Abstract

During the construction of the 325m long balanced cantilever bridge as part of the upgrade for the New England Highway at Bolivia Hill, a temporary access track of approx. 1,050m was required for the construction of the bridge piers. The design and construct of the temporary access track was challenging due to the highly variable rock formations, undulating topography and restricted footprint of the catchment area.

This necessitated the need for a large geogrid reinforced soil structure up to 7.8m high with multiple drainage crossings required for the catchment flow paths. Due to the significant loading applied to the geosynthetic reinforced soil structure during construction over its service life, foundation improvement was required together with the introduction of high strength geogrid. Site-won materials were engineered with the blending of limited import select fill to complete this highly challenging structure.

This presentation describes the engineering approach of the performance-based design methodology to assess the stability and deflection of the structure. Finite element and limit equilibrium analyses were performed to verify design sections and validated with field instrumented monitoring scheme adopted by the contractor to ensure the safety of the structures throughout the design life. A safety-in-design and emergency response plan were both evaluated during the process.

GEOANZ #1 ADVANCES IN GEOSYNTHETICS
7–9 JUNE 2022 | BRISBANE CONVENTION & EXHIBITION CENTRE

A Performance-Based Design for Large Reinforced Soil Structures and Risk Control Process During Construction

Jeroen Berends
FIEAust, RPEQ 23995, CPEng, EngExec, NER, APEC, IntPE (Aus), RMS Slope Risk Assessor

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Gareth Davie and Sean Roff From Georgiou Group
Barry Kok and Joas Christofan (Geoinventions)

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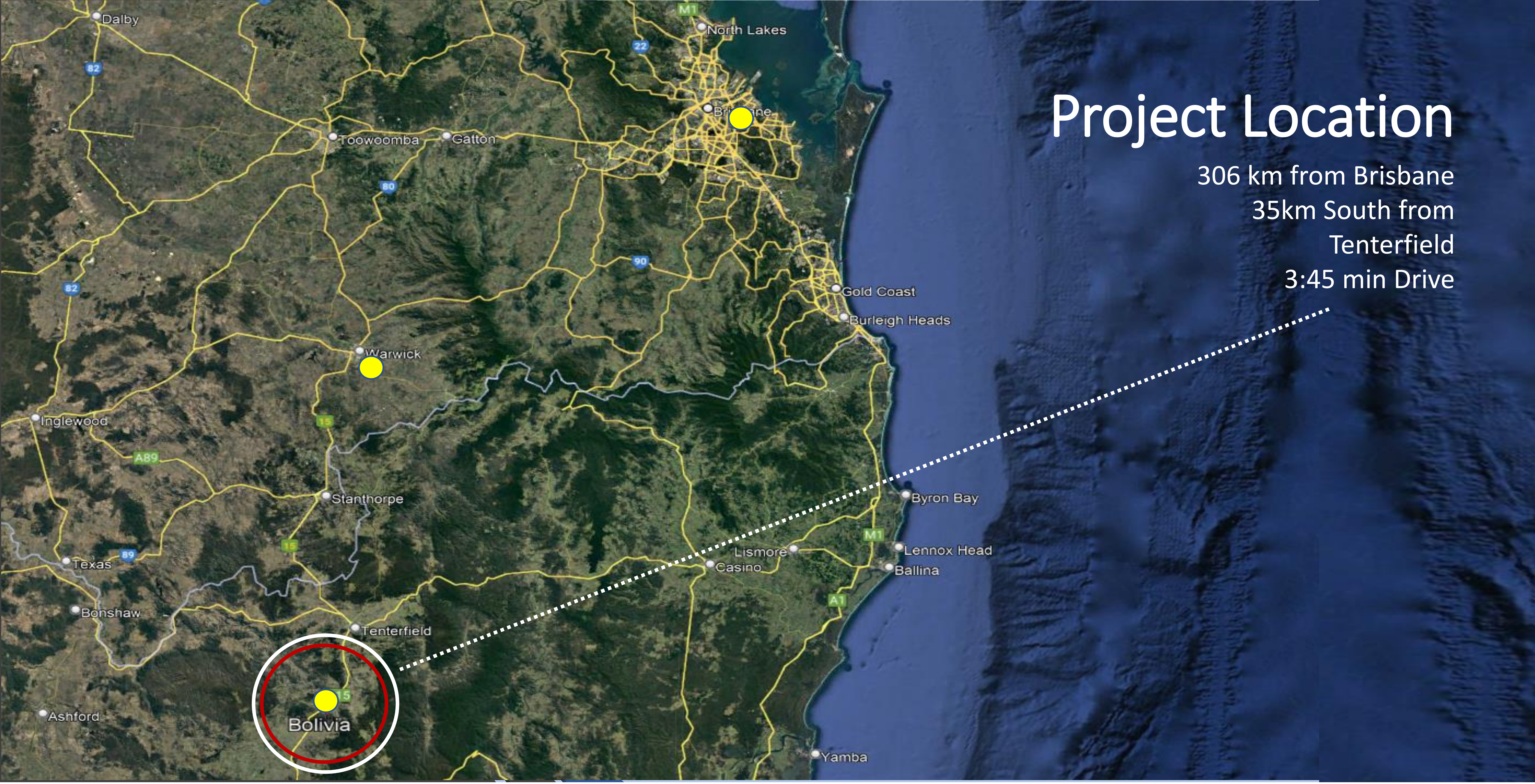
Project Location

306 km from Brisbane
35km South from Tenterfield
3:45 min Drive



New England Highway Upgrade At Bolivia Hill

Parties & Job Specific Requirement

Transport for NSW

Permanent Design

ARCADIS

Job Specific Requirement

19.7 GEOTECHNICAL ENGINEER

You must employ a Geotechnical Engineer to be on site as required to advise you whilst undertaking the Work under the Contract. The Geotechnical Engineer must be a Chartered Professional Engineer with Membership of Engineers Australia (or equivalent) and have at least 10 years' recent similar experience on projects with similar geotechnical conditions. The Geotechnical Engineer must also be accredited with RMS for slope risk assessment and have suitable recent experience in similar terrain.

The Geotechnical Engineer must be approved by the Principal.

The Principal is not obliged to accept any person proposed as your Geotechnical Engineer if that person's qualifications and experience are not acceptable. If the Principal advises that any proposed Geotechnical Engineer is not acceptable, you must then propose another person for that role.

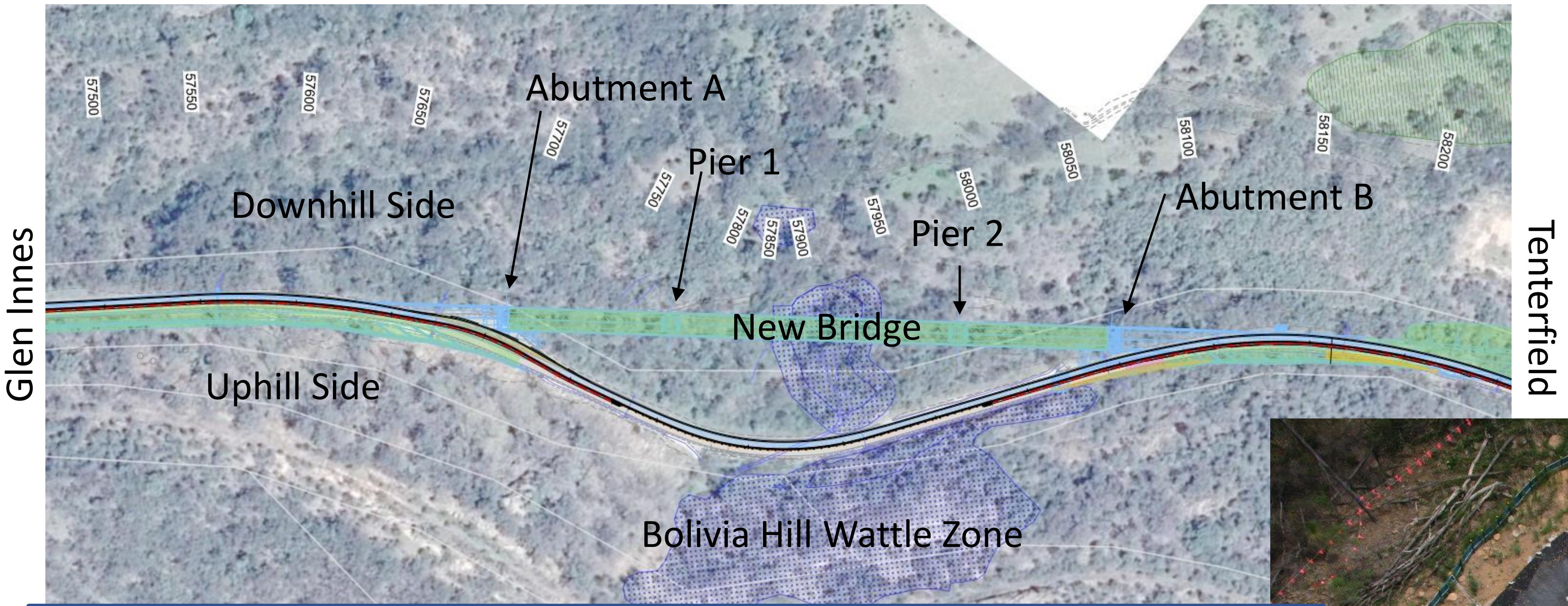
Georgiou SRG

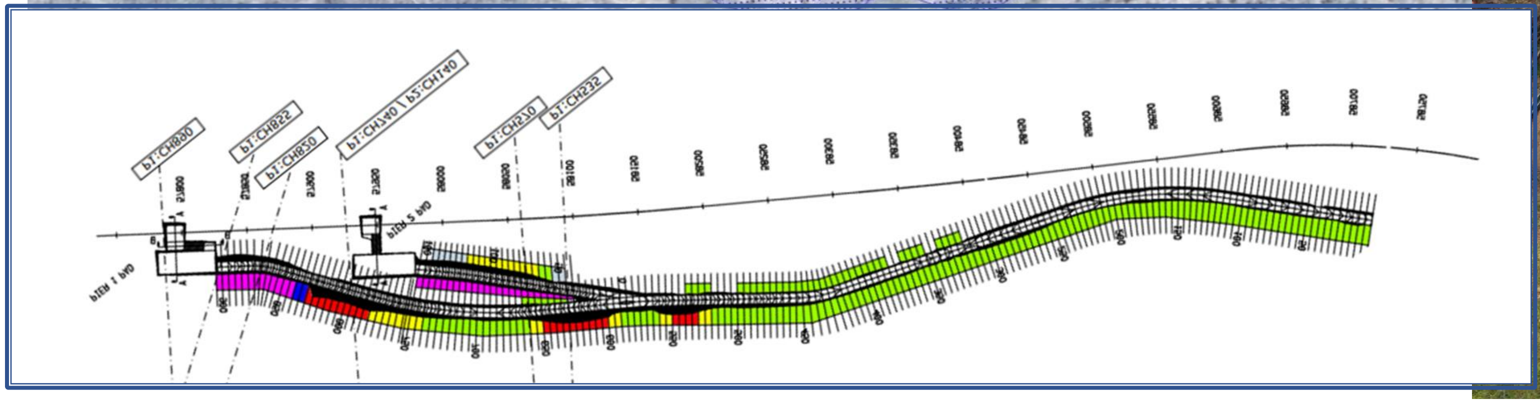
GEOINVENTIONS BETTER ENGINEERING

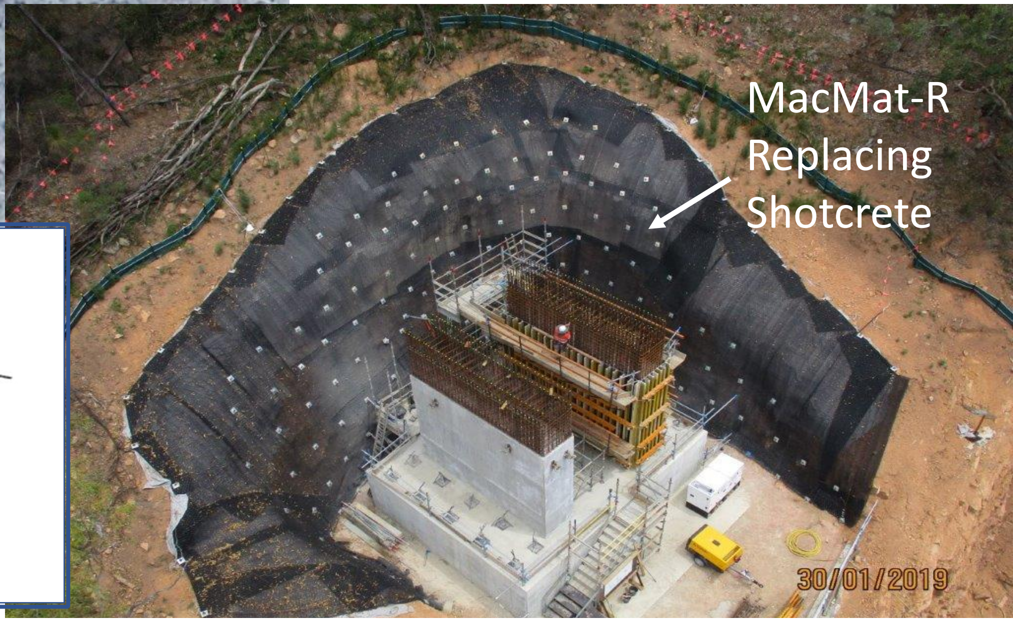
G1 was required to control risk through field observational approach due to variable ground conditions, deep excavations & rockfall hazards on steep slopes. G1 was responsible to apply mitigation measures during construction of the project.

Purpose/Aim

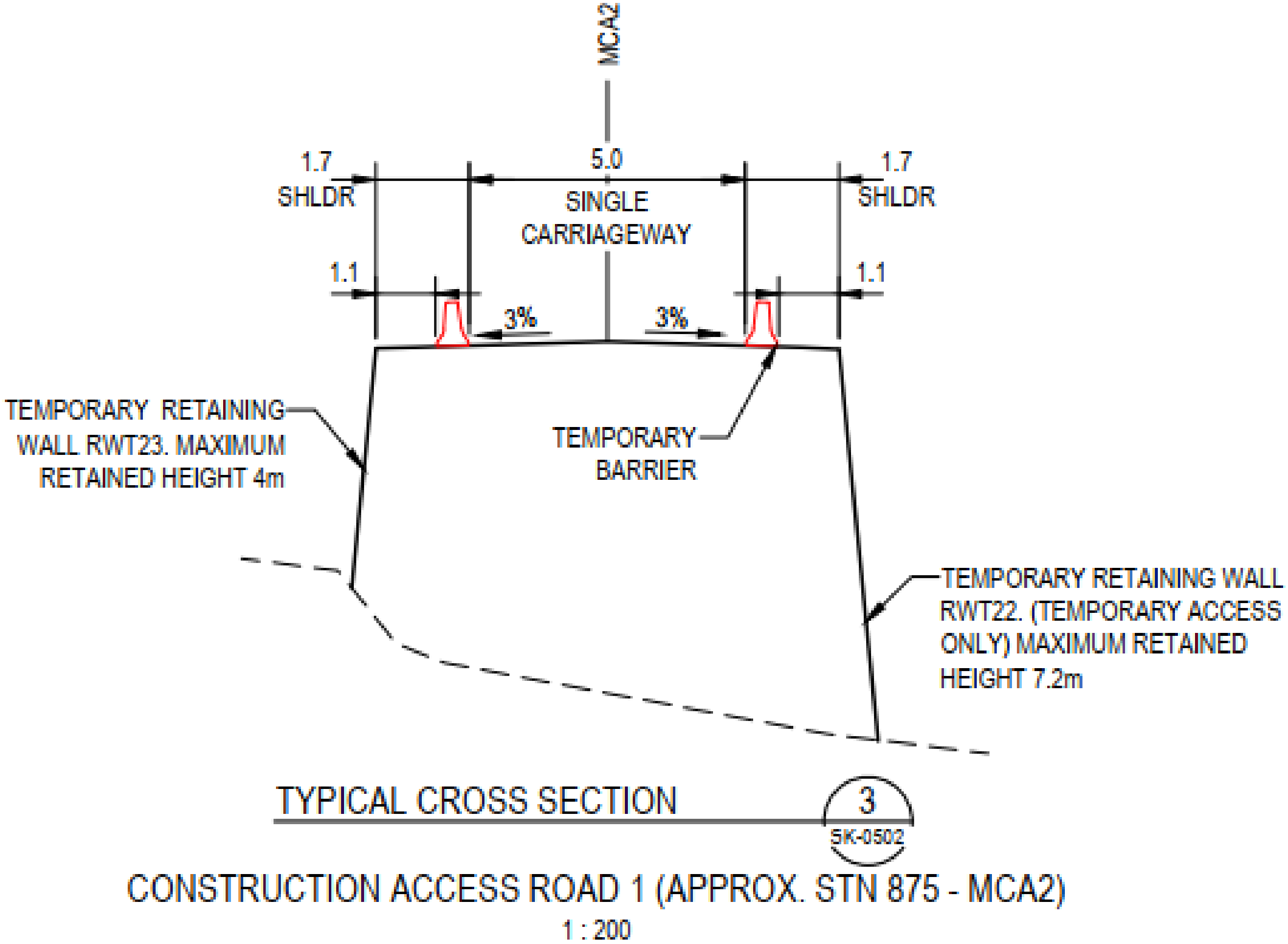
A temporary access track of ≈ 1,050m was required for the construction of the bridge piers 1 and 2.

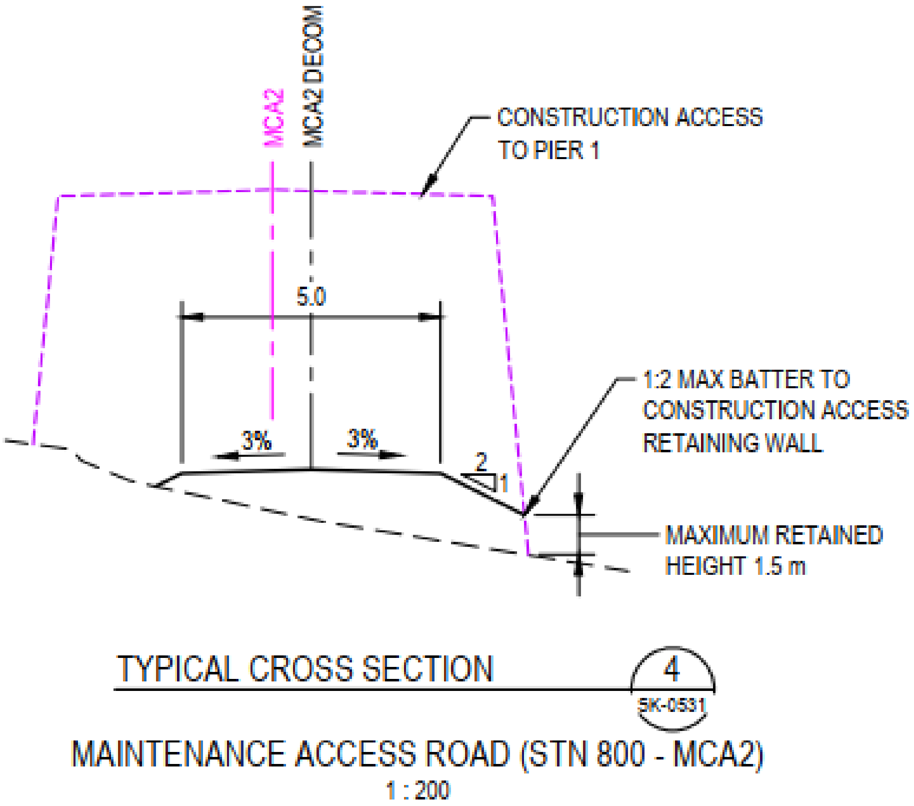






Principal Access Road Design





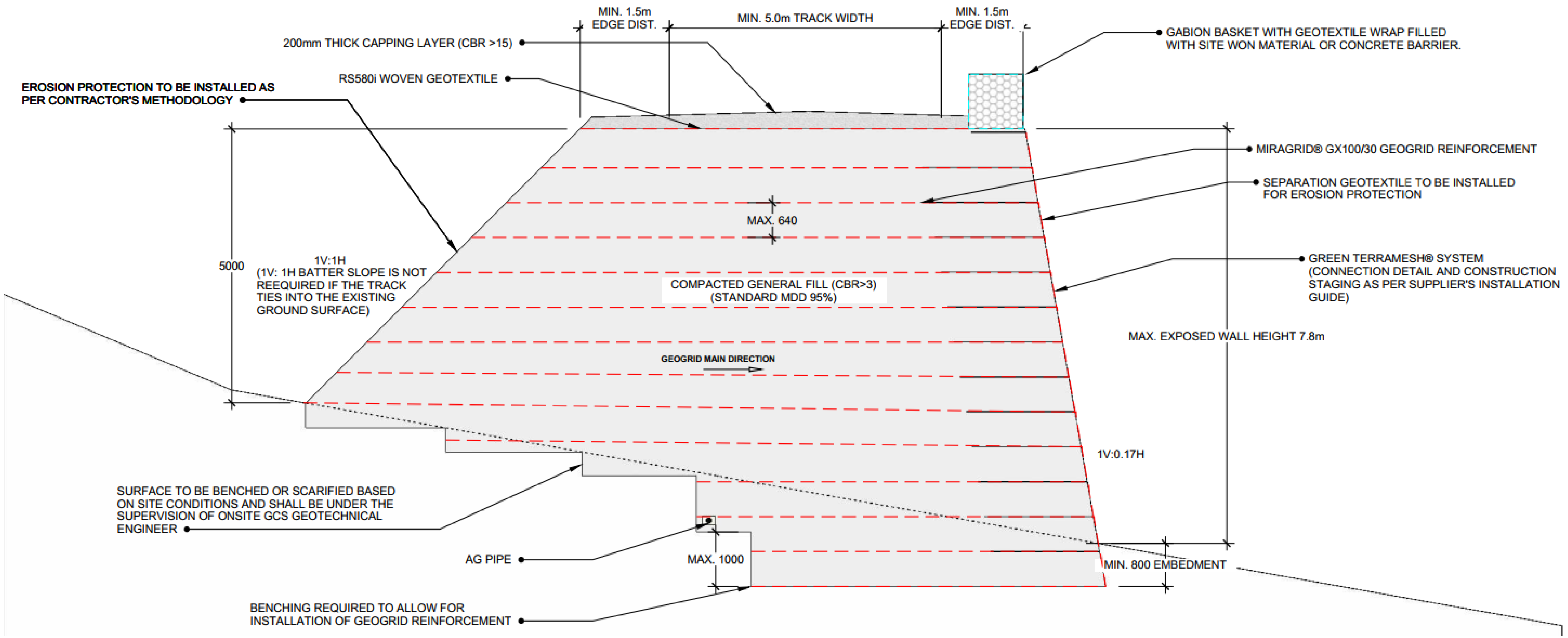
The Contractor Georgiou/SRG approached Geoinventions for a more practical cost-effective design which was easier to construct!

Design Objective

- Design Life of 2 Years.
- Be easily constructable on steep terrain.
- Not impact environmentally sensitive Wattle Zone.
- Reduce excavation and footprint.
- Adopt on site borrow material due to site location.
- Analyze actual load conditions = 150kPa (Max.)
- Design optimisation of current design
- Steepen Angles To Min. 5m Track Width.
- Must later serve as a 3.75m wide 4WD service track with design life of 40 years.


Steep Terrain – Pier 1

Alternative Access Road Design



A more practical design:

- Standard geogrid strength (110/30 to avoid confusion)
- Standard geogrid vertical spacing (640mm max.)
- Use of on-site borrow pit material which is tested on site

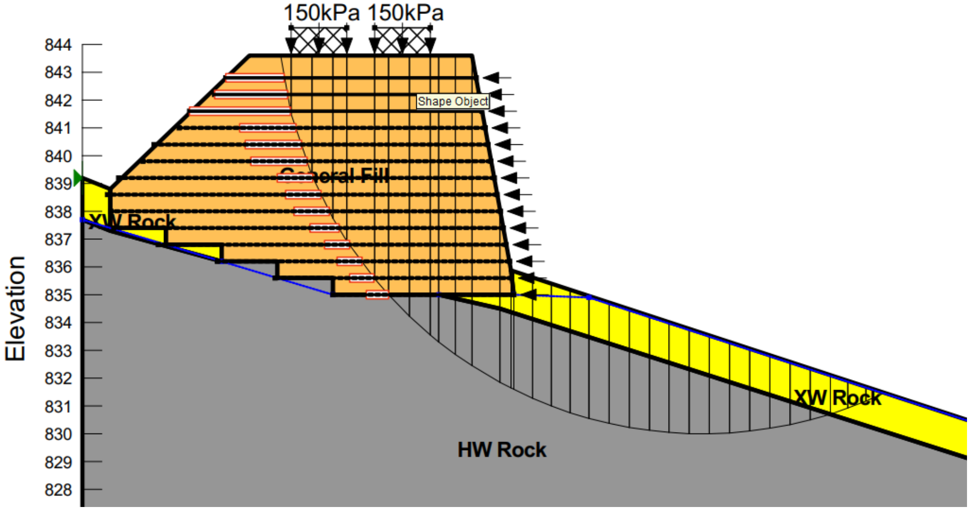
Design Parameters & Model

Geology for the Bolivia Range described as Pink Granite which is medium to coarse grained!

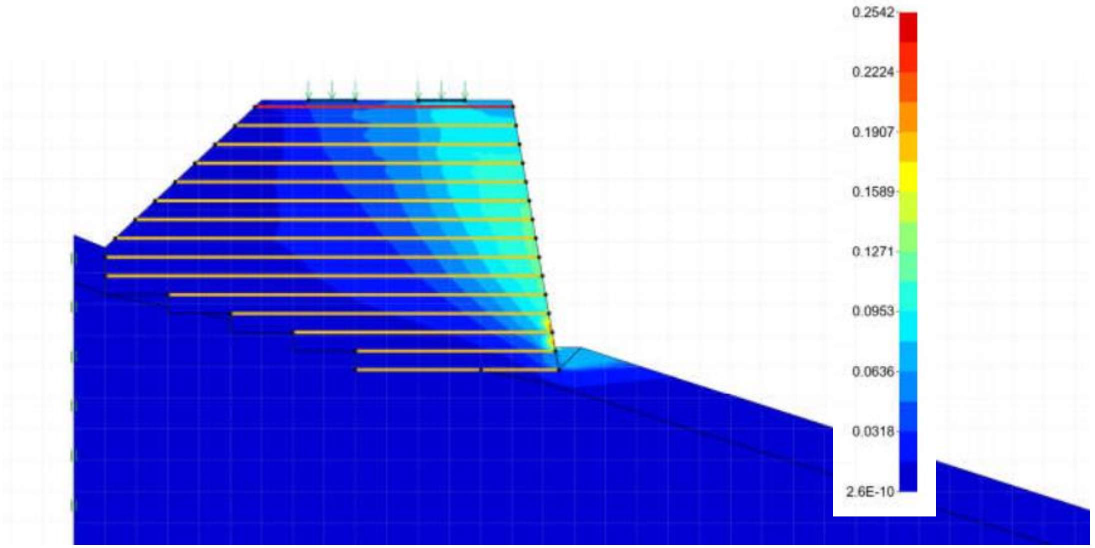
Material	γ (kN/m³)	c' (kPa)	ϕ (deg)
General Fill[1]	20	5	30
Rock Fill[2]	20	0	40
XW Rock	19	0	34
HW Rock	20	10	35
Fr Rock	Impenetrable (In stability analysis)		

Notes:
1. Onsite won general fill material shall have PI(%) of greater than 7 and fines contents of 15-30%.
2. Rock fill material shall be conforming with RMS R44 Table R44.6.

Site borrow material had a higher fines content – 15 – 30% so FEM strain-based analysis was conducted to determine possible wall deflection over time!



Stress Based Design – Minimum FOS ≥ 1.30

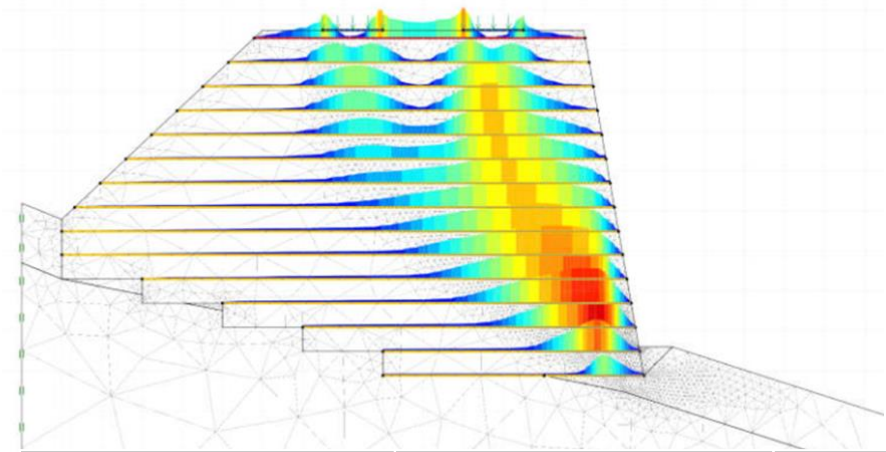


Strain Based Design Predict Wall Deflection

Performance Based Design

Under a 150kPa construction loading:

- Ground Surface Settlement expected was 54mm
- Total wall deflection results indicated the upper bound deflection of 250mm



Risk Mitigation Strategy
Monitor & Assess

↓

Contractor Strict ITP

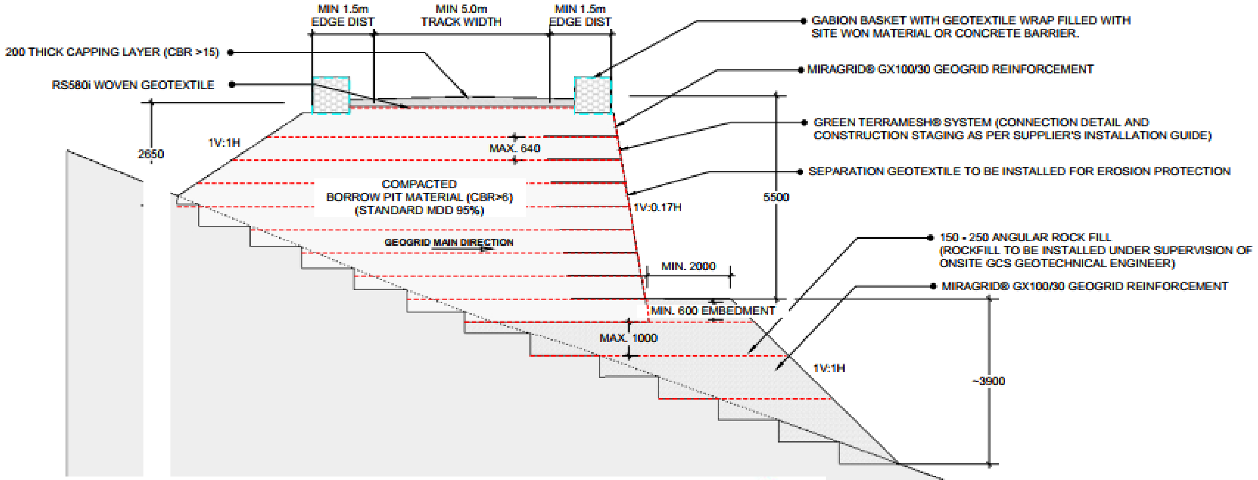
↓

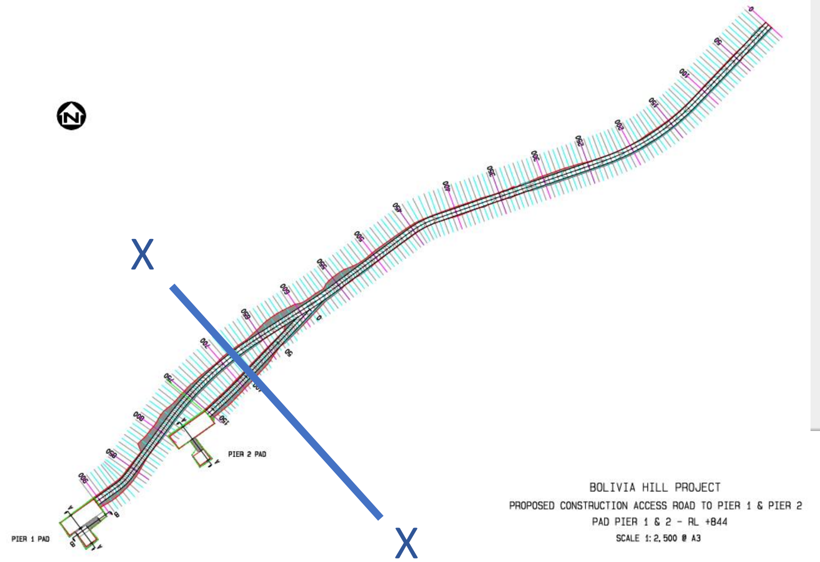
Survey Reference Markers

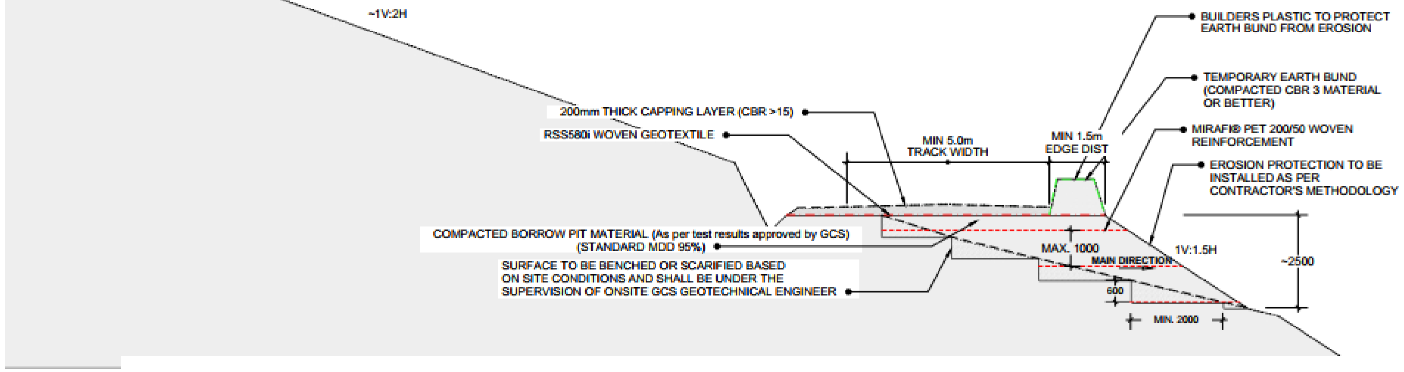
Trigger Level	Deflection (%)	Wall Deflection (mm)	Action
Tigger Level 1	40%	100	Continue Monitoring 1x Per Day
Trigger Level 2	60%	150	Increase Monitoring To 2x Per Day
Trigger Level 3	80%	>200mm	Stop Construction And Move Machinery Away From Structure. Stabilise Toe With More Rockfill.

Contractor Georgiou/SRG conducted daily survey and reported a maximum deflection of 72mm during crane operations.

Performance Based Design Solution







Geosynthetic Material Selection

80 Degree Geotextile Lined Green Terramesh Units

Rigid facing panel to limit deformation during compaction

2m Integral DT Mesh Reinforcement

Construction Methodology – HP1 Foundation Verification

Foundation treatments to create a competent level foundation included:

1) Remove and replace due to undulating granite rock surfaces

2) Installation of Tencate RSI 580 or PET woven geotextile over compacted fill in softer areas near natural gulley areas

Construction Methodology – HP2 Verify Materials

To complete the Reinforced Soil Structure the following materials were verified as being supplied to site:

- 1,200No. Green Terramesh units with 2m long integral mesh reinforcement
- 29,640m2 of Tencate GX100/30 geogrid
- 110 No. Galmac 2x1x1 Gabions For Delineation Boundary Above The Wall
- 4,000m2 Tencate RSI 580 Woven
- 32,000m2 Tencate PET Woven

Construction Methodology – HP3 Geogrid Connection & Lengths

- Lacing Geogrid & Mesh
- Reinforcement Together

Construction Methodology – HP4 Verify RSS Fill

Construction Methodology – HP5 Facing Angle & Alignment

Special manufactured scaffold tubing kept overlapping mesh away from work zone behind

Conclusions

- Field observational approach of having full time G1 Geotechnical Engineer to ensure innovation is implemented and control risk was important to the project.
- Detail and constructability of original design was not practical and not constructable.
- Use of on-site borrow material under our guidance and control of G1 provided significant cost savings to the project.
- Providing a practical performance-based design with monitoring, risk mitigation and contingency can be a major cost benefit to all stakeholders.
- Geosynthetics play a major importance to cost-effective design methods and should be taught efficiently within all Universities.

Project Success

Thank You