coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PROPOSED DEVELOPMENT, MUNIBUNG HILL

Fitzwalter Group Pty Ltd

GEOTWARA20281AE-AE
14 July 2009

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
19 Warabrook Boulevard Warabrook NSW 2304 Australia

14 July 2009

Fitzwalter Group Pty Ltd
41 McLaren Street
NORTH SYDNEY NSW 2060

Attention: Naomi L'Oste-Brown

Dear Naomi

RE: PROPOSED DEVELOPMENT

MUNIBUNG HILL, BOOLAROOO

URBAN CAPABILITY ASSESSMENT

Please find enclosed our report on the above project.

If you have any questions regarding this matter please do not hesitate to contact Andrew Tait or the undersigned.

For and on behalf of Coffey Geotechnics Pty Ltd

Arthur Love

Senior Principal Geotechnical Engineer

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1 INTRODUCTION

This report presents the results of an urban capability assessment carried out by Coffey Geotechnics Pty Ltd (Coffey) for the Munibung Hill area of the Pasminco Cockle Creek land holding. The work was commissioned by Cara Cheney of Fitzwalter Group on 14 March 2007.

The investigation was carried out to provide additional geotechnical investigation of Zone 3 areas within the proposed development boundary. The area of the proposed investigation is identified as per Coffey Proposal GEOTSGTE20288AA–AA - Figure 1. A plan showing the development boundary at Munibung Hill was prepared by CM^+ Pty Ltd and was provided for the investigation.

The purpose of the assessment was to alert parties involved in the project to the geotechnical issues at the site, and provide geotechnical data in a format that will assist in planning and feasibility studies. Of primary concern are slope stability constraints.

2 SITE ANALYSIS PLAN AND INFORMATION SOURCES

A Site Analysis Plan, (N09271/02-AA, 25 November 2004) was prepared by Coffey and included a review of the following information sources:

- Preliminary “structure / proposed land use plan” for Munibung Hill. Fitzwalter Group Pty Ltd, 24 November 2004;
- 1:25000 scale aerial photographs. Department of Lands, 3 October 2004;
- Digital Terrain Model (DTM) comprising survey and aerial photography (13 September 2004). AAMHatch Pty Ltd October 2004;
- Pasminco Metals Sulphide, Assessment of Land, Lake Road, Cockle Creek, Stability Assessment. Coffey Partners International Pty Ltd, N4171/2-AB, 16 November 1990;
- Pasminco Metals Sulphide, Third Street Boolaroo, Stability Assessment. Coffey Partners International Pty Ltd, N4171/1-AB, 12 March 1990;
- Aerial photographs. NSW Lands, 11 February 1979;
- Surface Geology Newcastle Coalfields. BHP 1968;
- Aerial photographs. NSW Lands, 22 August 1965;
- Aerial photographs. NSW Lands, 23 September 1961;
- ~ 1:30000 scale aerial photographs. Land Information Centre, 22 July 1954.

These sources have also been reviewed in the preparation of this report.

Coffey has previously conducted an Urban Capability Assessment for the southern corner of the site, the results of which are presented in Coffey report N09271/02 – AB dated 3 March 2005.

3 FIELD WORK

Field work comprised observation and mapping of surface conditions and the excavation of ten test pits. This work was conducted on 26 March 2007.

Test pits (TP1 to TP10) were excavated with a 5.5 tonne rubber tracked excavator to depths of 0.3 to 2.1m. Test pit locations were nominated by an Engineering Geologist from Coffey who also made engineering logs of the test pits. These are presented in Appendix A together with an explanation of the terms and symbols used in the log preparation. Engineering logs of Coffey test pits from a 1990 investigation are also presented in Appendix A. Test pit locations are plotted on Figure 2.

Test pit locations and selected surface features were located by hand held GPS survey. The elevation contours provided with the site survey plan were used to obtain reduced levels to AHD datum.

4 SURFACE CONDITIONS

4.1 General

The site is located on the north eastern side of Munibung Hill, Boolaroo, and east of the current Incitec Site and former Pasminco smelter site. A site location is included as Figure 1.

Topographically, the site is typified by a prominent north/south ridge located along the eastern boundary, with a series of spurs and gullies that splay off the ridgeline at a south westerly to north westerly trend. The sides of the spurs and gully bases are locally steep and incised toward the upper to middle slopes of the ridgeline and become less accentuated toward the lower slopes, with broader concave gullies and low uniform slopes/sides.

The overall slope angle toward the upper slopes of the ridge is in the order of 12° to 15°, flattening to slope angles in the order of 7° to 10° toward the lower section of the hillside. The overall middle to lower slope surface is predominantly uniform, with major surface discontinuity caused by rock outcrop and some minor hummocky surface features. The upper slope surface is irregular in areas where rock outcrop is present with undercutting and block fall occurring, predominantly toward the head of gullies.

The gullies are generally ephemeral, however water flow was observed in the most southern gully, draining to an earth dam, behind the current Incitec Site. No seepage was noted at the time of the investigation. Weather on the day of the investigation was overcast with intermittent light rain, with the month of March receiving 201mm of rain up to the date of the investigation. This is above the average rainfall for March of 122mm. (Reference: Bureau of Meteorology - www.bom.gov.au/climate/averages/tables).

The site is vegetated with a dense cover of high grasses, with some low bushes and young trees up to 4m in height established predominantly toward the upper slopes the hillside and within gullies. No predominant tilting or distortion of the trees was evident. From historical site photos, it is thought that the shrubs and trees were most likely established during the middle of the 1980’s.

4.2 Slope Instability Areas

No significant areas of slope instability were noted over the site. Areas of minor undercutting and block fall were noted toward the heads of gullies; however very low estimated volumes of fall spoil were noted at these areas (<1m^3). No significant signs of soil creep or deep slide debris were noted over the subject area.

5 SUBSURFACE CONDITIONS

5.1 Geology

Geologically the site is situated within the Moon Island Beach Sub- Group which situated within the upper stratigraphy of the Newcastle Coal Measures.

The most important members are as follows:

- Teralba Conglomerate – occurs on the tops of the ridges and consists predominantly of conglomerate with some sandstone layers. The member appears to be about 60m thick;
- Great Northern Seam to Upper Pilot Seam - consist of interbedded coal (including Fassifern Seam) and tuffaceous bands with minor conglomerate, sandstone and siltstone layers. The tuffaceous rocks, notably the Booragul Tuff and Awaba Tuff, weather to claystone and eventually clay of low shear strength and are associated with areas of instability. The Great Northern Seam thickness is unknown, however at Teralba to the west the seam is 6.9m thick.

No inferred sub crop of the coal seams was noted over the site during the investigation; however the Fassifern Seam was encountered in TP 3 at approximate RL 44m (AHD). Locations of some but not all observed exposures of conglomerate, sandstone and tuff are shown in Figure 2.

Munibung Hill is located about 1 km east of the Macquarie Syncline that trends north south roughly down the middle of Lake Macquarie. The syncline axis dips to the south with dips into this shallow trough (on the fold limbs) generally less than 3°, but with some local dips up to 6°. Boreholes drille d along the crest of the ridges for a land capability assessment on the adjoining property to the south indicate that the Teralba Conglomerate in this area dips to the south west at less than 2°. A dip of 6 ° toward the south west was measured on a sandstone bed at the top of the conglomerate escarpment. This higher dip is likely to represent a local variation rather than the general trend.

The Teralba Conglomerate is intersected by very widely spaced sub-vertical joints with a dominant north-west south-east strike and secondary jointing in the north-east south-west direction. The joints are often open or filled with weathered conglomerate. These joints often provide paths for groundwater seepage.

5.2 Conditions Encountered in the Subsurface Investigation

Test pits were conducted to better define the stratigraphy in areas over the site where development would be likely. One test pit (TP10) was conducted at the base of the northern gully to assess any possible slide debris.

A summary of geological units encountered over the site is presented in Table 1 and the depths encountered summarised in Table 2.

TABLE 1- SUMMARY OF GEOLOGICAL UNITS

GEOLOGICAL UNIT	GEOLOGICAL DESCRIPTION	MATERIAL DESCRIPTION
1	TOPSOIL	Silty SAND, fine medium grained, grey/black.
2A	COLLUVIUM	CLAY/Sandy CLAY, medium to high plasticity, mottled orange, grey, cobbles and coarse gravel of tuffaceous origin present, stiff consistency, moisture content greater than plastic limit.
2B	COLLUVIUM	Clayey SAND, fine to medium grained, low plasticity fines, mottled grey/orange
3A	RESIDUAL	Sandy CLAY, medium to high plasticity, fine to medium grained sand mottled orange, grey
3B	RESDIUAL	CLAY, high plasticity, brown /grey, very stiff consistency, moisture content greater than plastic limit
4	EXTREMELY TO HIGHLY WEATHERED TUFF	Pale grey, pale brow, indistinct sub - horizontal bedding
5	EXTREMELY WEATHERED COAL	Silty CLAY, low plasticity fines, poorly developed structure, trace of weak coal gravel, black
6	HIGHLY WEATHERED SANDSTONE	Fine to coarse grained, pale brown, orange, pale grey. Sub horizontal bedding

A summary of the subsurface investigation over the site includes:

- A total thickness of topsoil ranging between 0.1m – 0.2m;
- No filling was encountered in all of the test pits excavated;
- Colluvial soils where encountered were generally <1m thick and were associated more with slopewash processes rather than mass movement;
- Depth to rock is variable over the site ranging between 0.1m – 1.8m, predominantly more shallow in areas underlain by sandstone (several sandstone outcrops noted over the site) and deeper in areas underlain by tuff and coal.

5.3 Geotechnical Zones

The proposed development has been divided into a series of geotechnical zones in general accordance with previous Coffey report N09271/02-AB with the exception of Zone 3 being split into two subgroups Zone 3A and Zone 3B. The zones were based on the results of recent mapping, subsurface investigation and likely surface and subsurface conditions. Due to the size of the site, the classification into geotechnical zones is broad and based on the extent that conditions will impact on potential development. The geotechnical zones are defined in Table 2 and delineated over the development area in Figures 3 and 4.

TABLE 2 - SUMMARY OF GEOTECHNICAL AREAS

	ZONE 3A	**ZONE 3B**	**ZONE 4**
SETTING	Mid-slope areas of hillside	Incised gullies with steep flanks	Crests of ridge and uniform slope profiles of the hillside
SLOPE	4° to 12°	12° to 20°	0° to 5°
GEOLOGY	Tuff / Coal	Sandstone/Tuff/Coal	Sandstone/Tuff
SOIL TYPE	Colluvial Clays overlying residual Clays and Weathered Rock.	Recent Silty Clayey Sand, Sandy Clay gully infill, toward the lower slopes and thin residual Clays and exposed Weathered Rock present toward the mid to upper slopes	Residual Clays
SOIL DEPTH	1m to 2m	0.5m to 1m	0m to 2m
DRAINAGE	Well drained, some seepage may be evident in the vicinity of Fassifern seam.	Some wet areas on lower slopes	Well drained by runoff
INSTABILIITY / EROSION	Some minor rill erosion on slopes, no significant surface instability issues, localised colluvial soils up to 1m depth encountered possible dormant past shallow slides	Rill and scour erosion, undercutting and minor block fall toward the head and crest of gullies	No obvious erosion or instability issues

	ZONE 3A	ZONE 3B	ZONE 4
CONSTRAINTS	Possible highly reactive soils, poor construction/hillside practice may create/activate instability, appropriate earthwork controls (cutting and filling) and drainage required	Potentially poorly drained soils, wet subgrade conditions at the mouth of gullies. Erosion issues toward the head of gullies	Possible moderately to highly reactive soils, hard excavation conditions in rock

6 GEOTECHNICAL CONSTRAINTS ON RESIDENTIAL DEVELOPMENT

The following geotechnical constraints are based on slope stability and soil erosion considerations. The constraints are aimed at providing broad guidelines to assist in development planning. It is envisaged that further refinement and delineation of geotechnical constraints, including pavement and foundation designs, will occur with more detailed assessment of separate areas of the site as development proceeds.

6.1 Slope Stability

The risk of slope instability has been assessed from the observed site conditions in accordance with the classification system formulated in the Australian Geomechanics News, No 10, 1985 (See Attachment 1, Classification of Risk of Slope Instability for explanation of risk categories and implication for development).

Results of previous slope stability mapping based on field mapping and desk top study have been overlain onto Figure 4.

The slope stability risk assessment is based on three principal zones of instability which have been previously identified by Coffey over the site as;

- **ZONE 1** - **VERY HIGH RISK INSTABILITY:** areas immediately below identified slides and inferred instability associated with the Great Northern Seam, possible ongoing slope movement and rock falls toward crests;
- **ZONE 2** - **VERY HIGH RISK INSTABILITY:** likely areas within and down slope of potential debris flow;
- **ZONE 3A/3B - MODERATE RISK INSTABILITY:** areas toward the mid to lower slopes with slope angles greater than 12°**,** possible movement on tuffaceous or saturated subsurface profile if encountered.

Within Zone 3, no significant evidence of overall slope instability was observed on the site at the time of field work.

Table 3 summarises the risk of slope instability over the site based of the above characteristics.

TABLE 3 - ASSESSED RISK OF INSTABILITY

GEOTECHNICAL ZONE (Refer to Figure 2)	ASSESSED RISK OF INSTABILITY
ZONE 3A	MEDIUM
ZONE 3B	MEDIUM
ZONE 4	LOW

6.2 Area for Development

Land within Zones 1 and 2 has a very high risk of slope instability being on, and immediately below, areas of identified slides (Zone 1) or down slope of likely debris flow paths.

These areas of very high risk are considered unsuitable for development unless major geotechnical work can satisfactorily improve stability.

The delineation of the flow paths on the plans should only be considered an approximation based on available data at the time of preparation. This data included detailed desk top study and field mapping, however no detailed subsurface investigation has been conducted to accurately confirm and position the location of potential instability features over the site.

More accurate delineation of flow paths and associated restricted zones would require more detailed investigation of the potential landslip source areas further up the valley and more detailed survey including valley floor cross sectional profiles and analysis / modelling.

Due to the existing investigation scope and desktop / mapping methodology, the existing debris flow path zone boundaries are likely to be relatively conservative. The expectation is that the above works would see a reduction in width of this zone (up to 10m to 20m width) due to the greater confidence of data that a detailed subsurface investigation would provide.

It is understood that detailed subsurface investigations can be undertaken at a development application (DA) stage of development once the size and extent of development layout are finalised. As such it is recommended that the final residential development boundary for land adjacent to Zone 2 instability should be defined during development application submission in association with the proposed subdivision design.

Most of the site is considered suitable for development from a slope stability, soil erosion and drainage viewpoint. Due to the presence of the Fassifern seam and high slope angle, development proposed for Zone 3A will require detailed geotechnical investigation to assess the impact of proposed structures/ roads on possible instability in this area. Suitable development controls in relation to earthworks (cutting and filling) and drainage will be required. Zone 3B will require modification and control of natural surface and subsurface drainage paths and significant areas of filling. It is recommended that internal roads and utility easements be planned for this area, and residential or commercial development limited.

Development of the site should be undertaken in accordance with good hillside construction practice and sound engineering principles. Development in gully areas should minimise disturbance to slopes, and general constraints and recommendations in this report would apply.

6.3 Type of Structure and Foundations

There are no particular geotechnical constraints on the type of structures provided they are founded on footings designed and constructed in accordance with AS2870-1996, '*Residential Slabs and Footings'*.

Specific foundation requirements for geotechnical Zones 3A and 3B will need to be confirmed by more detailed investigation at the appropriate stage.

Development should be designed to accommodate the natural slope profile. A site classification should be undertaken once site layout and regrade designs are known.

Foundations should be designed and constructed in accordance with the recommendations and advice of AS2870-1996, '*Residential Slabs and Footings'*.

6.4 Site Clearance and Preparation

It is understood that topsoil is to be stripped over the site due to environmental site remediation measures proposed for the area. It is assessed that this process should have no impact on slope stability over the site provided appropriate erosion control measures are provided and revegetation is undertaken.

Soil erosion during and after construction on the site, will require careful management. Levels of erosion should be able to be maintained within normally acceptable levels by adopting good soil erosion and sedimentation control practices, including:

- Plan for soil and water management concurrently with engineering design and in advance of any earthworks;
- Minimise the area and duration of soil exposure by staged development and controlled clearing;
- Stockpile stripped soil for reuse and protect from erosion;
- Control stormwater run-off by diverting clean run-off from denuded areas, minimising slope gradient, length and run-off velocities;
- Control stormwater run-off by diverting clean run-off from denuded areas, minimising slope gradient, length and run-off velocities;
- Trap soil and water pollutants using silt traps, sediment basins, perimeter banks, silt fences and nutrient traps as appropriate;
- Promote regeneration of native vegetation in gullies and in areas previously cleared;
- Quick rehabilitation of disturbed areas.

6.5 Excavation

Where excavation is required, it is anticipated that all materials could be excavated by conventional dozer blade or excavator bucket at least to the depths indicated on the attached field logs. The near surface silty soils on-site particularly in Zone 3B are expected to be moisture sensitive and it is also possible that water inflows or seepages may be encountered within the depth of the excavation. Therefore, if wet weather is encountered prior to or during earthworks, over-excavation and placement of a working platform of granular fill will be required to allow site trafficability. Filling might be required to bring subgrade back to design level.

Excavations should preferably not exceed 1.5m in geotechnical Zones 3A and 3B and all excavations should be supported by properly designed and constructed retaining walls or else battered at 1V:2H or flatter and protected against erosion.

6.6 Reuse of Materials

The following comments are made regarding the suitability of the site materials for reuse in filled areas:

- Where site regrade is proposed, all existing topsoil, vegetation, coal or other potentially deleterious material should be removed to spoil or stockpiled for reuse as landscaping materials only. Stripping is generally expected to be required to depths of about 0.1m to 0.2m (topsoil layer), but may be significantly deeper where wet, silty soils are encountered;
- Underlying very stiff clays and sandy clays should be carefully stripped as necessary and stockpiled for reuse as general site fill;
- The clayey soils on-site are expected to be moderately to highly reactive (susceptible to volume changes with variation in moisture content) and will need to be placed and compacted within ±2% of OMC to minimise reactive soil movements.

6.7 Filling

Filling should be undertaken in accordance with sound engineering principles as set out in AS3798 '*Guidelines for Earthworks for Commercial and Residential Developments'*.

The residual and some colluvial clay soils that would be derived from cuts on the site are typically useful for site regrade fill with good moisture control during placement and compaction. The topsoil and soft colluvial materials are generally suitable for landscaping use only. Where fill is placed on slopes in excess of 1V:8H (7°), a prepared surface should be benched/stepped into the natural slope.

Where site regrading is proposed, the following general course of action should be taken:

- Strip existing topsoil, root affected material and deleterious material to spoil. Following stripping, the surface should be inspected for trafficability;
- Following stripping, the exposed subgrade materials should be proof rolled to identify any wet or excessively deflecting material. Any such areas should be over excavated and backfilled with an approved select material. The near surface soils onsite are expected to be moisture sensitive and therefore, if wet weather is encountered prior to or during earthworks, over excavation and placement of a working platform of granular fill may be required to assist site trafficability;
- Approved fill should be placed in layers not exceeding 300mm loose thickness and compacted to a minimum dry density ratio of 98% Standard (AS1289 5.1.1 or equivalent) beneath structures and 95% Standard as general site fill.

The expertise of the contractor, the nature of the fill material and the degree of supervision of the filling will determine the footing design required for any structures placed on the fill constructed in the manner discussed above.

Earthworks should be carried out in accordance with the recommendations outlined in AS3798-1996.

6.8 Retaining Walls

Retaining walls should be designed for surcharge loading from slopes, retaining walls, structures and other existing or future improvements in the vicinity of the wall.

Adequate subsurface and surface drainage should be provided behind all retaining walls. All structural retaining walls in should be designed by an experienced engineer familiar with the site conditions together with landscaping walls in excess of 1m in height.

6.9 Access and Road Construction

Access and site modifications should comply with the recommendations above.

Placement of roads through Zone 3A is likely to require some over-excavation of coal or colluvial material /or silty material, and subsequent subgrade replacement. The exposed subgrade should be inspected by experienced geotechnical personnel for instability and if encountered specific geotechnical design should be adopted. Waterlogging in silty soils at the within Zone 3B, particularly after wet weather, can result in the requirement for use of geofabric and placement of a granular working platform prior to placement and compaction of subsequent fill or pavement layers. Surface and sub-soil drains will also be required to improve drainage.

Further geotechnical assessment is required to identify areas where specific design requirements will be needed, such as recommendations regarding provision of drainage and evaluation of subgrade conditions for pavement thickness design.

6.10 Drainage

All collected stormwater run-off should be piped into an inter-allotment drainage system utilising the existing watercourses, in a controlled manner that limits erosion. Surface and sub-soil drains will be required to improve drainage, in particular run-off from the slopes extending up to the eastern ridgeline. In this regard a surface catch drain may be appropriate along the eastern extent of the proposed development.

Dispersible soils greatly limit water movement through the soil, often resulting in poor drainage and waterlogging. If dispersible soils are encountered over the site, the following principles should be considered in development of the site to limit water logging, and rising water table:

- Planting of deep rooted native trees to prevent rising of the water table in the low lying areas and gullies;
- Retaining or planting native vegetation where possible;
- Treating potentially sodic or dispersive soils with gypsum before landscaping;
- Designing storm water detention ponds and water features to reduce infiltration;
- Minimising soils disturbance, including reduced cut and fill;
- Improving or maintaining drainage around gully regions or natural drainage paths.

6.11 Sewage Disposal

Septic wastes should be connected to the reticulated disposal system.

6.12 Pavements

At the time of the field investigation, moisture content of the Unit 3 clayey soils were assessed to be at or slightly above Optimum Moisture Content (OMC).

It should therefore be anticipated that some drying back and moisture conditioning of the subgrade may be necessary prior to compaction and placement of pavement materials. The required time period to prepare the subgrade is likely to be dependent on the prevailing weather conditions at the time of construction. Where clayey materials are encountered at subgrade level, a CBR value ranging from 3% to 5% is assessed to be likely for pavement thickness calculations.

Where weathered rock (Unit 4 and 6) subgrades are encountered, the sandstone or tuff should be ripped and re-compacted to a minimum depth of 250mm to break-up preferential drainage paths and provide a dense homogenous surface on which to construct the pavement. Ripped and re-compacted weathered rock is likely to have a variable CBR value and appropriate design values would need to be determined by the geotechnical authority at the time of construction.

Where over wet colluvial clays or weathered coal are encountered, it is assessed that a CBR of <3% is likely and that subgrade improvement or replacement will be necessary. This may involve stabilising prepared subgrades with lime, use of geofabrics or removal of a nominal depth and replacement with select gravel.

It is recommended that a detailed pavement investigation be conducted incorporating CBR laboratory testing, when the alignment, level and traffic loading of the proposed roads are designed.

6.13 Mine Subsidence Constraints

6.13.1 General

Since the area is within a proclaimed mine subsidence district, the Mine Subsidence Board (MSB) is a consent authority for any future development of the site. As such, their concerns will need to be addressed. The mine subsidence issues concern the future land use of areas affected by both subsidence from the existing mine workings and subsidence from any future mining. The risk this represents must be acceptable to the Mine Subsidence Board.

A desktop study of the abandoned mine workings and general constraints on development for the “Pasminco Cockle Creek Smelter, Containment Cell” was carried out by Coffey as reported in our letter reference SE00013/03-AA dated 27 May 2005. Additional discussion on mine subsidence was provided in Coffey Report N09024/02 – AE dated 10 October 2005.

6.13.2 Existing Mine Workings

The above reports indicate that shallow mining, conducted by the Sulphide Corporation in the 1950’s, underlies the uppermost northern end of the study area as shown in Figure 2 with the drift into the workings encroaching into the area. The mining was conducted in the Hartley Hill Seam at depths ranging from 28m to 47m below ground surface. The majority of the site is not underlain by the workings.

One suspected surface subsidence feature is present over north eastern section of the area in the vicinity of the drift; however this feature could be attributed to past quarry/borrow activities.

Pillar stability calculations indicate that the majority of pillars are long term stable although some individual pillars that are particularly small, slender or adjacent to areas of second workings are less stable. The factor of safety of the majority of pillars however, is considered sufficient to prevent a large-scale pillar crush occurring should the less stable pillars fail.

Development restrictions and the need for further investigation and assessment work is required to address subsidence issues relating to the end land use. The amount of additional work and restrictions imposed by the Mine Subsidence Board will depend on the type and nature of the proposed development and predicted subsidence, strains and tilts for possible future mini-wall mining beneath the site. As a minimum, it is recommended that assessment and/or possibly also remediation of the shaft, drift and existing subsidence features be undertaken for the open space or light industrial land use.

6.13.3 Future Mining

The issue of possible future mining by Teralba Colliery beneath the site remains. At the time of writing this report, it was understood that no immediate plans for mining were in-place and future mining was unlikely but still possible.

It is understood that in this area, the proposed mining would be sub-critical mini-wall panels resulting in average surface subsidence of 150mm and up to 250mm. Restrictions on future development of the site, such as residential are likely to be imposed by the Mine Subsidence Board to reduce the risk of damage and repair costs should the mini-wall mining occur. Restrictions are likely to include a limit on the number of stories as well as building materials, building structural design, building length and footing design.

The mining potential in this area will be restricted due to the proximity of the existing Sydney to Newcastle main railway line. It is doubtful that extensive mining that result in surface subsidence will be allowed under the railway line itself or within its angle of draw.

Mini-wall mining with the limited predicted subsidence is unlikely to significantly affect the stability of the shallower Sulphide Corporation workings as the majority of pillars have very high factors of safety.

7 CONCLUSION

Development of the site is considered feasible from a geotechnical point of view. The scope of work for this assessment was based on a feasibility study, to satisfy Lake Macquarie Council in terms of urban land capability and provide input for planning. Based on the results of this assessment, it is considered that the land is suitable for proposed residential or commercial use.

Development should take into account the constraints and recommendations of this report.

The area lies within a region where geology and landform contribute to slope instability. No significant areas of instability were noted over the area, due mainly to a low, uniform slope profile, minimal groundwater migration and a geological profile that generally occurs below the sequence associated with the slope movements in the adjoining areas to the south. However care should be taken with development, so as to not create or reactivate possible dormant slide material within this slope instability sensitive area. Such impacts could be reduced if development is appropriately managed with regard to slope stability. The site management procedures should be constantly reviewed to ensure that opportunities for development of impacts from slope instability are minimised and controls effectively managed.

Further geotechnical investigations will be required at the design stage to allow pavement design and lot classifications to AS2870-1996. At that stage, further slope stability assessment should be undertaken to confirm the findings of this preliminary report.

8 LIMITATIONS

The findings contained in this report are the result of discrete/specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points. Should any site conditions be encountered during construction vary significantly from those discussed in this report, Coffey should be advised and appropriate action taken.

Contractors using this report as a basis for preparation of tender documents should avail themselves of all relevant background information regarding the site before deciding on selection of construction materials and equipment.

For and on behalf of Coffey Geotechnics Pty Ltd

Arthur Love

Senior Principal Geotechnical Engineer

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.
Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Attachment 1: Classification of Risk of Slope Instability

ASSESSMENT OF RISK

Natural hill slopes are formed by processes which reflect the site geology, environment and climate. These processes include downslope movement of the near surface soil and rocks, in geological time all slopes are unstable. The area of influence of these downslope movements may range from local to regional and are rarely related to property boundaries. The natural processes may be affected by human intervention in the form of construction and related activities.

A landslip (or landslide) is a downslope movement of a soil or rock mass as a result of shear failure at the boundaries of the moving mass. Soil creep, which is extremely slow and occurs without a well defined surface, is not included as a landslip.

It is not technically feasible to assess the stability of a particular site in absolute terms such as stable or unstable. However, the degree of risk of slope movement can be assessed by the recognition of surface features supplemented by limited information on the regional and local subsurface profile and with the benefit of experience gained in similar geological environments. The degree of risk is categorised below:

RISK OF INSTABILITY	EXPLANATION	IMPLICATIONS FOR DEVELOPMENT
VERY HIGH	Evidence of active or past landslips or rockface failure, extensive or rockface failure, extensive instability may occur.	Unsuitable for development unless major geotechnical work can satisfactorily improve the stability. Extensive geotechnical investigation necessary. Risk after development may be higher than usually accepted.
HIGH	Evidence of active soil creep or minor slips or rockface instability, significant instability may occur during and after extreme climatic conditions.	Development restrictions and/or geotechnical works required. Geotechnical investigation necessary. Risk after development may be higher than usually accepted.
MEDIUM	Evidence of possible soil creep or a steep soil covered slope, significant instability can be expected if the development does not have due regard for the site conditions.	Development restrictions may be required. Engineering practices suitable to hillside construction necessary. Geotechnical investigation may be needed. Risk after development generally no higher than usually accepted.
LOW	No evidence of instability observed, instability not expected.	Good engineering practices suitable for hillside construction required. Risk after development normally acceptable.
VERY LOW	Typically shallow soil cover with flat to gently sloping topography.	Good engineering practices should be followed.

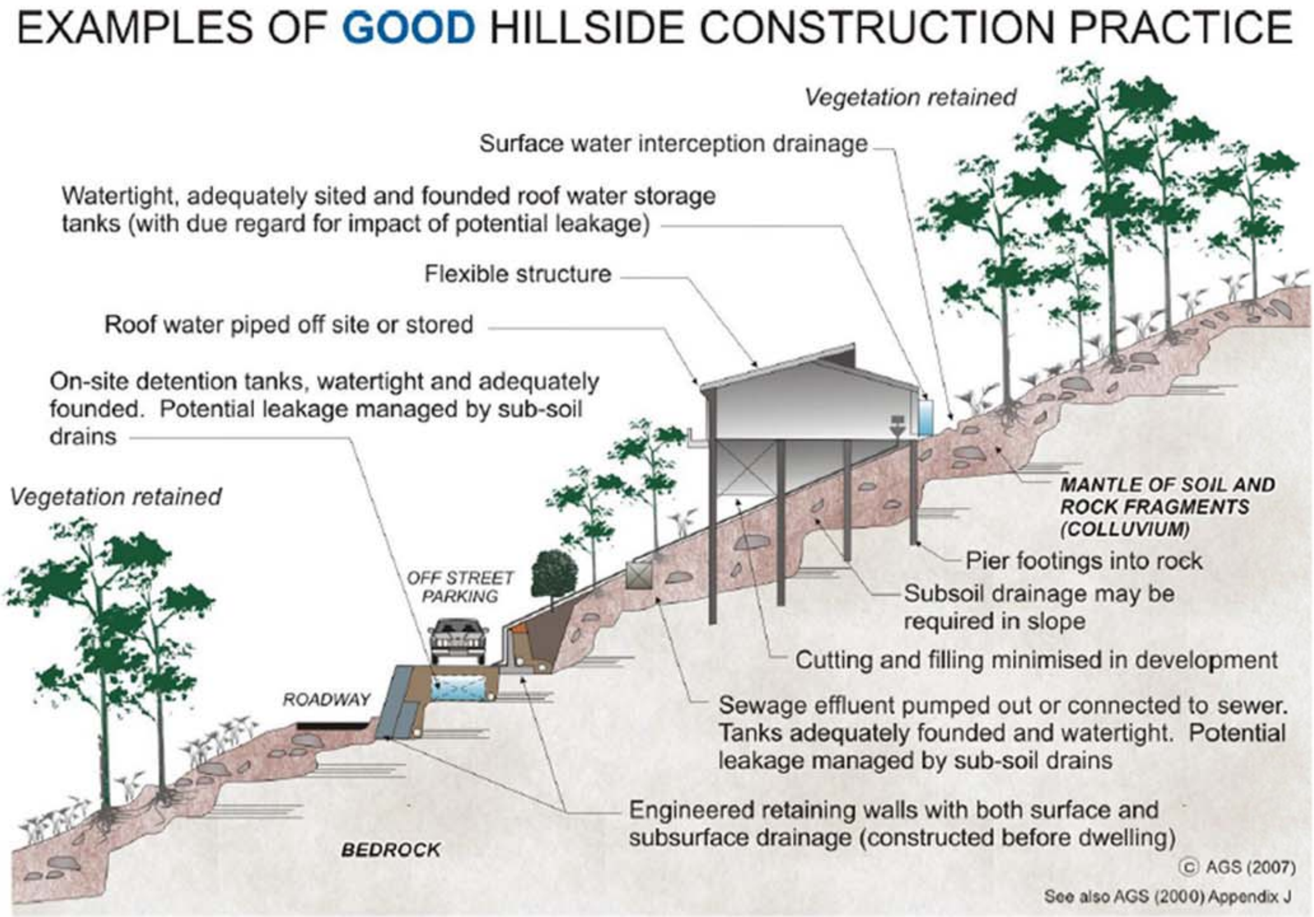
Ref 1: GEOTECHNICAL RISKS ASSOCIATED WITH HILLSIDE DEVELOPMENT Australian Geomechanics News, Number 10, December, 1985.

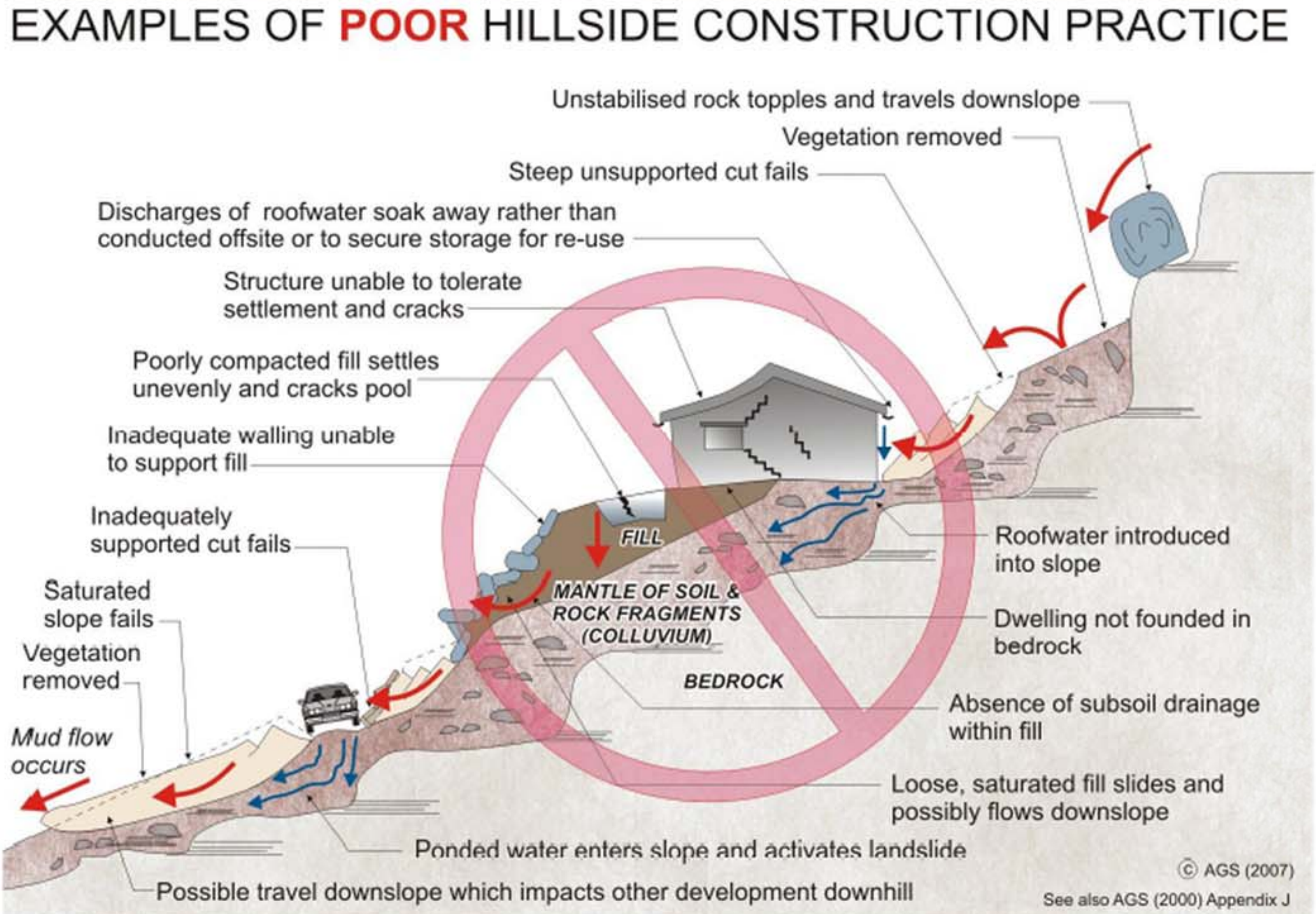
Attachment 2: Some Guidelines for Hillside Construction

	GOOD ENGINEERING PRACTICE	POOR ENGINEERING PRACTICE
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	

This table is an extract from Australian Geomechanics Journal and News of the Australian Geomechanics Society Volume 42 No1 March 2007.

Attachment 3: Illustrations of Good and Poor Hillside Practise





This figure is an extract from Australian Geomechanics Journal and News of the Australian Geomechanics Society Volume 42 No1 March 2007.

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

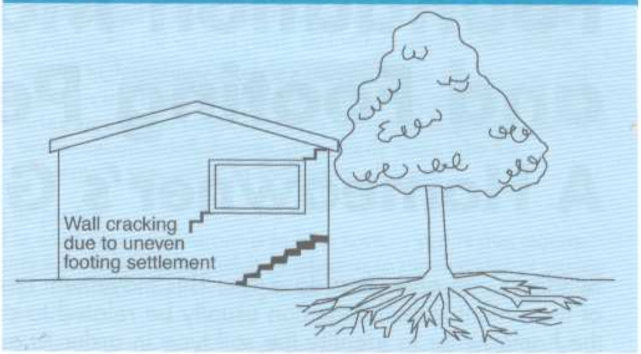
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter

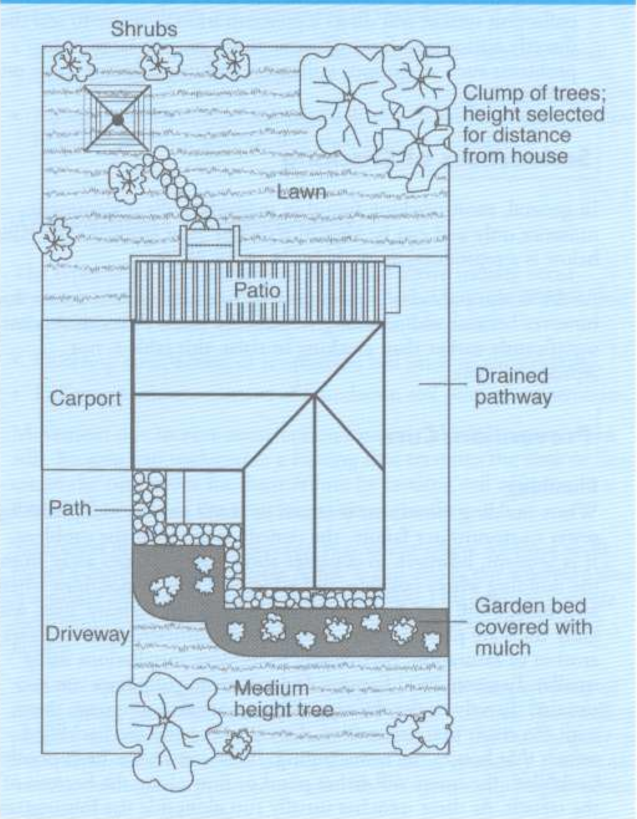
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

The information in this and other issues in the series was derived from various sources and was believed to be correct when published.

The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject.

Further professional advice needs to be obtained before taking any action based on the information provided.

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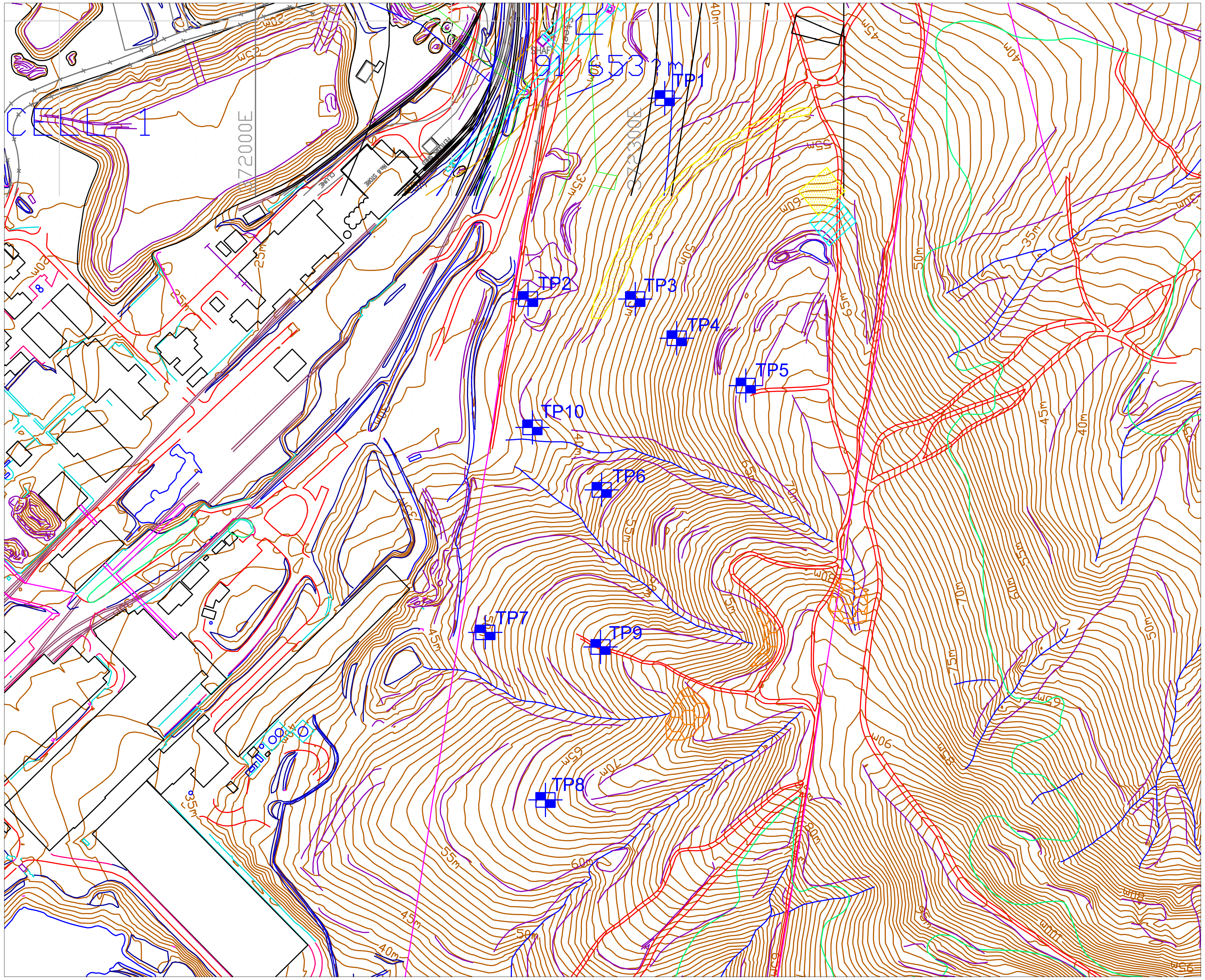
Figures

drawn	NLS	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	FITZWALTER GROUP PTY LTD	
approved	AMT		project:	PROPOSED DEVELOPMENTS MUNIBUNG HILL, BOOLAROO	
date	27-04-07		title:	SITE PLAN	
scale	NTS		project no:	GEOTWARA20281AE	figure no: FIGURE 1
original size	A4				



LEGEND

- APPROXIMATE TEST PIT LOCATION
- MINE SUBSIDENCE AREA
- SANDSTONE EXPOSURE
- CONGLOMERATE EXPOSURE
- TUFF EXPOSURE

revision	description	drawn	approved	date

Scale (metres): 0 5 10 20 30

drawn	NLS
approved	AMT
date	23-04-07
scale	1:3000
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

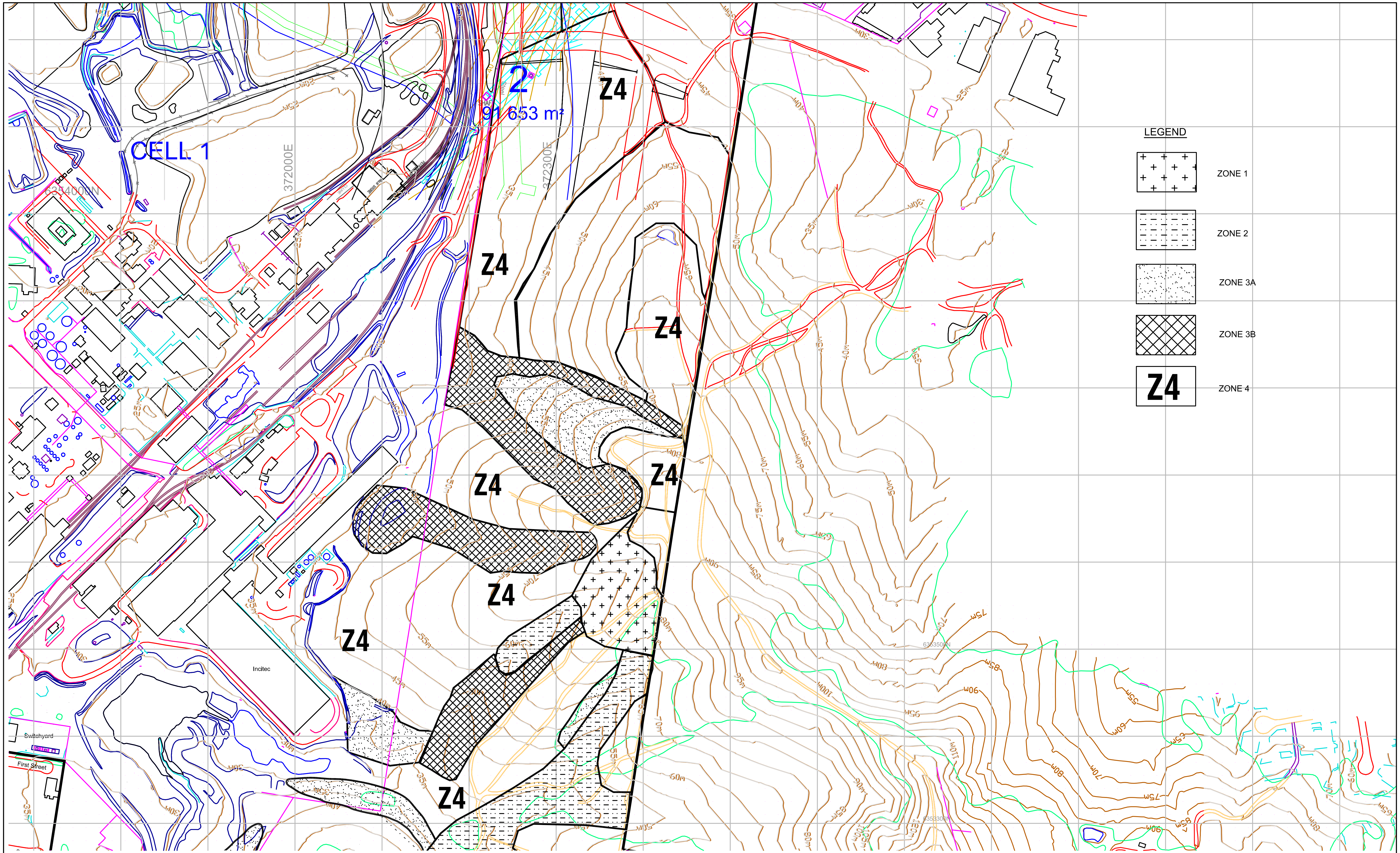
client: FITZWALTER GROUP

project: PROPOSED MUNIBUNG HILL DEVELOPMENT
MUNIBUNG HILL, BOOLAROO

title: SUBSURFACE INVESTIGATION AND MAPPING PLAN

project no: GEOTSGTE20281AE

figure no: FIGURE 2



revision	description	drawn	approved	date

0 40 80 160 240

Scale (metres)

drawn	NLS
approved	AMT
date	03-05-07
scale	1:4000
original size	A3

coffey geotechnics

SPECIALISTS MANAGING THE EARTH

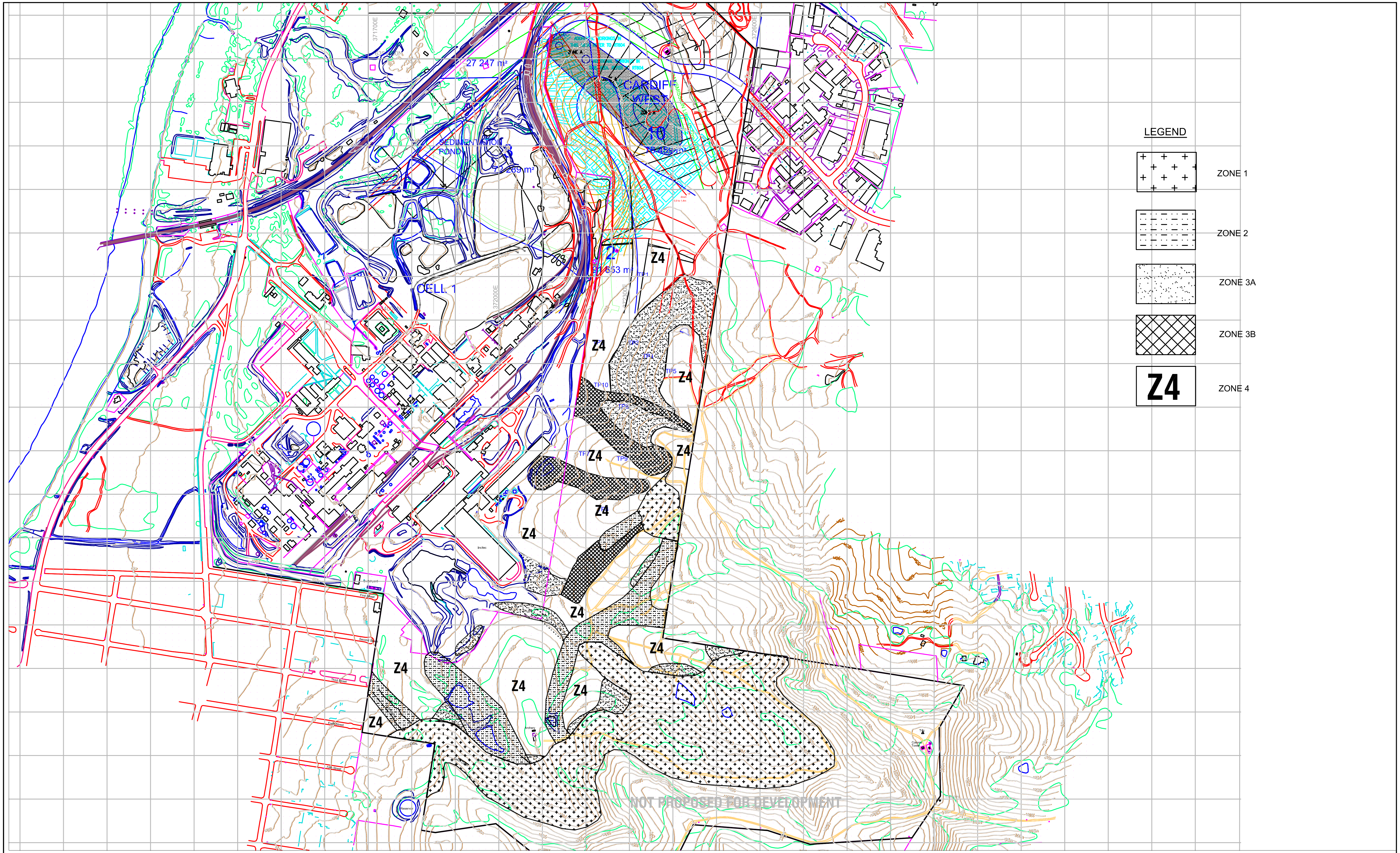
client: FITZWALTER GROUP

project: PROPOSED DEVELOPMENT MUNIBUNG HILL, BOOLAROO

title: SITE CONSTRAINTS PLAN - CURRENT INVESTIGATION

project no: GEOTSGTE20281AE

figure no: FIGURE 3



revision	description	drawn	approved	date

Scale (metres): 0 80 160 320 480

drawn	AMT/NLS
approved	AMT
date	24-07-09
scale	1:8000
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client: FITZWALTER GROUP

project: PROPOSED DEVELOPMENT
MUNIBUNG HILL, BOOLAROO

title: SITE CONSTRAINTS PLAN - SITE OVERVIEW

project no: GEOTSGTE20281AE

figure no: FIGURE 4

TP 1

TP 2

TP 3

drawn	NLS	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	FITZWALTER GROUP
approved	AMT		project:	URBAN CAPABILITY ASSESSMENT PASMINCO SITE, BOOLAROO
date	27/04/2007			
scale	NTS		title:	SITE PHOTOGRAPHS
original size	A4		project no: GEOTSGTE20281AE	figure no: FIGURE 5

F:\GEOTECHNICS\JOB FILES\WARA Misc Job Files\GEOTWARA20281AE\Drawings\GW20281AE-AE\[FIG 5.xls]A4 Portrait Figure

TP 4

TP 5

TP 6

drawn	NLS	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	FITZWALTER GROUP
approved	AMT		project:	URBAN CAPABILITY ASSESSMENT PASMINCO SITE, BOOLAROO
date	27/04/2007			
scale	NTS		title:	SITE PHOTOGRAPHS
original size	A4		project no: GEOTSGTE20281AE	figure no: FIGURE 6

F:\GEOTECHNICS\JOB FILES\WARA Misc Job Files\GEOTWARA20281AE\Drawings\GW20281AE-AE\[FIG 6.xls]A4 Portrait Figure

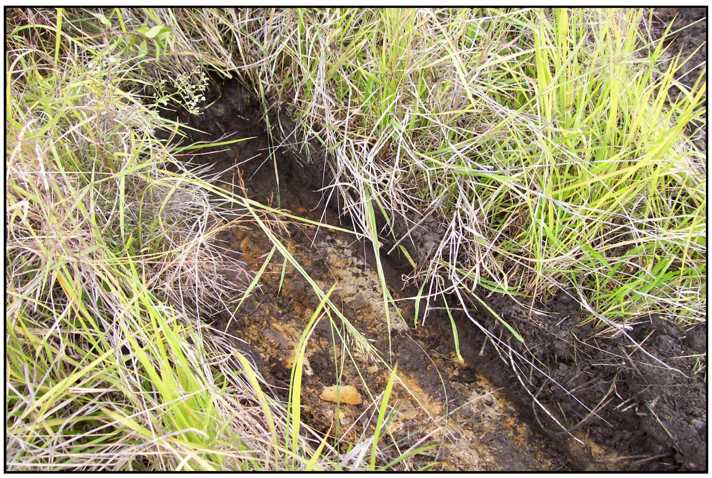
TP 7

TP 8

TP 9

drawn	NLS	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	FITZWALTER GROUP	
approved	AMT		project:	URBAN CAPABILITY ASSESSMENT PASMINCO SITE, BOOLAROO	
date	27/04/2007				
scale	NTS		title:	SITE PHOTOGRAPHS	
original size	A4		project no: GEOTSGTE20281AE	figure no:	FIGURE 7

F:\GEOTECHNICS\JOB FILES\WARA Misc Job Files\GEOTWARA20281AE\Drawings\GW20281AE-AE\[FIG 7.xls]A4 Portrait Figure



TP 10

drawn	NLS	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	FITZWALTER GROUP		
approved	AMT		project:	URBAN CAPABILITY ASSESSMENT		
date	27/04/2007			PASMINCO SITE, BOOLAROO		
scale	NTS		title:	SITE PHOTOGRAPHS		
original size	A4		project no:	GEOTSGTE20281AE	figure no:	FIGURE 8

F:\GEOTECHNICS\JOB FILES\WARA Misc Job Files\GEOTWARA20281AE\Drawings\GW20281AE-AE\[FIG 8.xls]A4 Portrait Figure

Appendix A

Results of Field Investigations

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP 1**

Sheet 1 of 1

Project No: **GEOTSGTE20281AE**

Client:	*FITZWALTER GROUP PTY LTD*	Date started:	*26.3.2007*
Principal:		Date completed:	*26.3.2007*
Project:	*PROPOSED DEVELOPMENT, MUNIBUNG HILL BOOLAROO*	Logged by:	*AMT*
Test pit location:	*REFER TO FIGURE 2*	Checked by:	

equipment type and model:	5.5t Hyundai Excavator	Pit Orientation:		Easting:	372313 m	R.L. Surface:	37.0
excavation dimensions:	m long m wide			Northing:	6354091 m	datum:	AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E		N						SM	**TOPSOIL:** Silty SAND, fine to medium grained, dark grey / black.	M			TOPSOIL
								SC	**Clayey SAND:** fine to medium grained, low plasticity fines, mottled pale grey / orange.		L/MD		COLLUVIAL
					36.5	0.5							
					36.0	1.0							
			►					CL-CH	**Sandy CLAY:** medium to high plasticity, sand fine to medium grained, mottled orange / pale grey.	M>Wp	VSt		RESIDUAL Minor water inflow.
					35.5	1.5							
									SANDSTONE: fine to medium grained, subhorizontal bedding, mottled orange / pale grey.	M			EXTREMELY TO HIGHLY WEATHERED SANDSTONE
					35.0	2.0			Terminated on refusal. Test pit TP 1 terminated at 2m				
					34.5	2.5							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP 2**

Sheet 1 of 1

Project No: *GEOTSGTE20281AE*

Client: *FITZWALTER GROUP PTY LTD*

Date started: *26.3.2007*

Principal:

Date completed: *26.3.2007*

Project: *PROPOSED DEVELOPMENT, MUNIBUNG HILL BOOLAROO*

Logged by: *AMT*

Test pit location: *REFER TO FIGURE 2*

Checked by:

equipment type and model:	5.5t Hyundai Excavator	Pit Orientation:	Easting: 372208 m	R.L. Surface:	33.0
excavation dimensions:	m long m wide		Northing: 6353937 m	datum:	AHD

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N	None Observed					SC	**TOPSOIL:** Clayey SAND, dark grey / grey, some roots and organics.	W			TOPSOIL
									SANDSTONE: fine to coarse grained, pale brown, orange, pale grey, subhorizontal bedding.	M			HIGHLY WEATHERED SANDSTONE
									Terminated on refusal. Test pit TP 2 terminated at 0.3m				
					32.5	0.5							
					32.0	1.0							
					31.5	1.5							
					31.0	2.0							
					30.5	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP 3**

Sheet 1 of 1

Project No: **GEOTSGTE20281AE**

Client: **FITZWALTER GROUP PTY LTD**

Date started: **26.3.2007**

Principal:

Date completed: **26.3.2007**

Project: **PROPOSED DEVELOPMENT, MUNIBUNG HILL BOOLAROO**

Logged by: **AMT**

Test pit location: **REFER TO FIGURE 2**

Checked by:

equipment type and model:	5.5t Hyundai Excavator	Pit Orientation:	Easting: 372291 m	R.L. Surface:	45.0
excavation dimensions:	m long m wide		Northing: 6353919 m	datum:	AHD

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N	None Observed					MS	**TOPSOIL:** Silty SAND, fine to medium grained, dark grey.				
								CH	**CLAY:** high plasticity, mottled orange, pale grey.	M>Wp	St		COLLUVIUM
					44.5	0.5							
					44.0	1.0			Tuffaceous cobbles up to 0.2m in dimension within a pale yellow, pale grey CLAY matrix.				
								CL	**Silty CLAY:** low plasticity fines, trace of weak carbonaceous coal gravel, black.				EXTREMELY WEATHERED COAL
					43.5	1.5							
					43.0	2.0			**Highly Weathered TUFFACEOUS:** pale grey.	M			HIGHLY WEATHERED TUFF
									Terminated on refusal. Test pit TP 3 terminated at 2.1m				
					42.5	2.5							

Sketch

method		support	notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation	**penetration** 1 2 3 4	U_{63}	undisturbed sample 63mm diameter		S	soft
BH	backhoe bucket	no resistance ranging to refusal	D	disturbed sample	**moisture**	F	firm
B	bulldozer blade	**water**	V	vane shear (kPa)	D dry	St	stiff
R	ripper	water level on date shown	Bs	bulk sample	M moist	VSt	very stiff
E	excavator	water inflow	E	environmental sample	W wet	H	hard
		water outflow	R	refusal	Wp plastic limit	Fb	friable
					W_L liquid limit	VL	very loose
						L	loose
						MD	medium dense
						D	dense
						VD	very dense

TESTPIT 20281AE LOGS.GPJ COFFEY.GDT 14.7.09
Form GEO 5.2 Issue 3 Rev.2

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP 4**

Sheet 1 of 1

Project No: **GEOTSGTE20281AE**

Client:	*FITZWALTER GROUP PTY LTD*	Date started:	*26.3.2007*
Principal:		Date completed:	*26.3.2007*
Project:	*PROPOSED DEVELOPMENT, MUNIBUNG HILL BOOLAROO*	Logged by:	*AMT*
Test pit location:	*REFER TO FIGURE 2*	Checked by:	

equipment type and model:	5.5t Hyundai Excavator	Pit Orientation:		Easting:	372322 m	R.L. Surface:	53.0
excavation dimensions:	m long m wide			Northing:	6353907 m	datum:	AHD

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N						CL	**TOPSOIL:** Sandy CLAY, fine to coarse grained, low plasticity fines, grey.	M			TOPSOIL
					52.5	0.5		CL	**Sandy CLAY:** low to medium plasticity, sand fine to medium grained, pale brown, orange.	M>Wp	St		COLLUVIUM
					52.0	1.0		CL	**Sandy CLAY:** medium plasticity, sand fine to medium grained, some fine to coarse grained weak tuffaceous gravel, pale grey.	M>Wp	H		RESIDUAL
			►		51.5	1.5		CL-SC	**Gravelly Clayey SAND:** medium plasticity, sand fine to coarse grained, tuff gravel fine to coarse grained, pale grey, orange.		VD		EXTREMELY TO HIGHLY WEATHERED TUFF
					51.0	2.0			Test pit TP 4 terminated at 2m				
					50.5	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
- water level on date shown
- ► water inflow
- ◄ water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. TP 5

Sheet 1 of 1

Project No: GEOTSGTE20281AE

Client:	FITZWALTER GROUP PTY LTD	Date started:	26.3.2007
Principal:		Date completed:	26.3.2007
Project:	PROPOSED DEVELOPMENT, MUNIBUNG HILL BOOLAROO	Logged by:	AMT
Test pit location:	REFER TO FIGURE 2	Checked by:	

equipment type and model:	5.5t Hyundai Excavator	Pit Orientation:		Easting:	372375 m	R.L. Surface:	68.0
excavation dimensions:	m long m wide			Northing:	6353871 m	datum:	AHD

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N	None Observed					CL	**TOPSOIL:** Sandy CLAY, low to medium plasticity, grey, some organics.	M			TOPSOIL
					67.5	0.5		CL	**Gravelly Sandy CLAY:** medium plasticity, sand fine to coarse grained, fine to coarse grained tuffaceous gravel up to 70mm in size, pale brown, orange, grey.	M>Wp	St		COLLUVIUM
								GP	**Clayey Sandy GRAVEL:** fine to coarse grained angular tuffaceous gravel, sand fine to coarse grained, medium plasticity fines, pale grey, indistinct subhorizontal bedding.	M	St		EXTREMELY WEATHERED TUFF
					67.0	1.0			Terminated on very slow progress. Test pit TP 5 terminated at 0.8m				
					66.5	1.5							
					66.0	2.0							
					65.5	2.5							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP 6**

Sheet 1 of 1
Project No: **GEOTSGTE20281AE**

Client: **FITZWALTER GROUP PTY LTD**
Date started: **26.3.2007**

Principal:
Date completed: **26.3.2007**

Project: **PROPOSED DEVELOPMENT, MUNIBUNG HILL BOOLAROO**
Logged by: **AMT**

Test pit location: **REFER TO FIGURE 2**
Checked by:

equipment type and model:	5.5t Hyundai Excavator	Pit Orientation:	Easting: 372265 m	R.L. Surface: 46.0	
excavation dimensions:	m long m wide		Northing: 6353791 m	datum: AHD	

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E		N	None Observed					SC	**TOPSOIL:** Clayey SAND, fine to medium grained, low plasticity fines, dark grey.	M			TOPSOIL
					45.5	0.5		CH	**CLAY:** high plasticity, brown, some sand fine grained.	M>Wp	St		COLLUVIUM
									SANDSTONE: fine to medium grained, orange, pale grey.	D			HIGHLY WEATHERED ~~SANDSTONE~~
									Test pit TP 6 terminated at 0.8m				
					45.0	1.0							
					44.5	1.5							
					44.0	2.0							
					43.5	2.5							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP 7*
Sheet	1 of 1
Project No:	*GEOTSGTE20281AE*

Client:	*FITZWALTER GROUP PTY LTD*	Date started:	*26.3.2007*
Principal:		Date completed:	*26.3.2007*
Project:	*PROPOSED DEVELOPMENT, MUNIBUNG HILL BOOLAROO*	Logged by:	*AMT*
Test pit location:	*REFER TO FIGURE 2*	Checked by:	

equipment type and model:	5.5t Hyundai Excavator	Pit Orientation:		Easting:	372176 m	R.L. Surface:	50.0
excavation dimensions:	m long m wide			Northing:	6353682 m	datum:	AHD

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N	None Observed					SC	**TOPSOIL:** Clayey SAND, fine to medium grained, low plasticity fines, dark grey.	M			TOPSOIL
					49.5	0.5		CH	**CLAY:** high plasticity, trace of fine grained tuff gravel, brown, grey. Becoming mottled orange, pale grey in colour.	M>Wp	VSt		RESIDUAL
					49.0	1.0			**SANDSTONE:** fine to medium grained, subhorizontal bedding, orange / grey.	D			HIGHLY WEATHERED SANDSTONE
					48.5	1.5							
					48.0	2.0							
									Test pit TP 7 terminated at 2m				
					47.5	2.5							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP 8**

Sheet 1 of 1

Project No: **GEOTSGTE20281AE**

Client:	FITZWALTER GROUP PTY LTD	Date started:	26.3.2007
Principal:		Date completed:	26.3.2007
Project:	PROPOSED DEVELOPMENT, MUNIBUNG HILL BOOLAROO	Logged by:	AMT
Test pit location:	REFER TO FIGURE 2	Checked by:	

equipment type and model:	5.5t Hyundai Excavator	Pit Orientation:		Easting:	372222 m	R.L. Surface:	65.0
excavation dimensions:	m long m wide			Northing:	6353554 m	datum:	AHD

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N	None Observed					CL	**TOPSOIL:** Sandy CLAY, low plasticity, sand fine to medium grained, brown, grey.	M			TOPSOIL
					64.5	0.5		CL	**Sandy CLAY:** medium plasticity, fine to coarse grained tuffaceous sand, pale grey, pale brown, orange.	M>Wp	St		RESIDUAL
					64.0	1.0			**TUFF:** pale grey, pale brown, subhorizontal bedding.	M			EXTREMELY TO HIGHLY WEATHERED TUFF
									Test pit TP 8 terminated at 1.2m				
					63.5	1.5							
					63.0	2.0							
					62.5	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP 9**

Sheet 1 of 1

Project No: **GEOTSGTE20281AE**

Client: *FITZWALTER GROUP PTY LTD*

Principal:

Project: *PROPOSED DEVELOPMENT, MUNIBUNG HILL BOOLAROO*

Test pit location: *REFER TO FIGURE 2*

Date started: **26.3.2007**

Date completed: **26.3.2007**

Logged by: **AMT**

Checked by:

equipment type and model:	5.5t Hyundai Excavator	Pit Orientation:	Easting: 372264 m	R.L. Surface:	66.0
excavation dimensions:	m long m wide		Northing: 6353671 m	datum:	AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E		N	None Observed					SC	**TOPSOIL:** Clayey SAND, fine to medium grained, dark grey.	M			TOPSOIL
					65.5	0.5		CH	**Sandy CLAY:** high plasticity, sand fine grained, grey.	M>Wp	St		RESIDUAL
					65.0	1.0			**TUFF:** pale grey, pale yellow.	M	VD		EXTREMELY TO HIGHLY WEATHERED TUFF
					64.5	1.5							
					64.0	2.0			Test pit TP 9 terminated at 2m				
					63.5	2.5							

Sketch

method		support	notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation		U_{63}	undisturbed sample 63mm diameter		S	soft
BH	backhoe bucket	**penetration** 1 2 3 4	D	disturbed sample		F	firm
B	bulldozer blade	no resistance ranging to refusal	V	vane shear (kPa)		St	stiff
R	ripper		Bs	bulk sample	**moisture**	VSt	very stiff
E	excavator		E	environmental sample	D dry	H	hard
		water	R	refusal	M moist	Fb	friable
		water level on date shown			W wet	VL	very loose
					Wp plastic limit	L	loose
		water inflow			W_L liquid limit	MD	medium dense
		water outflow				D	dense
						VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP10**

Sheet 1 of 1

Project No: **GEOTSGTE20281AE**

Client:	**FITZWALTER GROUP PTY LTD**	Date started:	**26.3.2007**
Principal:		Date completed:	**26.3.2007**
Project:	**PROPOSED DEVELOPMENT, MUNIBUNG HILL BOOLAROO**	Logged by:	**AMT**
Test pit location:	**REFER TO FIGURE 2**	Checked by:	

equipment type and model:	5.5t Hyundai Excavator	Pit Orientation:		Easting:	372212 m	R.L. Surface:	36.0
excavation dimensions:	m long m wide			Northing:	6353839 m	datum:	AHD

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N	None Observed					SM	**TOPSOIL:** Silty SAND, fine to coarse grained, dark grey.	W	L		ALLUVIUM (Recent gully infill)
					35.5	0.5			**SANDSTONE:** fine to medium grained, subhorizontal bedding, orange, white.	D			HIGHLY WEATHERED SANDSTONE
									Terminated on refusal. Test pit TP10 terminated at 0.5m				
					35.0	1.0							
					34.5	1.5							
					34.0	2.0							
					33.5	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense