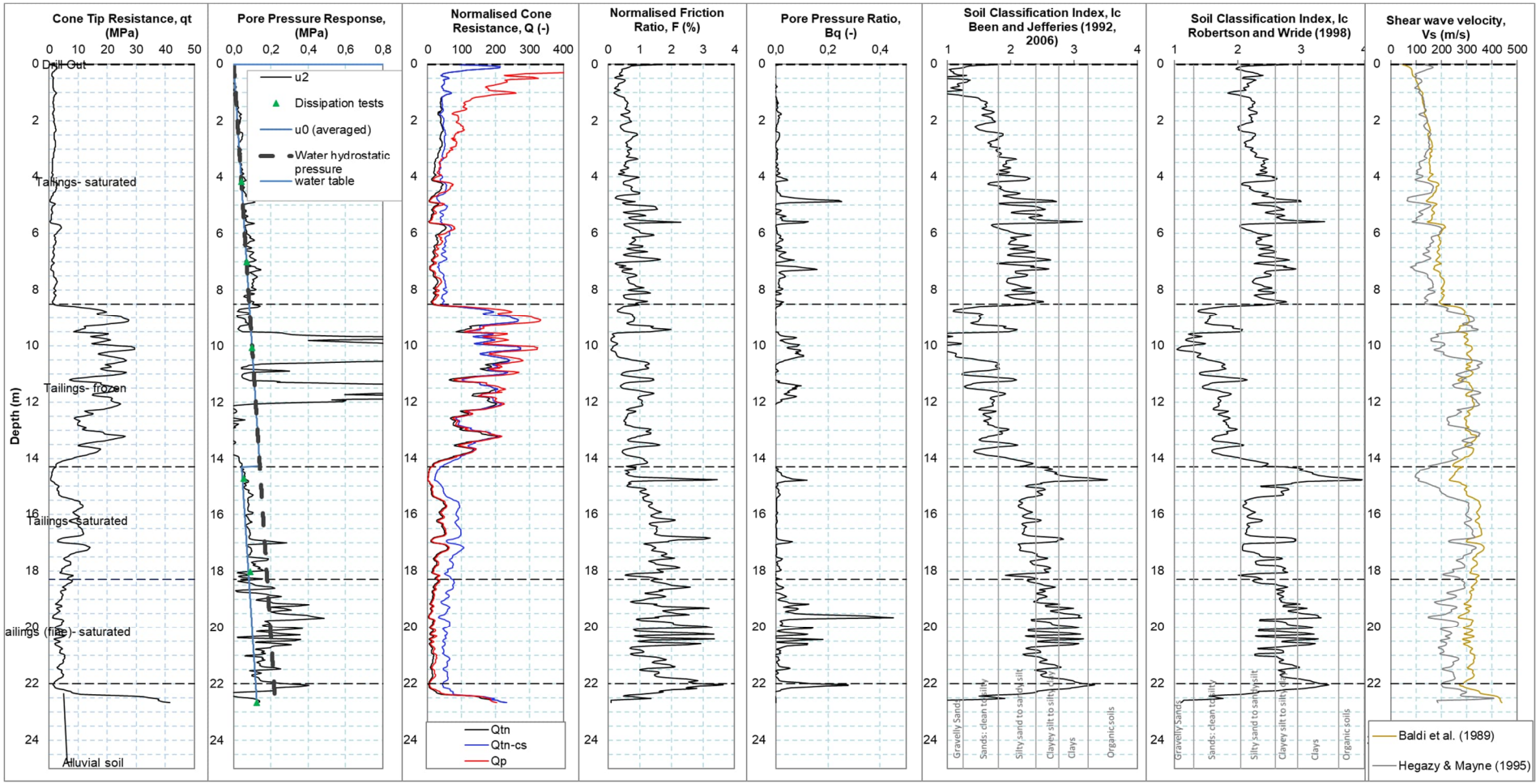






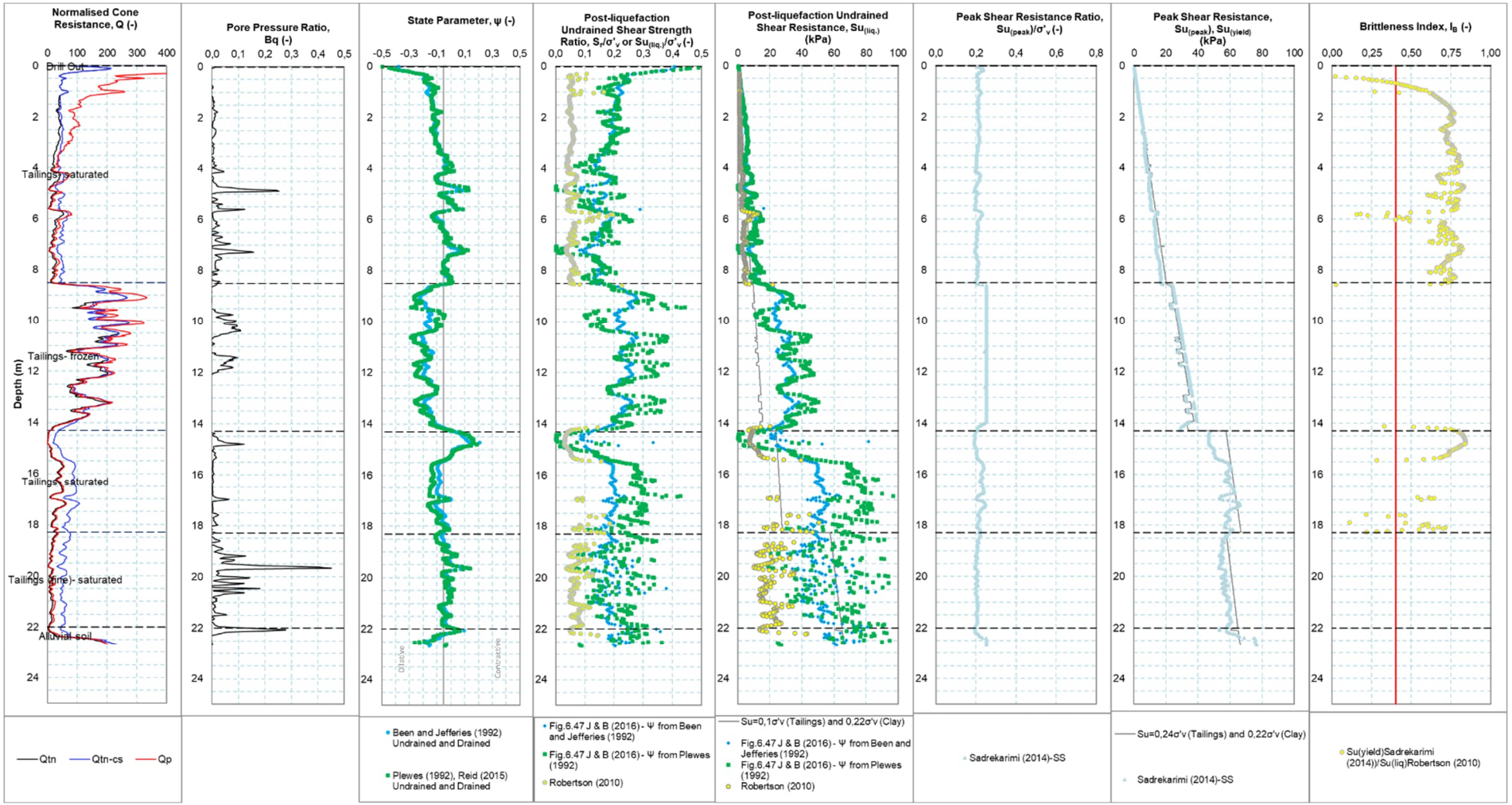
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

CPT-08



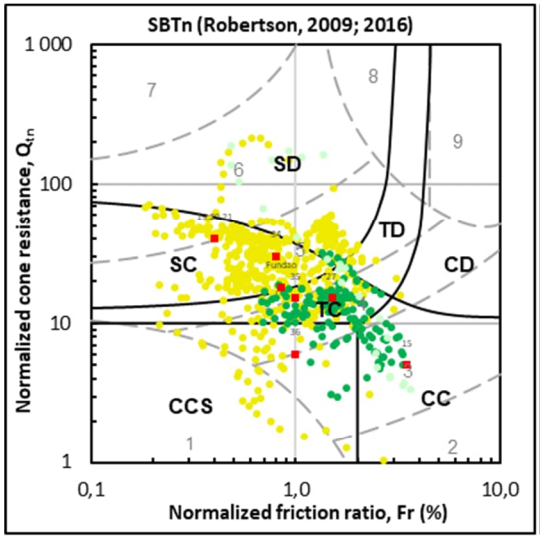
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

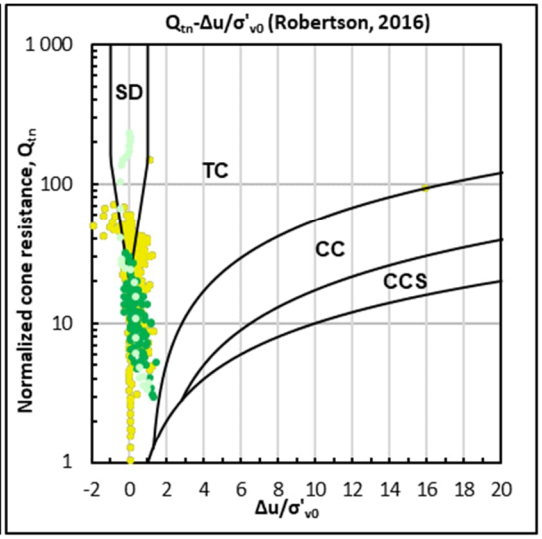
CPT-08



NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

CPT-08





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- Tailings- saturated
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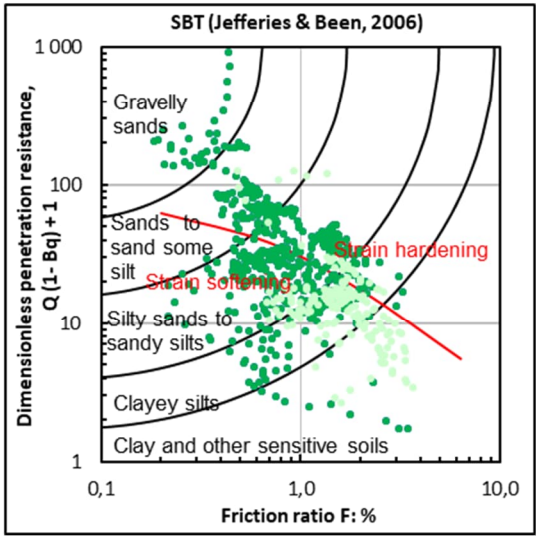
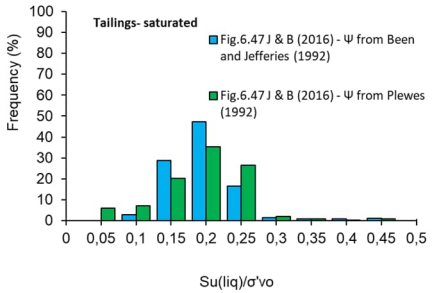
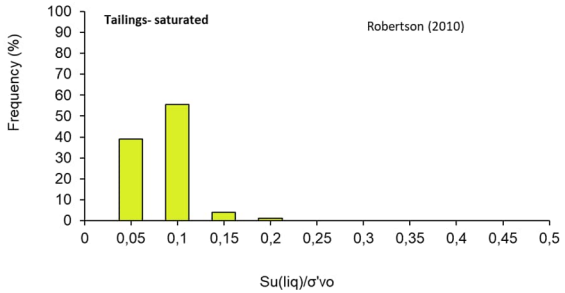
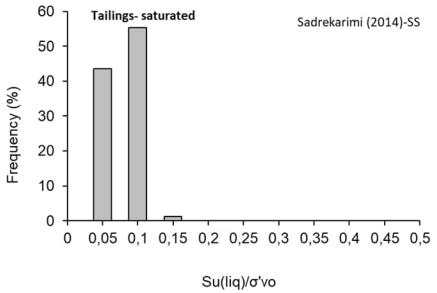


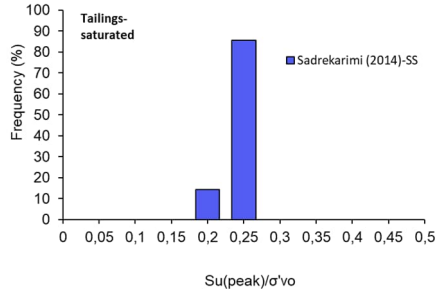
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

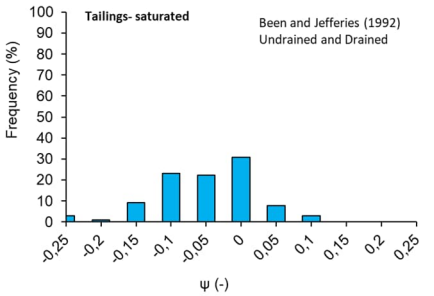
CPT-08
Saturated tailings

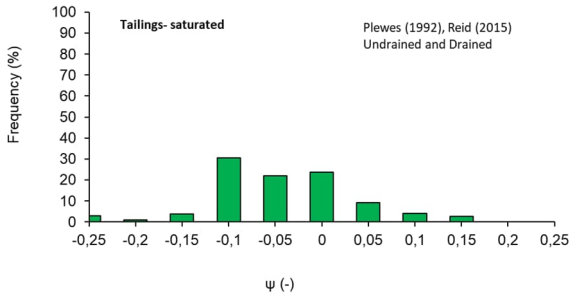






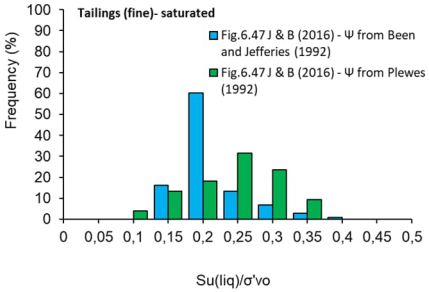


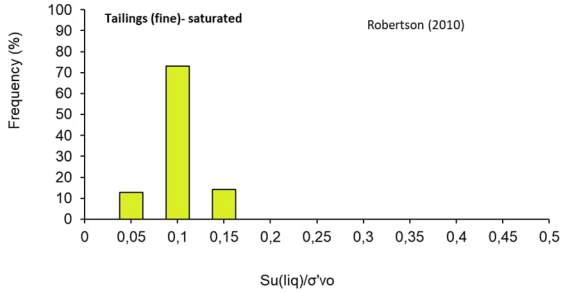


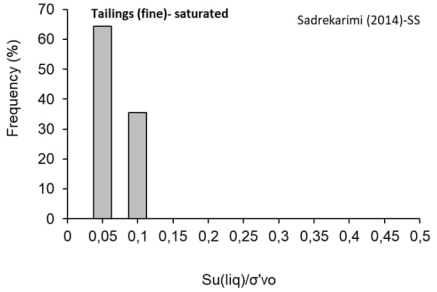


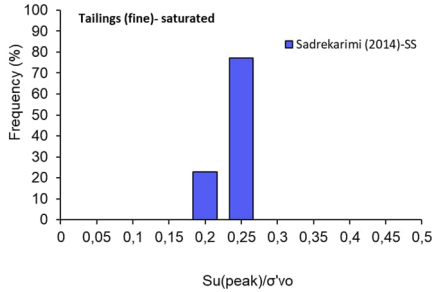
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

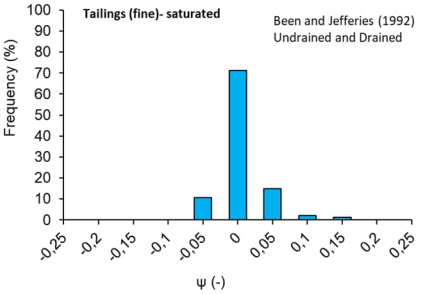
CPT-08
Fine saturated tailings

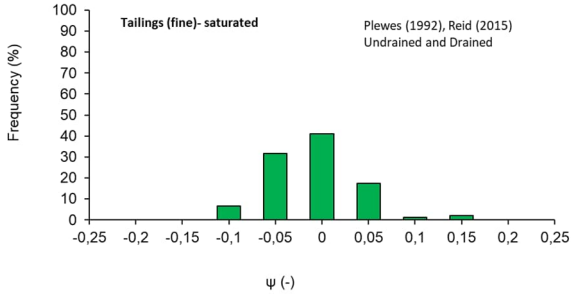






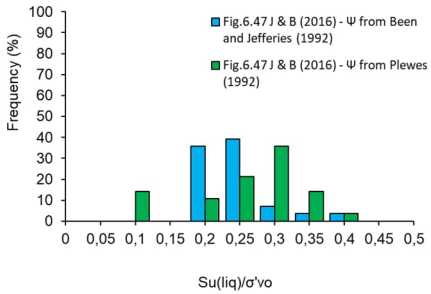


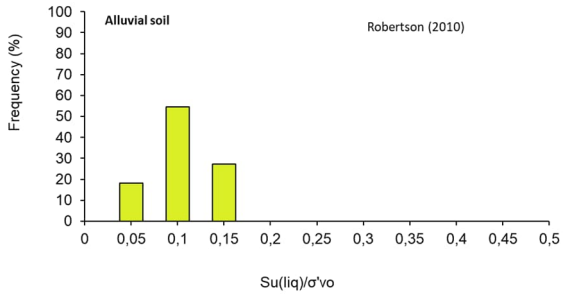


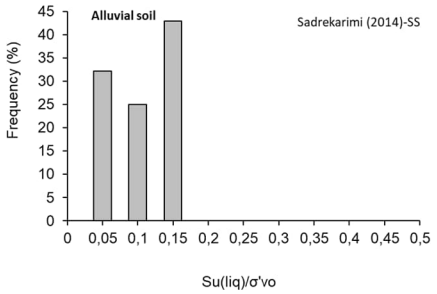


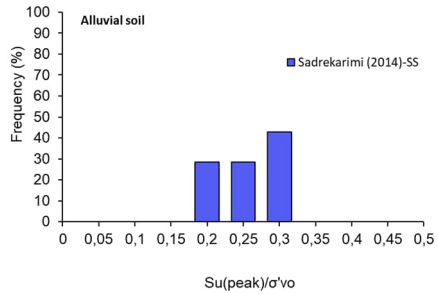
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

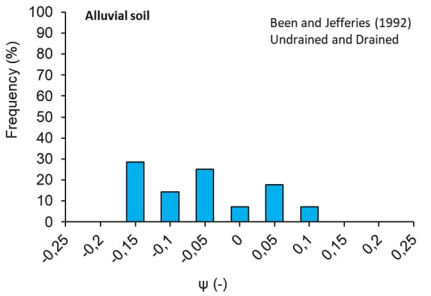
CPT-08
Alluvial soil (foundation)

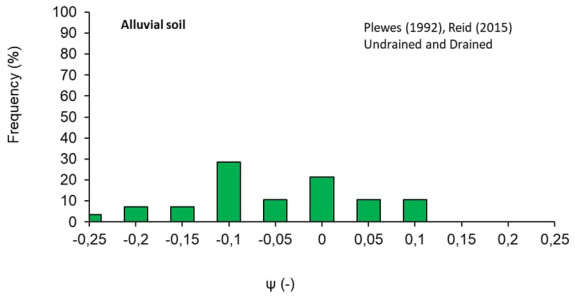






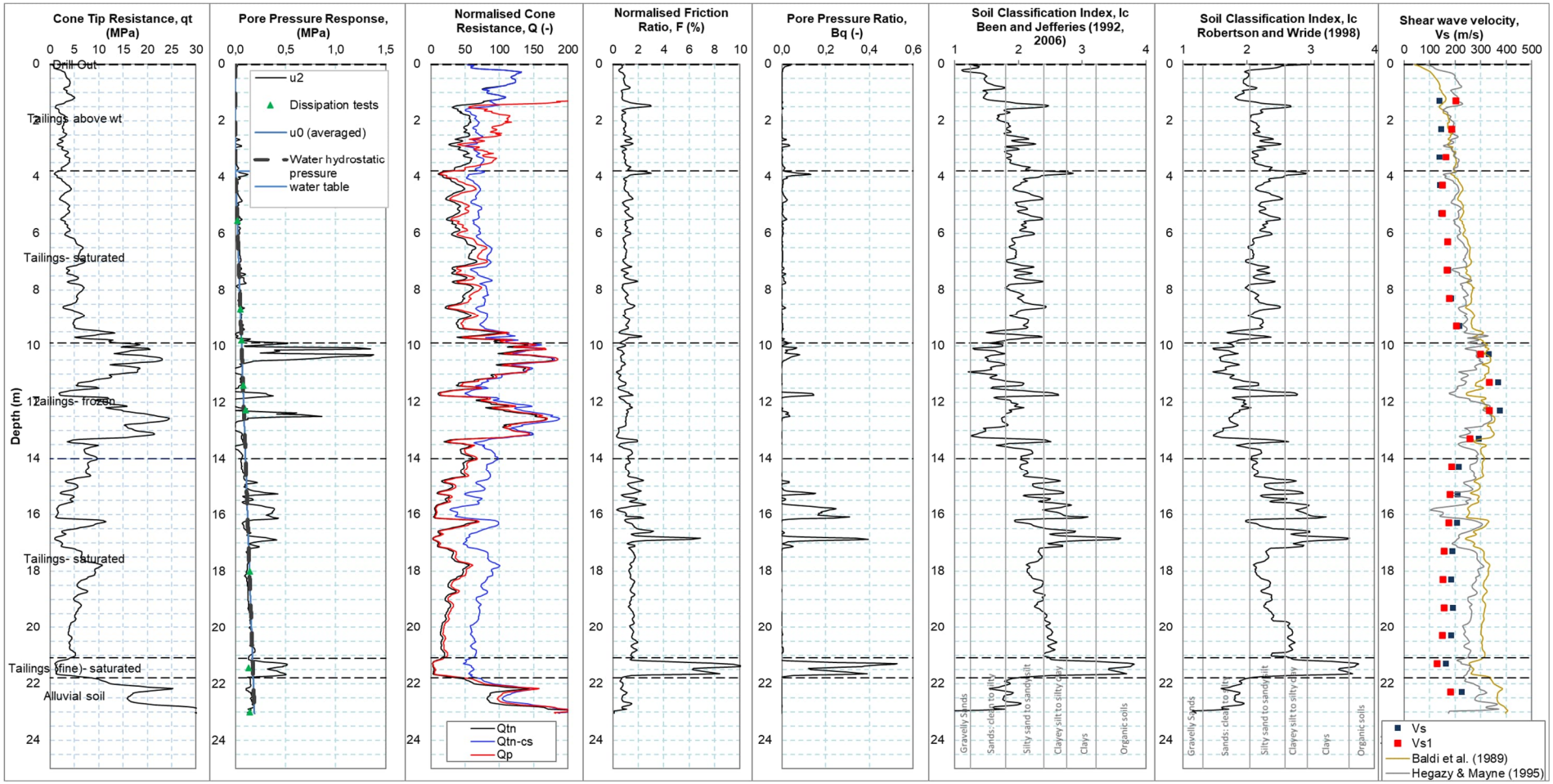






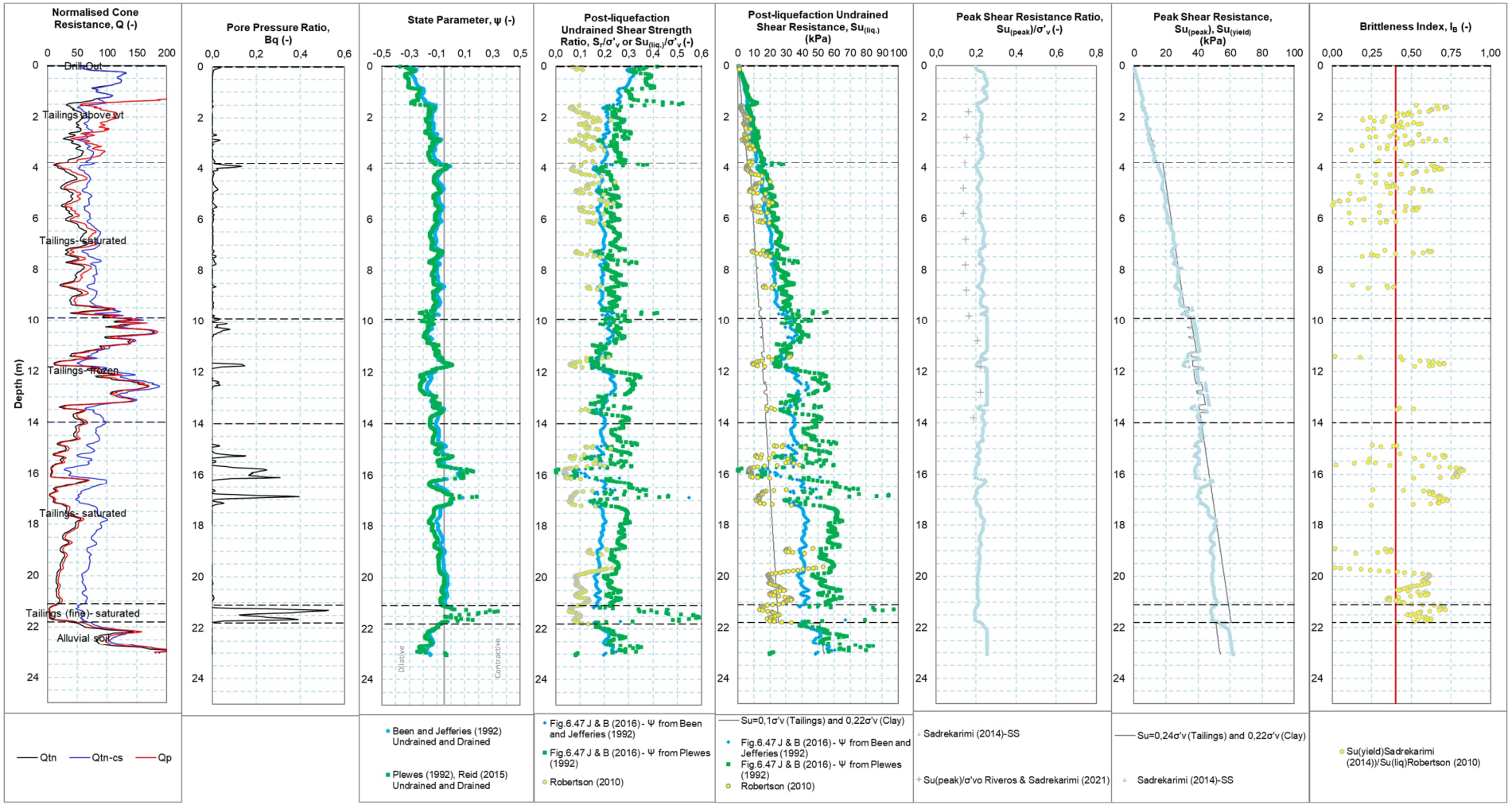
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-09



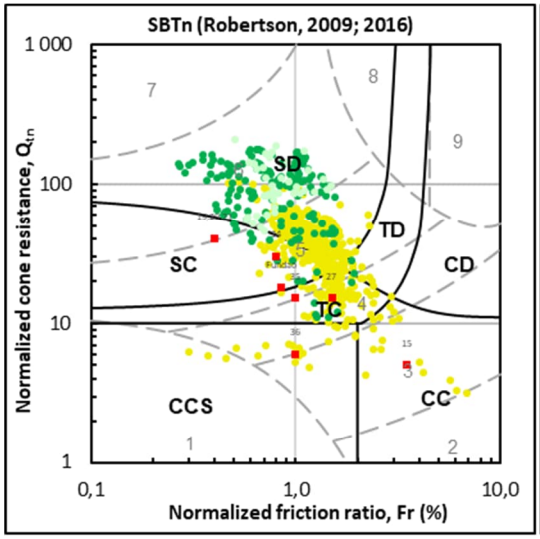
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

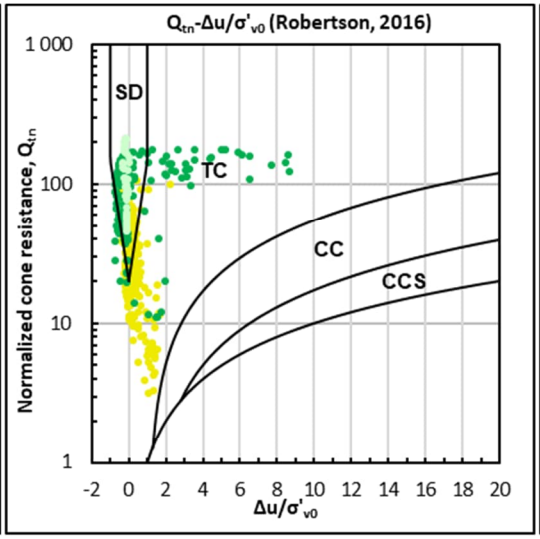
SCPT-09

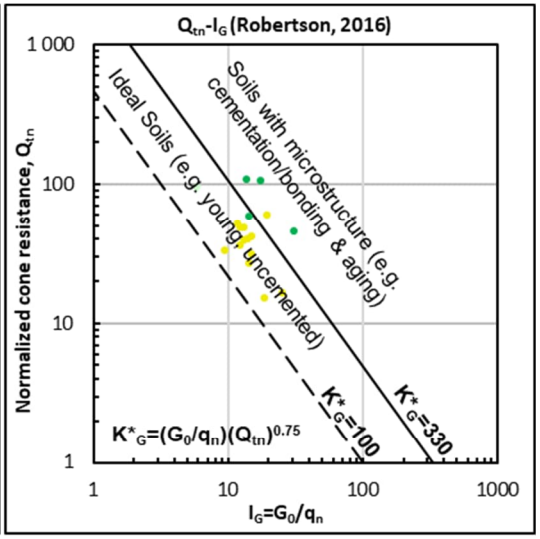


NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-09

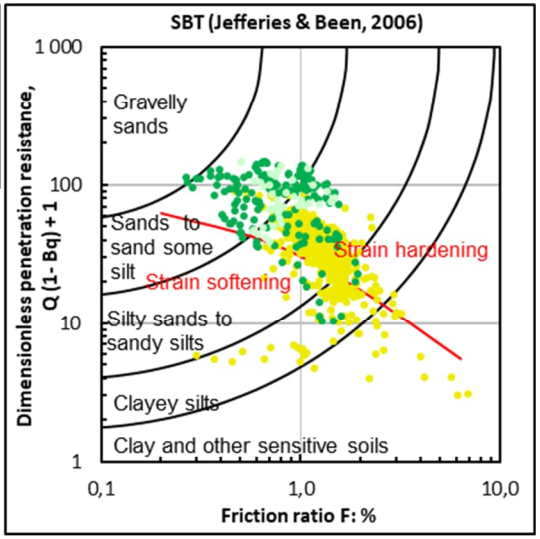






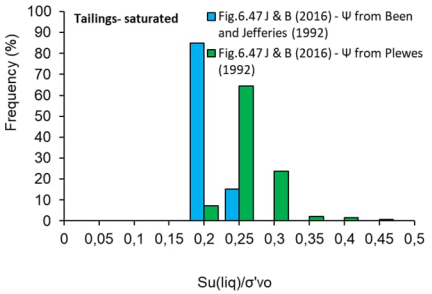
Robertson 2009	Robertson 2016
1 : Sensitive Clays and Silts	CCS : Clay-like - Contractive - Sensitive
2 : Organic Soils	CC : Clay-like - Contractive
3 : Clays	CD : Clay-like - Dilative
4 : Silt Mix	TC : Transitional - Contractive
5 : Sandy Mix	TD : Transitional - Dilative
6 : Sands	SC : Sand-like - Contractive
7 : Gravelly Sands	SD : Sand-like - Dilative
8 : Stiff Sands to Clayed Sands	
9 : Stiff Clays and Silts	

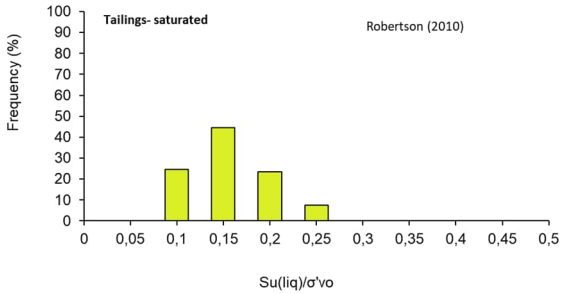
- Tailings- saturated
- Tailings- frozen
- Alluvial soil
- Case Histories (Robertson, 2010)
- Shuttle and Cunning (2008)

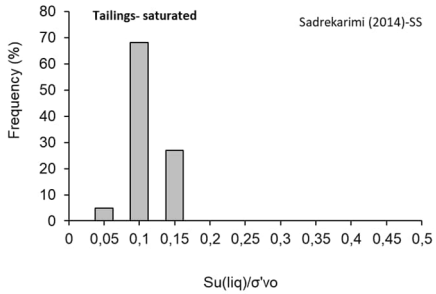


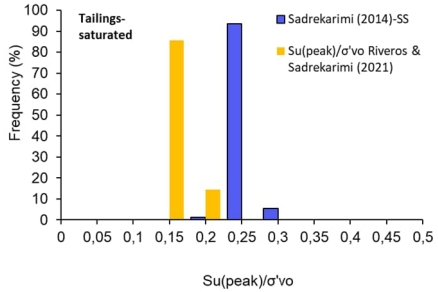
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

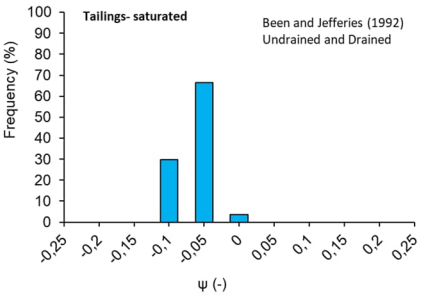
SCPT-09
Saturated tailings

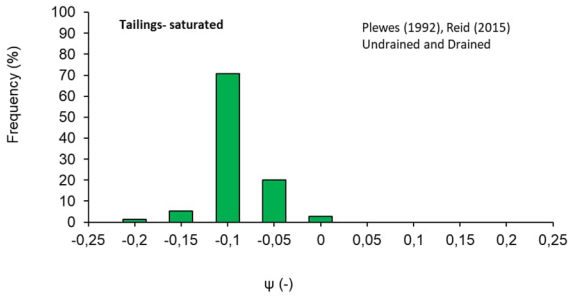






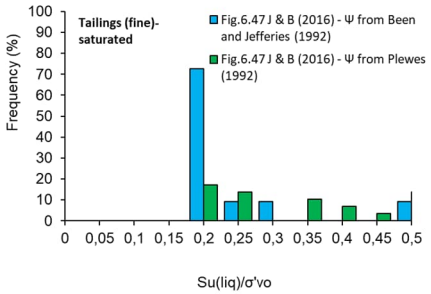


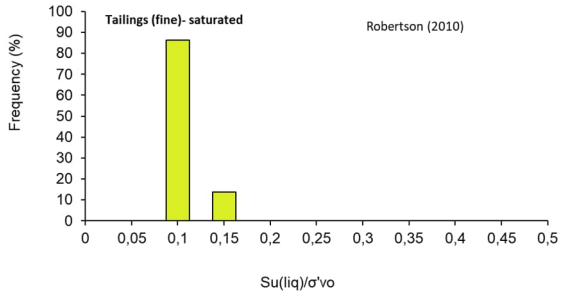


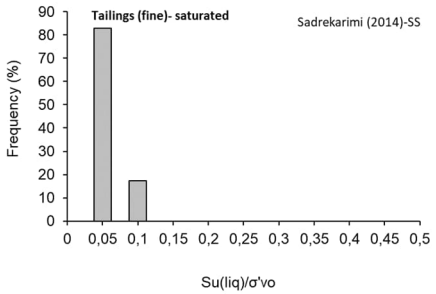


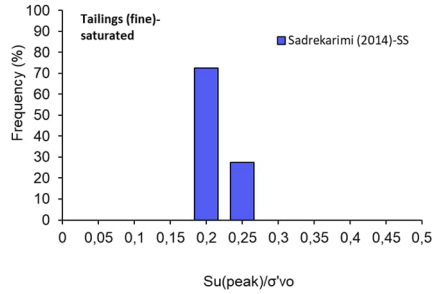
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

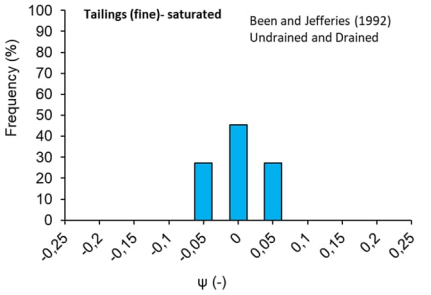
SCPT-09
Fine saturated tailings

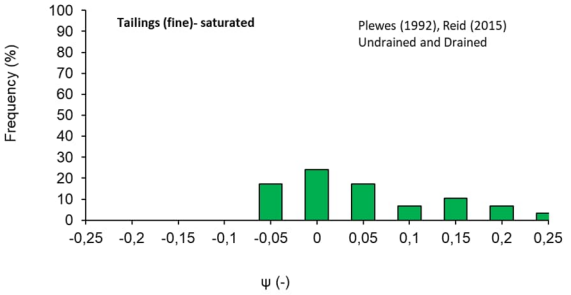






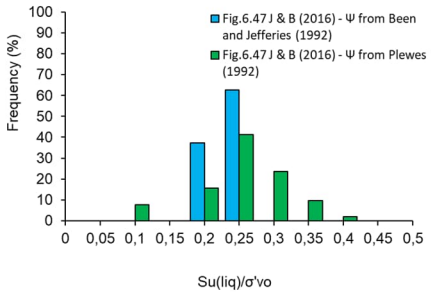


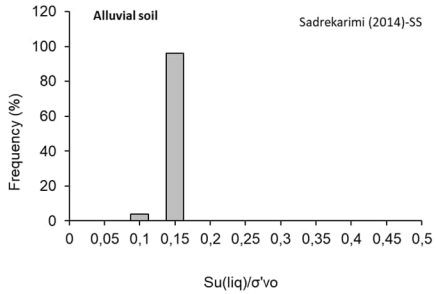


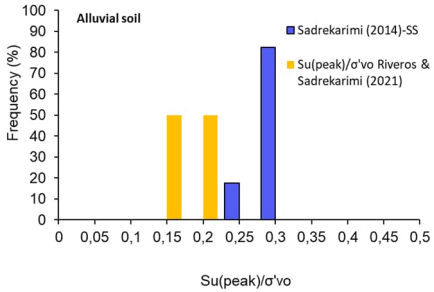


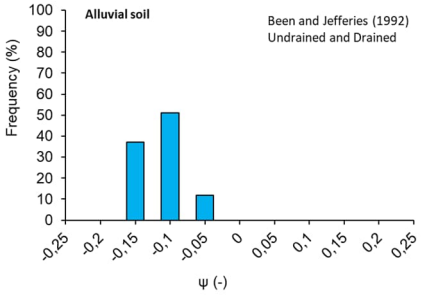
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

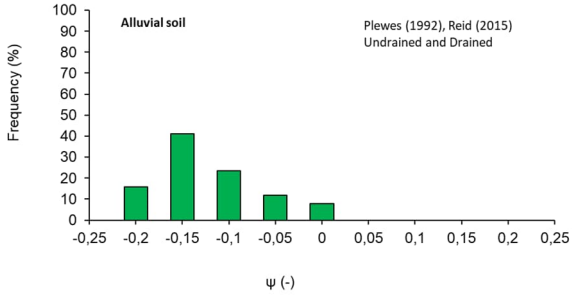
SCPT-09
Alluvial soil (foundation)





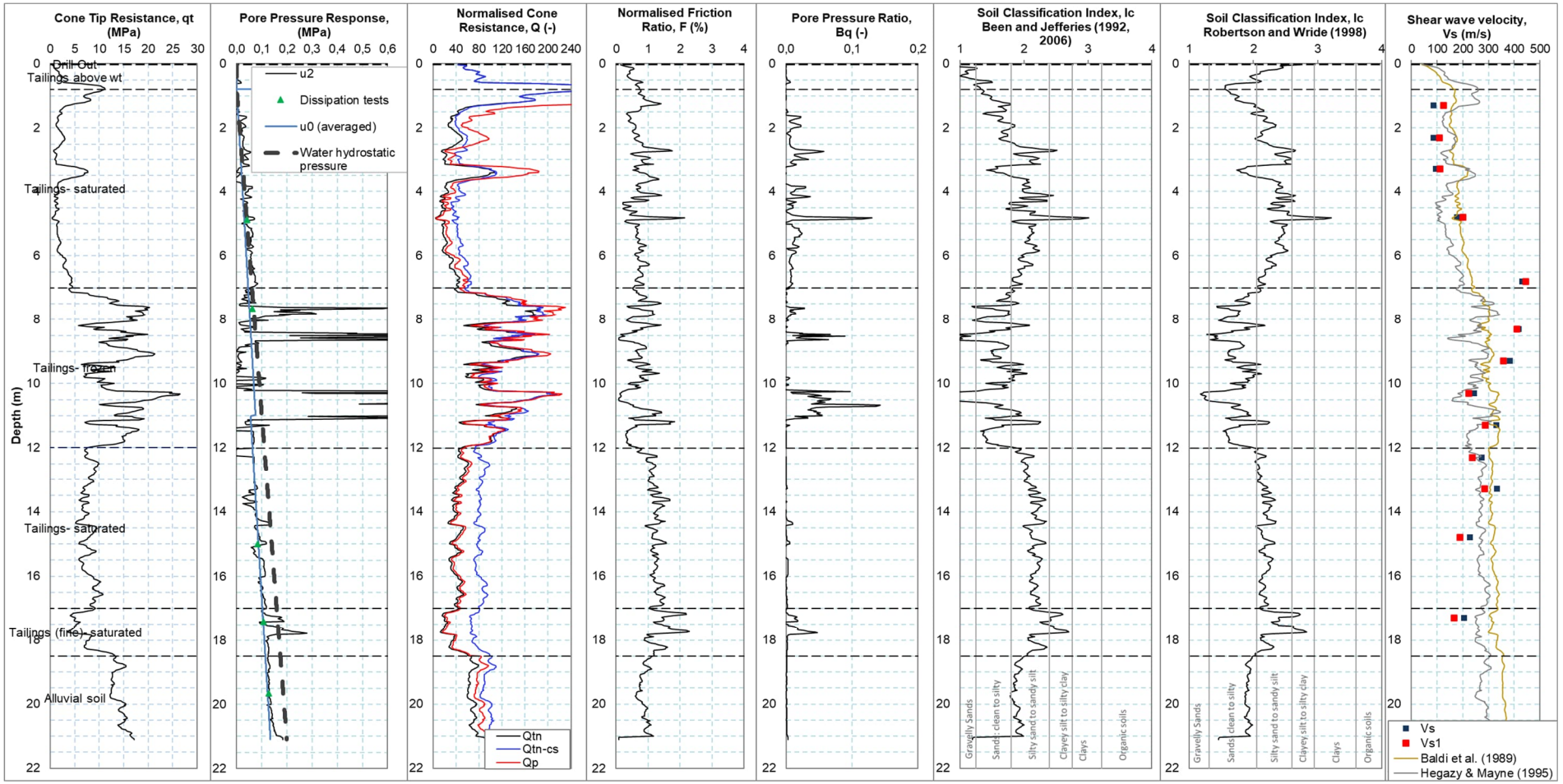






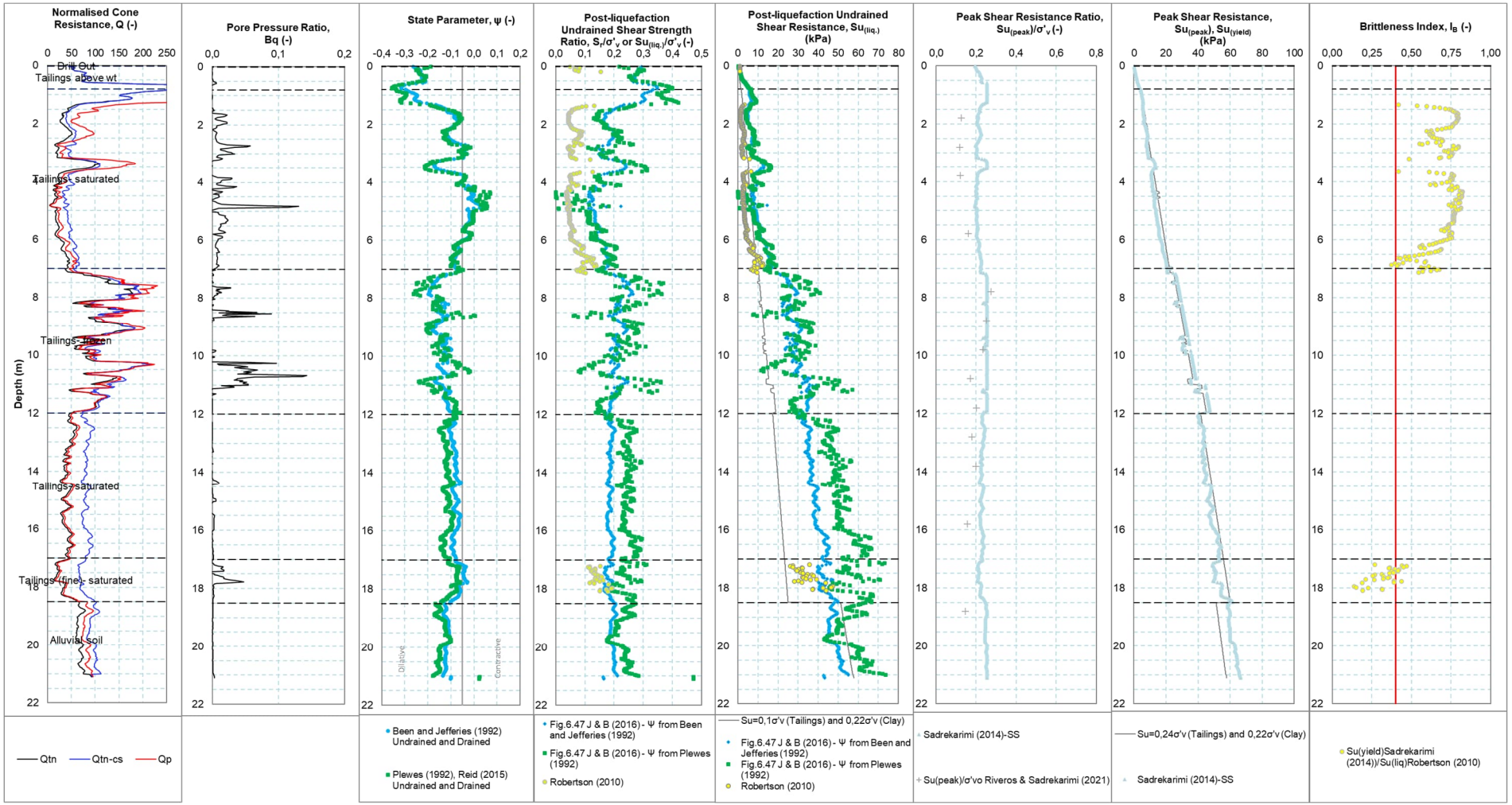
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-10-B



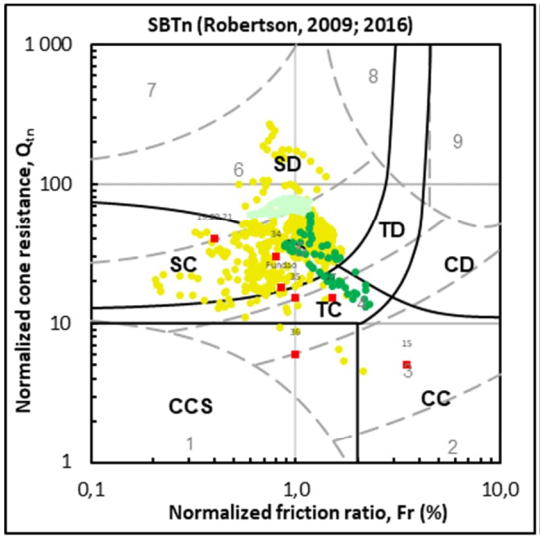
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

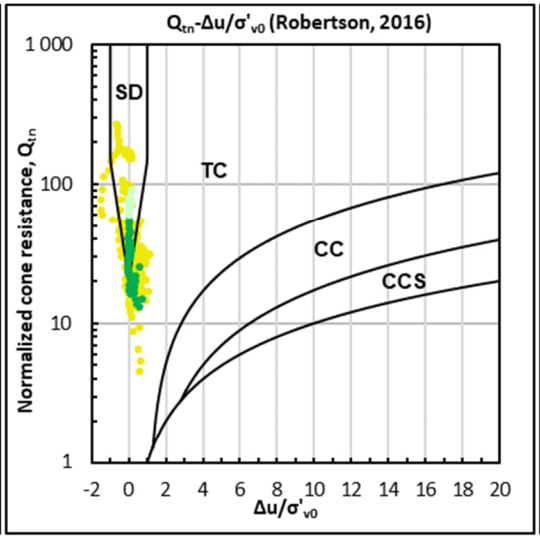
SCPT-10-B

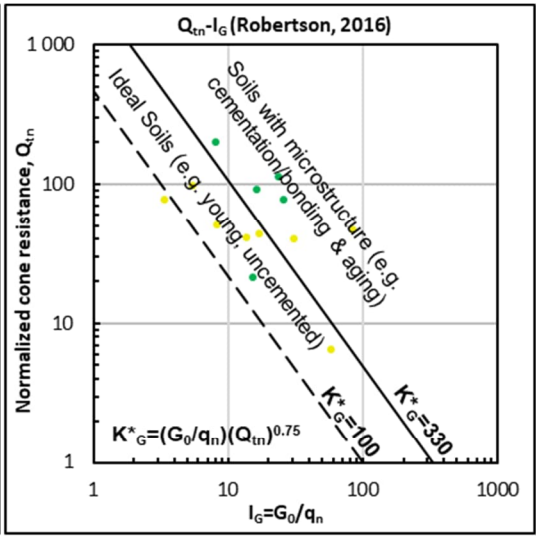


NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-10-B







Robertson 2009
1 : Sensitive Clays and Silts
2 : Organic Soils
3 : Clays
4 : Silt Mix
5 : Sandy Mix
6 : Sands
7 : Gravelly Sands
8 : Stiff Sands to Clayed Sands
9 : Stiff Clays and Silts

Robertson 2016
CCS : Clay-like - Contractive - Sensitive
CC : Clay-like - Contractive
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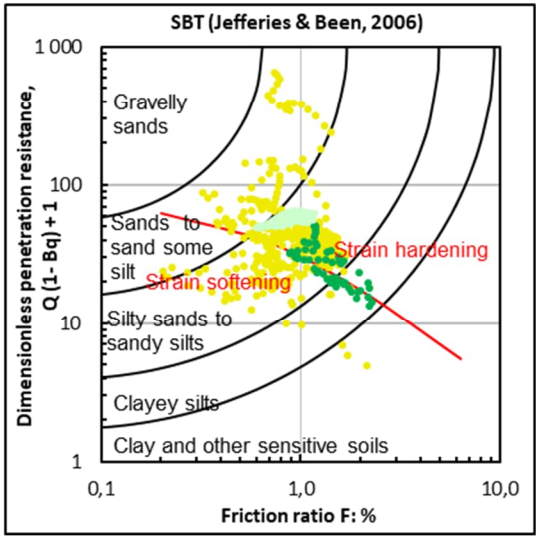
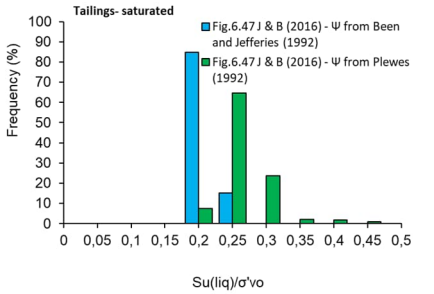
TD : Transitional - Dilative
SC : Sand-like - Contractive
SD : Sand-like - Dilative

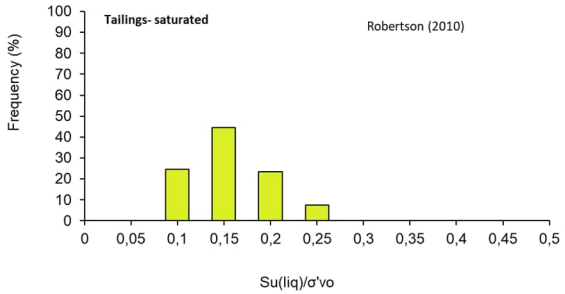
- Tailings- saturated
- Tailings (fine)- saturated
- Alluvial soil
- Case Histories (Robertson, 2010)
- Shuttle and Cunning (2008)

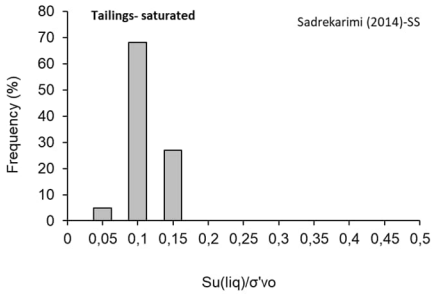


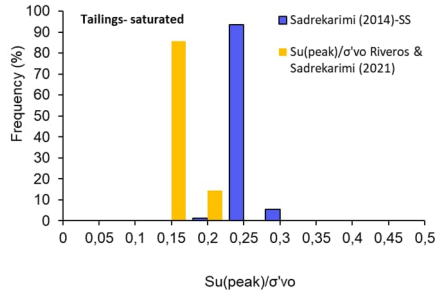
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

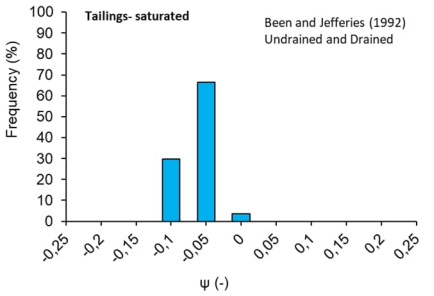
SCPT-10-B
Saturated tailings

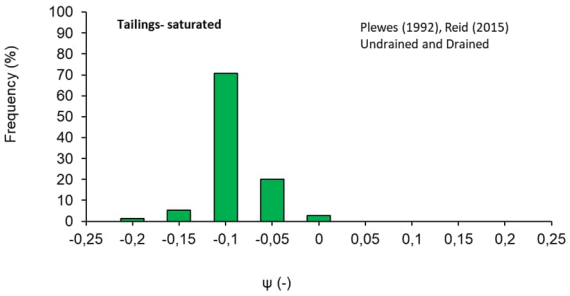






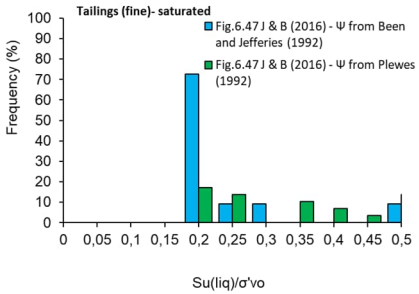


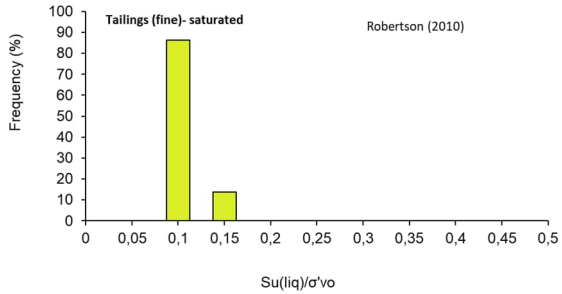


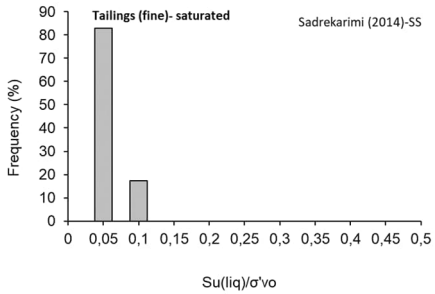


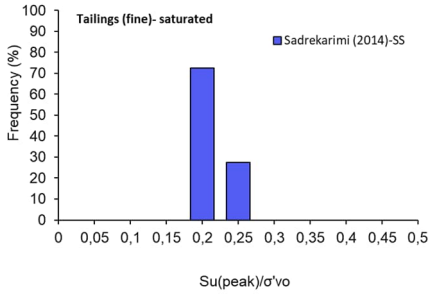
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

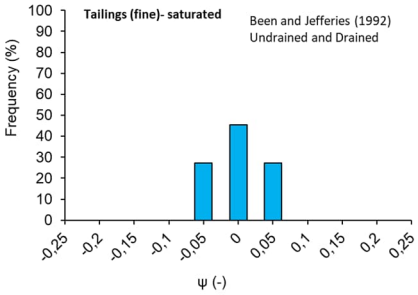
SCPT-10-B
Fine saturated tailings

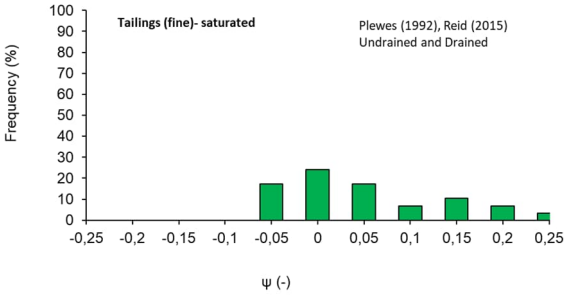






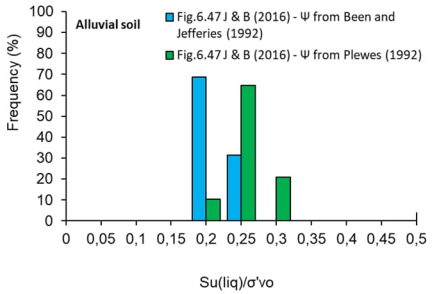


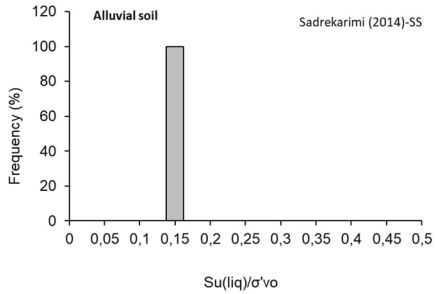


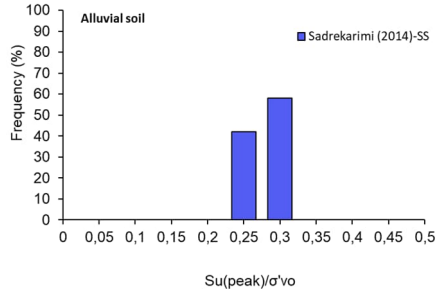


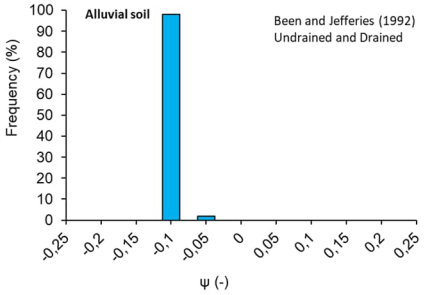
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

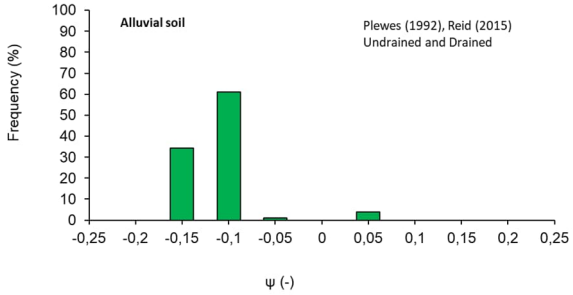
SCPT-10-B
Alluvial soil (foundation)





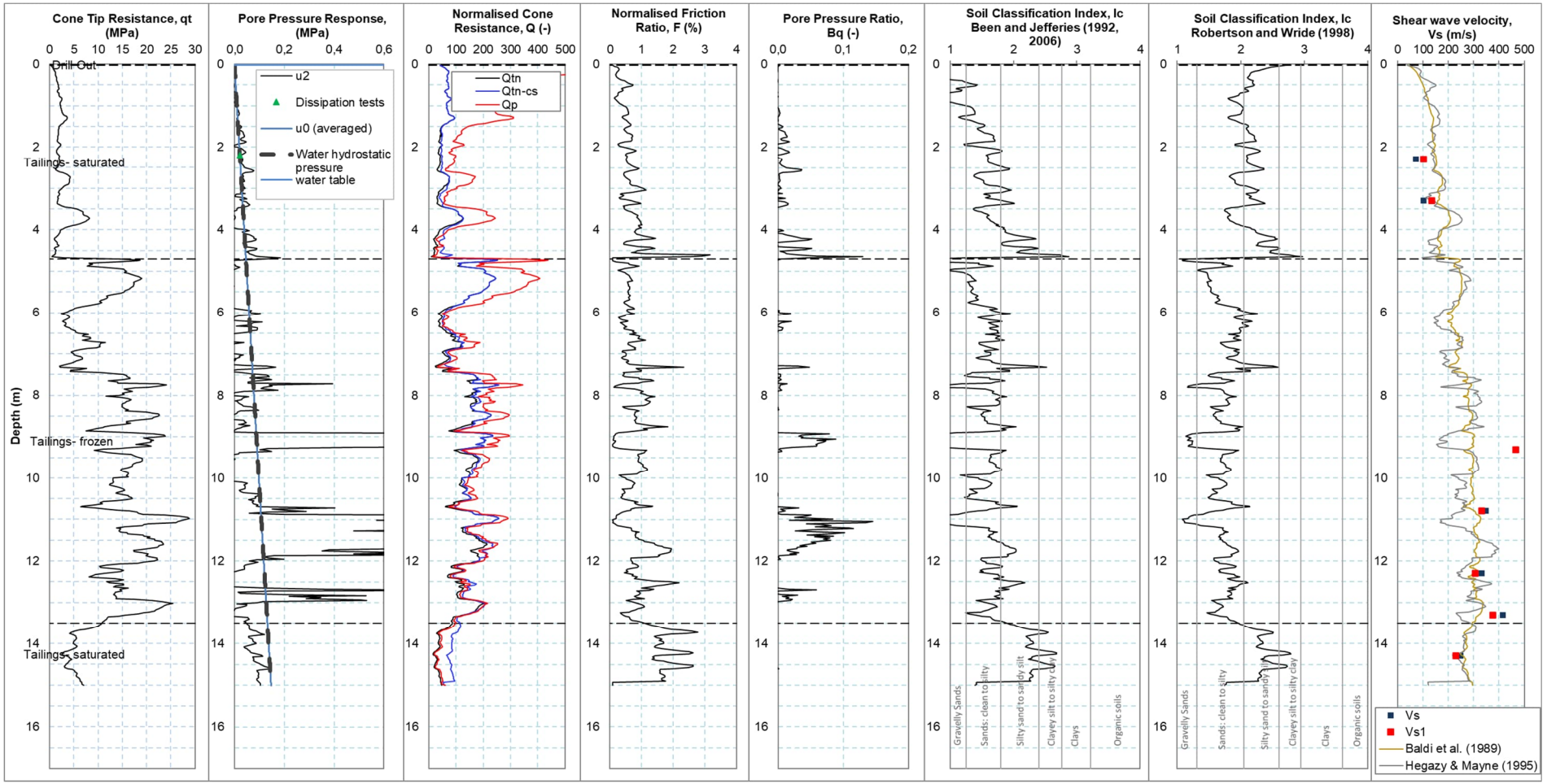






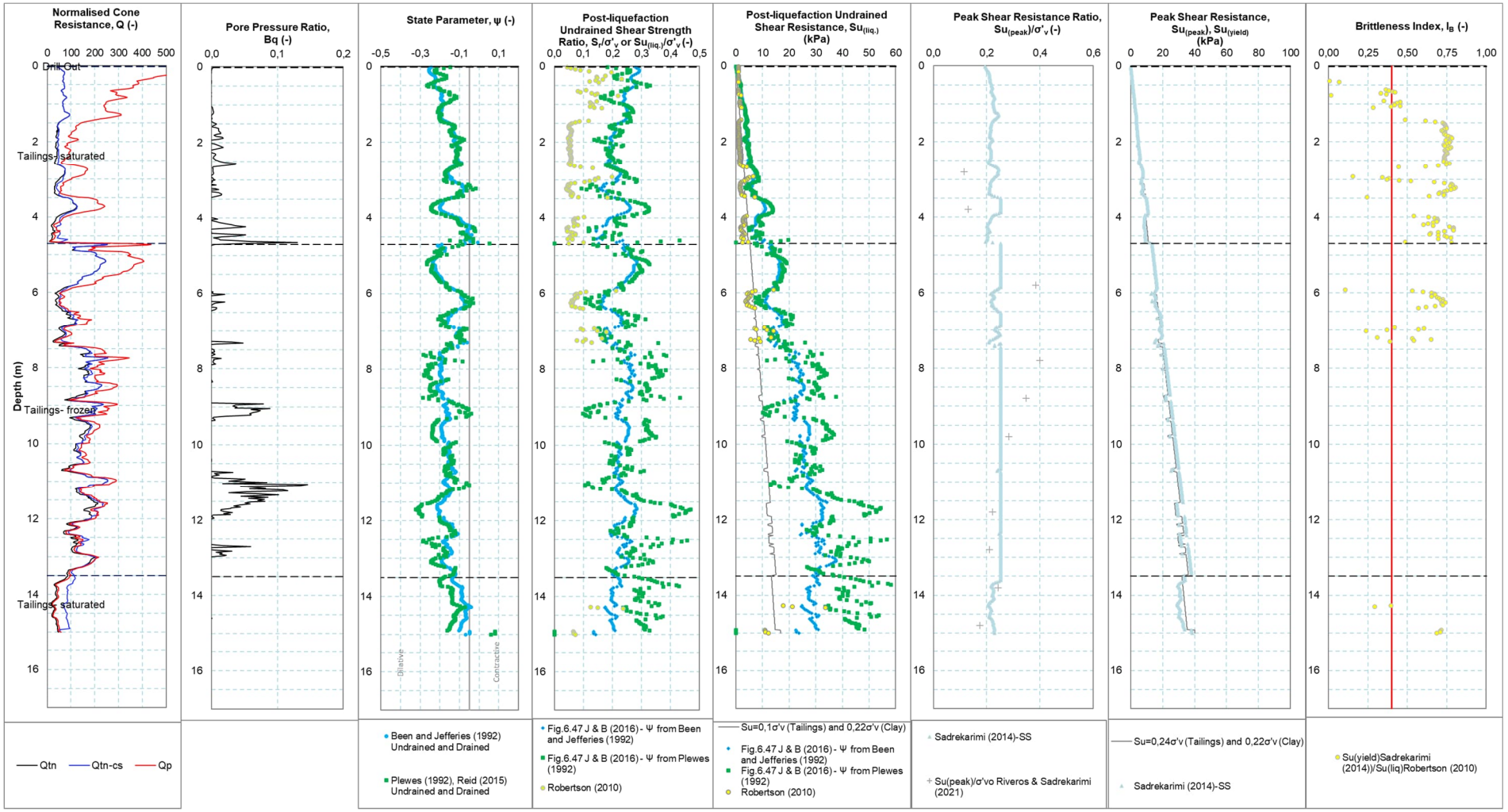
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-10-C



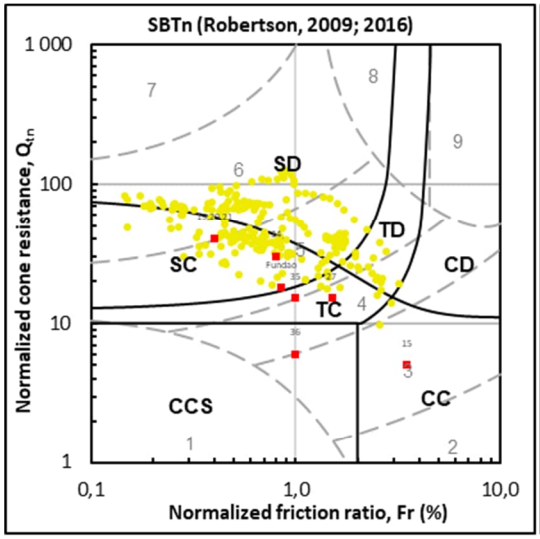
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

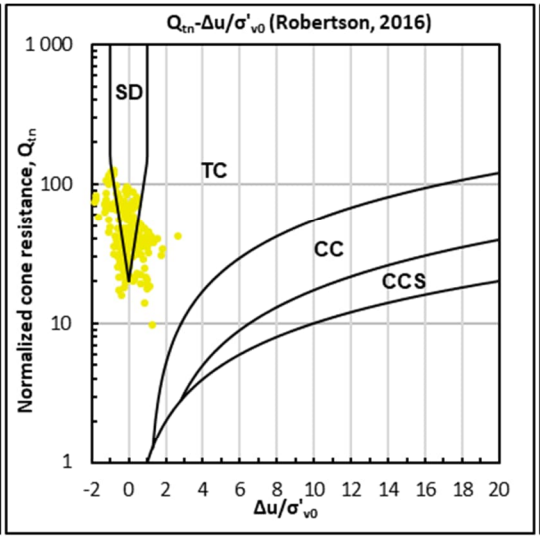
SCPT-10-C

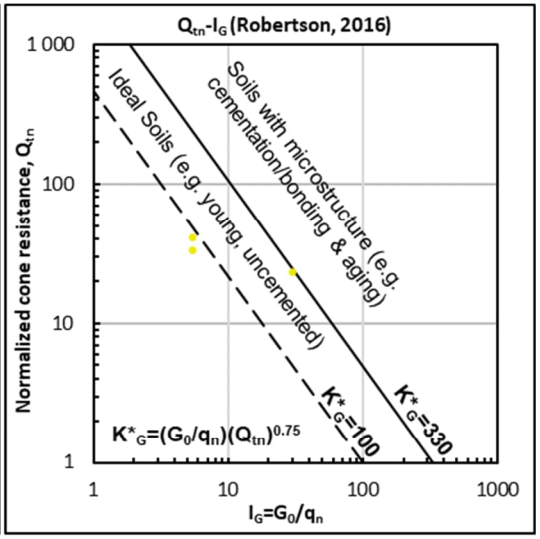


NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-10-C







Robertson 2009	Robertson 2016
1 : Sensitive Clays and Silts	CCS : Clay-like - Contractive - Sensitive
2 : Organic Soils	CC : Clay-like - Contractive
3 : Clays	CD : Clay-like - Dilative
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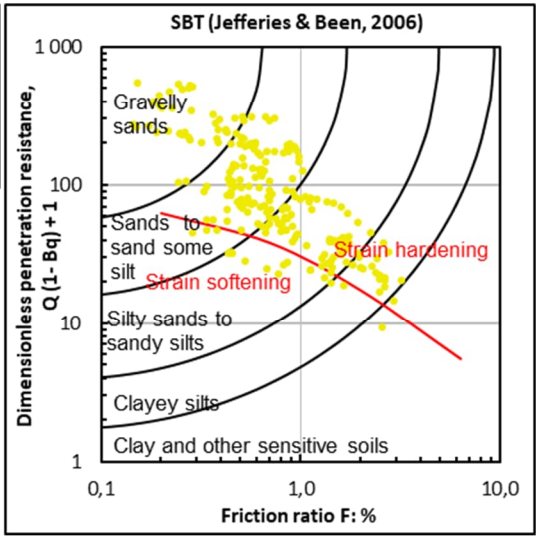
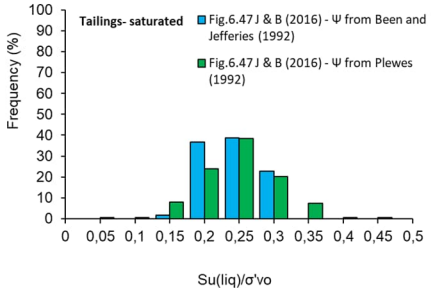
5 : Sandy Mix	TD : Transitional - Dilative
6 : Sands	SC : Sand-like - Contractive
7 : Gravelly Sands	SD : Sand-like - Dilative
8 : Stiff Sands to Clayed Sands	
9 : Stiff Clays and Silts	

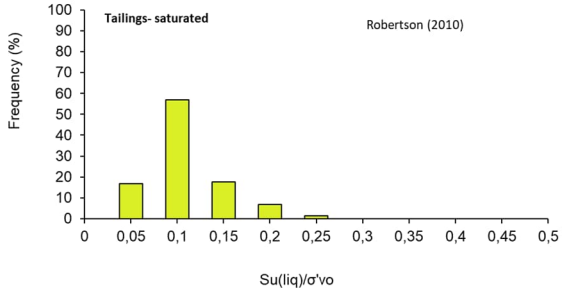
- Tailings- saturated
- Case Histories (Robertson, 2010)
- Shuttle and Cunning (2008)

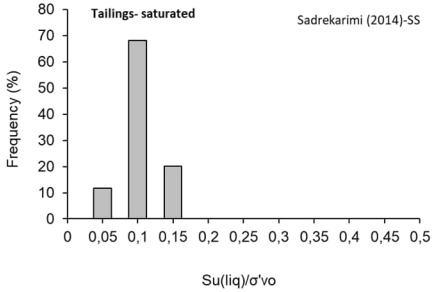


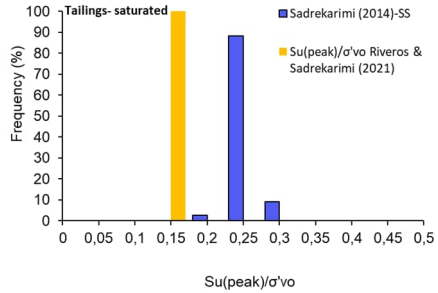
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

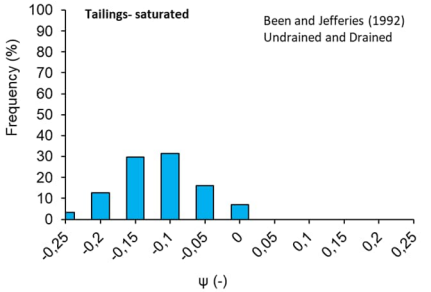
SCPT-10-C
Saturated tailings

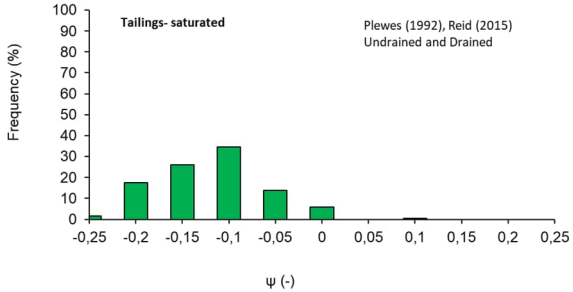






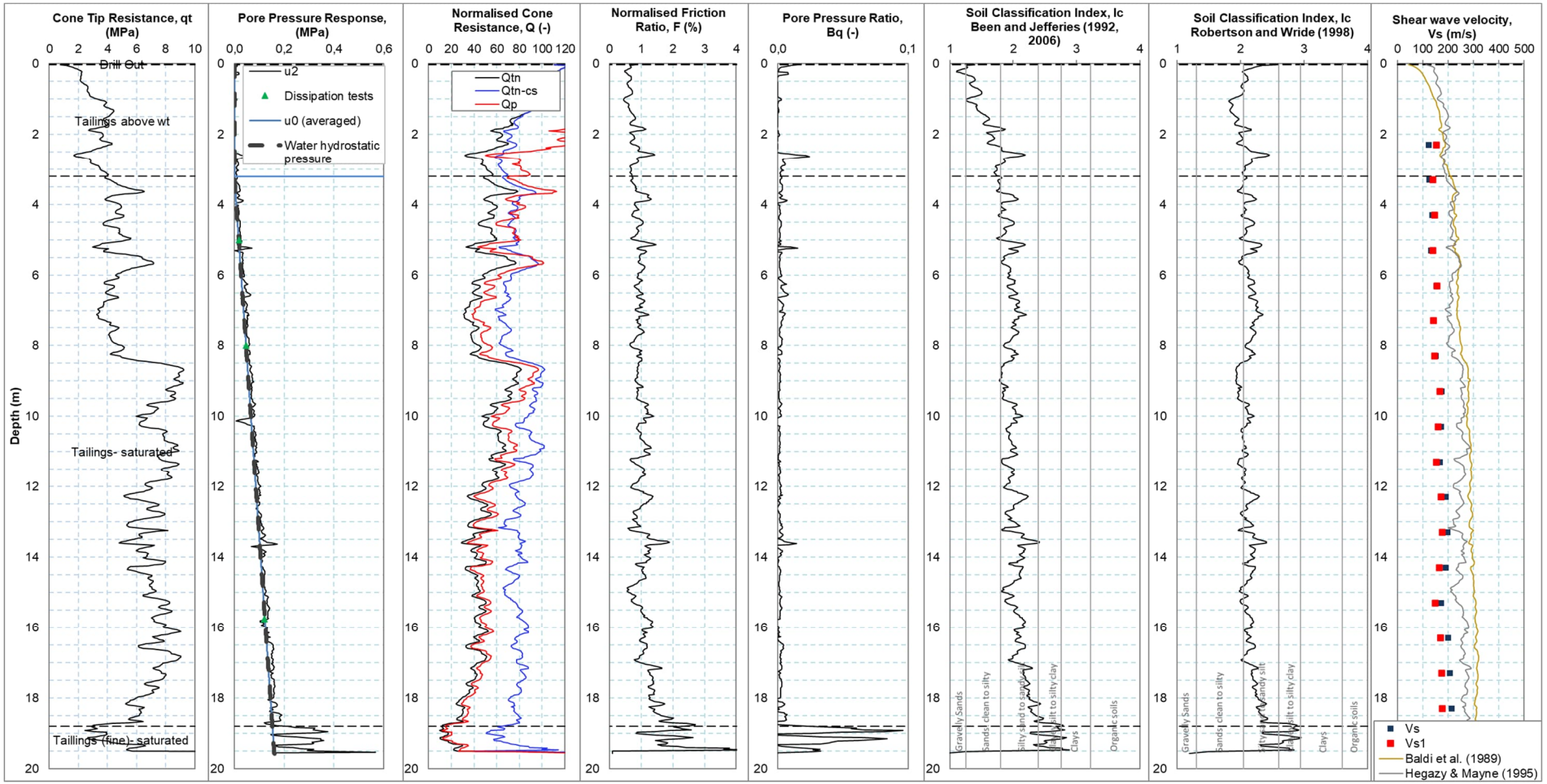






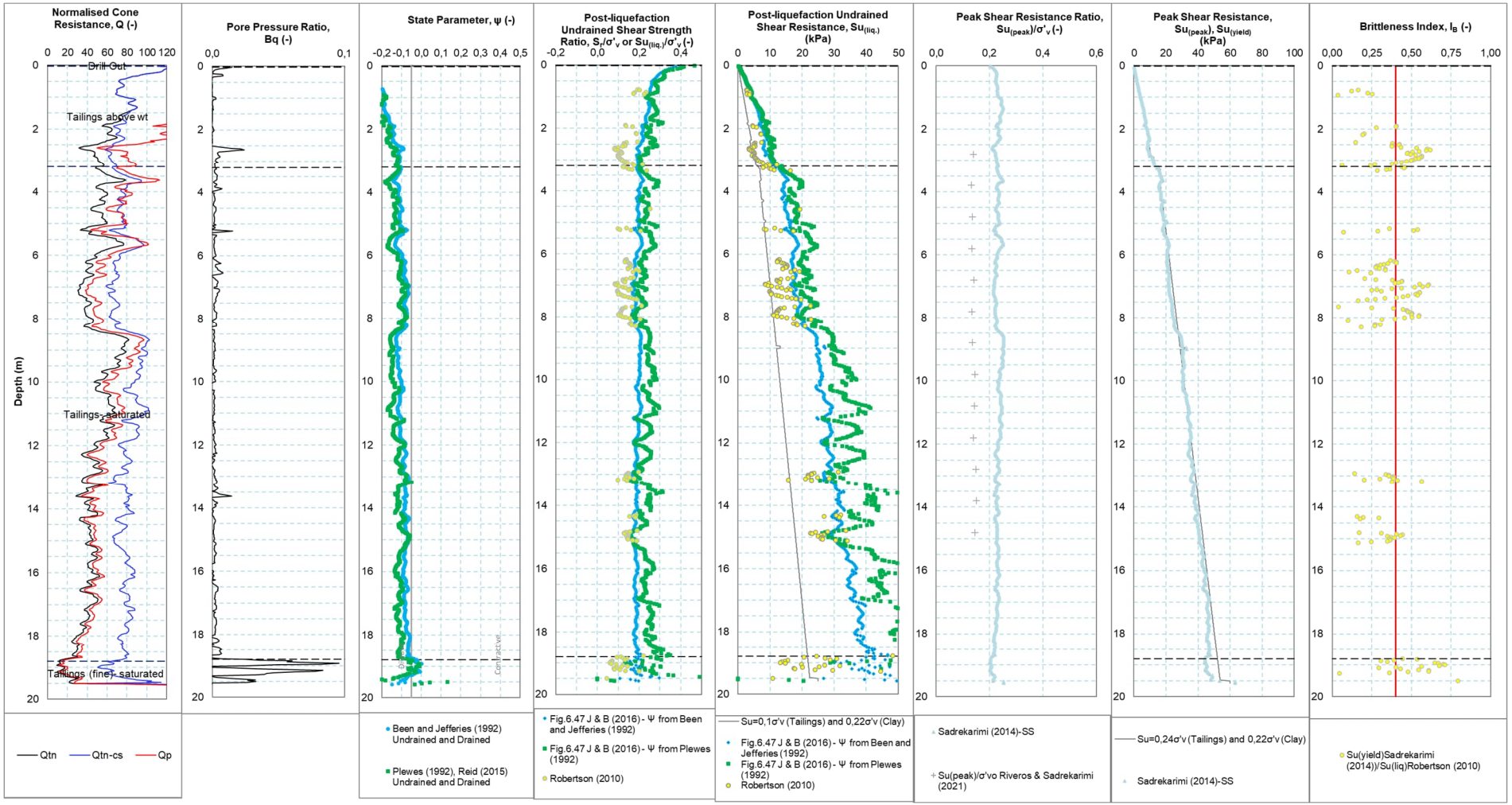
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-11



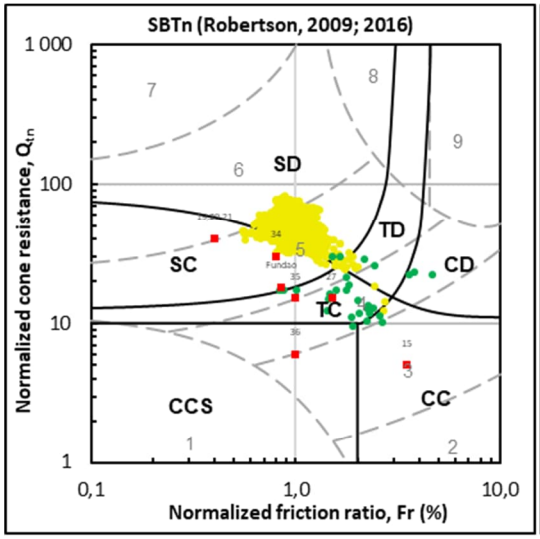
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

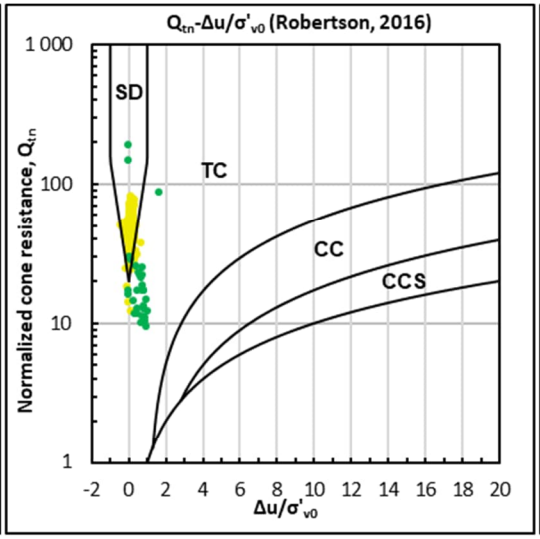
SCPT-11

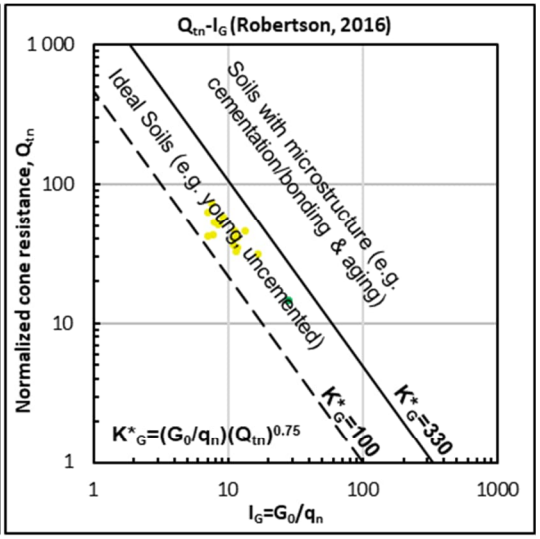


NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

SCPT-11







Robertson 2009	**Robertson 2016**
1 : Sensitive Clays and Silts	**CCS : Clay-like - Contractive - Sensitive**
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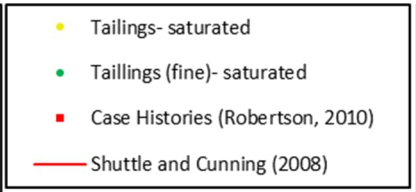
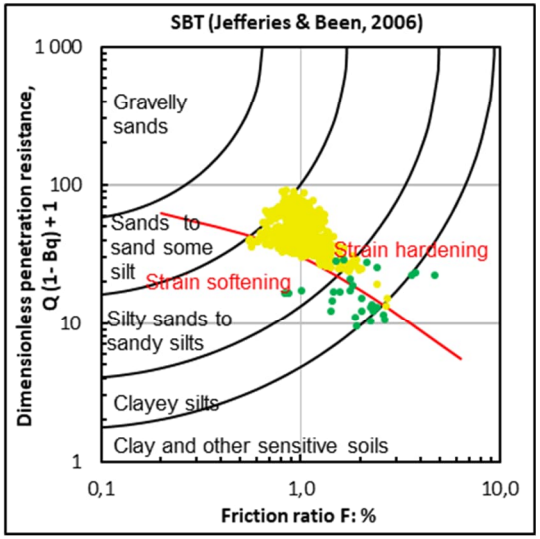
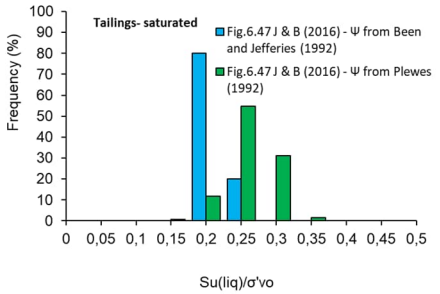
8 : Stiff Sands to Clayed Sands	
9 : Stiff Clays and Silts	

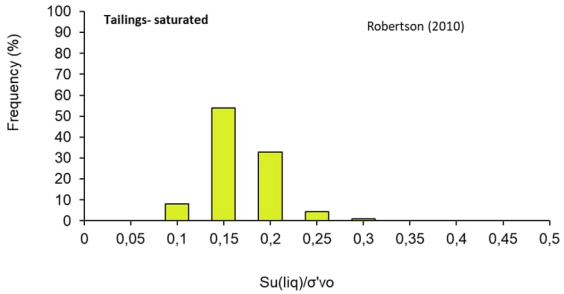


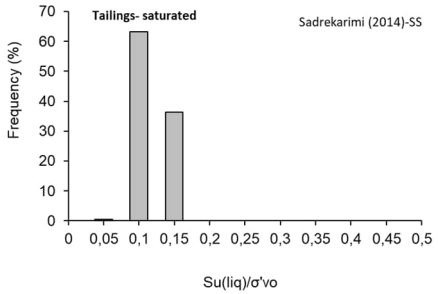


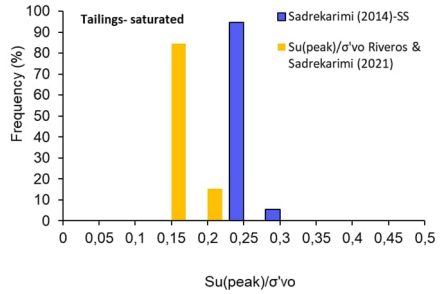
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

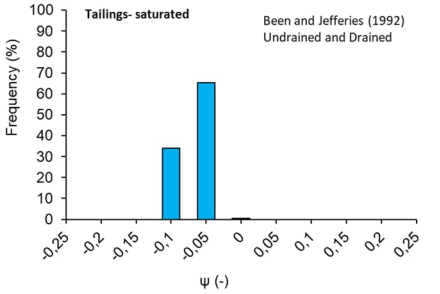
SCPT-11
Saturated tailings

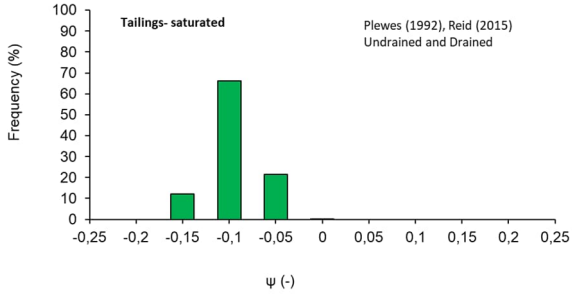






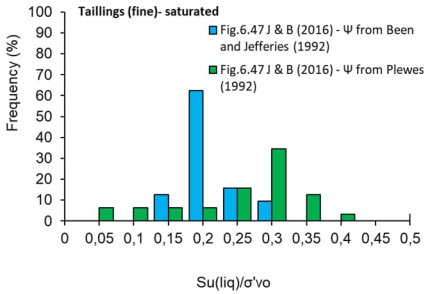


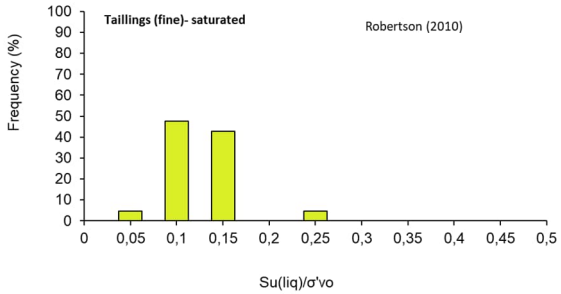


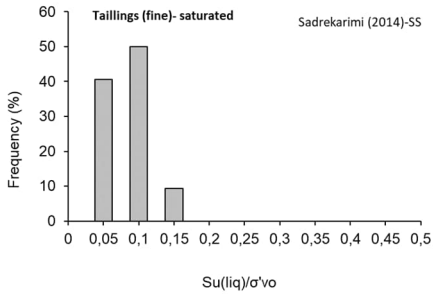


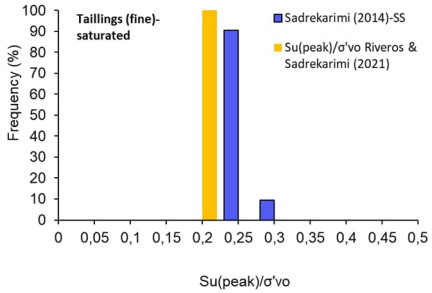
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

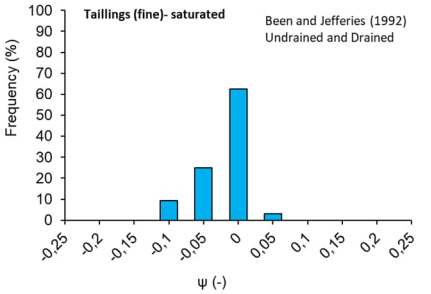
SCPT-11
Fine saturated tailings

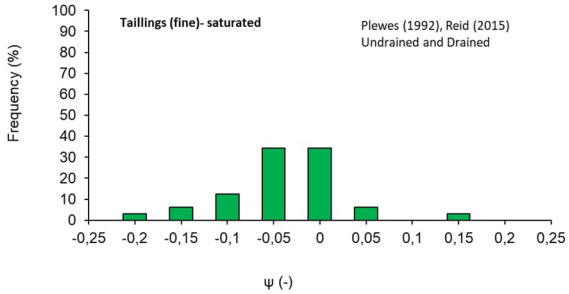






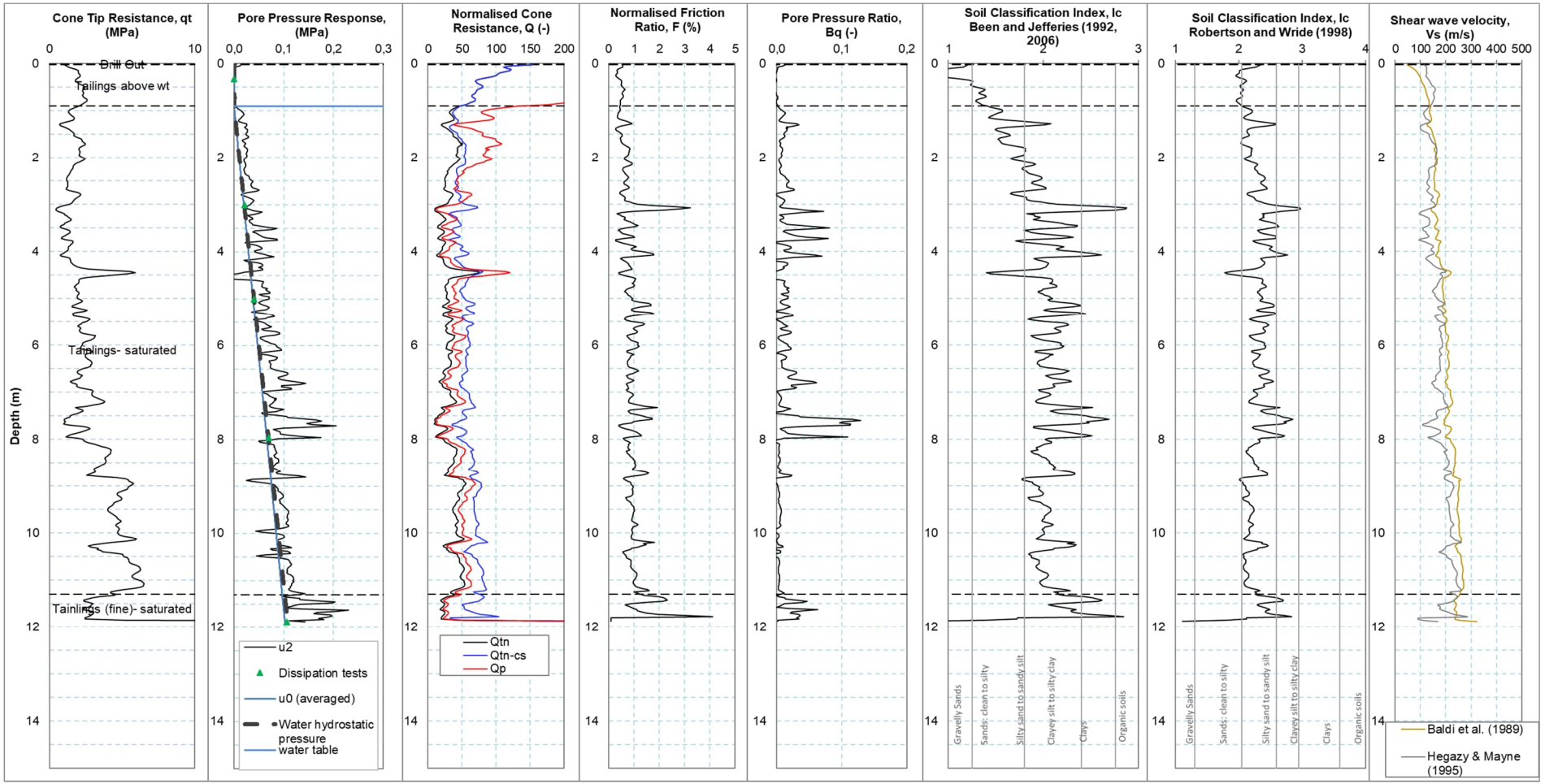






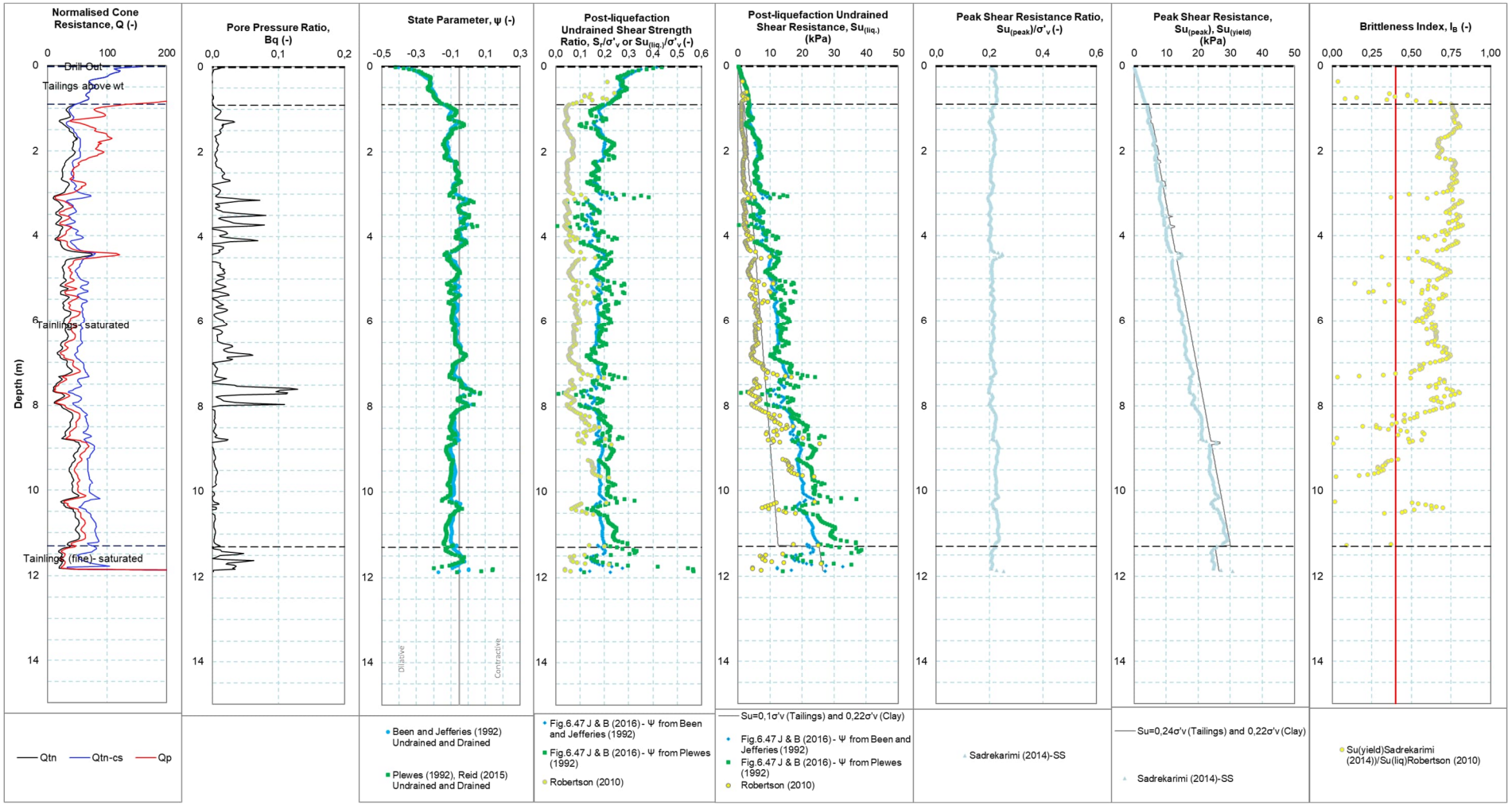
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

CPT-12



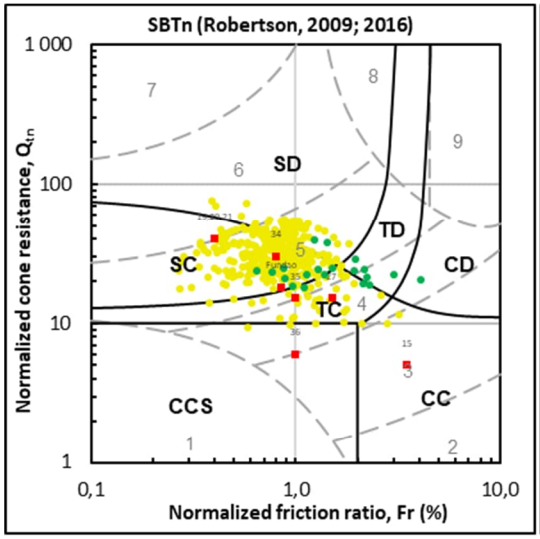
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

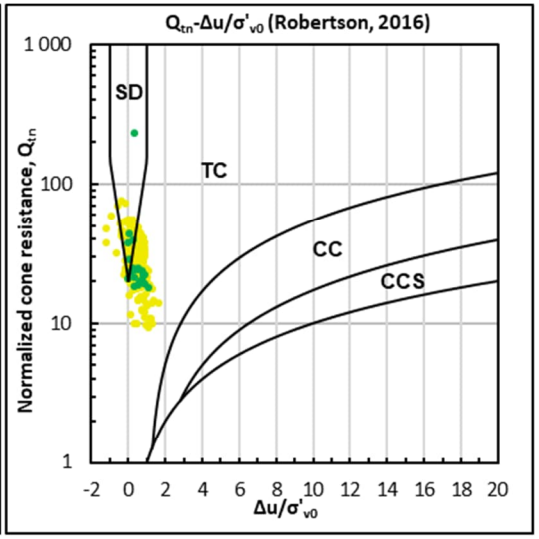
CPT-12



NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

CPT-12





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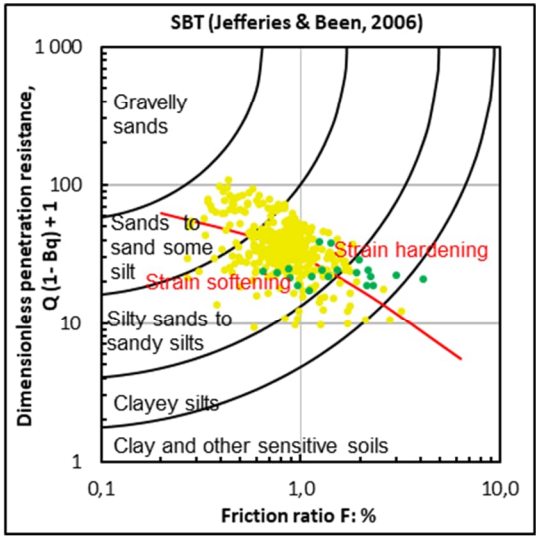
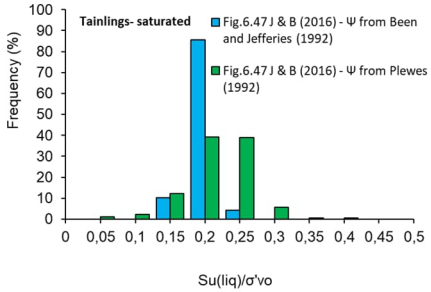
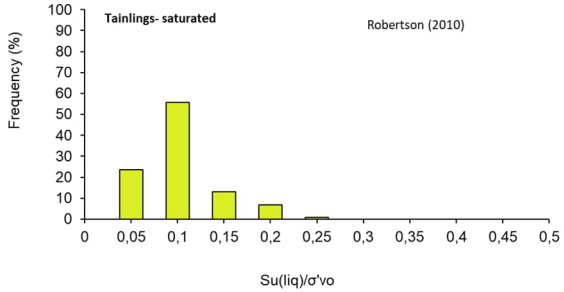
- Tainlings- saturated
- Tainlings (fine)- saturated
- Case Histories (Robertson, 2010)
- Shuttle and Cunning (2008)

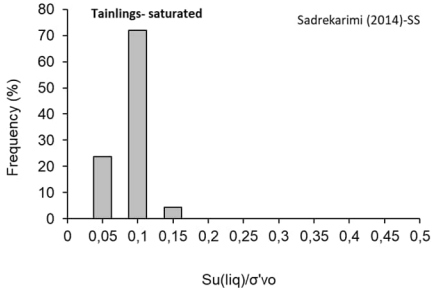


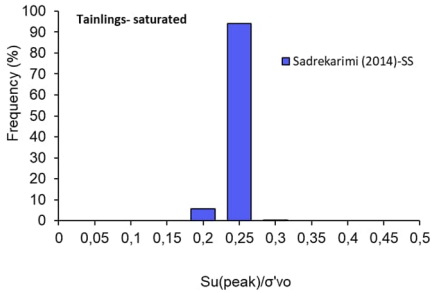
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

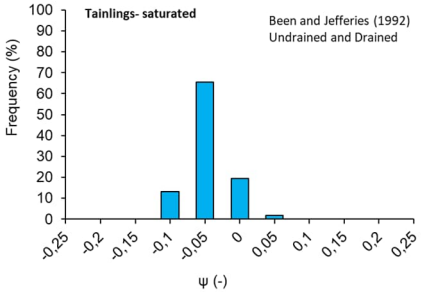
CPT-12
Saturated tailings

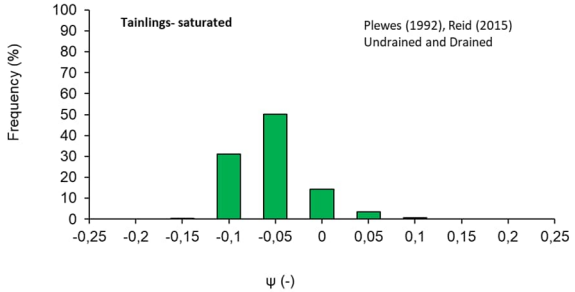






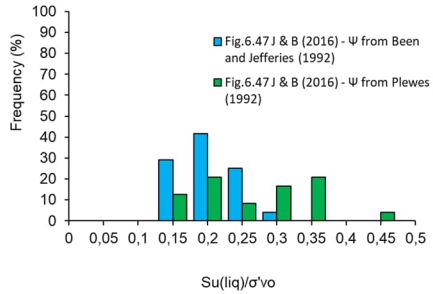


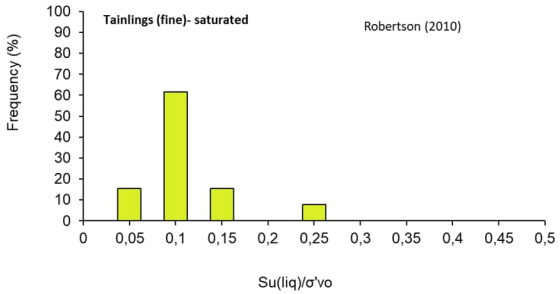


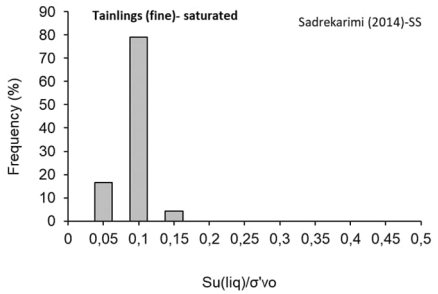


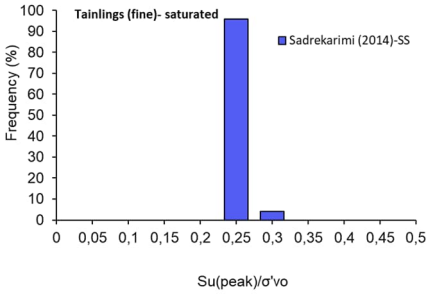
NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

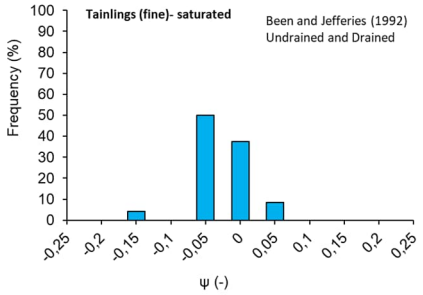
CPT-12
Fine saturated tailings

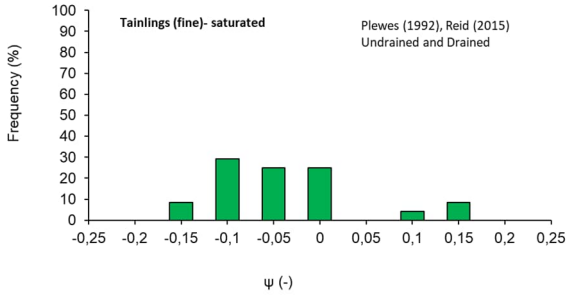












NB: Data points on unsaturated tailings and frozen tailings were not considered for the parameter interpretation.

WSP Canada Inc.

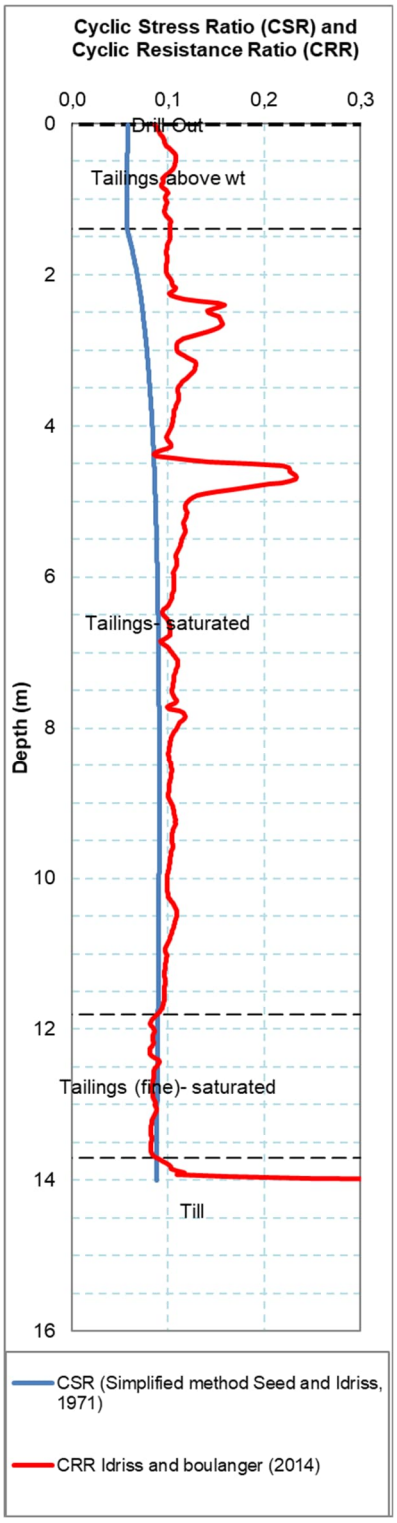
APPENDIX M

Results of Liquefaction Analysis

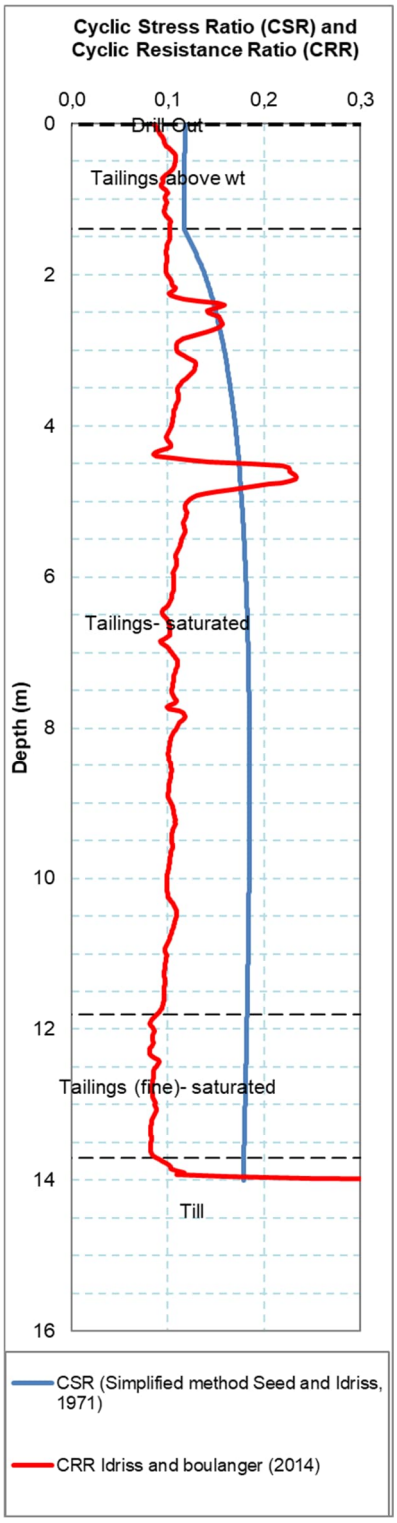
Figure M1

Comparison CSR-CRR
SCPT-01

PGA= 0.0884



PGA= 0.180

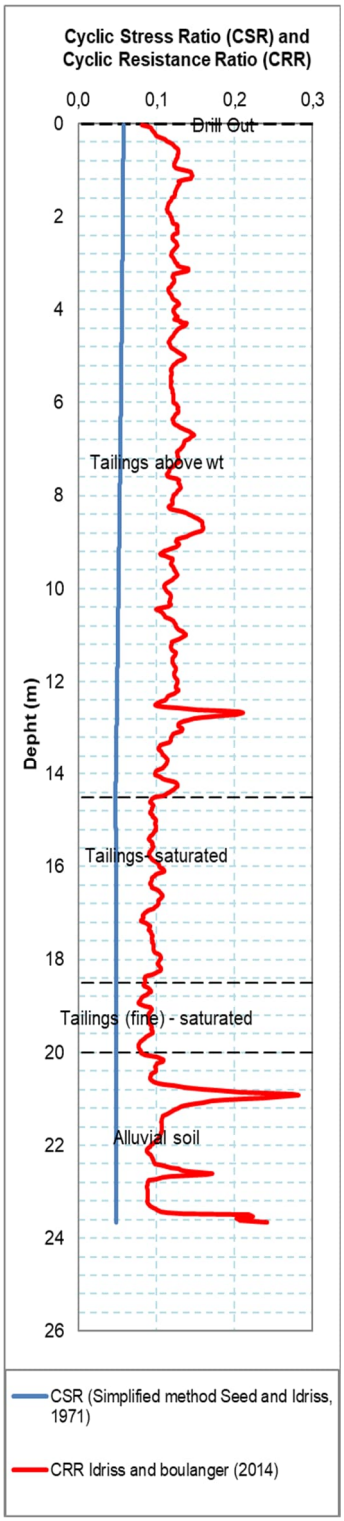


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

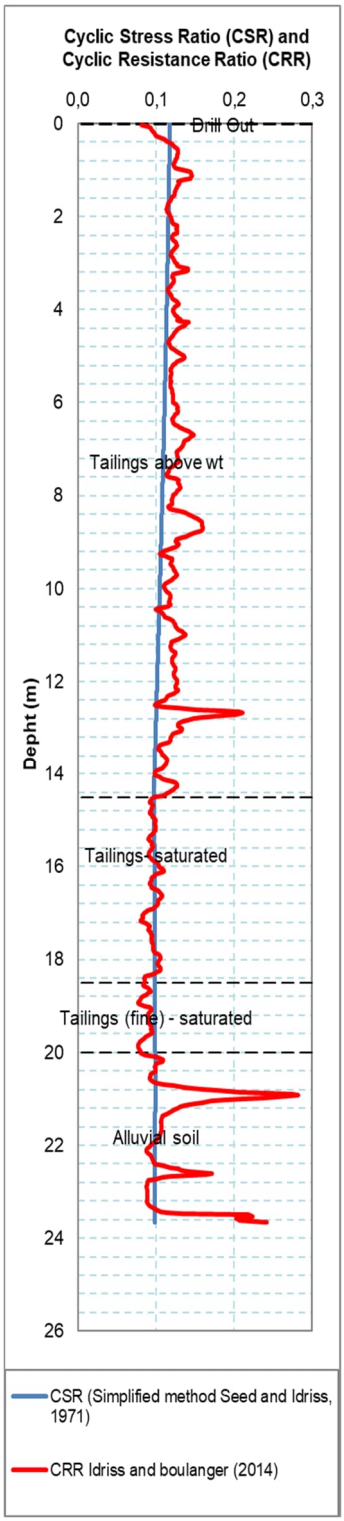
Figure M2

Comparison CSR-CRR
CPT-02

PGA= 0.0884



PGA= 0.180

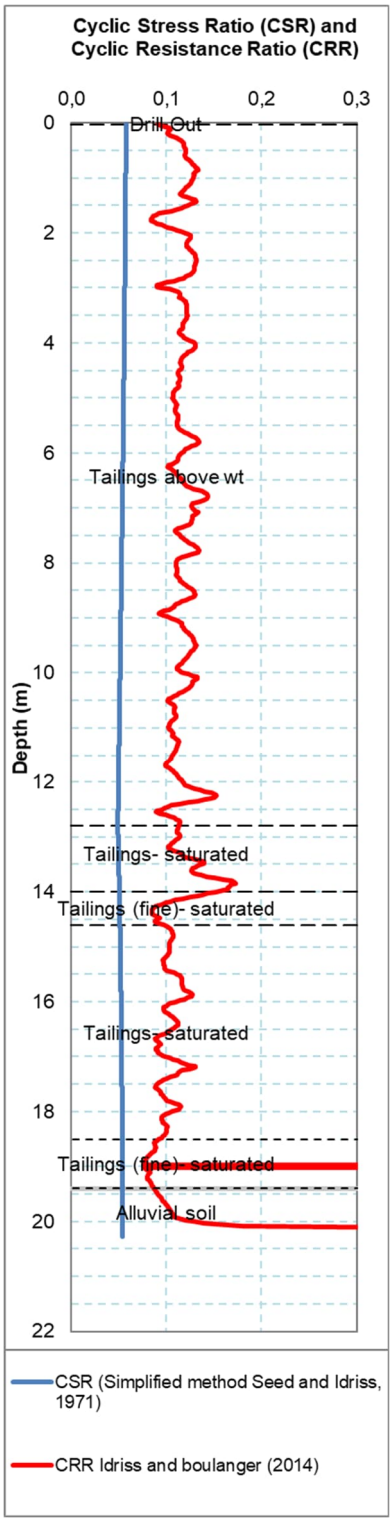


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

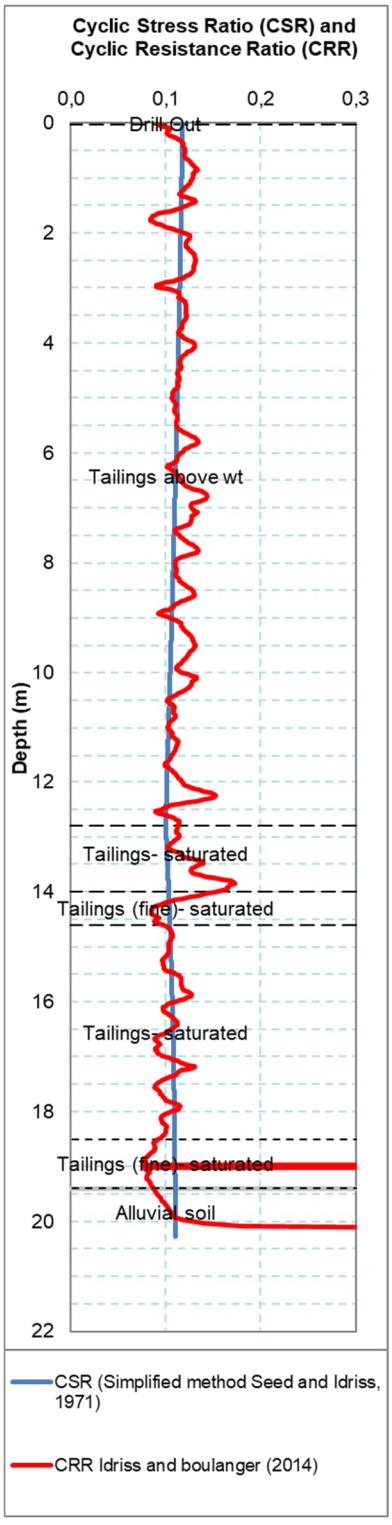
Figure M3

Comparison CSR-CRR
SCPT-03

PGA= 0.0884



PGA= 0.180

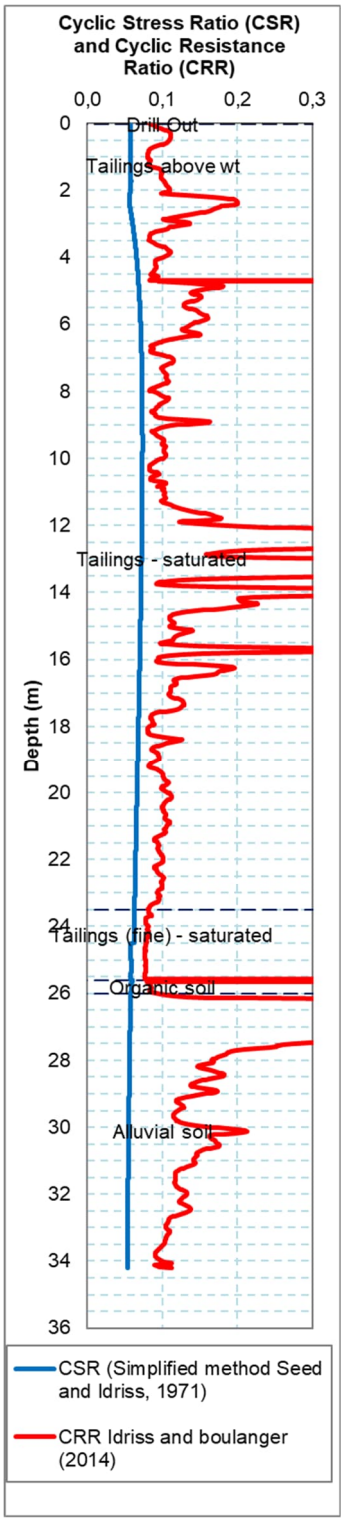


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

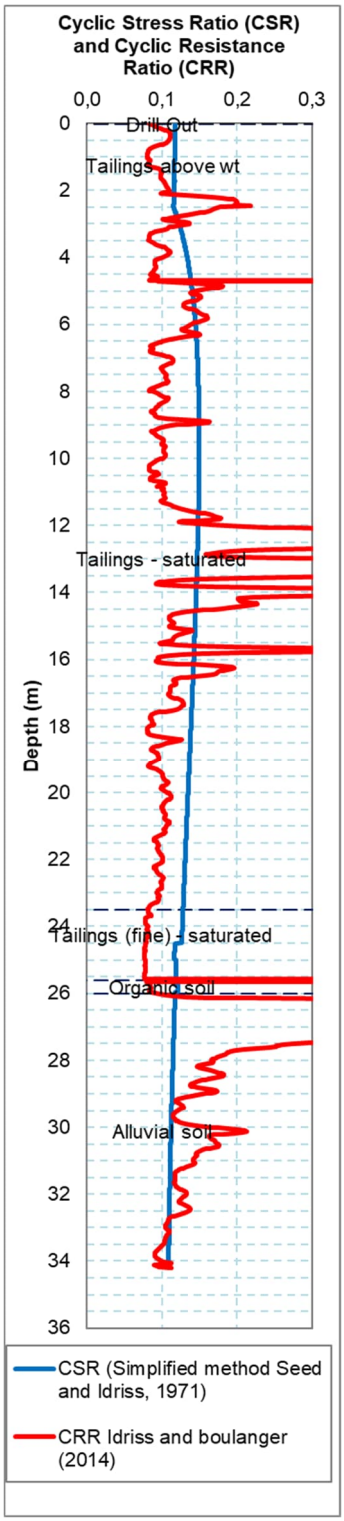
Figure M4

Comparison CSR-CRR
CPT-04

PGA= 0.0884



PGA= 0.180

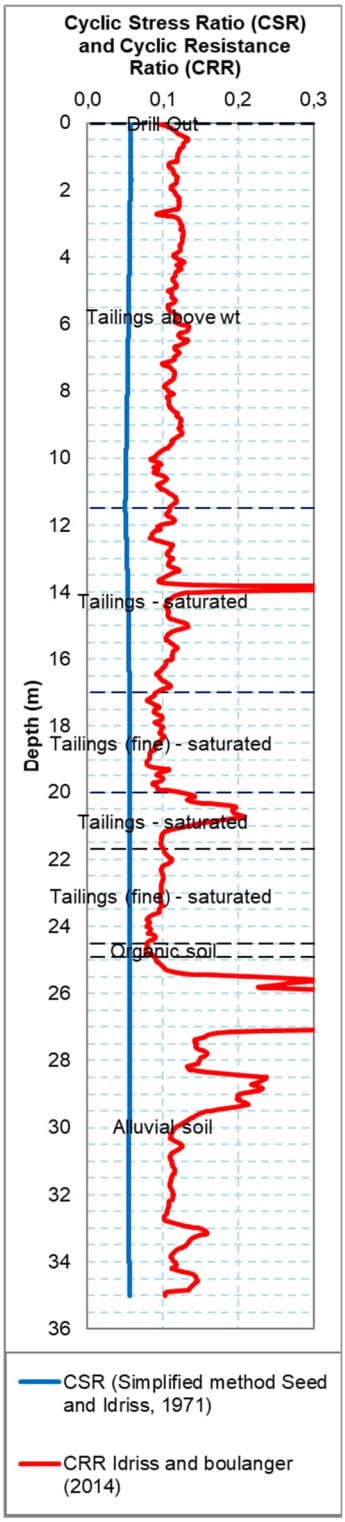


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

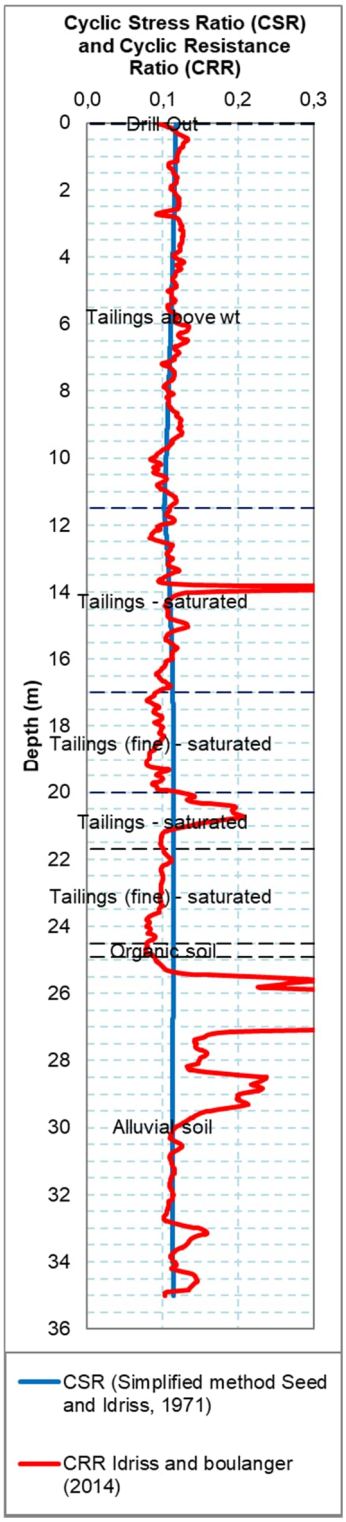
Figure M5

Comparison CSR-CRR
CPT-05

PGA= 0.0884



PGA= 0.180

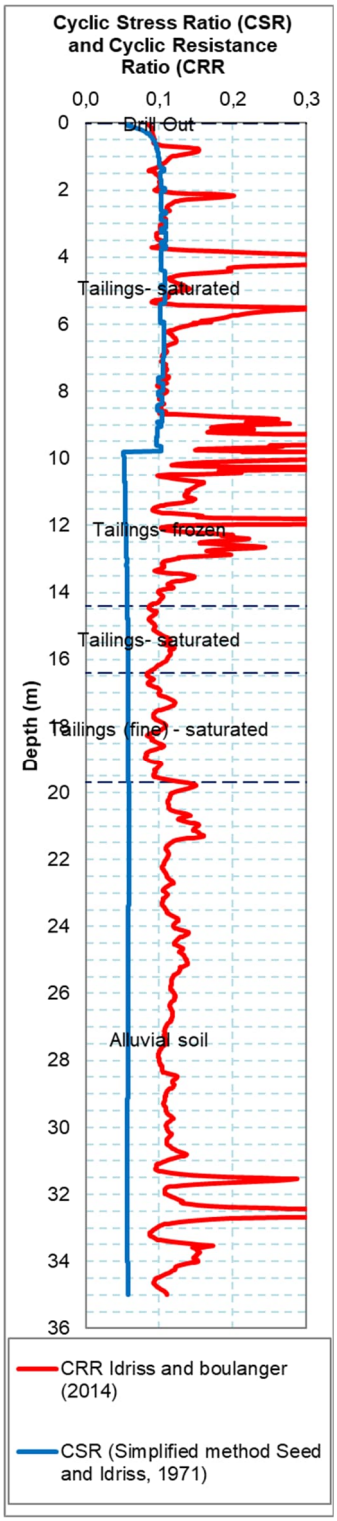


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

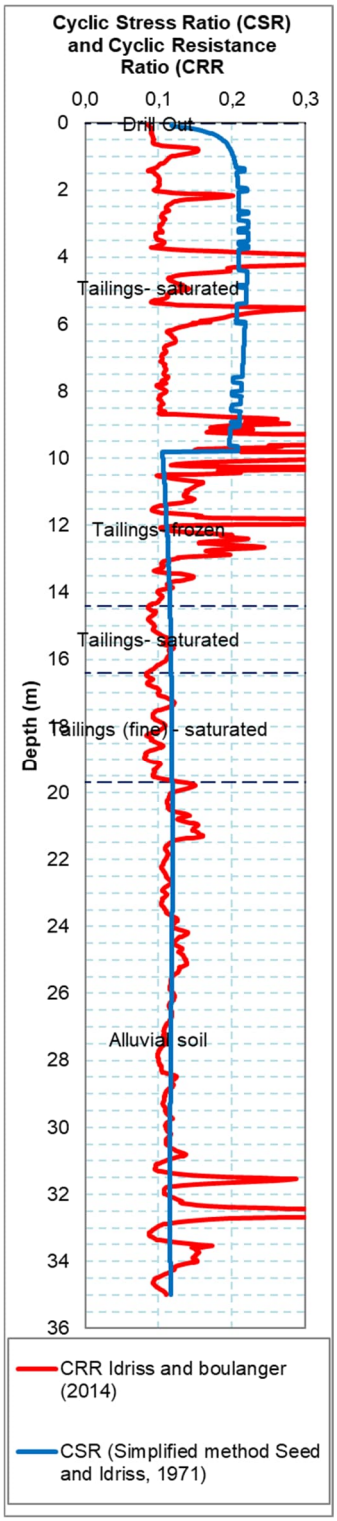
Figure M6

Comparison CSR-CRR
CPT-06

PGA= 0.0884



PGA= 0.180

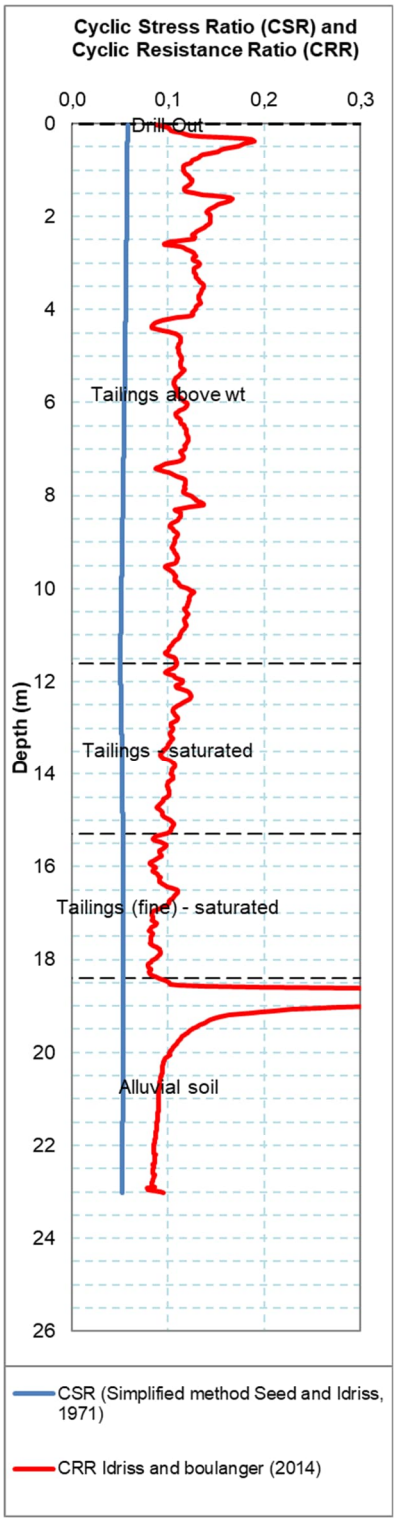


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

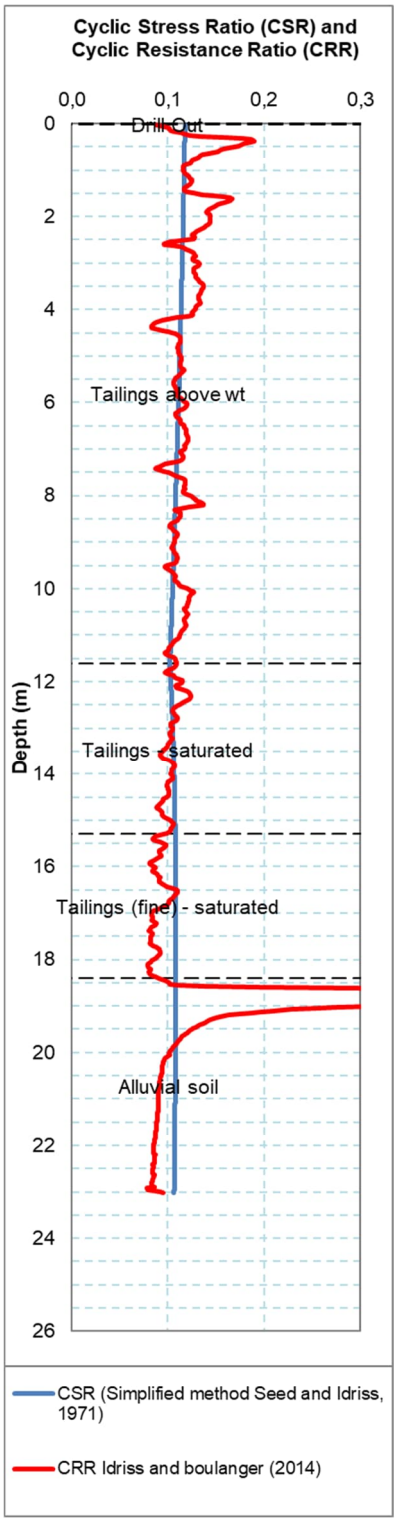
Figure M7

Comparison CSR-CRR
SCPT-07

PGA= 0.0884



PGA= 0.180

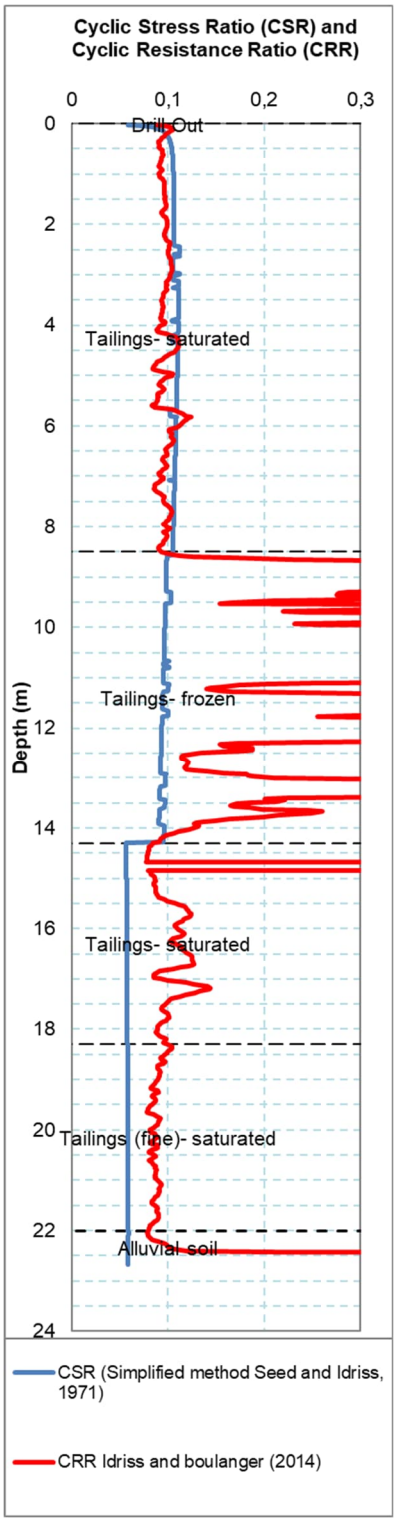


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

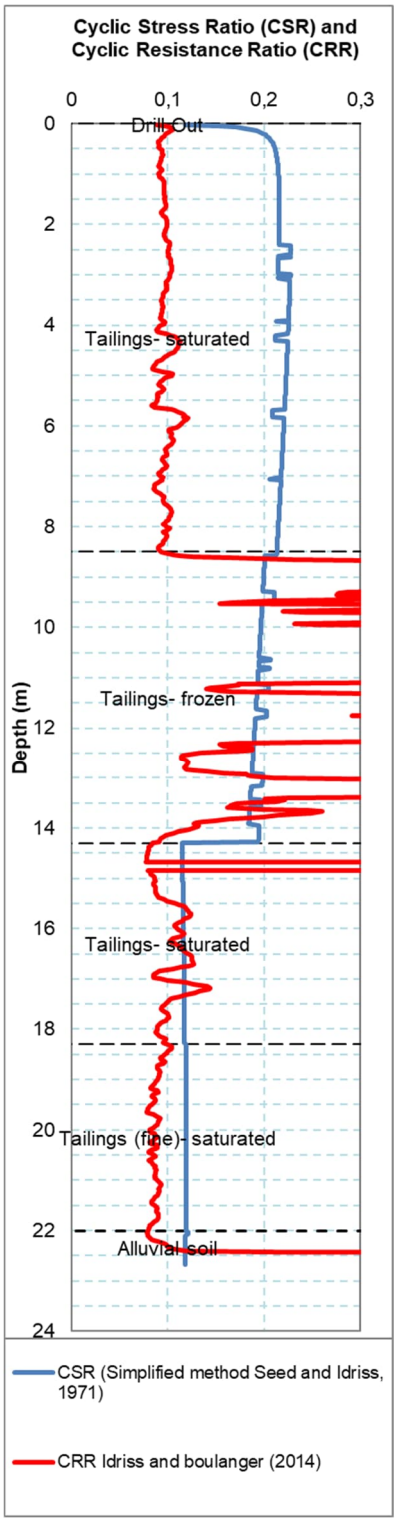
Figure M8

Comparison CSR-CRR
CPT-08

PGA= 0.0884



PGA= 0.180

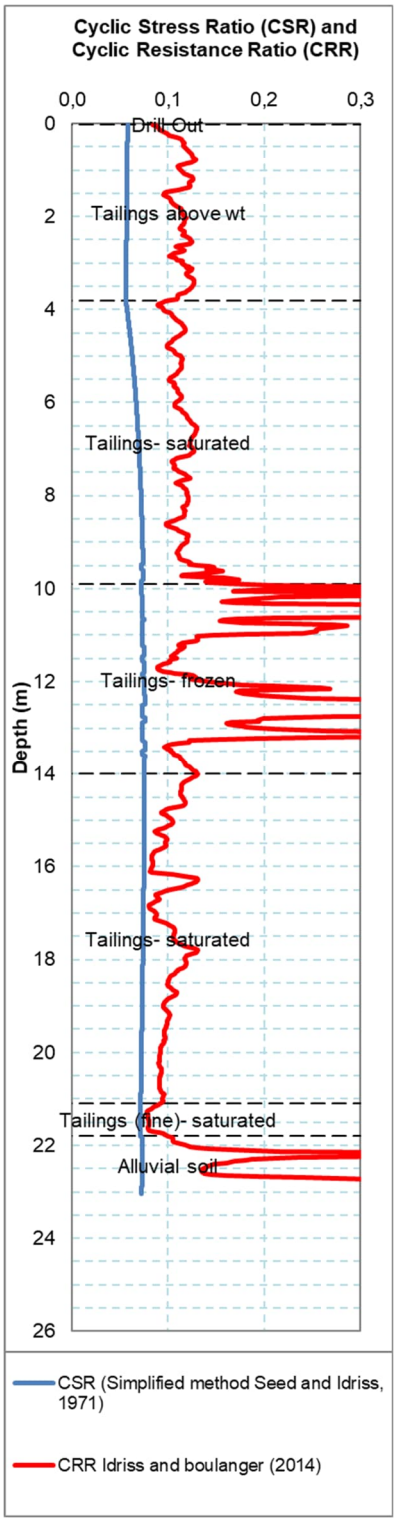


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

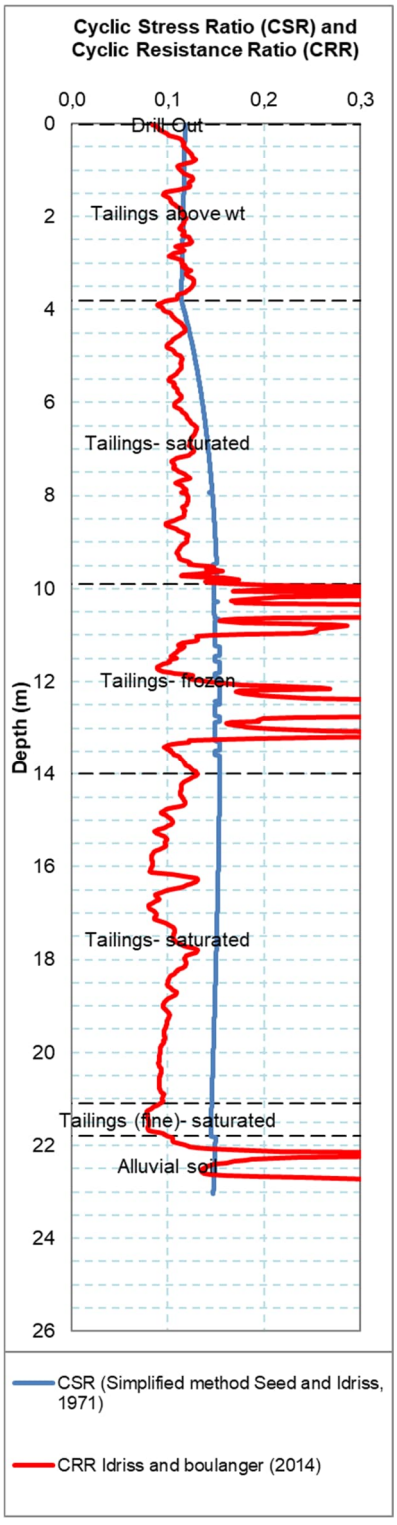
Figure M9

Comparison CSR-CRR
SCPT-09

PGA= 0.0884



PGA= 0.180

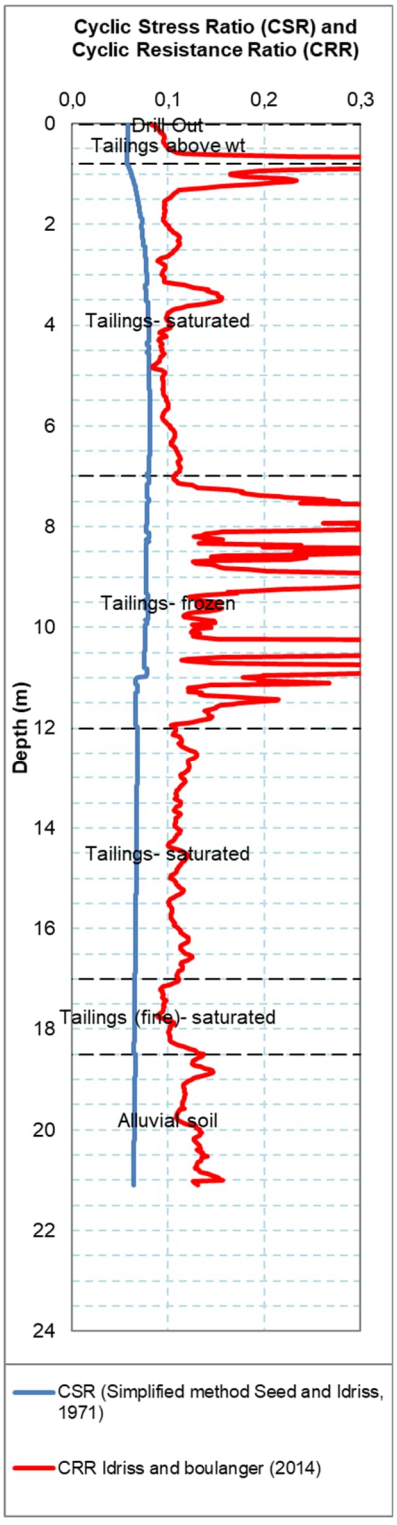


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

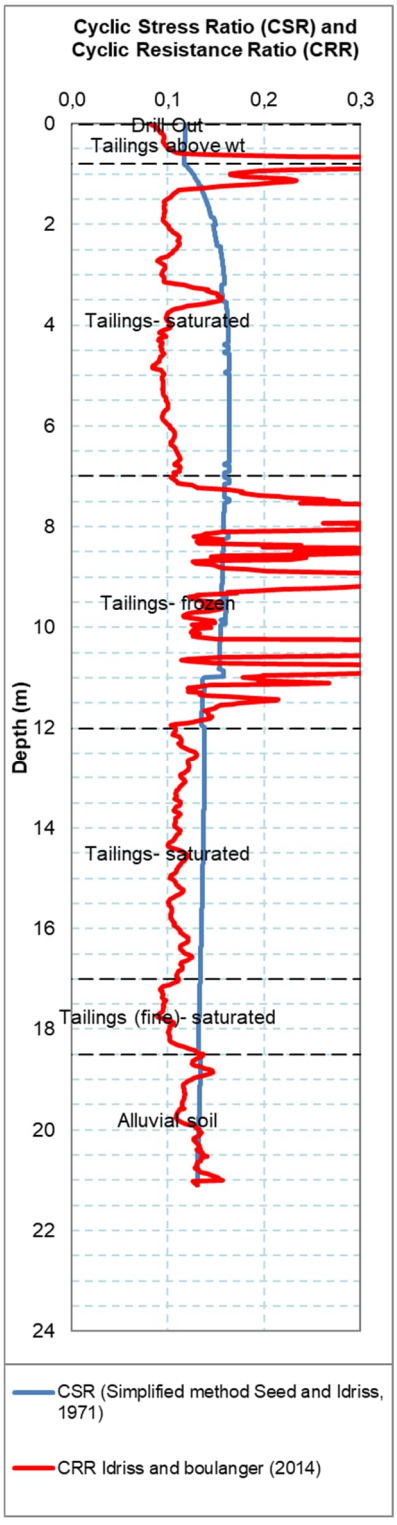
Figure M10

Comparison CSR-CRR
SCPT-10-B

PGA= 0.0884



PGA= 0.180

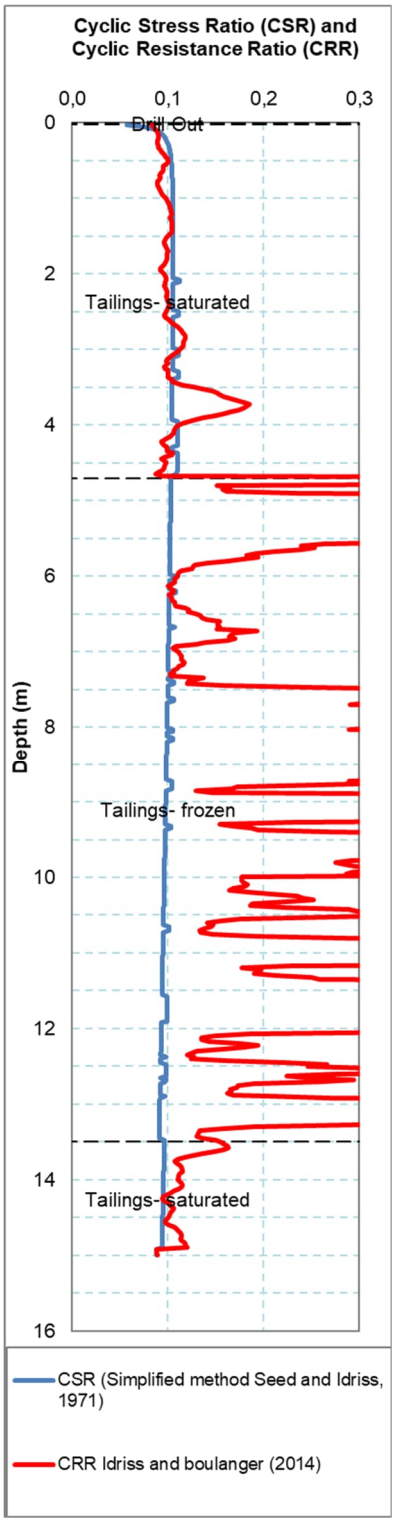


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

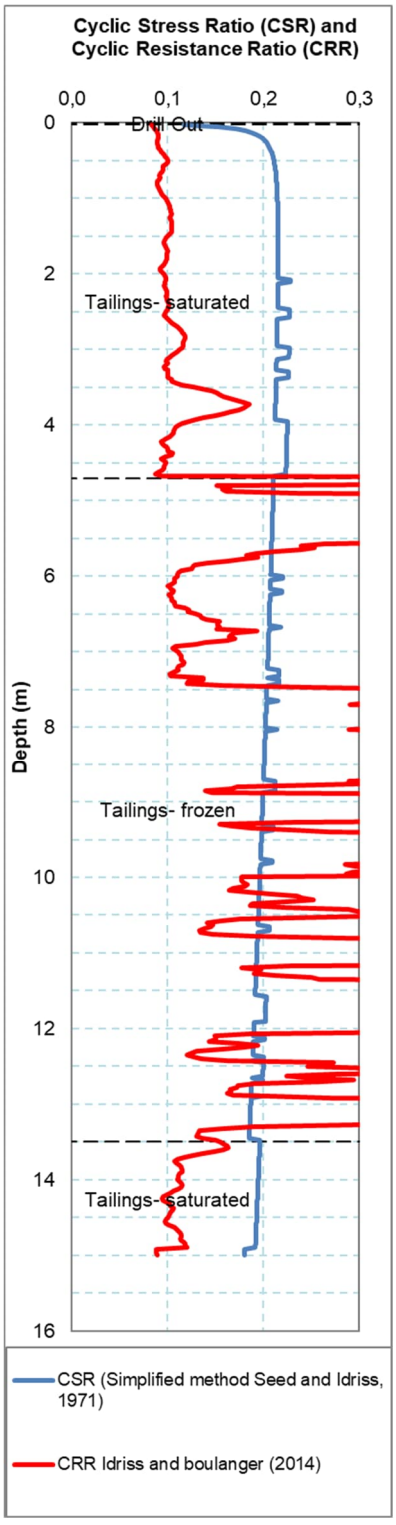
Figure M11

Comparison CSR-CRR
SCPT-10-C

PGA= 0.0884



PGA= 0.180

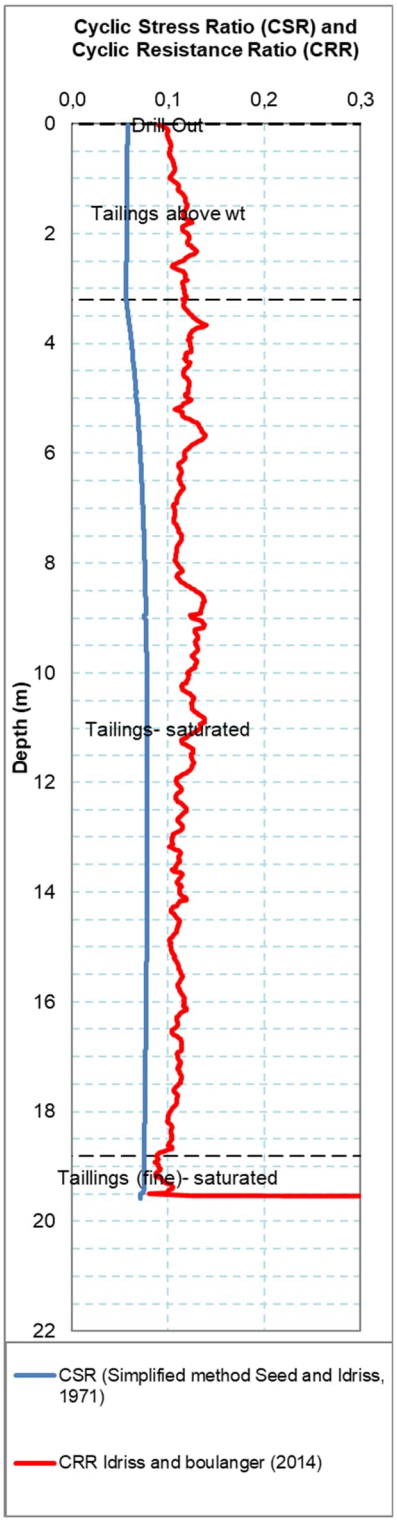


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

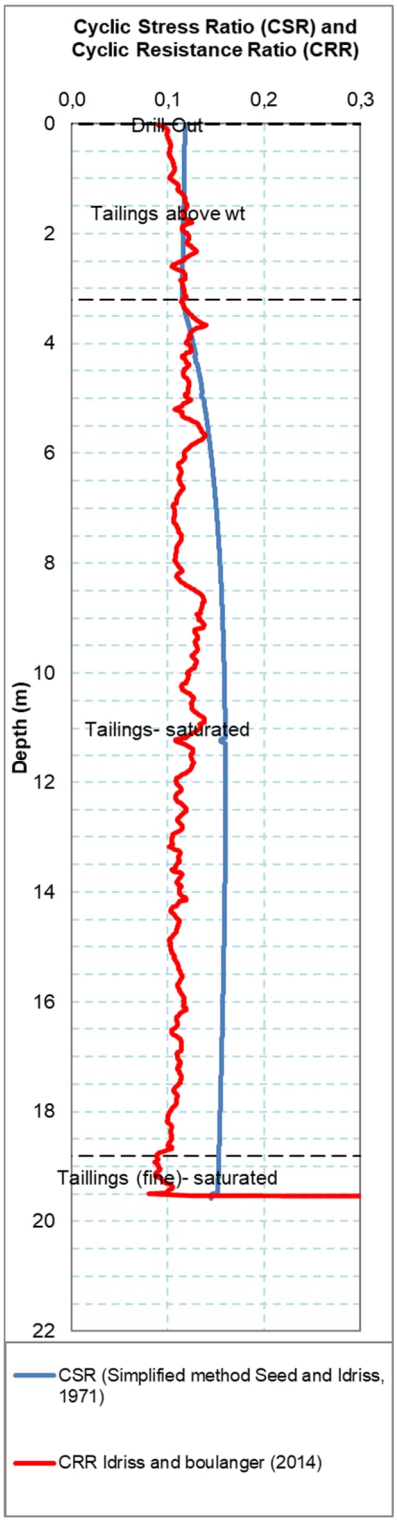
Figure M12

Comparison CSR-CRR
SCPT-11

PGA= 0.0884



PGA= 0.180

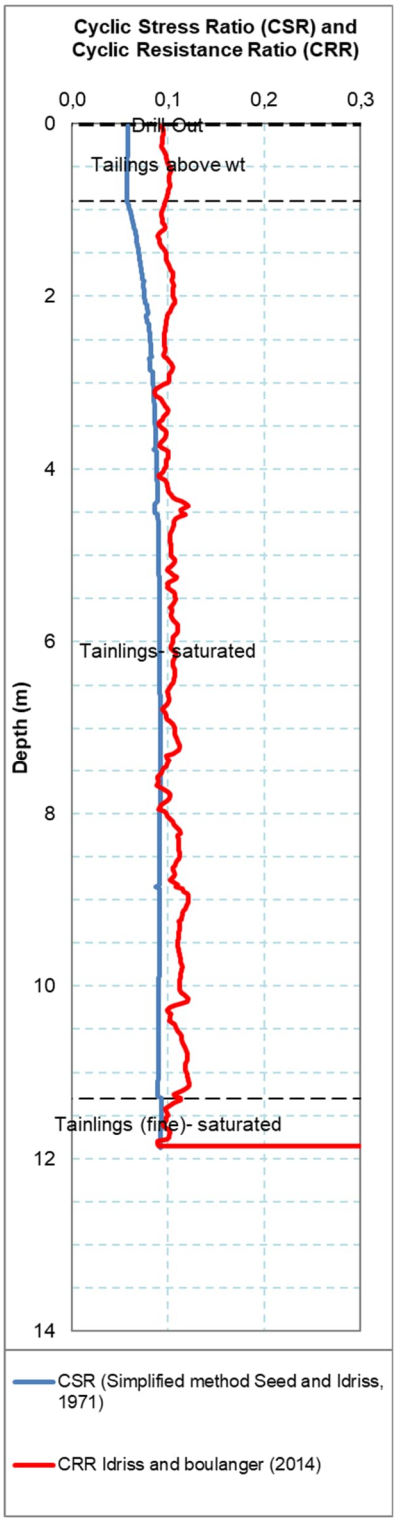


NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

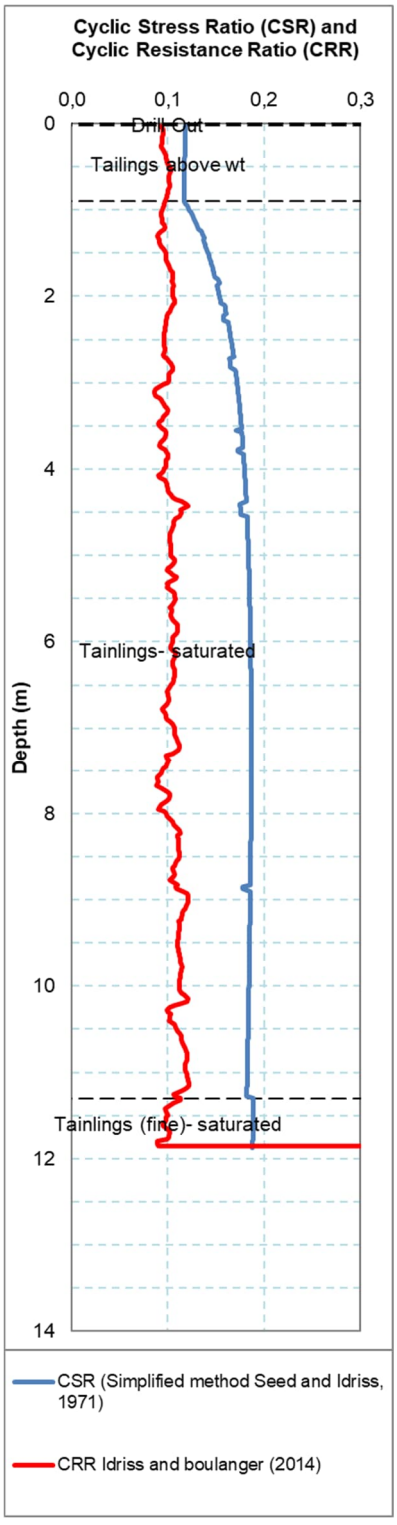
Figure M13

Comparison CSR-CRR
CPT-12

PGA= 0.0884



PGA= 0.180



NB: The results of CPT-06, CPT-08, CPT-10B are provided for comparison only. It is recommended that these CPTs not be considered for the design purposes.

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