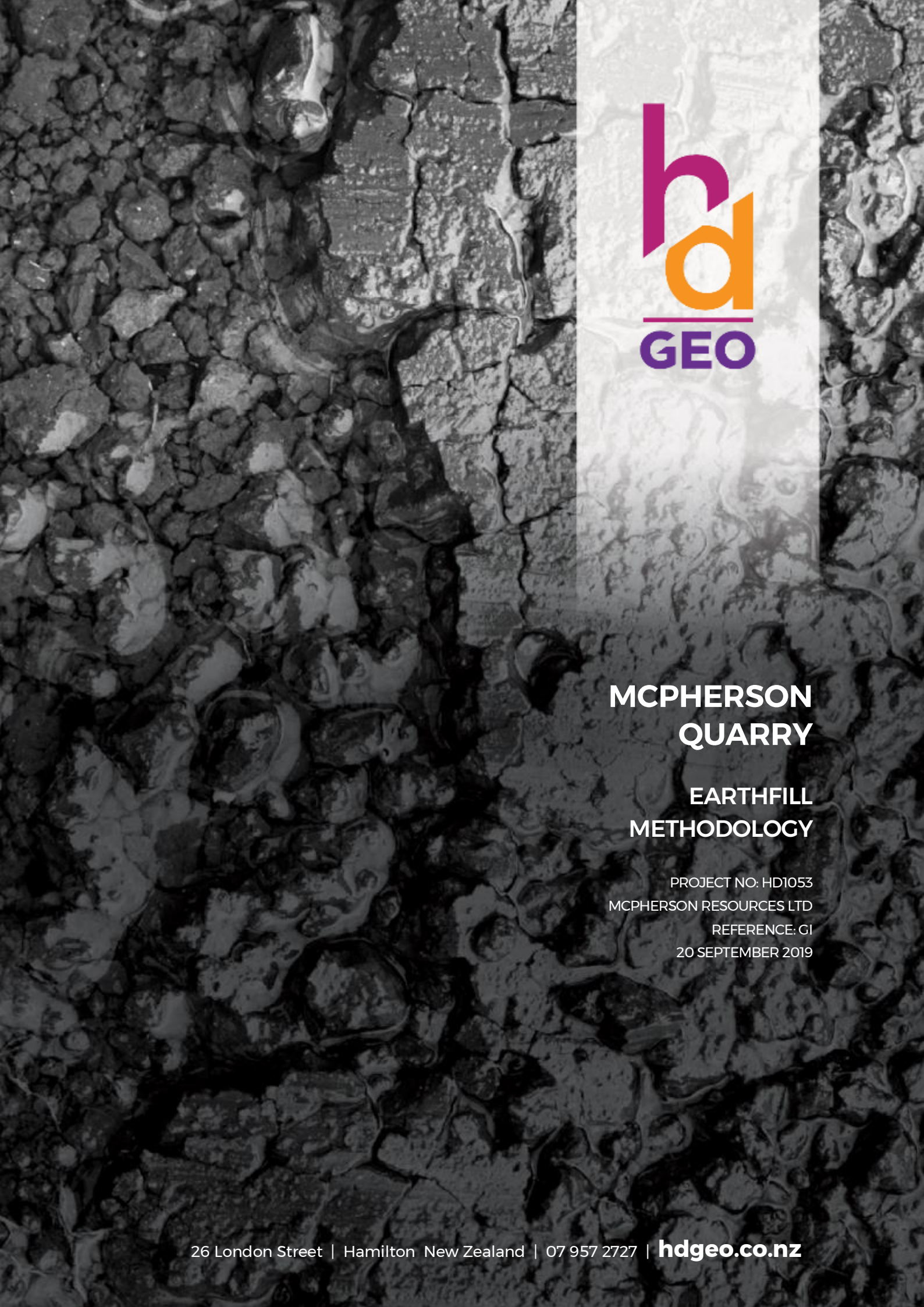
Appendix M

Earthfill Methodology (HD Geo)



MCPHERSON QUARRY

EARTHFILL METHODOLOGY

PROJECT NO: HD1053
MCPHERSON RESOURCES LTD
REFERENCE: GI
20 SEPTEMBER 2019

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Executive summary

McPherson Resources manage an operating aggregate quarry off McPherson Road, Mangatawhiri.

Following a site visit, the Waikato Regional Council have requested a geotechnical assessment of the fill disposal methodology at the site. The purpose of the assessment is to:

- comment on the risks of instability and erosion affecting the overburden disposal area
- provide oversight/ guidance on the fill disposal methodology.

McPherson Resources have engaged HD Geo to complete the geotechnical assessment and to document a recommended filling methodology to support their quarry management plan.

An engineering geologist from HD Geo has completed 2 site visits. A brief ground investigation was completed during one of those visits. The site investigation included 5 test pits and a walkover of the site.

Current fill disposal procedures are to spread fill in thin layers and track roll into place using a D10 bulldozer.

The current fill disposal practices are appropriate for the site and for the material type being placed. In preparation of the recommended fill disposal methodology we have generally adopted the procedures that are currently being used at the site and formalised or extended them as needed.

The existing procedures can be used for general filling operations. Additional site preparation and fill placement recommendations are needed where fill is to be placed within 20 m of the final landform to ensure stability of the final profile.

We have provided some guidance for slopes to inform design of the final landform (should this be required).

Contents

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Introduction

McPherson Resources are managing an operating aggregate quarry which is located off McPherson Road, Mangatawhairi. Overburden from the quarry is disposed of in a fill disposal area. The quarry has previously, and may in the future, also dispose of clean fill sourced from other sites in their fill disposal area.

McPherson Resources have engaged HD Geo to assess and document the recommended filling methodology for the fill disposal area. The filling methodology statement (this report) will form part of their quarry management plan which is being prepared by others. The objective of the filling methodology is to minimise the risk of instability and erosion in the fill disposal area.

Scope

Following a site visit, the Waikato District Council (WDC) requested that the proposed overburden disposal area be subject to a geotechnical assessment. WDC commented on the possibility of instability and erosion affecting the overburden disposal area if the ground conditions or management practices are not appropriate.

The scope of our assessment is defined in our letter dated 19 July 2019. Our scope was defined to respond to WDC comments.

Our scope included:

- review of supplied information
- summary of results of site visit 9 July 2019
- supervise ground investigation including 5 test pits to identify soil properties in the fill disposal area
- assessment of the appropriateness of the current methodology
- preparation of methodology statement for:
    - site preparation
    - cleanfill and overburden fill placement
- discussion and recommendations for layout of final landform
- preparation of a trigger action response plan ('TARP') for management of geotechnical aspects of the fill disposal area

Our scope is limited to assessment of the fill disposal area only. We have not been engaged to carry out inspection or assessment of the extraction operations.

Supplied information

We have been supplied with the following information:

- orthorectified plan view of site sourced from drone imagery (image taken mid 2017)
- construction notes and plans for erosion and sediment control structures[1]
- site plan of "Aquatic Features and Surveying Effort"[2] that shows key ponds, streams and wetlands across the site.

[1] Prepared by Southern Skies Environmental Ltd, dated 17/04/19, ref. ESCP-001
[2] Prepared by Ecology New Zealand, dated 19/03/19, revision 2

We have reviewed this information. Key parts of the supplied information have been incorporated into our assessment and recommendations contained in this report.

Site description

A senior engineering geologist from HD Geo visited the site on 09 and 29 July 2019. The purpose of the site visits was to identify the key geomorphic features at the site to support our assessment.

The site is located at the end of McPherson Road, Mangatawhiri. The quarry has been excavated into steep greywacke slopes that extend north of the site. Slopes are gentle near the toe of the greywacke slopes and extend out to approximately flat farmland to the south of the quarry. Fill is currently disposed of to the south of the quarry over the flatter lying farmland.

The fill disposal area is flat to gently sloping (less than 5 degrees). Depressions indicative of ephemeral or previous stream alignment cross the flat land bounded by the stream.

An incised stream meanders through the site and forms the southern boundary of the fill disposal area. The stream banks are near vertical in places and incised 2 m to 3 m below the surrounding ground. Instability in the form of slumping failure has occurred locally in the stream banks.

A two-stage sediment pond is located to the south east of the quarry.

Proposed development

Plans are to continue the quarrying operations to the north and then east in three stages. Overburden from the quarry extensions will be transported to the fill disposal area south of the current quarry. Over the quarry life the fill disposal area will be extended toward the incised stream that bounds the disposal area to the west and south. A standoff of 20 m from the stream has been nominated by the quarry operators. Existing batter slopes and fill methodology are proposed for the fill disposal area expansion.

A schematic plan showing the proposed site layout is included in Appendix A.

We understand that at the end of quarry operations, the fill disposal area will be used as pastureland.

Site investigation

Ground investigation

Five test pits (TP01 to TP05) were excavated around the perimeter of the proposed final landform to investigate the nature of the ground in that area. A 40 ton Caterpillar 336F excavator and operator was supplied by the quarry to excavate the test pits. Test pits were photographed and logged by HD Geo. Test pits were backfilled at completion of the logging. Engineering logs and photos of the test pits are included in Appendix B.

In general, the test pits indicated most of the proposed fill disposal area is underlain by very stiff silty clay interpreted as volcanic ash deposits to below 3 m depth. Sandy cobbles with some silt interpreted as river deposits were encountered from approximately 2 m depth in TP02 and TP05 on the southern extent of the site. The encountered ground conditions are consistent with the expected geology of the area.

Groundwater seepage was noted in TP02 and TP03 only with remainder of test pits dry.

Site observations

Filling was not taking place during either of our site visits to the quarry. Based on discussion with the quarry operator we understand that the current fill disposal methodology is:

1. transport the fill to the tip area by dump truck
2. tipping the fill in the disposal area
3. spreading, levelling and track rolling of the tipped fill to a depth of approximately 0.5m using a caterpillar D10 (90t) bulldozer

Fill is placed over wide areas (e.g. greater than 70 m x 70 m) and is built up to a final height in nearly horizontal layers. Tipping and spreading operations of subsequent layers results in some compaction to the underlying layers by laden dump trucks and the bulldozer.

Temporary fill batterslopes in the order of 1V:3H (18 degrees) have been adopted at the site. Fill areas are built up to a thickness of approximately 40 m.

During our site visit we observed no obvious indications of:

- recent slope failure or instability
- historic slope failure or instability
- precursors of possible slope failure (such as tension cracks, seepage, erosion/rilling)

The quarry operators were not aware of slope failure having occurred in the batterslopes of the fill disposal area. No obvious indications of erosion or rilling was noted in the temporary fill batter slopes. The fill batterslopes were well maintained and were able to be driven over with light vehicles with no bogging or noticeable loss of traction.

Qualitative risk assessment

If the recommendations outlined below are followed, we consider the risk of injury, loss of life, damage to structures or property as a result of slope failure in the temporary and final land use of the fill disposal areas to be low ('barely credible' in terms of relevant guidelines[3]).

This is based in on:

- our site observations
- our understanding of the performance of the existing operations from the quarry operators and
- our understanding of the end use of the fill disposal area (pasture).

The final landform will be offset 20 m from water courses with surface water collected in surface water control features and directed to engineer designed sediment control ponds (yet to be built). Assuming best practice construction methodologies are followed during construction, then risk to the environment from sediment entering watercourses is qualitatively assessed to be 'low'.

[3] '*Practice Note Guidelines for Landslide Risk Management 2007*', Australian Geomechanics Vol 242, No. 1, March 2007.

Recommendations

Earth fill disposal methodology statement

General philosophy

The fill disposal methodologies discussed in this report are considered appropriate for the end use of the site (pastureland). We don't anticipate any structures to be built on or nearby the fill disposal area. In preparing this methodology, the primary objective has been to minimise the risk of slope failure and erosion in the final landform.

Our disposal methodology statement is based on:

- our observations from the site walkover
- discussions with the quarry operators
- our experience with fill disposal methodologies with a similar risk level (mine tailings and other quarry fill disposal areas)

We anticipate that only limited compactive effort will be put into the fill placement. Given this, settlement of the fill may occur over time. We anticipate the consequence of such settlement to be low.

Site preparation

The proposed fill disposal area is to be situated over flat or gently sloping ground at less than 5 degrees. Based on the results of our site investigation and walkover, topsoil across the site is thin and there were no obvious indications of weak or near surface saturated soils.

Little or no site preparation is likely to be necessary for most of the fill disposal area. Geotechnical advice should be sought if any areas of weaker or saturated soils or seeps are identified in the fill disposal area. If encountered, these may require undercutting or placement of subsoil drains.

Removal of any unsuitable soils and installation of suitable subsoil drainage should be included where the fill disposal area is to pass over the ephemeral stream / previous stream alignment feature (refer to the site plan). We understand that a methodology for this is currently in discussion with WRC.

Disposal of general overburden fill

Overburden fill is generally silt, clay and gravel derived from ash soils and highly to moderately weathered greywacke. Overburden fill is won from the quarry operations at the site.

General overburden fill should be placed in accordance with the existing fill disposal methodology:

- spread fill in thin horizontal layers
- track roll using a D10 bulldozer

All surface water from the fill disposal area should be collected and directed to suitable sediment control structures.

The fill surface shape should be maintained so that it has a slight slope toward a water diversion channel that collects surface flows and directs them to the sediment control ponds.

Temporary batterslopes should be formed clean and straight to assist with monitoring. Temporary batterslope should be maintained at slopes up to a maximum of 1V:3H (18 degrees).

Disposal of clean fill

Cleanfill is imported to the site and is generally sourced from cut earthworks for residential construction carried out in the local area during winter months. By its nature, clean fill is highly variable and can be saturated. Cleanfill should be spread in thin layers (approximately 300 mm thickness) between layers of overburden fill or thoroughly mixed.

Fill disposal within 20 m of final landform shell

Fill disposal within 20 m of the final landform shell will require more careful site preparation and placement methodology to ensure long term stability.

The following methodology should be used for filling within 20 m of the final landform.

1. Stripping of topsoil / other unsuitable material. Topsoil depths in the order of 0.2 m thickness are expected.
2. Import and spread into thin (0.3 m) horizontal layers and compact with bulldozer by track rolling using min D10 dozers.
3. 'Overfill' the Final landform and then cut back to shape. Benches should include a slight slope back to the toe of the batters above to collect water into open channel drains.
4. Plant and maintain vegetation (e.g. grass, shrubs) on benches and batterslopes.

Stock should be restricted from steeper final fill batterslopes.

Discussion on final landform layout

We are not aware of a final landform having been designed and its design is outside the scope of our assessment. The following recommendations may be used for design of the final landform if necessary.

Final landform should include:

- A minimum offset of 20 m from the incised stream which bounds the disposal area
- 1V:3H (18 degree) maximum overall slope
- minimum 5 m wide benches at maximum 5 m lift heights
- maximum 5 m high batters at maximum 1V:1.8H (28 degrees)
- benches falling towards a suitably sized open channel drain located at the toe of the fill batter slope above
- channel drains should be formed to direct the collected water to the sediment control ponds
- check dams included in channel drains at 20 m intervals to reduce water velocities.

A schematic cross section of the layout of the final landform is included as Figure 1.

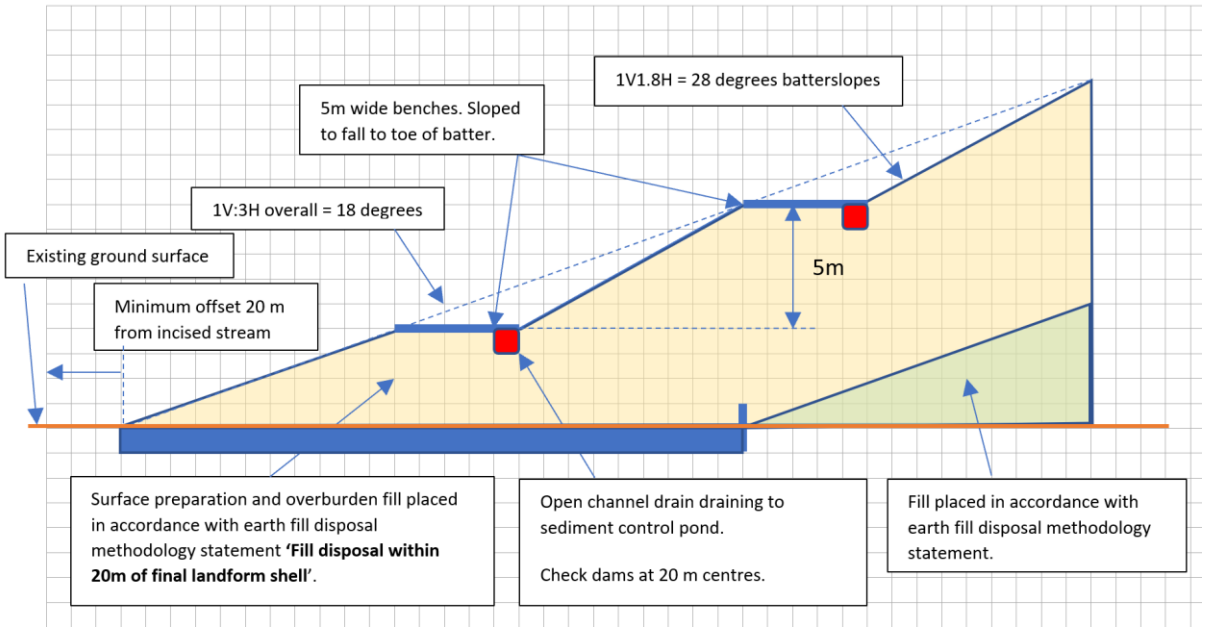

Figure 1 Schematic section of final landform layout

Fill disposal area geotechnical risk management TARP

This TARP has been prepared based on our understanding of the risks associated with the temporary and final land use for the fill disposal area.

Table 1 Trigger Action Response Plan ('TARP') for managing geotechnical risks relating to the fill disposal area

Trigger	Action	Response
Cracking noted in batter slopes (less than 20 mm dilation)	• Take photos of cracks and wider area • Record location and date when cracks noticed • Setup displacement monitoring points (measurement between two fixed points across cracking) • Record regular[4] measurements across displacement monitoring points.	• Seek advise of geoprofessional if change in dilation is noted.
Cracking noted in batter slopes (greater than 20 mm dilation)	• As above. • Seek advice of geoprofessional	• Geoprofessional to investigate cause of cracking and advise on required remedial measures. • Geoprofessional to review earthfill disposal methodology and revise if necessary.
New area of groundwater seepage from temporary or permanent fill batterslopes (less than 2lt /min)	• Take photos • Record location and date when seep first noticed • Monitor for increased flow or increase in sediment being carried by the water flow.	• Seek advice of geoprofessional if increase in rate of flow or carried sediment is noted.
New area of groundwater seepage from temporary or permanent fill batterslopes (greater than 2lt /min)	• As above. • Seek advice of geoprofessional	• Geoprofessional to investigate source of groundwater seepage and advise on required remedial measures.
Erosion / rilling noted	• Take photos of erosion and wider area • Record location and date when erosion first noticed • Investigate and record the cause of concentration of surface water that led to erosion	• Complete remedial measures to mitigate the surface water concentration • Review erosion control plan and revise if necessary.
Bulging noted in fill batter	• Seek advice of geoprofessional • Take photos of bulge and wider area • Monitor for changes • Record location and date when first noticed.	• Geoprofessional to investigate the cause of the bulge and advise on required remedial measures. • Review earthfill disposal methodology and revise if necessary. • Put in place measures to prevent sediment runoff to stream
Slope failure	• Seek advice of geoprofessional • Take photos of failure and wider area • Record location and date when failure noticed • Fulfil any notification requirements with regulatory bodies	• Geoprofessional to inspect site as soon as practical • Geoprofessional to advise on necessity / scope of remedial measures • Review earthfill disposal methodology and revise if necessary • Review TARP and revise as necessary
Significant water ponding or fill weaving under compaction equipment	• Shape the area to direct water away • Move fill operations away to allow the area to dry • Rip the area and allow to dry before re-compacting	• Seek advice of geoprofessional if fill needs to be placed in the area and it is within 10m of the batter face

[4] Daily measurements for two weeks then measurements weekly. Additional measurement required if daily rainfall >20 mm occurs.

Limitations

This report has been prepared for our client, McPherson Resources Ltd, for the purpose detailed above and may not be relied on by any other party or for any other purpose. This report is based on the results of geotechnical investigations, observations and measurements recorded during the site visit as well as information provided by our client.

Inferences about the conditions at the site have been made based on information provided, on the testing and observations undertaken and our understanding of the geological environment in which the site lies. Ground conditions are by their nature inherently variable and may change over short lateral and vertical distances. Should situations arise that are not covered in this document, or conditions vary significantly from those described herein, geoprofessional advice should be sought.

APPENDIX A

Schematic plan of site layout

Key

- Approximate location of Test pit

PROJECT: McPherson Quarry Fill Disposal Methodology	
PROJECT NO: HD1053	
CLIENT: McPherson Resources Ltd	
TITLE: Site layout plan	
SCALE: N/A	
Drawing No: 1	
Drawing by: BY	
Rev Number	
0	Initial

APPENDIX B

Engineering logs of test pits

INVESTIGATION LOG

Client:	McPherson Resoursces Ltd
Project:	McPherson Quarry
Location:	-
Co-ordinates:	-
Elevation:	Ground

Job No.:	HD1053
No.:	TP01
Date:	29.07.19
Logged By:	BY
Checked By:	SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)	Legend	Samples	PID (ppm)	Scala Penetrometer (Blows / 100 mm)	Vane Shear Strength (kPa) Vane: 2839	Water
Topsoil	Topsoil SILT (OL); light brown. Moist.	0.2						
Volcanic Ash	Silty CLAY (CL); light brown. Very stiff to hard; moist; moderate plasticity.	0.4, 0.6, 0.8					189, 47	
Waipapa Group	Silty CLAY (CL); light brown. Very stiff to hard; moist; moderate plasticity; Manganese staining.	1.0, 1.2, 1.4, 1.6, 1.8					UTP, -	Groundwater Not Encountered
	EOH: 2.00m	2.0						

Scala Penetrometer: 2 4 6 8 10 12 14 16 18

Vane Shear Strength (kPa): 50 100 150 200 250

Photo

Remarks

End of test pit at 2.0 m. target depth.

Shear Vanes

- Peak
- Remoulded

Water

- Standing Water Level
- Out flow
- In flow

Investigation Type

- [ ] Hand Auger
- [x] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Client:	McPherson Resourses Ltd	**Job No.:**	HD1053
Project:	McPherson Quarry	**No.:**	TP02
Location:	-	**Date:**	29.07.19
Co-ordinates:	-	**Logged By:**	BY
Elevation:	Ground	**Checked By:**	SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	Topsoil SILT (OL); light brown. Moist.	0.2
Volcanic Ash	Silty CLAY (CL); light brown, motled white. Very stiff; moist; low plasticity.	0.4, 0.6, 0.8, 1.0, 1.2
Alluvium	Silty CLAY (CL), with some cobbles; light brown. Very stiff; moist; low plasticity; cobbles, subround to rounded, poorly sorted.	1.4
	Silty CLAY (CL); orange. Very stiff; moist; low plasticity.	1.6, 1.8, 2.0
	Sandy COBBLES (GP), with some silt; bluish grey. Saturated; poorly graded; cobbles, subround, poorly sorted; sand, coarse, tightly packed, poorly sorted.	2.2, 2.4, 2.6, 2.8, 3.0
	EOH: 3.20m	3.2

Legend | Samples | PID (ppm)

Scala Penetrometer (Blows / 100 mm): 2, 4, 6, 8, 10, 12, 14, 16, 18

Vane Shear Strength (kPa) Vane: 2839: 50, 100, 150, 200, 250

Peak: 174 (at 1.2 m)
Remoulded: 70 (at 1.2 m)
Peak: 32 (at 2.0 m)
Remoulded: 13 (at 2.0 m)

Water: 0.4 m, 2.1 m

Photo

Remarks

End of test pit at 3.2 m. Target depth.

Water seepage at 0.4 m and 2.1 m.

Shear Vanes
- Peak
- Remoulded

Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [ ] Hand Auger
- [x] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Client:	McPherson Resourses Ltd	**Job No.:**	HD1053
Project:	McPherson Quarry	**No.:**	TP03
Location:	-	**Date:**	29.07.19
Co-ordinates:	-	**Logged By:**	BY
Elevation:	Ground	**Checked By:**	SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)
Topsoil	Topsoil SILT (OL); light brown. Moist.	0.2
Residual Ash	Silty CLAY (CL); light orange, motthed white. Very stiff to hard; moist; moderate plasticity.	0.4 – 0.8
Alluvium	Silty CLAY (CL); orange. Very stiff; saturated; moderate plasticity.	1.0 – 2.2
Alluvium	2.2m: light grey. low to moderate plasticity.	2.2 – 3.0
	EOH: 3.10m	3.0

Legend: TS

Samples: -

PID (ppm): -

Scala Penetrometer (Blows / 100 mm): 2, 4, 6, 8, 10, 12, 14, 16, 18

Vane Shear Strength (kPa) Vane: 2839: 50, 100, 150, 200, 250

- 137
- 116
- UTP
- 134
- 44

Water: 1.5 m

Photo

Remarks

End of test pit at 3.1 m. Target depth.
Water seepage at 1.5 m.

Shear Vanes
- Peak
- Remoulded

Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [ ] Hand Auger
- [x] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Client: McPherson Resoursces Ltd	**Job No.:** HD1053
Project: McPherson Quarry	**No.:** TP04
Location: -	**Date:** 29.07.19
Co-ordinates: -	**Logged By:** BY
Elevation: Ground	**Checked By:** SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)	Legend	Samples	PID (ppm)	Scala Penetrometer (Blows / 100 mm)	Vane Shear Strength (kPa) Vane: 2839	Water
Topsoil	Topsoil SILT (OL); light brown. Moist.	0.0	TS			2 4 6 8 10 12 14 16 18	50 100 150 200 250	Groundwater Not Encountered
Volcanic Ash	Silty CLAY (CL); white. Stiff to very stiff; moist; moderate plasticity.	0.2					145 / 32	
		0.4						
		0.6						
		0.8						
Waipapa Group	CLAY (CL); light brown. Very stiff to hard; moist; low to moderate plasticity.	1.0					UTP	
		1.2					-	
		1.4						
		1.6						
		1.8					UTP	
		2.0					-	
		2.2						
		2.4						
		2.6						
		2.8					UTP	
	EOH: 3.00m	3.0					-	

Photo

Remarks

End of test pit at 3.0 m. Target depth.

Shear Vanes
- Peak
- Remoulded

Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [ ] Hand Auger
- [x] Investigation Pit
- [ ] Machine Borehole

INVESTIGATION LOG

Client:	McPherson Resoursces Ltd	**Job No.:**	HD1053
Project:	McPherson Quarry	**No.:**	TP05
Location:	-	**Date:**	29.07.19
Co-ordinates:	-	**Logged By:**	BY
Elevation:	Ground	**Checked By:**	SH

Geology	Geological Interpretation (refer to separate Geotechnical and Geological Information sheet for further information)	Depth (m)	Legend	Samples	PID (ppm)	Scala Penetrometer (Blows / 100 mm)	Vane Shear Strength (kPa) Vane: 2839	Water
Topsoil	Topsoil SILT (OL); light brown. Moist.	0.2						
Volcanic Ash	CLAY (CL); light orange brown. Stiff to very stiff; moist; moderate plasticity.	0.4, 0.6, 0.8, 1.0					142 / 36	
Waipapa Group	Clayey SILT (ML); orange brown. Stiff to very stiff; moist; non-plastic. 1.5m: moderate plasticity. Manganese staining.	1.2, 1.4, 1.6						Groundwater Not Encountered
	Silty COBBLES (GM); light brown. Cobbles, subround, poorly graded; tightly packed.	1.8, 2.0, 2.2, 2.4, 2.6, 2.8					UTP -	
	EOH: 3.00m	3.0					UTP -	

Scala Penetrometer (Blows / 100 mm): 2, 4, 6, 8, 10, 12, 14, 16, 18

Vane Shear Strength (kPa): 50, 100, 150, 200, 250

Photo

Remarks

End of test pit at 3.0 m. Target depth.

Shear Vanes
- Peak
- Remoulded

Water
- Standing Water Level
- Out flow
- In flow

Investigation Type
- [ ] Hand Auger
- [x] Investigation Pit
- [ ] Machine Borehole