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REDBANK COMMUNITIES

REDBANK EXPANSION AREA (KEMSLEY PARK)
GROSE VALE ROAD, NORTH RICHMOND
PRELIMINARY GEOTECHNICAL ASSESSMENT

REPORT 12261/44-AA-R1
16 JULY 2024

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Job No: 12261/44
Our Ref: 12261/44-AA-R1
16 July 2024

Redbank Communities
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Email: andrewflaherty@redbankcommunities.com.au

Attention: Mr A Flaherty

Re **Redbank Expansion Area (Kemsley Park)**
Grose Vale Road, North Richmond NSW
Preliminary Geotechnical Assessment

This report provides the results of a Preliminary Geotechnical Assessment carried out at Redbank Expansion Area (Kemsley Park), Grose Vale Road, North Richmond NSW, hereafter referred to as the site. The work was carried out as per our fee proposal Q4523Q dated 18 April 2024 and was approved in a Redbank purchase order 422033 dated 19 April 2024.

The site is part of the broader Redbank master plan and necessitates rezoning. A Gateway Planning Proposal is required from Redbank to the Hawkesbury City Council as a precursor to this rezoning process. A preliminary geotechnical assessment is required for the rezoning of the site. This investigation aims to evaluate subsurface conditions, potential unexpected findings during site inspection, presence of uncontrolled fill, and site characteristics in relation to the greater Redbank area. It also includes preliminary recommendations on excavation conditions, salinity, aggressivity, acid sulphate assessment, slope stability, foundation design, and pavement design. The scope of work involves reviewing available maps, previous reports, and recent site testing, conducting site inspections and select testing if necessary, and identifying key undisturbed areas for future resolution in development application reports.

This preliminary report offers our assessment of the site's suitability for the proposed works, contingent upon adherence to the recommendations outlined within this report.

If you have any questions, please do not hesitate to contact the undersigned.

Yours faithfully
GEOTECHNIQUE PTY LTD

ZIAUDDIN AHMED
Principal Geotechnical Engineer
MIEAust CPEng NER

12261/44-AA-R1
Redbank Expansion Area (Kemsley Park)
Grose Vale Road, North Richmond NSW

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1. INTRODUCTION

1.1. General

We understand that the site forms part of the overall Redbank master plan. Figure 1 shows the locality of the proposed site within the greater Redbank Development area. The site requires rezoning, and as a pre-cursor a Gateway Planning Proposal is required to be prepared and lodged by Redbank to Hawkesbury City Council. In this regard, a preliminary geotechnical assessment is required for rezoning purposes of the site.

Figure 1: Redbank Expansion Area (Kemsley Park) within Greater Redbank Development

1.2. Aim of Report

A preliminary geotechnical assessment was required by reviewing available information to determine subsurface conditions across the site and provide the following:

- Expected site and sub-surface conditions
- Unexpected finds if found during the site inspection
- Presence of uncontrolled fill if any
- Characteristics of the site with respect to greater Redbank site
- Preliminary recommendations on excavation conditions
- Preliminary salinity, aggressivity, dispersivity and acid sulphate assessment
- Preliminary slope stability assessment
- Preliminary recommendations on foundation design including allowable bearing pressure values
- Preliminary recommendations on pavement design.

1.3. Scope of Works

The scope of works for preliminary geotechnical assessment included the following:

- Review of available maps including regional geology, soil landscape, salinity and acid sulphate maps.
- Review previous reports prepared by Geotechnique for rezoning and Das.
- Review subsequent reports prepared by Geotechnique for construction compliance testing.
- Review recently completed site testing for Southern Valley / Redbank Expansion Area (Kemsley Park) interface testing (several tests adjacent / on the common boundary and four (4) boreholes in late 2023 / early 2024) by Geotechnique.
- Conduct site inspection and new select testing, if required.
- Identify key areas which are not being disturbed at present due to current use (homestead, maintenance shed and ancillary storage surrounds) with these key areas to remain as essentially 'data gaps', within the reporting, to then be resolved with future DA reports.

2. FIELD WORK

Field work for the geotechnical investigation was conducted on 6 May 2024, and the following work was completed:

- Reviewing available geological, landscape, acid sulphate and salinity maps relevant to the site.
- Carrying out a walk over survey to assess existing site conditions including site slope stability.
- Reviewing the underground service plans obtained from “Before You Dig Australia” to determine the location of services across the site.
- Scanning test pit locations for underground services to ensure that the services are not damaged during field work. We engaged a specialist service locator for this purpose.
- Excavation of ten (10) test pits (TP1 to TP10) to depths of order of 1.5m, using a standard 5-tonne excavator. The test pit locations are shown on the attached Drawing No 12261/44-AA1, and the engineering logs are attached at the end of this report.
- Measuring groundwater levels during excavation of the boreholes.

The above field work was supervised by a suitably qualified Geotechnical Engineer from this company who was responsible for the walk over survey, nominating the test pit locations, supervision of in-situ testing, sampling, and preparation of field logs.

3. REVIEW OF AVAILABLE INFORMATION

3.1. Geological Map

The Geological Map of Penrith (Scale 1:100,000) published by the Department of Minerals and Energy indicates the bedrock at the site belongs to Ashfield Shale of the Wianamatta Group and comprises dark grey to black claystone-siltstone and fine sandstone-siltstone laminite. These rocks typically weather to form residual clays of medium to high plasticity.

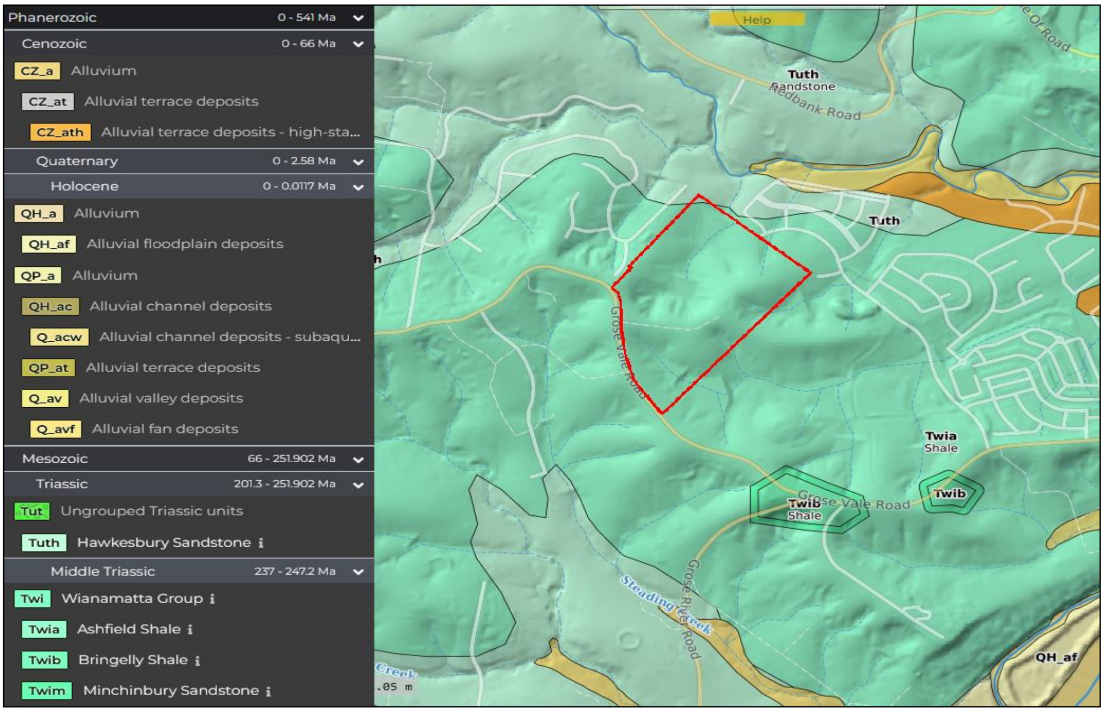

Figure 2: Geological Map of Redbank Expansion Area (Kemsley Park)

3.2. Soil Landscape

A reference to the eSPADE portal developed by the State of NSW and the Department of Planning, Industry, and Environment (2023), indicates that the landscape of the site belongs to the Luddenham Group, which is characterised by undulating to rolling low hills on Wianamatta Group shales, often associated with Minchinbury Sandstone, with local relief of 50m to 80m, ground surface slopes of 5% to 20%, narrow ridges, hillcrests and valleys. Soils in this group are likely to be up to 1.5m deep, high plasticity, moderately reactive, locally impermeable, and susceptible to high erosion hazards.

The map also indicates that the landscape of the northern portion of the site belongs to the Blacktown Group, which is characterised by undulating to rolling low hills on Wianamatta Group shales, with local relief to 30m, ground surface slopes of more than 5%, broad rounded crest and ridges with gently inclined slopes. Localised seasonal waterlogging, localised water erosion hazard, moderately reactive, high plasticity subsoil, localised surface movement potential are common.

3.3. Salinity

The Salinity Potential in Western Sydney (2002) map indicates that the site has moderate salinity potential.

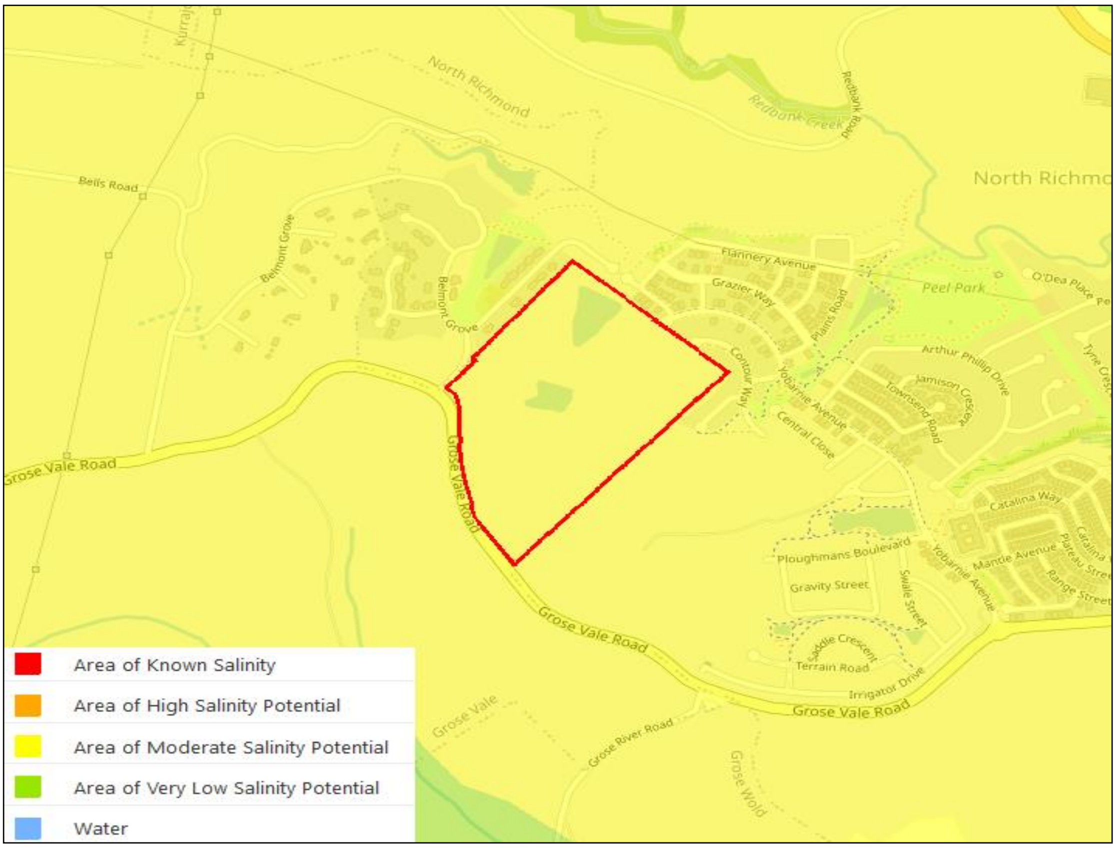

Figure 3: Salinity Potential of Redbank Expansion Area (Kemsley Park)

3.4. Acid Sulphate Soil

A reference to the Acid Sulphate Soil (ASS) Risk Mapping on the eSPADE portal developed by the State of NSW and the Department of Planning, Industry, and Environment (2023), indicates that the site maintains a distance of approximately 2km from potential environments containing ASS.

3.5. Previous Investigations at Redbank Development

Geotechnique has completed a number of geotechnical investigations in the vicinity of the site. A summary of some of the relevant investigations is provided below.

3.5.1. Southern Valley – Geotechnical Investigation for Development Application (Our Ref: 12261/35-AA-R2, dated 14 February 2022)

The geotechnical investigation conducted at the adjacent eastern site identified as Southern Valley as part of the development application submitted to the Council. This investigation took place in May 2021 and included drilling four (4) boreholes to depths ranging from 5.5m to 8m and excavating sixteen (16) test pits to depths ranging from 0.8m to 2.5m. The test pits and boreholes generally encountered 200mm of topsoil, followed by residual silty clays of medium to high plasticity, and then shale bedrock. The depths to bedrock ranged from 0.8 metres to more than 2.5 metres. The slope stability analysis indicates that the site has a "Low" risk of slope instability. The test to determine Exchangeable Sodium Percentage (ESP) of soil samples revealed that the soils at the site are dispersive and susceptible to excessive erosion. The salinity assessment (Electrical Conductivity) showed that the soils are generally non-saline with patches of moderately saline soils. The aggressivity tests indicated that most of the soils were mildly aggressive, with a few samples showing moderate aggressiveness. California Bearing Ratio (CBR) tests conducted on the bulk samples recovered during the investigation showed CBR values ranging from 3 to 5% with an average of 3.9%. A design CBR of 3.5% was used for pavement thickness design.

3.5.2. Southern Valley – Detailed Geotechnical Investigation for Proposed Residential Subdivision (Our Ref: 12261/41-AA-R2, dated 14 March 2024)

This geotechnical investigation was completed at Southern Valley development for the detailed design. The investigation was conducted between 12 October 2023 and 22 January 2024 and included the drilling of eight-seven (87) boreholes (BH410 to BH496) to the depth of 2m to 9.9m and excavating twenty-seven (27) test pits (TP497 to TP523) to the depths of order of 2.7m. Four shallow boreholes (BH493 to BH496) were located within Redbank Expansion Area (Kemsley Park) and near the boundary with Southern Valley.

The test pits and boreholes generally encountered 0.1m to 0.5m thick topsoil, overlying fill and residual silty clays of medium to high plasticity, overlying siltstone/claystone/shale bedrock. The depths to bedrock ranged from 0m to 4.3m. The bedrock was assessed to be extremely weathered grading to slightly weathered to fresh and very low strength grading to very high strength with depth. The laboratory tests conducted to assess soil erodibility and salinity revealed that the soils at the site are generally dispersive and non-saline to moderately saline, respectively. Further, the aggressivity to concrete and steel was assessed to be non-aggressive to mildly aggressive. CBR tests showed CBR values ranging from 3 to 13% with an average of 5.5%. The slope stability analysis indicated that the site has a "Low" risk of slope instability. For details for investigation results and geotechnical recommendations, please refer to the above report.

3.5.3. Yeomans and Ploughmans Precinct – Geotechnical and Salinity Assessment for Proposed Residential Subdivision (Our Ref: 12261/18-AC-R1, dated 7 June 2017)

The geotechnical investigation was conducted at Yeomans and Ploughmans precinct which is located north-east of the site. This investigation took place between 20 and 30 March 2017 and included drilling fourteen (14) boreholes to the depths of up to 6m and excavating sixteen (41) test pits to depths of up to 2.5m. The test pits and boreholes generally encountered a sequence of topsoil (100mm to 200mm thick) and natural clayey soils (medium to high plasticity) underlain by bedrock. The bedrock encountered at site included low strength, weathered shale / siltstone and occasional sandstone. Laboratory tests were conducted on selected soil samples to assess soil erodibility, salinity, and aggressivity. The tests indicated that the soils across the site to be dispersive and susceptible to excessive erosion, non-saline to slightly saline and non-aggressive and mildly aggressive towards steel and concrete, respectively. CBR values were generally found to range between 3% to 4% with an average of 3.5%. A design CBR of 3.5% was adopted to determine pavement thicknesses for various roads within this stage.

3.5.4. Belmont Precinct – Geotechnical Investigation for Proposed Residential Subdivision (Our Ref: 12261/15-AA, dated 28 July 2016)

A geotechnical investigation was conducted at Belmont Precinct, which is located on the north/north-western side of the site, between 11 and 13 July 2016. The investigation included drilling of twelve (12) boreholes to the depths up to 7m. The boreholes encountered a sequence of topsoil/fill (200mm thick) and natural clayey soils (medium to high plasticity) underlain by extremely weathered bedrock starting at the depths of 1m to 3.7m. The bedrock encountered at site consisted of shale, low to high strength.

3.5.5. Belmont Precinct – Pavement Investigation for Proposed Residential Subdivision (Our Ref: 12261/14-AA, dated 20 September 2016)

A pavement investigation was conducted a Belmont Precinct in April 2016 by drilling thirteen (13) boreholes located at the proposed road alignments. The boreholes were terminated at depths ranging from 0.9m to 2m. The boreholes disclosed 100mm to 200mm thick topsoil/fill, overlying natural residual clays, overlying shale and sandstone bedrock. Seven (7) bulk samples were collected during the investigation to conduct CBR tests. The tests showed CBR values ranging from 4% to 10% with an average of 6%. Design CBRs of 4% for internal roads and 6% for Grose Vale Road widening were adopted for pavement thickness design.

3.5.6. Area A and Area B – Geotechnical Investigation for Proposed Residential Development (Our Ref: 12261/6-AA, dated 27 February 2014)

The geotechnical investigation was also conducted north of the site at Belmont Precinct. This investigation took place between 11 and 13 July 2016 and included drilling twelve (12) boreholes to depths of up to 7 metres. The boreholes generally encountered a sequence of topsoil/fill (200mm thick) and natural clayey soils (medium to high plasticity) underlain by extremely weathered bedrock, starting at depths of 1m to 3.7m. The bedrock encountered at the site is generally low-strength weathered clayey shale/shale. Laboratory testing included point load testing of rock cores, which indicated that rock strengths range from low to medium and high strength to a depth of 7m.

3.5.7. Greater Redbank Area

In addition to the above investigations which were conducted by Geotechnique on the neighbouring sites, the following investigations were conducted at the greater Redbank area:

- Pavement Design for Stage 1A Roads (Report Ref.: 12261/1-AA, 17 May 2010)
- Geotechnical Investigation at Stages 3 and 4 (Report Ref.: 12261/5-AA, 20 July 2012)
- Pavement Thickness Design for Stages 3 and 4 Roads (Report Ref.: 12261/5-AB, 30 November 2012)
- Geotechnical Investigation at The Gallery/Mountain View (Report 12261/8-AA, 9 March 2015)
- Geotechnical Investigation at Yobarnie Rise (Report Ref.: 12261/8-AB, 9 March 2015)
- Dam Inspections and Dam Investigations (Dams 1,2, 4, 6,7,8,10,12,13, 14, 15; Report Ref.: 12261/9-AA to 12261/9-AL)
- Geotechnical Investigation at Neighbourhood Centre Stage 1 (Report Ref.: 12261/30-AB-R2, dated 2 December 2020)
- Geotechnical Investigation at Peel Park (Report Ref.: 12261/37-AA-R1, dated 20 April 2022).
- Geotechnical Investigation at Neighbourhood Centre Stage 3/4 (Report Ref.: 12261/40-AB-R1, dated 29 December 2023)

3.6. Compliance Testing

Geotech Testing conducted site fill and pavement testing during the bulk earthworks at various stages of Redbank Development. A summary of the compliance testing completed for major sites at Redbank Development is shown below:

- At Yobarnie Rise, ninety-four (94) density tests were conducted between June 24 and December 12, 2015 (Ref: 7747/14-AB, dated December 16, 2015).
- At Mountain View, eighty-five (85) density tests were conducted between September 11, 2016, and May 13, 2016 (Ref: 7747/16-AC, dated June 23, 2016).
- At Belmont, one hundred and ninety-two (192) density tests were conducted between February 9, 2017, and December 1, 2017 (Ref: 7747/27-AC, dated February 28, 2018).
- At Yeomans Precinct, six hundred and twenty-nine (629) field density tests were conducted between October 2017 and August 2018 (Ref: 7747/31-AA, dated September 10, 2018).
- At Ploughmans Precinct, eighty-seven (87) field density tests were conducted between April 2018 and September 2018 (Ref: 7747/36-AA, dated September 4, 2018).
- At Yoemans Entry, two hundred and twenty-three (223) field density tests were conducted between May 2018 and December 2018 (Ref: 7747/37-AB-R1, dated May 30, 2019).
- At Ploughmans & Belmont East, a total of sixty (60) field density tests were conducted between November 2019 and January 2020 (Ref: 7747/47-AA, dated March 27, 2020).
- At Southern Heights & Promenade, a total of one hundred and twenty-nine (129) field density tests were conducted between June 2021 and July 2021 (Ref: 7747/54-AB, dated July 22, 2021).

At present, Geotech Testing is provided Level 1 Supervision and Testing at Southern Valley development.

4. RESULTS OF WALK OVER SURVEY AND INVESTIGATION

4.1. Site Conditions

Redbank Expansion Area (Kemsley Park), located at 322 Grose Vale Road, Grose Vale NSW, spans approximately 35.4 hectares and is identified by Lot 26 DP1237271. The site is bound by low to medium density residential lots interspersed with internal roads, leading to open grassland and scattered trees to the north. Moving eastward, the landscape transitions to open grassland with dense vegetation and scattered trees, eventually giving way to medium to high density residential lots. Along the southern boundary lies the existing Grose Vale Road, bordered by dense vegetation, trees, and pockets of low-density residential lots. On the western side, the site is bordered by low density residential lots, followed by open grasslands and bushland.

The vegetation is predominantly characterised by dense grass and scattered trees. Existing features include localised ponds and single-storey dwellings situated towards the eastern border. The perimeters of the site are marked by steel wired fences, delineating paddock borders and internal divisions. The topography of the site varies from slight to steep slopes, with gradients increasing across the area. The majority of the slopes downwards towards the ponds to the south indicating the site's drainage patterns. Access to the site is facilitated by a pavement driveway originating from the Contour Way, connecting through Grose Vale Road.

4.2. Subsurface Profile

Sub-surface materials encountered in the test pits are detailed in the attached engineering logs and summarised in Table 1 below.

Table 1: Summary of Subsurface Conditions

Location	Termination Depth (m)	Topsoil (m)	Natural (m)	Bedrock (m)
TP1	1.5	0.0 – 0.1	0.1 – 0.5	0.5 – 1.5
TP2	2.5	0.0 – 0.1	0.1 – 2.3	2.3 – 2.5
TP3	1.5	0.0 – 0.1	0.1 – 1.2	1.2 – 1.5
TP4	2.0	0.0 – 0.1	0.1 – 1.6	1.6 – 2.0
TP5	1.5	0.0 – 0.1	0.1 – 1.0	1.0 – 1.5
TP6	1.0	0.0 – 0.1	0.1 – 0.6	0.6 – 1.0
TP7	2.0	0.0 – 0.1	0.1 – 1.1	1.1 – 2.0
TP8	0.9	0.0 – 0.1	0.1 – 0.6	0.6 – 0.9
TP9	1.9	0.0 – 0.1	0.1 – 0.6	0.6 – 1.9
TP10	1.7	0.0 – 0.1	0.1 – 1.3	1.3 – 1.7

Note: *NE: Not Encountered*

Topsoil	Silty Clay, low plasticity, dark brown, with rootlets
Natural Soils	Silty CLAY, medium to high plasticity, mottled red brown grey, grey mottled brown, orange mottled grey-brown, mottled orange red brown, trace gravel, trace rootlets
Bedrock	SHALE, grey-brown, extremely to highly weathered, low strength

Table 1 indicates that the sub-surface profile across the site comprises 0.1m to 0.1m thick topsoil overlying natural clays to depths ranging from 0.5m to 2.3m overlying shale bedrock. This subsurface profile corresponds with previous investigations conducted at nearby sites (Southern Valley, Yeomans and Ploughmans Precinct, Belmont Precinct).

4.3. Groundwater Condition

Groundwater inflow was not encountered to the termination depths of the test pits. Long-term groundwater monitoring was not considered essential for this investigation. It is important to note that groundwater levels typically fluctuate and are influenced by various factors beyond the scope of the current investigation. The groundwater conditions correspond to the results obtained from the previous investigations completed at the neighbouring stages.

5. DISCUSSION AND PRELIMINARY RECOMMENDATIONS

5.1. Erodibility Assessment

Erosion is the detachment and movement of soil materials. Depending on the local landscape and weather conditions, erosion could be very slow or very rapid. Susceptibility of soils to erosion depends on dispersivity (and sodicity) of soils. Soil dispersivity is generally assessed by conducting chemical tests such as Exchangeable Sodium Percentage (ESP), Sodium Absorption Ratio (SAR) and physical tests such as Emerson Class, Dispersion Percentage. It should be noted that assessment of soil dispersibility based on these methods might differ from each other. Soils with ESP values of 5% or more are considered sodic and those with ESP more than 15% are considered highly sodic (Lillicrap & McGhie, 2002). Sodic soils are susceptible to excessive erosion.

ESP tests conducted on the samples collected at the neighbouring stages of the site indicated the soils to be sodic. Based on these test results and considering the subsurface conditions encountered at the site, we assess that the soils will generally be dispersive and susceptible to erosion.

5.2. Salinity Assessment

Salinity refers to the presence of excess salt in the environment, either in soil or water. Salinity is a serious problem for any development due to the many environmental, economic and social impacts. Soil salinity is generally assessed by measuring Electrical Conductivity (EC) of a soil sample made up of 1:5 soil water suspension. Thus, determined EC is multiplied by a factor varying from 6 to 23, based on the texture of the soil sample, to obtain corrected Electrical Conductivity designated as ECe (Lillicrap & McGhie, 2002). Alternatively, ECe may be directly measured in soil saturation extracts. Salinity classification (Lillicrap & McGhie, 2002) based on ECe values are shown below.

Classification	EC_e (dS/m)	Comments
Non-saline	<2	Salinity effects mostly negligible
Slightly saline	2 – 4	Yields of very sensitive crops may be affected
Moderately saline	4 – 8	Yields of many crops affected
Very saline	8 – 16	Only tolerant crops yield satisfactorily
Highly saline	>16	Only a few tolerant crops yield satisfactorily

Several samples collected from the investigations on adjacent sites were tested to determine electrical conductivity. Based on the test results of these samples and the subsurface conditions across the site, we anticipate that the soils across the site will exhibit similar characteristics to those encountered at adjacent site, ranging from non-saline to moderately saline.

5.3. Aggressivity Assessment

Aqueous solution of chlorides causes corrosion of iron and steel, including steel reinforcement in concrete. High acidity and soils with high sulphates and magnesium affect the integrity of concrete structures buried in the soil. Concrete structures constructed in aggressive soils will require increased concrete strength proportional to the increased in soil aggressivity. In addition, the concrete cover and curing period should be increased depending on the degree of aggressivity of the soil.

The aggressivity classifications of soil and groundwater applicable to iron and steel, in accordance with AS2159 (Standards Australia, 2009), are given below:

Iron & Steel		
pH	**Chloride (ppm)**	**Low Permeability Soil**
>5.0	<5,000	Non-aggressive
4.0-5.0	5,000-20,000	Non-aggressive
3.0-4.0	20,000 – 50,000	Mild
<3.0	>50,000	Moderate

Concrete		
pH	**Sulphate (ppm)**	**Low Permeability Soil**
>5.5	<5,000	Non-aggressive
4.5-5.5	5,000-10,000	Mild
4.0-4.5	10,000 – 20,000	Moderate
<4.0	>20,000	Severe

1ppm=1mg/kg

Based on the aggressivity tests results of the neighbouring sites, we anticipate that the soils across the site will exhibit non-aggressive to moderately aggressive conditions.

5.4. Acid Sulphate Soil Assessment

A reference to the Acid Sulphate Soil (ASS) Risk Mapping on the eSPADE portal developed by the State of NSW and the Department of Planning, Industry, and Environment (2023), indicates no known occurrence of acid sulphate soil materials within the soil profiles in the site.

Based on the laboratory tests results highlighted in Table 15 of Geotechnique Report (Our Ref: 12261/6-AA, dated: 27 February 2014), the presence of acid sulphate soil was not anticipated in the neighbouring site. Based on this assessment, we anticipate that the soils across the site will exhibit similar characteristics to those described in the aforementioned report. Hence, we do not anticipate any acid sulphate soils across the site.

5.5. Excavation Conditions

At the current stage, the excavation depths remain to be finalised. However, we consider that overburden clayey soils and very low to low strength shale/siltstone bedrock could be excavated using conventional earthmoving equipment such as excavators. In cases where iron hardened rock bands are encountered, occasional rock hammering might be required. If excavation extends into medium to high strength shale/siltstone bedrock it will be more difficult to excavate and will require larger equipment such as ripper attached to Caterpillar D8 or D9 dozer. Rock sawing and hammering might be required for excavating trenches and pads required for construction of underground services and footings.

Selection of excavation equipment should be based on site access, strength of sub-surface materials and the likely impact of vibration to structures in the vicinity of the excavation. Acceptable vibration is based on the nature and state of neighbouring structures, which will have to be established by a dilapidation survey. As a general guide, the acceptable maximum peak particle velocity (PPV) in a residential area would range from about 5mm/s to 10mm/s. Contractors should make their own judgement when tendering for excavation works, using the engineering logs attached to this report and experience in such circumstances.

Groundwater/seepage was not encountered to the terminated depths of the test pits and to the auger refusal depths of the boreholes. We do not anticipate significant groundwater inflow during excavation except at some low-lying areas near the site's dams. Groundwater inflow during excavation, if any, could be adequately managed using a conventional pump and sump system. However, trafficability problems might arise locally during wet weather or if water is allowed to pond at the site. A layer of recycled gravel can be used to provide good working platform.

5.6. Fill Placement

For any placement of fill during site preparation for future development, we recommend the following procedures:

- Strip existing topsoil/fill and stockpile for possible future uses or dispose of the site. Topsoil may be used in landscaping.
- Undertake proof rolling (using an 8 to 10 tonnes roller) of the exposed residual soils to detect potentially weak ground (ground heave). Excavate areas of localised heaving to a depth of about 300mm and replace with granular fill/crushed sandstone, compacted as described below.
- Undertake proof rolling of weak ground replaced with granular fill/crushed sandstone, as described above. If the backfilled area shows movement during further proof rolling, this office should be contacted for additional recommendations, which may include stripping additional soft soils and replacing with granular materials with or without geogrid reinforcement. No proof rolling will be required of removal of soft ground exposed bedrock.
- Place suitable fill materials on proof rolled surface of residual soil in horizontal layers of 200mm to 250mm maximum loose thickness and compact to a Minimum Dry Density Ratio (MDDR) of 98% Standard, at moisture content within 2% of Optimum Moisture Content (OMC). Controlled fill should preferably comprise non-reactive fill (e.g., crushed sandstone), with a maximum particle size not exceeding 75mm, or low plasticity clay. Residual soils and bedrock obtained from excavations within the site may be used in controlled fill, after crushing to sizes finer than 75mm and moisture conditioning.
- Fill placement should be supervised to ensure that material quality, layer thickness, testing frequency and compaction criteria conform to the specifications. We recommend "Level 2" or better supervision and testing, in accordance with AS3798 (Standards Australia, 2007).

5.7. Batter Slopes and Earth Pressure

Site preparation for proposed development works may result in cut and fill slopes. Such cut and fill slopes should be battered for stability or retained by engineered retaining structures. Recommended batter slopes for stability of cut and fill slopes are presented below in Table 2.

Table 2: Preliminary Batter Slopes for Cut and Fill Slopes

Material	Temporary (Horizontal : Vertical)	Permanent (Horizontal : Vertical)
Residual Soil and Controlled Fill	1.5H:1.0V	2.5H:1.0V
Very Low to Low Strength Bedrock	1.0H:1.0V	1.5H:1.0V
Medium to High Strength Bedrock	Sub-vertical	

Surface protection of the slopes can be provided by shotcreting.

Sub-vertical excavations in medium to high strength shale will have very low risk of instability. However, some localised rock bolting may be required, depending on the relative orientations of rock discontinuities (bedding partings, fractures and joint systems) and slope faces.

If the cut and fill slopes steeper than those recommended in Table 2 are required, then the slopes should be retained by engineered retaining structures. Appropriate retaining structures for the proposed basement excavations would comprise bored pile walls or cantilever wall or gravity wall. Active earth pressure distribution on abovementioned types of retaining walls may be estimated using following equation:

$$p_h = \gamma k H$$

Where,

p_h = Horizontal active pressure (kN/m^2)
γ = Total density of materials to be retained (kN/m^3)
k = Coefficient of earth pressure (k_a or k_o)
H = Retained height (m)

For design of flexible retaining structures where some lateral movement is acceptable, an active earth pressure coefficient (K_a) is recommended. If it is critical to limit the horizontal deformation of a retaining structure, use of an earth pressure coefficient at rest (K_0) is recommended. Recommended earth pressure coefficients for design of retaining structures are presented in the following Table 3.

Table 3: Preliminary Earth Pressure Parameters

Retained Material	**Unit Weight, γ (kN/m^3)**	**Active Earth Pressure Coefficient, K_a**	**At Rest Earth Pressure Coefficient, K_0**	**Ultimate Passive Earth Coefficient / Pressure, K_p**
Controlled fill	18	0.40	0.60	Ignore
Natural clays	19	0.30	0.50	3.0
Very low to low strength bedrock	21	0.25	0.40	350kPa
Medium to high strength bedrock	23	Not Applicable	Not Applicable	1000kPa

The above coefficients are based on the assumptions that the ground level behind the retaining structure is horizontal, and the retained material is effectively drained. Additional earth pressures resulting from surcharge loads (buildings, infrastructures, etc) on retained materials and groundwater pressure, if any, should also be allowed for in design of retaining structures.

5.8. Site Classification

It is our assessment that the site is suitable for construction of residential buildings after completion of site preparation works.

At completion of earthworks (i.e. cut and fill operations) for proposed development works, when building platforms and footing subgrade are ready for construction of residences, sub-surface profiles within the residential lots are anticipated to comprise either of the following:

- Controlled fill overlying, natural clays overlying bedrock; or
- Natural clays overlying bedrock; or
- Shale/siltstone bedrock.

The magnitude of ground surface movement due to moisture variation, which is required for site classification, depends on shrink-swell index values and thickness of soils underlying a building slab. Based on the results of previous investigation in the vicinity, natural clayey soils are generally assessed as low to high plasticity. Hence, the natural soils and controlled fill are likely to be moderately to highly reactive. Weathered shale and siltstone bedrock would generally be non-reactive to slightly reactive.

Based on anticipated thickness of soils (including controlled fill and natural clays) and estimated shrink-swell movements, site classifications for future residential lots across the site are expected to be Class “M” (Moderately reactive) or “H1” (Highly reactive), in accordance with AS2870-2011 (Standards Australia, 2011). In areas where weathered shale/siltstone bedrock will be exposed, the residential lots would generally be classified as Class “A” (Non-reactive) or “S” (Slightly reactive). In areas where natural clays are exposed the site classification is expected to be Class “M” (Moderately Reactive). In fill areas (clayey soils) it is expected that the residential lots will be classified as Class “M” and Class “H1”.

Definitions of site classes provided in AS2870-2011 are reproduced below:

Site Classification	**Foundation Condition**	**Ground Surface Movement (mm)**
Class A	Most sand and rock sites with little or no ground movement from moisture changes	Not Applicable
Class S	Slightly reactive clay sites, which may experience with only slight ground movement from moisture changes	Less than 20
Class M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes	20 to 40
Class H1	Highly reactive clay sites, which may experience high ground movement from moisture changes	40 to 60
Class H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes	60 to 75

5.9. Floor Slabs and Footings

We anticipate foundation materials to be controlled fill, residual soils, or siltstone/shale bedrock. Under such circumstances, ground floor slabs for the future buildings may be designed and constructed as ground bearing slabs or suspended slabs supported by footings designed in accordance with recommendations provided in this report.

Site classification in accordance with AS2870-2011 is only applicable for the design of footing systems for a single dwelling, house, townhouse or similar structure that would be detached or separated by a party wall or common wall including buildings classified as Class 1 and Class 10a in the Building Code of Australia (BCA). Therefore, a geotechnical investigation will be required for dwellings that would be classified in accordance with the BCA.

Foundation materials across the site might vary from controlled fill to natural clayey soils to shale/siltstone bedrock, depending on the location of a building with regard to cut and fill profile. Therefore, assessment of foundation materials and allowable bearing pressure for specific buildings should be reassessed after completion of site preparation works and during footing construction. For preliminary design, the following is recommended.

Table 4: Preliminary Bearing Capacity Values

Founding Material	Allowable End Bearing Capacity (kPa)	Shaft Adhesion (kPa)
Controlled fill	100	-
Stiff to very stiff natural clays	150	-
Very low to low strength shale/siltstone bedrock	600	50*
Medium strength shale/siltstone bedrock	1500	150*

** Bored Piers only*

5.10. Risk of Slope Instability

Site factors such as slope angle, depth of in-situ soils, strength of sub-surface material, and concentrations of water generally govern the slope stability of a site. As per the guidelines (Australian Geomechanics Society, 2007) prepared by Australian Geomechanics Society the landslide risk of a site is assessed on the basis of the likelihood of a landslide event and the consequences of that event. The guidelines on qualitative measures for the likelihood and consequence of landslides and assumed level of risk are provided by AGS.

As mentioned earlier, topography of the site is generally undulating with elevation ranging from RL78m towards the north to RL81m to the east with a dip towards the centre of the site reaching elevation between RL48m to RL52m. The slope across the site is generally mild to moderate and inspection of these slopes did not indicate any signs of failure. Based on the existing site conditions and as per AGS guidelines, the site stability is assessed as below.

Qualitative Measures of Likelihood: It is our assessment that the event of a landslide within the site might occur under very adverse circumstances over the design life (Annual Probability $\approx 10^{-4}$), i.e., it is “Unlikely”.

Qualitative Measures of Consequences to Property: It is our assessment that the consequences of landslides within the site to properties would be “Minor”, causing limited damage to part of structures or part of the site requiring some reinstatement / stabilisation work.

Qualitative Risk Analysis: Based on the above Qualitative Measures, the site for the proposed development is assessed to have a “Low” Risk of slope instability. The abstract of definitions of risk levels provided by AGS is as follows:

Risk Level		Implication
VH	Very High Risk	Extensive detailed investigation and research, planning and implementation of treatment options, essential to reduce risk to acceptable levels; may be too expensive and not practical.
H	High Risk	Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable levels.
M	Moderate Risk	Tolerable, provided a treatment plan is implemented to maintain or reduce risks. May be accepted. May require investigation and planning of treatment options.
L	Low Risk	Usually accepted. Treatment requirements and responsibility to be defined to maintain or reduce risk.
VL	Very Low Risk	Acceptable. Manage by normal slope maintenance procedures.

Based on the above assessment the site is suitable for the proposed rezoning. It is important that excavation, formation of batter slopes and retaining structures should be carried out in accordance with good engineering and construction practices.

5.11. Pavement Thickness Design

Given the proximity to the previous investigation performed by Geotechnique (Our Ref: 12261/41-AA-R2, dated: 14 March 2024), subgrade conditions along the proposed roads are expected to be similar. Based on the CBR tests results from aforementioned report, a design CBR value of 3.5% is considered appropriate for the site.

Subgrade Material	Design CBR
Compacted Fill/ Natural Clay	3.5%

Based on Hawkesbury City Council's specifications, the following design traffic loading (ESA) values are considered appropriate for the design of the proposed roads.

Council Road Type	Design Traffic Loading (ESA)
Minor Collector	$2x10^5$
Local/Access	$5x10^4$

ESA: Equivalent Standard Axles

The pavement design is based on the Austroads Guide (Austroads, 2017). Based on above traffic loading and design CBR values, we recommend the following pavement compositions.

Table 5: Preliminary Pavement Compositions

Road Type	Design Traffic Loading (ESA)	Design CBR (%)	Wearing Course (mm)+	Base Course (mm)	Sub-base (mm)	Total (mm)
Minor Collector	$2x10^5$	3.5	50	150	250	450
Local/Access	$5x10^4$	3.5	50	150	200	400

+ Over single coat flush seal

The pavement depths are only valid if the subgrade and pavement materials are compacted to the following Minimum Dry Density Ratios (AS1289 5.4.1). Compaction of sub-base and base course layers should be in accordance with the Hawkesbury City Council specifications.

Base Course	98% Modified
Sub-base Course	98% Modified
Subgrade	100% Standard

The pavement design assumes provision of adequate surface and sub-surface drainage of the pavement and adjacent areas. It is recommended that a sub-surface drainage system is installed, as directed by Council Engineers.

6. CONCLUSIONS

A preliminary geotechnical assessment indicates no significant geotechnical constraints on the proposed Redbank Expansion Area (Kemsley Park) Rezoning. No unexpected materials were found during our investigation. Therefore, from geotechnical engineering considerations it is our assessment that the site is suitable for the proposed residential development provided the works are carried out in accordance with the recommendations provided in this report.

7. LIMITATIONS

It should be noted that there are existing structures on the eastern boundary of the site. This area was not investigated during the field work. Therefore, the assessment provided in the report covers the open areas of the site. We recommend that further inspection and/or investigation shall be conducted after the removal of the existing structures.

The services performed by Geotechnique in preparing this report were conducted in a manner consistent with the level of quality and skill generally exercised by members of the profession and consulting practice. To the best of our knowledge, all information obtained and contained in this report is true and accurate. No further investigation has been carried out to authenticate the information.

This report has been prepared for Redbank Communities for the purposes stated within. The Hawkesbury City Council may rely on the report in making development application determinations. Any reliance on this report by other parties shall be at such parties' sole risk as the report might not contain sufficient information for other purposes.

The geotechnical assessments and recommendations presented in this report are solely based on the results of a desktop study and walk-over survey and should be considered as preliminary only. A detailed geotechnical investigation should be carried out to confirm these assessments and recommendations prior to the detailed design of the proposed development.

8. References

Australian Geomechanics Society, 2007. Practice Note Guidelines for Landslide Risk Management. *Australian Geomechanics,* 1 March, Volume 42, pp. 63-114.

Austroads, 2017. *Guide to pavement technology: part 2: pavement structural design,* Sydney: Austroads.

Lillicrap, A. & McGhie, S., 2002. *Site Investigations for Urban Salinity.* Sydney(NSW): Department of Land and Water Conservation.

Standards Australia, 2007. *AS3798-2007 Guidelines on earthworks for commercial and residential developments.* Sydney: SAI Global Limited.

Standards Australia, 2009. *AS2159-2009 Piling - Design and installation.* Sydney: SAI Global Limited.

Standards Australia, 2011. *AS2870-2011 Residential slabs and footings.* Sydney: SAI Global Limited.

APPENDIX A

DRAWING NO 12261/44-AA1
(Test Pit Location Plan)

LEGEND

🟦 Test Pit

GEOTECHNIQUE® PTY LTD

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www.geotech.com.au

Redbank Communities
Redbank Expansion Area (Kemsley Park)
Grose Vale Road
North Richmond

Test Pit Locations

Drawing No: 12261/44-AA1R1
Job No: 12261/44
Drawn By: MH
Date: 15 July 2024
Checked By: JC/ZA

File No: 12261-44
Layers: 0, AA1

APPENDIX B

ENGINEERING EXCAVATION LOGS, LEGENDS & EXPLANATORY NOTES

engineering log - excavation

Client : Redbank Communities
Project : Redbank Expansion Area (Kemsley Park)
Location : Grose Vale Road, North Richmond

Job No : 12261/44
Pit No : TP1
Date : 6/05/2024
Logged/Checked by: JC/ZA

Equipment type and model: Yanmar Vio - 5 Tonne Excavator
R.L. surface : 81.573
Excavation dimensions : 2.0 **m long** 0.45 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	**MATERIAL DESCRIPTION** **soil type, plasticity or particle characteristic, colour, secondary and minor components.**	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
Dry					0	✓		TOPSOIL: Silty Clay, low plasticity, dark brown, with rootlets				Grass Cover
						▨	CI	Silty CLAY, medium plasticity, orange mottled grey brown, trace gravel	M≤PL	St-Vst		Residual
					0.5	▤		SHALE, grey brown, extremely to highly weathered, low strength				Bedrock
					1							
					1.5			TP1 terminated at 1.5m on bedrock				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

engineering log - excavation

Client : Redbank Communities
Project : Redbank Expansion Area (Kemsley Park)
Location : Grose Vale Road, North Richmond

Job No : 12261/44
Pit No : TP2
Date : 6/05/2024
Logged/Checked by: JC/ZA

Equipment type and model: Yanmar Vio - 5 Tonne Excavator
R.L. surface : 68.469
Excavation dimensions : 2.0 **m long** 0.45 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
					0	✓✓✓		TOPSOIL: Silty Clay, low plasticity, dark brown, with rootlets				Grass Cover
						▨	CI-CH	Silty CLAY, medium to high plasticity, mottled red brown grey, trace gravel & rootlets	M≥PL	Fr		Residual
					0.5	▨						
					1	▨				St		
						▨		@1.1m grey mottled orange red brown				
					1.5	▨				Vst-H		
					2	▨						
Dry						≡		SHALE, grey brown, extremely to highly weathered, low strength				Bedrock
					2.5			TP2 terminated at 2.5m target depth reached				
					3							
					3.5							
					4							
					4.5							

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engineering log - excavation

Client : Redbank Communities
Project : Redbank Expansion Area (Kemsley Park)
Location : Grose Vale Road, North Richmond

Job No : 12261/44
Pit No : TP3
Date : 6/05/2024
Logged/Checked by: JC/ZA

Equipment type and model: Yanmar Vio - 5 Tonne Excavator
R.L. surface : 52.882
Excavation dimensions : 2.0 **m long** 0.45 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
Dry					0			TOPSOIL: Silty Clay, low plasticity, dark brown, with rootlets				Grass Cover
					0.5 1		CI-CH	Silty CLAY, medium to high plasticity, mottled red brown grey, trace gravel & rootlets @0.4m orange brown mottled red grey	M<PL	St-Vst		Residual
								SHALE, grey brown, highly weathered, low strength				Bedrock
					1.5			TP3 terminated at 1.5m refusal on bedrock				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

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engineering log - excavation

Client :	Redbank Communities	**Job No :**	12261/44
Project :	Redbank Expansion Area (Kemsley Park)	**Pit No :**	TP4
Location :	Grose Vale Road, North Richmond	**Date :**	6/05/2024
		Logged/Checked by:	JC/ZA

Equipment type and model: Yanmar Vio - 5 Tonne Excavator **R.L. surface :** 48.389

Excavation dimensions : 2.0 **m long** 0.45 **m wide** **datum :** AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
Dry					0			TOPSOIL: Silty Clay, low plasticity, dark brown, with rootlets				Grass Cover
						▨	CI-CH	Silty CLAY, medium to high plasticity, mottled red brown grey, trace gravel & rootlets	M>PL	St		Residual
					0.5	▨						
					1	▨			M<PL			
						▨		@1.3m grey, with gravel		H		Extremely weathered bedrock
					1.5	▤		SHALE, grey brown, extremely to highly weathered, low strength				Bedrock
					2			TP4 terminated at 2.0m refusal on bedrock				
					2.5							
					3							
					3.5							
					4							
					4.5							

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engineering log - excavation

Client : Redbank Communities
Project : Redbank Expansion Area (Kemsley Park)
Location : Grose Vale Road, North Richmond

Job No : 12261/44
Pit No : TP5
Date : 6/05/2024
Logged/Checked by: JC/ZA

Equipment type and model: Yanmar Vio - 5 Tonne Excavator
R.L. surface : 48.818
Excavation dimensions : 2.0 **m long** 0.45 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
Dry					0			TOPSOIL: Silty Clay, low plasticity, dark brown, with rootlets				Grass Cover
							CI-CH	Silty CLAY, medium to high plasticity, mottled red brown grey, trace gravel & rootlets	M<PL	St-Vst		Residual
					0.5							
								@0.8m grey mottled brown				
					1			SHALE, grey brown, extremely to highly weathered, low strength				Bedrock
					1.5			TP5 terminated at 1.5m refusal on bedrock				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

engineering log - excavation

Client : Redbank Communities
Project : Redbank Expansion Area (Kemsley Park)
Location : Grose Vale Road, North Richmond

Job No : 12261/44
Pit No : TP6
Date : 6/05/2024
Logged/Checked by: JC/ZA

Equipment type and model: Yanmar Vio - 5 Tonne Excavator
R.L. surface : 71.609
Excavation dimensions : 2.0 **m long** 0.45 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
Dry					0			TOPSOIL: Silty Clay, low plasticity, dark brown, with rootlets				Grass Cover
							CH	Silty CLAY, high plasticity, red brown, trace gravel @0.4m grey mottled brown, with gravel				Residual
					0.5			SHALE, grey brown, highly weathered, low strength				Occasional clay bands
					1			TP6 terminated at 1.0m refusal on bedrock				
					1.5							
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

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engineering log - excavation

Client : Redbank Communities
Project : Redbank Expansion Area (Kemsley Park)
Location : Grose Vale Road, North Richmond

Job No : 12261/44
Pit No : TP7
Date : 6/05/2024
Logged/Checked by: JC/ZA

Equipment type and model: Yanmar Vio - 5 Tonne Excavator
R.L. surface : 64.092
Excavation dimensions : 2.0 **m long** 0.45 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
Dry					0			TOPSOIL: Silty Clay, low plasticity, dark brown, with rootlets				Grass Cover
							CI-CH	Silty CLAY, medium to high plasticity, mottled red brown grey, trace gravel & rootlets	M≤PL	St		Residual
					0.5			@0.5m red brown mottled grey orange				
								@0.8m grey mottled red brown orange		Vst-H		Extremely weathered bedrock
					1			SHALE, grey brown, extremely to highly weathered, low strength				Bedrock
					1.5							
					2			TP7 terminated at 2.0m refusal on bedrock				
					2.5							
					3							
					3.5							
					4							
					4.5							

engineering log - excavation

Client : Redbank Communities
Project : Redbank Expansion Area (Kemsley Park)
Location : Grose Vale Road, North Richmond

Job No : 12261/44
Pit No : TP8
Date : 6/05/2024
Logged/Checked by: JC/ZA

Equipment type and model: Yanmar Vio - 5 Tonne Excavator
R.L. surface : 78.273
Excavation dimensions : 2.0 **m long** 0.45 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
Dry					0			TOPSOIL: Silty Clay, low plasticity, dark brown, with rootlets				Grass Cover
					0.5		CH	Silty CLAY, high plasticity, brown, trace gravel	M≤PL	St-Vst		Residual
								SHALE, grey brown, highly weathered, low strength				Bedrock
					1			TP8 terminated at 0.9m refusal on bedrock				
					1.5							
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

engineering log - excavation

Client : Redbank Communities
Project : Redbank Expansion Area (Kemsley Park)
Location : Grose Vale Road, North Richmond

Job No : 12261/44
Pit No : TP9
Date : 6/05/2024
Logged/Checked by: JC/ZA

Equipment type and model: Yanmar Vio - 5 Tonne Excavator
R.L. surface : 74.032
Excavation dimensions : 2.0 **m long** 0.45 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
					0			TOPSOIL: Silty Clay, low plasticity, dark brown, with rootlets				Grass Cover
							CI-CH	Silty CLAY, medium to high plasticity, mottled red brown grey, trace gravel & rootlets	M<PL	St-H		Residual
					0.5							
								SHALE, grey brown, extremely to highly weathered, low strength				Bedrock
					1							
					1.5							
Dry												
								TP9 terminated at 1.9m on bedrock				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

engineering log - excavation

Client : Redbank Communities
Project : Redbank Expansion Area (Kemsley Park)
Location : Grose Vale Road, North Richmond

Job No : 12261/44
Pit No : TP10
Date : 6/05/2024
Logged/Checked by: JC/ZA

Equipment type and model: Yanmar Vio - 5 Tonne Excavator
R.L. surface : 77.705

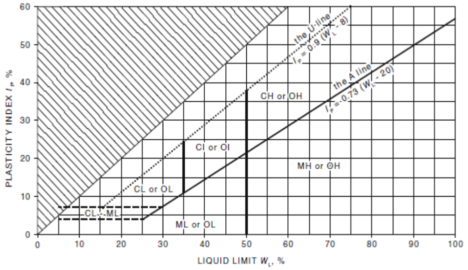
Excavation dimensions : 2.0 **m long** 0.45 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
Dry					0	✓		TOPSOIL: Silty Clay, low plasticity, dark brown, with rootlets				Grass Cover
						▨	CI-CH	Silty CLAY, medium to high plasticity, mottled red brown grey, trace gravel & rootlets	M<PL	St-Vst		Residual
					0.5	▨						
					1	▨		@1.0m grey mottled brown with gravel				Extremely weathered bedrock
						☰		SHALE, grey brown, extremely to highly weathered, low strength				Bedrock
					1.5	☰						
								TP10 terminated at 1.7m on bedrock				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

Log Symbols & Abbreviations (Non-cored Borehole Log)

<table>
<tr><th>Log Column</th><th colspan="2">Symbol/Value</th><th colspan="3">Description</th></tr>
<tr><td>Drilling Method</td><td colspan="2">V-bit</td><td colspan="3">Hardened steel 'V' shaped bit attached to auger</td></tr>
<tr><td></td><td colspan="2">TC-bit</td><td colspan="3">Tungsten Carbide bit attached to auger</td></tr>
<tr><td></td><td colspan="2">RR</td><td colspan="3">Tricone (Rock Roller) bit</td></tr>
<tr><td></td><td colspan="2">DB</td><td colspan="3">Drag bit</td></tr>
<tr><td></td><td colspan="2">BB</td><td colspan="3">Blade bit</td></tr>
<tr><td>Groundwater</td><td colspan="2">Dry</td><td colspan="3">Groundwater not encountered to the drilled or auger refusal depth</td></tr>
<tr><td></td><td colspan="2">▼</td><td colspan="3">Groundwater level at depths shown on log</td></tr>
<tr><td></td><td colspan="2">▶</td><td colspan="3">Groundwater seepage at depths shown on log</td></tr>
<tr><td>Environment Sample</td><td colspan="2">GP</td><td colspan="3">Glass bottle and plastic bag sample over depths shown on log</td></tr>
<tr><td></td><td colspan="2">G</td><td colspan="3">Glass bottle sample over depths shown on log</td></tr>
<tr><td></td><td colspan="2">P</td><td colspan="3">Plastic bag sample over depths shown on log</td></tr>
<tr><td>PID Reading</td><td colspan="2">100</td><td colspan="3">PID reading in ppm</td></tr>
<tr><td>Geotechnical Sample</td><td colspan="2">DS</td><td colspan="3">Disturbed Small bag sample over depths shown on log</td></tr>
<tr><td></td><td colspan="2">DB</td><td colspan="3">Disturbed Bulk sample over depths shown on log</td></tr>
<tr><td></td><td colspan="2">U_{50}</td><td colspan="3">Undisturbed 50mm tube sample over depths shown on log</td></tr>
<tr><td>Field Test</td><td colspan="2">N=10
3,5,5</td><td colspan="3">Standard Penetration Test (SPT) 'N' value. Individual numbers indicate blows per 150mm penetration.</td></tr>
<tr><td></td><td colspan="2">N=R
10,15/100</td><td colspan="3">'R' represents refusal to penetration in hard/very dense soils or in cobbles or boulders.
The first number represents10 blows for 150mm penetration whereas the second number represents 15 blows for 100mm penetration where SPT met refusal</td></tr>
<tr><td></td><td>DCP/PSP</td><td>5</td><td colspan="3">Dynamic Cone Penetration (DCP) or Perth Sand Penetrometer (PSP). Each number represents blows per 100mm penetration. 'R/10' represents refusal after 10mm penetration in hard/very dense soils or in gravels or boulders.</td></tr>
<tr><td></td><td></td><td>6</td><td colspan="3"></td></tr>
<tr><td></td><td></td><td>R/10</td><td colspan="3"></td></tr>
<tr><td>Classification</td><td colspan="2">GP</td><td colspan="3">Poorly Graded GRAVEL</td></tr>
<tr><td></td><td colspan="2">GW</td><td colspan="3">Well graded GRAVEL</td></tr>
<tr><td></td><td colspan="2">GM</td><td colspan="3">Silty GRAVEL</td></tr>
<tr><td></td><td colspan="2">GC</td><td colspan="3">Clayey GRAVEL</td></tr>
<tr><td></td><td colspan="2">SP</td><td colspan="3">Poorly graded SAND</td></tr>
<tr><td></td><td colspan="2">SW</td><td colspan="3">Well graded SAND</td></tr>
<tr><td></td><td colspan="2">SM</td><td colspan="3">Silty SAND</td></tr>
<tr><td></td><td colspan="2">SC</td><td colspan="3">Clayey SAND</td></tr>
<tr><td></td><td colspan="2">ML</td><td colspan="3">SILT / Sandy SILT / clayey SILT, low plasticity</td></tr>
<tr><td></td><td colspan="2">MI</td><td colspan="3">SILT / Sandy SILT / clayey SILT, medium plasticity</td></tr>
<tr><td></td><td colspan="2">MH</td><td colspan="3">SILT / Sandy SILT / clayey SILT, high plasticity</td></tr>
<tr><td></td><td colspan="2">CL</td><td colspan="3">CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, low plasticity</td></tr>
<tr><td></td><td colspan="2">CI</td><td colspan="3">CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, medium plasticity</td></tr>
<tr><td></td><td colspan="2">CH</td><td colspan="3">CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, high plasticity</td></tr>
<tr><td>Moisture Condition</td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td>Cohesive soils</td><td colspan="2">M<PL</td><td colspan="3">Moisture content less than Plastic Limit</td></tr>
<tr><td></td><td colspan="2">M=PL</td><td colspan="3">Moisture content equal to Plastic Limit</td></tr>
<tr><td></td><td colspan="2">M>PL</td><td colspan="3">Moisture content to be greater than Plastic Limit</td></tr>
<tr><td>Cohesionless soils</td><td colspan="2">D</td><td>Dry</td><td>-</td><td>Runs freely through hand</td></tr>
<tr><td></td><td colspan="2">M</td><td>Moist</td><td>-</td><td>Tends to cohere</td></tr>
<tr><td></td><td colspan="2">W</td><td>Wet</td><td>-</td><td>Tends to cohere</td></tr>
<tr><td>Consistency</td><td colspan="2"></td><td>Term</td><td>Undrained shear strength, C_u (kPa)</td><td>Hand Penetrometer (Qu)</td></tr>
<tr><td>Cohesive soils</td><td colspan="2">VS</td><td>Very Soft</td><td>≤12</td><td><25</td></tr>
<tr><td></td><td colspan="2">S</td><td>Soft</td><td>>12 & ≤25</td><td>25 – 50</td></tr>
<tr><td></td><td colspan="2">F</td><td>Firm</td><td>>25 & ≤50</td><td>50 – 100</td></tr>
<tr><td></td><td colspan="2">St</td><td>Stiff</td><td>>50 & ≤100</td><td>100 – 200</td></tr>
<tr><td></td><td colspan="2">VSt</td><td>Very Stiff</td><td>>100 & ≤200</td><td>200 – 400</td></tr>
<tr><td></td><td colspan="2">H</td><td>Hard</td><td>>200</td><td>>400</td></tr>
<tr><td>Density Index</td><td colspan="2"></td><td>Term</td><td>Density Index, I_D (%)</td><td>SPT 'N' (blows/300mm)</td></tr>
<tr><td>Cohesionless soils</td><td colspan="2">VL</td><td>Very Loose</td><td>≤15</td><td>≤5</td></tr>
<tr><td></td><td colspan="2">L</td><td>Loose</td><td>>15 & ≤35</td><td>>5 & ≤10</td></tr>
<tr><td></td><td colspan="2">M</td><td>Medium Dense</td><td>>35 & ≤65</td><td>>10 & ≤30</td></tr>
<tr><td></td><td colspan="2">D</td><td>Dense</td><td>>65 & ≤85</td><td>>30 & ≤50</td></tr>
<tr><td></td><td colspan="2">VD</td><td>Very Dense</td><td>>85</td><td>>50</td></tr>
<tr><td>Hand Penetrometer</td><td colspan="2">100
200</td><td colspan="3">Unconfined compressive strength (q_u) in kPa determined using pocket penetrometer, at depths shown on log</td></tr>
<tr><td>Remarks</td><td colspan="2"></td><td colspan="3">Geological origin of soils</td></tr>
<tr><td></td><td colspan="2">Residual</td><td colspan="3">Residual soils above bedrock</td></tr>
<tr><td></td><td colspan="2">Alluvium</td><td colspan="3">River deposited Alluvial soils</td></tr>
<tr><td></td><td colspan="2">Colluvial</td><td colspan="3">Gravity deposited Colluvial soils</td></tr>
<tr><td></td><td colspan="2">Aeolian</td><td colspan="3">Wind deposited Aeolian soils</td></tr>
<tr><td></td><td colspan="2">Marine</td><td colspan="3">Marine Soils</td></tr>
</table>

AS1726 : 2017– Unified Soil Classification System

Major Divisions		Particle size (mm)	Group Symbol	Typical Names	Field Identifications Sand and Gravels			Laboratory classification					
OVERSIZE	BOULDERS	>200						Use the gradation of material passing 63mm for classification of fractions according to the criteria given in 'Major Divisions'	% Fines (2)	Plasticity of Fine Fraction	$C_u = D_{60}/D_{10}$	$C_c = (D_{30})^2/(D_{10}D_{60})$	Notes
	COBBLES	63											
COARSE GRAINED SOIL (more than 65% of soil excluding oversize fraction is greater than 0.075mm)	GRAVEL (more than half of coarse fraction is larger than 2.36mm)	Coarse 19	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength				≤5	-	>4	between 1 and 3	1. Identify lines by the method given for fine grained soils 2. Borderline classifications occur when the percentage of fines (fraction smaller than 0.075mm size) is greater than 5% and less than 12%. Borderline classifications require the use of dual symbols e.g. SP-SM, GW-GC
		Medium 6.7	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength				≤5	-	Fails to comply with above		
			GM	Silty gravels, gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength				≥12	Below 'A' line or I_p<4	-	-	
		Fine 2.36	GC	Clayey gravels, gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength				≥12	Above 'A' line or I_p>7	-	-	
	SAND (more than half of coarse fraction is smaller than 2.36mm)	Coarse 0.6	SW	Well-graded sands, gravelly sands, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength				≤5	-	>6	between 1 and 3	
		Medium 0.21	SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength				≤5	-	Fails to comply with above		
		Fine 0.075	SM	Silty sands, sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength				≥12	Below 'A' line or I_p<4	-	-	
			SC	Clayey sand, sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength				≥12	Above 'A' line of I_p>7	-	-	
FINE GRAINED SOIL (more than 35% of soil excluding oversize fraction is less than 0.075mm)	SILT (0.075mm to 0.002mm) & CLAY (<0.002mm) Liquid Limit<50%		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	**Dry Strength**	**Dilatancy**	**Toughness**						
					None to low	Slow to rapid	Low		More than 35% passing 0.075mm	Below 'A' line			
			CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium to high	None to very slow	Medium			Above 'A' line			
			OL	Organic silts and organic silty clays of low plasticity	Low to medium	Slow	Low			Below 'A' line			
	SILT (0.075mm to 0.002mm) & CLAY (<0.002mm) Liquid Limit>50%		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Low to medium	None to slow	Low to medium			Below 'A' line			
			CH	Inorganic clays of medium to high plasticity, fat clays	High to very high	None	High			Above 'A' line			
			OH (1)	Organic clays of medium to high plasticity, organic silts	Medium to high	None to very slow	Low to medium			Below 'A' line			
	HIGHLY ORGANIC SOILS		Pt (1)	Peat and highly organic soils	Identified by colour, odour, spongy feel and generally by fibrous texture				Effervesces with H_2O_2				

Log Symbols & Abbreviations (Cored Borehole Log)

Log Column	**Symbol / Abbreviation**	**Description**		
Core Size		Nominal Core Size (mm)		
	NQ	47		
	NMLC	52		
	HQ	63		
Water Loss	——◀	Complete water loss		
	——◁	Partial water loss		
Weathering (AS1726:2017)	RS	Residual Soil	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported	
	XW	Extremely Weathered	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible	
	HW	Highly Weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.	
	MW	Moderately Weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable, but shows little or no change of strength from fresh rock	
	SW	Slightly Weathered	Rock is partially discoloured with staining or bleaching along joints but shows little or no change in strength from fresh rock	
	FR	Fresh	Rock shows no sign of decomposition of individual minerals or colour changes	
		Note : Where it is not possible to distinguish between HW and MW rock the term Distinctly Weathered (DW) may be used. DW is defined as 'Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased by deposition of weathering products in pores'		
Strength (AS1726:2017)		**Term**	**Point Load Strength Index (I_{s50}, MPa)**	
	VL	Very Low	≥0.03	≤0.1
	L	Low	>0.1	≤0.3
	M	Medium	>0.3	≤1
	H	High	>1	≤3
	VH	Very High	>3	≤10
	EH	Extremely High	>10	
Defect Spacing		**Description**	**Spacing (mm)**	
		Extremely closely spaced	<20	
		Very closely spaced	20 to 60	
		Closely spaced	60 to 200	
		Medium spaced	200 to 600	
		Widely spaced	600 to 2000	
		Very widely spaced	2000 to 6000	
		Extremely widely spaced	>6000	
Defect Description (AS1726:2017) Type				
	Pt	Parting		
	Jo	Joint		
	Sh	Sheared Surface		
	Sz	Sheared Zone		
	Ss	Sheared Seam		
	Cs	Crushed Seam		
	Is	Infilled Seam		
	Ews	Extremely Weathered Seam		
Macro-surface geometry	St	Stepped		
	Cu	Curved		
	Un	Undulating		
	Ir	Irregular		
	Pl	Planar		
Micro-surface geometry	Vro	Very Rough		
	Ro	Rough		
	Sm	Smooth		
	Po	Polished		
	Sl	Slickensided		
Coating or infilling	cn	clean		
	sn	stained		
	vn	veneer		
	cg	coating		

AS1726 – Identification of Sedimentary Rocks for Engineering Purposes

Grain Size mm		Bedded rocks (mostly sedimentary)									
More than 20	20	Grain Size Description				At least 50% of grains are of carbonate				At least 50% of grains are of fine-grained volcanic rock	
	6	RUDACEOUS		CONGLOMERATE Rounded boulders, cobbles and gravel cemented in a finer matrix Breccia Irregular rock fragments in a finer matrix		LIMESTONE and DOLOMITE (undifferentiated)		Calcirudite		Fragments of volcanic ejecta in a finer matrix Rounded grains AGGLOMERATE Angular grains VOLCANIC BRECCIA	SALINE ROCKS Halite Anhydrite
	2										
	0.6	ARENACEOUS	Coarse	SANDSTONE Angular or rounded grains, commonly cemented by clay, calcite or iron minerals Quartzite Quartz grains and siliceous cement Arkose Many feldspar grains Greywacke Many rock chips				Calcarenite		Cemented volcanic ash TUFF	Gypsum
	0.2		Medium								
	0.06		Fine								
	0.002	ARGILLACEOUS		MUDSTONE	SILTSTONE Mostly silt	Calcareous Mudstone		Calcisiltite	CHALK	Fine-grained TUFF	
	Less than 0.002			SHALE Fissile	CLAYSTONE Mostly clay			Calcilutite		Very fine-grained TUFF	
Amorphous or crypto-crystalline				Flint: occurs as hands of nodules in the chalk Chert: occurs as nodules and beds in limestone and calcareous sandstone							COAL LIGNITE
				Granular cemented – except amorphous rocks							
				SILICEOUS		CALCAREOUS				SILICEOUS	CARBONACEOUS
				SEDIMENTARY ROCKS Granular cemented rocks vary greatly in strength, some sandstones are stronger than many Igneous rocks. Bedding may not show in hand specimens and is best seen in outcrop. Only sedimentary rocks, and some metamorphic rocks derived from them, contain fossils Calcareous rocks contain calcite (calcium carbonate) which effervesces with dilute hydrochloric acid							

AS1726 – Identification of Metamorphic and Igneous Rocks for Engineering Purposes

Obviously foliated rocks (mostly metamorphic)		Rocks with massive structure and crystalline texture (mostly igneous)						Grain size (mm)
Grain size description		MARBLE QUARTZITE Granulite HORNFELS Amphibolite Serpentine	Grain size description	Pegmatite		GABBRO	Pyrosenite	More than 20 20
COARSE	GNEISS Well developed but often widely spaced foliation sometimes with schistose bands Migmatite Irregularly foliated: mixed schists and gneisses		COARSE	GRANITE	Diorite		Peridorite	6
				These rocks are sometimes phorphyritic and are then described, for example, as porphyritic granite				2
MEDIUM	SCHIST Well developed undulose foliation; generally much mica		MEDIUM	Micorgranite	Microdiorite	Dolerite		0.6
				These rocks are sometimes phorphyritic and are then described as porphyries				0.2
								0.06
FINE	PHYLLITE Slightly undulose foliation; sometimes 'spotted'		FINE	RHYOLITE	ANDESITE	BASALT		0.002
	SLATE Well developed plane cleavage (foliation)			These rocks are sometimes phorphyritic and are then described as porphyries				Less than 0.002
	Mylonite Found in fault zones, mainly in igneous and metamorphic areas			Obsidian	Volcanic glass			Amorphous or cryptocrystalline
CRYSTALLINE				Pale<-->Dark				
SILICEOUS		Mainly SILICEOUS		ACID Much quartz	INTERMEDIATE Some quartz	BASIC Little or no quartz	ULTRA BASIC	
METAMORPHIC ROCKS Most metamorphic rocks are distinguished by foliation which may impart fissility. Foliation in gneisses is best observed in outcrop. Non-foliated metamorphics are difficult to recognize except by association. Any rock baked by contact metamorphism is described as 'hornfels' and is generally somewhat stronger than the parent rock Most fresh metamorphic rocks are strong although perhaps fissile			IGNEOUS ROCKS Composed of closely interlocking mineral grains. Strong when fresh; not porous Mode of occurrence : 1 Batholith; 2 Laccoliths; 3 Sills; 4 Dykes; 5 Lava Flows; 6 Veins					