Report on
Geotechnical Investigation

Proposed Residential Subdivision - Stage 1 & 2
Canvey Road, Upper Kedron

Prepared for
Cedar Woods Ltd

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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Appendix A: Notes entitled ‘About This Report’
  Explanatory Notes
  (Sampling Procedures, Soil Descriptions, Rock Descriptions, Symbols and Abbreviations)

Appendix B: Drawing 1 – Test Location Plan

Appendix C: Borehole Logs (Nos 1 to 5)
  Test Pit Logs (Nos 6, 13 to 19)

Appendix D: Laboratory Report Sheets

Appendix E: Stability Analysis Results
1. Introduction

This report presents the results of a geotechnical investigation undertaken for Stages 1 and 2 of the proposed residential subdivision to be located at Canvey Road, Upper Kedron. The investigation was commissioned by the developer, Cedar Woods Ltd.

It is understood that existing farmland is to be subdivided into approximately 1000 residential allotments over a number of stages. Stages 1 and 2, located on the eastern side of the site, are expected to commence first, with the remainder of the site (the balance area) to be development over a number of years.

The aim of this investigation, as outlined in Douglas Partners Pty Ltd’s (DP) Proposal BNE150028 dated 16 January 2015, was to assess the conditions at the site in order to provide comments on:

- subsurface conditions including groundwater (if encountered);
- earthworks and site preparation requirements including excavatability, reuse of excavated materials including reuse to provide beneficial founding conditions for houses (i.e. improved site classification), earthworks construction on steep slopes, temporary and permanent batter slopes, compaction, and trafficability;
- design and construction recommendations for proposed detention basin embankments;
- retaining wall design parameters for likely founding conditions;
- stability of retaining walls and detention dams, including effects of hydrostatic and hydrodynamic loads;
- erosion potential; and
- indicative pavement subgrade CBR values.

The investigation comprised the drilling and sampling of five test bores and eight test pits, followed by laboratory testing, engineering analysis and reporting. Details of the field work are presented in this report together with comments and recommendations on the issues listed above.

Preliminary investigation carried out concurrently for the remainder of the site is reported separately.

This report must be read in conjunction with the notes entitled ‘About This Report’ attached and any other explanatory notes, and should be kept in its entirety without separation of individual pages or sections.
2. Site Description

The site is located off Canvey Road, Upper Kedron and is bounded by Mount Nebo Road to the south, national park to the west, Cedar Creek to the north, and existing residential developments to the east. At the time of the investigation, the site comprised a combination of cleared grazing land and some sparse to moderately dense vegetation. This vegetation was noted to be denser along the natural creek tributaries onsite which fed into Cedar Creek to the north, with the vegetation varied in size with trees ranging upwards of 20 m in height.

The terrain is generally described as rolling hills, with significant slopes of up to 1:1 (V:H) noted onsite. A wide (up to 30 m) tributary area was also encountered running in a northern direction through the eastern portion of the site. This area was generally flat, and free of significant vegetation. This tributary area bounded the western side of the ‘Stage 1’ and ‘Stage 2’ development areas.

An existing, single storey house was also noted in the eastern portion of the site.

General views of the site at the time of the investigation are presented below as Figures 1 to 3.

Figure 1: General view of the site, looking north west from Bore 10
Figure 2: General view of the tributary area, looking north west towards Bore 2

Figure 3: General view of the site, looking south east from Bore 3
3. Geology

Reference to the Geological Survey of Queensland’s 1:100,000 series ‘Caboolture’ map indicates that the site is underlain by Devonian to Carboniferous aged Bunya Phyllite, typically comprising “phyllite, minor labile arenite, rare basic metavolcanics”.

The investigation encountered localised alluvium/colluvium (in the tributaries) and residual soils, overlying phyllite rock with localised arenite, which is in general agreement with the geology described above.

4. Field Work Methods

The field work was undertaken between 23 and 27 February 2015 and comprised the drilling of five bores (designated Bores 1 to 5), and eight test pits (designated Pits 6 and 13 to 19) at the approximate test locations indicated on Drawing 1 in Appendix B.

Bores 1 and 3 to 5 were placed in areas of proposed significant cut, Pit 6 at the site of the proposed water storage tank (in lieu of a bore, due to steep site access), and Bore 2 and Pits 13 to 19 in areas of fill (including the proposed detention dam).

The bores were drilled to depths between 6.0 m and 7.7 m using a track mounted MD300 drill rig utilising a combination of drilling methods including Tungsten Carbide (TC) continuous flight augering, tricone wash boring, and NMLC coring. Standard penetration tests (SPTs) were undertaken within the bores at selected depths. Strata identification was undertaken through observation of the auger cutting returns, SPT and core samples. The bores were backfilled with compacted spoil on completion after checking for groundwater.

The test pits were excavated to depths of between 2.9 to 3.0 m depth with a 8T Cat 308E excavator using a 450 mm wide toothed bucket. Strata identification was undertaken through observation of the spoil and material in the face of the excavation. Samples were recovered from layers encountered to provide suitable samples for laboratory testing. Dynamic cone penetrometer (DCP) tests were undertaken adjacent to the bores to provide information on subsoil strength/density. Upon completion, the test pits were backfilled with the spoil material, which was tamped and track rolled for nominal compaction.

The test locations were set out by a geotechnical engineer in accessible locations close to those nominated by the client. The position of each test was recorded using a hand-held GPS accurate to approximately 5m, and the coordinates are shown on the bore report sheets in Appendix C.

The field work was undertaken by experienced geotechnical personnel who logged the bores and collected samples for visual and tactile assessment and for laboratory testing.
5. **Field Work Results**

The subsurface conditions encountered during field work are described in detail on the borehole log sheets in Appendix C. Notes defining the classification methods and descriptive terms used to describe the soils are given in Appendix A. The subsurface conditions for the two predominant areas are described below.

5.1 **‘Cut’ Areas**

In summary, the subsurface conditions encountered in Bores 1 and 3 to 5 in the proposed ‘cut’ areas comprised localised topsoil over residual clays and sands, with phyllite at relatively shallow depth. The subsurface conditions in the ‘cut’ area are further described below:

- **Topsoil** – Topsoil was encountered to between 0.05 m and 0.2 m depth in the ‘cut’ areas. The topsoil generally comprised loose and medium dense clayey sand, and firm to stiff, high plasticity silty clay. The topsoils were generally moist.

- **Residual Clays and Sands**: Residual soils were encountered in all bores beneath the topsoil to depths of 0.7 m to 2.9 m, and generally comprised stiff to hard, low to high plasticity sandy and silty clays, and locally medium dense clayey sands. The soils were generally yellow brown, grey, and red brown in colour, and were moist.

- **Phyllite**: Phyllite was encountered beneath the residual soils in the bores in this area, and continued to bore termination depths of between 6.0 m and 7.7 m. The phyllite was generally extremely low and very low strength, and extremely to highly weathered. In Bores 1, 4 and 5 this material graded to low strength with some medium strength bands at between 4.0 m and 6.9 m depth. The phyllite was dark grey, brown, and orange in colour. TC bit/bucket refusal was not encountered in any of the bores/pits, indicating that rock stronger than medium strength was not encountered within the depths of the investigation.

Groundwater was not encountered in any of the bores. It should be noted, however, that groundwater depths and ground moistures are affected by climatic conditions and soil permeability, and will therefore vary with time.

5.2 **‘Fill’ Areas**

In summary, the subsurface conditions encountered at the test locations in the ‘fill’ areas comprised topsoil over alluvium/colluvium and residual clays, with phyllite at relatively shallow depth. The subsurface conditions in the ‘cut’ area are further described below:

- **Topsoil** – Topsoil was encountered in the pits and bore in this area to between 0.1 m and 0.2 m depth. The topsoil generally comprised firm and stiff, dark brown, high plasticity silty clay and clayey silt, and locally medium dense, brown silty sand in Bore 2. The topsoil was generally moist, and contained organic content.
- **Alluvium/Colluvium**: Alluvial and colluvial soils were encountered below the overlying topsoil in Bore 2 and Pits 13, 15, and 17, and extended to depths of between 1.0 m and 1.7 m. The soils generally consisted of loose and medium dense clayey, silty, and gravelly sands, sandy gravels, and stiff and very stiff sandy clay. The alluvial/colluvial soils were generally brown and orange brown in colour, and moist and wet. The sand and gravels varied from fine to coarse grained, and the clays were of medium plasticity.

- **Residual Clays**: Residual clays were encountered in all bores beneath the topsoil in Pits 14, 16, 18, 19, and beneath the colluvium in Pit 17, and continued to depths of 0.7 m to 1.9 m. The residual soils generally comprised firm to hard, medium to high plasticity sandy and silty clays. The clays were generally orange brown, red brown, and grey in colour, and were moist.

- **Phyllite**: Phyllite was encountered beneath the overlying soils in the bore and all pits in this area to termination depths of between 2.9 m and 6.04 m. The phyllite was generally extremely low strength and extremely weathered, grading to very low, low, and medium strength and moderately to slightly weathered with depth. The phyllite was dark grey, brown, and orange in colour. TC bit/bucket refusal was not encountered in any of the bores/pits, indicating that rock stronger than medium strength was not encountered within the depths of the investigation.

Groundwater was encountered within the alluvial/colluvial soils in Bore 2 and Pits 13, 15, 17 at between 0.4 m and 1.3 m depth, but was not encountered in the remaining pits. It should be noted, however, that groundwater depths and ground moistures are affected by climatic conditions and soil permeability, and will therefore vary with time.

### 5.3 Water Tank Site

The subsurface conditions encountered in Pit 6 at the proposed water tank site comprised topsoil over residual clays with phyllite at relatively shallow depth. The subsurface conditions are further described below:

- **Topsoil**: Topsoil was encountered to 0.2 m depth generally comprised firm to stiff clayey silt. The topsoil was moist.

- **Residual Clays**: Residual silty and gravelly clays were encountered in the pit beneath the topsoil to a depth of 0.7 m and comprised high plasticity firm and firm to stiff silty and gravelly clay. The soils were generally brown or light brown and mottled orange in colour, and were moist.

- **Phyllite**: Phyllite was encountered beneath the residual soils and continued to pit termination at 3.0 m depth. The phyllite was extremely low initially, but low strength from 0.8 m depth onwards and then low to medium strength below 2.8 m depth. The phyllite was mainly dark grey and orange or red brown in colour. Bucket refusal was not encountered in the pit, indicating that rock stronger than medium strength was not encountered within the depths of the investigation.

Groundwater was not encountered in the pit. It should be noted, however, that groundwater depths and ground moistures are affected by climatic conditions and soil permeability, and will therefore vary with time.
6. Laboratory Testing

Laboratory testing comprised Emerson class dispersion tests to assess the dispersion potential of the materials encountered. Detailed test report sheets are given in Appendix D, and the results are summarised in Table 1 below.

<table>
<thead>
<tr>
<th>Bore No.</th>
<th>Depth (m)</th>
<th>Description</th>
<th>Emerson Class No.</th>
</tr>
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<tbody>
<tr>
<td>Bore 1</td>
<td>0.5</td>
<td>Sandy clay</td>
<td>4</td>
</tr>
<tr>
<td>Bore 2</td>
<td>0.5</td>
<td>Gravelly sand</td>
<td>3</td>
</tr>
<tr>
<td>Bore 3</td>
<td>0.5</td>
<td>Silty clay</td>
<td>3</td>
</tr>
<tr>
<td>Bore 4</td>
<td>0.5</td>
<td>Silty clay</td>
<td>3</td>
</tr>
<tr>
<td>Bore 5</td>
<td>0.5</td>
<td>Silty clay</td>
<td>4</td>
</tr>
<tr>
<td>Pit 13</td>
<td>0.5</td>
<td>Clayey sand</td>
<td>3</td>
</tr>
<tr>
<td>Pit 14</td>
<td>0.5</td>
<td>Silty clay</td>
<td>4</td>
</tr>
<tr>
<td>Pit 15</td>
<td>0.5</td>
<td>Sandy clay</td>
<td>3</td>
</tr>
<tr>
<td>Pit 16</td>
<td>0.5</td>
<td>Sandy clay</td>
<td>4</td>
</tr>
<tr>
<td>Pit 17</td>
<td>0.5</td>
<td>Silty sand</td>
<td>4</td>
</tr>
<tr>
<td>Pit 18</td>
<td>0.4</td>
<td>Sandy clay</td>
<td>4</td>
</tr>
<tr>
<td>Pit 19</td>
<td>0.5</td>
<td>Sandy clay</td>
<td>4</td>
</tr>
</tbody>
</table>

The test results indicate that the on-site soils have a medium to high potential for erosion and environmental harm to any water resources around this specific site, in accordance with Brisbane City Council’s “Erosion Hazard Assessment” guidelines (Ref. 1).

7. Proposed Development

It is understood that this development will involve the subdivision of existing into approximately 1000 residential allotments over a number of stages. Stages 1 and 2, located on the eastern side of the site, are expected to commence first, with the remainder of the site (the balance area) to be developed over a number of years.

In excess of 5 m of cut to fill is expected for the Stages 1 and 2 of the development. It is understood that cut and fill volumes will be finalised as part of detailed design.

8. Comments

8.1 Excavatability

Based on the conditions encountered within the bores and test pits, it is considered that excavations in the topsoil, alluvium/colluvium, residual soils, and extremely low strength phyllite could be carried out using small sized equipment such as 8-12 tonne hydraulic excavators, although it is likely larger equipment will be adopted for production rates. Bulk excavation of the very low strength and low to
medium strength phyllite is likely to be unproductive using small sized equipment, and larger equipment such as 30 tonne excavators would be likely to be required to excavate this material, especially on confined excavations. Rippling with D9 (or larger) dozers would be required for bulk excavation.

Excavation of medium to high strength or stronger rock (not anticipated) would require larger equipment and possibly rock breakers, particularly in confined excavations. DP should be contacted for further advice if excavation in this material is required.

The use of a rock breaker may be required to assist in the excavation of obstructions (e.g. boulders or concrete), should any be encountered.

It should be recognised that the above excavatability estimates are based on materials encountered at the test locations only and that excavation conditions may prove more difficult (or easier) between, beyond and at depths greater than the test locations.

8.2  Re-Use of Excavated Materials and Workability

The ground conditions encountered across the site indicate that the majority of the materials won from the proposed cut area of the site would comprise clayey sands, low to high plasticity clays, and weathered phyllite.

The clay soils may be considered suitable for reuse as structural filling beneath roadways, however the clay material may be difficult to handle and compact when wet, and is likely to be difficult to dry out. These materials may also exacerbate shrink-swell movements for residential allotments (to possibly Class H1), and as such reuse should comprise blending with a majority of weathered phyllite or placement at depth (at least 0.6 m below final; subgrade level) below less reactive filling.

It is recommended that where clay material is to be used as structural filling that the clays be overlain with at least 0.2 m of granular material (CBR 10% or better) won from cut in low strength (or stronger) phyllite to reduce the potential effects of seasonal moisture variation, and to improve site trafficability.

The results of the investigation indicate there may be some clayey and silty sands locally encountered. These materials can be difficult to compact when wet, and should preferably be blended with a majority of weathered phyllite material and placed at depth in filling (ie at least 1m below final; subgrade level).

The phyllite is likely to break down to form a clayey gravel/gravelly clay material when compacted with better trafficability and shrink-swell performance than the soils on the site. This material is considered to be suitable for reuse as structural filling onsite.

It is recommended the bulk earthworks be managed so that select phyllite fill won from cut areas is placed in areas where the improved quality is most beneficial to the development (e.g. in the upper 0.6 m under pavements, resulting in reduced pavement thickness). Indicative CBR design parameters for the materials encountered onsite are outlined further in Section 8.7 below.
Such re-use is contingent upon particle size distribution being controlled along with moisture content, and upon minimum placement and compaction requirements being met, all as indicated in the following section.

### 8.3 Earthworks and Site Preparation

It is recommended that the following subgrade preparation be carried out for areas to be filled (i.e. following bulk excavation):

- **Removal of any remaining uncontrolled filling, deleterious, soft, wet or highly compressible material or material rich in organics or root matter.**
- **Any sloping ground exceeding 1V:8H requiring filling should be cut into benches approximately 250 mm in height (one compacted layer thickness) and a minimum of 1 m in width (although benching to a width suitable for the selected compaction equipment is likely to be required).**
- **The subgrade should then be test rolled beneath the proposed filling, in order to detect the presence of any soft or loose zones, which should be ripped, dried and recompacted, or excavated and replaced with compacted select filling as appropriate.**
- **Test rolling should be carried out with a smooth drum roller with a minimum static weight of 12-tonne. The tyned natural subgrade soil should be compacted to a minimum density index of 65% (sands) or minimum dry density ratio of 95% Standard (clays).**
- **Approved filling should then be placed in layers not exceeding 300 mm loose thickness, with each layer compacted to a minimum dry density ratio of 95% Standard, but increased to 100% Standard in the upper 0.3 m under road subgrades. Where filling is clayey, the moisture content within the filling should be maintained within 2% of optimum moisture content (OMC) during and after compaction.**
- **Over-compacted clays (ie. minimum dry density ratio of >102%) may swell significantly and lose strength if they are wetted after compaction, potentially changing the site classification and reducing subgrade strengths assumed in design, and therefore should be avoided. It is recommended that the compaction specification set an upper level density of 102% for clay fill (eg. with OMC ≥ 20 %).**
- **Any structural filling required should be undertaken under ‘Level 1’ inspection and testing as detailed in AS 3798–2007 (Ref. 2), or ‘Level 2’ if for non-structural filling, if any.**

The above procedures will require geotechnical inspection and testing services to be employed during construction.

In order to maximise the quality of surface material during construction and for building footings it is recommended that, where possible, bulk filling should be arranged that silty and sandy clay is placed at depth and overlain by greater than 0.5 m of sand or weathered phyllite fill material.

It must be noted that where bulk filling is placed under controlled conditions there is potential for ‘creep’ of the filling material as the filling settles over time under self-weight. Potential movements for such filling are estimated as a percentage of the layer thickness, over a log cycle of time. Such settlement may be in the order of 0.5% to 1% of the fill thickness. This range is presented for sensitivity checks and is dependent upon the nature of the filling. Where the filling predominantly
comprises granular materials, a lower percentage is appropriate, and where the filling predominantly comprises clayey material, a higher percentage is appropriate.

The Emerson Class tests indicted results of 3 and 4 indicating moderately erodible soils are prevalent on the site. Detailed Erosion and Sediment Control design will be necessary, however in generally it is noted that good practice in erosion and sediment control will be required for the development, particularly given the steep slopes present. Good practice such as use of sedimentation dams, contour swales, silt fences/ hay bales and planning the works to limit exposed areas as far as practical, particularly in the wet season, will be required at the site.

8.4 Cut and Fill Batter Slopes

Temporary batter slopes cut to 1.5 m depth in the dense and stiff soils, may be designed near vertical for temporary trenches for footing and services installation, provided there are no loads, structures or services within 1.5 m from the crest of the trench. Cut slopes in loose sands and gravels, and in medium dense sands with water present will need to be battered to 1V:2H or less for temporary stability.

Other temporary and permanent cut batter slopes, up to 4 m in height should be formed no steeper than those recommended in Table 2 below.

<table>
<thead>
<tr>
<th>Material</th>
<th>Safe Batter Slopes (H:V)</th>
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<tr>
<td></td>
<td>Short Term (Temporary)</td>
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<tr>
<td>Residual soils</td>
<td>1.5:1</td>
</tr>
<tr>
<td>‘Controlled’ filling</td>
<td></td>
</tr>
<tr>
<td>Extremely low to very low strength</td>
<td></td>
</tr>
<tr>
<td>Low strength (or better) phyllite(1)</td>
<td>0.75:1</td>
</tr>
</tbody>
</table>

The above temporary batter slopes are suggested with respect to slope stability only, and do not allow for lateral stress relaxation which may result in movement of nearby in-ground services or shallow footings. If such services are settlement-sensitive, and are located such that a linear spread at 1H:1V outwards, down and away from the base of the service, intersects the cut face, then the excavation may have to be positively supported using shoring boxes or sheet piles.

Fill batter slopes may need to be flattened to 4H:1V or less (subject to Safety in Design assessment), in order to allow vehicular access for maintenance of grass. It is also recommended that all batters incorporate crest and toe drains, and fill slopes and cut batters in soils and extremely weathered phyllite be covered with vegetation (or similar) to provide erosion protection.

Fill batters should be overfilled and trimmed back final batter slopes to the desired profile to ensure adequate compaction of the face materials.

Cut slopes higher than 4 m would specific analysis and design. As a preliminary guide however, a bench should be adopted for slope higher than about 4 m.
8.5 Additional Earthworks Requirements for Basin Embankments

For basin embankments, the following recommendations should be adopted in addition to those in Section 8.4 above:

- Strip any topsoil and near surface loose silty sand which may be present. The pits indicate that the near surface sands are generally less about 0.6 m deep. Deeper alluvial sand appears to be present in Pit 1; however this is overlain by about 2.5 m of gravelly silty clay;
- Excavate a foundation key, which as a minimum should be 3 m wide at the base (to accommodate compaction plant), and not less than 1 m deep but deeper if required by inspection by a geotechnical engineer;
- Batter the sides of the foundation key to 1H:1V in clays and 1.5H:1V in sands. These batter slopes should be confirmed by inspection at the time of construction, and may need to be flattened if construction is carried out during periods of wet weather;
- Place approved filling won from excavation of the weathered phyllite on site with a maximum particle size of 75 mm, not less than 40% passing 0.075mm after compaction and an Emerson Class of 3 or more, in horizontal layers of maximum 300 mm loose thickness. Compact each layer of filling to at least 98% Standard maximum dry density ratio before placing the next layer;
- Maintain moisture contents for clay filling in the range 1% dry to 3% wet of OMC for Standard compaction;
- Overfill and trim back final batter slopes to the desired profile to ensure adequate compaction of the face materials; and
- Seal or cover any compacted clay foundation soil at or close to final level as soon as practicable, to reduce the opportunity for desiccation and cracking, or surface erosion protection (in this case rock mulch treatment, which may include sandstone derived from cut sections of the diversion, provided that there is a general absence of siltstone bands).

Any new embankment filling should be undertaken under full time geotechnical and testing supervision that is to a ‘Level 1’ standard, as defined in AS 3798-2007.

Stability of the proposed detention embankment is discussed in Section 8.7 below.

8.6 Retaining Wall Design Parameters

The design of mass gravity retaining walls could be undertaken using a triangular pressure distribution and the earth pressure parameters given in Table 3 below. Flexible walls are those which are free to rotate or tilt (such as mass gravity retaining walls) and should be designed using an active earth pressure coefficient (Ka). It is recommended that all permanent retaining walls be drained for full height in order to minimise hydrostatic pressure build-up behind the walls.
Table 3: Earth Pressure Coefficients (non sloping crest backfill)

<table>
<thead>
<tr>
<th>Material</th>
<th>Unit Weight (kN/m³)</th>
<th>Active $K_A$</th>
<th>Passive $K_p$ (pressure)</th>
<th>Base Interface Friction (°)</th>
<th>Allowable bearing pressure (kPa)</th>
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<td>'Controlled' filling(1) and silty/sandy clays</td>
<td>19</td>
<td>0.40</td>
<td>2.5</td>
<td>15</td>
<td>75</td>
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<tr>
<td>Weathered extremely low strength (or stronger) rock</td>
<td>21</td>
<td>0.30</td>
<td>3.0</td>
<td>20</td>
<td>150</td>
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(1) Assuming engineered filling is undertaken in accordance with the recommendations of this report and AS3798.

In addition, wall design should include the following considerations:

- The effects of surcharge loadings, including traffic, in the retained zone should be included by multiplying the vertical pressure developed by the surcharge by the appropriate lateral earth pressure coefficient from Table 3 above. Allowances should be made for compaction plant operating behind the wall, as well as for sloping crest backfill if applicable. The size of the compaction plant near the wall should be limited.

- Care should be taken when compacting soils immediately adjacent to retaining walls. A clearance from the wall equal to the height above the base of the wall up to a maximum of 2 m is a suitable guide to follow. Within that distance, the use of lighter equipment (e.g. 600 mm wide rollers or hand ‘wackers’) and possibly the use of more readily compactable material (e.g. crushed rock), is recommended.

- Drainage material behind the wall should be installed for the full height of the wall, for a width of at least 0.3 m. The material must be free draining and granular and have a perforated or slotted drainage pipe at the heel of the wall to rapidly remove the water into the stormwater system. Alternatively, the wall would need to be designed for full hydrostatic pressure.

Wall footings could be preliminarily designed using the parameters indicated in Table 3 above (pressures have been reduced by one-third to allow for horizontal load effects).

All retaining walls should be engineer-designed in accordance with AS 4678–2002 (Ref. 3) using the geotechnical parameters and advice provided above.

8.7 Stability Analysis

Global stability analysis has been carried out for several key selected locations of the development including:

- Detention Embankment – Stage 1 North;
- Typical worst case fill and retaining wall on steep slope (Pit 14); and
- Fill and bio-detnetion basin with retaining wall on steep slope.

It is understood that the Detention Embankment will be designed to allow low creek flows through a culvert, with floods detained by the embankment for a period of up to several hours. No water will be permanently retained by the embankment.
Ground conditions at the Detention Embankment were adopted based on those in Pit 13, assuming the loose material would be stripped (as recommended in this report), but that medium dense materials would be retained. A 7 m high embankment with 5 m wide crest and side slopes of 1V:2H was adopted, as per design drawings provided. A 5kPa surcharge, based on pedestrian traffic and occasional light maintenance vehicle was assumed. Groundwater conditions based on the peak Q100 flood levels and a hypothetical worse case drawdown were modelled.

Ground conditions for the typical “worst case” steep slope case were based on those in Pit 14, and included stiff clay and extremely low strength phyllite, with very low or low strength phyllite at approximately 1 m depth. A steep site slope of 1V:2.5H was assumed, both below, and above the wall prior to filling. A 4 m high wall with 2.5 m base width (based on typical mass gravity wall dimensions) keyed into the weathered rock was assumed. A 5kPa surcharge based on footpath traffic and occasional light maintenance vehicle was assumed within 3 m of the wall, with a 20 kPa surcharge based on heavy road traffic or development load elsewhere. For the bio-basin case, loose granular filter material was adopted. A perched water level at the base of the bio-basin was adopted in that case, but otherwise a perched water level at approximately one-third height of the wall was adopted.

Soil strength parameters for the various soil strata have been assessed from experience and published typical values and are shown in Table 4 below.

**Table 4: Parameters adopted for slope stability analysis**

<table>
<thead>
<tr>
<th>Material</th>
<th>Unit Weight (kN/m³)</th>
<th>Cohesion (kPa)</th>
<th>Friction Angle (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankment Fill</td>
<td>20</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>Silty sand/silty sandy gravel – loose</td>
<td>16</td>
<td>0</td>
<td>26</td>
</tr>
<tr>
<td>Silty sand/silty sandy gravel – medium dense</td>
<td>18</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>18</td>
<td>5</td>
<td>26</td>
</tr>
<tr>
<td>Extremely to very low strength phyllite</td>
<td>21</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>Very low to low strength phyllite</td>
<td>21</td>
<td>15</td>
<td>35</td>
</tr>
</tbody>
</table>

The commercially available SlopeW software was used to carry out the stability analysis for the representative profiles identified for the site. Spencer’s method of analysis was adopted with not less than 600 potential slip surfaces analysed for each case to assess the lowest factor of safety.

The results of the analysis are appended to this report and indicate a minimum safety factor of:
- 1.67 for the Detention Embankment – Stage 1 North;
- 1.51 for the fill and retaining wall on steep slope (Pit 14); and
- 1.60 for the bio-basin with retaining wall on steep slope.

The results indicate that all cases analysed exceeded the minimum safety factor of 1.5 required for permanent engineering works.

It is noted that these analysis have been carried out on a typical worst case analysis from the tests and earthworks information available at the time of this report, and on good construction practice.
including that indicated in this report. It will be necessary for specific retaining walls to be checked as part of detailed design, and geotechnical supervision and certification of the retaining wall construction. Further, detailed analysis of retaining walls will need to consider internal, sliding and overturning stability.

### 8.8 Indicative Pavement Design Parameters

Based on the investigation, it is expected that the subgrade conditions for pavements and on-ground slabs will vary across the site and generally comprise either filling or stiff sandy and silty clay soils, or extremely low strength rock.

The values in Table 5 (based on previous experience) could be used for the preliminary design of either flexible sealed, unsealed granular or rigid concrete pavements on the indicated subgrades.

#### Table 5: Pavement Design Parameters

<table>
<thead>
<tr>
<th>Subgrade Material</th>
<th>Subgrade CBR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural clay soils</td>
<td>3</td>
</tr>
<tr>
<td>Reworked extremely to very low strength phyllite</td>
<td>5</td>
</tr>
<tr>
<td>Reworked low strength (or stronger) phyllite</td>
<td>10</td>
</tr>
</tbody>
</table>

These values apply only to wheel loads and are based on the assumption that site preparation and earthworks will be carried out in accordance with this report and on the provision and maintenance of adequate surface and subsurface drainage. It is also contingent upon adequate site preparation by proof rolling (to detect any unsuitable soft or loose material) and subgrade compaction to a minimum dry density ratio of 98% Standard.

Further cut to fill earthworks are proposed for the site. Once earthworks have been completed, sampling and testing should be undertaken on the subgrade to confirm design values and pavement depths. For loaded areas of different proportion or different load intensity to standard wheel loads, DP should be contacted for further advice.

Where filling in excess of 1 m depth is placed under controlled conditions at the site, then a subgrade CBR value for that material could be used subject to confirmation by laboratory testing. For controlled filling depths of less than 1 m, the Japan Road Association method of assessing a weighted subgrade strength can be used:

\[
CBR_W = (D_F \times CBR_f^{0.33} + (1-D_F) \times CBR_s^{0.33})^3
\]

where
- \( CBR_W \) = weighted subgrade CBR (%)
- \( D_F \) = depth of filling (m)
- \( CBR_f \) = CBR of filling material (%)
- \( CBR_s \) = CBR of subgrade (%)

Report on Geotechnical Investigation
Proposed Residential Subdivision (Stage 1 & 2) – Canvey Road, Upper Kedron

Project 87335.00
March 2015
The above recommendations are based on the installation and maintenance of adequate surface and subsurface drainage being provided adjacent to pavements to minimise the risk of subgrades becoming ‘over wet’, particularly in areas of highly reactive clays and adjoining landscaping areas.

9. References


10. Limitations

DP has prepared this report for Stages 1 and 2 of the proposed Residential Subdivision to be located at Canvey Road, Upper Kedron in accordance with DP’s proposal BNE150028 (Rev. 1) dated 3 February 2015 as requested by Cedar Woods Ltd. The work was carried out under DP’s Conditions of Engagement. This report is provided for the exclusive use of Cedar Woods Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP’s field testing has been completed.

DP’s advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions across the site and between sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with the notes entitled ‘About This Report’ in Appendix A and any other explanatory notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.
This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP, as this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required by the Health and Safety Legislation and Regulations, to be included in a safety report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the ‘Comments’ section of this report, as an Upgrade to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd
Appendix A

Notes entitled ‘About This Report’

Explanatory Notes
Sampling Procedures
Soil Descriptions
Rock Descriptions
Symbols and Abbreviations
**Introduction**

These notes have been provided to amplify DP’s report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP’s reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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**Borehole and Test Pit Logs**

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

**Groundwater**

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

**Reports**

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.
Site Anomalies
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection
The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.
Sampling
Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits
Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers
Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers
The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling
The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling
A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests
Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the ‘N’ value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.
- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:
  \[\text{4, 6, 7} \quad \text{N=13}\]
- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:
  \[\text{15, 30/40 mm}\]
Sampling Methods

The results of the SPT tests can be related empirically to the engineering properties of the soils.

**Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests**

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.

- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.
Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

<table>
<thead>
<tr>
<th>Type</th>
<th>Particle size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulder</td>
<td>&gt;200</td>
</tr>
<tr>
<td>Cobble</td>
<td>63 - 200</td>
</tr>
<tr>
<td>Gravel</td>
<td>2.36 - 63</td>
</tr>
<tr>
<td>Sand</td>
<td>0.075 - 2.36</td>
</tr>
<tr>
<td>Silt</td>
<td>0.002 - 0.075</td>
</tr>
<tr>
<td>Clay</td>
<td>&lt;0.002</td>
</tr>
</tbody>
</table>

The sand and gravel sizes can be further subdivided as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>Particle size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse gravel</td>
<td>20 - 63</td>
</tr>
<tr>
<td>Medium gravel</td>
<td>6 - 20</td>
</tr>
<tr>
<td>Fine gravel</td>
<td>2.36 - 6</td>
</tr>
<tr>
<td>Coarse sand</td>
<td>0.6 - 2.36</td>
</tr>
<tr>
<td>Medium sand</td>
<td>0.2 - 0.6</td>
</tr>
<tr>
<td>Fine sand</td>
<td>0.075 - 0.2</td>
</tr>
</tbody>
</table>

The proportions of secondary constituents of soils are described as:

<table>
<thead>
<tr>
<th>Term</th>
<th>Proportion</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>And</td>
<td>Specify</td>
<td>Clay (60%) and Sand (40%)</td>
</tr>
<tr>
<td>Adjective</td>
<td>20 - 35%</td>
<td>Sandy Clay</td>
</tr>
<tr>
<td>Slightly</td>
<td>12 - 20%</td>
<td>Slightly Sandy Clay</td>
</tr>
<tr>
<td>With some</td>
<td>5 - 12%</td>
<td>Clay with some sand</td>
</tr>
<tr>
<td>With a trace of</td>
<td>0 - 5%</td>
<td>Clay with a trace of sand</td>
</tr>
</tbody>
</table>

Definitions of grading terms used are:
- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Abbreviation</th>
<th>Undrained shear strength (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very soft</td>
<td>vs</td>
<td>&lt;12</td>
</tr>
<tr>
<td>Soft</td>
<td>s</td>
<td>12 - 25</td>
</tr>
<tr>
<td>Firm</td>
<td>f</td>
<td>25 - 50</td>
</tr>
<tr>
<td>Stiff</td>
<td>st</td>
<td>50 - 100</td>
</tr>
<tr>
<td>Very stiff</td>
<td>vst</td>
<td>100 - 200</td>
</tr>
<tr>
<td>Hard</td>
<td>h</td>
<td>&gt;200</td>
</tr>
</tbody>
</table>

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

<table>
<thead>
<tr>
<th>Relative Density</th>
<th>Abbreviation</th>
<th>SPT N value</th>
<th>CPT qc value (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very loose</td>
<td>vl</td>
<td>&lt;4</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Loose</td>
<td>l</td>
<td>4 - 10</td>
<td>2 - 5</td>
</tr>
<tr>
<td>Medium dense</td>
<td>md</td>
<td>10 - 30</td>
<td>5 - 15</td>
</tr>
<tr>
<td>Dense</td>
<td>d</td>
<td>30 - 50</td>
<td>15 - 25</td>
</tr>
<tr>
<td>Very dense</td>
<td>vd</td>
<td>&gt;50</td>
<td>&gt;25</td>
</tr>
</tbody>
</table>

July 2010
Soil Origin
It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.
Rock Strength
Rock strength is defined by the Point Load Strength Index ($I_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

<table>
<thead>
<tr>
<th>Term</th>
<th>Abbreviation</th>
<th>Point Load Index $I_{(50)}$, MPa</th>
<th>Approx Unconfined Compressive Strength MPa*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely low</td>
<td>EL</td>
<td>&lt;0.03</td>
<td>&lt;0.6</td>
</tr>
<tr>
<td>Very low</td>
<td>VL</td>
<td>0.03 - 0.1</td>
<td>0.6 - 2</td>
</tr>
<tr>
<td>Low</td>
<td>L</td>
<td>0.1 - 0.3</td>
<td>2 - 6</td>
</tr>
<tr>
<td>Medium</td>
<td>M</td>
<td>0.3 - 1.0</td>
<td>6 - 20</td>
</tr>
<tr>
<td>High</td>
<td>H</td>
<td>1 - 3</td>
<td>20 - 60</td>
</tr>
<tr>
<td>Very high</td>
<td>VH</td>
<td>3 - 10</td>
<td>60 - 200</td>
</tr>
<tr>
<td>Extremely high</td>
<td>EH</td>
<td>&gt;10</td>
<td>&gt;200</td>
</tr>
</tbody>
</table>

* Assumes a ratio of 20:1 for UCS to $I_{(50)}$

Degree of Weathering
The degree of weathering of rock is classified as follows:

<table>
<thead>
<tr>
<th>Term</th>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely weathered</td>
<td>EW</td>
<td>Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.</td>
</tr>
<tr>
<td>Highly weathered</td>
<td>HW</td>
<td>Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable</td>
</tr>
<tr>
<td>Moderately weathered</td>
<td>MW</td>
<td>Staining and discolouration of rock substance has taken place</td>
</tr>
<tr>
<td>Slightly weathered</td>
<td>SW</td>
<td>Rock substance is slightly discoloured but shows little or no change of strength from fresh rock</td>
</tr>
<tr>
<td>Fresh stained</td>
<td>Fs</td>
<td>Rock substance unaffected by weathering but staining visible along defects</td>
</tr>
<tr>
<td>Fresh</td>
<td>Fr</td>
<td>No signs of decomposition or staining</td>
</tr>
</tbody>
</table>

Degree of Fracturing
The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fragmented</td>
<td>Fragments of &lt;20 mm</td>
</tr>
<tr>
<td>Highly Fractured</td>
<td>Core lengths of 20-40 mm with some fragments</td>
</tr>
<tr>
<td>Fractured</td>
<td>Core lengths of 40-200 mm with some shorter and longer sections</td>
</tr>
<tr>
<td>Slightly Fractured</td>
<td>Core lengths of 200-1000 mm with some shorter and loner sections</td>
</tr>
<tr>
<td>Unbroken</td>
<td>Core lengths mostly &gt; 1000 mm</td>
</tr>
</tbody>
</table>
**Rock Descriptions**

**Rock Quality Designation**
The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

\[ \text{RQD} \% = \frac{\text{cumulative length of 'sound' core sections } \geq 100 \text{ mm long}}{\text{total drilled length of section being assessed}} \]

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

**Stratification Spacing**
For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

<table>
<thead>
<tr>
<th>Term</th>
<th>Separation of Stratification Planes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinly laminated</td>
<td>&lt; 6 mm</td>
</tr>
<tr>
<td>Laminated</td>
<td>6 mm to 20 mm</td>
</tr>
<tr>
<td>Very thinly bedded</td>
<td>20 mm to 60 mm</td>
</tr>
<tr>
<td>Thinly bedded</td>
<td>60 mm to 0.2 m</td>
</tr>
<tr>
<td>Medium bedded</td>
<td>0.2 m to 0.6 m</td>
</tr>
<tr>
<td>Thickly bedded</td>
<td>0.6 m to 2 m</td>
</tr>
<tr>
<td>Very thickly bedded</td>
<td>&gt; 2 m</td>
</tr>
</tbody>
</table>
**Introduction**

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

**Drilling or Excavation Methods**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Core Drilling</td>
</tr>
<tr>
<td>R</td>
<td>Rotary drilling</td>
</tr>
<tr>
<td>SFA</td>
<td>Spiral flight augers</td>
</tr>
<tr>
<td>NMLC</td>
<td>Diamond core - 52 mm dia</td>
</tr>
<tr>
<td>NQ</td>
<td>Diamond core - 47 mm dia</td>
</tr>
<tr>
<td>HQ</td>
<td>Diamond core - 63 mm dia</td>
</tr>
<tr>
<td>PQ</td>
<td>Diamond core - 81 mm dia</td>
</tr>
</tbody>
</table>

**Water**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>Water seep</td>
</tr>
<tr>
<td>V</td>
<td>Water level</td>
</tr>
</tbody>
</table>

**Sampling and Testing**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Auger sample</td>
</tr>
<tr>
<td>B</td>
<td>Bulk sample</td>
</tr>
<tr>
<td>D</td>
<td>Disturbed sample</td>
</tr>
<tr>
<td>E</td>
<td>Environmental sample</td>
</tr>
<tr>
<td>U50</td>
<td>Undisturbed tube sample (50mm)</td>
</tr>
<tr>
<td>W</td>
<td>Water sample</td>
</tr>
<tr>
<td>pp</td>
<td>Pocket penetrometer (kPa)</td>
</tr>
<tr>
<td>PID</td>
<td>Photo ionisation detector</td>
</tr>
<tr>
<td>PL</td>
<td>Point load strength Is(50) MPa</td>
</tr>
<tr>
<td>S</td>
<td>Standard Penetration Test</td>
</tr>
<tr>
<td>V</td>
<td>Shear vane (kPa)</td>
</tr>
</tbody>
</table>

**Description of Defects in Rock**

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

**Defect Type**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Bedding plane</td>
</tr>
<tr>
<td>Cs</td>
<td>Clay seam</td>
</tr>
<tr>
<td>Cv</td>
<td>Cleavage</td>
</tr>
<tr>
<td>Cz</td>
<td>Crushed zone</td>
</tr>
<tr>
<td>Ds</td>
<td>Decomposed seam</td>
</tr>
<tr>
<td>F</td>
<td>Fault</td>
</tr>
<tr>
<td>J</td>
<td>Joint</td>
</tr>
<tr>
<td>Lam</td>
<td>Lamination</td>
</tr>
<tr>
<td>Pt</td>
<td>Parting</td>
</tr>
<tr>
<td>Sz</td>
<td>Sheared Zone</td>
</tr>
<tr>
<td>V</td>
<td>Vein</td>
</tr>
</tbody>
</table>

**Orientation**

The inclination of defects is always measured from the perpendicular to the core axis.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>h</td>
<td>horizontal</td>
</tr>
<tr>
<td>v</td>
<td>vertical</td>
</tr>
<tr>
<td>sh</td>
<td>sub-horizontal</td>
</tr>
<tr>
<td>sv</td>
<td>sub-vertical</td>
</tr>
</tbody>
</table>

**Coating or Infilling Term**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cln</td>
<td>clean</td>
</tr>
<tr>
<td>co</td>
<td>coating</td>
</tr>
<tr>
<td>he</td>
<td>healed</td>
</tr>
<tr>
<td>inf</td>
<td>infilled</td>
</tr>
<tr>
<td>stn</td>
<td>stained</td>
</tr>
<tr>
<td>ti</td>
<td>tight</td>
</tr>
<tr>
<td>vn</td>
<td>veneer</td>
</tr>
</tbody>
</table>

**Coating Descriptor**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ca</td>
<td>calcite</td>
</tr>
<tr>
<td>cbs</td>
<td>carbonaceous</td>
</tr>
<tr>
<td>cly</td>
<td>clay</td>
</tr>
<tr>
<td>fe</td>
<td>iron oxide</td>
</tr>
<tr>
<td>mn</td>
<td>manganese</td>
</tr>
<tr>
<td>slt</td>
<td>silty</td>
</tr>
</tbody>
</table>

**Shape**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cu</td>
<td>curved</td>
</tr>
<tr>
<td>ir</td>
<td>irregular</td>
</tr>
<tr>
<td>pl</td>
<td>planar</td>
</tr>
<tr>
<td>st</td>
<td>stepped</td>
</tr>
<tr>
<td>un</td>
<td>undulating</td>
</tr>
</tbody>
</table>

**Roughness**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>po</td>
<td>polished</td>
</tr>
<tr>
<td>ro</td>
<td>rough</td>
</tr>
<tr>
<td>sl</td>
<td>slickensided</td>
</tr>
<tr>
<td>sm</td>
<td>smooth</td>
</tr>
<tr>
<td>vr</td>
<td>very rough</td>
</tr>
</tbody>
</table>

**Other**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>fg</td>
<td>fragmented</td>
</tr>
<tr>
<td>bnd</td>
<td>band</td>
</tr>
<tr>
<td>qtz</td>
<td>quartz</td>
</tr>
</tbody>
</table>
Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General
- Asphalt
- Road base
- Concrete
- Filling

Soils
- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

Sedimentary Rocks
- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminate
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks
- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks
- Granite
- Dolerite, basalt, andesite
- Dacite, epidote
- Tuff, breccia
- Porphyry
Appendix B

Drawing 1 – Test Location Plan
LEGEND:-
- Geotechnical Bore Location and Number
- Geotechnical Test Pit Location and Number

NOTE:-
1. Plan adapted from Nearmap.
2. Test locations are approximate only and were located using handheld GPS.
Appendix C

Bore Log and Test Pit Report Sheets
Bores 1-5
Pits 6 and 13-19
### BOREHOLE LOG

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description of Strata</th>
<th>Degree of Weathering</th>
<th>Rock Strength</th>
<th>Fracture Spacing (m)</th>
<th>Discontinuities</th>
<th>Sampling &amp; In Situ Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 - 0.1</td>
<td>TOPSOIL - estimated firm, dark brown, medium plasticity silty clay, some sand, moist</td>
<td></td>
<td></td>
<td></td>
<td>B - Bedding</td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>CLAYEY SAND - estimated loose, dark grey brown, clayey medium to coarse grained sand with some silt, moist to wet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>SANDY CLAY - hard, light yellow and grey, low plasticity sandy clay/clayey sand, fine to medium grained sand, some fine gravel, dry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td>PHYLLITE - extremely low strength, extremely weathered, dark grey banded orange and dark brown phyllite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>- very low strength, highly weathered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>- extremely low strength, extremely weathered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>- extremely low to very low strength, extremely to highly weathered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>- very low strength, highly weathered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.7</td>
<td>- medium strength, slightly to moderately weathered, some quartz bands</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.7</td>
<td>Bore discontinued at 7.7 m depth - Limit of investigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Discontinuities**

- J - Joint
- F - Fault
- RL - Rock Mass Rating
- S - Shear
- B - Bedding
- Core Rec. %

**Test Results & Comments**

- RQD
- Degree of Weathering
- EW
- HWM
- WS
- FS
- FR

**Sampling & In Situ Testing**

- Gas sample
- Gas sample PID
- Gas sample PP
- Water sample
- Water sample PID
- Water sample PP
- Water level
- Standard penetration test
- Shear vane test
- Point load test
- Pocket penetrometer

**RIG:** MD300 (Track)  **DRILLER:** Taberner Drilling  **LOGGED:** BM  **CASING:** HWT to 3.0m

**TYPE OF BORING:** Auger to 3.0m, washbore to 4.72m then NMLC to 7.7m

**WATER OBSERVATIONS:** No free groundwater observed

**REMARKS:**
TOPSOIL - medium dense, brown, fine to medium grained silty sand topsoil, moist

GRAVELLY SAND - medium dense, brown, gravelly medium to coarse grained sand, well rounded gravel, damp, organics to 0.1m

- grey, wet

PHYLLITE - extremely low strength, extremely weathered, dark grey banded orange and brown phyllite

- some low and medium strength bands

- low strength with some medium and very low strength bands

Bore discontinued at 6.04m depth - Limit of investigation

CLIENT: Cedar Grove Developments
PROJECT: Proposed Cedar Grove Subdivision
LOCATION: Canvey Road, Upper Kedron

SURFACE LEVEL: --
EASTING: 491875
NORTHING: 6966501
DIP/AZIMUTH: 90°/--
DATE: 23/2/2015

BORE No: 2
PROJECT No: 87335.00

RIG: MD300 (Track)
DRILLER: Taberner Drilling
LOGGED: BM
CASING: Nil

TYPE OF BORING: Auger
WATER OBSERVATIONS: Groundwater ingress at 2.3m

REMARKS:

SAMPLING & IN SITU TESTING LEGEND
A Auger sample
B Bulk sample
BLK Block sample
C Core drilling
D Disturbed sample
E Environmental sample
G Gas sample
P Piston sample
PLR Pocket penetrometer (kPa)
P PID Photo ionisation detector (ppm)
PT Point load axial test (50) (MPa)
PLD Point load diametral test (50) (MPa)
S Standard penetration test
SCH Shear vane (kPa)
T Tube sample (x mm dia.)
W Water sample
X Water level

Dynamic Penetrometer Test
(blowes per 0mm)

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description of Strata</th>
<th>Type</th>
<th>Depth</th>
<th>Sample</th>
<th>Results &amp; Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>TOPSOIL - medium dense, brown, fine to medium grained silty sand topsoil, moist</td>
<td>S</td>
<td>1.5</td>
<td>1.64</td>
<td>30/140mm</td>
</tr>
<tr>
<td>1.4</td>
<td>PHYLLITE - extremely low strength, extremely weathered, dark grey banded orange and brown phyllite</td>
<td>S</td>
<td>3.0</td>
<td>3.14</td>
<td>30/140mm</td>
</tr>
<tr>
<td>4.5</td>
<td>- low strength with some medium and very low strength bands</td>
<td>S</td>
<td>4.5</td>
<td>4.74</td>
<td>13, 30/90mm</td>
</tr>
<tr>
<td>6.04</td>
<td>Bore discontinued at 6.04m depth - Limit of investigation</td>
<td>D</td>
<td>6.04</td>
<td></td>
<td>30/40mm</td>
</tr>
</tbody>
</table>
### TOPSOIL - firm, dark brown, high plasticity silty clay, some sand, moist

### SILTY CLAY - estimated stiff, brown and grey, medium plasticity silty clay with some fine grained sand, moist

### CLAYEY SAND - medium dense to dense, yellow brown clayey sand, dry to moist (weathered phyllite)

### PHYLLITE - very low strength, highly weathered, yellow brown and grey phyllite

- some low strength bands

### Extremely low strength, extremely weathered

Bore discontinued at 6.29m depth - Limit of investigation

### Sampling & In Situ Testing

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Type</th>
<th>Description of Strata</th>
<th>Graphic Log</th>
<th>Type</th>
<th>Depth</th>
<th>Sample</th>
<th>Results &amp; Comments</th>
<th>Water</th>
<th>Dynamic Penetrometer Test (blows per 0mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>TOPSOIL</td>
<td>firm, dark brown, high plasticity silty clay, some sand, moist</td>
<td><img src="image1" alt="Graphic Log" /></td>
<td>D</td>
<td></td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>SILTY CLAY</td>
<td>estimated stiff, brown and grey, medium plasticity silty clay with some fine grained sand, moist</td>
<td><img src="image2" alt="Graphic Log" /></td>
<td>D</td>
<td></td>
<td>0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>CLAYEY SAND</td>
<td>medium dense to dense, yellow brown clayey sand, dry to moist (weathered phyllite)</td>
<td><img src="image3" alt="Graphic Log" /></td>
<td>S</td>
<td>1.5</td>
<td>11,15,14</td>
<td>N = 29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>PHYLITE</td>
<td>very low strength, highly weathered, yellow brown and grey phyllite</td>
<td><img src="image4" alt="Graphic Log" /></td>
<td>S</td>
<td>3.0</td>
<td>30/90mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>PHYLITE</td>
<td>very low strength, highly weathered, yellow brown and grey phyllite</td>
<td><img src="image5" alt="Graphic Log" /></td>
<td>S</td>
<td>3.09</td>
<td>30/90mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>PHYLITE</td>
<td>very low strength, highly weathered, yellow brown and grey phyllite</td>
<td><img src="image6" alt="Graphic Log" /></td>
<td>S</td>
<td>4.58</td>
<td>30/90mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>PHYLITE</td>
<td>very low strength, highly weathered, yellow brown and grey phyllite</td>
<td><img src="image7" alt="Graphic Log" /></td>
<td>S</td>
<td>6.0</td>
<td>17, 30/140mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.29</td>
<td>PHYLITE</td>
<td>very low strength, highly weathered, yellow brown and grey phyllite</td>
<td><img src="image8" alt="Graphic Log" /></td>
<td>S</td>
<td>0.29</td>
<td>17, 30/140mm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**RIG:** MD300 (Track)  **DRILLER:** Taberner Drilling  **LOGGED:** BM  **CASING:** Nil

**TYPE OF BORING:** Auger  **WATER OBSERVATIONS:** No free groundwater observed

**REMARKS:**

- Sand Penetrometer AS1289.6.3.3
- Cone Penetrometer AS1289.6.3.2
## BOREHOLE LOG

**CLIENT:** Cedar Grove Developments  
**PROJECT:** Proposed Cedar Grove Subdivision  
**LOCATION:** Canvey Road, Upper Kedron  
**SAMPLING & IN SITU TESTING LEGEND**

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
<th>Sampling &amp; In Situ Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Auger sample</td>
<td>B - Bedding, J - Joint, S - Shear, F - Fault</td>
</tr>
<tr>
<td>B</td>
<td>Bulk sample</td>
<td>D - Disturbed sample</td>
</tr>
<tr>
<td>C</td>
<td>Core drilling</td>
<td>E - Environmental sample</td>
</tr>
<tr>
<td>D</td>
<td>Disturbed sample</td>
<td>F - Fault</td>
</tr>
<tr>
<td>E</td>
<td>Environmental sample</td>
<td>G - Gas sample</td>
</tr>
<tr>
<td>F</td>
<td>Open sample</td>
<td>H - Hardened sample</td>
</tr>
<tr>
<td>G</td>
<td>Gas sample</td>
<td>I - In situ test</td>
</tr>
<tr>
<td>H</td>
<td>Hardened sample</td>
<td>J - Joint</td>
</tr>
<tr>
<td>I</td>
<td>In situ test</td>
<td>K - Kernel</td>
</tr>
<tr>
<td>J</td>
<td>Joint</td>
<td>L - Lateral</td>
</tr>
<tr>
<td>K</td>
<td>Kernel</td>
<td>M - Moisture</td>
</tr>
<tr>
<td>L</td>
<td>Lateral</td>
<td>N - Not applicable</td>
</tr>
<tr>
<td>M</td>
<td>Moisture</td>
<td>O - Other</td>
</tr>
<tr>
<td>N</td>
<td>Not applicable</td>
<td>P - Penetration</td>
</tr>
<tr>
<td>O</td>
<td>Other</td>
<td>Q - Quantiative</td>
</tr>
<tr>
<td>P</td>
<td>Penetration</td>
<td>R - Rock</td>
</tr>
<tr>
<td>Q</td>
<td>Quantiative</td>
<td>S - Sample</td>
</tr>
<tr>
<td>R</td>
<td>Rock</td>
<td>T - Test</td>
</tr>
<tr>
<td>S</td>
<td>Sample</td>
<td>U - Unit</td>
</tr>
<tr>
<td>T</td>
<td>Test</td>
<td>V - Visual</td>
</tr>
</tbody>
</table>

### TOPSOIL - stiff, brown, medium plasticity silty clay, trace sand, moist

### SILTY CLAY - stiff, brown and grey, medium plasticity silty clay with some fine grained sand, moist

### PHYLITE - extremely low to very low strength, extremely to highly weathered, yellow brown phyllite

- **Joint:** 0.05m
- **Fracture Spacing:** 0.05m

### 5.24m: Cz (40mm)

### 5.28m: J, 80°, pl, ro, st, fe

### 4.5m: CORE LOSS:

### 5.45m: J, 0-25°, pl, un, ro, st, fe

### 5.75m: J, 0-25°, pl, un, ro, st, fe

### Bore discontinued at 6.0m depth - Limit of investigation

---

**RIG:** MD300 (Track)  
**DRILLER:** Taberner Drilling  
**LOGGED:** BM  
**CASING:** HWT to 3.0m  
**DATE:** 25/2/2015

**TYPE OF BORING:** Auger to 4.5m, then NMLC to 6.0m  
**WATER OBSERVATIONS:** No free groundwater observed

**REMARKS:**
**CLIENT:** Cedar Grove Developments  
**PROJECT:** Proposed Cedar Grove Subdivision  
**LOCATION:** Canvey Road, Upper Kedron  
**SURFACE LEVEL:** --  
**EASTING:** 492186  
**NORTHING:** 6965828  
**PROJECT No:** 87335.00  
**DATE:** 24/2/2015  
**BORE No:** 5  
**DIP/AZIMUTH:** 90°/--  
**SHEET** 1 OF 1

**BOREHOLE LOG**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description of Strata</th>
<th>Type</th>
<th>Depth Sample</th>
<th>Results &amp; Comments</th>
<th>Dynamic Penetrometer Test (blows per 0mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>TOPSOIL - stiff, dark brown, high plasticity silty clay topsoil, some sand, moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>SILITY CLAY - stiff, red brown, medium plasticity silty clay with some fine grained sand, dry to moist</td>
<td></td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>ARENITE - very low strength, highly weathered, light yellow arenite, some conglomerate bands</td>
<td>D</td>
<td>1.5</td>
<td>30/80mm</td>
<td></td>
</tr>
<tr>
<td>1.7</td>
<td>- some extremely low and low strength bands, light yellow brown banded grey</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>- very low to low strength</td>
<td>S</td>
<td>3.0</td>
<td>30/150mm</td>
<td></td>
</tr>
<tr>
<td>3.15</td>
<td>- low strength band</td>
<td>S</td>
<td>3.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>- very low to low strength</td>
<td>S</td>
<td>4.5</td>
<td>20, 30/90mm</td>
<td></td>
</tr>
<tr>
<td>4.74</td>
<td>- low strength band</td>
<td>S</td>
<td>4.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>Bore discontinued at 6.09m depth - Limit of investigation</td>
<td>S</td>
<td>6.0</td>
<td>30/90mm</td>
<td></td>
</tr>
</tbody>
</table>

**RIG:** MD300 (Track)  
**DRILLER:** Taberner Drilling  
**LOGGED:** BM  
**CASING:** Nil  
**TYPE OF BORING:** Auger  
**WATER OBSERVATIONS:** No free groundwater observed  
**REMARKS:**

- Sand Penetrometer AS1289.6.3.3
- Cone Penetrometer AS1289.6.3.2
TOPSOIL - firm to stiff, dark brown, high plasticity clayey silt topsoil with some organics and fine gravel, moist

GRAVELLY CLAY - firm, brown mottled light brown and orange, high plasticity gravelly clay with some silt and fine grained sand, moist

SILTY CLAY - firm to stiff, brown mottled orange, high plasticity silty clay with a trace of fine gravel and fine grained sand, moist

PHYLITE - extremely low strength, extremely weathered, brown, brown red and orange phyllite
- low strength, dark grey and orange brown
- low to medium strength, dark grey and red brown

Pit discontinued at 3.0m depth - Limit of investigation

**WATER OBSERVATIONS:** No free groundwater observed

**REMARKS:**

---

**SAMPLING & IN SITU TESTING LEGEND**

- **A Auger sample**
- **B Bulk sample**
- **C Core drilling**
- **D Disturbed sample**
- **E Environmental sample**
- **G Gas sample**
- **P Piston sample**
- **U Tube sample (x mm dia.)**
- **W Water sample**
- **X Water seep**
- **F Photo ionisation detector (ppm)**
- **PLA Point load axial (is(50) (MPa))**
- **PLD Point load diametral test (is(50) (MPa))**
- **pp Pocket penetrometer (kPa)**
- **pp Standard penetration test**
- **V Shear vane (kPa)**

---

**Douglas Partners**

**Geotechnics | Environment | Groundwater**
CLIENT: Cedar Woods Ltd

PROJECT No: 87335.00

OFFICE: Brisbane

PLATE No: -

DATE: March 2015

REVISION: -

Test Pit Photograph – Pit 6

Proposed Residential Subdivision

Canvey Road, Upper Kedron
TOPSOIL - estimated firm, dark brown and brown, high plasticity silty clay topsoil with some organics, moist

CLAYEY SAND - estimated loose, brown and dark brown, clayey fine to medium grained sand with some silt, moist

SANDY GRAVEL - estimated loose, brown and light brown, sandy fine to medium gravel with some silt, moist

SILTY SAND - estimated medium dense, light brown and brown, silty fine to medium grained sand with a trace of fine gravel, moist

PHYLLE - extremely low strength, extremely weathered, grey and orange phyllite

- very low to low strength

- medium strength

Pit discontinued at 2.9m depth - Limit of investigation

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description of Strata</th>
<th>Graphic Log</th>
<th>Sampling &amp; In Situ Testing</th>
<th>Results &amp; Comments</th>
<th>Dynamic Penetrometer Test (blows per 100mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>TOPSOIL - estimated firm, dark brown and brown, high plasticity silty clay topsoil with some organics, moist</td>
<td>D 0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>CLAYEY SAND - estimated loose, brown and dark brown, clayey fine to medium grained sand with some silt, moist</td>
<td>D 0.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>SANDY GRAVEL - estimated loose, brown and light brown, sandy fine to medium gravel with some silt, moist</td>
<td>D 0.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.7</td>
<td>SILTY SAND - estimated medium dense, light brown and brown, silty fine to medium grained sand with a trace of fine gravel, moist</td>
<td>D 1.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 2.9       | PHYLITE - extremely low strength, extremely weathered, grey and orange phyllite

- very low to low strength

- medium strength

Pit discontinued at 2.9m depth - Limit of investigation | | | | | |

RIG: Cat 308E

LOGGED: MS

SURVEY DATUM: MGA94

WATER OBSERVATIONS: Groundwater observed at 1.3m

REMARKS:

SAMPLING & IN SITU TESTING LEGEND:

A Auger sample
B Bulk sample
BLK Block sample
C Core drilling
D Disturbed sample
E Environmental sample
G Gas sample
P Piston sample
W Water sample
U Tube sample (x mm dia.)
AU Air sample
PLD Point load axial test (x)(MPa)
PL(D) Point load diametral test (x)(MPa)
PP Pocket penetrometer (kPa)
PIID Photo ionisation detector (ppm)
S Standard penetration test
V Shear vane (kPa)
CLIENT: Cedar Woods Ltd
OFFICE: Brisbane
DATE: March 2015

Test Pit Photograph – Pit 13
Proposed Residential Subdivision
Canvey Road, Upper Kedron

PROJECT No: 87335.00
PLATE No: -
REVISION: -
**TEST PIT LOG**

**CLIENT:** Cedar Grove Developments  
**PROJECT:** Proposed Cedar Grove Subdivision  
**LOCATION:** Canvey Road, Upper Kedron  
**SURFACE LEVEL:**  
**EASTING:** 491937  
**NORTHING:** 6966668  
**DATE:** 27/2/2015  
**PIT No:** 14  
**PROJECT No:** 87335.00

---

**SAMPLING & IN SITU TESTING LEGEND**

- A: Auger sample  
- B: Bulk sample  
- BLK: Block sample  
- C: Core drilling  
- D: Disturbed sample  
- E: Environmental sample  
- G: Gas sample  
- P: Piston sample  
- U: Tube sample (x mm dia.)  
- W: Water sample  
- S: Standard penetration test  
- PP: Pocket penetrometer (kPa)  
- PL(D): Point load diametral test (IS(50) (MPa)  
- PL(A): Point load axial test (IS(50) (MPa)  
- PID: Photo ionisation detector (ppm)  
- PP: Pocket penetrometer (kPa)  
- RL: Dynamic Penetrometer Test

---

**BULK SAMPLES**

<table>
<thead>
<tr>
<th>Type</th>
<th>Depth</th>
<th>Sample</th>
<th>Results &amp; Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>0.4</td>
<td>pp = 140-200</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>0.8</td>
<td>pp = 240-300</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**LOGGED:** MS  
**SURVEY DATUM:** MGA94

---

**WATER OBSERVATIONS:** No free groundwater observed

---

**REMARKS:**

---

**RIG:** Cat 308E  
**SURFACE LEVEL:** --  
**EASTING:** 491937  
**NORTHING:** 6966668  
**DATE:** 27/2/2015

---

**DYNAMIC PENETROMETER TEST**

<table>
<thead>
<tr>
<th>Blows per 100mm</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
</table>
| Pit discontinued at 3.0m depth - Limit of investigation

---

**PHOTOGRAPHIC LOG**

**REMARKS:**

---

**DESCRIPTION OF STRATA**

- **TOPSOIL:** firm, dark brown, high plasticity silty clay topsoil with some organics and fine gravel, moist
- **SILTY CLAY:** firm to stiff, brown mottled red brown, high plasticity silty clay with some fine grained sand, moist
- Stiff to very stiff, brown mottled orange brown with some fine gravel
- **PHYLLITE:** extremely low strength, extremely weathered, light brown and red brown phyllite
  - Very low strength
  - Low strength, dark grey and orange brown

---

**PIT 14**

---

**RESULTS & COMMENTS**

---

**D Dynamic Penetrometer Test**

---

**DATE:** 27/2/2015  
**SHEET 1 OF 1**
### Sampling & In Situ Testing

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description of Strata</th>
<th>Graphic Log</th>
<th>Sampling &amp; In Situ Testing</th>
<th>Results &amp; Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>TOPSOIL - stiff, dark brown, high plasticity silty clay topsoil with some organics and fine gravel, moist</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SANDY CLAY - very stiff, brown mottled orange brown, medium plasticity sandy clay with some silt and fine to coarse gravel, moist</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>PHYLITE - very low to low strength, highly weathered, light grey and orange brown phyllite with extremely low strength bands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- very low strength, highly weathered, brown and red brown phyllite</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>Pit discontinued at 3.0m depth - Limit of investigation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Dynamic Penetrometer Test (blows per 100mm)**

- 5
- 10
- 15
- 20

**RIG:** Cat 308E

**LOGGED:** MS

**SURVEY DATUM:** MGA94

**CLIENT:** Cedar Grove Developments

**PROJECT:** Proposed Cedar Grove Subdivision

**LOCATION:** Canvey Road, Upper Kedron

**SURFACE LEVEL:**

**EASTING:** 491973

**NORTHING:** 6966432

**DATE:** 27/2/2015

**PIT No:** 15

**PROJECT No:** 87335.00

**WATER OBSERVATIONS:** Groundwater observed at 0.4m
CLIENT: Cedar Woods Ltd
OFFICE: Brisbane
DATE: March 2015

Test Pit Photograph – Pit 15
Proposed Residential Subdivision
Canvey Road, Upper Kedron

PROJECT No: 87335.00
PLATE No: -
REVISION: -
TOPSOIL - firm, dark brown, high plasticity silty clay topsoil with some organics and fine gravel, moist

SANDY CLAY - stiff to very stiff, brown mottled light brown, medium plasticity sandy clay with some silt and fine gravel, fine to medium grained sand, moist

SILTY CLAY - very stiff, red brown mottled brown, medium plasticity silty clay with some fine grained sand and fine gravel, moist

- hard

PHYLITE - extremely low strength, extremely weathered, brown, orange brown and red phyllite

- very low strength

- low strength, highly weathered, dark grey, brown and orange phyllite

Pit discontinued at 3.0m depth - Limit of investigation

SAMPLING & IN SITU TESTING LEGEND

A Auger sample
B Bulk sample
BLK Block sample
C Core drilling
D Disturbed sample
E Environmental sample
G Gas sample
P Piston sample
PP Pocket penetrometer (kPa)
PL(D) Point load diametral test Is(50) (MPa)
PL(A) Point load axial test Is(50) (MPa)
RTI Photoionisation detector (ppm)
PIT Point load test (Is50) (MPa)
S Standard penetration test
SH Shear vane (kPa)
SLW Surface level
SW Water level
V Shear vane (kPa)
W Water sample
X Tube sample (x mm dia.)

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

RIG: Cat 308E
LOGGED: MS
SURVEY DATUM: MGA94

TEST PIT LOG
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description of Strata</th>
<th>Sampling &amp; In Situ Testing</th>
<th>Dynamic Penetrometer Test (blows per 100mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>TOPSOIL - firm, dark brown, high plasticity silty clay topsoil with some organics and fine gravel, moist</td>
<td>D 0.5</td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>SILTY SAND - dense to very dense, dark brown and brown, silty fine to coarse grained sand with a trace of high plasticity clay, moist</td>
<td>D 0.7</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>GRAVELLY SAND - dense to very dense, brown and light brown, gravelly fine to coarse grained sand with some silt, moist</td>
<td>D 1.1</td>
<td>pp = 150-170</td>
</tr>
<tr>
<td>1.7</td>
<td>SILTY CLAY - stiff, orange brown mottled brown, high plasticity silty clay with a trace of fine grained sand, moist</td>
<td>D 1.8</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>PHYLITE - extremely low strength, extremely weathered, dark grey and orange brown phyllite with a trace of fine gravel (possibly hard residual silty clay)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>Pit discontinued at 3.0m depth - Limit of investigation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sampling & In Situ Testing Legend**

- **A** Auger sample
- **B** Bulk sample
- **C** Core drilling
- **D** Disturbed sample
- **E** Environmental sample
- **G** Gas sample
- **P** Piston sample
- **U** Tube sample (x mm dia.)
- **W** Water sample
- **S** Water seep
- **V** Water level
- **R** Dynamic Penetrometer test

**Dynamic Penetrometer Test**

<table>
<thead>
<tr>
<th>Blows per 100mm</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topsoil</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Silty Sand</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gravelly Sand</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Silty Clay</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phyllite</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Water Observations**: Groundwater observed at 0.7m

**Remarks**: 

- Groundwater observed at 0.7m
- Pit discontinued at 3.0m depth - Limit of investigation
CLIENT: Cedar Woods Ltd

OFFICE: Brisbane

DATE: March 2015

PROJECT No: 87335.00

PLATE No: -

REVISION: -

Test Pit Photograph – Pit 17

Proposed Residential Subdivision

Canvey Road, Upper Kedron
TOPSOIL - firm, dark brown, high plasticity silty clay with some organics and gravel, moist

SANDY CLAY - stiff, brown mottled orange brown, high plasticity sandy clay with some fine gravel (phyllite), moist

SILTY CLAY - stiff, red brown mottled orange, high plasticity silty clay with a trace of fine gravel and sand, moist

PHYLLITE - extremely low strength, extremely weathered, grey white and orange brown phyllite

- very low strength
- low strength, grey brown and orange brown

Pit discontinued at 3.0m depth - Limit of investigation

Dynamic Penetrometer Test (blows per 100mm)

5 10 15 20

Dynamic Penetrometer Test

Sand Penetrometer AS1289.6.3.3
Cone Penetrometer AS1289.6.3.2

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND
A Auger sample
B Bulk sample
BLK Block sample
C Core drilling
D Disturbed sample
E Environmental sample
G Gas sample
P Piston sample
PL Block sample (x mm dia.)
W Water sample
Y Water level

Photo ionisation detector (ppm)
Point load axial test (Is(50)) (MPa)
Point load diametral test (Is(50)) (MPa)
Pocket penetrometer (kPa)
Standard penetration test
Shear vane (kPa)
CLIENT: Cedar Woods Ltd

OFFICE: Brisbane

DATE: March 2015

PROJECT No: 87335.00

PLATE No: -

REVISION: -

Test Pit Photograph – Pit 18

Proposed Residential Subdivision

Canvey Road, Upper Kedron
### Topsoil

- Firm, dark brown, high plasticity silty clay with some organics and gravel, moist

### Sandy Clay

- Firm to stiff, orange brown mottled grey brown, medium plasticity sandy clay with some gravel and silt, moist
- Hard

### Phyllite

- Extremely low strength, extremely weathered, brown grey and orange brown phyllite
- Very low to low strength with bands of extremely low strength phyllite

---

**Pit discontinued at 3.0m depth - Limit of investigation**

---

**Dynamic Penetrometer Test (blows per 100mm)**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Sampling &amp; In Situ Testing</th>
<th>Results &amp; Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>TOPSOIL</td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>SANDY CLAY</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>PHYLITE</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>Pit discontinued at 3.0m depth</td>
<td>Limit of investigation</td>
</tr>
</tbody>
</table>

---

**WATER OBSERVATIONS:** No free groundwater observed

---

**REMARKS:**

---

**SAMPLING & IN SITU TESTING LEGEND**

- A Auger sample
- B Bulk sample
- BLK Block sample
- C Core drilling
- D Disturbed sample
- E Environmental sample
- G Gas sample
- P Piston sample
- U Tube sample (x mm dia.)
- W Water sample
- S Water seep
- V Water level
- PLID Photo ionisation detector (ppm)
- PL(A) Point load axial test Is(50) (MPa)
- PL(D) Point load diametral test Is(50) (MPa)
- PP Pocket penetrometer (kPa)
- PP = 250-320
- SD Standard penetration test
- S Shear vane (kPa)

---

**RIG:** Cat 308E

**LOGGED:** MS

**SURVEY DATUM:** MGA94

---

**WATER LEVEL:** --

**EASTING:** 491990

**NORTHING:** 6965869

**DATE:** 26/2/2015
CLIENT: Cedar Woods Ltd
OFFICE: Brisbane
DATE: March 2015

PROJECT No: 87335.00

Test Pit Photograph – Pit 19
Proposed Residential Subdivision
Canvey Road, Upper Kedron

PLATE No: -
REVISION: -
Appendix D

Laboratory Report Sheets
## Determination of Emerson Class Number of Soil

### Client:
CEDAR WOODS PROPERTIES LTD

### Project:
Proposed Residential Subdivision

### Location:
Canvey Road, Upper Kedron

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Depth (m)</th>
<th>Description</th>
<th>Water Type</th>
<th>Water Temp</th>
<th>Class No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bore 1</td>
<td>0.5</td>
<td>Sandy clay</td>
<td>De-ionised</td>
<td>22°C</td>
<td>4</td>
</tr>
<tr>
<td>Bore 2</td>
<td>0.5</td>
<td>Gravelly sand</td>
<td>De-ionised</td>
<td>22°C</td>
<td>3</td>
</tr>
<tr>
<td>Bore 3</td>
<td>0.5</td>
<td>Silty clay</td>
<td>De-ionised</td>
<td>22°C</td>
<td>3</td>
</tr>
<tr>
<td>Bore 4</td>
<td>0.5</td>
<td>Silty clay</td>
<td>De-ionised</td>
<td>22°C</td>
<td>3</td>
</tr>
<tr>
<td>Bore 5</td>
<td>0.5</td>
<td>Silty clay</td>
<td>De-ionised</td>
<td>22°C</td>
<td>4</td>
</tr>
<tr>
<td>Pit 13</td>
<td>0.5</td>
<td>Clayey sand</td>
<td>De-ionised</td>
<td>22°C</td>
<td>3</td>
</tr>
<tr>
<td>Pit 14</td>
<td>0.5</td>
<td>Silty clay</td>
<td>De-ionised</td>
<td>22°C</td>
<td>4</td>
</tr>
<tr>
<td>Pit 15</td>
<td>0.5</td>
<td>Sandy clay</td>
<td>De-ionised</td>
<td>22°C</td>
<td>3</td>
</tr>
<tr>
<td>Pit 16</td>
<td>0.5</td>
<td>Sandy clay</td>
<td>De-ionised</td>
<td>22°C</td>
<td>4</td>
</tr>
<tr>
<td>Pit 17</td>
<td>0.5</td>
<td>Silty sand</td>
<td>De-ionised</td>
<td>22°C</td>
<td>4</td>
</tr>
<tr>
<td>Pit 18</td>
<td>0.4</td>
<td>Sandy clay</td>
<td>De-ionised</td>
<td>22°C</td>
<td>4</td>
</tr>
<tr>
<td>Pit 19</td>
<td>0.5</td>
<td>Sandy clay</td>
<td>De-ionised</td>
<td>22°C</td>
<td>4</td>
</tr>
</tbody>
</table>

### Test Methods:
AS 1289 3.8.1

### Sampling Methods:
Sampled by DP Engineering

### Remarks:

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NATA Accredited Laboratory Number: 828

The results of the tests, calibration and/or measurements included in this document are traceable to Australian/National Standards.

Accredited for compliance with ISO/IEC 17025

Tested: AC
Checked: SJ

Srdjan Jajcanin
Laboratory Manager
Appendix E

Stability Analysis Results
Stiff Clay/ELS
Name: Silty Clay
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 26 °

Stiff Clay/ELS
Name: Embankment Filling
Unit Weight: 20 kN/m³
Cohesion': 7 kPa
Phi': 28 °

Retaining Wall
Name: Retaining Wall
Unit Weight: 22 kN/m³

VLS Phyllite
Name: VLS Phyllite
Unit Weight: 21 kN/m³
Cohesion': 15 kPa
Phi': 35 °
Retaining Wall with Bio-Basin on Steep Slope (typ.)

Name: Silty Clay
Unit Weight: 18 kN/m³
Cohesion*: 5 kPa
Phi*: 26 °

Name: Embankment Filling
Unit Weight: 20 kN/m³
Cohesion*: 7 kPa
Phi*: 28 °

Name: Loose Sands
Unit Weight: 16 kN/m³
Cohesion*: 0 kPa
Phi*: 26 °

Name: Retaining Wall
Unit Weight: 22 kN/m³

Name: VLS Phyllite
Unit Weight: 21 kN/m³
Cohesion*: 15 kPa
Phi*: 35 °