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TO: PITTWATER COUNCIL

ATTENTION: NEIL O'DONNELL

FROM: VANESSA BENITEZ

DATE: 15 APRIL 2005.

PROJECT: WARRIEWOOD VALLEY

SECTOR 5

NEIL,

ATTACHED PLEASE FIND GEOTECH REPORT & SITE CONTAMINATION REPORT AS REQUESTED.
(BOTH IN HARD COPY & ON DISK.)

REGARDS

VANESSA.

DENIS LEECH AND ASSOCIATES PTY LIMITED
INCORPORATED IN NSW ACN 002 517 815
DENIS LEECH B.Sc. (ARCH), B. ARCH (HONS) UNIVERSITY OF NSW
SUITE 4, 9 FOAMCREST AVENUE NEWPORT BEACH NSW 2106
TELEPHONE: (02) 9997 7288 FACSIMILE: (02) 9997 3169

REPORT

TO

JUBILEE INVESTMENTS PTY LTD

ON

PRELIMINARY GEOTECHNICAL INVESTIGATION AND SLOPE STABILITY RISK ASSESSMENT

(IN ACCORDANCE WITH PITTWATER COUNCIL AMENDED INTERIM POLICY)

FOR

SECTOR 5 WARRIEWOOD VALLEY URBAN LAND RELEASE

AT

JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

14 April 2005

Ref: 19312VBrpt

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

A.B.N. 17 003 550 801 A.C.N. 003 550 801

Principals
B F WALKER BE DIC MSc
P STUBBS BSc MICE FGS
D TREWEEK Dip Tech
E H FLETCHER BSc (Eng)

Senior Associates
F A VEGA BSc(Eng) GDE
A ZENON BSc(Eng) GDE
P C WRIGHT BE(Hons) MEngSc
L J SPEECHLEY BE(Hons) MEngSc

Associates
A B WALKER BE(Hons) MEngSc

Consultant
R P JEFFERY BE DIC MSc

39 BUFFALO ROAD
GLADESVILLE
NSW 2111
Tel: 02-9809 7322
02-9807 0200
Fax: 02-9809 7626

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REPORT EXPLANATION NOTES

1 INTRODUCTION

This report presents the results of a preliminary geotechnical investigation and slope stability risk assessment for the proposed Sector 5 Warriewood Valley Urban Land Release at Jubilee Avenue and Forest Road, Warriewood, NSW. The investigation was commissioned by Mr Denis Leech of Denis Leech & Associates Pty Ltd, on behalf of Jubilee Investments Pty Ltd, by returned Acceptance of Proposal, Ref: P10165VBrev1). The investigation was carried out in consultation with Mr Mark du Cros of Brown Consulting (NSW) Pty Ltd.

The development of the site will comprise subdivision of the site into residential allotments as shown on Figure 1 and construction of the proposed houses. The allotments will be accessed via a new road network, as shown on Figure 1, which will link into the existing roadways at Jubilee Avenue in the north-eastern corner of the site and Forest Road in the south-eastern corner. Earthworks will be required as part of the development with excavations along the southern and south-western sides of the site to maximum depths of about 5.5m and filling in the north-eastern corner of the southern portion of the site to a maximum of about 4m. Retaining walls are proposed along the high side of the proposed Roads 1 and 2, as shown on Figure 1, to support the proposed excavations and retaining walls will also be required to support the proposed fill.

The scope of this preliminary investigation was to obtain information on the subsurface conditions in order to provide a broad coverage of the site where current access permitted as a basis for preliminary comments and recommendations on earthworks, retaining walls, foundation, pavements and future detailed geotechnical investigations. The geotechnical slope stability risk assessment has been prepared in accordance with the requirements of the Interim Geotechnical Risk Management Policy for Pittwater (adopted 16 June 2003) as discussed in Section 5 below. It is

understood that the report will be submitted to Council as part of the DA documentation. Our report is preceded by the completed Council Forms 1 and 1a.

This preliminary geotechnical investigation was carried out in conjunction with a contamination assessment and an acid sulfate soil assessment by our specialist division, Environmental Investigation Services (EIS). Reference should be made to the report by EIS (Ref: E19333F) for the results of the contamination assessment and acid sulfate assessment.

2 ASSESSMENT METHODOLOGY

2.1 Subsurface Investigation

Boreholes (BHs) 1 to 13 were auger drilled using our truck mounted JK550 or track mounted JK250 rigs to depths between 2.0m and 6.0m below the existing ground surface. The boreholes were drilled in locations accessible for our truck mounted rig in order to provide a broad coverage of the site. The borehole locations, as shown on Figure 1, were set out by hand held GPS equipment referenced to known points. The approximate surface levels of the boreholes, as shown on the borehole logs, were estimated by interpolation between contours and spot levels shown on the supplied survey plans by Mudgee Property Services Pty Ltd (Drawing Nos. 6407/6665 and SACKO, dated 23/12/02 and 4/8/00, respectively). The datum of the levels is Australian Height Datum (AHD).

The strength and relative density of the subsurface soils were assessed from Standard Penetration Test (SPT) 'N' values, augmented by hand penetrometer readings on cohesive soil samples recovered in the SPT split tube sampler. The strength of the underlying sandstone (where encountered) was assessed by observation of the drilling resistance of a tungsten carbide (TC) bit attached to the augers, together with examination of the recovered rock chips.

Groundwater observations were made both during drilling and soon after completion of the boreholes. No long term monitoring of groundwater levels was carried out.

Our geotechnical engineer, Mr N Smith, set out the borehole locations, nominated the sampling and testing locations, and prepared logs of the strata encountered. The borehole logs, which include field test results and groundwater observations, are attached to this report together with a set of explanatory notes, which describe the investigation techniques and their limitations and define the logging terms and symbols used.

Selected samples were tested by Soil Test Services Pty Ltd (STS), a NATA registered laboratory, to determine moisture contents, Atterberg limits, linear shrinkages, standard compaction and four day soaked CBR. The results of the laboratory testing are summarised in Tables A and B. Samples were collected from the boreholes for testing as part of the contamination assessment and acid sulfate assessment by EIS.

2.2 Walkover Assessment

The site was inspected by our Senior Geotechnical Engineer, Mr Daniel Bliss, on 18 March 2005 in order to assess the existing slope stability of the site and the effect of the proposed development on slope stability.

This assessment is based upon an inspection of the topographic, surface drainage and geological conditions of the site and its immediate environs. These features were compared to those of other similar lots in neighbouring locations to provide a comparative basis for assessing the risk of instability affecting the development. Appendix A defines the terminology adopted for the risk assessment together with a flow chart illustrating the Risk Management Process based on the guidelines given in AGS 2000 (Reference 1).

A summary of our observations is presented in Section 3 below. Our specific recommendations regarding the development are discussed in Sections 6 and 7 following our geotechnical slope stability assessment.

Figures 2 and 3 present survey plans showing the principal geotechnical features present at the site and are based on the supplied survey plans by Mudgee Property Services Pty Ltd. Additional features shown on Figures 2 and 3 have been measured by hand held clinometer and tape measure techniques and hence are only approximate. Should any of the features be critical to the proposed development, we recommend they be located accurately using instrument survey techniques.

3 SUMMARY OF OBSERVATIONS

The following observations were made during the site inspection. These summary observations may be read in conjunction with the attached Figures 2 and 3.

- The site is located at the toe of moderately sloping hillsides falling towards the north and east at about 20°. These slopes continue up to the south and west of the site and flatten out to gently sloping alluvial planes to the east and north. The site itself generally follows these ground slopes.
- The site can be divided into two portions, accessed from Jubilee Avenue (northern portion) and Forest Road (southern portion), respectively. Observations of each portion of the site are detailed below.

Northern Portion

- The northern portion of the site comprises moderate slopes on the southern and western sides of the site, with the majority gently sloping down towards the north-east and Narrabeen Creek that runs along the northern site boundary. The creek banks were heavily vegetated, but were estimated to be sloping at about 10° to 20°.

- The northern portion was occupied by numerous greenhouses, four metal and fibro sheds and a sandstone block and weatherboard house, as shown on Figure 2. These building appeared to be in poor to fair condition. The remainder of the site had a dense grass cover, with many mature trees on the steeper sloping sections of the site.
- The steeper slopes on the eastern and southern sides of the site had ground slopes of about 20° and had many sandstone boulders and cobbles on the surface. These areas were covered with dense bushland that continued further up the slopes. The sandstone boulders and cobbles are likely to represent shallow colluvium that has moved downslope previously.
- A large sandstone outcrop with a height of about 4.5m was present near the toe of the slopes (as shown on Figure 2) and the sandstone was assessed to be slightly weathered and of medium to high strength with bedding at 0° to 20°. A sub-vertical joint was observed within the sandstone outcrop. Several other sandstone outcrops were also observed near the existing house on site.
- At the rear (west) of the house was a sandstone cut of up to about 3m high. The sandstone was assessed to be distinctly to slightly weathered and of low to medium strength and contained sub-horizontal bedding partings and extremely weathered bands and between 0.5m and 2m spacing.
- A sandstone cliff was present below the north-eastern corner of the house, but inspection of the cliff was not possible due to a dense vegetation that covered the cliff. The cliff was estimated to be about 5m to 6m high and appeared to be similar to other exposed observed on site.
- A koppers log wall, which retained the subject site, was located along the eastern boundary of the site. The wall ranged in height due to the variable ground surface levels of the adjoining properties and appeared to be in good condition.

Southern Portion

- The southern portion of the site of the site was located on a hill that sloped down towards the north-east at between 3° and 13°. This portion of the site was occupied by a two storey brick house, with several metal clad sheds and a small, single storey, brick house located near the northern boundary (see Figure 3). The house appeared to be in good external condition and the remaining buildings appeared to be in fair external condition. The remainder of the site was grass covered, apart from a gravel driveway off Forest Road.
- To the south and west of the house were several concrete block and sandstone block retaining walls, which were in a fair to good condition with some minor cracking observed. A sandstone block retaining wall was also located along the southern and western sides of the small house, and this wall appeared to be in poor condition.
- The gravel driveway off Forest Road appeared to have been formed by minor excavations along its south-western side and fill along its north-eastern side. The fill embankment, as shown on Figure 3, had a slope of about 30° and was up to about 5m high.
- Along the eastern boundary of the site was a rendered brick wall and along the northern boundary was a koppers log wall. Both walls retained the subject site and appeared to be in good condition. The height of the walls varied due to the varied ground surface of the adjoining properties.

Adjoining Properties

- To the north of the northern portion of the subject site, on the northern side of Narrabeen Creek, was predominantly vacant farm land similar to the subject site.
- To the west and south of the northern portion and to the west of the southern portion were bush covered slopes, with the boundaries of the lot off Jubilee Avenue formed by Forest Road and Boundary Street, which are both unformed.

- To the south of the southern portion of the site was the unformed Forest Road and on the far side of the road reserve were the grounds of Mater Maria Catholic School.
- To the north-east of the site was a residential subdivision occupied by several one and two storey, brick houses. The houses appeared to be in good external condition and were located as close as 1m from the common boundaries. The houses were services by asphaltic concrete roadways of Hillview Crescent and Bert Close.
- To the east of the southern portion of the site were several two storey, brick townhouses, located about 5m from the common boundary. The townhouses appeared to be in good external condition when briefly viewed from within the subject site.

4 SUBSURFACE CONDITIONS

In summary, the boreholes indicated that the subsurface profile comprises shallow colluvium overlying residual soils grading into weathered sandstone at shallow depths within the steeper south-western portions of the site and deep alluvial soils within the flatter gently sloping portions of the site towards the adjoining creek. Further comments on these variable subsurface conditions are provided below. Reference should be made to the borehole logs for detailed descriptions of the variable conditions encountered.

Fill

Fill was encountered in BHs 1, 5, 9 and 11 to depths of 1.2m, 0.1m, 0.2m and 3.9m, respectively. The fill encountered within BH11 is associated with the filled embankment for formation of the driveway off Forest Road. Based on the SPT 'N' values the fill was assessed to be moderately compacted.

Topsoil

Silty sand topsoil was encountered in the remaining boreholes to depths between 0.2m and 0.5m.

Colluvium

Colluvium soils were encountered in BHs 3, 4 and 8, towards the steeper sloping portions of the site, to depths of 0.5m to 1.5m. These soils comprised silty sand, clayey sand and sand with sandstone gravel and cobbles. A sandstone boulder was encountered in BH8 of 0.6m thickness at a depth of 0.9m.

Residual Soils

Residual soils were encountered in BHs 3, 4 and 10, drilled on the upper slopes of the site, and comprised silty clay, sandy clay and clayey sand with ironstone and sandstone gravel bands. The clays were assessed to be of medium to high plasticity and of very stiff to hard strength. The clayey sands were of loose to medium dense relative density.

Alluvial Soils

Alluvial soils were encountered in most of the boreholes, with the exception of BHs 3, 4, 10 and 12. The alluvial soils comprised a mixture of clayey sand, sandy clay, silty sand, sand and silty clays. The sands were generally of loose or medium dense relative density with some dense and dense to very dense sands encountered within the deeper profiles. The clays were generally of medium plasticity and very stiff to hard strength, with some stiff layers.

Sandstone

Sandstone was encountered in BHs 3, 4, 10 and 12 at depths between 0.2m and 3.1m. In BHs 3, 4 and 10 the sandstone was extremely to distinctly weathered and of extremely low to very low strength for the full depth of the boreholes. However, in BH12, the sandstone was distinctly weathered and initially of very low to low

strength, but below a depth of 1.2m was of medium to high strength and caused refusal of the TC bit at a depth of 2.0m.

Groundwater

Groundwater seepage was observed during the drilling of BHs 1, 2, 6 and 7 at depths between 4.0m and 5.0m. Groundwater was measured in BHs 5 and 7 at depths of 4.0m and 5.5m, respectively, at on completion of drilling and in BH7 24 hours after completion. BHs 1, 2 and 6 collapsed on completion at depths of 1.8m, 3.9m and 4.7m, respectively, and further measurements of groundwater levels were then no longer possible. No groundwater was observed within the remaining boreholes.

4.1 Laboratory Test Results

Based on the laboratory test results the sandy clays and silty clays tested ranged from low to high plasticity and are assessed to have variable shrink/swell reactivity from slightly to highly reactive with changes in moisture content. Samples of sand from BH7 and clayey sand/sandy clay from BH10 were tested for four day soaked CBR and measured high CBR results of 25% and 9%, respectively.

5 GEOTECHNICAL SLOPE STABILITY RISK ASSESSMENT

The site is underlain by two main subsurface profiles. The steeper southern and western sections of the site comprise shallow colluvium underlain by residual soils grading into weathered sandstone, generally at shallow depths of less than 2m. These areas of the site had ground slopes of up to about 20°. The majority of the site is underlain by a deep alluvial profile of banded clayey sands and sandy clays. The ground slope of these alluvial areas was generally between 2° and 8°.

Evidence of shallow soil movements were observed around the southern and western edges of the site and were also indicated by the colluvium encountered in some of the boreholes. Sandstone boulders and cobbles were present within the colluvium and would have resulted from boulders falls rolling down slope.

No evidence of deep seated instability were observed on site.

5.1 Potential Landslide Hazards

Based on our inspection, the potential landslide hazards for the proposed development are associated with the following:

A Stability of existing sandstone cliffs in the vicinity of the existing house in the northern portion of the site.

B Stability of existing retaining walls along the site boundaries.

C Stability of proposed retaining walls, along the high side of the proposed roads, between the proposed houses and on the low side of the site.

D Stability of hillside slopes:

(i) Upslope of the proposed development.

(ii) Beneath the proposed development.

E Stability of the banks of Narrabeen Creek

5.2 Risk Analysis

Our slope stability risk assessment has been based on the preliminary layout of the proposed development as shown on Figure 1. In order to complete the risk analysis certain assumptions have been made regarding the use of the final development site

and the type of houses that will be constructed. Therefore, the risk assessment is approximate only, but is considered suitable for the current planning purposes.

Table C summarises our qualitative assessment of landslide hazards and of the consequences should the landslide hazard occur. Based on this, the qualitative risk to property has been determined. The terminology adopted for this qualitative assessment is in accordance with the Table A1 given in Appendix A.

Table C indicates that the assessed risk to property is "Very Low to Low" or "Low" which would be considered acceptable in accordance with the criteria given in Pittwater Council's Interim Geotechnical Risk Management Policy (June 2003).

We have also used the indicative probabilities associated with the assessed likelihood to calculate the risk to life. The temporal and vulnerability factors that have been adopted are given in the attached Table D together with the resulting risk calculation.

Our assessed risk to life for the person most at risk is about 5×10^{-7}. This would be considered to be acceptable in relation to the criteria given in Council's policy. For comparison purposes, we note that the risk to life whilst travelling in a car is of the order of 10^{-4}.

5.3 Risk Assessment

The Pittwater Amended Interim Policy requires suitable measures 'to remove risk'. It is recognised that, due to the many complex factors that can affect a site, the subjective nature of a risk analysis, and the imprecise nature of the science of geotechnical engineering, the risk of instability for a site and/or development cannot be completely removed. It is, however, essential that risk be reduced to at least that which could be reasonably anticipated by the community in everyday life and that landowners be made aware of reasonable and practical measures available to reduce

risk as far as possible. Hence, where the policy requires that 'reasonable and practical measures have been identified to remove risk', it means that there has been an active process of reducing risk, but it does not require the geotechnical engineer to warrant that risk has been completely removed, only reduced, as removing risk is not currently scientifically achievable.

Similarly, the Pittwater Interim Policy requires that the design project life be taken as 100 years unless otherwise justified by the applicant. This requirement provides the context within which the geotechnical risk assessment should be made. The required 100 years baseline broadly reflects the expectations of the community for the anticipated life of a residential structure and hence the timeframe to be considered when undertaking the geotechnical risk assessment and making recommendations as to the appropriateness of a development, and its design and remedial measures that should be taken to control risk. It is recognised that in a 100 year period external factors that cannot reasonably be foreseen may affect the geotechnical risks associated with a site. Hence, the Policy does not seek the geotechnical engineer to warrant the development for a 100 year period, rather to provide a professional opinion that foreseeable geotechnical risks to which the development may be subjected in that timeframe have been reasonably considered.

Our assessment of the probability of failure of existing structural elements such as retaining walls (where applicable) is based upon a visual appraisal of their type and condition at the time of our inspection. Where existing structural elements such as retaining walls will not be replaced as part of the proposed development, where appropriate we identify the time period at which reassessment of their longevity seems warranted.

In preparing our recommendations given below we have adopted the above interpretations of the Interim Policy requirements. We have also assumed that no activities on surrounding land which may affect the risk on the subject site would be

carried out. We have further assumed that all Council's buried services are, and will be regularly maintained to remain, in good condition.

We consider that our risk analysis has shown that the site and existing and proposed development can achieve the 'Acceptable Risk Management' criteria in the Pittwater Interim Policy provided that the recommendations given in Sections 6 and 7 below are adopted. These recommendations form an integral part of the Landslide Risk Management Process.

6 COMMENTS AND RECOMMENDATIONS

6.1 Further Geotechnical Investigations

Preliminary comments and recommendations are provided within this report on design and construction of the proposed subdivisional development. The boreholes drilled for this preliminary investigation provide a broad coverage of the development site for initial planning and preliminary design purposes. However, further geotechnical investigations will be required as part of the detailed design.

These further geotechnical investigations should include the following:

- Additional boreholes along the alignment of the proposed retaining walls on the high side of the site. These boreholes will be required in order to determine the materials that will need to be retained, including the depth of the colluvium on these portions of the site, as well as the excavation conditions. In BHs 3, 4 and 12 sandstone was encountered at depths of less than 2m and was of extremely low to very low strength in BHs 3 and 4 but of medium to high strength in BH12. Due to this medium to high strength sandstone, which caused refusal of the TC bit at a depth of 2.0m, cored boreholes may be required to reach the design excavation level, which near BH12 is at a depth of

about 5.5m. Cored boreholes would also allow the quality of the sandstone to be assessed in greater detail taking into account the rock strength and the defects present to determine if vertical unsupported rock excavations are feasible.

- Additional boreholes along the road alignments to determine pavement design parameters. These boreholes would be drilled following set out of the final road alignments and would be drilled to determine the expected subgrade soils and allow the collection of additional samples for CBR testing. The subsurface conditions below the site are variable and representative samples of the various subgrade soils will need to be tested to determine the suitable CBR values for design of the pavements.
- Detailed geotechnical assessment of the existing sandstone cliffs on site. the cliffs below the existing house in the northern portion of the site were covered with vegetation and a detailed inspection could not be carried out. Once the vegetation has bee cleared, these cliffs should be inspected by a geotechnical engineer to assess the stability of the cliffs and any additional support that is required. This additional support, if required, may then be incorporated within the design of the proposed retaining walls in front of the house.
- Detailed investigations for classification of the building allotments in accordance with AS2870. Prior to construction of the proposed houses, detailed site specific geotechnical investigations will be required to determine lot classifications to allow deign of the building footings. Such investigations should be carried out following bulk earthworks and once the final allotment layout has been determined and been set out on site.

The comments and recommendations provided within this report should be reviewed and amplified following the above detailed investigations.

6.2 Earthworks

Earthworks will be required to achieve the design levels and will comprise excavations along the southern and south-western edges of the site to a maximum of about 5.5m and filling in the north-eastern corner of the southern portion of the site to a maximum of about 4m.

6.2.1 Excavations

Excavations are anticipated to encounter colluvial and residual soils and weathered sandstone. Excavation of the soils should be achievable using conventional earthmoving equipment, such as hydraulic excavators. Some of the upper extremely weathered sandstone may also be able to be excavated using such equipment. Excavation of the sandstone of low strength or greater strength will require assistance with rock breaking/ripping equipment. For bulk excavations, the use of large dozers with ripping tynes will be required for effective excavations. Hydraulic rock hammers would be required for local excavations.

The sandstone in the vicinity of BH12, and possibly at other locations, will be of medium to high strength and will represent "hard ripping" and large excavation equipment will be required for effective excavation. The final excavation equipment should be determined following review of the results of additional boreholes drilled where the excavations are required.

6.2.2 Subgrade Preparation and Filling

Fill was encountered in BHs 1, 5, 9 and 11 to depths of 1.2m, 0.1m, 0.2m and 3.9m, respectively. The deeper fill encountered in BH11 is associated with the fill batter on the eastern side of the existing driveway. We are unaware of any records of placement or compaction control for the fill and as such it must be considered "Uncontrolled" and is not suitable for support of footings or slabs. It is

recommended that as part of the bulk earthworks the uncontrolled fill be fully excavated and replaced, as required, with controlled engineered fill. This will allow the use of shallow footings and floor slabs founded within the controlled fill.

Similarly, where colluvial soils are present and are not removed as part of the bulk excavation works, these soils should be removed and replaced with engineered fill. The colluvium will be of variable quality are not suitable as a foundation material. In addition, obstructions within the colluvium, such as sandstone boulders, may result in construction difficulties during the installation of piles if the colluvium is left in place. Replacement of the colluvium with engineered fill would allow the use of shallow footings for the proposed houses.

Within building and pavement areas the following measured should be included as part of the subgrade preparation and filling works.

- Stripping of surface vegetation and root affected soils.
- Excavation of uncontrolled fill to expose the natural soils.
- Proof rolling of the exposed subgrade with a minimum 7 tonne dead weight smooth drum vibratory roller. The final pass of the proof rolling should be carried out without vibration and within the presence of a geotechnical engineer or experienced geotechnician. The purpose of the proof rolling should be to improve the compaction of the near surface soils and to detect any weak or unstable areas.
- During proof rolling care should be taken to avoid damage to nearby structures and buried services by vibrations transmitted by the roller. If necessary, the vibrations should be reduced or ceased.
- Treatment of any unstable areas detected during proof rolling by excavation to a sound base and replacement with engineered fill or further advice should be sought.

- Placement of engineered fill to the required level in horizontal layers not greater than 200mm loose thickness (but of lesser thickness if light rollers are used).
- Any fill used to raise site levels or replace unstable areas must comprise engineered fill. Compaction of each fill layer should be done to the specifications provided below.

Engineered fill should preferably comprise well graded granular materials, such as ripped rock or crushed sandstone, free of deleterious substances and having a maximum particle size not exceeding 75mm. Such fill should be compacted in horizontal layers of not greater than 200mm loose thickness, to a density of at least 98% of Standard Maximum Dry Density (SMDD). For backfilling confined excavations such as service trenches, a similar compaction to engineered fill should be adhered to, but if light compaction equipment is used then the layer thickness should be limited to 100mm loose thickness.

The existing fill, natural soils and excavated sandstone may be reused as engineered fill provided it is free of deleterious materials and particles greater than 75mm in size. Any clay fill should be compacted in maximum 200mm loose thickness layers to a density strictly between 98% and 102% of SMDD and a moisture content within 2% of Standard Optimum Moisture Content (SOMC). The use of clay materials as engineered fill will require a greater attention to moisture content, time for drying of soils and possibly a greater overall cost for the earthworks. Preferably clay fill should be used within the lower fill layers.

Density tests should be regularly carried out on the fill to confirm the above specifications are achieved. The frequency of density testing should be at least one test per layer per 500m^2 or three tests per visit, whichever requires the most tests. We recommend that at least Level 2 control of fill compaction, as defined by AS3798, be adhered to on this site. However, where the fill is to support building loads it should be placed under Level 1 control. We can complete the

abovementioned testing and supervision if required. Preferably the geotechnical testing authority should be engaged directly on behalf of the client and not by the earthworks subcontractor.

6.3 Excavation Batters and Retaining Walls

Detailed design of suitable excavation batters and retaining walls will be required following the detailed geotechnical investigations, but the following is provided as a guide for preliminary design.

Excavations within the soils should be formed at temporary batters of no steeper than 1 Vertical in 1.5 Horizontal (1V:1.5H). These batters should remain stable in the short term provided all surcharge loads, including construction loads, are kept well clear of the crest of the batters. Permanent batters should be no steeper than 1V:2H, but flatter batters of the order of 1V:3H may be required to allow access for maintenance of vegetation. Permanent batters should be covered with topsoil and planted with a deep rooted runner grass following construction to reduce erosion. All stormwater run-off must be directed away from all temporary and permanent slopes.

Steeper batters or even vertical excavations may be appropriate within good quality sandstone, but this would need to be assessed as part of the detailed geotechnical investigations and by inspection by a geotechnical engineer of the sandstone cuts during excavation.

Cantilevered retaining walls may be designed based on a triangular earth pressure distribution using an active earth pressure coefficient, K_a, of at least 0.33 and a bulk unit weight of 20kN/m^3. Where walls are restrained from some lateral movements such as by structural elements, an 'at rest' earth pressure coefficient, K_o, of at least 0.6 should be used. These coefficients assume horizontal backfill surfaces and

where inclined backfill is proposed the coefficients would need to be increased or the inclined backfill taken as a surcharge load. Where good quality sandstone is encountered then no K values would be required, subject to inspection of the exposed sandstone by a geotechnical engineer.

All surcharge loads should be allowed for in the design. Full hydrostatic pressures should be considered unless measures are undertaken to provide complete and permanent drainage of the ground behind the wall. Caution will be required not to overcompact and cause excessive lateral pressures on the retaining walls. Only small rollers should be used for fill compaction adjacent to any retaining wall.

6.4 Foundations

Following completion of the bulk earthworks, it is expected that variable foundation conditions will be present for the proposed houses, comprising sandstone within areas where excavations have been undertaken near the southern and south-western edges of the site, engineered fill within the lower parts of the southern portion of the site, and alluvial soils within the majority of the northern portion of the site.

The use of shallow footings, such as stiffened raft slabs, would be suitable for most houses and would need to be designed to accommodate the shrink/swell movements of the fill and natural soils. Based on the results of this preliminary investigation, it is expected that most allotments would be classified as Class M or H in accordance with AS2870, depending on the reactivity of the clays underlying each individual lot and the fill materials used. The final lot classifications should be determine following completion of the bulk earthworks and detailed geotechnical investigations at each allotment.

Footings founded within engineered fill or natural sands of at least loose relative density or natural clays of at least stiff strength, may be designed for an allowable

bearing pressure of 100kPa. The performance expectations, site maintenance, vegetation precautions and additional architectural and construction requirements given in AS2870 for reactive sites should also be followed.

Where sandstone is encountered within the building footprint, it is recommended that the entire building be supported on footings founded within the sandstone to provide uniform support and reduce the risk of differential settlements. Where sandstone is exposed or is at shallow depths pad or strip footings may be used, but piled footings may be required where the sandstone is at greater depths.

Footings founded with a nominal socket of at least 0.3m into the sandstone may be designed for a preliminary allowable bearing pressure of 600kPa. This should be confirmed by detailed geotechnical investigations once the building layouts are known and may result in higher bearing pressure being appropriate if good quality sandstone is encountered.

6.5 Pavements

The pavement subgrade soils should be prepared as detailed in section 6.2.2. the soaked CBR tests on samples from BHs 7 and 10 measured high CBR values of 25% and 9%. This high values would be the result of the sand content in the samples and lower results would be expected where clays are exposed.

Detailed geotechnical investigation should be carried out along the proposed road alignments to assess the subgrade soils, together with additional soaked CBR tests on representative subgrade soils. It is expected that the majority of the pavement subgrades will comprise clayey sands/sandy clays, with areas of sandstone exposed where excavations are required. For preliminary design, we suggest that a design CBR value of no more than 5% be used for the clayey sand/sandy clays. However,

where high plasticity silty clays will be exposed lower CBR values of the order of 2% to 3% may be more appropriate.

Subsoil drains should be provided along the perimeter of the pavements, with inverts not less than 0.2m below clay subgrade level. The drainage trench should be excavated with a longitudinal fall to appropriate discharge points so as to reduce the risk of water ponding. The pavement subgrade should be graded to promote water flow or infiltration towards the subsoil drains.

Concrete pavements should have a subbase layer of at least 100mm thickness of crushed rock to RTA QA specification 3051 (1994) unbound base material (or equivalent good quality and durable fine crushed rock), which is compacted to at least 100% of SMDD. Concrete pavements should be designed with an effective shear transmission at all joints by way of either doweled or keyed joints.

7 CONDITIONS TO SATISFY PITTWATER COUNCIL'S INTERIM POLICY

We consider that the proposed development may proceed provided the following specific design, construction and maintenance recommendations are adopted to maintain and reduce the present risk of instability of the site and to control future risks. These recommendations address geotechnical issues only and other conditions may be required to address other aspects. These recommendations are based on the current preliminary layout of the development and the results of this preliminary geotechnical investigation. These recommendations should also be reviewed following the additional, more detailed geotechnical investigations are recommended in section 6.1.

7.1 Conditions Recommended to Establish the Design Parameters

7.1.1 The design and construction of the development should be carried out in accordance with the recommendations provided within Section 6 above.

7.1.2 Additional geotechnical investigations should be carried out as detailed in Section 6.1.

7.1.3 All surface water discharging from the roof and paved areas must be diverted to outlets for controlled discharge to the existing or upgraded stormwater system.

7.1.4 The Guidelines for Hillside Construction given in Appendix B should be adopted.

7.2 Conditions Recommended for Detailed Design to be Undertaken for the Construction Certificate

7.2.1 All structural design drawings must be reviewed by the geotechnical engineer and endorsed that the recommendations contained in this report have been adopted in principle.

7.2.2 All hydraulic design drawings must be reviewed by the geotechnical engineer and endorsed that the recommendations contained in this report have been adopted in principle.

7.2.3 The structural engineer is to document on his drawings the design life adopted for the structural elements.

7.3 Conditions Recommended During the Construction Period

7.3.1 Bulk excavations must be formed at suitable batters as recommended in section 6.3. Where sandstone is encountered and steeper excavation faces are adopted these should be inspected progressively by the geotechnical engineer. We recommend inspections at 1.5m vertical depth intervals and on completion.

7.3.2 The geotechnical engineer is to inspect proof rolling of the subgrade below the proposed fill areas and roadways prior to placement of fill or construction of the pavements.

7.3.3 Compaction density of the fill material must be checked by a NATA registered laboratory to at least Level 2 in accordance with, and to the frequency outlined in, AS3798, and the results submitted to the geotechnical engineer.

7.3.4 The hydraulic and/or geotechnical engineer is to inspect the subsoil drains to retaining walls before any backfill is placed.

7.3.5 An 'as-built' drawing of all buried services at the site must be prepared (including all pipe diameters, pipe depths, pipe types, inlet pits, inspection pits, etc).

7.3.6 The geotechnical engineer is to confirm that the development has been completed in accordance with the geotechnical report.

7.4 Conditions Recommended for Ongoing Management of the Site/Structure(s)

The following recommendations have been included so that the current and future owners of the subject property are aware of their responsibilities:

7.4.1 All existing and proposed surface (including roof) and subsurface drains must be subject to ongoing and regular maintenance by the property owners.

7.4.2 Where sandstone rock faces are left exposed they must be inspected by an experienced engineer/engineering geologist at ten yearly intervals; including provision of a written report confirming scope of work completed and identifying any required remedial measures.

7.4.3 No cut or fill in excess of 0.5m (e.g. for landscaping, buried pipes, retaining walls, etc.) is to be carried out on site without prior consent from Pittwater Council.

7.4.4 Where the structural engineer has indicated a design life of less than 100 years then the structure and/or structural elements must be inspected by

a structural engineer at the end of their design life; including a written report confirming scope of work completed and identifying the required remedial measures to extend the design life over the remaining 100 year period.

8 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. As an example, special treatment of soft spots may be required as a result of their discovery during proof-rolling, etc. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and Jeffery and Katauskas Pty Ltd accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long-term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgement from an experienced engineer. Such judgement often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

Occasionally, the subsurface conditions between the completed boreholes may be found to be different (or may be interpreted to be different) from those expected.

Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

The offsite disposal of soil may require classification in accordance with the EPA guidelines as inert, solid, industrial or hazardous waste. We can complete the necessary classification and testing if you wish to commission us. As testing requires about seven days to complete, allowance should be made for such testing in the construction program unless testing is completed prior to construction. If contamination is found to be present then substantial further testing and delays should be expected.

If there is any change in the proposed development described in this report then all recommendations should be reviewed.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. Copyright in this report is the property of Jeffery and Katauskas Pty Ltd. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees

due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

Should you have any queries regarding this report, please do not hesitate to contact the undersigned.

For and on behalf
JEFFERY AND KATAUSKAS PTY LTD

D J Bliss
Senior Geotechnical Engineer

QA Review by:

F Vega
Senior Associate

Reference 1: Australian Geomechanics Society (2000) *"Landslide Risk Management Concepts and Guidelines"*, Australian Geomechanics, Vol 35, No 1, March 2000, pp49-92.

Unit 3, 39 Buffalo Road
Gladesville, NSW 2111
Telephone: 02 9809 7322
Facsimile: 02 9809 7626
Email: dtreweek@jkgroup.net.au

SOIL TEST SERVICES
ABN 43 002 145 173

Ref No:19312VB

TABLE A
SUMMARY OF LABORATORY TEST RESULTS

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	DEPTH m	MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	LINEAR SHRINKAGE %
3	0.50-0.95	30.8	70	26	44	17.0
5	0.50-0.95	9.1	np	np	np	na
6	1.50-1.95	13.7	28	12	16	4.0
10	0.50-0.95	18.4	40	14	26	9.5

Notes:
- The test sample for liquid and plastic limit was oven-dried & dry-sieved
- The linear shrinkage mould was 125mm
- np denotes non-plastic
- na denotes not applicable

NATA Accredited Laboratory
Number:1327

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its scope of accreditation. This document shall not be reproduced except in full.

Authorised Signature
(A.Tatikonda)

Date: 5/4/05

Unit 3, 39 Buffalo Road
Gladesville, NSW 2111
Telephone: 02 9809 7322
Facsimile: 02 9809 7626
Email: dtreweek@jkgroup.net.au

SOIL TEST SERVICES
ABN 43 002 145 173

Ref No: 19312VB
Table B: Page 1 of 1

TABLE B
SUMMARY OF FOUR DAY SOAKED C.B.R.TEST RESULTS

BOREHOLE NUMBER		7	10
DEPTH (m)		0.20 - 1.00	0.10 - 1.00
Surcharge (kg)		4.5	4.5
Maximum Dry Density (t/m^3)		1.61 STD	1.78 STD
Optimum Moisture Content (%)		7.4	17.9
Moulded Dry Density (t/m^3)		1.58	1.75
Sample Density Ratio (%)		98	98
Sample Moisture Ratio (%)		100	100
Moisture Contents			
Insitu (%)		4.3	18.0
Moulded (%)		7.4	17.9
After soaking and			
After Test, Top 30mm(%)		18.6	19.2
Remaining Depth (%)		18.4	18.7
Material Retained on 19mm Sieve (%)		0	0
Swell (%)		0.0	0.4
C.B.R. value:	@2.5mm penetration	25	
	@5.0mm penetration		9

NOTES:

- Refer to appropriate Borehole logs for soil descriptions
- Test Methods :
  - (a) Soaked C.B.R. : AS 1289 6.1.1
  - (b) Standard Compaction : AS 1289 5.1.1
  - (c) Moisture Content : AS 1289 2.1.1

NATA Accredited Laboratory
Number:1327

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its scope of accreditation. This document shall not be reproduced except in full.

Authorised Signature
(A.Tatikonda)

Date: 5/4/05

TABLE C
SUMMARY OF RISK ASSESSMENT TO PROPERTY

Landslide Hazard	Assessed Likelihood	Assessed Consequences	Risk	Comments
A. Instability of Existing Sandstone Cliffs	Unlikely	Minor to Medium	Low	Detailed Assessment to be carried out during Construction
B. Instability of Existing Retaining Walls	Rare	Minor to Medium	Very Low to Low	Provided Walls Satisfy Structural Assessment
C. Instability of Proposed Retaining Walls	Rare	Medium	Very Low to Low	New retaining Walls or slopes to be properly engineered
D. Instability of Hillside Slope				
(i) Upslope of Proposed Development	Unlikely	Minor	Low	Stability improved by proposed retaining walls
(ii) Beneath the Proposed Development	Rare	Medium	Very Low to Low	
E. Instability of Narrabeen Creek Banks	Unlikely	Minor	Very Low to Low	

TABLE D
SUMMARY OF RISK ASSESSMENT TO LIFE

Landslide Hazard	A: Instability of Existing Sandstone Cliffs	B: Instability of Existing Retaining Walls	C: Instability of Proposed Retaining Walls	D(i): Instability of Hillside Slope Upslope of Proposed Development	D(ii): Instability of Hillside Slope Beneath Proposed Development	E: Instability of Narrabeen Creek Banks
Assessed Likelihood	Unlikely	Rare	Rare	Unlikely	Rare	Unlikely
Indicative Annual Probability	10^{-4}	10^{-5}	10^{-5}	10^{-4}	10^{-5}	10^{-4}
Persons at Risk	(a) Persons within existing house (b) Persons on Road 2	Persons in rear yards next to walls	(a) Persons on roadways (b) Persons within houses	Persons above roadways	Persons in and around houses	Persons on creek banks
Anticipated Daily Use of Area Affected (Temporal Probability)	(a) Say average 14 hours per day = 0.58 (b) Say average 2 minutes per day = 0.0014	Say average 1 hour per day = 0.042	(a) Say average 5 minutes per day = 0.0035 (b) Say average 14 hours per day = 0.58	Say average 2 hours per week = 0.012	Say average 14 hours per day = 0.58	Say average 2 hours per week = 0.012
Probability of Not Evacuating Area Affected	0.1	0.1	0.1	0.1	0.1	0.1
Vulnerability to Life if Failure Occurs Whilst Person Present	(a) 0.1 (b) 0.3	0.1	(a) 0.3 (b) 0.1	0.1	0.1	0.2
Risk for Person Most at Risk	(a) 5.80×10^{-7} (b) 4.20×10^{-9}	4.20×10^{-9}	(a) 1.05×10^{-9} (b) 5.80×10^{-8}	1.20×10^{-8}	5.80×10^{-8}	2.40×10^{-8}

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 1 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 20.5m

Date: 17-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Gravelly sand, fine to medium grained, grey brown, fine to coarse grained sandstone gravel.	D			GRASS COVER APPEARS MODERATELY COMPACTED
					N = 10 8,5,5	1							
								SC	CLAYEY SAND: fine to medium grained, yellow brown.	M	L		ALLUVIAL
					N = 8 2,3,5	2			as above, but orange brown mottled grey.		MD		
					N = 26 8,12,14	3							
						4				W	L		
					N = 5 3,2,3	5			as above, but grey.				
						6			END OF BOREHOLE AT 6.0m				
						7							

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Borehole No. 2
1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 17-3-05

Method: SPIRAL AUGER
JK550

R.L. Surface: ≈ 21.6m
Datum: AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			TOPSOIL: Sand, fine to medium grained, dark grey, with rootlets.	D			GRASS COVER
					N = 6 2,3,3			SP	SAND: fine to medium grained, grey brown.	M	L		ALLUVIAL
						1		SC	CLAYEY SAND: fine to medium grained, orange brown and grey.				
					N = 10 3,3,7	2							
								SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, medium plasticity, grey mottled orange brown.	M/ MC≈PL	MD/ H		
					N = 14 5,6,8	3						420 450 510	
						4		SC	CLAYEY SAND: fine to medium grained, grey mottled orange brown.	M	MD		
					N = 11 5,5,6			SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, medium plasticity, grey mottled orange brown.	W/ MC>PL	MD/ VSt	210 280 230	
						5							
						6			END OF BOREHOLE AT 6.0m				
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 3 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 17-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S./
R.L. Surface: ≈ 27.7m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			TOPSOIL: Silty sand, fine to medium grained, dark grey, with rootlets.	D-M			GRASS COVER
DRY ON COMPLET-ION								SM	SILTY SAND: fine to medium grained, with fine to coarse grained sandstone gravel and cobbles.	D-M	(L)		COLLUVIUM
					N = 11 3,4,7			CH	SILTY CLAY: high plasticity, grey mottled orange brown.	MC>PL	H	470 580 410	
						1		SC	CLAYEY SAND: fine to medium grained, grey mottled red brown.	M	(L)		RESIDUAL
					SPT 8/0mm REFUSAL			-	SANDSTONE: fine to medium grained, light grey, with iron indurated bands and clay bands.	XW-DW	EL-L		VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
						2							
						3							
						4							
									END OF BOREHOLE AT 4.5m				
						5							
						6							
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 4 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 17-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S.
R.L. Surface: ≈ 31.8m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			TOPSOIL: Silty sand, fine to medium grained, dark grey, with rootlets.	D			GRASS COVER
DRY ON COMPLET-ION								SM	SILTY SAND: fine to medium grained, grey, with fine to coarse grained sandstone gravel and sandstone cobbles.	M	(L)		COLLUVIUM
					N = 25 3,8,17			CL	SANDY CLAY: medium plasticity, light grey mottled red brown, with XW sandstone gravel.	MC≈PL	H	>600 >600	RESIDUAL
						1		-	SANDSTONE: fine to medium grained, grey mottled red brown, with clay and iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
						2			SANDSTONE: fine to medium grained, light grey mottled orange brown, with a trace of iron indurated bands.	XW-DW	EL-VL		VERY LOW TO LOW RESISTANCE
						3							
						4							VERY LOW RESISTANCE
									END OF BOREHOLE AT 4.5m				
						5							
						6							
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 5 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 22.4m

Date: 17-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Gravelly sand, fine to coarse grained, grey, fine to medium grained igneous gravel.	M			
								SP	SAND: fine to medium grained, grey.	M	(L)		POSSIBLY FILL
					N = 4 2,2,2	1		SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, low plasticity, orange brown.	M/ MC≈PL	VL-L/ (St)		ALLUVIAL
					N = 12 2,6,6	2					MD/ VSt-H	470 350	
					N = 25 9,11,14	3						470 380 310	
ON COMPLETION						4				W/ MC>PL			
					N = 11 5,4,7	5			as above, but grey mottled orange brown.		MD/ VSt	210 310 380	
						6			END OF BOREHOLE AT 6.0m				
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 6 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 17-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S./
R.L. Surface: ≈ 22.9m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			TOPSOIL: Silty sand, fine to medium grained, grey, with rootlets.	M			WEED COVER
								SP	SAND: fine to medium grained, grey.	M	MD		ALLUVIAL
					N = 17 4,8,9	1		SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, low plasticity, orange brown.	M/ MC≈PL	MD/ H	>600 >600	
					N = 22 13,11,11	2							
					N = 12 7,5,7	3					MD/ VSt -H	280 240 230	
						4			as above, but grey mottled orange brown.	MC>PL/ W			
ON COMPLET-ION & AFTER 24 HRS					N = 11 3,6,5	5					MD/ St-VSt	160 300 220	
						6			END OF BOREHOLE AT 6.0m				
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 7 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB

Date: 17-3-05

Method: SPIRAL AUGER
JK550

Logged/Checked by: N.E.S./

R.L. Surface: ≈ 24.0m

Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			TOPSOIL: Silty sand, fine to medium grained, dark grey, with rootlets.	M			GRASS COVER
					N = 8 2,3,5	0.5		SP	SAND: fine to medium grained, light grey to grey.	M	L		ALLUVIAL
					N = 7 3,3,4	2		SC	CLAYEY SAND: fine to medium grained, dark grey to grey.				
					N = 18 4,7,11	3		CL/SC	SANDY CLAY/CLAYEY SAND: medium plasticity, fine to medium grained orange brown.	M/ MC≈PL	MD/ VSt	380 350 340	
					N = 16 8,9,7	5			as above, but dark grey to grey.	W/ MC>PL		380 320 300	SLIGHT ORGANIC ODOUR
▼ ON COMPLETION & AFTER 24 HRS						6			END OF BOREHOLE AT 6.0m				

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 8 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 18-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S./
R.L. Surface: ≈ 27.0m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			TOPSOIL: Silty sand, fine to medium grained, dark grey, with rootlets.	M			GRASS COVER
								SP	SAND: fine to medium grained, light grey.	M	(L)		COLLUVIUM
					N > 22 2,9, 13/100mm			SC	CLAYEY SAND: fine to medium grained, orange brown mottled grey, with XW sandstone gravel.	M	(MD)		
					REFUSAL	1		-	SANDSTONE BOULDER: fine to coarse grained, light grey mottled orange brown.	DW	VL-L		MODERATE 'TC' BIT RESISTANCE WITH LOW BANDS
								CL	SILTY CLAY: medium plasticity, light grey, with fine grained sand.	MC>PL	H		COLLUVIUM SOIL STRENGTH 'TC' RESISTANCE
					N = 14 4,6,8	3						440 520 480	
								CL	SANDY CLAY: medium plasticity, light grey, fine grained sand.		VSt -H		
					N = 19 5,8,11	5			as above, but orange brown mottled light grey.			430 370 480	
						6			END OF BOREHOLE AT 6.0m				
						7							

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Borehole No. 9 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 18-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S.
R.L. Surface: ≈ 25.0m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			TOPSOIL/FILL: Silty sand, fine to medium grained, grey, with rootlets.	M			RUBBLE ON SURFACE
					N = 5 2,2,3	1		SM	SILTY SAND: fine to medium grained, orange brown.	M	L		ALLUVIAL
					N = 20 5,8,12	2		CL/SC	SANDY CLAY/CLAYEY SAND: medium plasticity, fine to medium grained, orange brown.	M/ MC>PL	MD/ VSt-H	380 380 400 390	
					N = 27 7,14,13	3					MD/ VSt	330 260 250	
						4			as above, but grey mottled orange brown.				
					N = 13 4,6,7	5					MD/H	530 450 430	
						6			END OF BOREHOLE AT 6.0m				
						7							

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Borehole No. **10** 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB

Date: 18-3-05

Method: SPIRAL AUGER JK550

Logged/Checked by: N.E.S./

R.L. Surface: ≈ 30.5m

Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET-ION						0		SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, medium plasticity, orange brown and red brown, with ironstone gravel bands.	M/ MC≈PL	MD/ (VSt)		DRIVEWAY GRAVEL ON SURFACE RESIDUAL
					N = 12 3,6,6	1							
					N = 25 7,9,16	2							
					N > 10 10,10/ 50mm REFUSAL	3		-	SANDSTONE: fine to medium grained, red brown, with iron indurated bands.	XW-DW	EL-VL		VERY LOW 'TC' BIT RESISTANCE
						4			END OF BOREHOLE AT 4.5m				
						5							
						6							
						7							

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Borehole No. 11 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 18-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S./
R.L. Surface: ≈ 29.6m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION					N = 14 7,7,7	0			FILL: Sandy gravel, fine to medium grained, igneous, grey, fine to medium grained sand, with a trace of clay fines.	M-W			DRIVEWAY GRAVEL ON SURFACE
									FILL: Sandy gravel, fine to medium grained, sandstone, grey, fine to medium grained sand, with a trace of clay fines.	M/ MC>PL			APPEARS MODERATELY COMPACTED
					N = 13 4,8,5	1			FILL: Clayey sand/sandy clay, fine to medium grained, medium plasticity, grey brown, with fine to coarse grained gravel.	M/ MC≈PL			
						2							
					N = 20 9,10,10	3							
						4		CL/SC	SANDY CLAY/CLAYEY SAND: medium plasticity, fine to medium grained, red brown mottled light grey, with iron indurated bands.	M/ MC>PL	D/ H	>600	ALLUVIAL
					N = 42 12,17,25	5			as above, but light grey mottled red brown.			>600 >600	
						6			END OF BOREHOLE AT 6.0m				
						7							

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Borehole No. 12 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 18-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S./
R.L. Surface: ≈ 41.8m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			TOPSOIL: Silty sand, fine to medium grained, grey, with rootlets and fine to coarse grained sandstone gravel.	M			
								-	SANDSTONE: fine to coarse grained, red brown, with iron indurated bands.	DW	VL-L		LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
						1			SANDSTONE: fine to medium grained, light grey mottled red brown.		M-H		MODERATE TO HIGH RESISTANCE
						2			END OF BOREHOLE AT 2.0m				'TC' BIT REFUSAL
						3							
						4							
						5							
						6							
						7							

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Borehole No. 13 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

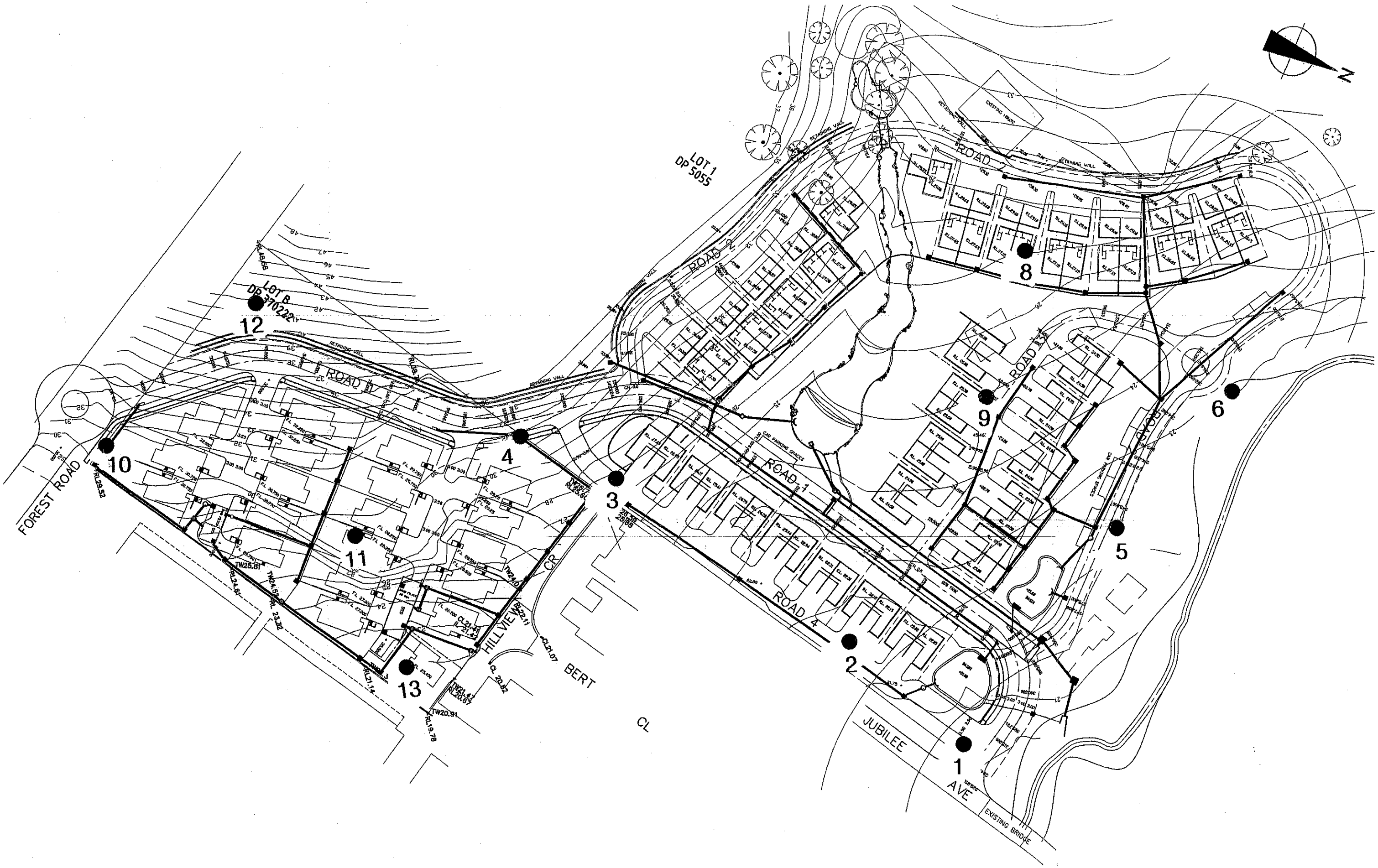
Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK250 **R.L. Surface:** ≈ 22.0m

Date: 18-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			TOPSOIL: Silty sand, fine to medium grained, grey, with rootlets.	M			GRASS COVER
DRY ON COMPLET-ION					N = 4 1,2,2	1		SC	CLAYEY SAND: fine to medium grained, orange brown.	M	VL-L		ALLUVIAL
					N = 11 3,5,6	2		SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, medium plasticity, orange brown, with ironstone gravel.	M/ MC>PL	MD/ VSt	330 220	
					N = 42 8,13,29	3			as above, but grey mottled red brown.			270 230	
					N = 50 10,24,26	4					D-VD/ H		
						5						>600 >600 >600	
						6			END OF BOREHOLE AT 6.0m				
						7							



SCALE

0 50m

BOREHOLE LOCATION PLAN

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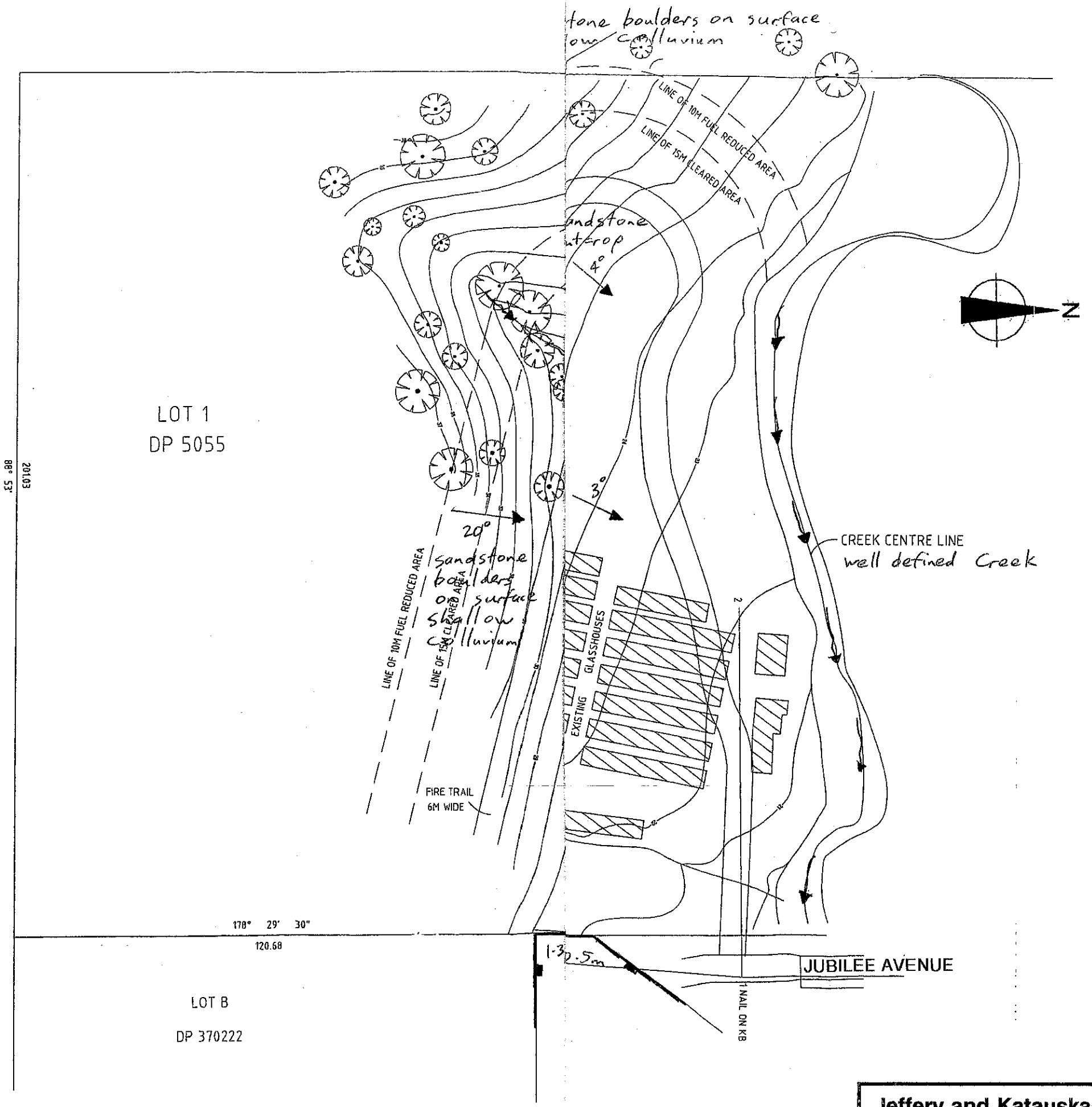
Report No. 19312VB Figure No. 1



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Report No. 19312VB Figure No. 2

N

FOREST ROAD (unformed)

1 DP 5055

1 DP 5055

Small sandstone exposures

concrete block retaining walls

sandstone block retaining wall 0.6m

1.2m

0.2m

1m

sandstone block retaining wall

concrete block retaining wall

2.9m

2.5m

1.8m

sandstone boulders and cobbles on surface / shallow colluvium

Koppers log retaining walls

sandstone block retaining wall 1.7m

0m

1.3m

8°

4°

30°

HILLVIEW CRESCENT

BERT CLOSE

AREA 9704.5m²
LOT B
DP 370222

rendered brick retaining wall

1.0m

2.1m

1.4m

3°

0.3m

1.8m

1.2m

ENTRY TO MATER MARIA CATHOLIC SCHOOL

FOREST ROAD

SP 38285

SP 38285

SCALE (M)
0
25m

GEOTECHNICAL SKETCH PLAN

Jeffery and Katauskas Pty Ltd
Report No. 19312VB Figure No. 3

TOPOGRAPHY

Symbol *Ground Profile*

convex
concave
} well defined or angular break of slope

convex
concave
} poorly defined or smooth change of slope

breaks of slope
changes of slope
} convex and concave too close together to allow the use of separate symbols

sharp
rounded
} ridge crest

3 Cliff or escarpment or sharp break 40° or more (estimated height in metres)

15 Uniform Slope
10 Concave Slope
8 Convex Slope
} Slope direction and angle (Degrees)

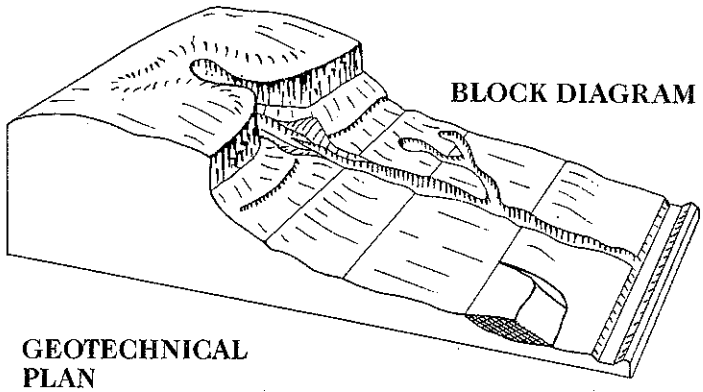
Top
Bottom
} Cut or fill slope, arrows pointing down slope

Hummocky or irregular ground

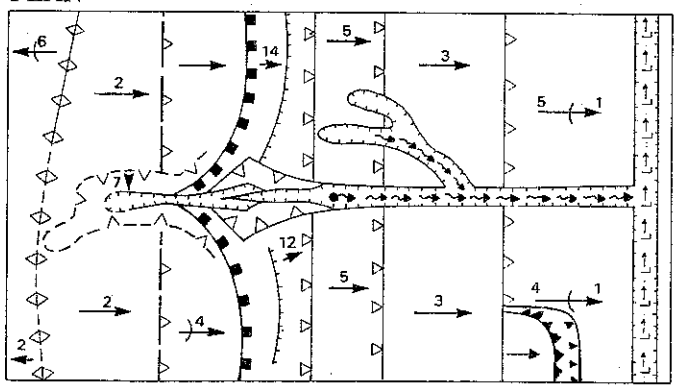
OTHER FEATURES

Boulder
Seepage/spring
Swallow hole for runoff
Natural water course
Open drain, unlined
Open drain, lined
Fenceline
Property boundary
Dry Stone Wall
J —— J 200 Major joint in rock face (opening in millimetres)
– T – T – 10 Tension crack (opening in millimetres)
Masonry or concrete wall
Ponding water
Boggy or swampy area

EXAMPLE OF USE OF TOPOGRAPHIC SYMBOLS:



GEOTECHNICAL PLAN



GEOTECHNICAL MAPPING SYMBOLS

Jeffery and Katauskas Pty Ltd
Report No. 19312VB Figure No. 4

APPENDIX A

LANDSLIDE RISK MANAGEMENT TERMINOLOGY

APPENDIX A

LANDSLIDE RISK MANAGEMENT

DEFINITION OF TERMS

Risk – A measure of the probability and severity of an adverse effect to health, property or the environment.
Risk is often estimated by the product of probability x consequences. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form.

Hazard – A condition with the potential for causing an undesirable consequence (*the landslide*). The description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the likelihood of their occurrence within a given period of time.

Elements at Risk – Meaning the population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by landslides.

Probability – The likelihood of a specific outcome, measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between 0 and 1, with 0 indicating an impossible outcome, and 1 indicating that an outcome is certain.

Frequency – A measure of likelihood expressed as the number of occurrences of an event in a given time. See also Likelihood and Probability.

Likelihood – used as a qualitative description of probability or frequency.

Temporal Probability – The probability that the element at risk is in the area affected by the landsliding, at the time of the landslide.

Vulnerability – The degree of loss to a given element or set of elements within the area affected by the landslide hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons, it will be the probability that a particular life (the element at risk) will be lost, given the person(s) is affected by the landslide.

Consequence – The outcomes or potential outcomes arising from the occurrence of a landslide expressed qualitatively or quantitatively, in terms of loss, disadvantage or gain, damage, injury or loss of life.

Risk Analysis – The use of available information to estimate the risk to individuals or populations, property, or the environment, from hazards. Risk analyses generally contain the following steps: scope definition, hazard identification, and risk estimation.

Risk Estimation – The process used to produce a measure of the level of health, property, or environmental risks being analysed. Risk estimation contains the following steps: frequency analysis, consequence analysis, and their integration.

Risk Evaluation – The stage at which values and judgements enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental, and economic consequences, in order to identify a range of alternatives for managing the risks.

Risk Assessment – The process of risk analysis and risk evaluation.

Risk Control or Risk Treatment – The process of decision making for managing risk, and the implementation, or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.

Risk Management – The complete process of risk assessment and risk control (*or risk treatment*).

Individual Risk – The risk of fatality or injury to any identifiable (named) individual who lives within the zone impacted by the landslide; or who follows a particular pattern of life that might subject him or her to the consequences of the landslide.

Societal Risk – The risk of multiple fatalities or injuries in society as a whole: one where society would have to carry the burden of a landslide causing a number of deaths, injuries, financial, environmental, and other losses.

Acceptable Risk – A risk for which, for the purposes of life or work, we are prepared to accept as it is with no regard to its management. Society does not generally consider expenditure in further reducing such risks justifiable.

Tolerable Risk – A risk that society is willing to live with so as to secure certain net benefits in the confidence that it is being properly controlled, kept under review and further reduced as and when possible.

In some situations risk may be tolerated because the individuals at risk cannot afford to reduce risk even though they recognise it is not properly controlled.

Landslide Intensity – A set of spatially distributed parameters related to the destructive power of a landslide. The parameters may be described quantitatively or qualitatively and may include maximum movement velocity, total displacement, differential displacement, depth of the moving mass, peak discharge per unit width, kinetic energy per unit area.

Note: Reference should also be made to Figure A1 which shows the inter-relationship of many of these terms and the relevant portion of Landslide Risk Management.

Reference should also be made to the paper referenced below for Landslide Terminology and more detailed discussion of the above terminology.

TABLE A1: LANDSLIDE RISK ASSESSMENT QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

Qualitative Measures of Likelihood

Level	Descriptor	Description	Indicative Annual Probability
A	ALMOST CERTAIN	The event is expected to occur.	$>\approx 10^{-1}$
B	LIKELY	The event will probably occur under adverse conditions.	$\approx 10^{-2}$
C	POSSIBLE	The event could occur under adverse conditions.	$\approx 10^{-3}$
D	UNLIKELY	The event might occur under very adverse circumstances.	$\approx 10^{-4}$
E	RARE	The event is conceivable but only under exceptional circumstances.	$\approx 10^{-5}$
F	NOT CREDIBLE	The event is inconceivable or fanciful.	$< 10^{-6}$

Note: "≈" means that the indicative value may vary by say ±½ order of magnitude, or more.

Qualitative Measures of Consequences to Property

Level	Descriptor	Description
1	CATASTROPHIC	Structure completely destroyed or large scale damage requiring major engineering works for stabilisation.
2	MAJOR	Extensive damage to most of structure, or extending beyond site boundaries requiring significant stabilisation works.
3	MEDIUM	Moderate damage to some of structure, or significant part of site requiring large stabilisation works.
4	MINOR	Limited damage to part of structure, or part of site requiring some reinstatement/stabilisation works.
5	INSIGNIFICANT	Little damage.

Note: The "Description" may be edited to suit a particular case.

Qualitative Risk Analysis Matrix – Level of Risk to Property

LIKELIHOOD	CONSEQUENCES to PROPERTY				
	1: CATASTROPHIC	2: MAJOR	3: MEDIUM	4: MINOR	5: INSIGNIFICANT
A – ALMOST CERTAIN	VH	VH	H	H	M
B – LIKELY	VH	H	H	M	L-M
C – POSSIBLE	H	H	M	L-M	VL-L
D – UNLIKELY	M-H	M	L-M	VL-L	VL
E – RARE	M-L	L-M	VL-L	VL	VL
F – NOT CREDIBLE	VL	VL	VL	VL	VL

Risk Level Implications

Risk Level		Example Implications(1)
VH	VERY HIGH RISK	Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to acceptable levels; may be too expensive and not practical.
H	HIGH RISK	Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable levels.
M	MODERATE RISK	Tolerable provided treatment plan is implemented to maintain or reduce risks. May be accepted. May require investigation and planning of treatment options.
L	LOW RISK	Usually accepted. Treatment requirements and responsibility to be defined to maintain or reduce risk.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (1) The implications for a particular situation are to be determined by all parties to the risk assessment; these are only given as a general guide.

(2) Judicious use of dual descriptors for Likelihood, Consequence and Risk to reflect the uncertainty of the estimate may be appropriate in some cases.

These tables are an extract from LANDSLIDE RISK MANAGEMENT CONCEPTS AND GUIDELINES as presented in *Australian Geomechanics*, Vol. 35, No. 1, 2000 which discusses the matter more fully.

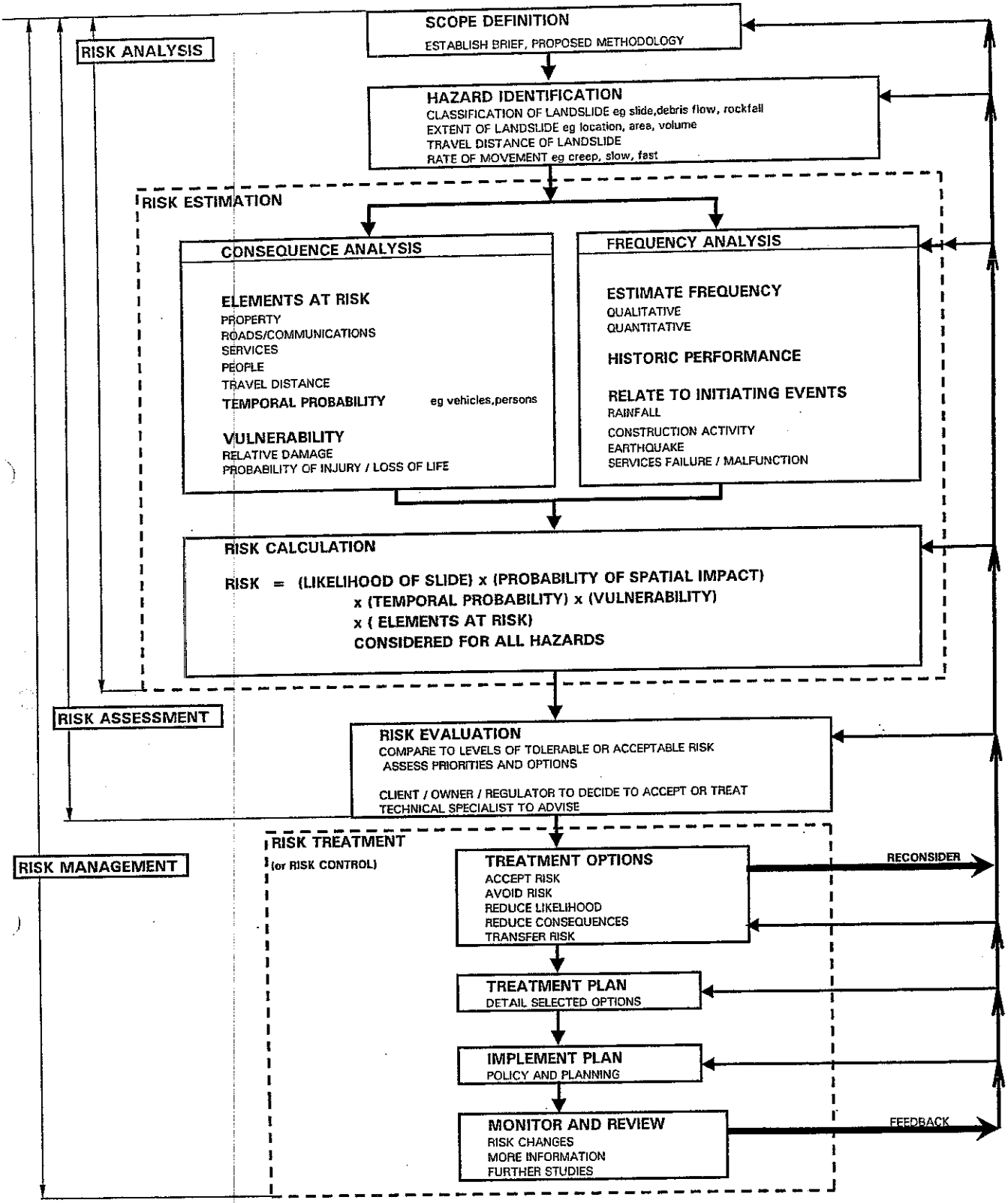


FIGURE A1: FLOWCHART FOR LANDSLIDE RISK MANAGEMENT

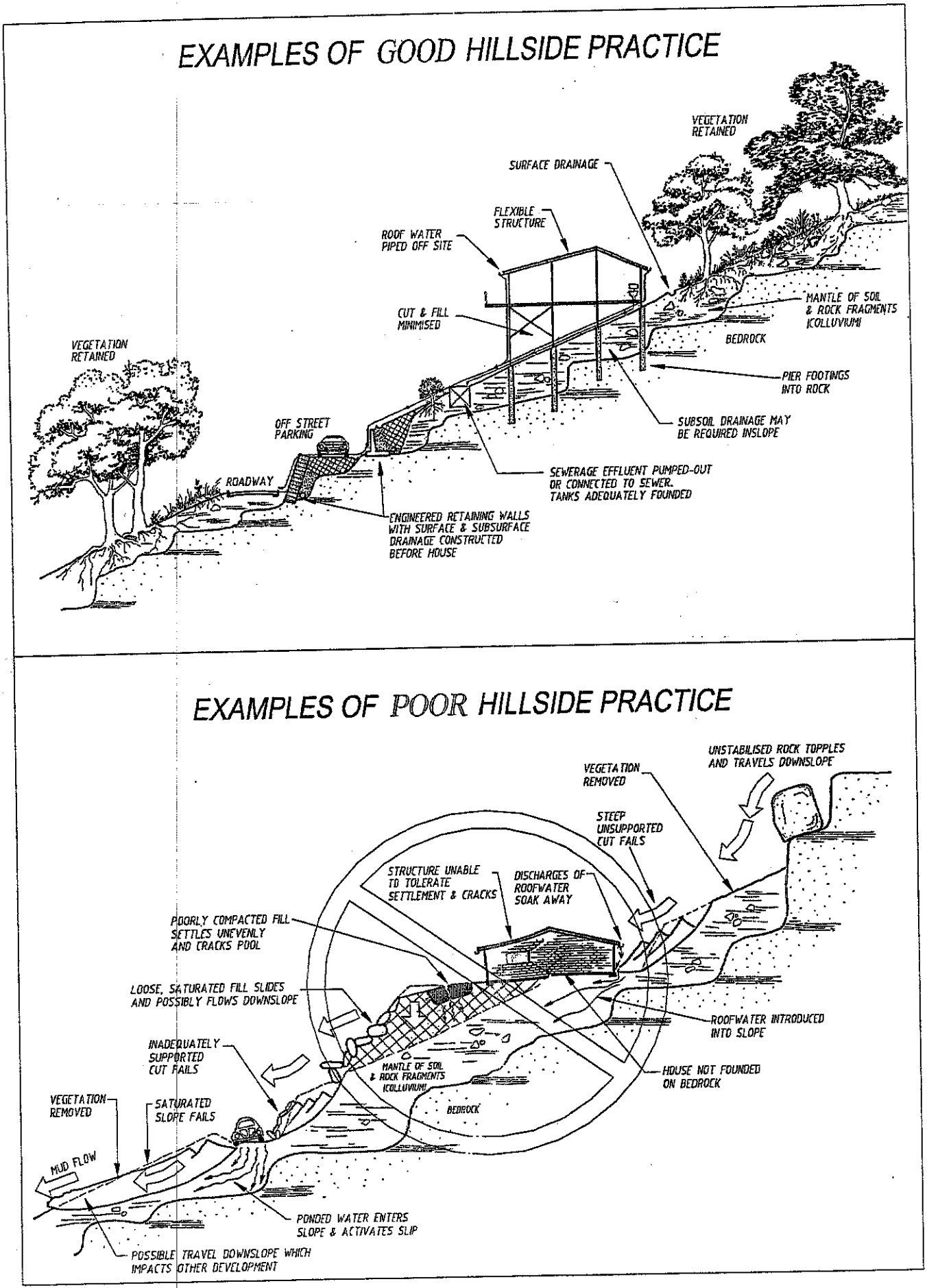
This figure is an extract from LANDSLIDE RISK MANAGEMENT CONCEPTS AND GUIDELINES as presented in Australian Geomechanics Vol35, No1, 2000 which discusses the matter more fully.

APPENDIX B

APPENDIX B – SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	POOR ENGINEERING PRACTICE
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant 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.	Indiscriminant 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 properties 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 bedrock 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 bedrock where practicable. User 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 generous 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 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 of roof run-off 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 of 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 a 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 seek advice. If seepage observed, determine cause or seek advice on consequences.	

This table is an extract from LANDSLIDE RISK MANAGEMENT CONCEPTS AND GUIDELINES as presented in *Australian Geomechanics*, Vol 25, No 1, March 2000 which discusses the matter more fully.



APPENDIX B1 - ILLUSTRATIONS OF GOOD AND POOR HILLSIDE PRACTICE

This figure is an extract form LANDSLIDE RISK MANAGEMENT CONCEPTS AND GUIDELINES as presented in *Australian Geomechanics*, Vol 35, No 1, 2000 which discusses the matter more fully.

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

A.B.N. 17 003 550 801 A.C.N. 003 550 801

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the SAA Site Investigation Code. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the grading of other particles present (eg sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, "Shale" is used to describe thinly bedded to laminated siltstone.

SAMPLING

Sampling is carried out during drilling or from other excavations to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table. Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock fragments.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term "mud" encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

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

The test results are reported in the following form:

- In the case where full penetration is obtained with successive blow counts for each 150mm of, say, 4, 6 and 7 blows, as

  N = 13

  4, 6, 7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as

  N>30

  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

A modification to the SPT test is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as "N_c" on the borehole logs, together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

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

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

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

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole or "reverted" chemically if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after stabilising at intervals ranging from several days to perhaps weeks

for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg bricks, steel etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg to a twenty storey building). If this happens, the company will be pleased to review the report and the sufficiency of the investigation work.

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

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

If these occur, the company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed that at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. License to use the documents may be revoked without notice if the Client is in breach of any objection to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

The company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to
ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
iii) full time engineering presence on site.

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL


FILL


TOPSOIL


CLAY (CL, CH)


SILT (ML, MH)


SAND (SP, SW)


GRAVEL (GP, GW)


SANDY CLAY (CL, CH)


SILTY CLAY (CL, CH)


CLAYEY SAND (SC)


SILTY SAND (SM)


GRAVELLY CLAY (CL, CH)


CLAYEY GRAVEL (GC)


SANDY SILT (ML)


PEAT AND ORGANIC SOILS

ROCK


CONGLOMERATE


SANDSTONE


SHALE


SILTSTONE, MUDSTONE, CLAYSTONE


LIMESTONE


PHYLLITE, SCHIST


TUFF


GRANITE, GABBRO


DOLERITE, DIORITE


BASALT, ANDESITE


QUARTZITE

DEFECTS AND INCLUSIONS


CLAY SEAM


SHEARED OR CRUSHED SEAM


BRECCIATED OR SHATTERED SEAM/ZONE


IRONSTONE GRAVEL


ORGANIC MATERIAL

OTHER MATERIALS


CONCRETE


BITUMINOUS CONCRETE, COAL


COLLUVIUM

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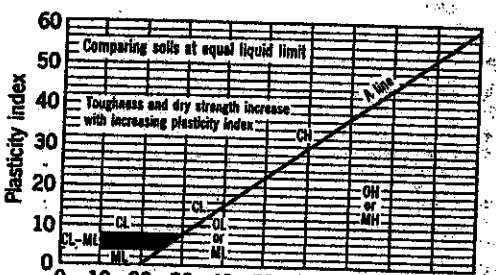
UNIFIED SOIL CLASSIFICATION TABLE

Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)						Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils More than half of material is *larger* than 75 μm sieve size[b]	Gravels More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes			*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP* More than 12% *GM, GC, SM, SC* 5% to 12% *Borderline* cases requiring use of dual symbols
			Predominantly one size or a range of sizes with some intermediate sizes missing			*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)			*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)			*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		
	Sands More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes			*SW*	Well graded sands, gravelly sands, little or no fines		
			Predominantly one size or a range of sizes with some intermediate sizes missing			*SP*	Poorly graded sands, gravelly sands, little or no fines		
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)			*SM*	Silty sands, poorly graded sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)			*SC*	Clayey sands, poorly graded sand-clay mixtures		
Fine-grained soils More than half of material is *smaller* than 75 μm sieve size (The 75 μm sieve size is about the smallest particle visible to naked eye)	Identification Procedures on Fraction Smaller than 380 μm Sieve Size		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)				Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols Atterberg limits above "A" line, with *PI* greater than 7
	Silts and clays Liquid limit less than 50		None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for *GW* Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols Atterberg limits above "A" line, with *PI* greater than 7 $C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for *SW* Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols Atterberg limits below "A" line with *PI* greater than 7
			Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity; gravelly clays; sandy clays, silty clays; lean clays		
			Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity		
	Silts and clays Liquid limit greater than 50		Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays		
			Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity		
Highly Organic Soils			Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils		



Plasticity chart
for laboratory classification of fine grained soils

NOTE: 1) Soils possessing characteristics of two groups are designated by combinations of group symbols (e.g. GW-GC, well graded gravel-sand mixture with clay fines).

2) Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

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LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record		Standing water level. Time delay following completion of drilling may be shown.
		Extent of borehole collapse shortly after drilling.
		Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY - runs freely through fingers.
	M	MOIST - does not run freely but no free water visible on soil surface.
	W	WET - free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT - Unconfined compressive strength less than 25kPa
	S	SOFT - Unconfined compressive strength 25-50kPa
	F	FIRM - Unconfined compressive strength 50-100kPa
	St	STIFF - Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF - Unconfined compressive strength 200-400kPa
	H	HARD - Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** / **SPT 'N' Value Range (Blows/300mm)**
	VL	Very Loose <15 0-4
	L	Loose 15-35 4-10
	MD	Medium Dense 35-65 10-30
	D	Dense 65-85 30-50
	VD	Very Dense >85 >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

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LOG SYMBOLS

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL	0.03	Easily remoulded by hand to a material with soil properties.
Very Low:	VL	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable.
Low:	L	0.3	A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
Medium Strength:	M	1	A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
High:	H	3	A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
Very High:	VH	10	A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	

REPORT

TO

JUBILEE INVESTMENTS PTY LTD

ON

PRELIMINARY SITE CONTAMINATION AND ACID SULFATE SOIL INVESTIGATION

FOR

SECTOR 5 WARRIEWOOD VALLEY LAND RELEASE

AT

JUBILEE AVENUE AND FOREST ROAD WARRIEWOOD

APRIL 2005

REF: E19312F-RPT

ENVIRONMENTAL INVESTIGATION SERVICES

REPORT

TO

JUBILEE INVESTMENTS PTY LTD

ON

PRELIMINARY SITE CONTAMINATION AND ACID SULFATE SOIL INVESTIGATION

FOR

SECTOR 5 WARRIEWOOD VALLEY LAND RELEASE

AT

JUBILEE AVENUE AND FOREST ROAD WARRIEWOOD

APRIL 2005

REF: E19312F-RPT

Principal: E H Fletcher BSc (Eng) ME
39 BUFFALO ROAD GLADESVILLE NSW 2111 TELEPHONE: (02) 9809 7322 (02) 9807 0200 FAX: (02) 9809 7626
EIS IS A DIVISION OF JEFFERY & KATAUSKAS PTY LTD A.B.N. 17 003 550 801 A.C.N. 003 550 801
Principals: B F Walker BE DIC MSc P Stubbs BSc MIEAust D Treweek Dip Tech

TABLE OF CONTENTS

1 INTRODUCTION

Jubilee Investments Pty Ltd commissioned Environmental Investigation Services (EIS), a division of Jeffery & Katauskas Pty Ltd (J&K), to undertake a preliminary environmental site screening to assess the likelihood of contamination of the subsurface soils and an acid sulfate soil assessment for the proposed Sector 5 Warriewood Valley Urban Land Release at Jubilee Avenue and Forest Road, Warriewood, NSW. The site is identified as Lot 1 in DP 5055 and Lot B in DP 370222 (subsequently described as Lot 1 and Lot B) and at the time of the investigation was occupied by residential buildings, glasshouses and bushland. The site location is shown on Figure 1 and the investigation was confined to the site boundaries as shown on Figure 2.

The screening was undertaken generally in accordance with an EIS proposal of 28 February 2005 and Jubilee Investments Pty Ltd acceptance by facsimile of 1 March 2005.

The proposed development consists of subdivision of the site into residential allotments and construction of one and two storey residential town-houses with carparks, access roads and gardens.

This report describes the investigation procedures and presents the results of the preliminary environmental site screening, together with comments, discussion and recommendations.

A geotechnical investigation was performed concurrently with the environmental site screening by J&K and the results are presented in a separate report (Ref. 19312VBrpt, dated 12th April, 2005).

2 ASSESSMENT OBJECTIVES

2.1 Investigation Objectives

The primary objective of the investigation was to assess the soil conditions at the site in relation to the suitability of the site for the proposed land use. A secondary investigation objective was to undertake an acid sulfate soil assessment for the proposed land use.

2.2 Scope of Work

The scope of work undertaken to achieve the objective included:

1. Assessment of historical site use, including review of historical aerial photographs, land title records search, review of the deposited plan and development applications/building approvals held by Council.
2. Review of regional geology and groundwater conditions, including the location of registered groundwater bores and major underground services in the vicinity of the site.
3. Search of WorkCover Dangerous Goods Licenses for underground fuel storage tanks (USTs), and investigation/remediation orders issued by the NSW EPA.
4. Design and implementation of a field sampling program.
5. Preparation of a report presenting the results of the assessment of potential soil contamination and acid sulfate soils.

Field work for the investigation was undertaken on 17 and 18 March 2005.

2.3 Data Quality Objectives

The purpose of Data Quality Objectives is to develop criteria to assess the reliability of the laboratory data. The Data Quality Objectives established for this project are summarised below:

- Collection and analysis of 10% of the field samples as inter-laboratory duplicates.
- Relative percentage differences (RPDs) were calculated for inter-laboratory duplicates. The RPD was calculated as the absolute value of the difference between the initial and repeat result divided by the average value, expressed as a percentage. The following acceptance criteria were used to assess the RPD results:
  - For results that were greater than 10 times the Practical Quantitation Limit (PQL) RPDs less than 50% were considered acceptable.
  - For results that were between 5 and 10 times PQL RPDs less than 75% were considered acceptable.
  - For results that were less than 5 times the PQL RPDs less than 100% were considered acceptable.
- Review of laboratory QA/QC data (including surrogate recovery, repeat analysis, duplicates, matrix spikes and method blanks).

The success of the Data Quality Objectives is based on assessment of the data set as a whole and not on individual acceptance or exceedance within the data set.

3 SITE INFORMATION

3.1 Site Description

The site identification details are summarised below:

Site Owner:	Jubilee Investments Pty Ltd
Site Address:	Jubilee Avenue & Forest Road, Warriewood
Lot & Deposited Plan:	Lot 1 in DP 5055 & Lot B in DP 370222
Local Government Authority:	Pittwater City Council
Current Zoning:	Residential/Commercial
Site Area:	Approximately 84,521m^2
AHD:	Approximately 25m
Geographical Location (MGA):	N: 627170 E: 340850 (approximately)
Site Locality Plan:	Refer to Figure 1
Site Layout Plan	Refer to Figure 2

The site comprises of Lot 1 and Lot B. Lot 1 is bound by Narrabeen Creek to the north, Jubilee Avenue to the north-east, residential buildings to the east, Boundary Street to the West, Lot B to the south-east and by bushland to the south. The site is located in an undulating topographic setting that generally falls to the north to Narrabeen Creek. Relatively flat areas exist at the site together with localized areas of more steeply sloping topography (up to approximately 8° to 10°) towards the south and west. The south and west boundaries of the site form a steep cliff face (up to approximately 20° to 25°) with sandstone outcrops.

Lot B is bound by Hill View Crescent and Bert Close to the north, Forest Road to the south, residential buildings to the east, Lot 1 to the north-west and by bushland to the west. The site is located in an undulating topographic setting that generally falls to the north-east.

At the time of the investigation the area to the north of Lot 1 was occupied by two brick buildings and a metal shed with an access road from Jubilee Avenue. Two rows of eighteen glasshouses were present to the south of the access road. Each glasshouse covered an area of approximately 112m^2. The area to the south of the glasshouses was occupied by two metal sheds with a chicken coup. The west, south and east boundaries of the site were vegetated with moderate to dense undergrowth, shrubs and medium to large trees. A two storey brick building was located to the south-west of the site.

The area to the north of Lot B was occupied by a timber building. The centre section of the site was occupied by a two storey brick building with a metal carport and awning. An access road was located from Forest Road to the building. The areas to the north-east, east and south of the site were vegetated with moderate to dense undergrowth, shrubs and medium to large trees.

3.2 Regional Geology and Hydrogeology

The 1:100,000 geological map of Sydney (Map 9130, 1:100,000 Department of Mineral Resources – 1983) indicates the site is located near the boundary of three geological profiles. The area to the west of the site is underlain by Hawkesbury Sandstone, with the Newport Formation to the east of the Hawkesbury Sandstone. The Newport Formation is predominantly sandstone with some shale. To the east of the site, in the vicinity of the creek the area is underlain by Quaternary alluvium, which consists of a mixture of sands and clays associated with creek line deposits.

Department of Infrastructure, Planning and Natural Resources (DIPNR) were researched for the investigation and indicated that one registered groundwater bores lie within 1km of the site. The details are summarised below:

Ref No	Approx. distance from site(m)	Approx. direction from site	Depth(m)	Registered Purpose
GW014463	950	North-west	1.5	Recreation

The stratigraphy of the site is expected to generally consist of alluvial clayey sandy soil overlying relatively shallow bedrock. Based on these conditions, groundwater is not considered to be a significant resource in the area.

3.2.1 Acid Sulfate Soil Risk Map

The acid sulfate soil risk maps indicate areas of high risk, low risk and no known occurrence of acid sulfate soils. The Acid Sulfate Soil Risk Map for Hornsby/Mona Vale (Acid Sulfate Soil Risk Map- 9130 S1 edition 1, December 1995, 1:25000, Department of Land and Soil Conservation) indicates that the site is located in an area of 'low probability' adjacent to Narrabeen Creek. The map indicates that there is a low possibility of occurrences of acid sulfate soils associated within soils at depths greater than 3m. Typical landform types consist of elevated alluvial plains and levees dominated by fluvial sediments, plains and dunes dominated by Aeolian soils and lacustrine and alluvial bottom sediments.

The majority of these landforms are not expected to contain acid sulfate soil materials. However, highly localised occurrences may be found and disturbance of these soil materials will result in an environmental risk that will vary with elevation and depth of disturbance.

4 SITE HISTORY ASSESSMENT

4.1 Aerial Photographs

Aerial photographs were reviewed as part of the assessment of the site history. The following information was obtained:

1930 - The photograph was of very poor quality. The site (Lot 1 & Lot B) and the immediate surrounds were located within a relatively large area of bushland. Narrabeen Creek was located to the north of Lot 1. A dirt track was located to the north of the site at the present location of Mona Vale Road.

1951 - The site and immediate surrounds appeared similar to the 1930 photograph. Numerous dirt tracks were located on Lot 1. The area to the east of the site was partially cleared. A dirt track was located to the north-east of the site at the present location of Jubilee Avenue.

1961 - Lot 1 was cleared and glasshouses existed over most of the site. Three rows of glasshouses were located at the centre of the site. A row of glasshouses was located to the west of the site. A large building was located on the south-west section of the site. Two small buildings were located on the north boundary. An unpaved access road ran from Jubilee Avenue to Lot 1. The area to the north of the Narrabeen Creek contained glasshouses. The area to the east of Lot 1 was vacant and cultivated. A small shed was located to the north-west section of Lot B. The area to the north and north-east of the site contained glasshouses.

1970 - Lot 1 and immediate surrounds appeared similar to the 1961 photograph. The north-west section of Lot B contained four small buildings surrounded by cultivated land. A dirt track was located at the present location of Forest Road. A dirt track ran from Forest Road to the buildings on site.

1978 - The site and immediate surrounds were similar to the 1970 photograph. The glasshouses located to the west of Lot 1 had been demolished.

1986 - The site and immediate surrounds were similar to the 1978 photograph. The glasshouses located to the north of Lot 1, adjacent to Narrabeen Creek had been demolished. Jubilee Avenue and Forest Road were paved.

1994 - The site and immediate surrounds were similar to the 1986 photograph. A large warehouse with a hardstand area was located to the north-east of Lot 1. The area to the east of Lot B contained buildings, access roads and gardens.

2002 - The glasshouses located on the south and west sections of Lot 1 had been demolished and the land was vacant. Lot B and immediate surrounds appeared similar to the 1994 photograph.

4.2 Land Title Search

A limited historical land title search is in progress on our behalf by the NSW Land Titles Office. The results of the search will be forwarded when received.

4.3 Council Records

A search of Development Application (DA) and Building Approval (BA) records/the property file held by Pittwater City Council is in progress and the results of the search will be forwarded when received.

4.4 WorkCover Database Records

A records search for underground storage tanks was undertaken on our behalf by WorkCover. The records did not indicate the existence of any licences for underground storage tanks at the site.

4.5 NSW EPA Records

A search of the NSW EPA on line database did not indicate the existence of any EPA notices for the site under section 58 of the Contaminated Land Management Act (1997).

4.6 Summary of Historical Site Use

The search of historical information has indicated the following:

- Aerial photographs indicate that Lot 1 has been used for agricultural and residential purposes since at least 1961 and Lot B has been used for residential purposes since at least 1970.
- There are no recorded notices listed on the NSW EPA register and WorkCover have no records of underground storage tank licenses issued for the site.

4.7 Potential Contamination Sources

4.7.1 General Contamination Processes

Contamination of surface and subsurface soils generally arises from previous land use that can include petroleum hydrocarbon and warehouse storage, manufacturing processes and pesticide and fertiliser usage. Imported fill soils may contain contaminants derived from unknown sources. Migration of contaminants can occur in permeable subsurface soil or fill materials and via man-made and natural drainage systems. The extent of contamination migration is dependent on the hydrogeological environment and the chemical and physical characteristics of the contaminants. Contamination migration in clayey soils can be expected to be limited, whilst sandy soils are conducive to greater spatial migration.

Backfill to service trenches can form contamination migration pathways via poorly compacted or permeable backfill. Backfill may also be contaminated.

The general history of contamination of sites in the Sydney region indicates that analysis for heavy metals including lead, copper and zinc should be incorporated in the schedule of laboratory testing. In addition screening tests should be performed on selected samples for polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCs), polychlorinated biphenyls (PCBs), petroleum hydrocarbons (TPH) and monocyclic aromatic hydrocarbons (BTEX).

4.7.2 Potential Site Specific Contamination

Potential contamination associated with agricultural activities (pesticides, fertilisers, insecticides etc.) and potentially contaminated uncontrolled fill material imported on-site are considered to be the main potential contamination sources. No obvious surrounding land use that would have significant potential for migration of contamination onto the site was identified.

4.8 Potential Receptors

The main potential contamination receptors are considered to include:

- Narrabeen Creek located adjacent to the north boundary of the site.
- Site visitors, workers and adjacent property owners, who may come into contact with contaminated soil and/or be exposed to contaminated dust arising from construction activity.
- Future site occupants.

4.9 Contaminant Laydown and Transport Mechanisms

At this site, mobile contaminants would be expected to move down to the rock surface and migrate laterally down-slope from the source. The movement of contaminants would be expected to be associated with groundwater flow and seepage at the top of the bedrock.

5 ASSESSMENT CRITERIA DEVELOPMENT

5.1 Regulatory Background

In 1997 the NSW Government introduced the *Contaminated Land Management Act, 1997* (CLM Act). This act, associated regulations, State Environmental Planning Policy (SEPP) No.55 – Remediation of Land (1998) and associated NSW EPA guidelines, were designed to provide uniform state-wide control of the management, investigation and remediation of contaminated land.

Prior to granting consent for any proposed rezoning or development, SEPP55 requires the consent authority to:

- consider whether the land is contaminated;
- consider whether the site is suitable, or if contaminated, can be made suitable by remediation, for the proposed land use;
- be satisfied that remediation works will be undertaken prior to use of the site for the proposed use.

Should the assessment indicate that the site poses a risk to human health or the environment, remediation of the site is required prior to commencement of the proposed development works. SEPP55 requires that the relevant local council be notified of all remediation works, whether or not development consent is required. Where development consent is not required, 30 days written notice of the proposed works must be provided to council. Details of validation of remediation work must also be submitted to Council within one month of completion of remediation works.

The consent authority may request that a site audit be undertaken during, or following the completion of the site assessment process. Under the terms of the CLM Act the NSW EPA Site Auditor Scheme was developed to provide a system of independent review for assessment reports. An accredited Contaminated Site Auditor is engaged to review reports prepared by suitably qualified consultants to ensure that the investigation has been undertaken in accordance with the guidelines and confirm that the sites are suitable for their intended use.

Section 59(2) of the CLM Act states that specific notation relating to contaminated land issues must be included on S.149 planning certificates prepared by Council where the land to which the certificate relates is:

- within an investigation or remediation area.
- subject to an investigation or remediation order by the EPA.
- the subject of a voluntary investigation or remediation proposal.
- the subject of a site audit statement.

Submission of contaminated site investigation and validation reports to council as part of rezoning or development application submissions may also result in notation of actual or potential site contamination on future S.149 certificates prepared for the site.

Section 60 of the CLM Act sets out a positive duty on an owner, or person whose activities cause contamination, to notify the EPA if they are aware that the contamination presents a significant risk of harm.

Off-site disposal of fill, contaminated material and excess soil/rock excavated as part of the proposed development works is regulated by the provisions of the Protection of the Environment Operations Act (POEO Act 1997) and associated regulations and guidelines including the *NSW EPA Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes* (1999). All materials should be classified in accordance with these guidelines prior to disposal.

Section 143 of the *Protection of the Environment Operations Act 1997* states that if waste is transported to a place that cannot lawfully be used as a waste facility for that waste, then the transporter and owner of the waste are each guilty of an offence. The transporter and owner of the waste have a duty to ensure that the waste is disposed of in an appropriate manner.

5.2 Soil Contaminant Threshold Concentrations

The soil investigation levels adopted for this investigation are derived from the NSW EPA document *Guidelines for the NSW Site Auditor Scheme (1998)* and the National

Environmental Protection Council document *National Environmental Protection (Assessment of Site Contamination) Measure 1999*. The contaminant thresholds listed below are levels at which further investigation and evaluation is required to assess whether the site is considered suitable for the proposed urban land use.

To accommodate the range of human and ecological exposure settings, a number of generic settings are used on which the Health based Investigation Levels (HILs) can be based. Four categories of HILs are adopted for urban site assessments. Contaminant levels for a standard residential site with gardens and accessible soil (Column A in Table A-1) are based on protection of a young child resident at the site. The remaining categories (Columns D to F) present alternative exposure settings where there is reduced access to soil or reduced exposure time. These categories include residential land use with limited soil access, recreational and public open space and commercial/industrial use. Where the proposed land use will include more than one land use category (eg. mixed residential/commercial development) the exposure setting of the most "sensitive" land use is adopted for the site.

Threshold concentrations for petroleum hydrocarbon contaminants including total petroleum hydrocarbons (TPH) and monocyclic aromatic hydrocarbon (BTEX) compounds have previously been established in the *NSW EPA Contaminated Sites: Guidelines for Assessing Service Station Sites* (1994) publication and this document is referenced in the 1998 Site Auditor Guidelines. Heavy fraction petroleum hydrocarbon aliphatic/aromatic component threshold concentrations have also been introduced in the *National Environmental Protection (Assessment of Site Contamination) Measure 1999* (NEPC Guidelines).

The urban interim Ecological Investigation Levels (EILs) are generic values based on phytotoxicity data for plant response to specific contaminants in a sandy loam matrix and are included in the contaminated site assessment where the proposed land use includes gardens and accessible soils.

5.2.1 Site Assessment Criteria for Soil Contaminants

The residential exposure setting has been adopted for this assessment and the appropriate soil criteria are listed in the following table:

Site Soil Assessment Criteria (mg/kg)			
Contaminant	**HIL Column A Exposure Setting**	**Guidelines for Assessing Service Station Sites (1994)**	**Ecological Investigation Levels**
Inorganics			
Arsenic (total)	100		20
Cadmium	20		3
Chromium (III)	12%		400
Copper	1000		100
Lead	300		600
Mercury (inorganic)	15		1
Nickel	600		60
Zinc	7000		200
Organic Contaminants			
TPH (C_6-C_9)		65	
TPH (C_{10}-C_{36})		1000	
Benzene		1	
Toluene		1.4	
Ethylbenzene		3.1	
Total Xylenes		14	
Total PAHs	20		
Benzo(a)pyrene	1		
Aldrin + Dieldrin	10		
Chlordane	50		
DDT+ DDD + DDE	200		
Heptachlor	10		
PCBs (Total)	10		

For the purpose of off-site disposal, the classification of soil into 'inert', 'solid', 'industrial' and 'hazardous' waste categories is defined by chemical contaminant criteria outlined in the *NSW EPA Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes - 1999*. These chemical contaminant criteria are summarised in Table A-2.

5.3 Evaluation of Soil Analysis Data and Contaminant Threshold Concentrations

Assessment of the soil analytical data using the soil contaminant threshold concentrations has been undertaken in accordance with the methodology outlined in the *National Environmental Protection (Assessment of Site Contamination) Measure (1999) Schedule 7(a) Soil Investigation Levels* and the statistical analysis methods outlined in the *NSW EPA Contaminated Sites Sampling Design Guidelines (1995)*.

The following criteria have been adopted for assessment of the analytical data:

- For a site to be considered suitable for the proposed land use the 95% Upper Confidence Limit (UCL) value of the arithmetic mean concentration of each contaminant should be less than the applicable contaminant threshold concentration.
- The relevance of localised elevated values must also be considered and should not be obscured by consideration only of the arithmetic mean of the results. The results must also meet the following criteria:
  - the standard deviation of the results must be less than 50% of the soil assessment criteria; and
  - no single value exceeds 250% of the relevant soil assessment criteria.

Where contamination results exceed the site criteria developed above a method of remediating the site is to physically and selectively remove the contamination hotspots from the site. This process should be continued until statistical analysis of the data meets the above criteria. Validation of the remediated site is generally required to demonstrate that the site is suitable for the proposed land use.

5.4 Acid Sulfate Soil

Acid sulfate soil (ASS) is the common term for naturally occurring soil and sediment that contains iron sulfides which, when exposed to oxygen generate sulfuric acid. These soils are formed from iron rich sediment and sulfate (found in seawater) in the presence of sulfate reducing bacteria and plentiful organic matter. These conditions are generally found in mangroves, salt marsh vegetation or tidal areas and at the bottom of coastal rivers and lakes. Disturbance and exposure to air of these sulfides, commonly through drainage or excavation, causes oxidation and the eventual production of sulfuric acid. This sulfuric acid can then drain into waterways through groundwater and surface flows. The impacts of acid drainage can include fish kills and cause disease, oyster damage and mortality, adverse impacts on soil structure and stability and damage to steel and concrete structures including bridge and building footings and corrosion of underground pipes.

The NSW government formed the Acid Sulfate Soils Management Advisory Committee (ASSMAC) in 1994 to coordinate a response to acid sulfate soil issues. In 1998 this group released the *Acid Sulfate Soil Manual* providing best practice advice for planning, assessment, management, laboratory methods, drainage, groundwater and the preparation of acid sulfate soil management plans.

These guidelines replaced the *NSW EPA Guidelines for Land Management in NSW Coastal Areas, Assessing and Managing Acid Sulfate Soils (1995)* and the *Acid Sulfate Soils, Assessment and Management Guidelines, NSW EPA, DUAP* and the *Acid Sulfate Soils Management Advisory Committee, Draft, November 1997.*

5.4.1 Assessment Guidelines and Criteria

Assessment of acid sulfate soil conditions and the impacts of the proposed development are based on information provided in the Acid Sulfate Soil Assessment Guidelines presented in the ASSMAC *Acid Sulfate Soil Manual* (1998). The guidelines include information on how to assess whether the site is likely to be within an acid sulfate soil area, whether an acid sulfate soil management plan should be prepared, and how to develop mitigation methods for the proposed development.

The assessment guidelines include recommendations for the density of sampling locations with the site. A minimum of four sampling locations should be undertaken for site with an area up to 1 Ha in size to assess development constraints. The sampling locations should include all areas where significant disturbance of soils will occur and/or areas with a high environmental sensitivity. In some instances more intensive sampling, at a density of 50m to 70m grid spacing may be necessary.

The depth of investigation should be at least one metre beyond the depth of proposed excavation/disturbance or estimated drop in watertable height, or to a minimum of two metres below existing ground level, whichever is greatest.

Standard methods for the laboratory analysis of samples are presented in the Laboratory Methods Guidelines presented in the ASSMAC *Acid Sulfate Soil Manual* (1998). The principle analytical methods are:

- TOS – Total Oxidisable Sulfur;
- POCAS – Peroxide Oxidation Combined Acidity and Sulfate.

POCAS testing provides a greater understanding of oxidisable sulfur content of the soil, particularly where the soil pH is less than 5.5 and is generally the preferred method.

The assessment guidelines include "action criteria" for the assessment of laboratory analysis results and provide trigger levels for the preparation of an acid sulfate soil management plan.

For developments where greater than 1000 tonnes of acid sulfate soil material will be disturbed the following "action criteria" apply for medium textured soils (5-40% soil is <0.002mm diameter):

- pH - less than 5.5
- Acid Trail Criteria: TPA/TSA (pH5.5) – greater than 18mol H^+/tonne.
- Sulfur Trail Criteria: S_{pos} – greater than 0.03% sulfur oxidisable.

Levels of oxidisable sulfur within a soil or sediment can indicate the risk to the environment if the soil is disturbed. For all soils with results greater than the "action criteria" a soil management plan must be developed to manage the potential harm to the environment. As a general rule the highest result from either the "acid trail" or "sulfur trail" should be used as the action criteria.

6 ASSESSMENT PLAN AND METHODOLOGY

The *NSW EPA Sampling Design Guidelines (1995)* for contaminated site investigations state a minimum of 95 evenly spaced sampling points should be undertaken for a site of this size (approximately 84,521m^2). A total of 29 sampling locations were undertaken for the Phase 1 preliminary investigation. This density is considered to be adequate for a preliminary investigation. Samples were obtained from the 13 geotechnical boreholes that were distributed relatively evenly over the site. An additional 16 locations (Ref Figure 3) were sampled from the glasshouses (composite samples with 2 sub-samples from each glasshouse) to target potential past use and spillage/contamination etc. associated with glasshouse agricultural production.

The 13 geotechnical boreholes were drilled on a relatively uniform grid with a spacing of up to 120m between sampling points. A systematic sampling plan was considered most appropriate for this investigation as:

- no specific potential contaminant sources were identified by the available site history (apart from the glasshouses described below).
- the distribution of contamination is expected to be associated with imported potentially contaminated fill material and is therefore likely to be random.

The 16 additional samples from the glasshouses were collected on a judgemental sampling plan with a spacing of up to 20m between sampling points (two locations per glasshouse). A judgemental sampling plan was considered most appropriate for the additional sampling as:

- specific potential contaminant source associated with agricultural activities in the glasshouses were identified by the available site history and site visit.

- the distribution of contamination is expected to be associated with the use of chemicals (fertilisers, pesticides, insecticides, etc) in the glasshouses and is therefore likely to be localised.

7 INVESTIGATION PROCEDURE

7.1 Subsurface Investigation and Soil Sampling Methods

Subsurface investigations were undertaken using a truck mounted hydraulically operated drill rig equipped with spiral flight augers. Soil samples were obtained from a Standard Penetration Test (SPT) sampler or directly from the auger when conditions did not allow use of the SPT sampler.

The SPT sampler was washed with phosphate free detergent and rinsed following each sampling event. The spiral flight augers were decontaminated using a scrubbing brush and potable water and Decon 90 solution (phosphate free detergent) followed by rinsing with potable water. Sampling personnel used disposable Nylex gloves during sampling activities.

Soil and rock samples were obtained at various depths, based on observations made during the field investigation. All samples were placed in glass jars with plastic caps and teflon seals with minimal headspace. During the investigation, samples were preserved by immediate storage in an insulated sample container with ice. Each sample was labelled with a unique job number, the sampling location, sampling depth and date. All samples were recorded on the borehole logs presented in Appendix A and on the chain of custody (COC) record presented in Appendix B.

On completion of the fieldwork, the samples were delivered in the insulated sample container to a NATA registered laboratory for analysis under standard chain of custody procedures. Detailed EIS field sampling protocols are included in Appendix D.

7.1.1 Photoionisation Detector (PID) Screening

A portable PID was used in this investigation to assist with selection of samples for laboratory hydrocarbon (TPH/BTEX) analysis. The PID is sensitive to volatile organic compounds. The sensitivity of the PID is dependent on the organic compound and varies for different mixtures of hydrocarbons. Some compounds give relatively high readings and some can be undetectable even though present in identical concentrations. The portable PID is best used semi-quantitatively to compare samples contaminated by the same hydrocarbon source.

The PID is calibrated before use by measurement of an isobutylene standard gas. All the PID measurements are quoted as parts per million (ppm) isobutylene equivalents.

Photoionisation detector (PID) screening of detectable volatile organic compounds (VOC) was undertaken on soil samples using the soil sample headspace method. VOC data was obtained from partly filled glass jar samples following equilibration of the headspace gases. The PID headspace data is included on the COC documents.

7.2 Laboratory Analysis

7.2.1 Soil Samples

Analysis of soil samples was undertaken by NATA registered laboratory using analytical methods detailed in the Schedule B(3) NEPC (1999) Guideline on Laboratory Analysis of Potentially Contaminated Soils. Laboratory analysis was undertaken by SGS Environmental Services Pty Ltd (NATA Accreditation No. 2562).

For this investigation selected soil samples were analysed for contaminants using the following laboratory techniques:

- Heavy metals – Nitric acid digestion. Analysis by ICP.
- Low level mercury – cold vapour AAS.
- OC/OP pesticides and PCBs – Extracted with acetone/hexane. Analysis by GC/ECD.
- PAHs – Soil extracted with dichloromethane/acetone. Analysis by GC/MS.
- TPH (volatile) – Soil extracted with methanol. Analysis by P&T GC/PID.
- TPH – Soil extracted with dichloromethane/acetone. Analysis by GC/FID.
- BTEX – Soil extracted with methanol. Analysis by P&T PID. Confirmed with column flame ionisation detection.
- Acid Sulphate Soil - Peroxide Oxidation-Combined Acidity and Sulfate (POCAS)

7.3 Composites

Composite samples were prepared in the laboratory from equal masses of near surface, similar soil type sub-samples from the glasshouses in order to provide economical screening for non-volatile heavy metals and organic pesticide contaminants. The assessment of contaminant concentrations must take into account the possibility that only one of the individual sub-samples forming the composite is contaminated. The maximum possible concentration is calculated by multiplying the composite result by the number of individual sub-samples in the composite. In the case of two sub-

samples forming the composite, the maximum potential concentration of any contaminant is two times the measured composite concentration.

8 RESULTS OF INVESTIGATION

8.1 Subsurface Conditions

Site details and borehole locations are shown on Figure 2. For details of the subsurface soil profile reference should be made to the borehole logs in Appendix A. A summary of the subsurface conditions encountered by the boreholes is presented below:

Topsoil

Topsoil was encountered in all boreholes except BH1, BH5, BH10 and BH11 to depths of approximately 0.2m to 0.5m. The silty sand topsoil was generally fine to medium grained and grey to dark grey. The topsoil generally contained traces of rootlets and sandstone gravel.

Fill

Fill was encountered in BH1, BH5 and BH11 to depths of approximately 0.1m to 3.9m. The gravely sandy fill was generally fine to medium grained and grey to grey brown. The fill generally contained sandstone and ironstone gravel and traces of clay fines.

Natural Soils

Natural soils were encountered in all the boreholes except BH12 (BH12 encountered fill directly overlying sandstone) to depths of approximately 1.0m to 6.0m. BH2, BH3, BH4, BH5, BH6, BH7, BH8 and BH9 encountered silty sand overlying clayey sand. The silty sand was generally fine to medium grained and light grey to orange brown. The clayey sand was generally fine to medium grained with medium plasticity clay and grey brown to light grey mottled red brown. BH1, BH10, BH11 and BH13 encountered clayey sand underlying the bedrock. The clayey sand was generally fine to medium grained with medium plasticity clay and brown mottled grey to orange mottled brown. The clayey sand in BH10 and BH13 contained ironstone gravel.

Bedrock

Sandstone bedrock was encountered in BH3, BH4, BH10 and BH12 at depths of approximately 0.2m to 3.1m. The sandstone was generally fine to medium

grained, extremely to distinctly weathered and light grey to red brown. The sandstone contained iron indurated bands.

Groundwater

Seepage was encountered in BH1, BH2, BH5, BH6 and BH7 during drilling to depths of approximately 4.0m to 5.0m. Seepage was not encountered in BH3, BH4, BH8, BH9, BH10, BH11, BH12 and BH13 during or after the completion of drilling. Standing water levels were recorded in BH5 and BH7 twenty four hours after completion of drilling at depths of approximately 4.0m to 5.5m.

8.2 Laboratory Results - Soil

The laboratory analysis results for soil samples are summarised in Table B to Table E inclusive and analysis reports are presented in Appendix B. The site soil assessment criteria for the investigation are specified in the "Site Assessment Criteria for Soil Contaminants" section earlier in this report. The results of the analyses are summarised below.

Sixteen composite glasshouse soil samples were prepared in the laboratory to provide economical screening for heavy metals and organic pesticide contaminants. Composite details are as follows:

- Composite 1 = GH1A (0.0-0.1m) & GH1B (0.0-0.1m)
- Composite 2 = GH2A (0.0-0.1m) & GH2B (0.0-0.1m)
- Composite 3 = GH3A (0.0-0.1m) & GH3B (0.0-0.1m)
- Composite 4 = GH4A (0.0-0.1m) & GH4B (0.0-0.1m)
- Composite 5 = GH5A (0.0-0.1m) & GH5B (0.0-0.1m)
- Composite 6 = GH6A (0.0-0.1m) & GH6B (0.0-0.1m)
- Composite 7 = GH7A (0.0-0.1m) & GH7B (0.0-0.1m)
- Composite 8 = GH8A (0.0-0.1m) & GH8B (0.0-0.1m)
- Composite 9 = GH9A (0.0-0.1m) & GH9B (0.0-0.1m)
- Composite 10 = GH10A (0.0-0.1m) & GH10B (0.0-0.1m)
- Composite 11 = GH11A (0.0-0.1m) & GH11B (0.0-0.1m)
- Composite 12 = GH12A (0.0-0.1m) & GH12B (0.0-0.1m)
- Composite 13 = GH13A (0.0-0.1m) & GH13B (0.0-0.1m)
- Composite 14 = GH14A (0.0-0.1m) & GH14B (0.0-0.1m)
- Composite 15 = GH15A (0.0-0.1m) & GH15B (0.0-0.1m)
- Composite 16 = GH16A (0.0-0.1m) & GH16B (0.0-0.1m)

Comparison of the composite sample results to guideline levels below is based on adjusting the guideline levels to reflect the composite nature of the samples.

Heavy Metals

Fourteen individual soil samples were analysed for heavy metals. The results of the analyses were below the site assessment criteria.

Sixteen composite soil samples were analysed for heavy metals. The results of the analyses were below the site assessment criteria.

Petroleum Hydrocarbons (TPH) and Monocyclic Aromatic Hydrocarbons (BTEX)

PID headspace readings on all samples screened for this investigation were zero. Fourteen individual soil samples were analysed for petroleum hydrocarbons and BTEX compounds. The results of the analyses were below the site assessment criteria.

Polycyclic Aromatic Hydrocarbons (PAHs)

Fourteen individual soil samples were analysed for a range of PAHs including Benzo(a)pyrene. The results of the analyses were below the site assessment criteria.

Organochlorine (OC) Pesticides and Organophosphate (OP) Pesticides

Fourteen individual soil samples were analysed for a range of OC pesticides. The results of the analyses were below the site assessment criteria.

Sixteen composite soil samples were analysed for a range of OC and OP pesticides. The results of the analysis were below the site assessment criteria.

Polychlorinated Biphenyls (PCBs)

Fourteen individual soil samples were analysed for a range of PCBs. The results of the analyses were below the site assessment criteria.

PID Screening - Volatile Organic Compounds (VOCs)

PID soil sample headspace readings were all zero ppm equivalent isobutylene. These results indicate a lack of PID detectable volatile organic contaminants.

Asbestos

Thirteen soil samples were analysed for asbestos. Sample BH9 (0.0m to 0.1m) was found to contain Chrysotile and Amosite asbestos.

Acid Sulphate Soil

Seven individual soil samples were analysed for acid sulfate soils (Peroxide Oxidation-Combined Acidity and Sulfate). The results of the analyses are summarised below:

Sample Location	Depth (metres)	Soil Type	pH_{KCl}	pH_{ox}	S_{POS} %w/w	TSA mol H^+/tonne	TPA mol H^+/tonne
BH1	5.5-6.0	Silty Sand	4.5	3.5	<0.005	12.2	48.9
BH2	2.5-3.0	Clayey Sand	4.5	3.8	<0.005	24.5	44.8
BH5	4.0-4.5	Clayey Sand	5.8	7.2	0.006	<10.2	<10.2
BH6	4.0-4.5	Clayey Sand	5.0	4.4	0.009	36.7	44.8
BH7	5.5-6.0	Clayey Sand	4.7	4.1	0.006	<10.2	40.8
BH9	4.0-4.5	Clayey Sand	4.3	3.5	0.008	25.0	59.1
BH13	4.0-4.5	Clayey Sand	4.6	4.1	0.009	<10.2	46.9

TSA results for samples BH2, BH6 and BH9 were greater than the 'action criteria' of 18molH^+/tonne soil. The TPA results for all the samples except BH5 were greater than the 'action criteria' of 18molH^+/tonne soil. The 'sulfur trail' results (S_{POS}%) for all samples were less than the 'action criteria' of 0.03%.

The results indicate that the soil is naturally acidic and is not considered to be caused by the sulfide content of the soil.

8.3 Assessment of Analytical QA/QC

The objective of the assessment of the laboratory QA/QC is to ensure that the sample data is reliable. All laboratory reports for project E19312F have been checked and issued as final by the following NATA Registered Laboratories unless stated otherwise:

- Laboratory — SGS Laboratories Pty Ltd
  NATA Accreditation No. 2562
  Report numbers: 36066, 36066A

Chain of custody documentation and/or sample receipt advice notices were signed and dated by SGS laboratory stating that all samples were received cool, in good order and in suitable containers. Compliance of holding times was met for all analyses undertaken by the above laboratory. EIS and laboratory QA/QC procedures for the site screening are summarised in the following table:

Contaminant	QA/QC Procedure				
	Total no. of Samples	Repeat Analysis	Matrix Spike	Lab Blank	Surrogate Spike
Heavy metals	30	2	2	2	-
TPH	14	1	1	1	-
BTEX	14	1	1	1	14
PAH	14	1	1	1	14
PCB	14	1	-	1	14
OC pesticides	30	2	2	2	30
OP pesticides	16	1	1	1	16
Asbestos	13	-	-	-	-
POCAS	7	1	-	1	-

The following comments are an overall summary of the quality of the analytical component of the project:

1. Sample integrity and container requirements were documented as satisfactory.
2. All sample and extraction and analyses were performed within the required holding times.
3. Matrix spike duplicate and surrogate recovery values indicated that the laboratory accuracy was very good, and that no outliers were reported.
4. All method blanks were found to be free of analyte concentrations above the PQLs.

The QA/QC data reported by SGS laboratory for the documented soil samples were assessed to be of sufficient quality to be considered acceptable for the environmental assessment of EIS project E19312F.

9 COMMENTS AND RECOMMENDATIONS

The preliminary environmental site screening undertaken for the proposed Sector 5 Warriewood Valley Urban Land Release at Jubilee Avenue and Forest Road, Warriewood, was designed to assess the suitability of the site for the proposed land use.

The proposed development consists of subdivision of the site into residential allotments and construction of one and two storey residential town-houses with carparks, access roads and gardens.

The site screening included performance of a site inspection, review of historical site use, including examination of regional aerial photographs and review of geology and groundwater conditions. Historical information and inspection of the site and surrounding areas did not indicate any obvious on-site or nearby off-site activity that could be expected to generate significant soil or groundwater contamination apart from potential contamination associated with agricultural activities (pesticides, fertilisers, insecticides etc). The site soil/fill sampling was subsequently undertaken on the basis of a relatively uniform exploration spacing apart from specific investigation in the vicinity of the glasshouses.

The results of the laboratory tests on selected soils samples covered a range of contaminants commonly encountered in the Sydney region. Elevated levels of contaminants were not detected in the samples analysed. All results were less than appropriate Health Investigation Levels.

Asbestos fibres were detected in a fill soil sample from BH9 (0.0m to 0.1m). Surface rubble was encountered at this location. There was no visual indication of the presence of asbestos in the fill soil sample. No fibre cement sheeting fragments were detected during inspection of the site during the geotechnical investigation. The detection of the asbestos fibres appeared to be an anomaly as all other asbestos results were negative (thirteen analyses in total). Further inspection by an asbestos specialist is recommended, together with additional surface soil sampling of the area surrounding the BH9 location to better assess the fill soil conditions. In the event that additional asbestos is encountered, a remedial strategy will be necessary for the site.

In order to assess the presence of actual or potential acid sulfate soil, Peroxide Oxidation-Combined Acidity and Sulfate (POCAS) analyses were undertaken on selected soil samples obtained during the investigation. Analyses of samples has indicated that there is a very low potential for the generation of actual acid sulfate conditions following the disturbance of the natural soils at the site. The acidic nature of the soil is not considered to be caused by the sulfide content of the soils. Preparation of an acid sulfate soil management plan is not considered necessary for the proposed development.

The acidic nature of the natural soils at the site should be taken into consideration when foundations are designed for the proposed development. Concrete that may come into contact with these soils (ie. building piled footings, floor slabs and driveway pavements) should be designed to resist acid and sulfate attack. Reference should be

made to the Cement and Concrete Association of Australia Technical Note TN57 for appropriate precautionary measure.

Further analysis of samples for waste classification will be required if off-site disposal of excess soil is undertaken as part of the proposed development. Fill and contaminated soil disposal costs are significant and may affect project viability. These costs should be assessed at an early stage of the project development to avoid significant future unexpected additional costs.

Groundwater was not encountered in most of the boreholes drilled for this project (to a maximum depth of 6m). Groundwater is not considered to be a significant resource in the area and on this basis has not been considered in any further detail for this screening.

The boreholes drilled for the investigation have enabled an assessment to be made of the existence of significant, large quantities of contaminated soils. The conclusions based on this investigation are that, while major contamination of the site is not apparent, problems may be encountered with smaller scale features between boreholes. EIS adopts no responsibility whatsoever for any problems such as underground storage tanks, buried items or contaminated material that may be encountered between sampling locations at the site. The proposed construction activities at the site should be planned on this basis, and any unexpected problem areas that are encountered between boreholes should be immediately inspected by experienced environmental personnel. This should ensure that such problems are dealt with in an appropriate manner, with minimal disruption to the project timetable and budget.

During demolition works, the site should be inspected by experienced environmental personnel to assess any unexpected conditions or subsurface facilities that may be discovered between investigation locations. This should facilitate appropriate adjustment of the works programme and schedule in relation to the changed site conditions.

Based on the scope of work undertaken, the site is considered to be suitable for the proposed development provided that a suitably qualified asbestos consultant inspects the site. Normal good engineering site management practice including control of run-off and dust suppression is recommended during earthworks and construction.

10 LIMITATIONS

The conclusions developed in this report are based on site conditions which existed at the time of the site assessment. They are based on investigation of conditions at specific locations, chosen to be as representative as possible under the given circumstances, and visual observations of the site and vicinity, together with the interpretation of available historical information and documents reviewed as described in this report.

Subsurface soil and rock conditions encountered between investigation locations may be found to be different from those expected. Groundwater conditions may also vary, especially after climatic changes.

Previous industrial use of this site may have involved excavation for the foundations of buildings, services, and similar facilities. In addition, unrecorded excavation and burial of material may have occurred on the site. Backfilling of excavations could have been undertaken with potentially contaminated material that may be discovered in discrete, isolated locations across the site during construction work.

During construction at the site, soil, fill and any unsuspected materials that are encountered should be monitored by qualified environmental and geotechnical engineers to confirm assumptions made on the basis of the limited investigation data, and possible changes in site level and other conditions since the investigation. Soil materials considered to be suitable from a geotechnical point of view may be unsatisfactory from a soil contamination viewpoint, and vice versa.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. Copyright in this report is the property of EIS. EIS has used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report.

Should you require any further information regarding the above, please do not hesitate to contact us.

Yours faithfully
For and on behalf of
ENVIRONMENTAL INVESTIGATION SERVICES

Vittal B.S.

Vittal Boggaram
Environmental Scientist

E H Fletcher
Principal Engineer

ABBREVIATIONS

AAS	Atomic Absorption Spectrometry
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment Conservation Council
B(a)P	Benzo(a)Pyrene
BH	Borehole
BTEX	Benzene, Toluene, Ethyl benzene, Xylene
COC	Chain of Custody documentation
DP	Deposited Plan
DQO	Data Quality Objective
EIL	Ecological Investigation Level
EPA NSW	Environment Protection Authority, New South Wales
GC-ECD	Gas Chromatograph-Electron Capture Detector
GC-FID	Gas Chromatograph-Flame Ionisation Detector
GC-MS	Gas Chromatograph-Mass Spectrometer
HIL	Health Based Investigation Level
HM	Heavy Metals
ICP-AES	Inductively Couple Plasma – Atomic Emission Spectra
NATA	National Association of Testing Authorities, Australia
NEPC	National Environmental Protection Council
NHMRC	National Health and Medical Research Council
OCPs	Organochlorine Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PID	Photoionisation Detector
PQL	Practical Quantitation Limit
P&T	Purge & Trap
RPD	Relative Percentage Difference
SWL	Standing Water Level
TP	Test Pit
TPH	Total Petroleum Hydrocarbons
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOC	Volatile Organic Compounds
UCL	Upper Confidence Limit

REFERENCE DOCUMENTS

- ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
- DUAP/NSW EPA (1998) Managing Land Contamination: Planning Guidelines SEPP 55 - Remediation of Land.
- NEPM (1999) National Environmental Protection (Assessment of Site Contamination) Measure (NEPC Guidelines).
- NSW EPA (1994) Contaminated Sites: Guidelines for Assessing Service Station Sites.
- NSW EPA (1995) Contaminated Sites: Sampling Design Guidelines.
- NSW EPA (1997) Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites.
- NSW EPA (1998) Contaminated Sites: Guidelines for the NSW Site Auditor Scheme.
- NSW EPA (1999) Contaminated Sites: Guidelines on Significant Risk of Harm and the Duty to Report.
- NSW EPA (1999) Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes.
- NSW Legislation (1997) Contaminated Land Management Act.
- NSW Legislation (1997) Protection of the Environment Operations Act No156 which includes Schedule 2 of the Clean Waters Regulations 1972 made under the Clean Waters Act (1970).

ENVIRONMENTAL INVESTIGATION SERVICES

IMPORTANT INFORMATION ABOUT YOUR ENVIRONMENTAL SITE ASSESSMENT

These notes have been prepared by Environmental Investigation Services (EIS) to assist with the assessment and interpretation of this assessment report.

An Environmental Assessment Report Is Based on a Unique Set of Project Specific Factors

This assessment report has been prepared in response to specific project requirements as stated in the EIS proposal document which may have been limited by instructions from the client. This report should be reviewed, and if necessary, revised if any of the following occur:

- the proposed land use is altered;
- the defined subject site is increased or subdivided;
- the proposed development details including size, configuration, location, orientation of the structures are modified;
- the proposed development levels are altered, eg addition of basement levels; or
- ownership of the site changes.

EIS/J&K will not accept any responsibility whatsoever for situations where one or more of the above factors have changed since completion of the assessment. If the subject site is sold, ownership of the assessment report should be transferred by EIS to the new site owners who will be informed of the conditions and limitations under which the assessment was undertaken. No person should apply an assessment for any purpose other than that originally intended without first conferring with the consultant.

Changes in Subsurface Conditions

Subsurface conditions are influenced by natural geological and hydrogeological process and human activities. Groundwater conditions are likely to vary over time with changes in climatic conditions and human activities within the catchment (eg. water extraction for irrigation or industrial uses, subsurface waste water disposal, construction related dewatering). Soil and groundwater contaminant concentrations may also vary over time through contaminant migration, natural attenuation of organic contaminants, ongoing contaminating activities and placement or removal of fill material. The conclusions of an assessment report may have been affected by the above factors if a significant period of time has elapsed prior to commencement of the proposed development.

This Assessment Is Based on Professional Interpretations of Factual Data

Site assessments identify actual subsurface conditions at the actual sampling locations at the time of the investigation. Data obtained from the sampling and subsequent laboratory analyses, available site history information and published regional information is interpreted by geologists, engineers or environmental scientists and opinions are drawn about the overall subsurface conditions, the nature and extent of contamination, the likely impact on the proposed development and appropriate remediation measures. Actual conditions may differ from those inferred, because no professional, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not

Principal : E H Fletcher BSc (Eng) ME CPE
39 BUFFALO ROAD GLADESVILLE NSW 2111 TELEPHONE: (02) 9809 7322 (02) 9807 0200 FAX: (02) 9809 7626
EIS IS A DIVISION OF JEFFERY & KATAUSKAS PTY LTD A.B.N 17 003 550 801 A.C.N 003 550 801
Principals: B F Walker BE DIC MSc P Stubbs BSc MIEAust D Treweek Dip Tech

TABLE A-1
ENVIRONMENTAL AND HEALTH-BASED SOIL INVESTIGATION LEVELS (mg/kg)

Substances	Health Investigation Levels (HILs)[1]				Interim Urban Ecological Investigation Levels (EILs)[1]	NSW EPA Guidelines for Assessing Service Station Sites[2]	Back-ground Ranges[1]
	A	D	E	F			
	'Standard' residential with garden/ accessible soil (home-grown produce contributing less than 10% of vegetable and fruit intake; no poultry); includes children's day-care centres, kindergartens, preschools and primary schools	Residential with minimal opportunities for soil access: includes dwellings with fully and permanently paved yard space such as high-rise apartments and flats	Parks, recreational open space and playing fields: includes secondary schools	Commercial/Industrial: includes premises such as shops and offices as well as factories and industrial sites			
METALS/METALLOIDS							
Arsenic (total)	100	400	200	500	20		1-50
Barium					300		100-3000
Beryllium	20	80	40	100			
Cadmium	20	80	40	100	3		1
Chromium(III)	12%	48%	24%	60%	400		
Chromium(VI)	100	400	200	500	1		
Chromium (total)							5-1000
Cobalt	100	400	200	500			1-40
Copper	1000	4000	2000	5000	100		2-100
Lead	300	1200	600	1500	600		2-200
Manganese	1500	6000	3000	7500	500		850
Methyl mercury	10	40	20	50			
Mercury (inorganic)	15	60	30	75	1		0.03
Nickel	600	2400	600	3000	60		5-500
Vanadium					50		20-500
Zinc	7000	28000	14000	35000	200		10-300
ORGANICS							
Aldrin + Dieldrin	10	40	20	50			
Chlordane	50	200	100	250			
DDT + DDD + DDE	200	800	400	1000			
Heptachlor	10	40	20	50			
Polycyclic aromatic hydrocarbons (PAHs)	20	80	40	100			
Benzo(a)pyrene	1	4	2	5			
Phenol	8500	34000	17000	42500			
PCBs (total)	10	40	20	50			
Petroleum Hydrocarbon Components (constituents):							
>C16 - C35 Aromatics	90	360	180	450			
>C16 - C35 Aliphatics	5600	22400	11200	28000			
>C35 Aliphatics	56000	224000	112000	280000			
C6-C9						65	
C10-C40						1000	
Benzene						1	
Toluene						1.4	
Ethyl Benzene						3.1	
Total Xylenes						14	
OTHER							
Boron	3000	12000	6000	15000			
Cyanides (complexed)	500	2000	1000	2500			
Cyanides (free)	250	1000	500	1250			
Phosphorus					2000		
Sulfur					600		
Sulfate					2000		

Reference should be made to the following guidelines for further details (as referenced in the above table):

1 National Environment Protection (Assessment of Site Contamination) Measure - 1999, National Environment Protection Council. Human exposure settings based on land use have been established for HILs and details are outlined in Taylor and Langley 1998.

2 NSW EPA Guidelines for Assessing Service station Sites - 1994.

TABLE B
SUMMARY OF LABORATORY TEST DATA
HEAVY METALS - SOILS
All data in mg/kg unless stated otherwise

ANALYTE	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
PQL - SGS	3	0.5	0.5	0.5	2	0.05	0.2	0.5
Guideline concentration-HIL *	100	20	12%	1000	300	15	600	7000
Guideline concentration -EIL *	20	3	400	100	600	1	60	200
SAMPLE (Depth in metres)								
BH1 (0.0-0.1)	LPQL	LPQL	1	LPQL	LPQL	LPQL	0.2	4
BH1 (1.2-1.5)	LPQL	LPQL	2	LPQL	2	LPQL	0.3	4
BH2 (0.0-0.1)	LPQL	LPQL	3	24	20	LPQL	1	56
BH3 (0.0-0.1)	LPQL	LPQL	6	4	17	0.1	0.8	37
BH4 (0.0-0.1)	LPQL	LPQL	3	9	44	LPQL	1	80
BH5 (0.0-0.1)	LPQL	LPQL	10	8	12	LPQL	11	130
BH6 (0.0-1.0)	LPQL	LPQL	10	36	38	0.1	4	***250***
BH7 (0.0-0.1)	LPQL	LPQL	2	9	27	LPQL	0.9	49
BH8 (0.0-0.1)	LPQL	LPQL	LPQL	0.9	LPQL	LPQL	0.3	5
BH9 (0.5-0.9)	LPQL	LPQL	8	***100***	86	LPQL	5	***330***
BH10 (0.0-0.1)	LPQL	LPQL	22	15	11	LPQL	50	44
BH11 (0.0-0.1)	LPQL	LPQL	35	38	15	LPQL	***120***	67
BH12 (0.0-0.1)	LPQL	LPQL	8	1	7	LPQL	3	8
BH13 (0.0-0.1)	LPQL	LPQL	4	8	23	LPQL	2	40
Total no. of samples	14	14	14	14	14	14	14	14
Maximum Value	0	0	35	100	86	0.1	120	330
Mean Value	NA	NA	9	21	25	0	14	79

EXPLANATION:
*: National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC Guidelines)
HIL - Column A, Residential with accessible soils
EIL - Interim Urban Ecological Investigation Levels (EILs)

Concentration above HIL **100**
Concentration above EIL ***100***

PQL: Practical Quantitation Limit
NA: Not Analysed

NOTE: Statistical analysis only shown where appropriate.

TABLE B-1
SUMMARY OF LABORATORY TEST DATA
HEAVY METALS - GLASSHOUSE SOILS
All data in mg/kg unless stated otherwise

ANALYTE	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
PQL - SGS	3	0.5	0.5	0.5	2	0.05	0.2	0.5
Guideline concentration-HIL *	100	20	12%	1000	300	15	600	7000
Guideline concentration -EIL *	20	3	400	100	600	1	60	200
SAMPLE (Depth in metres)								
Composite 1	LPQL	LPQL	9	62	28	LPQL	5	84
Composite 2	LPQL	LPQL	11	51	26	LPQL	5	98
Composite 3	LPQL	LPQL	10	59	26	LPQL	6	120
Composite 4	LPQL	LPQL	9	69	27	LPQL	6	120
Composite 5	LPQL	LPQL	10	66	33	0.05	6	130
Composite 6	LPQL	LPQL	13	58	25	0.06	5	110
Composite 7	LPQL	LPQL	12	56	23	0.05	5	96
Composite 8	LPQL	LPQL	11	77	30	LPQL	5	120
Composite 9	LPQL	LPQL	12	59	28	0.06	4	110
Composite 10	LPQL	LPQL	4	72	32	LPQL	2	***250***
Composite 11	LPQL	LPQL	3	40	18	LPQL	1	89
Composite 12	LPQL	LPQL	13	87	30	0.07	6	160
Composite 13	LPQL	LPQL	11	78	27	0.05	5	120
Composite 14	LPQL	LPQL	11	60	25	0.08	4	130
Composite 15	LPQL	LPQL	11	72	22	LPQL	5	120
Composite 16	LPQL	LPQL	12	68	21	0.05	5	94
Total no. of samples	16	16	16	16	16	16	16	16
Maximum Value	0	0	13	87	33	0.08	6	250
Mean Value	NA	NA	10	65	26	0	5	122

EXPLANATION:
*: National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC Guidelines)
HIL - Column A, Residential with accessible soils
EIL - Interim Urban Ecological Investigation Levels (EILs)

Concentration above HIL **100**
Concentration above EIL ***100***

PQL: Practical Quantitation Limit
LPQL: Less than PQL
NA: Not Analysed
NOTE: Statistical analysis only shown where appropriate.

Composite 1 = GH1A (0.0-0.1m) & GH1B (0.0-0.1m)
Composite 2 = GH2A (0.0-0.1m) & GH2B (0.0-0.1m)
Composite 3 = GH3A (0.0-0.1m) & GH3B (0.0-0.1m)
Composite 4 = GH4A (0.0-0.1m) & GH4B (0.0-0.1m)
Composite 5 = GH5A (0.0-0.1m) & GH5B (0.0-0.1m)
Composite 6 = GH6A (0.0-0.1m) & GH6B (0.0-0.1m)
Composite 7 = GH7A (0.0-0.1m) & GH7B (0.0-0.1m)
Composite 8 = GH8A (0.0-0.1m) & GH8B (0.0-0.1m)
Composite 9 = GH9A (0.0-0.1m) & GH9B (0.0-0.1m)
Composite 10 = GH10A (0.0-0.1m) & GH10B (0.0-0.1m)
Composite 11 = GH11A (0.0-0.1m) & GH11B (0.0-0.1m)
Composite 12 = GH12A (0.0-0.1m) & GH12B (0.0-0.1m)
Composite 13 = GH13A (0.0-0.1m) & GH13B (0.0-0.1m)
Composite 14 = GH14A (0.0-0.1m) & GH14B (0.0-0.1m)
Composite 15 = GH15A (0.0-0.1m) & GH15B (0.0-0.1m)
Composite 16 = GH16A (0.0-0.1m) & GH16B (0.0-0.1m)

TABLE C
SUMMARY OF LABORATORY TEST DATA
ORGANICS - SOILS
All data in mg/kg unless stated otherwise

ORGANICS	Total PAHs	B(a)P	Aldin and Dieldrin	Chlordane	DDT & DDD & DDE	Heptachlor	PCBs
PQL - SGS	-	0.05	0.1	0.1	0.1	0.1	0.1
Guideline concentration *	20	1	10	50	200	10	10
SAMPLE							
BH1 (0.0-0.1)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH1 (1.2-1.5)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH2 (0.0-0.1)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH3 (0.0-0.1)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH4 (0.0-0.1)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH5 (0.0-0.1)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH6 (0.0-1.0)	0	LPQL	LPQL	LPQL	0.9	LPQL	LPQL
BH7 (0.0-0.1)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH8 (0.0-0.1)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH9 (0.5-0.9)	0	LPQL	LPQL	LPQL	1.4	LPQL	LPQL
BH10 (0.0-0.1)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH11 (0.0-0.1)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH12 (0.0-0.1)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH13 (0.0-0.1)	0	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
Total no. of samples	14	14	14	14	14	14	14
Maximum Value	0	0	0	0	1.4	0	0

EXPLANATION:

*: National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC Guidelines) Column A, Residential with accessible soils

Concentration above guideline level

ABBREVIATIONS:

PCBs: Polychlorinated Biphenyls
PAH: Polycyclic aromatic hydrocarbons
B(a)P: Benzo(a)pyrene
PQL: Practical Quantitation Limit
LPQL: Less than PQL
NOTE: Statistical analysis only shown where appropriate

TABLE C-1
SUMMARY OF LABORATORY TEST DATA
ORGANICS - GLASSHOUSE SOILS
All data in mg/kg unless stated otherwise

ORGANICS	OP Pesticides	Aldin and Dieldrin	Chlordane	DDT & DDD & DDE	Heptachlor
PQL - SGS	0.1	0.1	0.1	0.1	0.1
Guideline concentration *	-	10	50	200	10
SAMPLE					
Composite 1	LPQL	LPQL	LPQL	2	LPQL
Composite 2	LPQL	LPQL	LPQL	1.7	LPQL
Composite 3	LPQL	LPQL	LPQL	2.9	LPQL
Composite 4	LPQL	LPQL	LPQL	2.1	LPQL
Composite 5	LPQL	LPQL	LPQL	2.7	LPQL
Composite 6	LPQL	LPQL	LPQL	1.6	LPQL
Composite 7	LPQL	LPQL	LPQL	1.9	LPQL
Composite 8	LPQL	LPQL	LPQL	1.9	LPQL
Composite 9	LPQL	LPQL	LPQL	2.6	LPQL
Composite 10	LPQL	LPQL	LPQL	0.4	LPQL
Composite 11	LPQL	LPQL	LPQL	LPQL	LPQL
Composite 12	LPQL	LPQL	LPQL	2.1	LPQL
Composite 13	LPQL	LPQL	LPQL	2.8	LPQL
Composite 14	LPQL	LPQL	LPQL	2.4	LPQL
Composite 15	LPQL	LPQL	LPQL	1.2	LPQL
Composite 16	LPQL	LPQL	LPQL	0.8	LPQL
Total no. of samples	16	16	16	16	16
Maximum Value	0	0	0	2.9	0
Mean Value	NA	NA	NA	1.94	NA

EXPLANATION:

*: National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC Guidelines) Column A, Residential with accessible soils

Concentration above guideline level

ABBREVIATIONS:
PCBs: Polychlorinated Biphenyls
PAH: Polycyclic aromatic hydrocarbons
B(a)P: Benzo(a)pyrene
PQL: Practical Quantitation Limit
LPQL: Less than PQL
NA: Not Analysed

Composite 1 = GH1A (0.0-0.1m) & GH1B (0.0-0.1m)
Composite 2 = GH2A (0.0-0.1m) & GH2B (0.0-0.1m)
Composite 3 = GH3A (0.0-0.1m) & GH3B (0.0-0.1m)
Composite 4 = GH4A (0.0-0.1m) & GH4B (0.0-0.1m)
Composite 5 = GH5A (0.0-0.1m) & GH5B (0.0-0.1m)
Composite 6 = GH6A (0.0-0.1m) & GH6B (0.0-0.1m)
Composite 7 = GH7A (0.0-0.1m) & GH7B (0.0-0.1m)
Composite 8 = GH8A (0.0-0.1m) & GH8B (0.0-0.1m)
Composite 9 = GH9A (0.0-0.1m) & GH9B (0.0-0.1m)
Composite 10 = GH10A (0.0-0.1m) & GH10B (0.0-0.1m)
Composite 11 = GH11A (0.0-0.1m) & GH11B (0.0-0.1m)
Composite 12 = GH12A (0.0-0.1m) & GH12B (0.0-0.1m)
Composite 13 = GH13A (0.0-0.1m) & GH13B (0.0-0.1m)
Composite 14 = GH14A (0.0-0.1m) & GH14B (0.0-0.1m)
Composite 15 = GH15A (0.0-0.1m) & GH15B (0.0-0.1m)
Composite 16 = GH16A (0.0-0.1m) & GH16B (0.0-0.1m)

TABLE D
SUMMARY OF LABORATORY TEST DATA
PETROLEUM HYDROCARBONS
All data in mg/kg unless stated otherwise

	PETROLEUM HYDROCARBONS								
	Total Petroleum Hydrocarbons				Benzene	Toluene	Ethyl Benzene	Total Xylenes	PID Reading
	C_6-C_9	C_{10}-C_{14}	C_{15}-C_{28}	C_{29}-C_{36}					
PQL - SGS	20	20	50	50	0.5	0.5	0.5	1.5	
Guideline concentration *	65		1000		1	1.4	3.1	14	
SAMPLE (Depth in metres)									
BH1 (0.0-0.1)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH1 (1.2-1.5)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH2 (0.0-0.1)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH3 (0.0-0.1)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH4 (0.0-0.1)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH5 (0.0-0.1)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH6 (0.0-1.0)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH7 (0.0-0.1)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH8 (0.0-0.1)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH9 (0.5-0.9)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH10 (0.0-0.1)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH11 (0.0-0.1)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH12 (0.0-0.1)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH13 (0.0-0.1)	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
Total no. of samples	14	14	14	14	14	14	14	14	14
Maximum Value	0	0	0	0	0	0	0	0	0

EXPLANATION:
* EPA Guidelines for Assessing Service Station Sites - 1994

Concentration above Guideline Level
Toluene guideline of 15.5mg/kg can be adopted as corrected value based on original data (ve de Plasse et al 1993)

PQL: Practical Quantitation Limit
LPQL: - Less than Practical QuantitationLimit
NOTE: Statistical analysis only shown where appropriate

TABLE E
SUMMARY OF LABORATORY TEST DATA
ACID SULFATE SOILS ANALYSIS (POCAS)

Location (sample depth, m)	Sample Description	pH_{KCL}	TAA pH 6.5	pH_{ox}	TPA pH 6.5	TSA pH 6.5	S_{POS} %w/w	Ca A %w/w	Mg A %w/w
BH1 (5.5-6.0)	Silty Sand	4.5	**36.7**	3.5	48.9	12.2	<0.005	<0.005	0.006
BH2 (2.5-3.0)	Clayey Sand	4.5	**20.4**	3.8	44.8	24.5	<0.005	<0.005	<0.005
BH5 (4.0-4.5)	Clayey Sand	5.8	10.2	7.2	<10.2	<10.2	0.006	0.04	0.012
BH6 (4.0-4.5)	Clayey Sand	5.0	<10.2	4.4	44.8	36.7	0.009	<0.005	<0.005
BH7 (5.5-6.0)	Clayey Sand	4.7	**42.8**	4.1	40.8	<10.2	0.006	<0.005	<0.005
BH9 (4.0-4.5)	Clayey Sand	4.3	**34.6**	3.5	59.1	25	0.008	<0.005	0.007
BH13 (4.0-4.5)	Clayey Sand	4.6	**42.8**	4.1	46.9	<10.2	0.009	0.005	<0.005

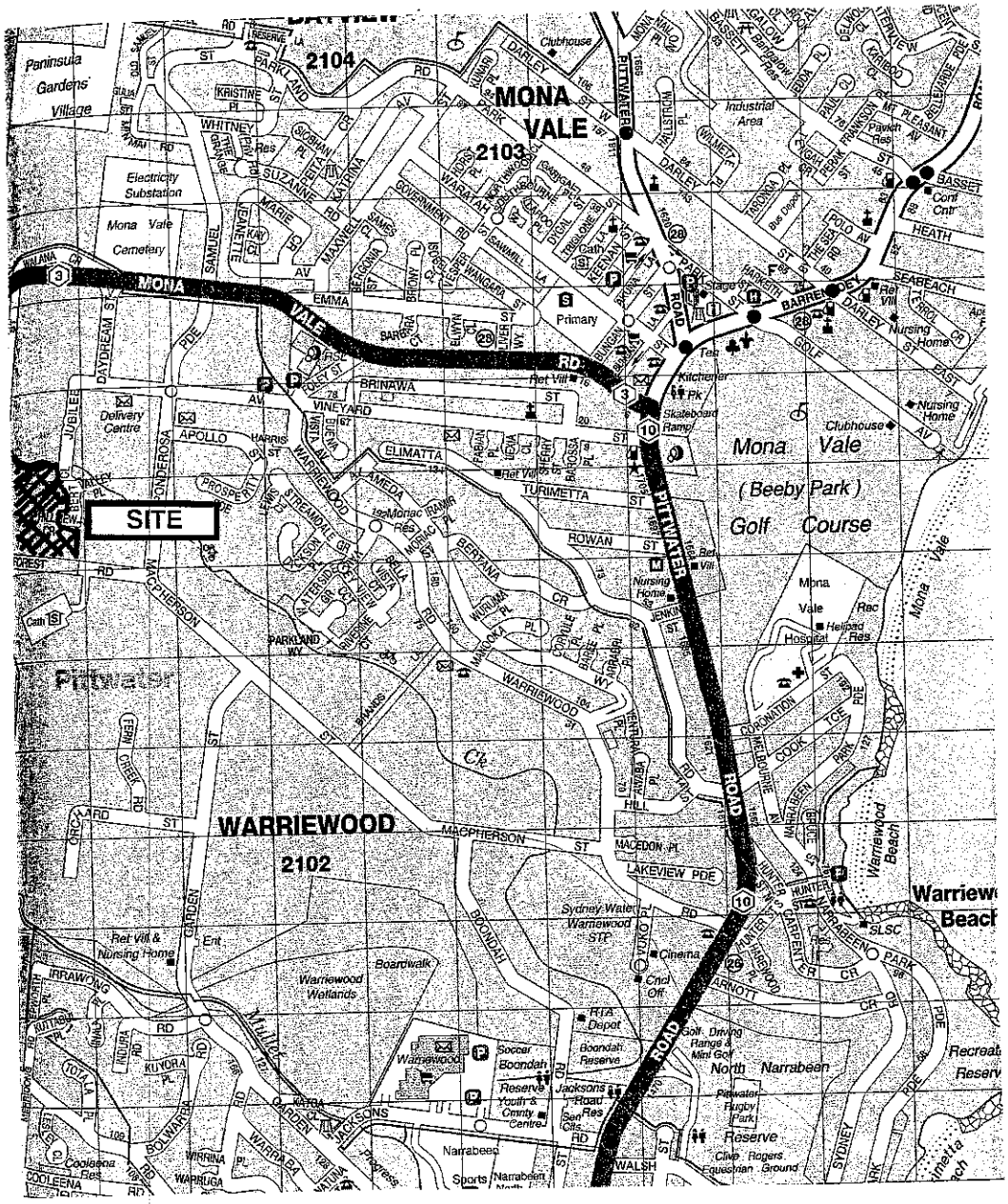
EXPLANATION:

TAA or S_{POS} % Values Exceeding Action Criteria | 20 |

Action criteria are defined as %S POS = 0.03 or 18mol H+/tonne for greater than 1000 tonnes disturbed material.

pH_{KCL} : pH of filtered 1:20, 1M KCL extract, shaken overnight
TAA pH 5.5 : Total Actual Acidity in 1M KCL extract titrated to pH5.5
pH_{ox} : pH filtered 1:20 1M KCl after peroxide digestion
TPA : Total Potential Acidity, 1M KCL peroxide digest titrated to pH5.5
TSA: Total Sulfide Acidity
S_{POS}: Peroxide oxidisable Sulfur (S_P - S_{KCL})
Ca A/Mg A/Na A: Calcium/Magnesium/Sodium reacted with acid generated by peroxide digest
Calcium and Magnesium values used to estimate additional Ca/Mg from acid-shell/carbonate/dolomite reaction

Reference: ASSMAC (Acid Sulfate Soils management Advisory Committee - **Acid Sulfate Soil Manual**, August 1998.



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N

SCALE (M)

0 1000m

Site Location Plan

Sector 5, Warriewood Valley Land Release

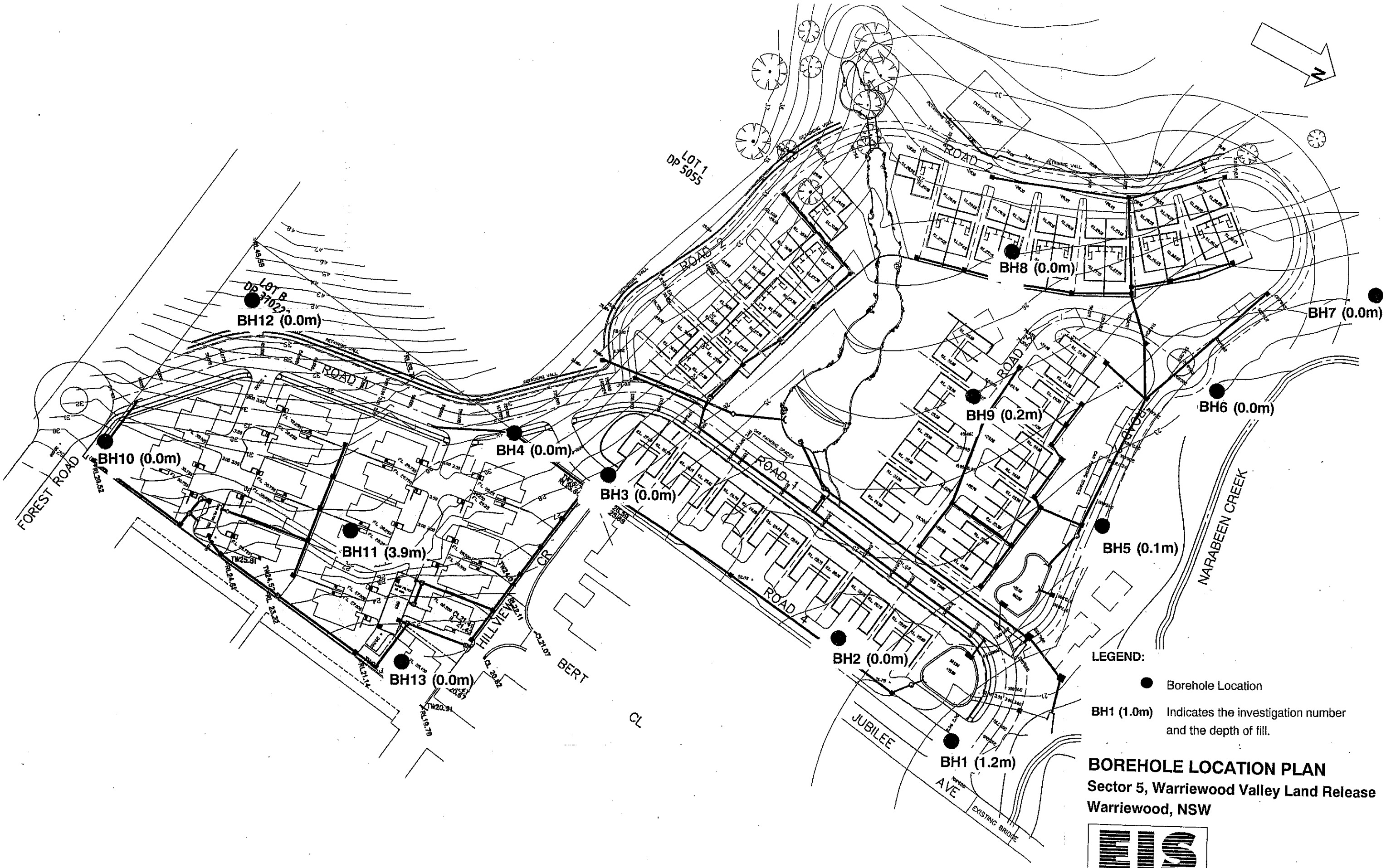
Warriewood, NSW

EIS

ENVIRONMENTAL INVESTIGATION SERVICES

Report No. E19312F

Figure: 1



SCALE

0 50m

NOTE: Reference should be made to the text for a full understanding of this plan.

LEGEND:

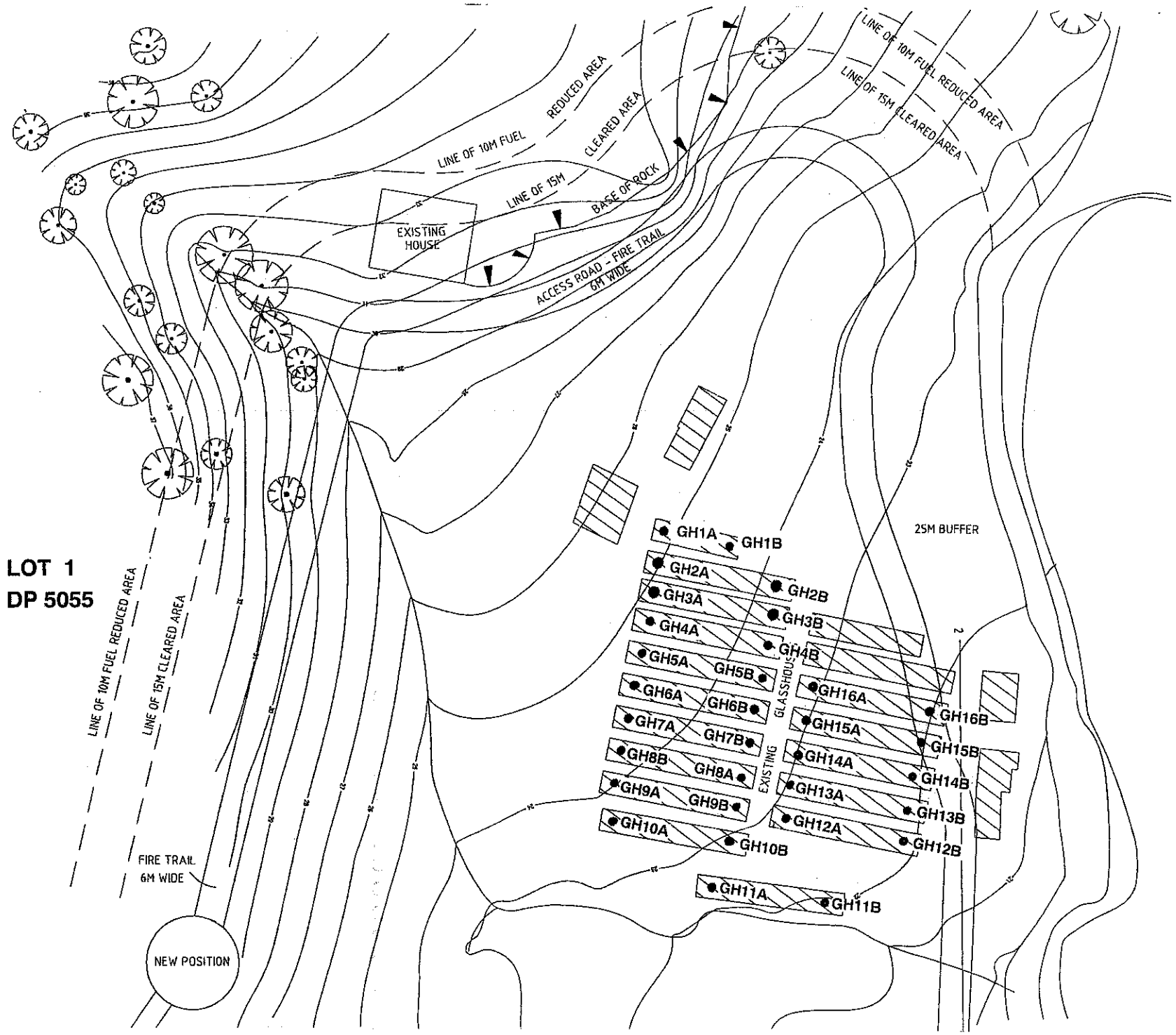
- ● Borehole Location
- **BH1 (1.0m)** Indicates the investigation number and the depth of fill.

BOREHOLE LOCATION PLAN

Sector 5, Warriewood Valley Land Release
Warriewood, NSW

EIS
ENVIRONMENTAL INVESTIGATION SERVICES

E19312F
Figure No. 2



NOTE: Reference should be made to the text for a full understanding of this plan.

SCALE (M)
0 50m

LEGEND:

● Sample Location

GH1A Indicates the investigation number

Composite 1 = GH1A (0.0-0.1m) & GH1B (0.0-0.1m)
Composite 2 = GH2A (0.0-0.1m) & GH2B (0.0-0.1m)
Composite 3 = GH3A (0.0-0.1m) & GH3B (0.0-0.1m)
Composite 4 = GH4A (0.0-0.1m) & GH4B (0.0-0.1m)
Composite 5 = GH5A (0.0-0.1m) & GH5B (0.0-0.1m)
Composite 6 = GH6A (0.0-0.1m) & GH6B (0.0-0.1m)
Composite 7 = GH7A (0.0-0.1m) & GH7B (0.0-0.1m)
Composite 8 = GH8A (0.0-0.1m) & GH8B (0.0-0.1m)
Composite 9 = GH9A (0.0-0.1m) & GH9B (0.0-0.1m)
Composite 10 = GH10A (0.0-0.1m) & GH10B (0.0-0.1m)
Composite 11 = GH11A (0.0-0.1m) & GH11B (0.0-0.1m)
Composite 12 = GH12A (0.0-0.1m) & GH12B (0.0-0.1m)
Composite 13 = GH13A (0.0-0.1m) & GH13B (0.0-0.1m)
Composite 14 = GH14A (0.0-0.1m) & GH14B (0.0-0.1m)
Composite 15 = GH15A (0.0-0.1m) & GH15B (0.0-0.1m)
Composite 16 = GH16A (0.0-0.1m) & GH16B (0.0-0.1m)

GLASSHOUSE SAMPLE LOCATION PLAN

Sector 5, Warriewood Valley Land Release
Warriewood, NSW

ENVIRONMENTAL INVESTIGATION SERVICES

E19312F
Figure No. 3

APPENDIX A

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 1 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 17-3-05
Method: SPIRAL AUGER JK550
R.L. Surface: ≈ 20.5m
Datum: AHD
Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Gravelly sand, fine to medium grained, grey brown, fine to coarse grained sandstone gravel.	D			GRASS COVER APPEARS MODERATELY COMPACTED
					N = 10 8,5,5	1							
					N = 8 2,3,5	2		SC	CLAYEY SAND: fine to medium grained, yellow brown.	M	L		ALLUVIAL
									as above, but orange brown mottled grey.		MD		
					N = 26 8,12,14	3							
						4				W	L		
					N = 5 3,2,3	5			as above, but grey.				
						6			END OF BOREHOLE AT 6.0m				
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **2** 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 21.6m

Date: 17-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			TOPSOIL: Sand, fine to medium grained, dark grey, with rootlets.	D			GRASS COVER
				■	N = 6 2,3,3			SP	SAND: fine to medium grained, grey brown.	M	L		ALLUVIAL
						1		SC	CLAYEY SAND: fine to medium grained, orange brown and grey.				
				■	N = 10 3,3,7	2							
								SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, medium plasticity, grey mottled orange brown.	M/ MC≈PL	MD/ H	420 450 510	
				■	N = 14 5,6,8	3							
						4		SC	CLAYEY SAND: fine to medium grained, grey mottled orange brown.	M	MD		
				■	N = 11 5,5,6			SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, medium plasticity, grey mottled orange brown.	W/ MC>PL	MD/ VSt	210 280 230	
						5							
						6			END OF BOREHOLE AT 6.0m				
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **3** 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 27.7m

Date: 17-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			TOPSOIL: Silty sand, fine to medium grained, dark grey, with rootlets.	D-M			GRASS COVER
								SM	SILTY SAND: fine to medium grained, with fine to coarse grained sandstone gravel and cobbles.	D-M	(L)		COLLUVIUM
					N = 11 3,4,7			CH	SILTY CLAY: high plasticity, grey mottled orange brown.	MC>PL	H	470 580 410	
						1		SC	CLAYEY SAND: fine to medium grained, grey mottled red brown.	M	(L)		RESIDUAL
					SPT 8/0mm REFUSAL			-	SANDSTONE: fine to medium grained, light grey, with iron indurated bands and clay bands.	XW-DW	EL-L		VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
						2							
						3							
						4							
						5			END OF BOREHOLE AT 4.5m				
						6							
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **4** 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 31.8m

Date: 17-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET-ION						0			TOPSOIL: Silty sand, fine to medium grained, dark grey, with rootlets.	D			GRASS COVER
								SM	SILTY SAND: fine to medium grained, grey, with fine to coarse grained sandstone gravel and sandstone cobbles.	M	(L)		COLLUVIUM
					N = 25 3,8,17			CL	SANDY CLAY: medium plasticity, light grey mottled red brown, with XW sandstone gravel.	MC≈PL	H	>600 >600	RESIDUAL
						1		-	SANDSTONE: fine to medium grained, grey mottled red brown, with clay and iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
									SANDSTONE: fine to medium grained, light grey mottled orange brown, with a trace of iron indurated bands.	XW-DW	EL-VL		VERY LOW TO LOW RESISTANCE
						4							VERY LOW RESISTANCE
									END OF BOREHOLE AT 4.5m				
						5							
						6							
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **5** 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 22.4m

Date: 17-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Gravelly sand, fine to coarse grained, grey, fine to medium grained igneous gravel.	M			
								SP	SAND: fine to medium grained, grey.	M	(L)		POSSIBLY FILL
					N = 4 2,2,2			SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, low plasticity, orange brown.	M/ MC≈PL	VL-L/ (St)		ALLUVIAL
						1							
					N = 12 2,6,6						MD/ VSt-H	470 350	
						2							
					N = 25 9,11,14	3						470 380 310	
ON COMPLETION						4				W/ MC>PL			
					N = 11 5,4,7				as above, but grey mottled orange brown.		MD/ VSt	210 310 380	
						5							
						6			END OF BOREHOLE AT 6.0m				
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 6 1/1

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 22.9m

Date: 17-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			TOPSOIL: Silty sand, fine to medium grained, grey, with rootlets.	M			WEED COVER
					N = 17 4,8,9			SP	SAND: fine to medium grained, grey.	M	MD		ALLUVIAL
						1		SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, low plasticity, orange brown.	M/ MC≈PL	MD/ H		
					N = 22 13,11,11							>600 >600	
						2							
						3					MD/ VSt -H	280 240 230	
					N = 12 7,5,7								
						4			as above, but grey mottled orange brown.	MC>PL/ W			
ON COMPLET-ION & AFTER 24 HRS					N = 11 3,6,5	5					MD/ St-VSt	160 300 220	
						6			END OF BOREHOLE AT 6.0m				
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 7
1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 17-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S./
R.L. Surface: ≈ 24.0m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			TOPSOIL: Silty sand, fine to medium grained, dark grey, with rootlets.	M			GRASS COVER
					N = 8 2,3,5			SP	SAND: fine to medium grained, light grey to grey.	M	L		ALLUVIAL
						1							
					N = 7 3,3,4			SC	CLAYEY SAND: fine to medium grained, dark grey to grey.				
						2							
					N = 18 4,7,11			CL/SC	SANDY CLAY/CLAYEY SAND: medium plasticity, fine to medium grained orange brown.	M/ MC≈PL	MD/ VSt	380 350 340	
						3							
						4						380 320 300	
					N = 16 8,9,7								
▼ ON COMPLETION & AFTER 24 HRS						5			as above, but dark grey to grey.	W/ MC>PL			SLIGHT ORGANIC ODOUR
						6			END OF BOREHOLE AT 6.0m				
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 8 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 27.0m

Date: 18-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET-ION						0			TOPSOIL: Silty sand, fine to medium grained, dark grey, with rootlets.	M			GRASS COVER
								SP	SAND: fine to medium grained, light grey.	M	(L)		COLLUVIUM
					N > 22 2,9, 13/100mm			SC	CLAYEY SAND: fine to medium grained, orange brown mottled grey, with XW sandstone gravel.	M	(MD)		
					REFUSAL	1		-	SANDSTONE BOULDER: fine to coarse grained, light grey mottled orange brown.	DW	VL-L		MODERATE 'TC' BIT RESISTANCE WITH LOW BANDS
								CL	SILTY CLAY: medium plasticity, light grey, with fine grained sand.	MC>PL	H		COLLUVIUM SOIL STRENGTH 'TC' RESISTANCE
					N = 14 4,6,8	3						440 520 480	
								CL	SANDY CLAY: medium plasticity, light grey, fine grained sand.		VSt -H		
					N = 19 5,8,11	5			as above, but orange brown mottled light grey.			430 370 480	
						6			END OF BOREHOLE AT 6.0m				
						7							

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BOREHOLE LOG

Borehole No. 9
1/1

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 18-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S.
R.L. Surface: ≈ 25.0m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET-ION						0			TOPSOIL/FILL: Silty sand, fine to medium grained, grey, with rootlets.	M			RUBBLE ON SURFACE
								SM	SILTY SAND: fine to medium grained, orange brown.	M	L		ALLUVIAL
					N = 5 2,2,3	1							
					N = 20 5,8,12	2		CL/SC	SANDY CLAY/CLAYEY SAND: medium plasticity, fine to medium grained, orange brown.	M/ MC>PL	MD/ VSt-H	380 380 400 390	
					N = 27 7,14,13	3					MD/ VSt	330 260 250	
						4			as above, but grey mottled orange brown.				
					N = 13 4,6,7	5					MD/H	530 450 430	
						6			END OF BOREHOLE AT 6.0m				
						7							

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Borehole No. **10** 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 30.5m

Date: 18-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET-ION						0		SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, medium plasticity, orange brown and red brown, with ironstone gravel bands.	M/ MC≈PL	MD/ (VSt)		DRIVEWAY GRAVEL ON SURFACE RESIDUAL
					N = 12 3,6,6	1							
					N = 25 7,9,16	2							
					N > 10 10,10/ 50mm REFUSAL	3		-	SANDSTONE: fine to medium grained, red brown, with iron indurated bands.	XW-DW	EL-VL		VERY LOW 'TC' BIT RESISTANCE
						4			END OF BOREHOLE AT 4.5m				
						5							
						6							
						7							

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Borehole No. 11 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK550 **R.L. Surface:** ≈ 29.6m

Date: 18-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			FILL: Sandy gravel, fine to medium grained, igneous, grey, fine to medium grained sand, with a trace of clay fines.	M-W			DRIVEWAY GRAVEL ON SURFACE
					N = 14 7,7,7	1			FILL: Sandy gravel, fine to medium grained, sandstone, grey, fine to medium grained sand, with a trace of clay fines.	M/ MC>PL			APPEARS MODERATELY COMPACTED
					N = 13 4,8,5				FILL: Clayey sand/sandy clay, fine to medium grained, medium plasticity, grey brown, with fine to coarse grained gravel.	M/ MC≈PL			
					N = 20 9,10,10	2							
						3							
					N = 42 12,17,25	4		CL/SC	SANDY CLAY/CLAYEY SAND: medium plasticity, fine to medium grained, red brown mottled light grey, with iron indurated bands.	M/ MC>PL	D/ H	>600 >600 >600	ALLUVIAL
						5			as above, but light grey mottled red brown.				
						6			END OF BOREHOLE AT 6.0m				
						7							

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Borehole No. **12** 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB
Date: 18-3-05
Method: SPIRAL AUGER JK550
Logged/Checked by: N.E.S./
R.L. Surface: ≈ 41.8m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET-ION						0			TOPSOIL: Silty sand, fine to medium grained, grey, with rootlets and fine to coarse grained sandstone gravel.	M			
								-	SANDSTONE: fine to coarse grained, red brown, with iron indurated bands.	DW	VL-L		LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
						1			SANDSTONE: fine to medium grained, light grey mottled red brown.		M-H		MODERATE TO HIGH RESISTANCE
						2			END OF BOREHOLE AT 2.0m				'TC' BIT REFUSAL
						3							
						4							
						5							
						6							
						7							

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Borehole No. 13 1/1

BOREHOLE LOG

Client: JUBILEE INVESTMENTS PTY LTD

Project: SECTOR 5, WARRIEWOOD VALLEY URBAN LAND RELEASE

Location: JUBILEE AVENUE AND FOREST ROAD, WARRIEWOOD, NSW

Job No. 19312VB **Method:** SPIRAL AUGER JK250 **R.L. Surface:** ≈ 22.0m

Date: 18-3-05 **Datum:** AHD

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET-ION						0			TOPSOIL: Silty sand, fine to medium grained, grey, with rootlets.	M			GRASS COVER
					N = 4 1,2,2	1		SC	CLAYEY SAND: fine to medium grained, orange brown.	M	VL-L		ALLUVIAL
					N = 11 3,5,6	2		SC/CL	CLAYEY SAND/SANDY CLAY: fine to medium grained, medium plasticity, orange brown, with ironstone gravel.	M/ MC>PL	MD/ VSt	330 220	
					N = 42 8,13,29	3			as above, but grey mottled red brown.			270 230	
					N = 50 10,24,26	4					D-VD/ H	>600 >600 >600	
						5							
						6			END OF BOREHOLE AT 6.0m				
						7							

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A.B.N. 17 003 550 801 A.C.N. 003 550 801

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the SAA Site Investigation Code. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the grading of other particles present (eg sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, "Shale" is used to describe thinly bedded to laminated siltstone.

SAMPLING

Sampling is carried out during drilling or from other excavations to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table. Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock fragments.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term "mud" encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

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

The test results are reported in the following form:

- In the case where full penetration is obtained with successive blow counts for each 150mm of, say, 4, 6 and 7 blows, as

  N = 13

  4, 6, 7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as

  N>30

  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

A modification to the SPT test is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as "N_c" on the borehole logs, together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

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

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

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

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole or "reverted" chemically if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after stabilising at intervals ranging from several days to perhaps weeks

for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg bricks, steel etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg to a twenty storey building). If this happens, the company will be pleased to review the report and the sufficiency of the investigation work.

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

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

If these occur, the company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed that at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

REVIEW OF DESIGN

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

The company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to
ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
iii) full time engineering presence on site.

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GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL


FILL


TOPSOIL


CLAY (CL, CH)


SILT (ML, MH)


SAND (SP, SW)


GRAVEL (GP, GW)


SANDY CLAY (CL, CH)


SILTY CLAY (CL, CH)


CLAYEY SAND (SC)


SILTY SAND (SM)


GRAVELLY CLAY (CL, CH)


CLAYEY GRAVEL (GC)


SANDY SILT (ML)


PEAT AND ORGANIC SOILS

ROCK


CONGLOMERATE


SANDSTONE


SHALE


SILTSTONE, MUDSTONE, CLAYSTONE


LIMESTONE


PHYLLITE, SCHIST


TUFF


GRANITE, GABBRO


DOLERITE, DIORITE


BASALT, ANDESITE


QUARTZITE

DEFECTS AND INCLUSIONS


CLAY SEAM


SHEARED OR CRUSHED SEAM


BRECCIATED OR SHATTERED SEAM/ZONE


IRONSTONE GRAVEL


ORGANIC MATERIAL

OTHER MATERIALS


CONCRETE


BITUMINOUS CONCRETE, COAL


COLLUVIUM

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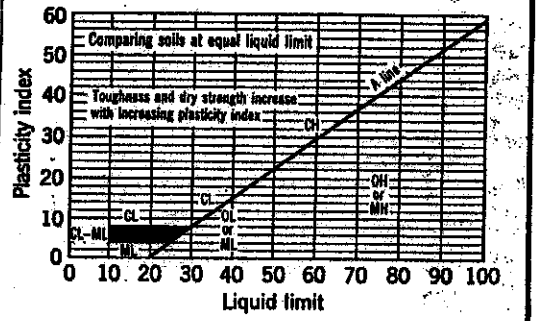
UNIFIED SOIL CLASSIFICATION TABLE

Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)				Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils: More than half of material is *larger* than 75 μm sieve size[b]	Gravels: More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows: Less than 5%: *GW, GP, SW, SP* More than 12%: *GM, GC, SM, SC* 5% to 12%: *Borderline* cases requiring use of dual symbols $C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for *GW* Atterberg limits below "A" line, or *PI* less than 4 Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols Atterberg limits above "A" line, with *PI* greater than 7
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		
	Sands: More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for *SW* Atterberg limits below "A" line or *PI* less than 5 Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols Atterberg limits below "A" line with *PI* greater than 7
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		
Fine-grained soils: More than half of material is *smaller* than 75 μm sieve size (The 75 μm sieve size is about the smallest particle visible to naked eye)	Identification Procedures on Fraction Smaller than 380 μm Sieve Size						
	Silts and clays: liquid limit less than 50	Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)			
		None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	
	Silts and clays: liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

NOTE: 1) Soils possessing characteristics of two groups are designated by combinations of group symbols (e.g. GW-GC, well graded gravel-sand mixture with clay fines).

2) Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

A.B.N. 17 003 550 801 A.C.N. 003 550 801

LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record	▼	Standing water level. Time delay following completion of drilling may be shown.
	C	Extent of borehole collapse shortly after drilling.
	▶	Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY - runs freely through fingers.
	M	MOIST - does not run freely but no free water visible on soil surface.
	W	WET - free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT - Unconfined compressive strength less than 25kPa
	S	SOFT - Unconfined compressive strength 25-50kPa
	F	FIRM - Unconfined compressive strength 50-100kPa
	St	STIFF - Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF - Unconfined compressive strength 200-400kPa
	H	HARD - Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** / **SPT 'N' Value Range (Blows/300mm)**
	VL	Very Loose <15 0-4
	L	Loose 15-35 4-10
	MD	Medium Dense 35-65 10-30
	D	Dense 65-85 30-50
	VD	Very Dense >85 >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

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LOG SYMBOLS

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL	0.03	Easily remoulded by hand to a material with soil properties.
Very Low:	VL	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable.
Low:	L	0.3	A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
Medium Strength:	M	1	A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
High:	H	3	A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
Very High:	VH	10	A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	

APPENDIX B

SGS

8 April 2005

TEST REPORT

Environmental Investigation Service
39 Buffalo Road
GLADESVILLE
NSW 2111

Your Reference: E19312F, Warriewood
Report Number: 36066

Attention: Vittal Boggaram

Dear Vittal
The following samples were received from you on the date indicated.

Samples: Qty.	96 Soils
Date of Receipt of Samples:	21/03/05
Date of Receipt of Instructions:	21/03/05
Date Preliminary Report Faxed:	06/04/05

These samples were analysed in accordance with your written instructions.
A copy of the instructions is attached with the analytical report.

The results and associated quality control are contained in the following pages of this report. Unless otherwise stated, solid samples are expressed on a dry weight basis (moisture has been supplied for your information only), air and liquid samples as received.

Should you have any queries regarding this report please contact the undersigned.

36066-27 Asbestos found in plaster fragments and loose in soil.
See attached POCAS.
Yours faithfully
SGS ENVIRONMENTAL SERVICES

Jacinta Hurst
Operations Manager

SGS Australia Pty Ltd
ABN 44 000 964 278
Environmental Services Botany Industrial Park Gate 3, Denison Street, Matraville 2036 NSW Australia
t +61 (0)2 9666 1426 f +61 (0)2 9666 1364 url www.sgs.com

BTEX in Soil Our Reference: Your Reference Sample Type Depth	UNITS --- ---	36066-1 BH1 soil 0.0-0.1	36066-4 BH1 soil 1.2-1.5	36066-5 BH2 soil 0.0-0.1	36066-8 BH3 soil 0.0-0.1	36066-11 BH4 soil 0.0-0.1
Benzene	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Toluene	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Ethylbenzene	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Total Xylenes	mg/kg	<1.5	<1.5	<1.5	<1.5	<1.5
Surrogate	%	98	98	96	97	99

BTEX in Soil Our Reference: Your Reference Sample Type Depth	UNITS --- ---	36066-14 BH5 soil 0.0-0.1	36066-18 BH6 soil 0.0-0.1	36066-21 BH7 soil 0.0-0.1	36066-24 BH8 soil 0.0-0.1	36066-26 BH9 soil 0.5-0.9
Benzene	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Toluene	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Ethylbenzene	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Total Xylenes	mg/kg	<1.5	<1.5	<1.5	<1.5	<1.5
Surrogate	%	93	94	93	101	95

BTEX in Soil Our Reference: Your Reference Sample Type Depth	UNITS --- ---	36066-29 BH10 soil 0.0-0.1	36066-32 BH11 soil 0.0-0.1	36066-39 BH12 soil 0.0-0.1	36066-42 BH13 soil 0.0-0.1
Benzene	mg/kg	<0.50	<0.50	<0.50	<0.50
Toluene	mg/kg	<0.50	<0.50	<0.50	<0.50
Ethylbenzene	mg/kg	<0.50	<0.50	<0.50	<0.50
Total Xylenes	mg/kg	<1.5	<1.5	<1.5	<1.5
Surrogate	%	93	94	97	93

Total Recoverable Hydrocarbons in Soil						
Our Reference:	UNITS	36066-1	36066-4	36066-5	36066-8	36066-11
Your Reference	----------	BH1	BH1	BH2	BH3	BH4
Sample Type	----------	soil	soil	soil	soil	soil
Depth		0.0-0.1	1.2-1.5	0.0-0.1	0.0-0.1	0.0-0.1
TRH C_6 - C_9 P&T	mg/kg	<20	<20	<20	<20	<20
TRH C_{10} - C_{14}	mg/kg	<20	<20	<20	<20	<20
TRH C_{15} - C_{28}	mg/kg	<50	<50	<50	<50	<50
TRH C_{29} - C_{36}	mg/kg	<50	<50	<50	<50	<50

Total Recoverable Hydrocarbons in Soil						
Our Reference:	UNITS	36066-14	36066-18	36066-21	36066-24	36066-26
Your Reference	----------	BH5	BH6	BH7	BH8	BH9
Sample Type	----------	soil	soil	soil	soil	soil
Depth		0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.5-0.9
TRH C_6 - C_9 P&T	mg/kg	<20	<20	<20	<20	<20
TRH C_{10} - C_{14}	mg/kg	<20	<20	<20	<20	<20
TRH C_{15} - C_{28}	mg/kg	<50	<50	<50	<50	<50
TRH C_{29} - C_{36}	mg/kg	<50	<50	<50	<50	<50

Total Recoverable Hydrocarbons in Soil					
Our Reference:	UNITS	36066-29	36066-32	36066-39	36066-42
Your Reference	----------	BH10	BH11	BH12	BH13
Sample Type	----------	soil	soil	soil	soil
Depth		0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1
TRH C_6 - C_9 P&T	mg/kg	<20	<20	<20	<20
TRH C_{10} - C_{14}	mg/kg	<20	<20	<20	<20
TRH C_{15} - C_{28}	mg/kg	<50	<50	<50	<50
TRH C_{29} - C_{36}	mg/kg	<50	<50	<50	<50

PAHs in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066-1 BH1 soil 0.0-0.1	36066-4 BH1 soil 1.2-1.5	36066-5 BH2 soil 0.0-0.1	36066-8 BH3 soil 0.0-0.1	36066-11 BH4 soil 0.0-0.1
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo[*a*]anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo[*b,k*]fluoranthene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo[*a*]pyrene	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Indeno[*123-cd*]pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo[*ah*]anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo[*ghi*]perylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Total +ve PAH's	mg/kg	0.00	0.00	0.00	0.00	0.00
Surrogate	%	99	103	108	106	108

PAHs in Soil Our Reference: Your Reference Sample Type Depth	UNITS --- ---	36066-14 BH5 soil 0.0-0.1	36066-18 BH6 soil 0.0-0.1	36066-21 BH7 soil 0.0-0.1	36066-24 BH8 soil 0.0-0.1	36066-26 BH9 soil 0.5-0.9
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo[*a*]anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo[*b,k*]fluoranthene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo[*a*]pyrene	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Indeno[*123-cd*]pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo[*ah*]anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo[*ghi*]perylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Total +ve PAH's	mg/kg	0.00	0.00	0.00	0.00	0.00
Surrogate	%	103	99	102	98	111

PAHs in Soil Our Reference: Your Reference Sample Type Depth	UNITS --- ---	36066-29 BH10 soil 0.0-0.1	36066-32 BH11 soil 0.0-0.1	36066-39 BH12 soil 0.0-0.1	36066-42 BH13 soil 0.0-0.1
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	<0.1	<0.1	<0.1	<0.1
Anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	<0.1	<0.1	<0.1	<0.1
Pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1
Benzo[*a*]anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1
Chrysene	mg/kg	<0.1	<0.1	<0.1	<0.1
Benzo[*b,k*]fluoranthene	mg/kg	<0.2	<0.2	<0.2	<0.2
Benzo[*a*]pyrene	mg/kg	<0.05	<0.05	<0.05	<0.05
Indeno[*123-cd*]pyrene	mg/kg	<0.1	<0.1	<0.1	<0.1
Dibenzo[*ah*]anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1
Benzo[*ghi*]perylene	mg/kg	<0.1	<0.1	<0.1	<0.1
Total +ve PAH's	mg/kg	0.00	0.00	0.00	0.00
Surrogate	%	115	105	112	94

OC Pesticides in Soil Our Reference: Your Reference Sample Type Depth	UNITS --- ---	36066-1 BH1 soil 0.0-0.1	36066-4 BH1 soil 1.2-1.5	36066-5 BH2 soil 0.0-0.1	36066-8 BH3 soil 0.0-0.1	36066-11 BH4 soil 0.0-0.1
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC(Lindane)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
trans-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
cis-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
trans-Nonachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Ketone	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate	%	120	118	120	114	112

OC Pesticides in Soil Our Reference: Your Reference Sample Type Depth	UNITS --- ---	36066-14 BH5 soil 0.0-0.1	36066-18 BH6 soil 0.0-0.1	36066-21 BH7 soil 0.0-0.1	36066-24 BH8 soil 0.0-0.1	36066-26 BH9 soil 0.5-0.9
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC(Lindane)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDE	mg/kg	<0.1	0.5	<0.1	<0.1	<0.1
alpha-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
trans-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	0.1
cis-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
trans-Nonachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	0.5
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1	0.1
beta-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	0.2
p,p'-DDT	mg/kg	<0.1	0.4	<0.1	<0.1	0.6
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Ketone	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate	%	124	122	122	124	129

OC Pesticides in Soil Our Reference: Your Reference Sample Type Depth	UNITS --- ---	36066-29 BH10 soil 0.0-0.1	36066-32 BH11 soil 0.0-0.1	36066-39 BH12 soil 0.0-0.1	36066-42 BH13 soil 0.0-0.1
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1
gamma-BHC(Lindane)	mg/kg	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1
o,p'-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1
alpha-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1
trans-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1
cis-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1
trans-Nonachlor	mg/kg	<0.1	<0.1	<0.1	<0.1
p,p'-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1
o,p'-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1
o,p'-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1
beta-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1
p,p'-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1
p,p'-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1
Endrin Ketone	mg/kg	<0.1	<0.1	<0.1	<0.1
Surrogate	%	125	119	123	124

PCBs in Soil Our Reference: Your Reference Sample Type Depth	UNITS --- ---	36066-1 BH1 soil 0.0-0.1	36066-4 BH1 soil 1.2-1.5	36066-5 BH2 soil 0.0-0.1	36066-8 BH3 soil 0.0-0.1	36066-11 BH4 soil 0.0-0.1
Arochlor 1016	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1221	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1232	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1242	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1248	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1254	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1260	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1262	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1268	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Total Positive PCB	mg/kg	<0.90	<0.90	<0.90	<0.90	<0.90
Surrogate	%	120	118	120	114	112

PCBs in Soil Our Reference: Your Reference Sample Type Depth	UNITS --- ---	36066-14 BH5 soil 0.0-0.1	36066-18 BH6 soil 0.0-0.1	36066-21 BH7 soil 0.0-0.1	36066-24 BH8 soil 0.0-0.1	36066-26 BH9 soil 0.5-0.9
Arochlor 1016	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1221	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1232	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1242	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1248	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1254	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1260	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1262	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Arochlor 1268	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Total Positive PCB	mg/kg	<0.90	<0.90	<0.90	<0.90	<0.90
Surrogate	%	124	122	122	124	129

PCBs in Soil Our Reference: Your Reference Sample Type Depth	UNITS --- ---	36066-29 BH10 soil 0.0-0.1	36066-32 BH11 soil 0.0-0.1	36066-39 BH12 soil 0.0-0.1	36066-42 BH13 soil 0.0-0.1
Arochlor 1016	mg/kg	<0.1	<0.1	<0.1	<0.1
Arochlor 1221	mg/kg	<0.1	<0.1	<0.1	<0.1
Arochlor 1232	mg/kg	<0.1	<0.1	<0.1	<0.1
Arochlor 1242	mg/kg	<0.1	<0.1	<0.1	<0.1
Arochlor 1248	mg/kg	<0.1	<0.1	<0.1	<0.1
Arochlor 1254	mg/kg	<0.1	<0.1	<0.1	<0.1
Arochlor 1260	mg/kg	<0.1	<0.1	<0.1	<0.1
Arochlor 1262	mg/kg	<0.1	<0.1	<0.1	<0.1
Arochlor 1268	mg/kg	<0.1	<0.1	<0.1	<0.1
Total Positive PCB	mg/kg	<0.90	<0.90	<0.90	<0.90
Surrogate	%	125	119	123	124

Acid Extractable Metals in Soil						
Our Reference:	UNITS	36066-1	36066-4	36066-5	36066-8	36066-11
Your Reference	----------	BH1	BH1	BH2	BH3	BH4
Sample Type	----------	soil	soil	soil	soil	soil
Depth		0.0-0.1	1.2-1.5	0.0-0.1	0.0-0.1	0.0-0.1
Arsenic	mg/kg	<3	<3	<3	<3	<3
Cadmium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	mg/kg	1	2	3	6	3
Copper	mg/kg	<0.5	<0.5	24	4	9
Lead	mg/kg	<2	2	20	17	44
Mercury	mg/kg	<0.05	<0.05	<0.05	0.10	<0.05
Nickel	mg/kg	0.2	0.3	1	0.8	1
Zinc	mg/kg	4	4	56	37	80

Acid Extractable Metals in Soil						
Our Reference:	UNITS	36066-14	36066-18	36066-21	36066-24	36066-26
Your Reference	----------	BH5	BH6	BH7	BH8	BH9
Sample Type	----------	soil	soil	soil	soil	soil
Depth		0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.5-0.9
Arsenic	mg/kg	<3	<3	<3	<3	<3
Cadmium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	mg/kg	10	10	2	<0.5	8
Copper	mg/kg	8	36	9	0.9	100
Lead	mg/kg	12	38	27	<2	86
Mercury	mg/kg	<0.05	0.10	<0.05	<0.05	<0.05
Nickel	mg/kg	11	4	0.9	0.3	5
Zinc	mg/kg	130	250	49	5	330

Acid Extractable Metals in Soil					
Our Reference:	UNITS	36066-29	36066-32	36066-39	36066-42
Your Reference	----------	BH10	BH11	BH12	BH13
Sample Type	----------	soil	soil	soil	soil
Depth		0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1
Arsenic	mg/kg	<3	<3	<3	<3
Cadmium	mg/kg	<0.5	<0.5	<0.5	<0.5
Chromium	mg/kg	22	35	8	4
Copper	mg/kg	15	38	1.0	8
Lead	mg/kg	11	15	7	23
Mercury	mg/kg	<0.05	<0.05	<0.05	<0.05
Nickel	mg/kg	50	120	3	2
Zinc	mg/kg	44	67	8	40

Asbestos						
Our Reference:	UNITS	36066-2	36066-6	36066-9	36066-12	36066-15
Your Reference	----------	BH1	BH2	BH3	BH4	BH5
Sample Type	----------	soil	soil	soil	soil	soil
Depth		0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1
Sample Description		20g Sand & Soil	20g Sand, Rocks & Plant Matter	20g Sand, Soil & Plant Matter	20g Sand, Soil & Plant Matter	20g Sand & Rocks
Asbestos ID in soil		No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected

Asbestos						
Our Reference:	UNITS	36066-19	36066-22	36066-27	36066-30	36066-33
Your Reference	----------	BH6	BH7	BH9	BH10	BH11
Sample Type	----------	soil	soil	soil	soil	soil
Depth		0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1
Sample Description		20g Sand & Rocks	20g Sand, Soil & Plant Matter	20g Sand, Soil & Rocks	20g Sand, Soil, Rocks & Plant Matter	20g Sand, Soil & Rocks
Asbestos ID in soil		No asbestos detected	No asbestos detected	Chrysotile asbestos detected Amosite asbestos detected	No asbestos detected	No asbestos detected

Asbestos				
Our Reference:	UNITS	36066-40	36066-43	36066-78
Your Reference	----------	BH12	BH13	BH8
Sample Type	----------	soil	soil	soil
Depth		0.0-0.1	0.0-0.1	0.0-0.1
Sample Description		20g Sand, Soil, Rocks & Plant Matter	20g Sand, Soil & Plant Matter	20g Sand, Soil, Rocks & Plant Matter
Asbestos ID in soil		No asbestos detected	No asbestos detected	No asbestos detected

POCAS and TPA						
Our Reference:	UNITS	36066-81	36066-83	36066-85	36066-87	36066-90
Your Reference	----------	BH1	BH2	BH5	BH6	BH7
Sample Type	----------	soil	soil	soil	soil	soil
Depth		5.5-6.0	2.5-3.0	4.0-4.5	4.0-4.5	5.5-6.0
POCAS		#	#	#	#	#

POCAS and TPA			
Our Reference:	UNITS	36066-91	36066-93
Your Reference	----------	BH9	BH13
Sample Type	----------	soil	soil
Depth		4.0-4.5	4.0-4.5
POCAS		#	#

Moisture						
Our Reference:	UNITS	36066-1	36066-4	36066-5	36066-8	36066-11
Your Reference	----------	BH1	BH1	BH2	BH3	BH4
Sample Type	----------	soil	soil	soil	soil	soil
Depth		0.0-0.1	1.2-1.5	0.0-0.1	0.0-0.1	0.0-0.1
Moisture	%	3.9	6.7	4.7	7.2	6.8

Moisture						
Our Reference:	UNITS	36066-14	36066-18	36066-21	36066-24	36066-26
Your Reference	----------	BH5	BH6	BH7	BH8	BH9
Sample Type	----------	soil	soil	soil	soil	soil
Depth		0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.5-0.9
Moisture	%	17	5.0	6.2	6.2	13

Moisture					
Our Reference:	UNITS	36066-29	36066-32	36066-39	36066-42
Your Reference	----------	BH10	BH11	BH12	BH13
Sample Type	----------	soil	soil	soil	soil
Depth		0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1
Moisture	%	8.7	7.3	8.9	16

Method ID	Methodology Summary
SEO-017	BTEX/TRH C6-C9 - Determination by Purge and Trap Gas Chromatography with Flame Ionisation Detection (FID) and Photo Ionisation Detection (PID). The surrogate spike used is aaa-trifluorotoluene.
SEO-020	TRH - Determination of Total Recoverable Hydrocarbons by gas chromatography following extraction with DCM/Acetone for solids and DCM for liquids.
SEO-030	PAHs by GC/MS - Determination of Polynuclear Aromatic Hydrocarbons (PAH's) by Gas Chromatography / Mass Spectrometry following extraction with dichloromethane or dichloromethane/acetone. The surrogate spike used is p-Terphenyl-d14.
SEO-005	OC/OP/PCB - Determination of a suite of Organchlorine Pesticides, Chlorinated Organo-phosphorus Pesticides and Polychlorinated Biphenyls (PCB's) by sonication extraction using dichloromethane for waters or acetone / hexane for soils followed by Gas Chromatographic separation with Electron Capture Detection (GC /ECD). The surrogate spike used is 2,4,5,6-Tetrachloro-m-xylene.
SEM-010	Metals - Determination of various metals by ICP-AES following aqua regia digest.
SEM-005	Mercury - Determination of Mercury by Cold Vapour Generation Atomic Absorption Spectroscopy.
SASB-002	Qualitative identification of asbestos type fibres in bulk using Polarised Light Microscopy and Dispersion Staining Techniques. Accreditation does not cover the identification of Synthetic Mineral Fibre.
Ext-002	Analysis subcontracted to SGS Environmental Cairns.
SEP-001	Air Dry - Cover air drying at 40 C, moisture content at 103 C - 105 C, wet slurrying, compositing and preparation of a 1:5 soil suspension.

QUALITY CONTROL BTEX in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Benzene	mg/kg	0.5	SEO-017	<0.50	36066-1	<0.50 || <0.50	Sand	84 || 87 || RPD: 4
Toluene	mg/kg	0.5	SEO-017	<0.50	36066-1	<0.50 || <0.50	Sand	85 || 87 || RPD: 2
Ethylbenzene	mg/kg	0.5	SEO-017	<0.50	36066-1	<0.50 || <0.50	Sand	81 || 87 || RPD: 7
Total Xylenes	mg/kg	1.5	SEO-017	<1.5	36066-1	<1.5 || <1.5	Sand	81 || 85 || RPD: 5
Surrogate	%		SEO-017	[NT]	36066-1	98 || 98 || RPD: 0	Sand	78 || 80 || RPD: 3
QUALITY CONTROL Total Recoverable Hydrocarbons in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
TRH C_6 - C_9 P&T	mg/kg	20	SEO-017	<20	36066-1	<20 || <20	Sand	83 || 85 || RPD: 2
TRH C_{10} - C_{14}	mg/kg	20	SEO-020	<20	36066-1	<20 || <20	Sand	73 || 87 || RPD: 18
TRH C_{15} - C_{28}	mg/kg	50	SEO-020	<50	36066-1	<50 || <50	Sand	82 || 92 || RPD: 11
TRH C_{29} - C_{36}	mg/kg	50	SEO-020	<50	36066-1	<50 || <50	Sand	132 || 132 || RPD: 0
QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Naphthalene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	107 || 106 || RPD: 1
Acenaphthylene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	104 || 101 || RPD: 3
Acenaphthene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	111 || 109 || RPD: 2
Fluorene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	[NT]
Phenanthrene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	80 || 83 || RPD: 4
Anthracene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	96 || 101 || RPD: 5
Fluoranthene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	107 || 108 || RPD: 1
Pyrene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	101 || 102 || RPD: 1
Benzo[*a*]anthracene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	[NT]
Chrysene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	[NT]
Benzo[*b,k*]fluoranthene	mg/kg	0.2	SEO-030	<0.2	36066-1	<0.2 || <0.2	Sand	[NT]
Benzo[*a*]pyrene	mg/kg	0.05	SEO-030	<0.05	36066-1	<0.05 || <0.05	Sand	114 || 113 || RPD: 1
Indeno[*123-cd*]pyrene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	[NT]
Dibenzo[*ah*]anthracene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	[NT]
Benzo[*ghi*]perylene	mg/kg	0.1	SEO-030	<0.1	36066-1	<0.1 || <0.1	Sand	[NT]
Total +ve PAH's	mg/kg	0	SEO-030	0.00	36066-1	0.00 || 0.00	Sand	[NT]
Surrogate	%		SEO-030	[NT]	36066-1	99 || 98 || RPD: 1	Sand	119 || 105 || RPD: 12

QUALITY CONTROL OC Pesticides in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
HCB	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
alpha-BHC	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
gamma-BHC(Lindane)	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Heptachlor	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	122 || 107 || RPD: 13
Aldrin	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	121 || 105 || RPD: 14
beta-BHC	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
delta-BHC	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	124 || 108 || RPD: 14
Heptachlor Epoxide	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
o,p'-DDE	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
alpha-Endosulfan	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
trans-Chlordane	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
cis-Chlordane	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
trans-Nonachlor	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
p,p'-DDE	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Dieldrin	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	121 || 109 || RPD: 10
Endrin	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
o,p'-DDD	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
o,p'-DDT	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
beta-Endosulfan	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
p,p'-DDD	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
p,p'-DDT	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	130 || 122 || RPD: 6
Endosulfan Sulphate	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	121 || 113 || RPD: 7
Endrin Aldehyde	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Methoxychlor	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Endrin Ketone	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Surrogate	%		SEO-005	[NT]	36066-4	118 || 101 || RPD: 16	Sand	115 || 102 || RPD: 12

QUALITY CONTROL PCBs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Arochlor 1016	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Arochlor 1221	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Arochlor 1232	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Arochlor 1242	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Arochlor 1248	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Arochlor 1254	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	87 || 80 || RPD: 8
Arochlor 1260	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Arochlor 1262	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Arochlor 1268	mg/kg	0.1	SEO-005	<0.1	36066-4	<0.1 || <0.1	Sand	[NT]
Total Positive PCB	mg/kg	0.9	SEO-005	0.90	36066-4	<0.90 || <0.90	Sand	[NT]
Surrogate	%		SEO-005	[NT]	36066-4	118 || 101 || RPD: 16	Sand	109 || 102 || RPD: 7
QUALITY CONTROL Acid Extractable Metals in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Arsenic	mg/kg	3	SEM-010	<3	36066-1	<3 || <3	36066-4	99 || 101 || RPD: 2
Cadmium	mg/kg	0.5	SEM-010	<0.5	36066-1	<0.5 || <0.5	36066-4	98 || 100 || RPD: 2
Chromium	mg/kg	0.5	SEM-010	<0.5	36066-1	1 || 1 || RPD: 0	36066-4	99 || 101 || RPD: 2
Copper	mg/kg	0.5	SEM-010	<0.5	36066-1	<0.5 || <0.5	36066-4	99 || 101 || RPD: 2
Lead	mg/kg	2	SEM-010	<2	36066-1	<2 || 2	36066-4	96 || 98 || RPD: 2
Mercury	mg/kg	0.05	SEM-005	<0.05	36066-1	<0.05 || <0.05	36066-4	110 || 110 || RPD: 0
Nickel	mg/kg	0.2	SEM-010	<0.2	36066-1	0.2 || 0.2 || RPD: 0	36066-4	97 || 100 || RPD: 3
Zinc	mg/kg	0.5	SEM-010	<0.5	36066-1	4 || 5 || RPD: 22	36066-4	99 || 101 || RPD: 2

QUALITY CONTROL POCAS and TPA	UNITS	PQL	METHOD	Blank
POCAS		#	Ext-002	0.00

QUALITY CONTROL Moisture	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD
Moisture	%		SEP-001	[NT]	36066-1	3.9 || 3.9 || RPD: 0

QUALITY CONTROL Moisture	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Moisture	%	36066-4	6.7 || 6.7 || RPD: 0

Result Codes

[INS]	:	Insufficient Sample for this test	[HBG]	:	Results not Reported due to High Background Interference
[NR]	:	Not Requested	*	:	Not part of NATA Accreditation
[NT]	:	Not tested	[N/A]	:	Not Applicable

Result Comments

ASBESTOS NB. Even after disintegration of certain bulk samples (vinyl tiles and bituminous type materials), the detection, of fibres may be difficult when using Polarised Light Microscopy and Dispersion Staining Techniques. This may be due to the matrix of the sample (uneven distribution), or fine fibres that are difficult to detect and positively identify.
POCAS analysed by SGS Perth report no. 48994.
Date Organics extraction commenced: 30/03/05
NATA Corporate Accreditation No. 2562, Site No 4354
Note: Test results are not corrected for recovery (excluding Dioxins/Furans and PAH in XAD and PUF).

Quality Control Protocol

Reagent Blank: Sample free reagents carried through the preparation/extraction/digestion procedure and analysed at the beginning of every sample batch analysis. For larger projects, a reagent blank is prepared and analysed with every 20 samples.
Duplicate: A separate portion of a sample being analysed which is treated the same as the other samples in the batch. A duplicate is prepared at least every 20 samples.
Matrix Spike Duplicates: Sample replicates spiked with identical concentrations of target analyte(s). The spiking occurs during the sample preparation and prior to the extraction/digestion procedure. They are used to document the precision and bias of a method in a given sample matrix. Where there is not enough sample available to prepare a spiked sample, another known soil/sand or water (or Milli-Q water) may be used. A duplicate spiked sample is prepared at least every 20 samples.
Surrogate Spike: Added to all samples requiring analysis for organics (where relevant) prior to extraction. Used to determine the extraction efficiency. They are organic compounds which are similar to the target analyte(s) in chemical composition and behaviour in the analytical process, but which are not normally found in environmental samples.
Internal Standard: Added to all samples requiring analysis for organics (where relevant) after the extraction process; the compounds serve to give a standard of retention time and response, which is invariant from run-to-run with the instruments.
Control Standards: Prepared from a source independent of the calibration standards. At least one control standard is included in each run to confirm calibration validity.
Additional QC Samples: A calibration standard and blank are run after every 20 samples of an instrumental analysis run to assess analytical drift.

Laboratory Report No: 36066

PRELIMINARY RESULTS I

Our Reference	Your Reference	Moisture* % H_2O	pH_{KCl}	TAA (pH 6.5) kgH_2SO_4/tonne	pH_{OX}	TPA (pH 6.5) kgH_2SO_4/tonne	TSA (pH 6.5) kgH_2SO_4/tonne	ANC_E % $CaCO_3$
Blank		-	5.3	-	6.0	-	-	-
36066-81	**BH1 5.5-6.0**	19	4.5	1.8	3.5	2.4	0.6	<0.1
Repeat 36066-81	***Repeat BH1 5.5-6.0***	-	4.5	2.0	3.6	2.4	<0.5	-
36066-83	**BH2 2.5-3.0**	10	4.5	1.0	3.8	2.2	1.2	<0.1
36066-85	**BH5 4.0-4.5**	12	5.8	0.5	7.2	<0.5	<0.5	<0.1
36066-87	**BH6 4.0-4.5**	12	5.0	<0.5	4.4	2.2	1.8	<0.1
36066-90	**BH7 5.5-6.0**	18	4.7	2.1	4.1	2.0	<0.5	<0.1
36066-91	**BH9 4.0-4.5**	12	4.3	1.7	3.5	2.9	1.2	<0.1
36066-93	**BH13 4.0-4.5**	15	4.6	2.1	4.1	2.3	<0.5	<0.1
	Limit of Reporting	1	0.1	0.5	0.1	0.5	0.5	0.1
	ASSMAC† method	2B1	23A	23F	23B	23G	23H	23Q

* NATA accreditation does not cover the performance of this analysis.
† ASSMAC - Acid Sulfate Soils Management Advisory Committee - Acid Sulfate Soil Manual, August 1998

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NATA Endorsed Test Report
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PRELIMINARY RESULTS I (continued)

Our Reference	Your Reference	S_{KCl} * % w/w	S_P * % w/w	S_{POS} * % w/w	Ca_{KCl} * % w/w	Ca_P * % w/w	Ca_A * % w/w	Mg_{KCl} * % w/w	Mg_P * % w/w	Mg_A * % w/w
36066-81	**BH1 5.5-6.0**	0.008	0.010	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	0.006
Repeat 36066-81	***Repeat BH1 5.5-6.0***	0.008	0.010	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
36066-83	**BH2 2.5-3.0**	0.010	0.013	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
36066-85	**BH5 4.0-4.5**	0.010	0.016	0.006	0.040	0.080	0.040	0.014	0.026	0.012
36066-87	**BH6 4.0-4.5**	0.007	0.016	0.009	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
36066-90	**BH7 5.5-6.0**	<0.005	0.006	0.006	<0.005	<0.005	<0.005	0.005	0.008	<0.005
36066-91	**BH9 4.0-4.5**	0.019	0.028	0.008	<0.005	<0.005	<0.005	<0.005	0.007	0.007
36066-93	**BH13 4.0-4.5**	0.035	0.044	0.009	0.034	0.039	0.005	0.013	0.016	<0.005
	Limit of Reporting	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
	ASSMAC Method	23Ce	23De	23Ee	23Vh	23Wh	23Xh	23Sm	23Tm	23Um

Results determined on a dry basis

SGS

VB

- 6 APR 2005

4 April 2005

TEST REPORT

Environmental Investigation Service
39 Buffalo Road
GLADESVILLE
NSW 2111

Your Reference: E19312F, Warriewood
Report Number: 36066A

Attention: Vittal Boggaram

Dear Vittal
The following samples were received from you on the date indicated.

Samples: Qty.	32 Soils
Date of Receipt of Samples:	21/03/05
Date of Receipt of Instructions:	23/03/05
Date Preliminary Report Faxed:	Not Issued

These samples were analysed in accordance with your written instructions.
A copy of the instructions is attached with the analytical report.

The results and associated quality control are contained in the following pages of this report. Unless otherwise stated, solid samples are expressed on a dry weight basis (moisture has been supplied for your information only), air and liquid samples as received.

Should you have any queries regarding this report please contact the undersigned.

Yours faithfully
SGS ENVIRONMENTAL SERVICES

Jacinta Hurst
Operations Manager

SGS Australia Pty Ltd
ABN 44 000 964 278
Environmental Services Botany Industrial Park Gate 3, Denison Street, Matraville 2036 NSW Australia
t +61 (0)2 9666 1426 f +61 (0)2 9666 1364 url www.sgs.com

OC Pesticides in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ---------- 	36066A-97 Composite 1 soil 45+46	36066A-98 Composite 2 soil 47+48	36066A-99 Composite 3 soil 49+50	36066A-100 Composite 4 soil 51+52	36066A-101 Composite 5 soil 53+54
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC(Lindane)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
trans-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
cis-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
trans-Nonachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDE	mg/kg	0.5	0.5	0.8	0.6	0.8
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDT	mg/kg	0.2	0.2	0.4	0.3	0.3
beta-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDD	mg/kg	0.3	0.2	0.4	0.3	0.4
p,p'-DDT	mg/kg	1.0	0.8	1.3	0.9	1.2
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Ketone	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate	%	111	122	74	103	71

OC Pesticides in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066A-102 Composite 6 soil 55+56	36066A-103 Composite 7 soil 57+58	36066A-104 Composite 8 soil 59+60	36066A-105 Composite 9 soil 61+62	36066A-106 Composite 10 soil 63+64
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC(Lindane)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
trans-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
cis-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
trans-Nonachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDE	mg/kg	0.5	0.8	0.7	0.9	0.2
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDT	mg/kg	0.2	0.3	0.2	0.3	<0.1
beta-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDD	mg/kg	0.2	0.1	0.2	0.1	<0.1
p,p'-DDT	mg/kg	0.7	0.7	0.8	1.3	0.2
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Ketone	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate	%	114	118	119	108	105

OC Pesticides in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066A-107 Composite 11 soil 65+66	36066A-108 Composite 12 soil 67+68	36066A-109 Composite 13 soil 69+70	36066A-110 Composite 14 soil 71+72	36066A-111 Composite 15 soil 73+74
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC(Lindane)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
trans-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
cis-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
trans-Nonachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDE	mg/kg	<0.1	0.8	0.9	0.7	0.5
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDT	mg/kg	<0.1	0.3	0.4	0.2	0.1
beta-Endosulfan	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
p,p'-DDD	mg/kg	<0.1	0.1	0.3	0.1	<0.1
p,p'-DDT	mg/kg	<0.1	0.9	1.2	1.4	0.6
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Ketone	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate	%	84	110	119	117	129

OC Pesticides in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066A-112 Composite 16 soil 75+76
HCB	mg/kg	<0.1
alpha-BHC	mg/kg	<0.1
gamma-BHC(Lindane)	mg/kg	<0.1
Heptachlor	mg/kg	<0.1
Aldrin	mg/kg	<0.1
beta-BHC	mg/kg	<0.1
delta-BHC	mg/kg	<0.1
Heptachlor Epoxide	mg/kg	<0.1
o,p'-DDE	mg/kg	<0.1
alpha-Endosulfan	mg/kg	<0.1
trans-Chlordane	mg/kg	<0.1
cis-Chlordane	mg/kg	<0.1
trans-Nonachlor	mg/kg	<0.1
p,p'-DDE	mg/kg	0.4
Dieldrin	mg/kg	<0.1
Endrin	mg/kg	<0.1
o,p'-DDD	mg/kg	<0.1
o,p'-DDT	mg/kg	<0.1
beta-Endosulfan	mg/kg	<0.1
p,p'-DDD	mg/kg	<0.1
p,p'-DDT	mg/kg	0.4
Endosulfan Sulphate	mg/kg	<0.1
Endrin Aldehyde	mg/kg	<0.1
Methoxychlor	mg/kg	<0.1
Endrin Ketone	mg/kg	<0.1
Surrogate	%	106

OP Pesticides in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066A-97 Composite 1 soil 45+46	36066A-98 Composite 2 soil 47+48	36066A-99 Composite 3 soil 49+50	36066A-100 Composite 4 soil 51+52	36066A-101 Composite 5 soil 53+54
Chlorpyrifos	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Fenitrothion	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Bromofos Ethyl	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Ethion	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Surrogate	%	111	122	74	103	71

OP Pesticides in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066A-102 Composite 6 soil 55+56	36066A-103 Composite 7 soil 57+58	36066A-104 Composite 8 soil 59+60	36066A-105 Composite 9 soil 61+62	36066A-106 Composite 10 soil 63+64
Chlorpyrifos	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Fenitrothion	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Bromofos Ethyl	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Ethion	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Surrogate	%	114	118	119	108	105

OP Pesticides in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066A-107 Composite 11 soil 65+66	36066A-108 Composite 12 soil 67+68	36066A-109 Composite 13 soil 69+70	36066A-110 Composite 14 soil 71+72	36066A-111 Composite 15 soil 73+74
Chlorpyrifos	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Fenitrothion	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Bromofos Ethyl	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Ethion	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
Surrogate	%	84	110	119	117	126

OP Pesticides in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066A-112 Composite 16 soil 75+76
Chlorpyrifos	mg/kg	<0.10
Fenitrothion	mg/kg	<0.10
Bromofos Ethyl	mg/kg	<0.10
Ethion	mg/kg	<0.10
Surrogate	%	106

Acid Extractable Metals in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066A-97 Composite 1 soil 45+46	36066A-98 Composite 2 soil 47+48	36066A-99 Composite 3 soil 49+50	36066A-100 Composite 4 soil 51+52	36066A-101 Composite 5 soil 53+54
Arsenic	mg/kg	<3	<3	<3	<3	<3
Cadmium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	mg/kg	9	11	10	9	10
Copper	mg/kg	62	51	59	69	66
Lead	mg/kg	28	26	26	27	33
Mercury	mg/kg	<0.05	<0.05	<0.05	<0.05	0.05
Nickel	mg/kg	5	5	6	6	6
Zinc	mg/kg	84	98	120	120	130

Acid Extractable Metals in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066A-102 Composite 6 soil 55+56	36066A-103 Composite 7 soil 57+58	36066A-104 Composite 8 soil 59+60	36066A-105 Composite 9 soil 61+62	36066A-106 Composite 10 soil 63+64
Arsenic	mg/kg	<3	<3	<3	<3	<3
Cadmium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	mg/kg	13	12	11	12	4
Copper	mg/kg	58	56	77	59	72
Lead	mg/kg	25	23	30	28	32
Mercury	mg/kg	0.06	0.05	<0.05	0.06	<0.05
Nickel	mg/kg	5	5	5	4	2
Zinc	mg/kg	110	96	120	110	250

Acid Extractable Metals in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066A-107 Composite 11 soil 65+66	36066A-108 Composite 12 soil 67+68	36066A-109 Composite 13 soil 69+70	36066A-110 Composite 14 soil 71+72	36066A-111 Composite 15 soil 73+74
Arsenic	mg/kg	<3	3	<3	<3	<3
Cadmium	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	mg/kg	3	13	11	11	11
Copper	mg/kg	40	87	78	60	72
Lead	mg/kg	18	30	27	25	22
Mercury	mg/kg	<0.05	0.07	0.05	0.08	<0.05
Nickel	mg/kg	1	6	5	4	5
Zinc	mg/kg	89	160	120	130	120

Acid Extractable Metals in Soil Our Reference: Your Reference Sample Type Depth	UNITS ---------- ----------	36066A-112 Composite 16 soil 75+76
Arsenic	mg/kg	<3
Cadmium	mg/kg	<0.5
Chromium	mg/kg	12
Copper	mg/kg	68
Lead	mg/kg	21
Mercury	mg/kg	0.05
Nickel	mg/kg	5
Zinc	mg/kg	94

Moisture Our Reference:	UNITS	36066A-97	36066A-98	36066A-99	36066A-100	36066A-101
Your Reference	----------	Composite 1	Composite 2	Composite 3	Composite 4	Composite 5
Sample Type	----------	soil	soil	soil	soil	soil
Depth		45+46	47+48	49+50	51+52	53+54
Moisture	%	14	6.0	14	3.2	7.8

Moisture Our Reference:	UNITS	36066A-102	36066A-103	36066A-104	36066A-105	36066A-106
Your Reference	----------	Composite 6	Composite 7	Composite 8	Composite 9	Composite 10
Sample Type	----------	soil	soil	soil	soil	soil
Depth		55+56	57+58	59+60	61+62	63+64
Moisture	%	14	2.2	2.2	8.3	6.7

Moisture Our Reference:	UNITS	36066A-107	36066A-108	36066A-109	36066A-110	36066A-111
Your Reference	----------	Composite 11	Composite 12	Composite 13	Composite 14	Composite 15
Sample Type	----------	soil	soil	soil	soil	soil
Depth		65+66	67+68	69+70	71+72	73+74
Moisture	%	3.5	7.3	2.3	5.4	1.4

Moisture Our Reference:	UNITS	36066A-112
Your Reference	----------	Composite 16
Sample Type	----------	soil
Depth		75+76
Moisture	%	2.0

Method ID	Methodology Summary
SEO-005	OC/OP/PCB - Determination of a suite of Organchlorine Pesticides, Chlorinated Organo-phosphorus Pesticides and Polychlorinated Biphenyls (PCB's) by sonication extraction using dichloromethane for waters or acetone / hexane for soils followed by Gas Chromatographic separation with Electron Capture Detection (GC /ECD). The surrogate spike used is 2,4,5,6-Tetrachloro-m-xylene.
SEM-010	Metals - Determination of various metals by ICP-AES following aqua regia digest.
SEM-005	Mercury - Determination of Mercury by Cold Vapour Generation Atomic Absorption Spectroscopy.
SEP-001	Air Dry - Cover air drying at 40 C, moisture content at 103 C - 105 C, wet slurrying, compositing and preparation of a 1:5 soil suspension.

QUALITY CONTROL OC Pesticides in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
HCB	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
alpha-BHC	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
gamma-BHC(Lindane)	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
Heptachlor	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	114 || 121 || RPD: 6
Aldrin	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	111 || 117 || RPD: 5
beta-BHC	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
delta-BHC	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	120 || 128 || RPD: 6
Heptachlor Epoxide	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
o,p'-DDE	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
alpha-Endosulfan	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
trans-Chlordane	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
cis-Chlordane	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
trans-Nonachlor	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
p,p'-DDE	mg/kg	0.1	SEO-005	<0.1	36066A-101	0.8 || 0.8 || RPD: 0	Sand	[NT]
Dieldrin	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	111 || 116 || RPD: 4
Endrin	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
o,p'-DDD	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
o,p'-DDT	mg/kg	0.1	SEO-005	<0.1	36066A-101	0.3 || 0.3 || RPD: 0	Sand	[NT]
beta-Endosulfan	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
p,p'-DDD	mg/kg	0.1	SEO-005	<0.1	36066A-101	0.4 || 0.4 || RPD: 0	Sand	[NT]
p,p'-DDT	mg/kg	0.1	SEO-005	<0.1	36066A-101	1.2 || 1.1 || RPD: 9	Sand	119 || 125 || RPD: 5
Endosulfan Sulphate	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	113 || 117 || RPD: 3
Endrin Aldehyde	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
Methoxychlor	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]

QUALITY CONTROL OC Pesticides in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Endrin Ketone	mg/kg	0.1	SEO-005	<0.1	36066A-101	<0.1 || <0.1	Sand	[NT]
Surrogate	%		SEO-005	[NT]	36066A-101	71 || 122 || RPD: 53	Sand	109 || 114 || RPD: 4
QUALITY CONTROL OP Pesticides in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Chlorpyrifos	mg/kg	0.1	SEO-005	<0.10	36066A-101	<0.10 || <0.10	Sand	111 || 116 || RPD: 4
Fenitrothion	mg/kg	0.1	SEO-005	<0.10	36066A-101	<0.10 || <0.10	Sand	[NT]
Bromofos Ethyl	mg/kg	0.1	SEO-005	<0.10	36066A-101	<0.10 || <0.10	Sand	[NT]
Ethion	mg/kg	0.1	SEO-005	<0.10	36066A-101	<0.10 || <0.10	Sand	[NT]
Surrogate	%		SEO-005	[NT]	36066A-101	71 || 122 || RPD: 53	Sand	109 || 114 || RPD: 4
QUALITY CONTROL Acid Extractable Metals in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Matrix Spike % Recovery Duplicate + %RPD
Arsenic	mg/kg	3	SEM-010	<3	36066A-97	<3 || <3	36066A-98	97 || 99 || RPD: 2
Cadmium	mg/kg	0.5	SEM-010	<0.5	36066A-97	<0.5 || <0.5	36066A-98	93 || 96 || RPD: 3
Chromium	mg/kg	0.5	SEM-010	<0.5	36066A-97	9 || 9 || RPD: 0	36066A-98	93 || 97 || RPD: 4
Copper	mg/kg	0.5	SEM-010	<0.5	36066A-97	62 || 55 || RPD: 12	36066A-98	89 || 95 || RPD: 7
Lead	mg/kg	2	SEM-010	<2	36066A-97	28 || 25 || RPD: 11	36066A-98	88 || 92 || RPD: 4
Mercury	mg/kg	0.05	SEM-005	<0.05	36066A-97	<0.05 || <0.05	36066A-98	93 || 97 || RPD: 4
Nickel	mg/kg	0.2	SEM-010	<0.2	36066A-97	5 || 4 || RPD: 22	36066A-98	92 || 95 || RPD: 3
Zinc	mg/kg	0.5	SEM-010	<0.5	36066A-97	84 || 77 || RPD: 9	36066A-98	84 || 95 || RPD: 12

QUALITY CONTROL Moisture	UNITS	PQL	METHOD	Blank
Moisture	%		SEP-001	[NT]

Result Codes

[INS]	:	Insufficient Sample for this test	[HBG]	:	Results not Reported due to High Background Interference
[NR]	:	Not Requested	*	:	Not part of NATA Accreditation
[NT]	:	Not tested	[N/A]	:	Not Applicable

Result Comments

Date Organics extraction commenced: 30/03/05
NATA Corporate Accreditation No. 2562, Site No 4354
Note: Test results are not corrected for recovery (excluding Dioxins/Furans and PAH in XAD and PUF).

Quality Control Protocol

Reagent Blank: Sample free reagents carried through the preparation/extraction/digestion procedure and analysed at the beginning of every sample batch analysis. For larger projects, a reagent blank is prepared and analysed with every 20 samples.
Duplicate: A separate portion of a sample being analysed which is treated the same as the other samples in the batch. A duplicate is prepared at least every 20 samples.
Matrix Spike Duplicates: Sample replicates spiked with identical concentrations of target analyte(s). The spiking occurs during the sample preparation and prior to the extraction/digestion procedure. They are used to document the precision and bias of a method in a given sample matrix. Where there is not enough sample available to prepare a spiked sample, another known soil/sand or water (or Milli-Q water) may be used. A duplicate spiked sample is prepared at least every 20 samples.
Surrogate Spike: Added to all samples requiring analysis for organics (where relevant) prior to extraction. Used to determine the extraction efficiency. They are organic compounds which are similar to the target analyte(s) in chemical composition and behaviour in the analytical process, but which are not normally found in environmental samples.
Internal Standard: Added to all samples requiring analysis for organics (where relevant) after the extraction process; the compounds serve to give a standard of retention time and response, which is invariant from run-to-run with the instruments.
Control Standards: Prepared from a source independent of the calibration standards. At least one control standard is included in each run to confirm calibration validity.
Additional QC Samples: A calibration standard and blank are run after every 20 samples of an instrumental analysis run to assess analytical drift.

SGS Ref: 36066A
Due: 1/4/05
Std TIA.

ENVIRONMENTAL INVESTIGATION SERVICES

FAX MESSAGE

2 of 3

ATTENTION:	Aileen Hie / Jacinta	EIS JOB No:	E19312F
OF:	SGS Environmental Services	DATE:	23/03/2005
FAX No:	9666 1364	PAGE:	1 of 1
FROM:	Vittal Boggaram		

RE: **ADDITIONAL ANALYSIS**
WARRIEWOOD VALLEY LAND RELEASE, WARRIEWOOD

Please note that the SGS reference number for the above project is **36066.** I would like to schedule additional analysis for **heavy metals (HM), organochlorine (OC) and organophosphate (OP) pesticides** on the following composites:

97 • Composite 1 – samples GH1A and GH1B 45 + 46
98 • Composite 2 – samples GH2A and GH2B 47 + 48
99 • Composite 3 – samples GH3A and GH3B 49 + 50
100 • Composite 4 – samples GH4A and GH4B 51 + 52
101 • Composite 5 – samples GH5A and GH5B 53 + 54
102 • Composite 6 – samples GH6A and GH6B 55 + 56
103 • Composite 7 – samples GH7A and GH7B 57 + 58
104 • Composite 8 – samples GH8A and GH8B 59 + 60
105 • Composite 9 – samples GH9A and GH9B 61 + 62
106 • Composite 10 – samples GH10A and GH10B 63 + 64
107 • Composite 11 – samples GH11A and GH11B 65 + 66
108 • Composite 12 – samples GH12A and GH12B 67 + 68
109 • Composite 13 – samples GH13A and GH13B 69 + 70
110 • Composite 14 – samples GH14A and GH14B 71 + 72
111 • Composite 15 – samples GH15A and GH15B 73 + 74
112 • Composite 16 – samples GH16A and GH16B 75 + 76

Should you require any further information regarding the above please do not hesitate to contact the undersigned.

Yours faithfully
For and on behalf of
ENVIRONMENTAL INVESTIGATION SERVICES

Vittal B.S

Vittal B. S.
Environmental Scientist

Principal: E H Fletcher BSc (Eng) ME
39 BUFFALO ROAD GLADESVILLE NSW 2111 TELEPHONE: (02) 9809 7322 (02) 9807 0200 FAX: (02) 9809 7626
EIS IS A DIVISION OF JEFFERY & KATAUSKAS PTY LTD A.B.N. 17 003 550 801 A.C.N. 003 550 801
Principals: B F Walker BE Dip MSc P Stubbs BSc MIEAust D Trewaek Dip Tech

APPENDIX C

Joanne

From: "SSC Bore Data SSC Bore Data" <SSCboredata@dipnr.nsw.gov.au>
To: <eis@Jkgroup.net.au>
Sent: Wednesday, 16 March 2005 2:00 PM
Attach: sscwarriewood160305.wmf; sscwarriewood160305.RTF
Subject: bore search - Warriewood

Hi Vittal, I have completed your 1km bore search at Jubilee Avenue - Warriewood. Please see attached files. Water Quality Data is Nil.

Thanks

Sofie Tanner

Sofie Tanner
GIS Operator
Parramatta
South Coast GIS
Ph: 9895 7146
Sofie.Tanner@dipnr.nsw.gov.au
Fax: 9895 7685

The work summary for the bore is in the attached file ***.rtf.

If you requested Water Quality Data and it is available for the bore - see the spreadsheet ****.csv

If you requested a map showing the location of the bore - see the file ***.wmf.
To print the map this procedure must be followed with the file:
1. Save it to your drive,
2. In Word or Excel or another Windows application,
3. Choose Insert, Picture, From File,
4. Select the file (*.wmf),
5. Map should appear.
We recommend that you set the page set up to Landscape
And reduce the margins to the smallest possible size.
If a map fails to open please let me know.

CAUTION TO CLIENTS

Water data have been supplied to the Department of Infrastructure, Planning and Natural Resources (DIPNR) by various sources. In some cases, analyses, plots and other data presentations make use of information on the DIPNR archive. Because of the historic nature of the archive, there may well be errors and omissions in the data provided to you, and the quality of the information may make it unsuitable for the intended purpose.

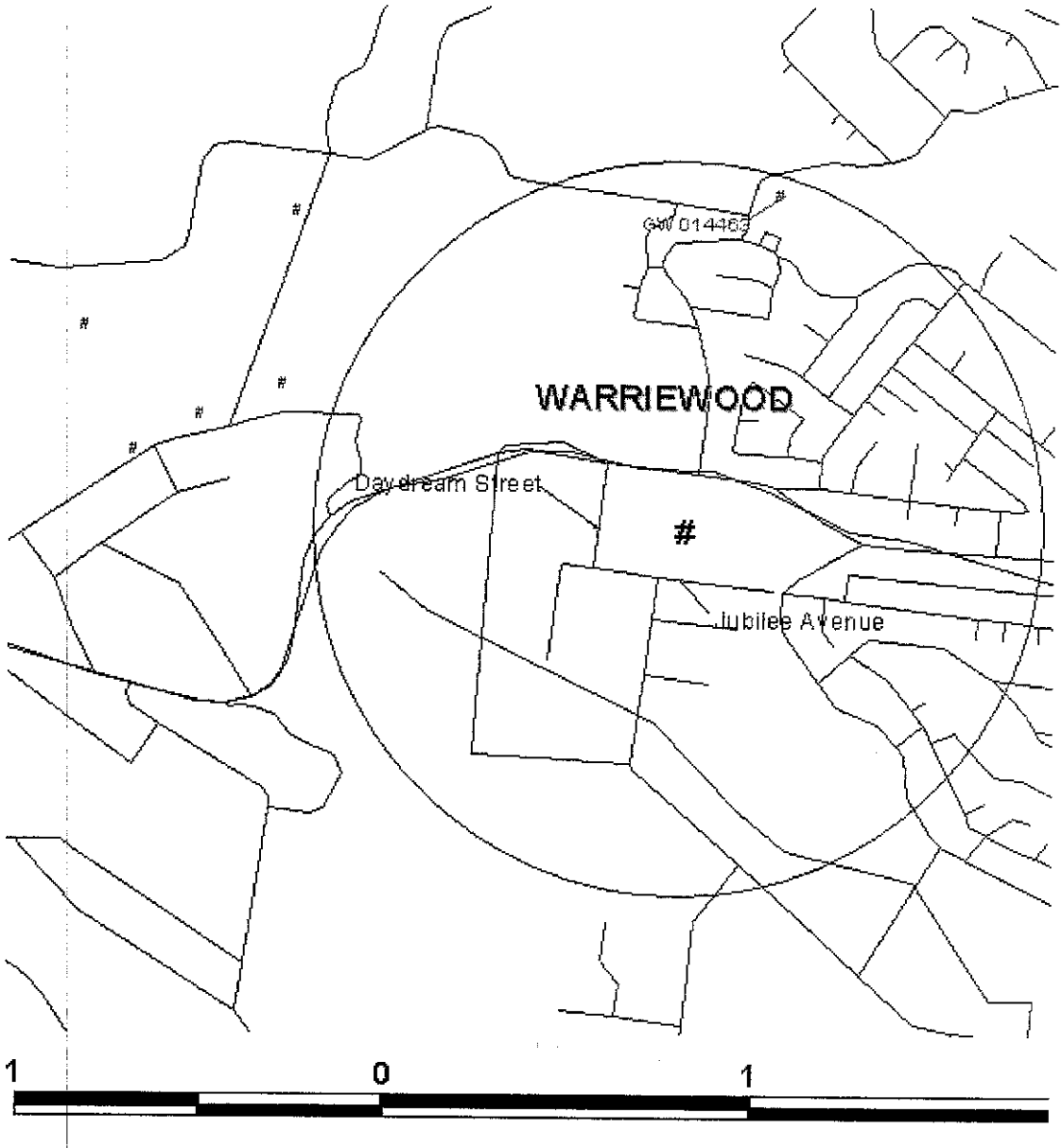
Data integrity may not have been examined before use in analytical programs and the DIPNR makes no guarantee that they conform to any guidelines. Users of these data should be aware that the use and any interpretation of the data is at their own risk and the DIPNR will not be held responsible for any decisions made based on these data.

Should you require further information please call or email me.

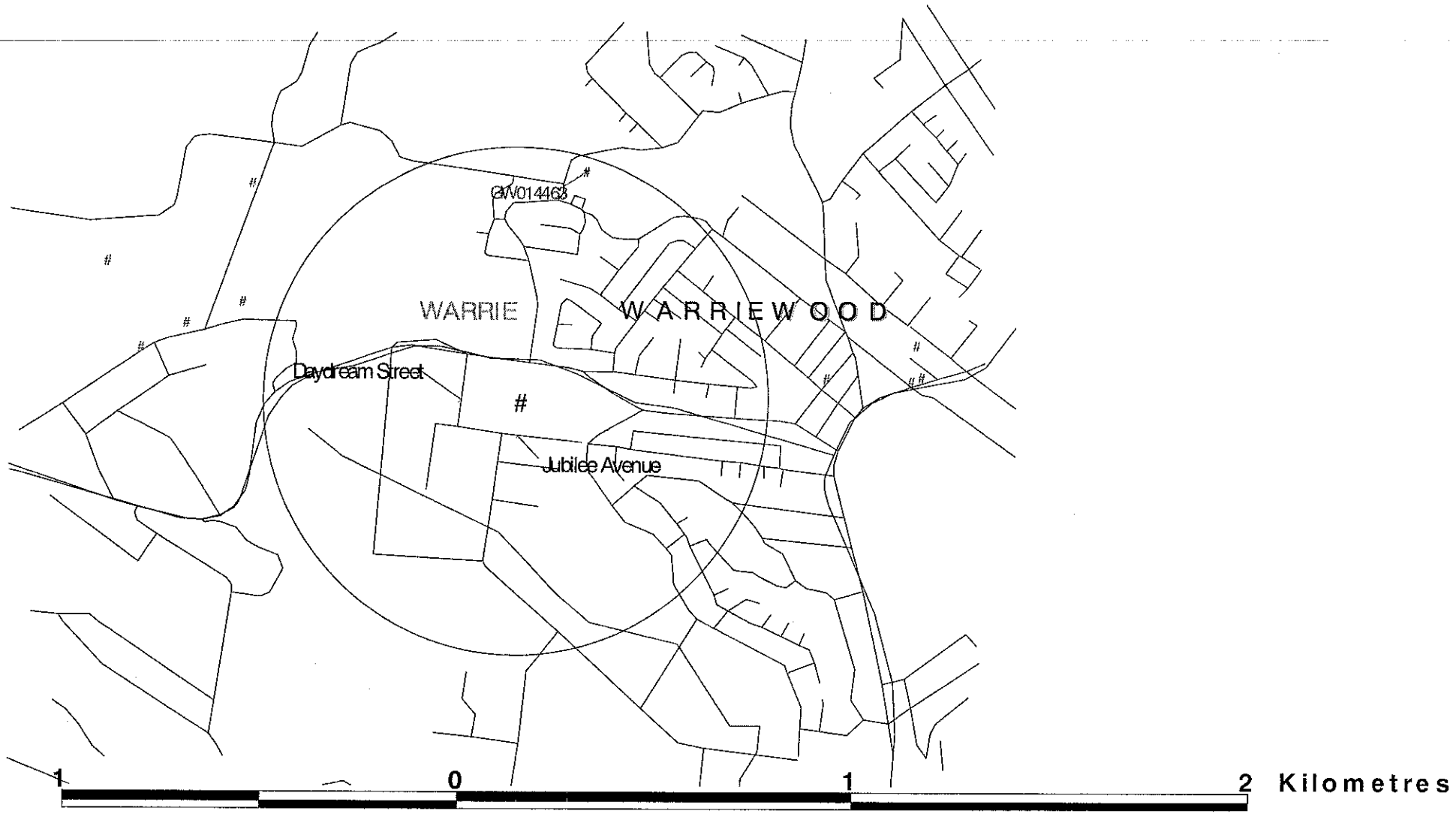
Dept. of Infrastructure, Planning and Natural Resources
Sydney South Coast Region Bore Requests
FAX: 02 4224 9689
PH: 02 4224 9600

PLEASE NOTE THIS IS AN OUTGOING EMAIL ADDRESS ONLY DO NOT REPLY TO THIS ADDRESS

Groundwater Bores at a 1km radius near Jubilee Warriewoood dated 16/03/2005



Groundwater Bores at a 1km radius near Jubilee Avenue Warriewood dated 1/03/2005



Date/Time :16-Mar-2005 01:05 PM
User :STANNER
Report :RMGW001D.QRP
Executable :S:\G5\PROD32\Ground.exe
Exe Date :13-Dec-2004
System :Groundwater
Database :Edbp

DEPARTMENT OF INFRASTRUCTURE, PLANNING AND NATURAL RESOURCES
Work Summary

GW014463

Converted From HYDSYS

License :10BL007411

Work Type : Excavation
Work Status : Supply Obtained
Construct. Method :> 100 sq.m.
Owner Type : Private

Authorised Purpose(s) RECREATION (GROUNDWATER)
Intended Purpose(s) IRRIGATION

Commenced Date :
Completion Date :01-Dec-1957
Final Depth : 1.50 m
Drilled Depth : 1.50 m

Contractor Name :
Driller :

Property : - N/A
GWMA :603 - SYDNEY BASIN
GW Zone : -

Standing Water Level :
Salinity : 501-1000 ppm
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	NARRABEEN	19
Licensed :	CUMBERLAND	NARRABEEN	PT 19

Region :10 - SYDNEY SOUTH COAST
River Basin :212 - HAWKESBURY RIVER
Area / District :

CMA Map :9130-1S MONA VALE
Grid Zone :56/1 **Scale :**1:25,000

Elevation :
Elevation Source :(Unknown)

Northing :6273020 **Latitude (S) :**33° 40' 15"
Easting :341570 **Longitude (E) :**151° 17' 28"

GS Map :0055B3 **AMG Zone :**56 **Coordinate Source :**GD.,PR. MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details

(No Construction Details Found)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

(No Water Bearing Zone Details Found)

Drillers Log

From (m)	To (m)	Thickness(m)	Drillers Description	Geological Material	Comments
0.00	0.60	0.60	Soil, Sandy		
0.60	1.52	0.92	Sand Water Supply	Sand	

Pumping Tests - Summaries

Pumping Test Type	Date	Duration (hr)	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Intake Depth (m)	Test Method	To Measure Water Level	To Measure Discharge	Tested By

(No Pumping Test Summary Details Found)

Pumping Tests - Readings

Pumping Test Type	Date	Time (mins)	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Intake Depth (m)	Test Method	To Measure Water Level	To Measure Discharge	Tested By

(No Pumping Test Reading Details Found)

Chemical Treatment

Treatment	Method	Duration	Success

(No Chemical Treatment Details Found)

Development

Method	Time Taken	Other Development Method

(No Development Details Found)

DEPARTMENT OF INFRASTRUCTURE, PLANNING AND NATURAL RESOURCES
Work Summary

GW014463 *Converted From HYDSYS*

Remarks

BAYVIEW GOLF LINKS MONA VALE

***** End of GW014463 *****

***** End of Report *****

16 MAR 2005 VB

WorkCover
NEW SOUTH WALES

Our Ref: D05/013510
Your Ref: Vittal Boggaram

15 March 2005

Attention:- Mr Vittal Boggaram
EIS
39 Buffalo Road
GLADESVILLE NSW 2111

Dear Sir

RE SITE: Lot 1 Sector 5, Jubilee Avenue WARRIEWOOD NSW 2102

I refer to your search request of 14 March 2005 requesting information on licenses to Keep Dangerous Goods for the above site.

A search of the Stored Chemical Information Database (SCID) and the microfiche records held by WorkCover has not located any records pertaining to the abovementioned premises.

An invoice for this search will be forwarded to you in due course.

If you have any further queries, please contact Dangerous Goods Licensing staff on (02) 4321 5500.

per

Brent Jones
Team Leader
Dangerous Goods

APPENDIX D

SOIL AND GROUNDWATER SAMPLING PROTOCOLS

These protocols specify the basic procedures to be used when sampling soils or groundwater for environmental site assessments undertaken by Environmental Investigation Services. The purpose of these protocols is to provide standard methods for: sampling, decontamination procedures for sampling equipment, sample preservation, sample storage and sample handling. Deviations from these procedures must be recorded.

SOIL SAMPLING

(i) Prepare a test pit/borehole log.

(ii) Layout sampling equipment on clean plastic sheeting to prevent direct contact with ground surface. The work area should be at a distance from the drill/rig excavator such that the drill rig/excavator can operate in a safe manner.

(iii) Ensure all sampling equipment has been decontaminated prior to use.

(iv) Remove any surface debris from the immediate area of the sampling location.

(v) Collect samples and place in a glass jar with a Teflon seal. This should be undertaken as quickly as possible to prevent the loss of volatiles. If possible, fill the glass jars completely.

(vi) Label the jar with the EIS job number, sample location (eg TP1), sampling interval and date. If more than one sample container is used, this should also be indicated (eg 2 = Sample jar 1 of 2 jars).

(vii) Photoionisation detector (PID) screening of volatile organic compounds (VOCs) should be undertaken on samples using the soil sample headspace method. Headspace measurements are taken following equilibration of the headspace gasses in partly filled glass jars. PID headspace data is recorded on the borehole/test pit log and the chain of custody forms.

(viii) Record the lithology of the sample and sample depth on the borehole/test pit log in accordance with AS1726-1993.

(ix) Store the sample in a sample container cooled with ice or chill packs. On completion of the sampling the sample container should be delivered to the lab immediately or stored in the refrigerator prior to delivery to the lab.

(x) Check for the presence of groundwater after completion of each borehole using an electronic dip metre or water whistle. Boreholes should be left open until the end of fieldwork. All groundwater levels in the boreholes should be re-checked on the completion of the fieldwork.

(xi) Backfill the boreholes/test pits with the excavation cuttings or clean sand prior to leaving the site.

DECONTAMINATION PROCEDURES FOR SOIL SAMPLING EQUIPMENT

(i) All of the equipment associated with the soil sampling procedure should be decontaminated between every sampling location.

(ii) The following equipment and materials are required for the decontamination procedure:

- Phosphate free detergent (Extran 100)
- Tap water
- Two buckets
- Stiff brushes
- Plastic sheets

(iii) Ensure the decontamination materials are clean prior to proceeding with the decontamination.

(iv) Fill both buckets with clean tap water and add phosphate free detergent to one bucket.

(v) In the bucket containing the detergent scrub the sampling equipment until all the material attached to the equipment has been removed.

(vi) Rinse sampling equipment in the bucket containing tap water.

(vii) Place cleaned equipment on clean plastic sheets.

If all materials are not removed by this procedure, high-pressure water cleaning is recommended. If any equipment is not completely decontaminated by both these processes that equipment should not be used until it has been thoroughly cleaned.

GROUNDWATER SAMPLING

Groundwater samples are more sensitive to contamination than soil samples and therefore adhesion to this protocol is particularly important to obtain reliable, reproducible results. The recommendations detailed in AS 2306.1 are considered to form a minimum standard.

The basis of this protocol is to maintain the security of the borehole and obtain accurate and representative groundwater samples. The following procedure should be used for collection of groundwater samples from previously installed piezometers.

(i) After piezometer installation, at least four bore volumes should be pumped from the piezometers to remove any water introduced during the drilling process. Piezometers should then be left to recharge for at least five days before purging and sampling. Prior to purging or sampling the condition of each well should observed and any anomalies recorded on the field data sheets. The following information should be noted: the condition of the well, noting any signs of damage, tampering or complete destruction; the condition and operation of the well lock; the condition of the protective casing and the cement footing (raised or cracked); and, the presence of water between protective casing and well.

(ii) Take the groundwater level from the collar of the piezometer using an electronic dipmeter. The collar level should be taken during the site visit using a dumpy level and staff.

(iii) Purging and sampling of piezometers should generally be done on the same site visit. Layout and organise all equipment associated with groundwater sampling in a location where they will not interfere with the sampling procedure and will not pose a risk of contaminating samples. Equipment generally required includes:

- New disposable polyethylene bailer and sufficient cord OR submersible pump
- Micropore filtration system (for heavy metals samples)
- Filter paper (glass fibre and 0.45(m)
- Buckets with volume increments
- Sample containers – at least 1 x teflon bottle with 1ml nitric acid, 1 x 75mL glass vial and 2 x 1L amber glass bottles for each piezometer.
- pH/Cond/Eh/T meters
- Glass jars for purged samples
- Esky and ice
- Latex gloves
- Distilled water (for cleaning)
- Electronic dipmeter

- Groundwater sampling forms and notebook
- Aluminium foil and labels

(iv) Clean the Micropore filtration system thoroughly with distilled water prior to use and between each sample. Filter paper should be changed between samples. 0.45um filter paper should be placed below the glass fibre filter paper in the filtration system.

(v) Ensure all non-disposable sampling equipment is decontaminated or that new disposable equipment is available prior to any work commencing at a new location. The procedure for decontamination of groundwater equipment is outlined at the end of this section.

(vi) Disposable gloves should be used whenever samples are taken to protect the sampler and to assist in avoidance of contamination.

(vii) Purge at least four bore volumes from the well. Take pH, conductivity, redox potential, and temperature measurements of the purged groundwater at regular intervals during purging. (Say every 5-10 litres if abundant groundwater and every 1 litre if only limited groundwater is encountered). Groundwater condition measurements should be taken from a sample in a clean glass jar which has been taken directly from the sampling equipment (either pump or bailer). Electrodes should be placed in the sample after the electrodes have been rinsed with distilled water. Purged volumes and groundwater measurements should be recorded on the field sampling sheet. An assessment of the turbidity of the sample should also be made based on three categories: silty, opaque and clear.

(viii) Prepare all sample bottles. Label bottles with EIS job number, borehole number and date of collection.

(ix) Fill amber sample bottles and BTEX vial directly from pump or bailer. Ensure sampling equipment does not touch sample containers. Sample bottles and vials must be filled to the brim, so that a reverse meniscus is formed, seal with aluminium foil and then cap. Check that no air has entered the sample invert and check for bubbles.

(x) Fill vacuum filtration system and turn on filter pump.

(xi) Undertake pH/Cond/Eh/T of a sample taken in a clean glass jar used only for groundwater condition measurements. Turn the meters on and insert the electrodes into the sample. Record the measurements when the instruments have stabilised, then discard the sample. Clean the electrodes with distilled water between measurements.

(xii) When the sample filtering is complete, (note: at least 50mL of filtered sample is required for heavy metal analysis), decant the filtered sample into a teflon bottle containing nitric acid. Check label of sample bottle to ensure container has been treated with nitric acid and not sulphuric acid. Clean the filtration system with distilled water and replace the filters ready for the next sample.

(xiii) Photoionisation detector (PID) screening of volatile organic compounds (VOC) should be undertaken on groundwater samples using the sample headspace method during fieldwork. VOC data is obtained from partly filled glass jar samples following equilibration of the headspace gases. The PID headspace data should be included on the chain of custody forms and borehole logs.

(xiv) Store the sample in a sample container cooled with ice or chill packs. On completion of the sampling the sample container should be delivered to the lab immediately or stored in the refrigerator prior to delivery to the lab.

(xv) Record the sample on the appropriate log in accordance with AS 1726-1993. At the end of each water sampling complete a chain of custody form.

DECONTAMINATION PROCEDURE FOR GROUNDWATER SAMPLING EQUIPMENT

(i) All of the equipment associated with the groundwater sampling procedure should be decontaminated between every sampling location.

(ii) The following equipment and materials are required for the decontamination procedure:

- Phosphate free detergent (Extran 100)
- Tap water
- Distilled water
- Two buckets
- Plastic sheets

(iii) Fill one bucket with clean tap water and phosphate free detergent, and one bucket with distilled water.

(iv) Flush tap water and detergent through pump. Wash sampling equipment and pump head using brushes in the bucket containing detergent until all materials attached to the equipment are removed.

(v) Flush pump with distilled water.

(vi) Change water and detergent solution after each sampling location.

(vii) Rinse sampling equipment in the bucket containing distilled water.

(viii) Place cleaned equipment on clean plastic sheets.

If all materials are not removed by this procedure that equipment should not be used until it has been thoroughly cleaned.

QA/QC DEFINITIONS

The QA/QC terms used in this report are defined below. The definitions are in accordance with current USEPA SW-846 (1994) methods and those described in *Environmental Sampling and Analysis, A Practical Guide*, (H. Keith 1991).

Practical Quantitation Limit (PQL), Limit of Reporting (LOR) and Estimated Quantitation Limit (EQL)

These terms all refer to the concentration above which results can be expressed with a minimum 95% confidence level. The laboratory reporting limits are generally set at ten times the standard deviation for the Method Detection limit (MDL) for each specific analyte. For the purposes of this report the LOR, PQL, and EQL are considered to be equivalent.

When assessing laboratory data it should be borne in mind that values at or near the LOR have two important limitations.
"The uncertainty of the measurement value can approach, and even equal, the reported value. Secondly, confirmation of the analytes reported is virtually impossible unless identification uses highly selective methods. These issues diminish when reliably measurable amounts of analytes are present. Accordingly, legal and regulatory actions should be limited to data at or above the reliable detection limit", Keith (1991).

Accuracy

The proximity of an averaged result to the true value, where all random errors have been statistically removed. Accuracy is measured by percent recovery. Acceptable limits for accuracy generally lie between 70% to 130% recoveries. Certain laboratory methods may allow for values that lie outside these limits.

Precision

The degree to which data generated from repeated measurements differ from one another due to random errors. Precision is measured using the standard deviation or Relative Percent Difference (RPD). Acceptable targets for precision in this report will be less than 50% RPD for concentrations greater than ten times the EQL, less than 75% RPD for concentrations between five and ten times the EQL and less than 100% RPD for concentrations that are less than five times the EQL.

Matrix Spikes

Samples are spiked with laboratory grade standards to detect interactive effects between the sample matrix and the analytes being measured. Matrix Spikes are reported as a percent recovery and are prepared for 1 in every 20 samples. Sample batches that contain less than 20 samples may be reported with a Matrix Spike from another batch. The percent recovery is calculated using the formula;

$$\frac{(\text{spiked sample result} - \text{sample result})}{\text{concentration of spike added}} \times 100$$

Acceptable recovery limits are 70% to 130%.

Blanks

The purpose of laboratory and field blanks is to check for artifacts and interferences that may arise during sampling and analysis.

Surrogate Spikes

Samples are spiked with a known concentration of compounds that are chemically related to the analyte being investigated but unlikely to be detected in the environment. The purpose of the Surrogate Spikes is to check the accuracy of the analytical technique. Surrogate Spikes are reported as percent recovery.

Duplicates

Laboratory duplicates measure precision, expressed as Relative Percent Difference. Duplicates are prepared from a single field sample and analysed as two separate extraction procedures in the laboratory. The RPD is calculated using the formula:

$$\frac{|\ D1-D2\ |}{|\ (D1+D2)/2\ |} \times 100$$

where D1 is the sample concentration and D2 is the duplicate sample concentration.

Blind Replicate samples (Intra-laboratory duplicates)

Blind replicates measure intra-laboratory precision. At least 10% of samples submitted for analysis are removed from the sampling point in a single action and divided into at least two separate sample containers for analysis at the same laboratory. Each container is labelled in a unique manner that conceals the fact that it is part of a replicate batch.

Split Replicate Samples (Inter-laboratory samples)

Split replicate samples measure inter-laboratory precision. At least 5% of the field samples are collected in duplicate. One of the duplicate samples is analysed at the primary laboratory and the other duplicate sample is analysed at a secondary laboratory. All samples shall be analysed by identical laboratory methods.