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Our Ref: JW:jw: BT 19320-1

30 September 2009

Lance Hansen
C/- Tweed Coast Homes Pty Ltd
PO Box 12
Cabarita Beach NSW 2488

Dear Sir,

Re: Geotechnical Investigation – Proposed Residential Development
Lots 1 – 3, Section 1 in DP29748 and Lot 4, Section 1 in DP31209 Corner of Tweed Coast Road and Cypress Crescent, Cabarita Beach

Enclosed is a copy of our report for the above development dated September the 30th 2009. This report presents the results of the field investigations including recommendations in regards to the foundations, retention systems and earthworks for the proposed three story unit development with basement level car parking. .

Border-Tech received authorisation to proceed with the investigation from Mr Lance Hansen on the 6th of August 2009.

If you should require any further information or clarification please do not hesitate to contact James Walle or Han Tiau Teo at our Head Office.

Yours faithfully
For and on behalf of
BORDER - TECH

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Senior Geotechnical Engineer

Distribution: Original held by Border-Tech
1 hard copy to Tweed Coast Homes
1 pdf CD copy to Tweed Coast Homes
21 Copies to Darryl Anderson Consulting Pty Ltd

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GEOTECHNICAL ENGINEERING SERVICES

GEOTECHNICAL ENGINEERING ASSESSMENT

PREPARED FOR
MR LANCE HANSEN
C/- TWEED COAST HOMES PTY LTD

AT

LOTS 1-3 IN DP29748
& LOT 4 IN DP31209
CYPRESS CRESCENT, CABARITA BEACH

PREPARED BY
BORDER-TECH
GEOTECHNICAL ENGINEERING SERVICES

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Our Ref: BT 19320-1

30 September 2009

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1. INTRODUCTION

As requested by Mr Lance Hansen, Border-Tech has completed the geotechnical investigation for the proposed multi unit development as part of a development application to the Tweed Shire Council.

The subject site is described as Lots 1 – 3, Section 1 in DP29748 and Lot 4, Section 1 in DP31209 located on the corner of Tweed Coast Road and Cypress Crescent, Cabarita Beach located in northern New South Wales.

The scope of services provided by Border-Tech has been detailed in Section 2.1 of this report.

The heights referred to in this report will be reduced levels (RL) with reference to the Australian Height Datum (AHD).

2. SCOPE OF WORKS AND PROPOSED DEVELOPMENT

2.1 Scope of Works

The scope of the geotechnical services provided by Border-Tech was directed towards evaluating the following items as outlined in our proposal referenced JW: P09 780-G dated the 28th of August 2009, which include the following:-

- Identify possible geotechnical constraints to the development.
- Borelogs and results of subsurface materials encountered including assessment of quality of these materials for use as structural fill.
- Site classification for structures within the scope of AS2870-1996.
- Foundation types and founding materials including allowable bearing pressures and likely settlement. Pile design parameters will also be provided.
- Excavation conditions and earthworks recommendations.

2.2 Proposed Development

Border-Tech has received a proposed conceptual design plans Pat Twohill Designs Pty Ltd (Ref: Project No.6005 dated 21-04-09) indicating the type of development proposed for the site. From these plans it is understood that the site will be developed into a multi storey

apartment building. The apartments will be used for residential purposes and typically comprise of two, three and four bedroom apartments. The building will be three stories with basement level parking.

Appendix C shows preliminary pad levels and as indicated basement finished floor level will be at RL 3.95m. Allowing for footings and slab preparation it is anticipated that excavations will continue to approximately RL 3.5m. Based on existing ground levels derived from the attached survey plan (See Appendix A) this indicates excavation depths of between 2.5 and 4.5m.

Appendix A shows the existing contours recently surveyed by B&P Surveys (Ref: T15510 dated 24-02-2009).

3. SITE DESCRIPTION

The subject site is located on the corner of Tweed Coast Road and Cypress Crescent, Cabarita Beach, NSW, described as Lots 1 – 3, Section 1 in DP 29748 and Lot 4, Section 1 in DP 31209. A vacant easement borders the site to the north with the Cabarita Beach foreshore approximately 200m to the east.

Covering an area of 2822 m^2 the site is currently occupied by a caravan park comprising of approximately 20 permanent sites. At the time of the site investigation the caravan park was still occupied.

The site is elevated at approximately RL 7.8 – 8.2m along the western boundary and slopes down to the east at less than 5 degrees where the eastern boundary has recorded ground levels of approximately RL 6 – 6.2m.

Figure 1 shows a topographic photo of the site and details surrounding features including roads, beach, existing structures and typical vegetation.

Figure 1 – Approximate Location of Subject Site

4. FIELD WORK AND METHODOLOGY

Field work consisted of the drilling of three (3) boreholes, nominated as BH 1 to BH 3 as detailed on the attached site plan *(See Appendix A)*. Site investigation drillers from our office carried out the borehole drilling on the 26th and 31st of August 2009. The borehole drilling was carried out using a truck mounted Gold Coats Hydraulic drilling rig employing spiral flight auguring and mud circulation techniques continuing until approximately 9.2m depth below existing surface levels.

Borehole BH 1 was drilled in the north eastern corner of the site to Standard Penetration Test (SPT) refusal (nominally SPT 'N' values of greater than 50 blows) in very dense sands to a depth of 9.2m.

Borehole BH 2 was drilled towards the south eastern portion of the site in very dense sand and continued to a depth of 9.2m.

Borehole BH 3 drilled in the south western portion of the site continued to 9.2m depth and was at SPT refusal in very dense sands.

The borehole drilling was carried out in the part time presence of a geotechnical engineer from Border-Tech who was responsible for locating the boreholes, nominating and directing sampling and insitu testing along with logging some of the subsurface materials encountered.

This investigation has been carried out in accordance with AS 1726 – 1993 'Geotechnical Site Investigations' in terms of soil description. Standard Penetrometer Testing (SPT) was carried out in accordance with AS 1289 6.3.1 – 1997.

5. GEOTECHNICAL CONDITIONS

5.1 Subsurface Profile

The Geological Survey of Queensland and NSW, Moreton Geology Map, 1:500,000 series, shows the site to be located on a Holocene beach ridge system. Soils in this area will likely consist of quartz and heavy mineral sands deposited as wind borne sediments.

Detailed engineering logs have been provided which include insitu uncorrected SPT 'N' values and subsurface material descriptions *(See Appendix B).*

Subsurface conditions encountered during the drilling investigations consisted of filled loose silty sands and sand from ground level continuing to 0.7 - 1.4m depth. The fill materials are underlain by alluvial loose (SPT N < 9) to medium dense sands (SPT N = 9 – 24) extending to the approximate water table depth where the sands appeared to become medium dense to dense. Very dense sand (SPT N > 50) was encountered in all boreholes below 6m depth and continued to the terminated depths of approximately 9.2m.

The fill material encountered on this site has been placed recently and we are unaware of geotechnical testing and/or inspections being carried out during placement, and we must consider the fill material to be uncontrolled in accordance with AS 2870 – 1996 'Residential Slabs and Footings – Construction'.

5.2 Groundwater

Groundwater was encountered at approximately 4.4 – 4.8m below existing surface levels at the time of the investigations. The water table may fluctuate with seasonal variations and during periods of high rainfall.

6. RESULTS AND RECOMMENDATIONS

6.1 Earthworks Recommendations

It is anticipated that the proposed development will comprise of stripping, clearing and bulk excavation works to form the basement car park and associated driveways. From the plans provided cut depths are not likely to exceed 4.5m and basement finished floor levels are nominated at RL 3.95m. Excavation depths will be just above the existing groundwater in areas and it is recommended that allowance be made for some dewatering in the event of regional groundwater levels been elevated at the time of excavations.

The following sections provide general earthworks recommendations and site preparation works that may be required as part of the development. All earthworks and site preparation works should be carried out in accordance with AS 3798-2007 *'Guidelines on earthworks for residential and commercial developments'.*

6.1.1 Traffickability and Site Preparation

At the time of the investigations traffickability was considered to be good across the majority of the site, with good access for 2WD vehicles.

Based on the limited borehole results it is considered that medium to large excavation equipment (20 – 30 tonne excavator and D6 dozer or equivalent) would be suitable for the soil conditions encountered.

When stripping topsoil and existing slabs, problems may arise from the disturbance of the upper level soil materials with the removal of existing buildings, footings, vegetation and roots. All soils containing building materials, grass and root material should be stripped

from the construction areas and removed from site. These materials are not considered suitable for structural fill.

6.1.2 General Earthworks Procedures and Recommendations

Earthwork procedures should be carried out in accordance with above mentioned standards (AS 3798-2007) and also include the following:-

- Any depressions formed by the removal of vegetation, underground elements etc. should have all disturbed weakened soil cleaned out, backfilled and compacted with suitable fill in a controlled manner unless above basement excavation depths.
- Material is to be placed in layers not exceeding 200mm loose thickness. Where backfill for service trenches is carried out the above layer thickness applies however if vibrating plates are used the layers are to be placed in 100mm loose thickness.
- Material is to be compacted to achieve the following standard Maximum Dry Density (MDD) ratios as determined by AS 1289 Test 5.5.1. These compaction standards are to be confirmed with the local council requirements and earthworks standards at the time of earthworks.

Commercial structures	98%
Base material for roadways	98%
Sub-base material for roadways	95%

- Sand material is to be compacted to 75-80% density index.
- Compaction is to be tested as per AS 3798 – 2007, Section 8.0 and carried out by a NATA accredited soils laboratory.
- Excavation faces, sides and all sloping ground over the site should be benched to 'key in' fill material, this optimising the compaction and stability of the fill material. The benches are required to slope back at 1V:10H to and be at least 0.5m wide.

It is recommended that the placement of all structural fill material be inspected, tested and certified by Border-Tech as per Level 1 requirements during the earthworks operations to ensure the recommendations in this report are adhered too and that all fill is placed in a controlled manner in accordance with AS 3798 – 2007.

6.1.3 Effects of Construction on Adjacent Structures

Due to the loose nature of the upper soils encountered in the boreholes, ground vibrations due to basement excavations and construction operations may result in settlement and lateral ground movements on the adjacent properties, and beyond these properties.

We would recommend a Dilapidation Survey of surrounding structures be carried out, and any retention systems, if required be designed for the support requirements of these surrounding structures. In addition construction traffic, equipment and installation of piles, sheet piles or other operations should be minimised where possible.

6.2 Ground Support Options

Schematic drawings of the proposed development indicate the basement excavation extending to within 1.5m of the eastern boundary and generally well set back (>3m) from all other boundaries. Excavations in the upper loose sand cannot be achieved through the use of temporary excavation batters along the eastern and southern boundaries as the effects may include undermining in-ground services or road reserves and can cause instability problems. However, battering along the northern and western boundries of the site is possible, provided sufficient horizontal setback is available to achieve the temporary batter requirements outlined in section 6.2.1.

6.2.1 Temporary Batters

Temporary batters excavated in the very loose to loose sand (fill or natural soil) may be formed no steeper than 26° (1V:H) for a vertical height no greater than 3.0m, provided the site has no visible surface water.

If batter heights exceed 3m or if batters will be subject to significant surcharge loads, site specific geotechnical advice on batter stability should be obtained or temporary shoring systems adopted.

6.2.2 Basement Retention

As discussed above excavations for the basement car park will require retaining wall support systems. Sheet pile walls are typically the most common used support systems for the underlying soil conditions encountered. Sheet piles can be a relatively low cost option however this option is offset by the need to construct a permanent basement wall structure inside the sheet piling. The sheet pile may be sacrificed or removed after the construction of the basement wall.

Due to the loose nature of the upper soils, expected to be consistent with surrounding sites, it is recommended that the use of low amplitude vibrators or pre-drilling sheet piles, if adopted. It is anticipated, however, at this site that the installation of sheet piles or other driven or vibrated systems may include unacceptably high ground vibrations that may result in damage to the neighbouring structures and in-ground services. The use of sheet piles may not be feasible without the use pre-boring techniques.

Other shoring options may be used as part of the basement wall which include, secant pile walls, soldier pile walls, contiguous pile walls, or cast in-situ systems. These are more expensive than sheet piles but can be used to form the permanent basement wall structure and be used as load bearing walls.

Secant pile walls are formed by intersecting adjacent piles. To avoid gaps it is usual to form a significant overlap. For example 600mm diameter piles are usually constructed at 500mm centres. These walls can be constructed with relatively low vibrations and provided a relatively water tight barrier is formed, dewatering outside the perimeter of the wall is generally not required.

Contiguous pile walls are constructed by abutting adjacent piles to form a continuous row. Due to construction tolerances in aligning the piles, it is not possible to avoid occasional gaps between the piles and therefore seepage of groundwater into the excavation may occur. This can usually be corrected by patching the inside face of the wall.

The retention system selected will require penetration into the under lying dense to very dense sands outlined in the borelogs for overall stability. These materials were encountered at a depth of 5 – 6m.

6.2.3 Basement Wall Design Parameters

In relation to basement walls, the following lateral pressure conditions in the various materials should be designed using the parameters given in Table 1.

The design of all retaining walls will need to take into account the sloping ground surface behind the walls, as well as the usual design constraints and issues. The lateral earth pressure coefficients provided in Table 1 have not made allowances for surcharge loadings from existing or future structures and these should be taken into consideration when designing the retaining wall system. The parameters presented in Table 1 assume horizontal backfill behind the walls.

Table 1: Retaining Wall Design Parameters

Material Description	Internal Angle of Friction Φ' (degrees)	Unit Weight γ (kN/m^3)	(k_o)	(k_a)	(k_p)
Very loose to loose sand and silty soils	28°	17	0.53	0.35	2.75
Medium dense sand and silty soils	32°	18	0.47	0.31	3.25
Dense sand and silty soils	35°	20	0.43	0.27	3.65

Notes: k_o - at rest lateral earth pressure coefficient
k_a - active lateral earth pressure coefficient
k_o - passive lateral earth pressure coefficient

In sand it is common to use a rectangular distribution to calculate horizontal pressures. Terzaghi and Peck (1967) suggest that the following formulae be adopted for calculating horizontal pressure for a rectangular distribution in sand:

$$\sigma'_h = 0.65 k_a \gamma H \qquad \textit{(Equation 1)}$$

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where;

$\gamma = approximate\ density\ of\ material\ being\ excavated\ (kN/m^3)$

$H = height\ of\ excavation\ (m)$

6.3 Foundation Recommendations

6.3.1 Piled Footings

It is likely that the proposed structure will be supported on piled footings. Likely pile types have been detailed in section 6.3.1.1 and 6.3.1.2.

6.3.1.1 Driven (Displacement) Piles

Driven piles may induce high vibrations that can cause excessive settlements to the upper loose sands in the vicinity of the site. This can cause damage to adjacent and near-by structures and services that are founded on these loose sands. It is therefore suggested that driven piles not be used for the proposed development.

Steel screw in piles would be suitable for the proposed structure with a founding depth of approximately 6.0 – 8.0m. This depth will be required to be confirmed by the piling contractor during the pile installation. It is recommended that the piles do not extend past 8m to avoid punching into strata below this depth which has not been assessed. If piles are required to extend beyond 8m it is recommended that further testing be carried out to determine the strength of the soils beyond 9m.

6.3.1.2 Bored (Non-Displacement) Piles

Grout injected or continuos flight augered (CFA) piles are suitable for the site. For these pile types, vibrations are generally low during installation. Piles are to be founded at least one pile diameter into the relevant founding material. Groundwater was encountered at reasonably shallow depths and will be encountered during pile construction if non-displacement piles are adopted. The piling contractor should make provision for the use of temporary or permanent liners to support the sides of the excavation and reduce groundwater inflow. It is also likely that temporary casing will be required to support the sides of the pile excavation in the alluvial soils.

The potential for the excavated spoil from the pile excavations to be acid sulphate soil, requiring treatment and disposal of in accordance with a site management plan, needs to be considered. Given the large volume of basement excavation that is proposed, this is not considered to be a major constraint on the use of these piles.

6.3.2 Geotechnical Design Parameters for Piled Footings

Ultimate geotechnical design parameters for pile design are presented in Table 2. For limit state design a geotechnical strength reduction factor of 0.5 should be applied to the values presented in Table 2 in accordance with AS2159-1995. The recommended end bearing pressures assume a length to diameter ratio for the piles of not less than 4.0.

Table 2 – Ultimate Geotechnical Parameters used for Pile Design

Material	Non-Displacement Piles		Displacement Piles	
	F_S (kPa)	F_b (kPa)	F_S (kPa)	F_b (kPa)
Loose sandy, silty sand soils (N= 4 < 9)	8	-	16	-
Medium dense sand and silty sand soils (N= 9 < 24)	22	-	44	-
Dense sands soils (N= 25 < 50)	40	-	80	-
Very dense sandy soils (N > 50)	60	2.80	120	5.50

Notes: F_S - Ultimate Shaft Adhesion
F_b - Ultimate Base Capacity
N - Uncorrected SPT N Value
(1) - Check for serviceability of the pile at these ultimate bearing pressures

6.3.3 Shallow Footing Recommendations

The subsurface materials below the proposed basement excavations are not considered suitable for the expected loadings from the proposed structure unless ground improvements are carried out. This would require over excavation of approximately 1m below proposed basement excavations and replacement of clean sand fill with compaction of these materials to the underside of footings and slab. This operation will require dewatering to allow dry working conditions and it is expected the costs in such works may exceed the costs of piled footings. The stiff floating rafts founding at basement level, may require tension anchors to resist uplift hydrostatic pressures beneath low rise podium sections of the development.

To allow a raft foundation system excavations are required to a minimum ***1m below*** design level. It is suggested that a working platform be made by applying moisture to the design level and compacting across the exposed sand subgrade with a minimum 10-tonne (static weight) roller operating in static mode in order to uniformly compact the subgrade materials and densify any loose sands at this level. Alternatively a vibrating probe could be used on a rectangular grid. Close supervision and testing by suitably qualified personnel from Border-Tech during compaction is suggested. It is recommended that sand subgrade materials in areas of proposed raft or stiffened slab (if adopted) be uniformly compacted to 75 – 80% density index for floor load support. This may require an initial bridging layer or layers, in order to support compaction equipment. Such initial bridging layers will require to be rolled to minimise movement prior to compaction for floor level supported as above.

For a stiffened raft applying an average of 80kPa bearing pressure, preliminary estimates suggest total settlement is likely to be in the order of 30mm to 50mm with differential settlement of up to 50% of this amount. If this option is to be considered, further investigations will be necessary to ensure that the foundation soils within the zone of influence of the footing system are adequate and more detailed analyses of potential total and differential settlement will be required once the variation in applied load across the site due to the proposed structure is known.

7. LIMITS OF INVESTIGATION

Recommendations given in this report are based on the information supplied regarding the proposed building construction and location in conjunction with the findings of the investigation.

Every reasonable effort has been made to locate test sites so that the bores are representative of the soil conditions within the area to be investigated. The client should be made aware however, that this assessment has been based on limited site data using small diameter boreholes and limited site access.

Notes on understanding your geotechnical report have been attached as Appendix D.

If you should require any further information or clarification or should building plans or soil conditions vary substantially from those indicated please do not hesitate to contact this office.

Yours faithfully
For and on behalf of
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