GEOTECHNICAL ASSESSMENT
TAILINGS OPERATIONS AND STORAGE

PROJECT:
BARRYTOWN MINERAL SANDS TAILINGS

TIGA MINERAL & METALS LTD

RDCL

CONTENTS

1 INTRODUCTION

TiGa Minerals & Metals Ltd (TiGa) engaged Resource Development Consultants Ltd (RDCL) to provide geotechnical services to assess geotechnical aspects of the proposed mining and tailings storage for the Barrytown Sands Project at Barrytown, Grey District, New Zealand.

Mining will be by open pit to ~14m below current ground level, and will be undertaken with excavators, mine trucks and dozers. It is anticipated that mining will be complete within 4 – 5 years.

An overview of mining geotechnical processes that could affect excavation stability was requested for inclusion with a Resource Consent Application.

1.1 SCOPE

Our scope has been to assess geotechnical aspects of:

- Mining Operations including stability of excavation and tailings operations; and
- Tailings storage assessment and risk assessment.

Other professional organisations involved relative to this work include:

- Subterra Ltd providing geotechnical services;
- Palaris Pty Ltd providing mining engineering services;
- RSC Consultants Ltd providing geological services; and
- Kōmanawa Solutions Ltd providing hydrogeological services.

2 GUIDELINES, STANDARDS AND LEGISLATIVE REQUIREMENTS

Operations, Storage and Closure of the proposed tailings facility has been assessed considering National requirements and International Guidelines including:

- Resource Management Act 1992;
- NZ Health and Safety at Work Act 2015;
- NZSOLD (2015) Design Guidelines for Large Dams
- Global Industry on Tailings Management (International Council on Mining and Metals et al., 2020);
- ANCOLD (2022) Recommendations for Tailings Dams;
- ICOLD 220131 Tailings Dam Safety Bulletin; and
- CDA (2021) Technical Bulletin on Tailings Dam Breach Analysis.

3 PROJECT DESCRIPTION

3.1 OVERVIEW

The proposed project is to extract Heavy Mineral sands contained within the Holocene Beach Placer deposit at Barrytown (Figure 1). The project geology, mining, processing and tailing storage are not complicated from a geotechnical perspective; also being without the use of chemical additives in the processing stream.

The site is within existing, modified farmland, sloping from SH6 west towards the coast, with elevation difference of ~15m across the project footprint. Wetlands border the property to the south and west, with a small drainage channel on the northern boundary and Collins Creek to the south.

3.2 RESOURCE AND PRODUCTION

The resource estimates is for ~4,800,000 tonnes of recoverable sand ore mined over 5 – 7 years for annual production rate ~250,000 tonnes of Heavy Mineral Concentrate for 1,100,000 tonnes total mined.

4 GEOLOGICAL SETTING

4.1 REGIONAL GEOLOGY

Summary geology in this report is taken from RSC (2022) which includes a detailed description of the regional and project geology, and which should be referred.

4.1.1 PUBLISHED GEOLOGY

For the geotechnical design and risk assessment the geological aspects of the project are:

- Mineralisation occurs as marine placer deposits of heavy minerals, concentrated by longshore drift and pushed up by wave action (Figure 2).
  - Lensoidal shaped mineral concentrations follow the dip of the beach towards the sea at ~5° to 10°;
  - Deposits are generally very well sorted fine sand, with occasional clay and gravel intercalations.
  - Maximum depth of deposit is ~14m.
- Overburden comprises Clayey, silty Gravel derived broadly from colluvial outwash;
- Basement comprises barren Gravel with the contact being abrupt and comprising a wave cut platform.

4.2 GROUNDWATER

Groundwater levels are assumed 1 to 2m below current ground level.

4.3 GEOHAZARDS

4.3.1 ACTIVE FAULTS

No active faults directly impacting the site have been identified in the New Zealand Active Faults Database (GNS Science, 2018).

The Canoe Fault (Figure 1) is oriented striking north-east and is ~1km east of the site at the centre of the block, and classified with:

- Reverse fault; with
- Holocene; and
- Unknown displacement and slip rate.

4.3.2 Liquefaction Risk

Grey District Council (GDC) does not cover liquefaction potential but shows Barrytown flats with an elevated ground shaking risk reflecting the sandy nature of the site.

Investigations for this project study (Subterra 2022) indicate surface clays are unlikely to liquefy, and that a non-liquefiable layer 4m thick is likely across the site at depths from 6m – 8m mbgl.

4.3.3 Summary of Geohazards

Table 1:Summary of Geohazards

Geohazard	Risk Level	Risk Summary
Active Faults	Low	No “known” active faults directly impacting the site
Liquefaction Susceptibility	Moderate	The property is underlain by fine sand and is likely susceptible to some form of liquefaction.
Ground Shaking	High	The property is within a ‘high’ amplification area – susceptible to ground shaking in an earthquake.
Slope Stability	Low	The site is not at risk of inundation by landslide.
Coastal Interaction	Low	The mining block is separated from wave action by the adjacent lagoon.
Tsunami	Low	The site is at low risk of tsunami hazard.

5 MINING METHOD

5.1 SUMMARY

The main elements of the mining process include (Figure 3):

- Preparatory works prior to mining to establish including but not limited to:
  - Overland water diversion drains,
  - Visual bund;
  - 20m offset established; and
  - Water Facility.
- Mining by excavator to ~14m depth below existing ground level with:
  - Barren overburden stripped in advance of the mining face; and
  - Mineralised sands fed to a mobile hopper;
  - Oversize and slimes removed at point of mining;
  - Mineralised slurry transported by pipeline; to the
- Processing plant with:
  - Mineral fraction separated by gravity using no chemical additives;
  - Waste sand fraction (tailings) returned to pit void as a slurry transported by pipeline; with
- Tailings will be:
  - Dewatered by cyclone at the discharge point to the mine void;
  - Pushed out by bulldozer within the pit; and
- Final landform formed as the mine advances by:
  - Overburden placed over to cap the tailings;
  - Shaped by mechanical (excavator, tractor, truck etc) means;
  - Top soiled and returned to farming.

5.2 MINING PLAN

The active mine void will cover 3 Ha in a 300m long x 100m wide strip. Over burden and topsoil will be stripped in advance of mining in 0.5Ha increments using an excavator. Overburden will be trucked and placed at the back of the mining void for use in progressive rehabilitation.

5.2.1 MINING

Ore (mineral sands) will be mined by 80T excavator from a ~1 Ha bench where the mining and desliming field units will be located on skids. The rate of mining advance will be approximately 5 metres per day (35 metres per week).

1 Ha of the mining void will be actively receiving tailings pumped from the processing plant. Tailings are dewatered and discharged to the mining void via cyclone. The tailings will be allowed to naturally beach out (spread out). The cyclone will be moved as required to distribute the tailings as necessary.

Mining will be undertaken during daylight hours only and provide enough material to enable 24 hour operation of the processing plant (i.e. The rate of mining is approximately double the rate of processing). Tailings will be pumped to the mining void at night.

The open pit will be excavated to ~14m below existing ground with temporary slopes at 50°-60°.

5.2.2 TAILINGS

Tailings will be levelled and contoured with the use of excavators and bulldozers ready to receive the pre stripped overburden and soil as out lined in point 1 of this section. The mining void will be progressively rehabilitated as the mining void advances.

5.2.3 REHABILITATION

Vegetative cover (sowing of grass) is established, and the area is removed from the disturbed area once 80% vegetative cover is achieved.

5.2.4 TIME FRAME

Each mining panel will take between 4 and 6 months to be mined and rehabilitated. Depending on volume of ore and weather conditions during rehabilitation.

6 TAILINGS OPERATION

Tailings are proposed to be discharged into the mining void being dewatered by cyclone at that point.

Dry tailings will be pushed out into the void by bulldozer, advancing 5m / day working within a 25m strip from the completed surface and with no operator entry into the pit.

6.1 TAILINGS STORAGE

Tailings:

- Are “clean” with no toxic potential;
  - Liners for containment are not required.
- Will be stored in the mine void which is:
  - Below ground level; with
  - No enclosing embankments; and
  - Freeboard always > 3m to ground level from final tailings surface as ~30% of the material is extracted as ore.
- Will be capped using overburden concurrent with mining advance, with the final surface finished to allow farming.

Tailings storage void:

- Is expected to be stable from a geotechnical perspective; with
- Free of active faults; with
- Low potential for liquefaction; and
- Rehabilitation plan to protect against overland water flows.

7 GEOTECHNCIAL ASSESMENT

7.1 GROUND MODEL

7.1.1 PROCESSING PLANT

A geotechnical drilling program was carried out for the processing plant site location (Subterra, 2022). The typical geotechnical ground profile from that work is in Table 2.

TABLE 2 PROCESSING PLANT GEOTECHNICAL GROUND MODEL (SUBTERRA, 2022)

Depth to base of unit (m bgl)	Material	Density / Consistency	SPT (N_{60})
1.7 to 2.2	CLAY	Soft	
5.9 to 8.0	CLAY with variable organic content	Soft to firm	
At least 11.4	SAND with variable gravel	Medium Dense to Dense	

7.1.2 MINING BLOCK

Within the mining block, the ground model is based on the geological section inferred from exploration drilling (Figure 4) with type sections in Figure 2.

The mining block ground model is in Table 3.

TABLE 3 MINING BLOCK GROUND SIMPLIFIED MODEL

Geotechnical Unit	Depth (From-To)	Material
Overburden	0-2	Clay, Silt and Gravel
Mineralised Sands	2-14	Sand, fine, well sorted
Barren Gravel Base	14-17	Gravel

7.2 MATERIAL GEOTECHNICAL PROPERTIES

7.2.1 LABORATORY TESTS

Laboratory tests have been undertaken on exploration sample splits (Figure 4) including:

- 11 x Particle size distribution (Plate 2);
- 11 x Compaction tests (Table 2); and
- 9 x Atterberg Limit Tests (Table 2).

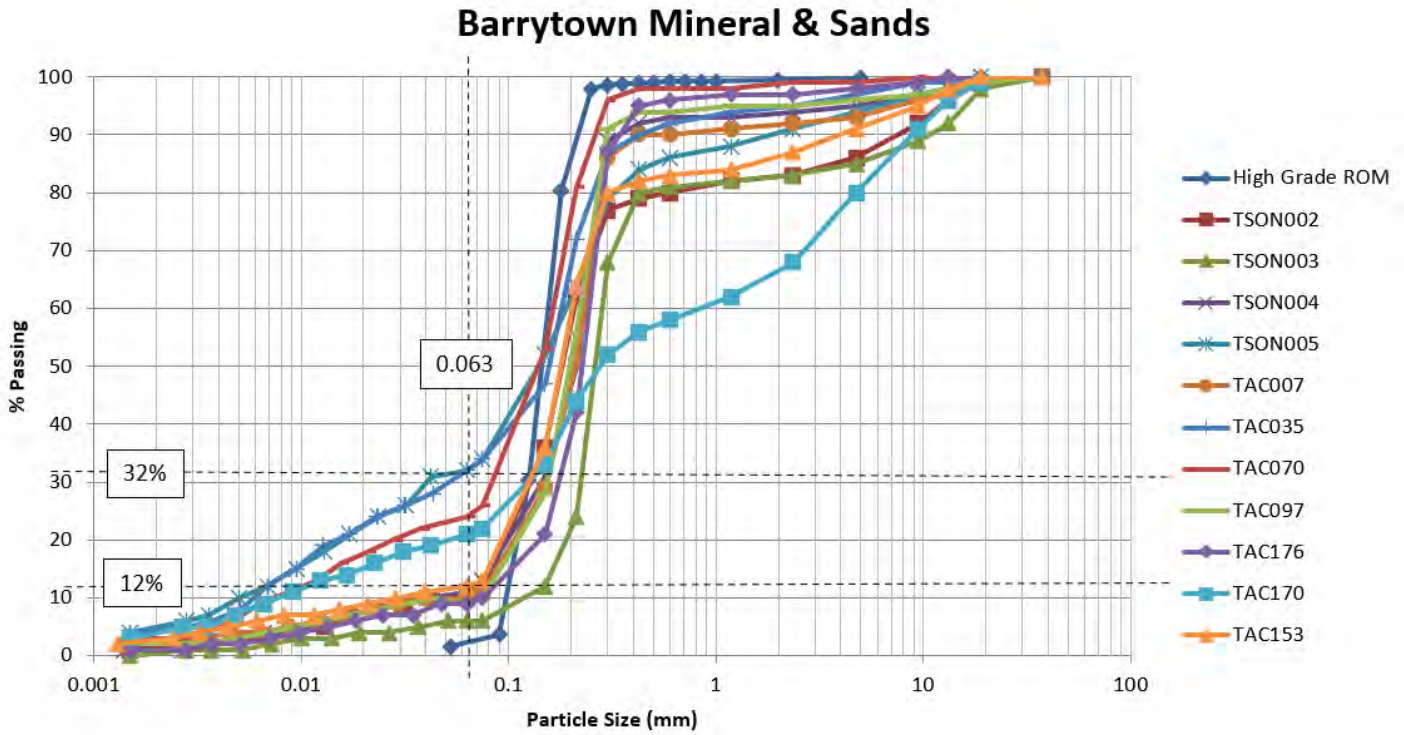
Laboratory tests results are in Appendix A.

TABLE 4: LABORATORY TEST RESULTS

Sample	Material (Laboratory Description)	Dry Density (t/m^3)	Natural WC (%)	Bulk Density at OWC (t/m^3)	OMC (%)
TAC007	Silt SAND with minor gravel and trace clay	1.89	0.5	2.16	14.0
TAC035	Silty SAND with trace gravel and clay	1.70	0.2	1.91	12.0
TAC070	Silty SAND with trace gravel and clay	1.96	0.1	2.19	12.0
TAC097	SAND with some silt, trace gravel and clay	1.84	0.2	2.02	11.0
TAC153	SAND with some gravel, minor silt and trace clay	2.24	0.2	2.43	8.0
TAC170	Gravelly SAND with some silt and trace clay	2.14	0.3	2.27	6.0
TAC176	SAND with minor silt, trace gravel and clay	1.75	0.0	1.97	12.0
TSON002	SAND with some gravel minor silt and trace clay	2.05	0.1	2.26	10.0
TSON003	SAND with some gravel and minor silt	1.88	0.2	2.04	10.0
TSON004	SAND with some gravel, silt and trace clay	1.80	0.1	2.06	14.0

Sample	Material (Laboratory Description)	Dry Density (t/m^3)	Natural WC (%)	Bulk Density at OWC (t/m^3)	OMC (%)
TSON005	Silty SAND with minor gravel and trace clay	1.94	0.2	2.18	12.0

PLATE 1: PARTICLE SIZE DISTRIBUTION CURVES



7.2.2 GEOTECHNICAL PARAMETERS FOR DESIGN

Material and deformation properties assumed for geotechnical modelling (Table 1) are based on assessment of:

- Discussion with exploration geologists (RSC) and hydrogeologists (Kōmanawa) who attended drilling at the site;
- Laboratory tests; and
- Engineering correlations from published sources (Look, 2007).

TABLE 2: GEOTECHNICAL PARAMETERS

Geotechnical Unit	Material	Depth (From-To)	Friction (°)	Cohesion (c', kPa)	Unit Weight (kN/m^2)	Permeability (m/s)
Overburden	Clay, Silt and Gravel	0-2	30	2	15	10^{-6}
Mineralised Sands	Sand, fine, well sorted	2-10	40	-	18	10^{-4}
Barren Gravel Base	Gravel	10-17	42	-	20	10^{-7}
Tailings	Sand, fine, well sorted, heavy metals removed	3-10	30		18	10^{-5}

7.3 SEISMIC DESIGN

Seismic stability has been checked against:

- ICOLD 220131criteria; using
- Christchurch 2011 seismic event captured from station located at Christchurch Hospital (CHHC) scaled to the ground accelerations developed by MBIE Module 1 2021.

7.3.1 SEISMIC SOIL CLASSIFICATION

The site subsoil class is assumed "Class D Deep Soil" in accordance with NZS1170.5:2004, part 5: Earthquake Actions – New Zealand. The site subsoil class was assessed based on regional geology.

7.3.2 Seismic Loads Basis of Assessment

Seismic design loads for a Low PIC dam (Section 8.3) are:

- Operating Base Earthquake (OBE): 150 year return period; and
- Maximum Credible Earthquake (MCE): 500 year return period.

Assessment of seismic loads has been undertaken using MBIE Guidelines Module 1, Overview of Earthquake Geotechnical Engineering Practice Guidelines, (2021, version 1) as appropriate for a Low PIC dam:

- Magnitude (M) = 6.5 (OBE) & 6.7 (MCE);
- Peak Ground Acceleration (PGA) = 0.30g (OBE) & 0.53g (MCE)

7.4 Stability Analysis

7.4.1 Mining Operations and Tailings Storage

Stability analyses has been undertaken using limit equilibrium to assess the Factor of Safety against failure for the:

- Initial Pit Excavation; and
- Initial Pit Excavation + Tailings backfill (initial placement only).

Finite Element Methods have also been undertaken to demonstrate deformation of the tailings storage facility:

- Under seismic loads (both OBE & MBE); and
- Considering liquefaction potential.

Analyses has been undertaken for cases:

- Initial Pit Excavation: Mining to ~14m depth; and
- Initial Pit Excavation + Tailings backfill: Tailings placed at 3 m from ground level.

Analytical outputs for all stages are in Appendix B.

7.4.2 LIMIT EQUILIBRIUM FACTOR OF SAFETY

- Limit equilibrium analyses has been used to assess factor of safety (FoS) using:
  - Program Slide2 v9.009 being widely accepted software by Rocscience; and

Derived Factors of Safety are compared with the ICOLD 220131criteria (Table 3).

- All conditions meet or exceed the stability criteria.

TABLE 35: LIMIT EQUILIBRIUM ASSESSMENT RESULTS

Stage	Load Condition	Factor of Safety	Criteria to Meet
Open Pit Cut Slope	Static	>1.5	1.5
	OBE (0.3g)	>1.1	1.1
	MCE (0.53g)		

7.4.3 DEFORMATION ANALYSES

Seismic induced deformation analyses have been undertaken using FEM (RS2) to provide an indication of deformation associated with the scaled (to 0.3 and 0.53g) earthquake load (Appendix B, Table 4).

- Deformation is estimated at the 20m setback boundary.

TABLE 46: DEFORMATION ASSESSMENT RESULTS

Stage	Load Condition	Total Deformation (m)
Open Pit Cut Slope	Static	< 0.08m
	OBE (0.3g)	0.4
	MCE (0.53g)	0.5
With Tailings Backfill	Static	0.02
	OBE (0.3g)	0.1
	MCE (0.53g)	0.2

8 MINING OPERATION AND TAILINGS

Key aspects of the mining operation from a geotechnical perspective are:

- Stability of initial pit excavation;
- Drainage potential of tailings for operating a bulldozer to achieve the proposed mining advance rate; and
- Safety in design.

8.1 STABILITY OF PIT SLOPES

The proposed initial pit slope will be excavated at 50°-65° to a depth up to 14m below original ground surface.

This temporary slope at the outer limit of the mining block will be buttressed as tailings are returned into the mine void; in effect the critical slope will be left unsupported for days to weeks only.

Slope stability numerical assessment (Section 6.4.1 and 6.4.2) indicate acceptable factors of safety against failure for the proposed initial cut considering all cases including seismic (~MCE) conditions.

8.2 DRAINAGE POTENTIAL AND MINING ADVANCE

The drainage potential of the tailings is an important consideration in mine advance as a bulldozer is proposed to push the tailings into the mine void with mining advance. The tails must be drained to allow the bulldozer onto the tailing surface without becoming stuck. Tailings advance is proposed at 5m / day to keep up with mining.

The permeability (and hence drainage potential) of the tailings has been assessed based on particle size distribution also considering Atterberg limits as being commonly available test in New Zealand. Specialised test to assess tailings material properties are otherwise not available in the country.

Representative material testing for estimating drainage potential of tailings was from Bulk Samples taken from exploration drill composites with 1 no. x ROM sample.

8.2.1 PARTICLE SIZE DISTRIBUTION

- Bulk Sample is very well sorted fine sand with:
  - Fines fraction (slimes; < 0.063mm) < 12% in 7 holes.
  - Fines fraction 20% to 32% in 4 holes.
- ROM Sample is very well sorted fine sand with:
  - Fines fraction (< 0.063mm) < 4%.

8.2.2 INFERRED PERMEABILITY

The Inferred Permeability of Bulk Sample is:

- ~10^{-5} to 10^{-4} m/s for samples with Fines content < 12%;
- ~10^{-7} m/s for the samples with Fines < 32%.
- Based on published correlations as in Table 5.

TABLE 5 INFERRED PERMEABILITY FROM PARTICLE SIZE DISTRIBUTION TESTS (FROM LOOK, 2007)

Table 8.1 Typical values of coefficient of permeability (k).

Soil type	*Description*		*k, m/s*	*Drainage*
Cobbles and boulders	Flow may be turbulent, Darcy's law may not be valid		1 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12}	Very good
Gravels	Coarse Clean	Uniformly graded coarse aggregate		
Gravel sand mixtures	Clean	Well graded without fines		Good
Sands	Clean, very fine Silty Stratified clay/silts	Fissured, desiccated, weathered clays Compacted clays – dry of optimum		
Silts	Homogeneous below zone of weathering			Poor
Clays		Compacted clays – wet of optimum		Practically impermeable
Artificial	Bituminous, cements stabilized soil Geosynthetic clay liner / Bentonite enriched soil concrete			

- Granular material is no longer considered free draining when the fines >15%.
- Granular material is often low permeability (if well compacted) when the fines >30%.

Table 8.3 Permeability based on Hazen's relationship.

Coarse grained size	>*Fine sands*		>*Medium sands*				>*Coarse sands*			
Effective grain size d_{10},mm	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Permeability ($k = Cd_{10}^2$)	10^{-4} m/s		10^{-3} m/s						10^{-2} m/s	
C = 0.10 (above equation)	1	4	0.9	1.6	2.5	3.6	4.9	6.4	0.8	1.0
C = 0.15	1.5	6	1.4	2.4	3.8	5.4	7.4	9.6	1,2	1.5

8.2.3 CLAY REACTIVITY

All samples are non-plastic with no reactivity based on linear shrink tests.

For the clay fraction testing indicates materials are:

- Non plastic; and
- Not susceptible to Linear shrinkage; being generally
- "Not reactive".

8.2.4 Geotechnical Assessment of Tailings Advance

We believe the mining cycle demand requiring 5m strip of tails to be pushed back into final landform can be achieved. This is based on test results taken for this assessment.

We understand that the tails will be discharged into the mine pit through a cyclone. The sand is likely to beach at (allow) 27° if discharged wet, steepening with drying, with the clay (slimes) fraction running out into the gap between the tails and mining face.

We believe the sand fraction will drain relatively quickly to allow handling into the final landform to meet the mining schedule. The clay fraction will take longer to dry but is a minor fraction in all cases so is not expected to drive the sequence.

We do not anticipate the drainage time to be significantly affected if the slimes are mixed into the tails at the point of discharge given the low fines fraction in most samples.

For the samples with higher slimes content (to 30%), at this stage we would anticipate the material would be blended through the mining cycle and that the resulting slimes content would not increase over say 15%. That would be unlikely to significantly affect the material drainage properties.

8.3 Safety in Design

NZ Health and Safety at Work Act (2015) requires consideration of Safety in Design with Section and Mine Safety Regulations. For the proposed mining method, principal hazards are:

- Stability of temporary slopes;
- Tailings inundation; and
- Flooding in the pit floor.

It is proposed to restrict personnel entry into the mining void, reducing exposure to the principal hazards and adequately mitigating risk.

8.4 Environmental Risk Due to Stability and Coastal Erosion

8.4.1 Open Pit Stability

The open pit is expected to be stable for the proposed configuration with no substantial ground displacement due to instability expected > 5m from the pit crest based on this study.

The coastal lagoon, Collins Creek, Northern Drain and property boundaries are at low to very low risk of being adversely affected due to mining during operations and for the finished landform.

8.4.2 COASTAL INTERACTION

The rehabilitated ground will be made up of hydraulically and mechanically placed tailings overlain by a clay cap placed and compacted by machines including oversize, finished to pasture for dairy use.

The resulting “engineered landform” is considered resilient from a geotechnical perspective considering earthquake, coastal process and weather.

There is a low to very low risk of adverse interaction with coastal processes for the proposed finished landform.

9 TAILINGS STORAGE

9.1 OVERVIEW

Tailings are proposed to be stored in the mining void. Tailings are:

- Are "clean" with no toxic potential;
  - Liners for containment are not required.
- Will be stored in the mine void which is:
  - Below ground level; with
  - No enclosing embankments; and
  - Freeboard always > 3m to ground level from final tailings surface as ~30% of the material is extracted as ore.
- Will be capped using overburden concurrent with mining advance, with the final surface finished to allow farming.

9.2 SITE ASSESSMENT

The geological setting including understanding of potential hazards is well known and meets the criteria for RMA (2015) Preliminary Geotechnical Assessment and the Global Industry on Tailings Management Topics 2 & 3 being relevant to this level of assessment.

9.3 NZSOLD PIC

The tailing storage facility is with Low Potential Impact Classification (PIC) in accordance with NZOLD (2015) Guidelines.

9.4 STABILITY

The stability of the tailings facility being within the mine void has been assessed:

- Considering seismic loads and liquefaction potential;
- Using limit equilibrium and Finite Element Methods (Section 6.4.2 & 6.4.3).

In all cases:

- Acceptable Factors of safety are achieved; and
- Deformation under earthquake loads and potential liquefaction is limited with no breach in freeboard likely.

9.5 RISK ASSESSMENT

A Potential Failure Mode Analysis (PFMA) is presented (Appendix C) focusing on geotechnical aspects of the tailing storage facility.

The work has been done in general accordance with:

- CDA (2019) Technical Bulletin on Tailings Dam Breach Analyses. Authors Martin, V et al Al-Mamun, M & Small, A.

Considering:

- NZSOLD (2015) Design Guidelines for Large Dams;
- Global Industry on Tailings Management (International Council on Mining and Metals et al., 2020);
- ANCOLD (2022) Recommendations for Tailings Dams;
- ICOLD 220131 Tailings Dam Safety Bulletin.

9.6 POTENTIAL FAILURE MODE ANALYSES

9.6.1.1 FRAMEWORK

CDA (2019) Technical bulletin for tailings dam analyses provides the framework to assess the hazard due to tailings dam breach.

Hazard due to tailings breach is controlled by supernatant water that leads to fluidised flow with more impact. A breach flow without supernatant water will not fluidise resulting in non-fluid flow (Landslide and Debris Flow) with less impact.

The CDA (2019) process flow diagram for tailings dam breach assessment is in Plate 1.

PLATE 1 TAILINGS BREACH ASSESSMENT PROCESS FLOW DIAGRAM

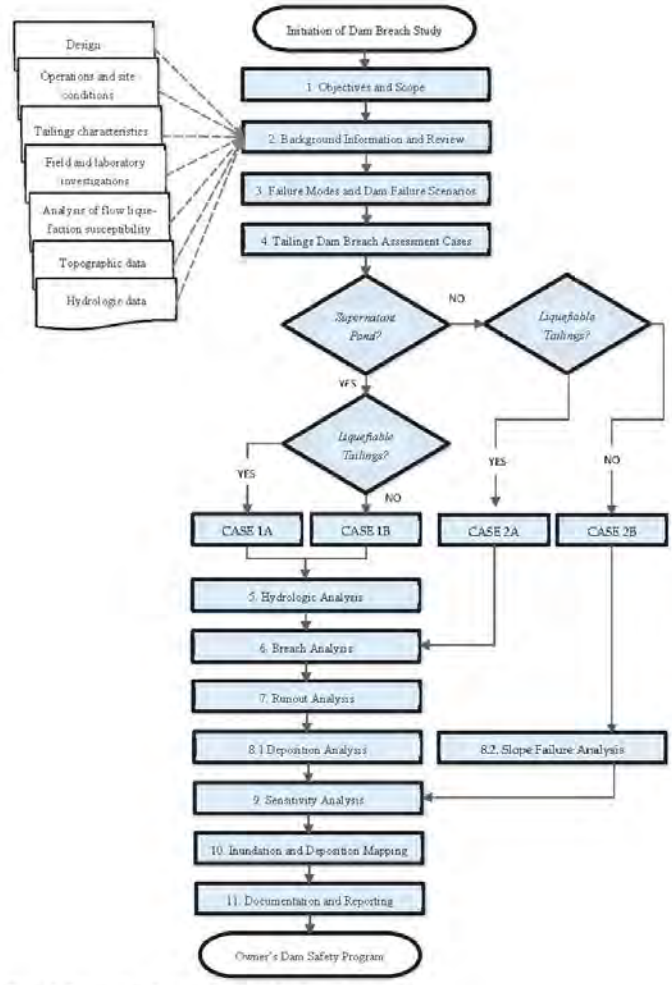


Figure 1. Process flow diagram for tailings dam breach assessments.

Description of the Tailings Dam Breach Assessment Case is in CDA (2019) (Plate 2).

PLATE 2 CDA (2019) TAILINGS DAM BREACH ASSESSMENT CASES

Table 1. Tailings dam breach assessment cases

Presence of supernatant pond near the dam	Potential for tailings runout as a result of flow liquefaction*	
	Yes	No
Yes	Case 1A – Liquefied Tailings with a Pond: Dam breach with flow of fluids and eroded and liquefied flowable tailings contributing additional volume of materials released	Case 1B – Non-Liquefied tailings with a Pond: Dam breach with eroded tailings, transported and deposited by the flow of fluids
No	Case 2A – Liquefied tailings without a Pond: Dam breach resulting from slope failure with mudflow or debris type flow of liquefied flowable tailings (depending on the degree of saturation)	Case 2B** – Non-Liquefied tailings without a Pond: Slope failure of the dam

* Flow liquefaction of tailings could be induced by any potential trigger (static or cyclic/seismic) including shear strains in the tailings as a result of the dam breach (e.g., lateral unloading).

** Hydrotechnical analyses or inundation mapping similar to other three cases would not be required for Case 2B. Landslide runout analysis may be more appropriate.

9.6.2 ASSUMPTIONS

The PFMA in this assessment assumes:

- Surface water flows are controlled by perimeter drains with no potential inflow to the mine void;
- Capping progresses with mining;
- There is no potential for supernatant ponding; so that
- There is no credible Rainy Day failure scenario.

9.7 POTENTIAL FAILURE MODES

The PFMA for the Barrytown storage facility is in Appendix C.

The facility presents a Low Risk of failure primarily because:

- The location is free of significant geological hazard;
- There is no credible rainy day failure mode as the site is surrounded by diversion drains, the tailings surface is always < 3m below ground level and tailings are capped and finished to the completed surface with advance;
- There is no significant risk of earthquake or liquefaction induced instability;
- There is no containment bund with tailings always stored < 3m below ground surface;
- There is no potential for piping.

9.8 RESIDUAL RISK

Residual risk require that the facility:

- Closure criteria are confirmed early in the project life;
- An adequate knowledge base including suitable environmental modelling and mine performance is maintained;
- Storage plans are reviewed if chemicals are introduced into the system;
- Diversion drains are maintained;
- Trigger Action Response Plans are developed considering principal hazards prior to the start of mining;
- Emergency Plans are developed prior to the start of mining;
- Suitable governance is maintained over the site for the life of the project.

9.9 INSPECTION AND MONITORING

- Suitable inspection and monitoring at this stage is simply for walkover and standard mine record keeping.
- Environmental compliance monitoring which will likely be required should also be captured as part of the tailings monitoring plan.

10 REFERENCES

- International Council on Mining and Metals, United Nations Environment Programme, & Principles for Responsible Investment. (2020). Global Industry Standard on Tailings Management. In Global Tailings Review. https://globaltailingsreview.org/wp-content/uploads/2020/08/global-industry-standard_EN.pdf
- Wells and Haverkamp (2020) Characterization of the Heavy Mineral Suite in a Holocene Beach Placer, Barrytown, New Zealand. Minerals 2020, 10, 86. https://doi.org/10.3390/min10020086.
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11 LIMITATIONS

- This report has been prepared for the particular purpose outlined in the project brief and no responsibility is accepted for the use of any part in other contexts or for any other purpose.
- No responsibility is accepted by Resource Development Consultants Ltd for inaccuracies in data supplied by others. Where data has been supplied by others, it has been assumed that this information is correct.
- This report is provided for sole use by the client and is confidential to the client and their professional advisors. No responsibility whatsoever for the contents of this report shall be accepted for any person other than the client.

12 CLOSURE

We trust this meets your current needs. Should you wish to discuss any aspect of the contents of this document please contact the undersigned on 06 877-1652.

Sincerely,

Prepared by: Approved by:

_____

C A Wylie
MSc; CMEngNZ; CPEng
Principal

1460000 1460500 1461000 1461500 1462000 1462500 1463000 1463500 1464000

5327500 5327000 5326500 5326000 5325500 5325000

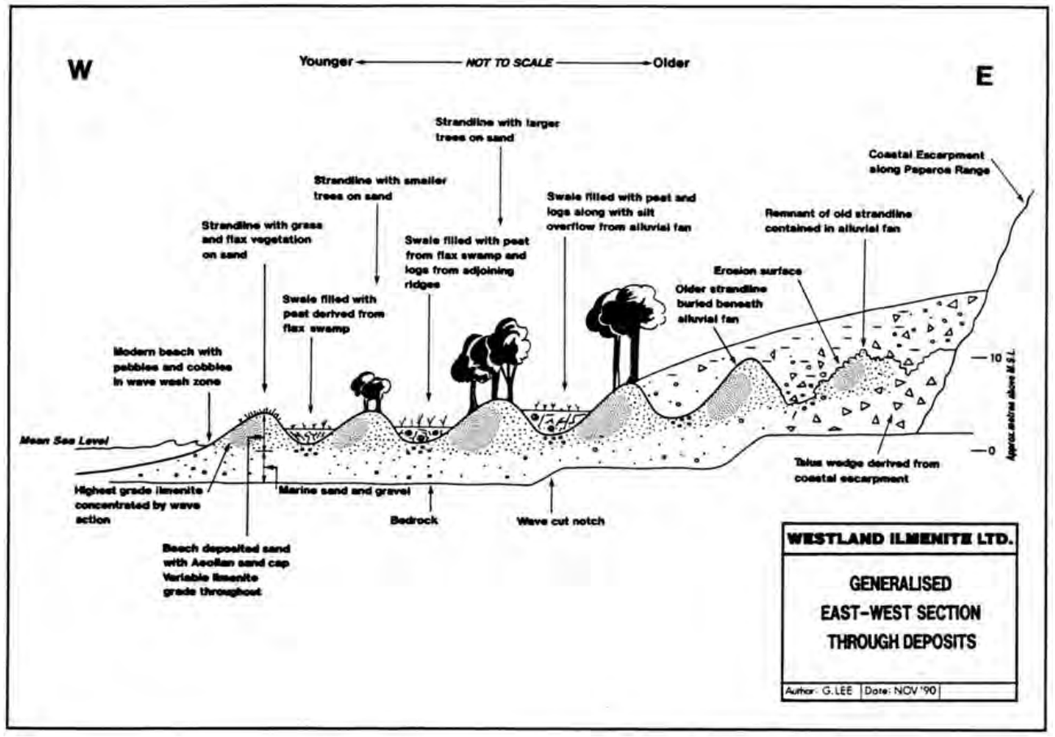
N

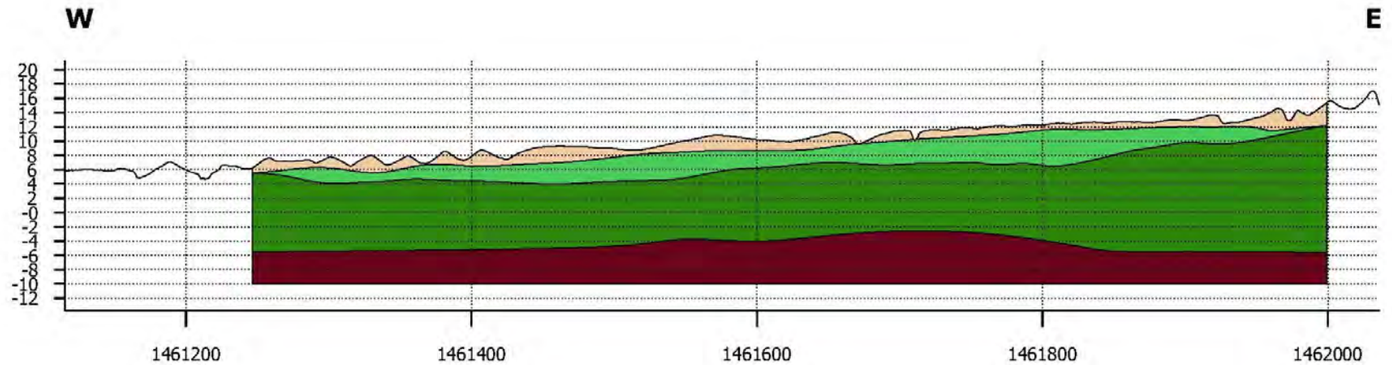
Legend

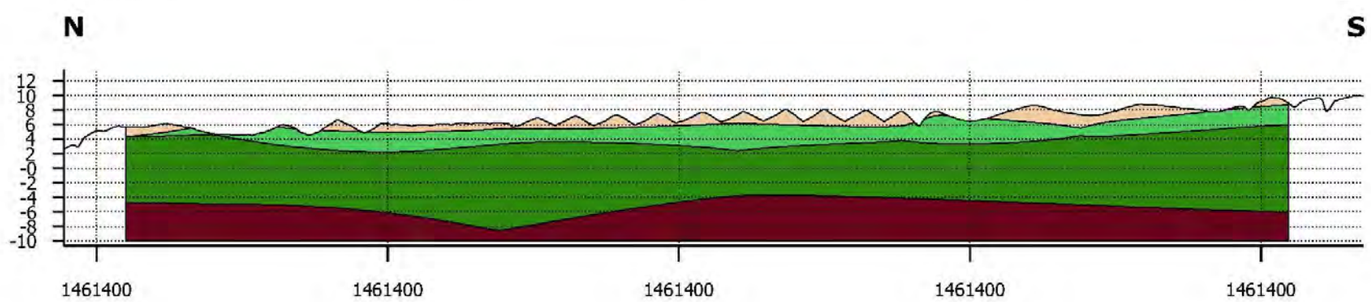
- Proposed Site Boundary
- Canoe Active Fault

100 0 100 200 300 400 500 m

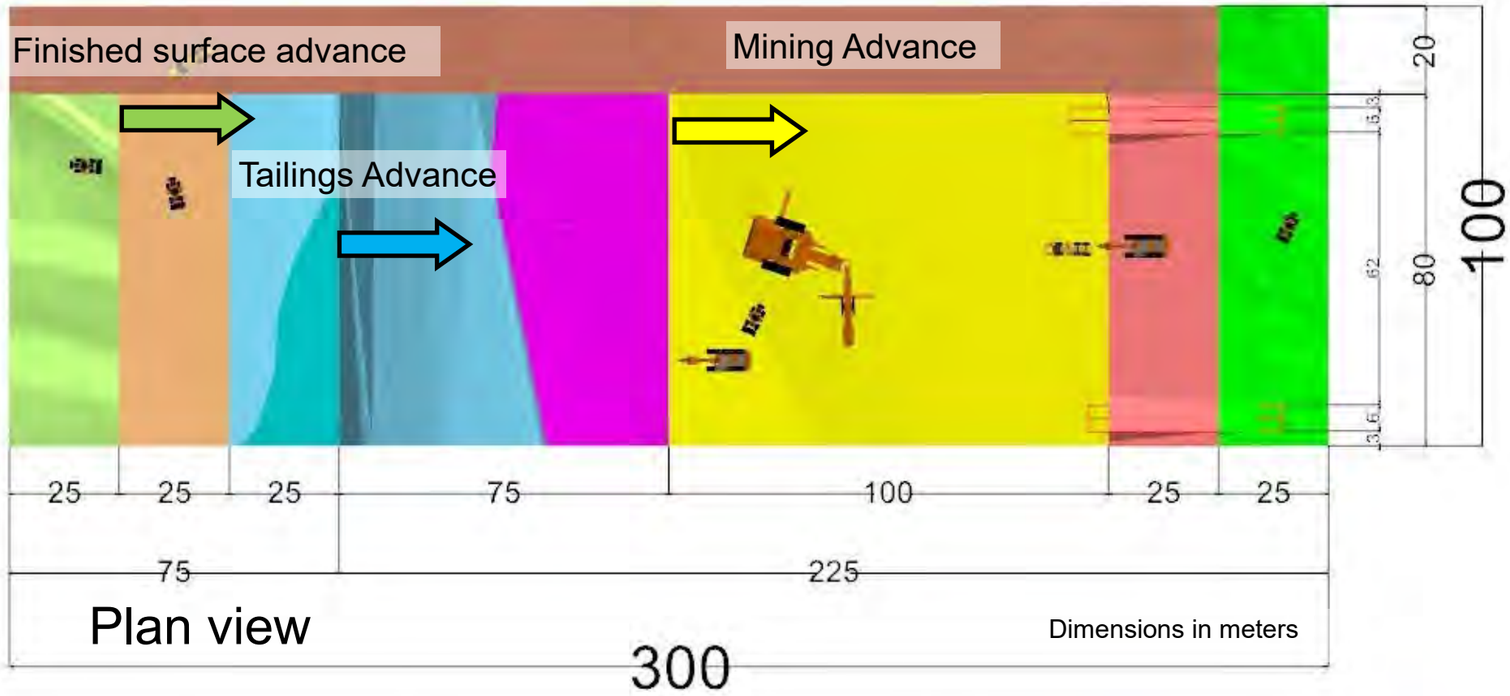
RDCL PO Box 28057 | 8/308 Queen St East Hastings NZ Tel: +64 6 8771652 | Fax: +64 6 877 5015 Email: info@rdcl.co.nz www.rdcl.co.nz	Title	Site Plan and Geohazards	Drawn By ID	Date 08/02/23	A3
	Project	Barrytown Mineral Sands Project	Checked By CW	Date 10/02/23	
	Client	TiGa Minerals and Metals Ltd	Approved By	Date	Figure 1

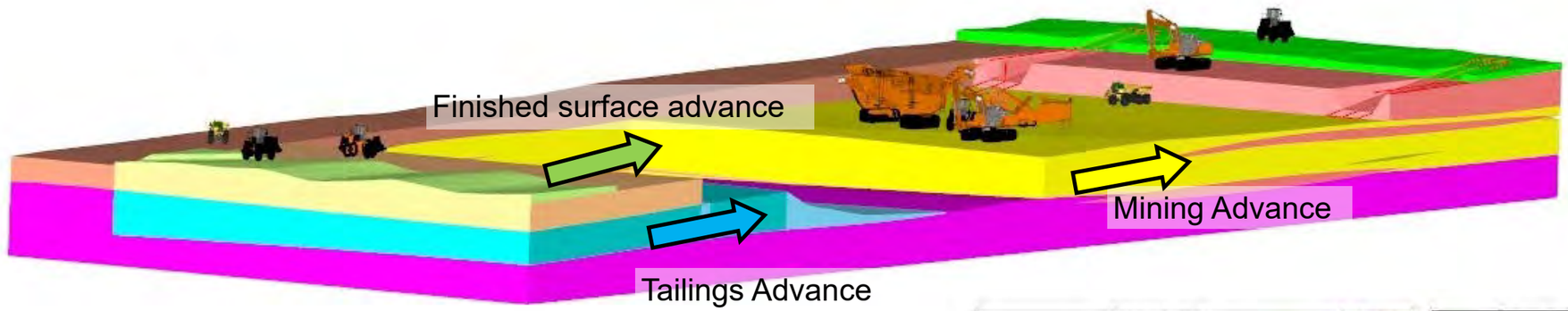






RDCL PO Box 28057 | 8/308 Queen St. East Hastings, NZ Tel: +64 6 8771652 | Fax: +64 6 877 5015 Email: info@rdcl.co.nz | www.rdcl.co.nz	Title: Geological Setting and Schematic Cross-sections (from RSC Consultants)	Drawn by:	Date:	Drawing Size - A3
	Project: Barrytown Mineral Sands Project	Approved by: CW	Date: 26/11/22	Figure Number
	Client: TiGa Minerals & Metals Ltd	RDCL Project No:	220986	02





Oblique view

Description	Color
Top soil grading	
Stripping	
Ore extraction	
Base gravel - No material movement	
Backfill sands - wet	
Backfill sands - dried	
Backfill top soil	
Backfill overburden	
Running Road	

Description	Color
Top Soil	
Overburden	
Sands	
Gravel	
Wet Tail	
Dried Tail	
Overburden Road	
Overburden Backfilled	
Top Soil Backfilled	

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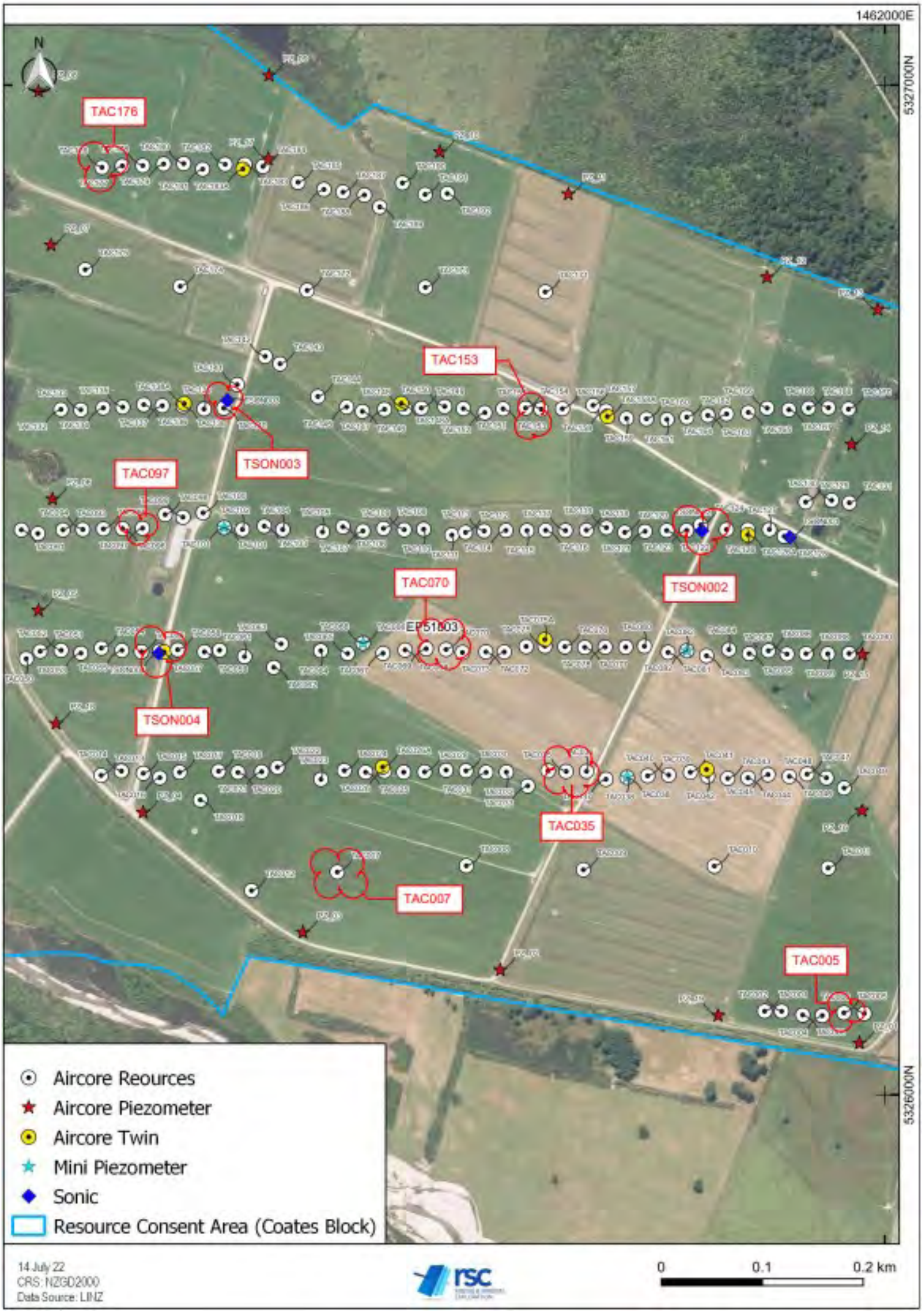
Hastings, NZ
Tel: +64 6 8771652 | Fax: +64 6 877 5015
Email: info@rdcl.co.nz | www.rdcl.co.nz

Title	Mining Method Schematics (all drawings from Palaris)	Drawn by: EL	Date: 10/22	Drawing Size - A3
Project	Barrytown Mineral Sands Project	Approved by: CW	Date: 26/11/22	Figure Number
Client	TiGa Minerals & Metals Ltd	RDCL Project No:	220986	3



RDCL	PO Box 28057 | 8/308 Queen St. East Hastings, NZ Tel: +64 8771652|Fax: +64 6 877 5015 Email: info@rdcl.co.nz | www.rdcl.co.nz	Title: Exploration Samples	Drawn by:		Drawing Size-A4
		Project: Barrytown Mineral Sands Project	Approved by: CW	Date: 26/11/22	Figure Number
		Client: TiGa Minerals & Metals Ltd	RDCL Project No:	220986	04

APPENDIX A
LABORATORY TEST RESULTS

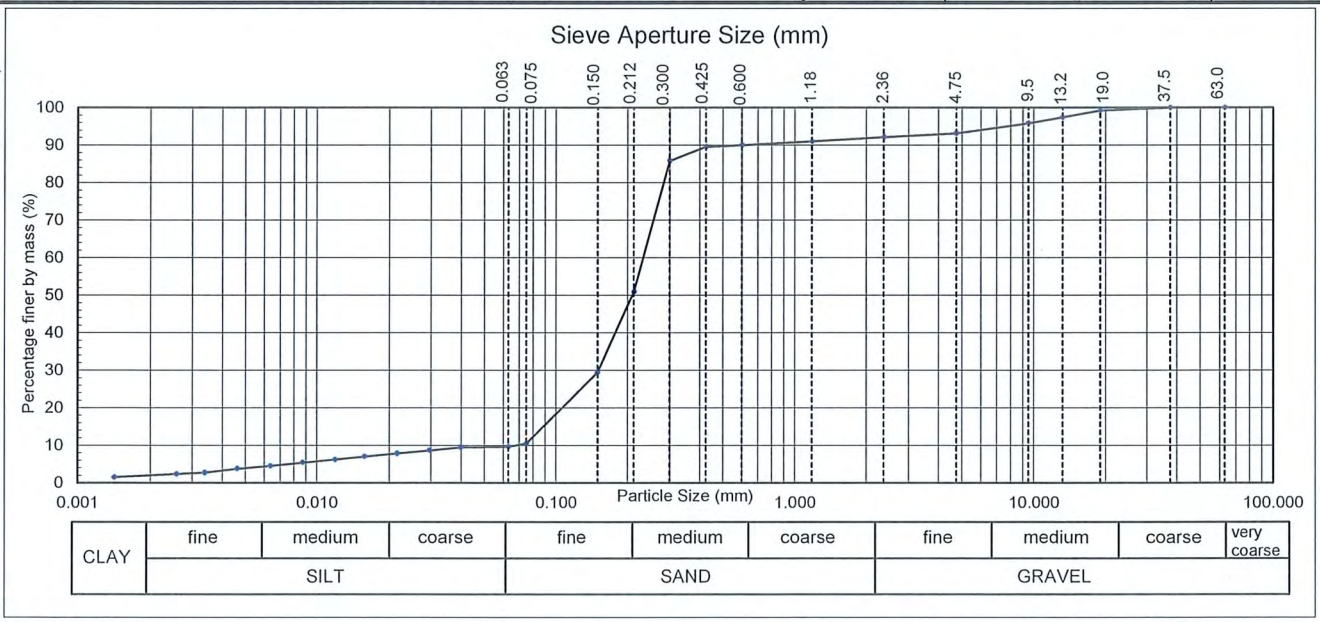
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Client/Sample Ref :	TAC007
Contractor :	Resource Development Consultants Limited

Sampled by :	Tom Bunny
Date received :	7 November 2022
Sampling method :	NZS 4402:1986 (Coarse)
Sample condition :	Damp as received
Sample description :	SAND with minor silt, gravel and trace clay
Solid Particle Density (t/m^3):	2.94 Tested
Water Content (as received):	0.5 %

Project No:	6-JRESD.16/6LC
Lab Ref No:	CH9468/5
Client Ref:	TAC007

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	93	0.300	86	0.0399	10	0.0064	4
37.5	100	2.36	92	0.212	51	0.0294	9	0.0046	4
19.0	99	1.18	91	0.150	29	0.0216	8	0.0034	3
13.2	97	0.600	90	0.075	11	0.0158	7	0.0026	2
9.5	96	0.425	90	0.063	10	0.0119	6	0.0014	2
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0087	5		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

This report may only be reproduced in full

Date Tested: 22 November 2022

Date Reported: 26 November 2022

IANZ Approved Signatory

Designation : *Laboratory Manager*

Date : 26 November 2022

ACCREDITED IANZ TESTING LABORATORY

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

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Telephone +64 3 343 0739
Website www.wsp.com/nz

DRY DENSITY / WATER CONTENT RELATIONSHIP
STANDARD COMPACTION

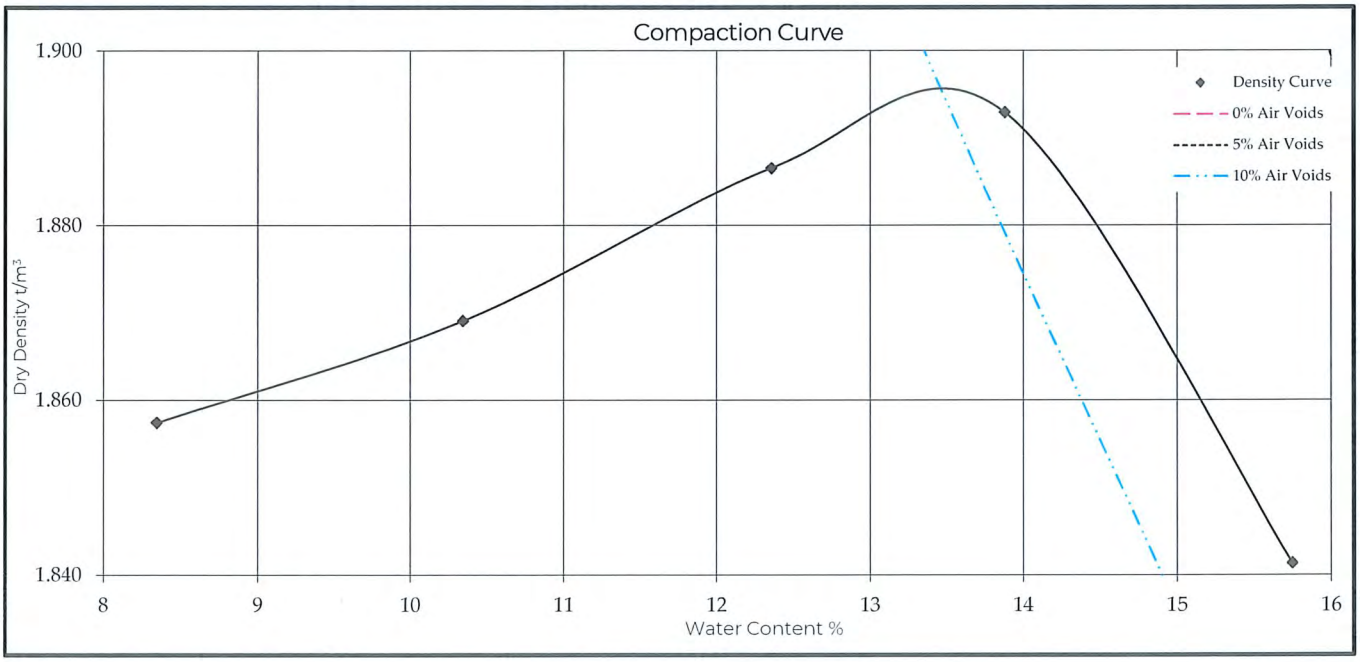
Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	Silty SAND witrh minor gravel and trace clay
Sample condition :	Damp as received
Solid density :	2.94 t/m³ (Tested)
Source :	TAC007

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/5
Client Ref No :	TAC007

Test Results

Maximum dry density	1.89	t/m³	Natural water content	0.5	%
Optimum water content	14.0	%	Fraction tested	Passing 19.0mm	

Sample ID		+8%	+10%	+12%	+14%	+16%	+18%	
Bulk density	t/m³	2.012	2.062	2.120	2.156	2.131	2.095	
Water content	%	8.3	10.3	12.4	13.9	15.8	17.3	
Dry density	t/m³	1.857	1.869	1.887	1.893	1.841	1.785	
Sample condition		Wet Firm	Wet Firm	Wet Firm	Wet Firm	Wet Soft	Saturated Soft	



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	All information supplied by Client

Date tested : 21 November 2022
Date reported : 26 November 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 26 November 2022

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SOLID DENSITY OF SOIL PARTICLES TEST REPORT

Project :	**Barrytown Mineral Sands Tailings**
Location :	**Barrytown West Coast**
Client :	**Resource Development Consultants Limited**
Contractor :	**Resource Development Consultants Limited**
Sampled by :	**Tom Bunny**
Date sampled :	**17 October 2022**
Sampling method :	**NZS 4402: 1986 (Coarse)**
Sample description :	**SAND with minor silt, gravel and trace clay**
Sample condition :	**Dry as received**
Source:	**TAC007**

Project No :	**6-JRESD.16/6LC**
Lab Ref No :	**CH9468/5**
Client Ref No :	**TAC007**

Test Results

Solid Density (t/m³): 2.94

Test Method: Determination of the Solid Density of Soil Particles NZS 4402 : 1986 : Test 2.7.1 (Passing 19.0mm)

Date tested : 21 November 2022
Date reported : 26 November 2022

Approved

Designation : *Laboratory Manager*
Date : 26 November 2022

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Quality Management Systems Certified to ISO 9001

52C Hayton Rd, Wigram
PO Box 1482, Christchurch Mail Centre,
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Telephone +64 3 343 0739
Facsimile
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PLASTICITY INDEX FOR AGGREGATES
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with minor silt, gravel and trace clay
Sample condition :	As Received
Source :	TAC007

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/5
Client Ref No :	TAC007

Test Results	
Client Ref No :	TAC007
Cone penetration limit :	23
Plastic limit :	Unable to Roll Threads
Plasticity index :	NP
Sample fraction :	Fraction passing 425µm test sieve
As received water content :	0.5

Test Methods	
Water Content	NZS 4407 : 2015 Test 3.1
Cone Penetration	NZS 4407 : 2015 : Test 3.2
Plastic Limit	NZS 4407 : 2015 : Test 3.3
Plasticity Index	NZS 4407 : 2015 : Test 3.4

Date tested : 22 November 2022
Date reported : 26 November 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
This report may only be reproduced in full
All information supplied by Client

IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 26 November 2022

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LINEAR SHRINKAGE TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with minor silt, gravel and trace clay
Sample condition :	Dry as received
Source:	TAC007

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/5
Client Ref No :	TAC007

Test Results	
Linear Shrinkage (%):	0

Test Methods		Notes
Linear Shrinkage	NZS 4402 : 1986, Test 2.6	Materials used: Passing 425um sieve

Date tested : 22 November 2022
Date reported : 26 November 2022

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IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 26 November 2022

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Website www.wsp-opus.co.nz

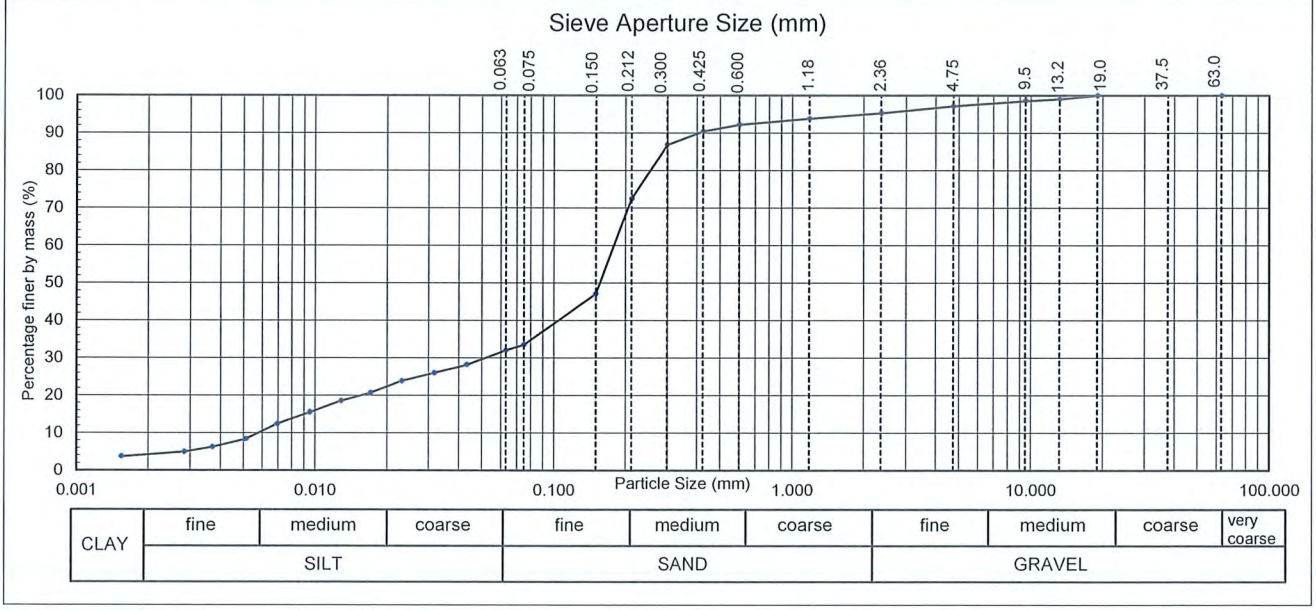
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Client/Sample Ref :	TAC035
Contractor :	Resource Development Consultants Limited

Sampled by :	Tom Bunny
Date received :	7 November 2022
Sampling method :	NZS 4402:1986 (Coarse)
Sample condition :	Damp as received
Sample description :	Silty SAND with trace gravel and clay
Solid Particle Density (t/m^3):	2.68 Tested
Water Content (as received):	0.2 %

Project No:	6-JRESD.16/6LC
Lab Ref No:	CH9468/6
Client Ref:	TAC035

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	97	0.300	87	0.0431	28	0.0069	12
37.5	--	2.36	95	0.212	72	0.0316	26	0.0051	8
19.0	100	1.18	94	0.150	47	0.0231	24	0.0037	6
13.2	99	0.600	92	0.075	34	0.0170	21	0.0028	5
9.5	99	0.425	90	0.063	32	0.0128	19	0.0015	4
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0095	15		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

Date Tested: 23 November 2022

Date Reported: 29 November 2022

IANZ Approved Signatory

Designation : *Laboratory Manager*

Date : 29 November 2022

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Website www.wsp.com/nz

DRY DENSITY / WATER CONTENT RELATIONSHIP
STANDARD COMPACTION

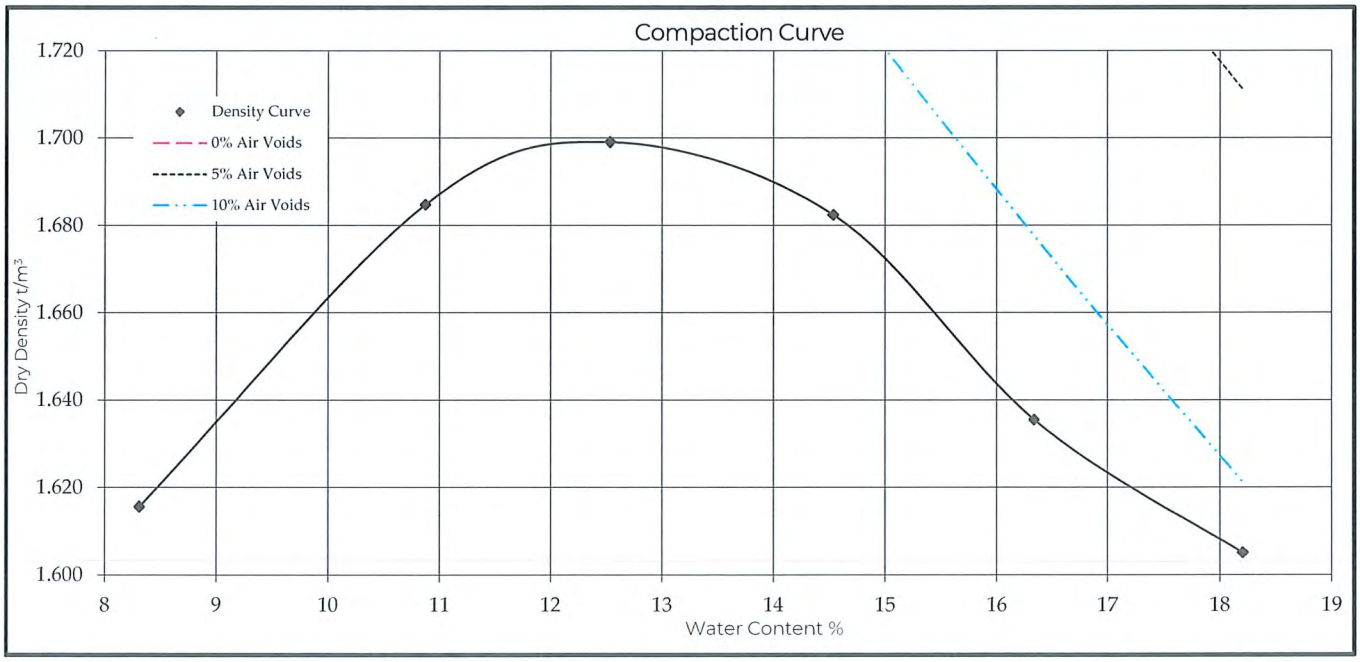
Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	Silty SAND with trace gravel and clay
Sample condition :	Damp as received
Solid density :	2.68 t/m³ (Tested)
Source :	TAC035

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/6
Client Ref No :	TAC035

Test Results

Maximum dry density	1.70	t/m³	Natural water content	0.2	%
Optimum water content	12.0	%	Fraction tested	Passing 19.0mm	

Sample ID		+8%	+10%	+12%	+14%	+16%	+18%	
Bulk density	t/m³	1.750	1.868	1.912	1.927	1.903	1.897	
Water content	%	8.3	10.9	12.5	14.5	16.3	18.2	
Dry density	t/m³	1.616	1.685	1.699	1.682	1.635	1.605	
Sample condition		Wet Firm	Wet Firm	Wet Firm	Wet Firm	Wet Soft	Saturated Soft	



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	All information supplied by Client

Date tested : 22 November 2022
Date reported : 29 November 2022

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IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 29 November 2022

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8140, Christchurch, New Zealand

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SOLID DENSITY OF SOIL PARTICLES TEST REPORT

Project :	**Barrytown Mineral Sands Tailings**
Location :	**Barrytown West Coast**
Client :	**Resource Development Consultants Limited**
Contractor :	**Resource Development Consultants Limited**
Sampled by :	**Tom Bunny**
Date sampled :	**17 October 2022**
Sampling method :	**NZS 4402: 1986 (Coarse)**
Sample description :	**Silty SAND with trace gravel and clay**
Sample condition :	**Dry as received**
Source:	**TAC035**

Project No :	**6-JRESD.16/6LC**
Lab Ref No :	**CH9468/6**
Client Ref No :	**TAC035**

Test Results

Solid Density (t/m³): 2.68

Test Method: Determination of the Solid Density of Soil Particles NZS 4402 : 1986 : Test 2.7.1 (Passing 19.0mm)

Date tested : 23 November 2022
Date reported : 29 November 2022 **This report may only be reproduced in full**

Approved

Designation : *Laboratory Manager*
Date : 29 November 2022

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PO Box 1482, Christchurch Mail Centre,
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Facsimile
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PLASTICITY INDEX FOR AGGREGATES
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	Silty SAND with trace gravel and clay
Sample condition :	As Received
Source :	TAC035

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/6
Client Ref No :	TAC035

Test Results	
Client Ref No :	TAC035
Cone penetration limit :	30
Plastic limit :	Unable to Roll Threads
Plasticity index :	NP
Sample fraction :	Fraction passing 425µm test sieve
As received water content :	0.2

Test Methods	
Water Content	NZS 4407 : 2015 Test 3.1
Cone Penetration	NZS 4407 : 2015 : Test 3.2
Plastic Limit	NZS 4407 : 2015 : Test 3.3
Plasticity Index	NZS 4407 : 2015 : Test 3.4

Date tested : 22 November 2022
Date reported : 29 November 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
This report may only be reproduced in full
All information supplied by Client

IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 29 November 2022

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52C Hayton Rd
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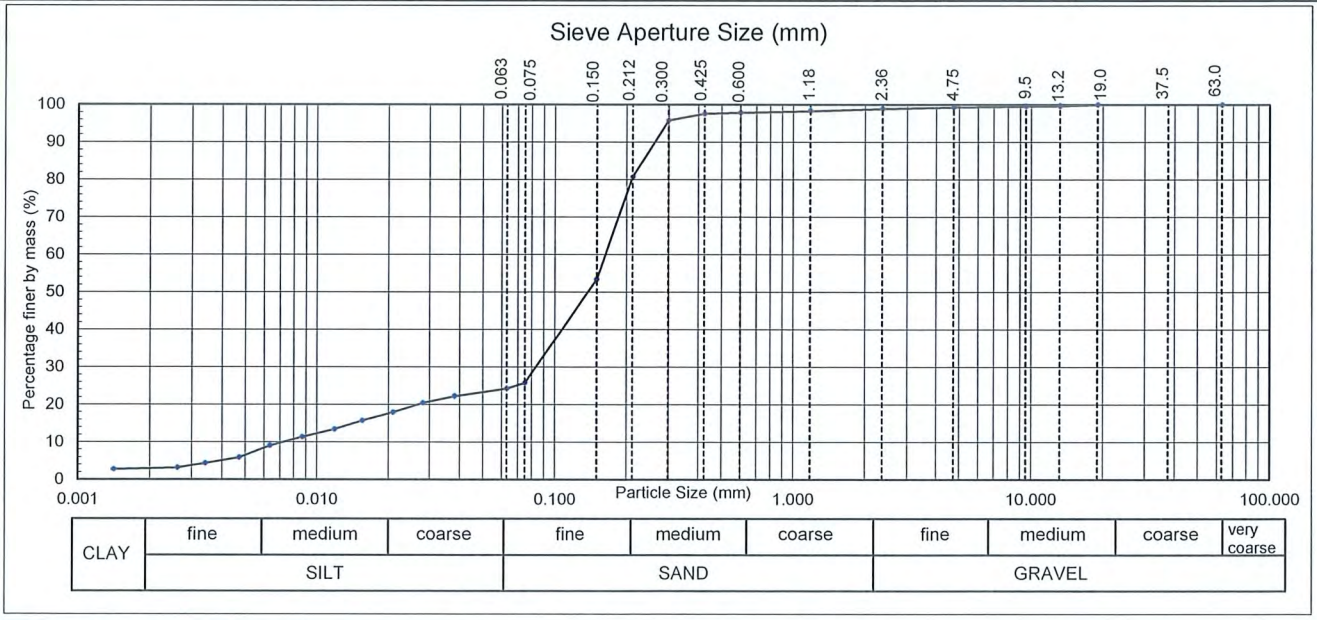
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Client/Sample Ref :	TAC070
Contractor :	Resource Development Consultants Limited

Sampled by :	Tom Bunny
Date received :	7 November 2022
Sampling method :	NZS 4402:1986 (Coarse)
Sample condition :	Damp as received
Sample description :	Silty SAND with trace gravel and clay
Solid Particle Density (t/m^3):	3.00 Tested
Water Content (as received):	0.1 %

Project No:	6-JRESD.16/6LC
Lab Ref No:	CH9468/7
Client Ref:	TAC070

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	99	0.300	96	0.0381	22	0.0063	9
37.5	--	2.36	99	0.212	81	0.0281	20	0.0047	6
19.0	100	1.18	98	0.150	53	0.0209	18	0.0034	4
13.2	100	0.600	98	0.075	26	0.0155	16	0.0026	3
9.5	100	0.425	98	0.063	24	0.0118	13	0.0014	3
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0087	11		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

This report may only be reproduced in full

Date Tested: 23 November 2022

Date Reported: 29 November 2022

IANZ Approved Signatory

Designation : *Laboratory Manager*

Date : 29 November 2022

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DRY DENSITY / WATER CONTENT RELATIONSHIP
STANDARD COMPACTION

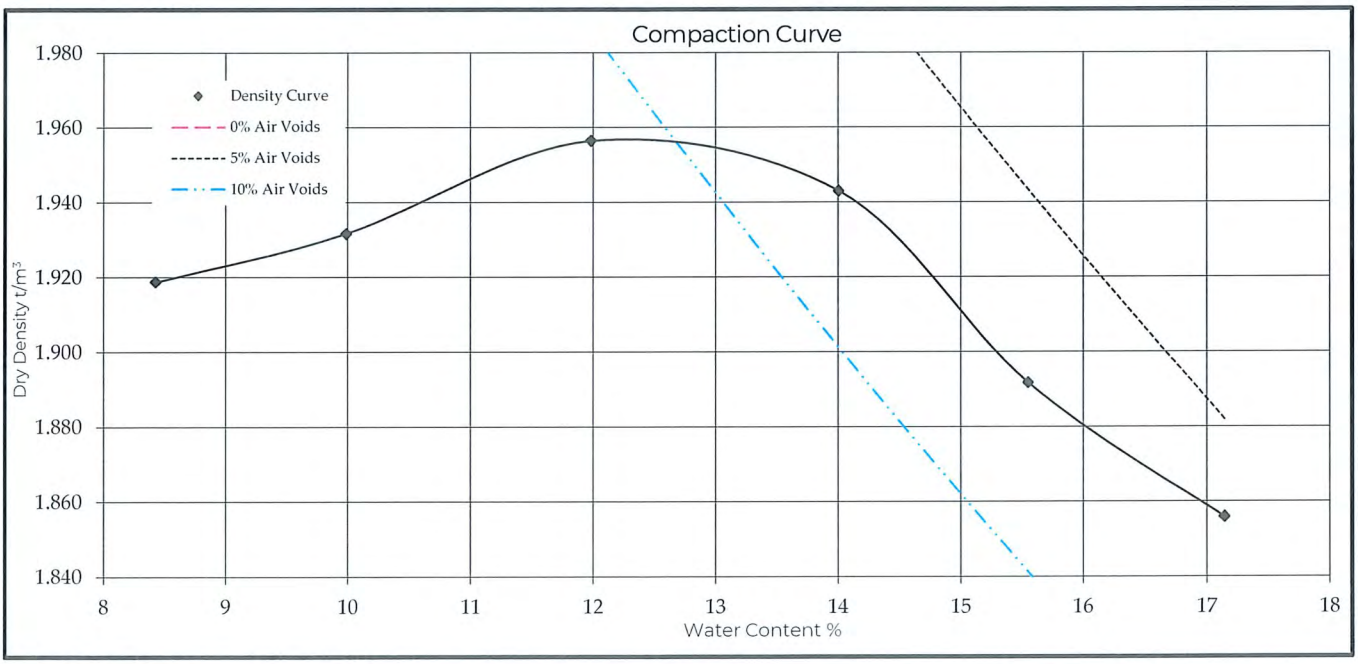
Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	Silty SAND with trace gravel and clay
Sample condition :	Damp as received
Solid density :	3.00 t/m³ (Tested)
Source :	TAC070

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/7
Client Ref No :	TAC070

Test Results

Maximum dry density	1.96	t/m³	
Optimum water content	12.0	%	
Natural water content	0.1	%	
Fraction tested	Passing 19.0mm		

Sample ID		+8%	+10%	+12%	+14%	+16%	+18%	
Bulk density	t/m³	2.081	2.125	2.191	2.215	2.186	2.174	
Water content	%	8.4	10.0	12.0	14.0	15.6	17.1	
Dry density	t/m³	1.919	1.932	1.956	1.943	1.892	1.856	
Sample condition		Wet Firm	Wet Firm	Wet Firm	Wet Firm	Wet Soft	Saturated Soft	



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	All information supplied by Client

Date tested : 21 November 2022
Date reported : 29 November 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 29 November 2022

ACCREDITED IANZ TESTING LABORATORY

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8140, Christchurch, New Zealand

Telephone +64 3 343 0739
Website www.wsp.com/nz

SOLID DENSITY OF SOIL PARTICLES TEST REPORT

Project :	**Barrytown Mineral Sands Tailings**
Location :	**Barrytown West Coast**
Client :	**Resource Development Consultants Limited**
Contractor :	**Resource Development Consultants Limited**
Sampled by :	**Tom Bunny**
Date sampled :	**17 October 2022**
Sampling method :	**NZS 4402: 1986 (Coarse)**
Sample description :	**Silty SAND with trace gravel and clay**
Sample condition :	**Dry as received**
Source:	**TAC070**

Project No :	**6-JRESD.16/6LC**
Lab Ref No :	**CH9468/7**
Client Ref No :	**TAC070**

Test Results

Solid Density (t/m³): 3.00

Test Method: Determination of the Solid Density of Soil Particles NZS 4402 : 1986 : Test 2.7.1 (Passing 19.0mm)

Date tested : 24 November 2022
Date reported : 29 November 2022

Approved

Designation : *Laboratory Manager*
Date : 29 November 2022

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Facsimile
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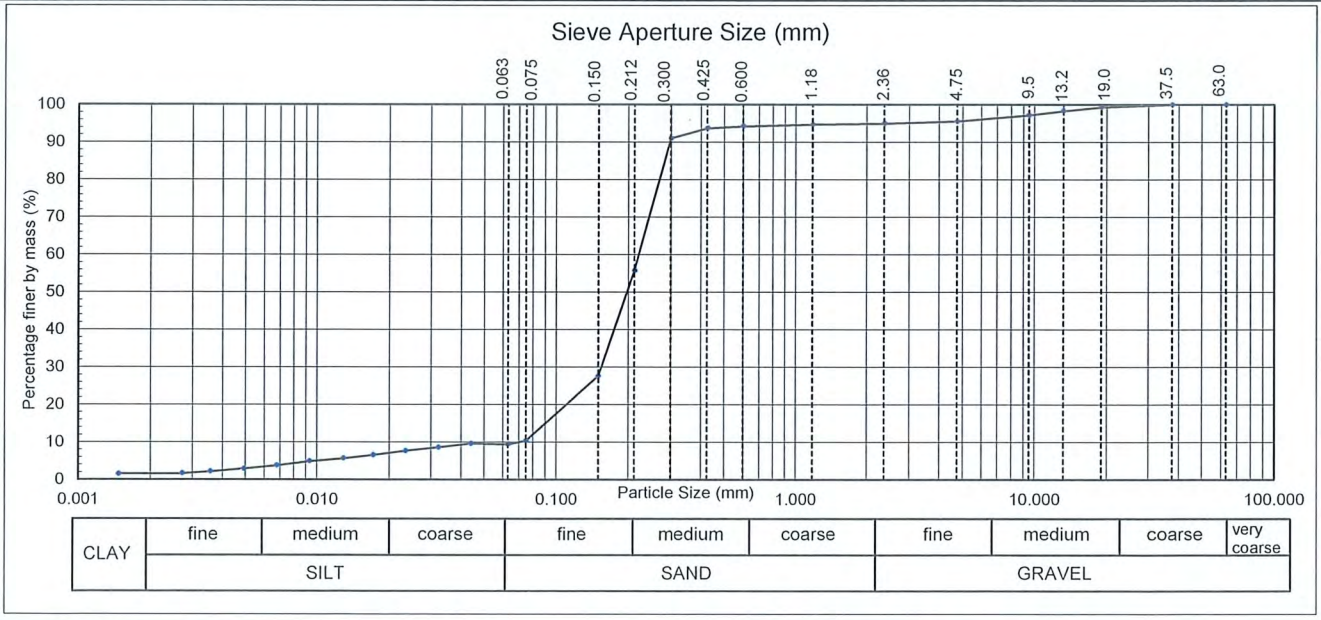
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Client/Sample Ref :	TAC097
Contractor :	Resource Development Consultants Limited

Sampled by :	Tom Bunny
Date received :	7 November 2022
Sampling method :	NZS 4402:1986 (Coarse)
Sample condition :	Damp as received
Sample description :	SAND with some silt, trace gravel and clay
Solid Particle Density (t/m^3):	2.86 Tested
Water Content (as received):	0.2 %

Project No:	6-JRESD.16/6LC
Lab Ref No:	CH9468/8
Client Ref:	TAC097

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	96	0.300	91	0.0440	10	0.0068	4
37.5	100	2.36	95	0.212	56	0.0322	9	0.0049	3
19.0	99	1.18	95	0.150	28	0.0234	8	0.0035	2
13.2	98	0.600	94	0.075	10	0.0172	7	0.0027	2
9.5	97	0.425	94	0.063	9	0.0129	6	0.0015	2
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0093	5		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

Date Tested: 23 November 2022

Date Reported: 30 November 2022

IANZ Approved Signatory

Designation : *Laboratory Manager*

Date : 30 November 2022

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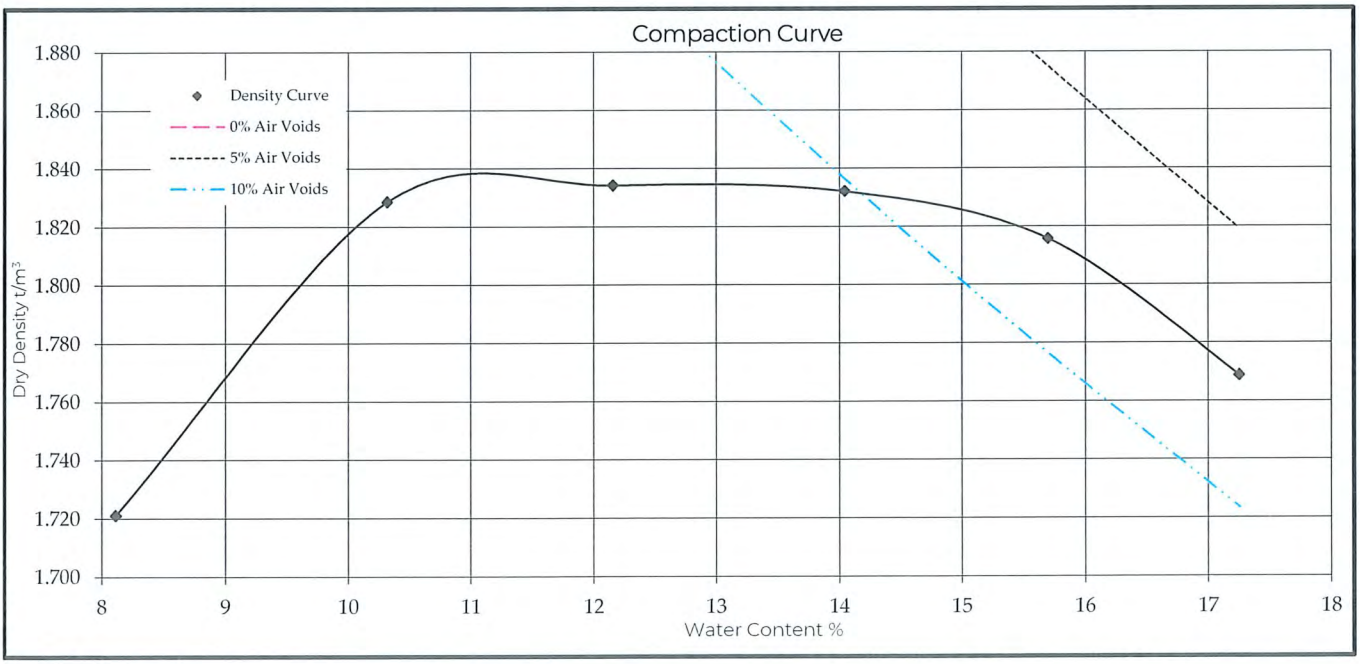
DRY DENSITY / WATER CONTENT RELATIONSHIP
STANDARD COMPACTION

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with some silt, trace gravel and clay
Sample condition :	Damp as received
Solid density :	2.86 t/m³ (Tested)
Source :	TAC097

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/8
Client Ref No :	TAC097

Test Results

Maximum dry density	1.84 t/m³			Natural water content	0.2 %	
Optimum water content	11.0 %			Fraction tested	Passing 19.0mm	
Sample ID	+8%	+10%	+12%	+14%	+16%	+18%
Bulk density t/m³	1.861	2.017	2.057	2.089	2.101	2.074
Water content %	8.1	10.3	12.2	14.0	15.7	17.3
Dry density t/m³	1.721	1.829	1.834	1.832	1.816	1.769
Sample condition	Wet Firm	Wet Firm	Wet Firm	Wet Firm	Wet Soft	Saturated Soft



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	All information supplied by Client

Date tested : 29 November 2022
Date reported : 30 November 2022

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Designation : *Laboratory Manager*
Date : 30 November 2022

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8140, Christchurch, New Zealand
Telephone +64 3 343 0739
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SOLID DENSITY OF SOIL PARTICLES TEST REPORT

Project :	**Barrytown Mineral Sands Tailings**
Location :	**Barrytown West Coast**
Client :	**Resource Development Consultants Limited**
Contractor :	**Resource Development Consultants Limited**
Sampled by :	**Tom Bunny**
Date sampled :	**17 October 2022**
Sampling method :	**NZS 4402: 1986 (Coarse)**
Sample description :	**SAND with some silt, trace gravel and clay**
Sample condition :	**Dry as received**
Source:	**TAC097**

Project No :	**6-JRESD.16/6LC**
Lab Ref No :	**CH9468/8**
Client Ref No :	**TAC097**

Test Results

Solid Density (t/m³): 2.86

Test Method: Determination of the Solid Density of Soil Particles NZS 4402 : 1986 : Test 2.7.1 (Passing 19.0mm)

Date tested : 24 November 2022
Date reported : 30 November 2022

Approved

Designation : *Laboratory Manager*
Date : 30 November 2022

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Quality Management Systems Certified to ISO 9001

52C Hayton Rd, Wigram
PO Box 1482, Christchurch Mail Centre,
Christchurch 8140, New Zealand

Telephone +64 3 343 0739
Facsimile
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PLASTICITY INDEX FOR AGGREGATES
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with some silt, trace gravel and clay
Sample condition :	As Received
Source :	TAC097

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/8
Client Ref No :	TAC097

Test Results	
Client Ref No :	TAC097
Cone penetration limit :	26
Plastic limit :	Unable to Roll Threads
Plasticity index :	NP
Sample fraction :	Fraction passing 425µm test sieve
As received water content :	0.2

Test Methods	
Water Content	NZS 4407 : 2015 Test 3.1
Cone Penetration	NZS 4407 : 2015 : Test 3.2
Plastic Limit	NZS 4407 : 2015 : Test 3.3
Plasticity Index	NZS 4407 : 2015 : Test 3.4

Date tested : 25 November 2022
Date reported : 30 November 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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All information supplied by Client

IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 30 November 2022

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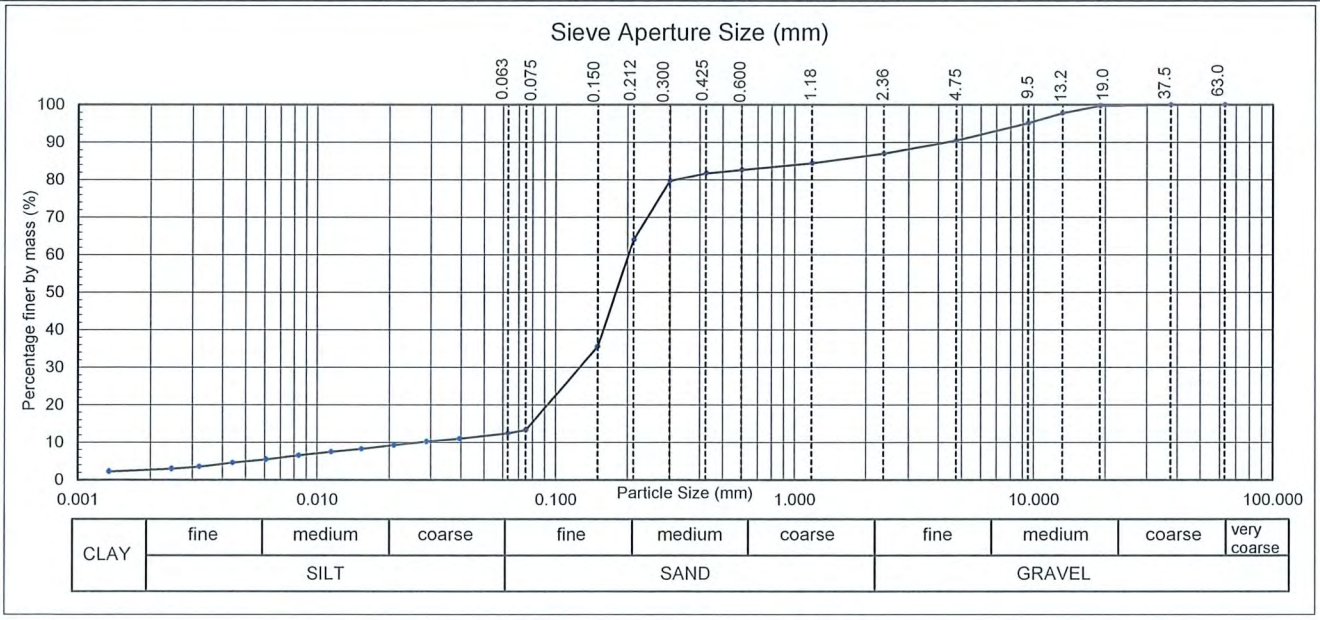
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Client/Sample Ref :	TAC153
Contractor :	Resource Development Consultants Limited

Sampled by :	Tom Bunny
Date received :	7 November 2022
Sampling method :	NZS 4402:1986 (Coarse)
Sample condition :	Damp as received
Sample description :	SAND with some gravel, minor silt and trace clay
Solid Particle Density (t/m^3):	3.16 Tested
Water Content (as received):	0.2 %

Project No:	6-JRESD.16/6LC
Lab Ref No:	CH9468/9
Client Ref:	TAC153

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	91	0.300	80	0.0394	11	0.0061	6
37.5	100	2.36	87	0.212	64	0.0286	10	0.0044	5
19.0	100	1.18	84	0.150	36	0.0209	9	0.0032	4
13.2	98	0.600	83	0.075	13	0.0153	8	0.0024	3
9.5	95	0.425	82	0.063	12	0.0115	7	0.0013	2
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0083	7		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

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Date Tested: 29 November 2022

Date Reported: 30 November 2022

IANZ Approved Signatory

Designation : *Laboratory Manager*

Date : 30 November 2022

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DRY DENSITY / WATER CONTENT RELATIONSHIP
STANDARD COMPACTION

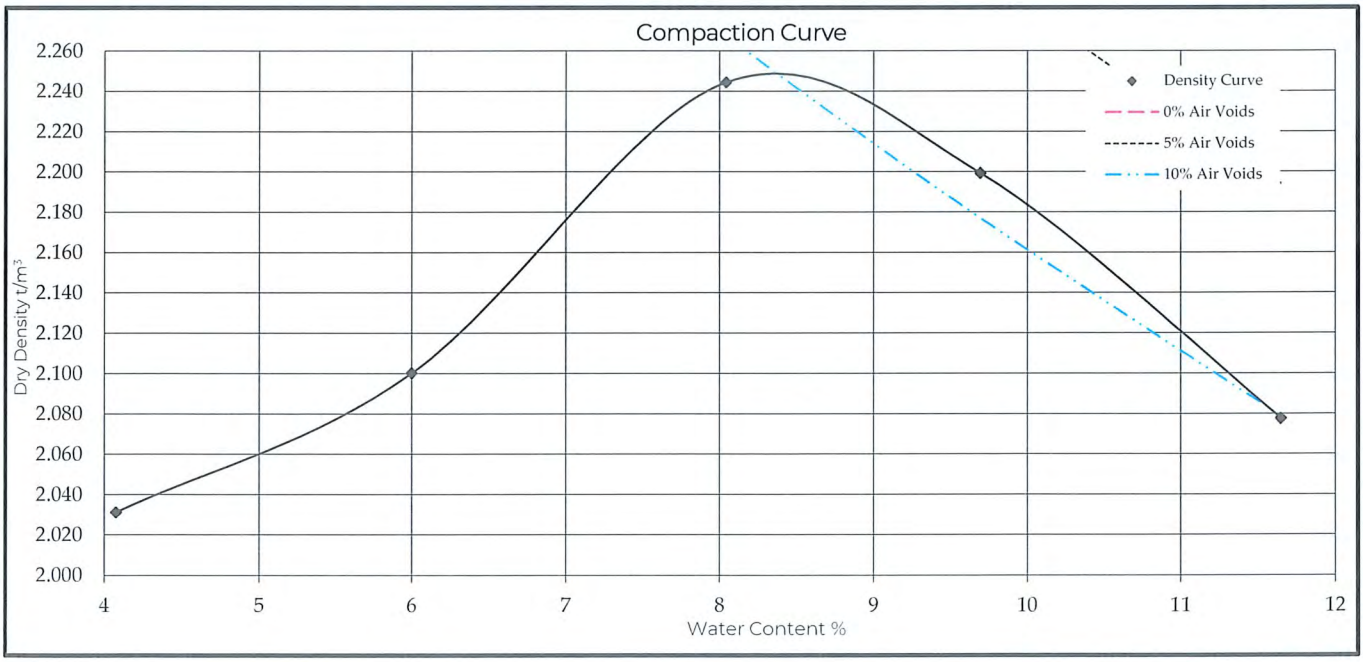
Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with some gravel, minor silt and trace clay
Sample condition :	Damp as received
Solid density :	3.16 t/m³ (Tested)
Source :	TAC153

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/9
Client Ref No :	TAC153

Test Results

Maximum dry density	2.24	t/m³	Natural water content	0.2	%
Optimum water content	8.0	%	Fraction tested	Passing 19.0mm	

Sample ID		+4%	+6%	+8%	+10%	+12%		
Bulk density	t/m³	2.114	2.226	2.425	2.413	2.320		
Water content	%	4.1	6.0	8.0	9.7	11.7		
Dry density	t/m³	2.031	2.100	2.244	2.199	2.078		
Sample condition		Moist Firm	Wet Firm	Wet Firm	Wet Soft	Saturated Soft		



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	All information supplied by Client

Date tested : 24 November 2022
Date reported : 30 November 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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Designation : *Laboratory Manager*
Date : 30 November 2022

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SOLID DENSITY OF SOIL PARTICLES TEST REPORT

Project :	**Barrytown Mineral Sands Tailings**
Location :	**Barrytown West Coast**
Client :	**Resource Development Consultants Limited**
Contractor :	**Resource Development Consultants Limited**
Sampled by :	**Tom Bunny**
Date sampled :	**17 October 2022**
Sampling method :	**NZS 4402: 1986 (Coarse)**
Sample description :	**SAND with some gravel, minor silt and trace clay**
Sample condition :	**Dry as received**
Source:	**TAC153**

Project No :	**6-JRESD.16/6LC**
Lab Ref No :	**CH9468/9**
Client Ref No :	**TAC153**

Test Results

Solid Density (t/m³): 3.16

Test Method: Determination of the Solid Density of Soil Particles NZS 4402 : 1986 : Test 2.7.1 (Passing 19.0mm)

Date tested : 28 November 2022
Date reported : 30 November 2022

Approved

Designation : *Laboratory Manager*
Date : 30 November 2022

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PO Box 1482, Christchurch Mail Centre,
Christchurch 8140, New Zealand

Telephone +64 3 343 0739
Facsimile
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PLASTICITY INDEX FOR AGGREGATES
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with some gravel, minor silt and trace clay
Sample condition :	As Received
Source :	TAC153

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/9
Client Ref No :	TAC153

Test Results	
Client Ref No :	TAC153
Cone penetration limit :	18
Plastic limit :	Unable to Roll Threads
Plasticity index :	NP
Sample fraction :	Fraction passing 425µm test sieve
As received water content :	0.2

Test Methods	
Water Content	NZS 4407 : 2015 Test 3.1
Cone Penetration	NZS 4407 : 2015 : Test 3.2
Plastic Limit	NZS 4407 : 2015 : Test 3.3
Plasticity Index	NZS 4407 : 2015 : Test 3.4

Date tested : 30 November 2022
Date reported : 1 December 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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All information supplied by Client

IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 1 December 2022

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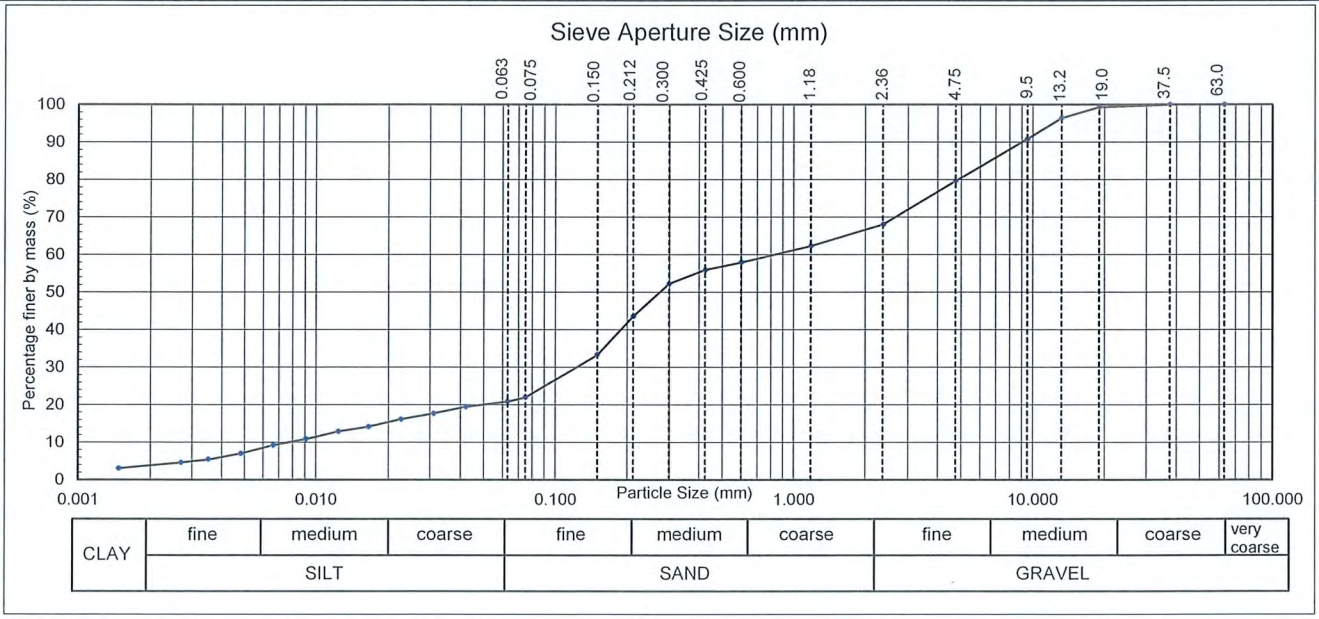
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Client/Sample Ref :	TAC170
Contractor :	Resource Development Consultants Limited

Sampled by :	Tom Bunny
Date received :	7 November 2022
Sampling method :	NZS 4402:1986 (Coarse)
Sample condition :	Damp as received
Sample description :	Gravelly SAND with some silt and trace clay
Solid Particle Density (t/m^3):	2.82 Tested
Water Content (as received):	0.3 %

Project No:	6-JRESD.16/6LC
Lab Ref No:	CH9468/10
Client Ref:	TAC170

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	80	0.300	52	0.0421	19	0.0066	9
37.5	100	2.36	68	0.212	44	0.0309	18	0.0048	7
19.0	99	1.18	62	0.150	33	0.0226	16	0.0035	5
13.2	96	0.600	58	0.075	22	0.0166	14	0.0027	5
9.5	91	0.425	56	0.063	21	0.0124	13	0.0015	3
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0091	11		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

This report may only be reproduced in full

Date Tested: 29 November 2022

Date Reported: 30 November 2022

IANZ Approved Signatory

Designation : *Laboratory Manager*

Date : 30 November 2022

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Christchurch, New Zealand

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DRY DENSITY / WATER CONTENT RELATIONSHIP
STANDARD COMPACTION

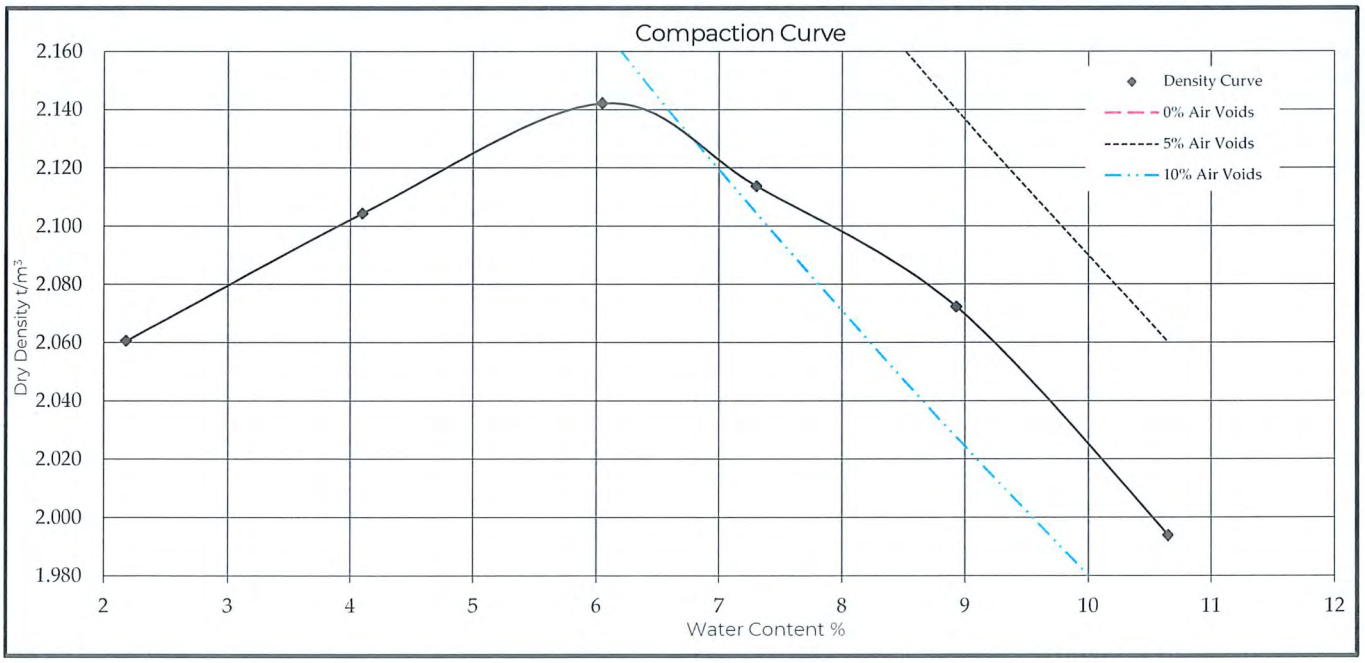
Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	Gravelly SAND with some silt and trace clay
Sample condition :	Damp as received
Solid density :	2.82 t/m³ (Tested)
Source :	TAC170

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/10
Client Ref No :	TAC170

Test Results

Maximum dry density	2.14	t/m³	Natural water content	0.3	%
Optimum water content	6.0	%	Fraction tested	Passing 19.0mm	

Sample ID	+2%	+4%	+6%	+8%	+10%	+12%	
Bulk density t/m³	2.106	2.191	2.272	2.268	2.257	2.206	
Water content %	2.2	4.1	6.1	7.3	8.9	10.7	
Dry density t/m³	2.061	2.104	2.142	2.114	2.072	1.994	
Sample condition	Moist Firm	Wet Firm	Wet Firm	Wet Firm	Wet Soft	Saturated Soft	



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	All information supplied by Client

Date tested : 28 November 2022
Date reported : 30 November 2022

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IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 30 November 2022

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52C Hayton Rd
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8140, Christchurch, New Zealand

Telephone +64 3 343 0739
Website www.wsp.com/nz

SOLID DENSITY OF SOIL PARTICLES
TEST REPORT

Project :	**Barrytown Mineral Sands Tailings**
Location :	**Barrytown West Coast**
Client :	**Resource Development Consultants Limited**
Contractor :	**Resource Development Consultants Limited**
Sampled by :	**Tom Bunny**
Date sampled :	**17 October 2022**
Sampling method :	**NZS 4402: 1986 (Coarse)**
Sample description :	**Gravelly SAND with some silt and trace clay**
Sample condition :	**Dry as received**
Source:	**TAC170**

Project No :	**6-JRESD.16/6LC**
Lab Ref No :	**CH9468/10**
Client Ref No :	**TAC170**

Test Results

Solid Density (t/m³): 2.82

Test Method: Determination of the Solid Density of Soil Particles NZS 4402 : 1986 : Test 2.7.1 (Passing 19.0mm)

Date tested : 25 November 2022
Date reported : 2 December 2022

Approved

Designation : *Laboratory Manager*
Date : 2 December 2022

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52C Hayton Rd, Wigram
PO Box 1482, Christchurch Mail Centre,
Christchurch 8140, New Zealand

Telephone +64 3 343 0739
Facsimile
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PLASTICITY INDEX FOR AGGREGATES
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	Gravelly SAND with some silt and trace caly
Sample condition :	As Received
Source :	TAC170

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/10
Client Ref No :	TAC170

Test Results	
Client Ref No :	TAC170
Cone penetration limit :	19
Plastic limit :	Unable to Roll Threads
Plasticity index :	NP
Sample fraction :	Fraction passing 425µm test sieve
As received water content :	0.3

Test Methods	
Water Content	NZS 4407 : 2015 Test 3.1
Cone Penetration	NZS 4407 : 2015 : Test 3.2
Plastic Limit	NZS 4407 : 2015 : Test 3.3
Plasticity Index	NZS 4407 : 2015 : Test 3.4

Date tested : 1 December 2022
Date reported : 2 December 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
This report may only be reproduced in full
All information supplied by Client

IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 2 December 2022

ACCREDITED IANZ TESTING LABORATORY

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Christchurch, New Zealand

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Website www.wsp.com/nz

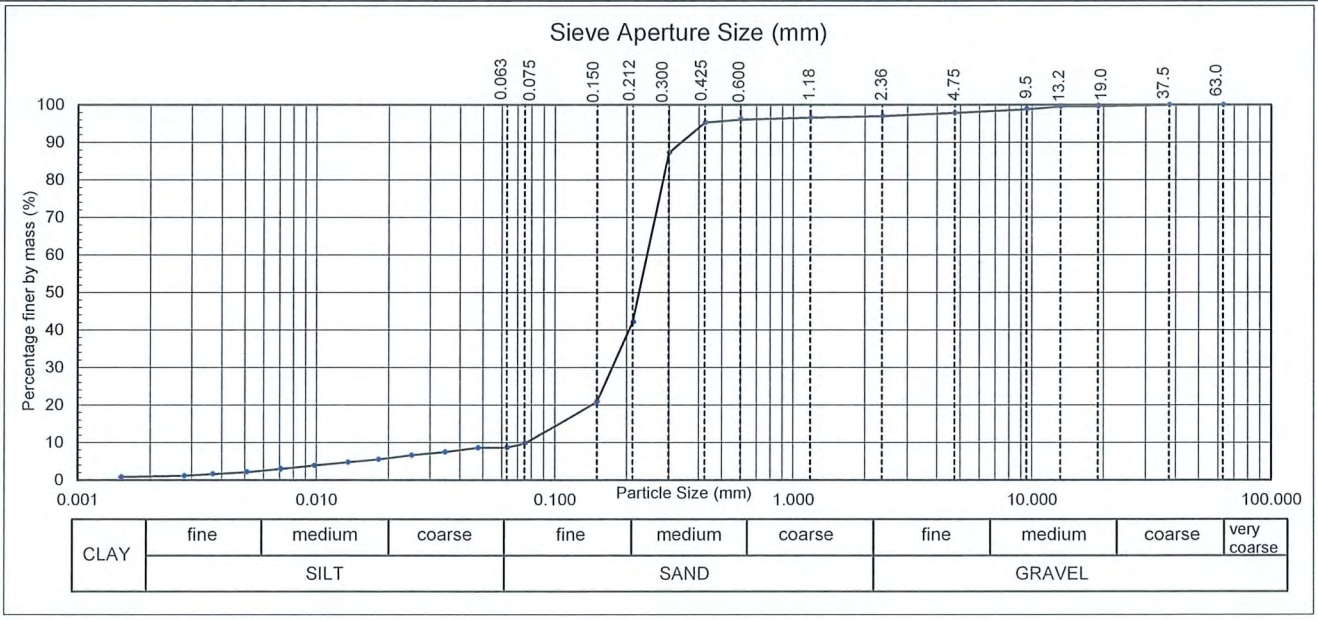
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Client/Sample Ref :	TAC176
Contractor :	Resource Development Consultants Limited

Sampled by :	Tom Bunny
Date received :	7 November 2022
Sampling method :	NZS 4402:1986 (Coarse)
Sample condition :	Damp as received
Sample description :	SAND wit minor silt, tracce gravel and clay
Solid Particle Density (t/m^3):	2.80 Tested
Water Content (as received):	0.0 %

Project No:	6-JRESD.16/6LC
Lab Ref No:	CH9468/11
Client Ref:	TAC176

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	98	0.300	87	0.0475	9	0.0071	3
37.5	100	2.36	97	0.212	42	0.0346	7	0.0051	2
19.0	100	1.18	97	0.150	21	0.0250	7	0.0037	2
13.2	100	0.600	96	0.075	10	0.0182	6	0.0028	1
9.5	99	0.425	95	0.063	9	0.0135	5	0.0015	1
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0098	4		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

Date Tested: 29 November 2022

Date Reported: 1 December 2022

IANZ Approved Signatory

Designation : *Laboratory Manager*

Date : 1 December 2022

ACCREDITED IANZ TESTING LABORATORY

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Christchurch, New Zealand

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DRY DENSITY / WATER CONTENT RELATIONSHIP
STANDARD COMPACTION

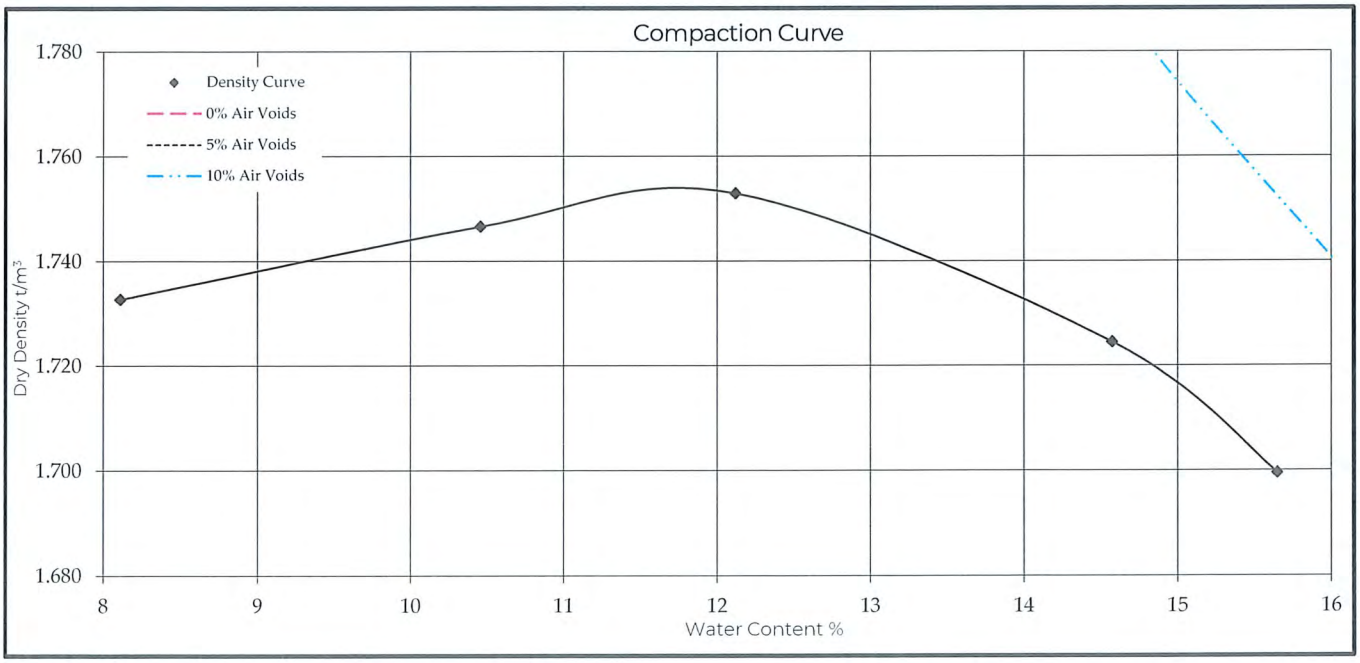
Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with minor silt, trace gravel and clay
Sample condition :	Damp as received
Solid density :	2.80 t/m³ (Tested)
Source :	TAC176

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/11
Client Ref No :	TAC176

Test Results

Maximum dry density	1.75	t/m³	Natural water content	0.0	%
Optimum water content	12.0	%	Fraction tested	Passing 19.0mm	

Sample ID		+8%	+10%	+12%	+14%	+16%	+18%	
Bulk density	t/m³	1.873	1.929	1.965	1.976	1.966	1.904	
Water content	%	8.1	10.5	12.1	14.6	15.6	18.1	
Dry density	t/m³	1.733	1.747	1.753	1.725	1.700	1.611	
Sample condition		Wet Firm	Wet Firm	Wet Firm	Wet Firm	Wet Soft	Saturated Soft	



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	All information supplied by Client

Date tested : 28 November 2022
Date reported : 1 December 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 1 December 2022

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SOLID DENSITY OF SOIL PARTICLES TEST REPORT

Project :	**Barrytown Mineral Sands Tailings**
Location :	**Barrytown West Coast**
Client :	**Resource Development Consultants Limited**
Contractor :	**Resource Development Consultants Limited**
Sampled by :	**Tom Bunny**
Date sampled :	**17 October 2022**
Sampling method :	**NZS 4402: 1986 (Coarse)**
Sample description :	**SAND with minor silt, trace gravel and clay**
Sample condition :	**Dry as received**
Source:	**TAC176**

Project No :	**6-JRESD.16/6LC**
Lab Ref No :	**CH9468/11**
Client Ref No :	**TAC176**

Test Results

Solid Density (t/m³): 2.80

Test Method: Determination of the Solid Density of Soil Particles NZS 4402 : 1986 : Test 2.7.1 (Passing 19.0mm)

Date tested : 1 December 2022
Date reported : 2 December 2022

Approved

Designation : *Laboratory Manager*
Date : 2 December 2022

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PO Box 1482, Christchurch Mail Centre,
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Facsimile
Website www.wsp-opus.co.nz

PLASTICITY INDEX FOR AGGREGATES
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with minor silt, trace gravel and clay
Sample condition :	As Received
Source :	TAC176

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/11
Client Ref No :	TAC176

Test Results	
Client Ref No :	TAC176
Cone penetration limit :	30
Plastic limit :	Unable to Roll Threads
Plasticity index :	NP
Sample fraction :	Fraction passing 425µm test sieve
As received water content :	0

Test Methods	
Water Content	NZS 4407 : 2015 Test 3.1
Cone Penetration	NZS 4407 : 2015 : Test 3.2
Plastic Limit	NZS 4407 : 2015 : Test 3.3
Plasticity Index	NZS 4407 : 2015 : Test 3.4

Date tested : 30 November 2022
Date reported : 2 December 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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All information supplied by Client

IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 2 December 2022

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LINEAR SHRINKAGE TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with minor silt, trace gravel and clay
Sample condition :	Dry as received
Source:	TAC176

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/11
Client Ref No :	TAC176

Test Results

Linear Shrinkage (%):	0

Test Methods		Notes
Linear Shrinkage	NZS 4402 : 1986, Test 2.6	Materials used: Passing 425um sieve

Date tested : 30 November 2022
Date reported : 2 December 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample teste
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IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 2 December 2022

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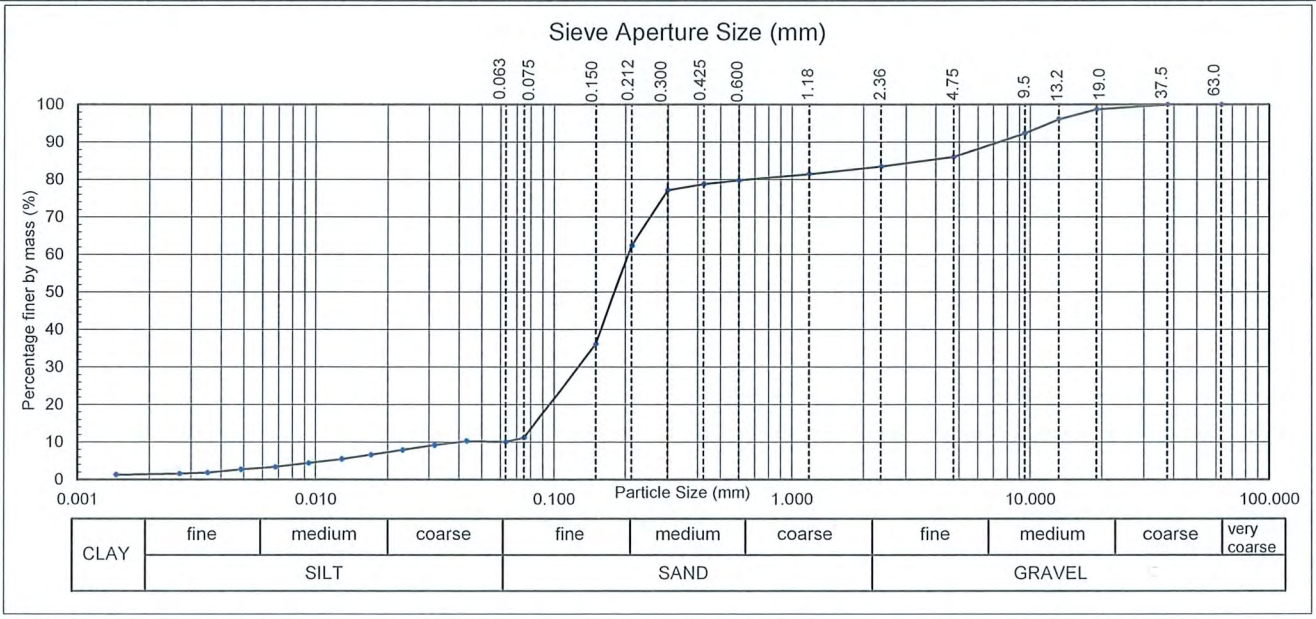
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Client/Sample Ref :	TSON002
Contractor :	Resource Development Consultants Limited

Sampled by :	Tom Bunny
Date received :	7 November 2022
Sampling method :	NZS 4402:1986 (Coarse)
Sample condition :	Damp as received
Sample description :	SAND with some gravel minor silt and trace clay
Solid Particle Density (t/m^3):	2.92 Tested
Water Content (as received):	0.1 %

Project No:	6-JRESD.16/6LC
Lab Ref No:	CH9468/1
Client Ref:	TSON002

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	86	0.300	77	0.0430	10	0.0068	3
37.5	100	2.36	83	0.212	62	0.0315	9	0.0049	3
19.0	99	1.18	82	0.150	36	0.0232	8	0.0035	2
13.2	96	0.600	80	0.075	11	0.0170	7	0.0027	2
9.5	92	0.425	79	0.063	10	0.0129	5	0.0015	1
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0093	4		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

Date Tested: 14 November 2022

Date Reported: 21 November 2022

IANZ Approved Signatory

Designation : *Laboratory Manager*

Date : 21 November 2022

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DRY DENSITY / WATER CONTENT RELATIONSHIP
STANDARD COMPACTION

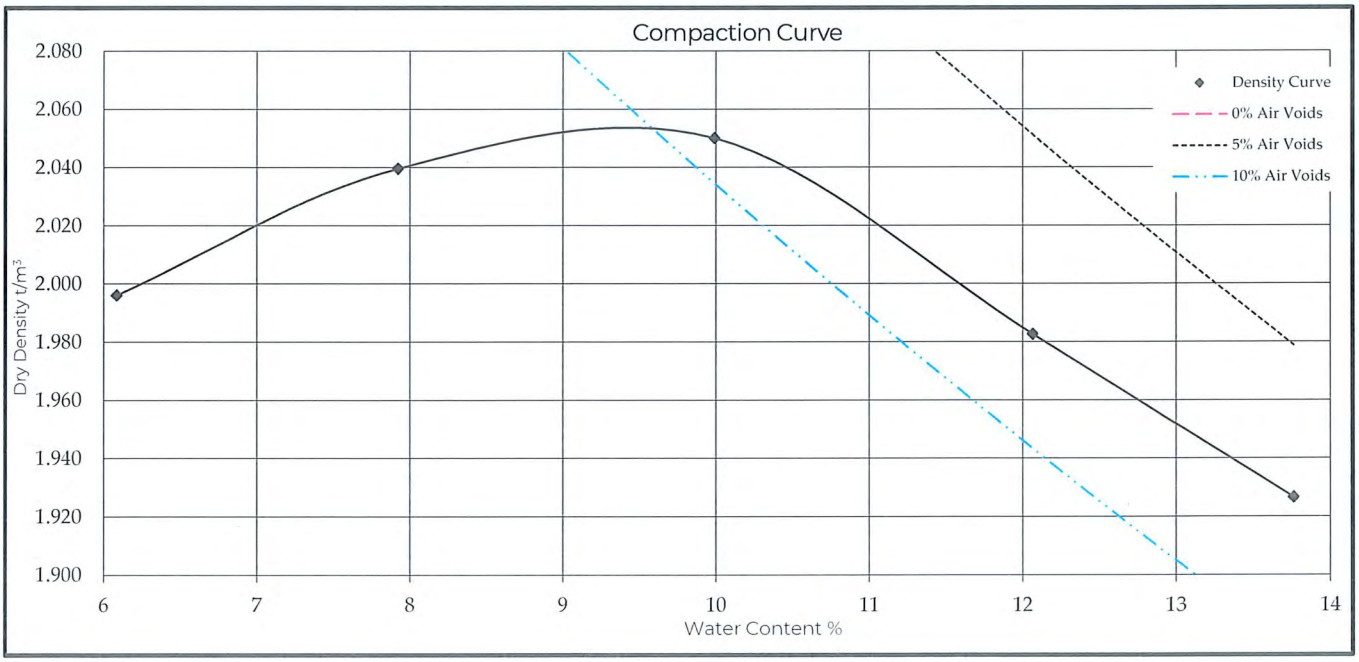
Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with some gravel minor silt and trace clay
Sample condition :	Damp as received
Solid density :	2.92 t/m³ (Tested)
Source :	TSON002

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/1
Client Ref No :	TSON002

Test Results

Maximum dry density	2.05	t/m³	Natural water content	0.1	%
Optimum water content	10.0	%	Fraction tested	Passing 19.0mm	

Sample ID		+6%	+8%	+10%	+12%	+14%		
Bulk density	t/m³	2.118	2.201	2.255	2.222	2.192		
Water content	%	6.1	7.9	10.0	12.1	13.8		
Dry density	t/m³	1.996	2.040	2.050	1.983	1.927		
Sample condition		Moist Hard	Wet Firm	Wet Firm	Wet Firm	Saturated Soft		



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	All information supplied by Client

Date tested : 14 November 2022
Date reported : 21 November 2022

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Designation : *Laboratory Manager*
Date : 21 November 2022

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SOLID DENSITY OF SOIL PARTICLES
TEST REPORT

Project :	**Barrytown Mineral Sands Tailings**
Location :	**Barrytown West Coast**
Client :	**Resource Development Consultants Limited**
Contractor :	**Resource Development Consultants Limited**
Sampled by :	**Tom Bunny**
Date sampled :	**17 October 2022**
Sampling method :	**NZS 4402: 1986 (Coarse)**
Sample description :	**SAND with some gravel minor silt and trace clay**
Sample condition :	**Dry as received**
Source:	**TSON002**

Project No :	**6-JRESD.16/6LC**
Lab Ref No :	**CH9468/1**
Client Ref No :	**TSON002**

Test Results

Solid Density (t/m³): 2.92

Test Method: Determination of the Solid Density of Soil Particles NZS 4402 : 1986 : Test 2.7.1 (Passing 19.0mm)

Date tested : 16 November 2022
Date reported : 21 November 2022

Approved

Designation : *Laboratory Manager*
Date : 21 November 2022

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PLASTICITY INDEX FOR AGGREGATES
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with some gravel minor silt and trace clay
Sample condition :	As Received
Source :	TSON002

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/1
Client Ref No :	TSON002

Test Results	
Client Ref No :	TSON002
Cone penetration limit :	24
Plastic limit :	Unable to Roll Threads
Plasticity index :	NP
Sample fraction :	Fraction passing 425µm test sieve
As received water content :	0.1

Test Methods	
Water Content	NZS 4407 : 2015 Test 3.1
Cone Penetration	NZS 4407 : 2015 : Test 3.2
Plastic Limit	NZS 4407 : 2015 : Test 3.3
Plasticity Index	NZS 4407 : 2015 : Test 3.4

Date tested : 16 November 2022
Date reported : 22 November 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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All information supplied by Client

IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 22 November 2022

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Telephone +64 3 343 0739
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LINEAR SHRINKAGE TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with some gravel minor silt and trace clay
Sample condition :	Dry as received
Source:	TSON002

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/1
Client Ref No :	TSON002

Test Results

Linear Shrinkage (%):	0

Test Methods		Notes
Linear Shrinkage	NZS 4402 : 1986, Test 2.6	Materials used: Passing 425um sieve

Date tested : 16 November 2022
Date reported : 22 November 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample teste
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IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 22 November 2022

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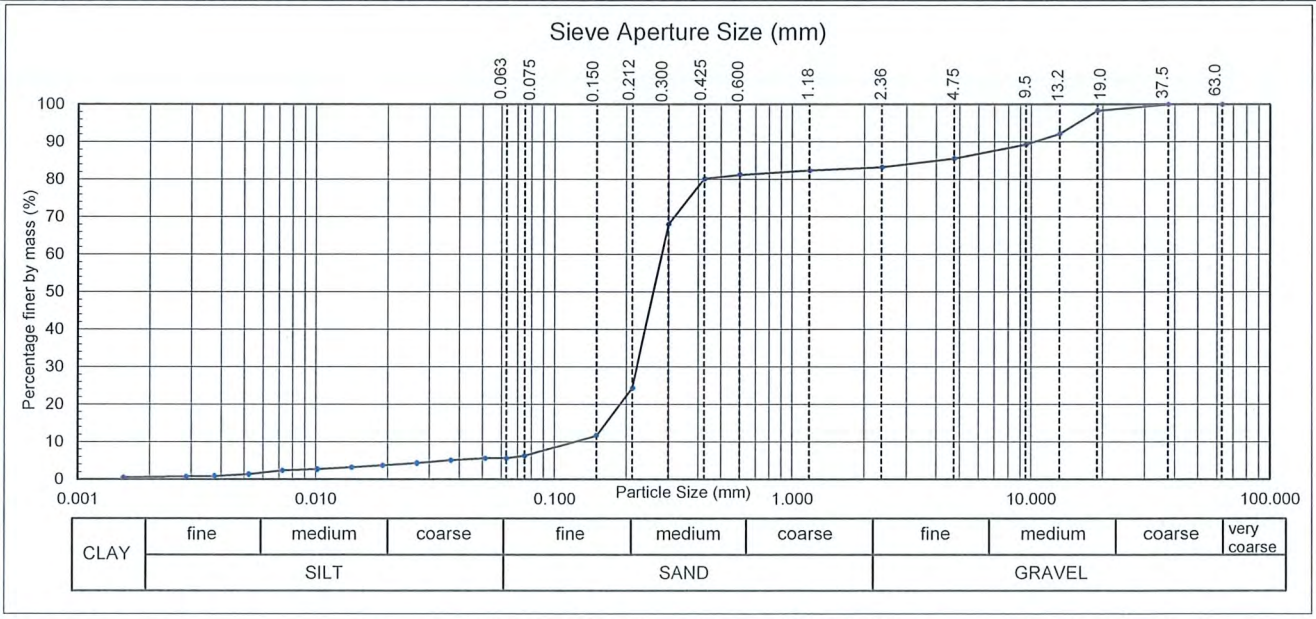
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Client/Sample Ref :	TSON003
Contractor :	Resource Development Consultants Limited

Sampled by :	Tom Bunny
Date received :	7 November 2022
Sampling method :	NZS 4402:1986 (Coarse)
Sample condition :	Damp as received
Sample description :	SAND with some gravel and minor silt
Solid Particle Density (t/m^3):	2.76 Tested
Water Content (as received):	0.2 %

Project No:	6-JRESD.16/6LC
Lab Ref No:	CH9468/2
Client Ref:	TSON003

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	85	0.300	68	0.0513	6	0.0072	2
37.5	100	2.36	83	0.212	24	0.0368	5	0.0052	1
19.0	98	1.18	82	0.150	12	0.0265	4	0.0037	1
13.2	92	0.600	81	0.075	6	0.0191	4	0.0028	1
9.5	89	0.425	80	0.063	6	0.0141	3	0.0015	0
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0101	3		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

This report may only be reproduced in full

Date Tested: 14 November 2022

Date Reported: 22 November 2022

IANZ Approved Signatory

Designation : *Laboratory Manager*

Date : 22 November 2022

ACCREDITED IANZ TESTING LABORATORY

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DRY DENSITY / WATER CONTENT RELATIONSHIP
STANDARD COMPACTION

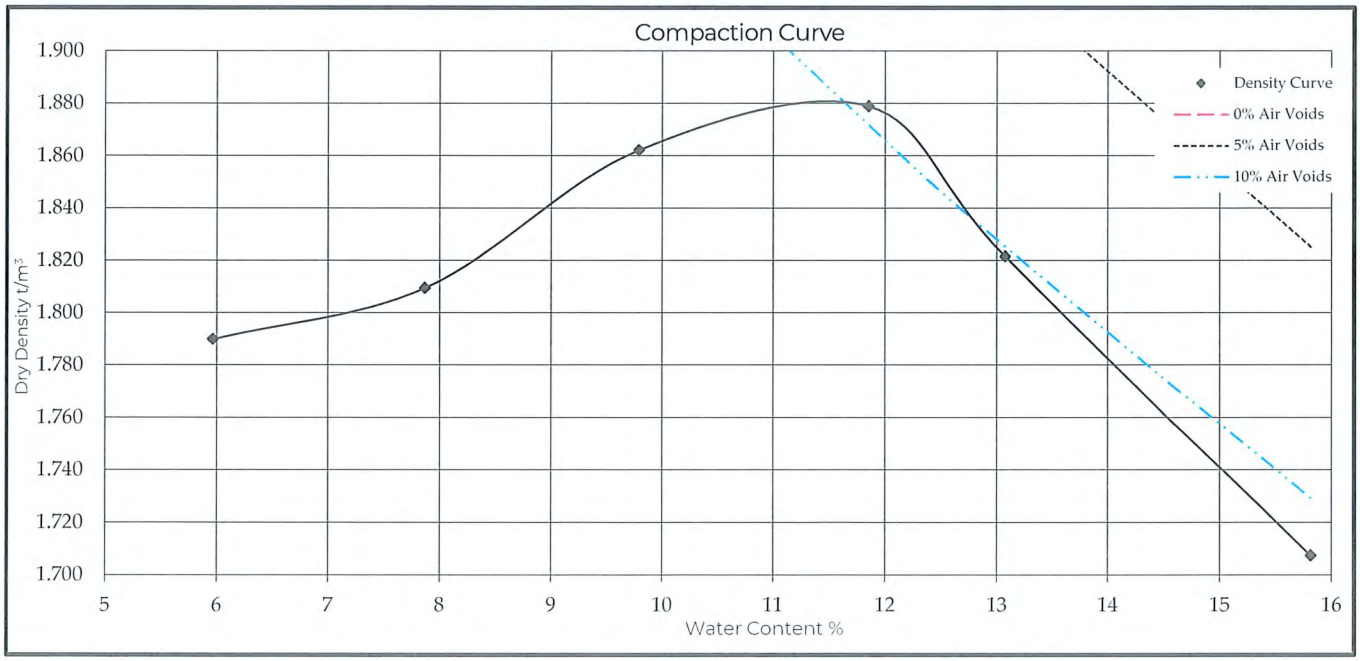
Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with some gravel minor silt and trace clay
Sample condition :	Damp as received
Solid density :	2.76 t/m³ (Tested)
Source :	TSON003

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/2
Client Ref No :	TSON003

Test Results

Maximum dry density	1.88	t/m³	Natural water content	0.2	%
Optimum water content	10.0	%	Fraction tested	Passing 19.0mm	

Sample ID		+6%	+8%	+10%	+12%	+14%	+16%	
Bulk density	t/m³	1.897	1.952	2.044	2.102	2.060	1.977	
Water content	%	6.0	7.9	9.8	11.9	13.1	15.8	
Dry density	t/m³	1.790	1.809	1.862	1.879	1.822	1.707	
Sample condition		Moist Hard	Wet Firm	Wet Firm	Wet Firm	Wet Soft	Saturated Soft	



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	All information supplied by Client

Date tested : 14 November 2022
Date reported : 22 November 2022

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IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 22 November 2022

ACCREDITED IANZ TESTING LABORATORY

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Telephone +64 3 343 0739
Website www.wsp.com/nz

SOLID DENSITY OF SOIL PARTICLES TEST REPORT

Project :	**Barrytown Mineral Sands Tailings**
Location :	**Barrytown West Coast**
Client :	**Resource Development Consultants Limited**
Contractor :	**Resource Development Consultants Limited**
Sampled by :	**Tom Bunny**
Date sampled :	**17 October 2022**
Sampling method :	**NZS 4402: 1986 (Coarse)**
Sample description :	**SAND with some gravel and minor silt**
Sample condition :	**Dry as received**
Source:	**TSON003**

Project No :	**6-JRESD.16/6LC**
Lab Ref No :	**CH9468/2**
Client Ref No :	**TSON003**

Test Results

Solid Density (t/m³): 2.76

Test Method: Determination of the Solid Density of Soil Particles NZS 4402 : 1986 : Test 2.7.1 (Passing 19.0mm)

Date tested : 17 November 2022
Date reported : 22 November 2022 **This report may only be reproduced in full**

Approved

Designation : *Laboratory Manager*
Date : 22 November 2022

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Telephone +64 3 343 0739
Facsimile
Website www.wsp-opus.co.nz

PLASTICITY INDEX FOR AGGREGATES
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with some gravel minor silt and trace clay
Sample condition :	As Received
Source :	TSON002

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/2
Client Ref No :	TSON003

Test Results	
Client Ref No :	TSON003
Cone penetration limit :	33
Plastic limit :	Unable to Roll Threads
Plasticity index :	NP
Sample fraction :	Fraction passing 425µm test sieve
As received water content :	0.2

Test Methods	
Water Content	NZS 4407 : 2015 Test 3.1
Cone Penetration	NZS 4407 : 2015 : Test 3.2
Plastic Limit	NZS 4407 : 2015 : Test 3.3
Plasticity Index	NZS 4407 : 2015 : Test 3.4

Date tested : 15 November 2022
Date reported : 22 November 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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All information supplied by Client

IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 22 November 2022

ACCREDITED IANZ TESTING LABORATORY

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PO Box 1482, Christchurch Mail Centre, 8140,
Christchurch, New Zealand
Telephone +64 3 343 0739
Website www.wsp.com/nz

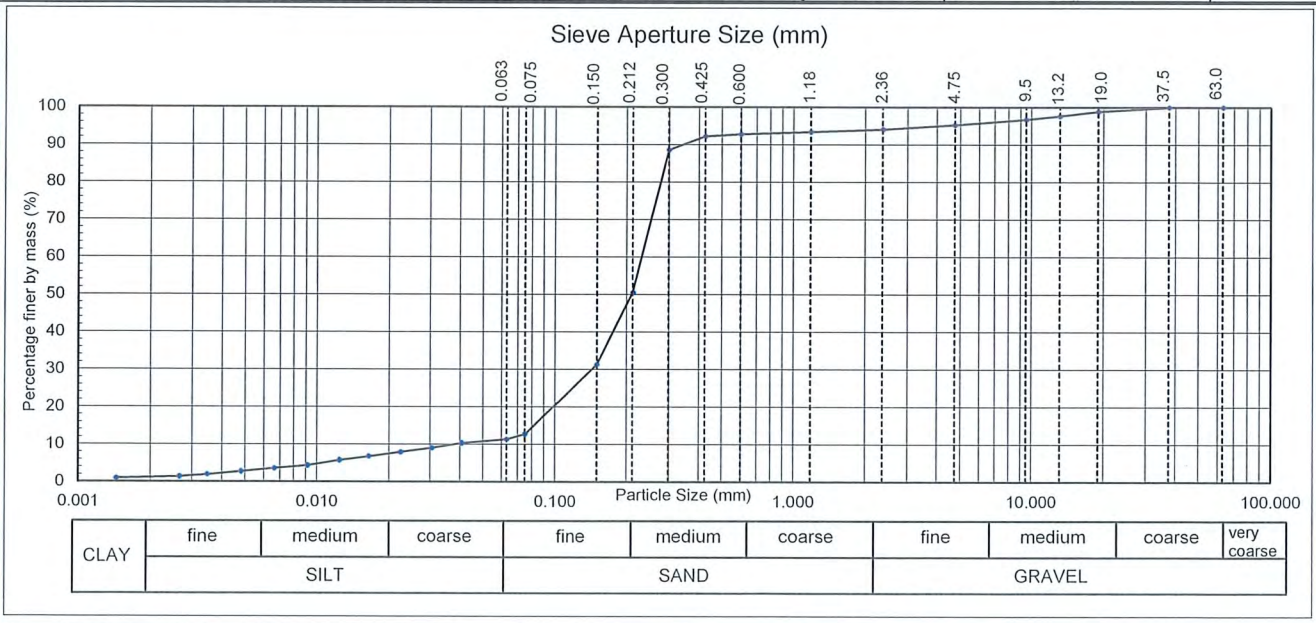
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Client/Sample Ref :	TSON004
Contractor :	Resource Development Consultants Limited

Sampled by :	Tom Bunny
Date received :	7 November 2022
Sampling method :	NZS 4402:1986 (Coarse)
Sample condition :	Damp as received
Sample description :	SAND with some gravel, silt and trace clay
Solid Particle Density (t/m^3):	2.96 Tested
Water Content (as received):	0.1 %

Project No:	6-JRESD.16/6LC
Lab Ref No:	CH9468/3
Client Ref:	TSON004

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	95	0.300	89	0.0407	10	0.0066	4
37.5	100	2.36	94	0.212	50	0.0305	9	0.0048	3
19.0	99	1.18	93	0.150	31	0.0224	8	0.0035	2
13.2	98	0.600	93	0.075	13	0.0165	7	0.0027	1
9.5	97	0.425	92	0.063	11	0.0124	6	0.0014	1
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0091	4		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

This report may only be reproduced in full

Date Tested: 14 November 2022

Date Reported: 22 November 2022

IANZ Approved Signatory

Designation : *Laboratory Manager*

Date : 22 November 2022

ACCREDITED IANZ TESTING LABORATORY

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DRY DENSITY / WATER CONTENT RELATIONSHIP
STANDARD COMPACTION

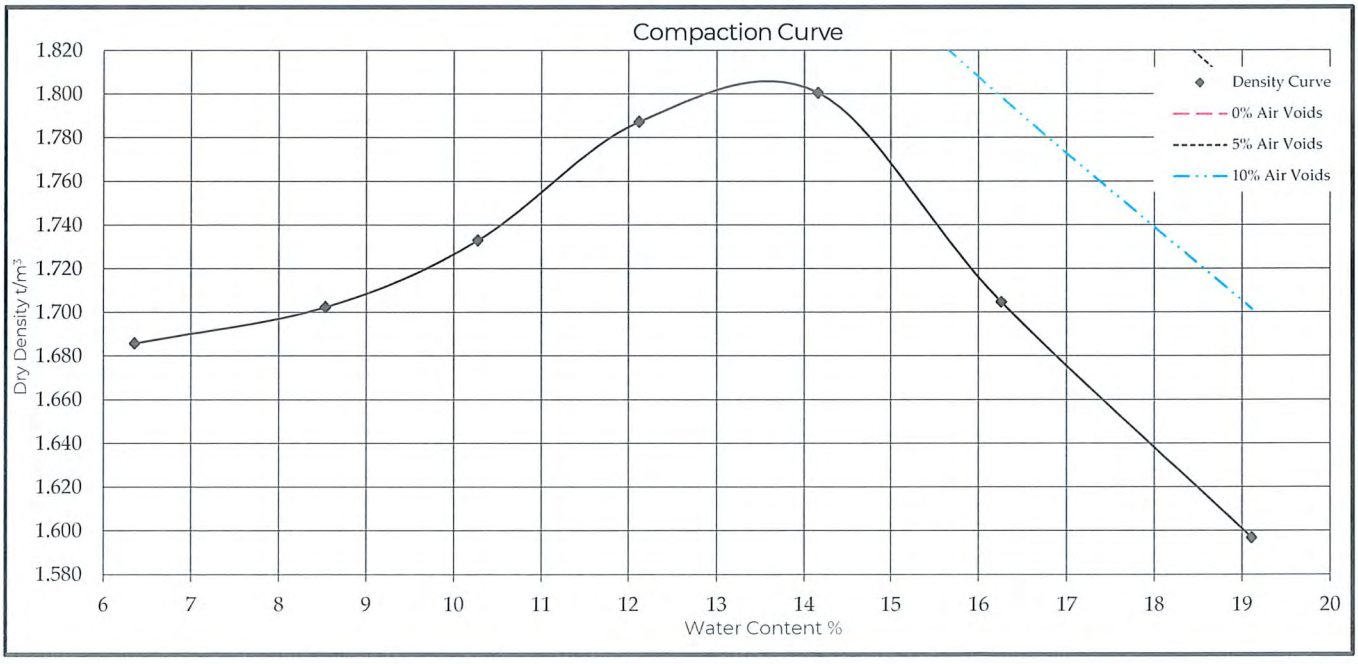
Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	SAND with minor gravel, silt and trace clay
Sample condition :	Damp as received
Solid density :	2.96 t/m³ (Tested)
Source :	TSON004

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/3
Client Ref No :	TSON004

Test Results

Maximum dry density	1.80	t/m³	Natural water content	0.1 %
Optimum water content	14.0	%	Fraction tested	Passing 19.0mm

Sample ID		+6%	+8%	+10%	+12%	+14%	+16%	+18%
Bulk density	t/m³	1.793	1.848	1.911	2.004	2.055	1.982	1.902
Water content	%	6.4	8.5	10.3	12.1	14.2	16.3	19.1
Dry density	t/m³	1.686	1.702	1.733	1.787	1.801	1.705	1.597
Sample condition		Moist Hard	Wet Firm	Wet Firm	Wet Firm	Wet Firm	Wet Soft	Saturated Soft



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	All information supplied by Client

Date tested : 17 November 2022
Date reported : 22 November 2022

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IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 22 November 2022

ACCREDITED IANZ TESTING LABORATORY

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Website www.wsp.com/nz

SOLID DENSITY OF SOIL PARTICLES TEST REPORT

Project :	**Barrytown Mineral Sands Tailings**
Location :	**Barrytown West Coast**
Client :	**Resource Development Consultants Limited**
Contractor :	**Resource Development Consultants Limited**
Sampled by :	**Tom Bunny**
Date sampled :	**17 October 2022**
Sampling method :	**NZS 4402: 1986 (Coarse)**
Sample description :	**SAND with minor gravel, silt and trace clay**
Sample condition :	**Dry as received**
Source:	**TSON004**

Project No :	**6-JRESD.16/6LC**
Lab Ref No :	**CH9468/3**
Client Ref No :	**TSON004**

Test Results

Solid Density (t/m³): 2.96

Test Method: Determination of the Solid Density of Soil Particles NZS 4402 : 1986 : Test 2.7.1 (Passing 19.0mm)

Date tested : 18 November 2022
Date reported : 22 November 2022 **This report may only be reproduced in full**

Approved

Designation : *Laboratory Manager*
Date : 22 November 2022

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Christchurch Laboratory
Quality Management Systems Certified to ISO 9001

52C Hayton Rd, Wigram
PO Box 1482, Christchurch Mail Centre,
Christchurch 8140, New Zealand

Telephone +64 3 343 0739
Facsimile
Website www.wsp-opus.co.nz

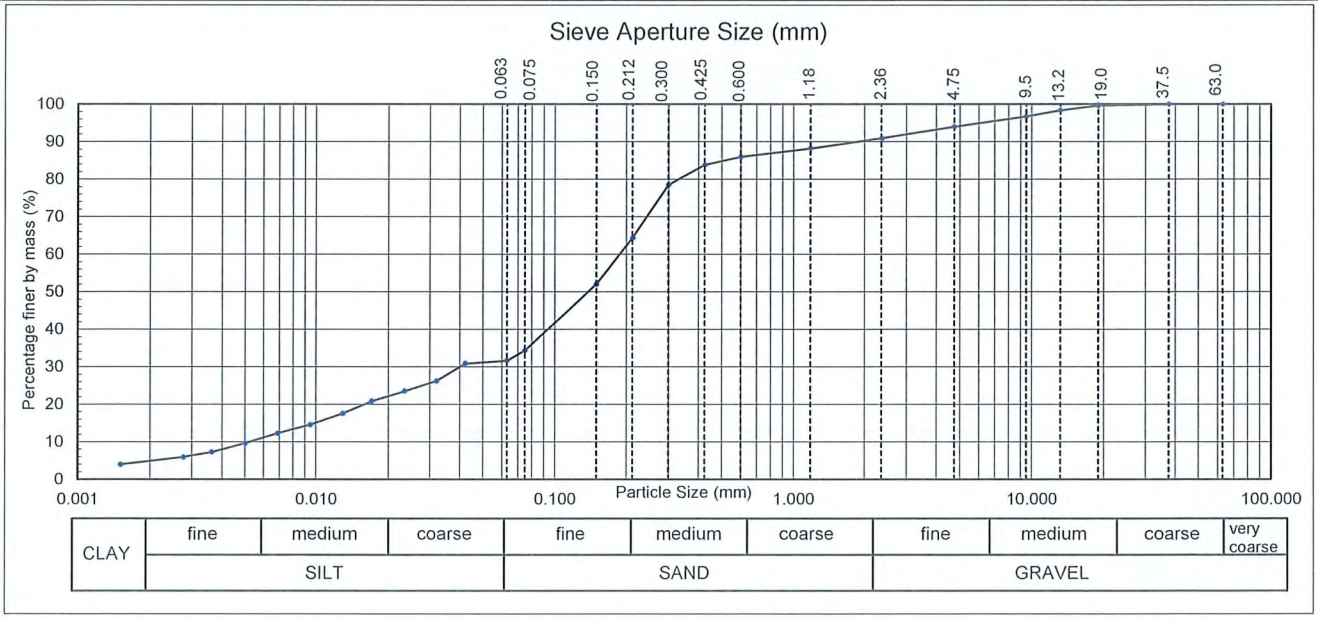
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Client/Sample Ref :	TSON005
Contractor :	Resource Development Consultants Limited

Sampled by :	Tom Bunny
Date received :	7 November 2022
Sampling method :	NZS 4402:1986 (Coarse)
Sample condition :	Damp as received
Sample description :	Silty SAND with minor gravel and trace clay
Solid Particle Density (t/m^3):	2.74 Tested
Water Content (as received):	0.2 %

Project No:	6-JRESD.16/6LC
Lab Ref No:	CH9468/4
Client Ref:	TSON005

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	94	0.300	79	0.0422	31	0.0069	12
37.5	100	2.36	91	0.212	64	0.0319	26	0.0050	10
19.0	100	1.18	88	0.150	52	0.0234	24	0.0036	7
13.2	98	0.600	86	0.075	34	0.0171	21	0.0028	6
9.5	97	0.425	84	0.063	32	0.0129	18	0.0015	4
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0095	15		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

This report may only be reproduced in full

Date Tested: 22 November 2022

Date Reported: 23 November 2022

IANZ Approved Signatory

Designation : *Laboratory Manager*

Date : 23 November 2022

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DRY DENSITY / WATER CONTENT RELATIONSHIP
STANDARD COMPACTION

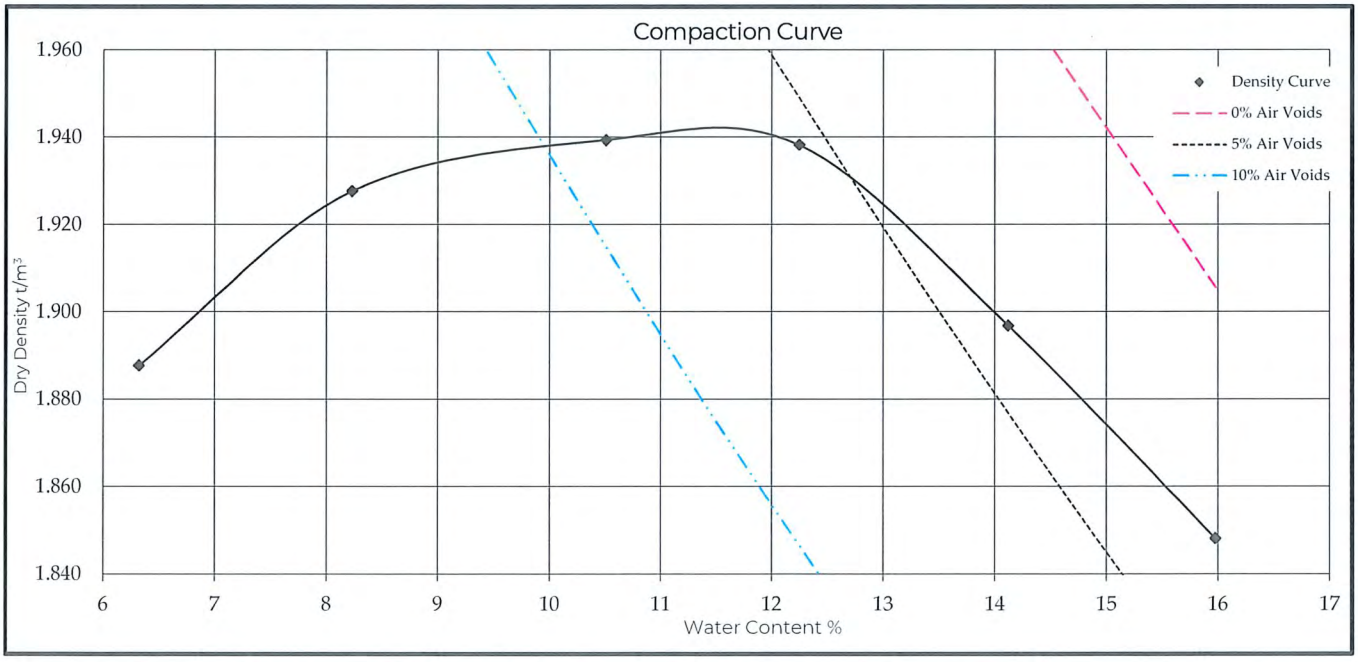
Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	Silty SAND witrh minor gravel and trace clay
Sample condition :	Damp as received
Solid density :	2.74 t/m³ (Tested)
Source :	TSON005

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/4
Client Ref No :	TSON005

Test Results

Maximum dry density	1.94	t/m³	Natural water content	0.2 %
Optimum water content	12.0	%	Fraction tested	Passing 19.0mm

Sample ID		+6%	+8%	+10%	+12%	+14%	+16%	
Bulk density	t/m³	2.007	2.086	2.143	2.176	2.165	2.143	
Water content	%	6.3	8.2	10.5	12.2	14.1	16.0	
Dry density	t/m³	1.888	1.928	1.939	1.938	1.897	1.848	
Sample condition		Moist Hard	Wet Firm	Wet Firm	Wet Firm	Wet Firm	Wet Saturated	



Test Methods		Notes
Compaction	NZS 4402 : 1986 Test 4.1.1 (Standard)	All information supplied by Client

Date tested : 18 November 2022
Date reported : 26 November 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
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Designation : *Laboratory Manager*
Date : 26 November 2022

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SOLID DENSITY OF SOIL PARTICLES TEST REPORT

Project :	**Barrytown Mineral Sands Tailings**
Location :	**Barrytown West Coast**
Client :	**Resource Development Consultants Limited**
Contractor :	**Resource Development Consultants Limited**
Sampled by :	**Tom Bunny**
Date sampled :	**17 October 2022**
Sampling method :	**NZS 4402: 1986 (Coarse)**
Sample description :	**Slity SAND with minor gravel and trace clay**
Sample condition :	**Dry as received**
Source:	**TSON005**

Project No :	**6-JRESD.16/6LC**
Lab Ref No :	**CH9468/4**
Client Ref No :	**TSON005**

Test Results

Solid Density (t/m³): 2.74

Test Method: Determination of the Solid Density of Soil Particles NZS 4402 : 1986 : Test 2.7.1 (Passing 19.0mm)

Date tested : 18 November 2022
Date reported : 26 November 2022

Approved

Designation : *Laboratory Manager*
Date : 26 November 2022

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Christchurch Laboratory
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PLASTICITY INDEX FOR AGGREGATES
TEST REPORT

Project :	Barrytown Mineral Sands Tailings
Location :	Barrytown West Coast
Client :	Resource Development Consultants Limited
Contractor :	Resource Development Consultants Limited
Sampled by :	Tom Bunny
Date sampled :	17 October 2022
Sampling method :	NZS 4402: 1986 (Coarse)
Sample description :	Silty SAND with minor gravel and trace clay
Sample condition :	As Received
Source :	TSON005

Project No :	6-JRESD.16/6LC
Lab Ref No :	CH9468/4
Client Ref No :	TSON005

Test Results	
Client Ref No :	TSON005
Cone penetration limit :	23
Plastic limit :	Unable to Roll Threads
Plasticity index :	NP
Sample fraction :	Fraction passing 425µm test sieve
As received water content :	0.2

Test Methods	
Water Content	NZS 4407 : 2015 Test 3.1
Cone Penetration	NZS 4407 : 2015 : Test 3.2
Plastic Limit	NZS 4407 : 2015 : Test 3.3
Plasticity Index	NZS 4407 : 2015 : Test 3.4

Date tested : 22 November 2022
Date reported : 26 November 2022

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
This report may only be reproduced in full
All information supplied by Client

IANZ Approved Signatory

Designation : *Laboratory Manager*
Date : 26 November 2022

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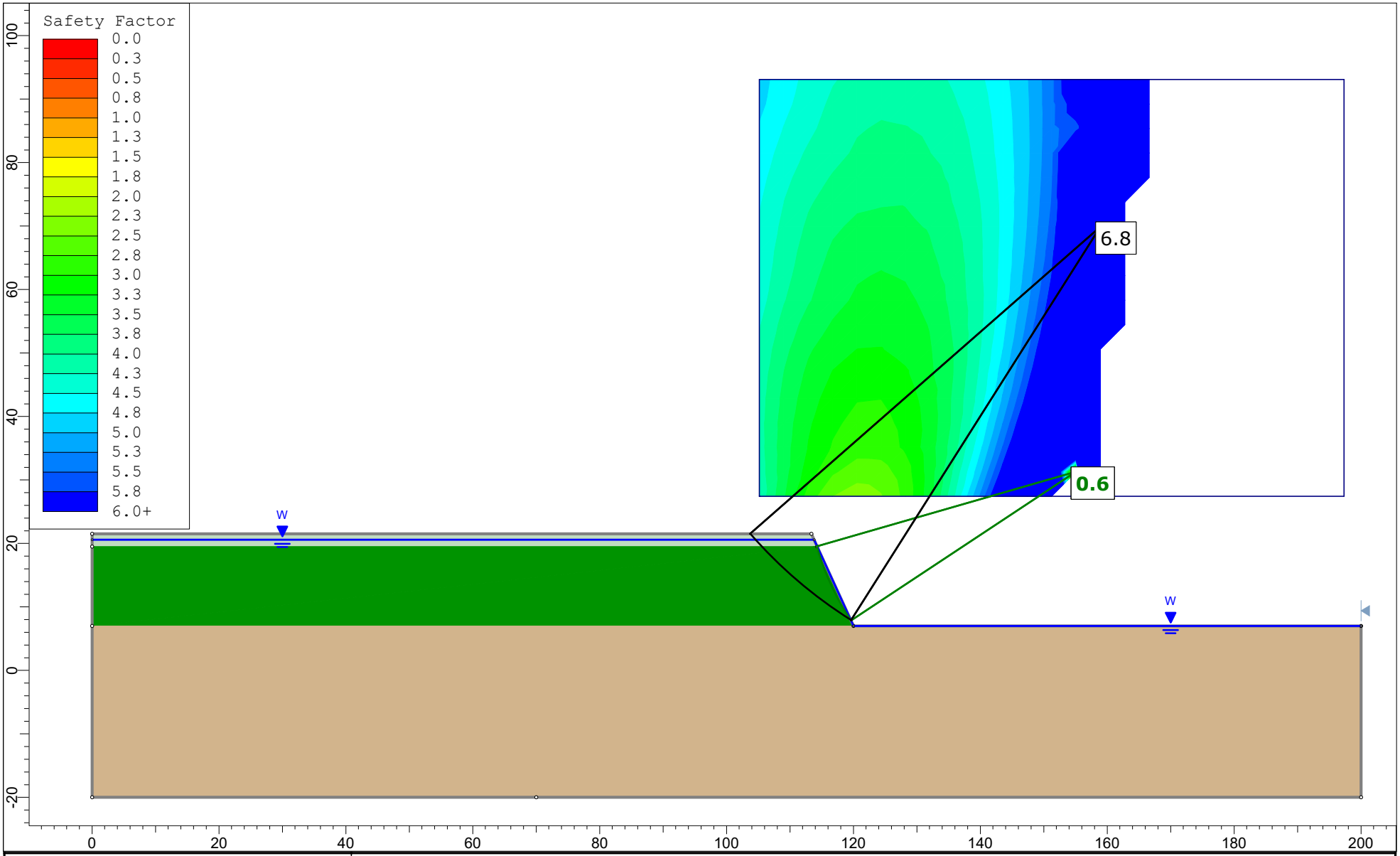
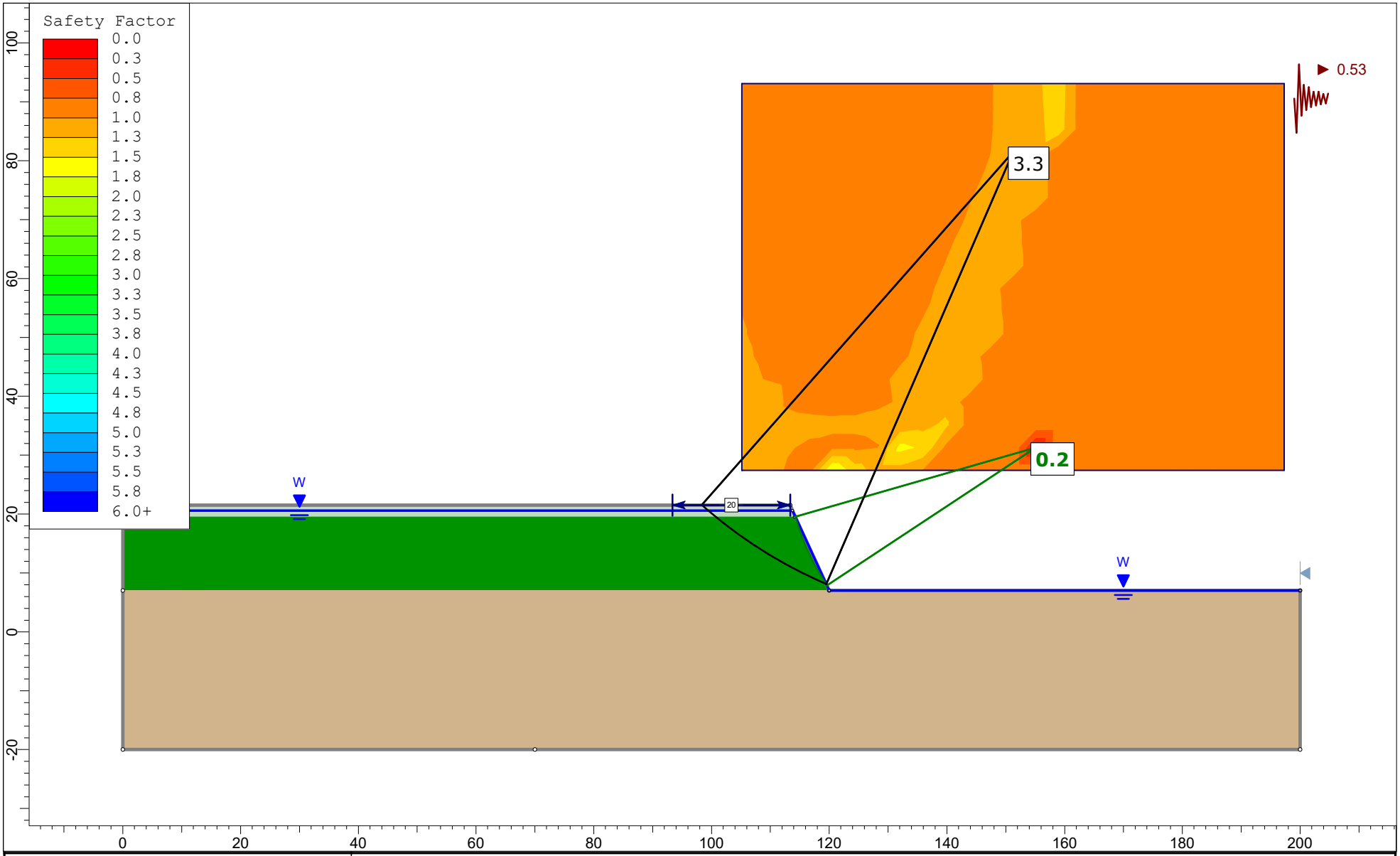
APPENDIX B
STABILITY ANALYSES RESULTS



RDCL

SLIDEINTERPRET 9.009

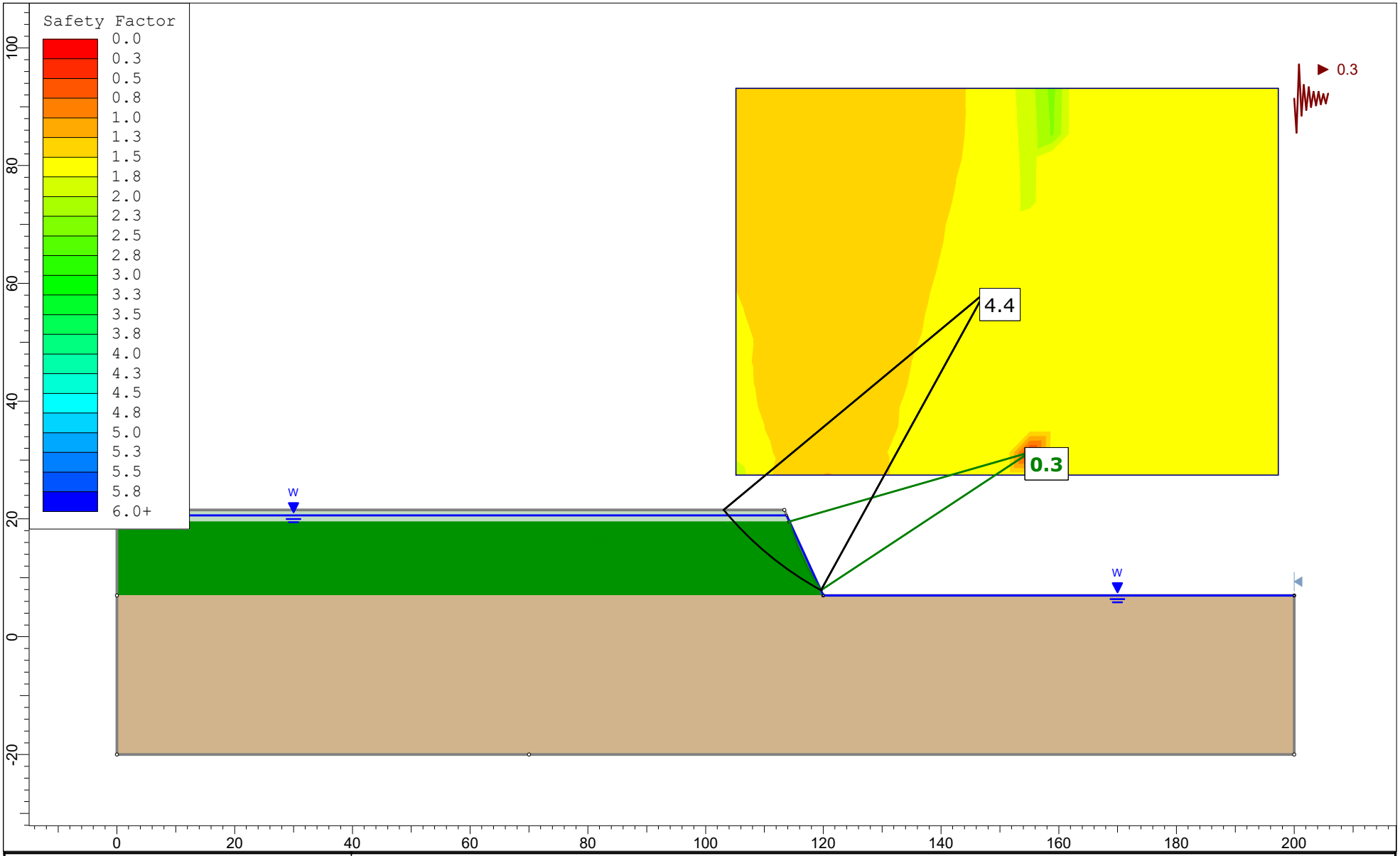
Project	Barrytown Sands Project		
	Starting Cut Unsupported		
Drawn By	CAW	*Company*	TiGa Minerals & Metals Ltd
Date	13/04/2023	*File Name*	65 degrees



RDCL

SLIDEINTERPRET 9.009

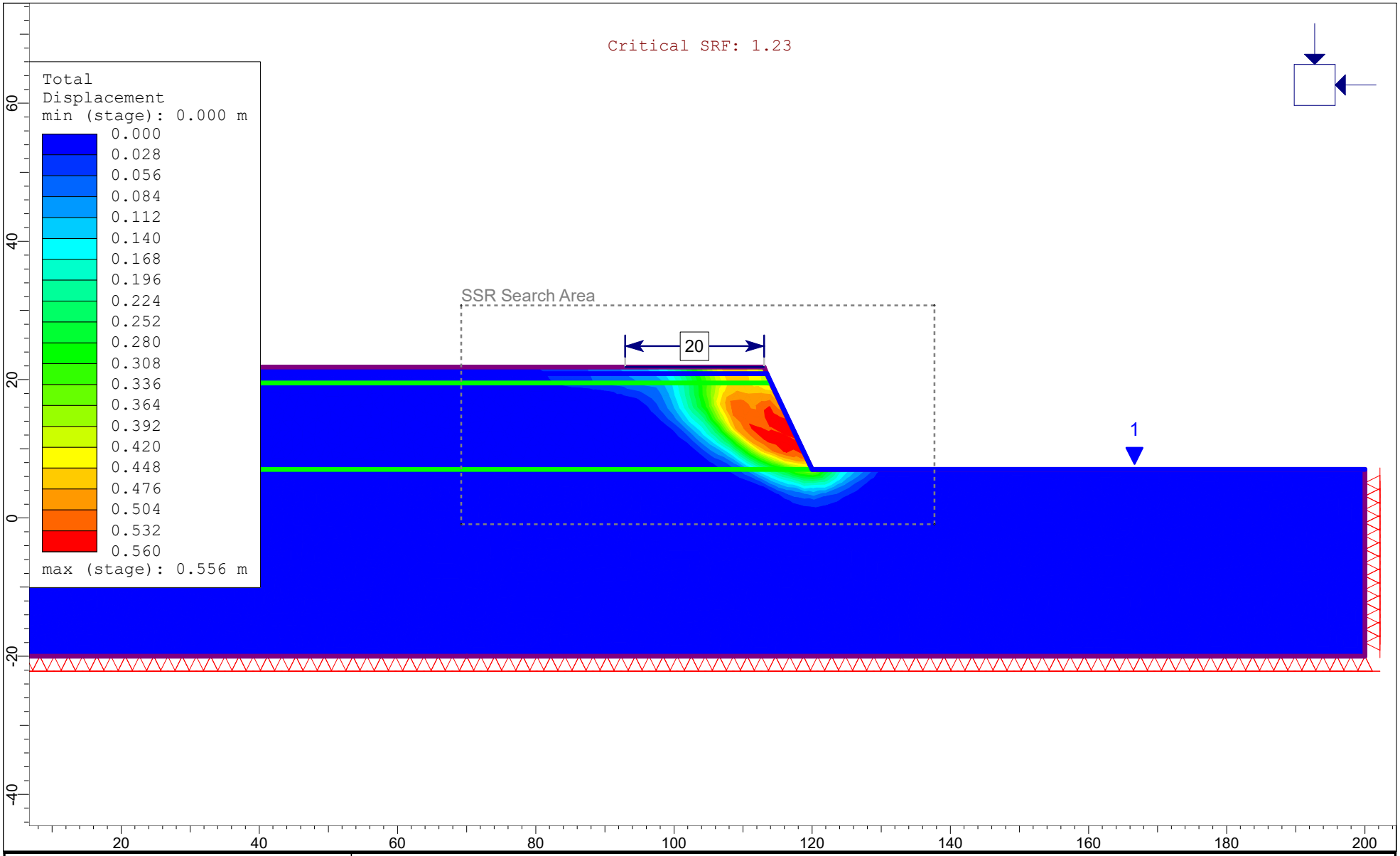
Project	Barrytown Sands Project		
	Starting Cut Unsupported MCE		
Drawn By	CAW	*Company*	TiGa Minerals & Metals Ltd
Date	13/04/2023	*File Name*	65 degrees



RDCL

SLIDEINTERPRET 9.009

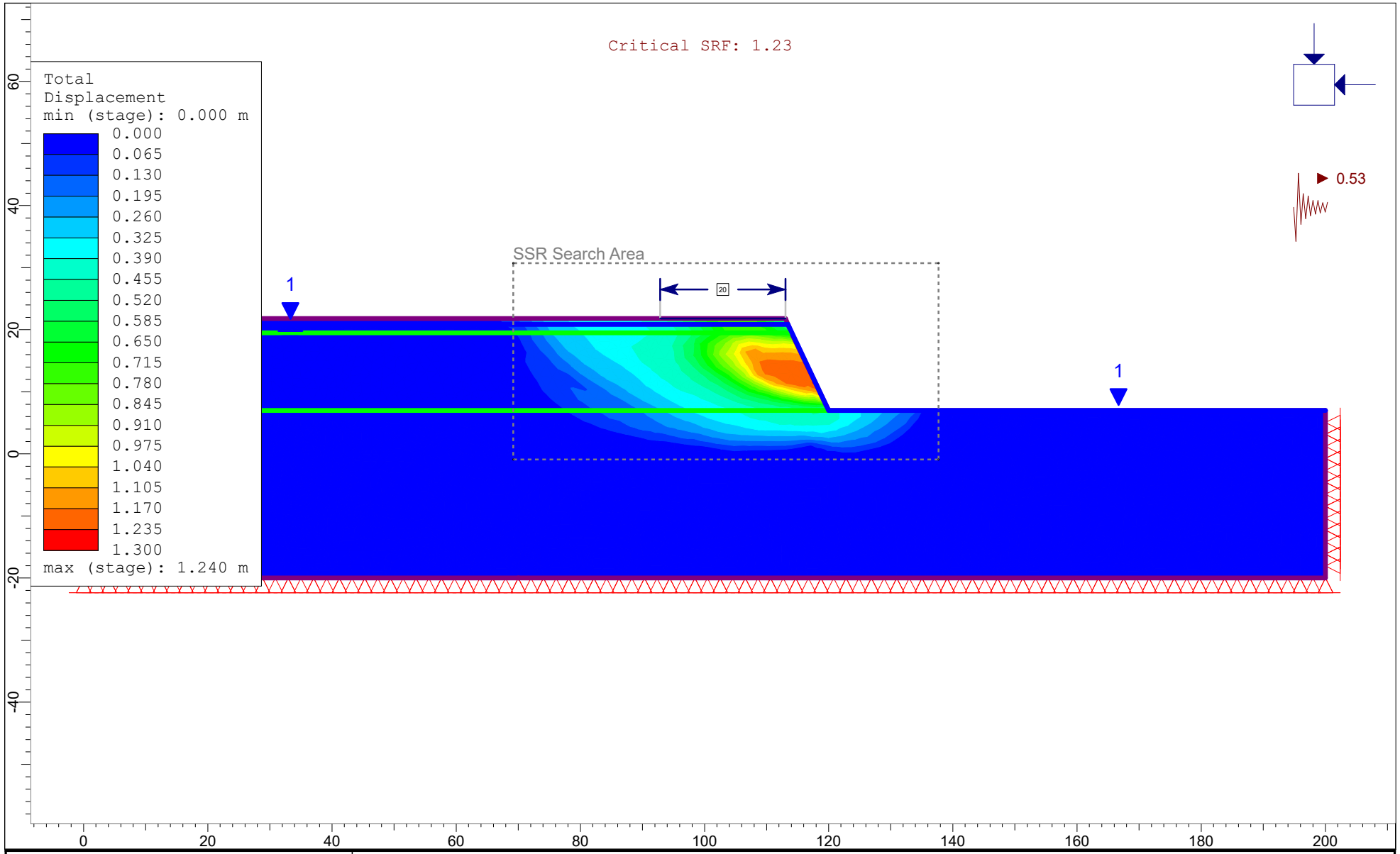
Project	Barrytown Sands Project		
	Starting Cut Unsupported OBE		
Drawn By	CAW	*Company*	TiGa Minerals & Metals Ltd
Date	13/04/2023	*File Name*	65 degrees



RDCL

INTERPRET 11.015

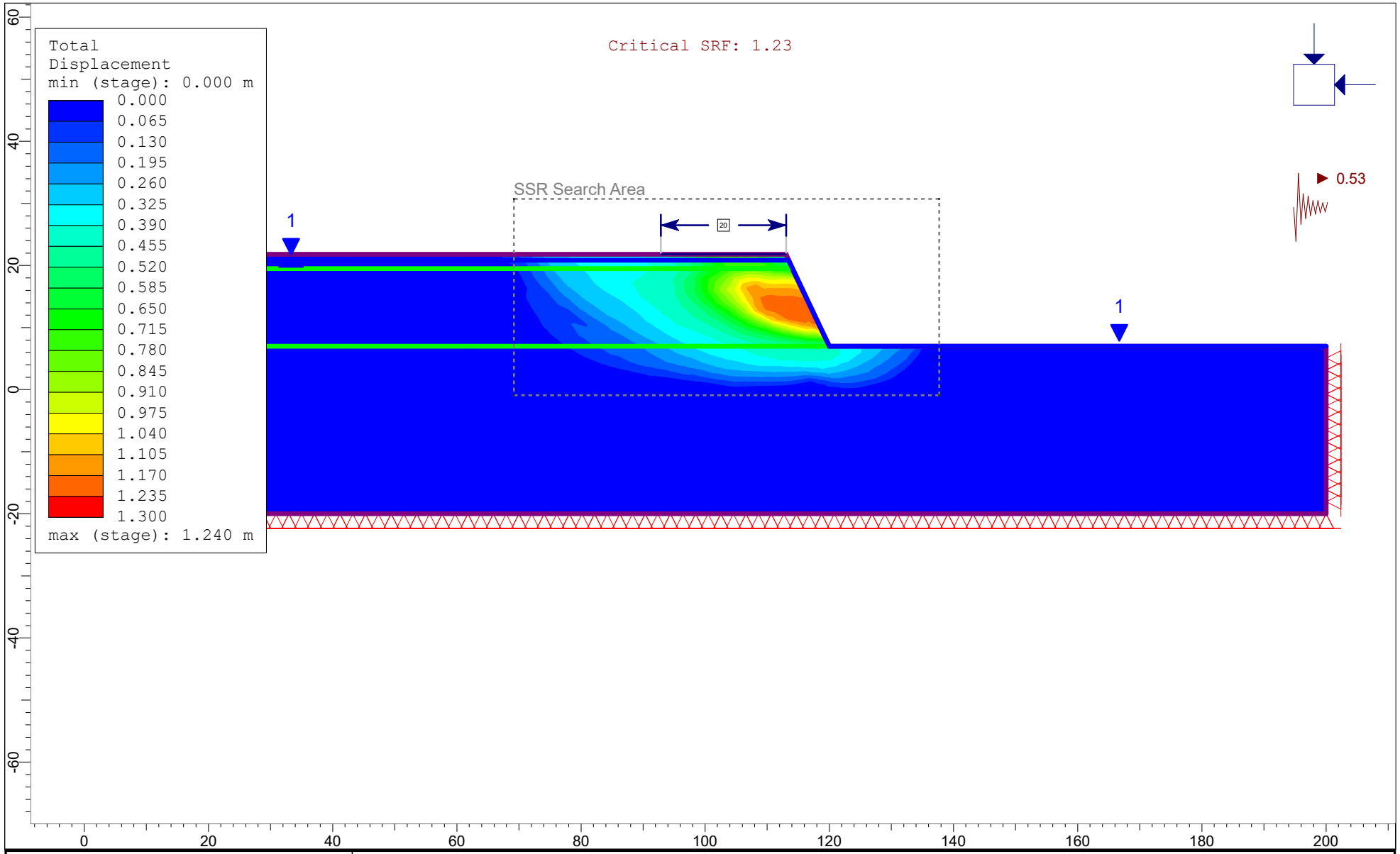
Project	Pit Excavation Deformation			
Analysis Description	Starting excavation, GWL at 1m, Static Loads			
Drawn By	CAWylie	*Scale*	1:777	*Company* TiGa Minerals & Metals Ltd
Date	13/04/2023			*Project:* Barrytown Sands Project



RDCL

INTERPRET 11.015

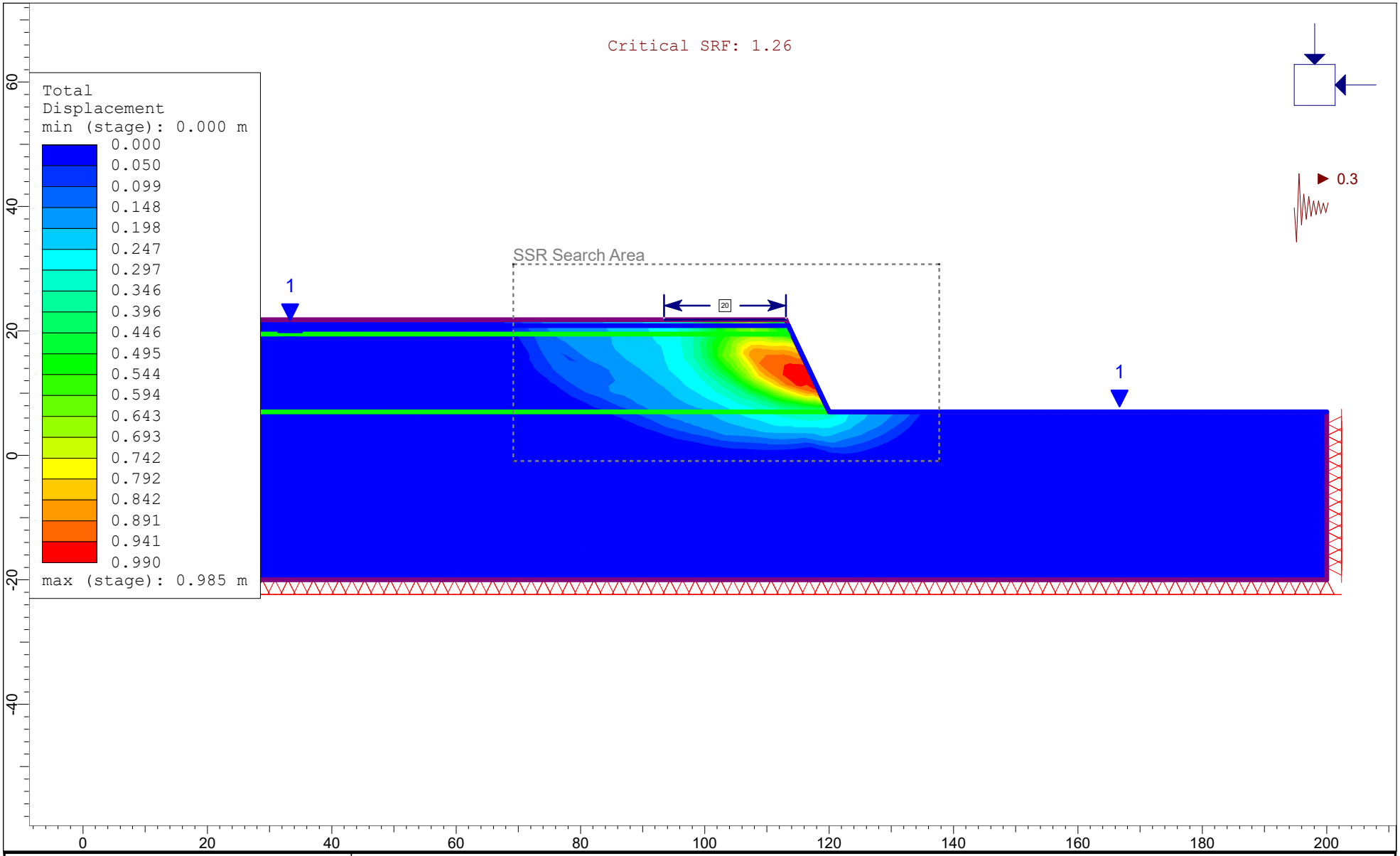
Project	Pit Excavation Deformation			
Analysis Description	Starting excavation, GWL at 1m, MCE			
Drawn By	CAWylie	*Scale*	1:864	*Company* TiGa Minerals & Metals Ltd
Date	13/04/2023			*Project:* Barrytown Sands Project



RDCL

INTERPRET 11.015

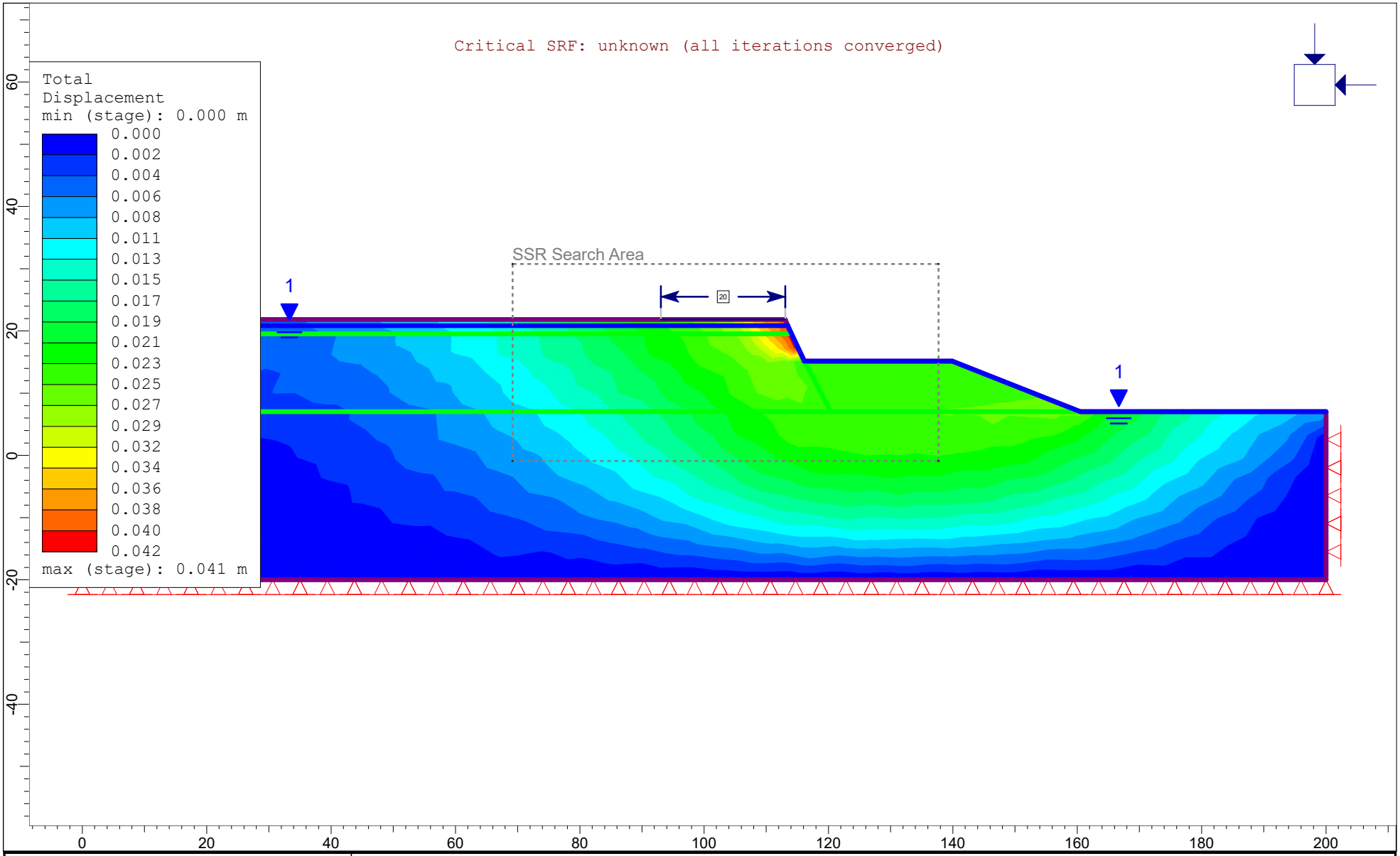
Project	Pit Excavation Deformation		
Analysis Description	Starting excavation, GWL at 1m, OBE		
Drawn By CAWylie	*Scale* 1:864	*Company*	TiGa Minerals & Metals Ltd
Date 13/04/2023		*Project:*	Barrytown Sands Project



RDCL

INTERPRET 11.015

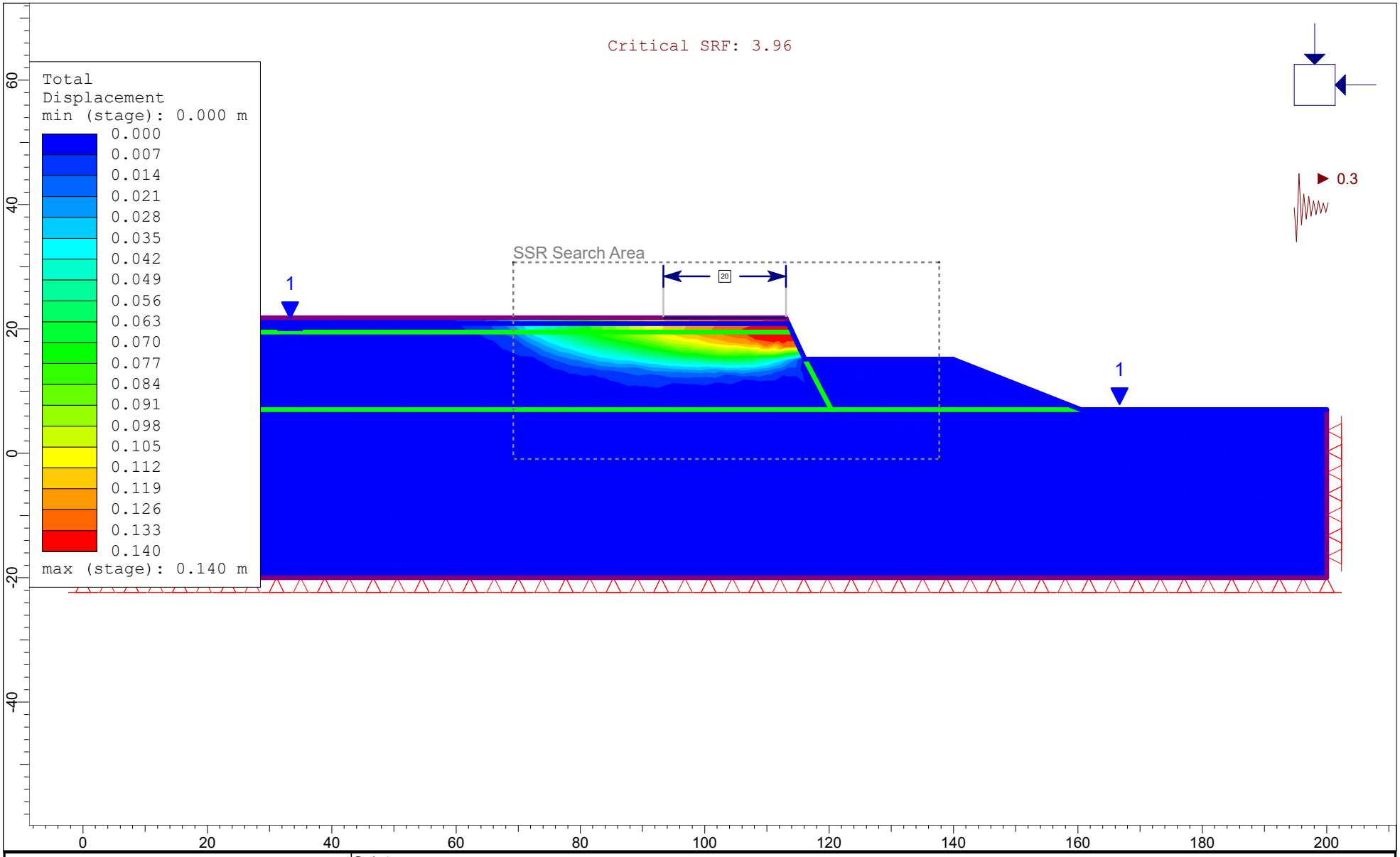
Project	Pit Excavation Deformation			
Analysis Description	Starting excavation, GWL at 1m, OBE			
Drawn By	CAWylie	*Scale*	1:864	*Company* TiGa Minerals & Metals Ltd
Date	13/04/2023			*Project:* Barrytown Sands Project



RDCL

INTERPRET 11.015

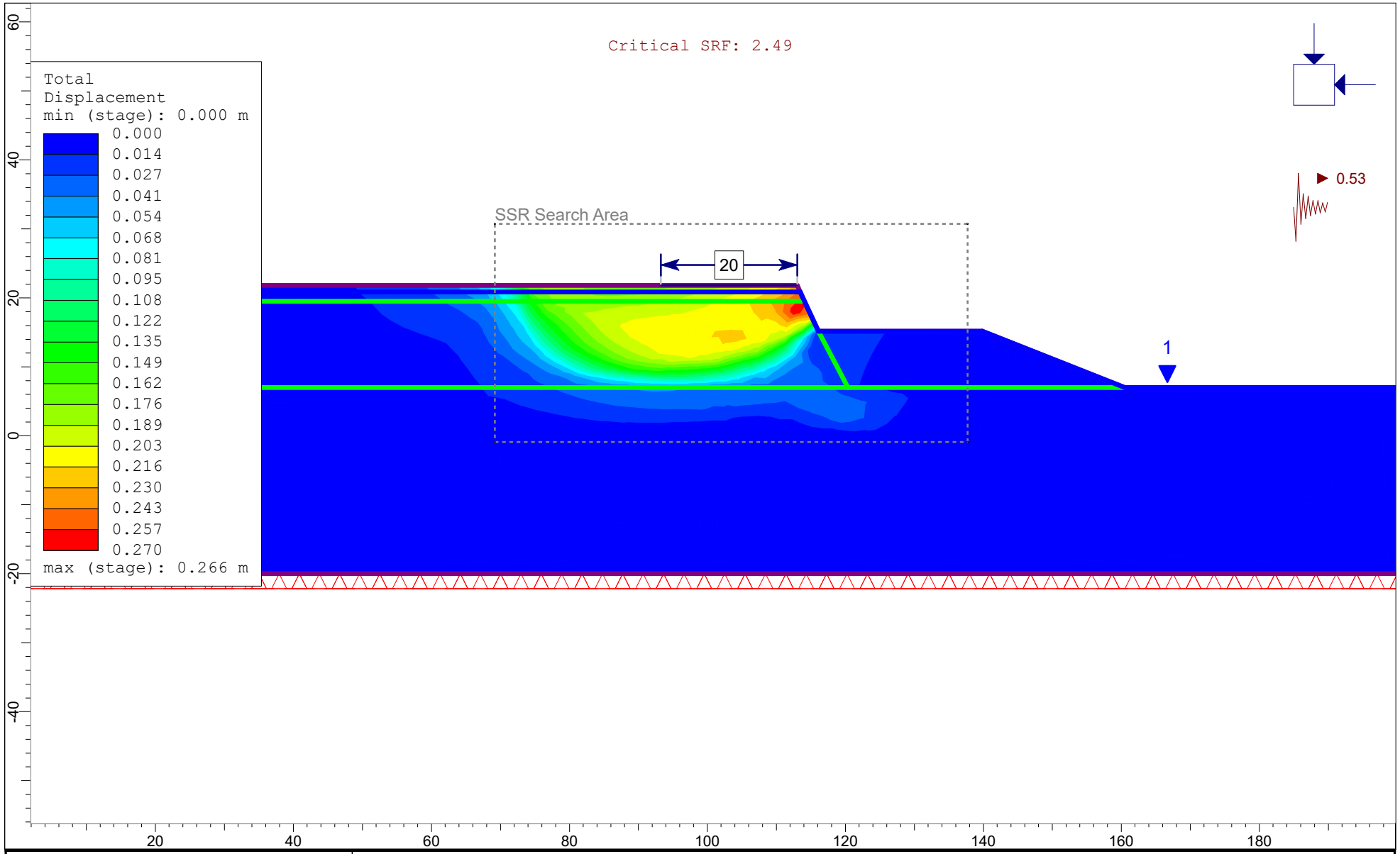
Project	Pit Excavation Deformation			
Analysis Description	Starting excavation, Tailings Backfill, GWL at 1m, Static			
Drawn By	CAWylie	*Scale*	1:864	*Company* TiGa Minerals & Metals Ltd
Date	13/04/2023			*Project:* Barrytown Sands Project



RDCL

INTERPRET 11.015

Project	Pit Excavation Deformation			
Analysis Description	Starting excavation, Tailings Backfill, GWL at 1m, OBE			
Drawn By	CAWylie	*Scale*	1:864	*Company* TiGa Minerals & Metals Ltd
Date	13/04/2023			*Project:* Barrytown Sands Project



RDCL	*Project*	Pit Excavation Deformation	
	Analysis Description	Starting excavation, Tailings Backfill, GWL at 1m, OBE	
	Drawn By CAWylie	*Scale* 1:777	*Company* TiGa Minerals & Metals Ltd
	Date 13/04/2023		*Project:* Barrytown Sands Project

INTERPRET 11.015

APPENDIX C
POTENTIAL FAILURE MODE ANALYSES

Barrytown Mineral Sands Tailings Storage Facility | **Author** CA Wylie | **Company** RDCL

Hazard Description	Hazard Type	Ranking / Evaluation of Risks: Consequence		Probability of occurrence		Risk Score		Controls: Preventative or intervention measures	Residual 1: Consequence		Probability of occurrence		Risk Score	
Compliance and Legislation International Standards														
Fail to planned, build and operate to Global Tailings Standard (2020) revlevant Priciples	Normal condition	Moderate	3	Possible	3	Moderate	9	Client to confirm criteria for design, and operations	Moderate	3	Rare	1	Low	3
Fail to consider appropriate standards, local guidance, industry guidelines, and MBIE Guidlines	Normal condition	Major	4	Possible	3	High	12	Confirm requirements and design appropriately	Moderate	3	Unlikely	2	Low	
Resource Consents not granted	Normal condition	Major	4	Possible	3	High	12	Adequatley develop a meaingful study considering NZ RMA and International Tailings Practice requirments	Major	4	Unlikely	2	Moderate	8
Knowledge Base inadequate	Normal operation	Major	4	Possible	3	High	12	Meaningfully colate and document use of the information for plan, operation, and design decisions	Major	4	Unlikely	2	Moderate	8
Design														
Fail to consider appropriate standards, local guidance, industry guidelines, and MBIE Guidlines	Normal operation	Major	4	Unlikely	2	Moderate	8	Documented methods, transparent references, third party checks.	Major	4	Rare	1	Moderate	4
Failure to achieve Resource Consent	Normal operation	Major	4	Possible	3	High	12	Design and address Preliminary Site Report as per GTS (2020) Principle 4.2 - " Develop a Prelimnary Design"	Major	4	Unlikely	2	Moderate	8
Contaminants in Tailings; total Life cylce	Normal condition	Major	4	Possible	3	High	12	Contaminants excluded from mining and process stream; Full disclosure policy, spillage controls and response plans for environmental spillage approriate monitioring.	Major	4	Unlikely	2	Moderate	8
Supernatant Water leads to tailings entrainment in the event of loss of confinement	Normal condition	Major	4	Unlikely	2	Moderate	8	Not Credible Failure Mode. 1) Tailings surface is always < 3m below Natural Ground level (freeboard). 2) Cap tailings for final landform concurrent with mining advance. 3) Surface drains to reduce overland water inflows to pit. 4) Prevent Supernatant Water from operations sumps; for example slurry densification, mining void control, sumps.	Major	4	Not Credible Failure Mode	0	0	0
Supernatant Water leads to tailings entrainment in the event of loss of confinement	Extreme condition	Major	4	Unlikely	2	Moderate	8	Not Credible Failure Mode. 1) Tailings surface is always < 3m below Natural Ground level (freeboard). 2) Cap tailings for final landform concurrent with mining advance. 3) Surface drains to reduce overland water inflows to pit. 4) Prevent Supernatant Water from operations sumps; for example slurry densification, mining void control, sumps.	Major	4	Not Credible Failure Mode	0	0	0
Loss of confinement due to overtopping	Extreme condition	Major	4	Rare	1	Moderate	4	Not Credible Failure Mode. 1) Tailings surface is always < 3m below Natural Ground level (freeboard). 2) Cap tailings for final landform concurrent with mining advance. 3) Surface drains to reduce overland water inflows to pit. 4) Prevent Supernatant Water from operations sumps; for example slurry densification, mining void control, sumps.	Major	4	Not Credible Failure Mode	0	0	0
Loss of confinement due to Slope Instability	Normal condition	Moderate	3	Possible	3	Moderate	9	1) Critical condition is in the initial short term only. Likelihood and consequence decreases as the mine void advances away from the initial cut (boundaries). 2) Design cut slope angle for adequate Factor of Safety considering preliminary geotechnical ground model.	Moderate	3	Unlikely	2	Low	6
Loss of confinement due to Slope Instability	Seismic condition	Moderate	3	Possible	3	Moderate	9	1) Critical condition is in the initial short term only. Likelihood and consequence decreases as the mine void advances away from the initial cut (boundaries). 2) Design cut slope angle for adequate Factor of Safety considering preliminary geotechnical ground model.	Moderate	3	Rare	1	Low	3

Barrytown Mineral Sands Tailings Storage Facility | **Author** CA Wylie | **Company** RDCL

		Ranking / Evaluation of Risks						Controls	Residual 1					
Hazard Description	**Hazard Type**	**Consequence**		**Probability of occurrence**		**Risk Score**		**Preventative or intervention measures**	**Consequence**		**Probability of occurrence**		**Risk Score**	
Loss of confinement due to Lateral Spread	Normal condition	Major	4	Rare	1	Moderate	4	1) Critical condition is in the initial short term only. Likelihood and consequence decreases as the mine void advances away from the initial cut (boundaries). 2) Tailings backfill is free draining	Moderate	3	Rare	1	Low	3
Loss of confinement due to Lateral Spread	Seismic condition	Major	4	Possible	3	High	12	1) Critical condition is in the initial short term only. Likelihood and consequence decreases as the mine void advances away from the initial cut (boundaries). 2) Tailings backfill is free draining	Major	4	Unlikely	2	Moderate	8
Loss of confinement due to Piping/Erosion	Normal operation	Major	4	Rare	1	Moderate	4	Not Credible Failure Mode. 1) Insitu material not prone to piping. 2)Piezometric levels within Tailings always lower than surrounding natural ground.	Major	4	Not Credible Failure Mode	0	0	0
Loss of confinement due to Foundation Failure	Seismic condition	Moderate	3	Rare	1	Low	3	Not Credible Failure Mode. 1) Storage void is in natural ground with foundation level (mine void invert / pit floor) ~8m below natural ground. 2) Tailings insitu density < than natural ground as "heavy mineral" fraction removed by mining.	Moderate	3	Not Credible Failure Mode	0	0	0
Failure to achieve Close Criteria at Completion	Normal condition	Major	4	Possible	3	High	12	1) Clarify on closure expectations. 2) Design for Closure from onset of operations.	Major	4	Rare	1	Moderate	4
Operations														
Failure to recognise risk of unforseen circumstances	Normal operation	Major	4	Possible	3	High	12	Risk Management oversight and systems mainatined over life cycle.	Major	4	Rare	1	Moderate	4
Safety in Design; working in mine void	Normal operation	Moderate	3	Possible	3	Moderate	9	1) Design mining method to reduce exposure, 2) Develop Principle Hazard Management Plan for the situation.	Moderate	3	Rare	1	Low	3
Tailings disposal method deviates from original design assumption; over life cycle.	Normal operation	Moderate	3	Possible	3	Moderate	9	Risk Management oversight and systems mainatined over life cycle.	Moderate	3	Unlikely	2	Low	6
Tailings Slurry Pipeline Spillage	Normal operation	Moderate	3	Possible	3	Moderate	9	Trigger Action Response Plans (TARP's) in place; physical containment infrastructure in place if required, clean up equipment in place if required.	Moderate	3	Unlikely	2	Low	6
Conent conditions not met; over life cycle.	Normal operation	Moderate	3	Possible	3	Moderate	9	Monitoring and review oversight and systems maintained over life cycle.	Moderate	3	Possible	3	Moderate	9
Emergency Response														
Emergency Planning	Extreme condition	Major	4	Possible	3	High	12	TARP's and Emergency Plans established and audited.	Major	4	Unlikely	2	Moderate	8
Recovery from Failure	Extreme condition	Major	4	Possible	3	High	12	Recovery from Catastrophic Failure plan established for life cycle.	Major	4	Unlikely	2	Moderate	8

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled*. No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

This Report May Not Be Reliable

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed*. The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only*. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org www.geoprofessional.org