Mining to Modern Landfill

GRP Ltd C&D Landfill

Luke Matheson and Dawn Mercado | Pattle Delamore Partners Ltd

Introduction

Case study of mine site remediation and land reuse as landfill

Mining history at Pukemiro Collieries

Geotechnical aspects of landfill design

Completed remediation


GRP
100% NEW ZEALAND OWNED & OPERATED

Where is GRP, Pukemiro, Glen Afton? Huntly, follow Rotowaro Road.

Coal Mining History

A lot of history in the area

Geology

Useful

Newcastle Group - Mesozoic Basement rocks at the site consist of indurated, siltstone with minor sandstone and mudstone. In outcrop at this site the unit is moderately to highly weathered and jointed siltstone/mudstone (argillite).

Useful

Te Kuiti Group - The Te Kuiti Group (TKG) include:

Waikato Coal Measures - The Waikato Coal Measures (WCM) include Late Eocene and Early Oligocene coal seams and associated carbonaceous claystone, siltstone and minor sandstone deposits. Directly overlie basement rock, usually with a distinct angular unconformity (erosional surface).

OB

Mangakotoku Formation - Conformable over the WCM with gradational contact. Comprises the Glen Afton Claystone, Pukemiro Sandstone and Mangakotoku Siltstone members. Shallow marine to marginal marine strata comprising predominantly massive non-calcareous siltstone with sandstone in places.

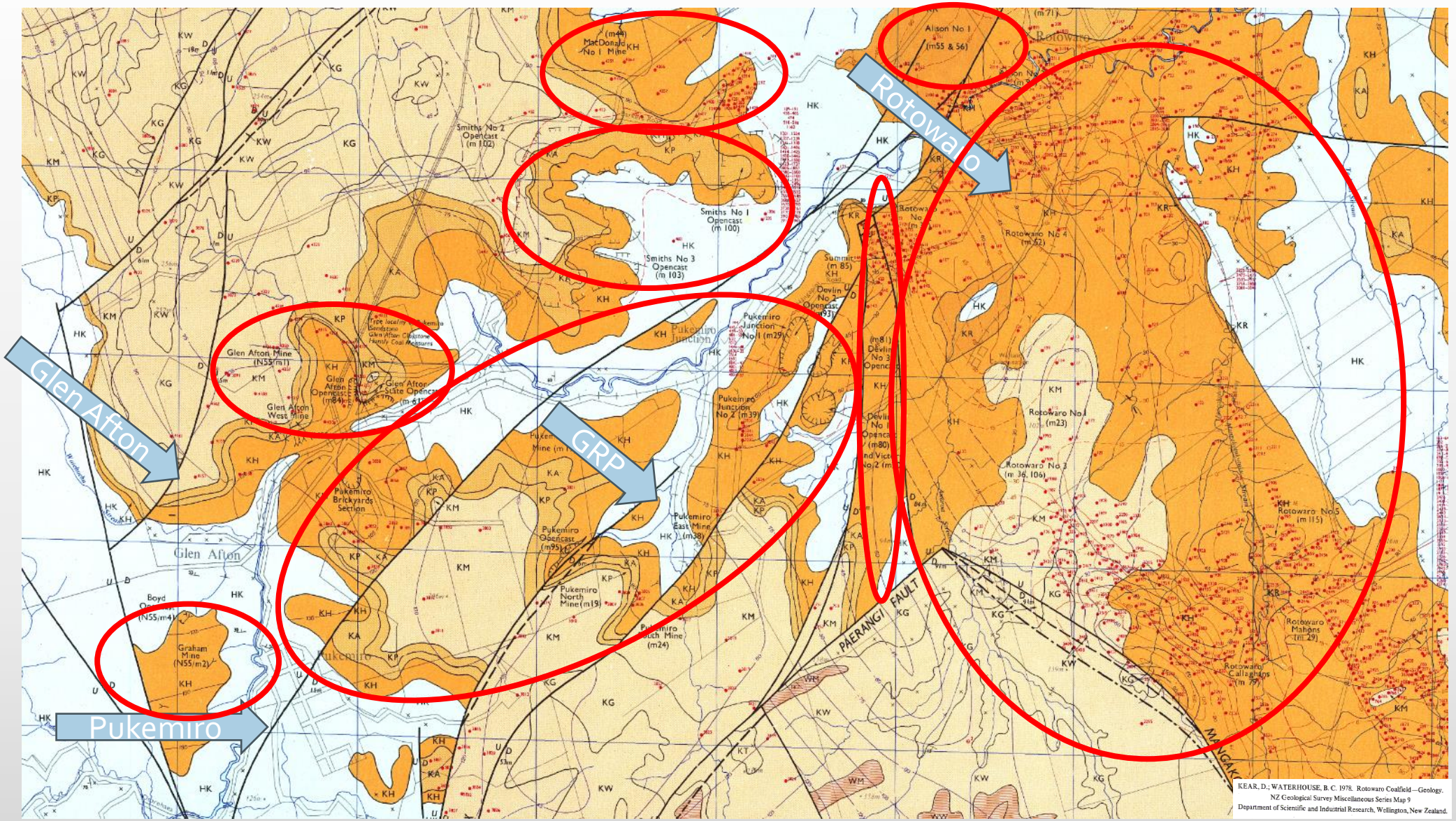
Useful

Glen Massey Formation - comprises calcareous marine mudstones, siltstones, and limestones. The formation is defined by 50 m high bluffs and steep incised gullies to the south-east and northwest of the site. Conformable above Mangakotoku and unconformable where it overlies Basement.

Mix

Tauranga Group - Fine to coarse Pliocene – Quaternary sediments and tephra derived from the underlying roc and volcanics from the Taupo and Waikato region. Unconformable over Te Kuiti Group rocks and consists of predominantly weathered volcanic ash and colluvium of variable thickness, typically 1 – 5 m thick in the site area. However, the unit thickness can range 0 – 60 m in the wider area.

Coal Mine Locations



Coal Seams

- The coal seams at the site include the Kupakupa Seam and the Renown Seam.
- The Renown Seam near the Pukemiro group of mines was around 1.2 m thick and at depths suitable for open pit mining.
- Seam separation between Renown and Kupakupa seams is <5 m (ranging 2.9 m to 4.3 m).
- The Kupakupa Seam in the wider area is typically 4 m to 6 m thick and up to 14 m thick (near MacDonald Mine, >2 km north of the site and landfill cell).
- The Kupakupa Seam near Pukemiro group of mines was reported as up to 9 m thick and averaged 6 m.
- There are splits in the Kupakupa Seam that give rise to the Kupakupa Upper, Main and Lower Seams.
- The Main Kupakupa seam (pre-mining) in the vicinity of the new landfill cell was around 3 m thick in the east to 5 m thick in the west.
- First workings of the coal seams would target minimum seam thickness of around 3.7 m, leaving 1.0 m of coal in the roof as support.
- Workings in seam thickness of <2 m was generally too difficult to be undertaken. Despite this, thin seams were still worked.
- The available mine plans show much of the Pukemiro group of mines has been extensively pillared, allowing delineation of areas where seam thickness was typically around 4.0 m thick.
- The coal splits of the Kupakupa Seam regionally are not well correlated over large distances. The exception to this is the moderately well-defined Lower Seam found in the wider Pukemiro sector (Manhire and Phelps 1986).
- However, the Lower Seam lacks sufficient data to be accurately modelled within the site boundary (Fergusson, R&R Ltd 2019), as many of the boreholes stop in the Main Seam or in lithology above the Lower Seam.
- The Lower Kupakupa Seam if present in the landfill area is likely >5 m below the Main Seam and likely being uneconomic to justify further exploration.
- More recently drilling for landfill development has not identified the lower split.

Pukemiro East Mine Entrance

Coal bins and screens at the Pukemiro Coal Mine, Waikato. Godber, Albert Percy, 1875-1949 :Collection of albums, prints and negatives. Ref: APG-0487-1/2-G. Alexander Turnbull Library, Wellington, New Zealand.

Auckland Libraries Heritage Collections 589-0046

Pukemiro East Mine Entrance – Current Site Office and Weighbridge

Entrance to the Pukemiro Coal Mine, Waikato. Photograph taken by Albert Percy Godber, in 1917. Dated from surrounding images in the Godber Album at Pa1-q-102 (p 61)

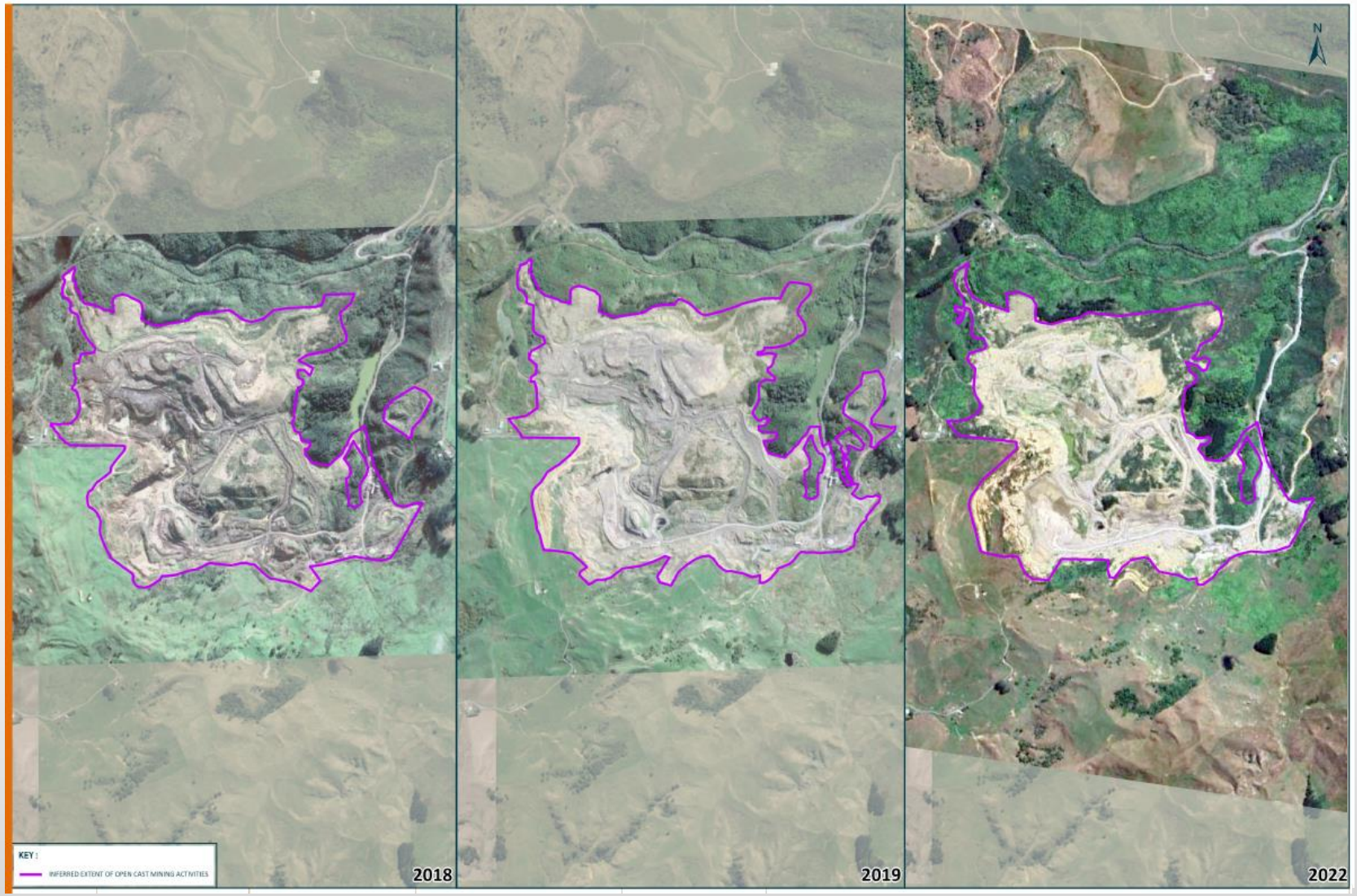
Glen Afton Branch Line

- The Glen Afton Branch Line - New Zealand Railways (NZR) branch line to the Pukemiro coal mine was opened in 1915 and closed in 1973.
- Was originally 14.1 km and built to serve coal mines in the Awaroa district west of Huntly at Rotowaro, Pukemiro and Glen Afton.
- The Bush Tramway Club is a heritage railway 12 km west of Huntly along the Rotowaro Road, in the Waikato region of New Zealand.
- BTC founded in 1965 to preserve equipment from New Zealand's former bush tramways and light industrial lines, railway lines which were used to remove timber from the bush and transport coal from mines to dairy factories.
- In either 1974 or 1977 the section to Rotowaro, Pukemiro and Glen Afton was handed over to the Bush Tramway Club also know as The Glen Afton Line - Heritage Railway
- It regularly operates restored locomotives along the Rotowaro-Glen Afton section of the former Glen Afton Branch.
- The last 2.5 km to Glen Afton is no longer usable.
- Rotowaro station was moved to the Bush Tramway Club.
- https://www.bushtramwayclub.com/newnewsletters.html

Coal Production Stats

- Pukemiro Collieries (underground and open pit) 1915 to 1967 produced >5,000,000 tonnes of coal.
  - Open pit in 1950's small area.
  - Transition to open pit mining in the 1970's.
  - Puke Coal Ltd most recent operation.
- McDonald Mine 1931 to 1971, produce close to 5,000,000 tonnes of coal.
- Glen Afton Mine 1920 to 1969, produced >3,000,000 tonnes of coal.
- Huntly Power Station 1983 - coal production increased, then declines due to reliance on gas.
- About 850,000 tonnes of coal a year is currently produced from opencast mines at Rotowaro and Maramarua.
- Coal-in-ground resources for the region are about 2 billion tonnes, but a large proportion of this is too deep to mine.
- The Huntly East mine closed in 2015 and the remaining opencast resources that have reasonable prospects for eventual economic extraction are limited.
- https://www.nzpam.govt.nz/nz-industry/nz-minerals/minerals-statistics/coal/regional-coal-resources

Open Pit Mining 1984 - 2020

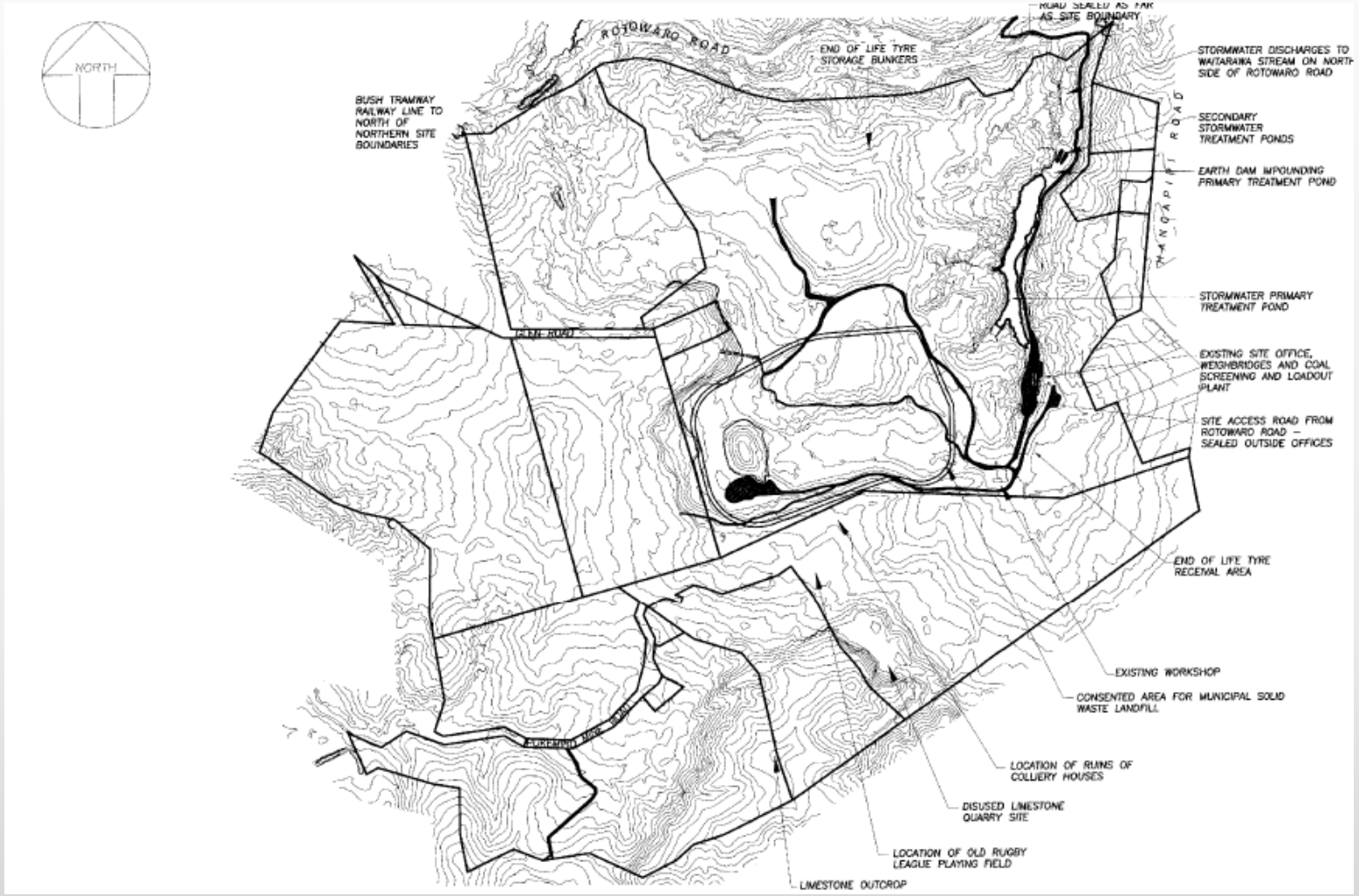


Landfill History

Puke Coal Ltd

Landfill History –

Existing cell has its own clay liner and leachate collection. GRP upgraded this by removal of old ponds and irrigation system.



New Owner, New Era and New Landfill Design

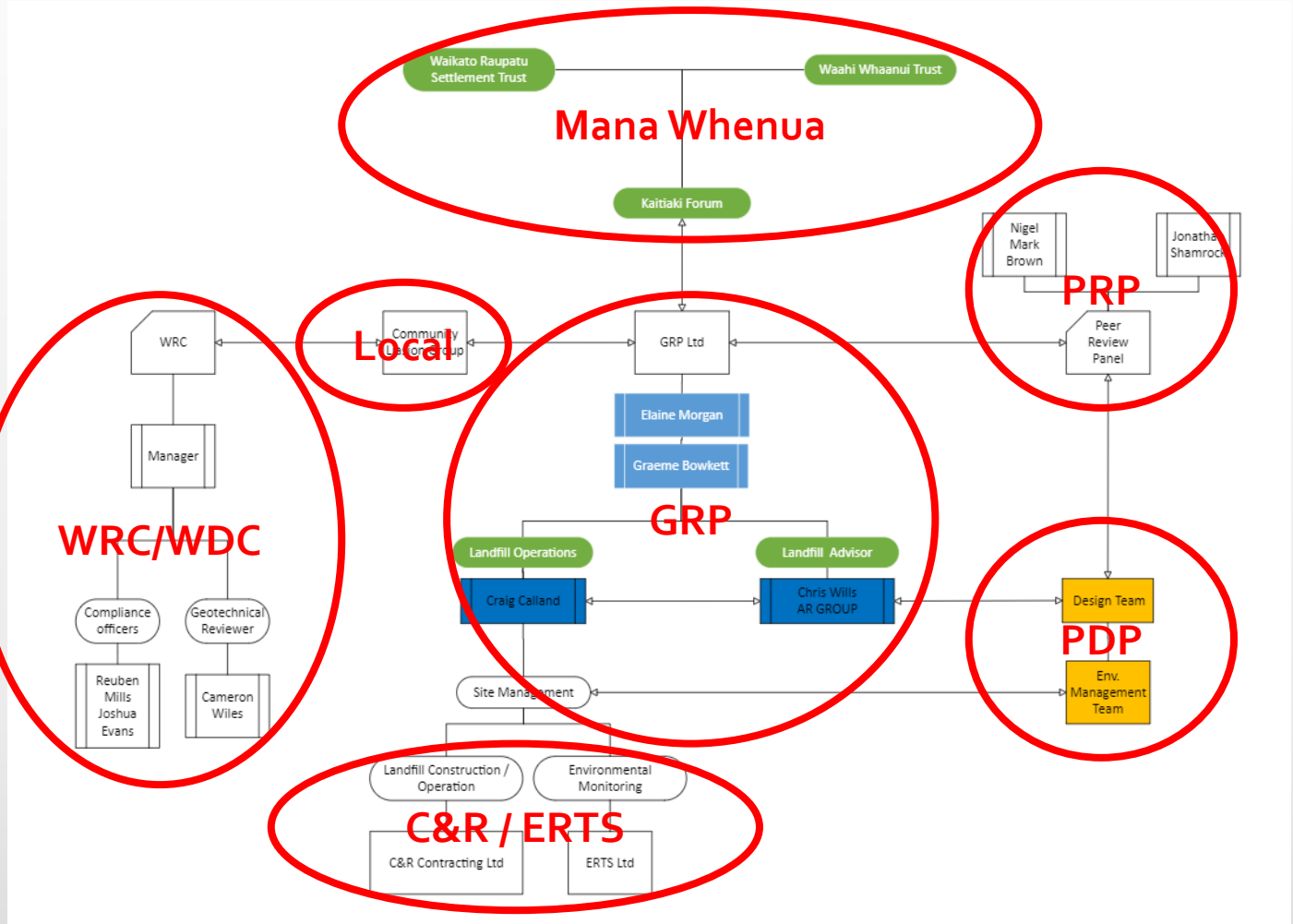
What's involved?

Consents / Ecology / Stormwater / Air Quality / Water Quality / Waste Acceptance Criteria / Groundwater Monitoring / Mātauranga Māori / Surface Water and Ecological Restoration / Site Remediation

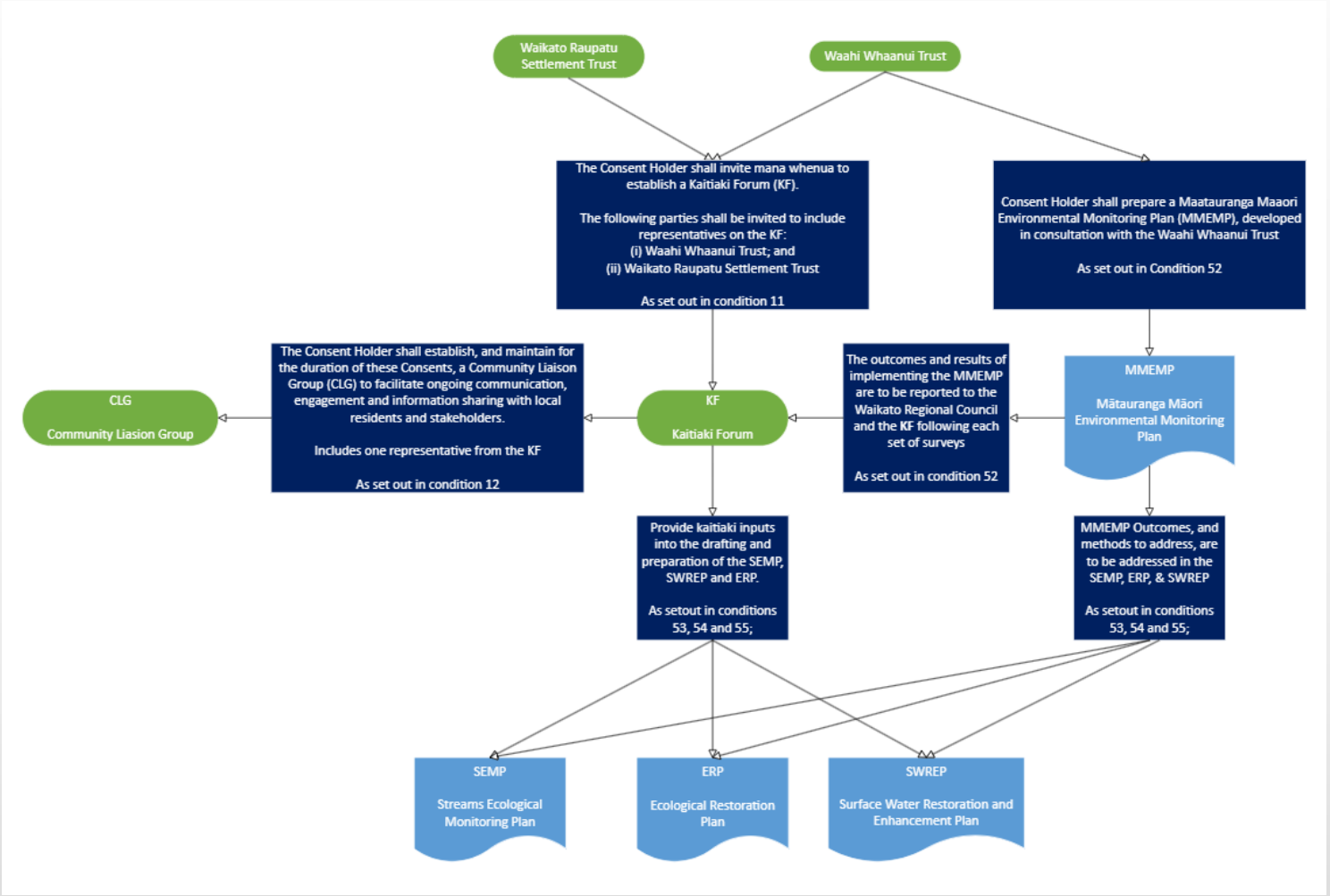
Waikato Regional Council - Kaitiaki Forum - Waahi Whaanui Trust – Waikato Ruapatu Settlement Trust

Objective Protection of Waitawhara Stream

General Framework



Navigation of Consultation Process



Site Management Plans

The GRP Site Management Plans include:

- Stormwater, Silt and Erosion Control Plan
- Mātaurangi Māori Environmental Monitoring Plan
- C&D Landfill Operations Plan
- Fire Response Plan
- Air Quality - Dust Management Plan
- Surface Water Restoration and Enhancement Plan
- Ecological Restoration Plan
- Streams Ecological Monitoring Plan
- Conceptual Closure Plan
- Rehabilitation and Aftercare Planning and Operations Plan

GRP Cell 1 Design

The landfill design utilises the guidelines (WasteMINZ, 2023) and industry best practice.

Liner Design

For a Class 2 Landfill (C&D), WasteMINZ (2023) recommends three different lining types as follows:

i. 900 mm thick compacted clay liner (CCL) with permeability<10^{-8} m/s only;

ii. A geocomposite liner comprising a HDPE geomembrane and 600 mm thick CCL layer; and

iii. A geocomposite liner comprising a HDPE geomembrane, geosynthetic clay liner (GCL) and a reduced thickness CCL (300 mm thick).

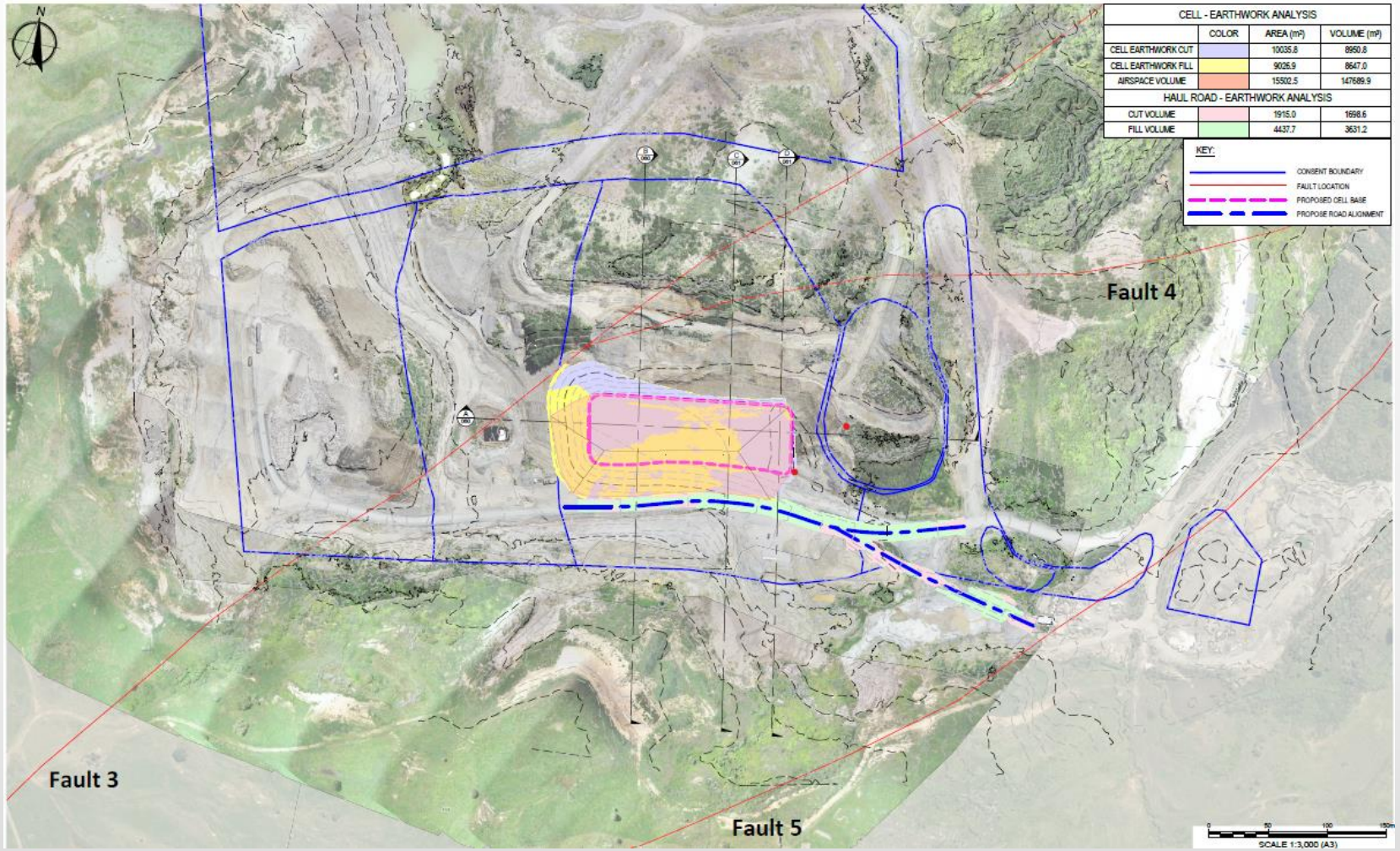
https://www.wasteminz.org.nz/guidelines

The geocomposite liner with a HDPE geomembrane, GCL, and reduced thickness CCL was selected for the land fill design at GRP Ltd, comprising (from top to bottom):

- 1.5 mm thick HDPE geomembrane.
- Geomembrane smooth both sides on base of Cell 2 and textured both sides on side slopes (see below).
- 5 mm thick GCL ($k < 5 \times 10^{-11}$ m/s), extending at least 1 m up the cell side above finished floor levels (fee board for leachate levels).
- 300 mm thick CCL ($k < 10^{-8}$ m/s) compacted in layers <= 150 mm thick on the floor.

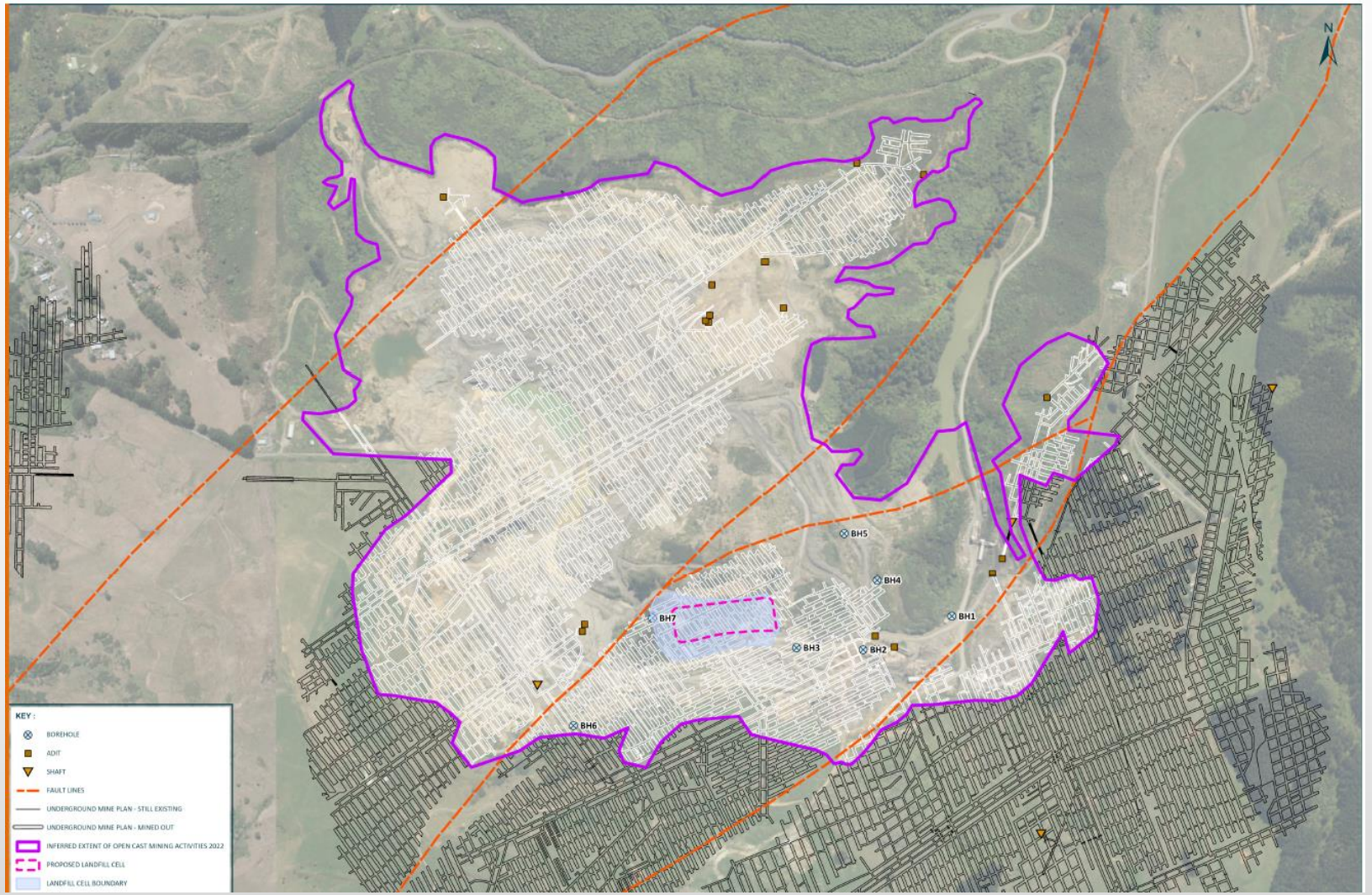
This proposed liner system provides a barrier to minimise the potential for leachate to leak from the landfill. The HDPE geomembrane is considered virtually impermeable when installed properly.

Cell 1 Design and Consent Boundaries (2000) – S127 for Stage 1 -2



New Stages 1 and 2

Disturbance areas – Underground and Open Pit



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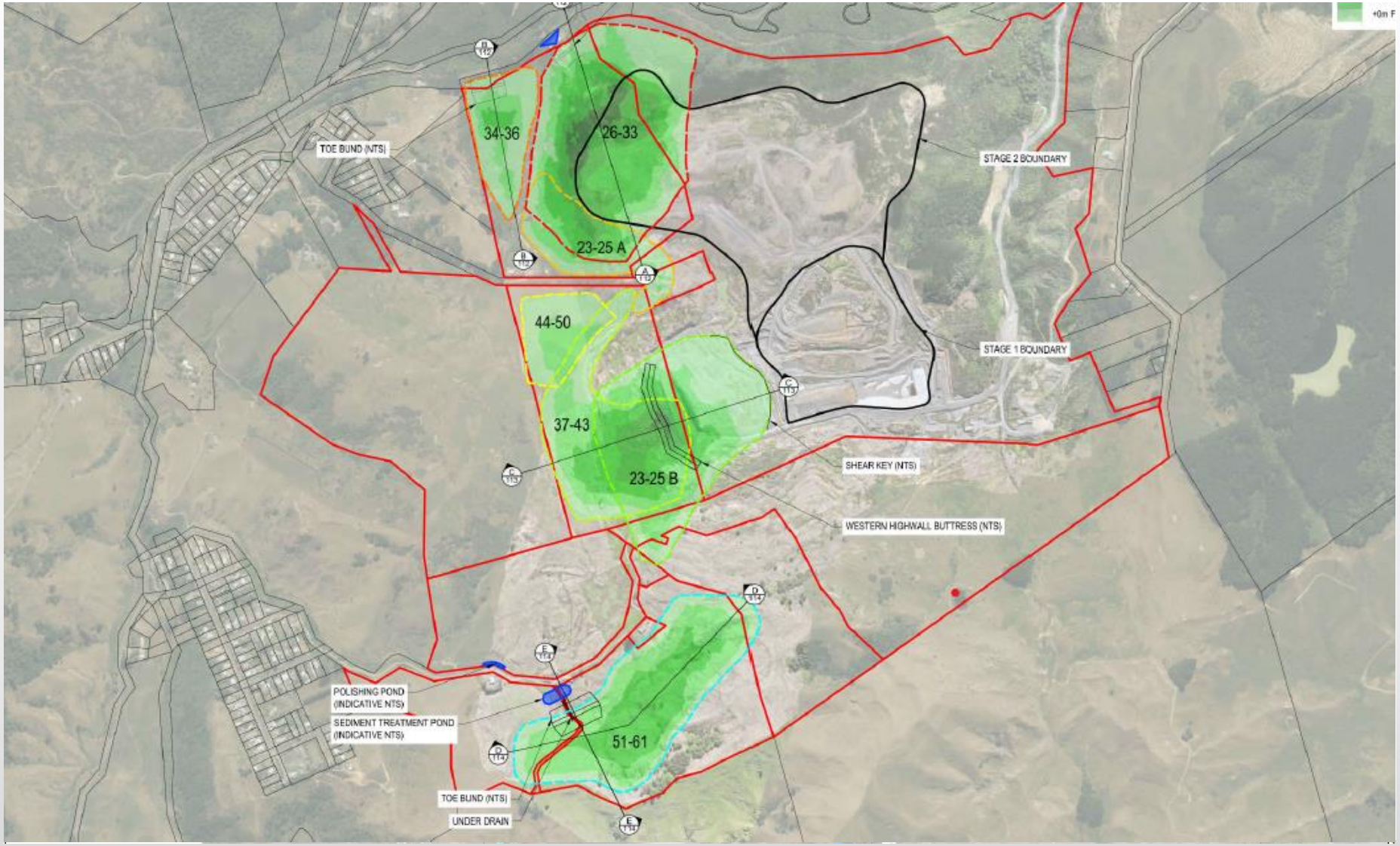


Still Mining! 7-8 Mm3 Overburden Fill to Move – Air Space is the Resource

- Stage 1 – 2 landfill boundaries will cover the disturbed area of the site.
- Stage 1 of the C&D landfill is expected to be operational and filled in approximately 15 years.
- Stage 2 is the larger stage, and it is expected to accommodate C&D waste for around a further 10 - 25 years.
- The total landfill airspace for Stages 1 and 2 is currently estimated to be around 14 Mm3.
- To provide sufficient airspace for approximately 1 years of waste acceptance (up to 208,000 tonnes, as per consent AUTH138113.04.02 Discharge Permit Land – Solid Waste).
- Table 1 summarises the total earthworks volumes and the airspace volumes for Stage 1 (around 4 Mm^3) and Stage 2 (around 10 Mm^3). These volumes are subject to the final design of the base contours for the two stages.

Table 1: Stage 1 and 2 Cut/Fill Volumes (m^3)

Stage	Cut	Fill	Air Space
1	1,861,200	30,400	3,817,500
2	7,227,700	12,600	10,061,300

Stage 1 – Cells and Leachate Collection

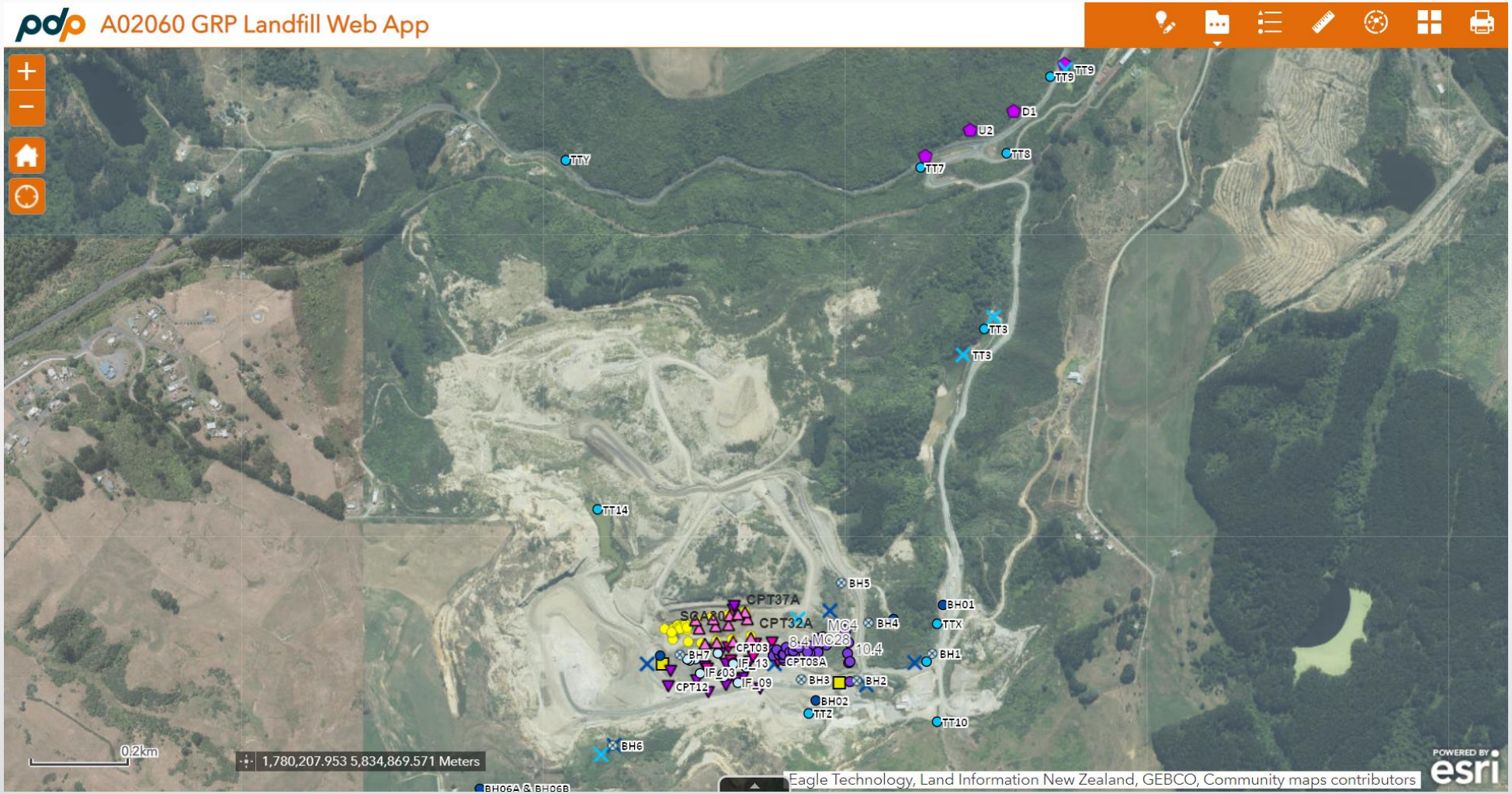
Peer Review and CQA

Design, Construction and Operations

Geology, Groundwater and Geotech

The good stuff! Dawn Mercado

Investigation Locations and Monitoring Points



Geology and Groundwater Investigations

- Cone penetrometer tests > 30 in total so far – more planned.
- Shallow investigations DCP, handaugers, shear vane, infiltration tests to support liner design and construction monitoring.
- Redrilled 5 twin monitoring wells (shallow and deep groundwater) total metres 300 m, with more planned for summer.
- Geotechnical boreholes in the cell.
- Geophysics trial.
- Laboratory tests have included:
  - CBR %
  - Triaxial Permeability
  - Standard Compaction
  - Direct shear tests
  - PSD
- Nuclear Densometer tests – compaction control (Geotechnics Ltd).

Borehole Drilling

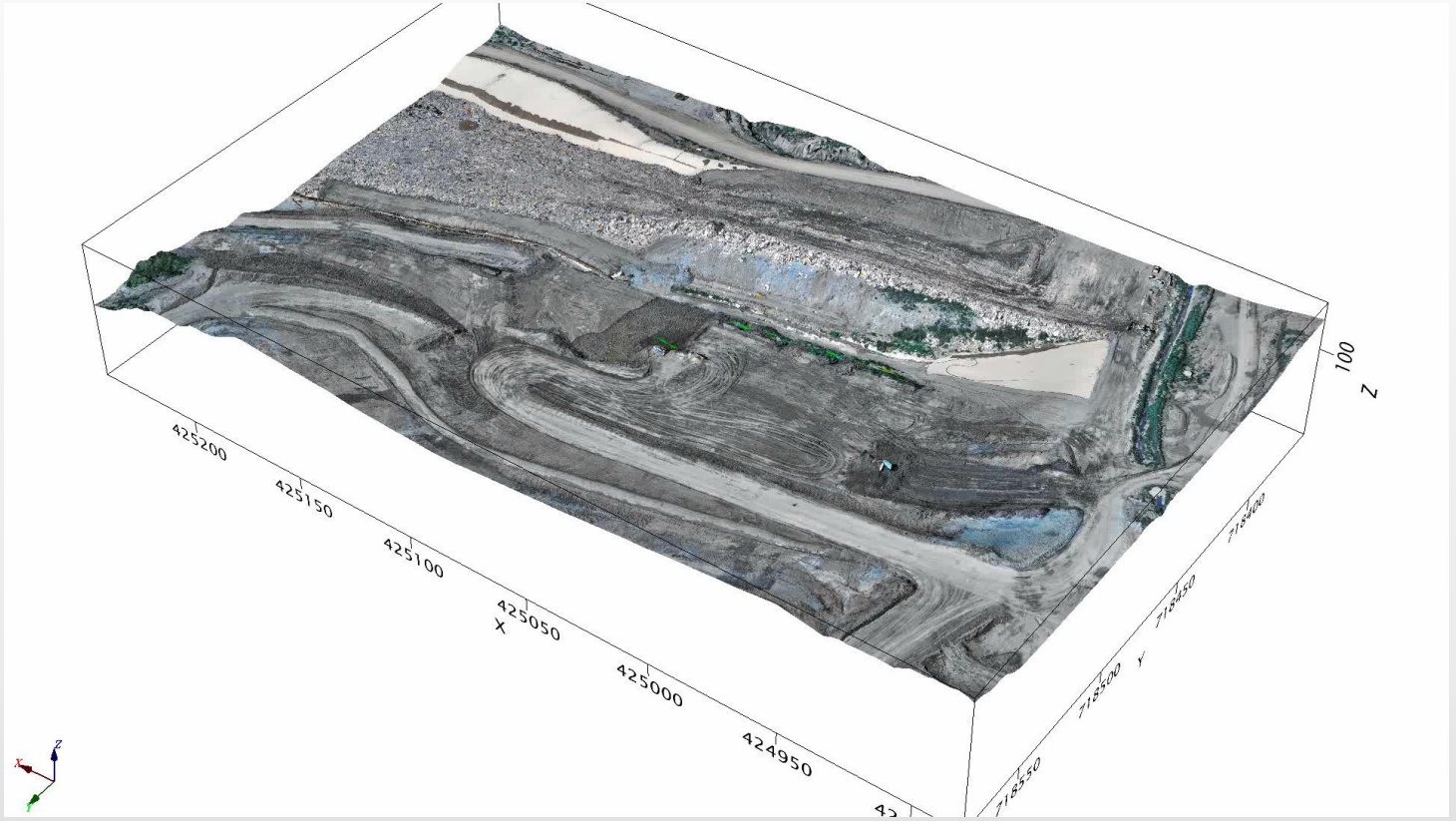
- Core geological logging of 5 No. boreholes to maximum depth of 92.5 m.
- Groundwater and geotechnical testing / laboratory testing.
- Groundwater level monitoring of deep and shallow groundwater levels.

Cone Penetration Tests

- Determine ground conditions under the cell.
  - Density of reworked overburden fill
  - Locate the top of the in-situ rock
  - Correlate with existing geological model
- Cell 13 No. CPTs to depth range 5 – 17 m bgl to coal floor.
- WSP and Brown Bros.

Geophysical Survey Trial Cell 3

- Electrical Resistivity Tomography (ERT)
- Changes in resistivity and conductivity indicate potential geology units
- Better 3D picture of the geological boundaries / depth of rock under the landfill
- Incorporate data into the geology model
- RDCL



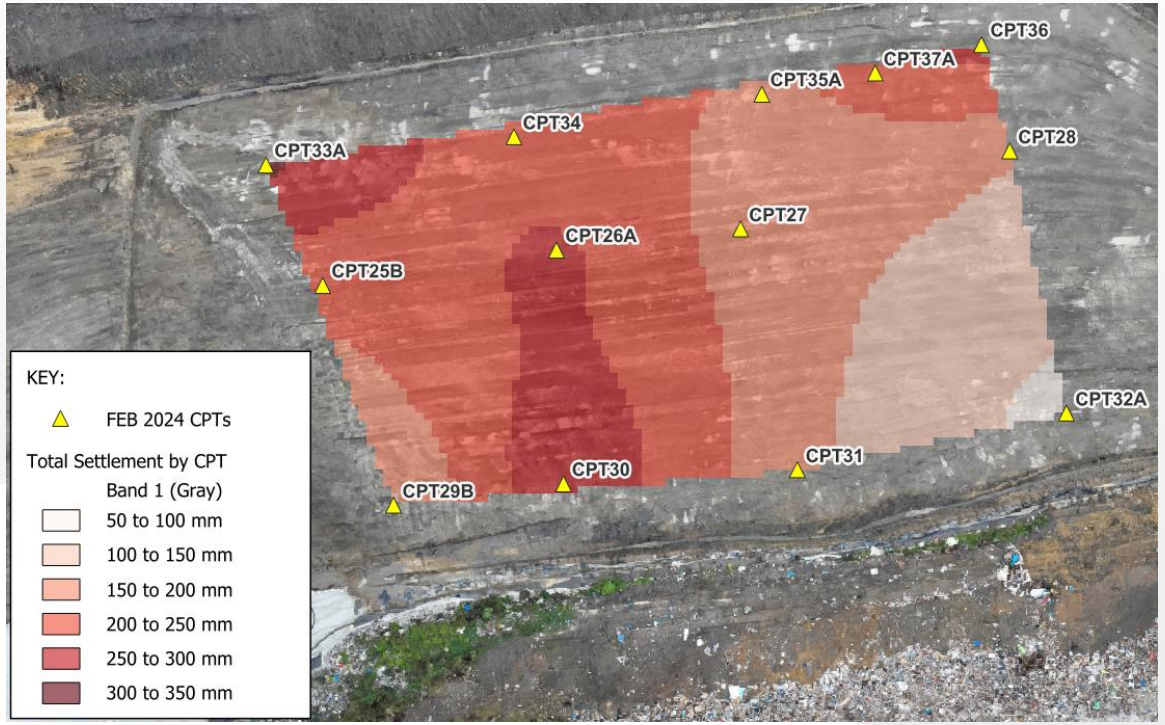
Geotechnical Design and Assessments

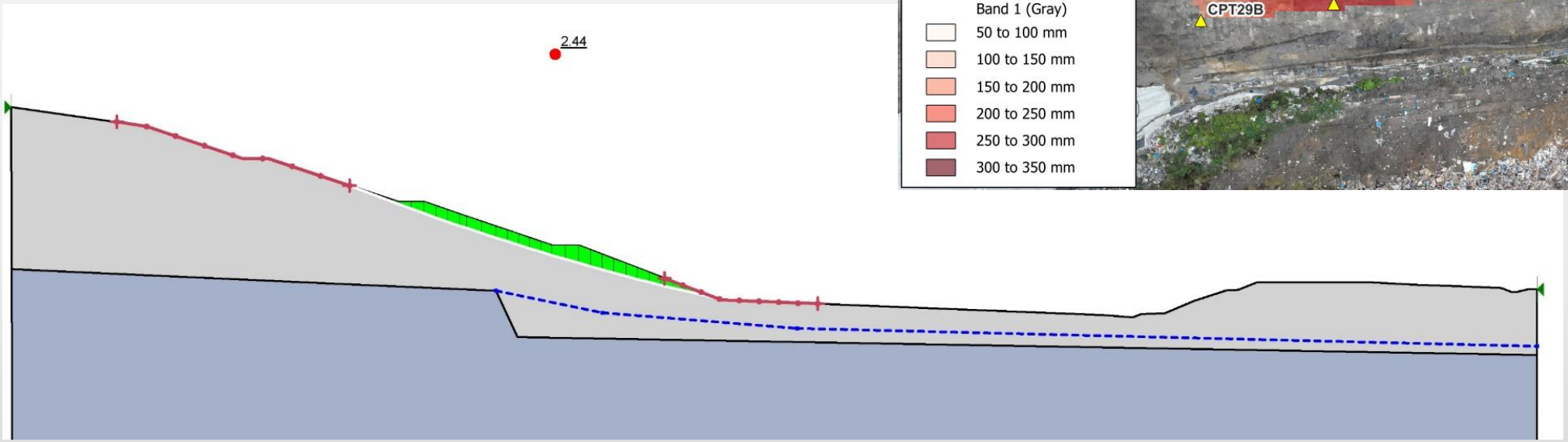
Geotechnical design and assessments include:

- Assessment of leachate generation
- Engineered fills (Compacted Clay Liner) – Typically Fire Clay we can achieve k = 10^{-10} m/s (lab tests)
- Designing with geosynthetics
- Liner anchor design
- Interface friction angles of liner (ASTM D5321 Direct Shear)
- HDPE protection layers (ASTM D5514/D5514M-14 (Mod) – Large Scale Hydrostatic Puncture Testing of Geosynthetics)
- Leachate collection system, pipe strengths and buckling
- Slope stability analysis
- Settlement assessments

Example Geotechnical Assessments

- Slope Stability Analysis
- Settlement Analysis
- Liner strain





Construction Phase

Laying it down

Earthworks, Investigate, Sub-soil Drainage, Cell Preparation, Lining

Leachate collection and Drainage Layer

CQA – Defect Mapping

Landfill Phase

Bottoms up

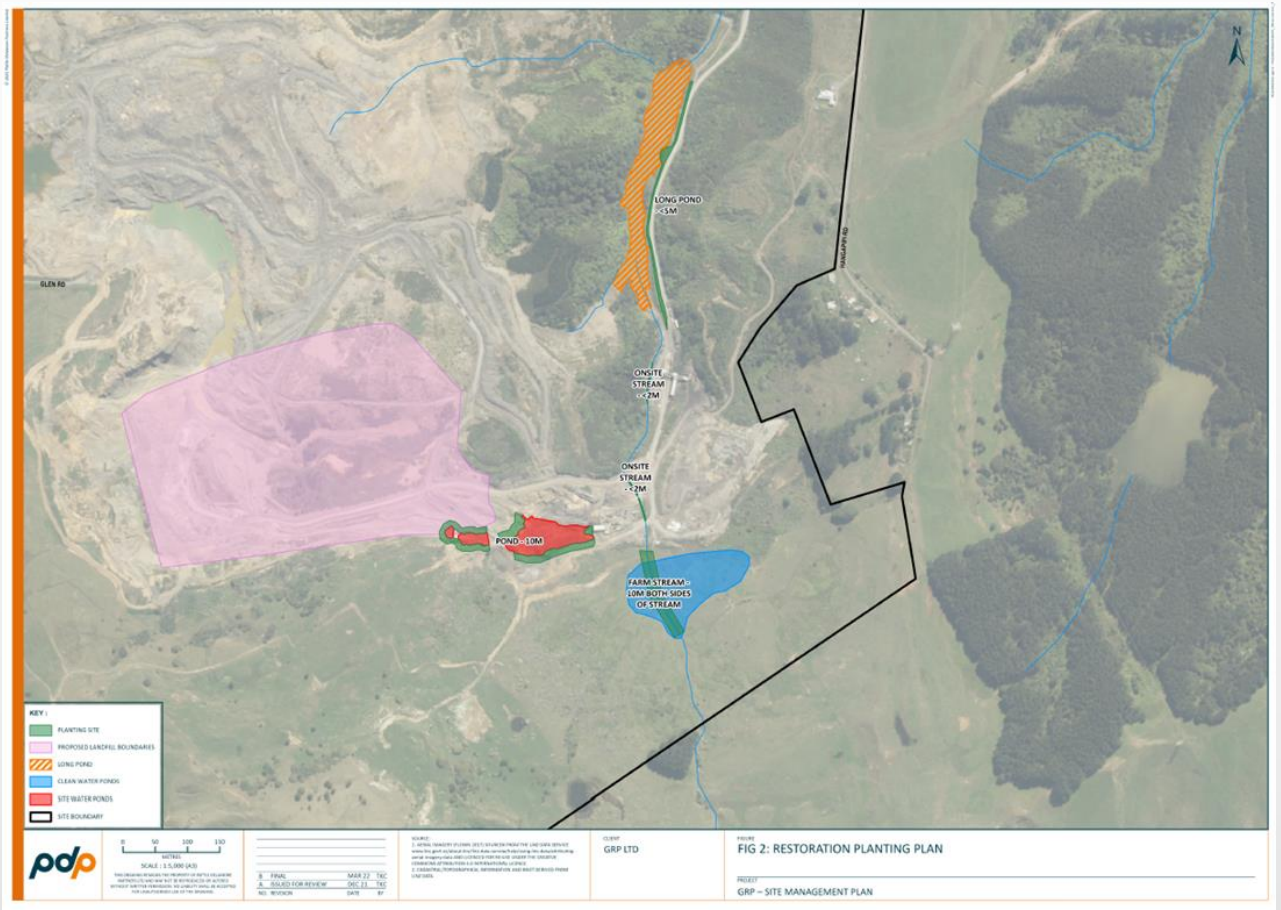
Filling process, Intermediate Capping, Leachate Management

Progressive Site Rehabilitation

Preparing for site closure in Year 35

Site Remediation and Restoration

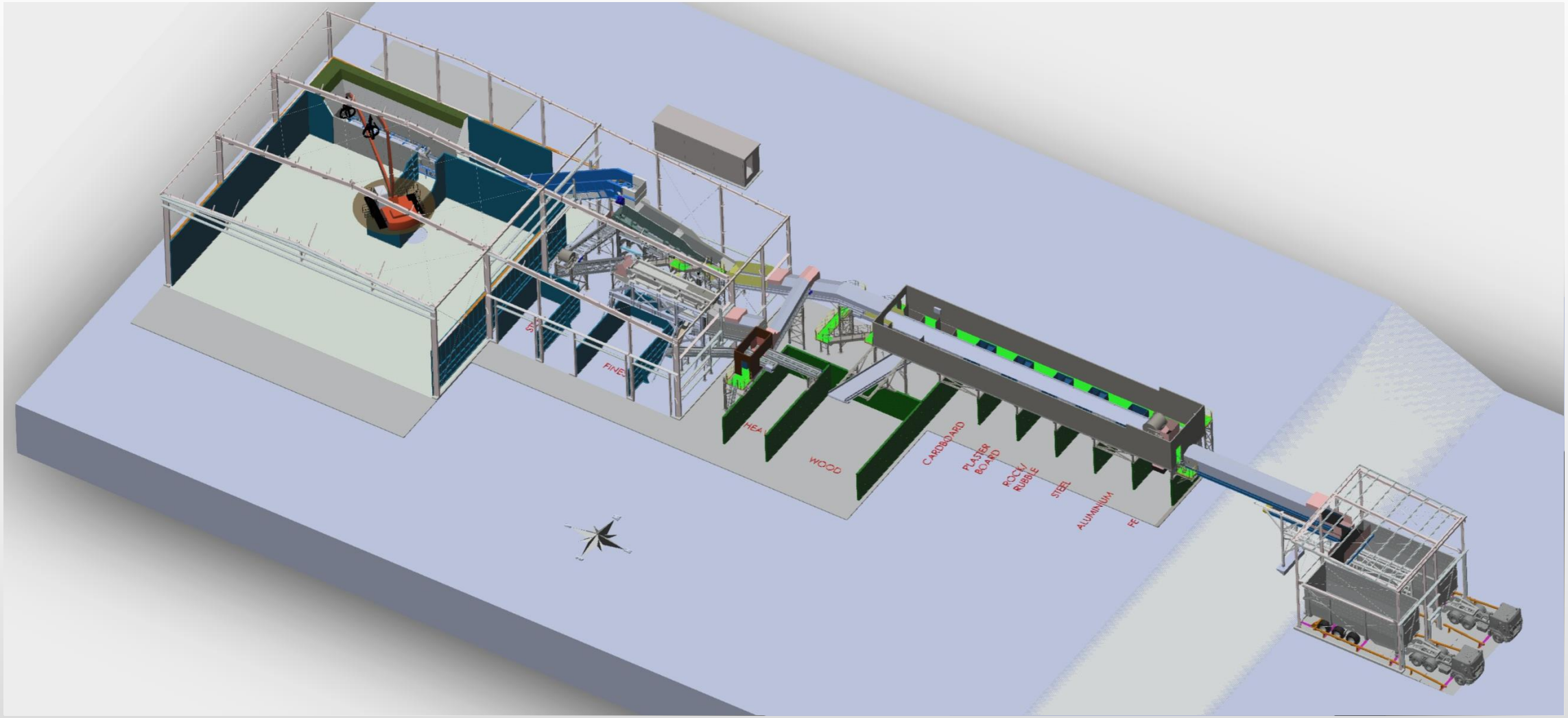
- Conceptual site closure and remediation plans.
- Undertaking stream restoration, riparian planting and land restoration.
- Recontouring unstable land and highwalls.
- Retirement of farmland.
- Areas identified for forestry plantation. To date 110 ha of forestry on and around the mine site.
- Forestry blocks will be fringed with native planting on the boundary.
- 9000 native planting seeded from the Whangamarino Wetlands.
- 9.5 ha riprarian planting.



Waikato Region Resource Recovery Facility

Optimising recovery of resources from construction waste and reducing landfilling

Recovery of resources and minimising landfill



Conclusions

Thoughts thus far

Before and After

Conclusions

- The site has a long history of coal mining and in more recent years has operated as C&D landfill and end of life tyre storage.
- The disturbed area due to open pit mining was >80ha largely unaccessiable, unusable and sparsely vegetated. Areas around the former highwalls are unstable and require recontouring. The site is challenging with limited options to undertake site remediation.
- GRP acquired the site and consents in mid to late 2021 and are remediating the site by developing a modern landfill. The landfill supports the remediation costs that would not be available for this site.
- GRP plan to move > 7 Mm3 of mine overburden fill and place this specifally designed stockpiles, which will not only improve the overall stability of the site it will allow creation of valuable landfill airspace.
- GRP have already completed capping and undertaking progressive rehabilitation of the former landfill cell. GRP have completed 110ha forestry & 9.5ha native planting; commencing stream restoration; and are now building a resource recovery facility.
- The Waikato Resource Recovery Facility will recover steel, aluminum, wood, cardboard, plasterboard, rock and rubble that would otherwise have been sent to landfill.
- Overall this is an example of sustainable land use and remediation options that may be available for other mines and quarries.
- Once the landfill is closed, the site will be stabilised, be accessible, the streams and ecology improved. The site will have potential future landuse as forestry and/or farming.

Questions?

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Lastly thanks to PDP and GRP for supporting this AusIMM event.