PF FORMATION

HITCHCOCK ROAD SAND EXTRACTION AND REHABILITATION PROJECT, MAROOTA

TECHNICAL PAPERS
Volume Two

Geotechnical assessment
Groundwater
Traffic and access
Noise

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DFA Consultants

TECHNICAL PAPER

GEOTECHNICAL ASSESSMENT

PF Formation, Hitchcock Road Sand Mine, Maroota

Geotechnical Assessment

April 2004

DFA Consultants Pty Ltd on behalf of
PF Formation

PARSONS BRINCKERHOFF
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1. Introduction

This report presents the results of a geotechnical assessment carried out by Parsons Brinckerhoff Pty Ltd (PB) at the Hitchcock Road Sand Mine in Maroota. PB have previously issued a draft report reference 2110178A.PR_4401RevA dated February 2004, which is now superseded by this version. The works were commissioned by Peter Cummins of PF Formation on 18 September 2003. The report was prepared for DFA Consultants Pty Ltd on behalf of PF Formation.

The purpose of the assessment was to develop a geotechnical/geological model of the subsurface conditions at the Hitchcock Road site and undertake a spatial and volumetric analysis of the results, with outputs comprising:

- an assessment of the subsurface conditions at the site in the form of a geotechnical/geological model;
- a review of the existing material volumes and resource estimates;
- an assessment of the overburden clay material bulking factor; and
- provision of technical advice on the mine plan, mine rehabilitation and landform plan.

PB was provided with existing subsurface information contained within a geological investigation report completed in September 2002 for CSR Readymix (Stenhouse, 2002). The current study was based on the data contained in this report, along with other data collected from the CSR report author, the site surveyors and PF Formation.

2. Site Location and Description

The Maroota Sand deposit is located between Glenorie and Wisemans Ferry in the rural area of Maroota, some 50 kilometres to the north-northwest of Sydney, as shown in *Figure 1*. The area is located atop a regional plateau at elevations of between 190 metres AHD and 240 metres AHD, where the regional topography generally comprises undulating hills and valleys.

The Maroota Sand deposit covers a total area of approximately 25 square kilometres, and is divided into two deposits comprising northern and southern sections. For at least 30 to 40 years various companies have extracted sand for construction purposes from the Maroota Sand Deposit at several locations. The area that is the subject of this report (the PF Formation Hitchcock Road operation) is located within the southern deposit, in a portion locally known as the Maroota Trig, and covers an area of about 90 hectares.

The PF Formation Hitchcock Road workings at Maroota are located directly to the south of the intersection of Wisemans Ferry Road and Old Northern Road. This area is roughly a triangular parcel of land that is elongated in a north south direction. The site is bounded by Old Northern Road to the northeast, Wisemans Ferry Road to the northwest, and existing rural developments to the south, as shown in *Figure 2*.

Sand extraction in the past has occurred over the southern portion of the site, while current extraction occurs from pits located both in the northern and southern parts of the site. These are separated by a portion of higher ground which accommodated the former Maroota Trigonometrical Station. Extraction has not occurred beneath this high point. Sand won from the extraction areas is pre-processed into a sand slurry and pumped to the west beneath Wisemans Ferry Road to the wash plant on Lot 198, where it is processed and stockpiled for distribution.

3. Regional and Local Geology

3.1 Regional Geology

Reference to the 1:250,000 Geological Sheet of Sydney (SI 56-5), along with papers by Etheridge (1980), and Whitehouse and Roy (2000), indicates that the Maroota Sand Deposit is located in an area where the regional geology comprises a Triassic basement of Hawkesbury Sandstone (along with some Narrabeen Group sandstones), unconformably overlain by the Tertiary Maroota Sands. Within the region, late Tertiary and Quaternary alluvial deposits are also encountered within the existing Hawkesbury River Valley, generally located to the north of Maroota.

The Hawkesbury Sandstone is generally a medium to coarse grained quartz rich sandstone, with a kaolinitic clay matrix, and secondary quartz and siderite (iron carbonate) cementation. The Narrabeen Group sandstones are generally a fine to coarse grained quartz lithic sandstone, with a similar matrix and cementation to the Hawkesbury Sandstone, although they are generally more cemented, less quartzose and less porous.

The basement rock surface within the Maroota region, which comprises the Hawkesbury Sandstone, is highly irregular and bears no direct relationship to the present day topography. This is interpreted to be due to erosion of the ancient basement land surface by a river system flowing along drainage lines that existed prior to the current Hawkesbury River Valley. Etheridge (1980) reports that the basement morphology appears to have been formed by two old river channels. One of the channels, situated on the western side of the deposit, had a north-south trend and is interpreted to have flowed to the north, while the other channel traverses the deposit with an east-west trend, and is interpreted to have flowed to the west. The confluence of these rivers is interpreted to be within the north-western part of the deposit.

These ancient drainage lines were incised into the upper portions of the Hawkesbury Sandstone Formation, and hence only currently exist on presently elevated surfaces. The rivers flowing within these ancient valleys deposited alluvial sediments, which are largely confined to the river channels described above, and now form the Tertiary Maroota Sands.

The Maroota Sand Deposit comprises a sequence of interbedded fluvial (river origin) sediments consisting dominantly of gravely sands, sand and clayey sand, along with lenses and layers of clay and gravel. The deposit undergoes rapid lateral and vertical facies changes, and gravel and clay lenses/layers are widely distributed throughout its extent.

Due to erosion of the ground surface to the present day surface, sediments within the north-south river channel described above have largely been eroded. This has separated the deposit into two known bodies of sediments that currently exist as isolated units. The body studied during this assessment is the southern of the two units, as shown in *Figure 3*. The present day surface topography, coupled with the irregular basement topography, has resulted in the Maroota Sand deposit having a highly variable thickness across its extent.

Late Tertiary and Quaternary alluvium has been deposited within the region, along the valley of the present Hawkesbury River. These younger deposits occur stratigraphically lower than the Maroota Sands.

Figure 4 depicts the stratigraphic relationship between the Triassic basement, Tertiary alluvial deposits and the later Tertiary and Quaternary alluvial deposits.

3.2 Local Geology

Etheridge (1980) describes the Maroota Sand deposit as a sequence of interbedded clayey gravels, gravels, gravely sands, pebbly sands, clayey/silty sand, sand, silty clay, and clay. Gravel commonly occurs as layers and stringers within the sand units and clay lenses and layers are widely distributed throughout the deposit. Generally, Etheridge found the granular component of the deposit to be well graded. Furthermore, based on the paleochannel map in the Etheridge (1980) report, the component of the Maroota Sands Deposit contained within the PF Formation Hitchcock Road area is located within the east-west trending river channel, as described in *Section 3.1*.

The resource, which comprises the Tertiary Sands, the PF Formation Hitchcock Road site, is generally a layered deposit made up of an Upper Sand unit, overlying an extensive Clay unit, beneath which lies an extensive Lower Sand unit. The deposit unconformably overlies a Triassic basement comprising Hawkesbury sandstone. These details are further expanded in *Section 6.1*.

4. Existing Operations

A fine to medium grained sand, often with a relatively high clayey fraction, is excavated from several working pits at this Hitchcock Road site. The sand unit targeted comprises the Lower Sand, which is overlain by the Upper Sand and Clay units. These upper units are stripped to expose the Lower Sand, which is excavated by tracked excavator and trucked to the pre processing area. Here the sand is formed into a sand slurry and pumped in a westerly direction beneath Wisemans Ferry Road to the wash plant on Lot 198.

Processing of the sand either comprises:

- scalping, to reduce the percentage of gravel sized particles. This leaves the finer fraction, producing a clay rich product that has traditionally been used mainly for mortar sand. The high clay content provides the sand with "slip" and workability which are desired qualities for this application; or
- washing and scalping to reduce the fine fraction as well as the gravel sized particles, to produce a clean fine to medium grained sand suitable for a wide range of applications such as concrete manufacture and asphalt (Pienmunne & Whitehouse, 2001).

Currently operations at the PF Formation Hitchcock Road sand mine are restricted to a base level of 187 metres AHD, under the current consent conditions.

5. Investigation Methodology

5.1 Existing Information

In order to carry out this assessment, PB was provided with existing subsurface information on the site contained within a geological investigation report completed in September 2002 for CSR Readymix (Stenhouse, 2000). This information was supplemented by summary borehole logs obtained from the author of the CSR Readymix report (Ian Stenhouse), a digital version of the site plan from Bell Cochrane and Associates, and borehole levels supplied from William Backhouse surveyor.

The existing information comprised the following:

- a site plan dated 23 September 2002, showing the locations of the boreholes and contours of the site;
- summary borehole logs for 27 boreholes drilled on a grid approximately 100 metres square;
- survey data positioning the boreholes within the site with respect to AMG and AHD;
- results of Particle Size Distribution tests carried out on samples collected during the CSR drilling;
- hand drawn geological cross sections; and
- an analysis and estimate of the resource.

Further information regarding the Maroota Sand Deposit was collected from three additional sources, comprising two Department of Mineral Resources reports (Etheridge, 1980, and Pienmunne & Whitehouse, 2001), and a paper on friable sandstone deposits within the Sydney region (Whitehouse and Roy, 2000).

5.2 PB Fieldwork and Laboratory Testing

Fieldwork carried out by PB comprised the excavation of three test pits, BFTP1 to BFTP3, on 21 October 2003 in order to assess the bulking factor of the clay materials, as described further in *Section 5.6*. The test pits were excavated with a 30 tonne tracked excavator to depths ranging between one and 2.5 metres. Bulk soil samples were collected from the pest pits at depths corresponding to where insitu density tests were conducted.

The test pits were logged by a geotechnical engineer, who was also responsible for ensuring the density tests were conducted at the correct locations and that samples were also collected. The test pit locations were selected by PF Formation staff.

Samples collected from the test pits were dispatched to a NATA registered laboratory for compaction testing.

The engineering logs of the test pits, a set of explanatory sheets defining the terms and symbols used in the log preparation are included within *Appendix A1* and the Laboratory Test results are presented in *Appendix A2*.

5.3 Formulation of the Geological Model

In order to develop a geotechnical/geological model of the site, all the summary borehole subsurface data, and the laboratory and location data were entered into PB's computerised geotechnical database package gINT.

Using this package, geotechnical cross sections were produced along the easting and northing grid lines along which the investigation boreholes were roughly located. The cross sections were used to assess the layer thicknesses across the site, and to identify the extent of the relevant resource units along each section line, along with water levels (where encountered) and rock levels.

Following cross section development, the Particle Size distribution (PSD) data for all the relevant laboratory gradings were entered into gINT and PSD grading curves developed. These were used to confirm the lithology logged in the boreholes, to classify the borehole lithologies, and aid in delineating geological units within the resource. Once this analysis was complete, the PSD grading curves for each unit were plotted.

A discussion detailing the interpreted geological model is provided in *Section 6.1*, while the Geological Cross Sections and the PSD grading curves are presented in *Appendix B* (as NS1 to NS6 and EW1 to EW6) and *Appendix C* (as PSD 1 to PSD 12), respectively.

5.4 Spatial Analysis

The spatial and analytical data derived from the geotechnical/geological model (comprising the geological cross sections and PSD grading curves), were entered into the 3D Geographic Information System (GIS) package Arc View – 3D Analyst. This package is able to display the spatial relationship between the various stratigraphic units within the deposit in 3D images. Using this package and the information derived during the compilation of the geotechnical/geological model, 3D images of the resource were prepared that show the spatial relationship between each of the geological units.

The 3D modelling output from the package is saved as a series of Virtual Reality Modelling Language files, (wrl files). These are viewed using a free 3D viewing package called PIVERON. The Compact Disc (CD) attached to this report contains the files produced during the modelling, along with the executable file to load the PIVERON program. These images show the whole site in a 3D perspective. Several 3D images of the resource area studied are presented in *Appendix D*.

The deposit was divided into 27, 100 metre square blocks. Each block is referenced using a grid naming system, as shown in *Drawing 1*. Using the Arc View – 3D Analyst package, vertical walls were applied to the four sides of each block. Each was then cut from the 3D model so that it could be viewed in space as an individual item. Using this approach, the relative thicknesses of each of the geological units within each block can be viewed from any perspective. To aid in visualising the relative thicknesses of each of the units, reference layers spaced at 10 metres elevation intervals are incorporated into each 100 metre square block image. Several 3D images of these blocks are presented in *Appendix D*.

The images are also saved on the CD presented with this report.

5.5 Volumetric Analysis

5.5.1 Assumptions

The reserve assessment was based on the following assumptions:

- Borehole location and lithology, and PSD data are reliable and accurate.
- Reserve assessment was calculated assuming the entire area depicted in *Drawing 1*, is to be extracted using a batter constructed at 2(H):1(V) down from the pit limits to the base extraction level.
- The pit limits along the north western and north eastern boundaries were formed based on a 30 metre off set from the existing road alignments of Wisemans Ferry Road and Old Northern Road, respectively. In the south eastern corner of the site, a 50 metre offset was employed adjacent to the neighbouring property, while the southern and western pit limits were formed based on the extent of borehole/subsurface data available. The western and southern boundaries are flexible and do not represent the final pit boundary locations.
- Material volumes were converted to tonnages based on the following assumed material bulk densities:

Upper Sand	1.85 tonnes per cubic metre
Clay	2.0 tonnes per cubic metre
Lower Sand	1.85 tonnes per cubic metre

- Reserve assessment was based on an extraction level extending to the basement sandstone or a level of 183 metres AHD. The volumes only include the Tertiary materials. No volume assessment has been completed for the sandstone, as there was insufficient data relating to these materials.
- The reserve assessment has not allowed for washing losses or scalping of the coarser fraction.
- Significant vertical and horizontal facies changes do not occur between boreholes.

5.5.2 Analysis Method

Following the 3D analysis (described in *Section 5.4*), the spatial and analytical data derived from the geotechnical/geological model (comprising the geological cross sections and PSD grading curves), were entered into the computer program MX, which is a 3D surface modelling package capable of creating design layers, and calculating and analysing layer volumes. This package is also able to produce plans showing

Isopachyte contours (lines joining points of equal layer thickness) and contour plans showing the bases of existing and design layers. In order to calculate the volumes of the resource, a pit boundary line, and a pit batter falling at 2(H):1(V) from the pit boundary to the base of the excavation were assumed. Using the package, information derived during the compilation of the geotechnical/geological model, and the assumed pit boundaries and batters, an estimate of the insitu volumes and tonnages of the various components of the resource was calculated.

The output from the MX modelling is presented as *Drawings 2 to 7*. *Drawings 2 to 4* present Isopachyte Contour plans for each of the Upper Sand, Clay and Lower Sand Units, while *Drawings 5 to 7* present Contour Plans show the base of the Upper Sand, Clay, and Lower Sand/Base of excavation.

Following the total volumetric analysis, the deposit was divided into 32, 100 metre square blocks. Each block is referenced using a grid naming system, as shown in *Drawing 1*. Using the MX package, vertical walls were applied to the four sides of each block. For blocks located along the pit boundary line, the design pit batter was also incorporated in the volume calculation. Each block was cut from the 3D model so that the volumes within each could be calculated. The volume and tonnage of each of the layers in each of the blocks was also calculated to refine the resource estimate. The relative thicknesses of each of the geological units within each block can be viewed from any perspective, while also providing an estimate of their volumes/tonnages.

The results of the volumetric assessment are presented in *Section 6.2*.

5.6 Estimation of Bulking Factor

Estimates of the bulking factor of the clay layer were undertaken as part of this assessment, using the following methodology:

- Three sites were selected by PF Formation staff for test pit excavation where the clay layer was exposed within the current extraction area. The locations of the test pit sites are shown approximately on *Drawing 1*.
- Using a 30 tonne track mounted excavator an L shaped test pit (viewed in plan) was excavated at each location to depths ranging between one and 2.5 metres, with both arm lengths of the L about 1.5 metres long. A cube of clay was marked out with dimensions of one metre cubed (one cubic metre). This area was excavated with the spoil placed into a skip bin.
- Prior to excavation of the soil, the internal dimensions of the skip bin were measured in order to calculate the internal volume of the bin.
- Insitu density tests were conducted within the soil materials at the top of the soil cube, and at a depth of 0.5 metres into the soil cube, in order to assess the relative density of the soil. The tests were carried out by technicians from a NATA registered laboratory. Bulk soil samples were collected and returned to the laboratory for compaction testing.
- At the completion of the excavation, the depth of soil in the skip bin was measured so the loose volume of soil in the bin could be calculated.

Once all measurements were taken and samples collected, the soil in the bin was replaced in the test pit and loosely compacted with the excavator bucket and tracks.

The results of the Bulking Factor Analysis are presented in *Section 6.3*.

6. Results of the Investigation

6.1 Geological Model

As described in *Section 3.1*, the Maroota Sand Deposit is of variable thickness and unconformably overlies an irregular basement of consisting dominantly of Triassic Hawkesbury Sandstone.

Based on the information contained within the summary borehole logs provided by Ian Stenhouse and using the Particle Size Distribution (PSD) analyses, the stratigraphy within the PF Formation Hitchcock Road site comprises three distinct units comprising the Upper Sand, Clay and Lower Sand. Geological cross sections constructed with North–South and East–West trends depicting the stratigraphy within the deposit are presented in *Appendix B*, as NS1 to NS6 and EW1 to EW6. Individual descriptions of each of the units are provided below.

6.1.1 Upper Sand Unit

The Upper Sand unit overlies the Clay Unit, and generally comprises fine to coarse grained silty sand and clayey sand with some gravel sized particles. Some of this unit is mined and used for washing and brickies sand.

A total of 20 PSD analyses were completed on samples collected from this unit during the drilling. Based on the results of these analyses, the fines component (silt and clay) generally ranges from between 22 percent and 30 percent, with one sample testing as sandy clay with 53 percent fines. The coarse component (gravel) generally ranges between one percent and 15 percent with particles up to about 10 millimetres detected in the PSD analysis. The PSD curves for the Upper Sand are presented as *PSD 1* and *PSD 2* in *Appendix C*.

The thickness of this unit is greatest beneath the southern end of former Maroota Trig Station, where it reaches about 17 metres. South of the Trig Station, the Upper Sand lenses out quickly over a distance of about 50 metres to 150 metres, while to the north and east the unit lenses out over distances of about 400 metres each. This is depicted in *Drawing 2*, which shows Isopachytes of the Upper Sand.

The base of the Upper Sand gently undulates between about 220 metres AHD to 225 metres AHD in the western and northern part of the site, and rises slowly to about 230 metres AHD as it lenses out towards the east. This is depicted in *Drawing 5*, which shows the contours of the base of the Upper Sand.

6.1.2 Clay Unit

An extensive layer of Clay underlies the Upper Sand, and overlies the Lower Sand. The materials within the Clay unit generally comprise Clay, Silty Clay, and Sandy Clay with trace gravel. This unit is generally stripped and stockpiled for later reuse as a liner or capping for the tailings ponds.

Four PSD analyses were completed on samples collected from this unit during the drilling. Based on the results of these analyses, the fines component ranged between 53 percent and 85 percent, while the coarse component was between one percent and six percent, leaving a sand component of between nine percent and 45 percent. The PSD curves for the Clay Unit are presented as *PSD 3* in *Appendix C*.

The thickness of this unit is highly variable across the site, particularly in the vicinity of the former Trig Station, as its base undergoes significant undulations. This is depicted in Geological Cross Sections NS2, NS3, and EW1. For example, in NS3 the clay thickness encountered decreases from 24 metres to 13 metres over a length of about 80 metres, and then increases to a thickness of 18 metres over a distance of 120 metres. The variable thickness of the clay unit is depicted in *Drawing 3*, which shows Isopachytes of the Clay.

Elsewhere on the site, the clay layer is generally between 10 metres to 15 metres thick and occurs between elevations of about 205 metres AHD to 215 metres AHD, except in the north eastern end of the site, where it occurs at about 220 metres AHD. The undulating base of the clay unit is depicted in *Drawing 6*, which shows the contours of the base of the Clay.

6.1.3 Lower Sand Unit

The Lower Sand is an extensive unit encountered underlying the Clay and overlying the basement Sandstone. Generally, the Lower Sand comprises fine to coarse grained, well graded silty sand and clayey sand with some gravel sized particles. This unit is generally the most economic and is targeted for extraction of construction sand products.

A total of 68 PSD analyses were completed on samples collected from this unit during the drilling. Based on the results of these analyses, the fines component (silt and clay) generally ranges from about 17 percent to 31 percent, with outlier samples between 10 percent and 55 percent. The coarse component (gravel) generally ranges from between one percent and 14 percent, with outlier samples between zero percent and 28 percent. Particles sizes up to about 13 millimetres were detected in the PSD analysis. The PSD curves for the Lower Sand are presented as *PSD 4* to *PSD 11* in *Appendix C*.

The thickness of the unit is quite variable across the site, as it is sandwiched between two undulating surfaces comprising the base of the clay, and the top of the basement sandstone. Based on the results of the drilling, the Lower Sand is thickest in the south eastern portion of the study area, as indicated in Geological Cross Sections NS4, NS5, NS6, EW1 and EW2. To the north and south of the former Trig Station reasonable thicknesses of the Lower Sand unit are present. However, to the north east of the former Trig Station (in the vicinity of RC02-12 and RC02-13), a low point in the undulating base of the clay layer nearly meets a high point in the basement sandstone, causing the Lower Sand unit to pinch out at this location. This is depicted in Geological Cross Sections NS2, NS3 and EW3. This will mean that extraction of the Lower Sand in the vicinity of the former Trig Station will be problematic as the over burden is highly variable and up to

25 metres thick. The variable thickness of the Lower Sand Unit is depicted in *Drawing 4*, which shows Isopachytes of the Lower Sand.

Over the south western and northern portions of the site, the base of the Lower Sand exists over varying reduced levels ranging between 195 metres AHD up to 205 metres AHD. In the south eastern corner of the site the base of the Lower Sand falls quickly from about 195 metres AHD to around 175 metres AHD. As described in *Section 5.5.*1, it has been assumed that sand extraction will extend no deeper than 183 metres AHD. *Drawing 7* shows contours depicting the base of the Lower Sand and includes a base extraction level of 183 metres AHD.

A feature of the Lower Sand is the presence of silty and clayey layers and lenses located wholly within the unit, or at its base, between the base of the lower Sand and the top of the basement Sandstone. These layers were not subject to PSD analyses and were identified during the drilling. Subsurface correlation of these silty and clayey layers/lenses has been carried out, as generally shown in the Geological Cross Sections in *Drawings 2* to *13*.

6.1.4 Basement Rock

Basement rock generally comprising Hawkesbury Sandstone is encountered underlying the entire study area and is unconformably overlain by the Lower Sand. Based on the results of the three PSD analyses carried out (presented at *PSD 12* in *Appendix C*), the sandstone is fine to medium grained and fine to coarse grained.

The surface of the sandstone is the same as that described for the Lower Sand Unit.

6.2 Resource Assessment

6.2.1 General

An estimate of the insitu material volume for each of the geological units has been prepared using the 3D surface modelling package MX. The estimate has been prepared using subsurface information collected by others, including:

- summary borehole logs recording the results of a drilling investigation;
- results of PSD analyses carried out on soils samples collected during the drilling; and
- a digitised site plan.

It was not possible to verify the reliability or accuracy of these results, therefore it has been assumed that they are sufficiently reliable for this study. It is also noted that the accuracy of the borehole survey (for both location and level), as well as the depths at which changes in lithology were logged in the boreholes, were all recorded to the nearest metre. The volumetric estimates provided in this report are therefore only as accurate as the input data. For example, if the Lower Sand unit was 0.5 metres thicker than logged, or the borehole collar levels were out by 0.5 metres, the variation of the

Lower Sand volume would amount to 450,000 cubic metres (assuming a Maroota Trig area of 90 hectares)

6.2.2 Reserve Assessment

In order to estimate the reserve, MX was programmed to construct the following surfaces:

- Topographic Surface – based on the digitised contoured site plan.
- Base of the Upper Sand
- Base of the Clay unit
- Base of the Lower Sand

  } Based on the lithology data from the boreholes.
- A horizontal layer at RL183, where the sediments dipped below the assumed lower extraction limit.

A pit batter sloping at 2(H):1(V) down from the assumed pit limits was formed in order to define the base of extraction. MX then calculated the volumes between each of the layers, including the volumes above the pit batter slopes, over the area shown in the *Drawing 1*. These volumes were converted to tonnages (using the unit weights assumed in *Section 5.5.1*), and are summarised in the *Table 1* below.

Table 1: Summary of Reserve Assessment

Material	Calculated Volume (m^3)	Calculated Tonnage (t)
Upper Sand	732,000	1,354,000
Clay Unit	1,684,000	3,368,000
Lower Sand (including silty materials)	2,619,000	4,845,000

Once the overall resource volumes and tonnages were calculated, the deposit was divided into 32 square blocks measuring one hundred metres square. The location and number of these blocks are shown in *Drawing 1*. The volumes and tonnages of each layer within each block were also estimated using MX in order to cross check the overall volume calculations. These results are summarised in *Table 2*.

Three blocks in *Table 2,* namely G8, G9 and H8, are left blank. Based on discussions with PF Formation staff it was determined that these areas have already been mined and have not been included in the volume assessments. Additionally, the volumes of blocks G10 and H9 have been reduced by values of one half and one third, respectively, to reflect the volume of extraction that has occurred within these blocks. The volumes listed in *Table 1* also include these reductions.

An estimate of the Stripping Ratio for each block is also included in *Table 2*, together with an over all stripping ratio for the entire deposit mined from within the pit boundary, as shown in *Drawing 1*. The Stripping Ratio is the ratio of the volume of over burden that has to be mined in order to reach the resource, compared to the amount of resource available beneath the over burden. The stripping ratios for each block vary considerably from 0.07 (Block G5) to 16.94. The over all Stripping Ratio for the assumed area is 0.97.

Table 2: Summary of Resource Estimates for Each Block

Block	Upper Sand		Clay		Lower Sand[1]		Stripping Ratio
	Volume (m^3)	Tonnage (t)	Volume (m^3)	Tonnage (t)	Volume (m^3)	Tonnage (t)	
G5	1,058	1,957	4,843	9,685	92,943	171,945	0.07
G6	4,612	8,532	110,283	220,567	148,834	275,344	0.83
G7	11,750	21,737	121,915	243,831	165,294	305,794	0.87
G8							
G9							
G10			6,764	13,527	41,098	76,031	0.18
H5	4,552	8,421	30,423	60,847	185,142	342,514	0.20
H6	48,538	89,796	146,185	292,371	241,890	447,497	0.85
H7	64,609	119,527	150,304	300,608	264,674	489,647	0.86
H8							
H9	3,361	6,217	38,539	77,079	83,754	154,945	0.54
H10	945	1,748	22,910	45,820	58,392	108,025	0.44
I4			25,927	51,855	15,302	28,309	1.83
I5	118,960	220,077	103,368	206,737	133,105	246,244	1.73
I6	94,082	174,051	140,804	281,607	118,237	218,739	2.08
I7	44,970	83,195	121,870	243,740	109,280	202,168	1.62
I8	3,813	7,054	2,057	4,114	356	659	16.94
I9							
J4			32,650	65,300	23,113	42,759	1.53
J5	122,121	225,925	116,529	233,059	135,117	249,966	1.84
J6	74,031	136,957	120,155	240,310	92,576	171,265	2.20
J7	14,129	26,139	66,318	132,636	39,049	72,241	2.20
J8							
K5	14,827	27,431	65,848	131,695	108,121	200,024	0.80
K6	60,209	111,387	59,947	119,895	163,610	302,678	0.76
K7	18,709	34,612	23,331	46,662	103,081	190,700	0.43
L5	1,033	1,911	8,838	17,676	38,977	72,108	0.27
L6	17,691	32,729	69,461	138,923	123,391	228,273	0.75
L7	7,828	14,481	27,678	55,357	35,404	65,498	1.07
M6			42,579	85,158	75,797	140,224	0.61
M7			18,546	37,092	5,618	10,392	3.57
N6			5,876	11,753	16,653	30,808	0.38
TOTAL	**731,828**	**1,353,883**	**1,683,951**	**3,367,902**	**2,618,810**	**4,844,798**	**0.97**

Note 1: Lower Sand Volumes and Tonnages include silty layers identified during the development of the geological model

6.3 Bulking Factor Assessment

6.3.1 Loose Bulking Factor

Materials excavated from the ground experience an increase in volume due to a reduction of the material density. This is referred to as bulking. If the materials are then engineered into place, their density increases and the volume is therefore reduced. In the following sections bulking factors for the clay material have been calculated in its loose state, and when it is engineered to form controlled fill.

The process used to collect the raw data for the Bulking Factor assessment is presented in *Section 5.6.*

The assessment was carried out to assess the amount of bulking that the Clay layer is likely to be subject to during excavation, and to assess its likely final bulking following placement as engineered fill.

Prior to commencement of the Bulking Factor Assessment, the internal dimensions of the skip bin were measured. Based on these measurements, an internal volume of the skip bin was calculated, which amounted to 1.7 cubic metres.

Summary descriptions of the materials encountered within the test pits, along with the other bulking factor assessment measurements are provided in *Table 3,* while the approximate locations of the test pits are shown in *Drawing 1.*

Table 3: Summary of Materials Encountered in Bulking Factor Test Pits

	Test Pit		
Test Pit No.	**TP1**	**TP2**	**TP3**
Materials Encountered	Silty Clay, high plasticity, white, cream, mottled purple (0.0 – 1.0m)	Topsoil (0.0 – 0.3m) Sandy Clay, medium plasticity, medium grained sand, yellow, white and mottled purple (0.3 – 2.5m)	Silty Clay, medium plasticity, white and cream with purple and yellow mottle (0.0 – 1.5m)
Test Pit Depth (m)	1.0m	2.5m	1.5
Depth over which soil cube was taken (m)	0.0m – 1.0m	1.4m – 2.4m	0.0m – 1.0m
Insitu Volume of soil excavated (m^3)	1.0m^3	1.0m^3	1.0m^3
Depth of insitu density tests (m)	0.0m and 0.5m	1.4m and 1.9m	0.0m and 0.5m
Depth to top of Soil in skip bin (m)	0.0m	0.17m	0.08m
Volume of Soil in skip bin (m^3)	1.7m^3	1.3m^3	1.5m^3
Bulking Factor	**1.7**	**1.3**	**1.5**

Based on the results of the test pitting and the Bulking Factor assessment, it is apparent that the soils from the Clay Unit exhibit a bulking factor between 1.3 and 1.7.

The high plasticity soil in test pit TP1 had the highest bulking factor at 1.7. A bulking factor of about 1.5 is considered normal for high plasticity clay. However, given that high plasticity soils generally form blocky soil pods upon excavation, this result is considered reasonable and likely to be at the high end of the scale.

The sandy clay from TP2 had the lowest bulking factor at 1.3. Low and medium plasticity clays normally bulk up to about 1.3 times their insitu volume. This result is therefore considered normal for such a material. However, given that the soil within the Maroota Sand deposit generally displays variations both laterally and vertically, it would be considered reasonable to expect a total bulking factor for the Clay unit of about 1.5.

6.3.2 Compacted Bulking factor

Insitu density tests were carried out at two levels within the soil cubes being tested, comprising the top of the soil cube and 0.5 metre depth into the soil cube. The purpose of the tests was to determine a measure of the field dry density of the soil. Bulk soil samples collected from each test location were dispatched to a NATA registered testing laboratory where they underwent Standard Compaction Tests. The purpose of these tests was to determine a measure of the density of the soil under standard compactive effort (Standard Maximum Dry Density). The ratio of the two densities (the insitu density and Standard Maximum Dry Density) will equal the Compacted Bulking Factor for the soils tested.

The results of the insitu and laboratory tests carried out in the field and on the samples collected are summarised in *Table 4* and presented in full in *Appendix A.*

Table 4: Summary of Insutu Density and Laboratory Compaction Test Results

	Test Pit					
	TP1		**TP2**		**TP3**	
Test/Sample Depth (m)	0.0	0.5	1.4	1.9	0.0	0.5
Field Dry density (t/m^3)	1.76	1.72	1.97	1.96	1.78	1.87
Field Moisture Content (%)	21.0	21.5	9.0	8.5	17.5	15.5
Standard Maximum Dry density (t/m^3)	1.63	1.63	1.98	2.01	1.69	1.71
Standard Optimum Moisture Content (%)	21.0	21.5	11.5	10.5	19.5	19.5
Density Ratio (%)	108.5	105.5	100.0	97.5	105.5	109.5
Compacted Bulking Factor	**1.09**	**1.06**	**1.0**	**0.98**	**1.06**	**1.1**

The compacted bulking factor ranges from 0.96 to 1.1. The low values (1.0 and 0.96) were returned from samples tested from test pit TP2. The materials within this test pit comprised sandy clay of medium plasticity. It is reasonable to expect that the soils within the Clay Unit are likely to be more clayey than those encountered in TP2. On this basis, we would expect that the Compacted Bulking Factor is more likely to be between 1.05 and 1.1, as the remainder of the results suggest.

7. Comments and Recommendations

7.1 Pit Design

Based on the results of the geological/geotechnical assessment described in the report, an assessment of a possible mine operation that comprises extraction of the resource over the Maroota Trig area has been prepared. The pit extraction limits have been based on a 30 metre off set from existing road alignments, a 50 metre off set from adjacent neighbours, or positioned at the extent of borehole/subsurface information.

Drawing 7 shows the predicted surface contours of the area assessed on completion of sand extraction. The drawing shows the pit batter constructed for mining purposes at a slope of 2(H):1(V). The countors shown over the northern portion of the site represent the basement rock level, with all the Tertiary sediments within the pit limits extracted down to rock, while those contours over the south eastern portion represent the extraction limit set to 183 metres AHD.

The thickness of the Lower Sand unit almost pinches out in the vicinity of boreholes RC02-12 and RC02-13 (see *Drawing 4*) as a low point in the undulating base of the Clay unit nearly meets a high point in the undulating basement sandstone . Furthermore, the overburden (Upper Sand and Clay units) in this area reaches a thickness of about 25 metres. On this basis, it may be prudent to divide the mining operation into two pits, comprising northern and southern pits, separated by an east west trending land bridge. This would have the affect of reducing the over all stripping ratio of the mining operation. However it would also reduce the over all volume of Lower Sand won from the mine and would sterilise the Lower Sand located beneath the land bridge.

7.2 Rehabilitation

The mine design has incorporated pit slopes constructed at an angle of 2(H):1(V). This slope angle would not be suitable or practical in the long term due to slope stability concerns, nor would it be permissible. Therefore, subsequent to mining there would be a requirement to rehabilitate the site to a manner where by the pit slopes are stable, consistent with the surrounding landside character, and to a design approved by the relevant statutory authority. On this basis it would be expected that the batters would require flattening to a grade of 4(H):1(V). We expect that the most efficient means of completing this would involve the placement of fill against the batters. Based on the volumetric analysis, we expect that up 2,536,800 tonnes/4,958,000 cubic metres of overburden materials derived during the mining operation would be available for site remediation. These figures have assumed that the material would be placed as engineered fill with a bulking factor of 1.05.

8. Limitations

It is possible that the subsurface soil and rock conditions encountered during construction may vary from those identified in this report. Should such variations or differences become apparent we recommend that this office should be immediately contacted for further geotechnical advice. This report should be read in conjunction with the appended notes that explain the limitations of the geotechnical investigations (*Appendix E*).

9. References

1. I. Stenhouse (2002), *Geological Assessment of the P.F. Formation Maroota Sand Deposit*, CSR Readymix (unpublished).

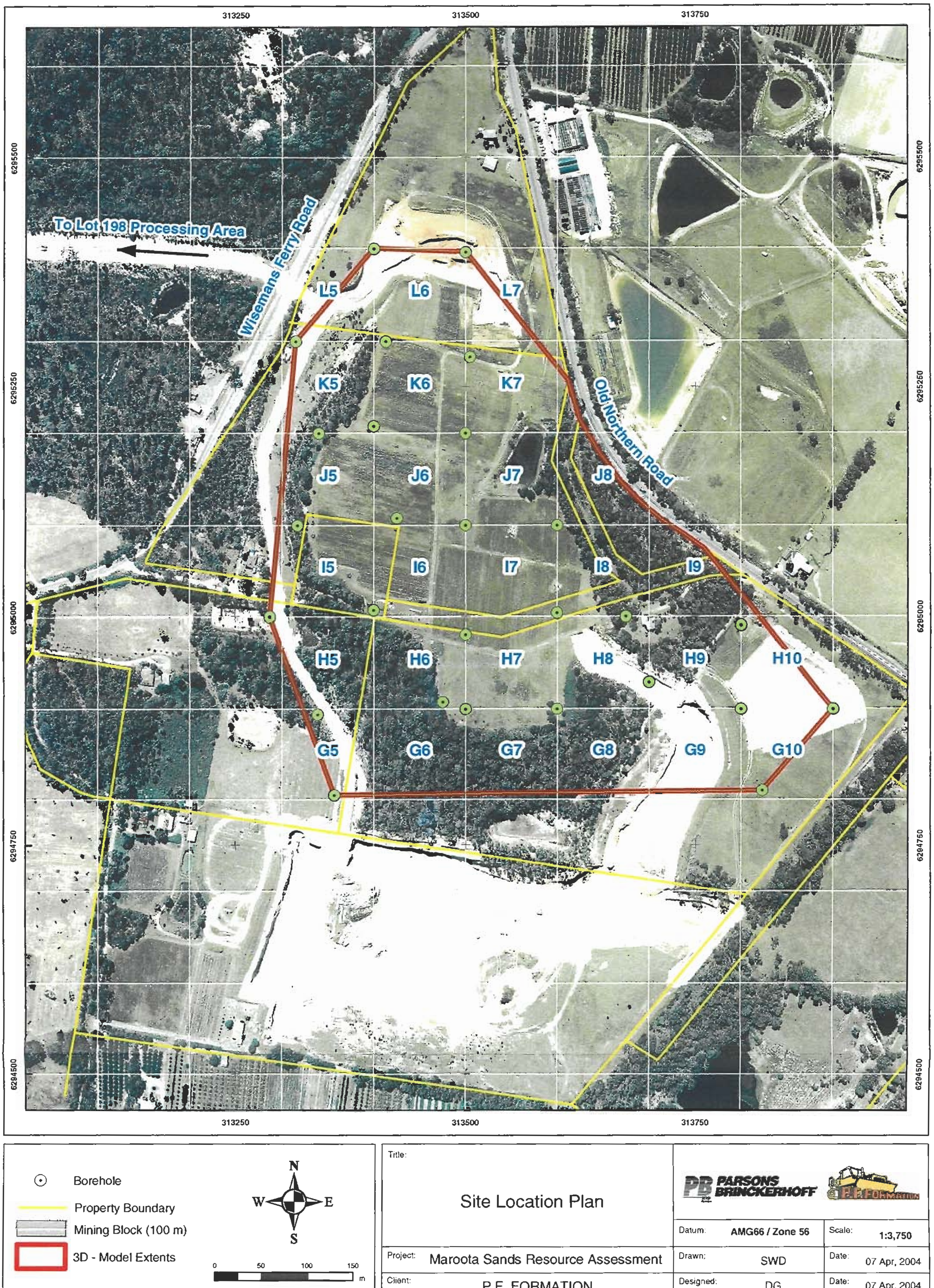
2. L. H. Etheridge, (1980), *Geological Investigation and resource Assessment of the Maroota Tertiary Alluvial Deposit*, Geological Survey of New South Wales, Department of Mineral resources, Report GS1980/201.

3. J. Whitehouse & P. Roy (2000), *Friable Sandstone Resources of the Sydney Planning Region and Nearby Areas*, in *Sandstone City – Sydney's Dimension Stone and Other Sandstone Geomaterials* (2000), edited by G.H. McNally & B.J. Franklin, Environmental Engineering and Hydrologeology Specialist Group (EEHSG). Geological Society of Australia, Monograph No. 5, SOS Printing, Alexandria, Australia, pp248 – 258.

4. J.T. Pienmunne & J. Whitehouse, (2001), *Supply and Demand for Construction Sand in the Sydney Planning Region*, Geological Survey of New South Wales, Department of Mineral resources, Report GS2001/086.

Figures

Figure 1: Regional Site Location Plan



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Proj. No. 2110178A	Layout Size: A3	Checked: DG	Date: 07 Apr, 2004
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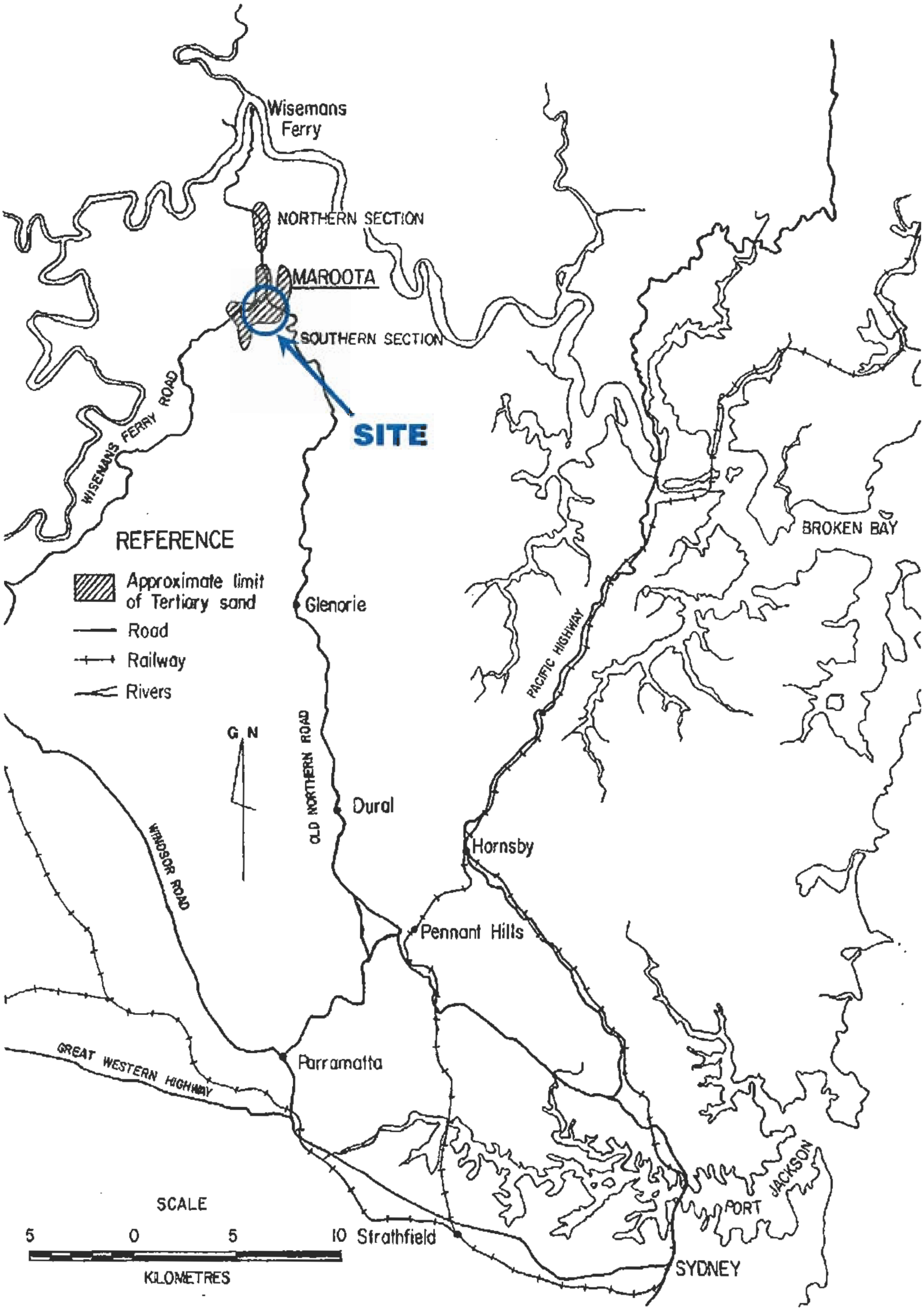


Figure 3: Northern and Southern Sections of the Tertiary Maroota Sand Deposit, showing location of the PF Formation Pty Ltd workings (Etheridge 1980).

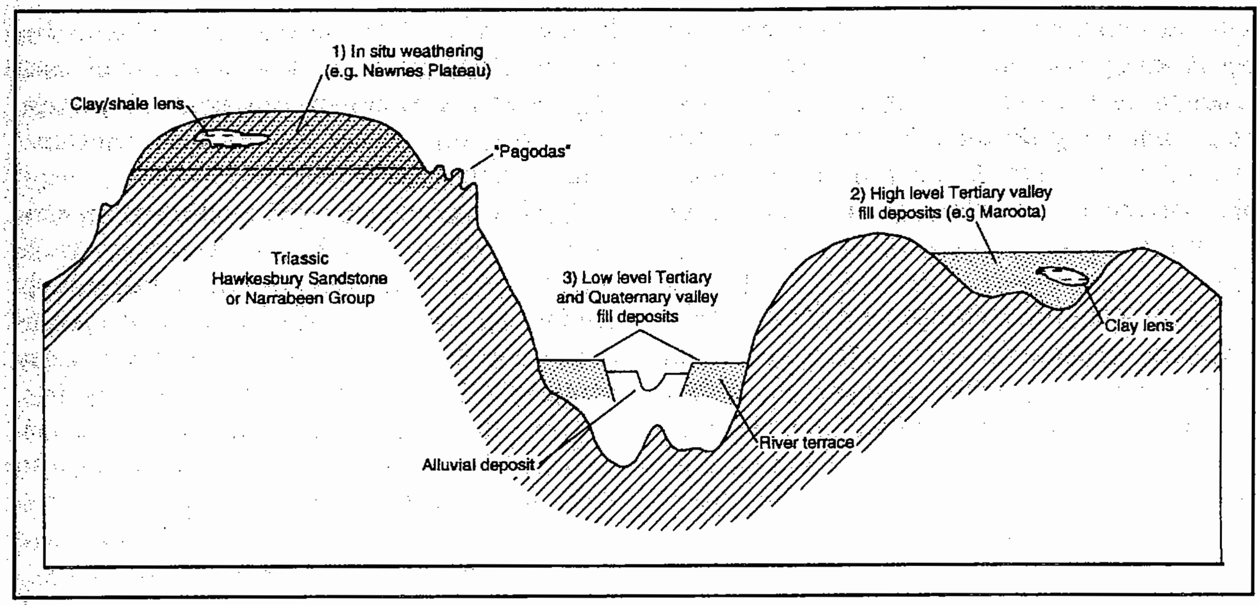
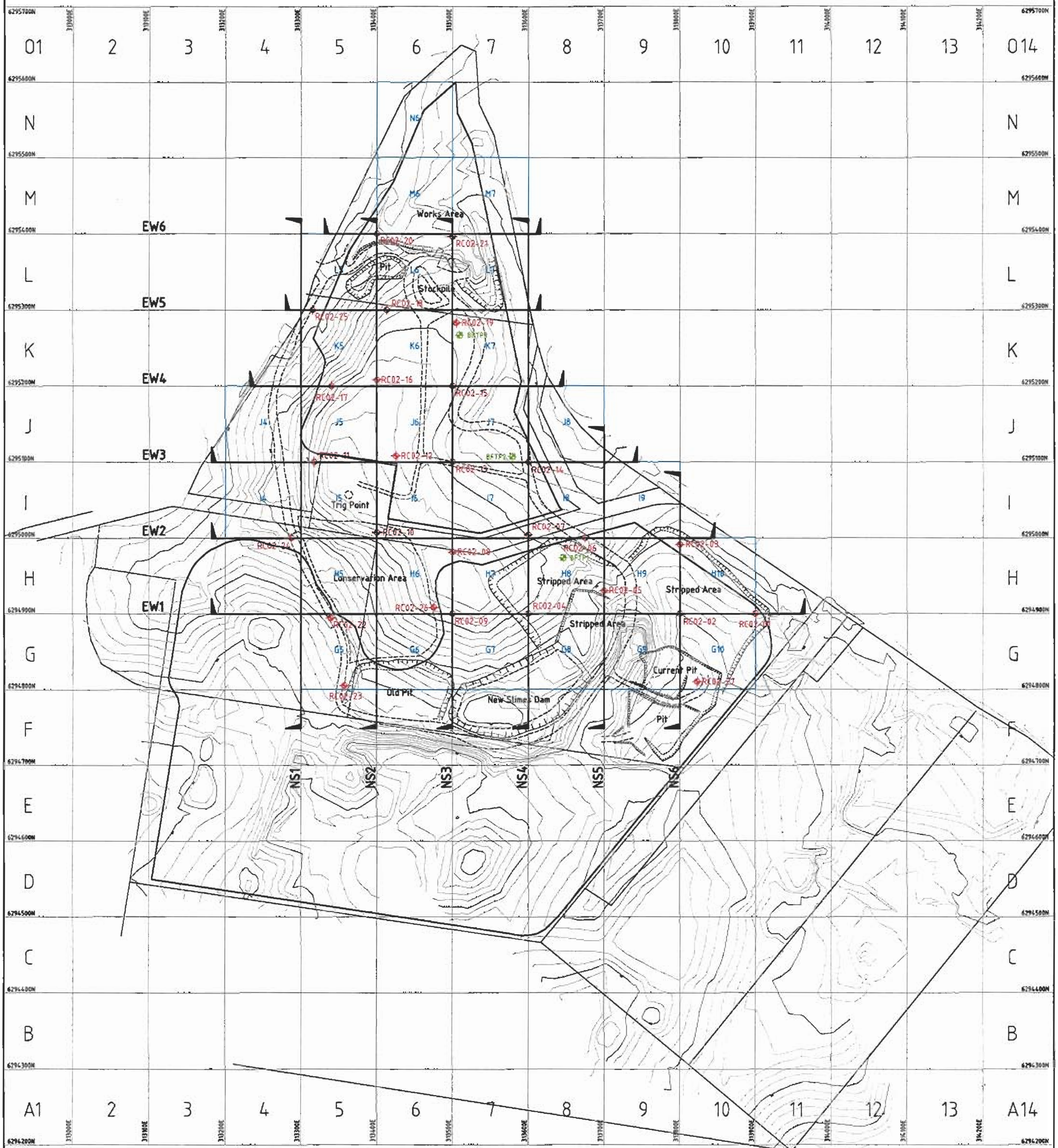


Figure 4: Stratigraphic relationship between the Triassic Basement, Tertiary alluvial deposits, and the late Tertiary and Quaternary alluvial deposits in the Maroota region (Whitehouse and Roy, 2000).

Drawings



LEGEND

RC02-01	NUMBER AND APPROXIMATE LOCATION OF BOREHOLES
BFTP1	NUMBER AND APPROIMATE LOCATION OF BULKING FACTOR TESTPIT
NS2	NUMBER AND APPROXIMATE LOCATION OF GEOTECHNICAL CROSS SECTIONS
G7	NUMBER AND APPROXIMATE LOCATION OF 3D BLOCK MODELS

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1		PRELIMINARY ISSUE FOR REVIEW	JSC	

Scale 0 50 100 A1 / A3 1:2500 / 1:5000 — A1 ORIGINAL

Drawn: JSC	Date
Designed	Date
Drawing Check	Date
Design Check	Date
Project Approval	Date

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Client: PF FORMATION

Project: MAROOTA SANDS GEOTECHNICAL ASSESSMENT

BOREHOLES AND CROSS SECTION LOCATION PLAN

Job No: 2110178A
File No: 2110178AD01
Drawing No: 01
Rev: 1

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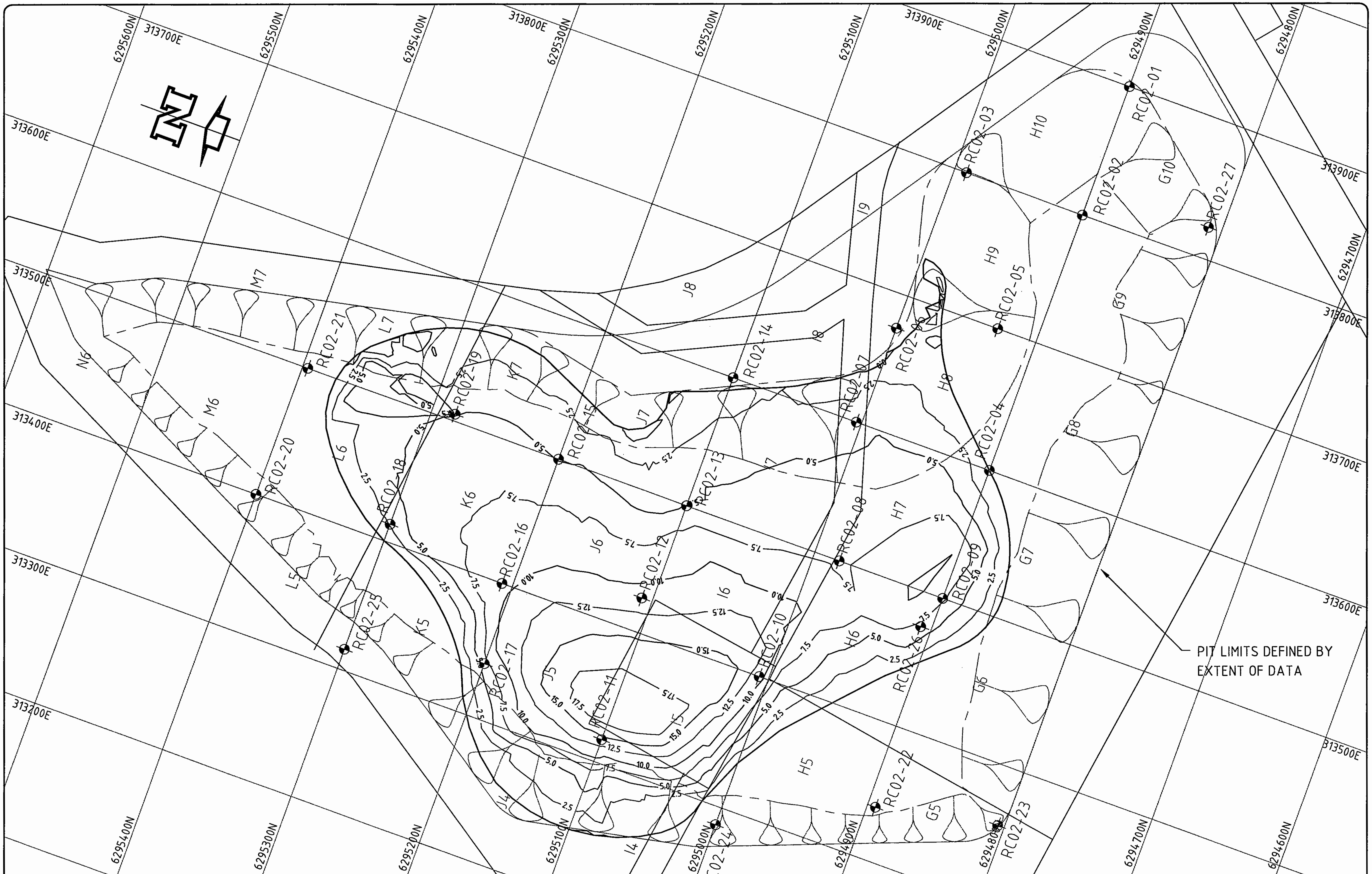

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NCSI certified Quality System to ISO 9001

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JDC	26.3.04
Designed	Date
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Design Check	Date
Project Approval	Date

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Project: Maroota Sands Resource Estimation

Upper Sand Isopachyte (Thickness) Contours

Job No	File No	Drawing No	Rev
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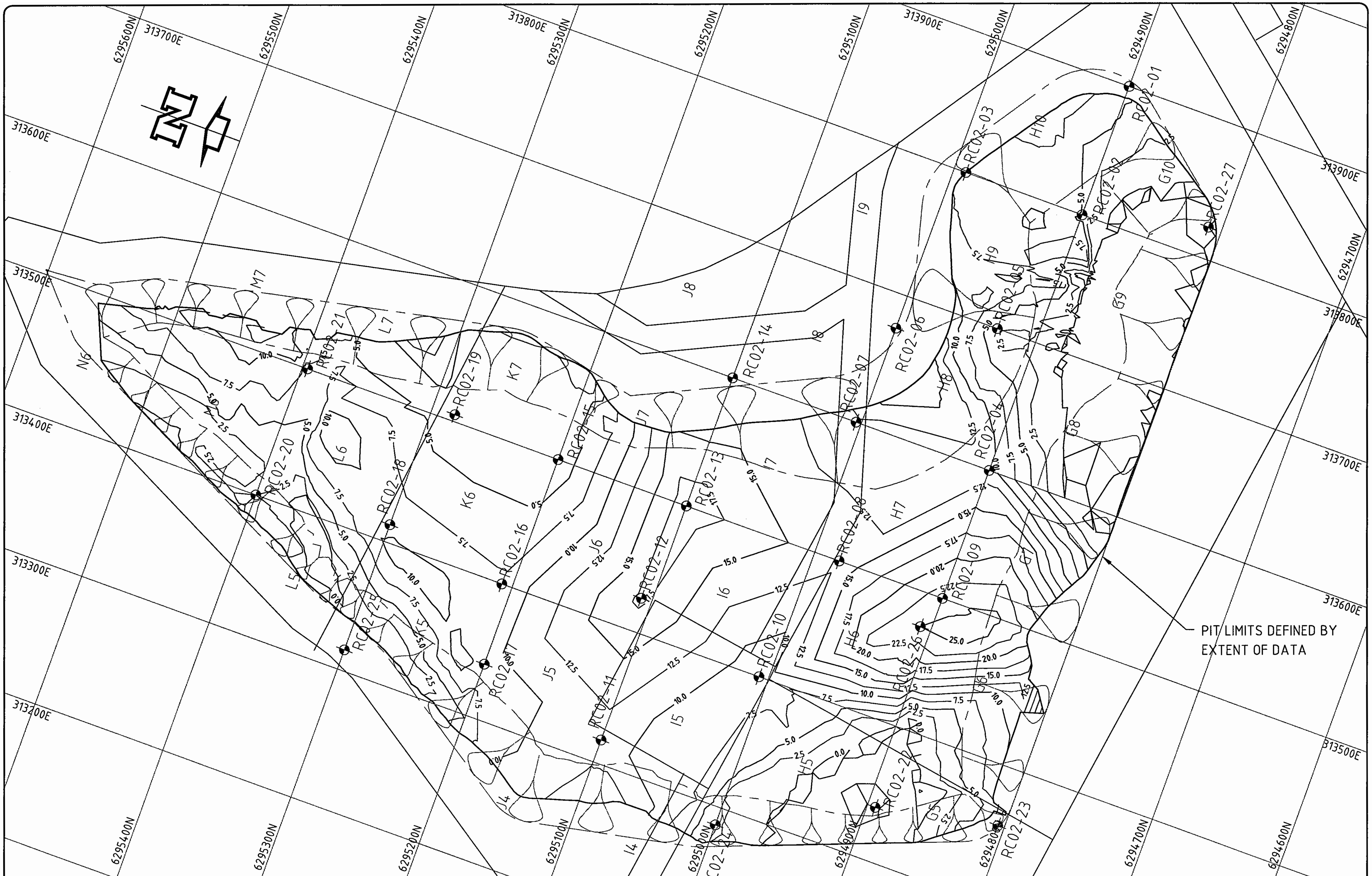

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Design Check	Date
Project Approval	Date

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Client: PF FORMATION
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Clay Isopachyte (Thickness) Contours

Job No: 2110178A
File No: 2110178AD01
Drawing No: 03
Rev: 1

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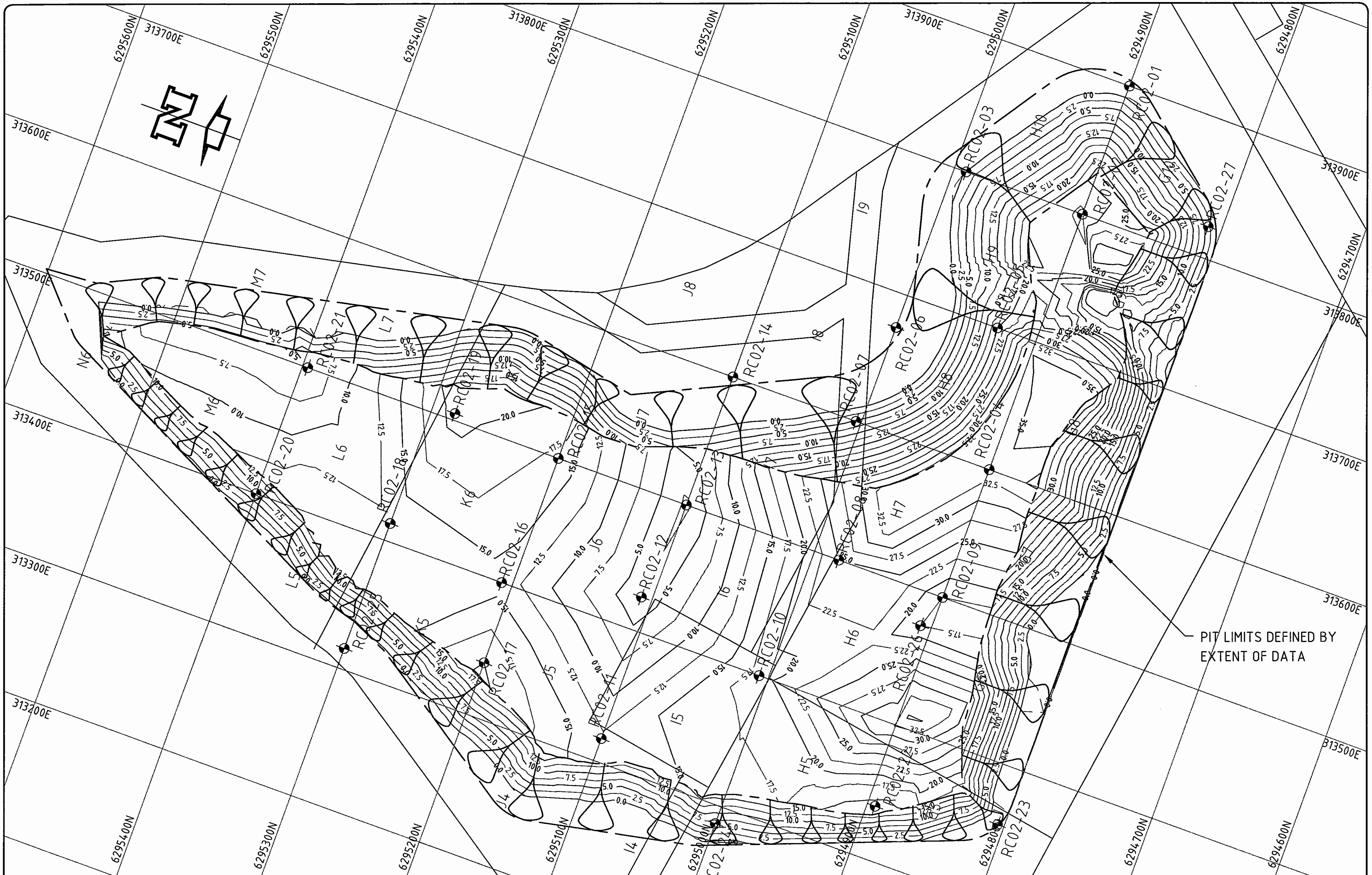

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Designed	Date
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Project Approval	Date

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Lower Sand Isopachyte (Thickness) Contours

Job No: 2110184A
File No: 2110184AD01
Drawing No: 04
Rev: 1

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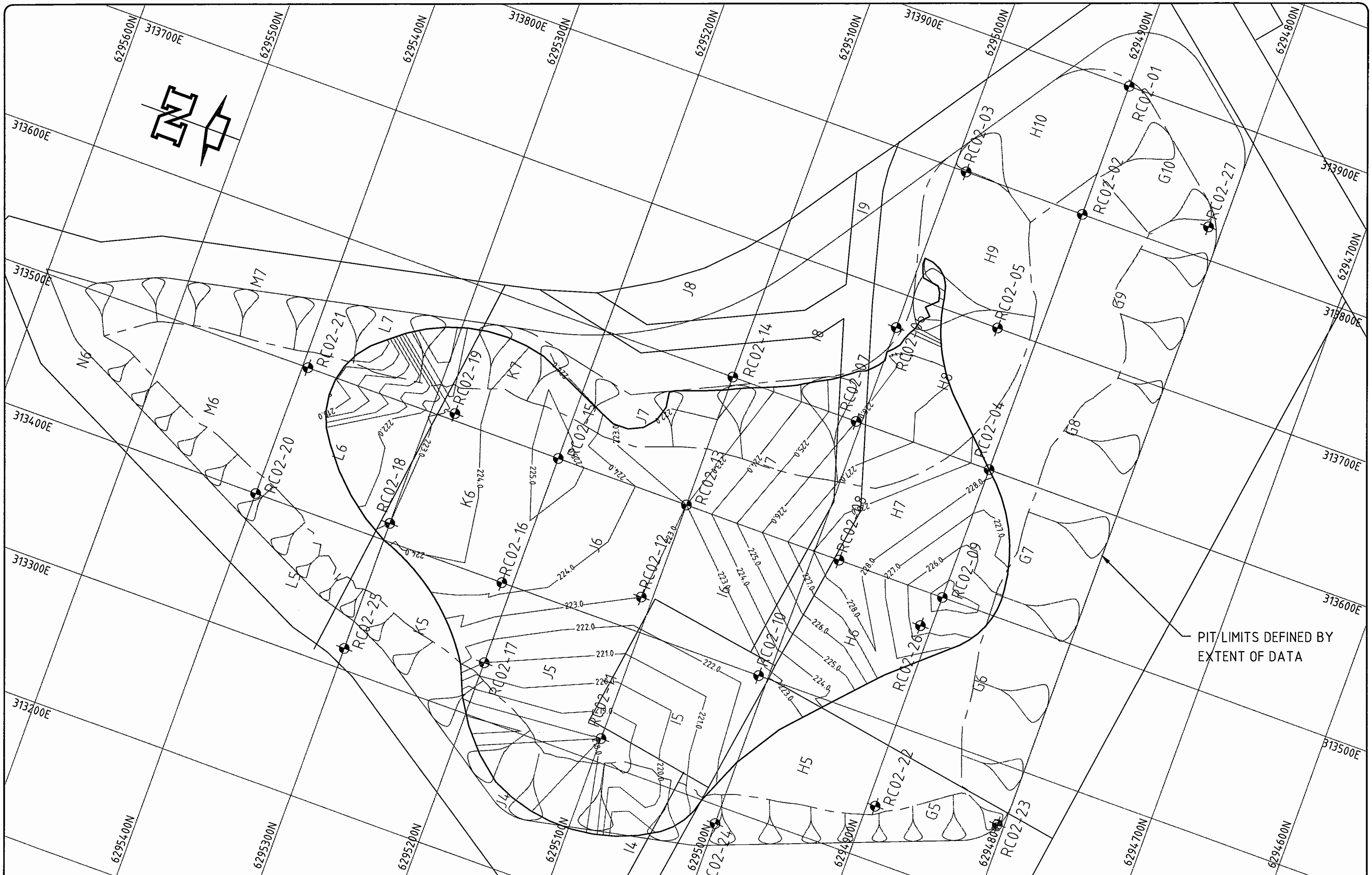

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NCSI certified Quality System to ISO 9001

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Design Check		Date	
Project Approval		Date	

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Client: PF FORMATION

Project: Maroota Sands Resource Estimation

Contour Plan Showing Base of Upper Sand

Job No 2110184A

File No 2110184AD01

Drawing No 05

Rev 1

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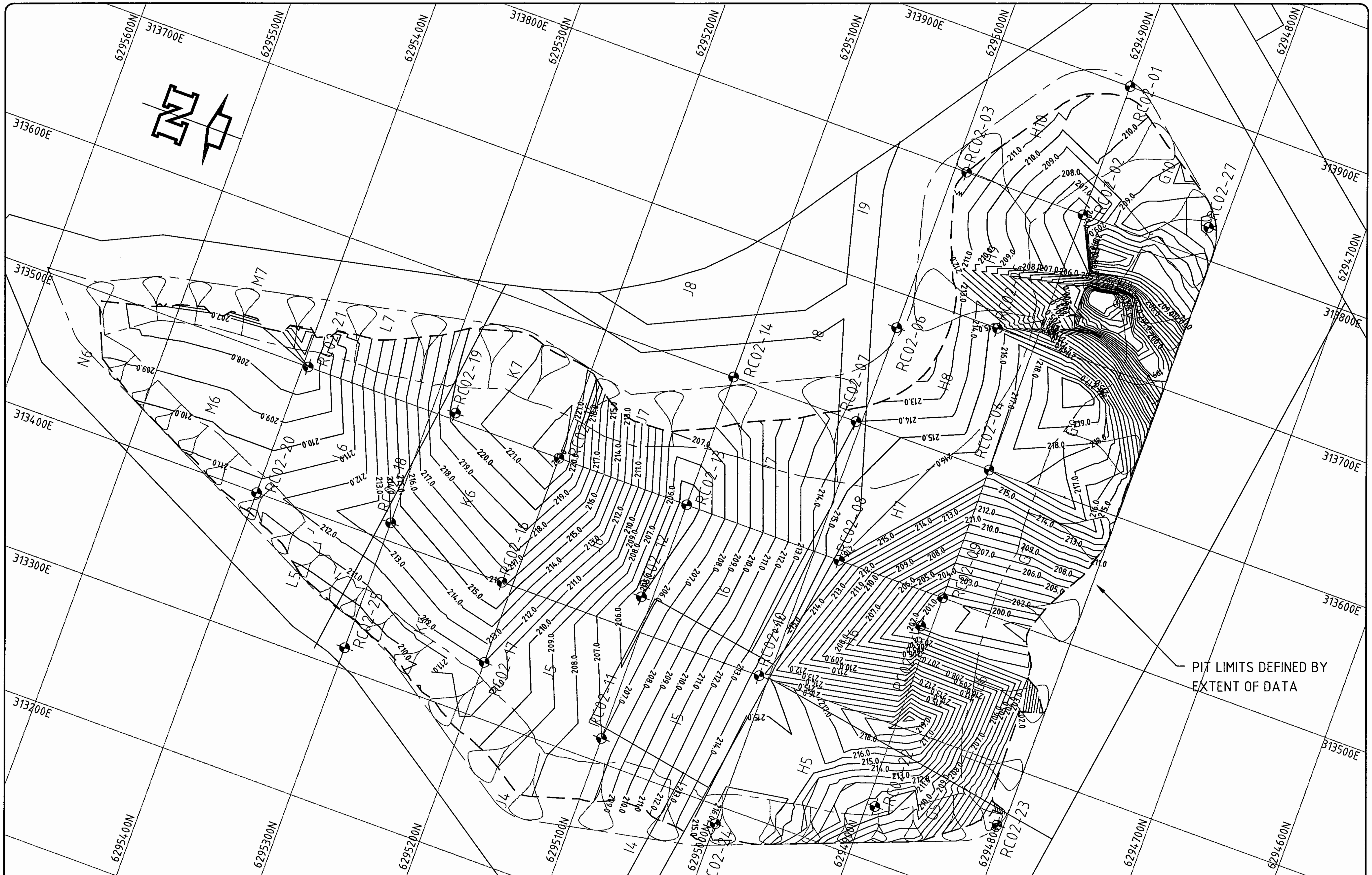

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Design Check	Date
Project Approval	Date

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Client: PF FORMATION
Project: Maroota Sands Resource Estimation
Contour Plan Showing Base Of Clay

Job No 2110184A
File No 2110184AD01
Drawing No 06
Rev 1

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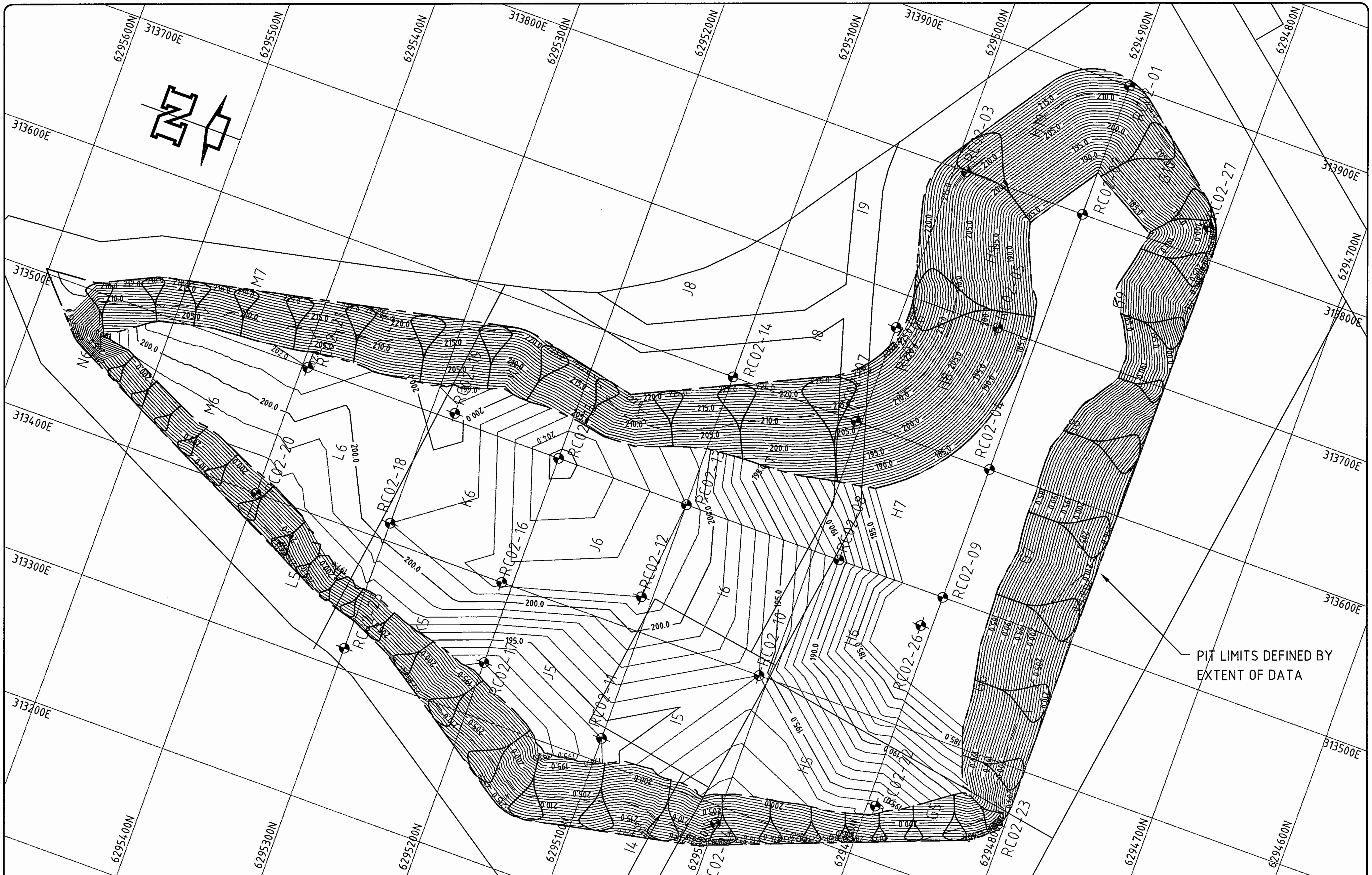

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Client: PF FORMATION

Project: Maroota Sands Resource Estimation

Contour Plan Showing Base of Lower Sand / Top of Rock / Excavation

Job No: 2110184A
File No: 2110184A
Drawing No: 07
Rev: 1

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Appendix A

A1. Engineering Test Pit Logs
A2. Laboratory Test Results

Appendix A1

A1. Engineering Test Pit Logs

Explanatory Notes - Soil Description

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from the Unified Soil Classification system and a soil symbol is used to define a soil layer .

METHOD

Method	Description
AS	Auger Screwing
BH	Backhoe
CT	Cable Tool Rig
EE	Existing Excavation/Cutting
EX	Excavator
HA	Hand Auger
HQ	Diamond Core-63mm
JET	Jetting
NMLC	Diamond Core –52mm
NQ	Diamond Core –47mm
PT	Push Tube
RAB	Rotary Air Blast
RB	Rotary Blade
RT	Rotary Tricone Bit
TC	Auger TC Bit
V	Auger V Bit
WB	Washbore
DT	Diatube

WATER

Water level at date shown

Partial water loss

Water inflow

Complete water loss

NFGWO: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

NFGWE: The borehole/test pit was dry soon after excavation. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING

Sample	Description
B	Bulk Disturbed Sample
D	Disturbed Sample
Jar	Jar Sample
SPT	Standard Penetration Test
U50	Undisturbed Sample –50mm
U75	Undisturbed Sample –75mm

UNIFIED SOIL CLASSIFICATION

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as, sieve analysis, liquid limit and plasticity index.

USC Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peaty Soil

MOISTURE CONDITION

Dry - Cohesive soils are friable or powdery
Cohesionless soil grains are free-running

Moist - Soil feels cool, darkened in colour
Cohesive soils can be moulded
Cohesionless soil grains tend to adhere

Wet - Cohesive soils usually weakened
Free water forms on hands when handling

For cohesive soils the following codes may also be used:

MC>PL Moisture Content greater than the Plastic Limit.
MC~PL Moisture Content near the Plastic Limit.
MC<PL Moisture Content less than the Plastic Limit.

PLASTICITY

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows:

Description of Plasticity	LL (%)
Low	<35
Medium	35 to 50
High	>50

COHESIVE SOILS - CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by hand penetrometer values and by resistance to deformation to hand moulding.

A Hand Penetrometer may be used in the field or the laboratory to provide an approximate assessment of the unconfined compressive strength (UCS) of cohesive soils. The undrained shear strength of cohesive soils is approximately half the UCS. The values are recorded in kPa as follows:

Strength	Symbol	Undrained Shear Strength (kPa)
Very Soft	VS	< 12
Soft	S	12 to 25
Firm	F	25 to 50
Stiff	St	50 to 100
Very Stiff	VSt	100 to 200
Hard	H	> 200

COHESIONLESS SOILS - RELATIVE DENSITY

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) 'N' values. Other condition terms, such as friable, powdery or crumbly may also be used.

Term	Symbol	Density Index	N Value (blows/0.3 m)
Very Loose	VL	0 to 15	0 to 4
Loose	L	15 to 35	4 to 10
Medium Dense	MD	35 to 65	10 to 30
Dense	D	65 to 85	30 to 50
Very Dense	VD	>85	>50

COHESIONLESS SOILS PARTICLE SIZE DESCRIPTIVE TERMS

Name	Subdivision	Size
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

Rock Description

The rock is described with strength and weathering symbols as shown below. Other features such as bedding and dip angle are given.

METHOD

Refer soil description sheet

WATER

Refer soil description sheet

ROCK QUALITY

The fracture spacing is shown where applicable and the Rock Quality Designation (RQD) or Total Core Recovery (TCR) is given where:

$$TCR\ (\%) = \frac{\text{length of core recovered}}{\text{length of core run}}$$

$$RQD\ (\%) = \frac{\text{Sum of Axial lengths of core > 100mm long}}{\text{length of core run}}$$

ROCK MATERIAL WEATHERING

Rock weathering is described using the abbreviations and definitions used in AS1726. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is deemed that there is no advantage in making such a distinction, DW may be used with the definition given in AS1726.

Symbol	Term	Definition
RS	Residual Soil	Soil definition on extremely weathered rock; the mass structure and substance are no longer evident; there is a large change in volume but the soil has not been significantly transported
XW	Extremely Weathered	Rock is weathered to such an extent that it has 'soil' properties, ie. It either disintegrates or can be remoulded in water
HW	Highly Weathered	The rock substance is affected by weathering to the extent that limonite staining or bleaching affects the whole rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength is usually decreased compared to the fresh rock. The colour and strength of the fresh rock is no longer recognisable.
DW (HW to MW)	*Distinctly Weathered*	
MW	Moderately Weathered	The whole of the rock substance is discoloured, usually by iron staining or bleaching, to the extent that the colour of the fresh rock is no longer recognisable
SW	Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength from fresh rock
FR	Fresh	Rock shows no sign of decomposition or staining

ROCK STRENGTH

Rock strength is described using AS1726 and ISRM - Commission on Standardisation of Laboratory and Field Tests, 'Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index', as follows:

Term	Symbol	Point Load Index $Is_{(50)}$ (MPa)
Extremely Low	EL	<0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	>10

● Diametral Point Load Index test

■ Axial Point Load Index test

DEFECT SPACING/BEDDING THICKNESS

Measured at right angles to defects of same set or bedding.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly Laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very Thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2 m	Thick
Very widely spaced	>2 m	Very Thick

DEFECT DESCRIPTION

Type:	Definition:
B	Bedding
BP	Bedding Parting
F	Fault
C	Cleavage
J	Joint
SZ	Shear Zone
CZ	Crushed Zone
DB	Drill Break

Planarity:	Roughness:
P – Planar	R – Rough
Ir – Irregular	S – Smooth
St – Stepped	Sl – Slickensides
U – Undulating	Po – Polished

Coating or Infill:	Description
Clean	No visible coating or infilling
Stain	No visible coating or infilling but surfaces are discoloured by mineral staining
Veneer	A visible coating or infilling of soil or mineral substance but usually unable to be measured (<1mm). If discontinuous over the plane, patchy veneer
Coating	A visible coating or infilling of soil or mineral substance, >1mm thick. Describe composition and thickness

The inclination if defects are measured from perpendicular to the core axis.

Graphic Symbols for Soil and Rock

Graphic symbols used on borehole and test pit reports for soil and rock are as follows. Combinations of these symbols may be used to indicate mixed materials such as clayey sand.

Soil Symbols

Main Components

- CLAY
- SILT
- SAND
- GRAVEL
- BOULDERS / COBBLES
- PEAT (Organic)

Minor Components

- Clayey
- Silty
- Sandy
- Gravelly

Other Symbols

- TOPSOIL
- FILL
- ASPHALT
- CONCRETE
- NO CORE

Rock Symbols

Sedimentary Rocks

- SANDSTONE
- SILTSTONE
- CLAYSTONE, MUDSTONE
- SHALE
- LAMINITE
- CONGLOMERATE
- BRECCIA
- TILL
- COAL
- LIMESTONE

Igneous Rocks

- PLUTONIC IGNEOUS (eg: Granite)
- VOLCANIC IGNEOUS (eg: Basalt)
- PYROCLASTIC IGNEOUS (eg: Ignimbrite)

Metamorphic Rocks

- SLATE, PHYLLITE, SCHIST
- GNEISS
- QUARTZITE

TEST PIT ENGINEERING LOG

TEST PIT NO. **BFTP1**

SHEET 1 OF 1

Client:	**P. F. Formation**	Date Commenced:	**21/10/03**
Project:	**Maroota Sands Resource Estimation**	Date Completed:	**21/10/03**
Test Pit Location:	**Hitchcock Road SAnd Mine**	Recorded By:	**RC**
Project Number:	**2110178A**	Log Checked By:	**EDG**

Excavation Method: **CAT 330BL**

Surface RL:

Co-ords:

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
NFGWE	0 – 1		B B		CH	Silty CLAY: high plasticity, white with purple mottle	M	H		Insitu Density Test ALLUVIAL Insitu Density Test 1 cubic m of soil excavated and placed into skip bin
	1					END OF TEST PIT AT 1.00 m				

Depth scale: 1, 2, 3, 4

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO. **BFTP2**

SHEET 1 OF 1

Client:	**P. F. Formation**	Date Commenced:	**21/10/03**
Project:	**Maroota Sands Resource Estimation**	Date Completed:	**21/10/03**
Test Pit Location:	**Hitchcock Road SAnd Mine**	Recorded By:	**RC**
Project Number:	**2110178A**	Log Checked By:	**EDG**

Excavation Method: **CAT 330BL**

Surface RL:

Co-ords:

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
NFGWE	0.00–0.30				CL	TOPSOIL: Silty Clayey SAND; medium grained, dark brown.	M	F–ST		TOPSOIL
	0.30–2.50		B (1.35–1.65); B (1.85–2.15)		CL	Sandy CLAY: medium plasticity, sand medium grained, yellow, white and purple mottle		H		ALLUVIAL; Insitu Density Test (1.4); Insitu Density Test (1.9)
	2.50					END OF TEST PIT AT 2.50 m				

1 cubic m of soil excavated and placed into skip bin

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

TEST PIT ENGINEERING LOG

TEST PIT NO.

BFTP3

SHEET 1 OF 1

Client:	**P. F. Formation**	Date Commenced:	**21/10/03**
Project:	**Maroota Sands Resource Estimation**	Date Completed:	**21/10/03**
Test Pit Location:	**Hitchcock Road SAnd Mine**	Recorded By:	**RC**
Project Number:	**2110178A**	Log Checked By:	**EDG**

Excavation Method: **CAT 330BL**

Surface RL:

Co-ords:

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) AHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
N F G W E	0–1.50		B, B		CL	Silty CLAY; medium plasticity, white with silght purple and yellwo mottle	M	H		Insitu Density Test ALLUVIAL Insitu Density Test
	1.50					END OF TEST PIT AT 1.50 m				

1 cubic m of soil excavated and placed into skip bin

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

Appendix A2

A2. Laboratory Test Results

Testrite Coring Pty. Ltd. ABN 16 001 124 830
Ph: 9736 3922 Fax: 9743 5860

TESTRITE

CONSTRUCTION MATERIALS TESTING

4 Rothwell Ave, (P.O. Box 329)
CONCORD WEST NSW 2138

REPORT ON COMPACTION CONTROL TESTS

REPORT NO : 25005

TOTAL TESTS 6

CLIENT : PARSONS BRINCKERHOFF AUSTRALIA PTY. LTD.
ADDRESS : Locked Bag 248
RHODES NSW 2138

This laboratory is accredited by the National Association of Testing Authorities, Australia. The tests reported herein have been performed in accordance with its terms of accreditation.

N.A.T.A. Accreditation No: 844

PROJECT : P.F. FORMATION
SAND QUARRY, MAROOTA.

DATE TESTED : 21-Oct-03

TEST NUMBER	1	2	3	4	5
RETEST OF NO.	--	--	--	--	--
TIME TESTED	10.05	10.45	12.00	12.45	14.50
ELEMENT TESTED	SAND QUARRY PIT 7 WEST END	SAND QUARRY PIT 7 WEST END	OFF ACCESS ROAD. (HAUL RD.)	OFF ACCESS ROAD. (HAUL RD.)	SOUTH OF WASH PLANT
LOCATION	Location 1 25m below surface.	Location 1 25m below surface.	Location 2	Location 2	Location 3
LEVEL AT TOP OF HOLE	Excavation Level	500mm below Excavation Level.	1.4m below Surface Level.	1.9m below Surface Level.	Excavation Level
MATERIAL DESCRIPTION	Clay	Clay	Sandy Clay	Sandy Clay	Clay
LAYER THICKNESS (mm)	N/A	N/A	N/A	N/A	N/A
PROBE DEPTH (mm)	300	300	300	300	300
FIELD DRY DENSITY (t / m3)	1.76	1.72	1.97	1.96	1.78
FIELD MOISTURE CONTENT (%)	21.0	21.5	9.0	8.5	17.5
OVERSIZE CONTENT, WET BASIS (%)	NIL	NIL	NIL	NIL	NIL
OVERSIZE CONT., OVEN DRY BASIS (%)	NIL	NIL	NIL	NIL	NIL
OVERSIZE SCREENING SIEVE (mm)	19.0	19.0	19.0	19.0	19.0
MAXIMUM DRY DENSITY (t/m3)	1.63 Standard	1.63 Standard	1.98 Standard	2.01 Standard	1.69 Standard
ADJUSTED MAX. DRY DENSITY (t/m3)	--	--	--	--	--
OPTIMUM. MOIST. CONTENT (%)	21.0 Standard	21.5 Standard	11.5 Standard	10.5 Standard	19.5 Standard
ADJUSTED OPTIMUM MOIST. CONT. (%)	--	--	--	--	--
MAXIMUM VIBRATED DENSITY (t/m3)	--	--	--	--	--
MINIMUM DENSITY (t/m3)	--	--	--	--	--
MAX. / MIN. DEN. MOULD VOLUME (l)	--	--	--	--	--
COMPACTION NUMBER	1	2	3	4	5
COMPACTION MATERIAL SOURCE	DENSITY HOLE	DENSITY HOLE	DENSITY HOLE	DENSITY HOLE	DENSITY HOLE
DENSITY RATIO (%)	108.5	105.5	100.0	97.5	105.5
MOISTURE VARIATION FROM O.M.C.(%)	0	0	2.0 dry	2.0 dry	2.0 dry
MOISTURE RATIO(%)	100.0	101.0	81.5	82.0	88.5
DENSITY INDEX (%)	--	--	--	--	--

STANDARDS AS1289 FIELD DENSITY - 5.8.1, MOISTURE CONTENT - 2.1.1,
DRY DENSITY / MOISTURE CONT. RELATIONSHIP: STANDARD - 5.1.1, MODIFIED - 5.2.1, MAXIMUM & MINIMUM DENSITY - 5.5.1
DENSITY RATIO, MOISTURE VARIATION, MOISTURE RATIO - 5.4.1, DENSITY INDEX - 5.6.1

SIGNED ....

THIS REPORT WAS PRODUCED UNDER CONDITIONS SET OUT IN 'BASIS OF TESTING 25005.

NAME OF APPROVED SIGNATORY: H.HUGHES

DATE 23.10.2003

Testrite Coring Pty. Ltd. ABN 16 001 124 830
Ph: 9736 3922 Fax: 9743 5860

TESTRITE

CONSTRUCTION MATERIALS TESTING

4 Rothwell Ave, (P.O. Box 329)
CONCORD WEST NSW 2138

REPORT ON COMPACTION CONTROL TESTS

REPORT NO : 25005

TOTAL TESTS 6

CLIENT : PARSONS BRINCKERHOFF AUSTRALIA PTY. LTD.

ADDRESS : Locked Bag 248
RHODES NSW 2138

This laboratory is accredited by the National Association of Testing Authorities, Australia.The tests reported herein have been performed in accordance with its terms of accreditation.

N.A.T.A. Accreditation No: 844

PROJECT : P.F. FORMATION
SAND QUARRY, MAROOTA.

DATE TESTED : 21-Oct-03

TEST NUMBER	6	--	--	--	--
RETEST OF NO.	--	--	--	--	--
TIME TESTED	15.10				
ELEMENT TESTED	SOUTH OF WASH PLANT.				
LOCATION	Location 3				
LEVEL AT TOP OF HOLE	500mm below Excavation Level.				
MATERIAL DESCRIPTION	Clay				
LAYER THICKNESS (mm)	N/A				
PROBE DEPTH (mm)	300				
FIELD DRY DENSITY (t / m3)	1.87	--	--	--	--
FIELD MOISTURE CONTENT (%)	15.5	--	--	--	--
OVERSIZE CONTENT, WET BASIS (%)	1	--	--	--	--
OVERSIZE CONT., OVEN DRY BASIS (%)	2	--	--	--	--
OVERSIZE SCREENING SIEVE (mm)	19.0	--	--	--	--
MAXIMUM DRY DENSITY (t/m3)	--	--	--	--	--
ADJUSTED MAX. DRY DENSITY (t/m3)	1.71 Standard	--	--	--	--
OPTIMUM. MOIST. CONTENT (%)	--	--	--	--	--
ADJUSTED OPTIMUM MOIST. CONT. (%)	19.5 Standard	--	--	--	--
MAXIMUM VIBRATED DENSITY (t/m3)	--	--	--	--	--
MINIMUM DENSITY (t/m3)	--	--	--	--	--
MAX. / MIN. DEN. MOULD VOLUME (l)	--	--	--	--	--
COMPACTION NUMBER	6	--	--	--	--
COMPACTION MATERIAL SOURCE	DENSITY HOLE	--	--	--	--
DENSITY RATIO (%)	109.5	--	--	--	--
MOISTURE VARIATION FROM O.M.C.(%)	3.5 dry	--	--	--	--
MOISTURE RATIO(%)	81.0	--	--	--	--
DENSITY INDEX (%)	--	--	--	--	--

STANDARDS AS1289 FIELD DENSITY - 5.8.1, MOISTURE CONTENT - 2.1.1,
DRY DENSITY / MOISTURE CONT. RELATIONSHIP: STANDARD - 5.1.1, MODIFIED - 5.2.1, MAXIMUM & MINIMUM DENSITY - 5.5.1
DENSITY RATIO, MOISTURE VARIATION,MOISTURE RATIO - 5.4.1, DENSITY INDEX - 5.6.1

SIGNED ....[signature]

THIS REPORT WAS PRODUCED UNDER CONDITIONS SET OUT IN 'BASIS OF TESTING 25005.

NAME OF APPROVED SIGNATORY: H.HUGHES

DATE 23-10-2003

Testrite Coring Pty. Ltd. ABN 16 001 124 830
Ph: 9736 3922 Fax: 9743 5860

TESTRITE

CONSTRUCTION MATERIALS TESTING

4 Rothwell Ave, (P.O. Box 329)
CONCORD WEST NSW 2138

BASIS OF TESTING.

BASISIND

BASIS UPON WHICH TESTING IS CARRIED OUT FOR:

CLIENT: PARSONS BRINCKERHOFF AUSTRALIA PTY. LTD.

PROJECT: P.F. FORMATION, SAND QUARRY, MAROOTA.

REPORT NO. 25005

1 LEVEL OF RESPONSIBILITY AS GIVEN IN AS 3798 - 1996 APPENDIX B : LEVEL :3 (THREE)

1.1 Attendance at site : as requested by: PARSONS BRINCKERHOFF AUSTRALIA PTY. LTD.

1.2 Method of test request : Verbal

1.3 Area nominated for testing by: PARSONS BRINCKERHOFF AUSTRALIA PTY. LTD.

1.4 Number of tests required as per: PARSONS BRINCKERHOFF AUSTRALIA PTY. LTD.

1.5 Selection of specific test location : PARSONS BRINCKERHOFF AUSTRALIA PTY. LTD.

1.6 Method of identifying test location :

a) Plan : AS NOMINATED BY CLIENT.

b) Level: As nominated by PARSONS BRINCKERHOFF AUSTRALIA PTY. LTD.

1.7 Contractor Q.A.system involving testing (lot nos. request forms etc.) established ? No

1.8 Documents : Plans: None

Specification: None

1.9 Stripping and / or test rolling inspections included in Testrite duties ? No

1.10 Method of notifying Testrite technician of required test value for a section of work: Verbal

1.11 Responsibility for monitoring compliance of test results with specification : Others

2 EARTHWORKS TESTING METHODS

2.1 Field Density , Laboratory Compaction & Density Index / Relative Density as per A.S. methods

2.2 Specific test methods nominated ? No

3 FINAL REPORT (as per A.S. 3798): Not required

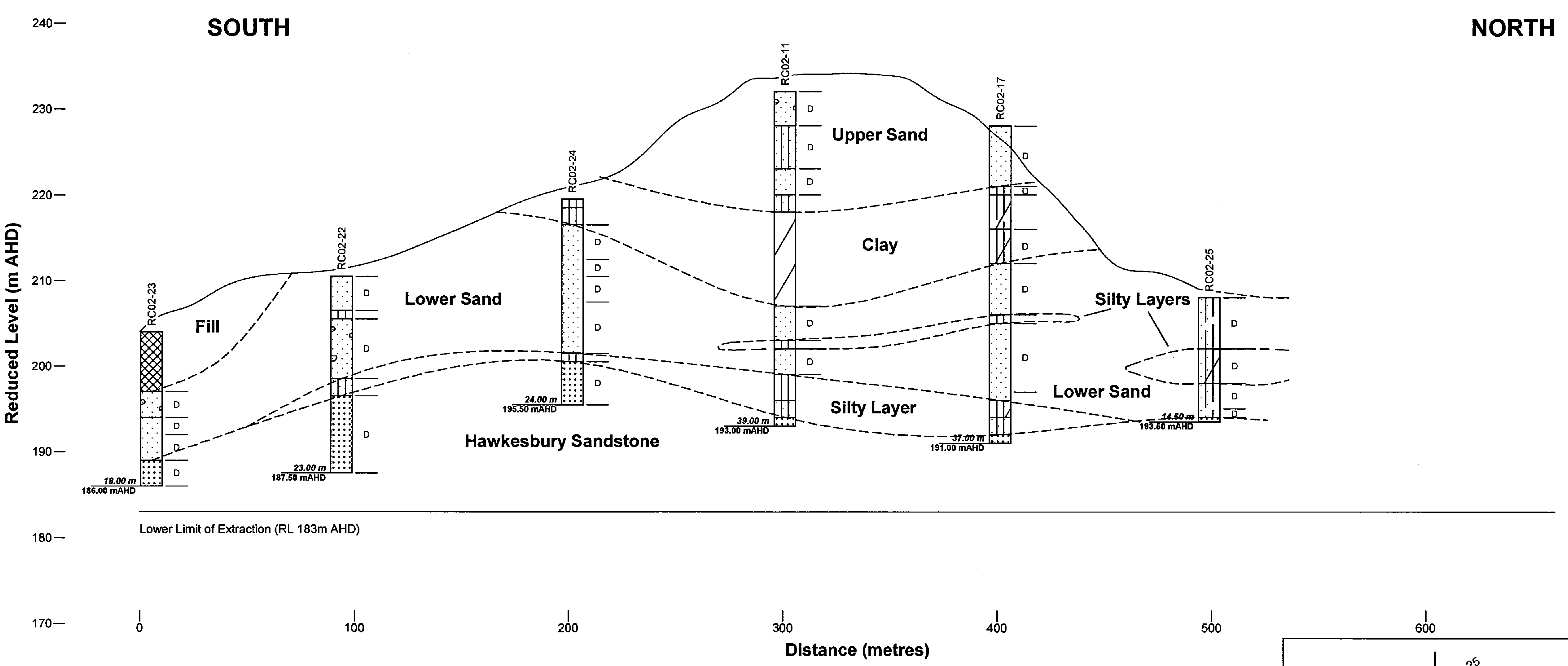
SIGNED : [signature]

POSITION: Laboratory Manager

DATE : 23-Oct-2003

Appendix B

Geological Cross Sections



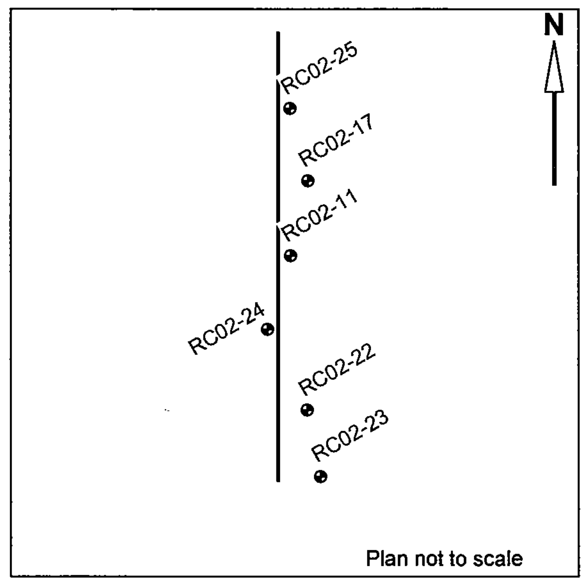
LEGEND:

- Gravelly Sand
- Sandy Silt
- Sand
- Silty Sand
- Clay
- Silty Clay
- Silt
- Sandstone
- Fill (man made ground)

D — Sample subject to Partical Size Distribution analysis

— ?— — Inferred Geotechnical Boundary

NOTE: FOUR FOLD VERTICAL EXAGERATION



Geotechnical section orientation plan

REV	DATE	DESCRIPTION	DRN.	APPR.

Scale 0 40 A3 ORIGINAL
Horizontal Scale (metres) 1:2000
Vertical Scale (metres) 1:500
0 10

Drawn	Date
Designed	Date
Drawing Check	Date
Design Check	Date
Project Approval	Date

NOTES

1. The subsurface conditions shown on this figure are considered accurate only at exploration locations. The subsurface conditions between these locations represents Parsons Brinckerhoff's preliminary assessment based on available data. The boundary between the various units has been inferred and should be confirmed for final design and construction.

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Facsimile +61 2 9736 1568
Email: sydney@pb.com.au

Client: P.F. Formation Pty Ltd

Project: **Maroota Sands Resource Estimation**

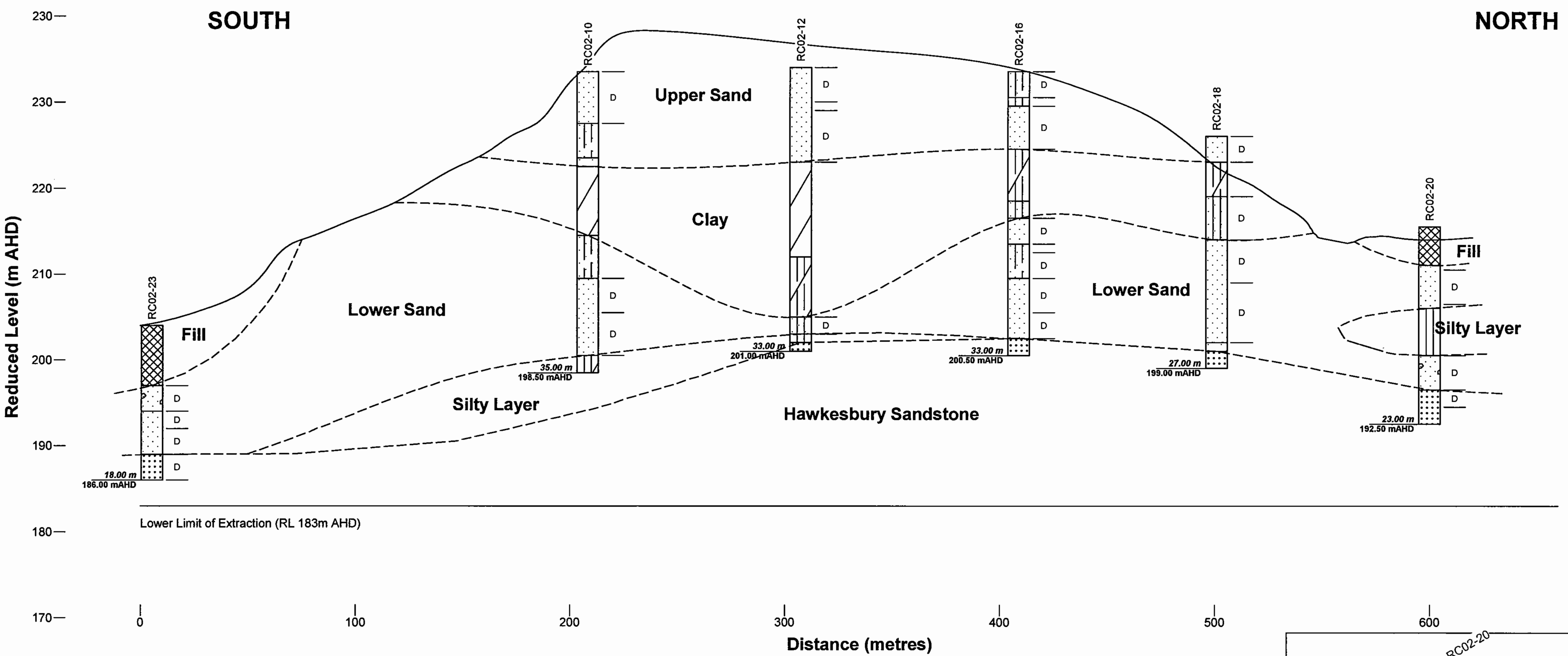
Maroota

Geological Cross Section NS1

Job No: 2110178A

File No:

Drawing No: **NS1** Rev: **1**



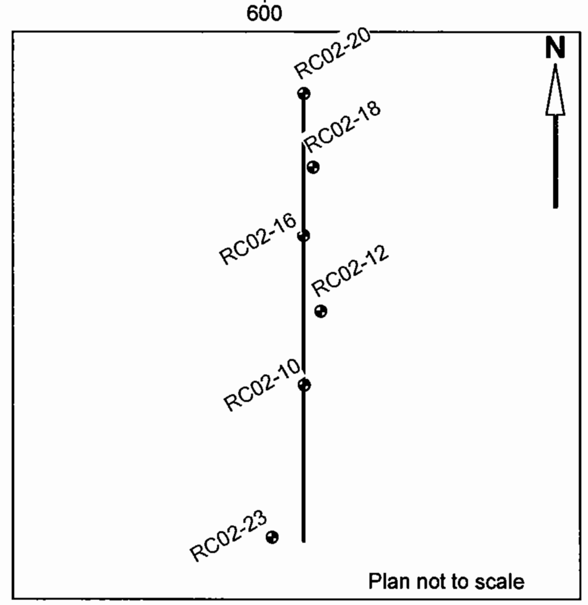
LEGEND:

- Sand
- Silty Sand
- Clayey Sand
- Clay
- Silty Clay
- Sandstone
- Sandy Silt
- Fill (man made ground)
- Silt
- Gravelly Sand

NOTE: FOUR FOLD VERTICAL EXAGERATION

D — Sample subject to Partical Size Distribution analysis

– –?– – Inferred Geotechnical Boundary



Geotechnical section orientation plan

REV	DATE	DESCRIPTION	DRN.	APPR.

Scale 0 40 A3 ORIGINAL
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Vertical Scale (metres) 1:500
0 10

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Australia

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Email: sydney@pb.com.au

Client: P.F. Formation Pty Ltd

Project: Maroota Sands Resource Estimation

Maroota

Geological Cross Section NS2

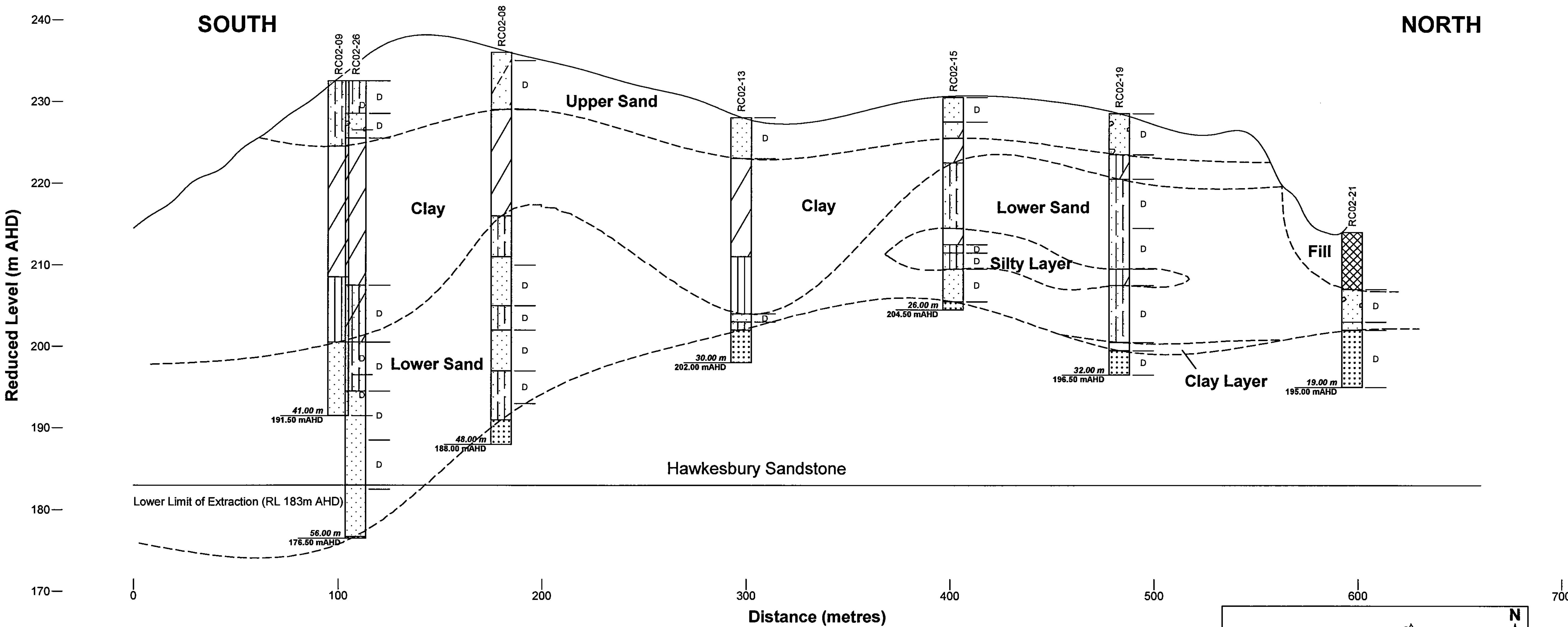
Job No: 2110178A

File No:

Drawing No: NS2

Rev: 1

MAROOTA FENCE EXPORT.GPJ GEOTECH.GDT 31/10/03



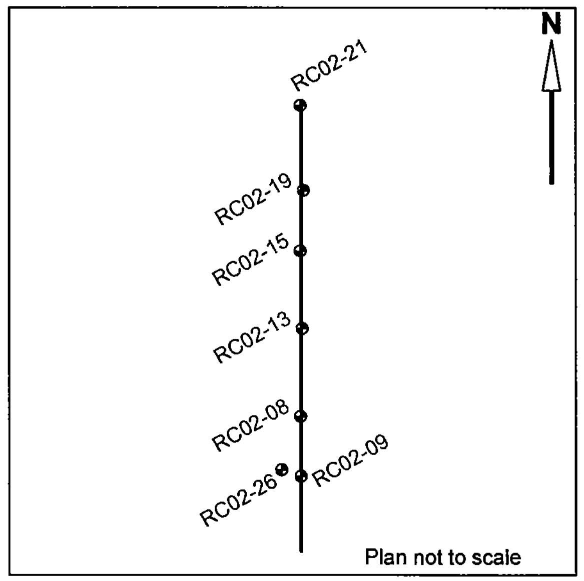
LEGEND:

- Clayey Sand
- Clay
- Silty Sand
- Sand
- Sandstone
- Silt
- Gravelly Sand
- Sandy Clay
- Sandy Silt
- Silty Clay
- Fill (man made ground)

NOTE: FOUR FOLD VERTICAL EXAGERATION

D — Sample subject to Partical Size Distribution analysis

— ?— — Inferred Geotechnical Boundary



Geotechnical section orientation plan

REV	DATE	DESCRIPTION	DRN.	APPR.

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Horizontal Scale (metres) 1:2000
Vertical Scale (metres) 1:500
0 — 10

Drawn	Date
Designed	Date
Drawing Check	Date
Design Check	Date
Project Approval	Date

NOTES

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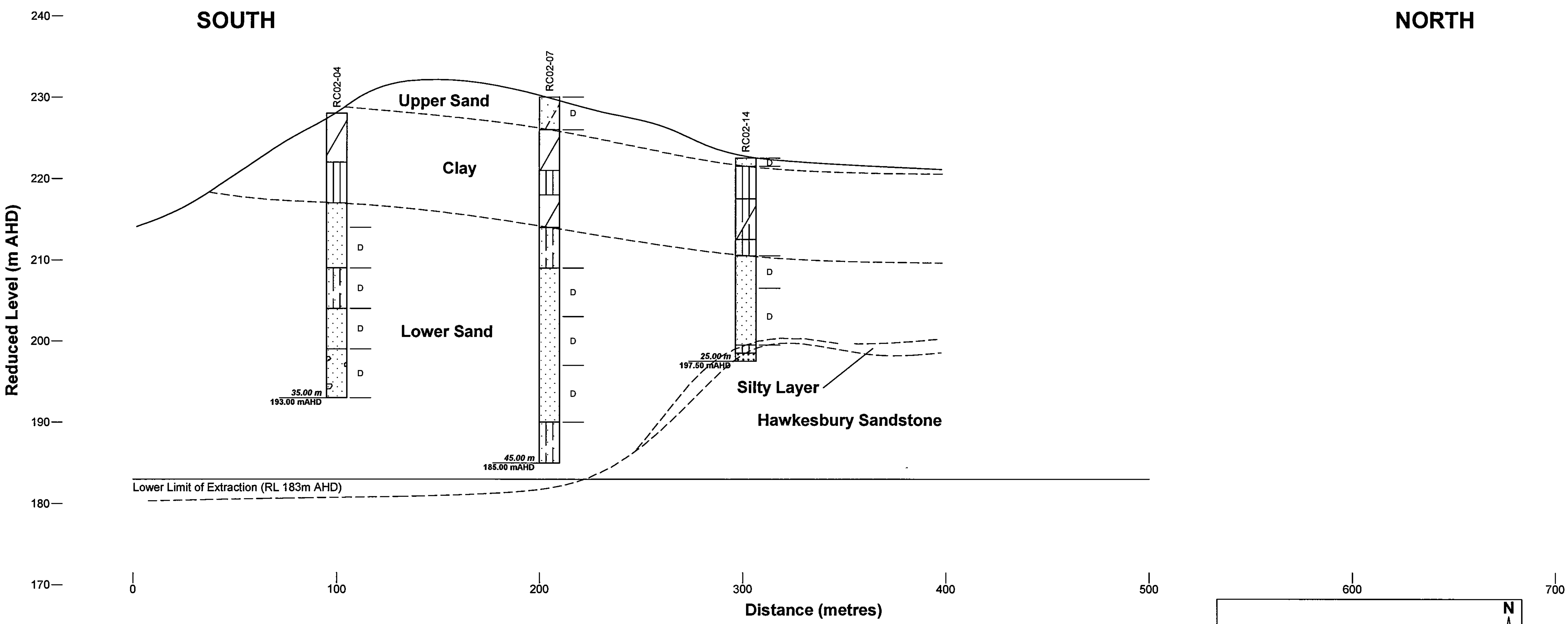
Email: sydney@pb.com.au

Client: P.F. Formation Pty Ltd
Project: Maroota Sands Resource Estimation
Maroota
Geological Cross Section NS3

Job No: 2110178A
File No:
Drawing No: NS3
Rev: 1



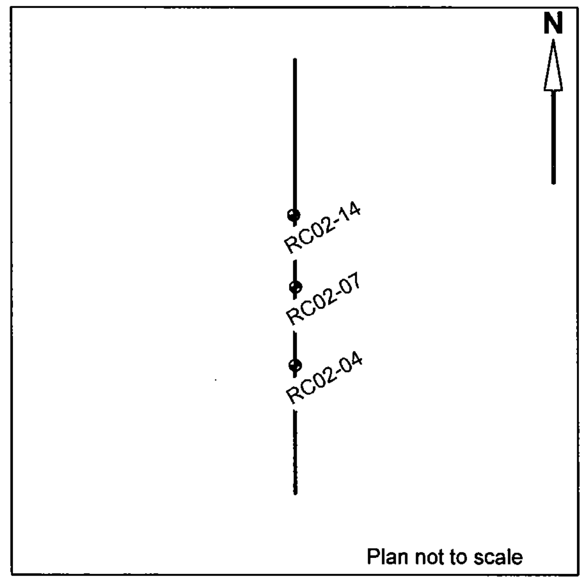
LEGEND:

- Clay
- Silt
- Sand
- Silty Sand
- Gravelly Sand
- Clayey Sand
- Silty Clay
- Sandstone

NOTE: FOUR FOLD VERTICAL EXAGERATION

D — Sample subject to Partical Size Distribution analysis

– –?– – Inferred Geotechnical Boundary



Geotechnical section orientation plan

REV	DATE	DESCRIPTION	DRN.	APPR.

Scale 0 40 A3 ORIGINAL
Horizontal Scale (metres) 1:2000
Vertical Scale (metres) 1:500
0 10

Drawn	Date
Designed	Date
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Project Approval	Date

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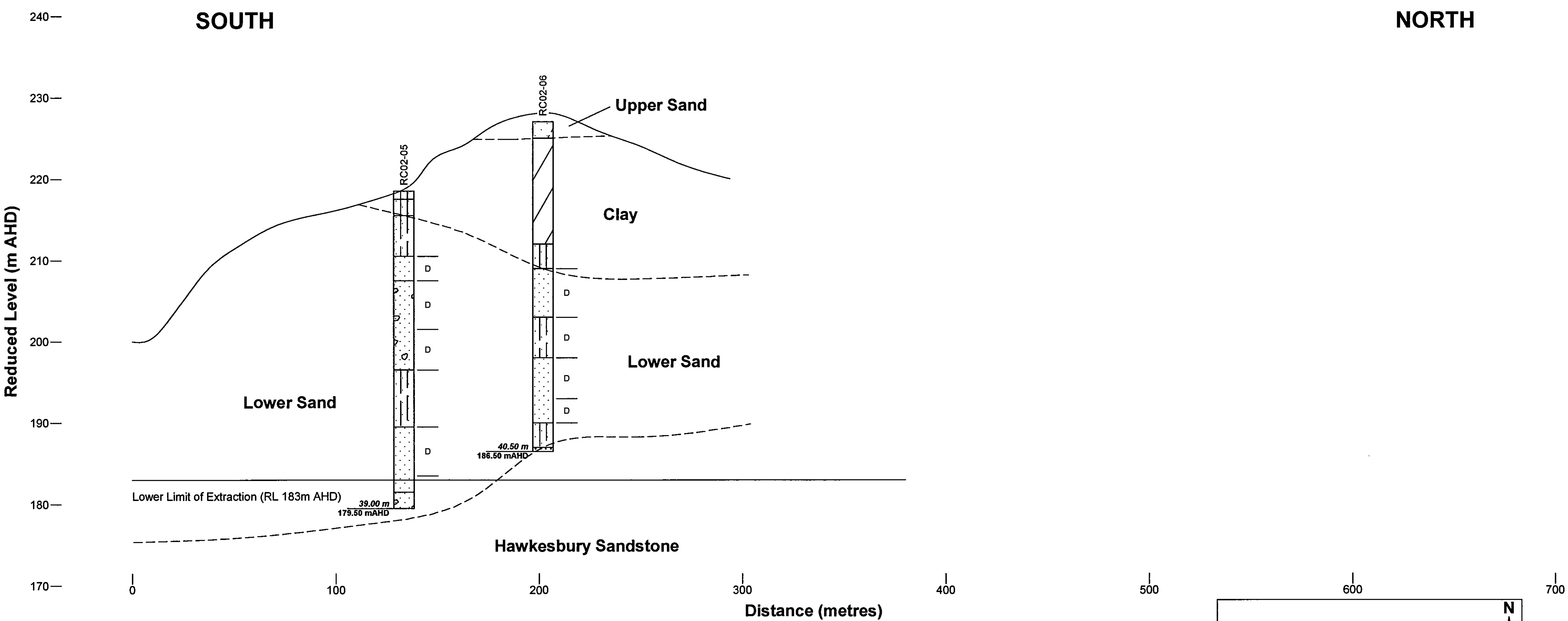
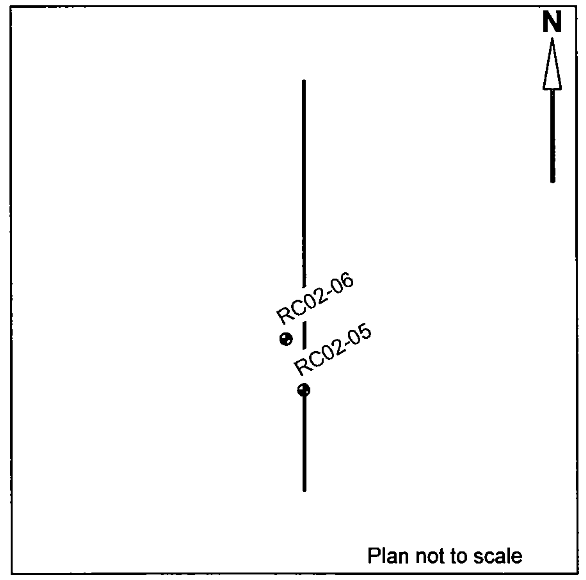
Facsimile +61 2 9736 1568
Email: sydney@pb.com.au

Client: P.F. Formation Pty Ltd
Project: Maroota Sands Resource Estimation
Maroota
Geological Cross Section NS4

Job No 2110178A
File No
Drawing No NS4
Rev 1

MAROOTA FENCE EXPORT.GPJ GEOTECH.GDT 31/10/03





Geotechnical section orientation plan

LEGEND:

- Silty Sand
- Sandy Silt
- Sand
- Gravelly Sand
- Clayey Sand
- Clay
- Sandstone

NOTE: FOUR FOLD VERTICAL EXAGERATION

D — Sample subject to Partical Size Distribution analysis

– –?– – Inferred Geotechnical Boundary

REV	DATE	DESCRIPTION	DRN.	APPR.

Scale 0 40 A3 ORIGINAL
Horizontal Scale (metres) 1:2000
Vertical Scale (metres) 1:500
0 10

Drawn	Date
Designed	Date
Drawing Check	Date
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Project Approval	Date

NOTES

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Project: Maroota Sands Resource Estimation

Maroota

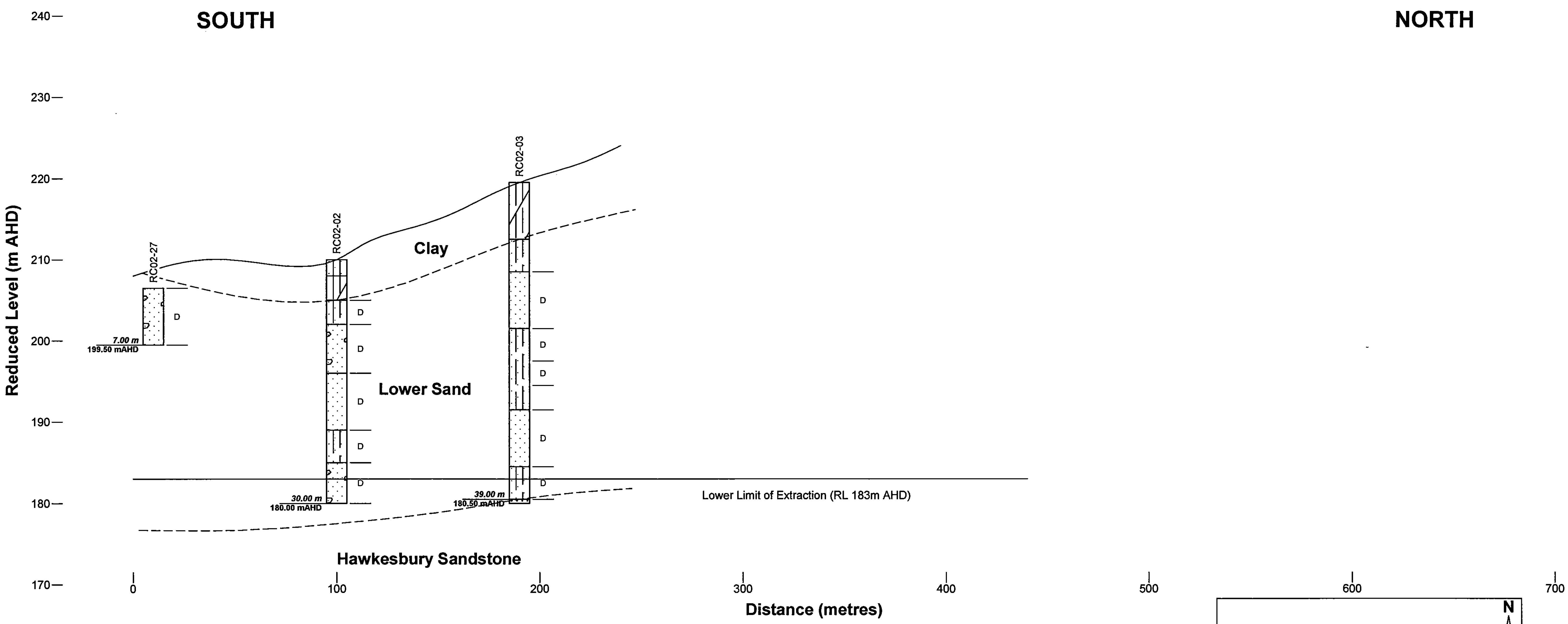
Geological Cross Section NS5

Job No 2110178A

File No

Drawing No NS5 | Rev 1

MAROOTA FENCE EXPORT.GPJ GEOTECH.GDT 31/10/03



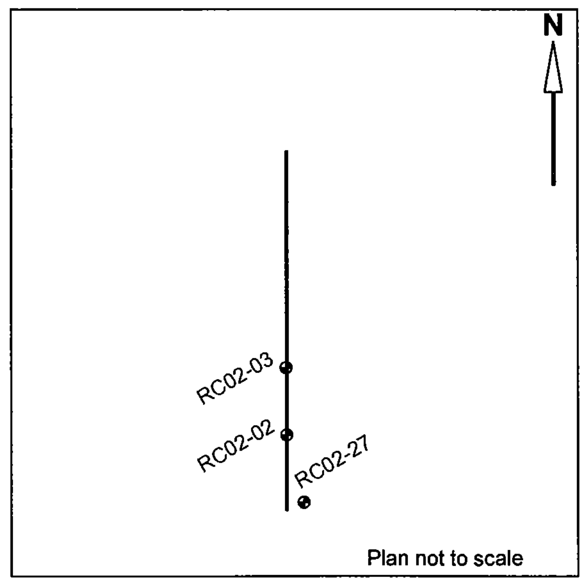
LEGEND:

- Silty Sand
- Silty Clay
- Gravelly Sand
- Sand
- Sandstone

NOTE: FOUR FOLD VERTICAL EXAGERATION

D — Sample subject to Partical Size Distribution analysis

— ?— — Inferred Geotechnical Boundary



Geotechnical section orientation plan

REV	DATE	DESCRIPTION	DRN.	APPR.

Scale 0 40 A3 ORIGINAL
Horizontal Scale (metres) 1:2000
Vertical Scale (metres) 1:500
0 10

Drawn	Date
Designed	Date
Drawing Check	Date
Design Check	Date
Project Approval	Date

NOTES

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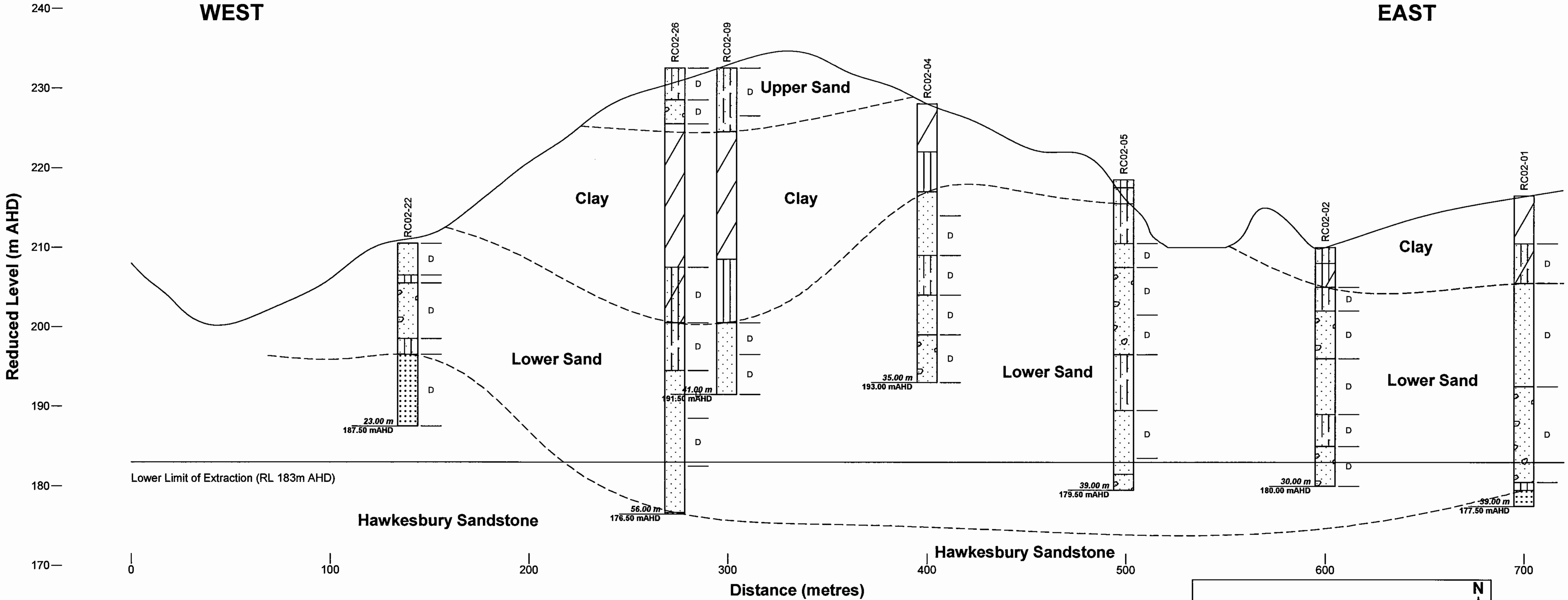
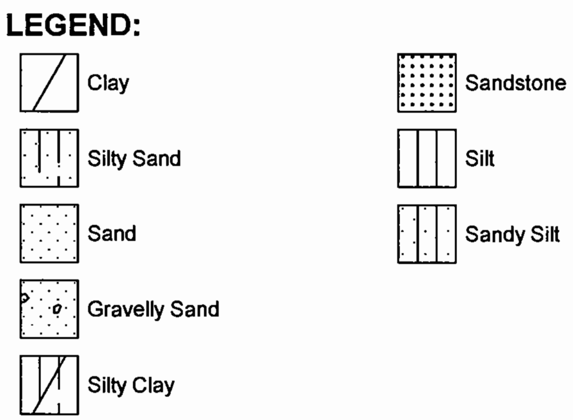
Client: P.F. Formation Pty Ltd
Project: **Maroota Sands Resource Estimation**
Maroota
Geological Cross Section NS6

Job No: 2110178A
File No:
Drawing No: **NS6**
Rev: **1**

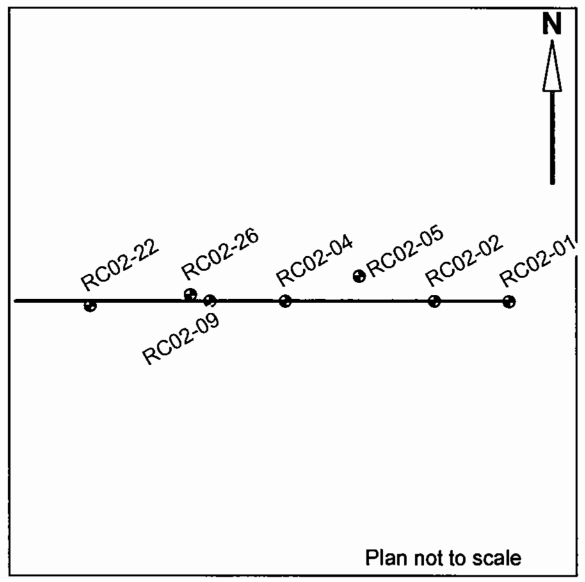
MAROOTA FENCE EXPORT.GPJ GEOTECH.GDT 31/10/03





NOTE: FOUR FOLD VERTICAL EXAGERATION

D	Sample subject to Partical Size Distribution analysis
– –?– –	Inferred Geotechnical Boundary



Geotechnical section orientation plan

REV	DATE	DESCRIPTION	DRN.	APPR.

Scale 0 40 A3 ORIGINAL
Horizontal Scale (metres) 1:2000
Vertical Scale (metres) 1:500
0 10

Drawn	Date
Designed	Date
Drawing Check	Date
Design Check	Date
Project Approval	Date

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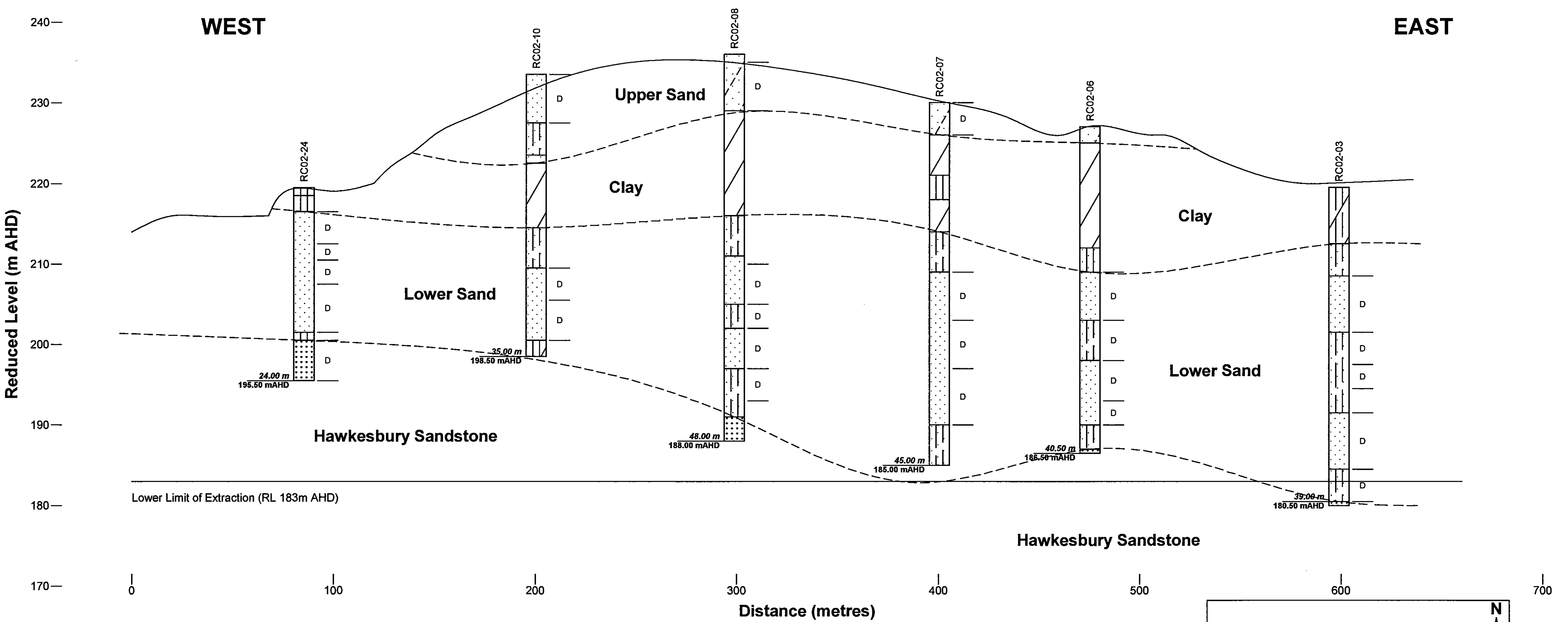
Project: **Maroota Sands Resource Estimation**
Maroota
Geological Cross Section EW1

Job No: 2110178A
File No:
Drawing No: EW1
Rev: 1



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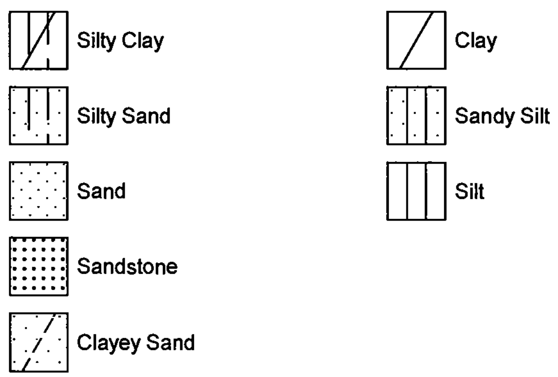
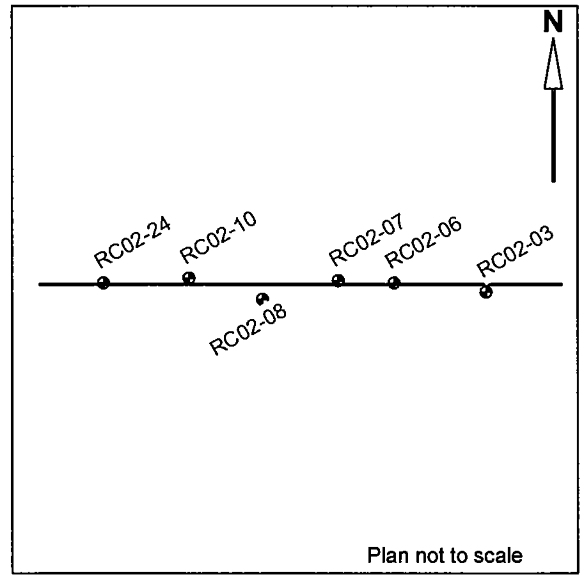


NOTE: FOUR FOLD VERTICAL EXAGERATION

D — Sample subject to Partical Size Distribution analysis

— —?— — Inferred Geotechnical Boundary



Geotechnical section orientation plan

REV	DATE	DESCRIPTION	DRN.	APPR.

Scale 0 40 A3 ORIGINAL

Horizontal Scale (metres) 1:2000

Vertical Scale (metres) 1:500

0 10

Drawn	Date
Designed	Date
Drawing Check	Date
Design Check	Date
Project Approval	Date

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Project: Maroota Sands Resource Estimation

Maroota

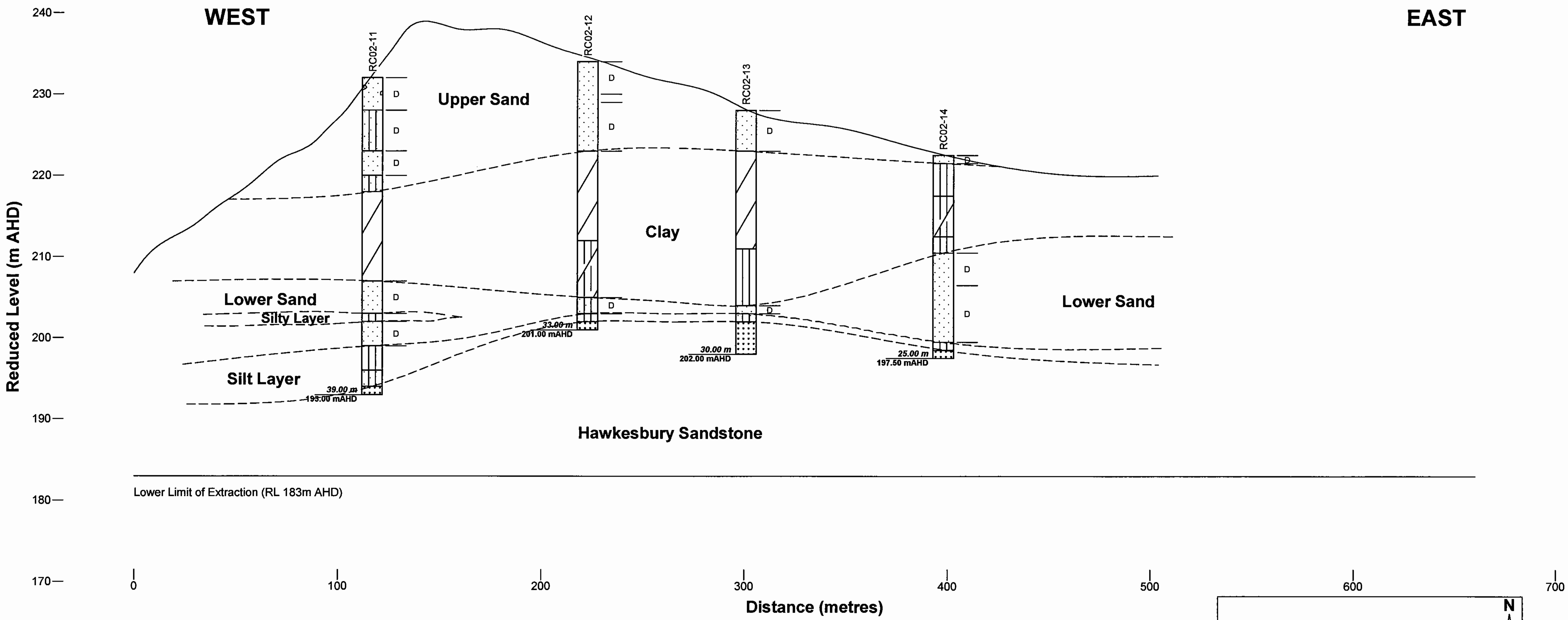
Geological Cross Section EW2

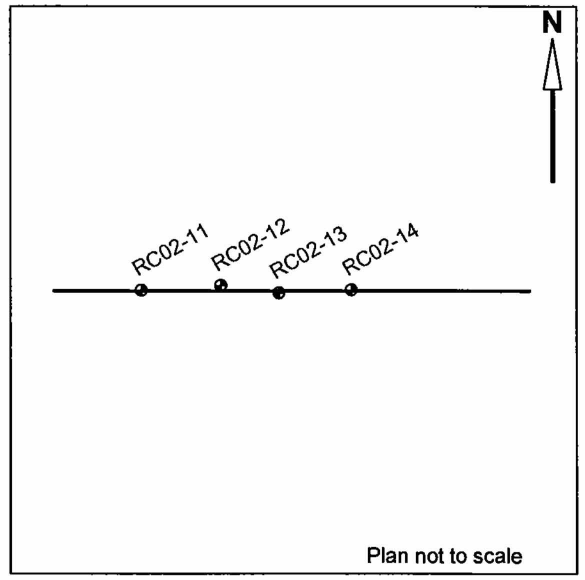
Job No: 2110178A

File No:

Drawing No: EW2

Rev: 1





Geotechnical section orientation plan

LEGEND:

- Gravelly Sand
- Sandy Silt
- Sand
- Silty Sand
- Clay
- Silty Clay
- Silt
- Sandstone

NOTE: FOUR FOLD VERTICAL EXAGERATION

D — Sample subject to Partical Size Distribution analysis

—?— — Inferred Geotechnical Boundary

REV	DATE	DESCRIPTION	DRN.	APPR.

Scale: 0 — 40 A3 ORIGINAL

Horizontal Scale (metres) 1:2000
Vertical Scale (metres) 1:500

0 — 10

Drawn	Date
Designed	Date
Drawing Check	Date
Design Check	Date
Project Approval	Date

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Project: Maroota Sands Resource Estimation

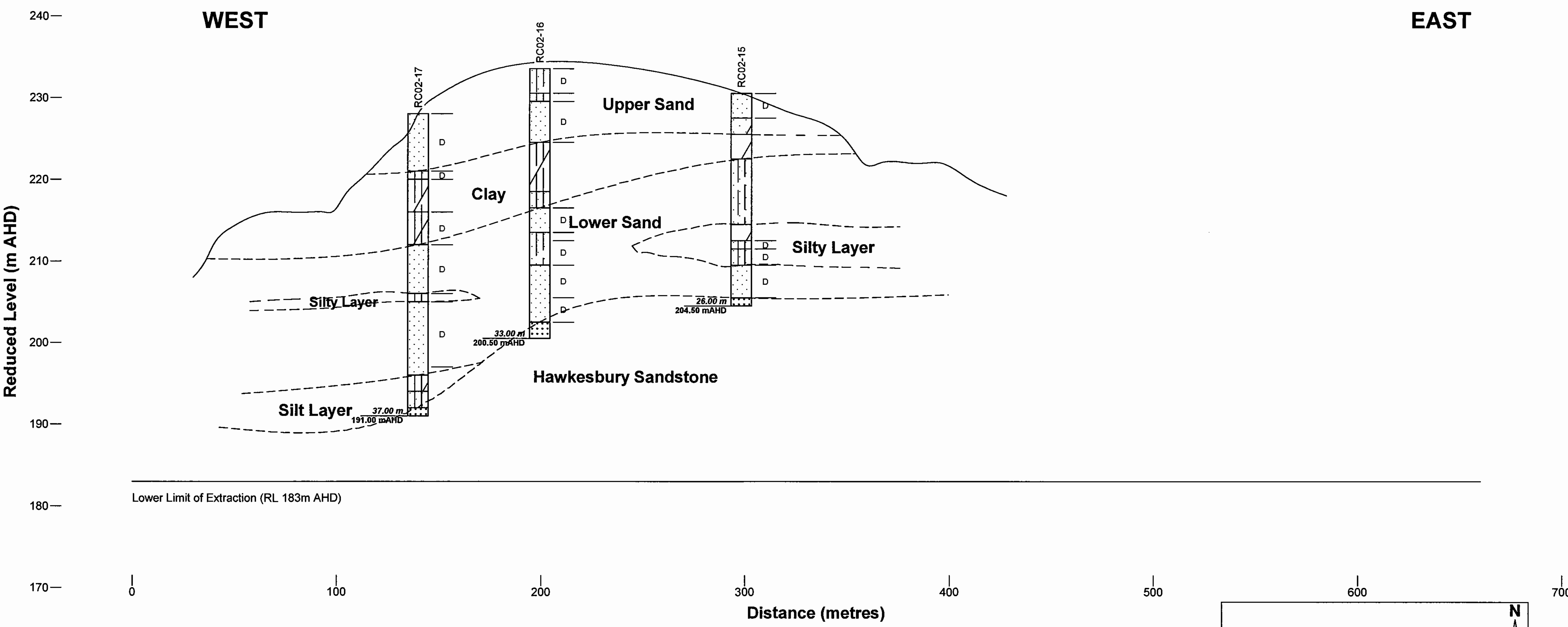
Maroota

Geological Cross Section EW3

Job No: 2110178A

File No:

Drawing No: EW3 | Rev: 1



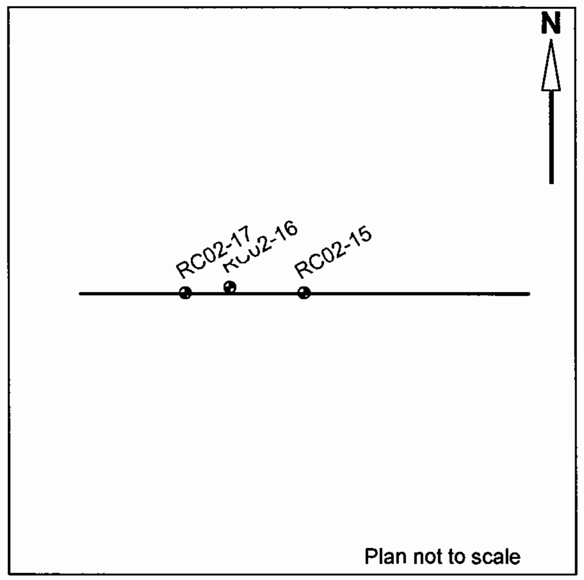
LEGEND:

- Sand
- Sandy Clay
- Clay
- Silty Sand
- Sandy Silt
- Sandstone
- Silty Clay
- Silt

NOTE: FOUR FOLD VERTICAL EXAGERATION

D — Sample subject to Partical Size Distribution analysis

--?-- — Inferred Geotechnical Boundary



Geotechnical section orientation plan

REV	DATE	DESCRIPTION	DRN.	APPR.

Scale 0 40 10 A3 ORIGINAL
Horizontal Scale (metres) 1:2000
Vertical Scale (metres) 1:500

Drawn	Date
Designed	Date
Drawing Check	Date
Design Check	Date
Project Approval	Date

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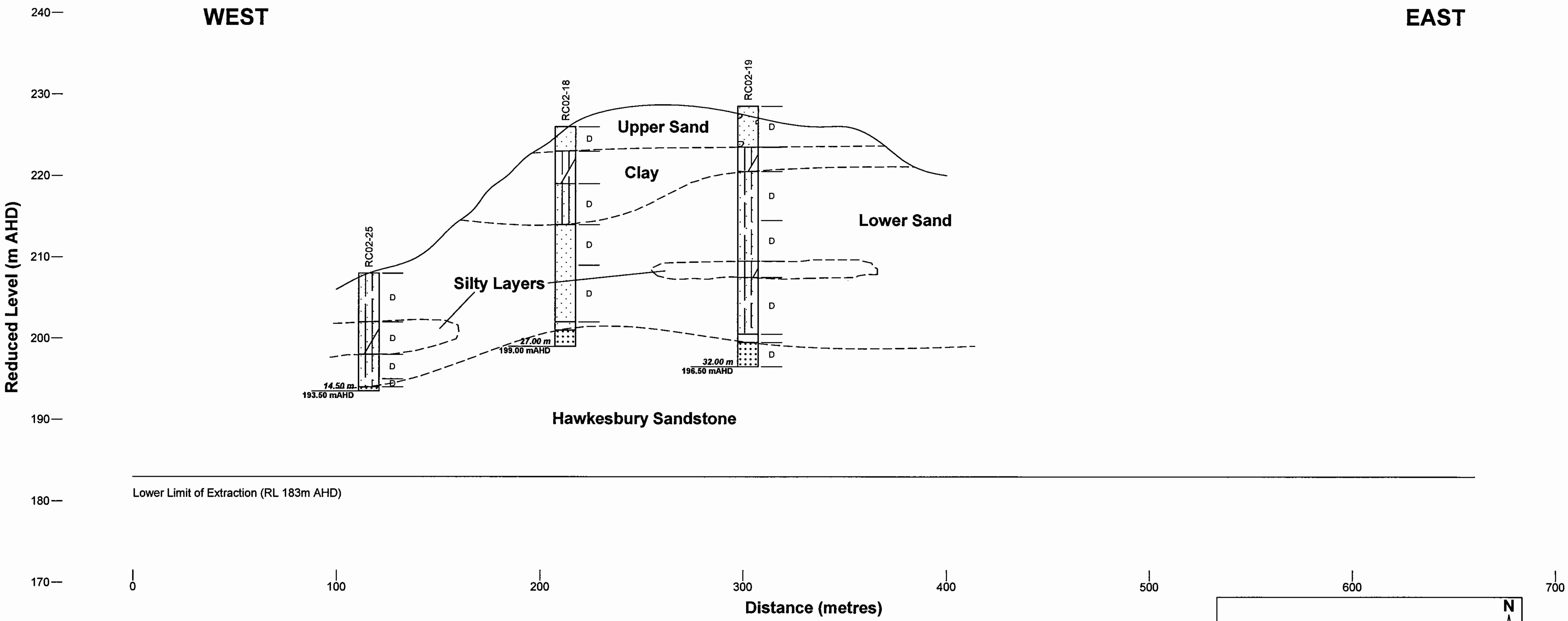
Project: Maroota Sands Resource Estimation
Maroota
Geological Cross Section EW4

Job No: 2110178A
File No:
Drawing No: EW4
Rev: 1

MAROOTA FENCE EXPORT.GPJ GEOTECH.GDT 31/10/03

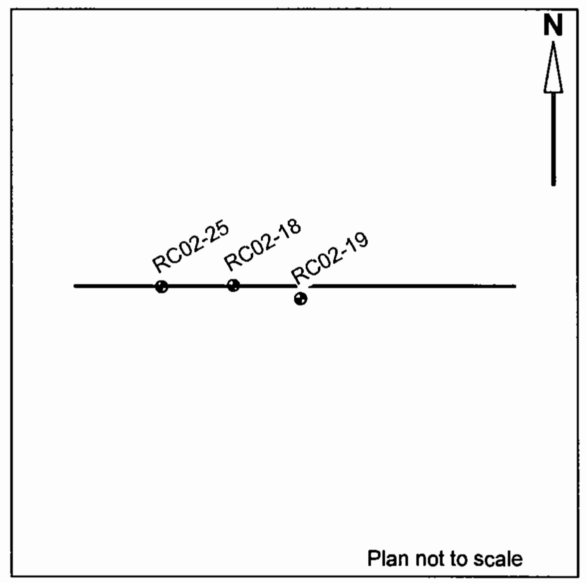


LEGEND:

- Sand
- Silty Clay
- Sandy Silt
- Clayey Sand
- Sandstone
- Gravelly Sand
- Silty Sand
- Clay

NOTE: FOUR FOLD VERTICAL EXAGERATION

- D — Sample subject to Partical Size Distribution analysis
- — ?— — Inferred Geotechnical Boundary



Geotechnical section orientation plan

REV	DATE	DESCRIPTION	DRN.	APPR.

Scale 0 40 A3 ORIGINAL
Horizontal Scale (metres) 1:2000
Vertical Scale (metres) 1:500
0 10

Drawn	Date
Designed	Date
Drawing Check	Date
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Project Approval	Date

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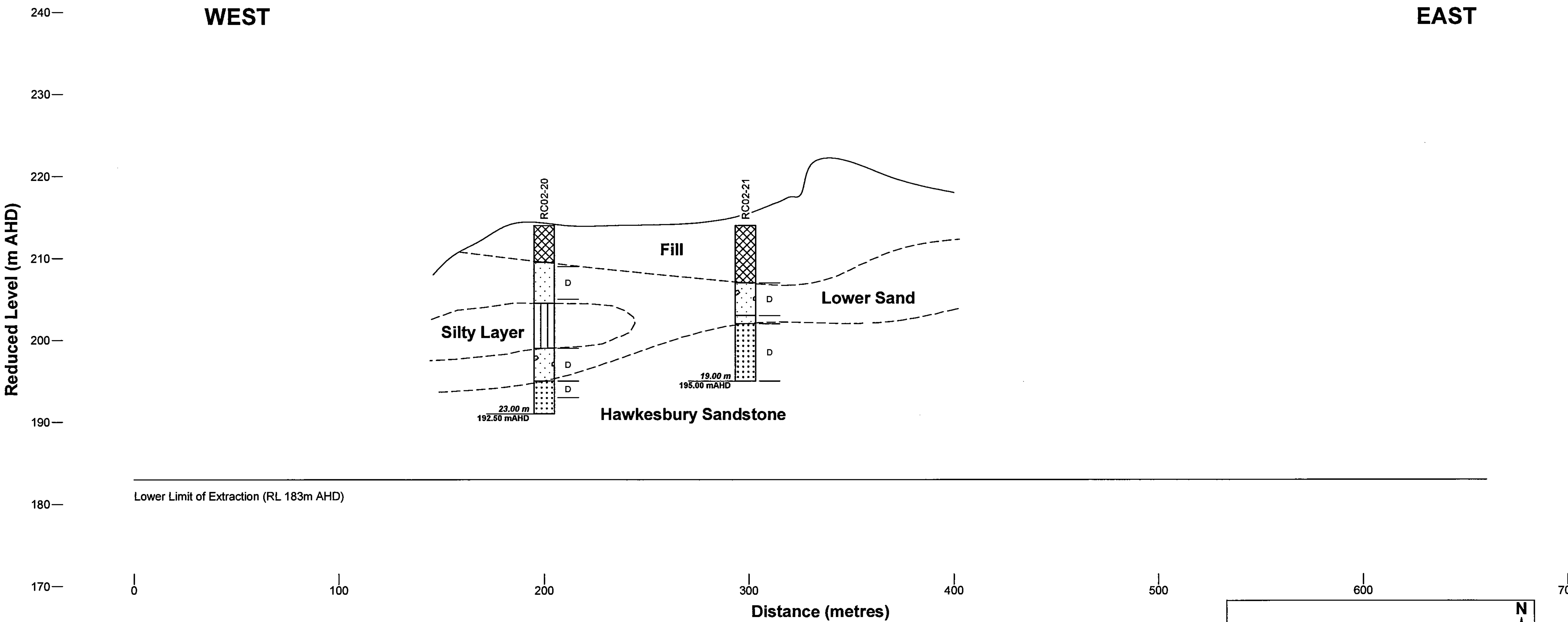
Project: Maroota Sands Resource Estimation
Maroota
Geological Cross Section EW5

Job No: 2110178A
File No:
Drawing No: EW5
Rev: 1



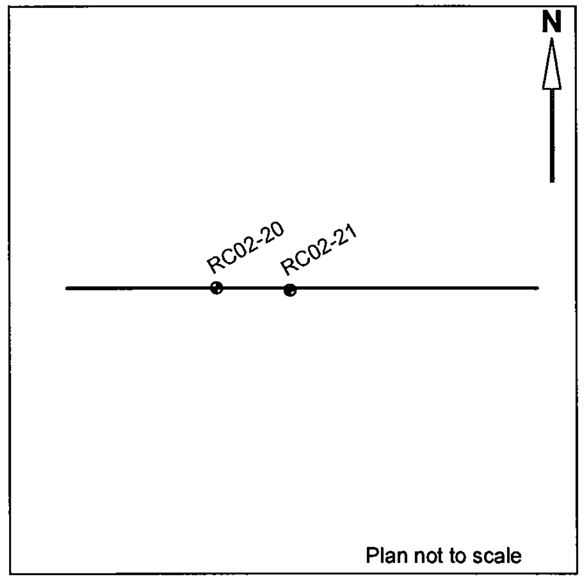
LEGEND:

- Fill (man made ground)
- Sand
- Silt
- Gravelly Sand
- Sandstone

NOTE: FOUR FOLD VERTICAL EXAGERATION

D — Sample subject to Partical Size Distribution analysis

— ?— — Inferred Geotechnical Boundary



Geotechnical section orientation plan

REV	DATE	DESCRIPTION	DRN.	APPR.

Scale 0 40 A3 ORIGINAL
Horizontal Scale (metres) 1:2000
Vertical Scale (metres) 1:500
0 10

Drawn	Date
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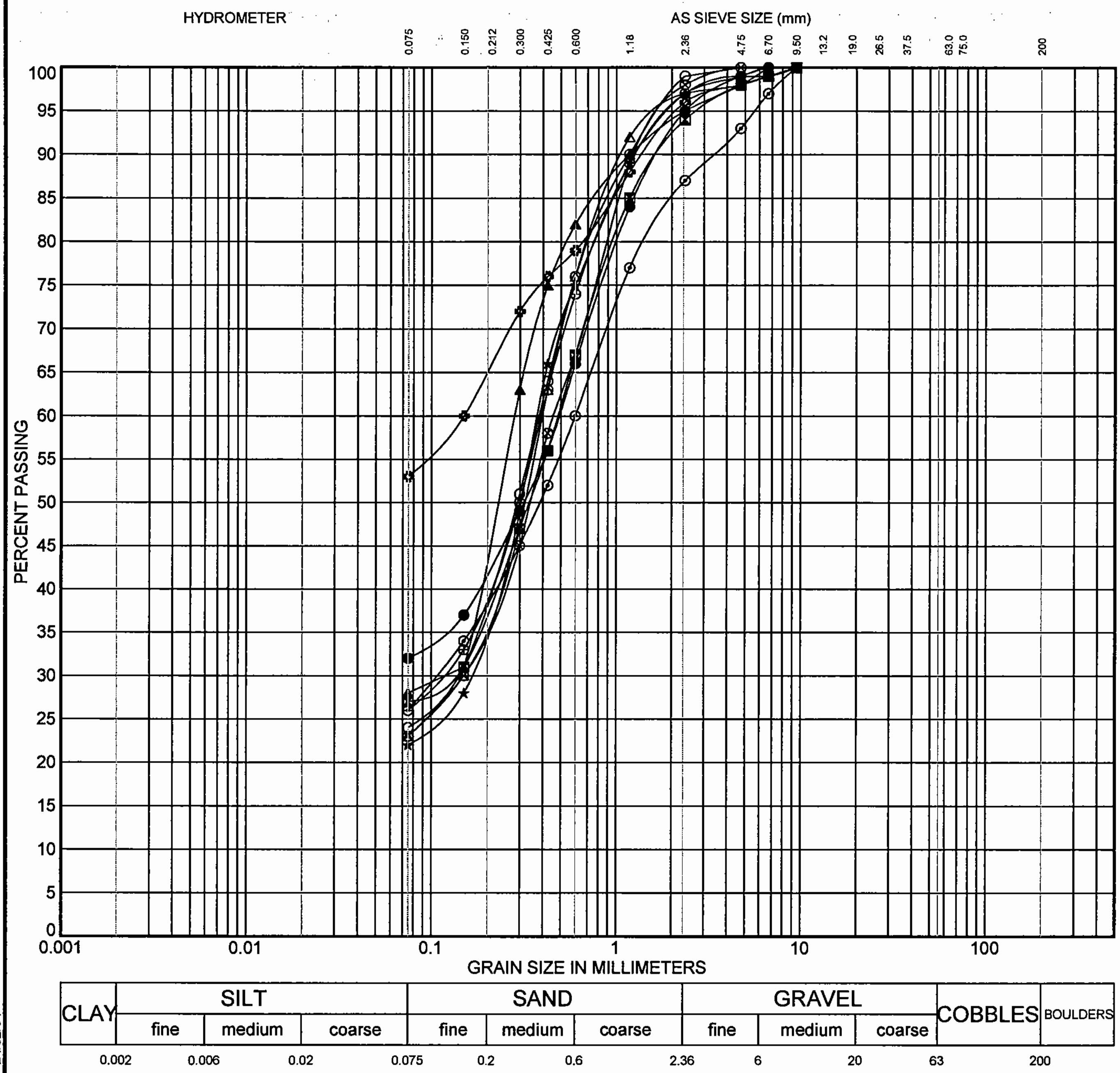
Maroota
Geological Cross Section EW6
Job No: 2110178A
File No:
Drawing No: EW6
Rev: 1

MAROOTA FENCE EXPORT.GPJ GEOTECH.GDT 31/10/03

Appendix C

Particle Size Distribution Curves



	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	RC02-07	0.40						
⊠	RC02-08	1.70						
▲	RC02-09	0.60						
★	RC02-10	0.60						
⊙	RC02-11	0.40						
✿	RC02-11	4.90						
○	RC02-11	9.12						
△	RC02-12	0.40						
⊗	RC02-12	5.11						
⊕	RC02-13	0.50						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	RC02-07	0.40	9.5	0.488			5.0	63.0	32.0	
⊠	RC02-08	1.70	9.5	0.482	0.126		6.0	67.0	27.0	
▲	RC02-09	0.60	6.7	0.281	0.119		5.0	67.0	28.0	
★	RC02-10	0.60	9.5	0.376	0.16		3.0	75.0	22.0	
⊙	RC02-11	0.40	9.5	0.6	0.106		13.0	61.0	26.0	
✿	RC02-11	4.90	9.5	0.15			4.0	43.0	53.0	
○	RC02-11	9.12	9.5	0.382	0.136		1.0	75.0	24.0	
△	RC02-12	0.40	9.5	0.398	0.15		3.0	74.0	23.0	
⊗	RC02-12	5.11	9.5	0.459	0.15		2.0	75.0	23.0	
⊕	RC02-13	0.50	9.5	0.392	0.111		3.0	71.0	26.0	

PARSONS BRINCKERHOFF
100 YEARS

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Project: Maroota Sands Resource Estimation
Upper Tertiary Sand

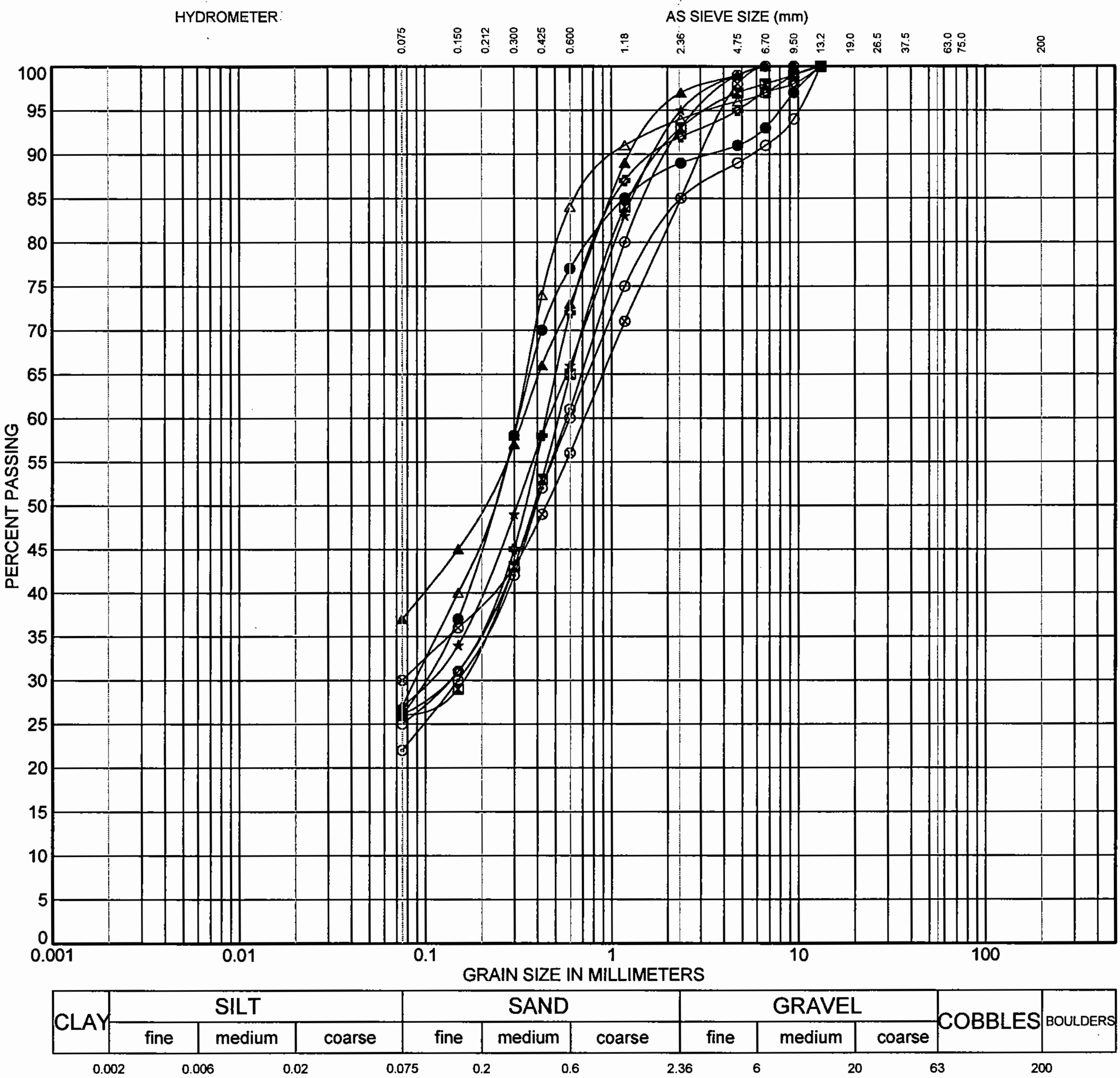
GRAIN SIZE DISTRIBUTION

Project No: 2110178A

File No:

Drawing No: PSD 1

Rev: 1



Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● RC02-14	0.10						
⊠ RC02-15	0.30						
▲ RC02-16	0.30						
★ RC02-16	4.90						
⊙ RC02-17	0.70						
✿ RC02-18	0.30						
○ RC02-19	0.50						
△ RC02-26	0.40						
⊗ RC02-26	4.70						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● RC02-14	0.10	13.2	0.318	0.096		11.0	63.0	26.0	
⊠ RC02-15	0.30	13.2	0.52	0.158		7.0	67.0	26.0	
▲ RC02-16	0.30	9.5	0.337			3.0	60.0	37.0	
★ RC02-16	4.90	9.5	0.463	0.101		5.0	68.0	27.0	
⊙ RC02-17	0.70	9.5	0.577	0.15		7.0	71.0	22.0	
✿ RC02-18	0.30	13.2	0.446	0.131		8.0	66.0	26.0	
○ RC02-19	0.50	13.2	0.6	0.134		15.0	60.0	25.0	
△ RC02-26	0.40	13.2	0.313	0.088		6.0	67.0	27.0	
⊗ RC02-26	4.70	9.5	0.719	0.075		15.0	55.0	30.0	

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Client: P.F. Formation Pty Ltd

Project: Maroota Sands Resource Estimation Upper Tertiary Sand

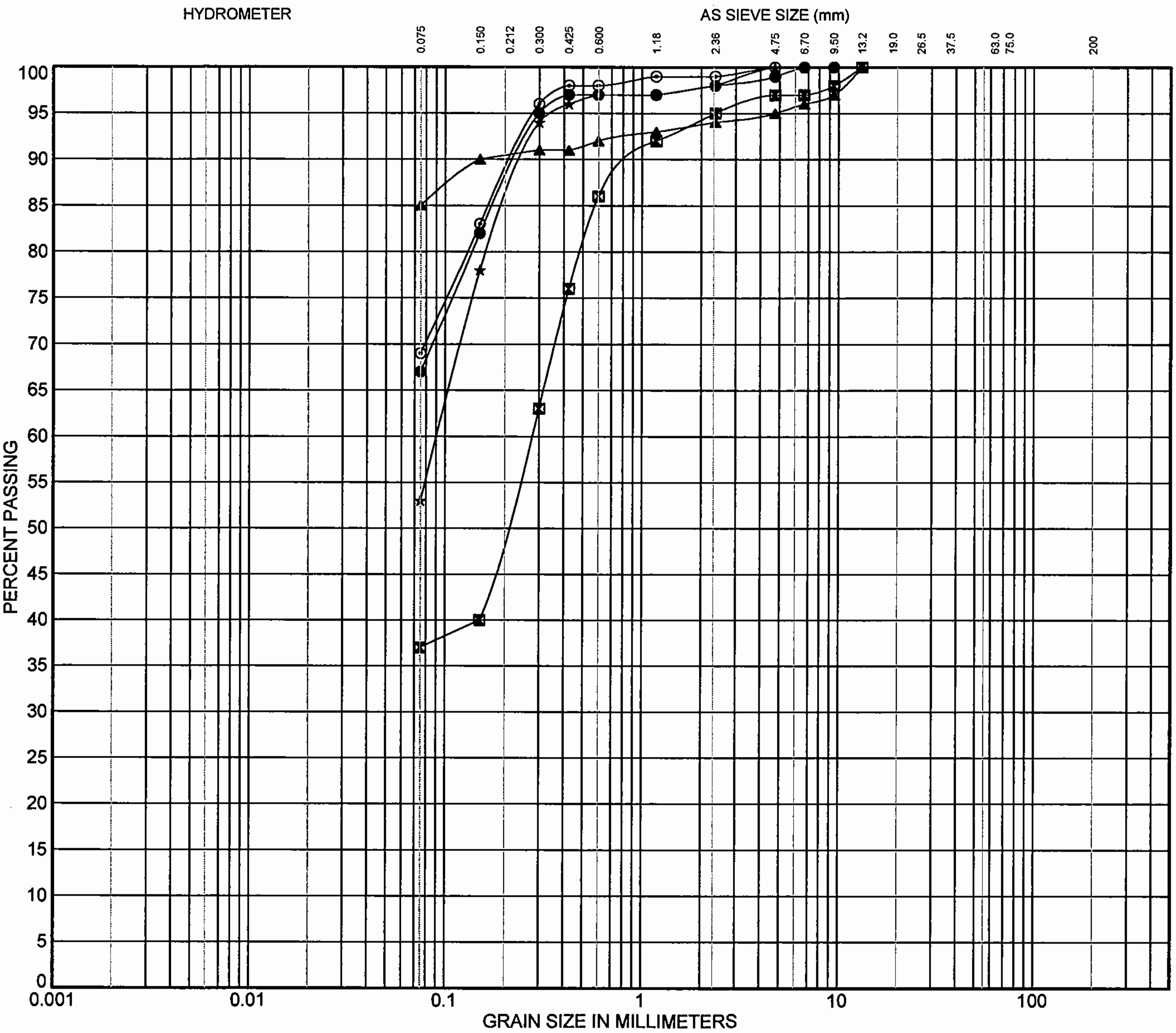
GRAIN SIZE DISTRIBUTION

Project No: 2110178A

File No:

Drawing No: PSD 2

Rev: 1



CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse		

0.002 0.006 0.02 0.075 0.2 0.6 2.36 6 20 63 200

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	RC02-01	6.11						
⊠	RC02-17	7.80						
▲	RC02-17	12.16						
★	RC02-18	7.12						
⊙	RC02-26	25.32						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	RC02-01	6.11	9.5				2.0	31.0	67.0	
⊠	RC02-17	7.80	13.2	0.274			5.0	58.0	37.0	
▲	RC02-17	12.16	13.2				6.0	9.0	85.0	
★	RC02-18	7.12	9.5	0.091			2.0	45.0	53.0	
⊙	RC02-26	25.32	9.5				1.0	30.0	69.0	

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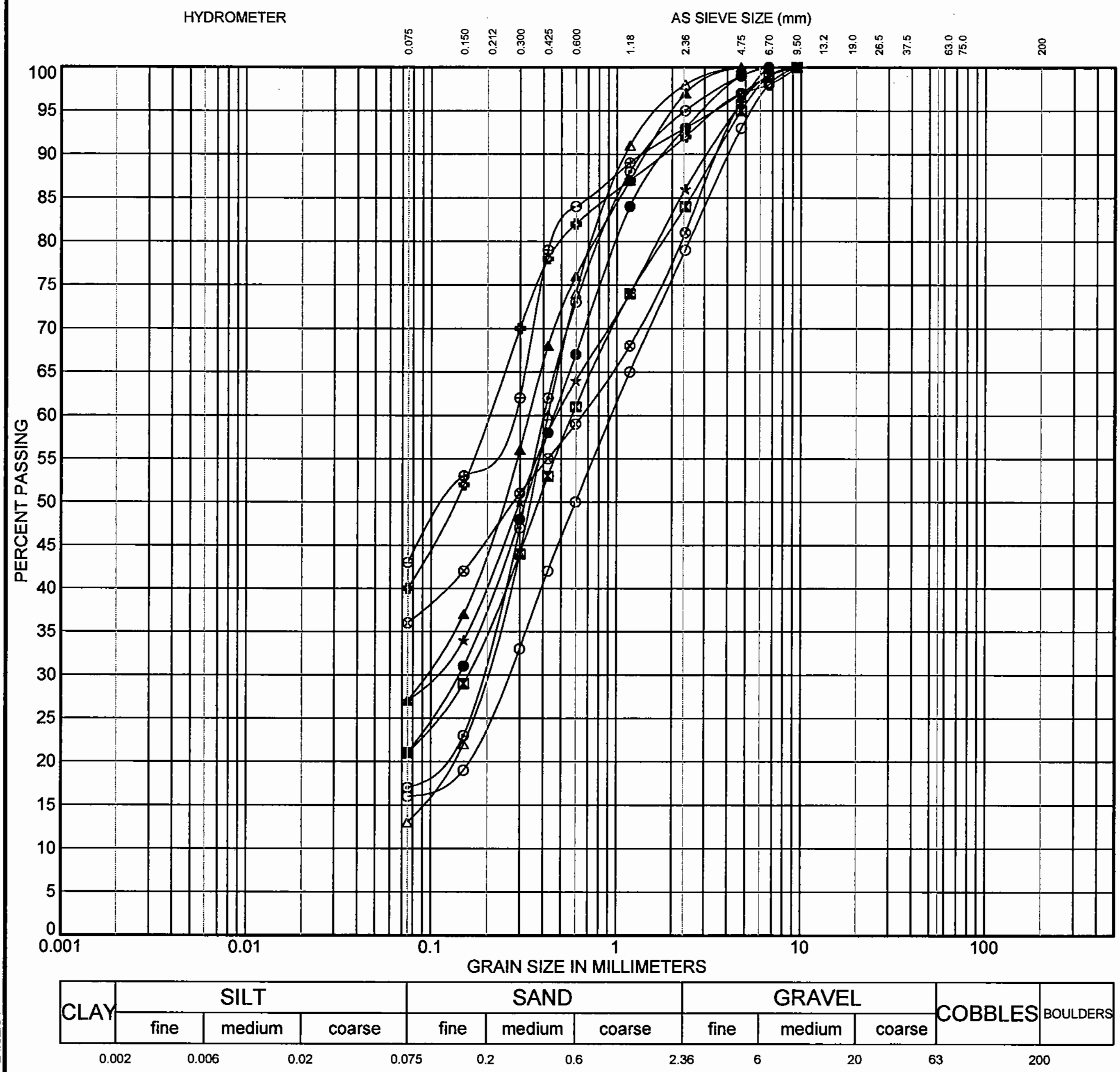
Client	P.F. Formation Pty Ltd
Project	Maroota Sands Resource Estimation Tertiary Clay
Project No	2110178A
File No	
Drawing No	PSD 3
Rev	1

GRAIN SIZE DISTRIBUTION



Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● RC02-01	11.24						
⊠ RC02-01	24.36						
▲ RC02-02	5.80						
★ RC02-02	8.14						
⊙ RC02-02	14.21						
✪ RC02-02	21.25						
○ RC02-02	25.30						
△ RC02-03	11.18						
⊗ RC02-03	18.22						
⊕ RC02-03	22.25						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● RC02-01	11.24	9.5	0.459	0.14		7.0	72.0	21.0	
⊠ RC02-01	24.36	9.5	0.575	0.157		16.0	63.0	21.0	
▲ RC02-02	5.80	4.75	0.337	0.092		3.0	70.0	27.0	
★ RC02-02	8.14	9.5	0.477	0.101		14.0	59.0	27.0	
⊙ RC02-02	14.21	9.5	0.406	0.184		5.0	78.0	17.0	
✪ RC02-02	21.25	9.5	0.204			8.0	52.0	40.0	
○ RC02-02	25.30	9.5	0.942	0.259		21.0	63.0	16.0	
△ RC02-03	11.18	9.5	0.425	0.193		2.0	85.0	13.0	
⊗ RC02-03	18.22	9.5	0.647			19.0	45.0	36.0	
⊕ RC02-03	22.25	9.5	0.257			7.0	50.0	43.0	

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Client: P.F. Formation Pty Ltd

Project: Maroota Sands Resource Estimation
Lower Tertiary Sand

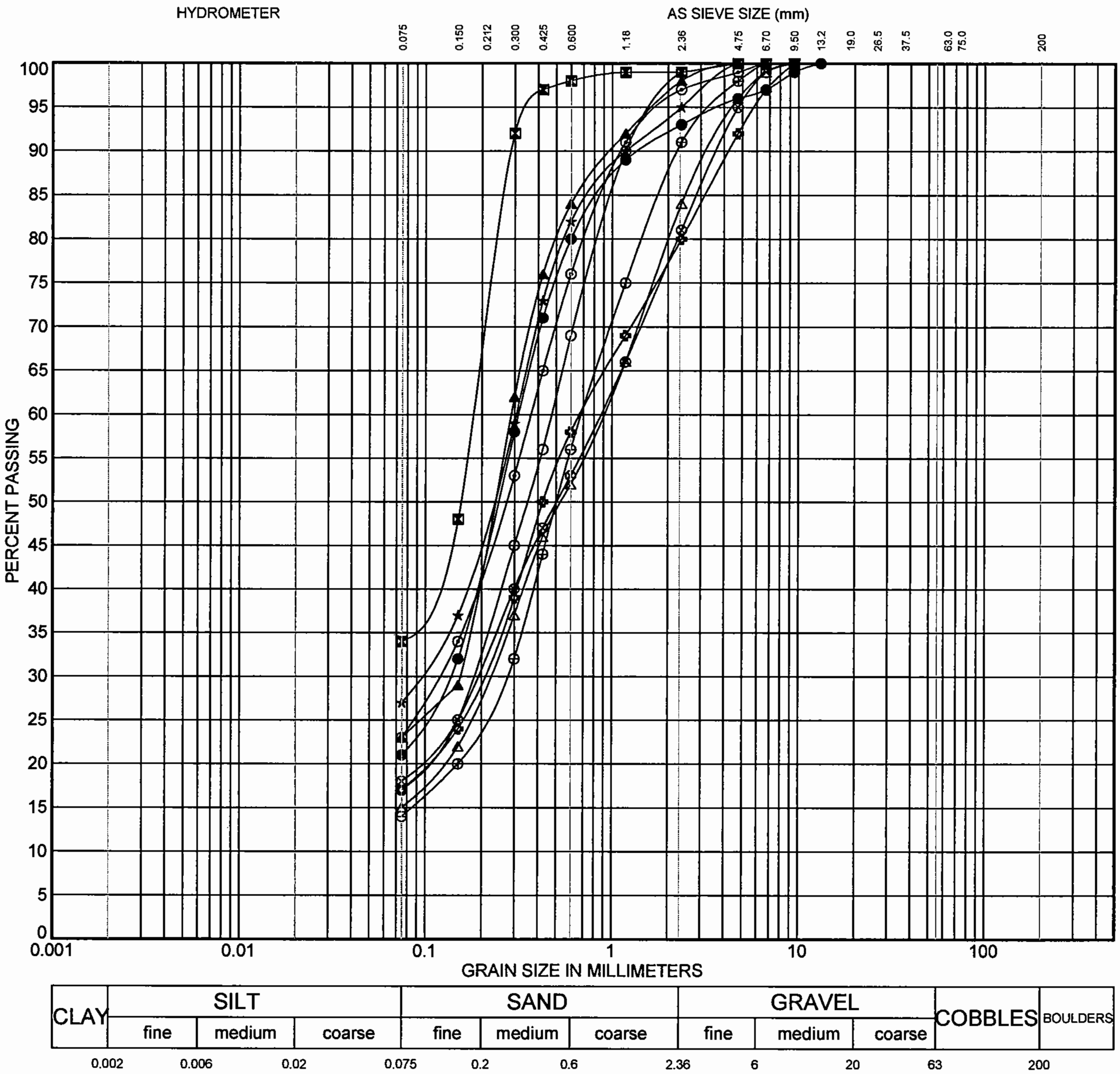
GRAIN SIZE DISTRIBUTION

Project No: 2110178A

File No:

Drawing No: PSD 4

Rev: 1



Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● RC02-03	28.35						
⊠ RC02-03	35.39						
▲ RC02-04	14.19						
★ RC02-04	19.24						
⊙ RC02-04	24.29						
✪ RC02-04	29.35						
○ RC02-05	8.11						
△ RC02-05	11.17						
⊗ RC02-05	17.22						
⊕ RC02-05	29.35						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt / %Clay
● RC02-03	28.35	13.2	0.317	0.132		7.0	72.0	21.0
⊠ RC02-03	35.39	9.5	0.181			1.0	65.0	34.0
▲ RC02-04	14.19	9.5	0.288	0.153		2.0	75.0	23.0
★ RC02-04	19.24	9.5	0.308	0.092		5.0	68.0	27.0
⊙ RC02-04	24.29	9.5	0.368	0.117		3.0	74.0	23.0
✪ RC02-04	29.35	9.5	0.679	0.198		20.0	63.0	17.0
○ RC02-05	8.11	9.5	0.473	0.178		1.0	82.0	17.0
△ RC02-05	11.17	9.5	0.883	0.217		16.0	69.0	15.0
⊗ RC02-05	17.22	9.5	0.864	0.189		19.0	63.0	18.0
⊕ RC02-05	29.35	9.5	0.692	0.267		9.0	77.0	14.0

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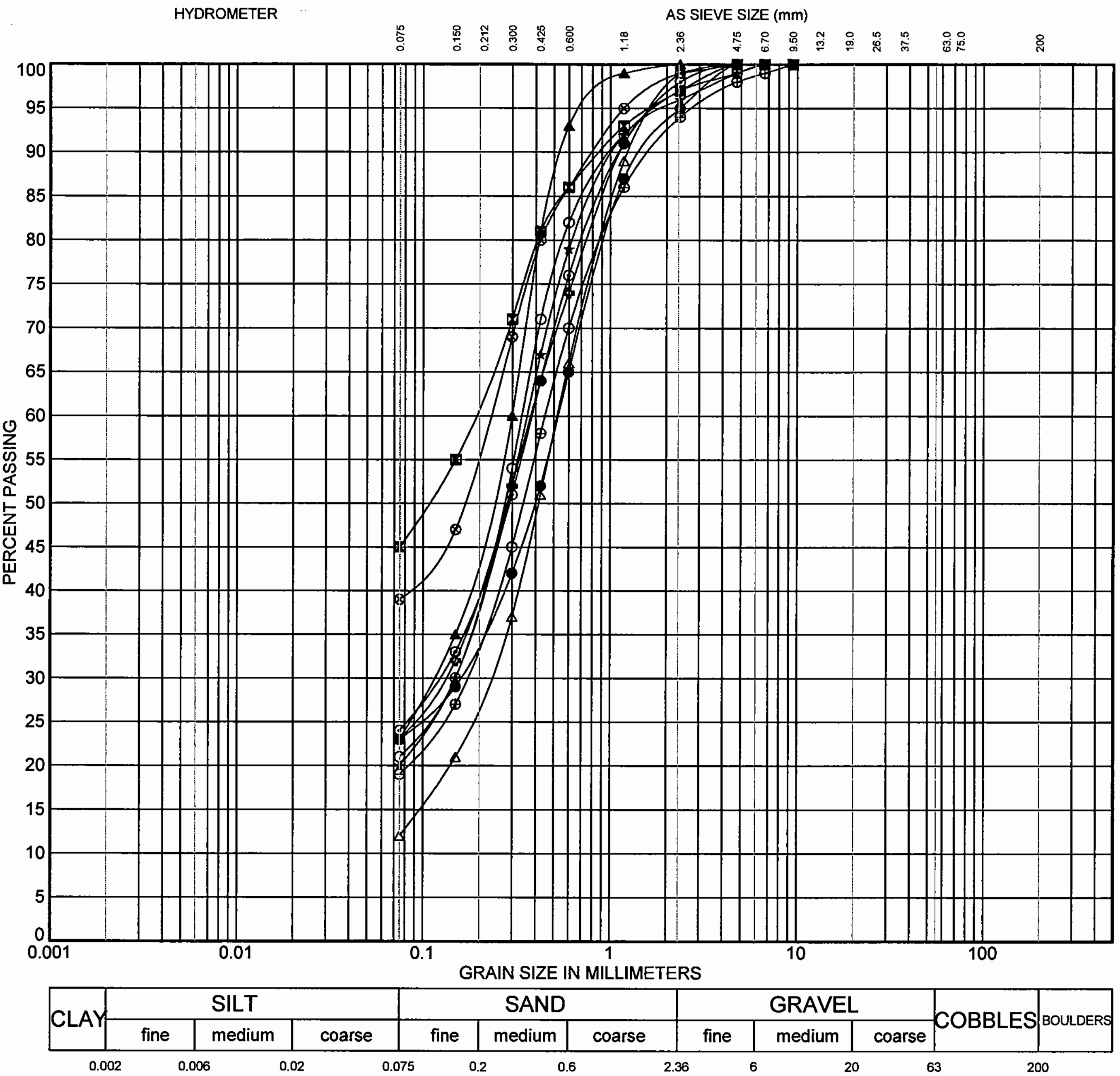
Project: Maroota Sands Resource Estimation
Lower Tertiary Sand

GRAIN SIZE DISTRIBUTION

Project No: 2110178A
File No:
Drawing No: PSD 5
Rev: 1



Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● RC02-06	18.24						
⊠ RC02-06	24.29						
▲ RC02-06	29.34						
★ RC02-06	34.37						
⊙ RC02-07	21.27						
✪ RC02-07	27.33						
○ RC02-07	33.40						
△ RC02-08	26.31					1.46	8.13
⊗ RC02-08	31.34						
⊕ RC02-08	34.39						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● RC02-06	18.24	9.5	0.525	0.158		5.0	72.0	23.0	
⊠ RC02-06	24.29	9.5	0.186			3.0	52.0	45.0	
▲ RC02-06	29.34	9.5	0.3	0.112		0.0	77.0	23.0	
★ RC02-06	34.37	9.5	0.361	0.15		4.0	76.0	20.0	
⊙ RC02-07	21.27	9.5	0.382	0.119		2.0	74.0	24.0	
✪ RC02-07	27.33	9.5	0.378	0.129		3.0	74.0	23.0	
○ RC02-07	33.40	9.5	0.339	0.15		3.0	76.0	21.0	
△ RC02-08	26.31	9.5	0.523	0.222		1.0	87.0	12.0	
⊗ RC02-08	31.34	9.5	0.226			1.0	60.0	39.0	
⊕ RC02-08	34.39	9.5	0.45	0.168		6.0	75.0	19.0	

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Project: Maroota Sands Resource Estimation
Lower Tertiary Sand

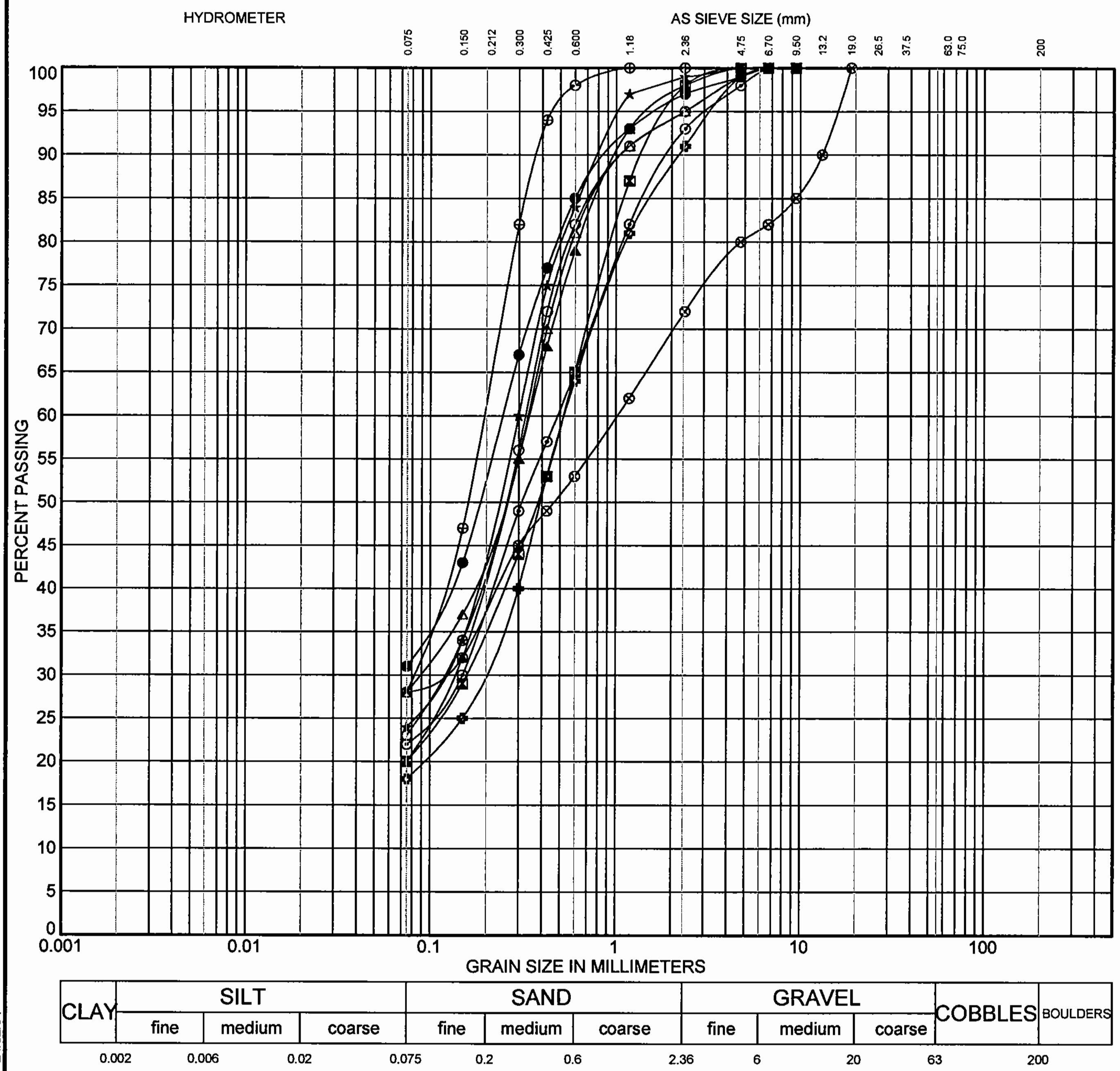
GRAIN SIZE DISTRIBUTION

Project No: 2110178A

File No:

Drawing No: PSD 6

Rev: 1



Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	RC02-08	39.43						
⊠	RC02-09	32.36						
▲	RC02-09	36.41						
★	RC02-10	24.28						
⊙	RC02-10	28.33						
✪	RC02-11	25.29						
○	RC02-11	30.33						
△	RC02-12	29.31						
⊗	RC02-13	24.25						
⊕	RC02-14	12.16						

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	RC02-08	39.43	9.5	0.245			3.0	66.0	31.0	
⊠	RC02-09	32.36	9.5	0.52	0.157		2.0	78.0	20.0	
▲	RC02-09	36.41	9.5	0.343	0.134		2.0	78.0	20.0	
★	RC02-10	24.28	9.5	0.3	0.114		1.0	75.0	24.0	
⊙	RC02-10	28.33	9.5	0.484	0.15		7.0	71.0	22.0	
✪	RC02-11	25.29	9.5	0.529	0.189		9.0	73.0	18.0	
○	RC02-11	30.33	9.5	0.327	0.117		5.0	72.0	23.0	
△	RC02-12	29.31	9.5	0.337	0.087		5.0	67.0	28.0	
⊗	RC02-13	24.25	19	1.015	0.106		28.0	44.0	28.0	
⊕	RC02-14	12.16	9.5	0.194	0.081		0.0	72.0	28.0	

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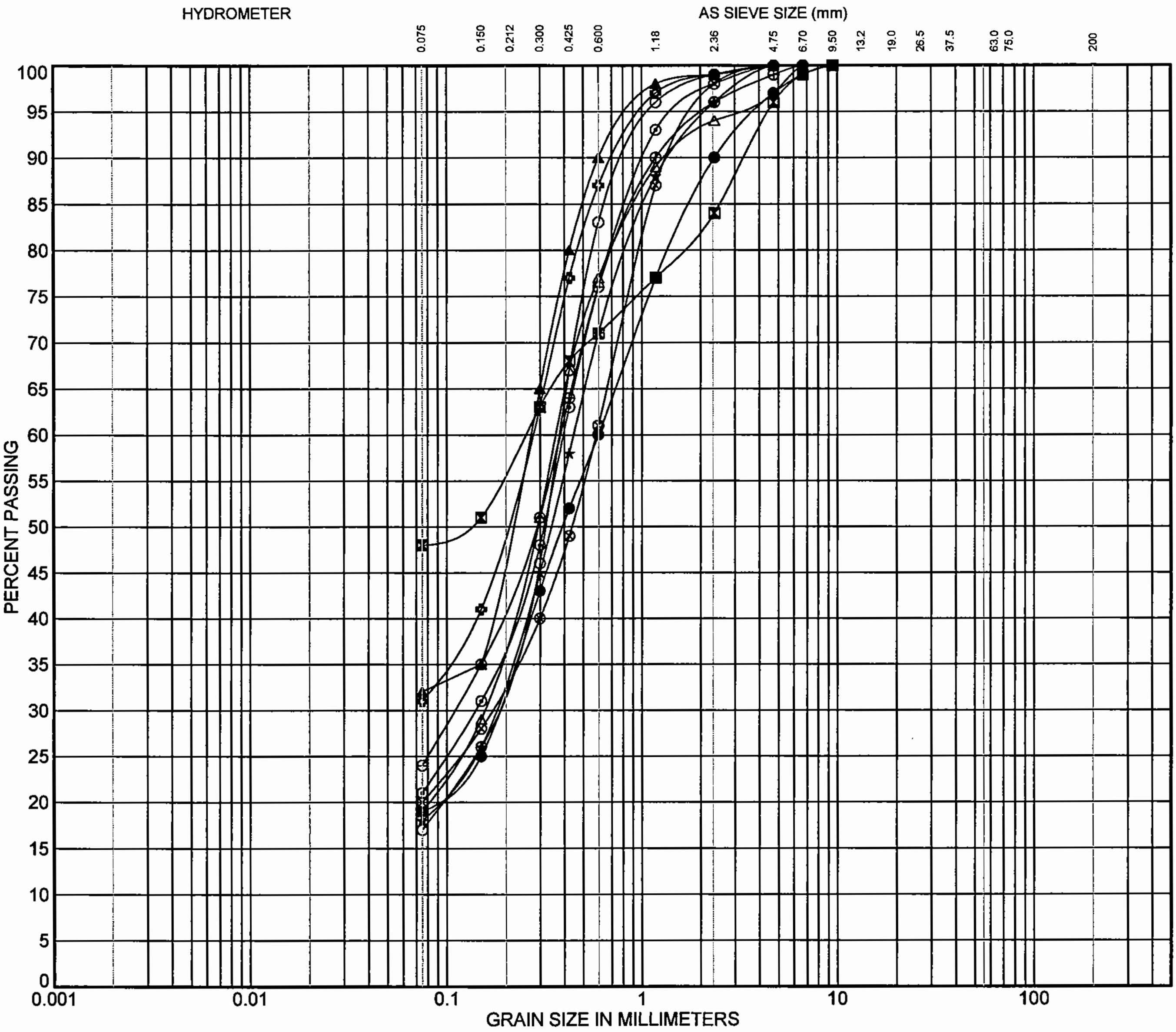
Project: Maroota Sands Resource Estimation
Lower Tertiary Sand

GRAIN SIZE DISTRIBUTION

Project No: **2110178A**

File No:

Drawing No: **PSD 7** Rev: **1**



CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse		

0.002 0.006 0.02 0.075 0.2 0.6 2.36 6 20 63 200

Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	RC02-14	16.23						
⊠	RC02-15	18.19						
▲	RC02-15	19.21						
★	RC02-15	21.25						
⊙	RC02-16	17.20						
✪	RC02-16	21.24						
○	RC02-16	24.28						
△	RC02-16	28.31						
⊗	RC02-17	16.22						
⊕	RC02-17	23.31						

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	RC02-14	16.23	9.5	0.6	0.182		10.0	71.0	19.0	
⊠	RC02-15	18.19	9.5	0.252			16.0	36.0	48.0	
▲	RC02-15	19.21	9.5	0.267			1.0	67.0	32.0	
★	RC02-15	21.25	9.5	0.448	0.174		4.0	78.0	18.0	
⊙	RC02-16	17.20	9.5	0.396	0.14		2.0	77.0	21.0	
✪	RC02-16	21.24	9.5	0.273			1.0	68.0	31.0	
○	RC02-16	24.28	9.5	0.378	0.172		1.0	82.0	17.0	
△	RC02-16	28.31	9.5	0.365	0.155		6.0	75.0	19.0	
⊗	RC02-17	16.22	9.5	0.583	0.168		2.0	78.0	20.0	
⊕	RC02-17	23.31	9.5	0.382	0.109		4.0	72.0	24.0	

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Lower Tertiary Sand

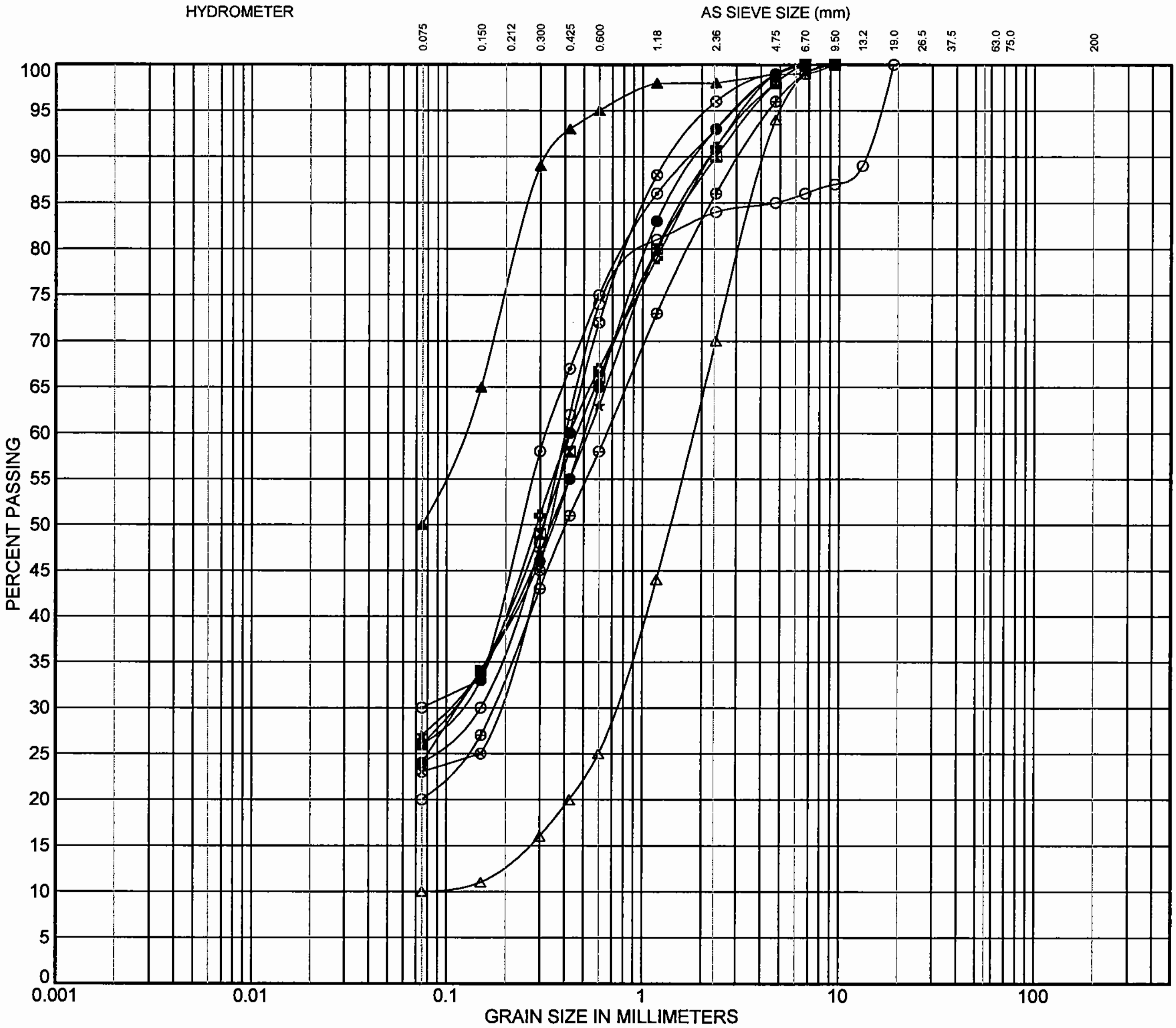
GRAIN SIZE DISTRIBUTION

Project No: 2110178A

File No:

Drawing No: PSD 8

Rev: 1



CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse		

0.002 0.006 0.02 0.075 0.2 0.6 2.36 6 20 63 200

Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	RC02-18	12.17						
⊠	RC02-18	17.24						
▲	RC02-19	8.14						
★	RC02-19	14.19						
⊙	RC02-19	21.28						
✿	RC02-20	5.90						
○	RC02-20	15.19						
△	RC02-21	7.11					3.79	24.10
⊗	RC02-22	0.40						
⊕	RC02-22	5.12						

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	RC02-18	12.17	9.5	0.505	0.114		7.0	69.0	24.0	
⊠	RC02-18	17.24	9.5	0.463	0.106		10.0	64.0	26.0	
▲	RC02-19	8.14	9.5	0.119			2.0	48.0	50.0	
★	RC02-19	14.19	9.5	0.527	0.101		9.0	64.0	27.0	
⊙	RC02-19	21.28	9.5	0.324	0.075		7.0	63.0	30.0	
✿	RC02-20	5.90	9.5	0.425	0.111		9.0	65.0	26.0	
○	RC02-20	15.19	19	0.404	0.15		16.0	60.0	24.0	
△	RC02-21	7.11	9.5	1.808	0.717	0.075	30.0	60.0	10.0	
⊗	RC02-22	0.40	9.5	0.425	0.178		4.0	73.0	23.0	
⊕	RC02-22	5.12	9.5	0.657	0.171		14.0	66.0	20.0	

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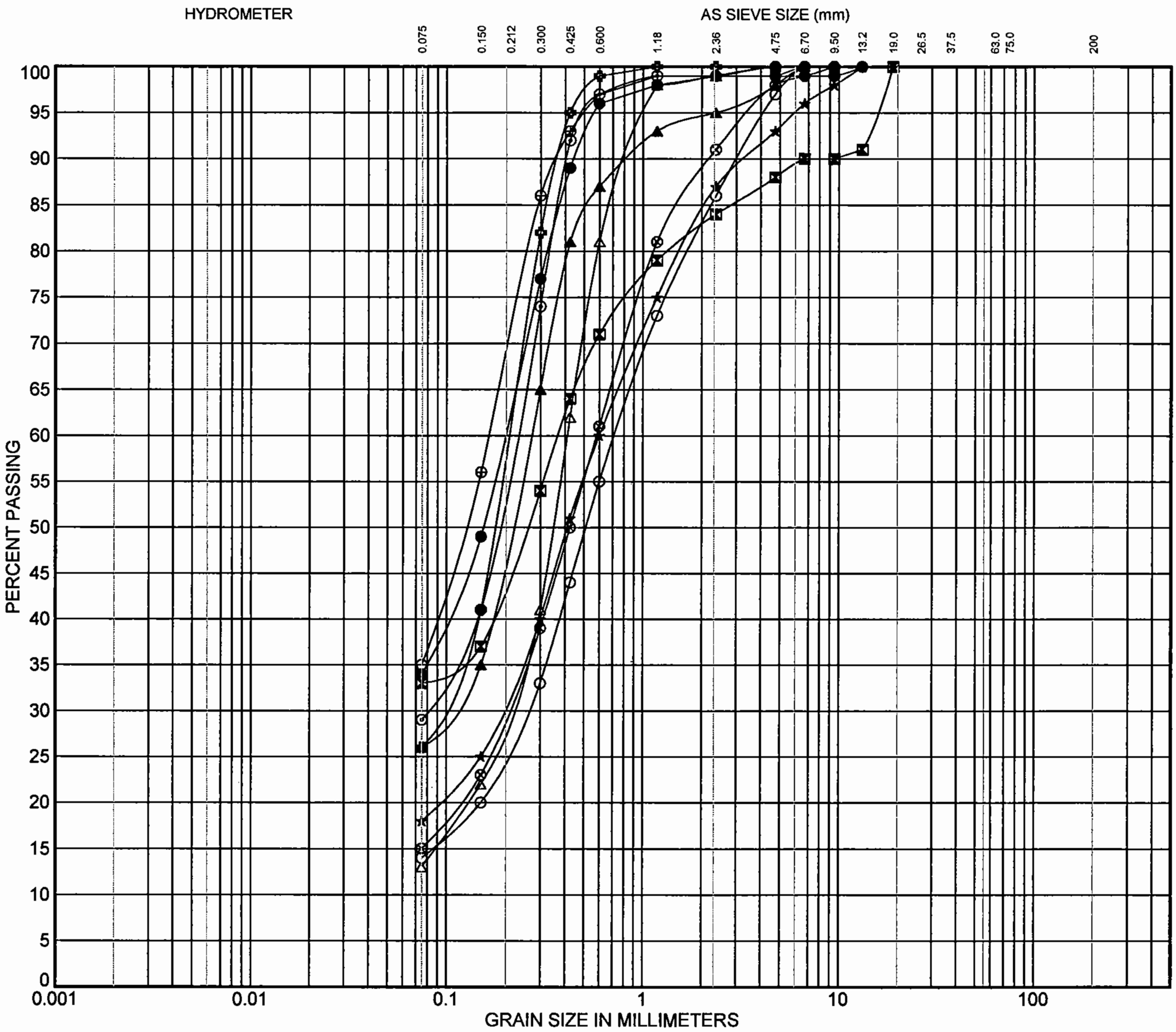
Project: Maroota Sands Resource Estimation
Lower Tertiary Sand

GRAIN SIZE DISTRIBUTION

Project No: 2110178A
File No:
Drawing No: PSD 9
Rev: 1



CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse		

0.002 0.006 0.02 0.075 0.2 0.6 2.36 6 20 63 200

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	RC02-22	14.23						
⊠	RC02-23	7.10						
▲	RC02-23	10.12						
★	RC02-23	12.15						
⊙	RC02-23	15.18						
✪	RC02-24	3.70						
○	RC02-24	7.90						
△	RC02-24	9.12						
⊗	RC02-24	12.18						
⊕	RC02-24	19.24						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt / %Clay
●	RC02-22	14.23	13.2	0.197			1.0	65.0	34.0
⊠	RC02-23	7.10	19	0.37			16.0	51.0	33.0
▲	RC02-23	10.12	9.5	0.267	0.102		5.0	69.0	26.0
★	RC02-23	12.15	13.2	0.6	0.189		13.0	69.0	18.0
⊙	RC02-23	15.18	9.5	0.224	0.079		1.0	70.0	29.0
✪	RC02-24	3.70	9.5	0.207	0.09		0.0	74.0	26.0
○	RC02-24	7.90	9.5	0.724	0.256		14.0	72.0	14.0
△	RC02-24	9.12	9.5	0.411	0.201		1.0	86.0	13.0
⊗	RC02-24	12.18	9.5	0.581	0.203		9.0	76.0	15.0
⊕	RC02-24	19.24	9.5	0.165			1.0	64.0	35.0

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Project: Maroota Sands Resource Estimation
Lower Tertiary Sand

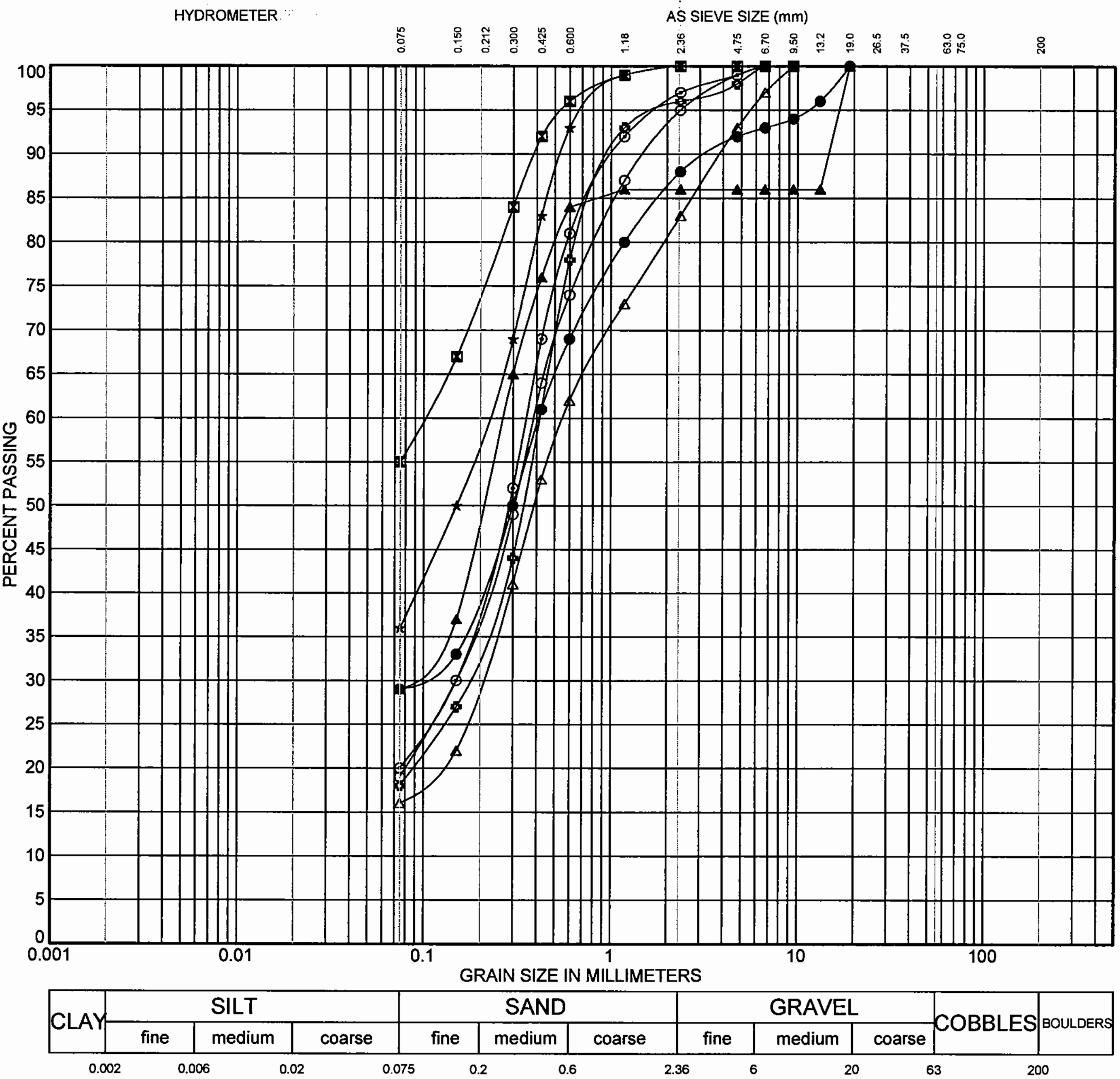
GRAIN SIZE DISTRIBUTION

Project No: 2110178A

File No:

Drawing No: PSD 10

Rev: 1



Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● RC02-25	0.60						
⊠ RC02-25	6.10						
▲ RC02-25	10.13						
★ RC02-25	13.14						
⊙ RC02-26	32.38						
✪ RC02-26	38.44						
○ RC02-26	44.50						
△ RC02-27	0.70						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● RC02-25	0.60	19	0.412	0.089		12.0	59.0	29.0	
⊠ RC02-25	6.10	9.5	0.1			0.0	45.0	55.0	
▲ RC02-25	10.13	19	0.265	0.082		14.0	57.0	29.0	
★ RC02-25	13.14	9.5	0.216			0.0	64.0	36.0	
⊙ RC02-26	32.38	9.5	0.353	0.15		3.0	77.0	20.0	
✪ RC02-26	38.44	9.5	0.416	0.17		4.0	78.0	18.0	
○ RC02-26	44.50	9.5	0.387	0.15		5.0	76.0	19.0	
△ RC02-27	0.70	9.5	0.556	0.201		17.0	67.0	16.0	

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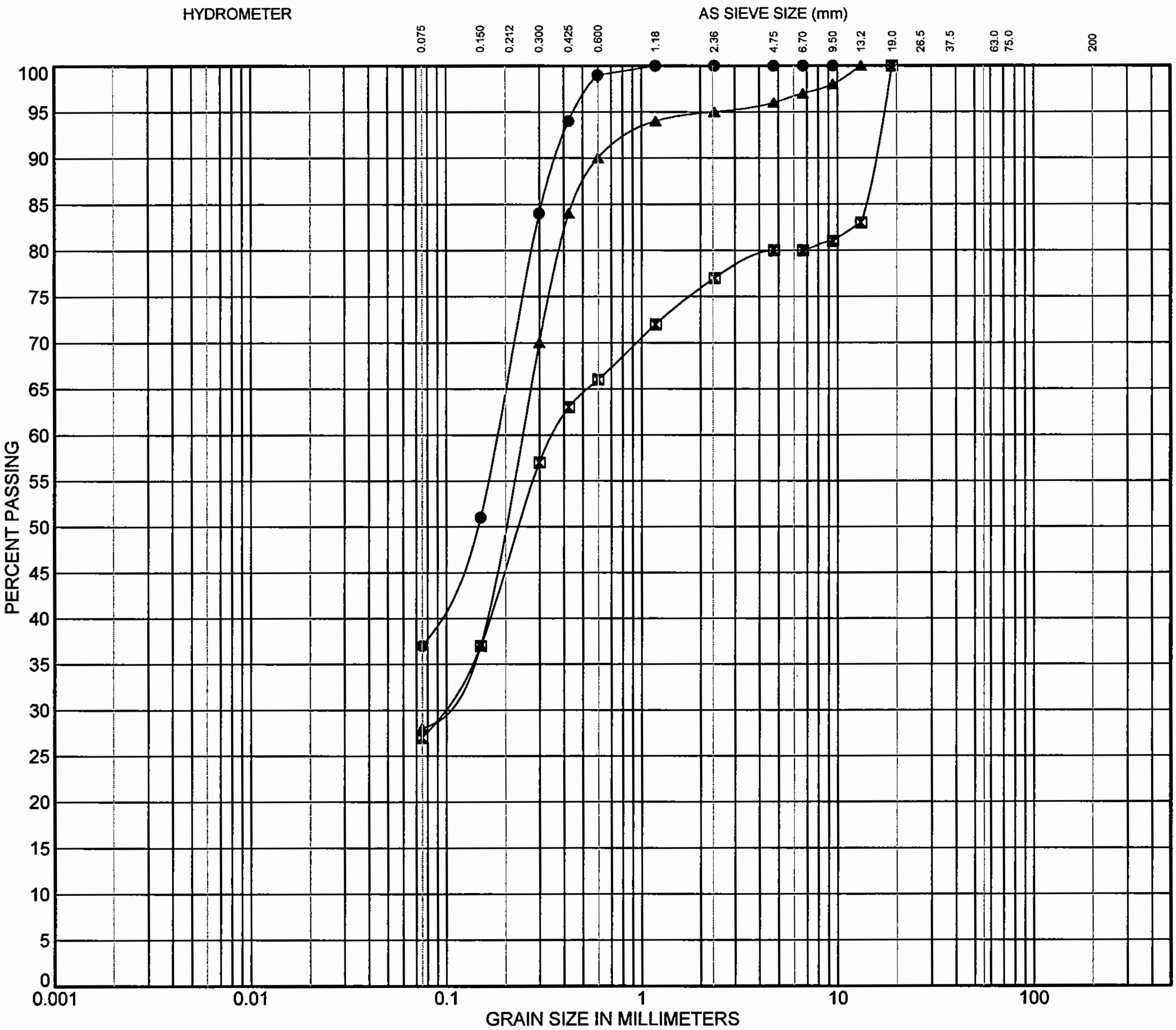
Client	P. F. Formation
Project	Maroota Sands Resource Estimation Lower Tertiary Sand
	GRAIN SIZE DISTRIBUTION
Project No	**2110178A**
File No	
Drawing No	**PSD 11**
Rev	**1**



CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse		

0.002 0.006 0.02 0.075 0.2 0.6 2.36 6 20 63 200

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	RC02-19	29.32						
⊠	RC02-20	19.21						
▲	RC02-21	12.19						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	RC02-19	29.32	9.5	0.181			0.0	63.0	37.0	
⊠	RC02-20	19.21	19	0.357	0.092		23.0	50.0	27.0	
▲	RC02-21	12.19	13.2	0.243	0.087		5.0	67.0	28.0	

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Client: P. F. Formation

Project: Maroota Sands Resource Estimation
Weathered Sandstone

GRAIN SIZE DISTRIBUTION

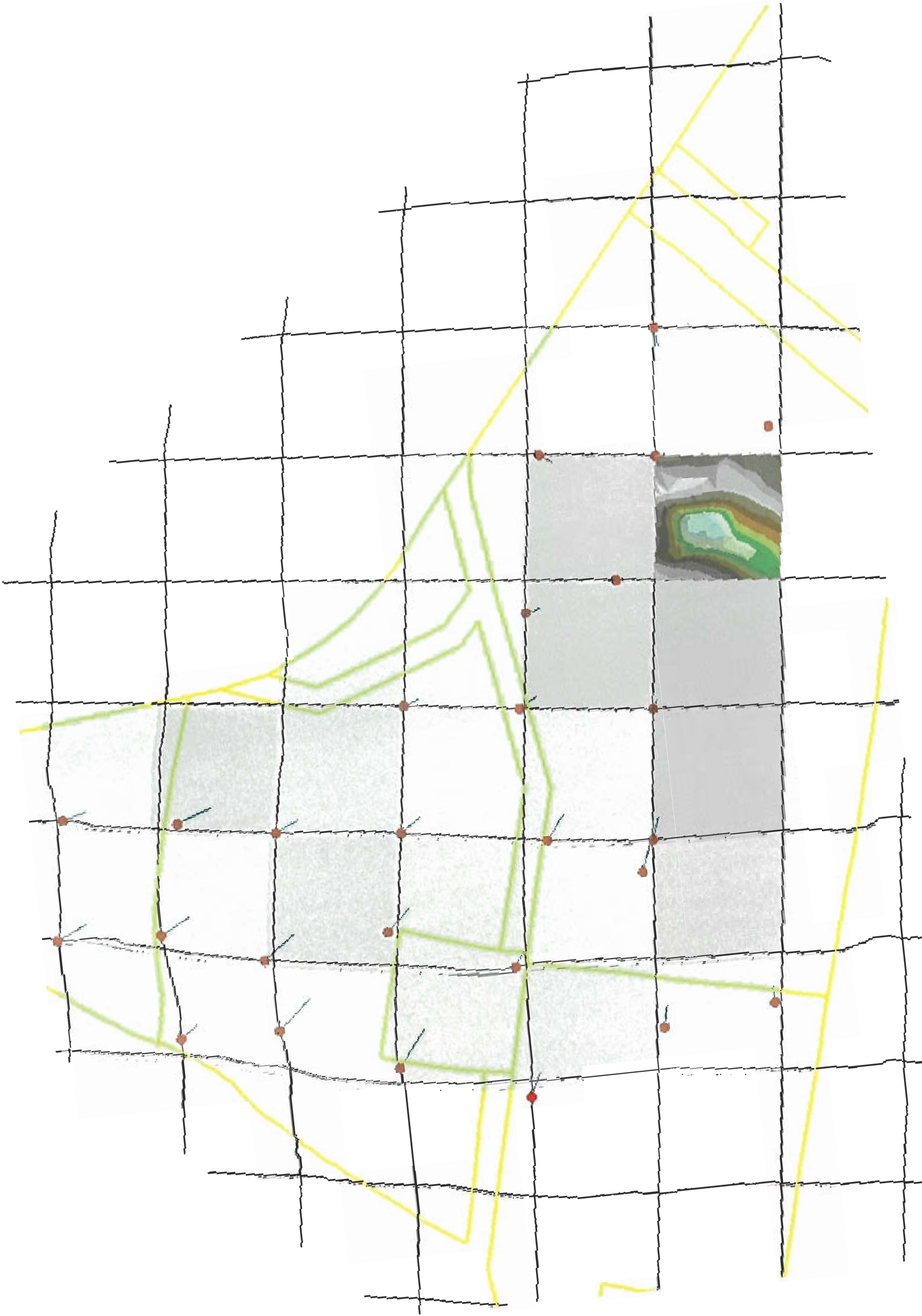
Project No: 2110178A

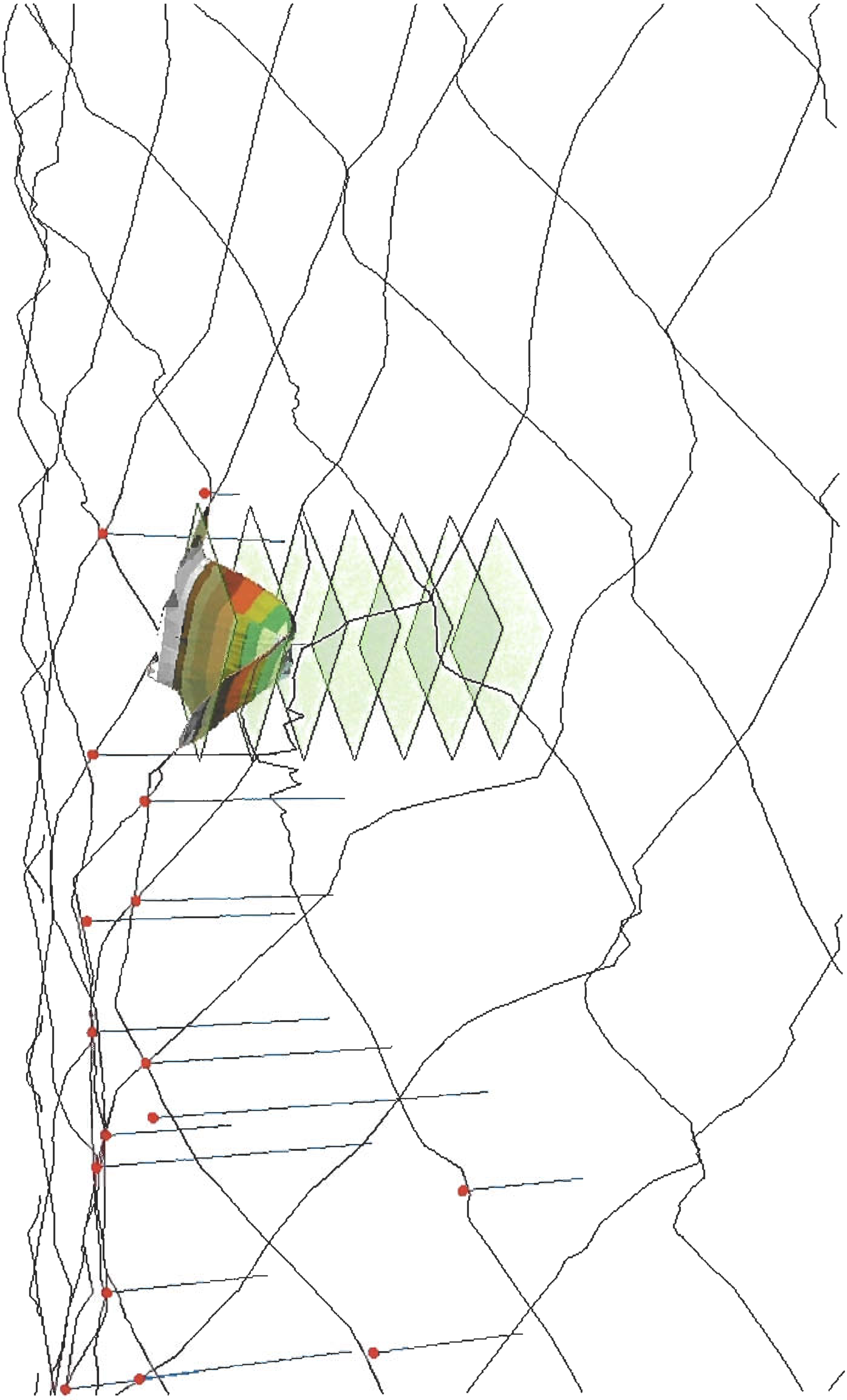
File No:

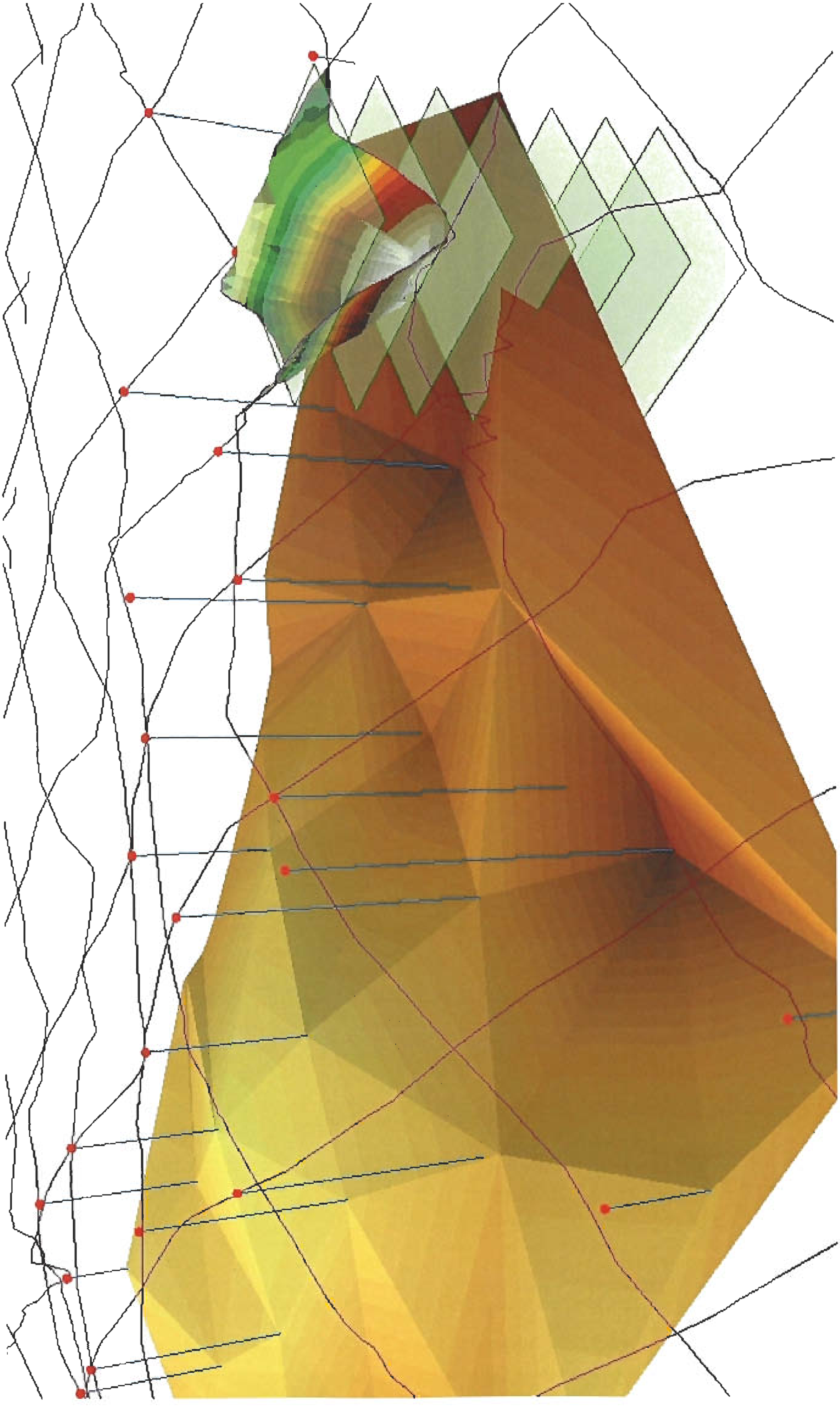
Drawing No: PSD 12 | Rev: 1

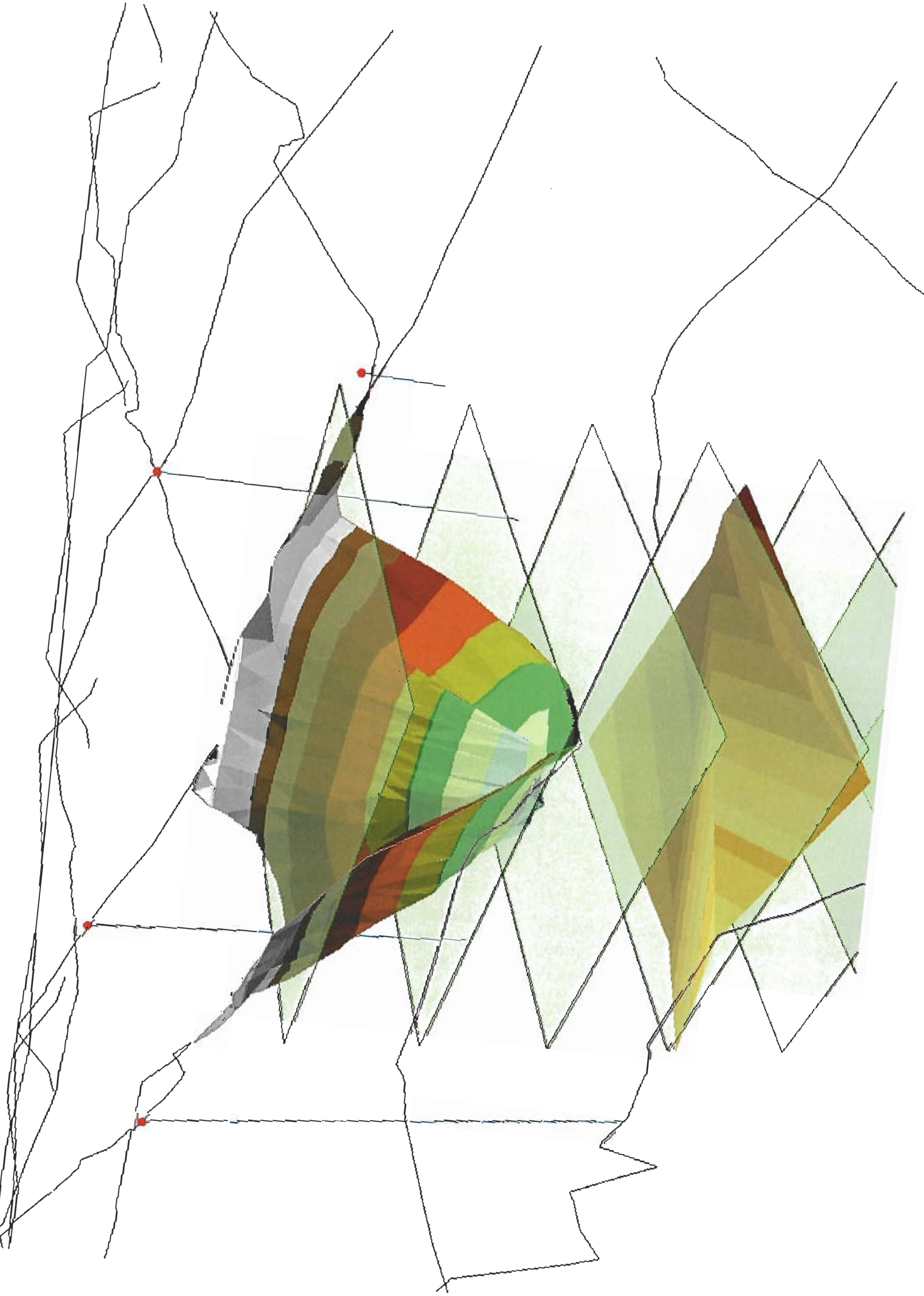
Appendix D

Selected 3D Images of the Maroota Sand Resource









Appendix E

Limitations of Geotechnical Site Investigation

Limitations of Geotechnical Site Investigations

Scope of Services

This geotechnical site assessment report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Parsons Brinckerhoff (PB) ("scope of services"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

Reliance on Data

In preparing the report, PB has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise stated in the report, PB has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. PB will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to PB.

Geotechnical Investigation

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared to meet the specific needs of individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor or even some other consulting civil engineer. This report was prepared expressly for the Client and expressly for purposes indicated by the Client or his representative. Use by any other persons for any purpose, or by the Client for a different purpose, might result in problems. The Client should not use this report for other than its intended purpose without seeking additional geotechnical advice.

This Geotechnical Report is Based on Project-specific Factors

This geotechnical engineering report is based on a subsurface investigation which was designed for project-specification factors, including the nature of any development, its size and configuration, the location of any development on the site and its orientation, and the location of access roads and parking areas. Unless further geotechnical advice is obtained this geotechnical engineering report cannot be used:

- when the nature of any proposed development is changed; or
- when the size, configuration location or orientation of any proposed development is modified.

This geotechnical engineering report cannot be applied to an adjacent site.

The Limitations of Site Investigation

In making an assessment of a site from a limited number of boreholes or test pits there is the possibility that variations may occur between test locations. Site exploration identifies specific subsurface conditions only at those points from which samples have been taken. The risk that variations will not be detected can be reduced by increasing the frequency of test locations; however this often does not result in any overall cost savings for the project. The investigation programme undertaken is a professional estimate of the scope of investigation required to provide a general profile of the subsurface conditions. The data derived from the site investigation programme and subsequent laboratory testing are extrapolated across the site to form an inferred geological model and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration programme, no matter how comprehensive, can reveal all subsurface details and anomalies.

The borehole logs are the subjective interpretation of subsurface conditions at a particular location, made by trained personnel. The interpretation may be limited by the method of investigation, and can not always be definitive. For example, inspection of an excavation or test pit allows a greater area of the subsurface profile to be inspected than borehole investigation, however, such methods are limited by depth and site disturbance restrictions. In borehole investigation, the actual interface between materials may be more gradual or abrupt than a report indicates.

Subsurface Conditions are Time Dependent

Subsurface conditions may be modified by changing natural forces or man-made influences. A geotechnical engineering report is based on conditions which existed at the time of subsurface exploration.

Construction operations at or adjacent to the site, and natural events such as floods, or groundwater fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept appraised of any such events, and should be consulted to determine if additional tests are necessary.

Avoid Misinterpretation

A geotechnical engineer should be retained to work with other appropriate design professionals explaining relevant geotechnical findings and in reviewing the adequacy of their plans and specifications relative to geotechnical issues.

Bore/Profile Logs Should Not Be Separated from the Engineering Report

Final bore/profile logs are developed by geotechnical engineers based upon their interpretation of field logs and laboratory evaluation of field samples. Customarily, only the final bore/profile logs are included in geotechnical engineering reports. These logs should not under any circumstances be redrawn for inclusion in architectural or other design drawings. To minimise the likelihood of bore/profile log misinterpretation, contractors should be given access to the complete geotechnical engineering report prepared or authorised for their use. Providing the best available information to contractors helps prevent costly construction problems. For further information on this matter reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by the Institution of Engineers Australia, National Headquarters. Canberra 1987.

Geotechnical Involvement During Construction

During construction, excavation is frequently undertaken which exposes the actual subsurface conditions. For this reason geotechnical consultants should be retained through the construction stage, to identify variations if they are exposed and to conduct additional tests which may be required and to deal quickly with geotechnical problems if they arise.

Report for Benefit of Client

The report has been prepared for the benefit of the Client and no other party. PB assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of PB or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

Other Limitations

PB will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

2

TECHNICAL PAPER

GROUNDWATER

R E P O R T

Environmental Assessment of the Hitchcock Road Sand Extraction and Rehabilitation Project. Maroota, NSW. Groundwater Assessment.

Prepared for

PF Formation

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Maroota NSW 2756

30 October 2006

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URS

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1.1 Introduction

The Director-General's requirements for the environmental assessment (EA) to be prepared under the provisions of Part 3A of the *Environmental Planning and Assessment Act 1979* included the following:

> ***Surface and Groundwater*** *– including detailed modelling of surface and groundwater impacts, a site water balance and explicit consideration of the project against the relevant findings of the Maroota Groundwater Study; a detailed description of the proposed water management system, including any creek diversions and sediment/water supply dams; and a surface and groundwater contingency strategy setting out the measures that would be implemented in some circumstances to protect the water supply of surrounding landowners and the environment.*

In response, DFA Consultants Pty Ltd (DFA) argued on behalf of PF Formation (PF) that groundwater modelling at the scale of the Maroota area would be unlikely to provide reliable results because of the large uncertainties for input into the model related to water use by all activities in the area, including farming activities. A water balance of the area could more effectively be carried out by using historical data recorded from the monitoring bores on the site.

In a reply dated the 31st August 2006, the Department accepted the proposed alternative method of assessing the impacts of sand mining at PF's Hitchcock Road quarry (Figure 1).

The following report, prepared by URS Australia Pty Ltd (URS), presents all available monitoring data collected by PF Formation since 1996 and, in addition, those collected by H.B. Maroota and Maroota Mining since 1999. These records, that include water level, water quality, water pumping and rainfall data, were made available to the Department of Land and Water Conservation (then DIPNR and now DNR) for inclusion in their Groundwater Status Report for the area and are the most extensive records available for the Maroota Sand and Hawkesbury Sandstone aquifers in the region.

The daily rainfall data presented in the hydrographs are those recorded at the PF offices in Portion 198, as the Bureau of Meteorology station located at the Maroota Fire Station was discontinued for some time and only relocated after a representation from URS to DLWC.

1.2 The site

The site is located immediately to the south of the intersection of Wisemans Ferry Road and Old Northern Road, Maroota, approximately 50 km north of Sydney. The site is included within the Maroota Sector of *Sydney Regional Environmental Plan No. 9 - Extractive Industry (No.2).* The area is zoned rural 1(b) under Baulkham Hills *Local Environment Plan 1991.*

The site, shown in Figure 1, is basically triangular in shape with an additional area (Portion 214, Lot2 DP752039) to the southeast. The distance from the apex of the triangle at Wisemans Ferry Road to the base along the southeastern part of Portion 214 is approximately 1500 m and the width of the base is approximately 1300 m.

The area includes the former Trigonometrical Reserve, Lot 1 DP1013943. With the additional Portion 214 to the south, the area covers 84.9 ha.

Figure 2 shows the existing and proposed development areas at the Hitchcock Road site and Figure 3 shows the extraction areas in the Maroota area.

1.3 Groundwater Technical Status Report

Following concerns expressed by the farming community about the continued availability of groundwater from the shallow Maroota Sand aquifer in the area, the Department of Land and Water Conservation (DLWC, now DNR) released a Groundwater Study Technical Status Report in September 1996, which contained, inter alia, the following conclusions:

- In order to protect the integrity of the Maroota Sand aquifer, sand mining would not be allowed to proceed below the water table and a 2 m buffer zone must be kept above it;
- The largest use of groundwater in the area was for irrigation, with extraction occurring from large excavations below the water table and to the top of the Hawkesbury Sandstone; and
- the majority of irrigation dams were not licensed under the Water Act 1912. An amnesty was declared to allow the issue of licenses for irrigation purposes.

A programme of installation of groundwater monitoring bores in the shallow (Maroota Sand) and deep (Hawkesbury Sandstone) aquifers was implemented by the DLWC. The initial 1996 Groundwater Status report was followed by two more reports in 1998 and 2001. These reports included water level and water quality monitoring data collected by the DLWC and those provided to the Department by PF Formation, Dr Martin (now H.B. Maroota) and Vella (now Maroota Mining).

1.4 Groundwater users

As indicated in Section 1.3, the main users of groundwater (and surface water) in the area are farming activities followed by sand miners. As part of their consent conditions, the sand miners must prepare and submit a yearly Water Management Plan including records of water use. A similar management tool does not appear to be available from the farming community. The lack of available records of groundwater usage by activities other than the sand miners gives a high degree of uncertainty to the development of modelling and water balance calculations.

2.1 Rainfall and Evaporation

Rainfall in the area has been recorded at the Maroota Bush Fire Brigade Station (No.067014), located opposite the junction with Roberts Road, from 1925 to 1998. In 1998 the station was closed due to the lack of availability of personnel. These records show that the average rainfall for Maroota between 1925 and 1998 has been 884.8 mm/year. Records also show that rainfall is highly variable, with a maximum of 1637 mm in 1990 and a minimum of 354 mm in 1953.

In 1999 the station was re-opened a short distance away in Roberts Road and identified by the same number. Records for this station indicate that during the period 2000 – 2005 (data for 2006 have not been compiled) rainfall in the Maroota area has been below average, with the lowest year being 2003 (721.6 mm). Data obtained from the Bureau of Meteorology in October 2006 combine the full records of the two stations into one table as presented in Table 1. The table shows that since the 1998 period the average annual rainfall has declined from 884.8 mm to 869.9 mm/year.

Evaporation data are available from station No. 067033 at Richmond AMO/MO, located some 30 km southwest of Maroota. Although this station is located in a different topographic setting, in the absence of other data, the records are considered applicable to Maroota for the purpose of the study. Mean daily pan evaporation ranges from 1.8 mm in June to 7.0 mm in December, with the annual average of 4.2 mm per day.

TABLE 1 - CLIMATE STATISTICS

Combined Maroota Bush Fire Brigade and Roberts Road Station No. 067014 - Monthly Rainfall, mm (1925-2005)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year
Mean	97.8	107.6	103.1	84.9	60.7	82.5	45.3	52.8	51.8	67.6	78.4	75.3	869.9
Median	73.6	78.3	84.0	56.2	45.4	50.0	26.4	23.0	38.7	53.8	68.8	71.5	819.2
Highest	395.5	464.9	437.7	467.2	370.1	445.4	250.6	497.4	174.0	220.3	208.3	375.0	1636.6
Lowest	0.0	0.0	2.1	0.0	1.5	0.0	0.0	0.0	0.4	0.6	0.5	0.0	353.9

Mean Daily Pan Evaporation, mm

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
6.3	5.4	4.4	3.3	2.1	1.8	2.0	3.1	4.3	5.4	5.9	7.0	4.3

Daily rainfall is also recorded by at the PF offices located in Portion 198, north of Wisemans Ferry Road. The daily records held by PF Formation have been used in the hydrographs of the monitoring bores presented in Appendix A.

2.2 Topography

The area's landscape is formed on a Hawkesbury Sandstone plateau and reflects the characteristic morphology of this formation, with steep valleys flanked by massive cliff faces. The sharp relief ranges from 170 m AHD, south of the project area, to 240.7 m AHD at the former trigonometric station, as shown on the Lower Portland 1:25 000 topographic map. Figure 2, compiled from aerial photography flown on the 15thApril 2004, shows the current area topography.

The former Trigonometrical Reserve, located within the proposed development area, is the dividing point of three surface water catchment subdivisions, the boundaries of which essentially coincide with the main roads system in the area. These three main sub-catchment areas are:

- east of the north-south Old Northern Road along the Maroota Ridge,
- west of the Old Northern Road and north of Wisemans Ferry Road, and
- south of the junction of Wisemans Ferry Road and Old Northern Road, where the subject site is located.

The three sub-catchments are all part of the greater Hawkesbury River catchment. The southern two-thirds of the proposed development area fall within the catchment of Little Cattai Creek, which joins the Hawkesbury River through Broadwater Swamp approximately 15 km southwest of the site. However, the current mining operations have modified the original drainage and, at present, most of the mined area is internally draining. A drainage line approximately 250 m long cuts Portion 214 at right angle and joins the upper reaches of Little Cattai Creek. Three dams within the property north of Portion 214 are built on this drainage line.

An additional drainage line cuts the southeastern corner of Portion 214 in southwesterly direction below a large dam in Lot 2 DP555184.

This area has also become internally draining since the start of mining.

2.3 Geology

The Maroota area is known for the production of sand, which represents a valuable resource to the building industry. The sand is obtained from two main sources, the Maroota Sand and the weathered profiles of the Hawkesbury Sandstone. The extent of the Maroota Sand has, in the past, been systematically mapped by the Department of Minerals and Energy of New South Wales (Etheridge, 1980) and its distribution over the area is well documented. Figure 4, adapted from Etheridge, shows the occurrence of the Maroota Sand in relation to the area under study.

The general stratigraphy of the area is as shown in the table below:

TABLE 2 - STRATIGRAPHIC SEQUENCE

AGE	UNIT	LITHOLOGY
Quaternary	Soils	Variable
Tertiary	Unnamed	Basalt
	Maroota Sand	Sand, gravel, clayey sand and clay
Triassic	Ashfield Shale	Shale and laminite
	Hawkesbury Sandstone	Quartzose sandstone with shale lenses

2.3.1 Maroota Sand

The Maroota Sand comprises a sequence of interbedded and poorly sorted sands, gravels, clayey gravels, gravelly sands, pebbly sands, clayey/silty sands and clay which range from compacted to partly consolidated materials. However, the bulk of these sediments consists of sand-sized material. Ferricrete bands are common and occur at a number of levels within the Maroota Sand.

The formation unconformably overlies the Hawkesbury Sandstone. It was deposited on the exposed and scarred surface of the Hawkesbury Sandstone and its base corresponds with, and is delimited by, that surface, which was characterised by sharp relief and broad meandering palaeochannels and depressions. The sediments making up the Maroota Sand derive from eroded and re-worked material of the Hawkesbury Sandstone and Permian conglomerates.

As a consequence of their origin and mode of deposition in meandering palaeochannels, the Maroota Sand sediments are characterised by rapid lateral and vertical facies changes. The Maroota Sand units occur as a channel system of fluvial and alluvial origin and were deposited by an old Tertiary age river system cut into the Triassic sandstone bedrock, giving rise to a highly irregular surface on the Hawkesbury Sandstone. The main components of this old river system comprise a major north-south channel aligned with, and to the west of, the current Maroota Ridge, and an east to west orientated channel close to the southern boundary of

Portion 167. The confluence of these two palaeochannels appears to have been west of the property and in the northwestern portion of the present Haerses Road ridge (Etheridge), as shown on Figure 4 and Figure 5.

Due to the irregular surface of the Hawkesbury Sandstone bedrock, the thickness of the Maroota Sand is not directly related to the present topography. The Maroota Sand formation attains a maximum thickness of 39 m at the site of the former Trigonometrical Reserve just west of the now mostly eroded away north-south palaeochannel. An equivalent thickness has been identified in the palaeochannel crossing Lot 2 DP228308, close to Old Northern Road.

North of Maroota, the thickness is variable and commonly not more than 5 m. The southern known extent of the Maroota Sand outcrop occurs within Portion 214. The formation appears to have been eroded along the edge of the plateau where it falls steeply at the property's southern margin and is missing in the southeastern and southwestern corners of the site.

Clay beds are common throughout the Maroota Sand formation. These clays layers were probably deposited as overbank deposits and abandoned channel fill deposits. A significant and extensive clay bed outcrops in Lot1 DP1013943 and lenses out towards the north and east. The clay, which is composed of kaolinite and silica, reaches a thickness of 13.4 m in this area. In other areas to the southwest and north, this clay has been extracted in the past for use as ceramic clay in the manufacture of cream-burning bricks.

2.3.2 Hawkesbury Sandstone

The Hawkesbury Sandstone is a widespread formation occupying a large portion of the Sydney Basin. It comprises a thick sequence of sub-horizontal, massive, cemented quartz sandstone, with well-developed cross bedding and intercalations of shale and siltstone beds. Grain size is generally in the range of fine to medium sand, but sorting is generally poor with some silt and pebble grains. Shale layers and bands and occasional carbonaceous beds are also common within the Hawkesbury Sandstone and are often clearly visible in road cuttings. Shale beds have been identified at various locations at the contact between the Maroota Sand and the underlying Hawkesbury Sandstone bedrock.

The Hawkesbury Sandstone outcrops at the southeastern and southwestern corners of Portion 214, marking the edge of the Maroota Sand outcrop.

The weathered profile of the Hawkesbury Sandstone, which is the primary target of other quarrying operations in the area, is of variable thickness and can be as much as 15 m deep. It is represented by a soft and friable rock ranging in colour from white to red-brown, the latter resulting upon the presence of variable iron oxides content. Where this weathered zone is consistently above water table, it has been leached by infiltrating rainwater and is present as weakly cemented, white sandy soil, referred to as Eluvial Sand (Etheridge).

2.4 Hydrogeology

The formations present in the Maroota area have dissimilar hydrogeological characteristics. The high degree of lithological variability (i.e., sands, clays, shale, sandstone, etc.) often results in the establishment of perched water tables in both the Maroota Sand and in the Hawkesbury Sandstone and, possibly within the latter, between the weathered profile and the fresher sandstone.

Under these conditions, three separate aquifers can be identified, although the extent of their hydrogeological separation or, conversely, interconnection, is sometimes uncertain. These aquifer units are:

- the Maroota Sand;
- the eluvial/weathered profile of the underlying Hawkesbury Sandstone; and,
- the fresh Hawkesbury Sandstone.

The more significant aquifers are the Maroota Sand and the deeper Hawkesbury Sandstone.

2.4.1 Maroota Sand

The Maroota Sand is a sandy formation of limited areal extent, which was deposited mainly in two palaeochannels eroded into the exposed surface of the Hawkesbury Sandstone. The presence of the palaeochannels (Figure 4 and Figure 5) was first identified by Etheridge (1980) and confirmed by subsequent drilling and investigations. One palaeochannel runs south to north from the general area of Haerses Road and generally follows the Old Northern Road. A second palaeochannel follows a spur in the Hawkesbury Sandstone east of Old Telegraph Road, then runs in a southwesterly direction north of Roberts Road, then westwards through Portion 167 to join the first palaeochannel near Haerses Road.

Following subsequent processes of erosion and landscape forming, the thickest sequence of the Maroota Sand, with the exception of the former Trigonometric Station, is now found within the palaeochannels and it is in these areas that the major sand mining efforts are directed. The palaeochannels contain the more continuous aquifers in this formation, which also display the more consistent water table elevation in the area.

Away from the palaeochannels, the presence of considerable clay and cemented layers give rise to localised perched water tables. These water bodies are found at variable elevations and depend upon rainfall infiltration for their persistence.

The Maroota Sand, where it occurs below water table, as in the deeper sections of the palaeochannels, constitutes a substantially unconfined, or water table, aquifer open to direct rainfall infiltration. As a consequence, it is subject to seasonal variations in response to rainfall patterns and climatic cycles.

The aquifer derives its permeability (its ability to store and transmit groundwater) from the pore spaces between its constituent sand grains. The permeability of the Maroota Sand aquifer is variable and is limited by its clay content, the degree of cementation of the ferricrete and ferruginous bands and the presence of substantial clay layers. Although the storativity of the Maroota Sand aquifer is greater than that of the underlying Hawkesbury Sandstone, its total storage capacity is reduced by the formation's limited saturated thickness, particularly north of Maroota, and by its relatively small areal extent.

The natural groundwater flow (underflow) within the Maroota Sand aquifer is dictated by its position at the top of the Maroota Ridge along the Old Northern Road and the Wisemans Ferry Road. The underflow, therefore, follows the topographic relief pattern and, where this relief intersects the base of the aquifer, seepages can be expected to occur at the contact with the less permeable underlying material. These seepage points, identified by Etheridge and Formosa at the margins of the Maroota Sand outcrop, supply water to a number of perennial creeks outside the proposed development area.

Where the water table in the Maroota Sand aquifer is at a higher elevation than that of the underlying Hawkesbury Sandstone, a potential exists for groundwater recharge to the Hawkesbury Sandstone to occur from this source.

The extraction of groundwater from the Maroota Sand aquifer requires large diameter excavations and dams, due to the relatively low permeability and storage capacity of the aquifer, even in the deeper sections of the buried palaeochannels. Irrigation supplies to orchards and market gardens in the area are drawn in this manner.

In addition to the regional water table within the Maroota Sand aquifer, perched water tables occur above the extensive clay layers and ferricrete bands present within the formation.

From a resource viewpoint, the perched water table aquifers have limited value due to their small extent and storage, but they may be significant in the maintenance of vegetation capable of tapping this source. However, where sand mining takes place, by necessity the vegetation is removed and the local aquifer excavated, so that the vegetation-perched water table interdependence is no longer an issue.

Estimates of hydraulic conductivity for the Maroota Sand aquifer, calculated from contributions from several authors, have been summarised in Table 23 of the Maroota Groundwater Study Technical Status Report, where a value of 4 m/day has been recommended. Storativity is estimated to be in the order of 0.20.

2.4.2 Eluvial Sand/Weathered Sandstone Profile

Small aquifer zones have developed in the eluvial sand, which comprises the leached and weathered profile of the Hawkesbury Sandstone. These zones often form perched aquifer systems above the deeper regional water level of the Hawkesbury Sandstone.

In the majority of cases, these perched aquifer systems have limited resource value because, like the Maroota Sand, have small extent and storage. They act as temporary storage of groundwater prior to release to streams or leakage to underlying aquifers. Dams and large diameter wells constructed into this material can provide a source of farm water supplies, but generally the permeability is too low to yield significant supplies to small diameter boreholes.

2.4.3 Hawkesbury Sandstone

The Hawkesbury Sandstone is generally an impermeable rock, due to the large degree of grain cementation resulting from the development of secondary minerals in the interpore spaces, such as kaolinitic clay and iron oxides. The presence of these minerals in the groundwater gives the characteristic red-brown staining of the rock visible in road cuttings and building stone. Although the rock has negligible primary permeability, fracturing and jointing, where open and interconnected, provide secondary permeability and storativity.

A review of the bore records held by the Department of Infrastructure, Planning and Natural Resources for the Maroota area is summarised in Table 3 and their location plotted in Figure 4 and Figure 5. The table and figure include observation bores established by the Department of Infrastructure, Planning and Natural Resources during their Stage 2 Maroota Groundwater Study, by PF Formation both in the former Trigonometrical Reserve area and in other properties around the site and by other sand miners. In total, the records search returned 61 recorded sites. Table 3 includes 17 records of monitoring and production bores installed by PF Formation, SunArise Sand (now H.B.Maroota), Maroota Mining and Department of Infrastructure, Planning and Natural Resources, but not yet registered in the records. The majority of the records in Table 3 relate to bores completed in the Hawkesbury Sandstone (70%).

The records show that different water tables are intersected during drilling into the Hawkesbury Sandstone, due to the different degree of fracturing and the presence of confining layers (such as the shale lenses) within the rockmass. However, because most bores in the Hawkesbury Sandstone are completed open hole, an equilibrium water table is eventually established with time, often coinciding with the deeper water table intersection, through drainage from the upper strata.

Most of the bores in the area are located at high elevations along the Maroota Ridge, which represents both a surface divide and a groundwater divide. The low density and the distribution of the groundwater monitoring points on either sides of a surface and groundwater divide complicate the production of a reliable water table contour map. Groundwater gradients measured in recent investigations in closely spaced bores are variable and steep in places due to the low permeability of the rockmass. Groundwater flow directions are expected to be generally to the northwest, east and south, away from the main axis of the groundwater divides, which coincide with the main surface divides.

Estimates of hydraulic conductivity for the Hawkesbury Sandstone, calculated from contributions from several authors, have been summarised in Table 24 of the Maroota Groundwater Study Technical Status Report, where a value of 0.1 m/day has been recommended. Storativity is estimated to be in the order of 0.0045, due to the secondary permeability characteristics of the aquifer.

TABLE 3 - DNR BORE RECORDS

Licence Number	Bore Number .	Surface RL m AHD	Total Depth m b.g.	SWL m b.g.	SWL Elevation m AHD	Yield L/sec	TDS mg/L	Aquifer
10BL006118	GW015051	230**	85.3	30.4	200**	0.44	fresh	HS
10BL006847	GW016348	215**	73.1	30.4	185**	0.13	NA	MS+HS
NA	GW034628	212**	5.4	5.4	207**	0.23	NA	HS
			91.4	41.1	171**	0.13	NA	
10BL029356	GW035725	198**	155.4	NA	NA	NA	NA	aband.
10BL112968	GW038147	200**	18.8	17	183**	NA	NA	HS, soft
			38.7	29.5	161.3**	NA	NA	HS, soft
			84.1	37.1	162.9**	NA	NA	HS, soft
			121.9	64.9	135.1**	0.69	NA	HS, soft
10BL107252	GW048741	223**	30.0	23.2	200**	0.08	NA	sandy
10BL143406	GW053898	183**	31.0	6.0	177**	0.5	56	HS
10BL121786	GW055962 (VELMW1)	187.6*	22.0	3.84	183.63*	0.43	170	HS
10BL158230	GW101051 (VELMW2)	158.7*	20	6.64	152.1*	<0.1	170	HS
10BL158230	GW101053 (VELMW3)	182.2*	39	7.94	174.21*	<0.1	140	HS
10BL114973	GW059118	208**	6.0	5.0	203**	0.5	NA	HS?
10BL127968	GW059742	208**	23.2	7.6	200**	1.52	NA	HS?

TABLE 3 - DIPNR Bore Records (cont.)

Licence Number	Bore Number.		Surface RL m AHD	Total Depth m b.g.	SWL m b.g.	SWL Elevation m AHD	Yield L/sec	TDS mg/L	Aquifer
NA	GW060147		185**	46	16.8	168**	NA	150	HS?
10BL130437	GW060051		215**	172.2	34.2	181**	1.4	fresh	HS
NA	GW067403		NA	NA	NA	NA	NA	NA	HS
NA	GW067405		NA	NA	NA	NA	NA	NA	HS
NA	GW071883		219**	120.0	48	171**	0.3	70	HS
10BL	GW072037		NA	99.0	NA	NA	NA	NA	HS
NA	GW072274		NA	168.5	NA	NA	0.4	0-500	HS
NA	GW072363		NA	162.5	NA	NA	0.4	0-500	HS
NA	GW075000/1	(Site 1)^	194.59	21.5	14.4	180.19	0.2	79	MS
NA	GW075000/2	(Site 1)^	194.60	42.3(43.5)[1]	27.7	166.90	0.1	141	HS
NA	GW075000/3	(Site 1)^	194.61	56.0(110)[1]	29.2	165.41	0.3	142	HS
NA	GW075001	(Site 2)^	191.71	80.0(150.0)[1]	31.1	160.61	0.1	200	HS
NA	GW075002/1	(Site 2)^	187.59	12.0	7.0	180.59	0.1	207	MS
NA	GW075002/2	(Site 2)^	187.78	23.0(27.5)[1]	9.2	178.58	0.1	54	MS

TABLE 3 - DNR BORE RECORDS

Licence Number	Bore Number	Surface RL m AHD	Total Depth m b.g.	SWL m b.g.	SWL Elevation m AHD	Yield L/sec	TDS mg/L	Aquifer
NA	GW075003 (Site 3)^	225.46	84.5(109.0)[1]	45.0	180.46	0.45	84	HS
NA	GW075004 (Site 3)^	226.90	60.0	44.8	182.10	0.05	40	HS
	LOT 2, DP535538							
10BL157655	PFL2MW1	197.19*	40.0	17.8	179.58*	NA	48-102	HS
	PFl2MW2	209.48*	49.5	29.71	179.94*	NA	222-336	HS
	PFL2MW3	194.60*	35.7	17.96	176.64*	NA	66-162	HS
	Lot 198							
10BL158453	PF198PB1	169.57*	150.0	35.0	134.57	1	90	HS
10BL158454	PF198PB2	177.13*	138.0	20.0	157.13	2.5	108	HS
	Portion 166							
10BL158452	PF166MW1	209.94*	11.80	10.57	199.37	0.1	162	MS
	Portion 167							
10BL157656	PF167MW1	187.64*	22.86	9.0	178.64	0.1	156-370	MS
10BL158274	GW101212	NA	60.0	15.0	NA	0.7	88.0	HS
10BL158506	GW101689 (PFL3MW1)	186.35*	30.30	12.05	174.30	0.1	96	HS
10BL157517	GW101839	NA	48.8	42.7	NA	0.33	NA	HS
10BL158549	GW102005	NA	61.0	18.0	NA	0.4	Fresh	HS

TABLE 3 - DNR BORE RECORDS

Licence Number	Bore Number	Surface RL m AHD	Total Depth m b.g.	SWL m b.g.	SWL Elevation m AHD	Yield L/sec	TDS mg/L	Aquifer
10BL158808	Lot2, DP228308 PT84MW1	213.43	12	5.34	208.09	NA	242	MS
10BL158808	Lot1, DP228308 PT84MW2 PT84MW3	226.8	26.5	24.52	202.28	NA	530	MS
		187.64	23.0	9.0	178.8	NA	266	MS
10BL159032	GW102133	NA	150.5	NA	NA	1.2	234	HS
10BL159150	GW102450	NA	126.0	NA	NA	1.5	55.0	HS
10BL159150	GW102451	NA	156.5	NA	NA	0.3	50.0	HS
10BL159366	GW102583	NA	102.0	42	NA	0.2	42	HS
10BL159604	GW103148	NA	60.0	11.0	NA	0.23	52.0	HS
10BL157591	GW103254	NA	62.0	NA	NA	NA	NA	HS
10BL159997	GW103570	NA	57.91	NA	NA	NA	0.33	HS

^ DLWC Maroota Groundwater Stage 2 Study * = Surveyed MS = Maroota Sand TDS = Total Dissolved Solids **= Estimated from contour map
HS = Hawkesbury Sandstone NA = Not Available SWL = Static Water Level [1] = depth cased (depth drilled)

2.5 The groundwater monitoring network

In the preparation of the assessment of the groundwater balance at the Hitchcock Road quarry, URS is able to use data from long term records of other sand miners in the area. These same data are those provided to DNR for the Groundwater Status report and more recently on an annual basis. This information is also presented in the annual Water Management Plans prepared for the Baulkham Hills Shire Council and Hornsby Shire Council.

The available groundwater monitoring network operated by PF Formation, H.B. Maroota and Maroota Mining consists of the bores listed in Table 1. Records from this network have been used in the following water balance assessment. The Table include also records from bores in mining areas that have been discontinued and rehabilitated. In particular, these are:

- the three bores in PF Formation Lot 2, which have been handed over to DNR for continued monitoring in 2002;
- one bore in the Maroota Mining site which has been destroyed by the mine expansion and which has been replaced; and
- one bore in the H.B. Maroota site which was dry.

In addition, the two production bores in Portion 198, the site of PF Formation wash plant, have been included as they are monitored for water quality and water extraction volumes.

The location of the bores is given in Figure 4.

Other monitoring bores have been installed and are monitored by DNR (75000 series) and Dixon Sands, but those records are not available to URS.

TABLE 4 – GROUNDWATER MONITORING BORES

Bore	Owner	Year	Surface RL (m AHD)	Total Depth (m below Surface)	Aquifer	Status
PF166MW1	PF Formation	1998	209.94	11.8	M.S.	Current
PF167MW1	PF Formation	1996	187.64	22.9	M.S.	Current
PFL3MW1	PF Formation	1998	186.35	30.3	H.S.	Current
PFL2MW1	PF Formation	1996	197.19	40.0	H.S.	To DNR
PFL2MW2	PF Formation	1996	209.487	49.5	H.S.	To DNR
PFL2MW3	PF Formation	1996	194.60	35.7	H.S.	To DNR
PF198PB1	PF Formation	1998	169.57	150.0	H.S.	Production
PF198PB2	PF Formation	1998	177.13	138.0	H.S.	Production
PT84MW1	H.B. Maroota	1998	213.43	12.0	M.S.	Current
PT84MW2	H.B. Maroota	1998	226.8	26.5	M.S.	Abandoned
PT84MW3	H.B. Maroota	1998	187.64	23.0	M.S.	Current
VELMW1	Maroota Mining	1982	187.6	22.0	H.S.	Destroyed
VELMW1A	Maroota Mining	2006	185.49	36.5	H.S.	Current
VELMW2	Maroota Mining	1997	158.7	20.0	H.S.	Current
VELMW3	Maroota Mining	1997	182.2	39.0	H.S.	Current

2.6 Water levels

The water levels in the monitoring bores in Table 4 have been monitored since January 1999 by means of automatic data loggers. Before 1999, water level measurements have been effected manually in some of the bores.

Between January 1999 and January 2006, the data loggers used were the Dataflow model, the same as those used by DLWC in their bores. In January 2006, the loggers have been replaced by Solinst Levelogger instruments.

Hydrographs for all the available bores (including rainfall data recorded at the PF offices site in Portion 198) are attached and following is a discussion of each individual bore's behaviour.

2.6.1 PF Formation Monitoring Records

PF167 Dam

Purpose: The water supply excavation in Portion 167 was established prior to 1995 at the start of the mining operation at the site. The dam is licensed by DNR for an annual extraction of 50 ML.

Water level: Water level at the dam has been measured weekly against a surveyed staff since September 1996.

Range: Over the monitoring period, the water level in this dam, which represents a "window" in the Maroota Sand water table, has generally ranged between 180.5 and 182 m AHD.

Comment: The excavation is located in the centre of the palaeochannel running through the site (Figure 2). The dam receives direct rainfall and site run-off so that the annual pumpage is only in part derived from the Maroota Sand aquifer. During periods of high rainfall, when limited volumes are required at the wash plant, the dam acts as a recharge point to the Maroota Sand aquifer. The fluctuations in the water level visible in the hydrograph are a combination of all these factors, and indicate that the extraction rates of groundwater are in balance with the needs of the aquifer, as there is no long term decline in the level.

PF166MW1

Purpose: The bore was drilled to monitor a perched water table in the Maroota Sand.

Water level: Between March 1998 and June 2002, the water level in this bore has steadily risen following a period of above average rainfall. Since then, the water level has fallen to near the base of the bore (and the base of the Maroota Sand at that location) as a result of a prolonged below average rainfall period.

Range: The maximum water table elevation occurred in May 2002 (201 m AHD) and the minimum in the first half of 2006 (198.5 m AHD).

Comment: This bore is distant from the excavation (184 m AHD) at the former Trig site and is not affected by those activities. The water table changes at this site are a reflection of long term climatic conditions. The hydrograph shows that the water table responds readily to a period of sustained rainfall and recharge and, vice versa, it declines during periods of low rainfall.

PF167MW1

Purpose: This bore was drilled to monitor the Maroota Sand in the vicinity of the Hitchcock Road site.

Water level: Water level measurements commenced in March 1996 by manual means. The records indicate that the water table rose steadily until June 2002, which marks a period of below average rainfall. The water table has stabilised at around 179.5 m AHD since the second half of 2004.

Range: The water table has ranged between 178 m AHD in May 1998 and 182.7 m AHD in June 2001.

Comment: The hydrograph shows that the water table in the Maroota Sand at this site responds readily to periods of wet and dry conditions.

PFL2MW1

Purpose: Monitoring the water table in the Hawkesbury Sandstone in Lot 2 of PF Formation. Monitoring ceased in June 2002.

Water level: Water level records commenced in Lot 2 by manual measurement in September 1996 and by data logger from January 1999. Monitoring by PF was completed in June 2002 when the quarry ceased operations. At that time, the monitoring bores in Lot 2 were handed over to DIPNR who took over the task of maintaining and downloading the data during the rehabilitation period.

Range: The water table ranged between 178.8 m AHD in May 1998 and 180.5 m AHD in January 2000 and averaged 180 m AHD.

Comment: The records indicate that the Hawkesbury Sandstone is also responding rapidly at this site to rainfall recharge as illustrated by the rise in level following a period of sustained rainfall. There was no pumping from bores at this site, as the water supply for the operation was from a surface storage dam.

PFL2MW2

Purpose: Monitoring the water table in the Hawkesbury Sandstone in Lot 2 of PF Formation. Monitoring ceased in June 2002.

Water level: The water table ranged between 179 m AHD in May 1998 and 181 m AHD in January 2000 and averaged 180.6 m AHD.

Comment: The water table follows the same pattern as that in bore PFL2MW1 showing a similar behaviour.

PFL2MW3

Purpose: Monitoring the water table in the Hawkesbury Sandstone in Lot 2 of PF Formation. Monitoring ceased in June 2002.

Water level: The water table ranged between 175.8 m AHD in May 1998 and 177.8 m AHD in August 2001.

Comment: Although the water table at this site shows a similar rise and fall pattern to the other two bores on the site in response to the rainfall, the overall trend has been generally upward, indicating no effect by the mining operations.

PFL3MW1

Purpose: Monitoring the water table in the Hawkesbury Sandstone in Lot 3 of PF Formation.

Water level: Water table monitoring commenced manually at this site in April 1998 and by data logger from January 1999. The bore is located between the two main operation areas.

Range: The water table response to rainfall is evident in this bore also and shows an average around 174 m AHD.

Comment: As the record commenced before the start of mining in Quarry 3, the hydrograph shows that the mining operations did not have any effect upon the water table, as the water supply requirements are low at this site and supply is provided from surface storages.

The Dataflow logger in this bore was replaced by a Solinst Levelogger in January 2006. However, because of an operational problem, no data were recorded for the first semester of the year. The unit has been replaced. In consideration of the previous seven years average, it is considered that this loss of data has not seriously compromised the reliability of the water table behaviour knowledge at this site.

PF198PB1 and PF198PB1

No water level monitoring has been undertaken at the production bores in Portion 198 other than for operational reasons, as the water level draws down and recovers in response to pumping.

2.6.2 HB Maroota Monitoring Records

PT84MW1

Purpose: The bore was drilled to monitor a perched water table in the Maroota Sand.

Water level: Monitoring at this site started in January 1999. A loss of data occurred after June 2004 due to the particular design of the Dataflow data logger and to invasion of the screened section of the bore by rootlets, which prevented the manual measurement of the water table. This aspect has been addressed and the bore cleaned and re-developed. In January 2006 the data logger was replaced with a Solinst Levelogger unit.

Range: The hydrograph shows an overall steady fall of the perched water table from an initial level of around 208 m AHD to 205 m AHD in July 2006.

Comment: The hydrograph shows a loss of data for the first semester of 2006. As for PFL3MW1, an operational malfunction failed to start the logger at the programmed time. The unit was replaced in July 2006. However, as the water level is close to the base of the bore (and to the base of the Maroota Sand) and in view of the persisting drought, it is considered that the loss of data does not compromise the validity of the assessment of the water table at this site.

PT84MW2

Purpose: This bore was drilled to monitor the Maroota Sand at some distance from the central excavation and close to the 75000 series monitoring bores installed by DLWC in the Maroota Sand and the Hawkesbury Sandstone.

Water level: The bore was drilled to a depth expected to be below the water table at this site. The target depth was chosen on the basis of the geological information obtained by the adjacent DLWC drill sites. However, the bore resulted to be marginally above the water table which soon fell below the base of the bore. As a result, no continued water level monitoring has been possible.

PT84MW3

Purpose: The bore was drilled to monitor the Maroota Sand in the vicinity of the central excavation on this site.

Water level: The central excavation at this site was licensed to be below the water table and sand mining occurred by sand dredging. This was the only occurrence of mining below the water table in the Maroota area. The water table in the central "pond" was monitored and was generally around 179 m AHD, returning at that level after the end of the day shift of the dredge. The water level in the monitoring bore shows a pattern in response to rainfall and, at a lowest level of around 182 m AHD, has maintained a head of about 3 m above the central pond, considered to be a "window" in the Maroota Sand water table. The operation of the dredge was discontinued at the end of 2002. This would suggest that the operation of the dredge and the current water management of the site have been in balance with the hydrogeological regime of the site.

Range: The water table has fluctuated between 184 and 182 m AHD over the monitoring period started in January 1999 and has stabilised at 182 m AHD. As with other monitoring bores in the Maroota area, a fall in the water table occurred in mid 2002 at the inception of a below average rainfall period.

2.6.3 Maroota Mining Monitoring Records

VELMW1

Purpose: Monitoring the water table in the Hawkesbury Sandstone.

Water level: This bore was drilled in 1982 as a water supply for a short-lived duck farming operation. The bore was not used for many years, but it was equipped with a data logger in 1999 at the time of preparation of the EIS documentation for the planned mining operations.

The bore was shallow (22 m) for a typical supply from the Hawkesbury Sandstone with the water table close to the surface. These two conditions made the bore dependent upon the rainfall over the site, as the hydrograph shows. Since mid 2002, the water level started a decline in response to the weather pattern. In mid 2004, at the start of mining operations, and due to its vicinity to the main excavation, the water table fell to just above 177 m AHD followed by a modest recovery. The bore was “mined out” at the beginning of 2005 and replaced by bore VELMW1A in November 2005.

VELMW1A

Purpose: To monitor the water table in the Hawkesbury Sandstone as a replacement of VELMW1.

Water level: The water level shows a small decline in response to the prolonged dry period.

Range: The water level fell from 166 m AHD to 165.6 m AHD.

VELMW2

Purpose: To monitor the water table in the Hawkesbury Sandstone

Water level: The water level in this bore shows a pattern which can be considered typical of most of the Hawkesbury Sandstone bores in the area. The bore is located down-gradient from the mining area along the drainage line running north from it.

Range: Between November 1999 and November 2002, the water level has ranged between 152 m AHD and 153 m AHD in response to rainfall events. After that time, the water table has stabilised at around 152 m AHD. During the first half of 2006, when the Dataflow data logger was replaced with a Solinst Levelogger unit, a small shift of less than 0.5 m is evident in the hydrograph. The difference may be due to the different measuring system of the loggers.

VELMW3

Purpose: To monitor the water table in the Hawkesbury Sandstone

Water level: The bore is located at some distance to the east of the mining area and is separated from it by a drainage line. It is considered that this bore is representative of generally undisturbed conditions in the Hawkesbury Sandstone aquifer in this area. Due to the peculiar measuring method of the Dataflow loggers, the horizontal lines in the hydrograph indicate that the water level rose above the measuring point of the unit. The water level at this site has remained fairly constant at around 170 m AHD, with lesser impact from rainfall than at other sites.

Range: The water level in this bore rose from around 166 m AHD at the time of installation in November 1999 to nearly 170 m AHD by 2001.

2.7 Water Quality

Water quality records from all available bores in both aquifers in the Maroota area indicate that the groundwater is generally of potable quality, of low salinity, slightly acidic and often iron-rich.

Water chemistry data for all bores are presented in the appendices together with the hydrographs. Table 5 below presents a summary of Electro Conductivity (EC) and Total Dissolved Solids (TDS) averages for the monitoring bores and water supply bores.

The table indicates that the groundwater in the Hawkesbury Sandstone is generally of lower salinity than that in the Maroota Sand aquifer. This is due to the highly siliceous and inert nature of the sandstone, which is made of up to 62% of quartz grains. Seasonal variations are at times visible in conjunction with changes in rate of rainfall recharge. In general, there is no apparent deterioration of the water quality in neither of the aquifers as a result of the farming and mining activities of the area.

TABLE 5 – WATER QUALITY SUMMARY

Bore	Owner	Year	E.C. (µS/cm)	TDS (mg/L)	Aquifer	Status
PF166MW1	PF Formation	1998	221	190	M.S.	Current
PF167MW1	PF Formation	1996	200	126	M.S.	Current
PFL3MW1	PF Formation	1998	159	92	H.S.	Current
PFL2MW1	PF Formation	1996	91	66	H.S.	To DNR
PFL2MW2	PF Formation	1996	366	212	H.S.	To DNR
PFL2MW3	PF Formation	1996	124	69	H.S.	To DNR
PF198PB1	PF Formation	1998	185	113	H.S.	Production
PF198PB2	PF Formation	1998	143	95	H.S.	Production
PT84MW1	H.B. Maroota	1998	289	180	M.S.	Current
PT84MW2	H.B. Maroota	1998	543	530	M.S.	Abandoned
PT84MW3	H.B. Maroota	1998	157	97	M.S.	Current
PT84PB2	H.B. Maroota	1999	133	83	H.S.	Current
VELMW1	Maroota Mining	1982	146	88	H.S.	Destroyed
VELMW1A	Maroota Mining	2006	138	83	H.S.	Current
VELMW2	Maroota Mining	1997	317	190	H.S.	Current
VELMW3	Maroota Mining	1997	167	100	H.S.	Current

2.8 Sand production

The graph in Appendix D shows the water consumption from the water supply dam in Portion 167 vs the sand production from the Hitchcock Road site. The graph highlights the reduced water consumption since 2002 in spite of an increase of sand production and illustrates the effect of more efficient water management practices recently introduced at the site.

2.9 Contingency plans

The Department of Planning letter dated the 31st August 2006 indicates the requirement for the development of contingency plans to protect the water supply of surrounding uses and the environment in the event of drawdown of groundwater levels from sand extraction.

The data presentation and discussion in the previous sections indicate that the current groundwater extraction from mining at the Hitchcock Road site (and at other sand extraction localities) is at present in balance with the hydrogeological regime of the area. Therefore, should conditions not vary from the present activities, it is unlikely that further drawdown would occur.

Contingency plans would only be required in the event that the water table levels fall to such an extent as to prevent sand mining or, for that matter, other uses in the area. In such eventuality, contingency plans would, by necessity, entertain the need for the reduction of sand production or stopping it altogether. This would have very significant impacts on the economy of the area.

The DLWC Groundwater Technical Status Report indicated that the largest user of groundwater from the Maroota Sand aquifer in the region is agriculture and recommended that a mining depth limitation related to the depth of the water table be applied to all mining operations. The latter recommendation was adopted and included in the Baulkham Hills Shire Council and Hornsby Shire Councils Developments plans. In addition, sand production is mainly tied to construction market demand. Water efficient procedures introduced by the miners have resulted in decreased demand for water in spite of an increased rate of sand production following the recent construction boom.

During persistent drought periods, it is likely that an increased demand for groundwater may arise from the agricultural pursuits of the Maroota area, which at present are not monitored nor managed by the regulatory authority.

Given the relative demand for groundwater use in the area, it would be logical for the preparation of contingency plans not to be limited to the sand miners, whose records indicate that they are careful managers of the groundwater resources and their activities are in balance with the hydrogeological regime. Contingency plans in the event of a serious decline of the water table, which could derive from a combination of an extended drought and increased pumpage, should be created and implemented within the overall context of agriculture and sand mining in the area and based on an evaluation by the Water Management Act managers of the available monitoring records.

3.1 Conclusions

The data presented in this report demonstrate that groundwater extraction from the Maroota Sand and the Hawkesbury Sandstone in the Maroota area is in a hydrogeological balance, as no decline in the water table has occurred apart from that which can be imputed to the persistent drought conditions. The sand mining operations continue the monitoring of groundwater levels and quality through an extensive network of monitoring bores. Results from this monitoring network are reported in the annual Water Management Plans submitted to Baulkham Hills and Hornsby Shire Councils.

3.2 Recommendations

An effective contingency plan could not be created for one property only in isolation from the whole of the activities carried out in the Maroota area. Therefore, it is recommended that the DNR should take the initiative in setting the framework for the creation of an area contingency plan to be implemented in the event of a decline in the water table of such an extent that it endangers the economic activities of the area. Contributions to such a plan would be provided by the sand miners monitoring network and from that managed by the DNR itself.

URS Australia Pty Ltd (URS) has prepared this report for the use of DFA Consultants Pty Ltd in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 29 April 2004.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between the 25 September 2006 and 30 October 2006 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing or other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. The borehole logs indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of conditions as constrained by the project budget limitations. The behaviour of groundwater and some aspects of contaminants in soil and groundwater are complex. Our conclusions are based upon the analytical data presented in this report and our experience. Future advances in regard to the understanding of chemicals and their behaviour, and changes in regulations affecting their management, could impact on our conclusions and recommendations regarding their potential presence on this site.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, URS must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

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Term:	***Definition***
AHD	Australian Height Datum. The standard reference level used to express the relative evaluation of various features. A height given in metres AHD is essentially the height above sea level.
Anisotropic	Having some physical property that varies with direction.
Aquiclude	A geologic formation, group of formations, or part of a formation through which virtually no water moves.
Aquifer	Geologic formation, group of formations, or part of a formation capable of transmitting and yielding significant quantities of water.
Aquifer properties	The characteristics of an aquifer that determine its hydraulic behaviour and its response to abstraction.
Aquitard	A saturated, but relatively poorly permeable formation, or group of formations that does not transmit or yield water freely.
Boundary	A lateral discontinuity of change in the aquifer resulting in a significant change in hydraulic conductivity, storativity, or recharge.
Claystone	A non-fissile rock of sedimentary origin composed primarily of clay-sized particles (less than 0.004 mm).
Cone of depression	A depression of the potentiometric surface which has the shape of an inverted cone that develops around a well from which water is being withdrawn. It defines the area of influence of a well.
Confined aquifer	A completely saturated aquifer in which the upper and lower boundaries are relatively impermeable layers (aquitards or aquicludes). The groundwater is contained under sufficient pressure to cause it to rise above the aquifer if the top impermeable layer is breached.
Confining bed	A layer of relatively impermeable material underlying, overlying, or adjacent to one or more aquifers.
Development	Removal of sand and other fines (including drilling mud) from the aquifer immediately surrounding the well and creating a filter zone around the well that prevents further movement of aquifer particles into the well.
Drawdown	The difference between the observed water level during pumping and the pre-pumping water level.

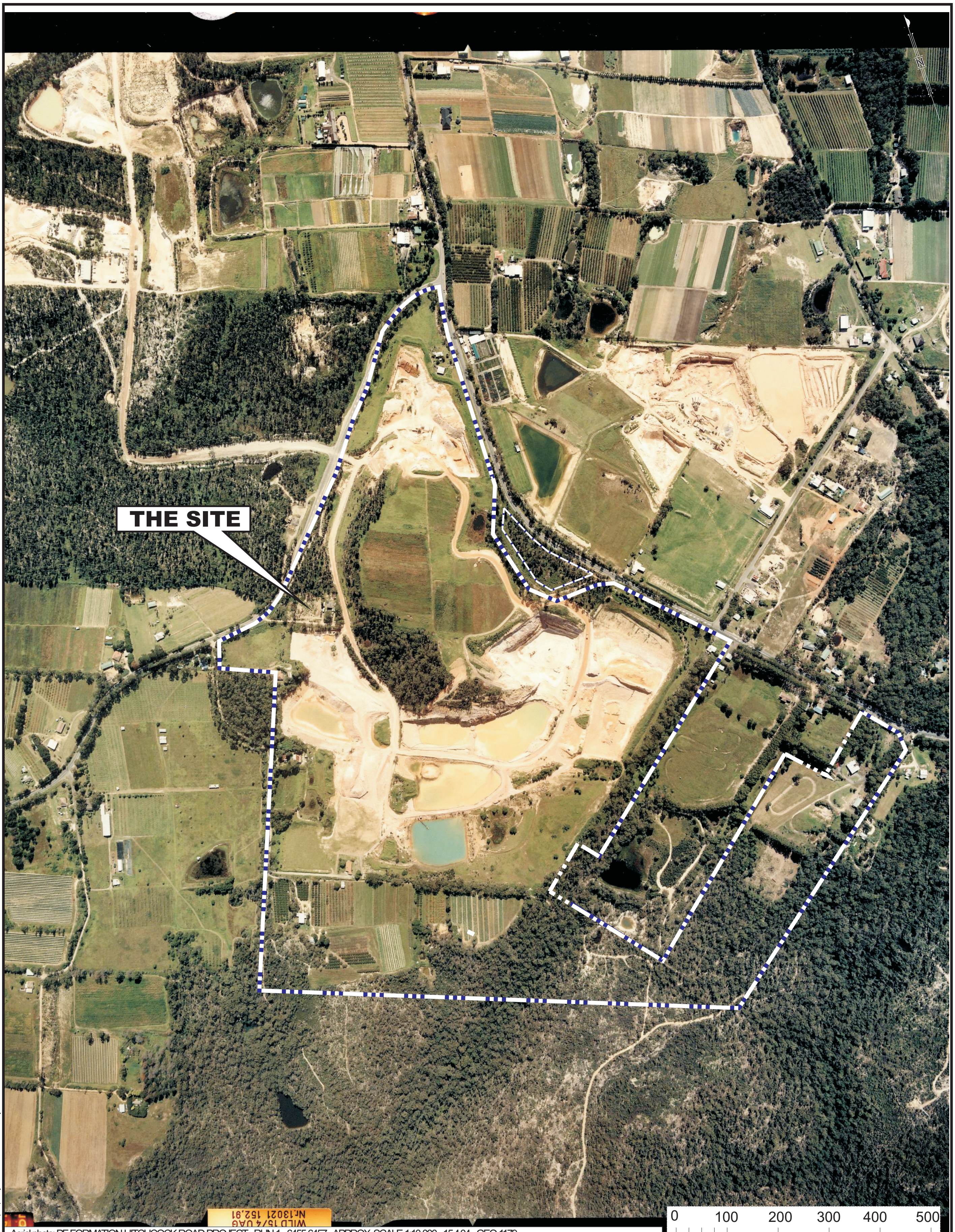
Term:	***Definition***
Environmental Impact Statement (EIS)	A formal description of a project and an assessment of its likely impact on the physical, social and economic environment. It includes an evaluation of alternatives and an overall justification of the project. The EIS is used as a vehicle to facilitate public comment and as the basis for analysing the project with respect to granting approval under relevant legislation.
Eluvial deposit	A deposit formed as the result of in situ weathering of a rock and located at its site of formation.
EPA	Environment Protection Authority
Evapotranspiration	Loss of water from a land mass through transpiration from plants and evaporation from the soil.
Ferricrete	A duricrust or a soil zone more or less cemented with iron oxide
Groundwater	Subsurface water contained within the saturated zone.
Head (hydraulic head)	Energy contained in a water mass produced by elevation, pressure or velocity.
Hydraulic conductivity	The rate at which water at the prevailing kinematic viscosity will move under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow, expressed in metres per day. (Note: This definition assumes medium in which the pores are completely filled with water.)
Hydraulic gradient	The change in static head per unit of distance in a given direction.
Hydrogeology	The study of subsurface water in its geological context.
Infiltration	The process of surface water soaking into the soil.
Isotropic	Having the same physical properties in all directions.
Lithology	Science of the nature and composition of rock.
Observation well	A well constructed or utilised for the purpose of observing groundwater parameters such as water levels, pressure changes and water quality.
Overbank deposit	A flood plain deposit.
Palaeochannel	An ancient river bed, often infilled with more recent sediments.
Perched water	Unconfined groundwater separated from an underlying body of groundwater by an unsaturated zone and supported by an aquitard

Term:	***Definition***
	or aquiclude.
Permeable material	Material that permits water to move through it at perceptible rates under the hydraulic gradients normally present.
Permeability	The property or capacity of a porous rock, sediment, clay or soil to transmit a fluid. It is a measure of the relative ease of fluid flow under unequal pressure. The hydraulic conductivity is the permeability of a material for water at the prevailing temperature.
Permian	The last period of the Palaeozoic era, finished approximately 230 millions years before present.
pH	A measure of acidity or alkalinity of a solution, numerically equal to 7 for neutral solution, increasing with increasing alkalinity and decreasing with increasing acidity. Originally stood for the words potential of hydrogen.
Piezometer	A pipe in which the elevation of the water level or potentiometric surface can be determined.
Porosity	The percentage of bulk rock, which is void space between rock particles.
Potentiometric surface	A surface, which represents the standing or total hydraulic head. (Note: 1. In an aquifer system it represents the levels to which water will rise in tightly cased wells. 2. The water table is the potentiometric surface of an unconfined aquifer.)
Recharge	Addition of water to the zone of saturation; also the amount of water added.
Recovery	The difference between the observed water level during the recovery period after cessation of pumping and the water level measured immediately before pumping stopped.
Residual drawdown	The difference between the observed water level during the recovery period following pumping and the pre- pumping water level.
RL	Reduced level, usually in metres to an arbitrary datum.
Run-off	The proportion of precipitation discharged through surface water systems.

Term:	***Definition***
Sandstone	A fine grained rock of sedimentary origin composed primarily of sand-sized particles (0.06 to 2 mm).
Saturated zone	That part of an aquifer in which all voids are filled with water under pressure greater than atmospheric pressure.
Screen	A type of lining tube or casing of special construction, with apertures or slots designed to permit the flow of water into a well while preventing the entry of aquifer or filter pack material.
Semiconfined aquifer	An aquifer confined by a layer of moderate permeability (aquitard) that allows vertical leakage of water into or out of the aquifer.
Shale	A laminated sediment in which the constituent particles are predominantly in the clay size.
Siltstone	A fine grained rock of sedimentary origin composed primarily of silt-sized particles (0.004 to 0.06 mm).
Static water level	The level of groundwater standing in a well uninfluenced by pumping in that well.
Static head	The height, relative to an arbitrary reference level, of a column of water that can be supported by the static pressure of the aquifer at a given point.
Storage coefficient	The volume of water an aquifer releases from or takes into storage per unit surface area per unit change in head.
Storativity	The volume of water an aquifer releases or takes into storage per unit surface area per unit change in head. (Note: 1. In an unconfined aquifer, it is normally referred to as specific yield. 2. In confined aquifers it may be referred to as storage coefficient.)
Tertiary	Geologic time at the beginning of the Cainozoic era, 65 to 2 million year ago, after the Cretaceous and before the Quaternary.
Thalweg	The line joining the deepest points of a stream channel.
Total Dissolved Solids	The dissolved mineral content of groundwater, commonly expressed in milligrams/Litre.
Transmissivity	The rate at which water at the prevailing kinematic viscosity is transmitted through a unit width of an aquifer under a unit

Term:	*Definition*
	hydraulic gradient, expressed in square metres per day. (Note: Transmissivity is equal to hydraulic conductivity times the thickness of the aquifer.)
Triassic	The earliest of the three periods that constitute the Mesozoic Era. Approximately between 230 and 180 millions years before present.
Unconfined aquifer	An aquifer in which the upper boundary of the saturated zone is at atmospheric pressure.
Underflow	The volume of groundwater that flows through an aquifer through a cross sectional area. It depends on permeability and the prevailing gradient.
Unsaturated zone	That part of an aquifer between the land surface and water table.
Water table	The surface of saturation in an unconfined aquifer at which the pressure of the water is equal to that of the atmosphere.
Well	A hole sunk into the ground and completed for the abstraction or injection of water or for water observation purposes. Generally synonymous with bore.

Figures

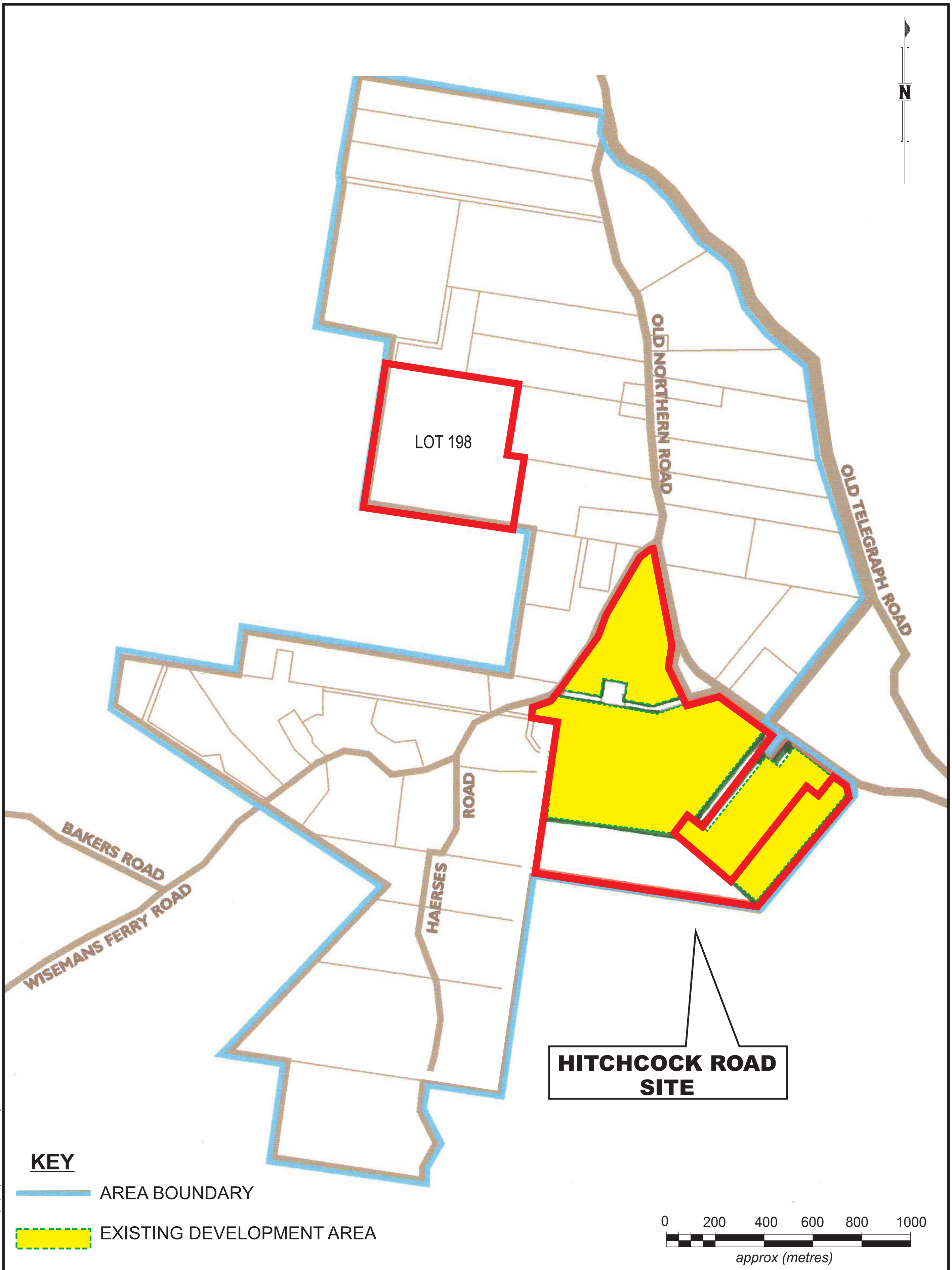


Aerial photo: PF FORMATION HITCHCOCK ROAD PROJECT - RUN 1 - 6455-6457 - APPROX. SCALE 1:10 000 - 15.04.04 - GEO 1179

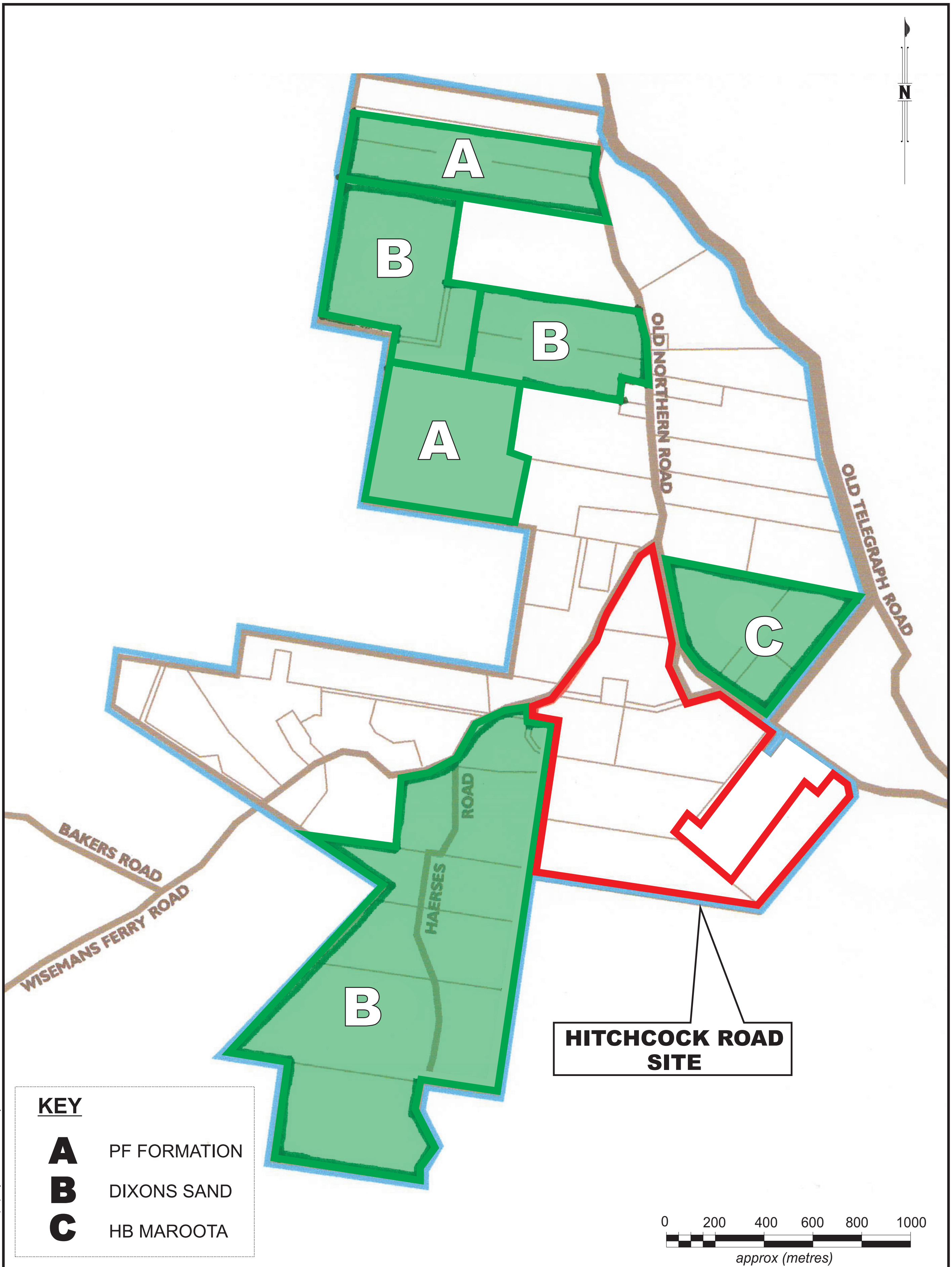
0 100 200 300 400 500

1:10000 (metres)

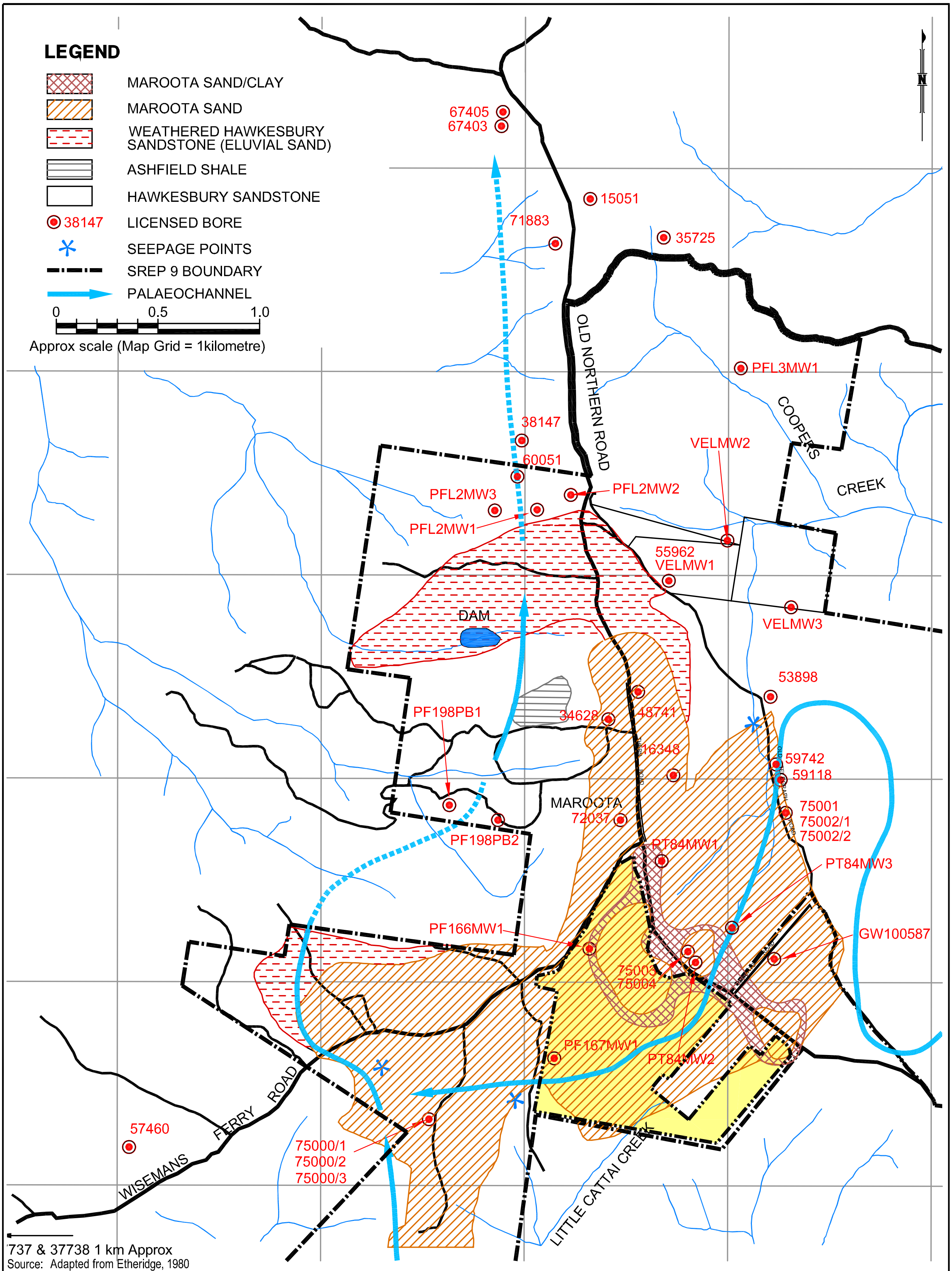
Client	Project	Title
PF FORMATION	HITCHCOCK ROAD, SAND EXTRACTION AND REHABILITATION PROJECT	**HITCHCOCK ROAD SITE**
URS	Drawn: HC; Approved: FC; Date: 07/11/2007	Figure: **1**
	Job No.: **43346029**; File No. 008.cdr	Rev. A; A4



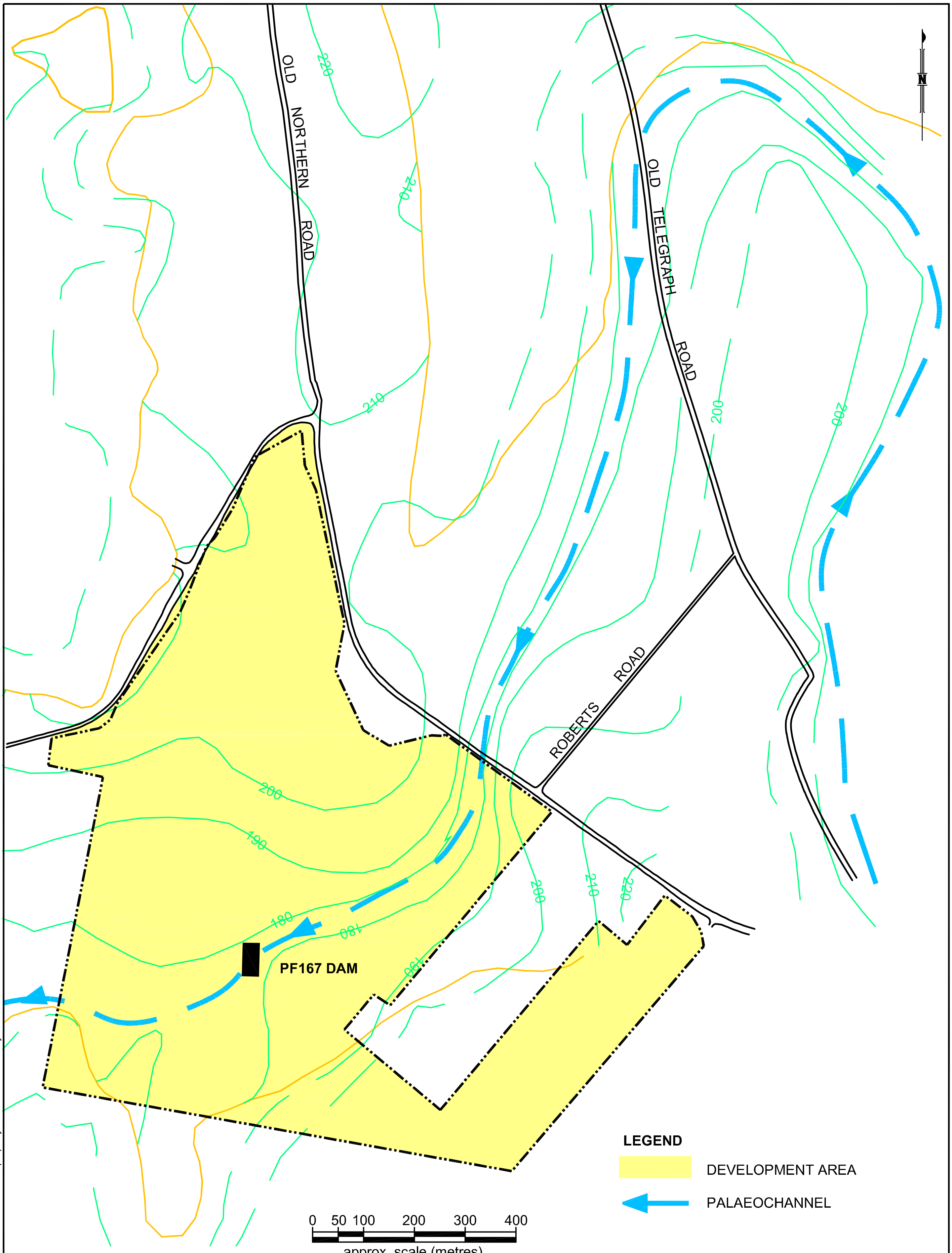
Client	Project	Title
PF FORMATION	HITCHCOCK ROAD, SAND EXTRACTION AND REHABILITATION PROJECT	EXISTING AND PROPOSED DEVELOPMENT AREAS
URS	Drawn: HC / Approved: FC / Date: 07/11/2007	Figure: 2 / Rev. A
	Job No.: 43346029 / File No. 010.cdr	A4



Client	Project	Title
PF FORMATION	HITCHCOCK ROAD, SAND EXTRACTION AND REHABILITATION PROJECT	**MAROOTA EXTRACTION OPERATIONS**
URS	Drawn: HC / Approved: FC / Date: 07/11/2007	Figure: **3** / Rev. A
	Job No.: **43346029** / File No. 009.cdr	A4



Client PF FORMATION	Project HITCHCOCK ROAD SAND EXTRACTION AND REHABILITATION PROJECT	Title LOCALITY AND GEOLOGY
URS	Drawn: HC · Approved: FC · Date: 07/11/2007 Job No.: 43346029 · File No.: 007.dwg	Figure: 4 · Rev. A · A4

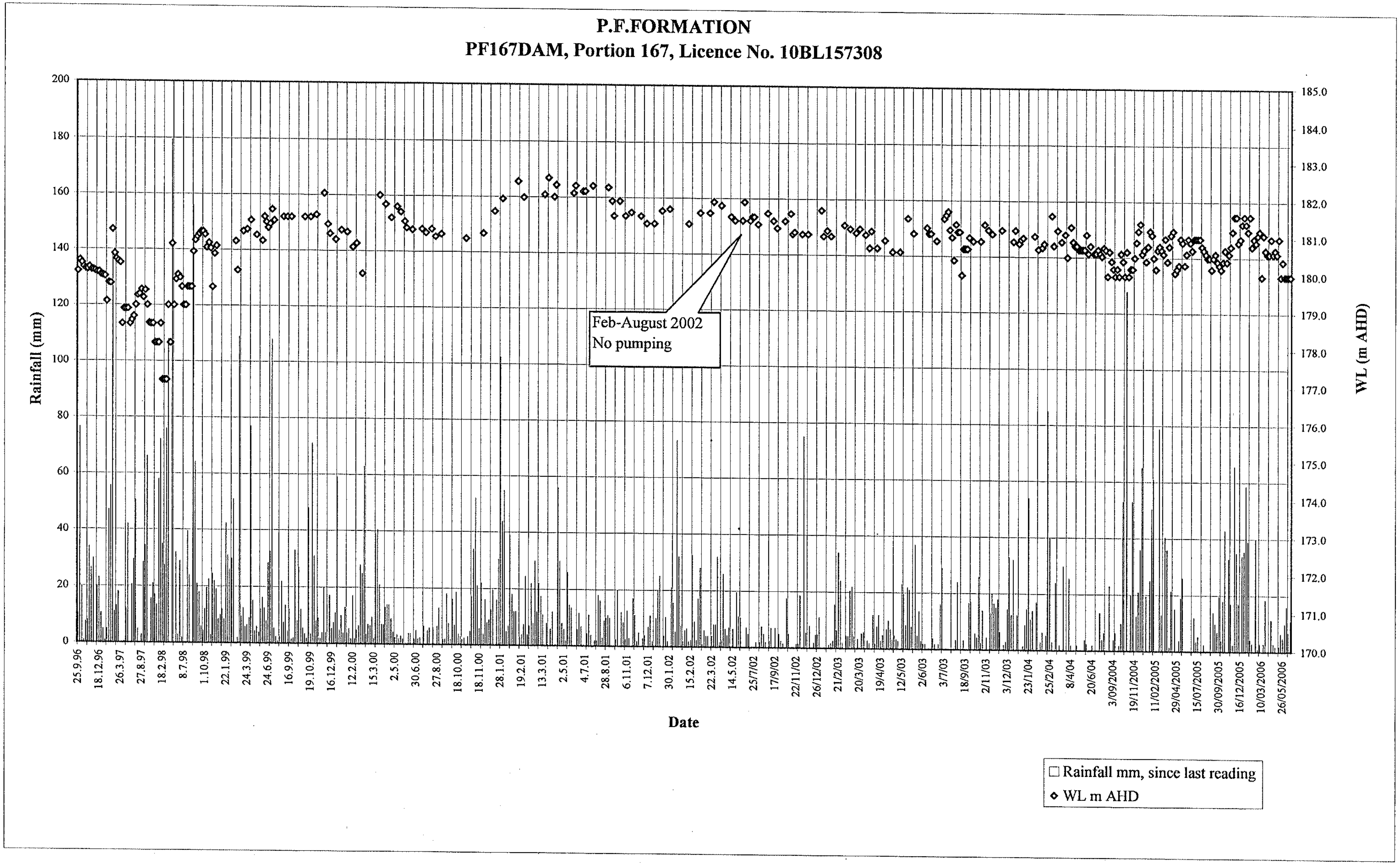


Source: Adapted from Etheridge, 1980

Client	Project	Title
PF FORMATION	HITCHCOCK ROAD SAND EXTRACTION AND REHABILITATION PROJECT	BASE OF MAROOTA SAND, TOP OF HAWKESBURY SANDSTONE
URS	Drawn: HC; Approved: FC; Date: 07/11/07	Figure: 5
	Job No.: 43346029; File No.: 008.dwg	Rev. A; A4

Appendix A

Bore Hydrographs and Water Chemistry Summaries - PF Formation



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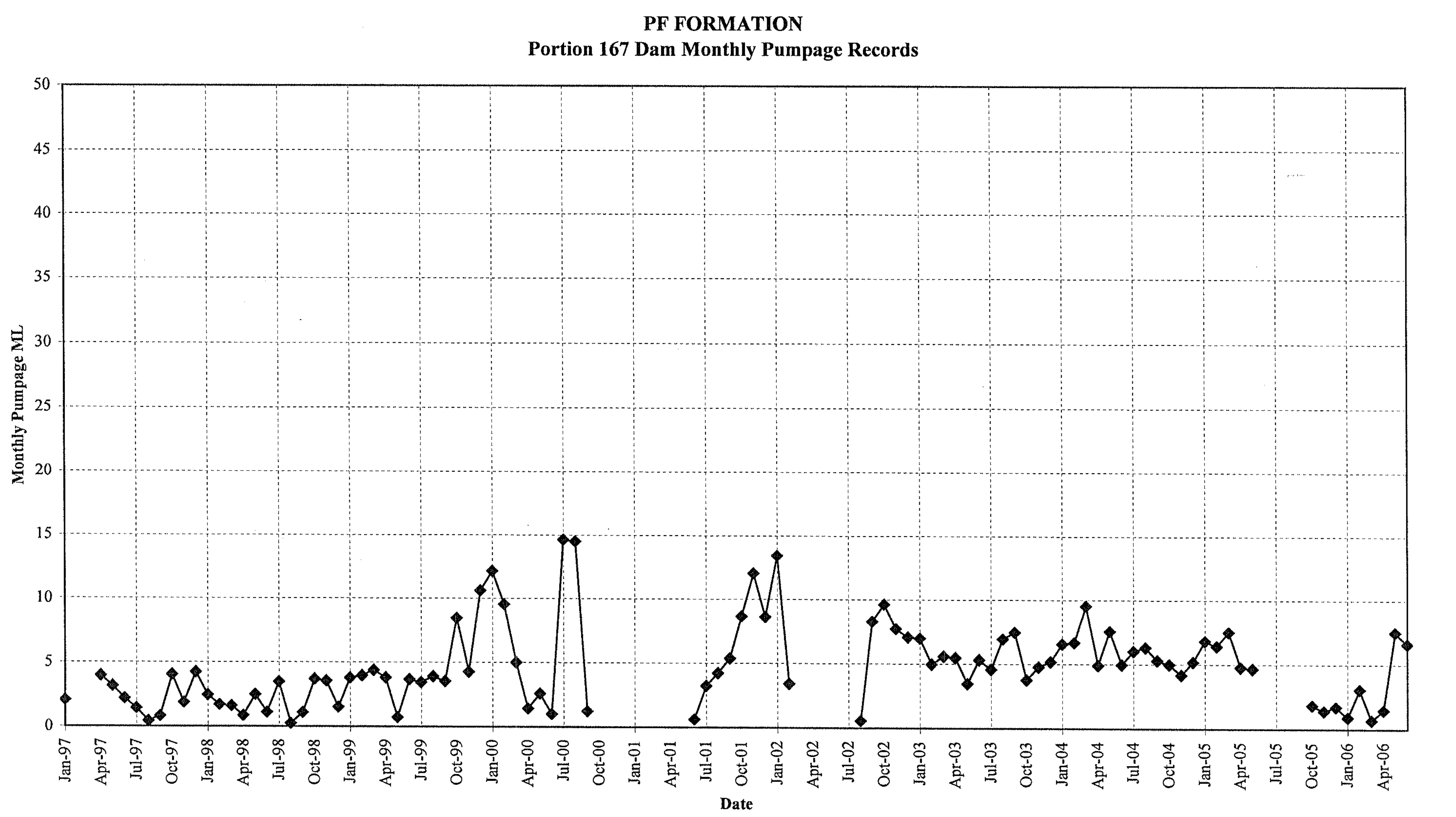
Prepared by: FC
Checked by:



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Prepared By : FC
Checked By : .

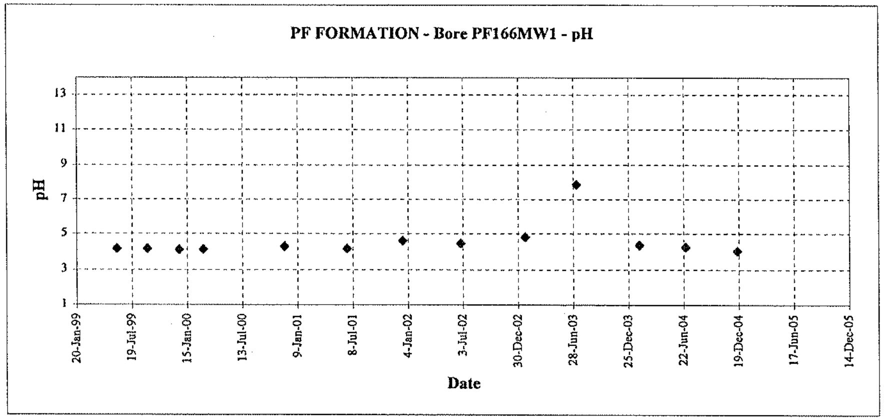
PF FORMATION - MAROOTA
BORE PF166MW1 GROUNDWATER ANALYTICAL SUMMARY

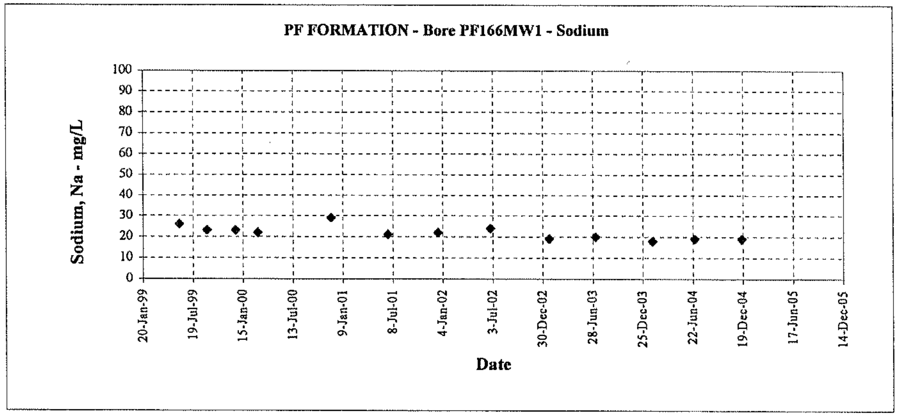
Analysis	Units	LOR	1-Jun-99	8-Sep-99	21-Dec-99	9-Mar-00	28-Nov-00	21-Jun-01	19-Dec-01	26-Jun-02	23-Jan-03	9-Jul-03	30-Jan-04	29-Jun-04	15-Dec-04	22-Jun-05	19/01/2006	6/07/2006
pH		0.01	4.18	4.19	4.13	4.14	4.31	4.19	4.63	4.48	4.82	7.86	4.39	4.27	4.06	DRY	DRY	DRY
Electrical Conductivity	µS/cm	1	222	240	230	214	266	194	228	219	203	221	193	235	203			
Total Dissolved Solids	mg/L	1	118	108	137	170	460	115	210	280	128	134	204	280	120			
Calcium	mg/L	1	1	1	1	1	1	1	1	2	1	1	<1	1	1			
Magnesium	mg/L	1	6	6	6	5	6	5	6	6	5	4	5	5	4			
Sodium	mg/L	1	26	23	23	22	29	21	22	24	19	20	18	19	19			
Potassium	mg/L	1	<1	<1	1	1	1	1	2	1	<1	<1	<1	1	1			
Bicarbonate	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1			
Sulphate	mg/L	1	1	7	1	1	16	2	1	2	<1	<1	2	<1	2			
Chloride	mg/L	1	58	49	51	52	58	49	58	61	46	50	47	44	36			
Oil and Grease	mg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	6	<5	<5	5	<5			

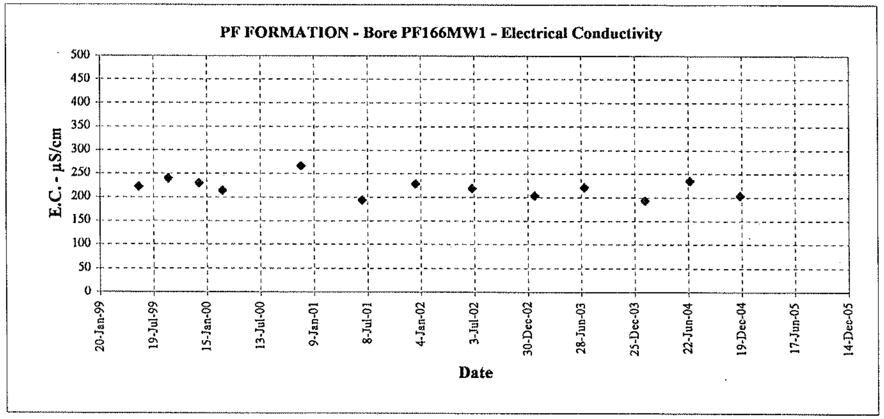
LOR = Limit of Reporting

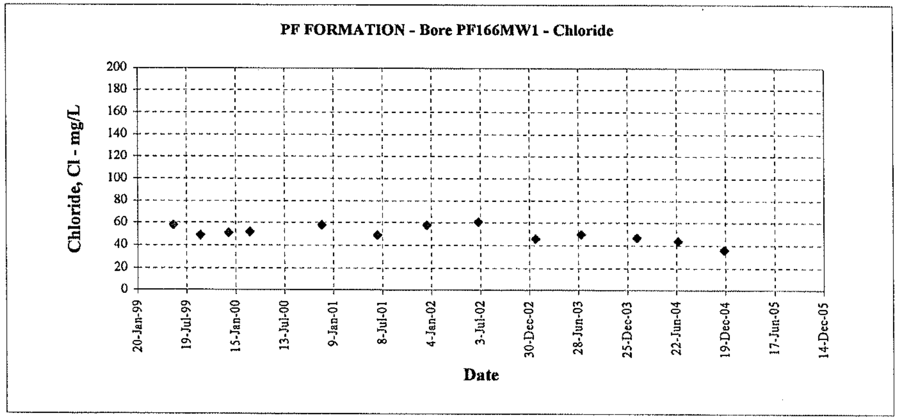
Average EC = 221 µS/cm
Average TDS = 190 mg/L

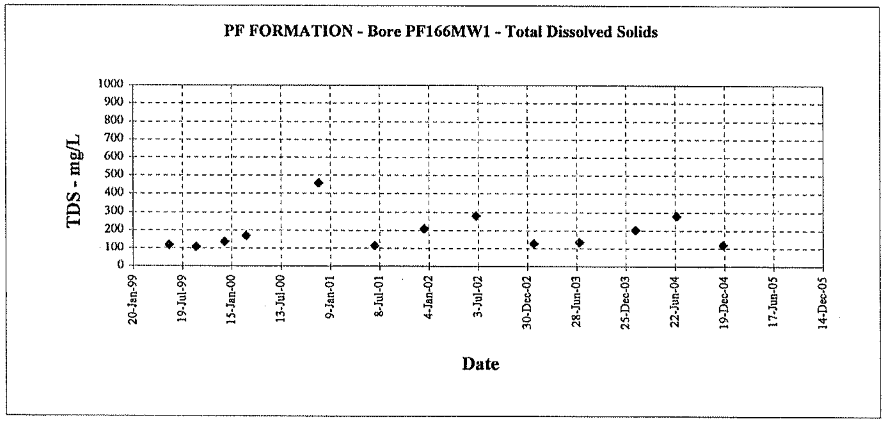
N.B. = TDS value in November 2000 is unusually high because of the presence of particulate matter in the sample.











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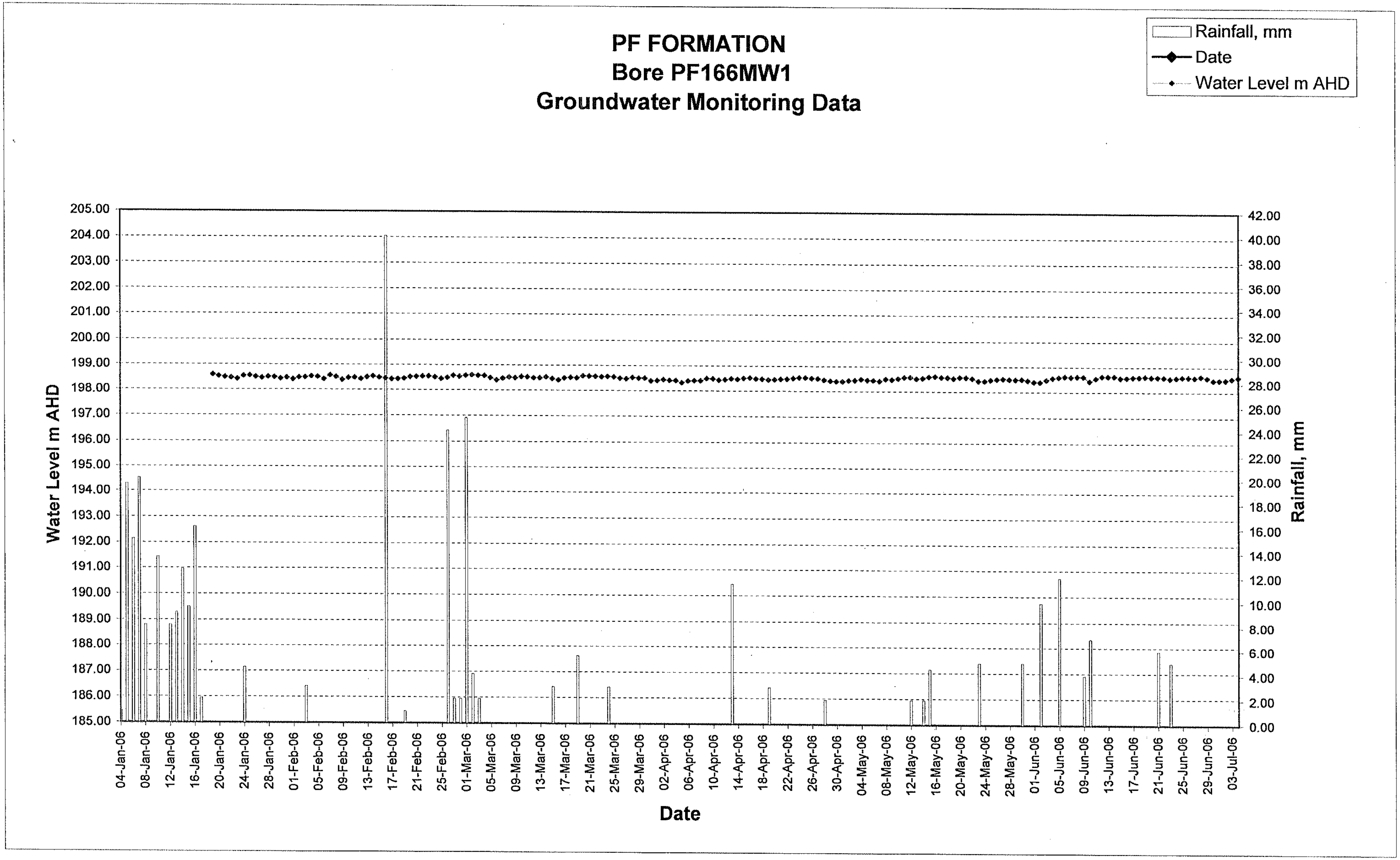
PF FORMATION
Bore PF166MW1
Groundwater Monitoring Data
Rainfall, mm
Date
Water Level m AHD
Water Level m AHD
205.00
204.00
203.00
202.00
201.00
200.00
199.00
198.00
197.00
196.00
195.00
194.00
193.00
192.00
191.00
190.00
189.00
188.00
187.00
186.00
185.00
Rainfall, mm
42.00
40.00
38.00
36.00
34.00
32.00
30.00
28.00
26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
04-Jan-06
08-Jan-06
12-Jan-06
16-Jan-06
20-Jan-06
24-Jan-06
28-Jan-06
01-Feb-06
05-Feb-06
09-Feb-06
13-Feb-06
17-Feb-06
21-Feb-06
25-Feb-06
01-Mar-06
05-Mar-06
09-Mar-06
13-Mar-06
17-Mar-06
21-Mar-06
25-Mar-06
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04-May-06
08-May-06
12-May-06
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24-May-06
28-May-06
01-Jun-06
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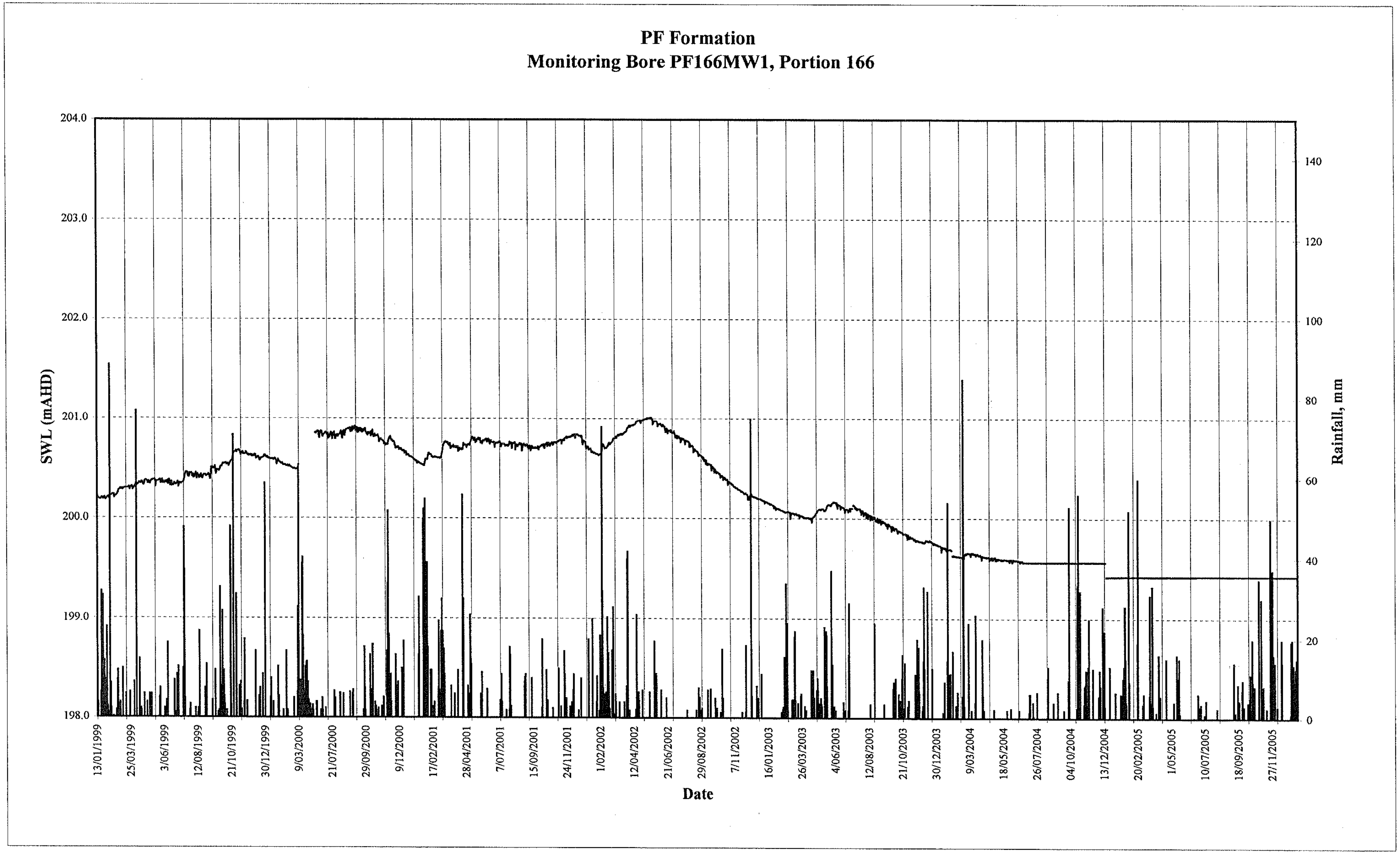
29-Jun-06
03-Jul-06
Date



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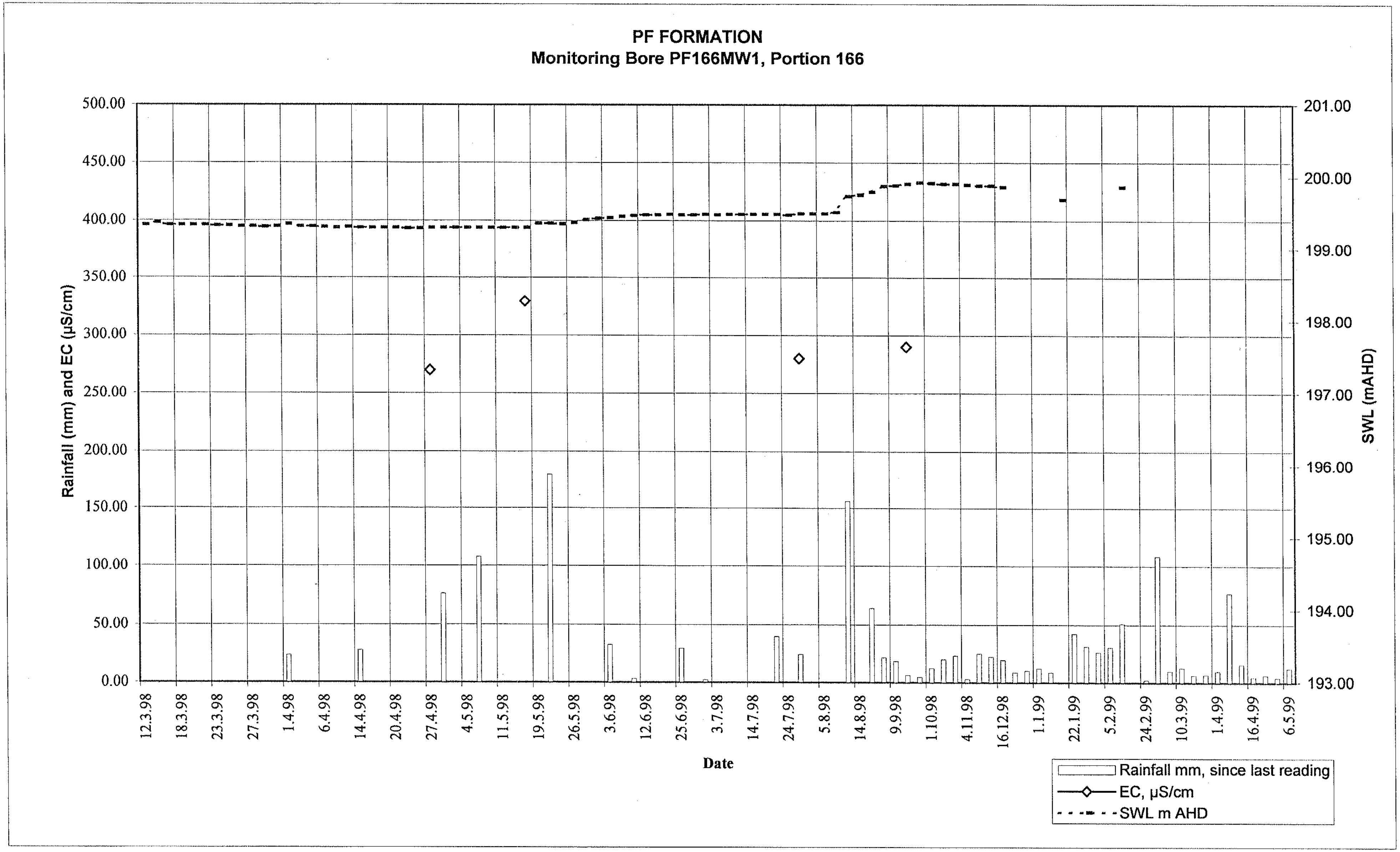

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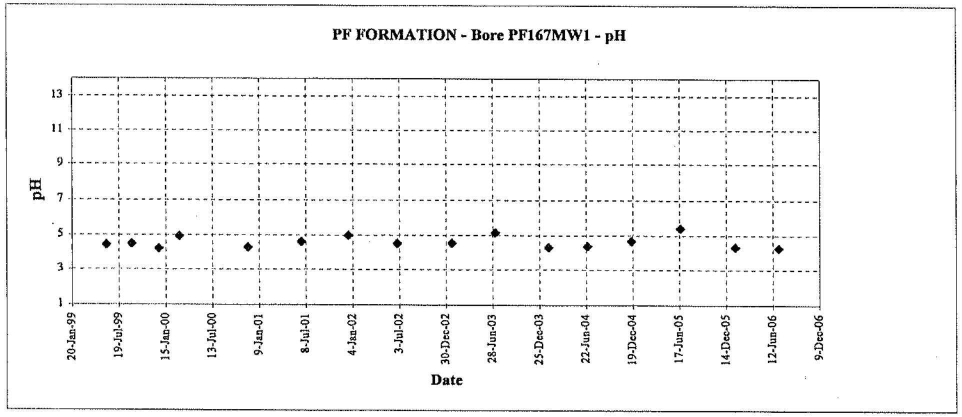
PF FORMATION - MAROOTA
BORE PF167MW1 GROUNDWATER ANALYTICAL SUMMARY

Analysis	Units	LOR	1-Jun-99	8-Sep-99	21-Dec-99	9-Mar-00	28-Nov-00	21-Jun-01	19-Dec-01	26-Jun-02	23-Jan-03	9-Jul-03	30-Jan-04	29-Jun-04	15-Dec-04	22-Jun-05	19/01/2006	6/07/2006
pH		0.01	4.43	4.49	4.21	4.93	4.28	4.61	4.98	4.52	4.54	5.15	4.31	4.38	4.68	5.42	4.32	4.27
Electrical Conductivity	µS/cm	1	164	190	201	179	184	170	188	215	199	204	225	221	240	215	205	199
Total Dissolved Solids	mg/L	1	118	90	105	115	207	120	108	121	101	116	157	110	143	137	141	119
Calcium	mg/L	1	3	3	5	6	3	6	6	5	3	4	4	5	5	5	4	4
Magnesium	mg/L	1	5	4	4	4	4	4	5	4	4	3	4	4	4	4	4	4
Sodium	mg/L	1	16	18	16	15	18	16	18	25	20	19	22	23	26	28	25	23
Potassium	mg/L	1	2	2	3	3	3	5	4	5	2	2	2	3	3	3	3	3
Bicarbonate	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	2	1	<1
Sulphate	mg/L	1	9	<1	13	17	16	15	15	14	9	13	12	10	13	13	10	6
Chloride	mg/L	1	36	11	35	32	35	36	47	58	44	48	51	53	50	56.6	57.4	53.1
Oil and Grease	mg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

Average EC = 200 µS/cm
Average TDS = 126 mg/L

LOR = Limit of Reporting

N.B. = TDS value in November 2000 is unusually high because of the presence of particulate matter in the sample.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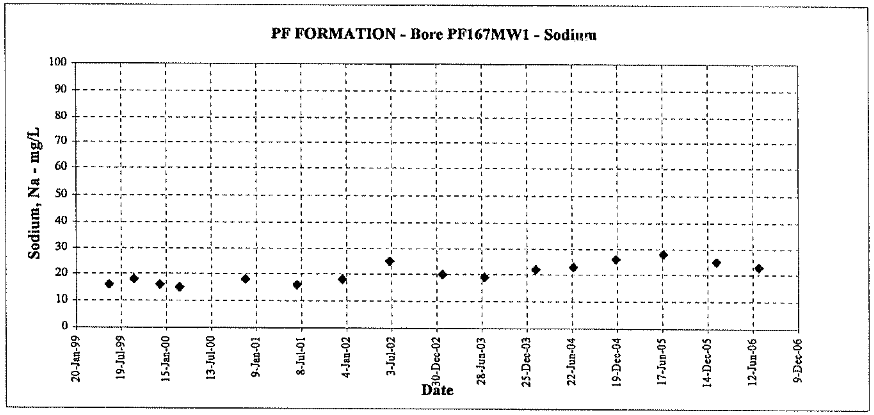
pH
13
11
9
7
5
3
1
20-Jan-99
19-Jul-99
15-Jan-00
13-Jul-00
9-Jan-01
8-Jul-01
4-Jan-02
3-Jul-02
30-Dec-02
28-Jun-03
25-Dec-03
22-Jun-04
19-Dec-04
17-Jun-05
14-Dec-05
12-Jun-06
9-Dec-06
Date


PF FORMATION - Bore PF167MW1 - Sodium
Sodium, Na - mg/L
100
90
80
70
60
50
40
30
20
10
0
20-Jan-99
19-Jul-99
15-Jan-00
13-Jul-00
9-Jan-01
8-Jul-01
4-Jan-02
3-Jul-02
30-Dec-02
28-Jun-03
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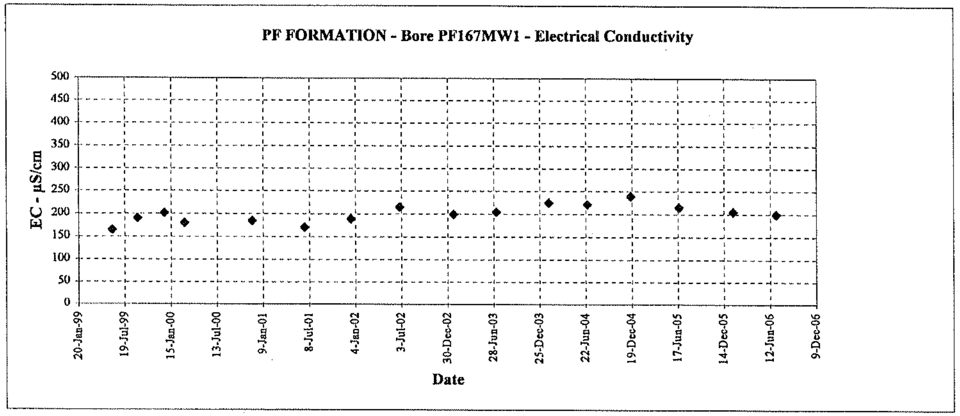
12-Jun-06
9-Dec-06
Date


PF FORMATION - Bore PF167MW1 - Electrical Conductivity
EC - µS/cm
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450
400
350
300
250
200
150
100
50
0
20-Jan-99
19-Jul-99
15-Jan-00
13-Jul-00
9-Jan-01
8-Jul-01
4-Jan-02
3-Jul-02
30-Dec-02
28-Jun-03
25-Dec-03
22-Jun-04
19-Dec-04
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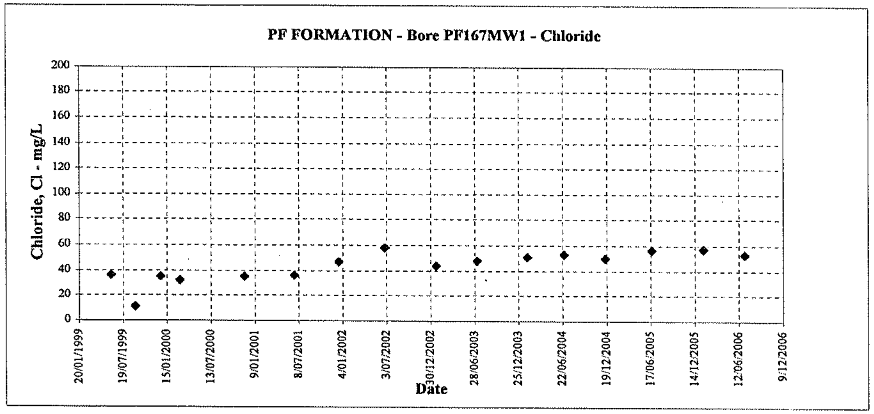
14-Dec-05
12-Jun-06
9-Dec-06
Date


PF FORMATION - Bore PF167MW1 - Chloride
Chloride, Cl - mg/L
200
180
160
140
120
100
80
60
40
20
0
20/01/1999
19/07/1999
15/01/2000
13/07/2000
9/01/2001
8/07/2001
4/01/2002
3/07/2002
30/12/2002
28/06/2003
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22/06/2004
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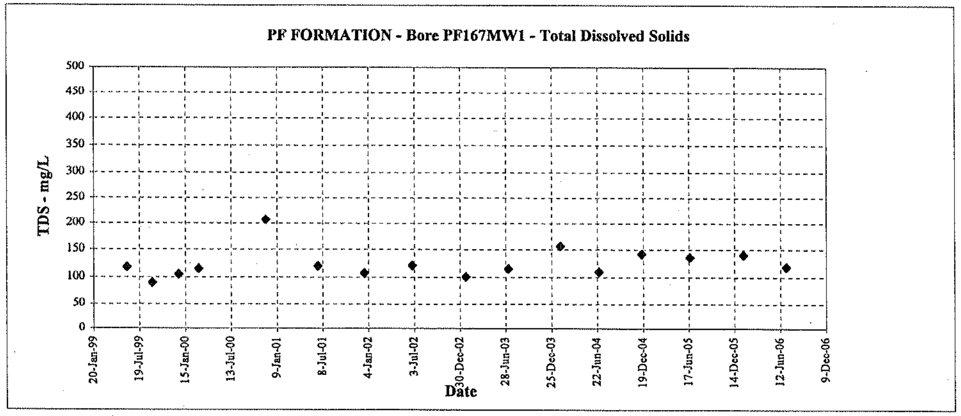
17/06/2005
14/12/2005
12/06/2006
9/12/2006
Date


PF FORMATION - Bore PF167MW1 - Total Dissolved Solids
TDS - mg/L
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400
350
300
250
200
150
100
50
0
20-Jan-99
19-Jul-99
15-Jan-00
13-Jul-00
9-Jan-01
8-Jul-01
4-Jan-02
3-Jul-02
30-Dec-02
28-Jun-03
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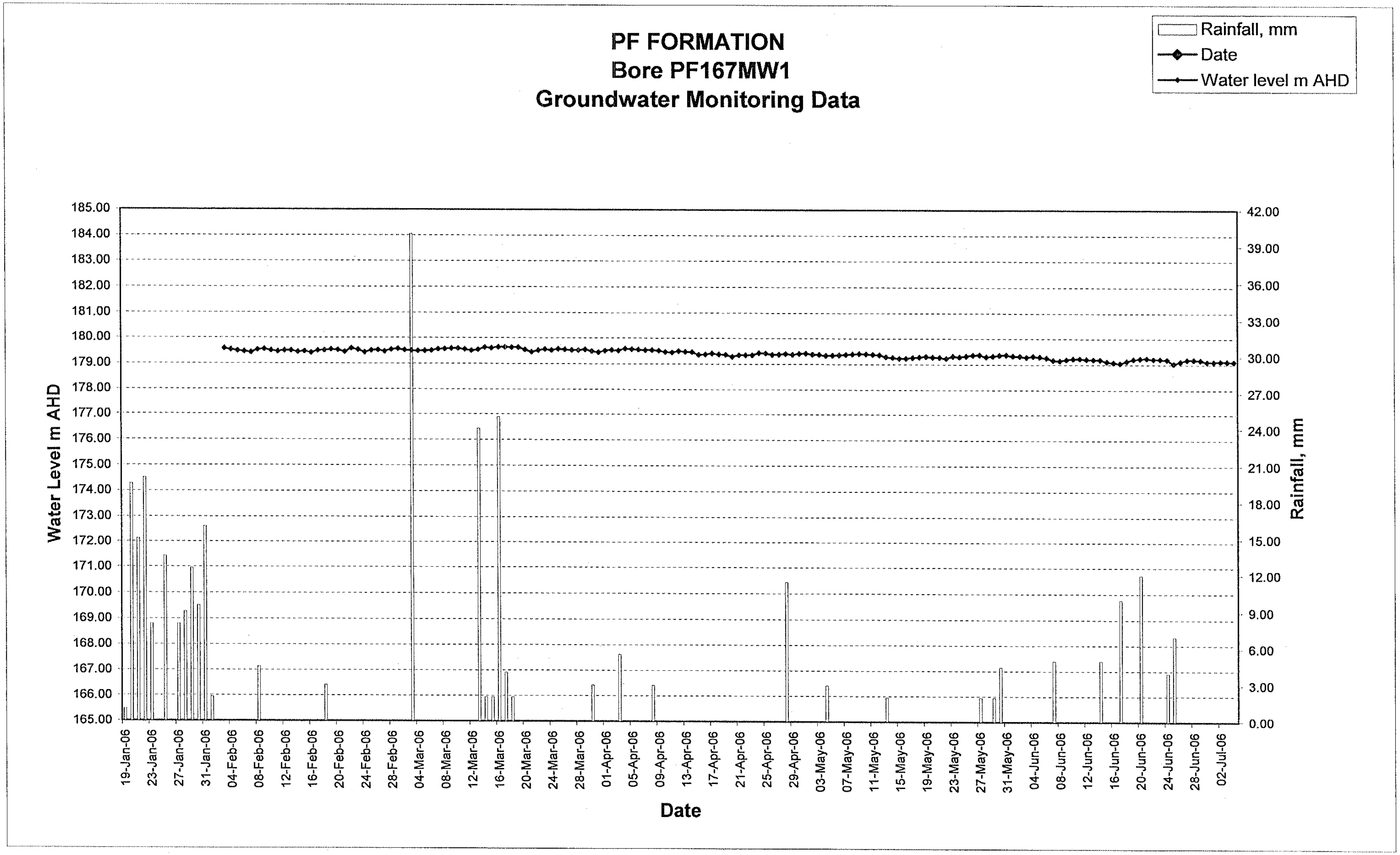
12-Jun-06
9-Dec-06
Date


PF FORMATION
Bore PF167MW1
Groundwater Monitoring Data
Rainfall, mm
Date
Water level m AHD
Water Level m AHD
Rainfall, mm
Date
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184.00
183.00
182.00
181.00
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179.00
178.00
177.00
176.00
175.00
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23-May-06
27-May-06
31-May-06
04-Jun-06
08-Jun-06
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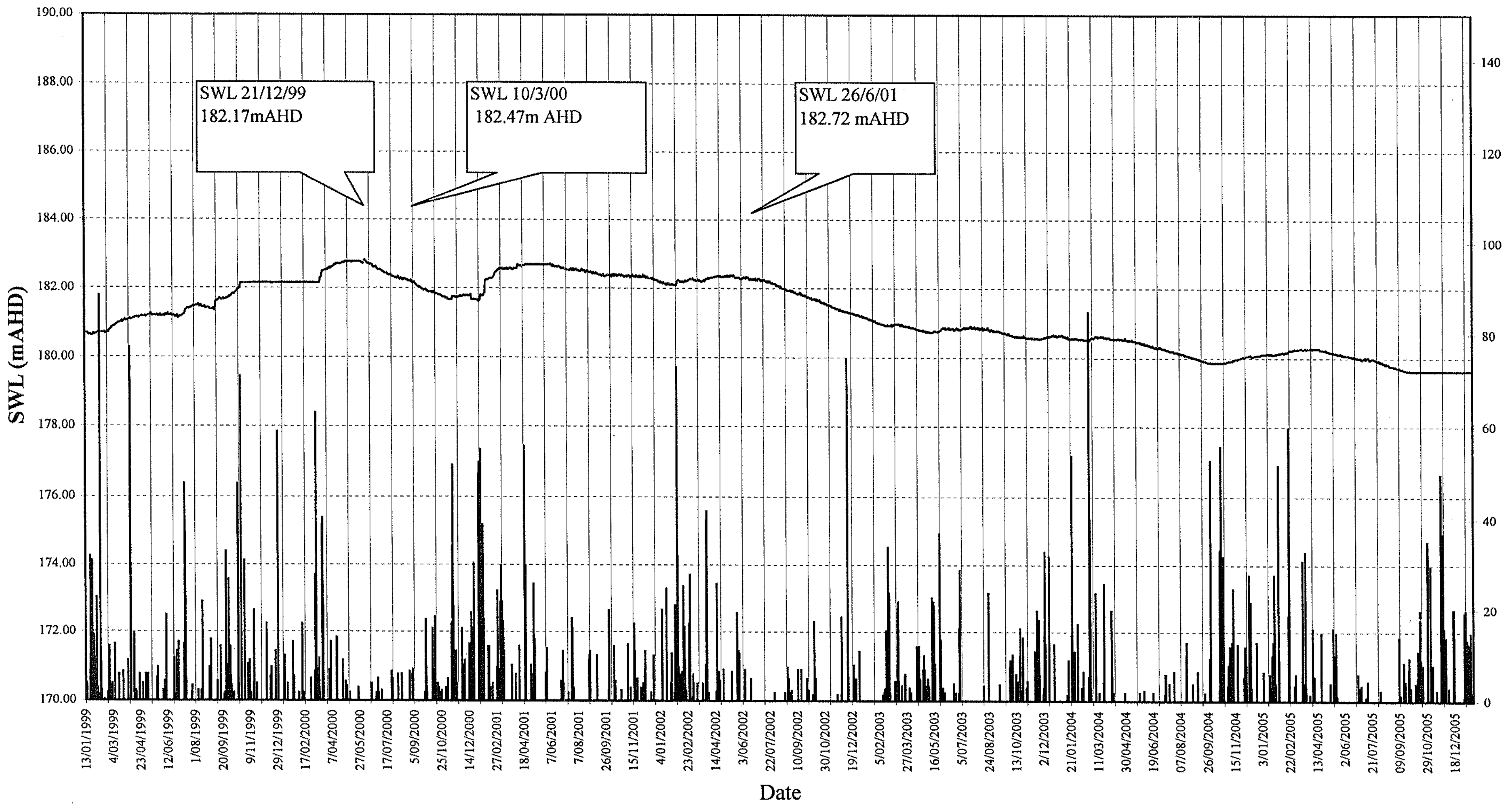
16-Jun-06
20-Jun-06
24-Jun-06
28-Jun-06
02-Jul-06

PF Formation
Monitoring Bore PF167MW1, Portion 167



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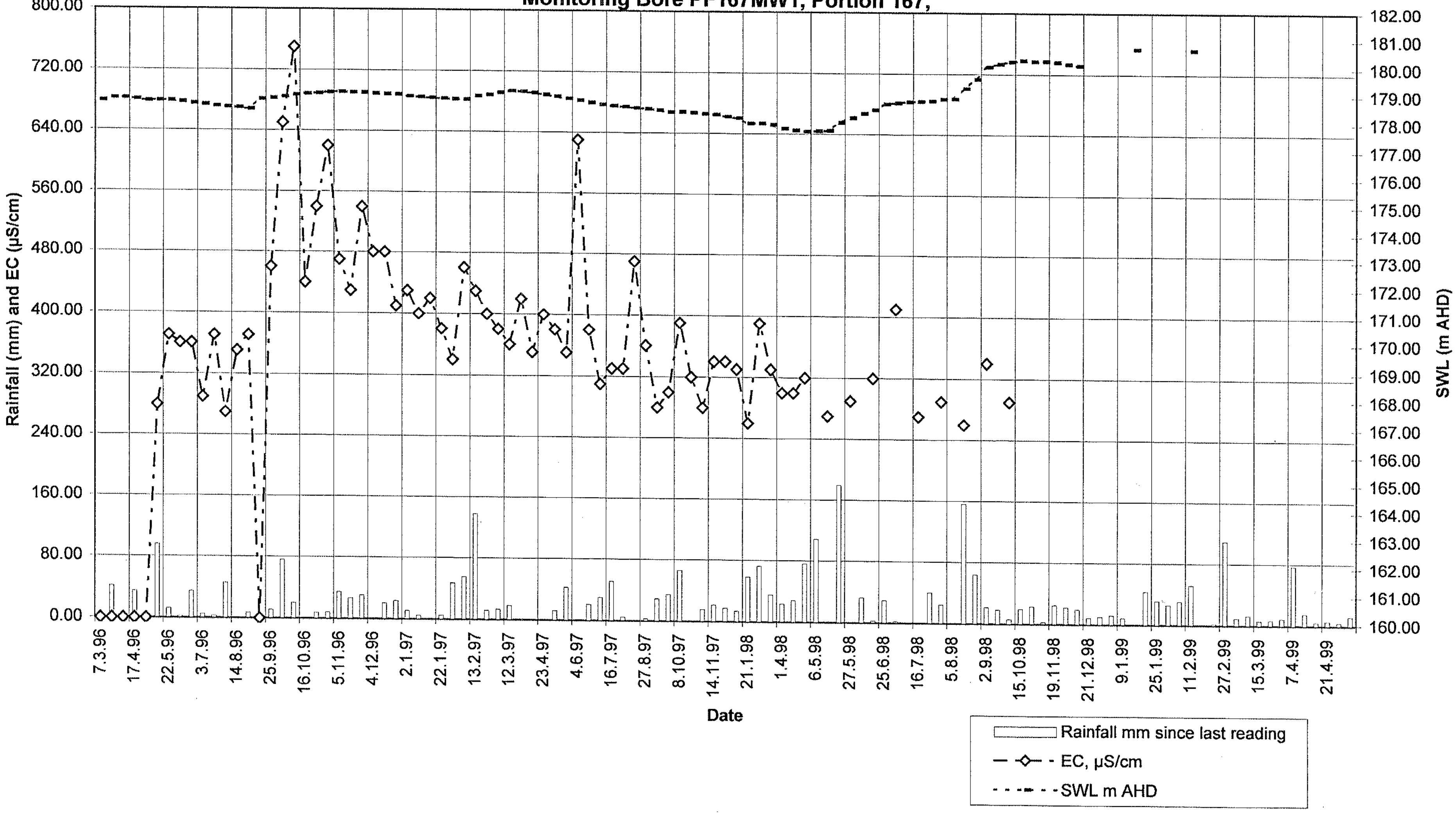
P.F.FORMATION
Monitoring Bore PF167MW1, Portion 167,



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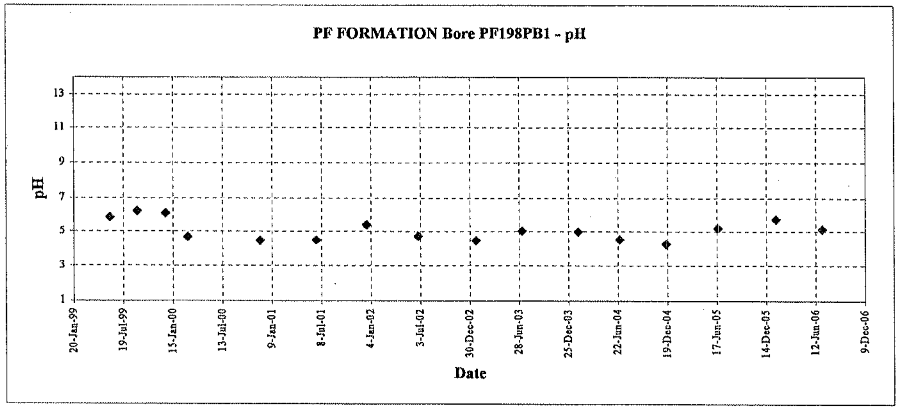
Prepared by: FC
Checked by: .

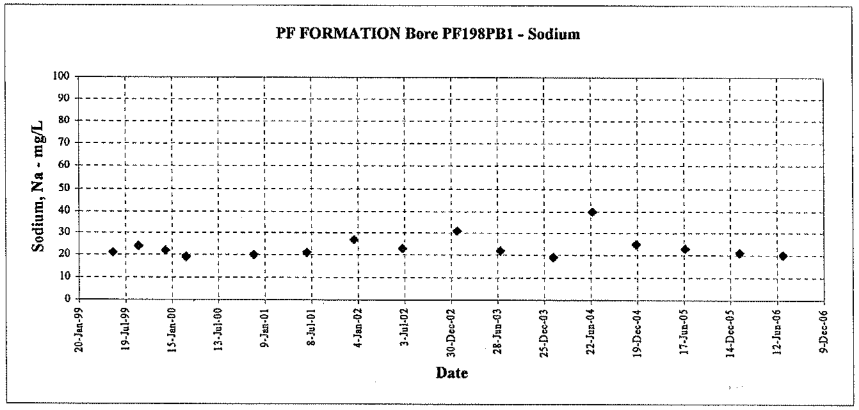
PF FORMATION - MAROOTA
BORE PF198PB1 GROUNDWATER ANALYTICAL SUMMARY

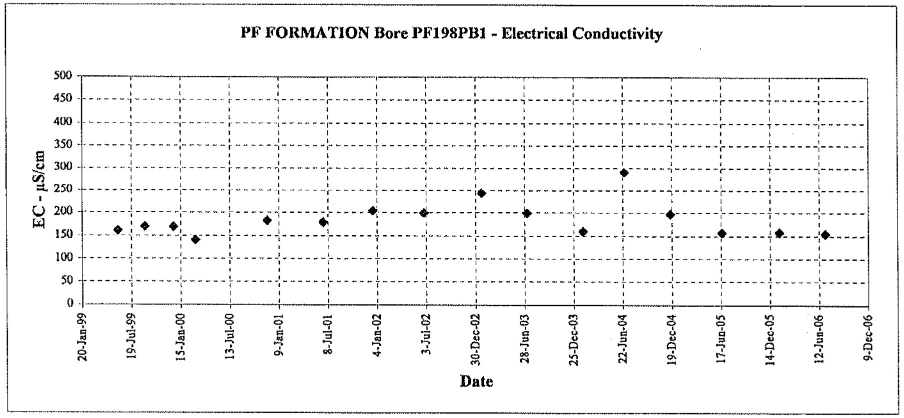
Analysis	Units	LOR	1-Jun-99	8-Sep-99	21-Dec-99	10-Mar-00	28-Nov-00	21-Jun-01	20-Dec-01	26-Jun-02	23-Jan-03	9-Jul-03	30-Jan-04	29-Jun-04	15-Dec-04	22-Jun-05	19-Jan-06	6-Jul-06
pH		0.01	5.87	6.24	6.11	4.69	4.49	4.51	5.41	4.73	4.49	5.06	5	4.53	4.28	5.22	5.74	5.16
Electrical Conductivity	µS/cm	1	161	170	169	141	182	179	204	199	243	199	160	291	197	157	158	155
Total Dissolved Solids	mg/L	1	124	116	98	97	107	102	116	112	139	102	116	174	88	105	115	98
Calcium	mg/L	1	1	<1	1	1	3	2	2	4	3	2	2	4	1	1	2	1
Magnesium	mg/L	1	4	6	5	3	3	4	4	4	4	3	2	5	2	2	4	3
Sodium	mg/L	1	21	24	22	19	20	21	27	23	31	22	19	40	25	23	21	20
Potassium	mg/L	1	1	<1	1	1	2	5	5	3	3	2	2	3	2	2	2	2
Bicarbonate	mg/L	1	13	29	22	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	12	5
Sulphate	mg/L	1	4	4	4	2	8	8	3	7	4	8	6	9	8	8	6	2
Chloride	mg/L	1	39	35	36	36	40	49	60	58	64	49	43	83	42	47.1	43.4	43.8
Oil and Grease	mg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	6	<5	<5	<5	<5	<5	5	<5

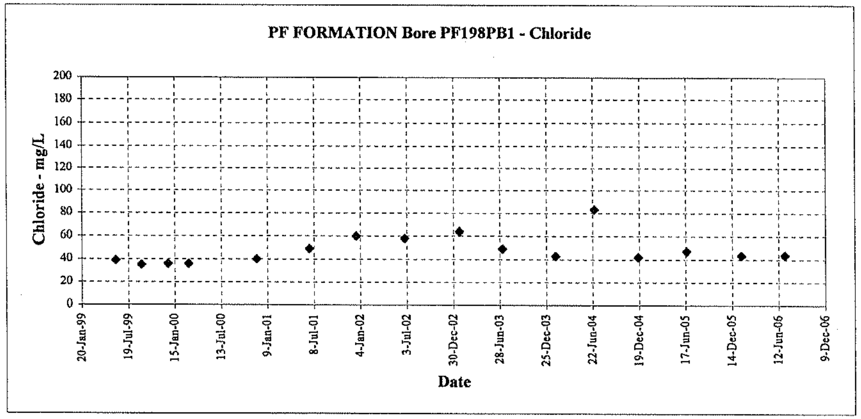
LOR = Limit of Reporting

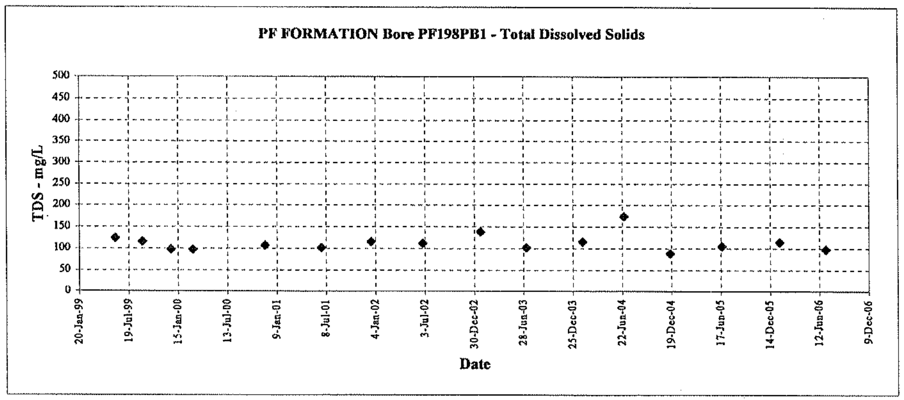
Average EC = 185 µS/cm
Average TDS = 113 mg/L











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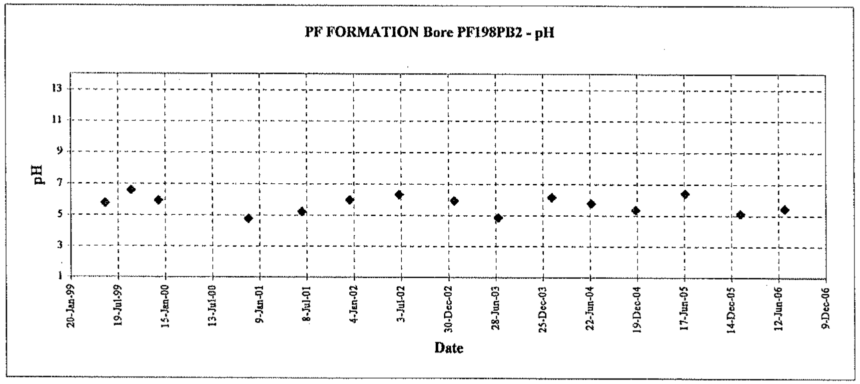
PF FORMATION - MAROOTA
BORE PF198PB2 GROUNDWATER ANALYTICAL SUMMARY

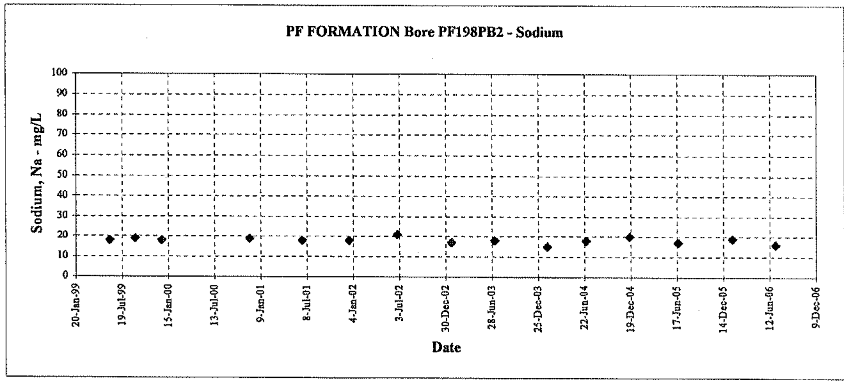
Analysis	Units	LOR	1-Jun-99	8-Sep-99	21-Dec-99	28-Nov-00	21-Jun-01	20-Dec-01	26-Jun-02	23-Jan-03	9-Jul-03	30-Jan-04	29-Jun-04	15-Dec-04	22-Jun-05	19-Jan-06	6-Jul-06
pH		0.01	5.78	6.61	5.96	4.8	5.24	5.99	6.33	5.96	4.87	6.18	5.78	5.39	6.43	5.13	5.46
Electrical Conductivity	µS/cm	1	139	174	146	152	130	141	151	146	162	133	136	156	133	126	122
Total Dissolved Solids	mg/L	1	126	102	85	100	87	87	102	84	87	113	79	105	87	104	79
Calcium	mg/L	1	1	2	2	<1	<1	<1	1	<1	<1	<1	1	1	<1	<1	1
Magnesium	mg/L	1	5	5	5	4	3	4	4	4	2	4	4	2	4	3	4
Sodium	mg/L	1	18	19	18	19	18	18	21	17	18	15	18	20	17	19	16
Potassium	mg/L	1	2	2	2	1	1	2	2	1	<1	1	1	2	2	1	2
Bicarbonate	mg/L	1	23	33	19	4	3	13	8	16	<1	16	9	2	14	7	24
Sulphate	mg/L	1	3	3	2	1	1	3	2	<1	4	2	1	4	4	1	1
Chloride	mg/L	1	31	28	31	41	38	33	46	33	40	31	37	35	34.9	38.8	30.2
Oil and Grease	mg/L	5	<5	<5	<5	<5	<5	11	<5	<5	<5	<5	<5	<5	<5	<5	<5

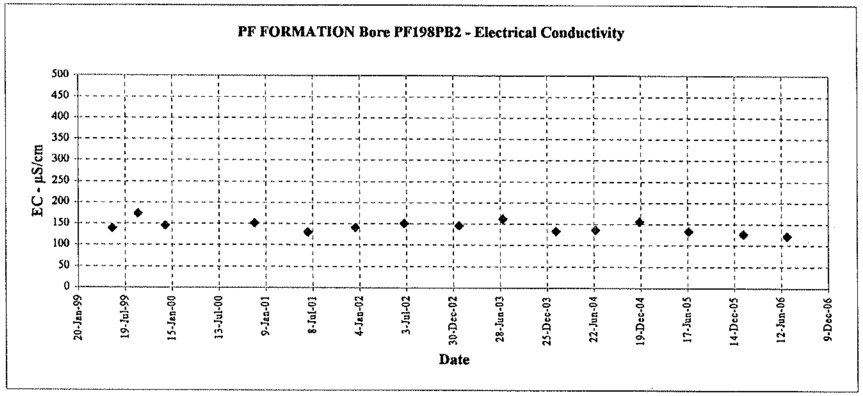
Average EC = 143 µS/cm
Average TDS = 95 mg/L

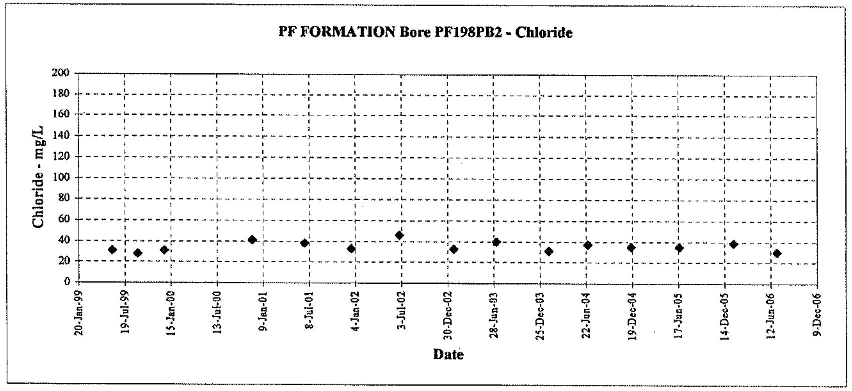
LOR = Limit of Reporting

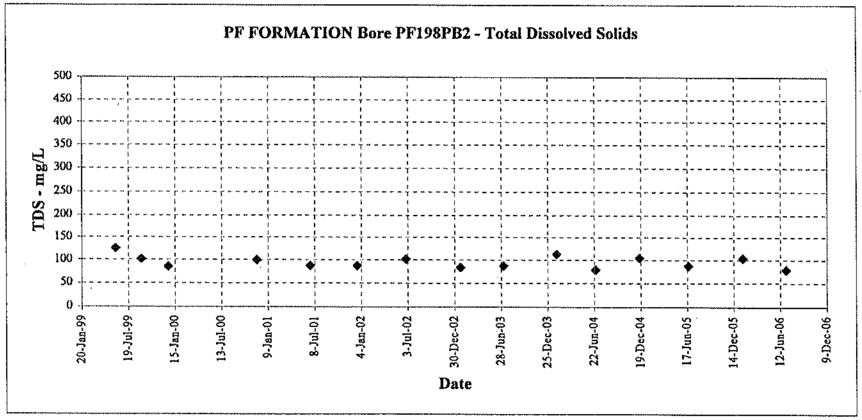
Note: PF198PB2 could not be sampled in March 2000


PF FORMATION Bore PF198PB2 - pH
pH
Date


PF FORMATION Bore PF198PB2 - Sodium
Sodium, Na - mg/L
Date


PF FORMATION Bore PF198PB2 - Electrical Conductivity
EC - µS/cm
Date


PF FORMATION Bore PF198PB2 - Chloride
Chloride - mg/L
Date

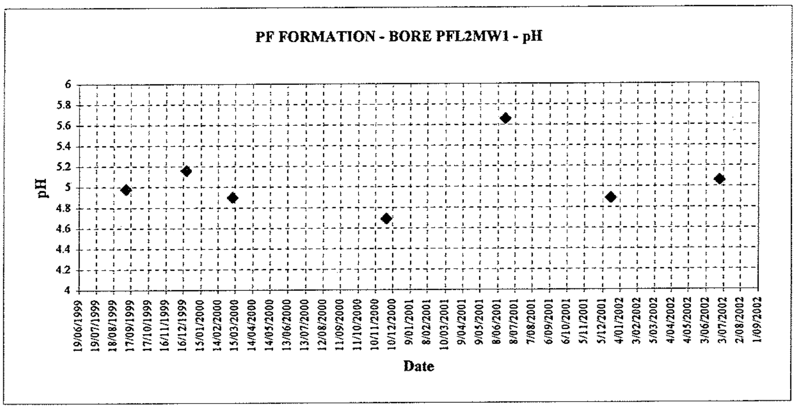

PF FORMATION Bore PF198PB2 - Total Dissolved Solids
TDS - mg/L
Date

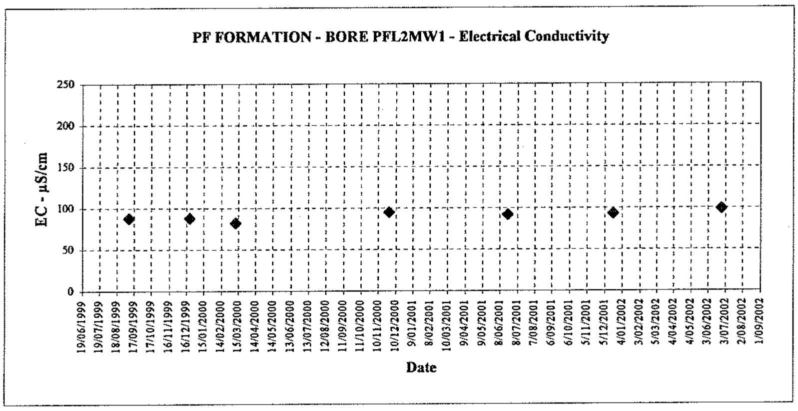
PF FORMATION - MAROOTA
BORE PFL2MW1 GROUNDWATER ANALYTICAL SUMMARY

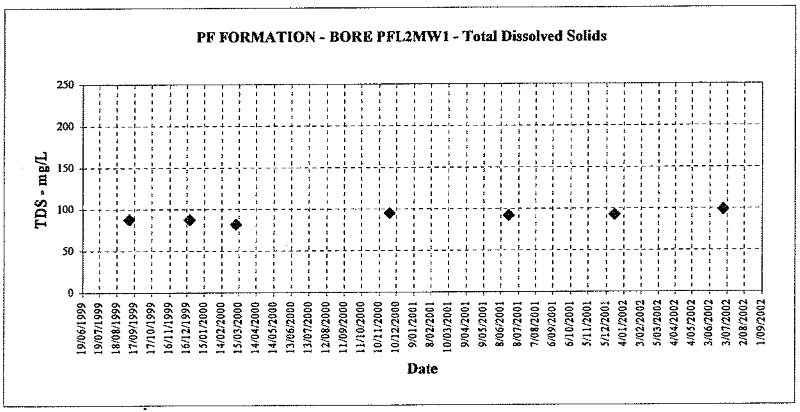
Analysis	Units	LOR	2-Jun-99	8-Sep-99	21-Dec-99	10-Mar-00	28-Nov-00	21-Jun-01	19-Dec-01	26-Jun-02
pH		0.01	N.S.	4.98	5.16	4.90	4.69	5.66	4.89	5.06
Electrical Conductivity	µS/cm	1	N.S.	88	88	82	95	92	93	99
Total Dissolved Solids	mg/L	1	N.S.	56	45	52	131	61	56	60
Calcium	mg/L	1	N.S.	<1	<1	<1	<1	3	<1	<1
Magnesium	mg/L	1	N.S.	2	2	2	2	2	2	2
Sodium	mg/L	1	N.S.	11	12	11	13	10	11	13
Potassium	mg/L	1	N.S.	<1	<1	<1	<1	<1	<1	<1
Bicarbonate	mg/L	1	N.S.	<1	8	<1	4	7	<1	<1
Sulphate	mg/L	1	N.S.	<1	<1	<1	3	1	<1	<1
Chloride	mg/L	1	N.S.	19	19	19	20	17	24	32
Oil and Grease	mg/L	5	N.S.	<5	<5	<5	<5	<5	<5	<5

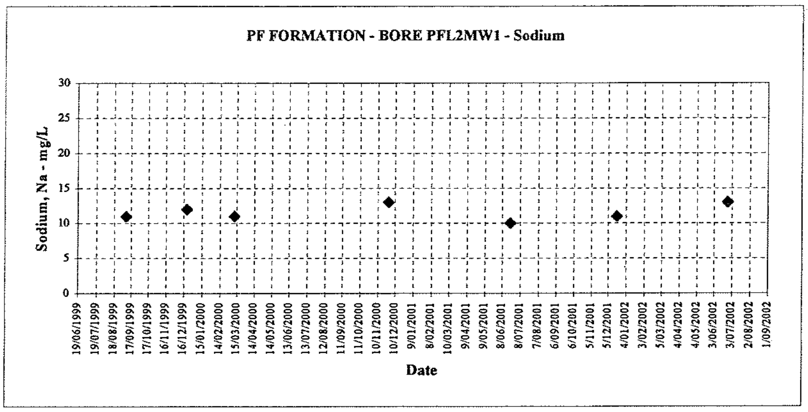
LOR = Limit of Reporting
N.S. = Not Sampled
N.B. = TDS value in November 2000 is unusually high because of the presence of particulate matter in the sample.

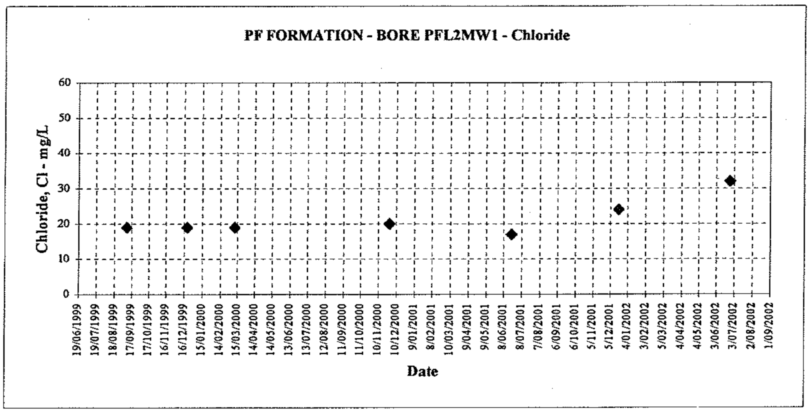
Average EC = 91 µS/cm
Average TDS = 66 mg/L

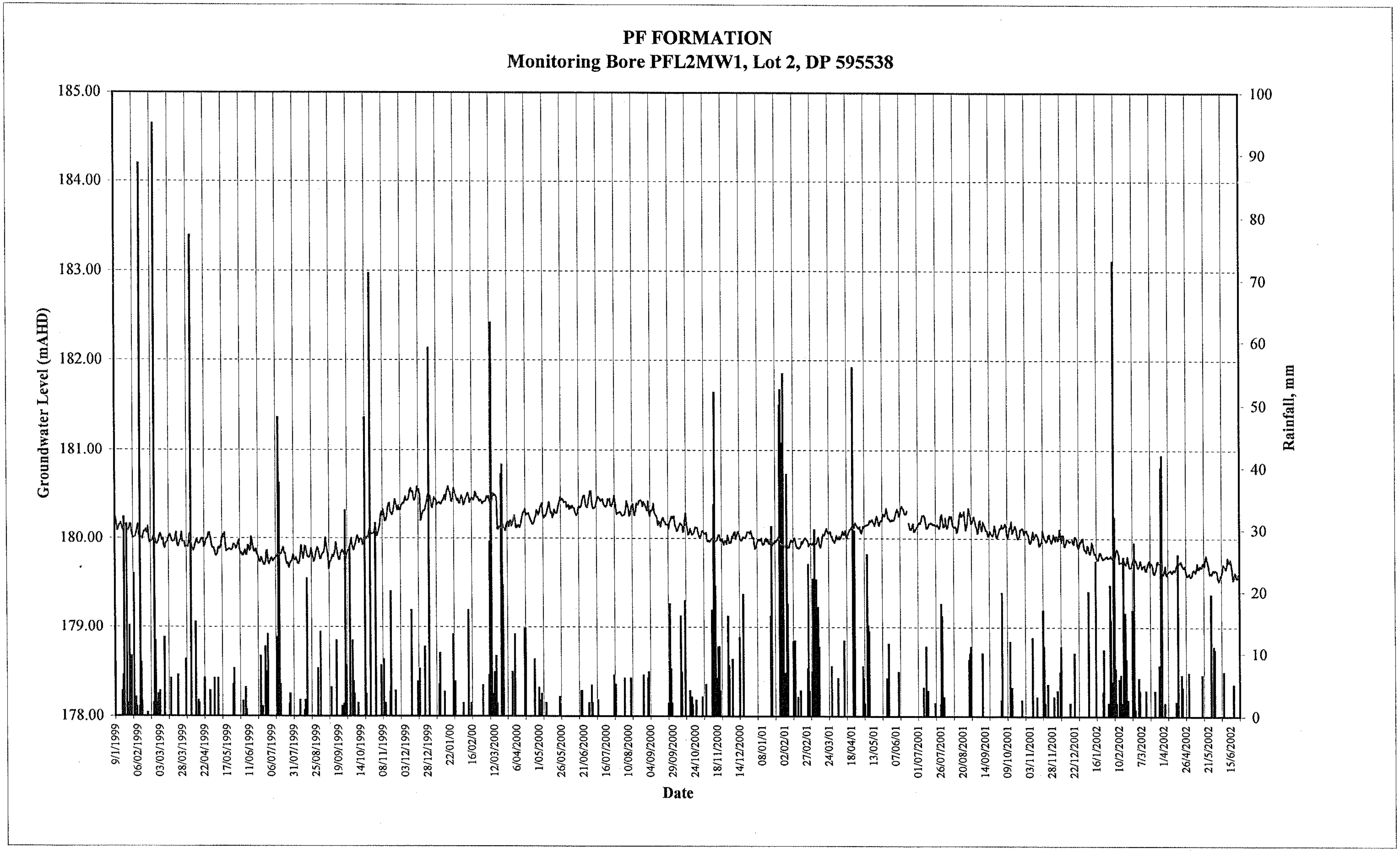

PF FORMATION - BORE PFL2MW1 - pH
pH
Date


PF FORMATION - BORE PFL2MW1 - Electrical Conductivity
EC - µS/cm
Date


PF FORMATION - BORE PFL2MW1 - Total Dissolved Solids
TDS - mg/L
Date


PF FORMATION - BORE PFL2MW1 - Sodium
Sodium, Na - mg/L
Date


PF FORMATION - BORE PFL2MW1 - Chloride
Chloride, Cl - mg/L
Date



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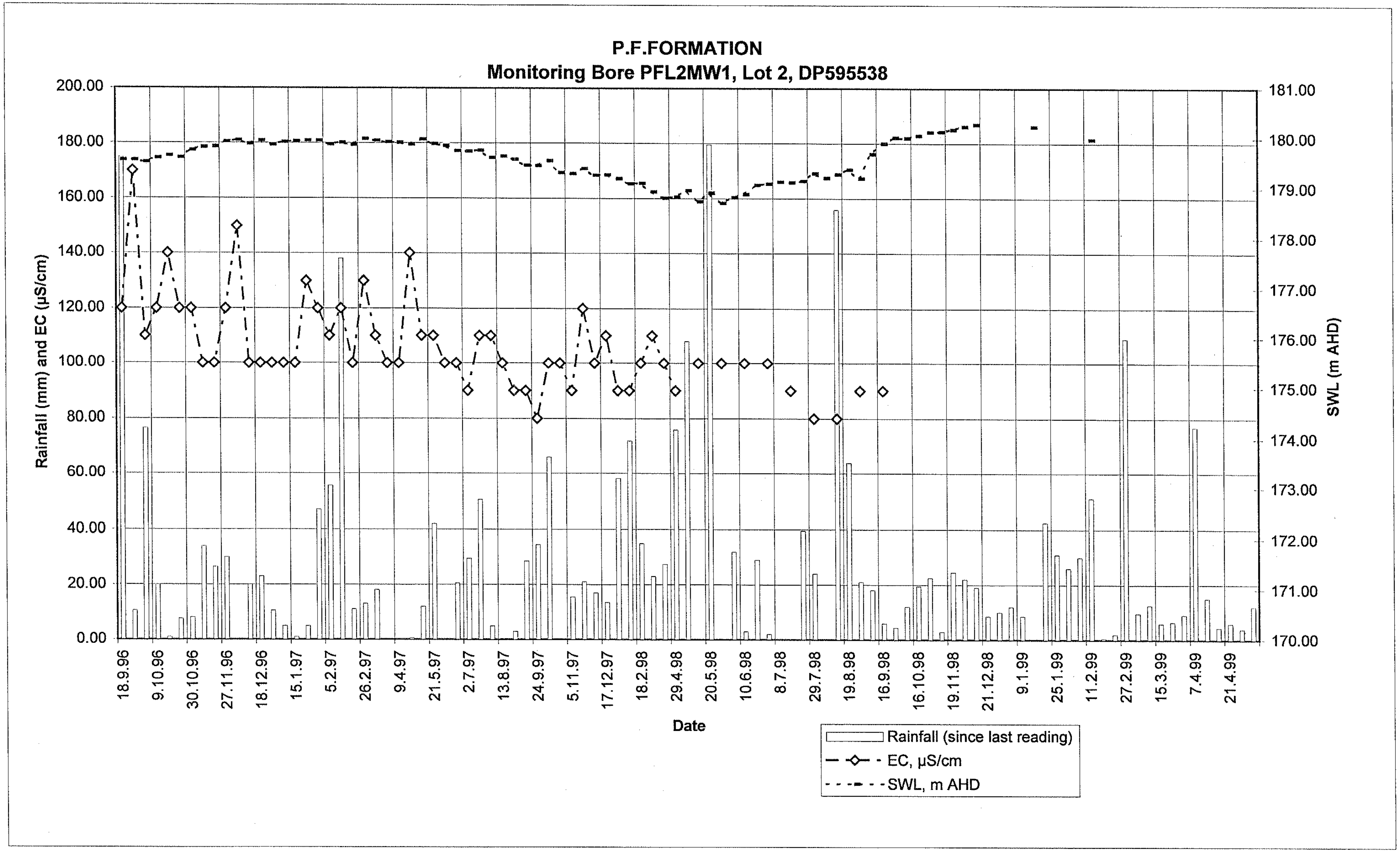

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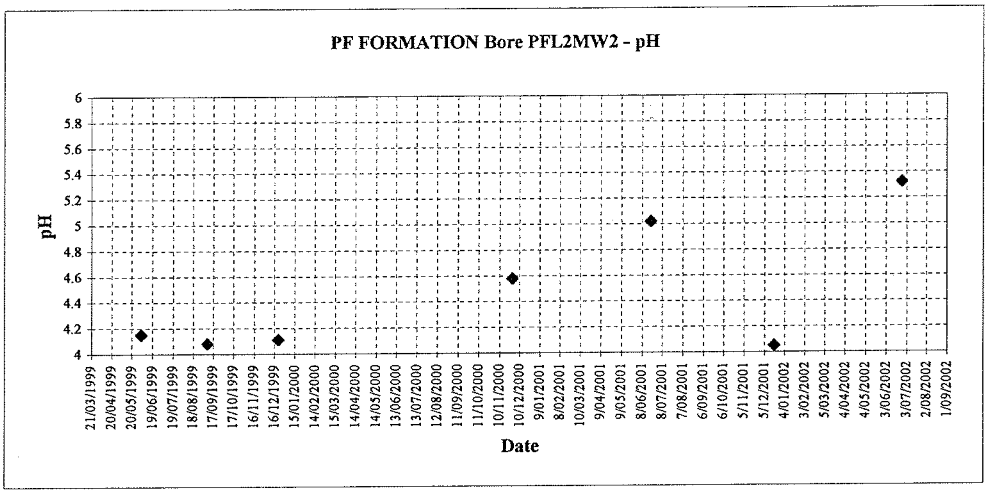
Prepared by: FC
Checked by: ____

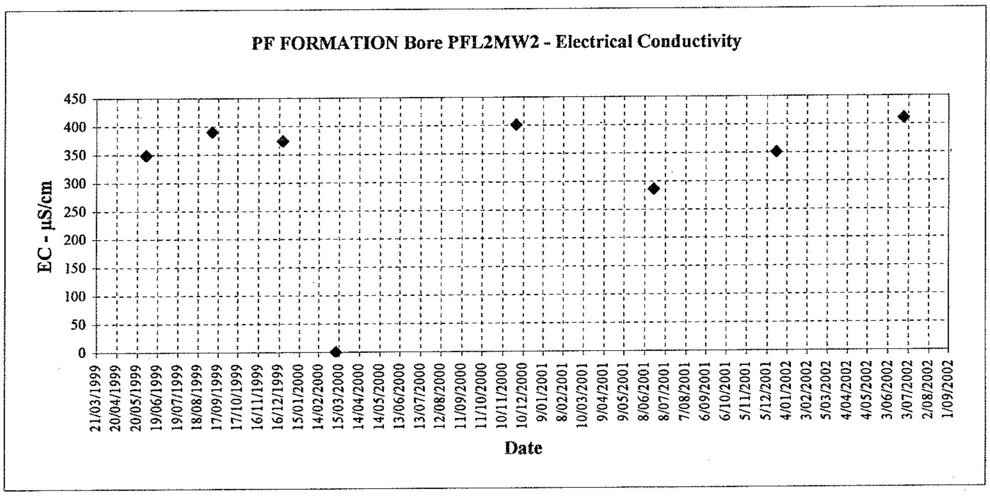
PF FORMATION - MAROOTA
BORE PFL2MW2 GROUNDWATER ANALYTICAL SUMMARY

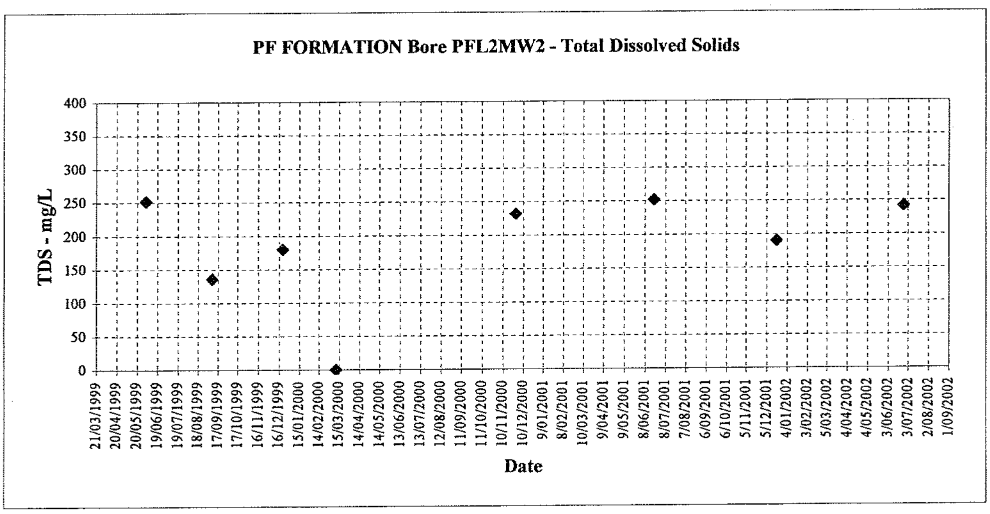
Analysis	Units	LOR	2-Jun-99	8-Sep-99	21-Dec-99	10-Mar-00	29-Nov-00	21-Jun-01	19-Dec-01	26-Jun-02
pH		0.01	4.15	4.08	4.11	-	4.58	5.02	4.05	5.32
Electrical Conductivity	µS/cm	1	349	390	374	-	401	286	351	411
Total Dissolved Solids	mg/L	1	252	136	180	-	232	252	190	242
Calcium	mg/L	1	<1	<1	<1	-	<1	6	<1	8
Magnesium	mg/L	1	7	7	7	-	8	6	6	8
Sodium	mg/L	1	60	46	50	-	54	46	46	67
Potassium	mg/L	1	<1	<1	<1	-	<1	<1	<1	2
Bicarbonate	mg/L	1	<1	<1	<1	-	7	3	<1	3
Sulphate	mg/L	1	3	2	3	-	4	3	3	6
Chloride	mg/L	1	27	95	98	-	102	99	90	132
Oil and Grease	mg/L	5	<5	<5	<5	-	<5	<5	7	<5

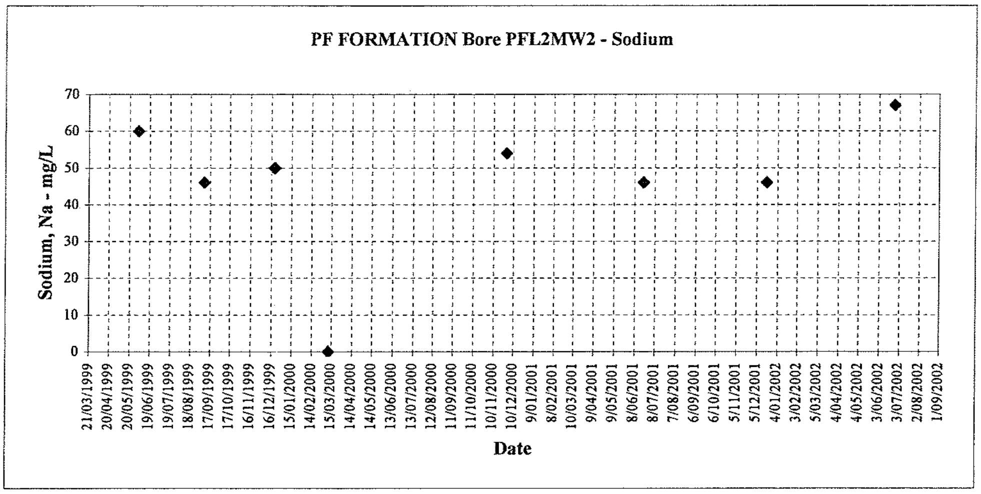
LOR = Limit of Reporting

Average EC = 366 µS/cm
Average TDS = 212 mg/L


PF FORMATION Bore PFL2MW2 - pH
pH
Date


PF FORMATION Bore PFL2MW2 - Electrical Conductivity
EC - µS/cm
Date


PF FORMATION Bore PFL2MW2 - Total Dissolved Solids
TDS - mg/L
Date



PF FORMATION Bore PFL2MW2 - Sodium
Sodium, Na - mg/L
0
10
20
30
40
50
60
70
21/03/1999
20/04/1999
20/05/1999
19/06/1999
19/07/1999
18/08/1999
17/09/1999
17/10/1999
16/11/1999
16/12/1999
15/01/2000
14/02/2000
15/03/2000
14/04/2000
14/05/2000
13/06/2000
13/07/2000
12/08/2000
11/09/2000
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9/01/2001
8/02/2001
10/03/2001
9/04/2001
9/05/2001
8/06/2001
8/07/2001
7/08/2001
6/09/2001
6/10/2001
5/11/2001
5/12/2001
4/01/2002
3/02/2002
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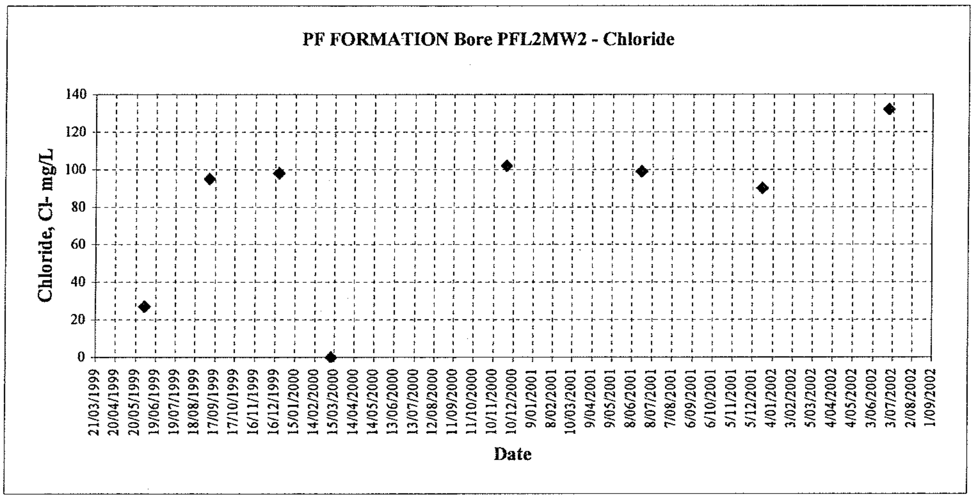
4/04/2002
4/05/2002
3/06/2002
3/07/2002
2/08/2002
1/09/2002
Date



PF FORMATION Bore PFL2MW2 - Chloride
Chloride, Cl- mg/L
0
20
40
60
80
100
120
140
21/03/1999
20/04/1999
20/05/1999
19/06/1999
19/07/1999
18/08/1999
17/09/1999
17/10/1999
16/11/1999
16/12/1999
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9/05/2001
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4/01/2002
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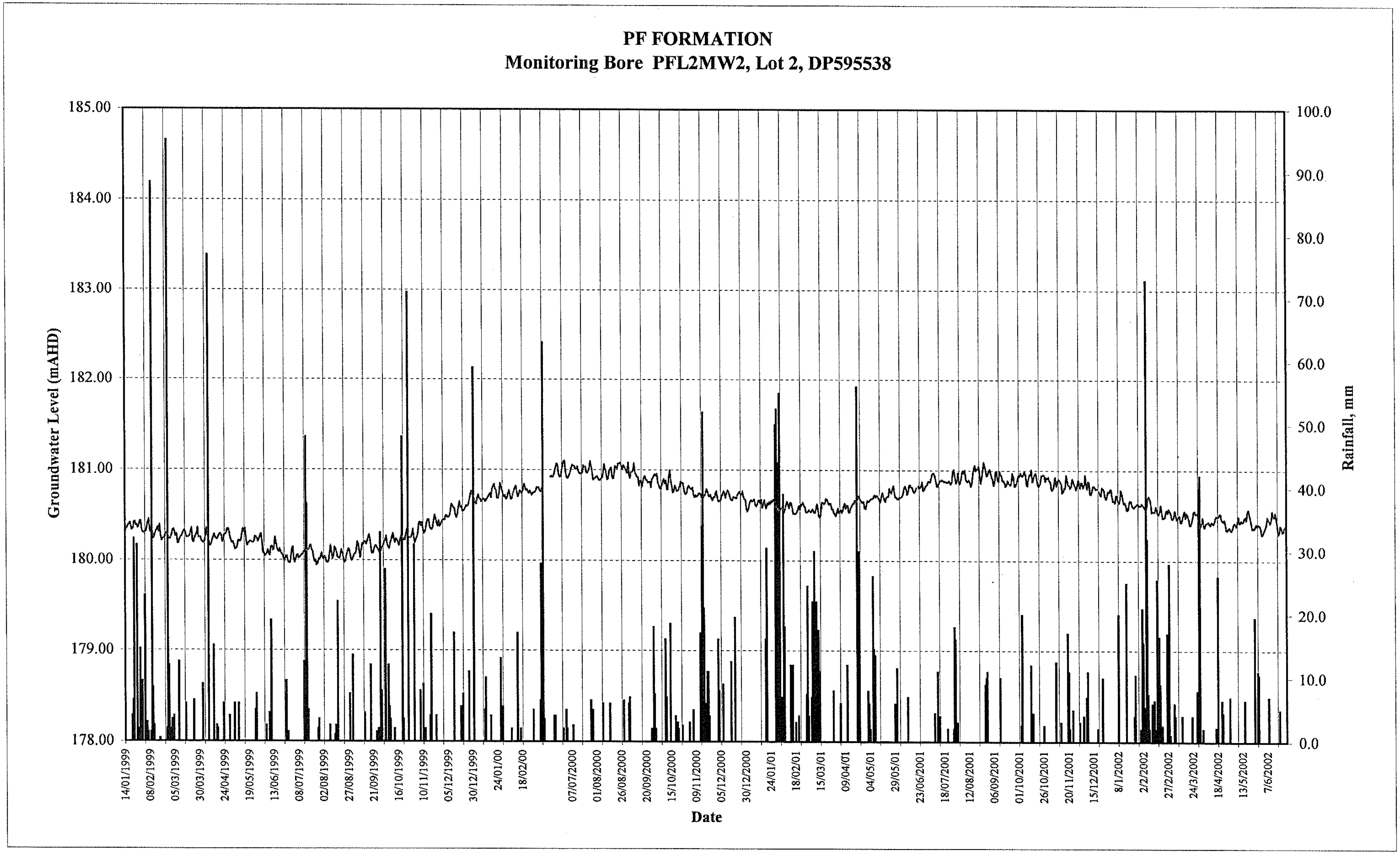
2/08/2002
1/09/2002
Date



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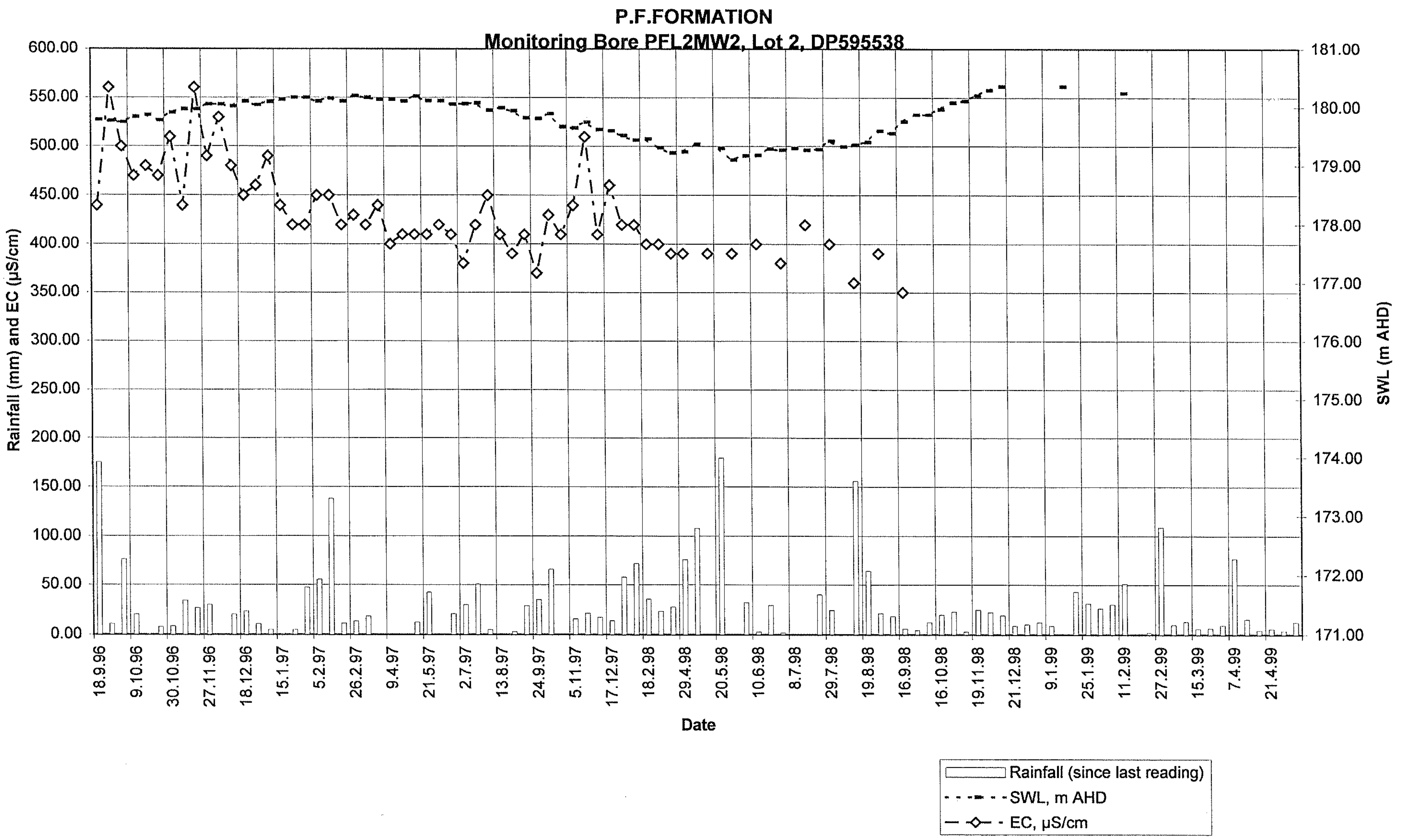

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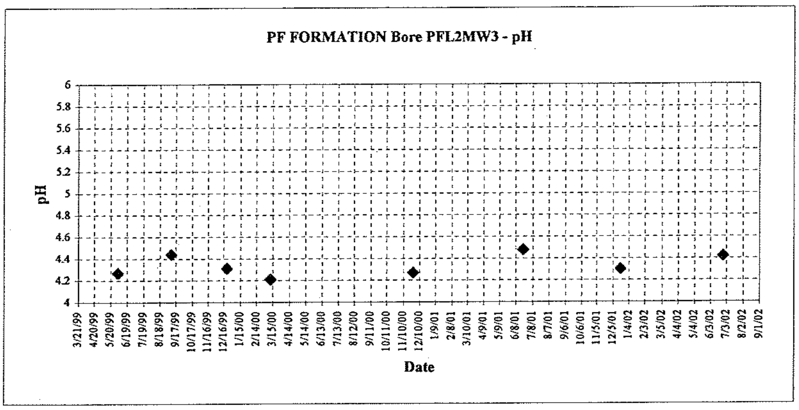
Prepared by: FC
Checked by: ____

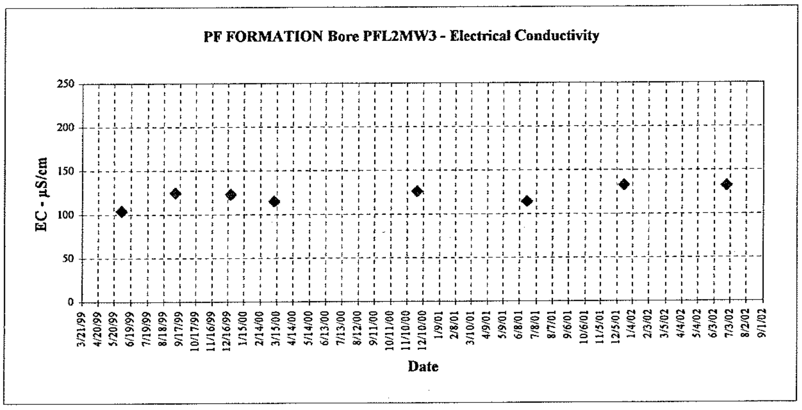
PF FORMATION - MAROOTA
BORE PFL2MW3 GROUNDWATER ANALYTICAL SUMMARY

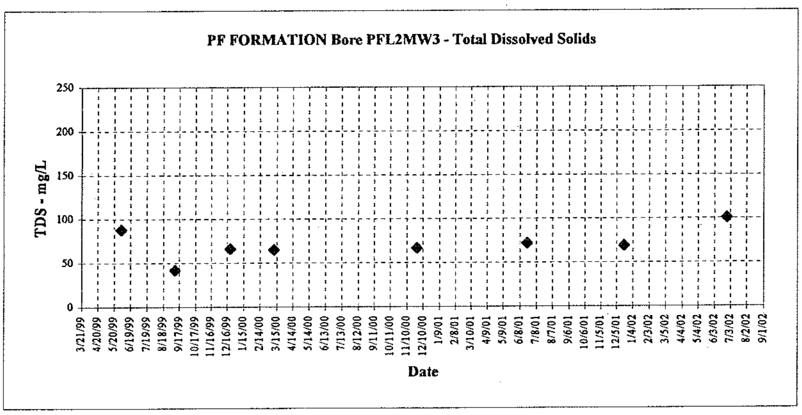
Analysis	Units	LOR	2-Jun-99	8-Sep-99	21-Dec-99	10-Mar-00	28-Nov-00	21-Jun-01	19-Dec-01	26-Jun-02
pH		0.01	4.27	4.44	4.31	4.21	4.27	4.48	4.3	4.42
Electrical Conductivity	µS/cm	1	104	125	123	115	126	114	133	132
Total Dissolved Solids	mg/L	1	88	42	66	65	67	72	69	101
Calcium	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1
Magnesium	mg/L	1	2	2	2	2	2	2	2	2
Sodium	mg/L	1	14	14	15	14	15	13	16	17
Potassium	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1
Sulphate	mg/L	1	3	2	3	3	4	3	2	3
Chloride	mg/L	1	27	26	27	27	28	27	30	36
Oil and Grease	mg/L	5	<5	<5	<5	<5	<5	<5	<5	<5

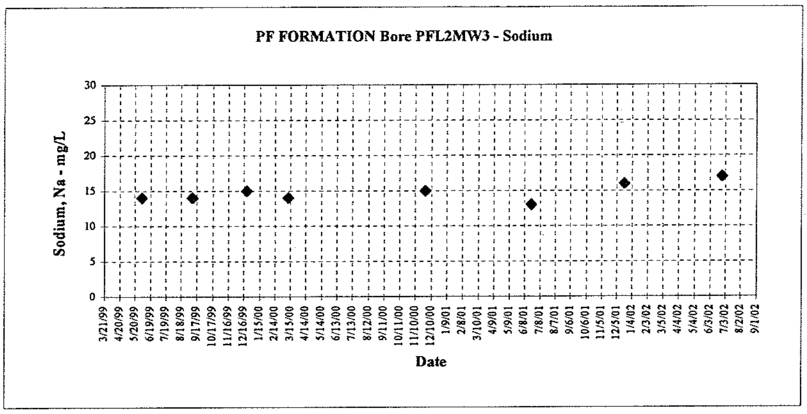
LOR = Limit of Reporting

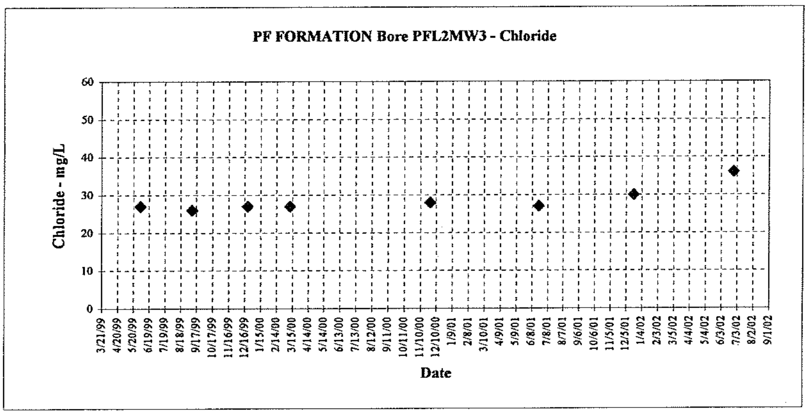
Average EC = 124 µS/cm
Average TDS = 69 mg/L

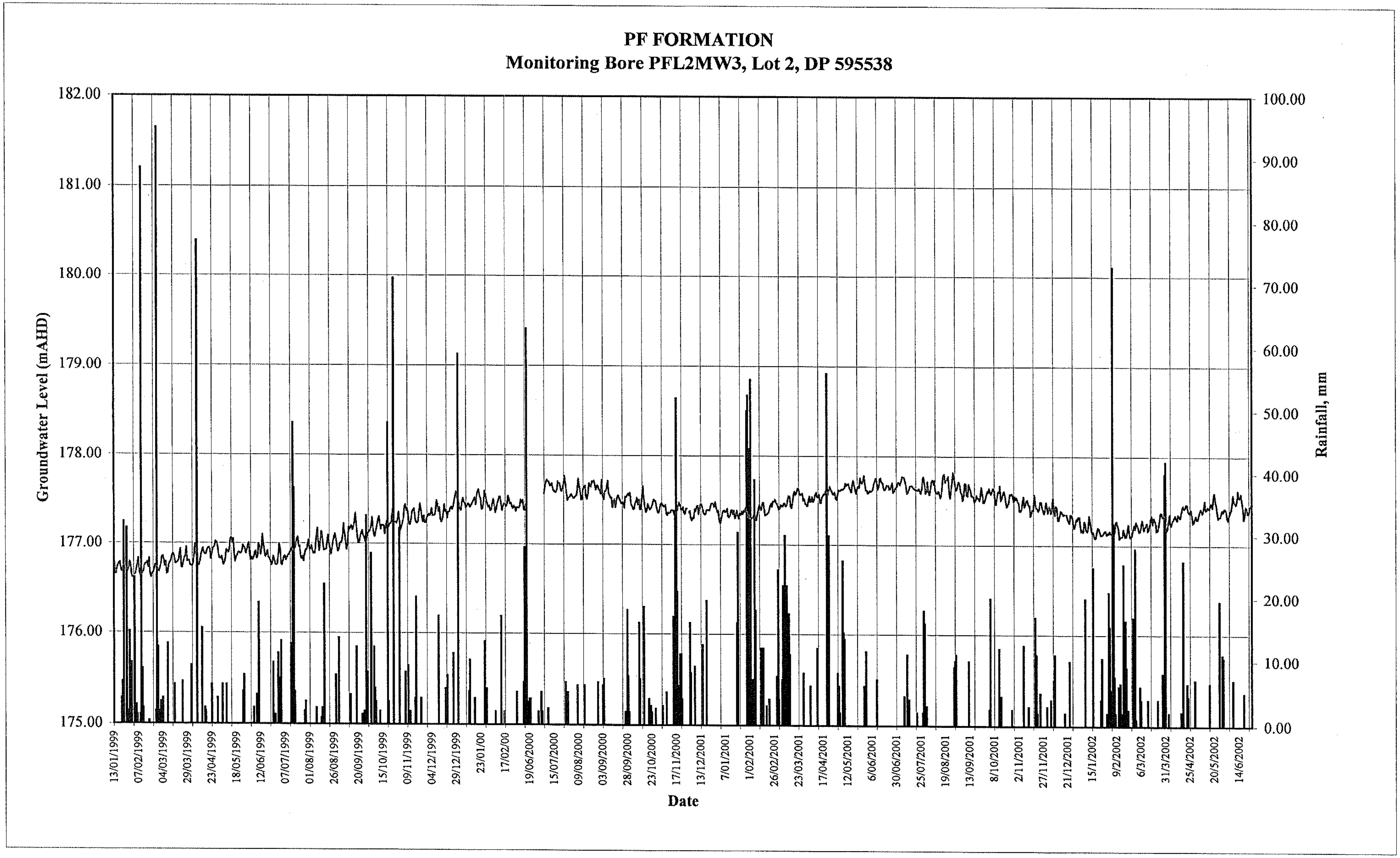

PF FORMATION Bore PFL2MW3 - pH
pH
Date


PF FORMATION Bore PFL2MW3 - Electrical Conductivity
EC - µS/cm
Date


PF FORMATION Bore PFL2MW3 - Total Dissolved Solids
TDS - mg/L
Date


PF FORMATION Bore PFL2MW3 - Sodium
Sodium, Na - mg/L
Date


PF FORMATION Bore PFL2MW3 - Chloride
Chloride - mg/L
Date



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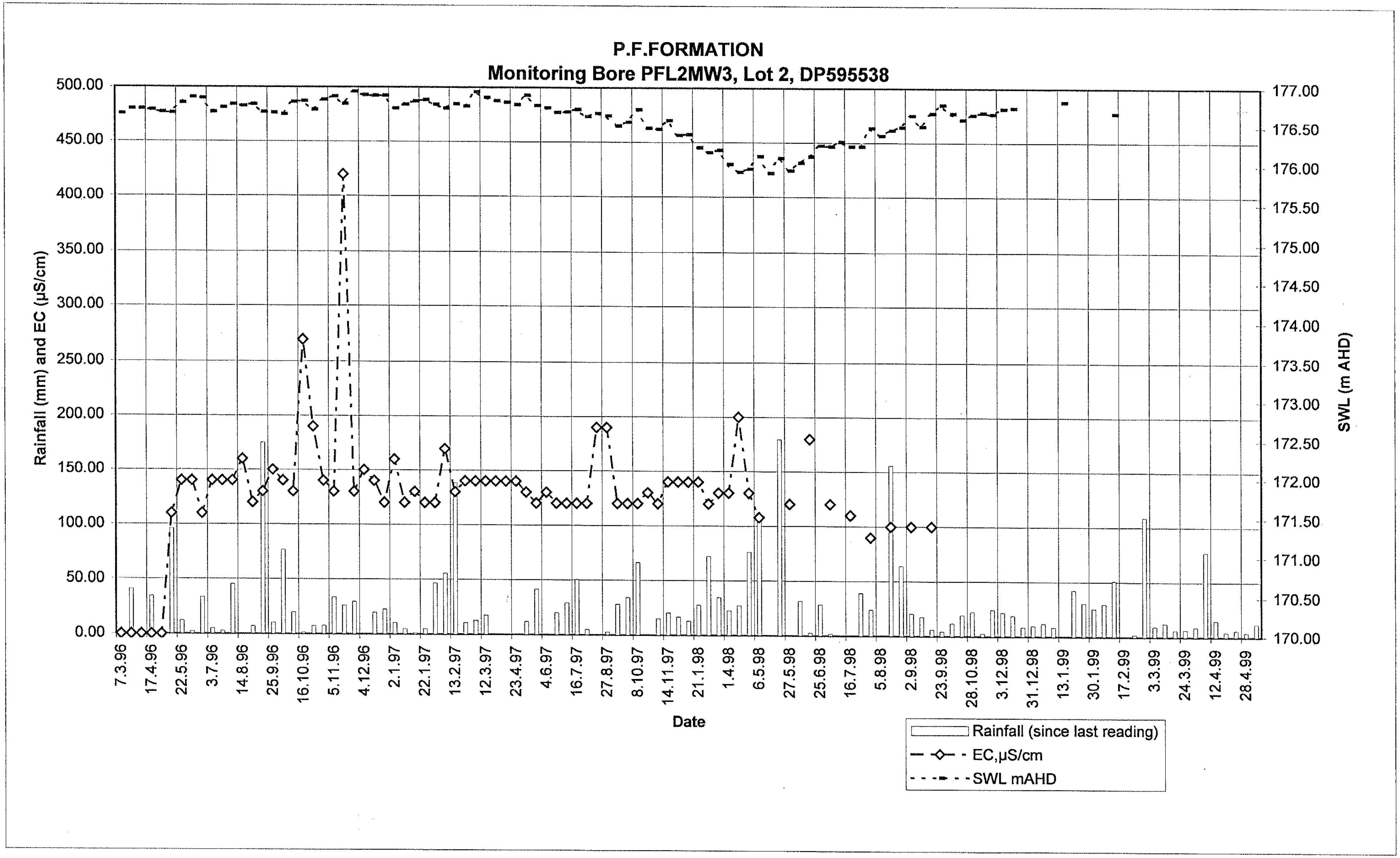

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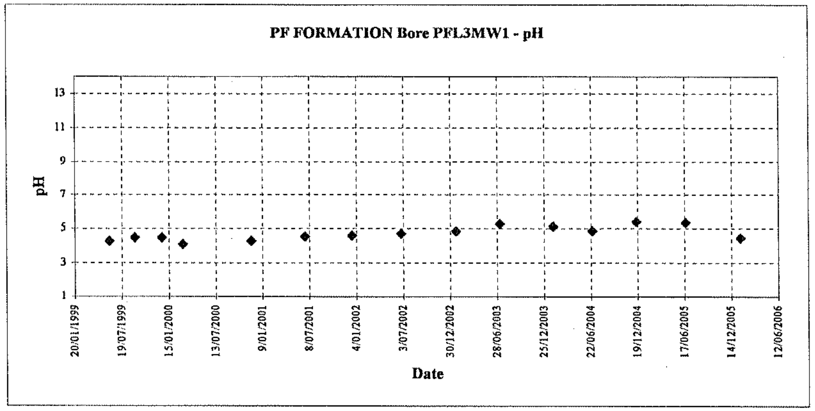
Prepared by: FC
Checked by:

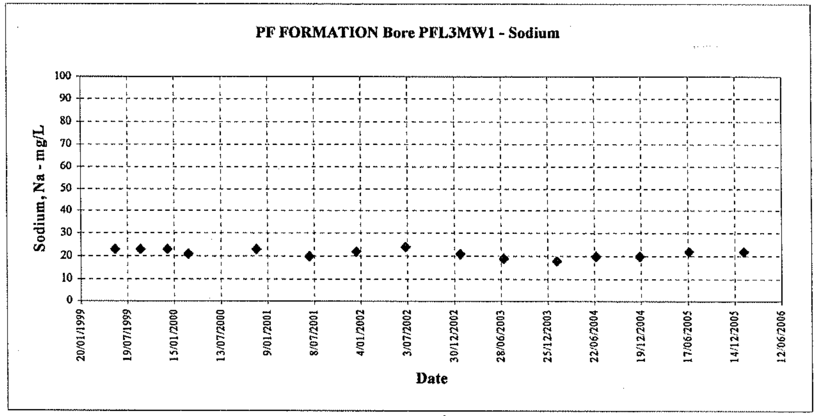
PF FORMATION - MAROOTA
BORE PFL3MW1 GROUNDWATER ANALYTICAL SUMMARY

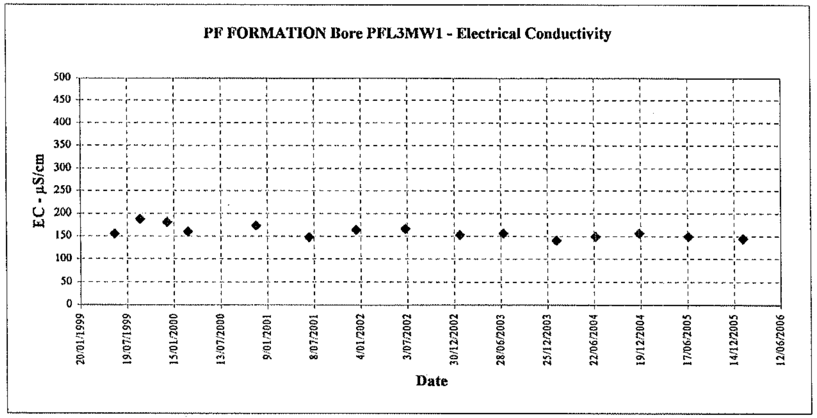
Analysis	Units	LOR	2-Jun-99	8-Sep-99	21-Dec-99	10-Mar-00	28-Nov-00	21-Jun-01	19-Dec-01	26-Jun-02	23-Jan-03	9-Jul-03	30-Jan-04	29-Jun-04	15-Dec-04	22-Jun-05	19/01/2006	6/07/2006
pH		0.01	4.25	4.47	4.47	4.09	4.27	4.53	4.58	4.7	4.82	5.26	5.11	4.84	5.39	5.34	4.45	
Electrical Conductivity	µS/cm	1	155	188	181	160	173	148	164	166	153	156	141	149	156	149	144	
Total Dissolved Solids	mg/L	1	116	88	104	105	107	79	90	98	88	86	104	95	105	98	18	
Calcium	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<	<1	
Magnesium	mg/L	1	4	4	3	3	3	3	3	3	3	2	3	3	2	3	3	
Sodium	mg/L	1	23	23	23	21	23	20	22	24	21	19	18	20	20	22	22	
Potassium	mg/L	1	1	<1	1	1	1	1	1	1	<1	1	<1	1	2	1	1	
Bicarbonate	mg/L	1	<1	<1	1	<1	<1	<1	<1	<1	<1	3	2	2	2	4	2	
Sulphate	mg/L	1	4	4	5	5	6	5	5	5	2	4	4	2	4	4	3	
Chloride	mg/L	1	49	43	42	40	41	41	41	48	39	38	40	43	35	43.8	44.1	
Oil and Grease	mg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	

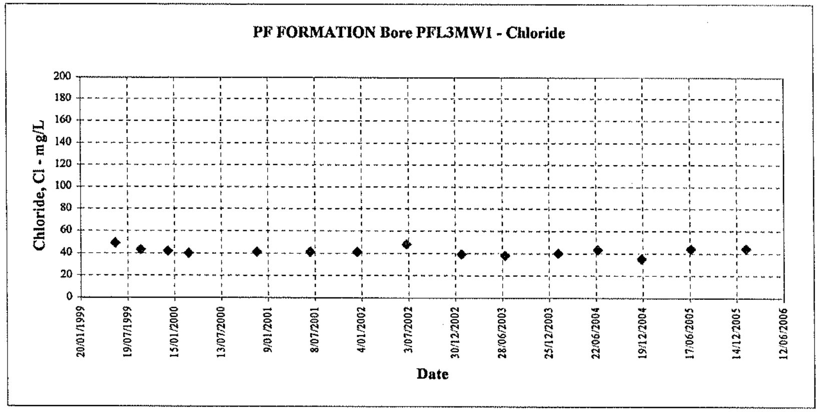
Average EC = 159 µS/cm
Average TDS = 92 mg/L

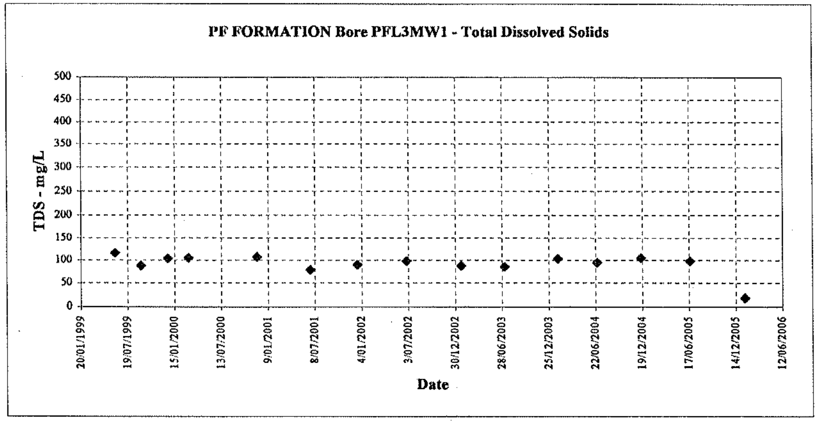
LOR = Limit of Reporting











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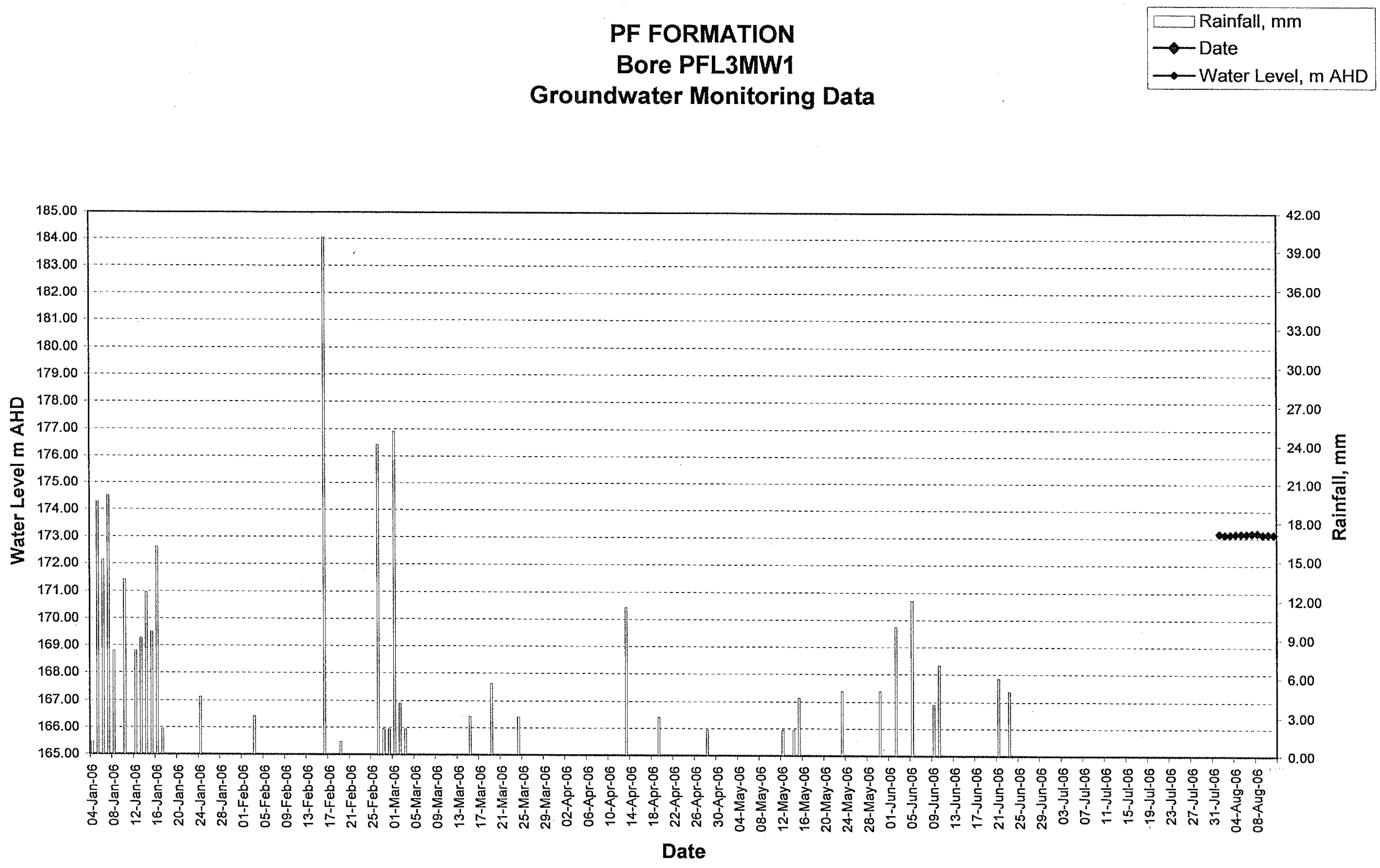
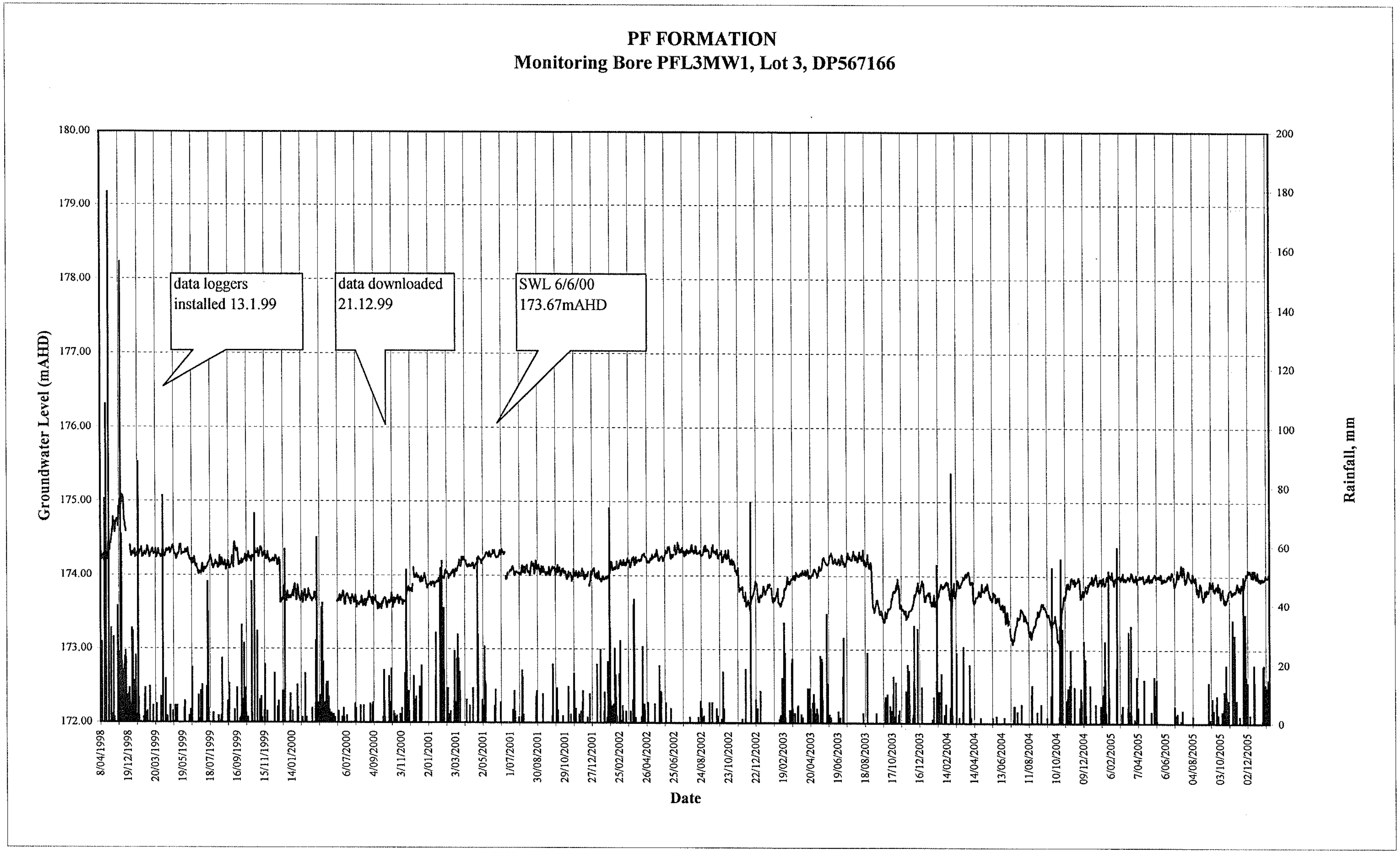
PF FORMATION
Bore PFL3MW1
Groundwater Monitoring Data





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Appendix B

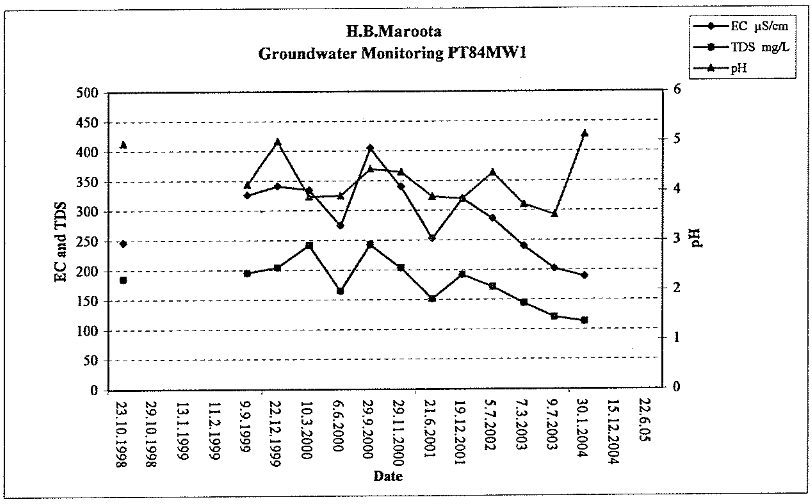
Bore Hydrographs and Water Chemistry Summaries - HB Maroota

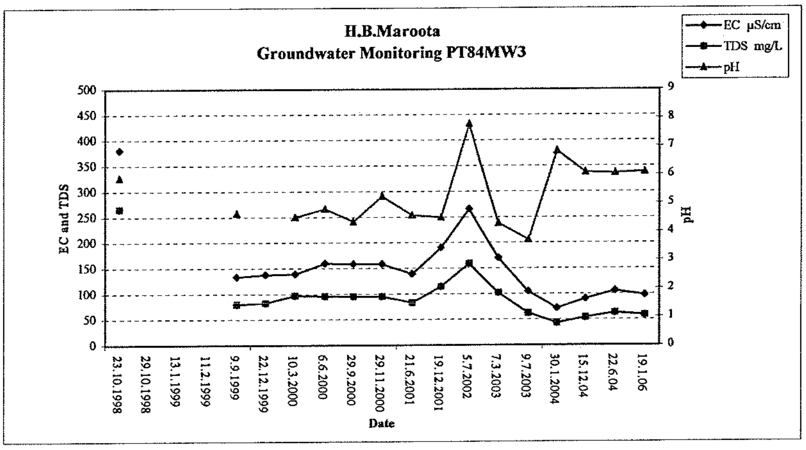
TABLE 1 - **H.B. MAROOTA. FIELD MEASUREMENTS AND LABORATORY SUMMARY**

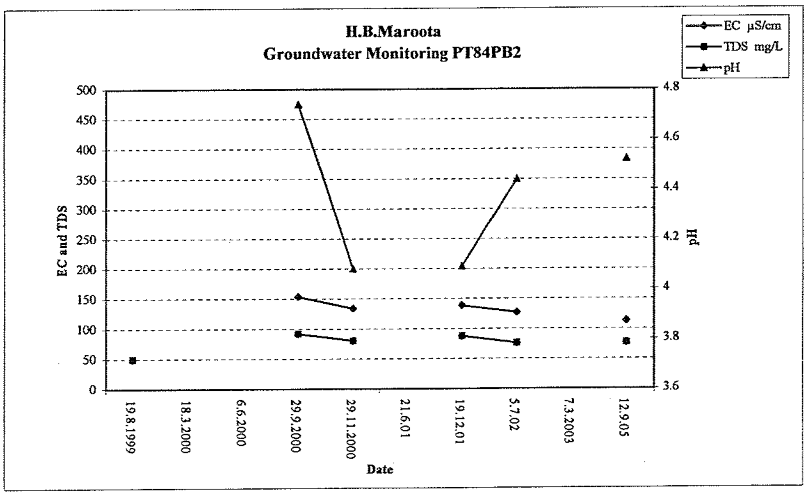
Bore	Aquifer	Date	pH	EC µS/cm	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	HCO3 mg/L	H2SO4 mg/L	SWL m b.TOC	TOC m AHD	SWL m AHD
PT84MW1	M.S.	23.10.1998	*4.96*	*246*	*186*	*3*	*9*	*27*	*3*	*50*	*4*	*3*	5.05	214.24	209.19
PT84MW1	M.S.	29.10.1998											6.15	214.24	208.09
PT84MW1	M.S.	13.1.1999											6.43	214.24	207.81
PT84MW1	M.S.	11.2.1999											6.51	214.24	207.73
PT84MW1	M.S.	9.9.1999	4.13	326	196								6.37	214.24	207.87
PT84MW1	M.S.	22.12.1999	5	341	205								6.00	214.24	208.24
PT84MW1	M.S.	10.3.2000	*3.88*	*335*	*242*	-	-	-	-	-	-	-	5.52	214.24	208.72
PT84MW1	M.S.	6.6.2000	3.90	275	165								6.33	214.24	207.91
PT84MW1	M.S.	29.9.2000	4.44	405	243								6.81	214.24	207.43
PT84MW1	M.S.	29.11.2000	4.38	340	204								6.80	214.24	207.44
PT84MW1	M.S.	21.6.2001	3.88	253	152								6.09	214.24	208.15
PT84MW1	M.S.	19.12.2001	3.84	320	192								6.78	214.24	207.46
PT84MW1	M.S.	5.7.2002	4.36	286	172								6.77	214.24	207.47
PT84MW1	M.S.	7.3.2003	3.72	240	144								7.38	214.24	206.86
PT84MW1	M.S.	9.7.2003	3.51	202	121								7.52	214.24	206.72
PT84MW1	M.S.	30.1.2004	5.13	189	113								7.60	214.24	206.64
PT84MW1	M.S.	15.12.2004				dry							8.07	214.24	206.17
PT84MW1	M.S.	22.6.05				dry									
PT84MW1	M.S.	19.1.06				dry									
Average				**289**	**180**										
PT84MW2	M.S.	23.10.1998											25.00	227.63	202.63
PT84MW2	M.S.	29.10.1998											25.35	227.63	202.28
PT84MW2	M.S.	13.1.1999											25.43	227.63	202.20
PT84MW2	M.S.	11.2.1999											25.49	227.63	202.14
PT84MW2	M.S.	9.9.1999											25.43	227.63	202.20
PT84MW2	M.S.	22.12.1999	-	-										227.63	
PT84MW2	M.S.	10.3.2000	*6.10*	*543*	*530*	-	-	-	-	-	-	-	24.55	227.63	203.08
PT84MW2**															
PT84MW3	M.S.	23.10.1998	*5.88*	*381*	*266*	*<1*	*2*	*79*	*1*	*9*	*14*	*9*	19.61	203.25	183.64
PT84MW3	M.S.	29.10.1998											18.84	203.25	184.41
PT84MW3	M.S.	13.1.1999											20.40	203.25	182.85
PT84MW3	M.S.	11.2.1999											20.58	203.25	182.67
PT84MW3	M.S.	9.9.1999	4.64	134	80								20.43	203.25	182.82
PT84MW3	M.S.	22.12.1999		138	83								19.88	203.25	183.37
PT84MW3	M.S.	10.3.2000	*4.51*	*139*	*97*	-	-	-	-	-	-	-	19.83	203.25	183.42
PT84MW3	M.S.	6.6.2000	4.80	160	96								19.65	203.25	183.60
PT84MW3	M.S.	29.9.2000	4.35	159	95								19.82	203.25	183.43
PT84MW3	M.S.	29.11.2000	5.24	159	95								19.95	203.25	183.30
PT84MW3	M.S.	21.6.2001	4.57	139	83								19.53	203.25	183.72
PT84MW3	M.S.	19.12.2001	4.49	191	115								19.41	203.25	183.84
PT84MW3	M.S.	5.7.2002	7.79	266	160								19.17	203.25	184.08
PT84MW3	M.S.	7.3.2003	4.29	170	102								21.08	203.25	182.17
PT84MW3	M.S.	9.7.2003	3.72	105	63								21.00	203.25	182.25
PT84MW3	M.S.	30.1.2004	6.83	72	43								21.28	203.25	181.97
PT84MW3	M.S.	15.12.04	6.07	90	54								21.44	203.25	181.81
PT84MW3	M.S.	22.6.04	6.05	106	64								21.77	203.25	181.48
PT84MW3	M.S.	19.1.06	6.10	98	59								21.48	203.25	181.77
Average				**157**	**97**										
PT84PB1	H.S.	19.8.1999			60								14.80	193.51	178.71
PT84PB1	H.S.	7.3.2003											pumping		
PT84PB2	H.S.	19.8.1999			50	To be surveyed							51.50	*212.50*	*161.00*
PT84PB2	H.S.	18.3.2000											48.38	*212.00*	*163.62*
PT84PB2	H.S.	6.6.2000											46.72	*212.50*	*165.78*
PT84PB2	H.S.	29.9.2000	4.74	154	92								46.09	*212.50*	*166.41*
PT84PB2	H.S.	29.11.2000	4.08	134	80								44.91	*212.50*	*167.59*
PT84PB2	H.S.	21.6.01											43.00	*212.50*	*169.50*
PT84PB2	H.S.	19.12.01	4.09	139	88								43.24	*212.50*	*169.26*
PT84PB2	H.S.	5.7.02	4.44	127	76								42.81	*212.50*	*169.69*
PT84PB2	H.S.	7.3.2003											pumping		
PT84PB2	H.S.	12.9.05	*4.52*	*113*	*77*	*<1*	*3*	*17*	*<1*	*34*	*<1*	*<1*	pumping		

212.5 = estimated from contour plan
M.S. = Maroota Sand
H.S. = Hawkesbury Sandstone
97 = laboratory measurements
** = data logger no longer operational

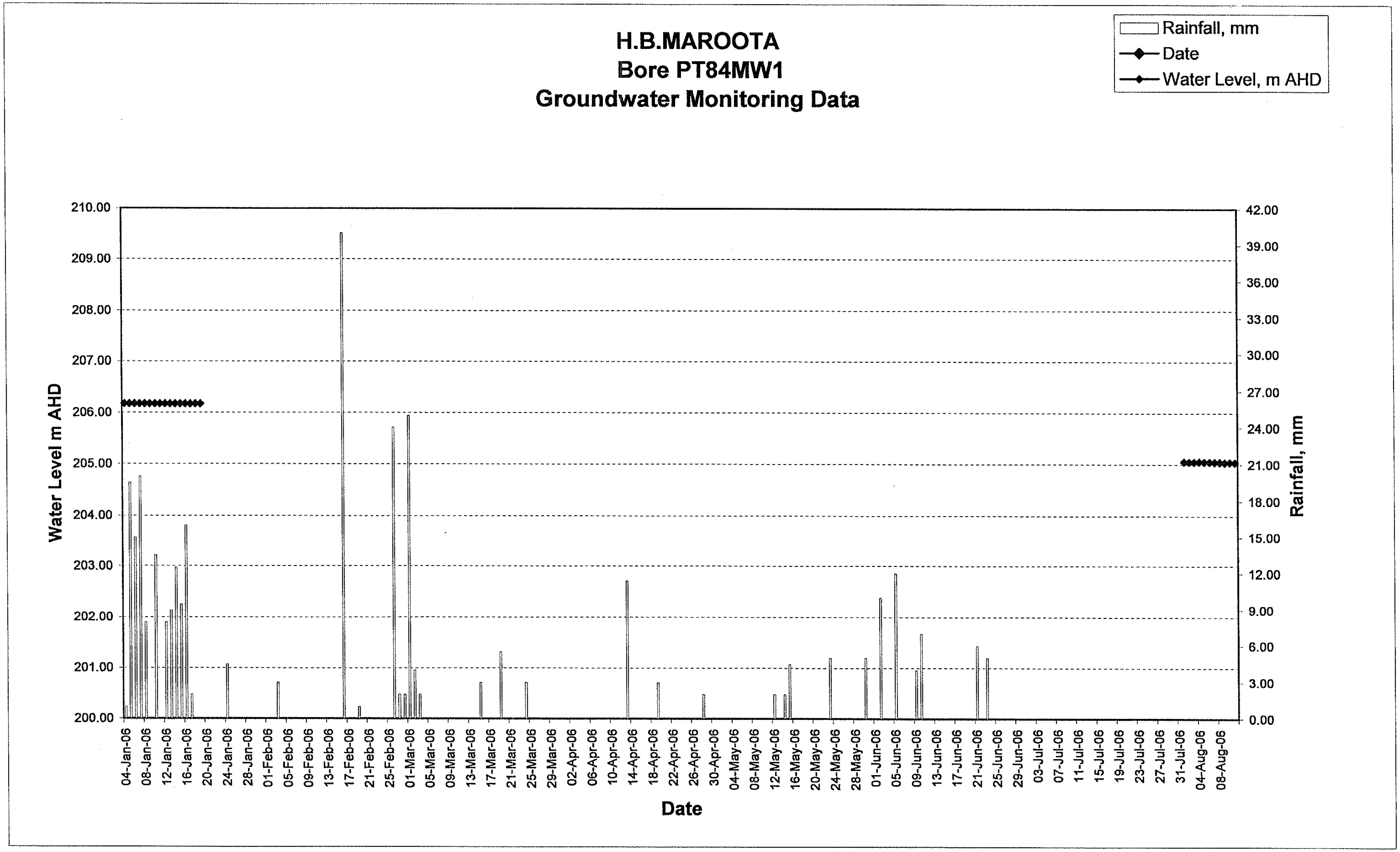
H.B.Maroota - Groundwater Monitoring Data Plots







Prepared by: FC
Checked by: ....



H.B.MAROOTA
Bore PT84MW1
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Water Level m AHD
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207.00
206.00
205.00
204.00
203.00
202.00
201.00
200.00
Rainfall, mm
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18.00
15.00
12.00
9.00
6.00
3.00
0.00
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12-Jan-06
16-Jan-06
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23-Jul-06
27-Jul-06
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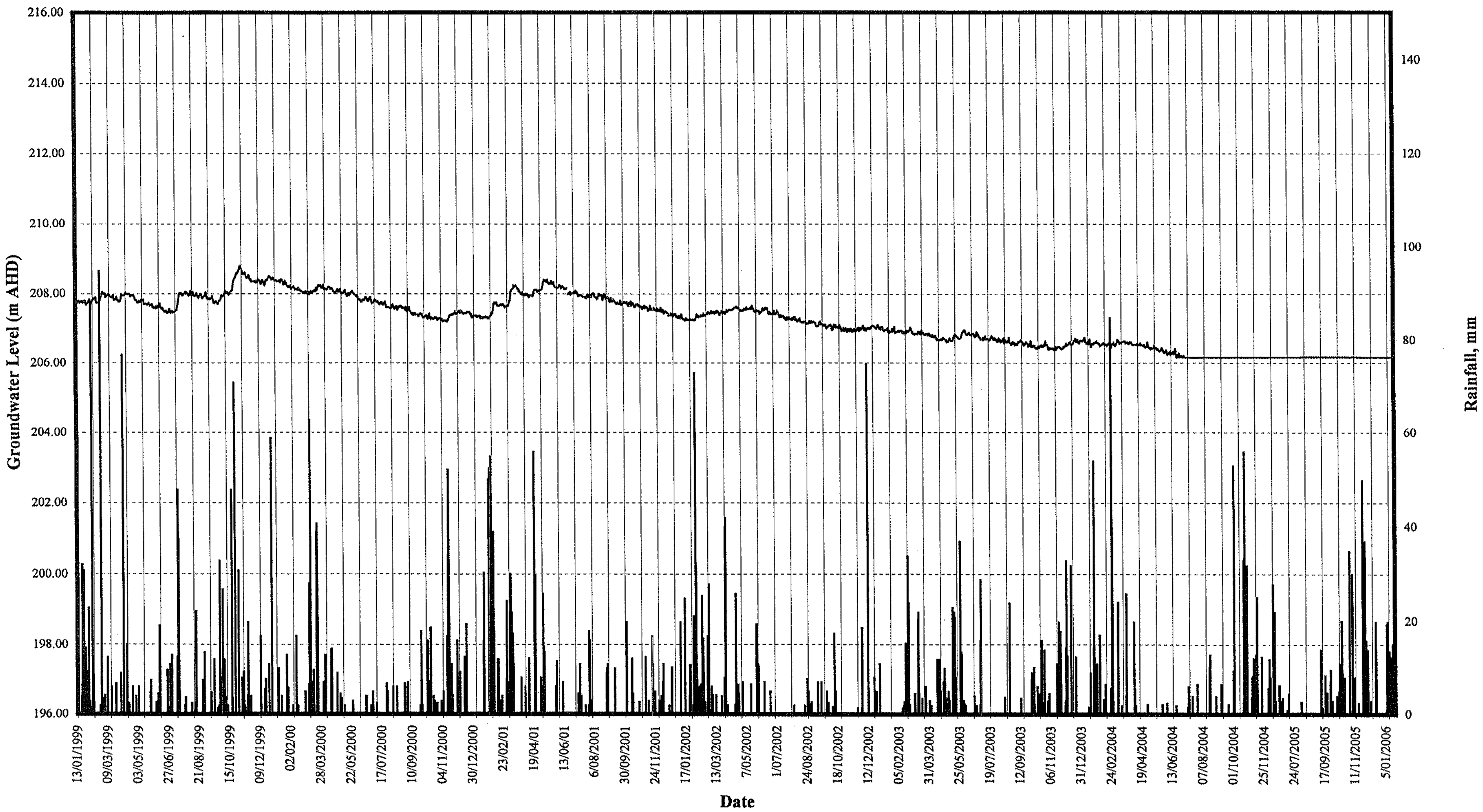
04-Aug-06
08-Aug-06
Date

H.B.Maroota Pty Ltd, Lot 2, DP228308, Maroota
Groundwater Monitoring Bore PT84MW1



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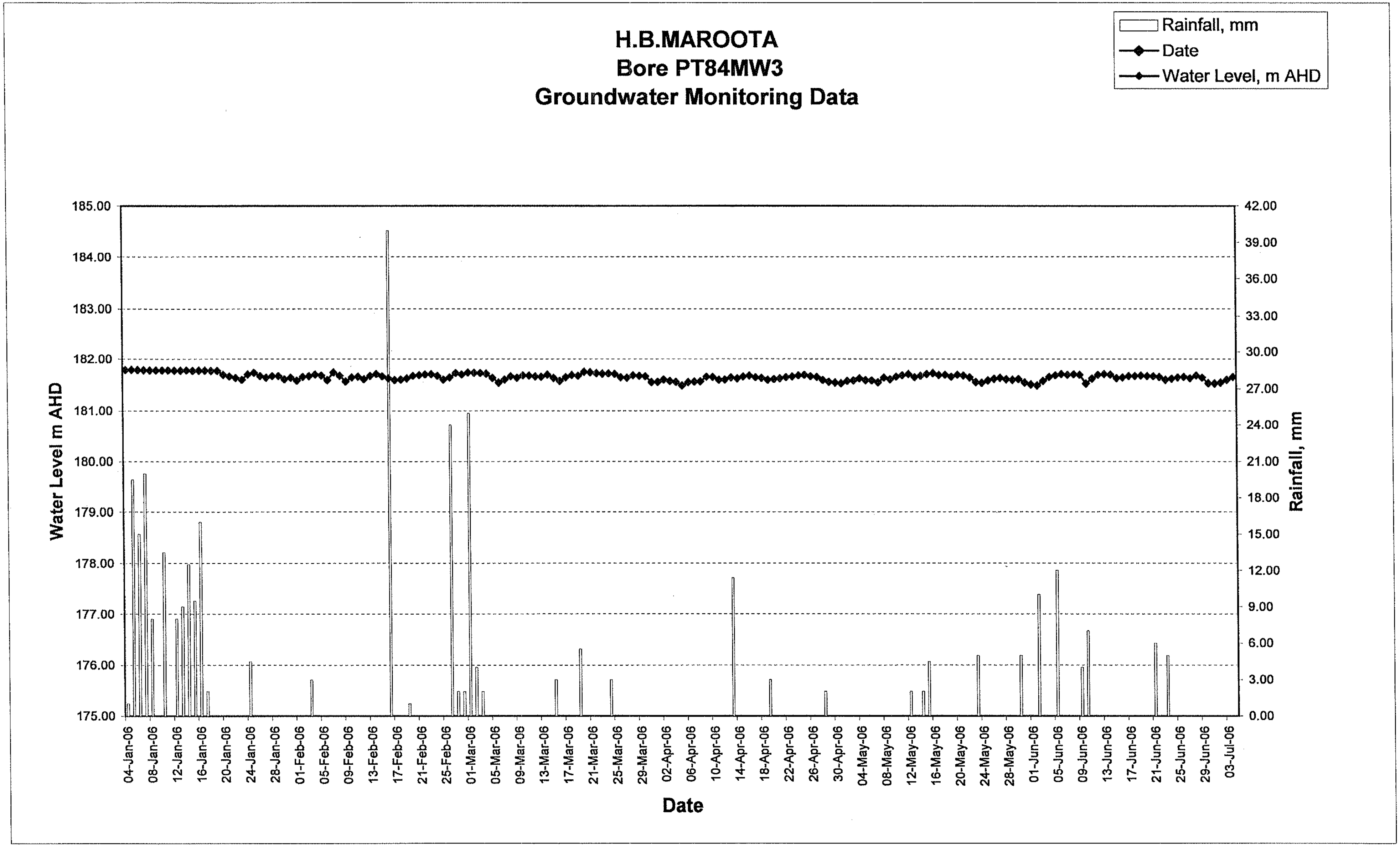
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Bore PT84MW3
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Water Level m AHD
Rainfall, mm
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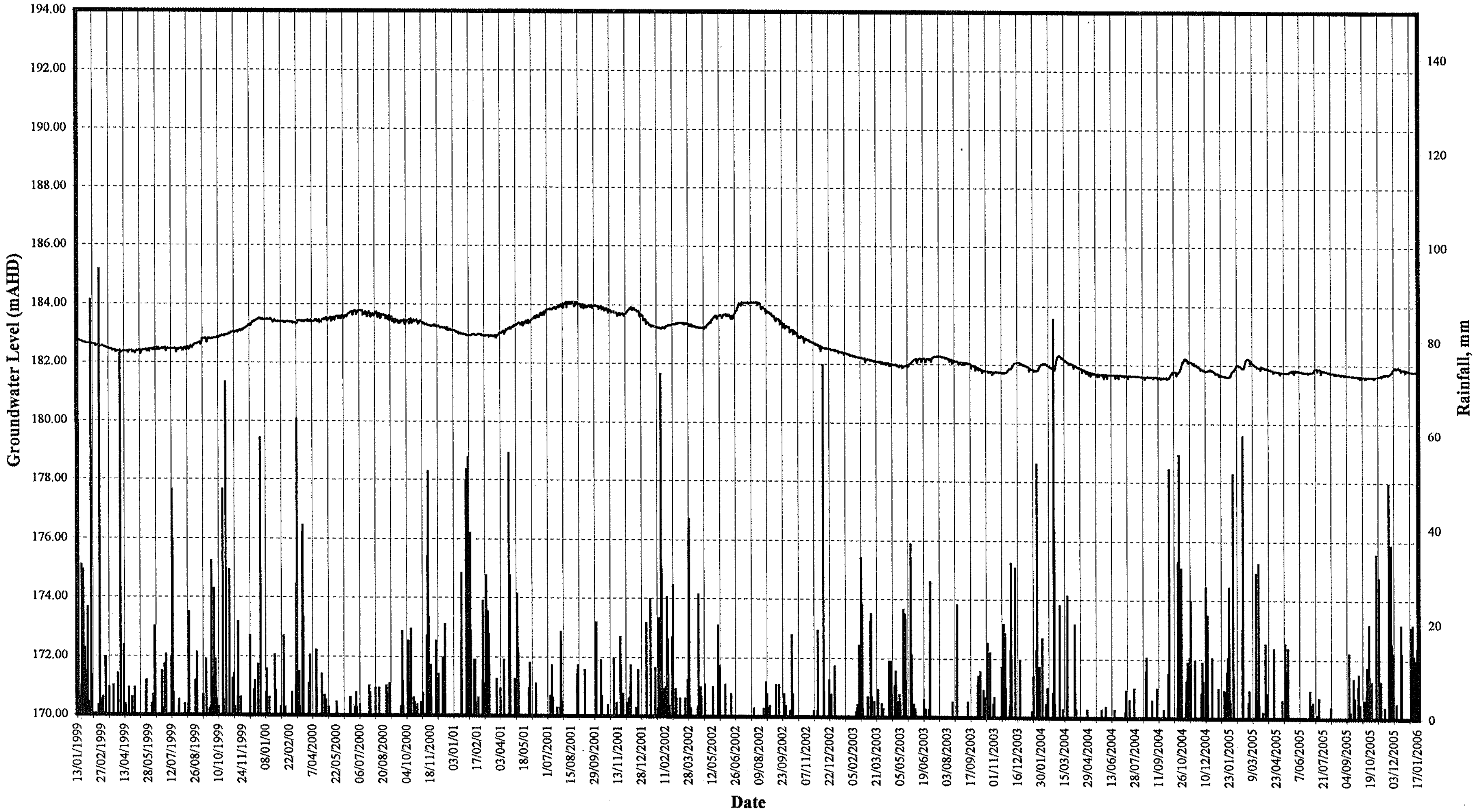
Groundwater Monitoring Bore PT84MW3



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Appendix C

Bore Hydrographs and Water Chemistry Summaries - Maroota Mining

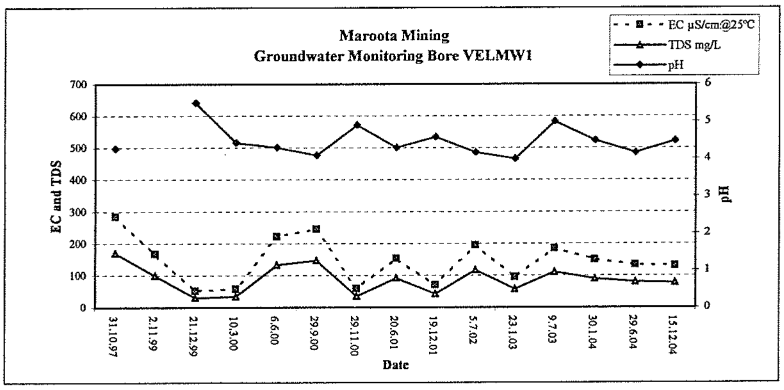
MAROOTA MINING, LOT 2, OLD TELEGRAPH ROAD, MAROOTA

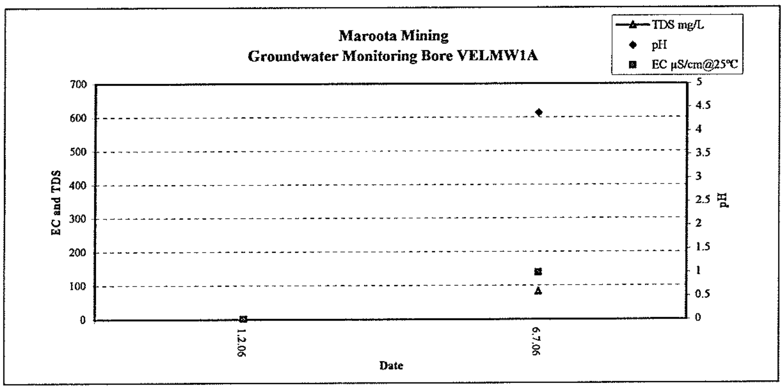
SUMMARY OF FIELD MEASUREMENTS

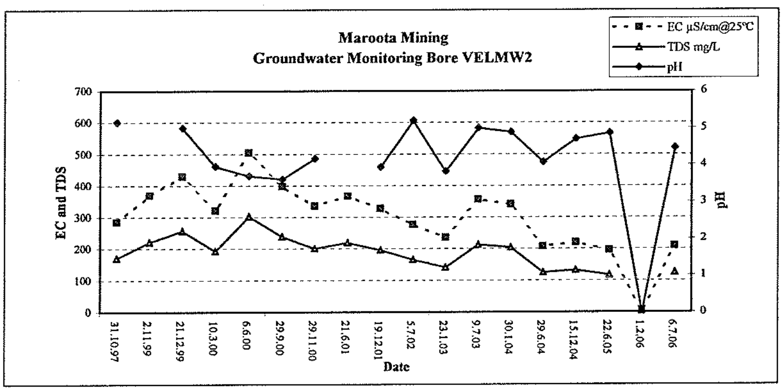
Bore	Aquifer	Date	pH	EC µS/cm@25°C	TDS mg/L	SWL m b. TOC	TOC m AHD	SWL m AHD
VELMW1	H.S	31.10.97	4.27	284	170	3.94	187.57	183.63
VELMW1	H.S	2.11.99		167	100	2.53	187.57	185.04
VELMW1	H.S	21.12.99	5.5	51	31	2.82	187.57	184.75
VELMW1	H.S	10.3.00	4.43	57	34	2.82	187.57	184.75
VELMW1	H.S	6.6.00	4.3	222	133	2.92	187.57	184.65
VELMW1	H.S	29.9.00	4.09	245	147	3.57	187.57	184.00
VELMW1	H.S	29.11.00	4.9	58	35	3.31	187.57	184.26
VELMW1	H.S	20.6.01	4.3	153	92	2.73	187.57	184.84
VELMW1	H.S	19.12.01	4.58	70	42	3.64	187.57	183.93
VELMW1	H.S	5.7.02	4.17	195	117	3.37	187.57	184.20
VELMW1	H.S	23.1.03	3.99	95	57	4.71	187.57	182.86
VELMW1	H.S	9.7.03	5	185	111	4.15	187.57	183.42
VELMW1	H.S	30.1.04	4.49	149.5	90	6.37	187.57	181.20
VELMW1	H.S	29.6.04	4.16	133	80	10.32	187.57	177.25
VELMW1	H.S	15.12.04	4.48	130	78	8.57	187.57	179.00
Average				**146.3**	**88**			
VELMW1A	H.S	1.2.06	-	-		19.86	186.36	166.50
VELMW1A	H.S	6.7.06	4.38	138	83	20.39	186.36	165.97
VELMW2	H.S	31.10.97	5.15	285	171	7.49	159.58	152.09
VELMW2	H.S	2.11.99		369	221	6.71	159.58	152.87
VELMW2	H.S	21.12.99	5	429	257	6.97	159.58	152.61
VELMW2	H.S	10.3.00	3.95	322	193	7.1	159.58	152.48
VELMW2	H.S	6.6.00	3.7	505	303	6.87	159.58	152.71
VELMW2	H.S	29.9.00	3.61	398	239	7.13	159.58	152.45
VELMW2	H.S	29.11.00	4.17	336	202	7.10	159.58	152.48
VELMW2	H.S	21.6.01		367	220	6.75	159.58	152.83
VELMW2	H.S	19.12.01	3.94	328	197	7.3	159.58	152.28
VELMW2	H.S	5.7.02	5.2	277	166	6.89	159.58	152.69
VELMW2	H.S	23.1.03	3.82	236	142	7.46	159.58	152.12
VELMW2	H.S	9.7.03	5	356	214	7.1	159.58	152.48
VELMW2	H.S	30.1.04	4.88	341	205	7.52	159.58	152.06
VELMW2	H.S	29.6.04	4.07	208	125	7.76	159.58	151.82
VELMW2	H.S	15.12.04	4.7	220	132	7.59	159.58	151.99
VELMW2	H.S	22.6.05	4.86	195	117	7.55	159.58	152.03
VELMW2	H.S	1.2.06	-	-		7.55	159.58	152.03
VELMW2	H.S	6.7.06	4.46	209	125	8.01	159.58	151.57
Average				**317**	**190**			
VELMW3	H.S	31.10.97	5.4	225	135	8.61	182.82	174.21
VELMW3	H.S	2.11.99		173	104	16.95	182.82	165.87
VELMW3	H.S	21.12.99	5	184	110	16.43	182.82	166.39
VELMW3	H.S	18.3.00				15.00	182.82	167.82
VELMW3	H.S	6.6.00	4.78	198	119	14.58	182.82	168.24
NA*	H.S	29.9.00						
VELMW3	H.S	20.12.00	6.13	166	100	14.38	182.82	168.44
VELMW3	H.S	21.6.01		157	94	13.26	182.82	169.56
VELMW3	H.S	19.12.01	4.18	156	94	13.88	182.82	168.94
VELMW3	H.S	5.7.02	4.78	142	85	13.14	182.82	169.68
VELMW3	H.S	23.1.03	4.13	145	87	13.05	182.82	169.77
VELMW3	H.S	9.7.03	5	198	119	12.48	182.82	170.34
VELMW3	H.S	30.1.04	4.56	160	96	12.73	182.82	170.09
VELMW3	H.S	29.6.04	4.76	137	82	13.51	182.82	169.31
VELMW3	H.S	15.12.04	4.09	150	90	12.77	182.82	170.05
VELMW3	H.S	22.6.05	4.01	157	94	12.64	182.82	170.18
VELMW3	H.S	1.2.06	-	-		12.62	182.82	170.20
VELMW3	H.S	6.7.06	4.01	158	95	12.9	182.82	169.92
Average				**167**	**100**			

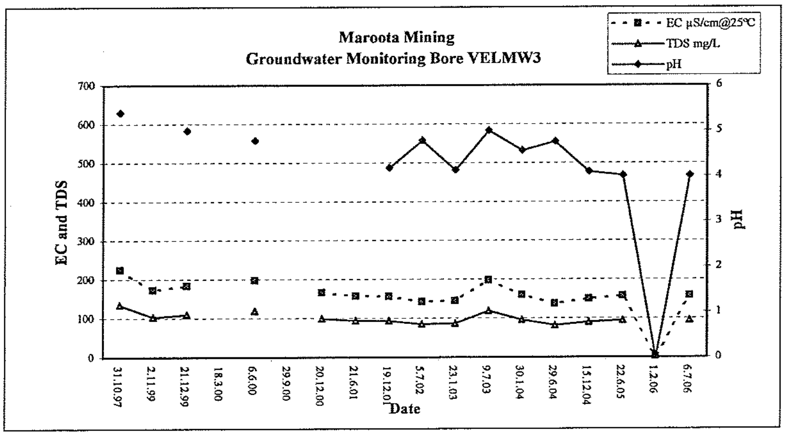
H.S. = Hawkesbury Sandstone
*Access to VELMW3 denied via Hart Place

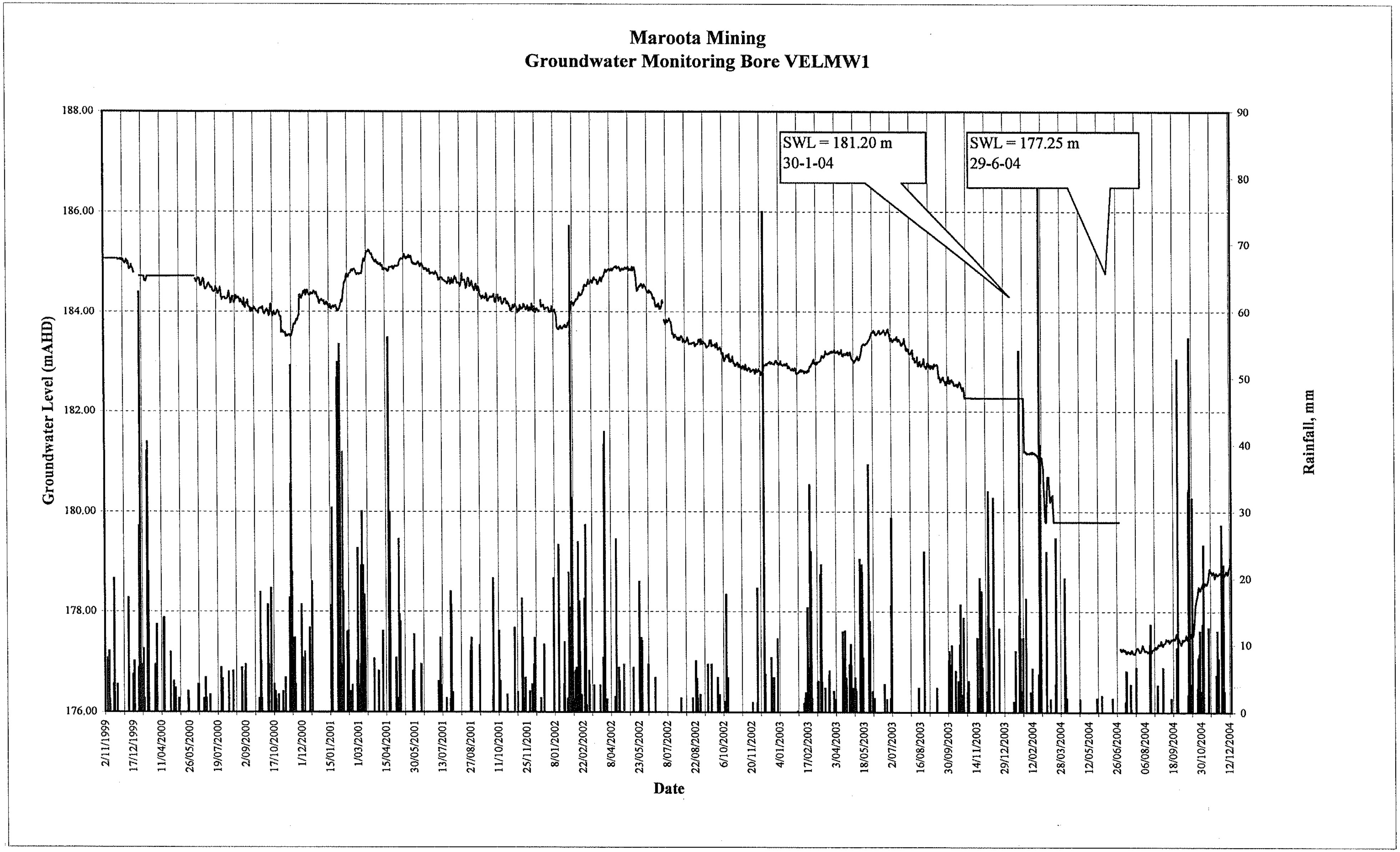
Maroota Mining - Groundwater Monitoring Data Plots











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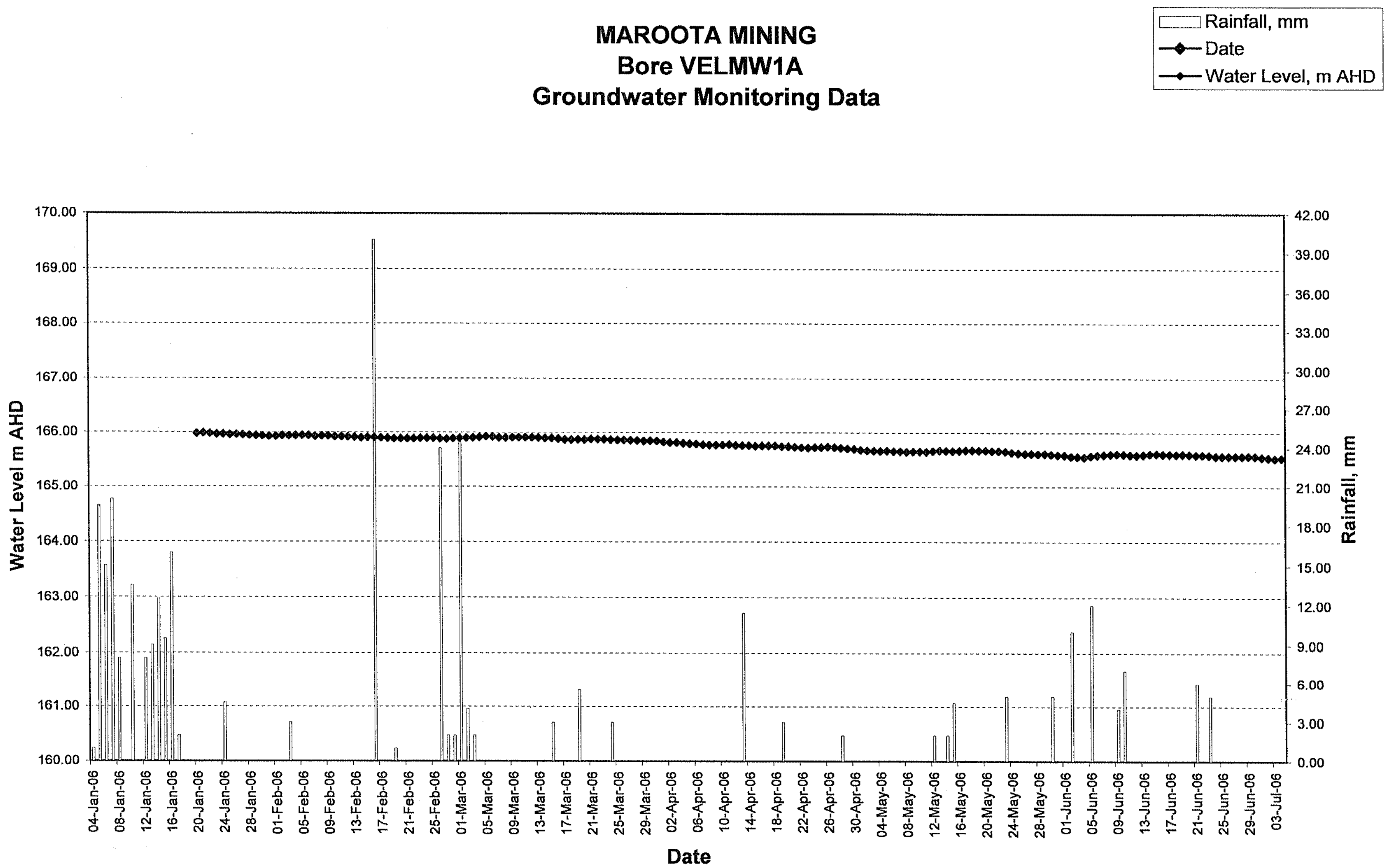
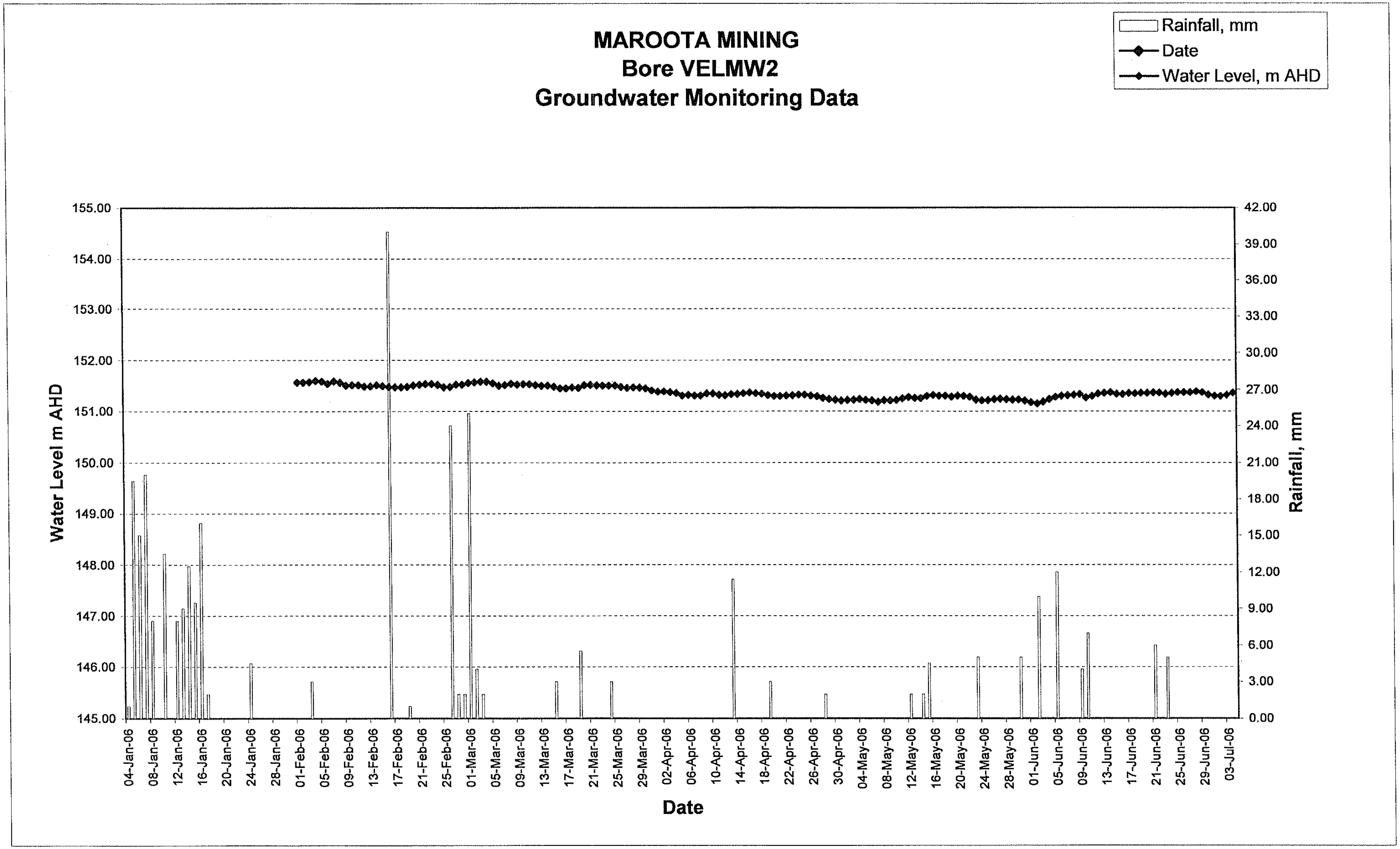
MAROOTA MINING
Bore VELMW1A
Groundwater Monitoring Data





MAROOTA MINING
Bore VELMW2
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Water Level m AHD
Rainfall, mm
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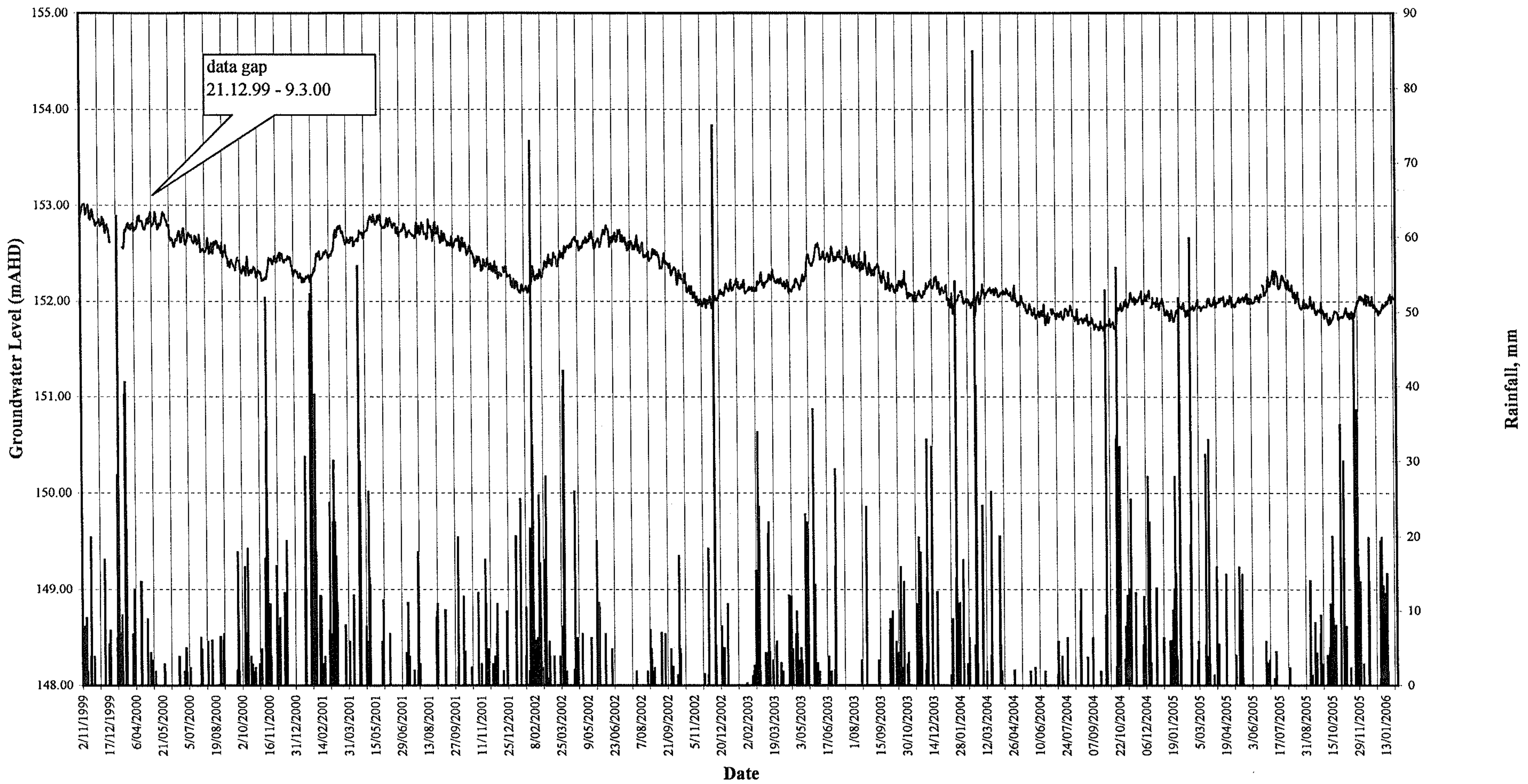
Maroota Mining
Groundwater Monitoring Bore VELMW2



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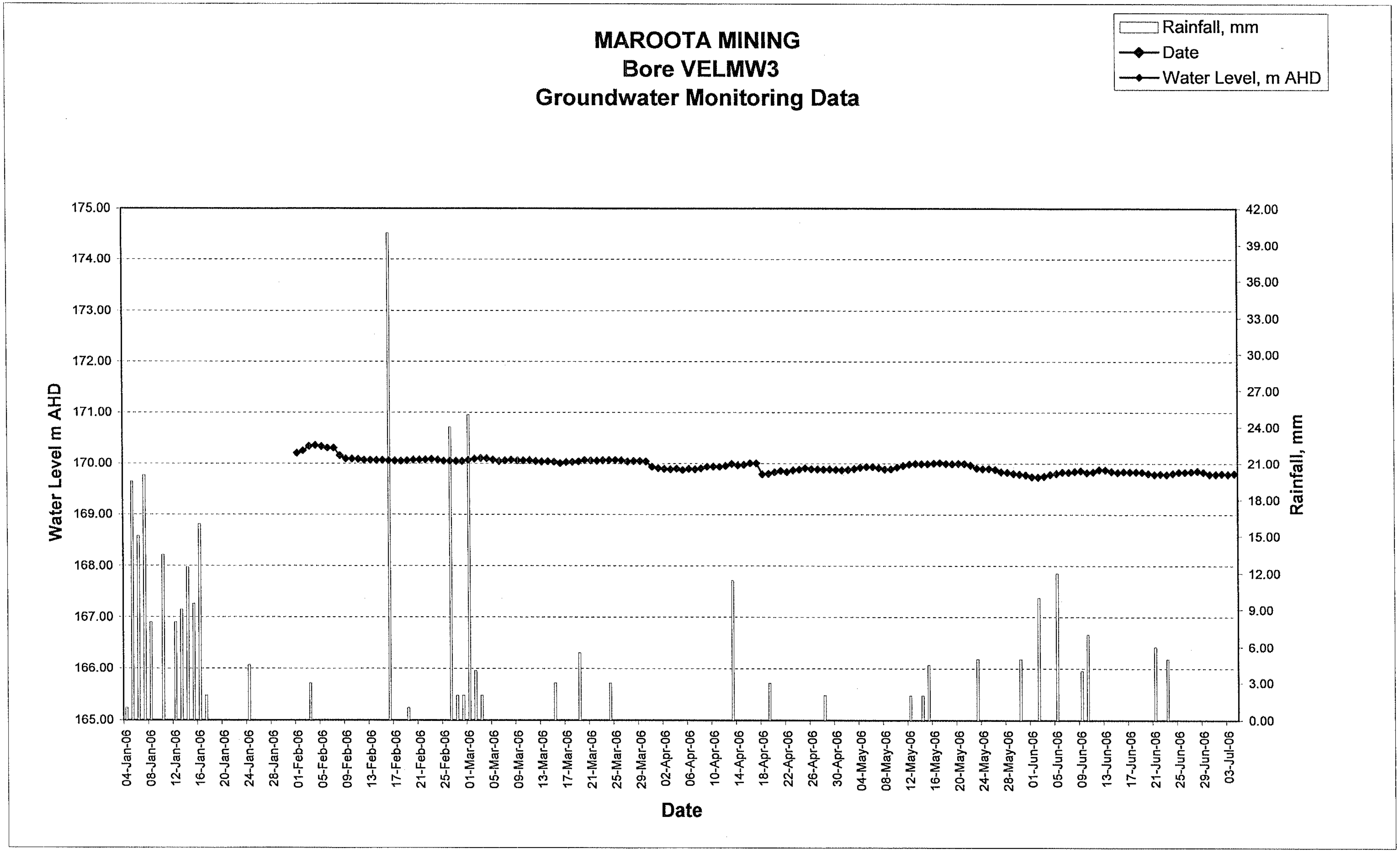
MAROOTA MINING
Bore VELMW3
Groundwater Monitoring Data
Rainfall, mm
Date
Water Level, m AHD
Water Level m AHD
175.00
174.00
173.00
172.00
171.00
170.00
169.00
168.00
167.00
166.00
165.00
Rainfall, mm
42.00
39.00
36.00
33.00
30.00
27.00
24.00
21.00
18.00
15.00
12.00
9.00
6.00
3.00
0.00
04-Jan-06
08-Jan-06
12-Jan-06
16-Jan-06
20-Jan-06
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29-Mar-06
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28-May-06
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13-Jun-06
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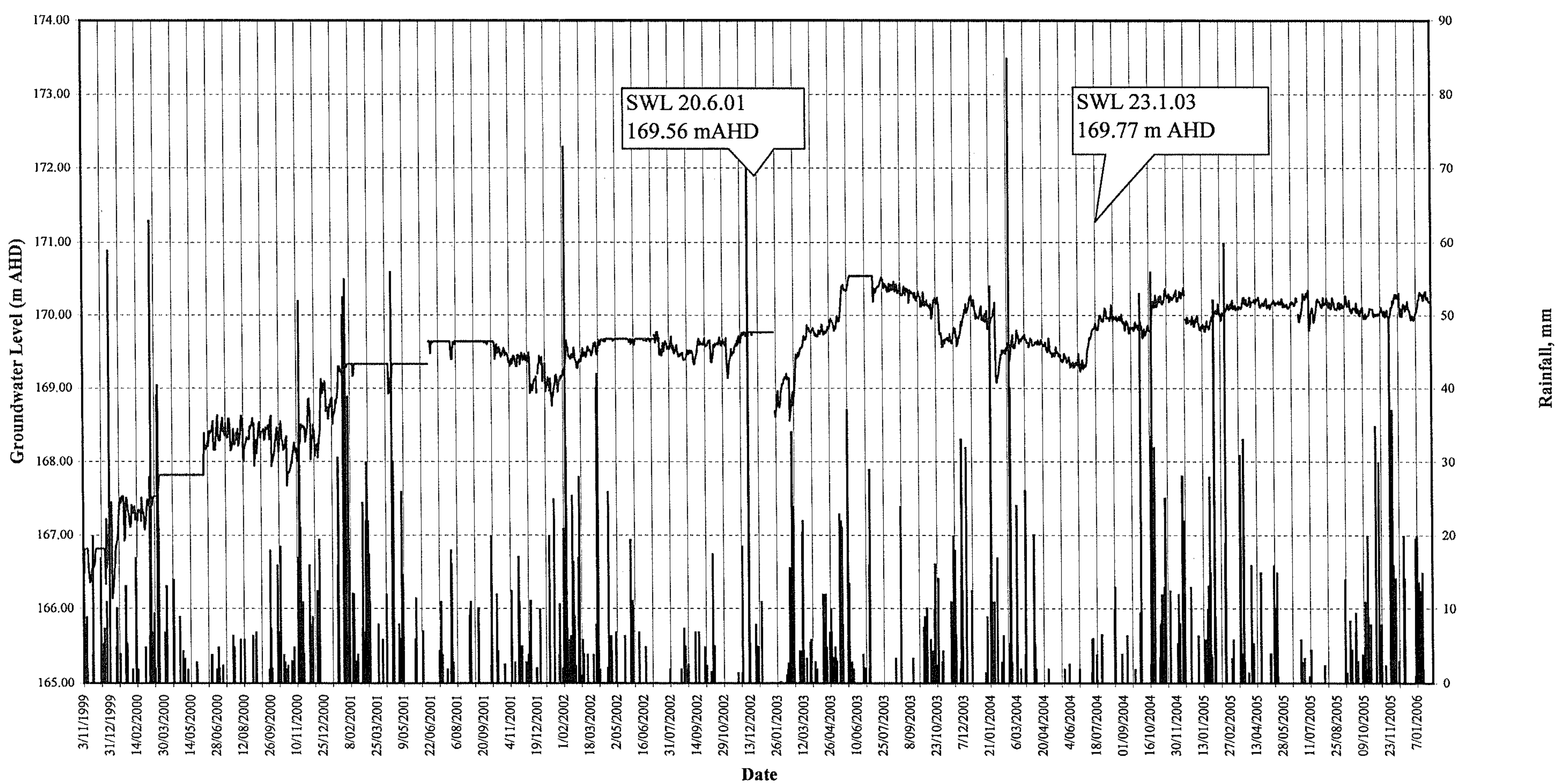
25-Jun-06
29-Jun-06
03-Jul-06
Date

Maroota Mining
Groundwater Monitoring Bore VELMW3



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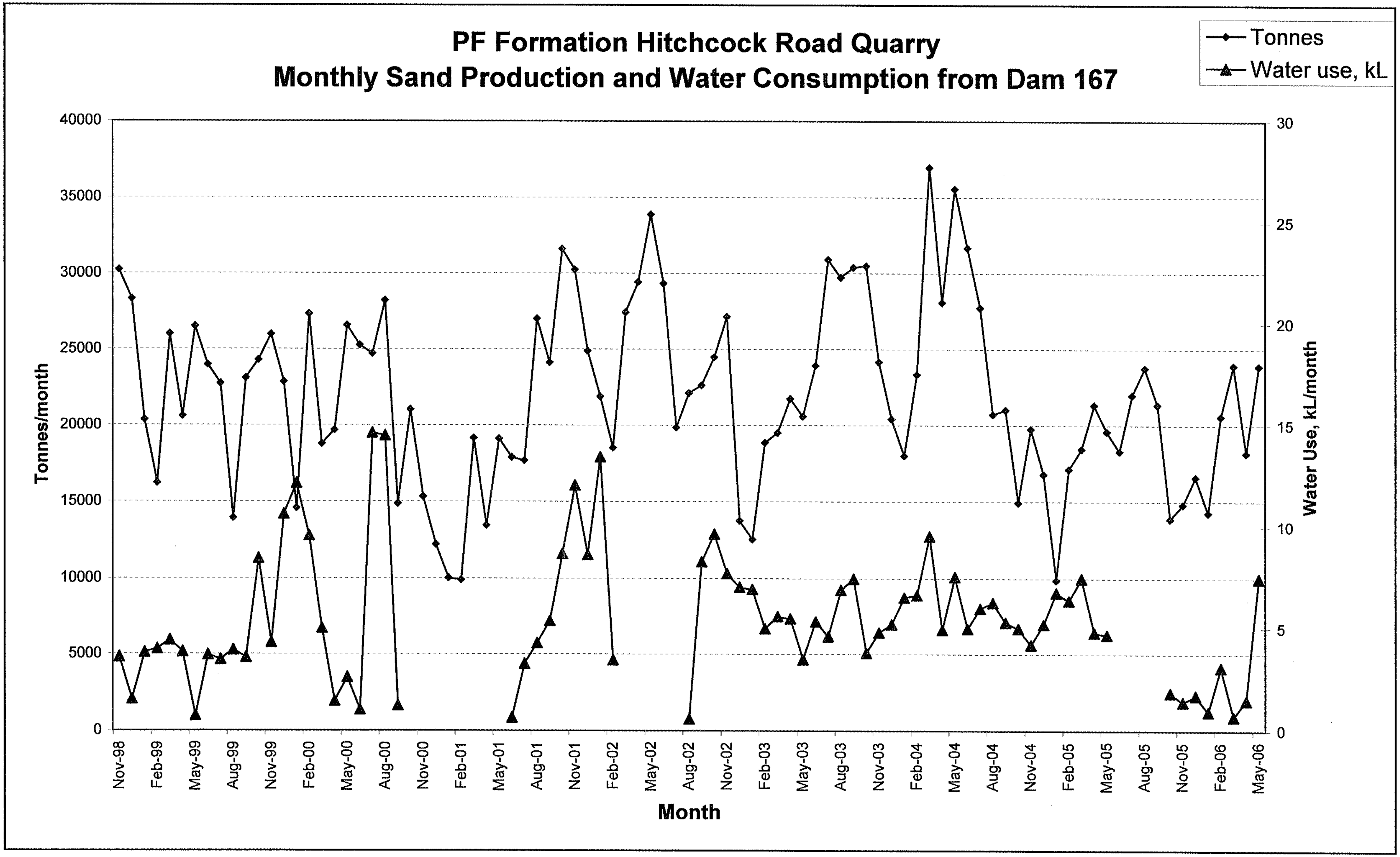
Appendix D

Sand Production and Water Consumption from Dam 1967


PF Formation Hitchcock Road Quarry
Monthly Sand Production and Water Consumption from Dam 167
Tonnes
Water use, kL
Tonnes/month
Water Use, kL/month
Month
40000
35000
30000
25000
20000
15000
10000
5000
0
30
25
20
15
10
5
0
Nov-98
Feb-99
May-99
Aug-99
Nov-99
Feb-00
May-00
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Nov-05
Feb-06
May-06

3

TECHNICAL PAPER

TRAFFIC AND ACCESS

Proposed Hitchcock Road Sand Extraction and Rehabilitation Project Traffic and Access

October 2006

PF Formation

Parsons Brinckerhoff Australia Pty Limited ACN 078 004 798 and Parsons Brinckerhoff International (Australia) Pty Limited ACN 006 475 056 trading as Parsons Brinckerhoff ABN 84 797 323 433

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Signed:	....
Date:	20 July 2006..
Distribution:	Client, Project File ....

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1. Traffic and access

PF Formation is proposing to submit a development application to the Department of Planning to undertake a major sand extraction operation on land located at the intersection of Old Northern Road and Wisemans Ferry Road, Maroota. The site is located approximately 50 kilometres to the north-west of the Sydney Central Business District.

This site has been operated for sand extraction since the 1980s, and the proposal includes the following:

- continuation of sand extraction within the existing site boundary
- increasing the area subject to extraction beyond the present boundary and
- increasing the depth of extraction over the whole site.

The current operations are undertaken in compliance with consent orders issued by the NSW Land and Environment Court in July 1998. The present application does not seek any significant change to the existing consent which would affect traffic impacts.

A maximum of 400,000 tonnes of tertiary sand would be extracted from the site in any year, which represents no change to the current consent. There would therefore be no change in the generation of truck traffic on local roads as a result of the proposal.

All the tertiary sand extracted from the site would be transferred by articulated dump trucks to the existing plant located at the northern end of the site. The sand would then be mixed with water and transported via pipeline to the central wash plant located on Lot 198 approximately one kilometre to the west.

In addition to this proposal, PF Formation is seeking to lodge a separate development application for the Lot 198 Old Northern Road site. That proposal would propose extraction of sand to a depth of between five and seven metres, depending on the quality of the material.

1.1 Existing road network and traffic conditions

1.1.1 Wisemans Ferry Road

Wisemans Ferry Road is a two lane, two-way rural road with a posted speed of 70 kilometres per hour in the vicinity of the site entrance. The quarry site is accessed through an existing intersection on Wisemans Ferry Road, located approximately 400 metres south of the Old Northern Road intersection. This intersection provides access to both the western section (Lot 198) and eastern section (Hitchcock Road) of the quarry site. Wisemans Ferry Road provides access to Pitt Town and Windsor to the south-west and connects to Old Northern Road to the north-west of the site.

Table 1.1 shows the changes in traffic volumes from 1987 to 2002 on Wisemans Ferry Road, south of Old Northern Road. The annual average daily traffic (AADT) in 2002 was 1,745 vehicles per day (vpd). Over the 15 year period, the AADT on Wisemans Ferry Road increased at a rate of less than 1 percent per annum, well below the metropolitan average.

Since 1999, AADT on Wisemans Ferry Road has actually declined at a rate of 1.3 percent per annum in the most recent three year period.

Table 1.1: Traffic on Wisemans Ferry Road, south of Old Northern Road (AADT)

Year	Annual Average Daily Traffic[1]
1987	1,663
1989	1,481
1991	1,573
1993	1,636
1996	–
1999	1,820
2002	1,745

Source: Traffic Volume Data for Sydney Region, RTA, 2002

Full traffic classification counts were conducted on Wisemans Ferry Road north of the site entrance. These data were collected for a week between 17 July 2004 and 23 July 2004. The traffic counts show that an average daily traffic (seven-day average) of 1,505 vehicles per day was recorded at this point on Wisemans Ferry Road. This is equivalent to 1,862 axle pairs per day, which is slightly higher than the AADT figure reported by the RTA for 2002. While this may indicate an increase in traffic volumes on Wisemans Ferry Road, the difference could also be attributed to seasonal variation in the traffic flows.

From the data on Wisemans Ferry Road, the two-way peak hour traffic for an average weekday occurred between 0800 to 0900 and 1600 to 1700 during the morning and evening peak periods respectively. The peak hour volumes are summarised in Table 1.2 below.

Table 1.2: Average weekday peak hour volumes on Wisemans Ferry Road, north of the site entrance

	Northbound	Southbound	Total
Morning Peak (0800 to 0900)	78 (9.8%)	48 (6.1%)	126 (8.0%)
Evening Peak (1600 to 1700)	52 (6.6%)	88 (11.2%)	140 (8.9%)

At this location, the average weekday traffic volume is 1,578 vehicles per day. The classification count shows that of the 1,578 vehicles:

- 79 percent (or 1,249 vehicles) were light vehicles including cars, vans, car towing boat etc (Classes 1 and 2)
- 13 percent (or 200 vehicles) were rigid trucks and buses (Classes 3, 4 and 5)
- 8 percent (or 121 vehicles) were articulated trucks with three to six axles (Classes 6, 7, 8 and 9) and
- less than one percent (or 7 vehicles) were B-Doubles including road trains (Classes 10, 11 and 12).

[1] This figure is obtained by counting the number of axle pairs (not the number of vehicles) passing a given point over a full year period and dividing this number by 365 days. Despite this, this figure is quoted as vehicles per day (vpd) rather than axle pairs. With the exception of AADT, all vehicle volumes quoted this is report are actual number of vehicles unless stated otherwise.

While overall traffic volumes were similar in both directions, the data show that there were an additional 47, or 94 percent of Class 3 vehicles (two axles trucks) travelling southbound compared to that class in northbound traffic. There was a similar reduction in the number of Class 1 vehicles (passenger cars) recorded for the southbound traffic. It should be noted that Class 3 vehicles (two axle trucks) had the second highest vehicle count for both directions followed by Class 9 vehicles (six axle articulated trucks). The highest number of vehicles counted was Class 1 vehicles (passenger cars).

The average weekday traffic by vehicle class for northbound, southbound and two-way combined traffic on Old Northern Road, south of Wisemans Ferry Road, are represented graphically in Figure 1.1 to Figure 1.3 respectively.

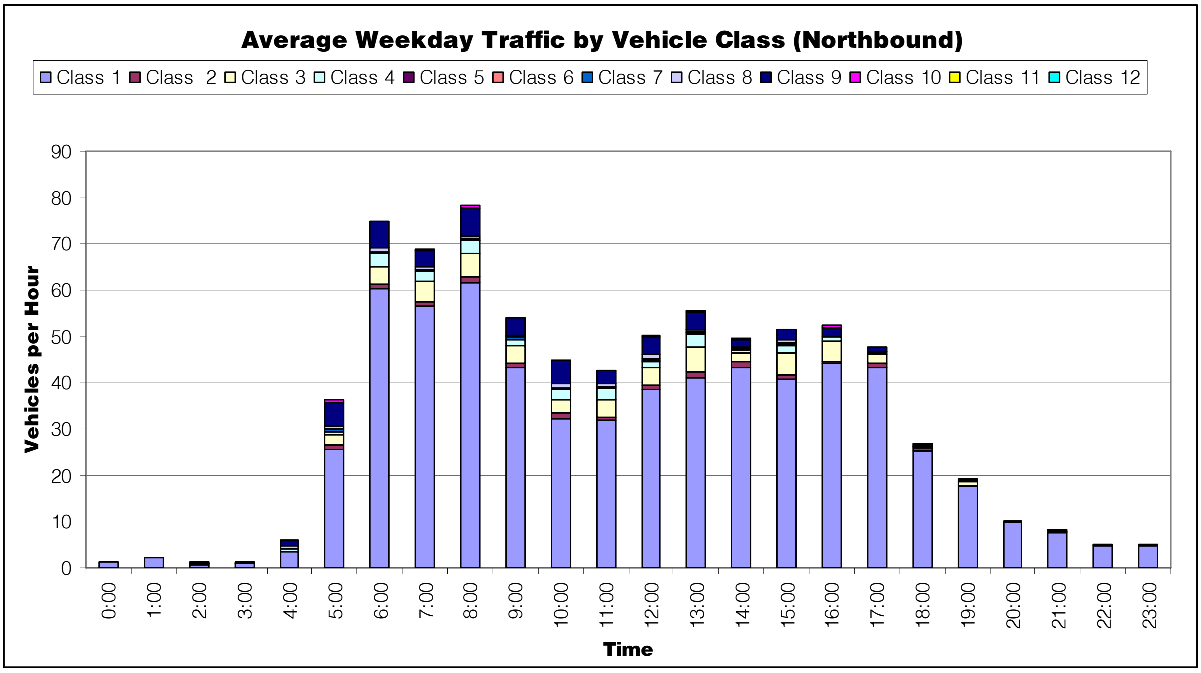

Figure 1.1: Average weekday traffic by vehicle class (northbound) on Wisemans Ferry Road, north of site entrance

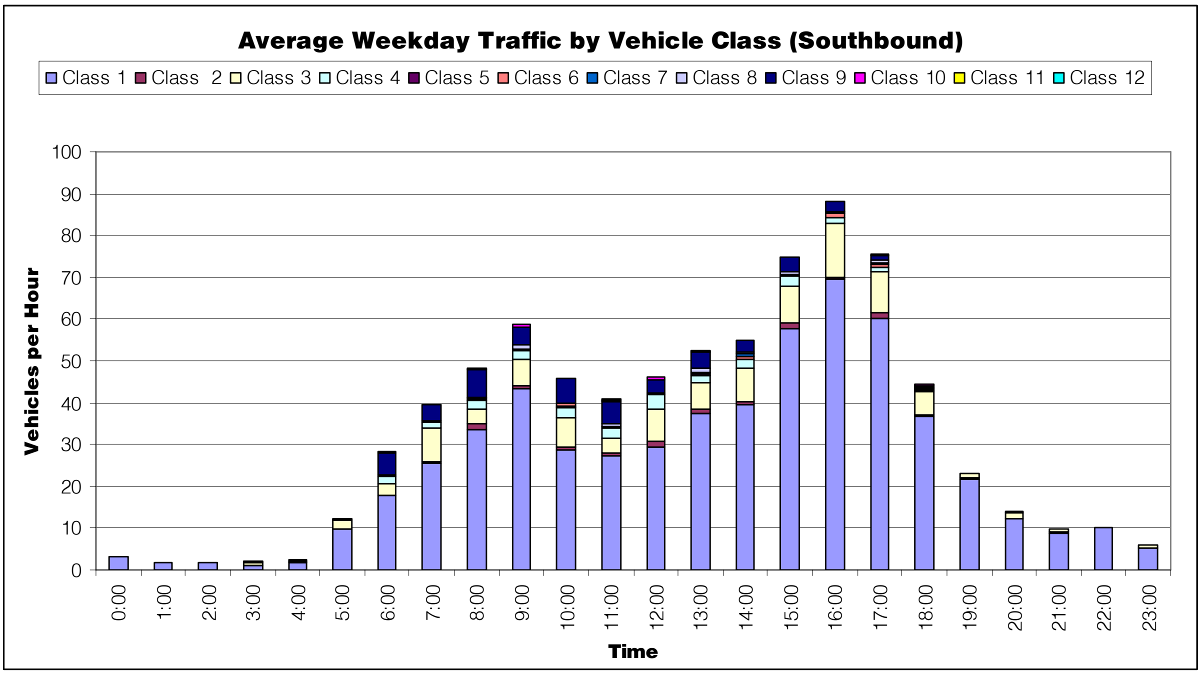

Figure 1.2: Average weekday traffic by vehicle class (southbound) on Wisemans Ferry Road, north of site entrance

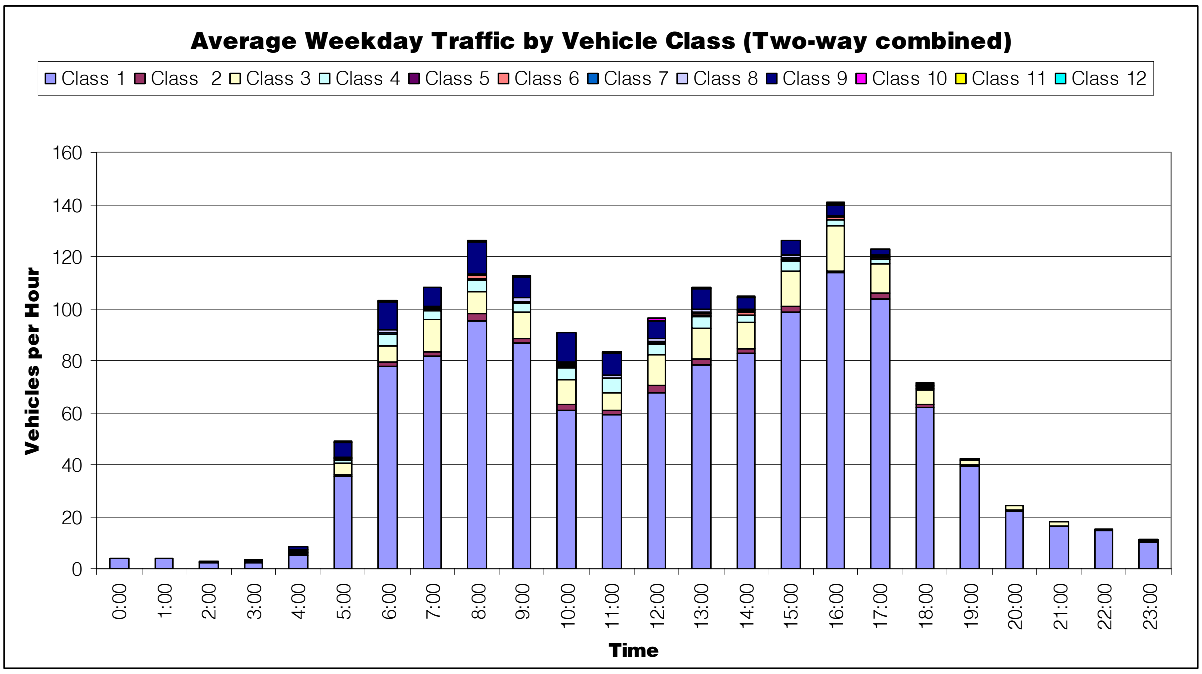

Figure 1.3: Average weekday traffic by vehicle class (two-way combined) on Wisemans Ferry Road, north of site entrance

These figures indicate a slight bias toward northbound traffic during the morning peak period and the reverse is true for the evening peak period where there was a slight bias toward southbound traffic. It should be noted that the number of Class 3 vehicles (two axle trucks) are the highest during the evening peak period and the number of Class 9 vehicles (six axle articulated trucks) are the highest following the morning peak period.

1.1.2 Old Northern Road

Old Northern Road is a two lane, two-way rural road with a posted speed of 70 kilometres per hour in the vicinity of the Wisemans Ferry Road intersection. Maroota Public School is located some 600 metres to the north of the intersection. Speeds are limited to 40 kilometres per hour in the school zone during school periods. There is a posted speed limit of 90 kilometres per hour to the south of the intersection. Old Northern Road provides access to Wisemans Ferry to the north, Glenorie and Dural to the south.

Table 1.3 shows the changes in traffic volumes from 1987 to 2002 on Old Northern Road, south of Wisemans Ferry Road. Annual average daily traffic in 2002 was 2,212 vehicles per day. Annual average daily traffic on Old Northern Road has increased at a rate of 1.5 percent per annum over the 15 year period.

Table 1.3: AADT on Old Northern Road, south of Wisemans Ferry Road

Year	Annual Average Daily Traffic
1987	1,806
1989	1,502
1991	1,677
1993	1,996
1996	-
1999	2,108
2002	2,212

Source: Traffic Volume Data for Sydney Region, RTA, 2002

Full classification counts were conducted on Old Northern Road, south of Wisemans Ferry Road. These data were collected for the week between 17 July 2004 and 23 July 2004. The traffic counts generate an average daily traffic (seven-day average) of 1,837 vehicles per day for Old Northern Road. This is equivalent to 2,178 axle pairs per day, which is comparable with the annual average daily traffic figure for 2002. There has been no significant increase in traffic over the past two years.

From the data collected on Old Northern Road, the two-way peak hour traffic for an average weekday occurred from 0700 to 0800 and 1600 to 1700 during the morning and evening peak periods respectively. The peak hour volumes are summarised in Table 1.4.

Table 1.4: Average weekday peak hour volumes on Old Northern Road, south of Wisemans Ferry Road

	Northbound	Southbound	Total
Morning Peak (0700 to 0800)	102 (10.9%)	47 (7.9%)	149 (7.9%)
Evening Peak (1600 to 1700)	61 (6.5%)	111 (11.5%)	172 (9.1%)

At this location, the average weekday traffic volume was 1,895 vehicles per day. The classification count shows that of the 1,895 vehicles:

- 83 percent (or 1,567 vehicles) were light vehicles including cars, vans, car towing boat etc (Classes 1 and 2)
- 11 percent (or 209 vehicles) were rigid trucks and buses (Classes 3, 4 and 5)

- 6 percent (or 112 vehicles) were articulated trucks with three to six axles (Classes 6, 7, 8 and 9) and
- less than one percent (or 6 vehicles) were B-Doubles including road trains (Classes 10, 11 and 12).

The vehicle composition of traffic was similar in both directions, with northbound carrying slightly more articulated trucks during the day. It should be noted that Class 3 vehicles (two axle trucks) had the second highest vehicle count for both directions, followed by Class 9 vehicles (six axle articulated trucks). The highest number of vehicles counted was Class 1 vehicles (passenger cars).

The average weekday traffic by vehicle class for northbound, southbound and two-way combined traffic on Old Northern Road, south of Wisemans Ferry Road are represented graphically in Figure 1.4 to Figure 1.6 respectively.

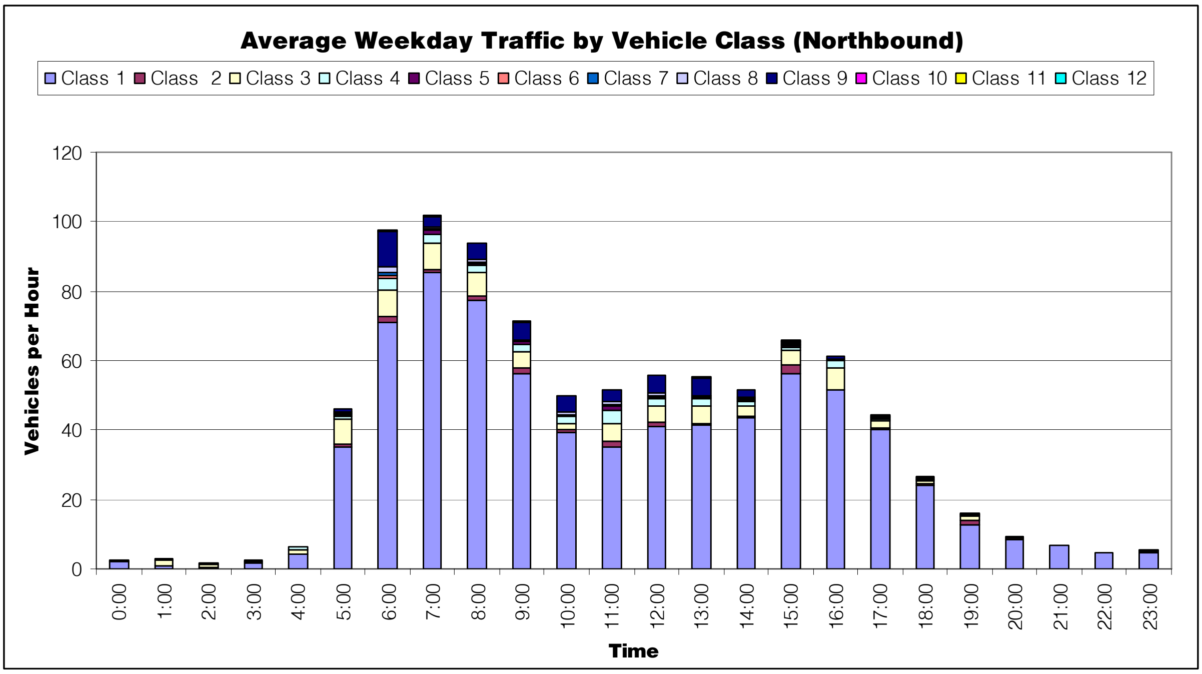

Figure 1.4: Average weekday traffic by vehicle class (northbound) on Old Northern Road, south of Wisemans Ferry Road

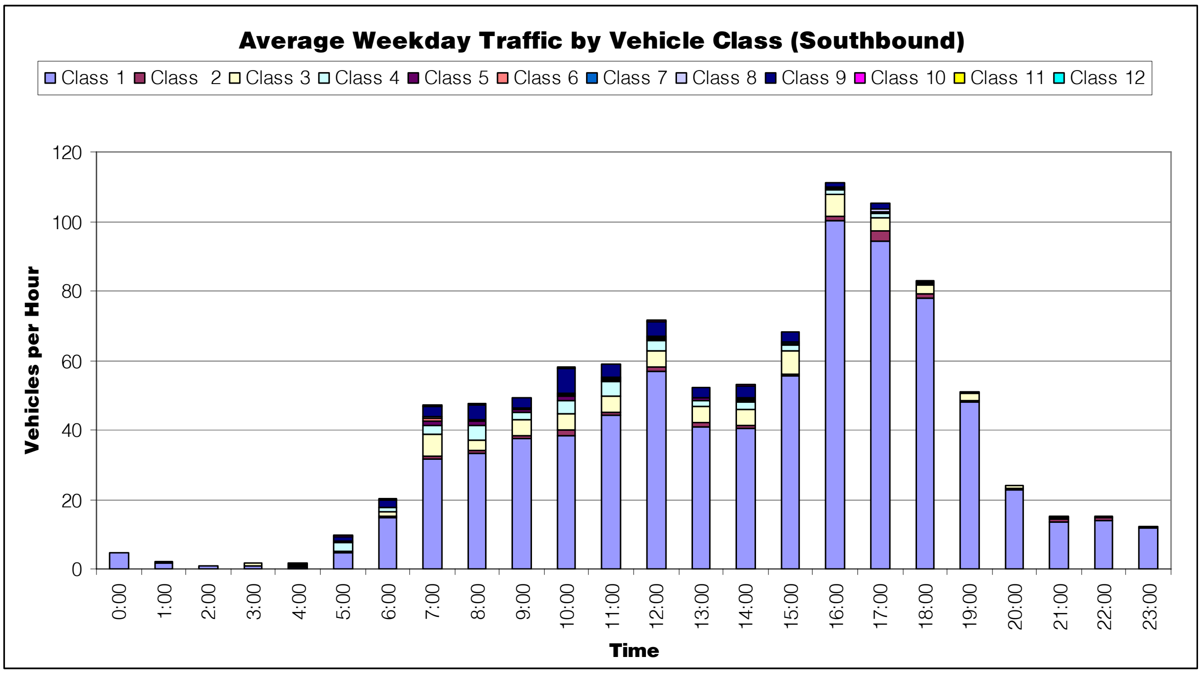

Figure 1.5: Average weekday traffic by vehicle class (southbound) on Old Northern Road, south of Wisemans Ferry Road

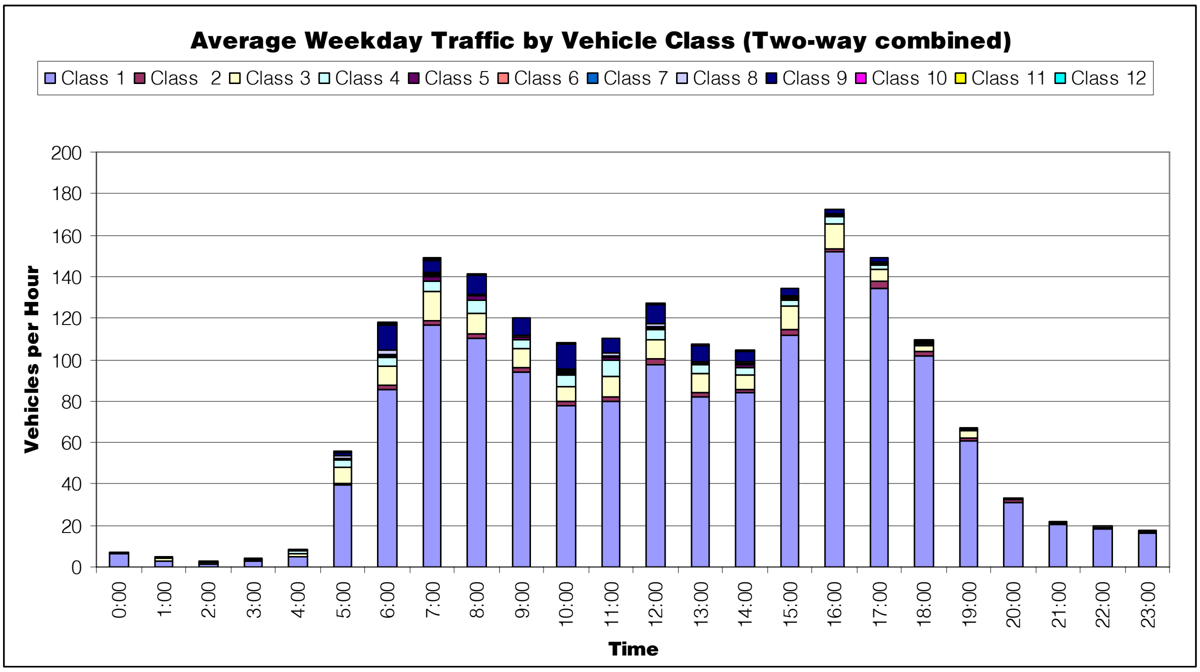

Figure 1.6: Average weekday traffic by vehicle class (two-way combined) on Old Northern Road, south of Wisemans Ferry Road

The figures reveal a distinctive tidal flow during the peak periods, with a bias towards the northbound traffic during the morning peak period, with the reverse being true for the evening peak period where the bias was towards the southbound traffic. It should be noted that the number of Class 3 vehicles and Class 9 vehicles (two axle trucks and six axle articulated trucks respectively) were the highest before the morning peak period.

1.1.3 Intersection turning movements

Full intersection turning movement counts were conducted at two key intersections near the site along Wisemans Ferry Road, at Old Northern Road and at the site entrance. The counts were conducted on 22 July 2004 for four hours covering the morning peak period (from 0500 to 0900) and for three hours covering the evening peak period (from 1600 to 1900).

At the intersection of Wisemans Ferry Road with the Quarry site entrance, the morning peak hour occurred between 0800 and 0900. At the intersection of Wisemans Ferry Road with Old Northern Road, the morning peak hour was determined to occur from 0715 to 0815. The evening peak hour for both intersections occurred from 1600 to 1700.

It is noted that the morning peak hour for the heavy vehicle movements at the Quarry site entrance occurs from 0600 to 0700, which is earlier than the morning peak hour determined for all vehicles. As the variation in the heavy vehicle movements was minor compared to the light vehicle movements during the surveyed period, the morning peak hour for the light vehicle movements was determined to be more significant and is used in this report.

The surveyed morning and evening peak hour turning movement volumes at the two intersections are shown in Figure 1.7. The heavy vehicle volumes are given in parentheses.

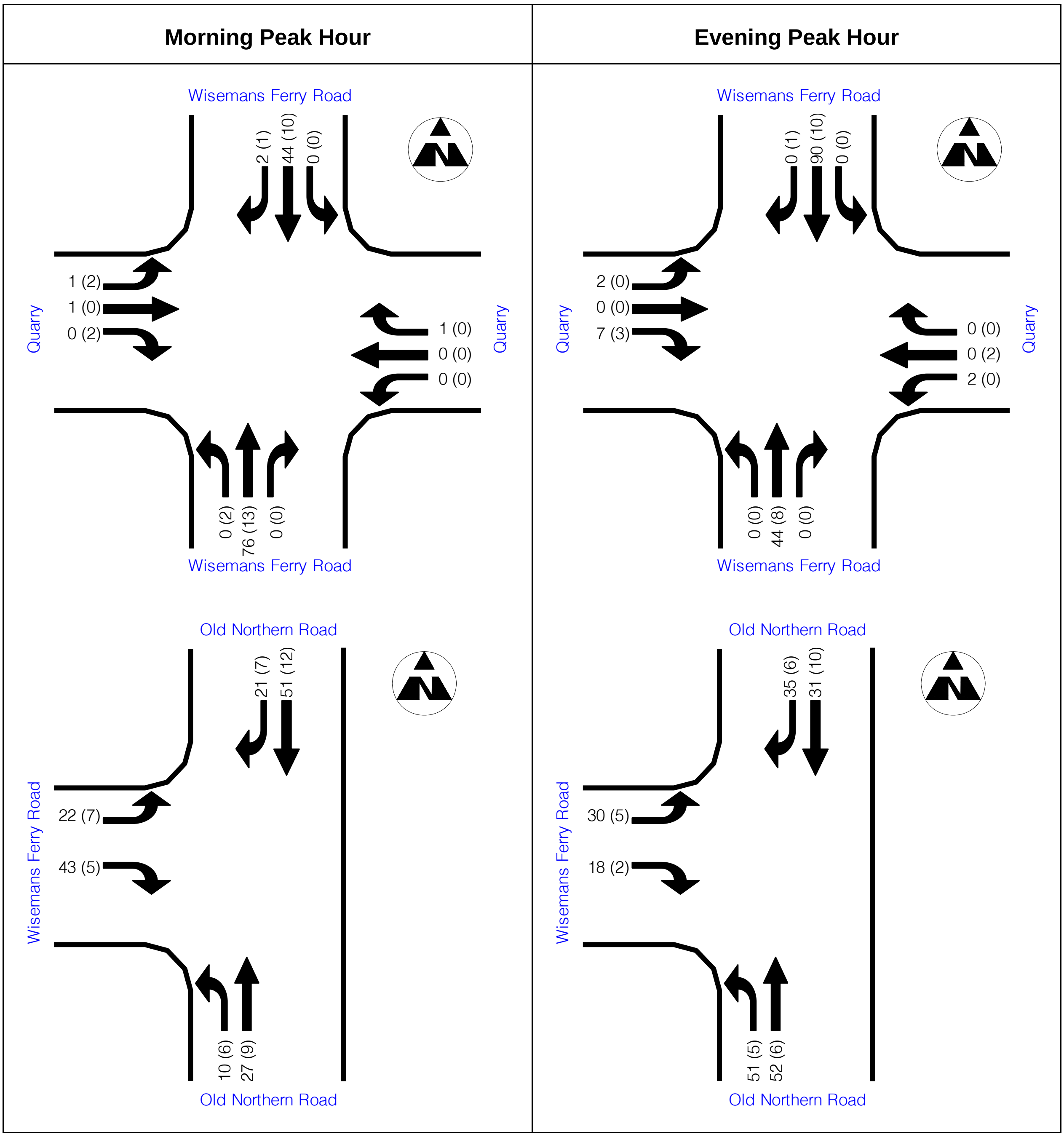

Figure 1.7: Existing intersection turning movement volumes (vph)

Intersection analyses were undertaken for two intersections using the intersection modelling software known as SIDRA. The intersection assessment results are summarised in Table 1.5. Appendix A provides a brief background discussion on the criteria used for assessing intersection performance.

Table 1.5: Existing condition intersection assessment results

Intersection Name	Peak Period	Ints Control Type	Ints DoS	Delay (Sec)	Ints LoS	Max Queue (m)
Wisemans Ferry Rd/Old Northern Rd	Morning	Priority	0.11	11	A	4
	Evening	Priority	0.08	11	A	3
Quarry Site Entry/ Wisemans Ferry Rd	Morning	Priority	0.07	10	A	1
	Evening	Priority	0.07	10	A	1

The two intersections analysed are currently operating satisfactorily with a level of service A in both peak periods. The intersection results indicate that both intersections currently operate with minimal delays and virtually no queues form in either peak periods analysed. The results produced by SIDRA correlate very well with on-site observation of the current intersection performance.

1.2 Site access and internal haulage road

The quarry site is accessed through an existing intersection, purposely built to accommodate heavy vehicle movements, on Wisemans Ferry Road, located approximately 400 metres south of the Old Northern Road intersection. This intersection provides access to both the western section (Lot 198) and eastern section (Hitchcock Road) of the quarry site.

As the proposed changes to sand extraction occur mainly within the existing site boundaries, any additional traffic generated would utilise the existing access on Wisemans Ferry Road.

The majority of traffic generated by the proposal to use Wisemans Ferry Road would be from the western site (Lot 198), as there will be no transport of tertiary sand by truck from the site to the central wash plant, except during periods of routine maintenance or as a result of plant/pipeline breakdown.

1.3 Site traffic movements

The existing consent allows for 200 laden trucks (or 400 truck movements) per day to be generated as a result of all PF Formation's sand extraction activities in Baulkham Hills. The site operates from 0600 to 1800, Monday to Saturday. This proposal does not seek to amend the consent conditions limiting the daily number of truck movements allowed.

Currently, there are between 50 and 60 laden truck movements per day generated by activities on the Hitchcock Road site. It is expected that future development on this site would not significantly increase the daily generation of laden truck movements although this would vary depending on market conditions. It is anticipated that up to an additional 20 laden trucks could be generated in each direction if the consent is extended to permit the processing of materials transported from sites other than the Hitchcock Road or Lot 198 developments. Depending on the material type, the incoming trucks would be processed at either the Hitchcock Road or the Lot 198 site.

In addition to the Hitchcock Road development, the development of Lot 198 would generate a maximum of 10 laden trips per day over the period from 2005 to 2010 onto Wisemans Ferry Road.

Due to the variability in market demand over time and the low volume of heavy vehicles at the quarry site entrance, no specific pattern can be established for the truck movements in the area. In this report, it is assumed that there is a 50:50 split in truck movements between Old Northern Road and Wisemans Ferry Road. There are no existing route restrictions applying to truck movements in the region. In addition, it is assumed that the inbound and outbound truck movements are evenly distributed during the operating hours of the site.

As there is no proposed change to staff numbers in the proposed development, it is assumed that there would not be significant variations in the movements of light vehicles to the site in the future.

Table 1.6 shows the estimated peak hour generation of the ultimate development. This includes the development of Hitchcock Road and Lot 198 site and the extension of the consent to process materials transported from other sites. The impact is small as for the most part the truck movements do not occur in peak traffic periods

Table 1.6: Estimated peak hour traffic generation (trucks only)

Development	Origin/ destination	Morning peak hour		Evening peak hour	
		Wisemans Ferry Rd	Old Northern Rd	Wisemans Ferry Rd	Old Northern Rd
Hitchcock Road Site	**Inbound**	2	2	2	2
	Outbound	2	2	2	2
Lot 198	**Inbound**	1	1	1	1
	Outbound	1	1	1	1
Recycling	**Inbound**	1	1	1	1
	Outbound	1	1	1	1

1.4 Assessments of impacts

The performance of the two key intersections in the vicinity of subject sites under post-development conditions was assessed using aaSIDRA. As the proposed development could generate up to an additional 10 laden truck movements per day until the year 2015, this future year was adopted as being the year representing the maximum generation of truck movements from the site. The post development conditions were analysed in two scenarios – one based on the projected 2006 traffic volumes and the other based on the projected 2015 traffic volumes using a growth factor derived from a 15 year range of RTA AADT traffic volumes.

1.4.1 2006 scenario

The intersection movement volumes for 2006 were estimated by projecting the surveyed traffic flows shown in Figure 1.7 using an average growth rate derived from traffic data for Old Northern Road, south of Wisemans Ferry Road. It can be seen from the historical traffic volume data shown in Table 1.3, that annual average daily traffic on Old Northern Road increased at a rate of 1.5 percent per annum. This conservative rate was applied to through traffic movements at both intersections to ensure a worst case impact was observed.

The projected morning and evening peak hour volumes for 2006 post-development conditions were derived by superimposing the 2006 projected volumes onto traffic generated by the proposed developments shown in Table 1.6. The resultant volumes are shown in Figure 1.8. The heavy vehicle volumes are shown in parentheses.

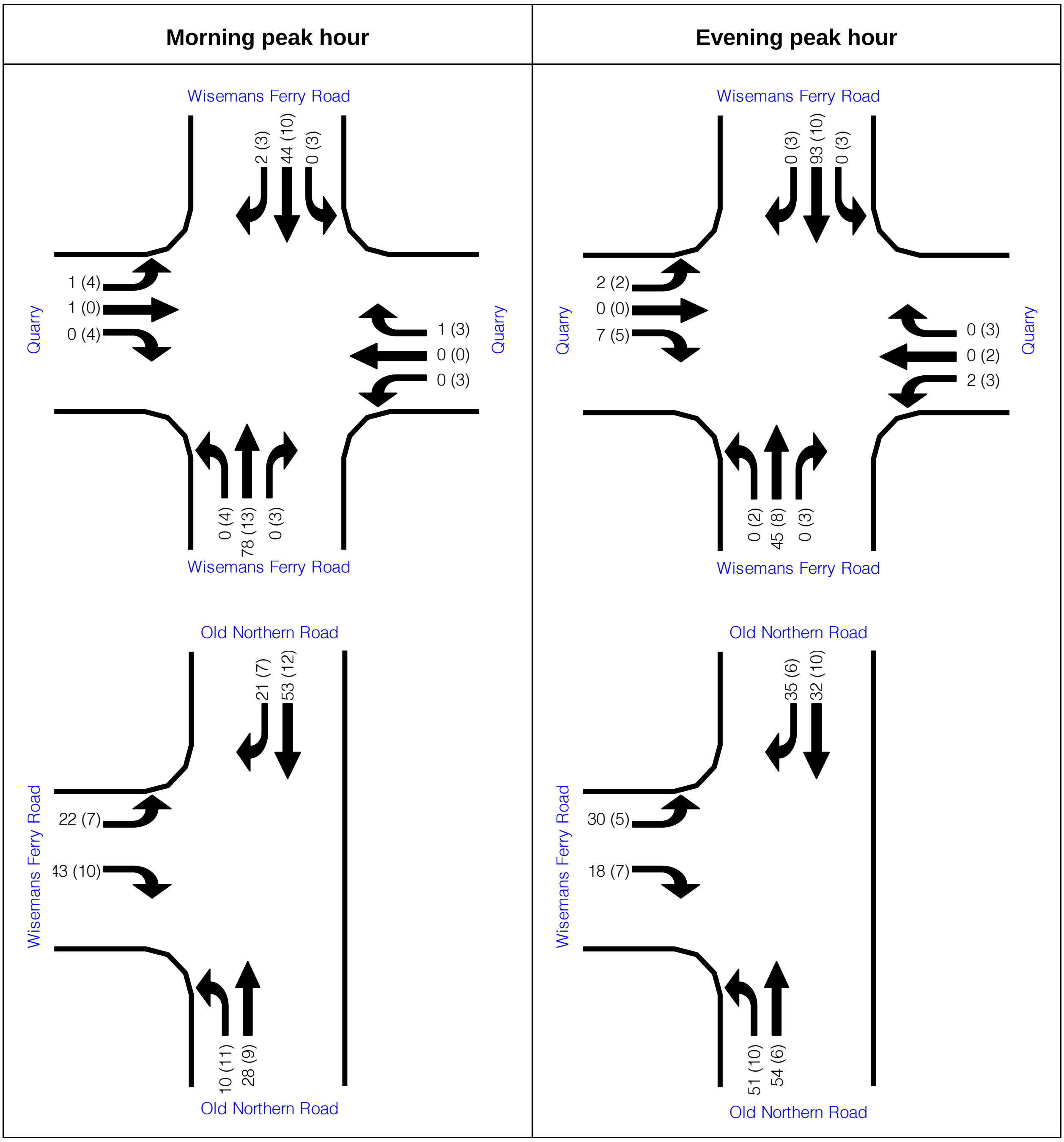

Figure 1.8: 2006 post development intersection turning movement volumes (vph)

Intersection analyses were repeated using the volumes shown in Figure 1.8. The post-development intersection assessment results are summarised in Table 1.7.

Table 1.7: 2006 post-development intersection assessment results

Intersection Name	Peak Period	Ints Control Type	Ints DoS	Delay (Sec)	Ints LoS	Max Queue (m)
Wisemans Ferry Rd/Old Northern Rd	Morning	Priority	0.13	11	A	5
	Evening	Priority	0.10	11	A	4
Quarry Site Entry/ Wisemans Ferry Rd	Morning	Priority	0.07	10	A	1
	Evening	Priority	0.07	10	A	1

The proposed developments would have no significant impact on the performance of the two intersections analysed and would be operating satisfactorily with a level of service of A in both peak periods. Under 2006 post-development traffic conditions, the two key intersections would continue to experience minimal delays and virtually no queue in both peak periods. In essence, current intersection performance would be retained.

1.4.2 2015 scenario

The intersection movement volumes in 2015 were also estimated by projecting the surveyed traffic flows shown in Figure 1.7.

The projected morning and evening peak hour volumes for 2015 post-development conditions were derived by superimposing the 2015 projected volumes onto traffic generated by the proposed developments shown in Table 1.6. The resultant volumes are shown in Figure 1.9. The heavy vehicle volumes are shown in parentheses.

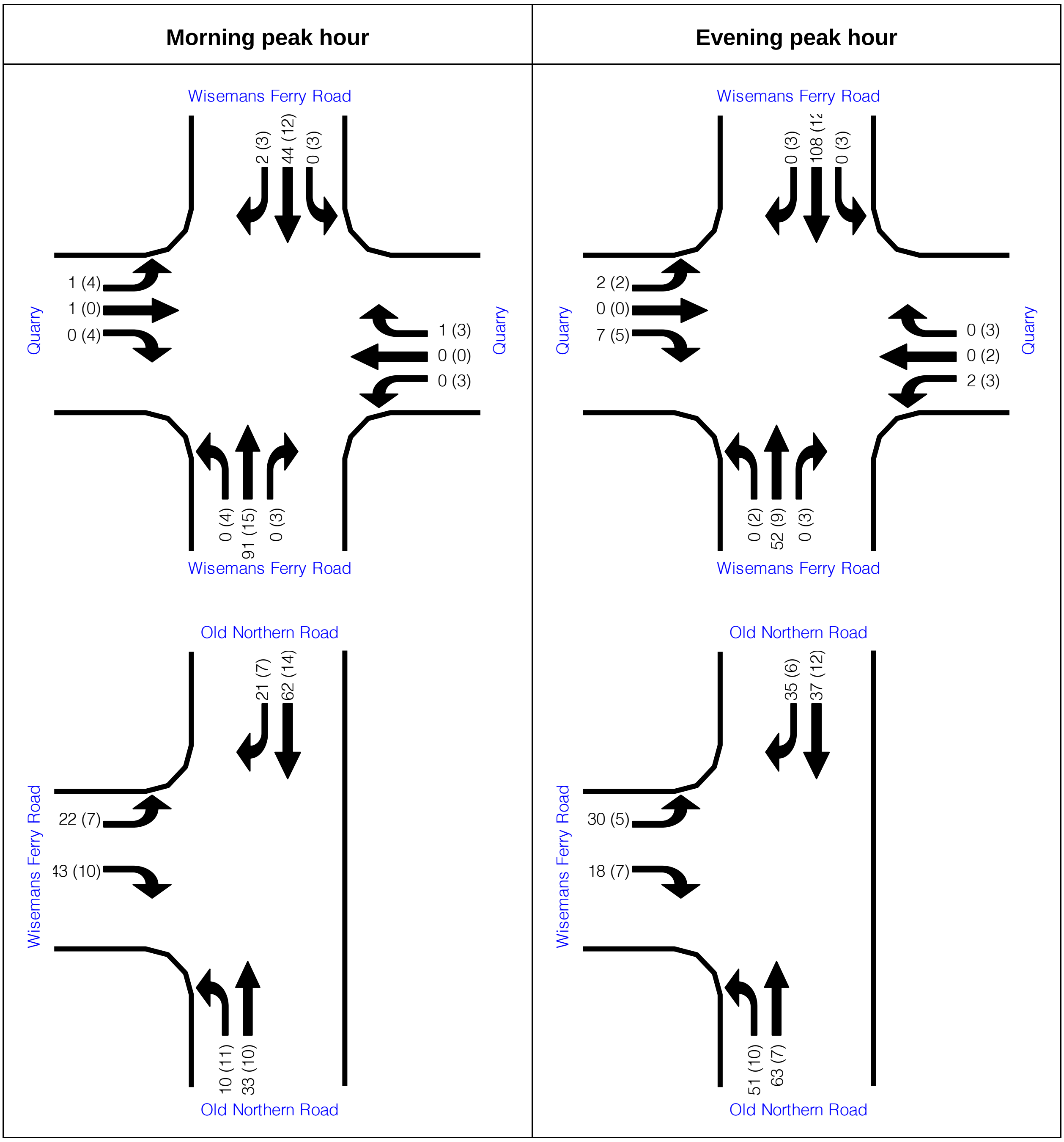

Figure 1.9: 2015 post-development intersection turning movement volumes (vph)

Intersection analyses were repeated using the volumes shown in Figure 1.9. The post-development intersection assessment results for 2015 are summarised in Table 1.8.

Table 1.8: Post-development (2015) intersection assessment results

Intersection Name	Peak Period	Ints Control Type	Ints DoS	Delay (Sec)	Ints LoS	Max Queue (m)
Wisemans Ferry Rd/Old Northern Rd	Morning	Priority	0.13	11	A	5
	Evening	Priority	0.10	12	A	4
Quarry Site Entry/ Wisemans Ferry Rd	Morning	Priority	0.08	10	A	1
	Evening	Priority	0.08	11	A	1

The proposed developments would have no significant impact on the performance of the two intersections analysed. They would continue to operate satisfactorily with a level of service of A in both peak periods. The analysis results indicate that both intersections would operate with minimal delays and queue for both peak periods during the 2015 post development conditions. Both intersections would essentially retain their current 2004 base intersection performance even under the worst case scenario for traffic impact.

1.5 Mitigation measures

From the intersection analyses, the results indicate that there would significant spare capacity at the two key intersections within the vicinity of the subject sites. It was concluded that with the additional traffic generated from the ultimate development of Lot 198 and Hitchcock Road sites, along with the extension of the consent to process materials transported from other sites and projected traffic growth along Wisemans Ferry Road and Old Northern Road, the intersections would be operating satisfactorily with a level of service of B or better in both peak periods. In essence, both intersections would retain their current intersection performance for both peak periods under the 2006 and 2015 peak post-development traffic conditions. Therefore, it can be concluded that no additional mitigation measures would be needed.

Appendix A

Intersection assessment criteria

Intersection assessment criteria

The operation of the intersections was assessed using the aaSIDRA (SIDRA) intersection modelling software. SIDRA calculates intersection performance measures such as:

- level of service
- degree of saturation
- average delay and
- maximum queue length.

Level of service

Level of service (LOS) is one of the basic performance parameters used to describe the operation of an intersection. The levels of service range from A (indicating good intersection operation) to F (indicating over saturated conditions with long delays and queues). At signalised and roundabout intersections, the LOS criteria is related to average intersection delay (seconds per vehicle). At priority controlled intersections, the LOS is based on the average delay (seconds per vehicle) for the worst movement. See *Table A1*.

Degree of saturation

Degree of saturation (DOS) is defined as the ratio of demand flow to capacity, and therefore has no unit. As it approaches 1.0, extensive queues and delays could be expected. For DOS greater than 1.0, small increment in the traffic volumes would result in exponential increase in delays and queue length. For a satisfactory situation, DOS should be less than the nominated practical degree of saturation, usually 0.9. The intersection DOS is based on the movement with the highest ratio for all types of intersection.

Average delay

Delay is the difference between interrupted and uninterrupted travel times through the intersection and is measured in seconds per vehicle. The delays include queued vehicles decelerating and accelerating to and/or from stop, as well as delays experienced by all vehicles negotiating the intersection. At signalised and roundabout intersections, the average intersection delay is usually reported and is taken as the weighted average delay by summing the product of the individual movement traffic volume and its corresponding calculated delays and dividing by the total traffic volume at the intersection. At priority controlled intersections, the average delay for the worse movement is usually reported.

Maximum queue length

Queue length is the number of vehicles waiting at the stop line and is usually quoted as the 95th percentile back of queue, which is the value below which 95 percent of all observed queue lengths fall. It is measured as the number of vehicles per traffic lane at the start of the green period, when traffic starts moving again after a red signal. The intersection queue length is usually taken from the movement with the longest queue length.

Table A1: Level of service criteria for intersections

Level of service	Average delay (seconds per vehicle)	Traffic signals, roundabout	Give way and stop signs
A	Less than 14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity and accident study required
E	57 to 70	At capacity. At signals, incidents will cause excessive delays. Roundabouts require other control mode	At capacity; requires other control mode
F	Greater than 71	Unsatisfactory with excessive queuing	Unsatisfactory with excessive queuing; requires other control mode

Source: RTA Guide to Traffic Generating Developments, 2002

4

TECHNICAL PAPER

HEGGIES

REPORT 10-3138-R2

Revision 4

Hitchcock Road, Maroota Sand Extraction Project Noise Impact Assessment

PREPARED FOR

DFA Consultants Pty Ltd
30 Cumberland Avenue
CASTLE HILL NSW 2154

12 NOVEMBER 2007

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Hitchcock Road, Maroota

Sand Extraction Project

Noise Impact Assessment

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This document has been prepared in accordance with the requirements of that System.

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
10-3138-R2	Revision 4	12 November 2007	Mark Latal	Dick Godson	Dick Godson
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1 INTRODUCTION

Heggies Pty Ltd (Heggies) has been commissioned by DFA Consultants to prepare a noise impact assessment for inclusion in the Environmental Assessment (EA) for the proposed sand extraction project at Hitchcock Road, Maroota, NSW.

PF Formation (PF) proposes to continue the extraction of sand at Maroota, situated approximately 22 km northeast of Windsor in northwestern Sydney. The proposed project site is located immediately south of the intersection of Old Northern Road and Wisemans Ferry Road.

A maximum of 400,000 tonnes of Tertiary sand would be extracted from the site each year for a maximum period of 30 years, from November 1998. This would represent no change to the current consent issued by the NSW Land and Environment Court in July 1998.

Since the acoustic modelling reported in this Technical paper was completed, the area included in the proposal has been amended by the removal of Lot 2 DP555184. This would result in changes in Stage 2 operations shown in **Appendix H2**. Noise impacts have not been remodelled to reflect this change. The results reported in Section 8.1 (Locations 1 to 4) would therefore be influenced by this change. However, Locations 3 and 4 have not been included in the assessment as Location 3 is located on Lot 1 DP223323 which is now included in the proposal and Location 4 is on a property subject to sand extraction (HB Maroota) and is not therefore a sensitive receiver.

This report identifies the potential operational and cumulative traffic noise impacts associated with the proposed project on the nearby community. There is, however, no additional traffic generated by the subject operations.

2 PROJECT DESCRIPTION, SITE LAYOUT AND OPERATING HOURS

2.1 Outline of the Proposal

The proposal includes the continuation of the extraction of sand to a maximum depth of 2 metres above the water table. The site has been operated for sand extraction since the 1980s and since November 1998 on the basis of Consent Orders issued by the NSW Land and Environment Court in July 1998.

All Tertiary sand would be extracted using an excavator and transferred to articulated dump trucks in order to transport the material to the existing slurry plant located at the northern end of the site. It would then be mixed with water and pumped via pipeline to the central wash plant located on Lot 198, approximately 1 km from the Hitchcock Road site. The wash water would be returned to the site for settlement in a series of basins prior to reuse. The final landform would largely comprise one gently sloping bowl with steeper slopes defining its boundary and the central area where the largest volume of clay overlies the Tertiary sand.

The assessment of the reserve suggests that a total mass of approximately 5,355,000 tonnes of material would be available for feasible extraction. Extraction rates at the Hitchcock Road site have ranged between 200,000 and 250,000 tonnes per year over the past five years. This is not expected to change, although annual rates may vary depending on market conditions. Extraction of the entire resource at these rates would require between 21 and 26 years to complete, which is consistent with the existing consent.

The site is located immediately to the south of the intersection of Old Northern Road and Wisemans Ferry Road, Maroota, approximately 50 kilometres to the northwest of the Sydney CBD and about 8 kilometres south of Wisemans Ferry. The site is basically triangular in shape with an additional rectangular portion located to the southeast. The distance from the apex of the triangle at the intersection of Wisemans Ferry Road and Old Northern Road to its most southerly corner is just under 1,500 metres while the distance of the base of the triangle from the junction with Hitchcock Road to its most easterly corner is approximately 1,300 metres.

A Locality Plan showing the proposed project site and surrounding area is shown in **Appendix A**.

2.2 Statutory Issues and Approval Requirements

The project site and surrounding area is located on land zoned Rural 1(b) under the Baulkham Hills Shire Council Local Environmental Plan (LEP) 1991. Extractive industry is permitted, with Council consent, within this zone. The proposal requires development consent under Part 3A of the Environmental Planning and Assessment Act (1979).

2.3 Noise Assessment Locations

Several private residences are located along Old Northern Road and Wisemans Ferry Road which are potentially affected by operations at PF's existing and proposed operations at Hitchcock Road. These residences, together with other sensitive receivers, are shown in **Table 1**.

Table 1 Noise Assessment Locations

Location	Lot Number	Owner	Distance to Hitchcock Road Site Perimeter
1	Lot 1 DP 580223	Hammond	500 m
2	Lot 4 DP 206018	Hitchcock	250 m
3[1]	Lot 1 DP 223323[1]	Jurd[1]	50 m
4[2]	Lot 2 DP 312327	Martin	50 m
5	Lot 2 DP 588936	Pignataro	150 m
6	Lot 2 DP 703821	Camilleri	400 m
7	Lot 78 DP 752025	Maroota Public School	650 m
8	Lot 1 DP 531835	Portelli	400 m
9	Lot 10 DP 835992	Young	150 m
10	Lot 91 DP 594889	Tornatola	250 m

Note 1: This location is on Lot 1 DP223323 which is included in the proposal.

Note 2: This location is on a property subject to sand extraction (HB Maroota) and has therefore not been included in this assessment.

The results of background noise monitoring undertaken at Location 5 (Pignataro) have been used to derive assessment criteria for nearby residential assessment locations.

2.4 Extraction Plan

The sand resource would be extracted and processed as follows:

- Topsoil and overburden would be removed and stored in their final location where possible, in order to reduce the handling of material.
- A bulldozer would be used to rip the easily worked component of the exposed sand resource and move it into a number of large mounds.

- Crude crushed sandstone would be transported by dump truck to the slurry plant where it would be fed into a portable dry screening plant or transported via the existing pipeline to the central wash plant. The product would be distributed via a series of conveyors and slurry pumps to various stockpiles, and silt-laden water is pumped to tailings dams to be cleaned before being discharged to the clean water storage dam where it would be recycled to the wash plant.
- The dry screening plant uses vibrating wire screens to separate over-coarse particles from the product. A mobile screen could be located on the extraction site if there was sufficient space for the associated stockpiles and working area during the various stages of development.
- Specific grades of processed sand would be separately stockpiled on the pit floor or at the central process plant and picked up by product truck as required.
- The extracted areas would be rehabilitated by the reformation of final ground contours using overburden, stockpiled topsoil and seeding as appropriate.

2.5 Plant and Equipment

Table 2 lists the typical plant and equipment that would be used for sand extraction at the Hitchcock Road site.

Table 2 Proposed Sand Extraction Plant and Equipment

Equipment Type	Equipment Model	Quantity	Function
Dozers	CAT D9L/D10N	2	Strip topsoil, overburden and sand resource
Scraper	CAT 633	1	Strip sand resource
Loader	CAT 962G/966G	2	General product movement around storage/ plant areas
Mobile Power Screen	8x4 foot Commander with F4L912 Deutz	1	On-site screening of sand
Mobile Crusher	APK1010 Hazemag with 250 hp Cummins	1	On-site crushing of sandstone/overburden
Excavator	CAT 330CL	1	Extraction of sand resource
Dump Truck	CAT 730	2	Movement of sand resource to wash plant
Water Truck	LTD18 with 350 hp Cummins	1	General dust suppression
Central Wash Plant	Approx 500 kVA electric	1	Washing, processing and sorting of sand resource
Slurry Plant		1	Mixing sand resource for transfer to Central Wash Plant

2.6 Transport

Product is currently trucked from stockpiles with trucks leaving the existing site via the weighbridge and the access road to Wisemans Ferry Road turning either left to the intersection with Old Northern Road and right to Dural and Castle Hill or right along Wisemans Ferry Road to Windsor, Richmond and Penrith. The proportion of trips on these routes is approximately equal.

PF advises that the maximum number of truck movements generated by its operations at Maroota is 60 per day, and this volume has been used in the assessment process. The number of truck movements expected to be attributable to operations at Hitchcock Road is a maximum of 50 per day, with 10 movements per day expected to be attributable to PF's proposed Lot 198 operations.

2.7 Hours of Operation

The proposed hours of operation for the existing activities involved in the project are presented in **Table 3**.

Table 3 Proposed Hours of Operation

Activity	Operating Hours	Days
Gates open to allow entry of vehicles to site	0545 hours to 0600 hours	Monday to Saturday
Trucks entering or leaving site only	0600 hours to 0700 hours	Monday to Saturday
Extraction, transportation, processing and maintenance	0700 hours to 1800 hours	Monday to Saturday

3 NOISE IMPACT ASSESSMENT PROCEDURE

3.1 Environmental Noise Control - General Objectives

3.1.1 Residential Receivers

Responsibility for the control of noise emission in New South Wales is vested in local government and the DECC (Department of Environment and Climate Change), formerly the DEC. The DECC has released the NSW Industrial Noise Policy (INP), dated January 2000, which provides a framework and process for deriving noise criteria for consents and licences that will enable the DECC to regulate premises that are scheduled under the Protection of the Environment Operations Act 1997.

The specific policy objectives are to:

- Establish noise criteria that would protect the community from excessive intrusive noise and preserve the amenity for specific land uses.
- Use the criteria as the basis for deriving project specific noise levels.
- Promote uniform methods to estimate and measure noise impacts, including a procedure for evaluating meteorological effects.
- Outline a range of mitigation measures that could be used to minimise noise impacts.
- Provide a formal process to guide the determination of feasible and reasonable noise limits for consents or licences that reconcile noise impacts with the economic, social and environmental considerations of industrial development.
- Carry out functions relating to the prevention, minimisation and control of noise from premises scheduled under the Act.

3.1.2 Assessing Intrusiveness

For assessing intrusiveness, the background noise generally needs to be measured. The intrusiveness criterion essentially means that the equivalent continuous noise level (L_{Aeq}) of the source should not be more than five (5) decibels above the measured (or default) Rated Background Level (RBL).

3.1.3 Assessing Amenity

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria relate only to industrial-type noise and do not include road, rail or community noise. If present, the existing noise level from industry is generally measured. If it approaches the criterion value, then noise levels from new industries need to be designed so that the cumulative effect does not produce noise levels that would significantly exceed the criterion. For high-traffic areas there is a separate amenity criterion. The cumulative effect of noise from industrial sources also needs to be considered in assessing the impact.

An extract from the NSW INP that relates to the amenity criteria is given in **Table 4** and **Table 5**.

3.1.4 Cumulative Noise Emissions

The NSW INP also provides non-mandatory cumulative noise assessment guidelines that address existing and successive industrial development by setting acceptable (and maximum) cumulative $L_{Aeq(period)}$ amenity levels for all industrial (ie non-transport related) noise in an area. Note, the INP does not set acceptable cumulative $L_{Aeq(15minute)}$ intrusive criteria for all industrial noise sources in an area, but rather seeks to control cumulative noise via its amenity criteria.

Table 4 Amenity Criteria - Recommended LAeq Noise Levels from Industrial Noise Sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended LAeq Noise Level	
			Acceptable	Recommended Maximum
Residence	Rural	Day	50 dBA	55 dBA
		Evening	45 dBA	50 dBA
		Night	40 dBA	45 dBA
	Suburban	Day	55 dBA	60 dBA
		Evening	45 dBA	50 dBA
		Night	40 dBA	45 dBA
	Urban	Day	60 dBA	65 dBA
		Evening	50 dBA	55 dBA
		Night	45 dBA	50 dBA
	Urban/Industrial Interface - for existing situations only	Day	65 dBA	70 dBA
		Evening	55 dBA	60 dBA
		Night	50 dBA	55 dBA
School classrooms - internal	All	Noisiest 1-hour period when in use	35 dBA	40 dBA
Hospital ward				
- internal	All	Noisiest 1-hour period	35 dBA	40 dBA
- external	All	Noisiest 1-hour period	50 dBA	55 dBA
Place of worship - internal	All	When in use	40 dBA	45 dBA
Area specifically reserved for passive recreation (eg National Park)	All	When in use	50 dBA	55 dBA
Active recreation area (eg School playground, golf course)	All	When in use	55 dBA	60 dBA
Commercial premises	All	When in use	65 dBA	70 dBA
Industrial premises	All	When in use	70 dBA	75 dBA

Notes: For Monday to Saturday, Daytime 0700 hours - 1800 hours; Evening 1800 hours - 2200 hours; Night-time 2200 hours - 0700 hours.

On Sundays and Public Holidays, Daytime 0800 hours - 1800 hours; Evening 1800 hours - 2200 hours; Night-time 2200 hours - 0800 hours.

The LAeq index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

Table 5 Modification to Acceptable Noise Level (ANL)* to Account for Existing Levels of Industrial Noise

Total Existing LAeq Noise Level from Industrial Noise Sources	Maximum LAeq Noise Level for Noise from New Sources Alone, dBA
≥Acceptable noise level plus 2 dBA	If existing noise level is *likely to decrease* in future acceptable noise level minus 10dBA If existing noise level is *unlikely to decrease* in future existing noise level minus 10 dBA
Acceptable noise level minus 1 dBA	Acceptable noise level minus 8 dBA
Acceptable noise level	Acceptable noise level minus 8 dBA
Acceptable noise level minus 1 dBA	Acceptable noise level minus 6 dBA
Acceptable noise level minus 2 dBA	Acceptable noise level minus 4 dBA
Acceptable noise level minus 3 dBA	Acceptable noise level minus 3 dBA
Acceptable noise level minus 4 dBA	Acceptable noise level minus 2 dBA
Acceptable noise level minus 5 dBA	Acceptable noise level minus 2 dBA
Acceptable noise level minus 6 dBA	Acceptable noise level minus 1 dBA
<Acceptable noise level minus 6 dBA	Acceptable noise level

*ANL = Recommended acceptable LAeq noise level for the specific receiver, area and time of day from **Table 4**.

3.2 INP Assessment of Prevailing Weather Conditions

3.2.1 Wind

Wind has the potential to increase noise at a receiver when it is light and stable and blows from the direction of the noise source. As the strength of the wind increases the noise produced by the wind will obscure noise from most industrial and transport sources.

Wind effects need to be considered when wind is a feature of the area under consideration. Where the source to the receiver wind component at speeds of up to 3 m/s for 30% or more of the time in any seasonal period (ie day, evening or night), then wind is considered to be a feature of the area and noise level predictions must be made under these conditions.

The NSW INP Section 5.3 Wind Effects states:

> *"Wind effects need to be assessed where wind is a feature of the area. Wind is considered to be a feature where source to receiver wind speeds (at 10 m height) of 3 m/s or below occur for 30 percent of the time or more in any assessment period in any season."*

In order to determine the prevailing conditions for the subject site, weather data during the period April 2003 to April 2004 were obtained from a Bureau of Meteorology (BOM) weather station located at Mangrove Mountain for the period June 2002 to June 2003.

The results of the Mangrove Mountain weather station analysis for daytime, evening and night-time winds are presented in **Table 6**, **Table 7** and **Table 8,** respectively.

In each table, the wind directions and percentage occurrence are those dominant during each season.

Table 6 Seasonal Frequency of Occurrence Wind Speed Intervals - Daytime

Period	Calm (<0.5 m/s)	Wind Direction (±45°)	Wind Speed		
			0.5 to 2 m/s	2 to 3 m/s	0.5 to 3 m/s
Summer	1%	S±45°	0.6%	2.3%	2.9%
Autumn	3.5%	S±45°	1.0%	4.0%	5.0%
Winter	1.6%	NW±45°	1.0%	4.9%	6.0%
Spring	0.8%	NW±45°	0.2%	2.7%	2.8%

Table 7 Seasonal Frequency of Occurrence Wind Speed Intervals - Evening

Period	Calm (<0.5 m/s)	Wind Direction (±45°)	Wind Speed		
			0.5 to 2 m/s	2 to 3 m/s	0.5 to 3 m/s
Summer	0.8%	SE±45°	1.1%	2.8%	3.9%
Autumn	11.6%	S±45°	3.4%	4.2%	7.7%
Winter	7.9%	NW±45°	1.0%	5.7%	6.7%
Spring	17.1%	SSE±45°	2.3%	3.7%	6.0%

Table 8 Seasonal Frequency of Occurrence Wind Speed Intervals - Night-time

Period	Calm (<0.5 m/s)	Wind Direction (±45°)	Wind Speed		
			0.5 to 2 m/s	2 to 3 m/s	0.5 to 3 m/s
Summer	20.3%	S±45°	5.8%	10.8%	16.6%
Autumn	27.6%	SW±45°	6.5%	12.8%	19.3%
Winter	7.9%	NW±45°	8.1%	**34.2%**	**42.2%**
Spring	19.9%	NW±45°	7.7%	15.9%	23.6%

The frequency analysis showed that winds from a northwesterly direction occurred for 30% or more (42%) of the night-time (winter only) assessment period. In this situation, the INP states that this wind component be considered as prevailing for the area and accordingly has been adopted for the night-time period.

3.2.2 Temperature Inversion

Temperature inversions, when they occur, have the ability to increase noise levels by focusing sound waves. Temperature inversions occur predominantly at night during the winter months. For a temperature inversion to be a significant characteristic of the area it needs to occur for 30% or more of the total night-time during winter or about two nights per week.

The NSW INP states that temperature inversions need only be considered for the night-time noise assessment period ie 2200 hours to 0700 hours.

The NSW INP, Section 5.2 Temperature Inversions, states:

> *"Assessment of impacts is confined to the night noise assessment period (10.00 pm to 7.00 am), as this is the time likely to have the greatest impact - that is, when temperature inversions usually occur and disturbance to sleep is possible."*

In the absence of measured data the INP nominates default inversion parameters for non-arid areas where the average rainfall is greater than 500 mm namely:

> *"3°C/100 m temperature inversion for all receivers, plus a 2 m/s source-to-receiver component drainage-flow wind speed for those receivers where applicable."*

Fixed plant and equipment at the site are not required to operate during the evening or night-time periods. Consequently, in accordance with the NSW INP, only the night-time operation of the trucks are required to be assessed under prevailing temperature inversion conditions.

3.3 Additional DECC Noise Assessment Information

The DECC's recommended noise assessment criteria aim to limit potential intrusive noise emissions and to preserve noise amenity. In cases where the limiting noise assessment criterion (in this case $L_{Aeq(15minute)}$ intrusiveness criterion) cannot be achieved, then practicable and economically feasible noise control measures should be applied. This usually requires demonstration that Best Achievable Technology and Best Environmental Management Practices have been implemented in order to mitigate adverse acoustical impacts.

In the event that the lowest achievable noise emission levels remain above the noise assessment criteria, then the potential noise impact needs to be balanced and assessed against any economic and social benefits the project may bring to the community. It then follows that where the consent authority may consider that the development does offer community benefits, then these may be grounds for permitting achievable noise emission levels as statutory compliance levels.

4 EXISTING ACOUSTICAL ENVIRONMENT

4.1 Unattended Background Noise Surveys

Unattended background noise monitoring was conducted between Tuesday 20 July and Thursday 29 July 2004 at a number of representative receiver locations in the vicinity of the proposed extraction operations. Environmental noise loggers were used to continuously record noise levels at the respective monitoring locations throughout the survey period.

A summary of the results of the background noise surveys are presented in **Table 9** (and presented graphically in **Appendices B to E**) for the operational hours of the project.

Table 9 Summary of Existing LA90 Rating Background (RBL's) and Existing LAeq Ambient Noise Levels - dBA re 20 µPa

Monitoring Locations	LA90(15minute) Rating Background Noise Level[2]		LAeq(period) Existing Ambient Noise Level[3]	
	Daytime 0700-1800 Hours	Night 2200-0700 Hours	Daytime 0700-1800 Hours	Night 2200-0700 Hours
Location 3 - Jurd[1]	32	30	51	46
Location 5 - Pignataro	37	30	59	52
Location 9 - Young	34	30	62	61
Location 11 - Black	30	30	42	39

Note 1:This location is on Lot 1 DP223323 which is included in the proposal.

Note 2: The LA90 represents the level exceeded for 90% of the interval period and is referred to as the average minimum or background noise level.

Note 3: The LAeq is the equivalent continuous noise level defined as the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

Review of the data presented in **Table 9** indicates that the LA90(15minute) RBLs at the various monitoring locations ranged from 30 dBA to 37 dBA during the daytime and was 30 dBA during the night-time. The measured background noise levels are typical of those of a rural environment with natural noise sources and some transportation noise contributions associated with traffic on the Old Northern and Wisemans Ferry Roads.

4.2 Operator-Attended Noise Surveys

At the four locations given in **Table 9**, operator-attended noise surveys of 15 minutes duration were conducted during the deployment and collection of the noise loggers on Tuesday 20 July and Thursday 29 July 2004 respectively.

The operator-attended noise measurements were conducted using a precision integrating sound level meter in order to qualify the results obtained with the unattended noise loggers. During the attended noise surveys, the operator identified the character and duration of acoustically significant ambient noise sources. Wherever possible, the operator quantified local traffic flows and made a qualitative assessment of the prevailing weather conditions.

The operator-attended noise survey results are presented in **Table 10** for the 20 July 2004 survey and **Table 11** for the 29 July 2004 survey.

Table 10 $L_{A(15minute)}$ Operator-Attended Noise Survey Results - 20 July 2004

Location	Date/ Time (hrs)	Primary Noise Descriptor (dBA re 20 µPa)						Description of Noise Emission Sources
		L_{Amax}	L_{A1}	L_{A10}	L_{A90}	L_{Amin}	L_{Aeq}	
Location 3[1] Jurd	20.07.05 10.57	67	59	51	43	40	49	Cars 52-56 dBA Trucks 58-63 dBA Wind 46-52 dBA PF Scraper & Truck 45-46 dBA
Location 5 Pignataro	20.07.05 11.41	81	67	59	40	36	57	Cars 45-63 dBA Birds 40-48 dBA PF Trucks 41-45 dBA
Location 9 Young	20.07.05 12.28	69	60	53	37	33	50	Cars 46-56 dBA Trucks 46-64 dBA Wind 42-46 dBA PF Scraper 33-35 dBA
Location 11 Black	20.07.05 13.18	55	41	39	32	30	36	Cars 39-41 dBA Trucks 39-42 dBA Wind 32-38 dBA PF Scraper 33-40 dBA

Note 1: This location is on Lot 1 DP223323 which is included in the proposal.

Table 11 $L_{A(15minute)}$ Operator-Attended Noise Survey Results - 29 July 2004

Location	Date/ Time (hrs)	Primary Noise Descriptor (dBA re 20 µPa)						Description of Noise Emission Sources
		L_{Amax}	L_{A1}	L_{A10}	L_{A90}	L_{Amin}	L_{Aeq}	
Location 3[1] Jurd	29.07.05 09.45	77	65	53	35	31	52	Cars 49-59 dBA Trucks 58-63 dBA Birds 36-39 dBA PF Truck 41-51 dBA
Location 5 Pignataro	29.07.05 10.30	70	66	59	38	34	55	Cars 52-68 dBA Birds 38-55 dBA PF Trucks 43-48 dBA
Location 9 Young	29.07.05 11.00	72	65	55	37	33	53	Cars 55-65 dBA Trucks 59-66 dBA Birds 37-42 dBA PF Scraper 36-37 dBA
Location 11 Black	29.07.05 11.45	65	48	38	29	28	37	Trucks 37 dBA Birds 36-54 dBA PF Truck 29 dBA

Note 1: This location is on Lot 1 DP223323 which is included in the proposal.

The operator-attended noise measurement results confirm the results obtained from the unattended noise loggers and support the use of the noise levels in being representative of the background noise environment at the nearby residences. Some intermittent noise contribution from existing PF operations at the Lot 198 and Hitchcock Road sites was noted at all locations. However, these contributed noise levels were intermittent in nature and did not affect the measured $L_{A90(15minute)}$ background noise level.

5 OPERATIONAL NOISE ASSESSMENT CRITERIA

The Hitchcock Road operational noise emission criteria have been set with reference to the DECC's NSW INP, as outlined in **Section 3.1**. Establishing the operational noise criteria includes an assessment of the RBLs, the intrusiveness criteria and the amenity criteria.

The intrusiveness criteria have been set for the proposed hours of operations based on the RBLs (presented in **Table 9**) at the surrounding residences.

The residences in the vicinity of the proposed extraction operations are best described by the "rural" receiver type, the amenity criteria have therefore been set using the $L_{Aeq(period)}$ contribution from industrial noise (refer to **Table 9**) in conjunction with **Table 4**.

The resulting operational intrusive and amenity noise emission criteria for all assessment locations are given in **Table 12**. Criteria for locations not measured directly are based upon the data from the nearest measurement location representative of that locality.

Location 3 is situated on Lot 1 DP223323 which is included in the proposal and Location 4 (Martin) is on a property subject to sand extraction (HB Maroota). These are therefore not included in the noise assessment. A residence is also located on Lot 2 DP555184 adjacent to the operational area. As this property is subject to a current application for sand extraction, this location is not considered to be a sensitive receiver and has not been included in the assessment.

Table 12 Operational Noise Emission Criteria - dBA

Receiver	Intrusiveness Criteria $L_{Aeq(15minutes)}$		Amenity Criteria $L_{Aeq(15minute)}$	
	Daytime 0700-1800 Hours	Night 2200-0700 Hours	Daytime 0700-1800 Hours	Night 2200-0700 Hours
Location 1 - Hammond	42	35	49	42
Location 2 - Hitchcock	42	35	49	42
Location 5 - Pignataro	42	35	49	42
Location 6 - Camilleri	42	35	49	42
Location 7 - Maroota P.S.	42	N/A	45*	N/A
Location 8 - Portelli	42	35	49	42
Location 9 - Young	39	35	52	51
Location 10 - Tornatola	39	35	52	51

Note : Controlling criteria (PSNL) are shaded.

Note *: External criterion, assuming a typical 10dB insertion loss from inside to outside.

The amenity criteria noise levels presented in **Table 12** are higher than the intrusiveness criteria noise levels. Compliance with the intrusiveness criteria, therefore, will generally demonstrate compliance with the amenity criteria. Accordingly, the following assessment is based on the intrusiveness criteria being the controlling noise criteria. The project Specific Noise Levels (PSNL) for the project are shaded in **Table 12**.

6 ROAD TRANSPORTATION NOISE ASSESSMENT CRITERIA

Existing road vehicle noise contributions are included in the overall predicted $L_{Aeq(15minute)}$ project operational noise emissions while operating on the privately owned internal haul road. On public roads, different noise assessment criteria apply to the vehicles, which would be regarded as "traffic", rather than as part of the project operations noise sources.

In some instances, an intermediate approach between the "private" and "public" roadway assessment approaches may be appropriate. This could, for example, apply to the access roads well away from extraction and processing operations, where the vehicle noise would be clearly perceived as "traffic" noise, rather than as part of the operations.

In June 1999, the DECC issued a document entitled "*Environmental Criteria for Road Traffic Noise*" (ECRTN). The relevant assessment criteria from the ECRTN for the existing operations are presented in **Table 13**.

Table 13 New Land Use Road Traffic Noise Criteria

Type of Development	Criteria $L_{Aeq(1hour)}$ Daytime	Criteria $L_{Aeq(1hour)}$ Night-time	Where Criteria Are Already Exceeded
8. Land use developments with potential to create additional traffic on collector roads	60 dBA	55 dBA	Where feasible and reasonable, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using "quiet" vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dBA.

Note: Total traffic noise contribution including existing and project related vehicle movements.
$L_{Aeq(1hour)}$ represents the highest LAeq noise level for any hour during daytime (0700 hrs to 2200 hrs) and night-time (2200 hrs to 0700 hrs).

7 PROJECT NOISE MODELLING PROCEDURE

7.1 Prediction of Noise Emissions - General Discussion

In order to determine the acoustical impact of the proposed Hitchcock Road operations, a computer model was developed to incorporate the significant noise sources and the intervening terrain to the closest potentially affected residential properties.

The computer model was prepared using the SoundPLAN V6.3 Industrial Module, a commercial software system developed by Braunstein and Berndt GmbH in Germany. The software allows the use of various internationally recognised noise prediction algorithms. The CONCAWE algorithm, suitable for the assessment of large industrial plants, has been selected for this assessment as it also enables meteorological influences to be assessed.

The noise modelling takes into account source sound level emissions and locations, screening effects, receiver locations, meteorological effects, ground topography and noise attenuation due to spherical spreading and atmospheric absorption. Ground contours and site topographical data were provided by the client.

Noise predictions were calculated to the ten assessment locations surrounding the site of the proposal and are shown in the Locality Map in **Appendix A**.

7.2 Prediction of Noise Emissions - Operation

Four daytime operational scenarios and one early morning scenario were assessed in order to represent the development stages throughout the project's life. The scenarios have been referred to as:

- Stage 1: Daytime operations as detailed in **Appendix H1.**
- Stage 2: Daytime operations as detailed in **Appendix H2.**
- Stage 3: Daytime operations as detailed in **Appendix H3.**
- Stage 4: Daytime operations as detailed in **Appendix H4.**
- Early morning operations (0600 hours to 0700 hours) - Existing transport trucks operating along the stockpile access road from the intersection at Wisemans Ferry Road, westwards and northwards past the weighbridge and westwards to the Wash Plant stockpile area.

For all of these stages there is a full complement of plant and equipment operating during daytime hours. During the early morning hour (0600 hours to 0700 hours), only existing trucks entering or leaving the existing processing plant site via the haul road are operating.

Table 14 presents the overall L_{Aeq} A-weighted sound power level (SWL) for each item of plant and equipment which PF indicated would be used at the Hitchcock Road site. These SWLs have been obtained from measurements of similar equipment conducted by Heggies.

Table 14 Plant and Equipment Sound Power Levels (SWLs)

Plant Item	L_{Aeq} Sound Power Level
Dozer - CAT D9L/D10N	108 dBA
Loader - CAT 962G/966G	103 dBA
Power Screen - 8x4 foot Commander with F4L912 Deutz	103 dBA
Excavator - CAT 330CL	101 dBA
Dump Truck - CAT 730	108 dBA
Water Truck - LTD18 with 350 hp Cummins	100 dBA
Product Trucks	105 dBA
Slurry Plant	108 dBA
Central Wash Plant - Approx 500 kVA electric	109 dBA

Within the noise model, operations consisted of all modelled plant items operating concurrently in order to simulate the overall maximum potential noise emission, however it should be noted that the sound power levels given for each item of mobile equipment do not include noise emissions which emanate from reversing alarms.

In the event that reversing alarm noise is considered to be a source of disturbance, the alarm noise level should be checked against the appropriate regulatory and health and safety requirements and the necessary mitigating action taken to achieve an acceptable noise reduction without compromising safety standards.

7.3 Meteorological Parameters

SoundPLAN Noise Modelling Meteorology

The contributed noise emissions for the proposed operational scenarios at the nearest potentially affected residential properties have been calculated with the following meteorological parameters (refer to **Section 3.1**):

Daytime Operations (0700 hours to 1800 hours)

Calm

- During "calm" conditions (20°C air temperature, 60% Relative Humidity, 0 m/s wind speed and 0°C/100 m temperature gradient).

Early Morning Operations (0600 hours to 0700 hours)

Calm

- During "calm" conditions (5°C air temperature, 90% Relative Humidity, 0 m/s wind speed and 0°C/100 m temperature gradient).

NW Wind

- North-westerly wind (5°C air temperature, 90% Relative Humidity, 3 m/s wind speed (from the northwest) and 0°C/100 m temperature gradient).

Temperature Inversion

- During default temperature inversion conditions (5°C air temperature, 90% relative humidity, 3°C/100 m temperature gradient).

8 OPERATIONAL NOISE IMPACT ASSESSMENT

8.1 Noise Modelling Results

Based on the output from the noise model and on the noise emissions criteria presented in **Table 12**, **Table 15** and **Table 16** present the predicted daytime and early morning $L_{Aeq(15minute)}$ noise level contributions from the proposed Hitchcock Road operations respectively, together with the respective criteria.

Table 15 Predicted Daytime $L_{Aeq(15minute)}$ Noise Level - dBA re 20 µPa

Receiver	Daytime (0700-1800 hours) - Calm				Daytime $L_{Aeq(15minute)}$ Operational Criterion
	Stage 1 Operations	Stage 2 Operations	Stage 3 Operations	Stage 4 Operations	
Location 1 - Hammond	41	34	22	21	42
Location 2 - Hitchcock	38	40	38	36	42
Location 5 - Pignataro	41	45	45	43	42
Location 6 - Camilleri	37	40	40	39	42
Location 7 - Maroota P.S.	33	36	36	35	42
Location 8 - Portelli	32	38	39	36	42
Location 9 - Young	42	44	39	42	39
Location 10 - Tornatola	39	44	38	39	39

Note : Noise levels lightly shaded in the table above in the Moderate Noise Management Zone (3 dBA to 5 dBA above PSNL) and noise levels heavily shaded in the table above are in the Noise Affectation Zone (over 5 dBA above PSNL).

Table 16 Predicted Existing Early Morning $L_{Aeq(15minute)}$ Noise Level - dBA re 20 µPa

Receiver	Early Morning (0600-0700 hours)			Night-time $L_{Aeq(15minute)}$ Operational Criterion
	Calm	NW Wind	Inversion	
Location 1 - Hammond	<10	<10	<10	35
Location 2 - Hitchcock	12	18	18	35
Location 5 - Pignataro	33	35	37	35
Location 6 - Camilleri	33	34	37	35
Location 7 - Maroota P.S.	N/A	N/A	N/A	N/A
Location 8 - Portelli	28	30	32	35
Location 9 - Young	31	34	35	35
Location 10 - Tornatola	34	37	38	35

Note : Noise levels lightly shaded in the table above in the Moderate Noise Management Zone (3 dBA to 5 dBA above PSNL) and noise levels heavily shaded in the table above are in the Noise Affectation Zone (over 5 dBA above PSNL).

The resulting noise contours for the Stage 1 through Stage 4 daytime operational scenarios are presented in **Appendices F1** through **F4** respectively.

8.2 Discussion

From a review of **Table 15**, various assessment locations, namely Locations 5, 9 and 10, are impacted up to between 3 dBA and 5 dBA above the relevant daytime $L_{Aeq(15minute)}$ noise criteria, with Stage 2 operations resulting in the greatest number of assessment locations exceeding the relevant criteria.

From **Table 16**, during the early morning hour when the existing trucks are operating along the haul road, the received $L_{Aeq(15minute)}$ noise emission levels at the various assessment locations are below the relevant criteria except for marginal exceedances at Location 10 (Tornatola) under prevailing NW winds (of 2 dBA) and Locations 5 (Pignataro), 6 (Camileri) and 10 (Tornatola) under temperature inversion conditions (of 2 dBA, 2 dBA and 3 dBA respectively).

Section 3.3 of the NSW DECC's INP states that:

> *"where early morning (5am to 7am) operations are proposed, it may be unduly stringent to expect such operations to be assessed against the night-time criteria - especially if existing background noise levels are steadily rising in these early morning hours. In these situations, appropriate noise level targets may be negotiated with the regulatory / consent authority on a case-by-case basis. As a rule of thumb it may be appropriate to assign a shoulder period RBL as the mid-point value between the RBLs of the two assessment periods that are on either side of the shoulder period."*

It would be reasonable to use the above or a similar approach in this locality, as due to the nature of the area (predominantly rural and agricultural), it is expected that the local community would be commencing daytime activities during the early morning hour (0600 hours to 0700 hours).

The scenarios modelled represent 'worst-case' situations when all fixed and mobile plant and equipment likely to be used during the project's life is operating concurrently. In practice, not all equipment is expected to be in use at the same time, and correspondingly lower received noise levels at the various assessment locations would result.

9 NOISE MANAGEMENT AND CONTROL

The NSW INP states that the project specific criteria derived in accordance with the policy have been designed to protect at least 90% of the population living in the vicinity of industrial noise sources from the adverse effects of noise for at least 90% of the time. Provided the criteria in the INP are achieved, it is unlikely that most people would consider the resultant noise levels excessive.

In those cases where the INP project specific assessment criteria are not achieved, it does not automatically follow that all people exposed to the noise would find the noise unacceptable. In subjective terms, exceedances of the INP project specific assessment criteria can be generally described as follows:

- Negligible noise level increase <1 dBA (Not noticeable by all people)
- Marginal noise level increase 1 dBA to 2 dBA (Not noticeable by most people)
- Moderate noise level increase 3 dBA to 5 dBA (Not noticeable by some people but may be noticeable by others)
- Appreciable noise level increase >5 dBA (Noticeable by most people)

In view of the foregoing, **Table 17** presents the methodology for assessing noise levels which may exceed the INP project specific noise assessment criteria.

Table 17 Project Noise Impact Assessment Methodology

Assessment Criteria	Project Specific Criteria	Noise Management Zone		Noise Affectation Zone
		Marginal	Moderate	
Intrusive $L_{Aeq(15minute)}$	Rating background level plus 5 dBA	1 to 2 dBA above project specific criteria	3 to 5 dBA above project specific criteria	> 5 dBA above project specific criteria
Amenity $L_{Aeq(period)}$	INP based on existing industrial level			

For the purposes of assessing the potential noise impacts, the management and affectation criteria are further defined as follows:

Noise Management Zone

Depending on the degree of exceedance of the project specific criteria, noise impacts could range from negligible to appreciable. It is recommended, in accordance with the NSW INP, that management procedures be implemented including:

- Noise monitoring on site and within the community.
- Prompt response to any community issues of concern.
- Refinement of on site noise mitigation measures and mine operating procedures, where practical.
- Discussions with relevant property holders to assess concerns.
- Consideration of acoustical mitigation at receivers.
- Consideration of negotiated agreements with property holders.

Recommended Noise Compliance Limits

In accordance with the procedures described in the NSW INP initial consultation should be undertaken with the DECC in relation to the setting of achievable noise limits for the project.

10 ROAD TRAFFIC NOISE IMPACT ASSESSMENT

Further to the road vehicles included in the Hitchcock Road noise model as described in **Section 7.2**, the noise impact of the project related road traffic on Wisemans Ferry and Old Northern Roads was conducted via the prediction of the existing peak hourly traffic noise levels on the subject roads. In this assessment, the estimated peak traffic from the ultimate combined Lot 198 and pre-existing sites has been used for a cumulative assessment of traffic noise impacts.

The US Environment Protection Agency's method was used for the prediction of the L_{Aeq} traffic noise levels for the offset distances of the closest residences adjacent to the proposed project.

The US EPA's method for prediction of the L_{Aeq} noise levels from traffic is an internationally accepted theoretical traffic noise prediction model which takes into account the L_{Amax} vehicle noise levels (light and heavy), receiver offset distance, passby duration, vehicle speed, ground absorption (based on the ratio of soft ground and average height of propagation), number of hourly vehicle movements, receiver height, truck exhaust height and the height and location of any intervening barriers.

Based on the existing traffic flows presented in the Traffic and Access Report for the site prepared by Parsons Brinckerhoff in July 2006, and on the existing Lot 198 related traffic volumes, **Table 18** summarise the current traffic flows.

Table 18 Worst-Case Total Future Traffic Movements

Traffic Count Location	Estimated Worst-Case Hourly Traffic Flows			
	Daytime (0700 - 1800 hours)		Early Morning (0600 - 0700 hours)	
	Light	Heavy	Light	Heavy
Wisemans Ferry Rd, south of Old Northern Rd intersection	59	31	78	32
Old Northern Rd, south of Wisemans Ferry Rd intersection	91	29	93	38

Given that there is no additional traffic generated by the subject operations, the traffic noise level calculated at the closest receivers adjacent to the existing transport routes are presented in **Table 19**.

Table 19 Predicted L_{Aeq} Traffic Noise Levels - dBA re 20 µPa

Location	Offset	Daytime $L_{Aeq(1hour)}$ Noise Levels	Early Morning $L_{Aeq(1hour)}$ Noise Levels
		Existing	Existing
Location 1 - Hammond	100 m	50.4 dBA	51.4 dBA
Location 2 - Hitchcock	40 m	56.4 dBA	57.4 dBA
Location 5 - Pignataro	65 m	53.2 dBA	54.2 dBA
Location 9 - Young	35 m	57.3 dBA	57.5 dBA
Location 10 - Tornatola	35 m	57.3 dBA	57.5 dBA

Review of the road traffic noise level predictions presented in **Table 19** (as well as Table 18 of Heggies Report 10-3138-R1) indicates the following:

- The existing minimum daytime $L_{Aeq(1hour)}$ noise levels are lower than the NSW DECC's recommended assessment criterion of 60 dBA at all assessment locations.
- For the worst case existing cumulative project related traffic volumes, the predicted increase in the peak daytime $L_{Aeq(1hour)}$ traffic noise levels following the inclusion of the Lot 198 project at all assessment locations is 1.2 dBA.
- The existing minimum early morning $L_{Aeq(1hour)}$ traffic noise levels are within the NSW DECC's recommended assessment criterion of 55 dBA at two assessment locations, and up to 2.5 dBA higher than the criterion at the remaining three locations.
- For the worst case existing project related traffic volumes, the predicted increase in the peak early morning $L_{Aeq(1hour)}$ traffic noise levels following the inclusion of the Lot 198 project at all assessment locations is 1.0 dBA or lower.

In conclusion, the predicted minimum approved existing plus worst case cumulative project traffic noise levels comply with the NSW DECC's daytime and night-time traffic noise criteria nominated in **Table 13**.

11 CUMULATIVE NOISE IMPACT ASSESSMENT

11.1 General

Several other sand extraction operations currently exist in the vicinity of the project site. Existing and approved operations include Dixon Sands, PF Formation's proposed Lot 198 site and HB Maroota. A summary of DECC Licence Conditions with respect to noise is attached as **Appendix G**.

In order to assess any cumulative noise impacts, it is important to appreciate and distinguish between the INP's first and second environmental noise control objectives as follows:

Intrusive Noise Criteria $L_{Aeq(15minute)}$

The INP's first objective, that the intrusive noise emission from any single source does not exceed the background level by more than 5 dBA, relates to individual industrial sites where the intrusive noise limit is generally specified in the Development Consent and/or Pollution Control Licence.

There is no established procedure (or regulatory requirement) to derive intrusive $L_{Aeq(15minute)}$ noise criteria for the cumulative operation of existing and/or approved industrial developments in a locality.

Noise Amenity Criteria $L_{Aeq(period)}$

The INP's second objective, that the $L_{Aeq(period)}$ amenity level (ie non-transport related) does not to exceed the specified "acceptable" or "maximum" noise level appropriate for the particular locality and land use, is aimed at restricting the potential cumulative increase in amenity noise levels otherwise known as "background creep".

The INP based acceptable and maximum noise amenity criteria for the nine assessment localities are summarised in **Table 20**.

Table 20 NSW INP Project Specific Noise Assessment Criteria (dBA re 20 µPa)

Assessment Location	Land Use	Project Specific Assessment Criteria			
		Amenity $L_{Aeq(period)}$[1] Acceptable		Amenity $L_{Aeq(period)}$[1] Maximum	
		Day	Night	Day	Night
Location 1 - Hammond	Rural Residential	50	40	55	45
Location 2 - Hitchcock	Rural Residential	50	40	55	45
Location 5 - Pignataro	Rural Residential	50	40	55	45
Location 6 - Camilleri	Rural Residential	50	40	55	45
Location 7 - Maroota P.S.	School	35[2]	N/A	40[2]	N/A
Location 8 - Portelli	Rural Residential	50	40	55	45
Location 9 - Young	Rural Residential	50	40	55	45
Location 10 - Tornatola	Rural Residential	50	40	55	45

Note 1: Daytime 0700 hours to 1800 hours, Night-time 2200 hours to 0700 hours.
Note 2: External criterion, assuming a typical 10dB insertion loss from inside to outside.

11.2 Cumulative Noise Assessment

The potential for the simultaneous operation of adjoining developments to exceed the acceptable and maximum noise amenity criteria can be assessed on a worst case scenario basis by adding the predicted intrusive noise levels from the Lot 198 project and the Hitchcock Road project, together with the approved noise limits from the Licence Conditions for Dixon Sands and HB Maroota. The cumulative intrusive noise level is then adjusted to the equivalent amenity level for comparison with the criteria presented in **Table 20**. Note, this is clearly a worst case assessment as it assumes that all projects simultaneously emit their maximum noise emission to a common receiver during non-adverse or adverse weather conditions.

The cumulative noise amenity levels during non-adverse and adverse weather conditions are presented in **Table 21** for the nine assessment locations.

Table 21 Non-Adverse/Adverse Cumulative Noise Amenity (dBA re 20 µPa)

Assessment Location	Operating Period	Hitchcock Road Project L_{Aeq} (15minute)	Dixon L_{Aeq} (15minute)	PF Formation - Lot 198 L_{Aeq} (15minute)	HB Maroota L_{Aeq} (15minute)	Cumulative $L_{Aeq(period)}$ Amenity Level	Acceptable /Maximum Cumulative $L_{Aeq(period)}$ Amenity Criteria
Location 1- Hammond	Daytime	36/41	39/44	5/10	37/42	42/47	50/55
	Night-time	5/10	32/37	5/10	37/42	38/43	40/45
Location 2 - Hitchcock	Daytime	35/40	39/44	17/22	37/42	42/47	50/55
	Night-time	13/18	32/37	13/18	37/42	38/43	40/45
Location 5 - Pignataro	Daytime	40/45	39/44	35/40	37/42	44/49	50/55
	Night-time	32/37	32/37	32/37	37/42	40/45	40/45
Location 6 - Camilleri	Daytime	35/40	39/44	38/43	37/42	44/49	50/55
	Night-time	32/37	32/37	32/37	37/42	40/45	40/45
Location 7 - Maroota P.S.	Daytime	31/36	40/45	35/40	37/42	43/48	45/50[1]
	Night-time	N/A	N/A	N/A	N/A	N/A	N/A
Location 8 - Portelli	Daytime	34/39	39/44	31/36	37/42	42/47	50/55
	Night-time	27/32	32/37	27/32	37/42	39/44	40/45
Location 9 - Young	Daytime	39/44	39/44	29/34	37/42	43/48	50/55
	Night-time	30/35	32/37	30/35	37/42	39/44	40/45
Location 10 - Tornatola	Daytime	39/44	39/44	32/37	37/42	44/49	50/55
	Night-time	33/38	32/37	32/37	37/42	40/45	40/45

Note 1: External criterion, assuming a typical 10 dB insertion loss from inside to outside.

At all eight noise assessment locations, the cumulative noise emissions from the subject project and adjoining developments are below the relevant acceptable amenity criteria for industrial noise (ie non-transport related) during the daytime and night-time periods.

12 SUMMARY OF RESULTS AND FINDINGS

12.1 General

This report presents the results and findings of an assessment of the potential impacts of the operation of the proposed sand extraction project off Hitchcock Road, Maroota, NSW.

From an analysis of background noise measurements conducted in accordance with the DECC's INP (refer to **Section 3.1**), the daytime and night-time intrusive noise level criteria at the potentially most affected residences were established.

In relation to the operational noise impact assessment for this project, compliance with operational $L_{Aeq(15minute)}$ intrusive noise criterion would also result in compliance with the $L_{Aeq(period)}$ amenity criteria. The controlling noise criterion is therefore the intrusive criterion.

12.2 Operational Noise Assessment

Various assessment locations, namely Locations 5, 9 and 10 are impacted up to between 3 dBA and 5 dBA above the relevant daytime $L_{Aeq(15minute)}$ noise criteria, with Stage 2 operations resulting in the greatest number of assessment locations exceeding the relevant criteria.

During the early morning hour when the existing trucks are operating along the haul road, received $L_{Aeq(15minute)}$ noise emission levels at the various assessment locations are below the relevant criteria except for marginal exceedances at Location 10 (Tornatola) under prevailing NW winds (of 2 dBA) and Locations 5 (Pignataro), 6 (Camileri) and 10 (Tornatola) under temperature inversion conditions (of 2 dBA, 2 dBA and 3 dBA respectively).

12.3 Traffic Noise Assessment

The US Environment Protection Agency's method was used for the prediction of the $L_{Aeq(1hour)}$ existing daytime and early morning traffic noise levels for the various assessment locations around the site.

Review of the road traffic noise level predictions given in **Section 10** indicates that all existing peak hour noise levels are lower than the NSW DECC's recommended daytime (0700 hours to 2200 hours) traffic noise assessment criterion of $L_{Aeq(1hour)}$ 60 dBA. Existing peak hour noise levels during the early morning hour (0600 hours to 0700 hours) are also lower than the NSW DECC's night-time criterion of $L_{Aeq(1hour)}$ 55 dBA at two of the five assessment locations, while the remaining three locations show an increase in traffic noise level with the inclusion of the Lot 198 project of less than 2 dBA, also in compliance with the DECC's criteria.

12.4 Cumulative Noise Impact Assessment

The NSW INP provides non-mandatory cumulative noise assessment guidelines that address existing and successive industrial development by setting acceptable (and maximum) cumulative $L_{Aeq(period)}$ amenity levels for all industrial (ie non-transport related) noise in an area. Note, that the INP does not set acceptable cumulative $L_{Aeq(15minute)}$ intrusive criteria for all industrial noise sources in an area, but rather seeks to control cumulative noise via its amenity criteria.

At all eight noise assessment locations the cumulative noise emissions from the subject project and adjoining developments are below the relevant acceptable amenity criteria for industrial noise (ie non-transport related) during the daytime and night-time periods.

LOCALITY PLAN

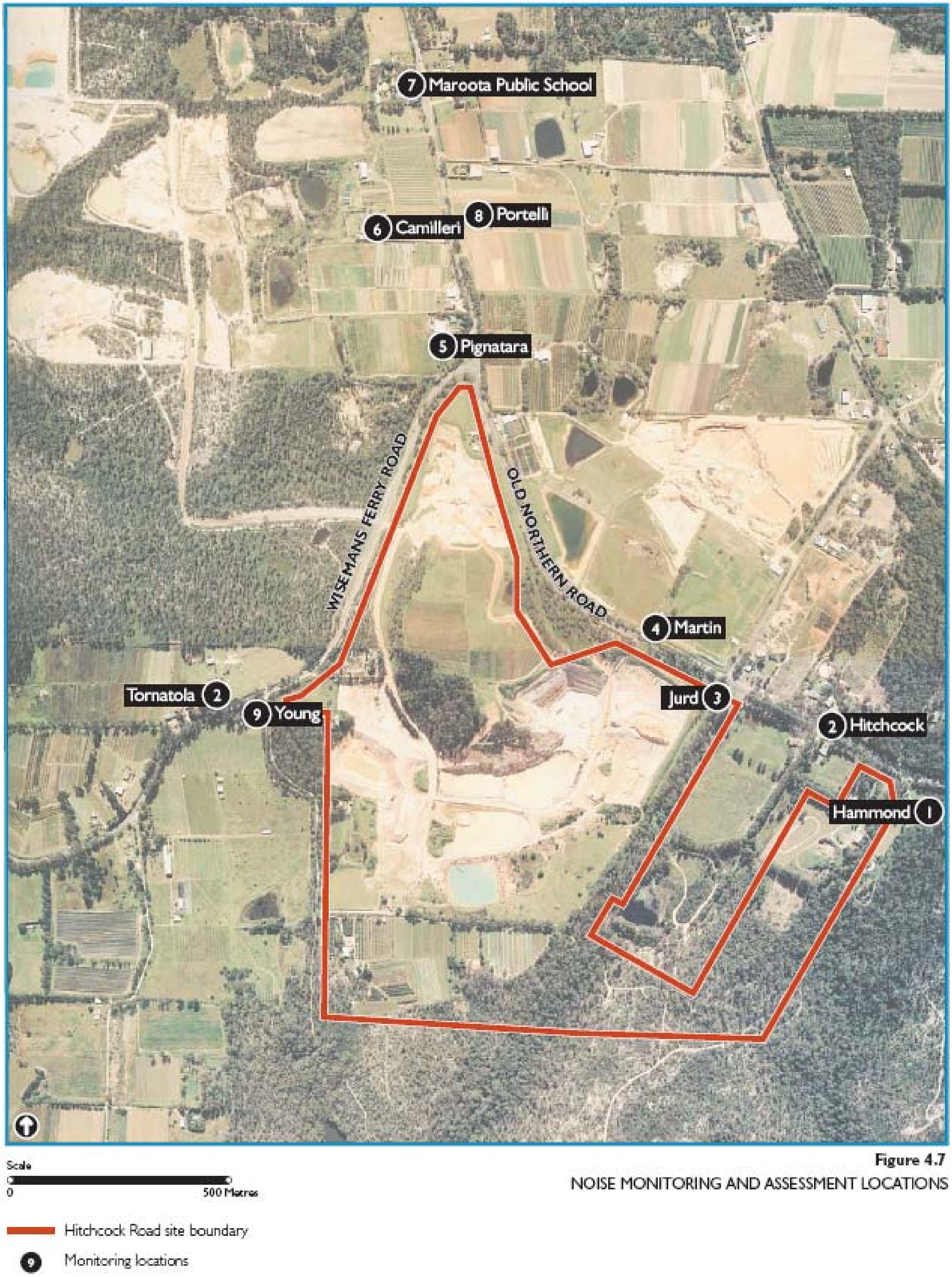
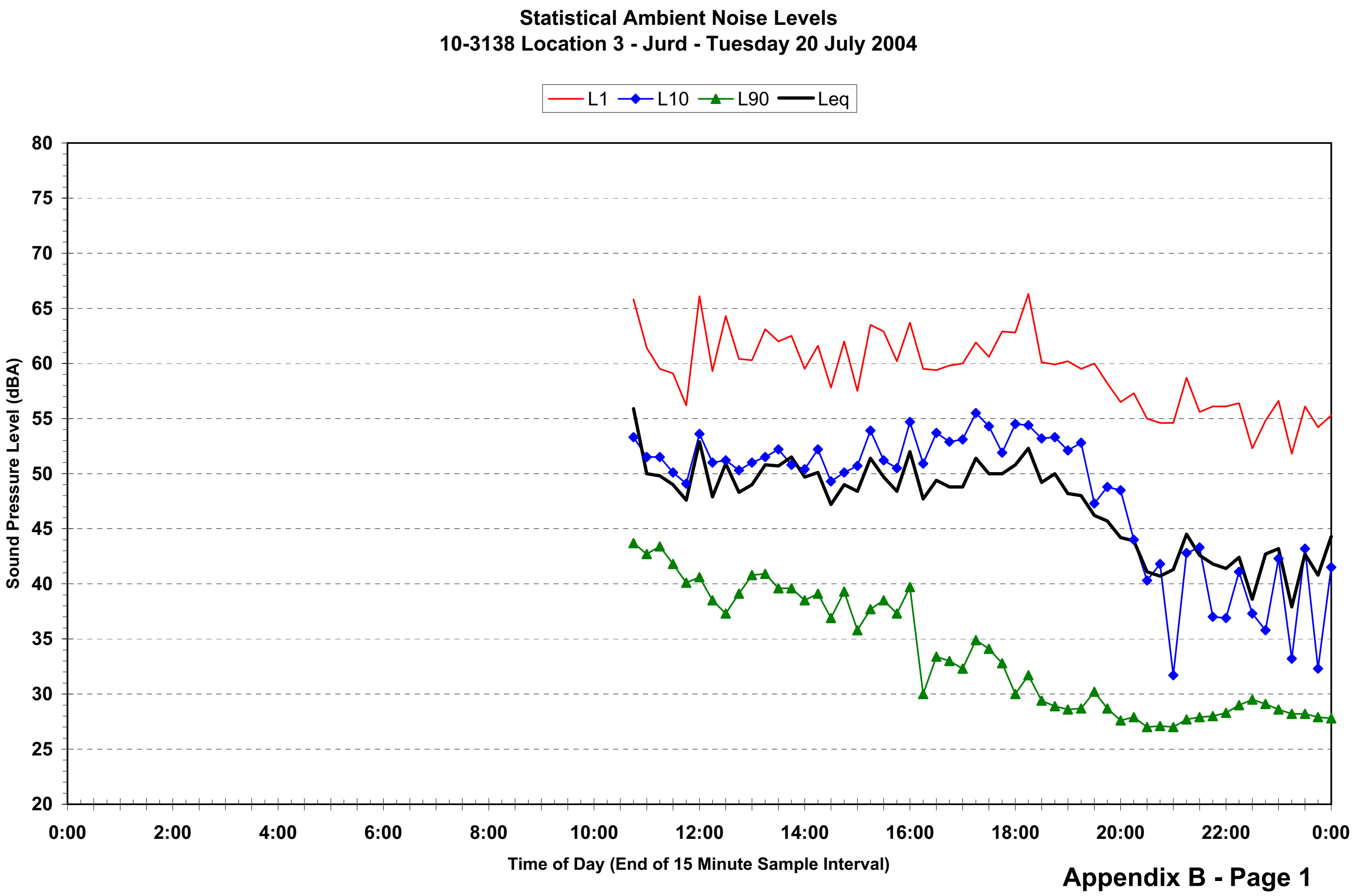


Figure 4.7
NOISE MONITORING AND ASSESSMENT LOCATIONS



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Statistical Noise Levels
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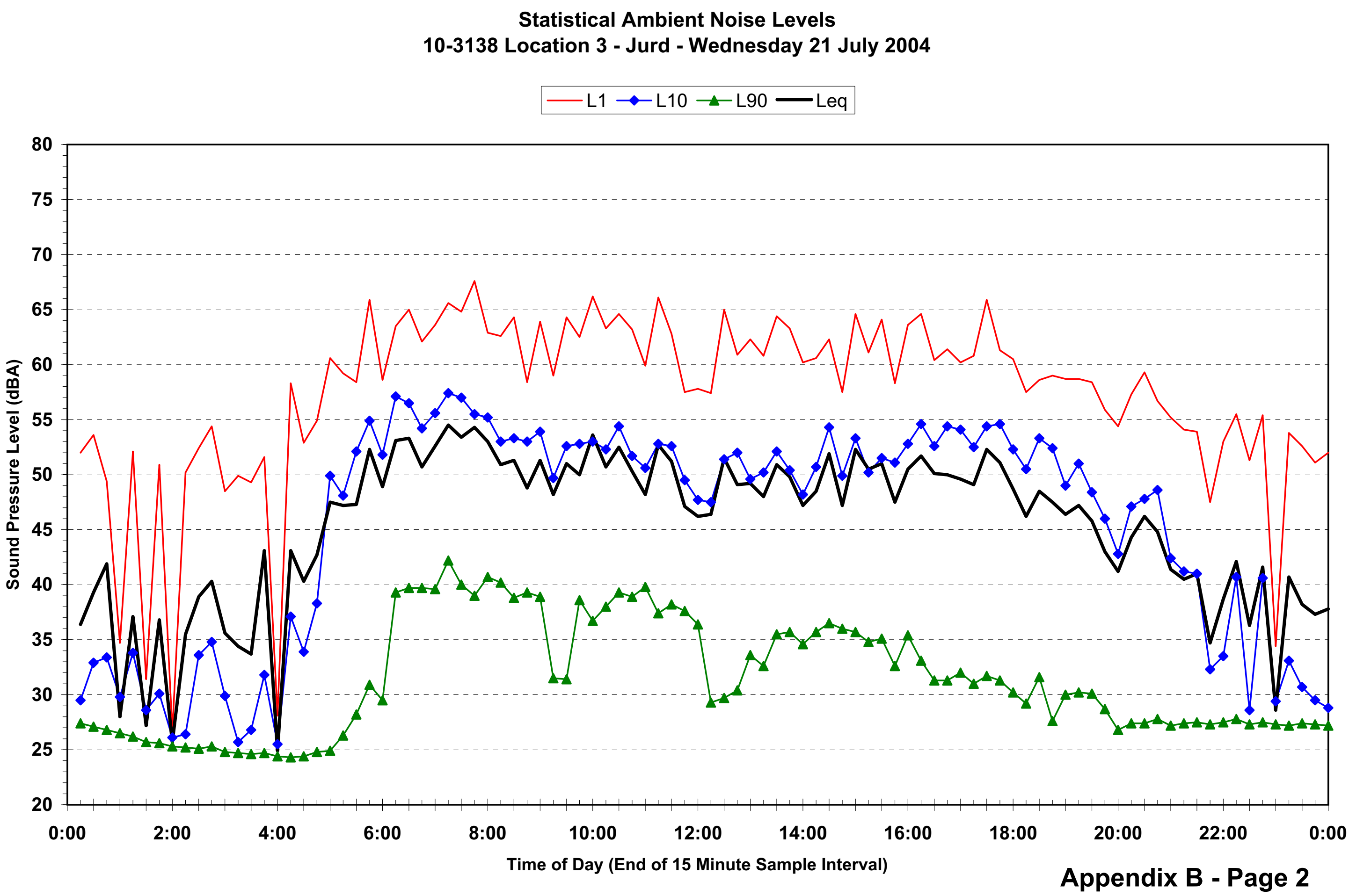

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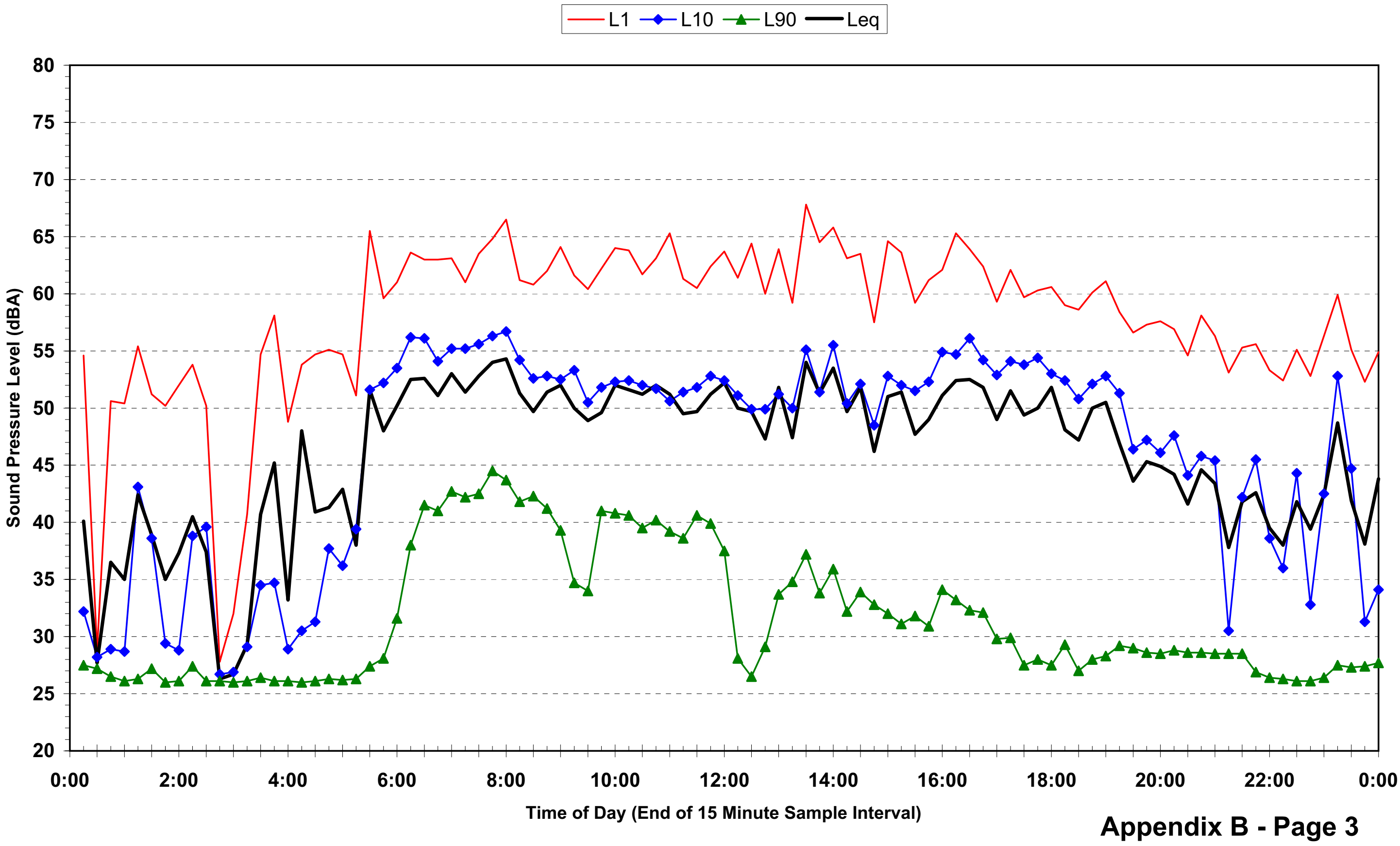
Statistical Ambient Noise Levels
10-3138 Location 3 - Jurd - Thursday 22 July 2004



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Statistical Noise Levels
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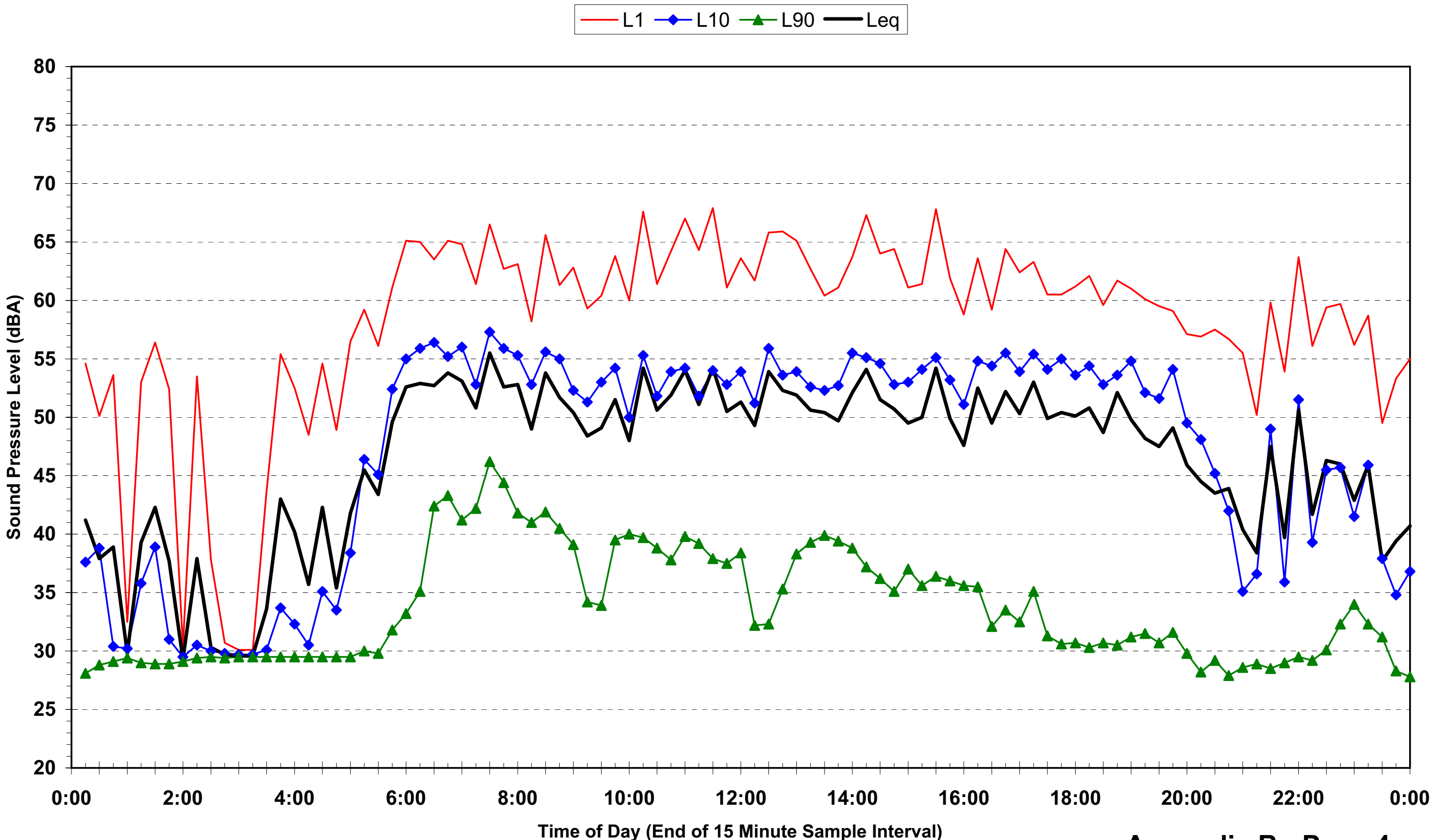
Statistical Ambient Noise Levels
10-3138 Location 3 - Jurd - Friday 23 July 2004



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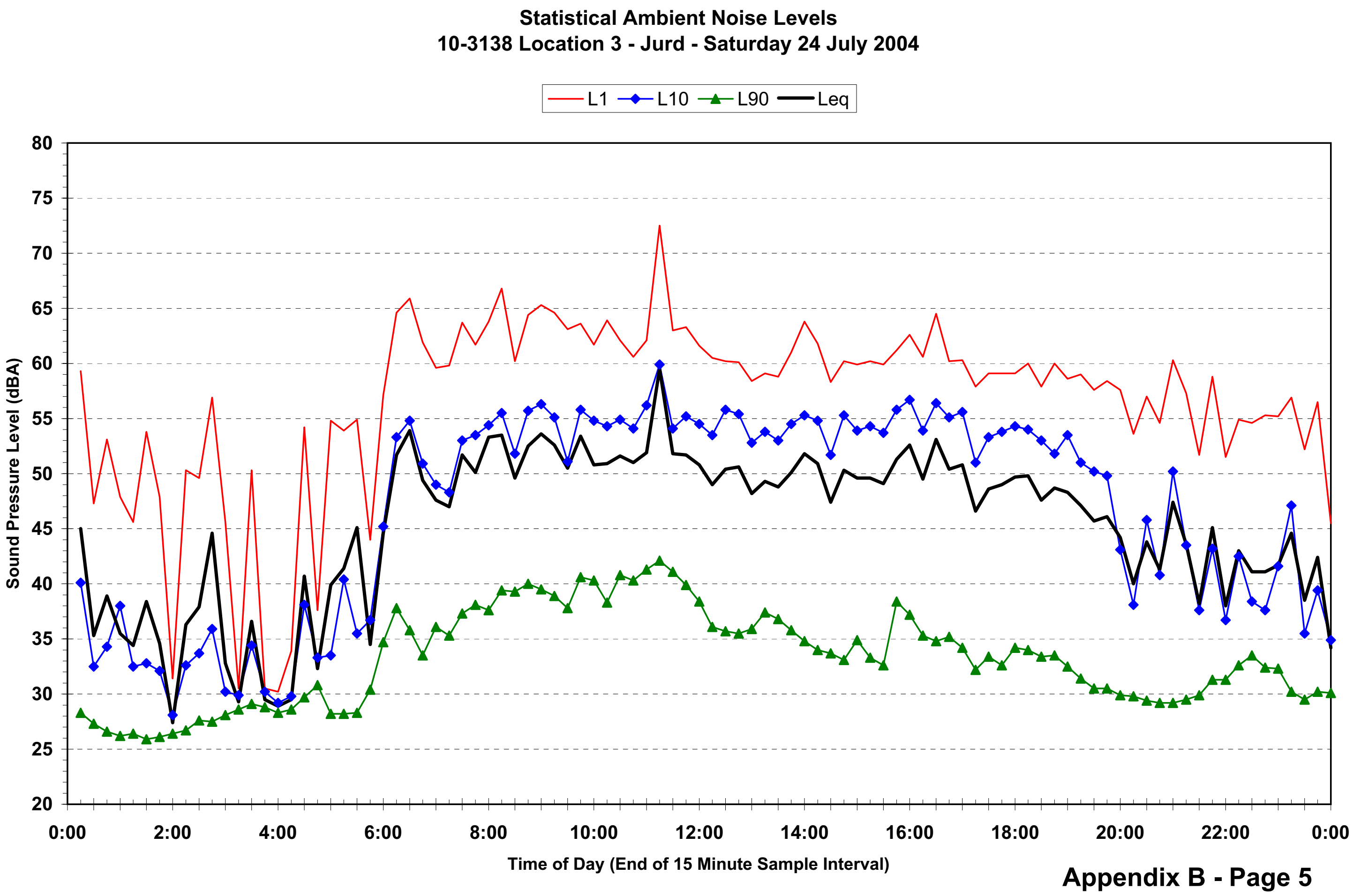
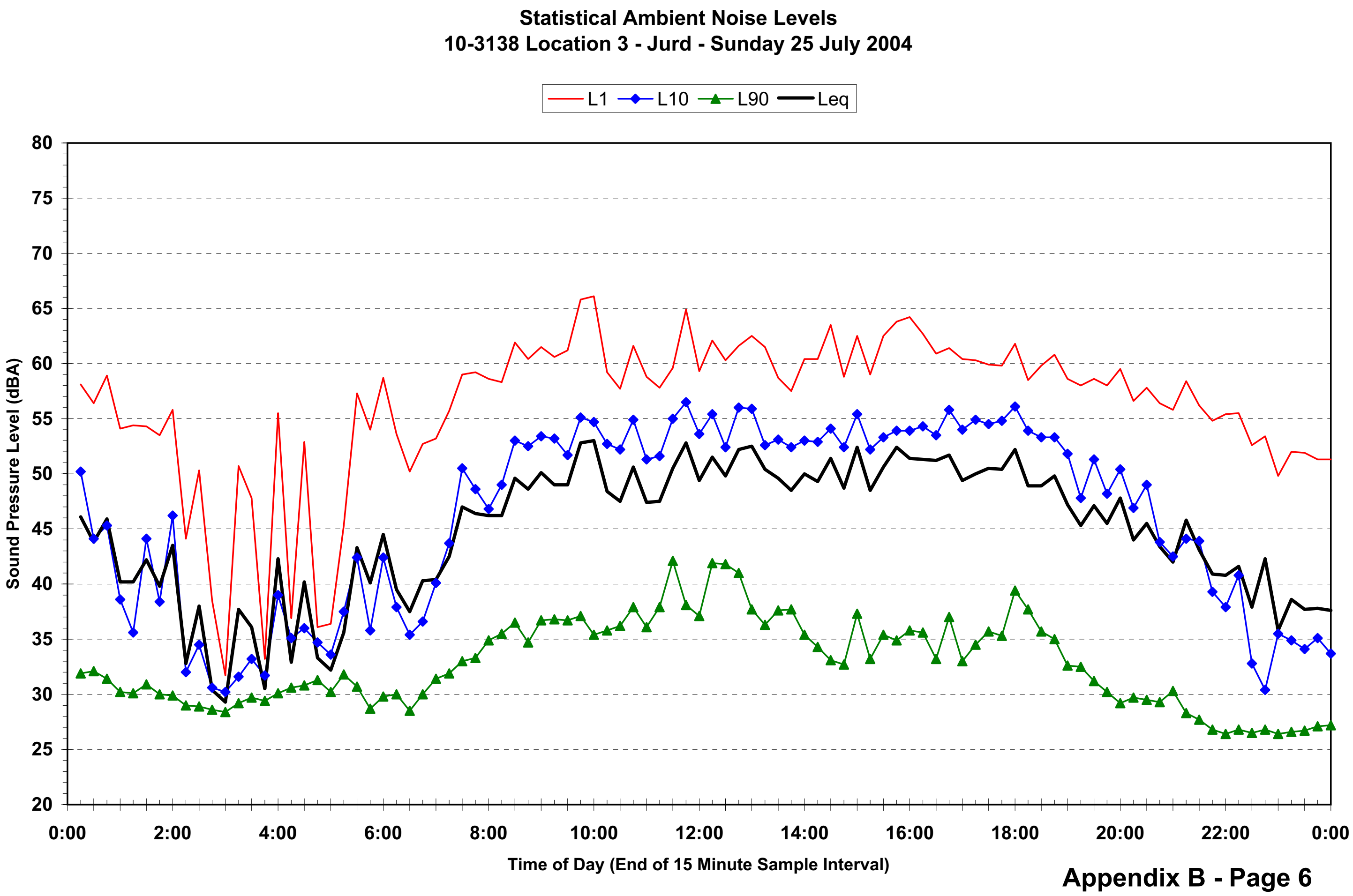
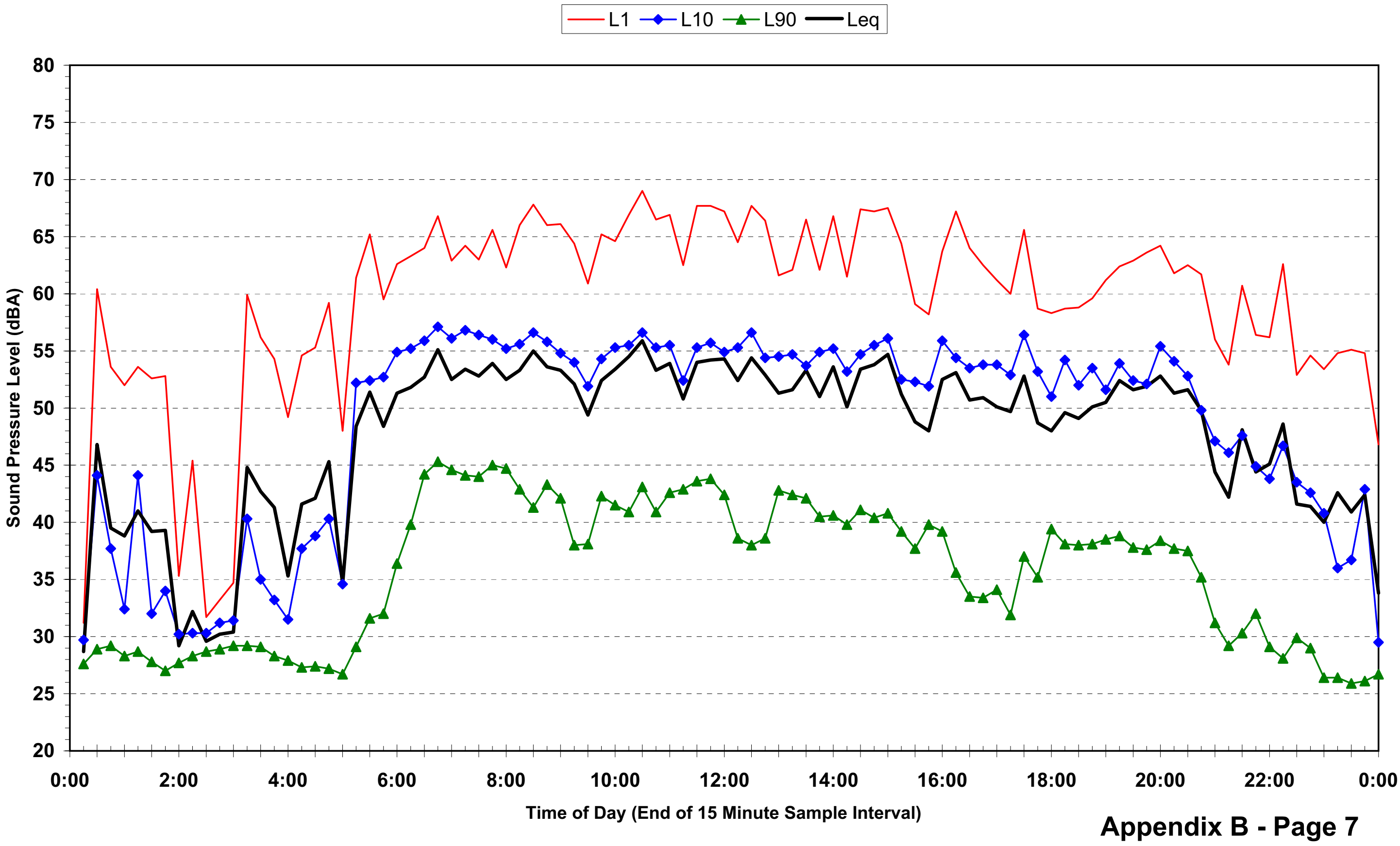


Statistical Ambient Noise Levels
10-3138 Location 3 - Jurd - Saturday 24 July 2004
L1
L10
L90
Leq
Sound Pressure Level (dBA)
80
75
70
65
60
55
50
45
40
35
30
25
20
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)



Statistical Ambient Noise Levels
10-3138 Location 3 - Jurd - Sunday 25 July 2004
L1
L10
L90
Leq
Sound Pressure Level (dBA)
80
75
70
65
60
55
50
45
40
35
30
25
20
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
10-3138 Location 3 - Jurd - Monday 26 July 2004



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Statistical Noise Levels

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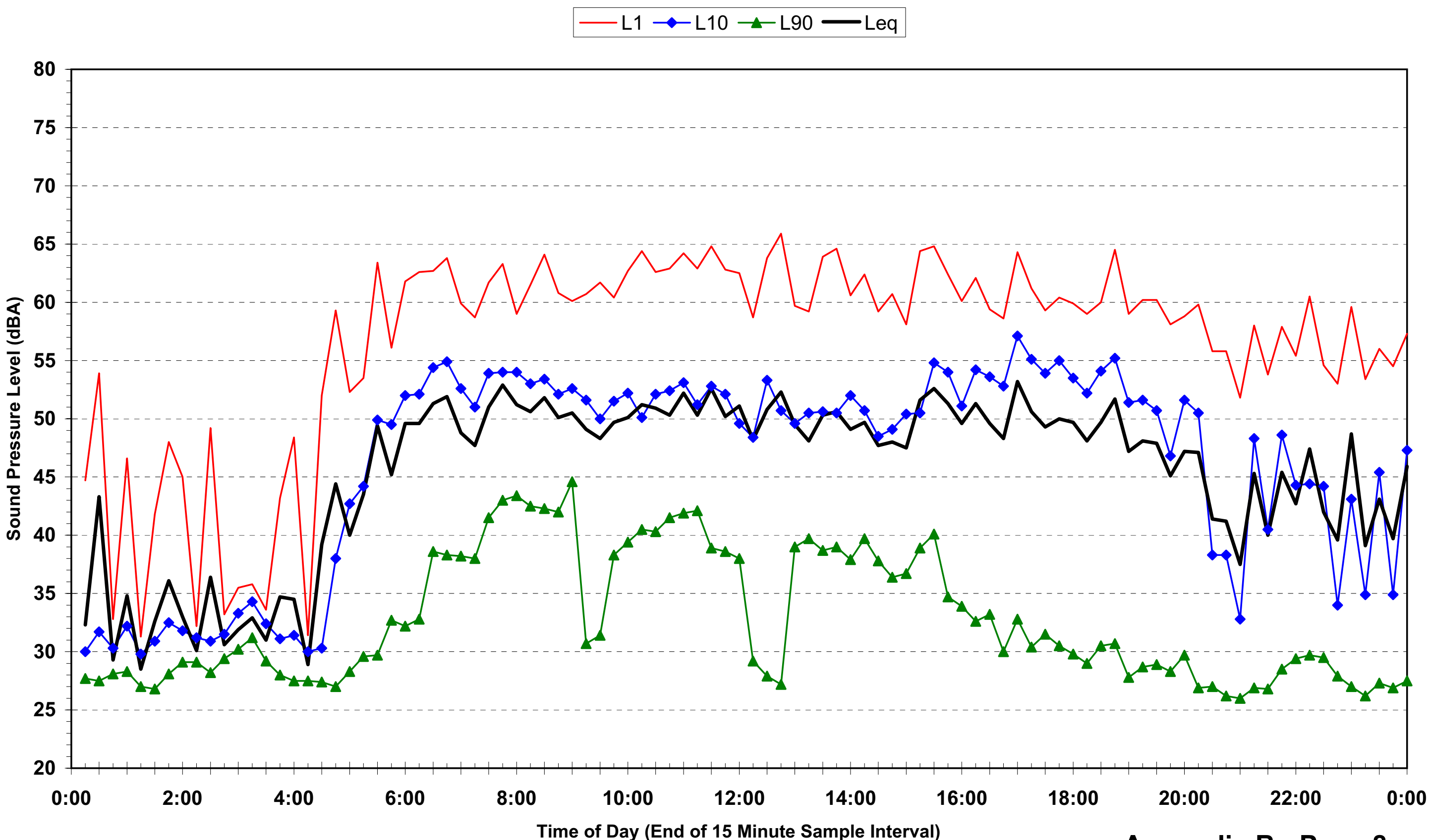
Statistical Ambient Noise Levels
10-3138 Location 3 - Jurd - Tuesday 27 July 2004



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Statistical Noise Levels

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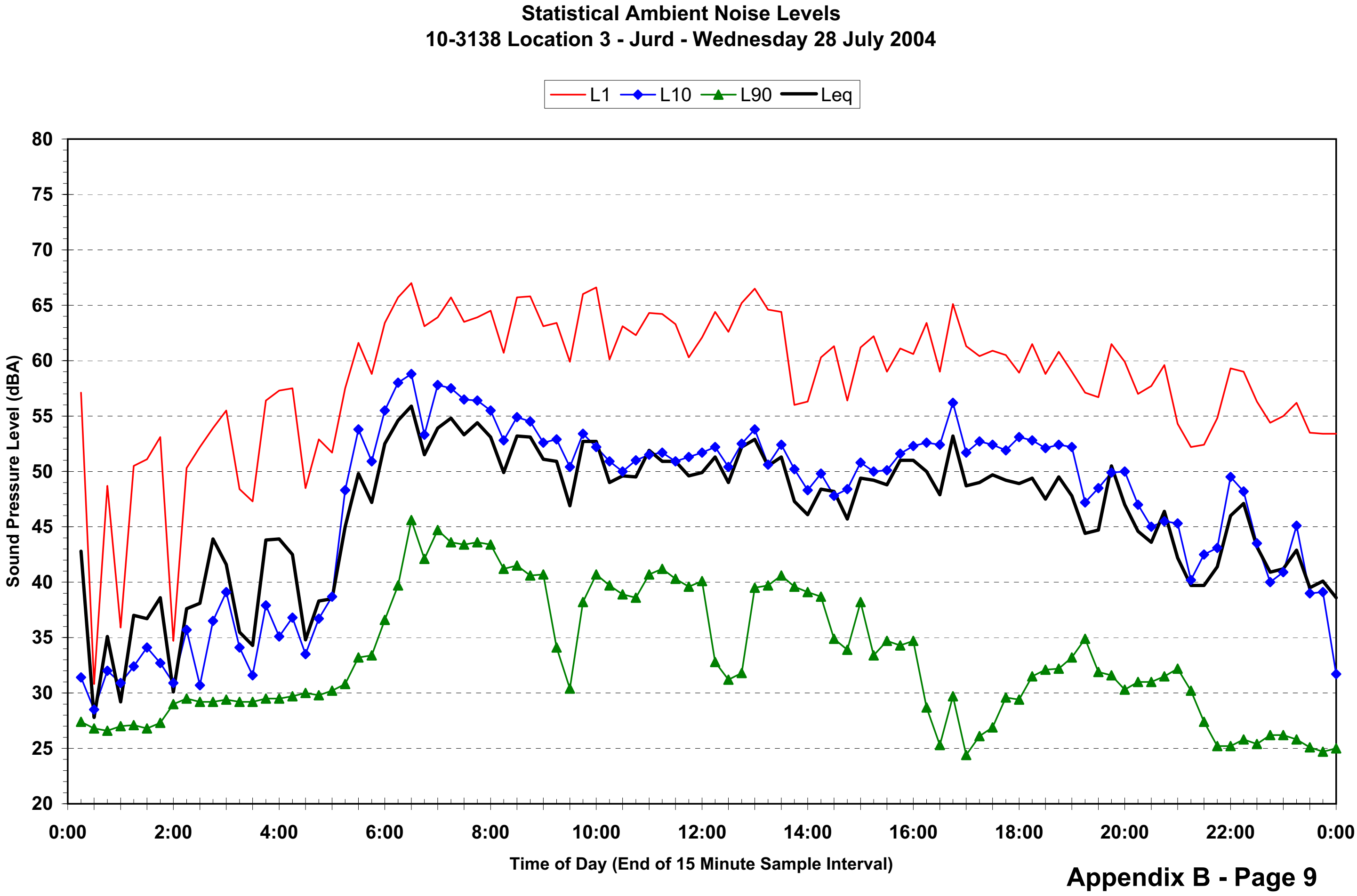

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Statistical Noise Levels
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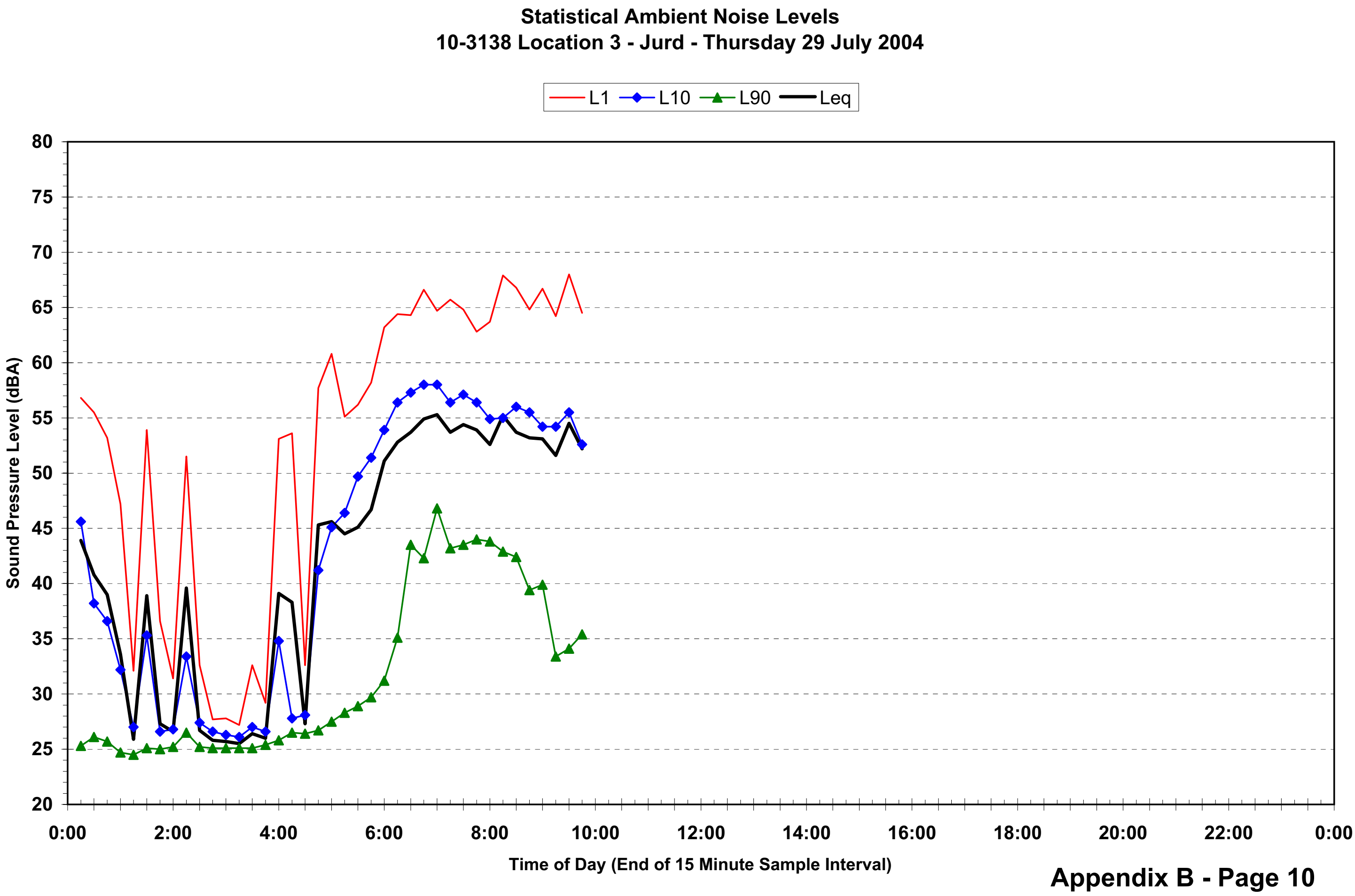

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Statistical Noise Levels
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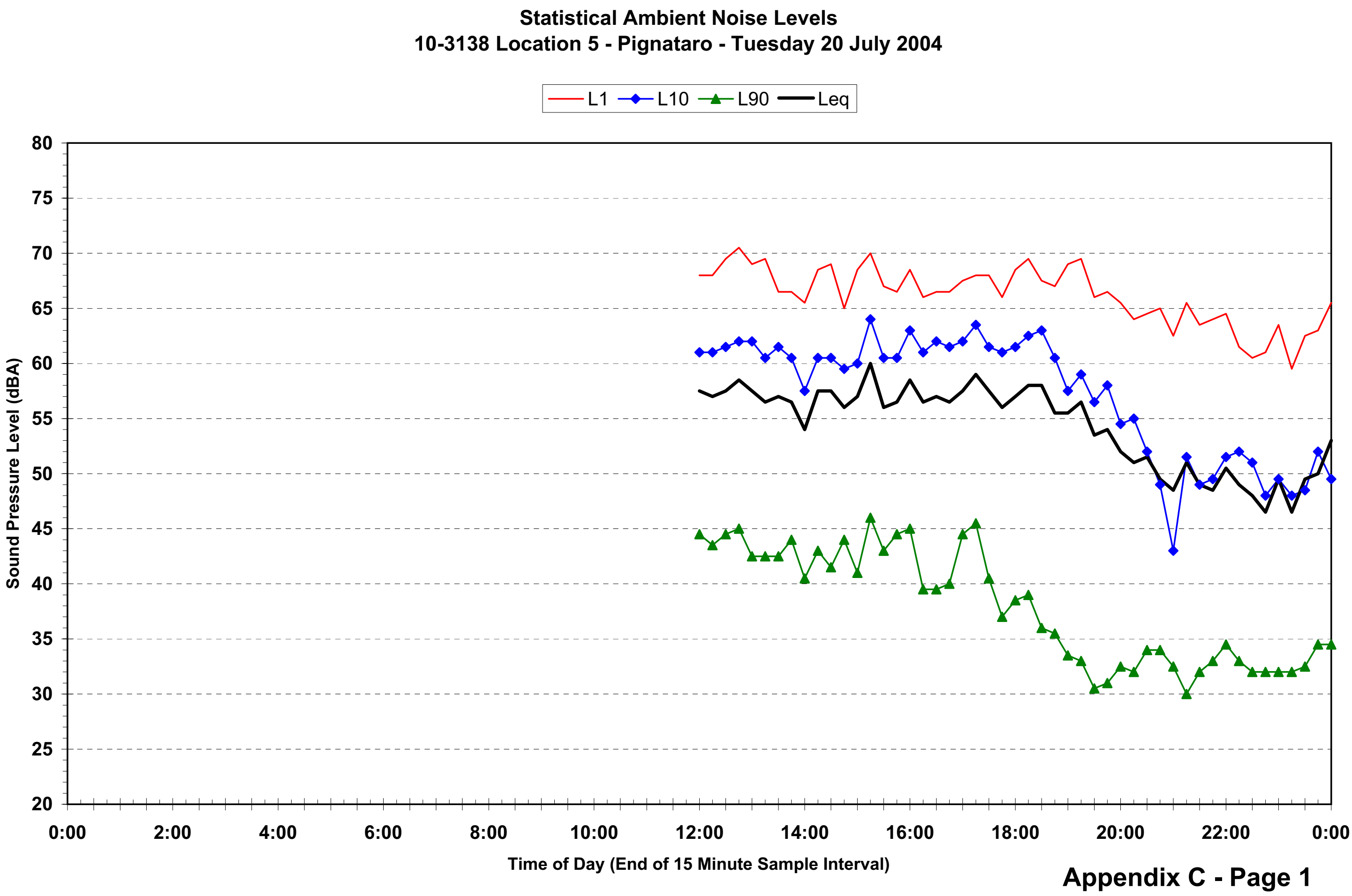

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Statistical Noise Levels
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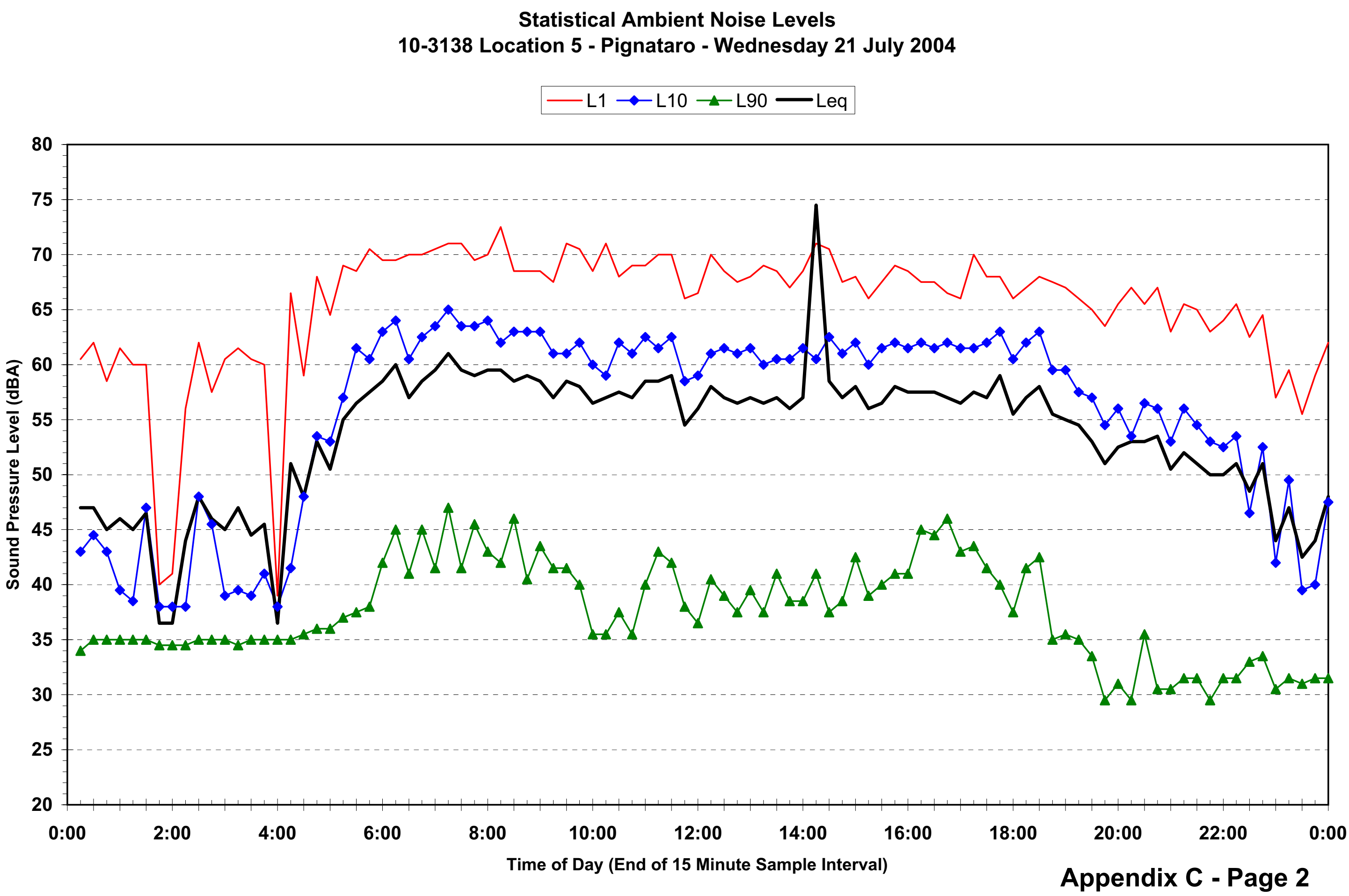

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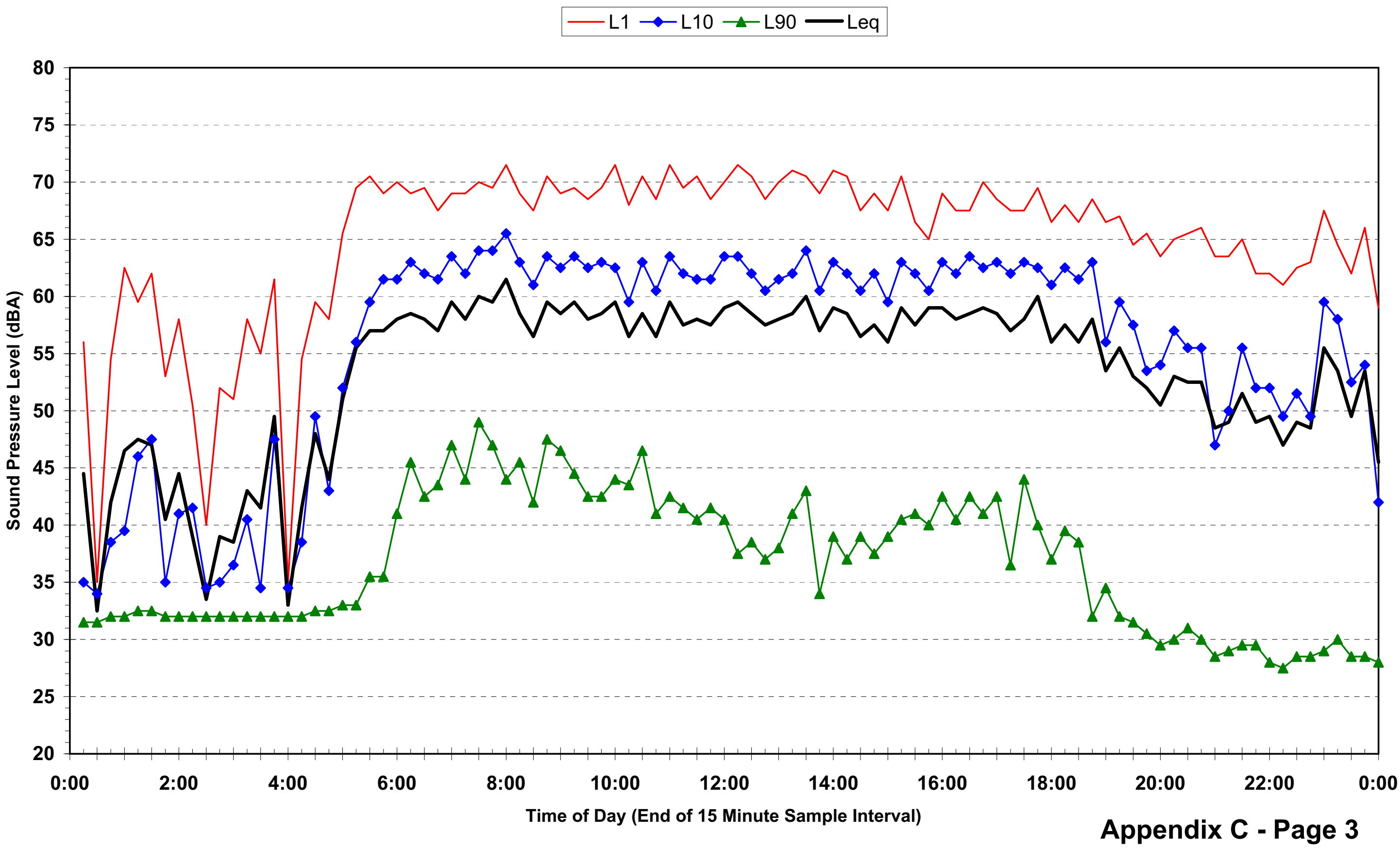
Statistical Noise Levels
RHA Report 10-3138

Statistical Ambient Noise Levels
10-3138 Location 5 - Pignataro - Thursday 22 July 2004



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Statistical Noise Levels

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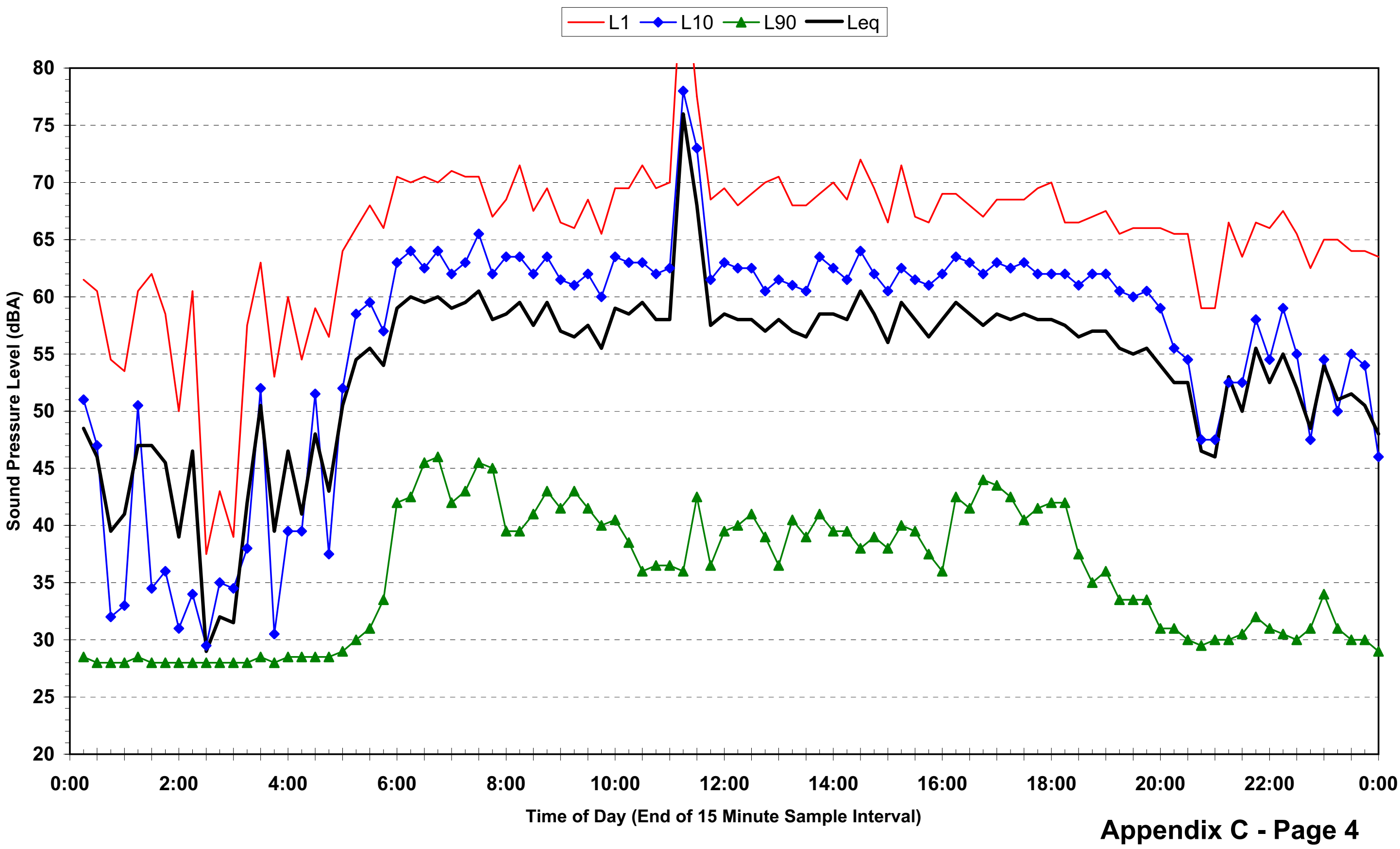
Statistical Ambient Noise Levels
10-3138 Location 5 - Pignataro - Friday 23 July 2004



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Statistical Noise Levels

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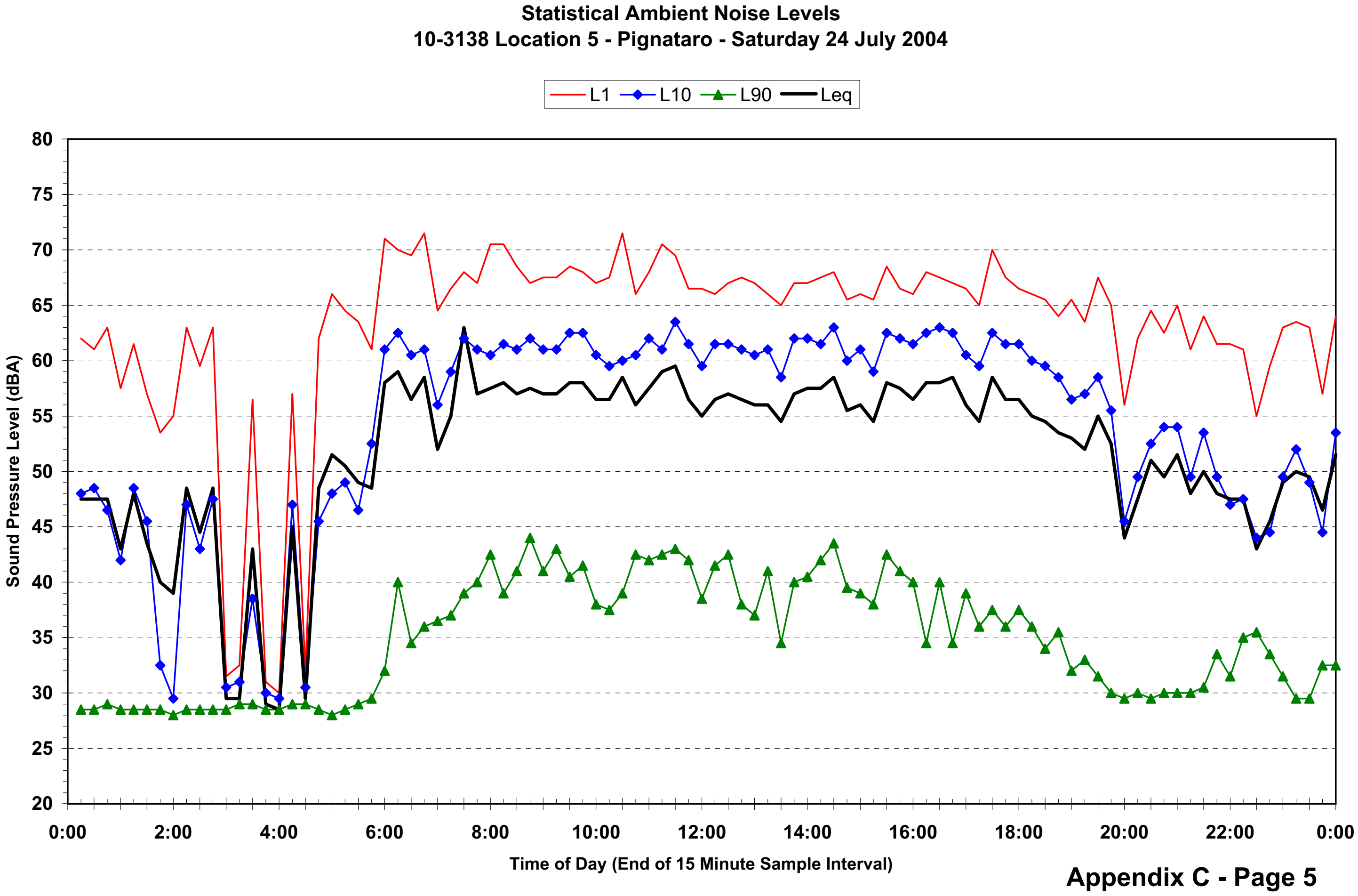

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Statistical Noise Levels

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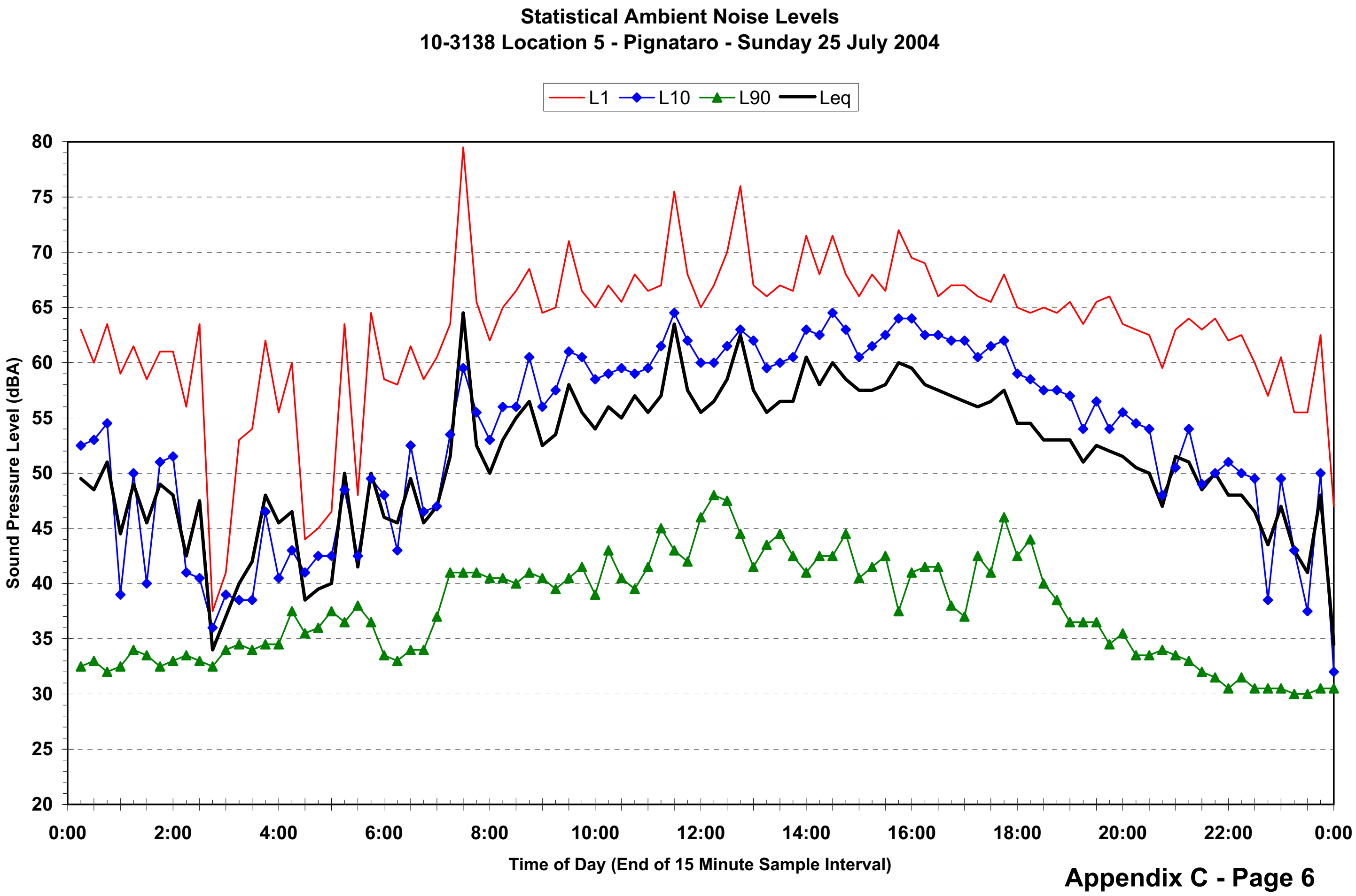

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Statistical Noise Levels

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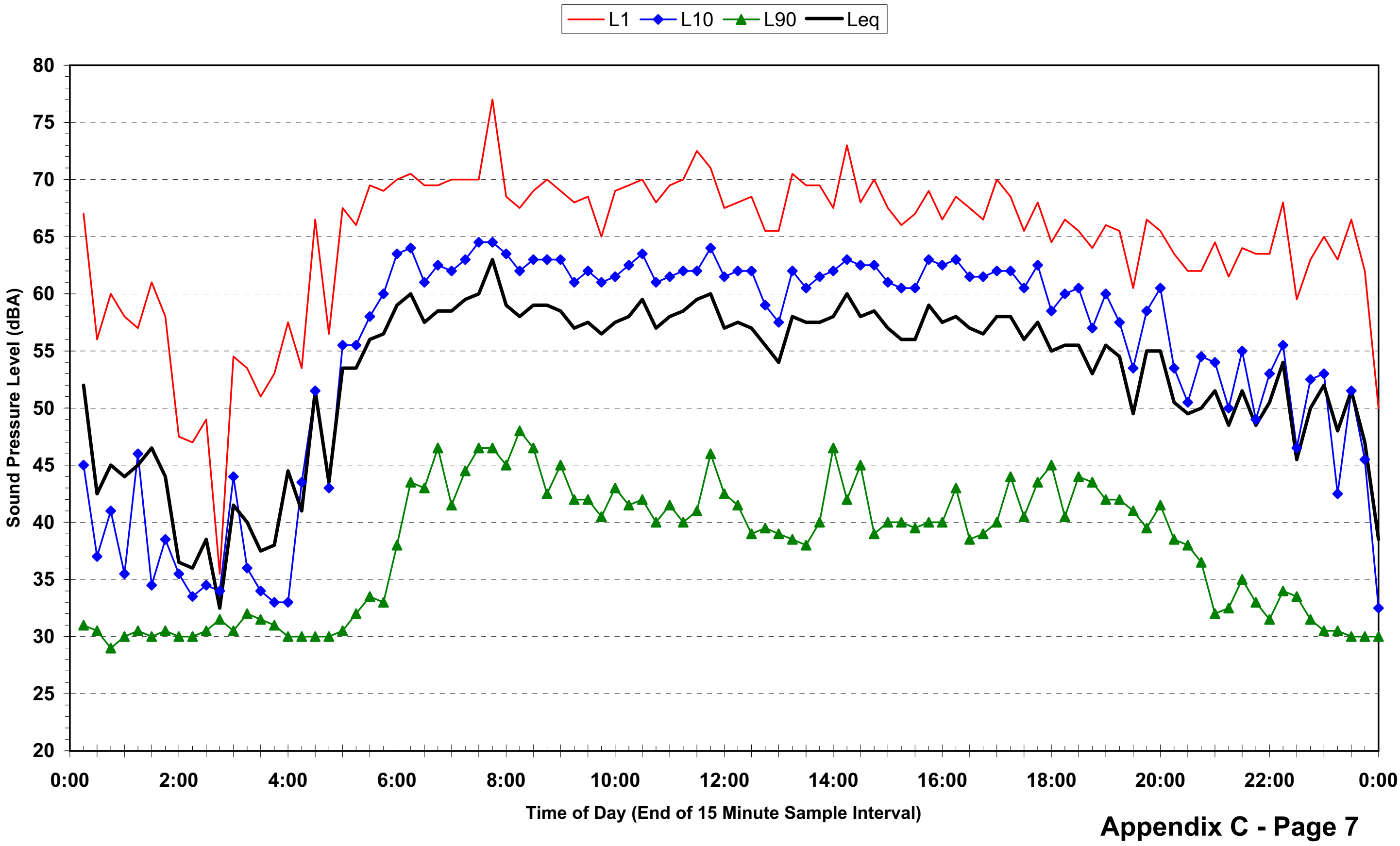
Statistical Ambient Noise Levels
10-3138 Location 5 - Pignataro - Monday 26 July 2004



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Statistical Noise Levels
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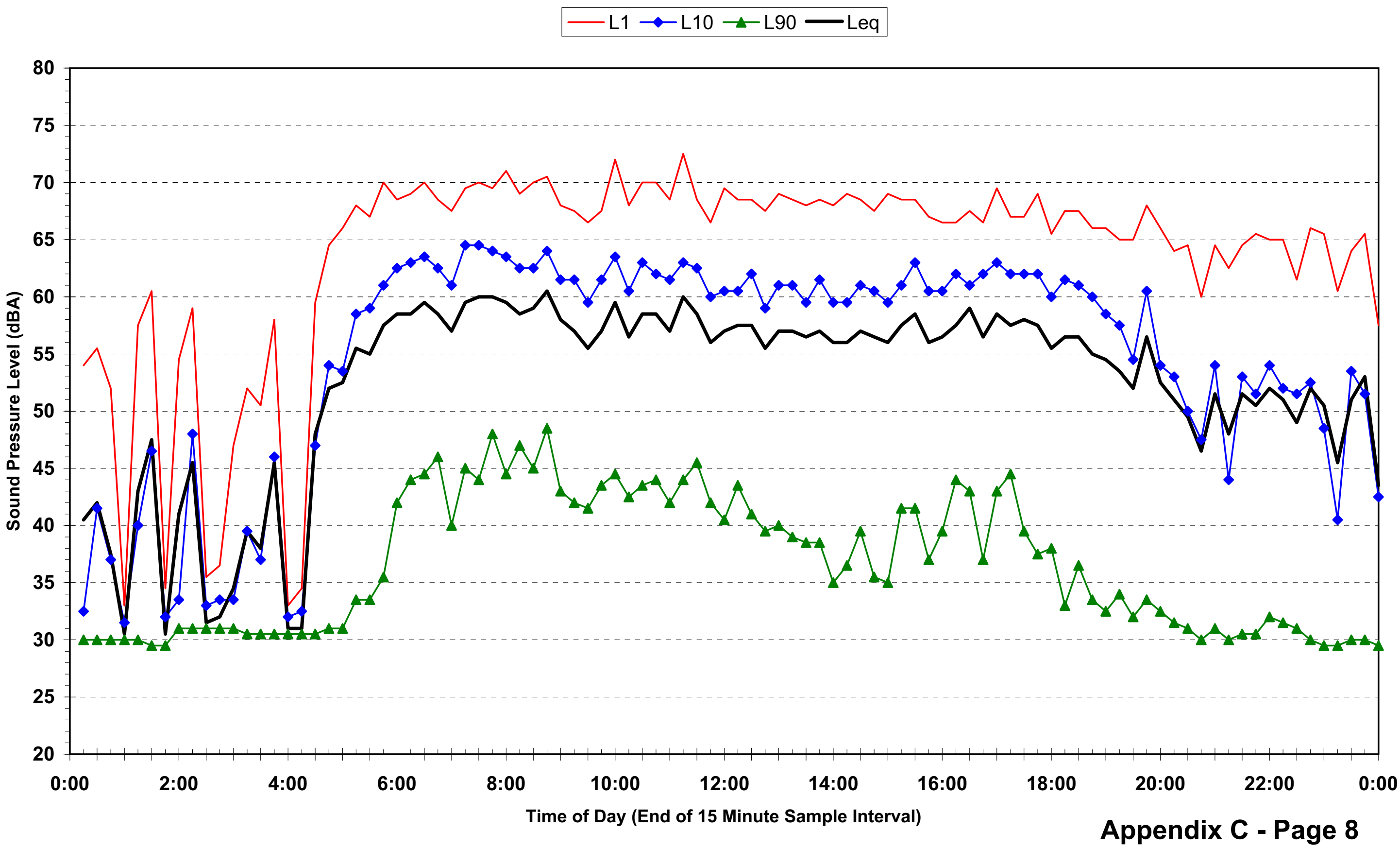
Statistical Ambient Noise Levels
10-3138 Location 5 - Pignataro - Tuesday 27 July 2004



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Statistical Noise Levels
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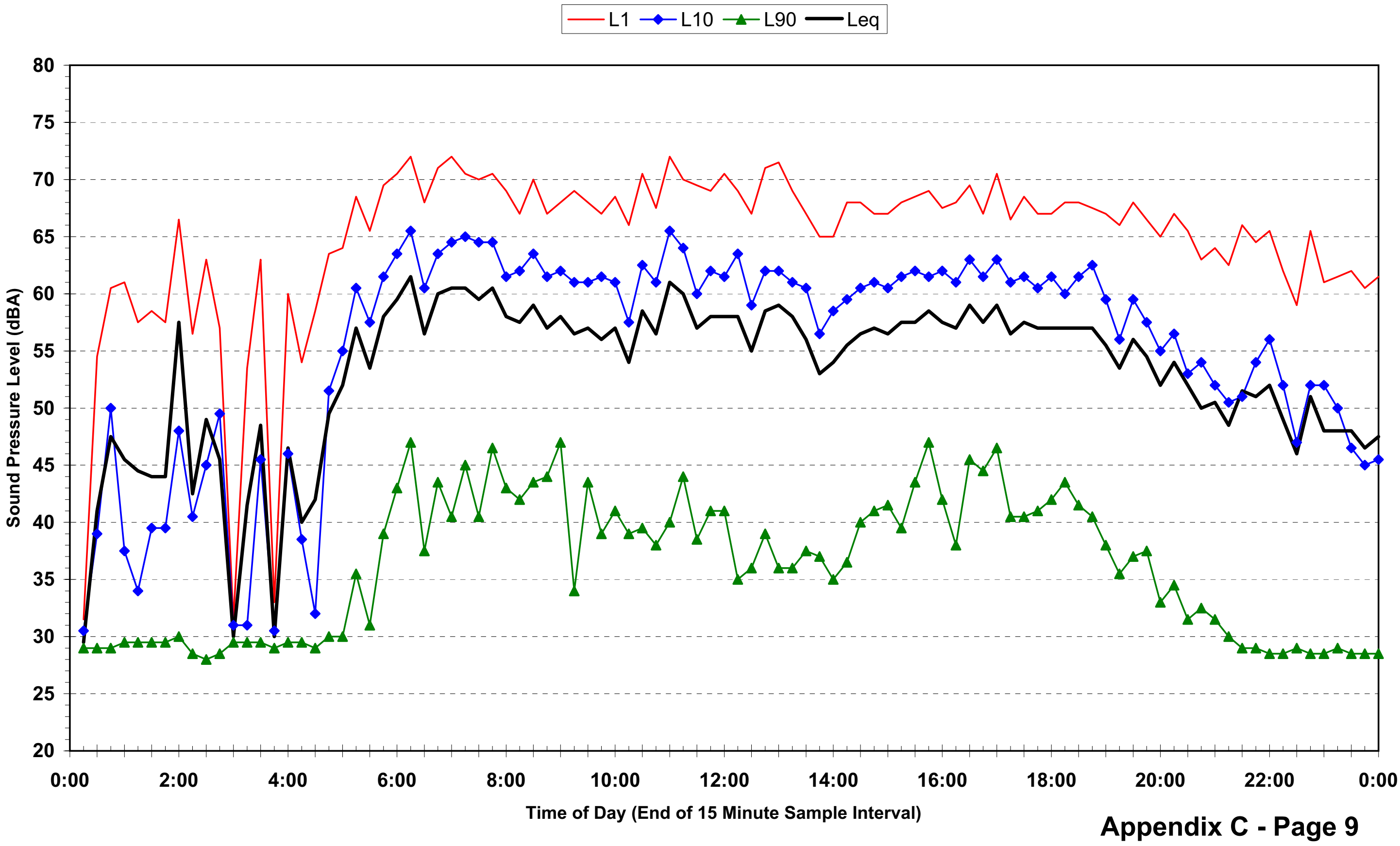
Statistical Ambient Noise Levels
10-3138 Location 5 - Pignataro - Wednesday 28 July 2004



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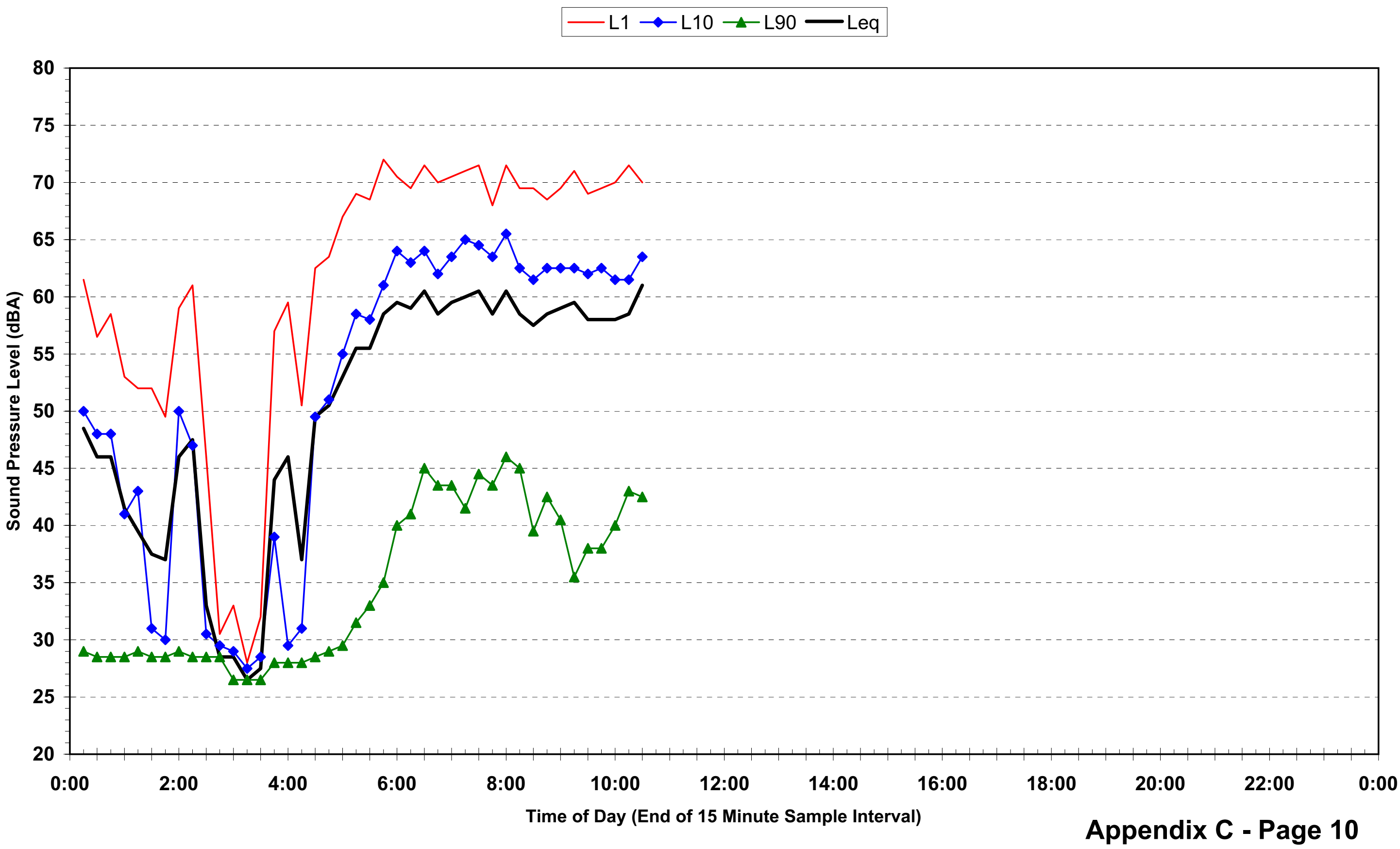
Statistical Ambient Noise Levels
10-3138 Location 5 - Pignataro - Thursday 29 July 2004



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Statistical Noise Levels
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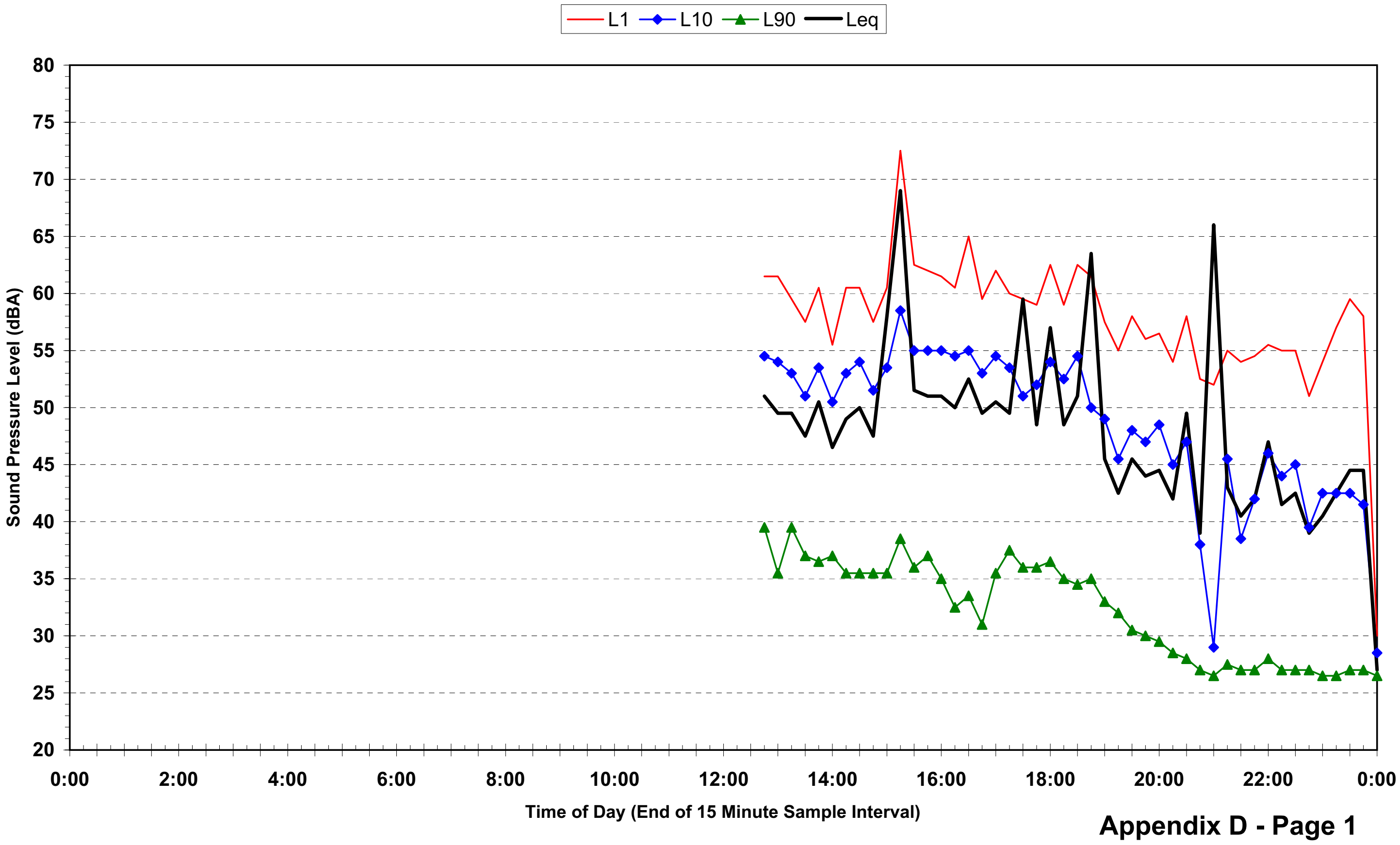
Statistical Ambient Noise Levels
10-3138 Location 9 - Young - Tuesday 20 July 2004



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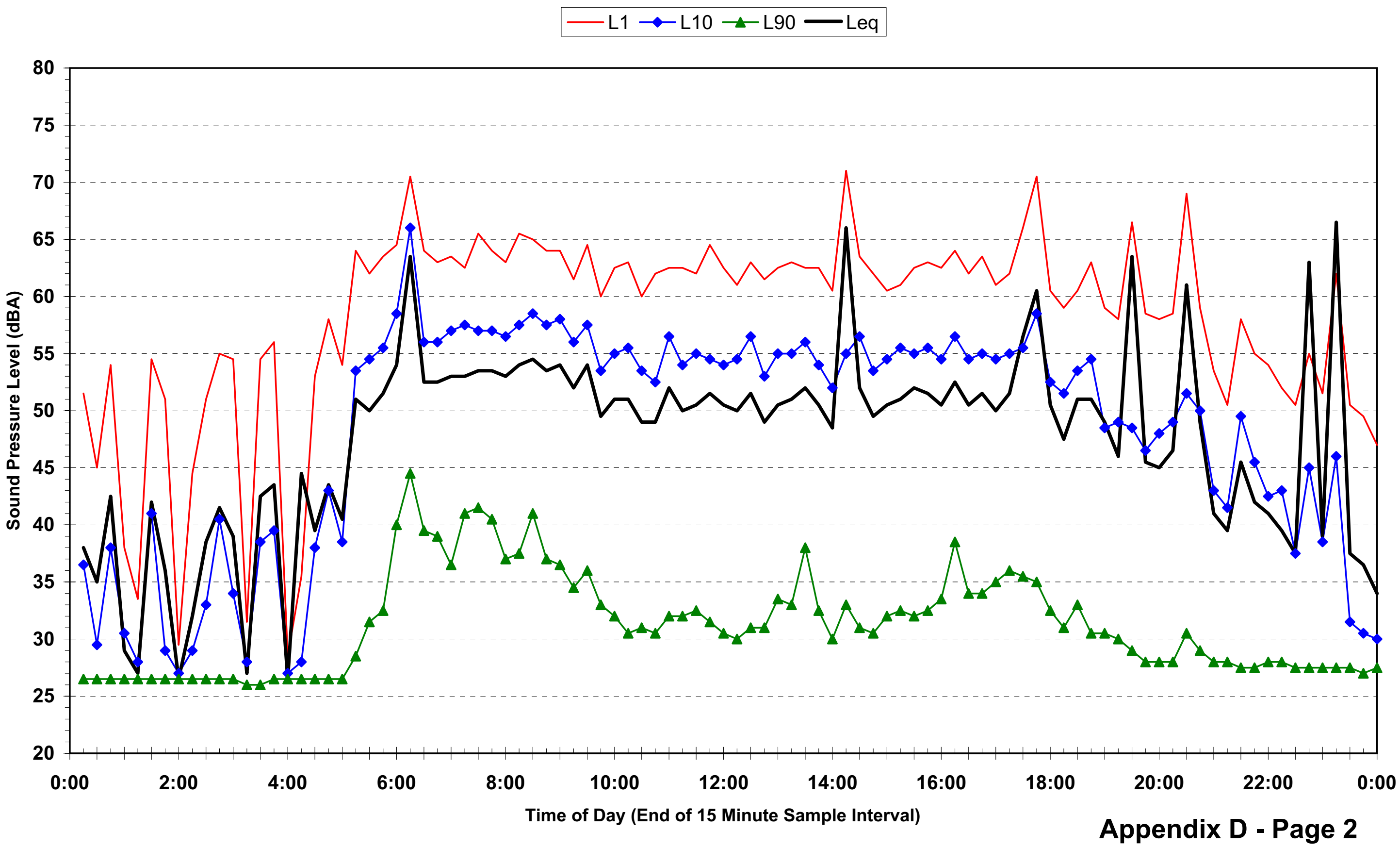
Statistical Ambient Noise Levels
10-3138 Location 9 - Young - Wednesday 21 July 2004



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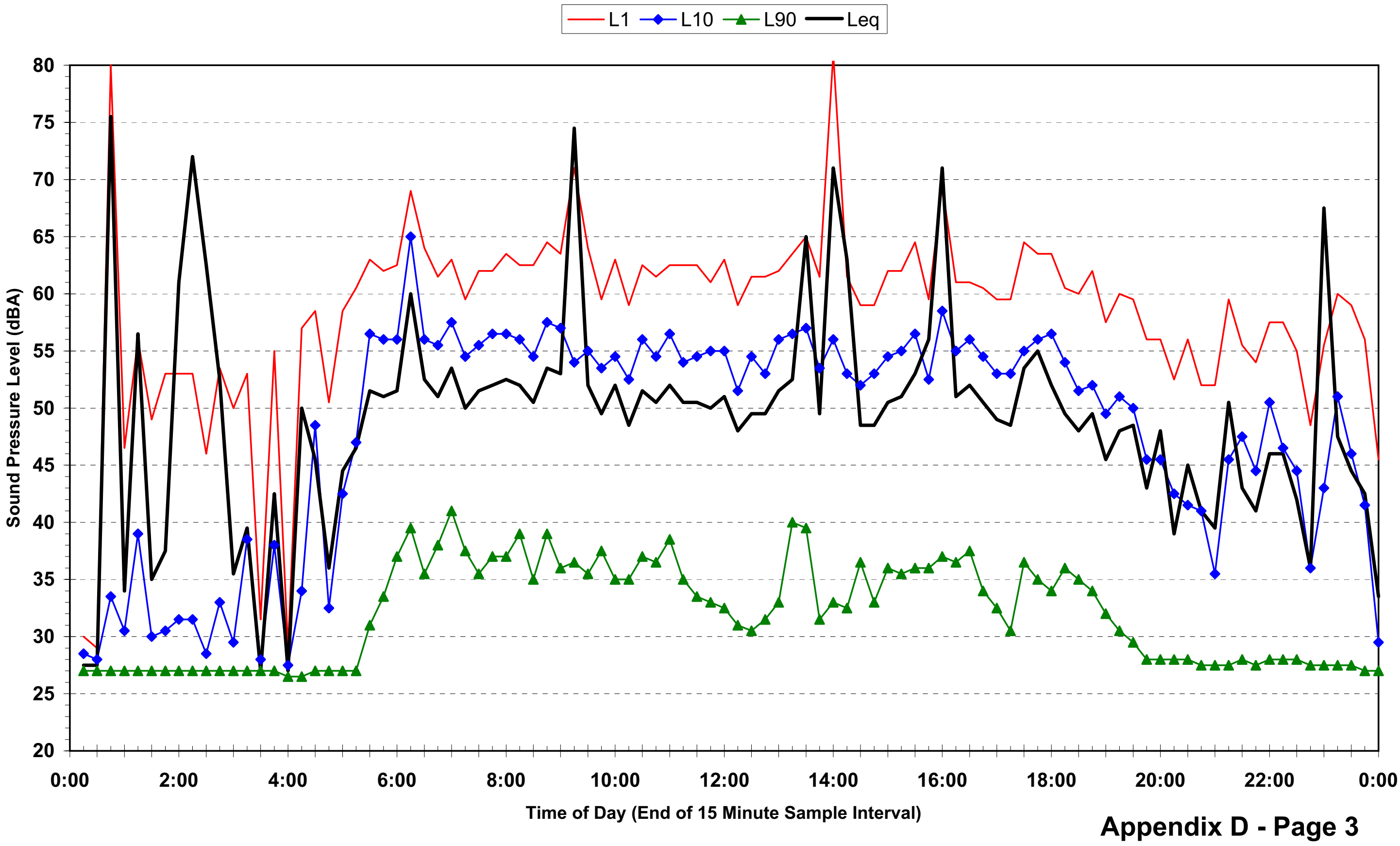
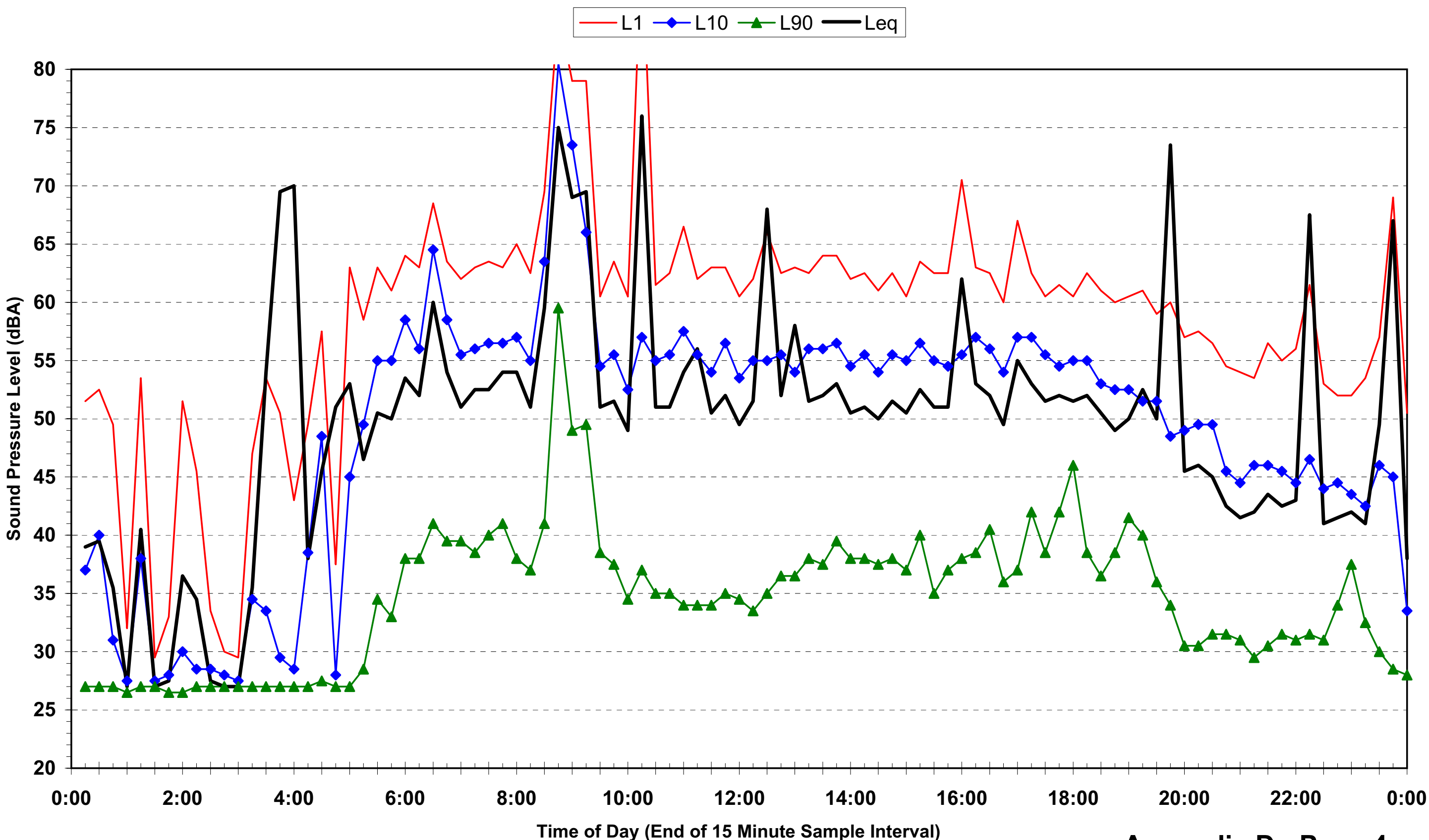
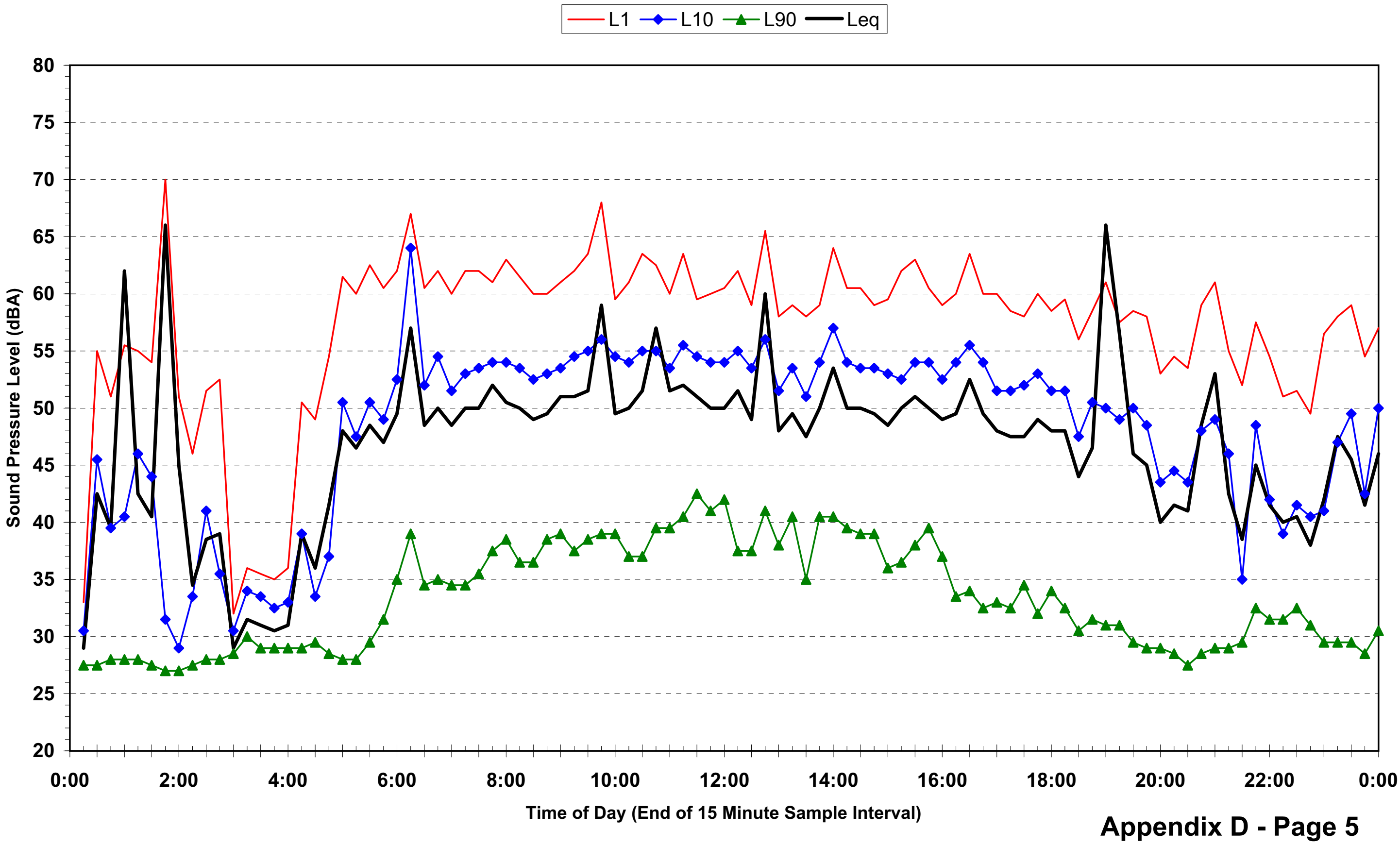
Statistical Ambient Noise Levels
10-3138 Location 9 - Young - Thursday 22 July 2004



Statistical Ambient Noise Levels
10-3138 Location 9 - Young - Friday 23 July 2004



Statistical Ambient Noise Levels
10-3138 Location 9 - Young - Saturday 24 July 2004



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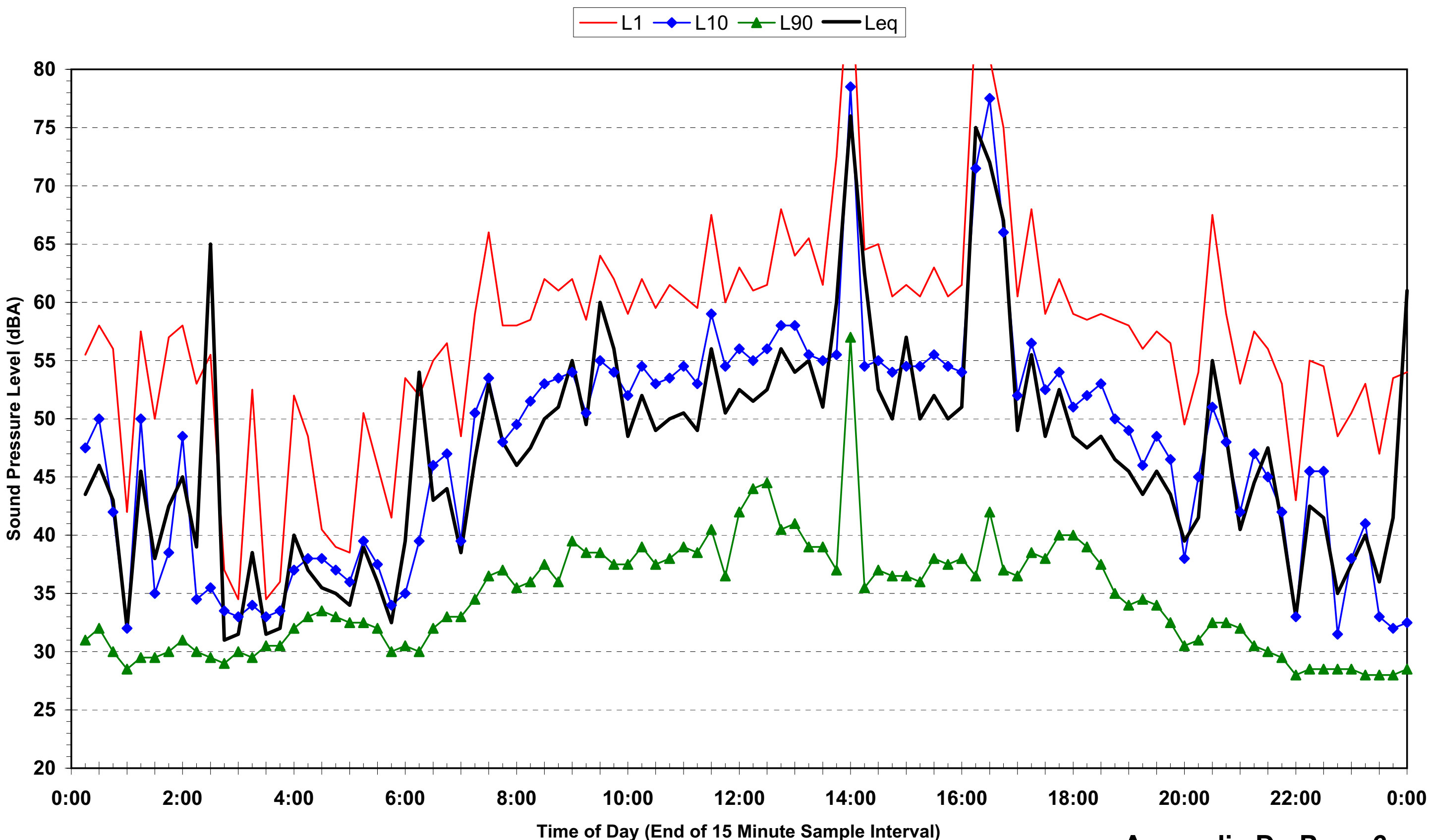
Statistical Ambient Noise Levels
10-3138 Location 9 - Young - Sunday 25 July 2004



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Statistical Noise Levels
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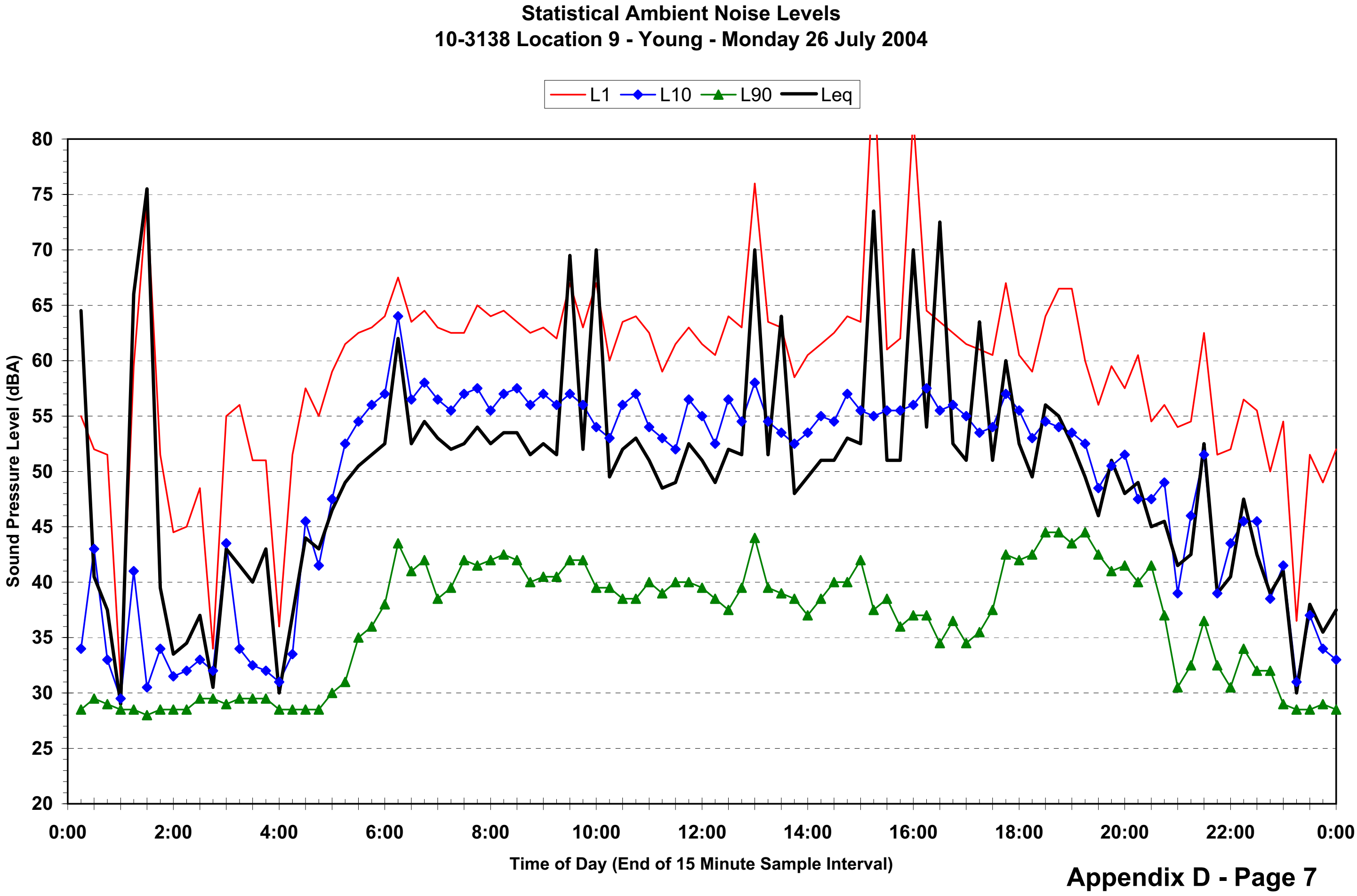

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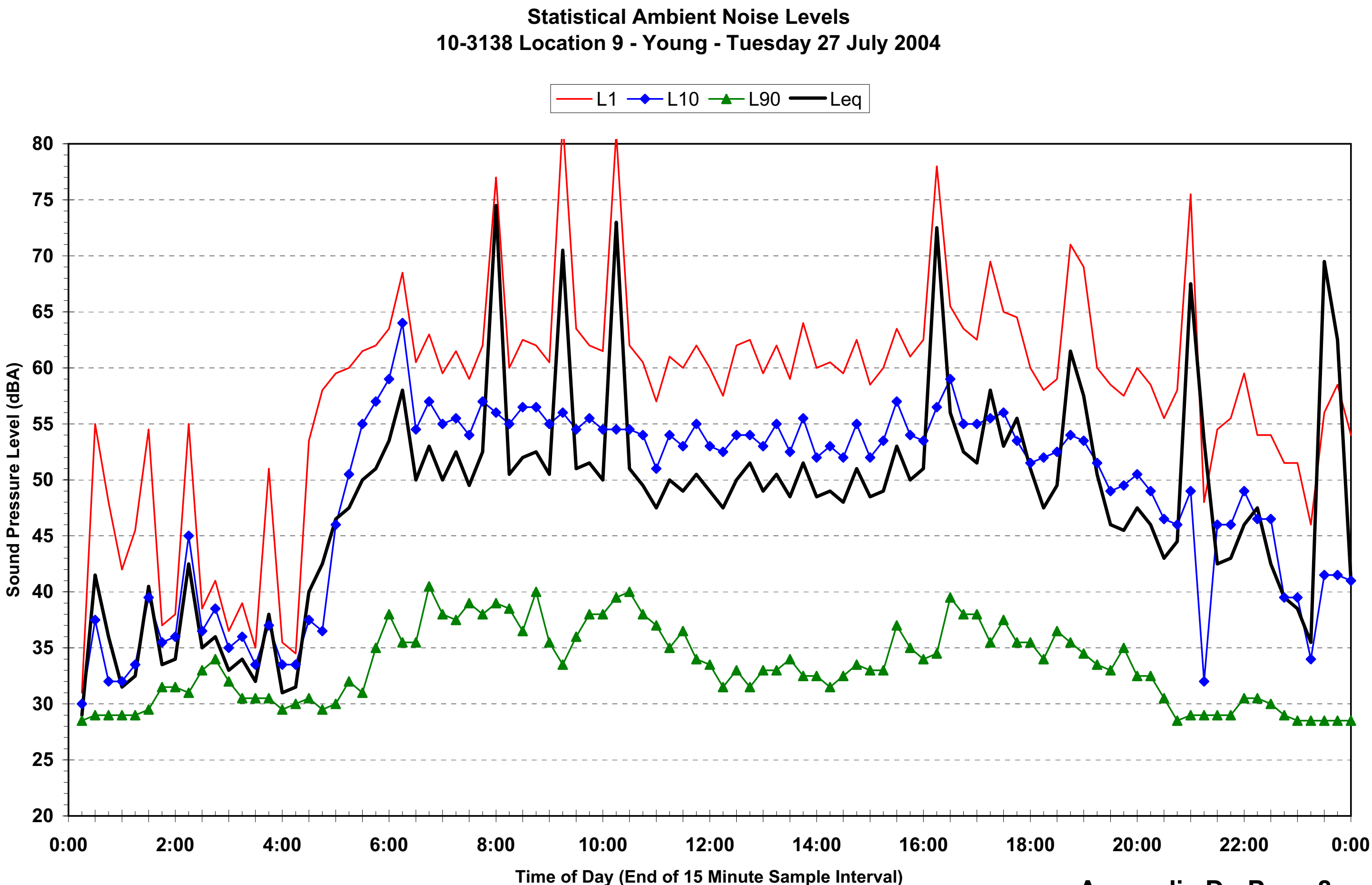

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Statistical Noise Levels
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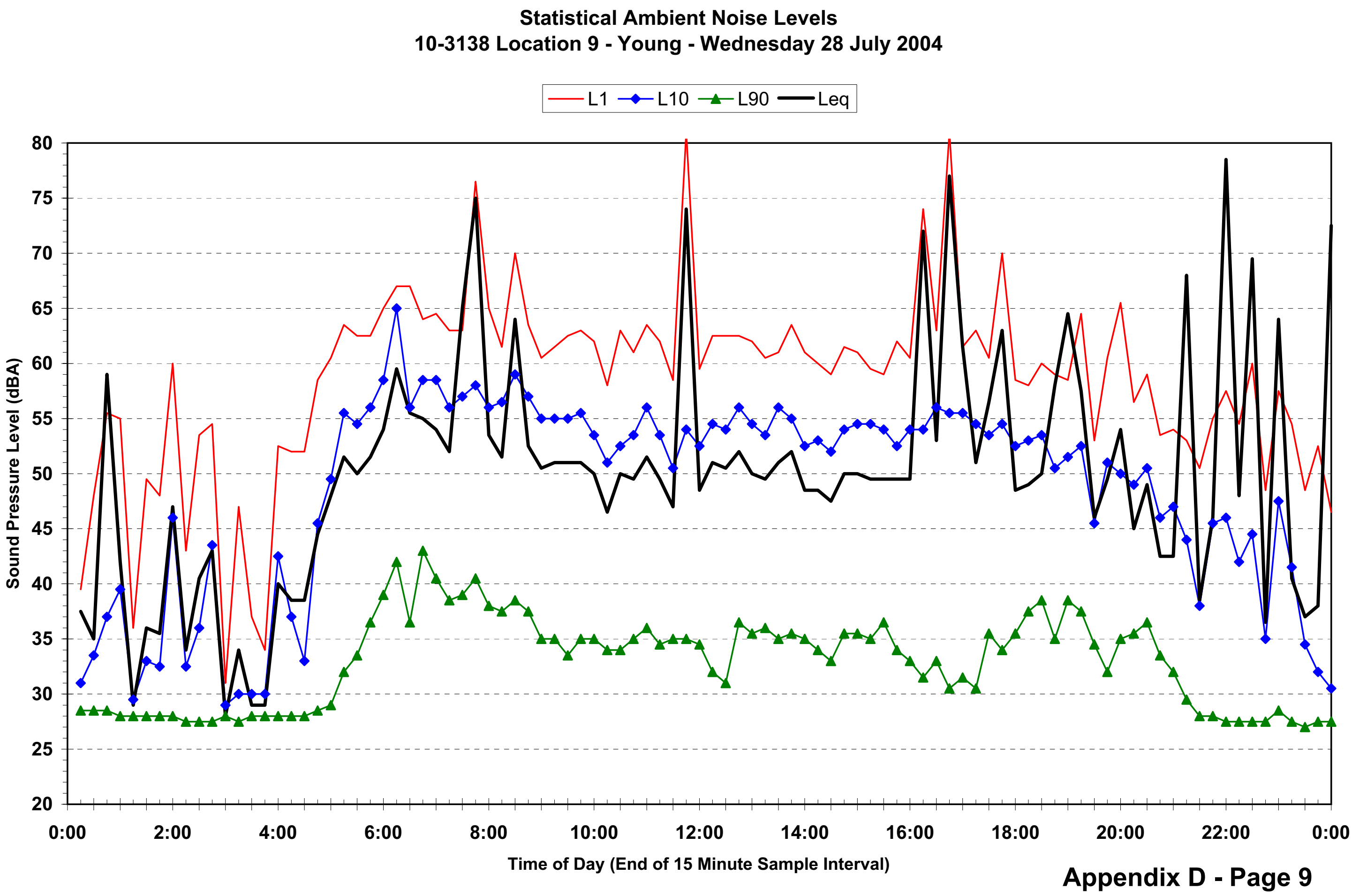

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Statistical Noise Levels
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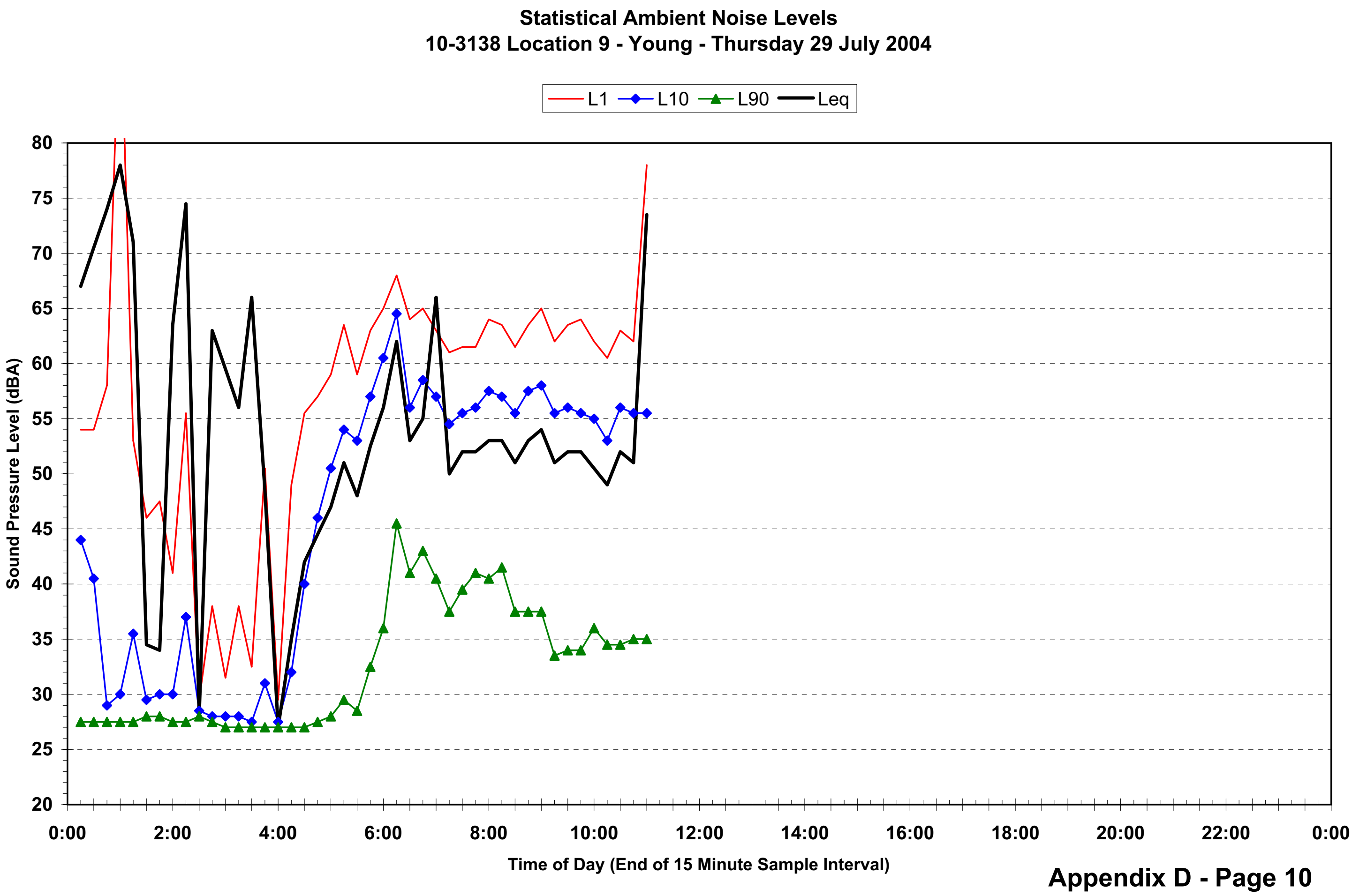

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Statistical Noise Levels
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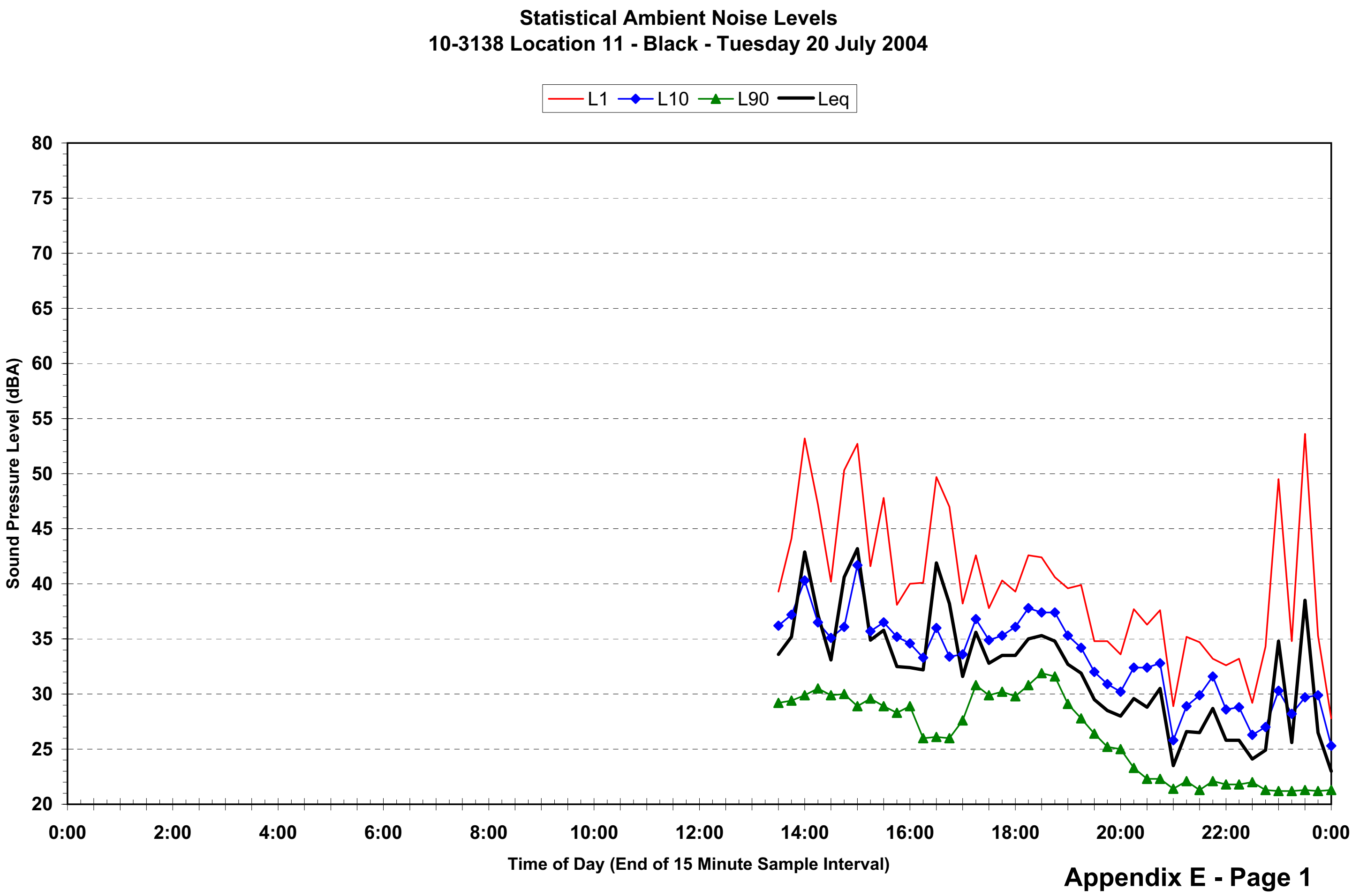

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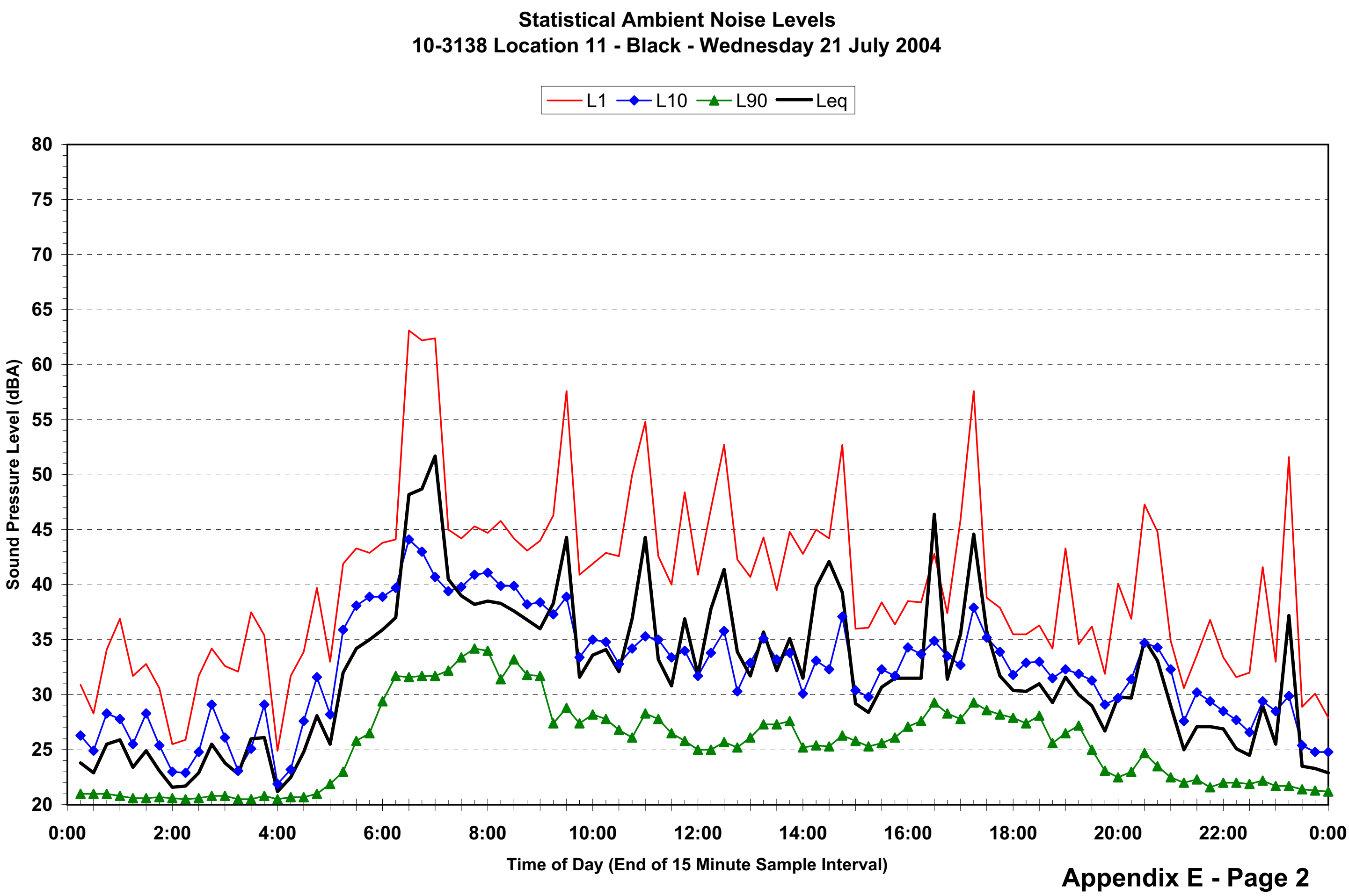
Statistical Noise Levels
RHA Report 10-3138



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Statistical Noise Levels
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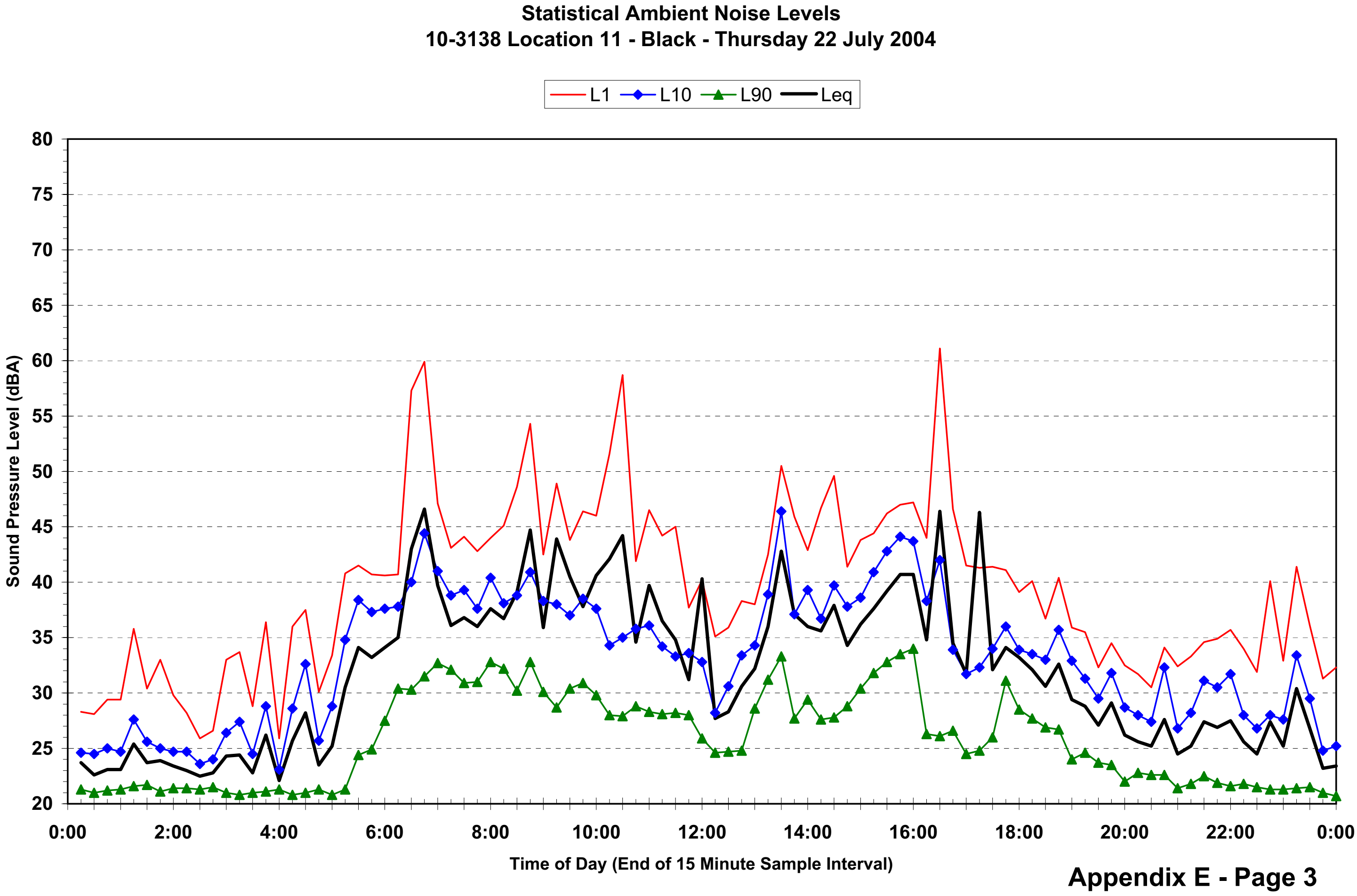

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Statistical Noise Levels

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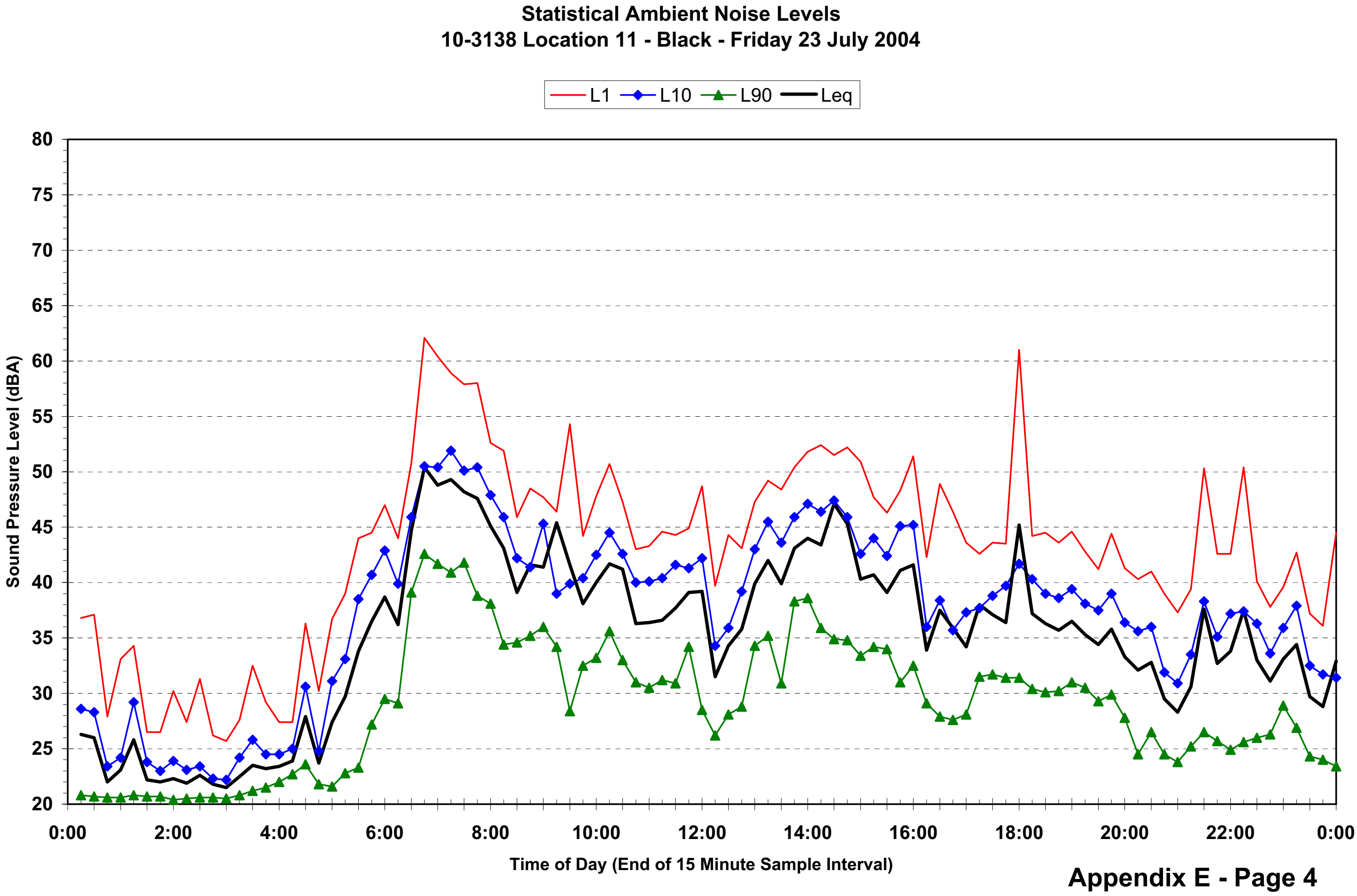

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Statistical Noise Levels

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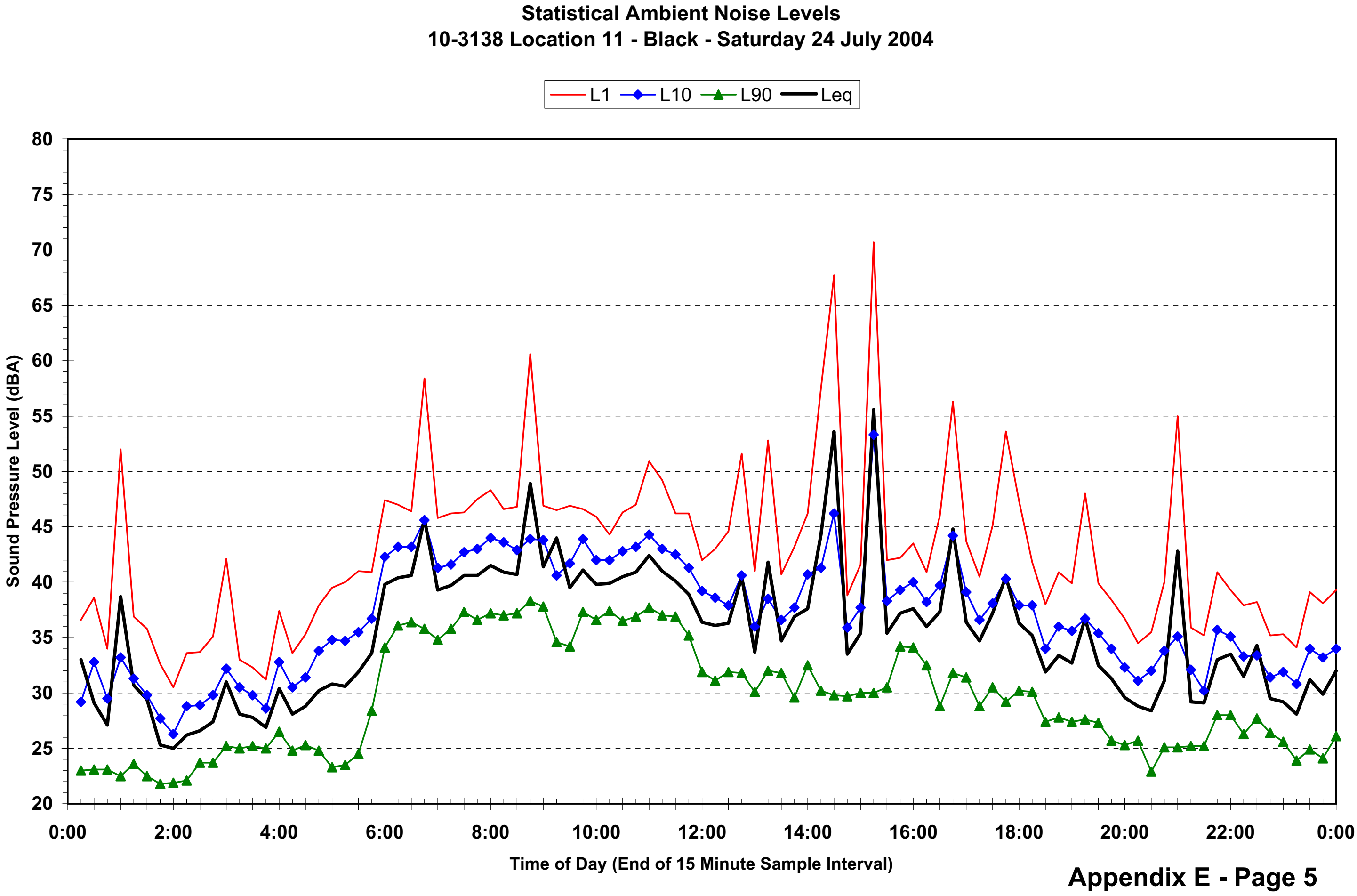

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Statistical Noise Levels

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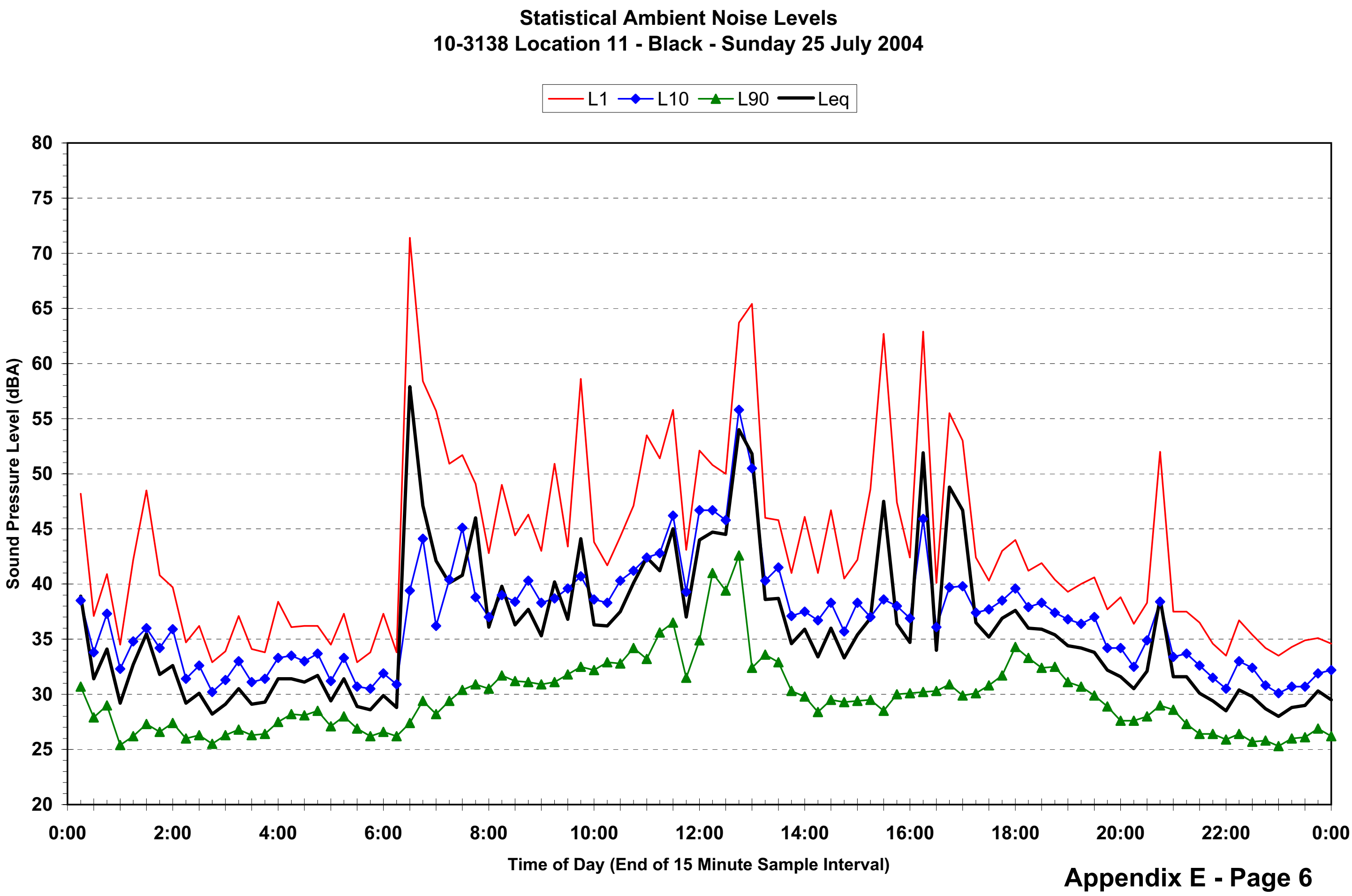

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Statistical Noise Levels

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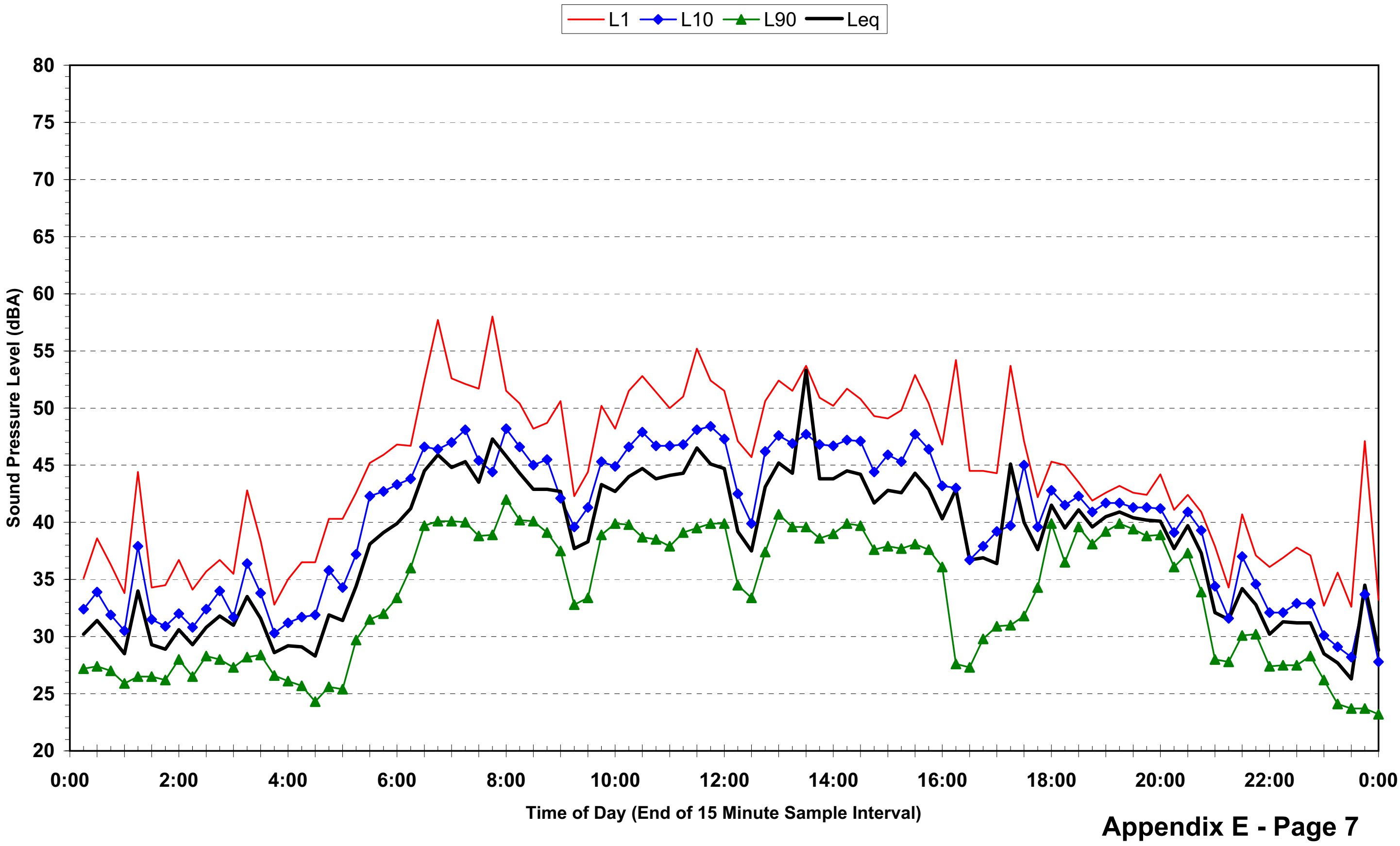
Statistical Ambient Noise Levels
10-3138 Location 11 - Black - Monday 26 July 2004



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Statistical Noise Levels

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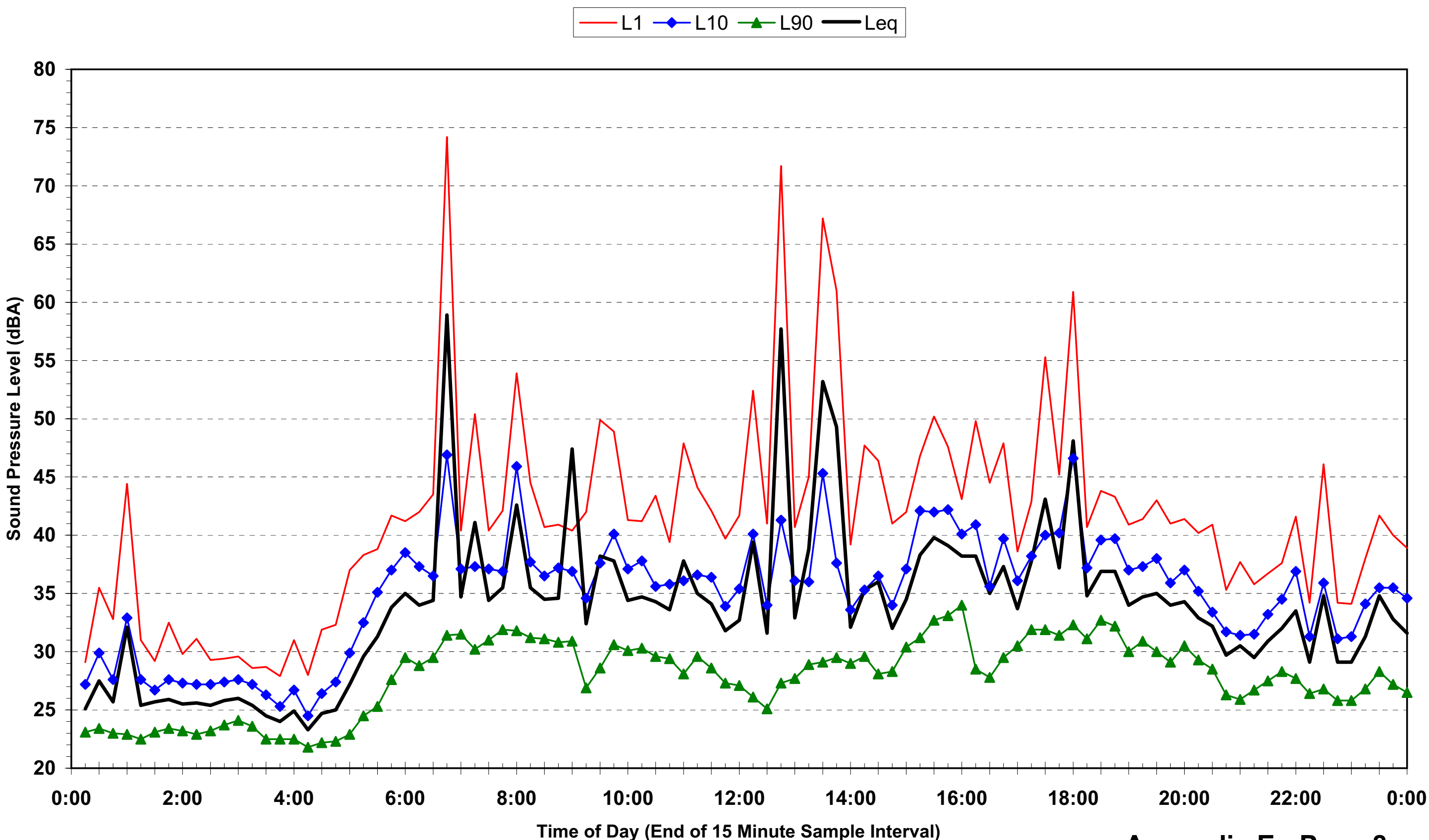
Statistical Ambient Noise Levels
10-3138 Location 11 - Black - Tuesday 27 July 2004



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Statistical Noise Levels

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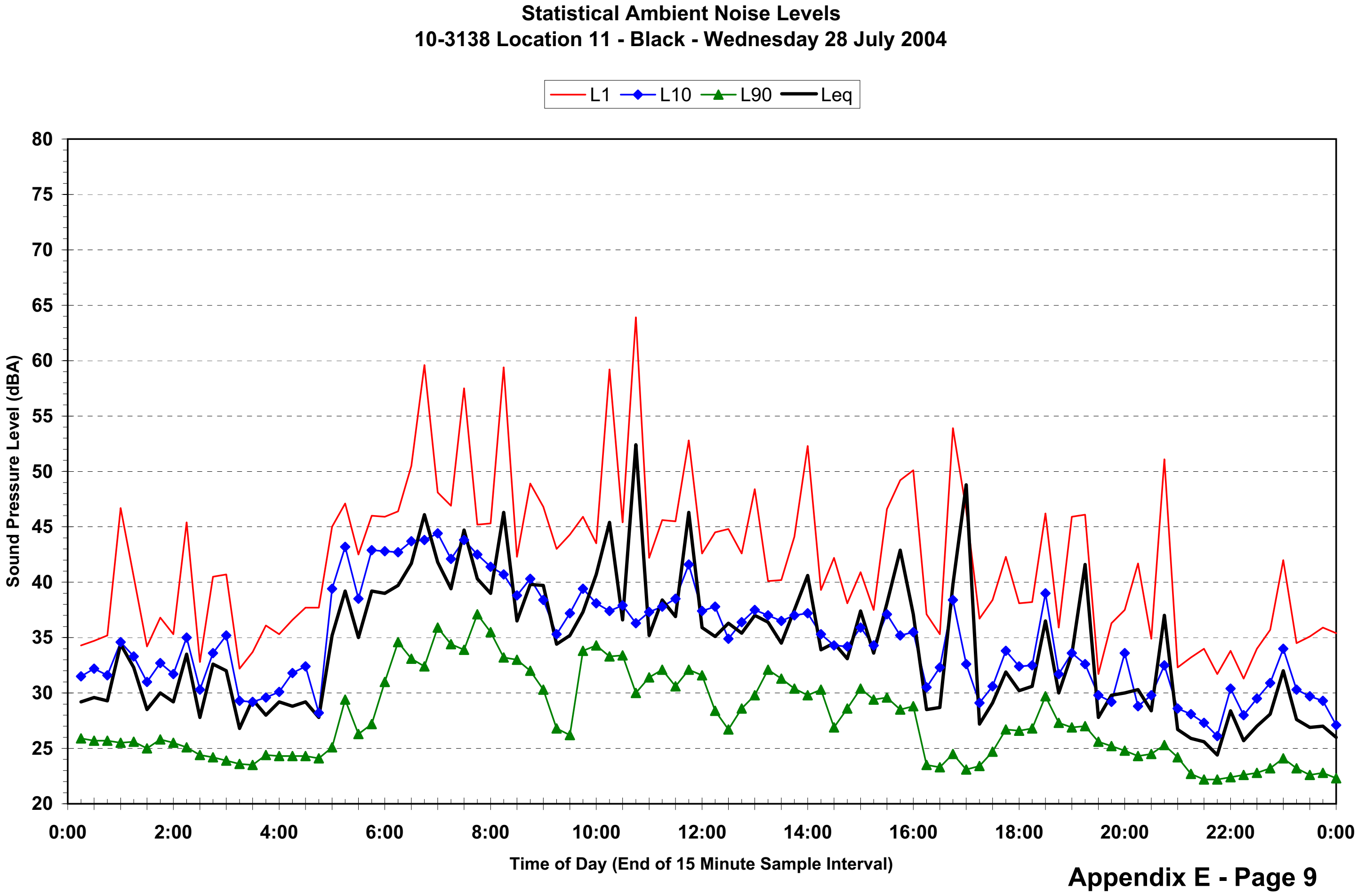

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Statistical Noise Levels
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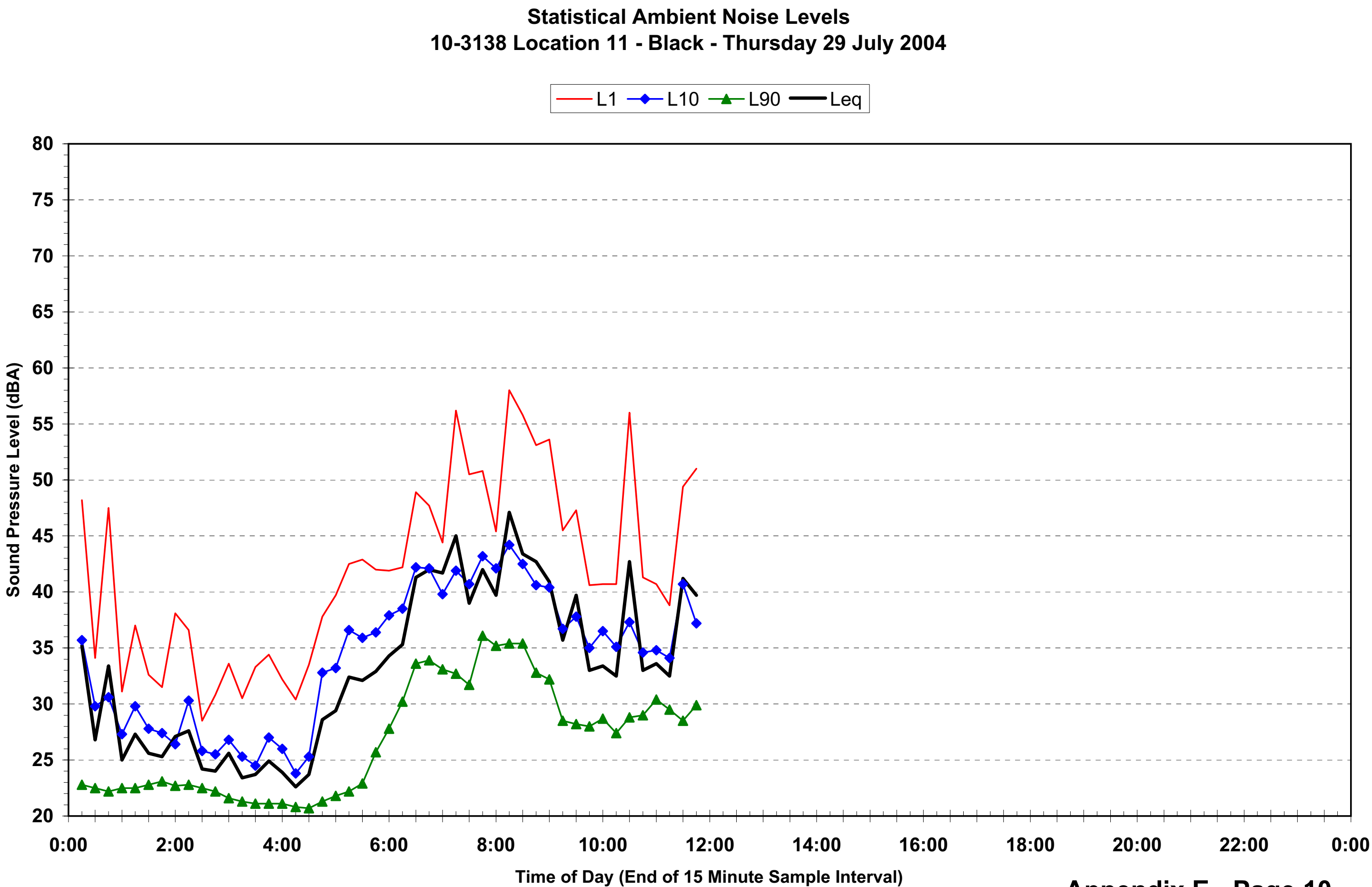

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Statistical Noise Levels
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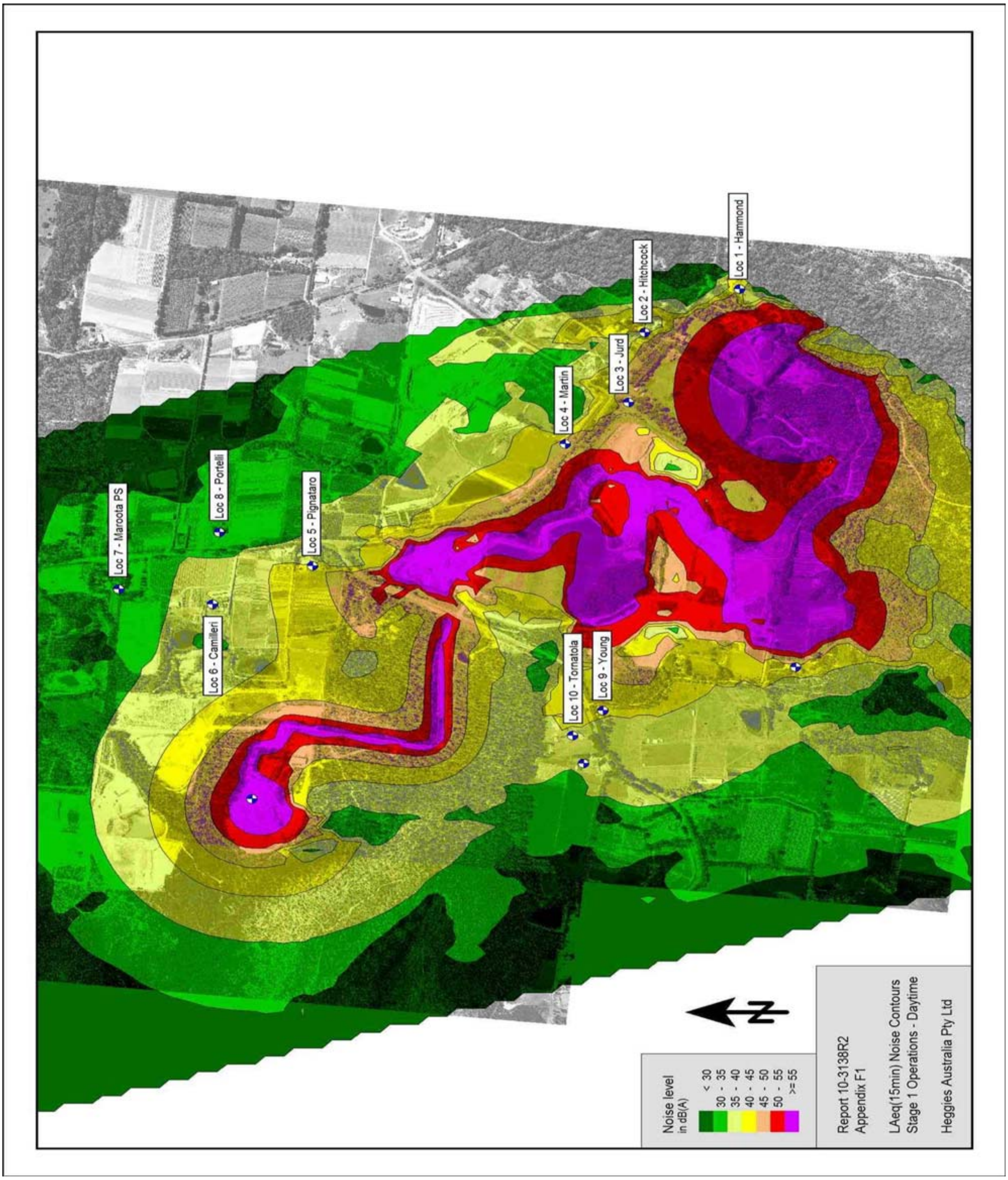
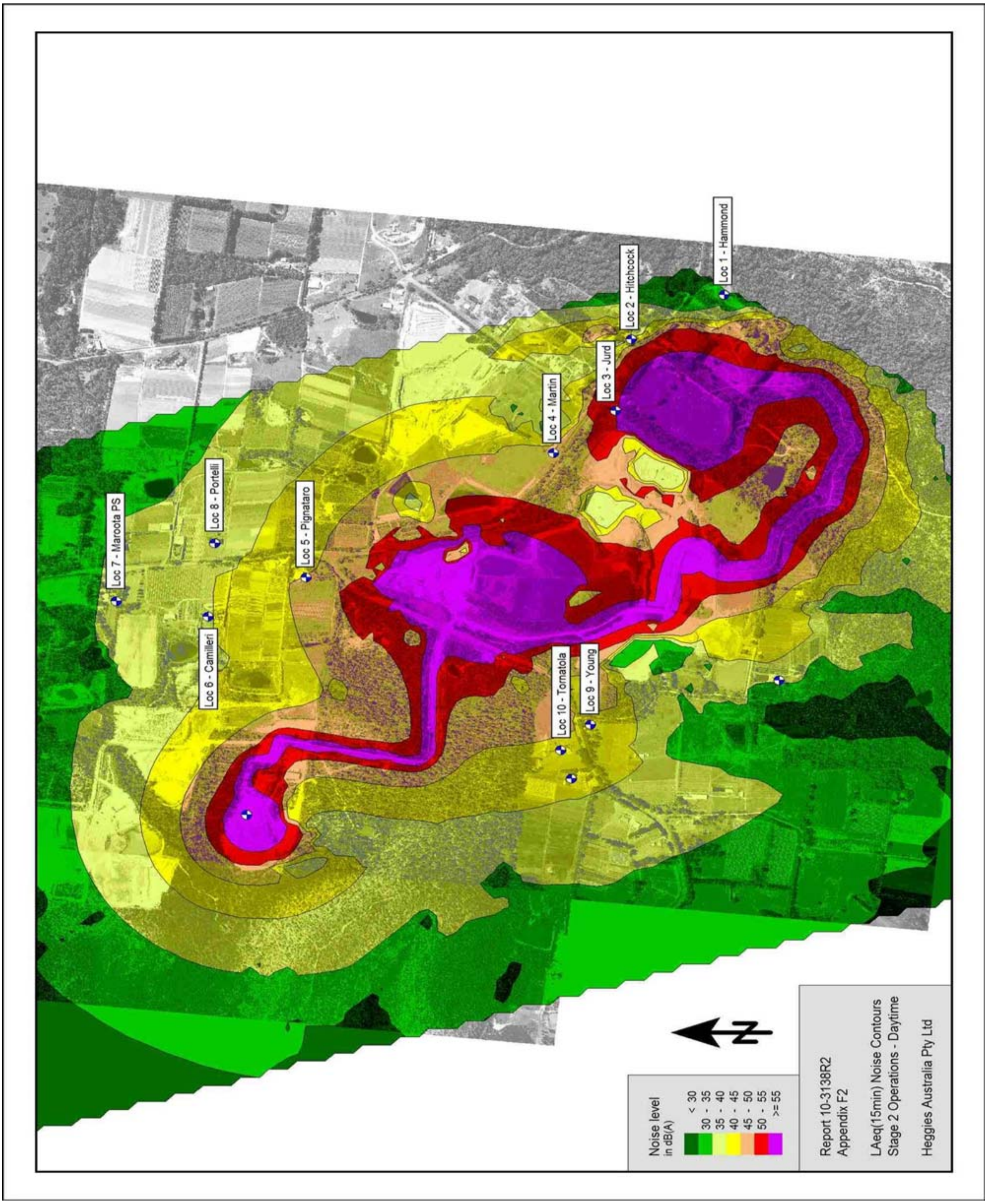
LAeq(15min) NOISE CONTOURS
STAGE 1 OPERATIONS - DAYTIME

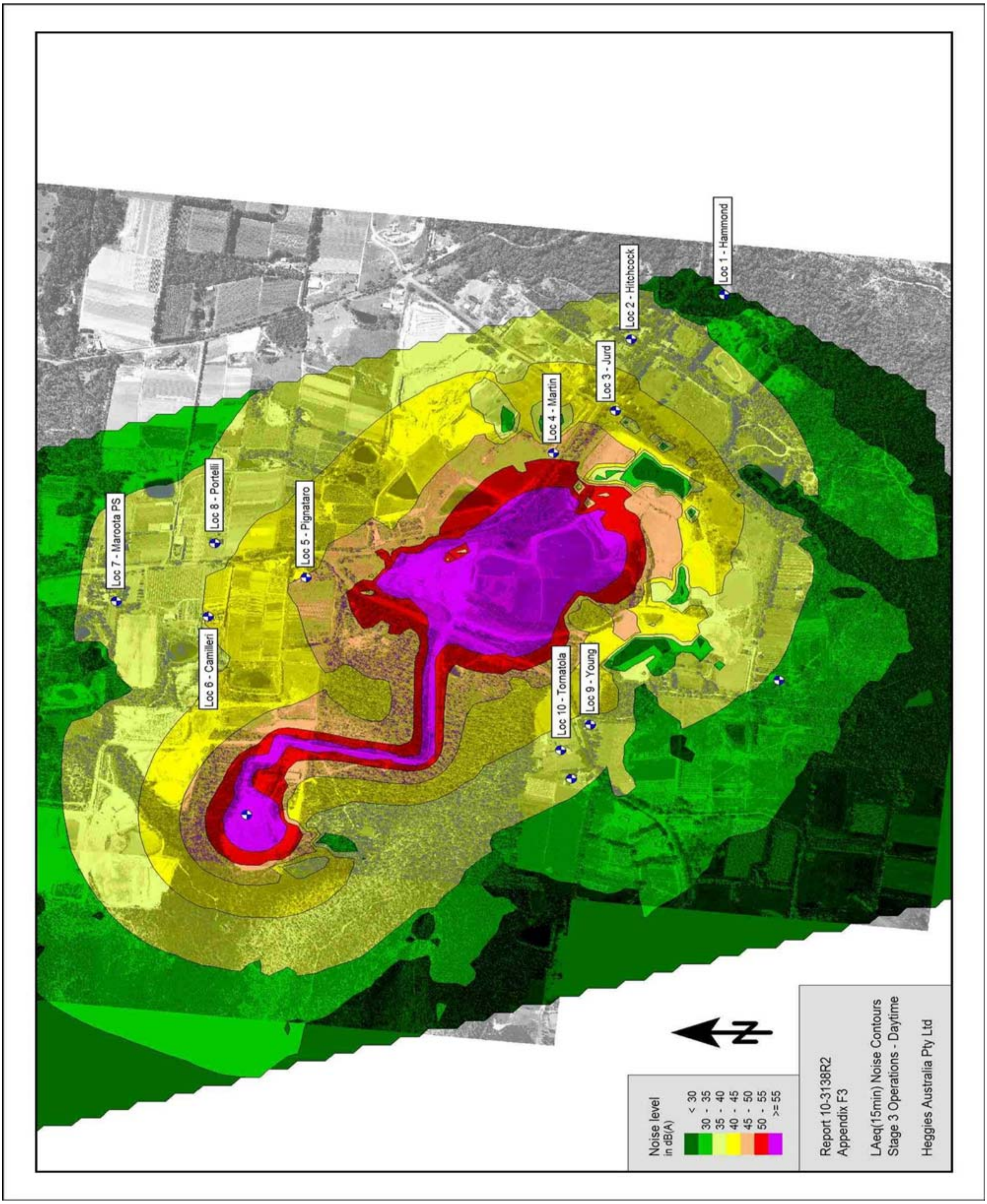


LAeq(15min) NOISE CONTOURS

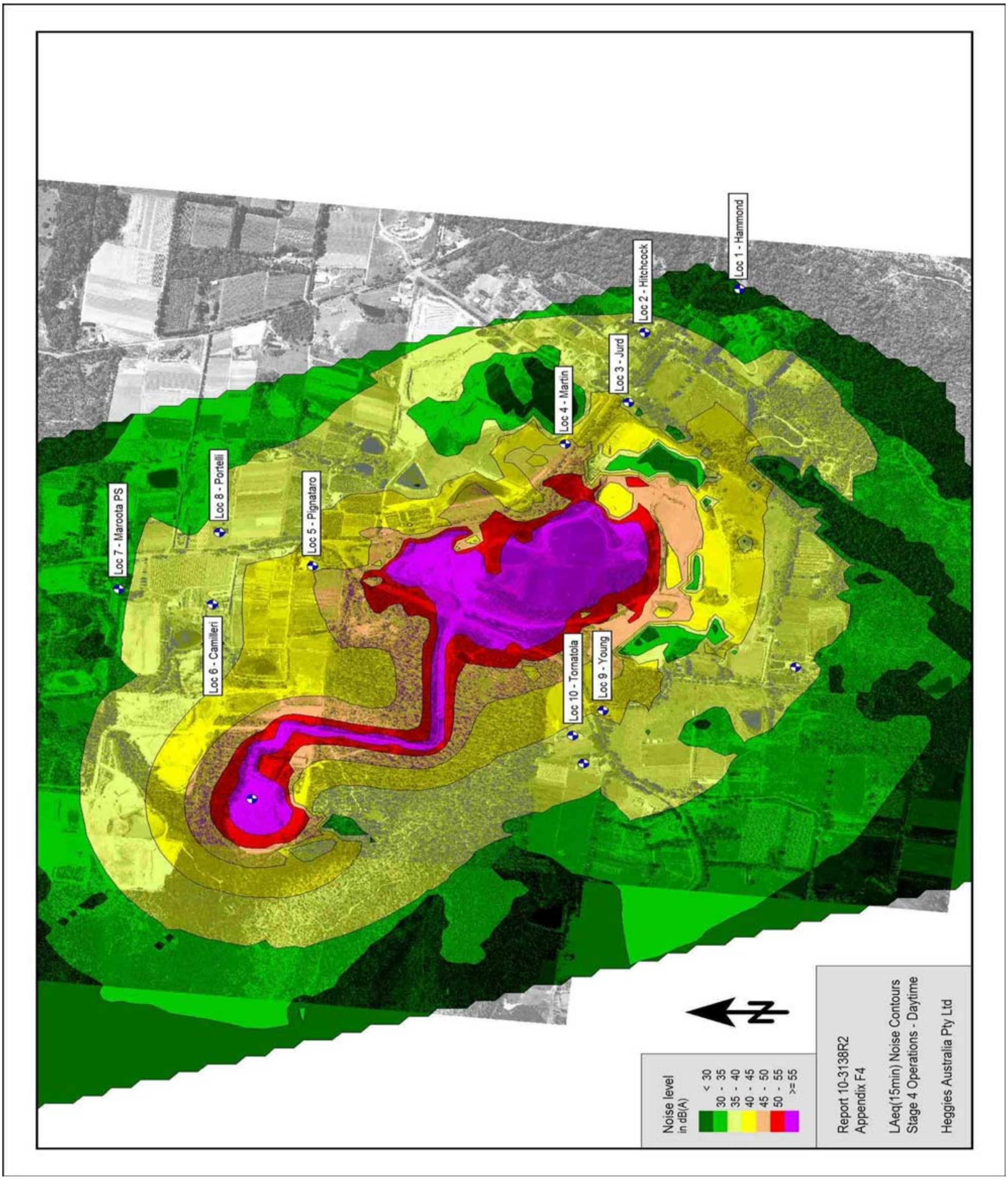
STAGE 2 OPERATIONS - DAYTIME



LAeq(15min) NOISE CONTOURS
STAGE 3 OPERATIONS - DAYTIME



LAeq(15min) NOISE CONTOURS
STAGE 4 OPERATIONS - DAYTIME



SITE: DIXON SAND (PENRITH) PTY LTD

LICENCE NUMBER: 3916

AMENDMENT: 1004327 DATED 15/03/2001
1014768 DATED 18/10/2002
1041380 DATED 03/12/2004

NOISE CRITERIA: L6 NOISE LIMITS

Location	**Operating Noise Limits Non-Adverse**		**Operating Noise Limits Adverse**	
	Daytime $L_{Aeq(15minute)}$	**Night-time $L_{Aeq(15minute)}$**	**Daytime $L_{Aeq(15minute)}$**	**Night-time $L_{Aeq(15minute)}$**
Non-site owned dwelling	39	32	44	37
Maroota Public School	40	N/A	45	N/A

Note: "Non-adverse" relates to average conditions (neutral atmosphere) that is calm winds and the absence of temperature inversion, or as otherwise determined by the EPA.

"Adverse" weather conditions means the presence of winds up to 3 m/s, and or temperature inversions of up to $3^oC/100$ m.

NOISE MANAGEMENT PLAN: N/A

CUMULATIVE REQUIREMENTS: N/A

SITE: ETRA PTY LTD (PF FORMATION)

LICENCE NUMBER: 3407

AMENDMENT: 1007929 DATED 02/07/2001
1010310 DATED 23/08/2002
1024315 DATED 16/01/2003

NOISE CRITERIA: L6 NOISE LIMITS

Location	Operating Noise Limits Non-Adverse		Operating Noise Limits Adverse	
	Daytime $L_{A10(15minute)}$	Night-time $L_{A10(15minute)}$	Daytime $L_{A10(15minute)}$	Night-time $L_{A10(15minute)}$
Non-site owned dwelling	40	40	45	45

Note: "Non-adverse" relates to average conditions (neutral atmosphere) that is calm winds and the absence of temperature inversion, or as otherwise determined by the EPA.

"Adverse" weather conditions means the presence of winds up to 3 m/s, and or temperature inversions of up to 3ºC/100 m.

NOISE MANAGEMENT PLAN: N/A

CUMULATIVE REQUIREMENTS: N/A

MINE: HB MAROOTA PTY LTD

LICENCE NUMBER: 6535

AMENDMENT: 1012523 DATED 21/05/2002
1034428 DATED 13/12/2004

NOISE CRITERIA: L6 NOISE LIMITS

Location	Operating Noise Limits Non-Adverse		Operating Noise Limits Adverse	
	Daytime $L_{A10(15minute)}$	Night-time $L_{A10(15minute)}$	Daytime $L_{A10(15minute)}$	Night-time $L_{A10(15minute)}$
Non-site owned dwelling	40	40	45	45

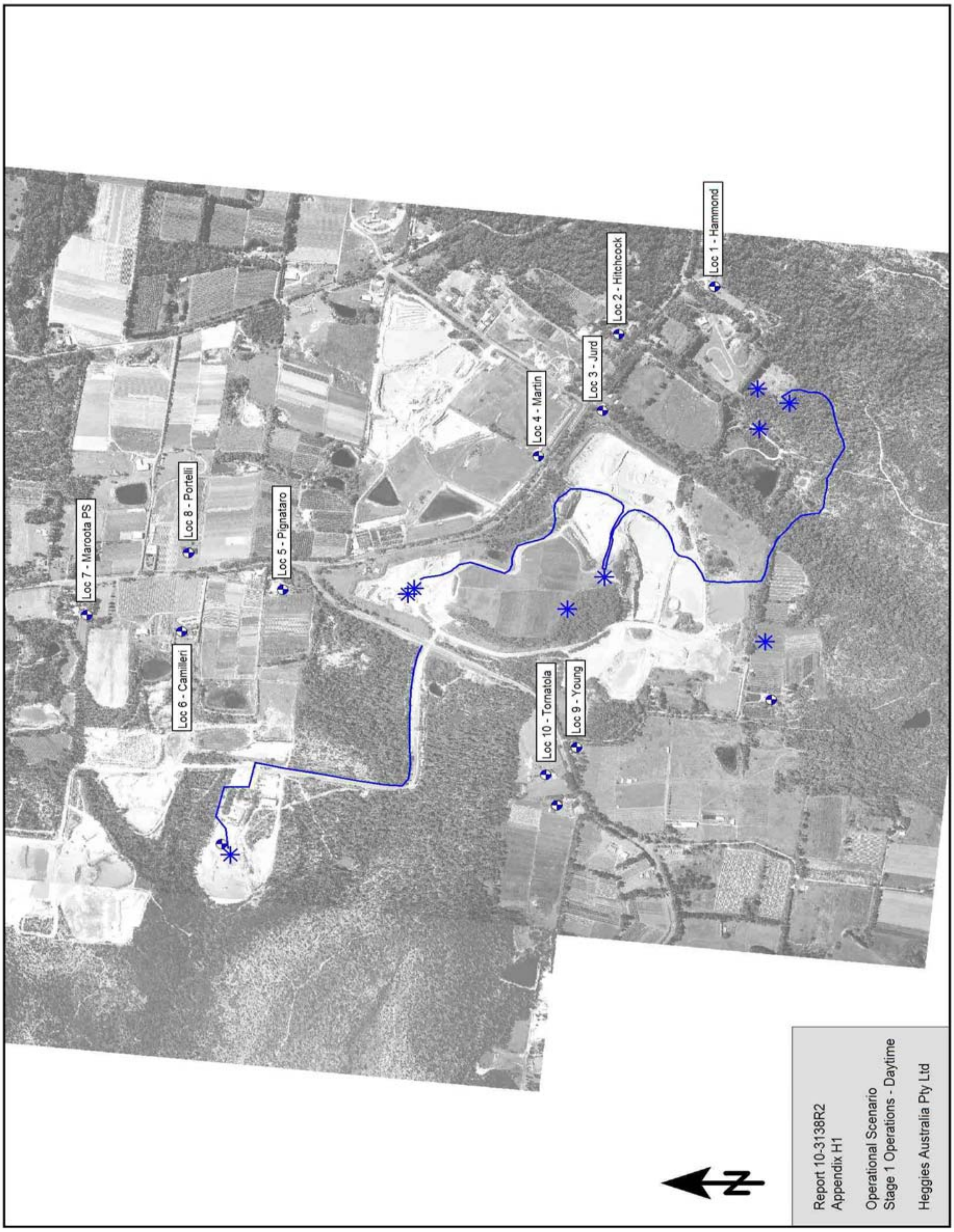
Note: "Non-adverse" relates to average conditions (neutral atmosphere) that is calm winds and the absence of temperature inversion, or as otherwise determined by the EPA.

"Adverse" weather conditions means the presence of winds up to 3 m/s, and or temperature inversions of up to 3oC/100 m.

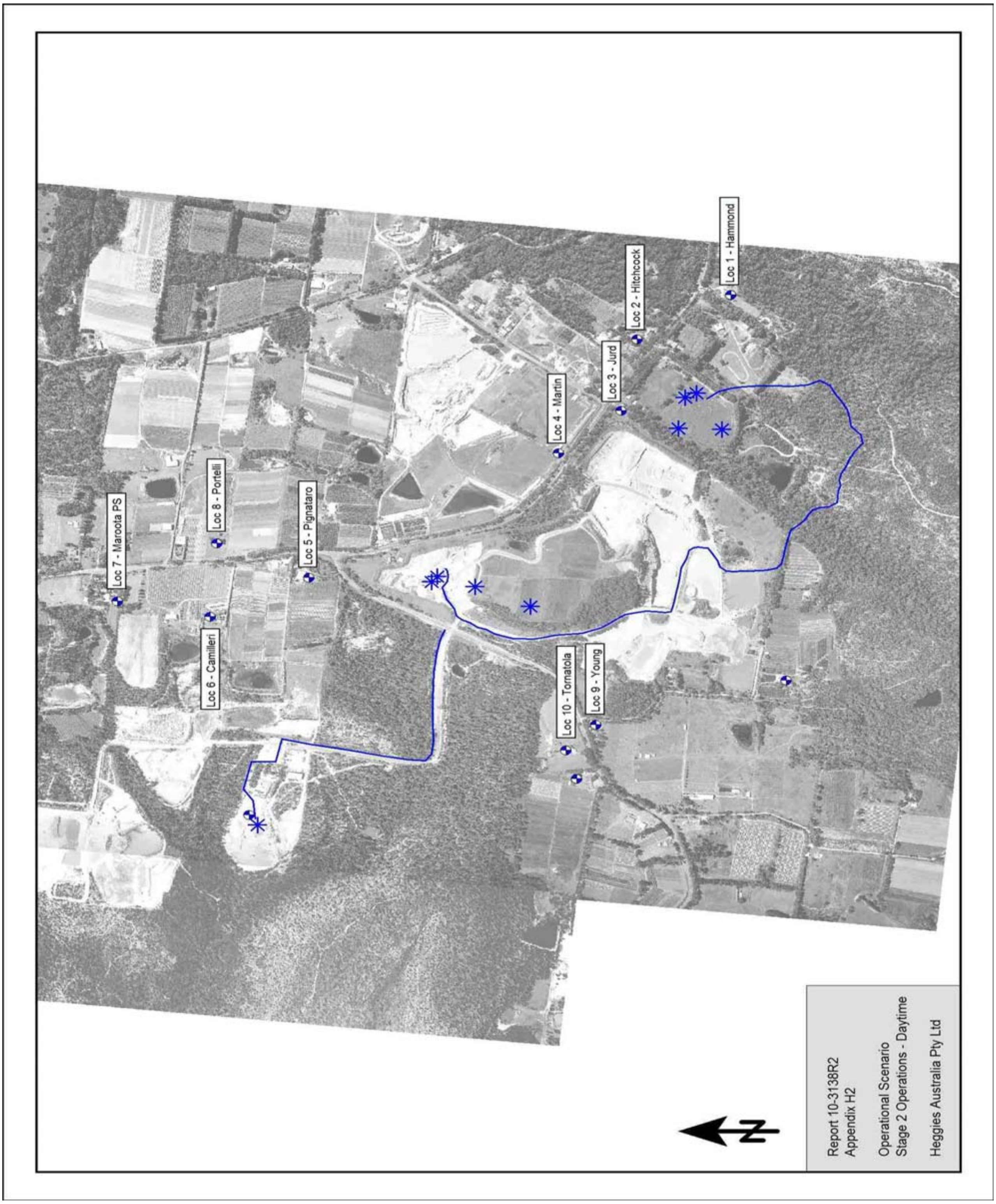
NOISE MANAGEMENT PLAN: N/A

CUMULATIVE REQUIREMENTS: N/A

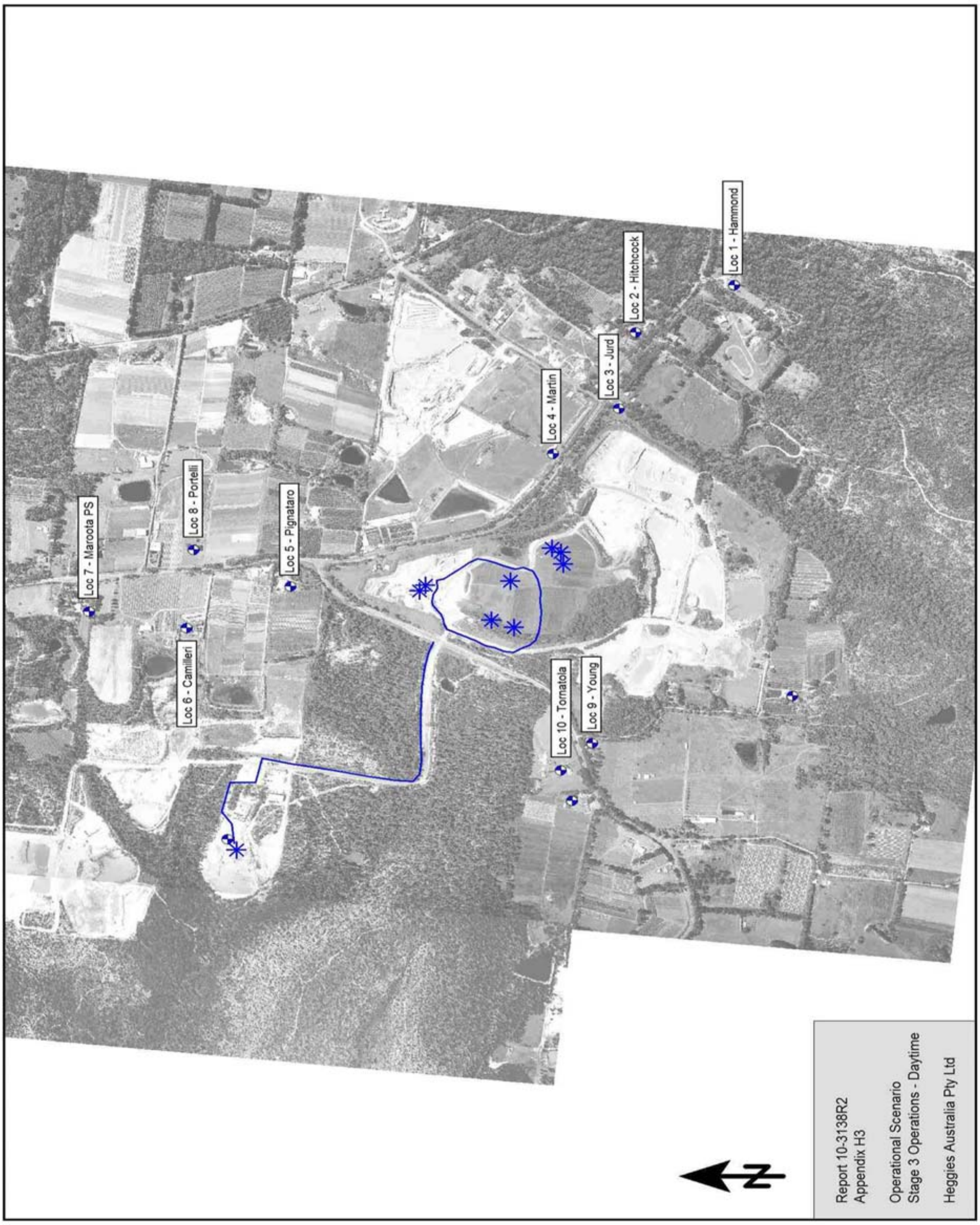
OPERATIONAL SCENARIO
STAGE 1 OPERATIONS - DAYTIME



OPERATIONAL SCENARIO
STAGE 2 OPERATIONS - DAYTIME



OPERATIONAL SCENARIO
STAGE 3 OPERATIONS - DAYTIME



OPERATIONAL SCENARIO
STAGE 4 OPERATIONS - DAYTIME