Appendix 1 – Bioscience Geotech Report

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GEOTECHNICAL REPORT

LOTS 13, 14, 21 & 22
SOUTHERN RIVER ROAD
AND
LOTS 18, 19 & 20
MATISON STREET
SOUTHERN RIVER
MARCH 2010

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1. Executive Summary

- This report covers 7 adjoining lots of land in the City of Gosnells Precinct 3E which are proposed for rezoning. The objective of the work reported herein is to determine the areas suitability for urban development from a geotechnical perspective.
- Bioscience undertook a range of field and laboratory investigation, including using a hand auger at 25 locations, and a mechanical excavator at 15 locations to characterise soil profiles, and laboratory testing of selected samples from recovered soils.
- The site has generally flat relief from 20 – 23 m AHD. Groundwater levels vary annually by between 1 – 1.4 m, and at maximum is greater than 1.5 m below the surface over the entire site except for wetland areas.
- Acid Sulfate Soil investigations were undertaken, and the only minor traces of potential acid sulphate were found at depths greater than 2.5 m below the surface. The potential for Acid Sulphate Soil requires further investigations if deeper excavation and dewatering is required for the installation of services such as sewers.
- The soils on the site are Bassendean Sands over Guildford clay. Sands are well sorted, medium textured quartz. The clay fraction has low to intermediate plasticity.
- The majority of the site is Class A" as defined in the Residential Slab and Footings (Australian Standard 2870). Lower lying areas with sandy clay less than 1.5 m from the surface are Class S, but can be upgraded to class A by fill from available suitable sandhills within the site to give a sand layer 1.5 m deep.
- The sandy areas have high permeability, so are suitable for onsite infiltration of stormwater.
- Recommendations are made for site preparation earthworks.

2. Introduction

This report describes the geotechnical investigations undertaken by Bioscience Pty Ltd on Lots, 13, 14, 21 and 22 Southern River Road and Lots 18, 19 and 20 Matison Street. The Department of Housing (DoH) in collaboration with two private land owners intends to develop seven adjoining lots of land, collectively 25.778 hectares, in Southern River towards urban subdivision (Figure 1 and Table 1).

Table 1 - Legal Land Area and Description

Lot No.	Certificate of Title	Registered Owner	Land Area
13	208/84A	The State Housing Commission	4.0494ha
14	27/389A	The State Housing Commission	4.0469ha
21	1813/671	The State Housing Commission	2.0011ha
22	1813/672	The State Housing Commission	2.2199ha
18	358/11A	Carmelo Radici and Rosina Radici	4.5072ha
19	1342/833	The State Housing Commission	4.5881ha
20	1311/770	Landflow Holdings Pty Ltd care of Turco & Co	4.3655ha
		TOTAL	**25.7781ha**

This report has been developed for the owners, based on the proposals presented and their contained terms of reference which have been accepted. The advice contained within this report is based on the information obtained and the assumptions which are expressed herein. Should the information received or the assumptions be incorrect, then Bioscience shall accept no liability in respect of the advice whether under law of contract, tort or otherwise.

Within Southern River region, the City of Gosnells has identified several precincts, of which the site is located within Precinct 3. Precinct 3 is bounded by Southern River Road, Ranford Road, Matison Road and the Southern River and is characterised by areas of flat, low lying land and a relatively high water table. Bioscience was asked to investigate the land, with the objective of determining any geotechnical condition present, and whether it is suitable for rezoning to urban, and any requirements to enable development.

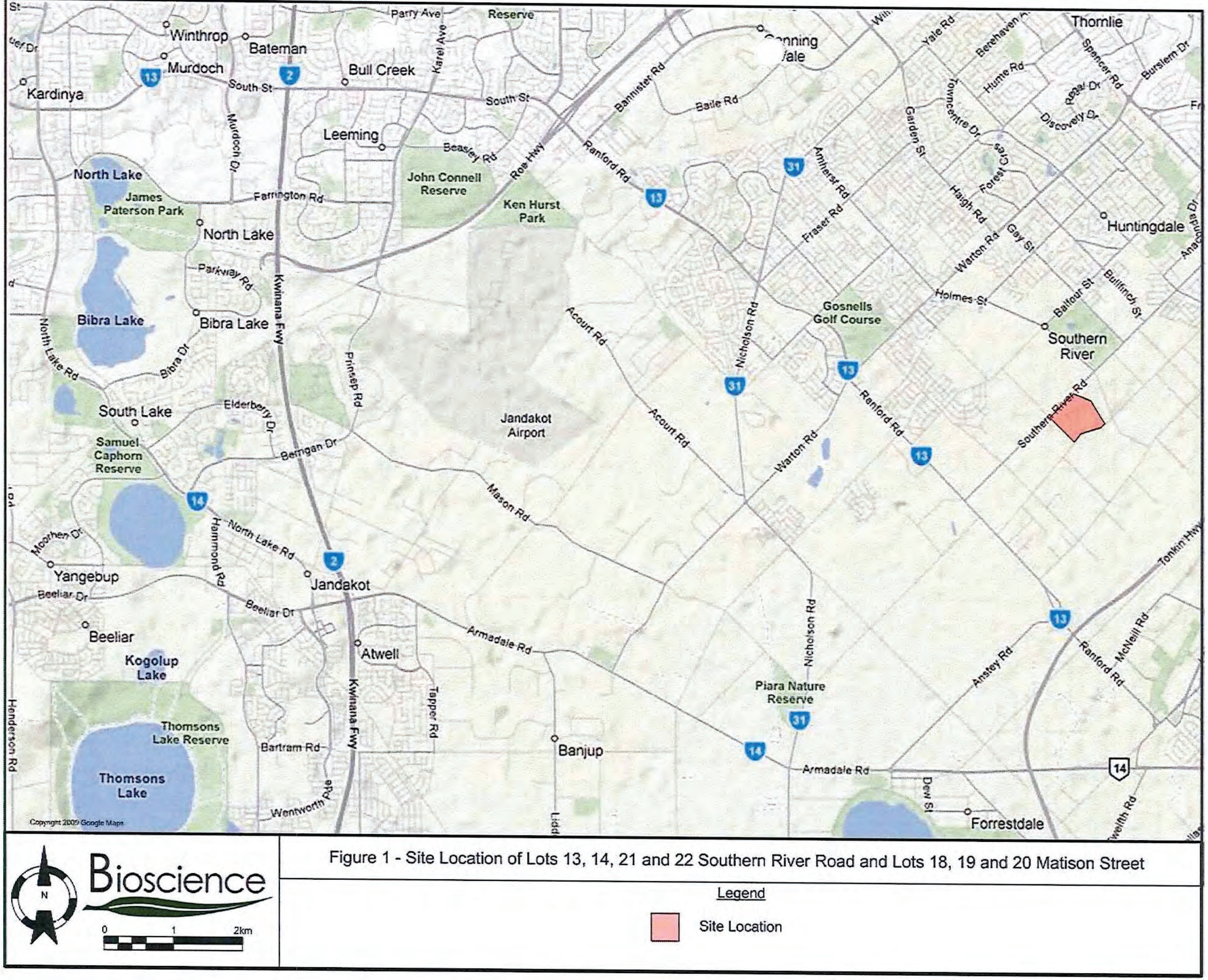

Figure 1 - Site Location of Lots 13, 14, 21 and 22 Southern River Road and Lots 18, 19 and 20 Matison Street

Legend

Site Location

3. Proposed Development

The land is proposed for standard residential development with a base density of R20, with medium density developments of R30 and R40 in areas close to Public Open Space (POS) (Figure 2). Retail, commercial and industrial land uses are not proposed nor are schools or community specific sites.

The location and distribution of the proposed POS areas will be strategically located to maximise the conservation of remnant bushland and for natural drainage and filtration of groundwater and/or rainwater.

4. Site Description

4.1. Land Use

In the past the land was used for agricultural purposes with some of the land cleared and fenced for grazing. More recently, land use has been for rural living with some evidence of minor home industry use. With the exception of lots 18 and 20, dwellings have been demolished and the land is currently vacant and unused.

4.2. Topography

Generally the area has a low relief with minor variations in topography. The site has a gentle slope from the centre of lots 13 and 14 at approximately 23m AHD towards the northern areas of lots 22 and 21 in addition to the central areas of lots 18, 19, and 20 down to approximately 20m AHD (Figure 3).

4.3. Vegetation

The vegetation broadly fits within the community types described in Gibson et al 1994 as type 23a, Central *Banksia attenuata* – *B. menziesii* woodlands, type 4 *Melaleuca preissiana* damplands and type 5 mixed shrub damplands. There is evidence that much of the land has been previously cleared for grazing, and more recently it has been disturbed through the dumping of domestic and building rubbish.

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Figure 2 – Outline Development Plan (ODP)

Legend

R40 Zoning

R20 Zoning

Native Vegetation POS

Living Stream POS

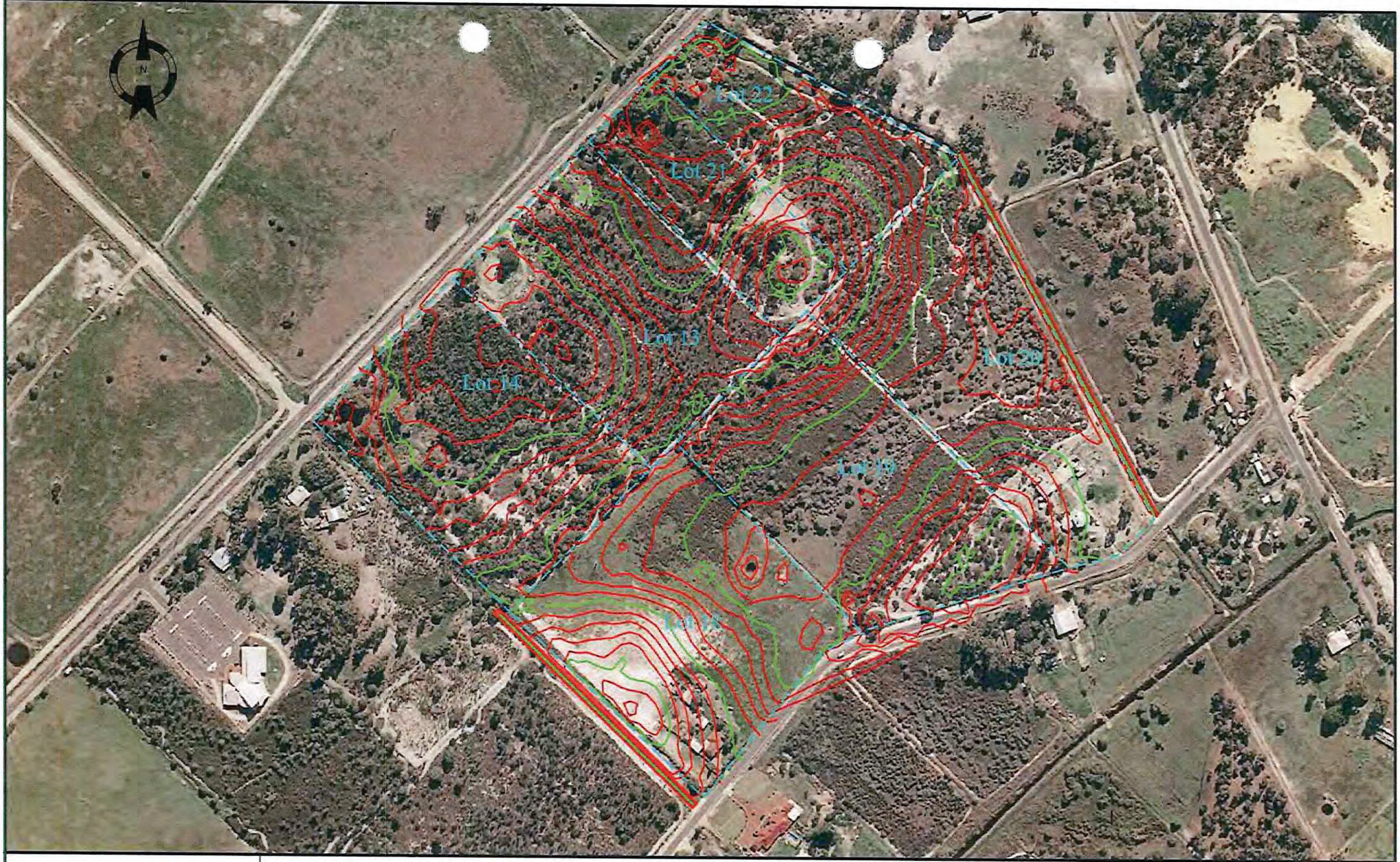

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Figure 3 – Site Topography (mAHD)

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Lot Boundaries

Minor Contour (0.2m)

Major Contour (1.0m)

4.4. *Regional Geology*

Coarse scale (1:250,000) soil mapping (Lowry, 1963) indicates the property comprises the Bassendean sands and Guildford formations; also known as the Pinjarra Plains.

Bassendean Sands are the oldest of the three dune systems, thought to be about 800,000 years old, and so are the most leached, infertile and acidic. These sands contain little silt or clay, and very low levels of nutrient elements, with any nutrient element content being associated with organic matter. The dunes are low lying hills with poorly drained areas between the hills. The depth to ground-water varies from close to the surface to at most 10 m below the surface.

Pinjarra Plain soils are highly leached and infertile, with low cation exchange capacities, with almost all nutrients coming from organic matter in the surface layer. These soils are complex, and comprise a successive layering of soils formed from erosion of material from the scarp to the east. Rivers and streams have mostly carried the eroded material, which is deposited from the water as fans of alluvium. Therefore, the plain, is made up of layers of soils of different ages. The typical Pinjarra Plain soil, in the top 30 cm, contains about 90 per cent sand, 6 per cent silt and 4 per cent clay; consequently it is therefore classified as sand. Below this, the soil comprises about 60 to 80 per cent sand, 5 per cent silt and from 15 to 31 per cent clay, with the percentage clay content increasing with depth, so the subsoil changes to a sandy loam increasing depth (Bolland, 1998).

The Pinjarra Plain system is characterised by poor drainage due to the low permeability of sub-soil clays which prevent the downward infiltration of rainfall, consequently during the winter month's water logging and surface inundation can occur. In addition, the clay fraction of the Guildford formation is known to have highly variable Plasticity Indices (Hillman et al 2003).

4.5. *Site Geology*

The subject site is located on the Swan Coastal Plain within the Bassendean dune system, an area characterised by low dunes of siliceous sand interspersed with poorly drained areas or wetlands. Two soil types occur within the site:

- Bassendean B1 Phase which are described as extremely low to very low relief dunes, undulating sand plains and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m.

- Pinjarra P1b Phase which are described as being flat to very gently undulating plain with deep acidic mottled yellow duplex soils. Moderately deep pale sand to loamy sand over clay: imperfectly drained and moderately susceptible to salinity in limited areas.

The geology at the site as per the Geological Survey of Western Australia 1:50000 Environmental Geological Series Armadale Map Sheets 2033 I and 2133 IV are either (Figure 4):

- SP1 – PEATY SAND – grey to black, fine-medium grained, moderately sorted quartz sand, slightly peaty of lacustrine origin.
- S8 – SAND – white to pale grey at surface, yellow at depth, fine-medium grained, moderately sorted, subangular and subrounded, minor heavy minerals of Aeolian origin. (Bassendean Sand).
- S10 – SAND – as S8 over sandy clay to clayey sand of the Guildford Formation of Aeolian origin, (Bassendean Sand over Guildford Formation).

4.6. Hydrology

4.6.1. Regional Hydrology

The hydrology of the Southern River area on a broad scale is characterised by flat land of Bassendean sand dunes with quite low relief hosting a superficial aquifer which is about 30 m thick. The Southern River itself acts as a local discharge point for this superficial aquifer and is thus the lowest local groundwater level. The Perth Groundwater Atlas (2004) shows the groundwater contours slope downwards in a north easterly direction parallel with the local alignment of the Southern River. The groundwater atlas suggests that groundwater is between 3 – 4 m below the surface across the site, based on May 2003 data when local groundwater would be approaching annual minimum levels (Figure 5). Groundwater monitoring and modelling of the southern river district was conducted initially by JDA (2002) and then by Rockwater (2005). Both the JDA and Rockwater reports indicate that groundwater flow on the site is in a generally easterly direction, towards Southern River with an Average Annual Maximum Groundwater Levels (AAMGL) varying between 20.5m AHD towards the west of the property sloping down to19.5m AHD towards the east.

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Figure 4 – Site Geology (Environmental Geological Series Armadale Map Sheets 2033)

Legend

SP1-Peaty Sand

S8- Sand

S10- Sand

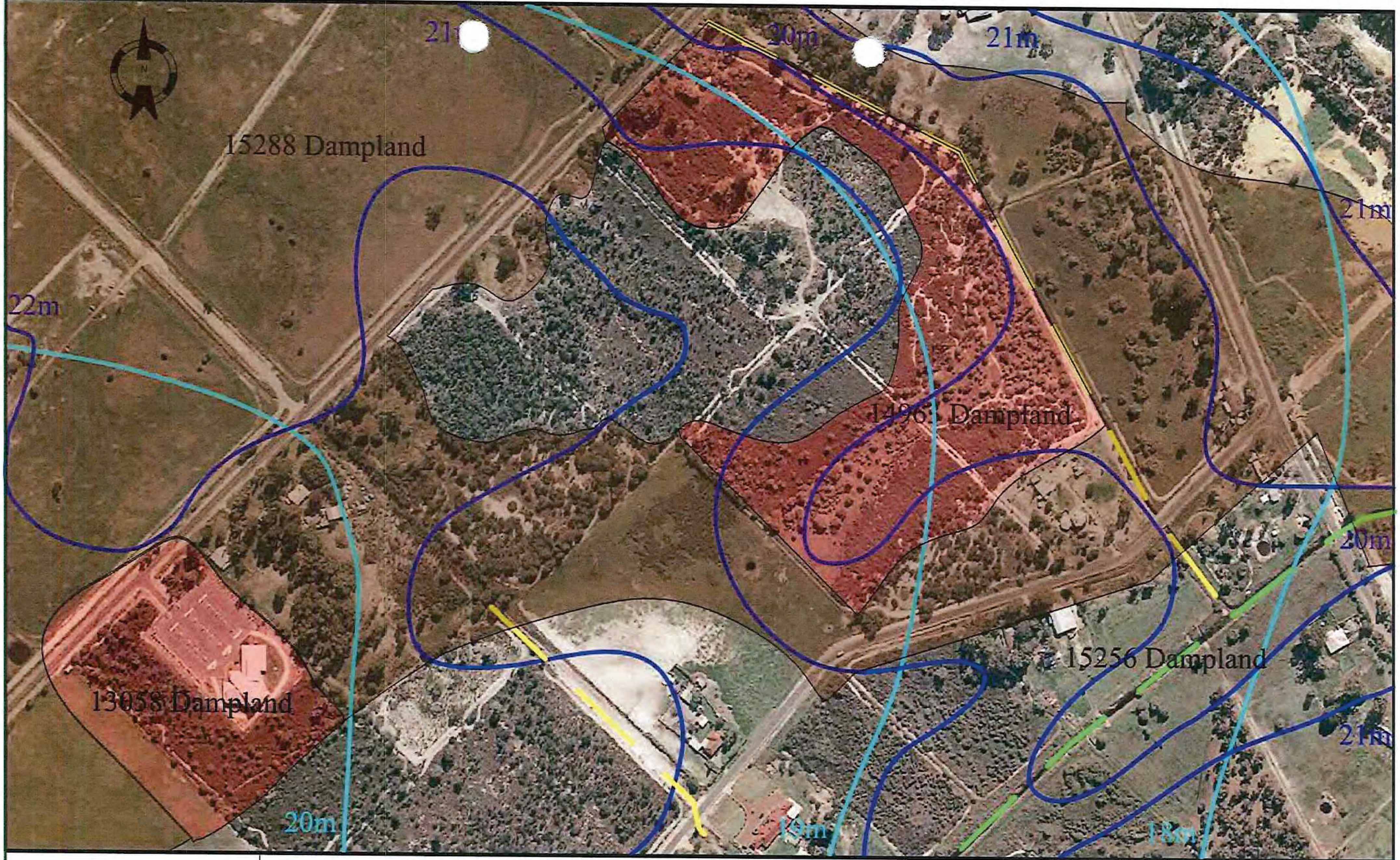

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Figure 5 – Current DEC Wetlands and DoW Regional Groundwater Data

Legend

Multiple Use
Max Groundwater Contours
Rehabilitation
Groundwater Contours May 2003
Local Authority Drain
Forrestdale Main Drain

Note: Data from the online Perth Groundwater Atlas, accessed at www.water.wa.gov.au

4.7. Wetlands

A recent search on the Shared Land Information Platform (SLIP) database indicated that currently two wetlands are on the site, with the same boundaries as per Hill *et al* (1996), however in Hill *et al* (1996) the wetlands are described as being a MUW and CCW, whereas the SLIP portal records them as being MUW and a Resource enhancement wetland (RHW) (UFI number 15288 and 13963, respectively).

This REW located on the proposed development site is in poor condition and is more suited to a MUW category, consequently a detailed re-evaluation of wetland boundaries and management categories was undertaken by Bioscience, and resulted in a formal request to modify the Swan Coastal Plain Geomorphic Wetland Mapping to the wetland's office of the Department of Conservation and Environment. We concluded that the current wetland boundaries probably were accurate prior to local drainage being constructed. The wetland office agreed with our findings that a large proportion REW is in fact not wetland, but rather is upland with vegetation dominated by upland species and has thus reclassified the boundaries and management categories (Figure 5).

A very recent policy shift has come to light, regarding wetland classification (Conversation with Gordon Wyre, DEC's Director of Nature Conservation). REW are to be renamed "Rehabilitation Wetlands" (RW). The management objective of RW is similar to REW in that it aims to restore the values and attributes of such areas towards that of a CCW. However unlike REW policy, this process for RW is now entirely at the discretion of the landowner, and thus no longer constitute a constraint on development for the site.

4.8. Surface Drainage

Two Local Authority drains exist within the site, the first is located along the south western boundary of lot 18 in the Landor St road reserve and has a maximum depth of 21.07m AHD, whereas the second is located directly north east of lots 20 and 22 and has a maximum depth of 19.6m ADH (Figure 5). The purpose of these drains is to redirect and/or reduce surface water from accumulating on surrounding properties.

A recent Urban Water Management Strategy report from the Southern River / Forrestdale / Brookdale / Wungong, Structure Plan titled "Impact of Existing Drains and Proposed Living Streams on Groundwater table and Nutrient Export" (JDA, 2002) specifies the drawdown influence of drains of varying depths within this region. Their results can be used to estimate desirable drains depth and distances from significant environmental features such as CCWs to provide protection from groundwater lowering (Table 2). Consequently, it can be used in the reverse manner to deduce the impact a drain has on a wetland given its invert below AAMGL and distance are known.

Table 2 – Impact of Drain Invert on AAMGL Drawdown.

Drain Invert below AAMGL (m)	Drawdown of AAMGL at Varying Distance from Drain (m)			
	0m from Drain	100m from Drain	500m from Drain	1km from Drain
0.5	0.3	0.19	0.03	0
0.9	0.57	0.38	0.07	0.008
1	0.63	0.41	0.08	0.01
1.5	0.98	0.67	0.14	0.02

In relation to the site, the drain invert located on the south western boundary of lot 18 in the Landor St road reserve is approximately 0.3 m below AAMGL. Consequently, groundwater levels within 0.5km of this drain will decline logarithmically from between 0.30m to 0.03m, thus having an impact on groundwater levels within the vicinity of this drain.

The second drain invert located to the north east of lots 20 and 22 is approximately 0.9 m below AAMGL which is consistent with (JDA, 2002) findings of Local Authority drains within the area. Consequently, groundwater levels within 1km of this drain will decline logarithmically from between 0.57m to 0.08m, thus having a very significant impact on groundwater levels of the entire site (Photo 1).

Photo 1 – Local Authority Drain (taken on the 21th May 2009)

5.Hydrological Investigations

5.1. *Flooding Risk*

According to the Southern River/ Forrestdale/ Brookdale/ Wungong Urban Water Management Strategy (2002) the site has no associated flood risk even in a 1 in 100 year ARI event. However, observation take during site visitors indicate that the areas of lots 18, 19 and to limited extent lot 20 (i.e areas are generally under 20.8m AHD) are prone to surface inundation in the winter months (Photo 2).

Photo 2 – Surface water on lots 18 and 19 (taken on the 4th September 2009).

5.2. *Site Hydrogeology*

Initially five piezometers were installed on the 31st October 2008 to traverse an area which demonstrated clear geomorphic, vegetation and surface soil evidence of being a wetland. These were placed to form an east-west, and a north-south transect. On the 9th April 2009 ten additional piezometers were then installed outside this core area. The proposed locations were firstly conveyed to the DEC's wetland office, and after discussions and their recommendations, the locations were modified where necessary to capture the most useful data. In July 2009, another ten piezometers were installed, four on lot 18 and six on lot 20.

All piezometers were installed using a hand auger and were made from 50 mm PVC pipe with 1m of slotted interval buried to at least 0.5 m below the water table in March, when the water table was expected to be at or near the minimum level. The initial five piezometers installed in October were deepened where necessary. After installation and development, water was collected (if present) from each piezometer for chemical analyses, and monthly measurement of depth from the natural surface was commenced.

Seven (i.e. DHW2, 4, 5, 6, 9, 14, and 15) of the piezometers did not intersect the March groundwater level due to an impenetrable layer formed by the indurated ferruginous deposit or "coffee rock" layer. Given such deposits typically only occur below the maximum water table, it is likely that as water levels rise, these piezometers will fill with water.

The site was surveyed by licensed surveyors who recorded the location and height of each piezometer to 1 mm, and who produced a surface contour map to 100 mm lines. The data from the surveying instruments was directly imported into CAD and GIS systems and into the hydrological modelling suite Hydro GeoAnalyst v2009.1 to accurately model groundwater levels and depth to groundwater or meters below ground level (m BGL).

Groundwater levels have been monitored since the 30th October 2008, and most recently on the 13th January 2010. Details of the groundwater levels in meters AHD and meters BGL are contained in Appendix 1 and 2, respectively. Groundwater levels varied significantly throughout the site from a maximum of 21.348m AHD (DHW6 on the 9th October 2009) to a minimum of 18.34m AHD (DHW1 on the 12th June 2009) (Figure 6). In relation to depth below ground level a maximum depth of 3.65m BGL (DHW 8 on the 12th June 2009) and a minimum of -0.04 m BGL or 0.04m above the natural ground levels was recorded (DHW 19 on the 4th October 2009) (Figure 7).

Average Annual Lowest Groundwater Level (AALGL)

June 2009 groundwater levels varied from 20.07m AHD at DHW18 to 18.34m AHD at DHW1, although several piezometers were either not installed at this time (DHW20 to 25) or there was insufficient water for a reading to be taken (DHW2, 4, 6, 9 14, and 15). To more accurately determine the AALGL for the entire site, June 2009 groundwater levels were compared with 30 years of DoW monitoring bore records, specifically T75 (WIN ID 4880).

Based on the calculation in Appendix 3 and 4 we have estimated that the AALGL for the site varied between 19.25 m AHD (DHW18) and 17.59 m AHD (DHW1).

Average Annual Maximum Groundwater Level (AAMGL)

October 2009 groundwater levels varied from 21.35m AHD at DHW6 to 20.05m AHD at DHW24. To more accurately determine the AAMGL for the entire site, October 2009 groundwater levels were compared with 30 years of DoW monitoring bore records, specifically T75 (WIN ID 4880). Based on the calculations in Appendix 3 and 4 we have estimated that the AAMGL for the site varied from between 21.04 m AHD (DHW6) and 19.76 m AHD (DHW24) (Figure 8). This estimate is in accord with work by JDA (2002) undertaken on the broader scale of the entire Southern River area. Figure 7 also shows the estimated depth to groundwater (expressed as AAMGL) from natural surface. The majority of lots 13 and 14 and to some degree the southern half of lots 20 and 21 and the south western half on lot 18 of the site has in excess of 1.2m clearance to AAMGL, whereas area of lots 18, 19 and 20 and the northern half of lots 20 and 21 typically have depth to AAMGL of less than 1.2m.

Extreme 1 in 100 Year Recurrence Interval

1 in 100 groundwater recurrence intervals were calculated (see Appendix 3 and 4 for calculations). Results indicated that groundwater levels vary from a maximum of 21.60 and to a minimum 20.29m ADH across the site. Depth to groundwater modelling indicates that a significant area of Lots 18, 19 and 20 have ponding surface water (Figure 9).

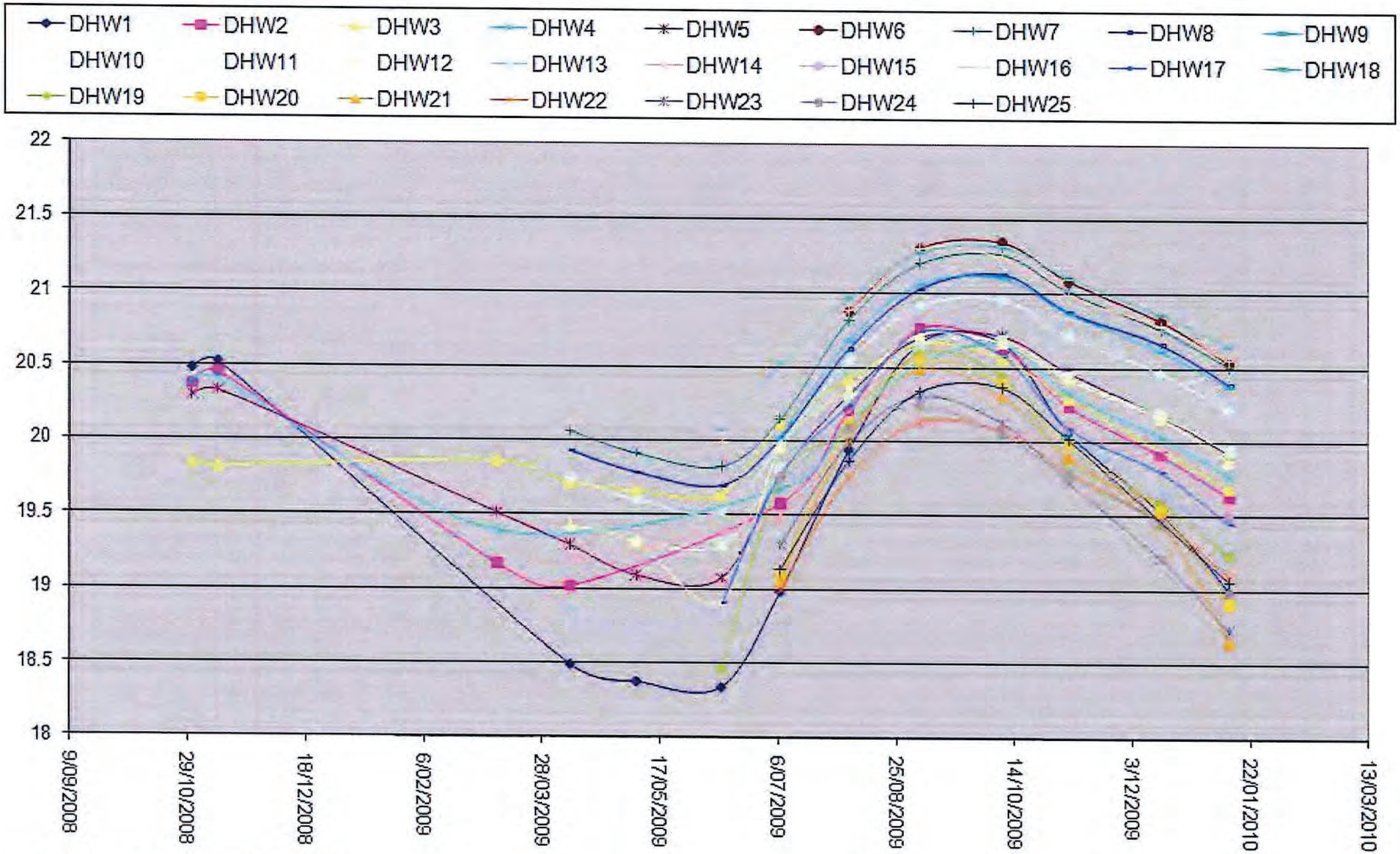


Figure 6- Groundwater Levels (mAHD)

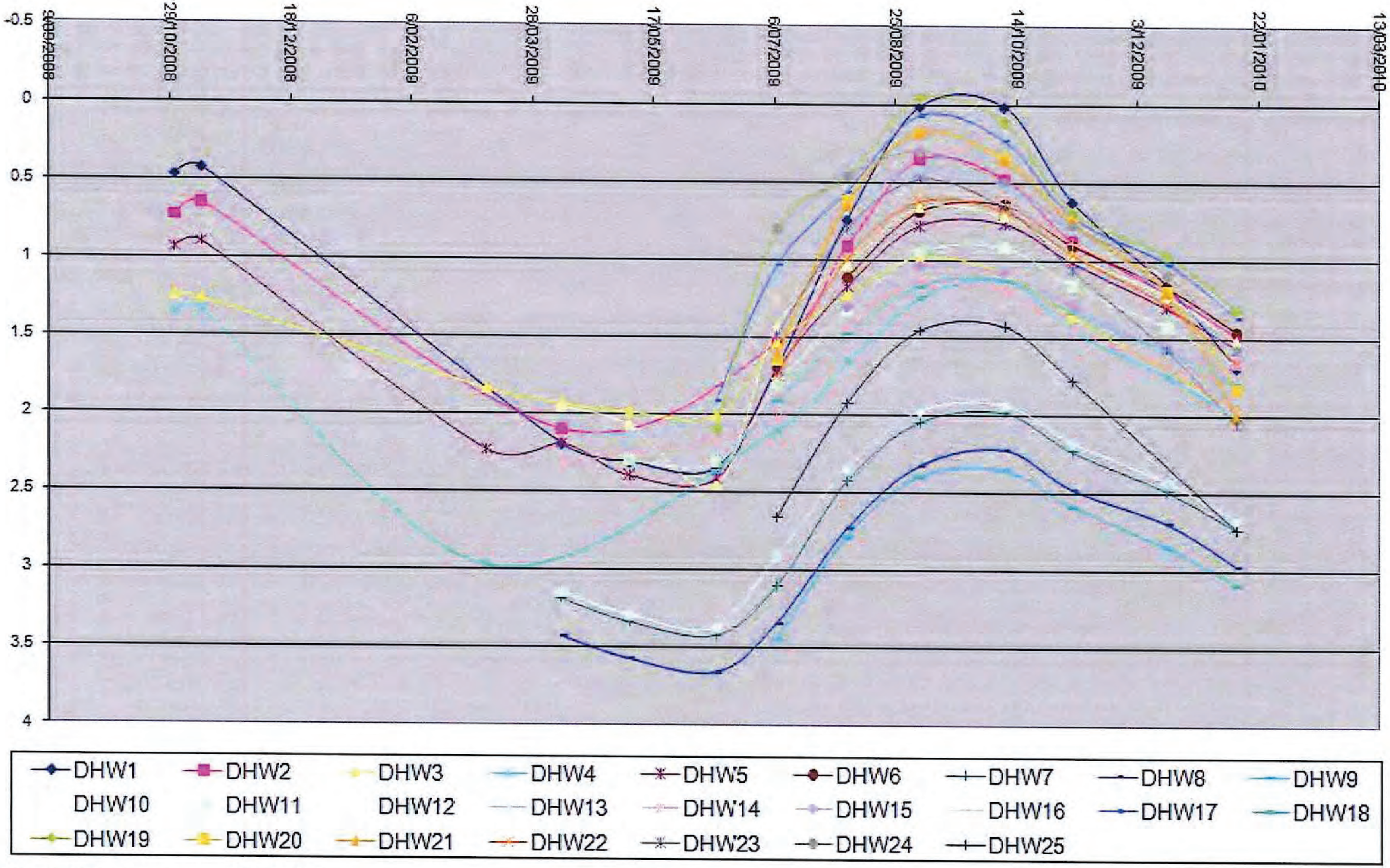
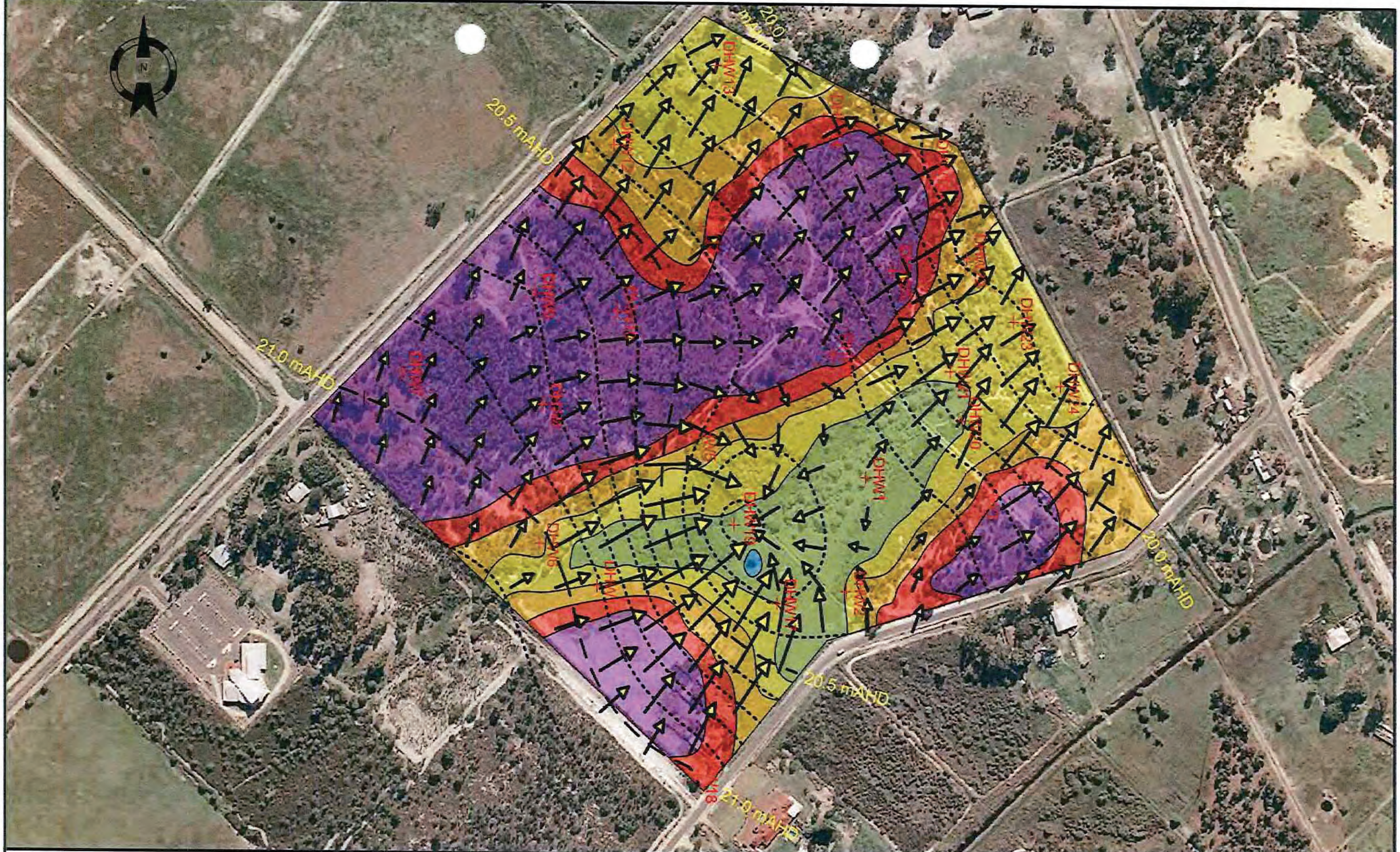


Figure 7- Groundwater Levels (mBGL)



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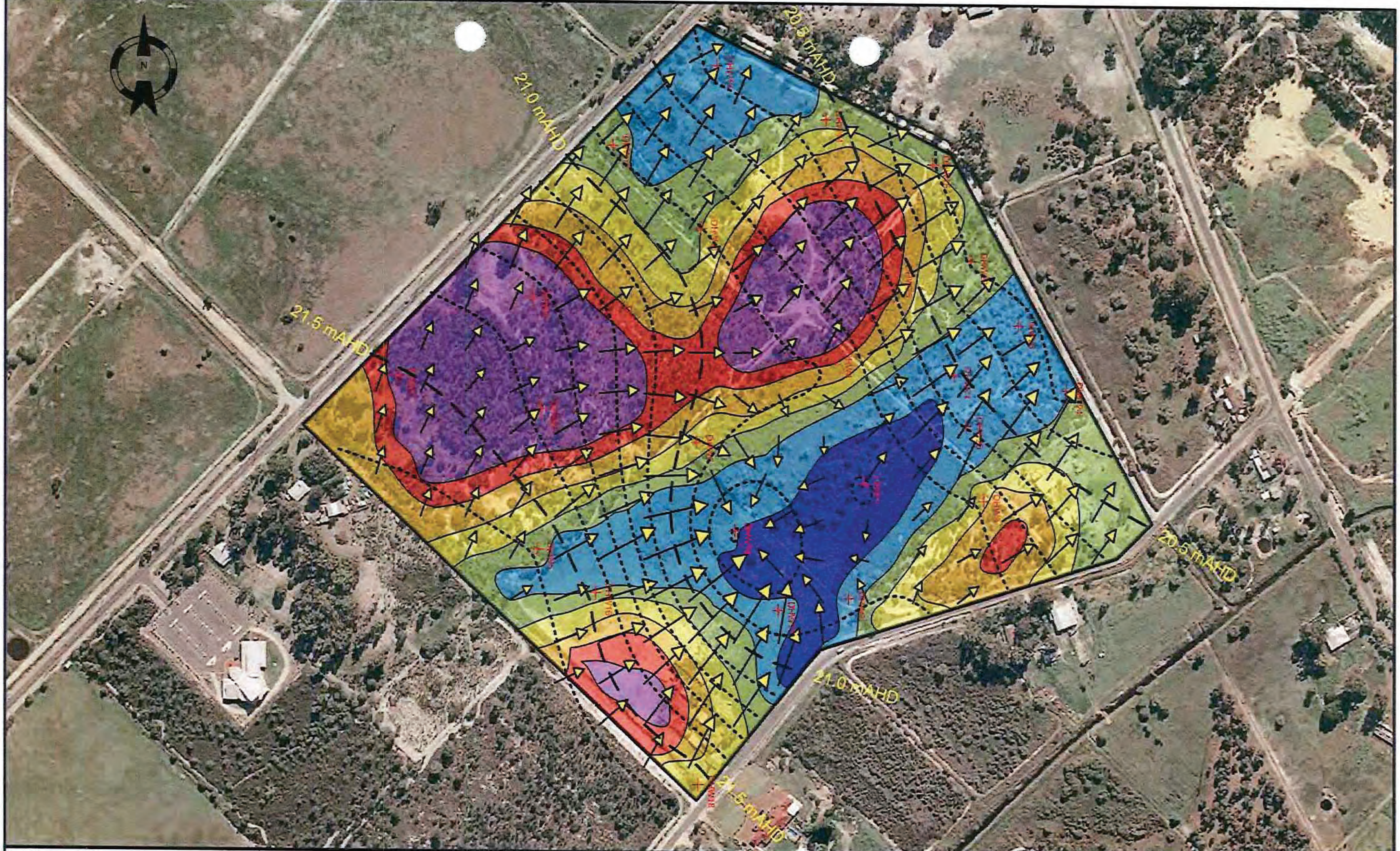
0 100 200m

Figure 8 – AAMGL Contours (m AHD), Groundwater Flow and Depth Below Ground Level (m BGL) .

Legend

- GW Flow
- Minor GW Contour (0.1m)
- Major GW Contour (0.5m)
- Piezometer
- Surface Water
- 0 to 0.3m BGL
- 0.3 to 0.6m BGL
- 0.6 to 0.9m BGL
- 0.9 to 1.2M BGL
- 1.2 to 1.5m BGL
- <1.5m BGL



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0 100 200m

Figure 9 – 1 in 100 Year Groundwater Contours (m AHD), Flow and Depth Below Ground Level (m BGL) .

Legend

- GW Flow
- Minor GW Contour (0.1m)
- Major GW Contour (0.5m)
- Piezometer
- Surface Water
- 0 to 0.3m BGL
- 0.3 to 0.6m BGL
- 0.6 to 0.9m BGL
- 0.9 to 1.2M BGL
- 1.2 to 1.5m BGL
- <1.5m BGL

6. Geotechnical Investigations

6.1. Objectives

- Determine soil and (if encountered) groundwater conditions to 2.5 meters below existing surface levels.
- Determine soil permeability and suitability for stormwater infiltration.
- Provide advice on any need for groundwater control or sub soil drainage.
- Determine the site classification according to AS 2870 (1996) and, if appropriate, determine the boundary between areas which may have different classification and recommend suitable measures to upgrade classification.
- Provide advice in relation to excavation control requirements, site preparation earthworks, characteristics of fill requirements and compaction control.

6.2. Field Investigations

Preliminary field investigations for this project was undertaken on the 31st October 2008, 9th March 2009, 12th June 2009, and the 7th July 2009 and followed by a more intensive investigation undertaken on the 11th February 2010. The earlier field work component of the project involved installing 25 piezometers (DHW1to DHW25) in which representative soil samples were photographed (Appendix 5) and collected for laboratory testing. The later component involved excavation of the 15 test pits (DHW-H1 to DHW-H15) using a 14 tonne mechanical excavator and secondary collection of representative samples for laboratory testing. See Figure 10 for location of all geotechnical and hydrogeological sites.

6.2.1. Excavated Test Pits

Test pits locations were determined based on earlier desk top investigations, from piezometer experience and from field observation of surface soils. The fifteen test pits were excavated to investigate the sub-surface soil and groundwater conditions (Appendix 6).

The site has three distinct geological areas. The first is uniform in regards to the geological layers and is summarised as possessing a light grey to grey organic sandy topsoil to a depth of approximately 250mm, overlying a grey to white medium texture, poorly sorted Bassendean sandy soil to a depth up to 3000mm.

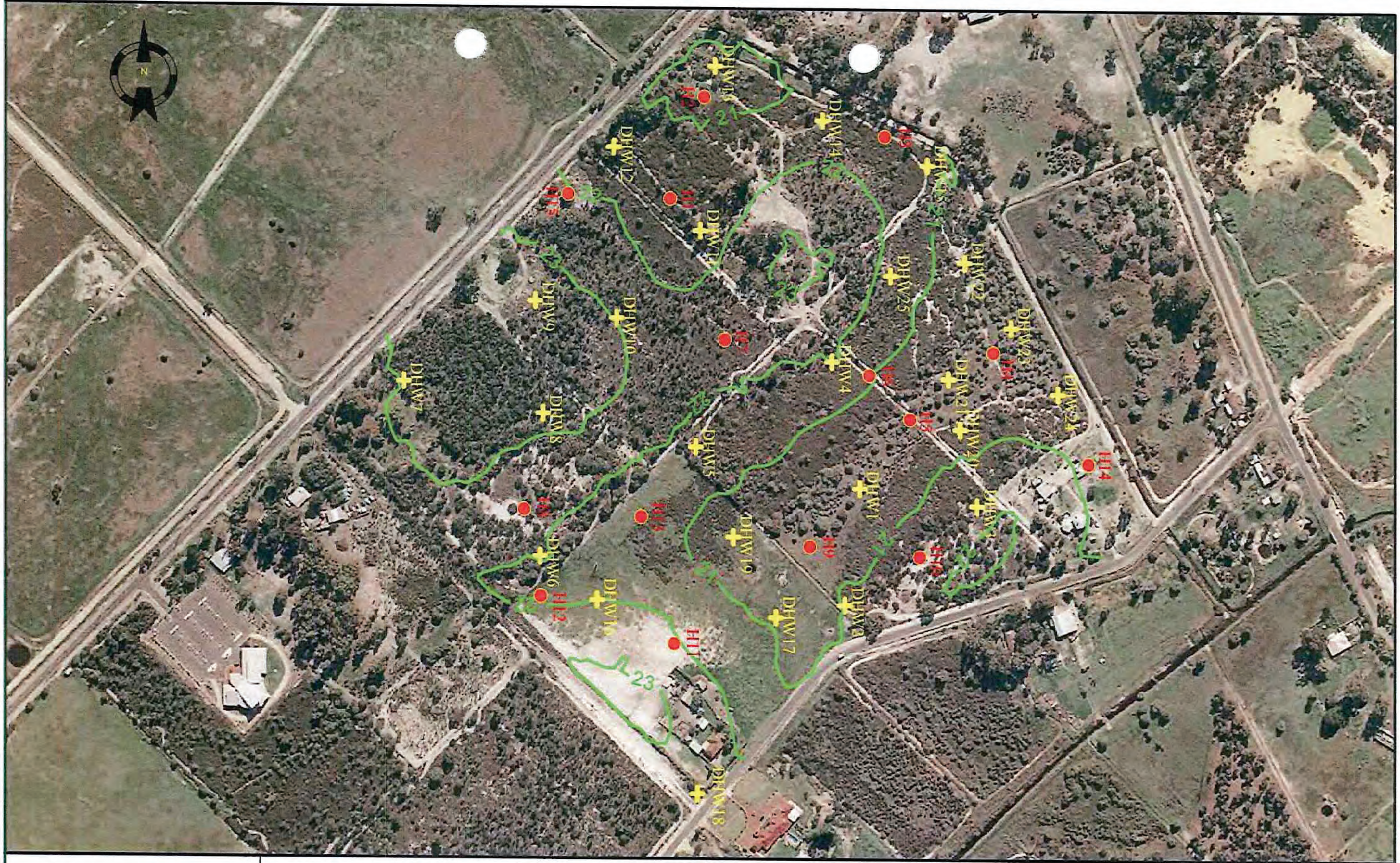

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Figure 10 – Geotechnical and Hydrogeological Investigation Sites.

Legend

Surface Contour (1m) Excavation Sites Piezometer Sites

The second is relatively uniform in regards to the geological layers and is summarised as possessing a dark grey to grey organic sandy topsoil to a depth of approximately 250mm, overlying a light grey to white medium texture, poorly sorted Bassendean sandy soil to a depth of approximately 700mm, overlying a mottled cream to orange loamy sand to sandy loam to a sandy clay loam with increasing depth to approximately 2000mm, overlying a mottled green to grey sandy loam to sandy clay loam with increasing depth to approximately 3000mm.

The third appears to be a transition zone between the first and second areas, however is more similar to the second geological areas in that it possess a dark grey to grey organic sandy topsoil to a depth of approximately 250mm, overlying a light grey to white medium texture, poorly sorted Bassendean sandy soil to a depth of approximately 1000 to 1500mm, overlying a dark brown to black, rocky ferrunginous induration or "coffee rock" layer to a depth of approximately 2000mm, overlying a mottled green to grey sandy loam to sandy clay loam with increasing depth to approximately 3000mm.

6.3. Laboratory Investigations

At the completion of the fieldwork, a programme of laboratory tests was performed on selected soil samples. Test results have been used to assist with the classification and determination of engineering properties of the soil for this geotechnical investigation.

- Particle size distribution – AS1289.3.6.1
- Atterberg limit
  - Liquid limit – AS1289.3.1.2
  - Plastic limit - AS1289.3.2.1
  - Plasticity index – AS1289.3.3.1
  - Linear shrinkage – AS1289.3.4.1
- Acid Sulfate Soil SPOCAS Suite - AS 4969.12

The laboratory tests were carried out in accordance with the requirements specified in AS 1289 and AS 4969.12 by Bioscience's soil laboratory in Forrestdale.

6.3.1. Particle size distribution

Particle size distribution (PSD) was determined on soil samples collected during the geotechnical investigation (Appendix 7). Of the 54 soil tested, the vast majority (39 samples) contained over 90% of particles within the 2mm to 0.075mm range (sand fraction), and thus classified sandy soils. Of the remaining six samples were classified as loamy sands as each had greater that 90% but less than 80% of particles within the 2mm to 0.075mm range (sand fraction), and another six were classified as sandy loams as each had greater that 80% but less than 70% of particles within the 2mm to 0.075mm range (sand fraction). The remaining 3 samples were consolidated rock like material and did not undergo PSD.

6.3.2. Atterberg Limit

The Atterberg limits tests are simple standardized tests that were developed to determine the water contents that will induce particular behaviour, and provides a useful measure of potential soil reactivity and ground movements, which are fundamental in foundation design. Of the samples collected during the excavation of the 12 test pits, four samples of interest underwent Atterberg limits investigations.

Without exception, all four soils samples tested plot above the "A" line and have LL less than 50%, thus they are referred to as clays with low or intermediate plasticity. Of the four representative soil samples tested, two have low plasticity, whereas the other two have intermediate plasticity. Raw results are summarised on Table 3 and Figure 11.

Table 3 - Atterberg Limits Results.

Borehole	Sample Depth (mm)		Cobble (%) >6.3mm	Gravel (%) >2mm	Sand (%) <2mm	Silt/Clay (%) <0.075mm	Fines (%) <0.425mm	LL (%)	PL (%)	PI (%)	LS (%)
DHW-H5	1500	3000	0.0	0.1	79.2	20.8	89.9	36.3	17.6	18.7	3.3
DHW-H5	1000	1500	0.0	0.2	73.2	26.6	62.6	39.9	16.9	23.0	5.3
DHW-H12	1600	3000	0.0	0.2	73.2	27.5	56.4	33.6	17.2	16.4	2.7
DHW-H4	700	2000	0.0	0.1	79.2	21.5	54.7	31.6	17.1	14.5	1.3

6.3.3. Acid Sulfate Soil SPOCAS Suite

Eleven soil samples were examined for their acid sulfate properties (i.e. SPOCAS suite). No single method, including SPOCAS, will provide all the answers to the complex chemistry involved in reactions of acid sulfate soils. However results the SPOCAS test procedures will provide guidance to identify ASS and the nature of cations contributing to total and potential acidity (Acid Sulfate Soils – Laboratory Methods Guideline, 2004). Action criteria are defined and give advice when soils disturbed at a site will require ASS management. These action criteria are based on the sum of existing plus potential acidity (Table 4).

Figure 11 - Atterberg Limits Results

Plasticity	Non-Plastic	Low	Inter-mediate	High	Very High	Extreme
Symbol	NP	L	I	H	VH	E

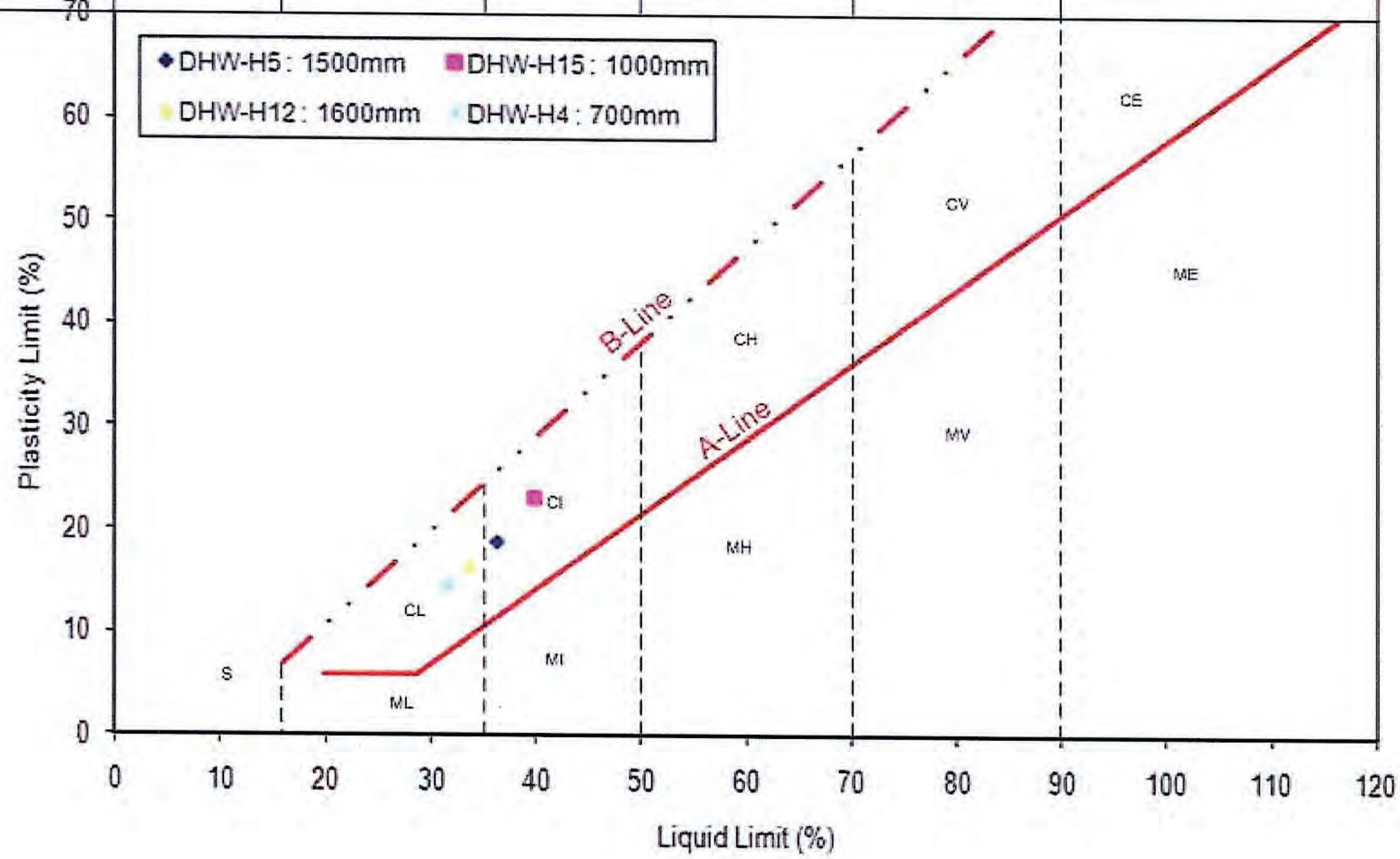

Table 4 – Acid Sulphate Soil Action Criteria (Ahern et al, 1998).

Type of Material		Action Criteria, <1000 tonnes		Action Criteria, >1000 tonnes	
Texture	Approx. Clay Content (%<0.002mm)	Sulfur Trail SPOS %	Acid Trail TPA mole H^+/t	Sulfur Trail SPOS %	Acid Trail TPA mole H^+/t
Coarse (sand)	≤5	0.03	18	0.03	18
Medium (Loams to Light Clays)	5 to 40	0.06	36	0.03	18
Fines (Silts and Clays)	≥40	0.10	62	0.03	18

Results (Appendix 8) indicate that none of the 11 samples tested exceeds the action criteria for both TPA and total Sulfur (Note, S_{POS} gives a measure of the maximum "oxidisable" sulphur present in a soil sample, where as total sulphur S_{TOTAL} (as measured in this report) gives a measure of total sulphur present with a soil sample, consequently S_{TOTAL} will always be equal to or greater than S_{POS}). Three of the 11 samples do exceed the Titratable Peroxide Acidity (TPA), however as they all possess S_{TOTAL} less than the action criteria (i.e. 0.03%) are considered to have an inconsequential ASS risk.

7.Site Evaluation and Recommendations

7.1. *Site Classification*

The "Residential Slab and Footings Australian Standard 2870" provides a site classification system and associated generic foundation design recommendations, for residential development. The site classification system is based on the potential soil reactivity, and associated ground movements attributable to seasonal soil moisture variations or potential problems sites due to adverse geotechnical conditions.

The majority site is classified as "Class A" as defined in the Residential Slab and Footings (Australian Standard 2870), as the natural sand cover over the more reactive sandy loam layer is greater than 1.5m, thus little to no ground movement from moisture is expected. A proportion of the site which currently has less than 1.5m, but greater than 0.8m of natural sand cover over the more reactive sandy loam layer is classified as "Class S", as it may be slightly reactive and thus result in slight movement from moisture changes (Figure 12). Notwithstanding, "Class S" areas can be upgraded to "Class A" via the application of engineered sandy fill, provided the sand cover over the sandy loam layer is greater than 1.5m thick. Such fill is available on site, in areas above 22.5m ADH (Figure 12).

7.2. *Soil Reactivity*

The sandy loams of the Pinjarra Plain system, if encountered within 1.5m BGL are generally considered to be a poor quality material for construction of foundations, due to their higher plasticity, and thus potential reactivity.

Atterberg Limits analysis provides a useful measure of the potential soil reactivity and ground movements, which relate to shallow foundation design. Whereas the Pinjarra Plain formations are known to be generally reactive (they shrink in response to drying and swell under rewetting), without exception, all soils samples tested plot above the "A" line and have LL less than 50%, thus they are referred to as sandy loam with low or intermediate plasticity (Figure 12).

Bioscience

0 100 200m

Figure 12 – Site Classification and Fill Excavation Areas.

Legend

Surface Contour (1m)

Class A

Class S

Fill Extraction Areas

7.3. *Infiltration and Drainage*

The permeability or infiltration rates of the various soil found on site is related to the particle size distribution. The infiltration rates of precipitation on the sandy soils are approximately $1x10^{-3}$ m/s, whereas the infiltration rates on the loamy sands and sandy loams soils is approximately $1x10^{-7}$ m/s and $1x10^{-8}$ m/s, respectively. Consequently, drainage is considered to be good throughout the sandy soil areas and poor in the finer loamy sands to sandy loams areas.

Bioscience considers that there is an excess of surface water in winter, which needs to be dealt with. Several dewatering design possibilities exist, however Bioscience favours the use of living stream to drain water into the Southern River via the Forrestdale main drain. Detail of area drainage will be contained in a Local Water Management Strategy according to Department of Water guidelines and will include principles of Water Wise Urban Design and Best Management Practice.

7.4. *ASS Management Strategy*

Both the desktop and preliminary filed investigation suggest that ASS is only a concern where site works disrupt soil greater than 3m from the natural soil surface. The only a foreseeable site works that might disrupt soil greater than 3m from the natural soil is sewer construction, thus further assessment maybe required prior to the submission of a dewatering licence (if required). As the sewer excavation depths at this point in time are unknown, undertaking an ASS assessment before plans are finalised may results in samples being undertaken in inappropriate locations and depths. Should the proposed investigations indicate actual and/or potential ASS are present on the site, then an ASS management plan will be developed.

7.5. *Site Preparation*

The following site preparation procedure is recommended:

- Identification and diversion or protection of any buried services within the work areas.
- Removal of topsoil, organics, roots, old services, rubbish and any other deleterious material from the site.
- Proof compact the exposed surface using a suitable compaction plant. A minimum of 12 tonne static mass vibratory smooth drum roller is preferred to achieve densification of sandy soil at depth. A minimum of eight overlapping passes should be provided.

- Where the surface deforms excessively during compaction or wet and/or week material is exposed, over-excavation and replacement with compacted few draining sand fill may be required.
- Site works and preparation should be undertaken in summer or autumn, where groundwater levels are near their seasonal lows, as soil will become very difficult to work with in wet conditions.
- Dewatering or drainage may be required to control groundwater levels. Experience indicates that difficulties with compaction may occur when groundwater is present within about 1.0 to 1.5m of the level at which compaction is applied.
- Confirm that adequate compaction is achieved as outlined below.
- Should compaction to satisfactory depth not be achieved by surface compaction it may be necessary to over excavate, compact the base of the excavation and re-place the soil in compaction layers.
- Place and compact approved clean free draining fill material in layers of no greater than 0.3m thickness, up to the level required.

7.5.1. Excavation and Dewatering

Based on the observed soil properties intersected during the fieldwork it is anticipated that excavations across the site should be achieved using standard earthmoving equipment. Excavations in sand area prone to instability, consequently care must be exercised in such excavation and appropriate safety measures adapted where necessary.

Where excavations extend close to the groundwater level (i.e. below 21m ADH), dewatering may be required to draw down the water level to 1m below the base of the excavation to achieve adequate compaction. If possible, site preparation should occur during dry periods to reduce or eliminate dewatering requirements. Should dewatering be required, care must be taken to ensure neighbouring wetlands are not affected.

7.5.2. Compaction

Fill materials, placement and compaction methods and quality control should apply with relevant structure fill requirements according to standard industry practice and AS 3798 "Guidelines on Earthworks for Commercial and Residential Developments". The fill should generally be placed in loose layers not exceeding 300mm thickness and each layer should be adequately moist and compacted with suitable equipment to a minimum of 95% modified maximum density (MMDD) or 70% density index as appropriate.

A Perth Sand Penetrometer in accordance with AS1289.6.3.3 may be used for compaction control in sand provided it is calibrated for each material type on-site. All areas within the building envelopes should be compacted to achieve a minimum blow count of 8 blows per 300 mm penetration to a depth of 1 m below the existing ground level, when tested in accordance with the above test method. If difficulties arise in achieving this blow count, then *in situ* density testing in accordance with the Australian Standard (AS1289) should be performed to correlate between blow counts and density to ensure that a density index of 70% is achieved.

7.5.3. Fill Material

Bioscience identified that the sandy material below the upper topsoil layer (i.e. 250mm) is considered suitable fill material and as such can be used as infill on the provision that it contains less than 5% fines (i.e. <0.075mm) and has a maximum particle size of 40mm and is free of any organic or deleterious material. Several area on site have been identified as being suitable for fill excavation, as they have natural sand cover over the clay of greater than 3m (Figure 12).

8. Conclusions

The results of this investigation indicate that the site is physically capable of development for an urban development, subject to the recommendation of this report.

The majority of the site is classified as "Class A" as defined in the Residential Slab and Footings code AS2870 and suitable for building foundations. Areas classified as "Class S" require fill material to increase the depth of sand above a more reactive sandy loam layer to 1.5m in order for it to be upgraded to "Class A". Survey and further geotechnical work may be required to confirm that site fill works have conformed to these recommendations.

The site can best be summarised as sandy soils over a layer of less permeable loamy sand and sandy loams at depth. Generally, the sandy loams are encountered at approximately 19.5m ADH (Standard Deviation of 0.5m). The loamy sand / sandy loams encountered underwent Atterberg limits analysis. Of the samples analysed, all possessed Liquid and Plastic Limits indicating a low to intermediate Plastic Index (Figure 11 and Table 3). Consequently, this layer displays a low to intermediate reactivity and low permeability. The design of buried services and structures on shallow footings (i.e. more than 1.5mBGL) needs to take into account the reactivity of these near-surface sandy loams soil. Bioscience recommend that fill material be used to maintain a 1.5m layer of sandy soil on top of the sandy loam layer.

High groundwater levels in the winter months results in surface inundation of low lying areas (i.e. less than 20.8m AHD). Bioscience recommends that these areas be retained as part POS in the form of living streams. Living streams serve an important function in Stormwater management as they allow for the creation of a basin of adequate size to enable detention and nutrient stripping, prior to export to a suitable receiver such as the Southern River via the local authority and Forrestdale main drains.

9. References

AS 1289-2000. Methods of Testing Soils for Engineering Purposes. Standards Australia.

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Perth Groundwater Atlas (2004). Department of Environment.

Hillman M, Cocks, G and Ameratunga J. (2003) Guildford Formation, Australian Geomechanics 38: 31-39

10. Scope and Limitations

This report presents the results of a geotechnical investigation, the data and advice provided herein relate only to the project and/or structures described herein and must be reviewed by a competent geotechnical engineer before being used for any other purpose. Bioscience accepts no responsibility for other use of the data.

The advice tendered in this report id based on information obtained from the investigation locations tests points and sample points and is not warranted in respect to the conditions that may be encountered across the site at other than these locations. It is emphasised that the actual characteristics of the subsurface materials may vary significantly between adjacent test points and sample intervals and at allocations other than where observation, exploration and investigation have been made. Subsurface conditions, including groundwater levels and contaminants concentrations can change in a limited time.

It should be noted that because of the inherent uncertainties in subsurface evaluations, changed or unanticipated subsurface conditions may occur that could affect total project cost and I or execution. Bioscience does not accept responsibility for the consequences of significant variances in the conditions and the requirements for execution of the work.

The subsurface and surface earthworks, excavations and foundations should be examined by a suitably qualified and experienced Engineer who shall judge whether the revealed conditions accord with both the assumptions in this report and/or the design of the works. If they do not accord, the Engineer shall modify advice in this report and/or design of the works to accord with the circumstances that are revealed.

An understanding of the geotechnical site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experienced based. Hence this report should not be altered, amended or abbreviated, issued in part and issued incomplete in any way without prior checking and approval by Bioscience. Bioscience accepts no responsibility for any circumstances, which arise from the issue of the report, which has been modified in any way as outlined above.

Appendix 1 – Groundwater Data (m AHD)

	31/10/2008	11/11/2008	9/03/2009	9/04/2009	7/05/2009	12/06/2009	7/07/2009	5/08/2009	4/09/2009	9/10/2009	6/11/2009	15/12/2009	13/01/2010
DHW 1	20.480	20.524	#N/A	18.490	18.377	18.340	18.985	19.941	20.671	20.671	20.065	19.528	18.998
DHW 2	20.369	20.450	19.167	19.017	#N/A	#N/A	19.577	20.204	20.764	20.639	20.237	19.913	19.631
DHW 3	19.835	19.813	19.856	19.708	19.656	19.634	20.112	20.418	20.667	20.564	20.289	#N/A	19.687
DHW 4	20.381	20.405	19.390	#N/A	#N/A	#N/A	19.673	20.115	20.526	20.655	20.326	20.033	19.769
DHW 5	20.294	20.330	19.513	19.296	19.092	19.074	19.774	20.314	20.706	20.718	20.473	20.183	19.926
DHW 6	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	20.876	21.305	21.348	21.088	20.816	20.531
DHW 7	#N/A	#N/A	#N/A	20.062	19.914	19.828	20.148	20.821	21.204	21.265	21.017	20.764	20.514
DHW 8	#N/A	#N/A	#N/A	19.925	19.783	19.696	20.014	20.623	21.029	21.131	20.878	20.661	20.388
DHW 9	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	20.017	20.680	21.065	21.108	20.874	20.615	20.375
DHW 10	#N/A	#N/A	#N/A	19.742	19.600	19.520	19.981	20.544	20.915	20.956	20.714	20.465	20.219
DHW 11	#N/A	#N/A	#N/A	#N/A	19.303	19.292	19.800	20.277	20.654	20.683	20.443	20.181	19.938
DHW 12	#N/A	#N/A	#N/A	19.424	19.310	18.921	19.949	20.348	20.722	20.662	20.420	20.157	19.868
DHW 13	#N/A	#N/A	#N/A	18.820	18.729	18.934	19.790	20.206	20.447	20.351	20.055	19.668	19.268
DHW 14	#N/A	#N/A	#N/A	19.200	#N/A	#N/A	19.502	20.094	20.382	20.325	20.087	19.851	19.562
DHW 15	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	19.856	20.122	20.080	19.867	19.602	19.502
DHW 16	#N/A	#N/A	#N/A	#N/A	#N/A	19.990	20.623	20.884	21.303	21.242	20.990	20.786	20.550
DHW 17	#N/A	#N/A	#N/A	#N/A	#N/A	18.904	19.775	20.251	20.744	20.584	20.094	19.800	19.451
DHW 18	#N/A	#N/A	#N/A	#N/A	#N/A	20.072	20.527	20.962	21.274	21.313	21.108	20.860	20.650
DHW 19	#N/A	#N/A	#N/A	#N/A	#N/A	18.467	19.751	20.093	20.597	20.441	19.867	19.589	19.239
DHW 20	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	19.084	20.115	20.549	20.388	19.985	19.539	18.908
DHW 21	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	19.051	20.013	20.488	20.306	19.905	19.457	18.650
DHW 22	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	18.999	19.758	20.130	20.071	19.792	19.470	19.095
DHW 23	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	19.298	19.985	20.307	20.128	19.729	19.216	18.729
DHW 24	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	19.749	20.086	20.242	20.053	19.771	19.458	18.980
DHW 25	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	19.130	19.866	20.337	20.366	20.017	#N/A	19.056

Appendix 2 – Groundwater Data (m GBL)

	31/10/2008	11/11/2008	9/03/2009	9/04/2009	7/05/2009	12/06/2009	7/07/2009	5/08/2009	4/09/2009	9/10/2009	6/11/2009	15/12/2009	13/01/2010
DHW1	0.465	0.421	#N/A	2.193	2.306	2.343	1.698	0.742	0.012	0.012	0.618	1.155	1.685
DHW2	0.730	0.649	#N/A	2.096	#N/A	#N/A	1.536	0.909	0.349	0.474	0.876	1.200	1.482
DHW3	1.241	1.263	1.838	1.936	1.988	2.010	1.532	1.226	0.977	1.080	1.355	#N/A	1.957
DHW4	1.354	1.330	2.973	#N/A	#N/A	#N/A	2.098	1.656	1.245	1.116	1.445	1.738	2.002
DHW5	0.935	0.899	2.230	2.189	2.393	2.411	1.711	1.171	0.779	0.767	1.012	1.302	1.559
DHW6	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.113	0.684	0.641	0.901	1.173	1.458
DHW7	#N/A	#N/A	#N/A	3.184	3.332	3.418	3.098	2.425	2.042	1.981	2.229	2.482	2.732
DHW8	#N/A	#N/A	#N/A	3.427	3.569	3.656	3.338	2.729	2.323	2.221	2.474	2.691	2.964
DHW9	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	3.443	2.780	2.395	2.352	2.586	2.845	3.085
DHW10	#N/A	#N/A	#N/A	3.148	3.290	3.370	2.909	2.346	1.975	1.934	2.176	2.425	2.671
DHW11	#N/A	#N/A	#N/A	#N/A	2.297	2.308	1.800	1.323	0.946	0.917	1.157	1.419	1.662
DHW12	#N/A	#N/A	#N/A	1.959	2.073	2.462	1.434	1.035	0.661	0.721	0.963	1.226	1.515
DHW13	#N/A	#N/A	#N/A	2.048	2.139	1.934	1.078	0.662	0.421	0.517	0.813	1.200	1.600
DHW14	#N/A	#N/A	#N/A	2.326	#N/A	#N/A	2.024	1.432	1.144	1.201	1.439	1.675	1.964
DHW15	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.302	1.036	1.078	1.291	1.556	1.656
DHW16	#N/A	#N/A	#N/A	#N/A	#N/A	1.886	1.253	0.992	0.573	0.634	0.886	1.090	1.326
DHW17	#N/A	#N/A	#N/A	#N/A	#N/A	1.908	1.037	0.561	0.068	0.228	0.718	1.012	1.361
DHW18	#N/A	#N/A	#N/A	#N/A	#N/A	2.368	1.913	1.478	1.166	1.127	1.332	1.580	1.790
DHW19	#N/A	#N/A	#N/A	#N/A	#N/A	2.087	0.803	0.461	-0.043	0.113	0.687	0.965	1.315
DHW20	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.647	0.616	0.182	0.343	0.746	1.192	1.823
DHW21	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.609	0.647	0.172	0.354	0.755	1.203	2.010
DHW22	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.751	0.992	0.620	0.679	0.958	1.280	1.655
DHW23	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	1.484	0.797	0.475	0.654	1.053	1.566	2.053
DHW24	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.798	0.461	0.305	0.494	0.776	1.089	1.567
DHW25	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	2.659	1.923	1.452	1.423	1.772	#N/A	2.733

Appendix 3 – Statistical Analysis of DoW monitoring bore T75 (Win ID 4880).

Maximum Groundwater Recurrence Intervals				*Minimum Groundwater Recurrence Intervals*			
Year	**Max Groundwater Levels (m AHD)**	**Recurrence Interval (years)**	**Groundwater Level (m AHD)**	**Year**	**Min Groundwater Levels (m AHD)**	**Recurrence Interval (years)**	**Groundwater Level (m AHD)**
1994	19.317	1	18.21	1980	16.63	1	15.79
1992	19.267	1.02	18.42	1978	16.64	1.02	16.32
1978	19.167	1.04	18.48	1982	16.67	1.04	16.47
1991	19.097	1.06	18.52	1981	16.73	1.06	16.57
1984	19.047	1.08	18.55	1977	16.76	1.08	16.65
1996	19.037	1.1	18.57	1983	16.82	1.1	16.71
2003	18.987	1.2	18.65	1988	16.85	1.2	16.92
1986	18.977	1.3	18.70	1987	16.88	1.3	17.05
1999	18.957	1.4	18.73	1991	17.03	1.4	17.15
1980	18.947	1.5	18.76	1989	17.04	1.5	17.23
1993	18.947	1.6	18.79	1984	17.06	1.6	17.29
1975	18.937	1.7	18.81	1976	17.26	1.7	17.35
1983	18.937	1.8	18.82	1986	17.28	1.8	17.40
2001	18.927	1.9	18.84	1979	17.38	1.9	17.44
2000	18.877	2	18.85	1995	17.39	2	17.48
1988	18.857	3	18.94	1994	17.43	3	17.75
2002	18.857	4	19.00	1985	17.44	4	17.90
1981	18.831	5	19.03	1975	17.53	5	18.01
1995	18.817	6	19.06	1998	17.69	6	18.09
2005	18.807	7	19.08	1990	17.81	7	18.16
1985	18.787	8	19.10	1993	17.81	8	18.21
1987	18.787	9	19.11	1992	17.83	9	18.26
2004	18.767	10	19.13	1999	17.83	10	18.30
1997	18.727	20	19.20	2000	18.06	20	18.54
1979	18.697	30	19.25	2003	18.12	30	18.67
1990	18.677	40	19.27	1996	18.16	40	18.76
2006	18.637	50	19.29	1997	18.17	50	18.82
1998	18.627	60	19.31	2001	18.19	60	18.87
1982	18.597	70	19.32	2006	18.27	70	18.92
1976	18.567	80	19.33	2004	18.40	80	18.95
1989	18.457	90	19.34	2002	18.41	90	18.99
1977	18.407	100	19.35	2005	18.68	100	19.01

Appendix 4 – Site AALGL, AAMGL and 1 in 100 ARI Calculations.

AALGL

Site	June 09 Data	% Difference	AALGL
T75	18.25	0.95781	17.48
DHW1	18.34	0.95781	17.57
DHW2	#N/A	0.95781	#N/A
DHW3	19.634	0.95781	18.81
DHW4	#N/A	0.95781	#N/A
DHW5	19.074	0.95781	18.27
DHW6	#N/A	0.95781	#N/A
DHW7	19.828	0.95781	18.99
DHW8	19.696	0.95781	18.86
DHW9	#N/A	0.95781	#N/A
DHW10	19.52	0.95781	18.70
DHW11	19.292	0.95781	18.48
DHW12	18.921	0.95781	18.12
DHW13	18.934	0.95781	18.14
DHW14	#N/A	0.95781	#N/A
DHW15	#N/A	0.95781	#N/A
DHW16	19.99	0.95781	19.15
DHW17	18.904	0.95781	18.11
DHW18	20.072	0.95781	19.23
DHW19	18.467	0.95781	17.69
DHW20	#N/A	0.95781	#N/A
DHW21	#N/A	0.95781	#N/A
DHW22	#N/A	0.95781	#N/A
DHW23	#N/A	0.95781	#N/A
DHW24	#N/A	0.95781	#N/A
DHW25	#N/A	0.95781	#N/A
		T75 AALGL	17.48
		Site Max	19.23
		Site Min	17.57

AAMGL

Site	Oct 09 Data	% Difference	AAMGL
T75	19.12	0.98564	18.85
DHW1	20.671	0.98564	20.37
DHW2	20.639	0.98564	20.34
DHW3	20.564	0.98564	20.27
DHW4	20.655	0.98564	20.36
DHW5	20.718	0.98564	20.42
DHW6	21.348	0.98564	21.04
DHW7	21.265	0.98564	20.96
DHW8	21.131	0.98564	20.83
DHW9	21.108	0.98564	20.80
DHW10	20.956	0.98564	20.66
DHW11	20.683	0.98564	20.39
DHW12	20.662	0.98564	20.37
DHW13	20.351	0.98564	20.06
DHW14	20.325	0.98564	20.03
DHW15	20.08	0.98564	19.79
DHW16	21.242	0.98564	20.94
DHW17	20.584	0.98564	20.29
DHW18	21.313	0.98564	21.01
DHW19	20.441	0.98564	20.15
DHW20	20.388	0.98564	20.10
DHW21	20.306	0.98564	20.01
DHW22	20.071	0.98564	19.78
DHW23	20.128	0.98564	19.84
DHW24	20.053	0.98564	19.77
DHW25	20.366	0.98564	20.07
		T75 AAMGL	18.85
		Site Max	21.04
		Site Min	19.77

1 in 100 ARI

Site	Oct 09 Data	% Difference	1 in 100
T75	19.12	1.01179	19.35
DHW1	20.671	1.01179	20.91
DHW2	20.639	1.01179	20.88
DHW3	20.564	1.01179	20.81
DHW4	20.655	1.01179	20.90
DHW5	20.718	1.01179	20.96
DHW6	21.348	1.01179	21.60
DHW7	21.265	1.01179	21.52
DHW8	21.131	1.01179	21.38
DHW9	21.108	1.01179	21.36
DHW10	20.956	1.01179	21.20
DHW11	20.683	1.01179	20.93
DHW12	20.662	1.01179	20.91
DHW13	20.351	1.01179	20.59
DHW14	20.325	1.01179	20.56
DHW15	20.08	1.01179	20.32
DHW16	21.242	1.01179	21.49
DHW17	20.584	1.01179	20.83
DHW18	21.313	1.01179	21.56
DHW19	20.441	1.01179	20.68
DHW20	20.388	1.01179	20.63
DHW21	20.306	1.01179	20.55
DHW22	20.071	1.01179	20.31
DHW23	20.128	1.01179	20.37
DHW24	20.053	1.01179	20.29
DHW25	20.366	1.01179	20.61
		T75 1 in 100	19.35
		Site Max	21.60
		Site Min	20.29

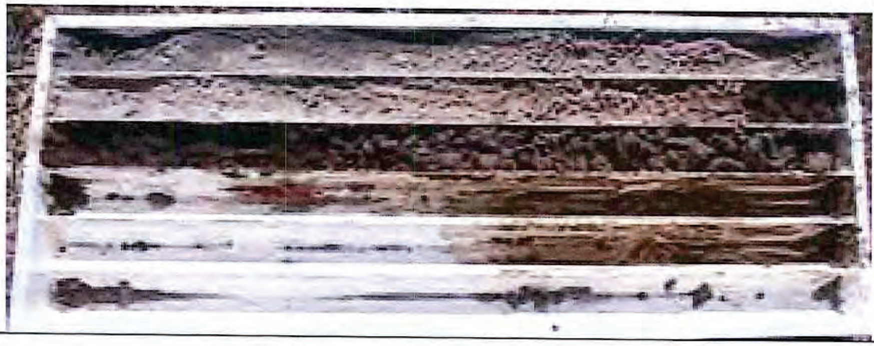
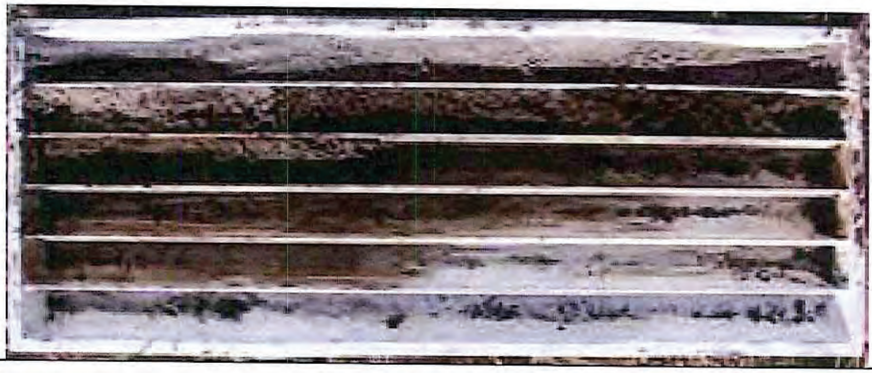
Appendix 5 – Soil Description as collected from Piezometer Installation.

Bore ID	Soil Profile Photo	Soil Depth (mm)		Redox Potential (mV)	Soil Description
DHW1	No Photo Taken.	0	150	454	Light grey, medium textured, Bassendean quarts sand, with organic material.
		150	300	348	White to cream, medium textured, Bassendean quarts sand.
		300	400	206	Medium texture Bassendean quarts sand
		400	700	183	Light brown, medium textured, Bassendean quarts sand.
		700	800	227	White to cream, medium to fine textured, Bassendean quarts sand with ferrunginous induration "coffee rock".
		800	2500	233	White to cream, coarse to medium textured, rounded, Bassendean quarts clayey sand.
		2500	3200	131	Light grey to grey, fine textured Bassendean quarts clay.
DHW2	No Photo Taken.	0	250	457	Light grey, medium textured, Bassendean quarts sand, with organic material.
		250	600	470	Light grey, medium textured, Bassendean quarts sand.
		600	1500	464	Light grey to white, medium textured, Bassendean quarts sand over an impassable ferrunginous induration "coffee rock".
DHW3	No Photo Taken.	0	200	469	Dark grey, medium textured, Bassendean quarts sand, with organic material.
		200	400	478	Grey, medium textured, Bassendean quarts sand.
		400	2000	469	White, medium textured, Bassendean quarts sand.
DHW4	No Photo Taken.	0	300	469	Grey, medium textured, Bassendean quarts sand, with organic material.
		300	600	478	Light grey, medium textured, Bassendean quarts sand, with organic material.
		600	1500	487	Light grey to white, medium textured, Bassendean quarts sand over an impassable ferrunginous induration "coffee rock".

DHW5	No Photo Taken.	0	300	462	Grey, medium textured, Bassendean quarts sand, with organic material.
		300	700	484	Light grey, medium textured, Bassendean quarts sand.
		700	1500	422	Light brown, medium textured, Bassendean quarts sand over an impassable ferruginous induration "coffee rock".
DHW6		0	1000	328	Dark grey to grey, medium textured, Bassendean quarts sand, with organic material.
		1000	1600	424	Light brown to cream, medium to fine textured, Bassendean quarts sand.
		1600	1800	311	Brown, medium to fine textured, Bassendean quarts sand.
		1800	1900	306	Dark drown to black, medium to fine textured, Bassendean quarts sand over an impassable ferruginous induration "coffee rock".
DHW7		0	400	402	Dark grey to grey, medium textured, Bassendean quarts sand, with organic material.
		400	1200	421	Grey to light grey, medium textured, Bassendean quarts sand.
		1200	2800	385	White to cream, medium to fine textured, Bassendean quarts sand.
		2800	3500	338	White to light grey, medium to fine textured, Bassendean quarts sand.
DHW8		0	800	439	Dark grey to grey, medium textured, Bassendean quarts sand, with organic material.
		800	1200	477	Grey to light grey, medium to fine textured, Bassendean quarts sand.
		1200	3900	438	White/cream to light grey, medium to fine textured, Bassendean quarts sand.

DHW9		0	700	318	Grey, medium textured, Bassendean quarts sand, with organic material.
		700	3800	413	White to light grey, medium to fine textured, Bassendean quarts sand.
		3800	3900	249	Brown, medium textured, Bassendean quarts sand over an impassable ferrunginous induration "coffee rock" layer.
DHW10		0	450	386	Grey to light grey, medium textured, Bassendean quarts sand, with organic material.
		450	3500	475	White, medium textured, Bassendean quarts sand.
DHW11		0	600	471	Grey to light grey, medium textured, Bassendean quarts sand, with organic material.
		600	1700	506	White to cream, medium to fine textured, Bassendean quarts sand.
		1700	2600	322	Light brown, medium textured, Bassendean quarts sand.

DHW12		0	300	338	Dark grey to black, medium textured, Bassendean quarts sand, with organic material.
		300	900	413	Grey, medium textured, Bassendean quarts sand.
		900	1700	447	Light grey to white, medium textured, Bassendean quarts sand.
		1700	2500	298	Light brown, medium textured, Bassendean quarts sand over an impassable ferrunginous induration "coffee rock".
DHW13		0	100	403	Dark grey to grey, medium textured, Bassendean quarts sand, with organic material.
		100	600	320	White to pink, medium to fine textured, Bassendean quarts sand.
		600	1600	236	Light brown to cream, medium to fine textured Bassendean quarts Clayey Sand.
		1600	2400	196	Light grey to grey, fine textured Bassendean quarts clay.
		2400	2900	54	Grey to white, Coarse to fine textured, rounded, Bassendean quarts clayey sand.
DHW14		0	400	417	Dark grey to grey, medium textured, Bassendean quarts sand, with organic material.
		400	2100	397	White medium textured, Bassendean quarts sand
		2100	2500	361	Brown, medium textured, Bassendean quarts sand.

DHW15		0	300	419	Dark grey to grey, medium textured, Bassendean quarts sand, with organic material.
		300	850	434	Light grey, medium textured, Bassendean quarts sand.
		850	1800	429	White, medium textured, Bassendean quarts sand.
		1800	2200	294	Dark drown to black, medium to fine textured, Bassendean quarts sand over an impassable ferrunginous induration "coffee rock" layer.
DHW16		0	200	401	Dark grey to grey, medium textured, Bassendean quarts sand, with organic material.
		200	1000	463	Grey to light grey, medium textured, Bassendean quarts sand.
		1000	1800	453	Light grey to white, medium textured, Bassendean quarts sand
		2300	3000	351	Light brown medium textured, Bassendean quarts sand
DHW17		0	250	415	Dark grey to grey, medium textured, Bassendean quarts sand, with organic material.
		250	1300	469	Grey to light grey, medium textured, Bassendean quarts sand.
		1300	1900	496	Brown, medium textured, Bassendean quarts sand.
		1900	2500	319	Light brown medium textured, Bassendean quarts sand

DHW18		0	200	468	Light grey medium textured, Bassendean quarts sand
		200	2500	515	Light grey to white medium textured, Bassendean quarts sand
		2500	3000	468	Light brown medium textured, Bassendean quarts sand
DHW19		0	400	452	Dark grey to grey, medium textured, Bassendean quarts sand, with organic material.
		400	600	377	Light grey to cream medium textured, Bassendean quarts sand
		600	1100	352	Light brown to cream medium textured, Bassendean quarts clayey sand
		1100	1400	348	Orange medium textured, Bassendean quarts clayey sand
		1400	1800	294	Light brown to cream medium to fine textured, Bassendean quarts sand
		1800	2500	187	Grey to green fine textured Bassendean quarts sandy clay
		2500	2600	495	Light grey to white medium textured, Bassendean quarts sand
DHW20		0	200	461	Dark grey to grey, medium textured, Bassendean quarts sand, with organic material.
		200	500	365	Light grey to cream medium textured, Bassendean quarts sand
		500	1800	324	Brown to orange fine to medium textured, Bassendean quarts sand
		1800	3100	247	Grey to green fine textured Bassendean quarts sandy clay

DHW21		0	200	479	Black to dark grey, medium textured, Bassendean quarts sand, with organic material.
		200	400	435	Light grey to cream medium textured, Bassendean quarts sand
		400	1000	350	Brown to cream medium textured, Bassendean quarts sand
		1000	1500	316	Orange medium textured, Bassendean quarts clayey sand with ferrunginous induration or "coffee rock" layer
		1500	2500	299	Grey to cream fine textured Bassendean quarts sandy clay
		2500	3000	274	Grey to green fine textured Bassendean quarts sandy clay
DHW22		0	250	497	Black to dark grey, medium textured, Bassendean quarts sand, with organic material.
		250	1600	512	Light grey to cream medium textured, Bassendean quarts sand
		1600	2600	507	Brown medium textured, Bassendean quarts sand
DHW23		0	150	484	Black to dark grey, medium textured, Bassendean quarts sand, with organic material.
		150	500	478	Light grey to cream medium textured, Bassendean quarts sand
		500	950	316	Brown to cream medium textured, Bassendean quarts sand
		950	2200	274	Cream to orange fine textured Bassendean quarts sandy with ferrunginous induration or "coffee rock" material
		2200	3000	196	Grey to green fine textured Bassendean quarts sandy clay

DHW24		0	100	463	Black to dark grey, medium textured, Bassendean quarts sand, with organic material.
		100	600	421	Light grey to cream medium textured, Bassendean quarts sand
		600	800	381	Brown medium textured, Bassendean quarts sand
		800	1000	365	Light grey to cream medium textured, Bassendean quarts sand
		1000	1500	307	Cream to light brown fine textured Bassendean quarts sandy clay
		1500	1700	298	Cream fine textured Bassendean quarts sandy clay
DHW25		0	300	483	Black to dark grey, medium textured, Bassendean quarts sand, with organic material.
		300	1300	521	Light grey medium textured, Bassendean quarts sand
		1300	2250	498	Cream medium textured, Bassendean quarts sand
		2250	2600	379	Brown medium textured, Bassendean quarts sand
		2600	4400	267	Grey to green fine textured Bassendean quarts sandy clay

Appendix 6 – Soil Description as collected from Excavations.

Investigator/s: ANJ
Client: Urban Plan
Location: Sub-Precinct 3E - Southern River
Site No: DHW-H1

Date: 11/02/2010
Photo No:
Eastings/Long: 6447653
Northings/Lat: 402150

Notes:

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	200	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.79	95.35	3.86
200	1200	Sand	Light Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.00	98.59	1.41
1200	2200	Sand	White	Poor	Sub A	Moist	Non-cohesiv.	Layer	-	0.00	0.13	98.30	1.57
2200	3000	Sand	Brown	Poor	Sub A	Wet	Non-cohesiv.	Layer	-	0.00	0.37	97.01	2.62

Investigator/s: ANJ

Client: Urban Plan

Location: Sub-Precinct 3E - Southern River

Site No: DHW-H2

Date: 11/02/2010

Photo No:

Eastings/Long: 6447753

Northings/Lat: 402174

Notes:

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	200	Sand	Light Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.30	95.34	4.36
200	400	Sand	White	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.64	96.26	3.10
400	1600	Sand	Red/Brown	Poor	Sub A	Moist	Non-cohesiv.	Layer	-	0.00	0.00	96.95	3.05
1600	2000	Sand	Grey/Brown	Poor	Sub A	Moist	Non-cohesiv.	Layer	-	0.00	0.82	92.67	6.51
2000	3000	Sand	Grey	Poor	Sub A	Wet	Non-cohesiv.	Layer	-	0.00	0.09	91.28	8.63

Investigator/s: ANJ
Client: Urban Plan
Location: Sub-Precinct 3E - Southern River
Site No: DHW-H3

Date: 11/02/2010
Photo No:
Eastings/Long: 6447725
Northings/Lat: 402340

Notes:

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	300	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	1.05	95.25	3.70
300	1500	Sand	Grey to White	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.74	95.70	3.56
1500	1800	Rock	Black to Brown	-	-	Moist	Stiff	Layer	-	-	-	-	-
1800	3000	Loamy Sand	Grey to Green	Poor	Sub A	Wet	Soft	Layer	-	0.00	0.09	86.66	13.25

Investigator/s: ANJ
Client: Urban Plan
Location: Sub-Precinct 3E - Southern River
Site No: DHW-H4

Date: 11/02/2010
Photo No:
Eastings/Long: 6447539
Northings/Lat: 402430

Notes:

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	30	Sand	White	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.79	95.35	3.86
30	700	Sand	Cream to White	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.82	91.52	7.66
700	2000	Loamy Sand	Yellow to White	Poor	Sub A	Moist	Soft	Layer	-	0.00	0.00	86.18	13.82
2000	3000	Sandy Loam	Grey to Green	Poor	Sub A	Wet	Soft	Layer	-	0.00	0.06	77.82	22.12

Investigator/s:	ANJ	Date:	11/02/2010	Notes:
Client:	Urban Plan	Photo No:		
Location:	Sub-Precinct 3E - Southern River	Eastings/Long:	6447475	
Site No:	DHW-H5	Northings/Lat:	402366	

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	200	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.09	96.96	2.95
200	1000	Sand	White to Orange	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.35	97.16	2.49
1000	1500	Gravel Loamy Sand	Orange	Poor	Sub A	Moist	Non-cohesiv.	Layer	-	0.00	5.72	75.25	19.03
1500	3000	Sandy Loam	Grey to Green	Poor	Sub A	Wet	Soft	Layer	-	0.00	0.06	79.19	20.76

Investigator/s: ANJ
Client: Urban Plan
Location: Sub-Precinct 3E - Southern River
Site No: DHW-H6

Date: 11/02/2010
Photo No:
Eastings/Long: 6447521
Northings/Lat: 402323

Notes:

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	100	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.77	96.69	2.54
100	1400	Sand	Grey to White	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.00	99.30	1.30
1400	1600	Rock	Black to Brown	Poor	Sub A	Moist	Firm	Layer	-	-	-	-	-
1600	3000	Loamy Sand	Grey to Green	Poor	Sub A	Wet	Soft	Layer	-	0.00	0.00	84.98	15.02

Investigator/s:	ANJ	**Date:**	11/02/2010
Client:	Urban Plan	**Photo No:**	
Location:	Sub-Precinct 3E - Southern River	**Eastings/Long:**	6447542
Site No:	DHW-H7	**Northings/Lat:**	402188

Notes:

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	300	Sand	Light Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.12	98.34	1.53
300	3000	Sand	White	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.64	96.26	3.10

Investigator/s:	ANJ	**Date:**	11/02/2010	**Notes:**	
Client:	Urban Plan	**Photo No:**			
Location:	Sub-Precinct 3E - Southern River	**Eastings/Long:**	6447404		
Site No:	DHW-H8	**Northings/Lat:**	402003		

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	300	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.36	97.12	2.52
300	3000	Sand	Light Grey	Poor	Sub A	Moist	Non-cohesiv.	Layer	-	0.00	0.69	95.91	3.39

Investigator/s:	ANJ	**Date:**	11/02/2010	**Notes:**	
Client:	Urban Plan	**Photo No:**			
Location:	Sub-Precinct 3E - Southern River	**Eastings/Long:**	6447357		
Site No:	DHW-H9	**Northings/Lat:**	402267		

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	200	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.74	95.63	3.63
200	1100	Sand	White	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.76	95.51	3.74
1100	2300	Loamy Sand	Grey	Poor	Sub A	Moist	Non-cohesiv.	Layer	-	0.00	0.82	87.90	11.28
2300	3000	Sandy Loam	Grey to Green	Poor	Sub A	Wet	Non-cohesiv.	Layer	-	0.00	0.06	76.53	23.41

Investigator/s:	ANJ	**Date:**	11/02/2010	**Notes:**			
Client:	Urban Plan	**Photo No:**					
Location:	Sub-Precinct 3E - Southern River	**Eastings/Long:**	6447338				
Site No:	DHW-H10	**Northings/Lat:**	402364				

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	200	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.76	97.63	1.61
200	2100	Sand	White	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.00	95.69	4.31
2100	3000	Loamy Sand	Grey to Brown	Poor	Sub A	Moist	Non-cohesiv.	Layer	-	0.00	0.00	84.98	15.02

Investigator/s:	ANJ	Date:	11/02/2010	Notes:
Client:	Urban Plan	Photo No:		
Location:	Sub-Precinct 3E - Southern River	Eastings/Long:		
Site No:	DHW-H11	Northings/Lat:		

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	200	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.09	96.98	2.92
200	1700	Sand	White	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.36	97.12	2.52
1700	3000	Sand	Brown	Poor	Sub A	Moist	Non-cohesiv.	Layer	-	0.00	0.82	94.14	5.04

Investigator/s:	ANJ	Date:	11/02/2010	Notes:
Client:	Urban Plan	Photo No:		
Location:	Sub-Precinct 3E - Southern River	Eastings/Long:	6447332	
Site No:	DHW-H12	Northings/Lat:	402024	

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	400	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.00	96.43	3.57
400	1200	Sand	Light Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.95	94.41	4.64
1400	1600	Loamy Sand	Black	Poor	Sub A	Moist	Soft	Layer	-	0.00	0.00	87.84	12.16
1600	3000	Sandy Loam	Grey to Green	Poor	Sub A	Moist	Soft	Layer	-	0.00	0.17	73.19	27.48

Investigator/s:	ANJ	Date:	11/02/2010	Notes:
Client:	Urban Plan	Photo No:		
Location:	Sub-Precinct 3E - Southern River	Eastings/Long:	6447386	
Site No:	DHW-H13	Northings/Lat:	402108	

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	200	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.30	95.34	4.36
200	1100	Sand	Light Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.76	95.51	3.74
1100	2000	Loamy Sand	Brown	Poor	Sub A	Moist	Soft	Layer	-	0.00	0.00	87.84	12.16
2000	3000	Loamy Sand	Grey to Green	Poor	Sub A	Wet	Soft	Layer	-	0.00	0.00	85.03	14.97

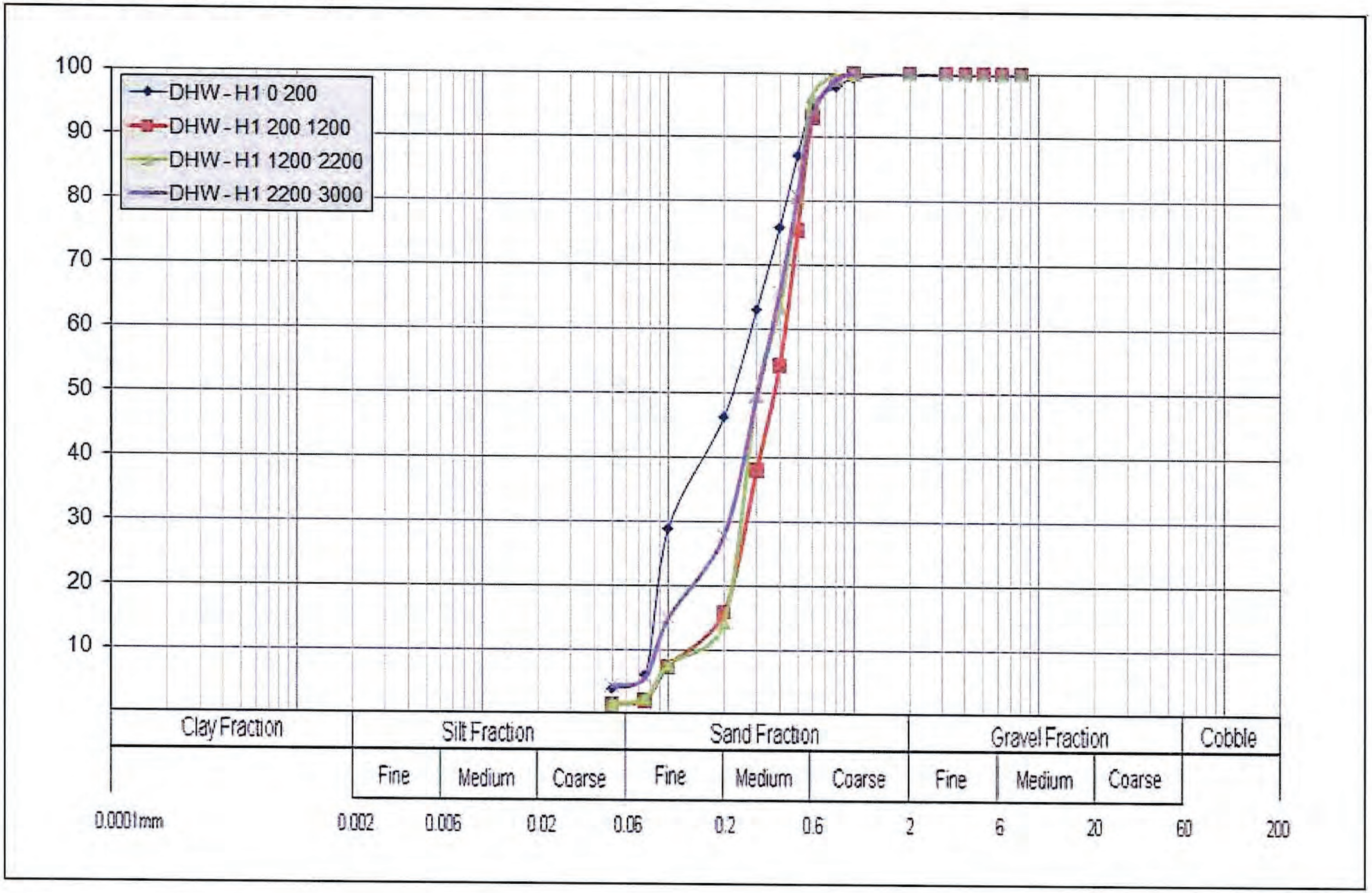
Investigator/s:	ANJ	**Date:**	11/02/2010	**Notes:**	
Client:	Urban Plan	**Photo No:**			
Location:	Sub-Precinct 3E - Southern River	**Eastings/Long:**	6447464		
Site No:	DHW-H14	**Northings/Lat:**	402512		

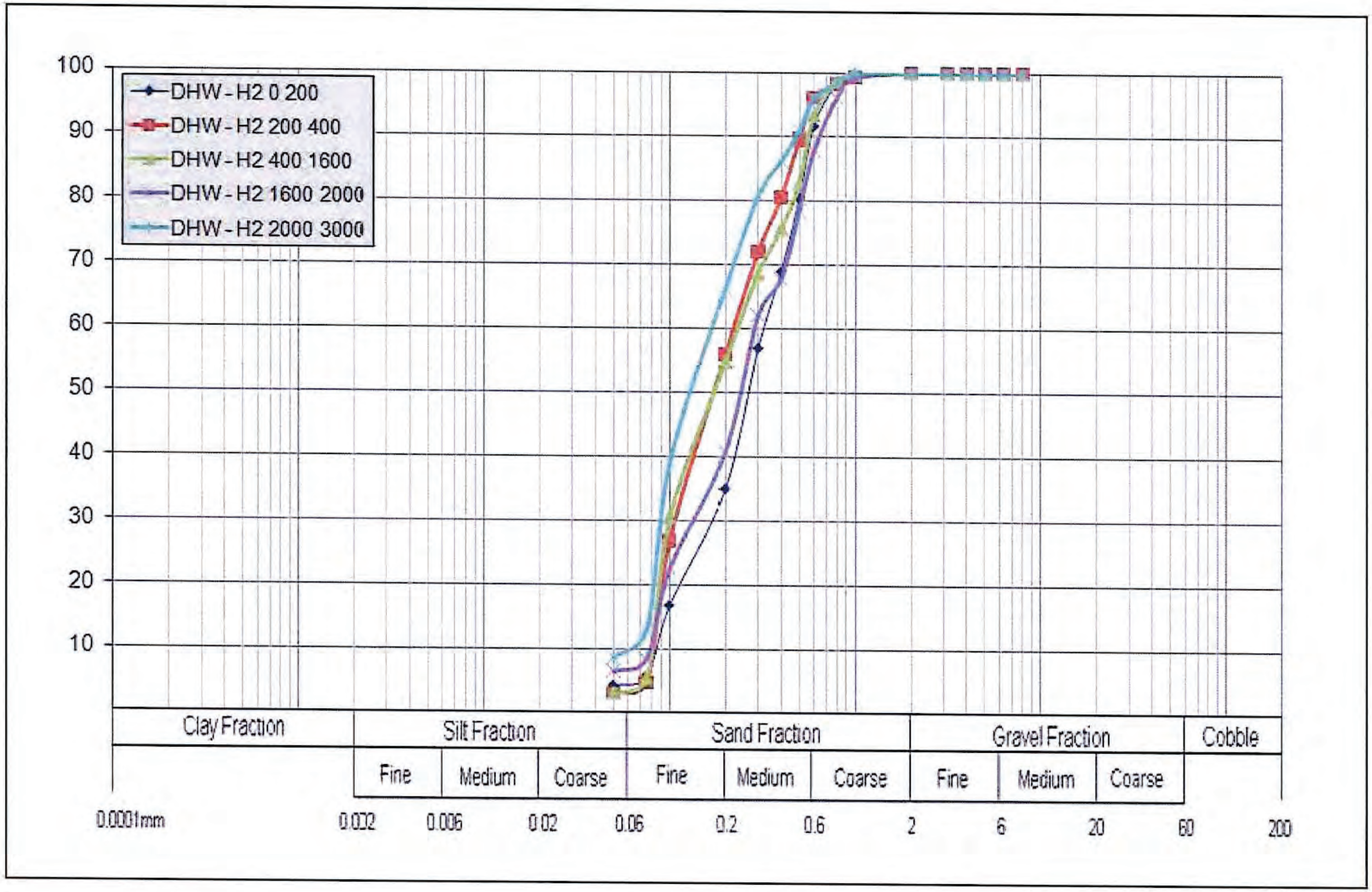
Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	200	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.30	95.34	4.36
200	1400	Sand	Light Grey to White	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	0.09	96.98	2.92
1400	1600	Loamy Sand	Brown	Poor	Sub A	Moist	Non-cohesiv.	Layer	-	0.00	0.09	89.22	10.68
1600	3000	Sand	Grey/Green	Poor	Sub A	Wet	Non-cohesiv.	Layer	-	0.00	0.82	91.52	7.66

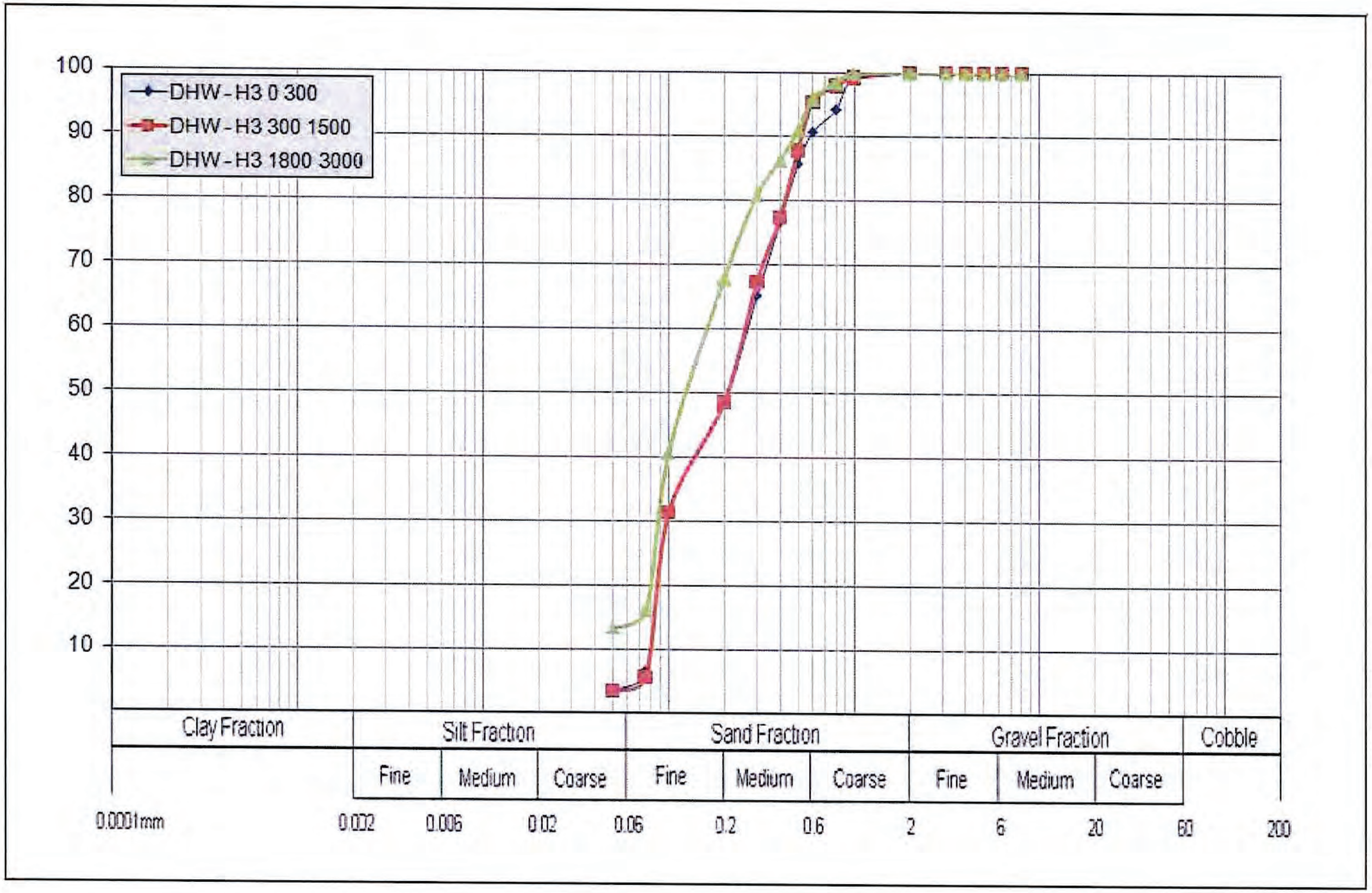
Investigator/s:	ANJ	**Date:**	11/02/2010	**Notes:**	
Client:	Urban Plan	**Photo No:**			
Location:	Sub-Precinct 3E - Southern River	**Eastings/Long:**	6447686		
Site No:	DHW-H15	**Northings/Lat:**	402064		

Depth (mm)		Type	Colour	Grade	Shape	Condition	Consistency	Structure	Organic / Fill / Waste	Cobble (%)	Gravel (%)	Sand (%)	Silt/Clay (%)
To	From									>6.3mm	>2mm	<2mm	<0.075
0	200	Sand	Grey	Poor	Sub A	Dry	Non-cohesiv.	Layer	Organic mat.	0.00	0.28	95.59	4.12
200	2500	Sand	Grey to White	Poor	Sub A	Dry	Non-cohesiv.	Layer	-	0.00	1.30	96.67	2.18
350	3000	Sand	Brown	Poor	Sub A	Moist	Non-cohesiv.	Layer	-	0.00	0.75	97.07	2.18

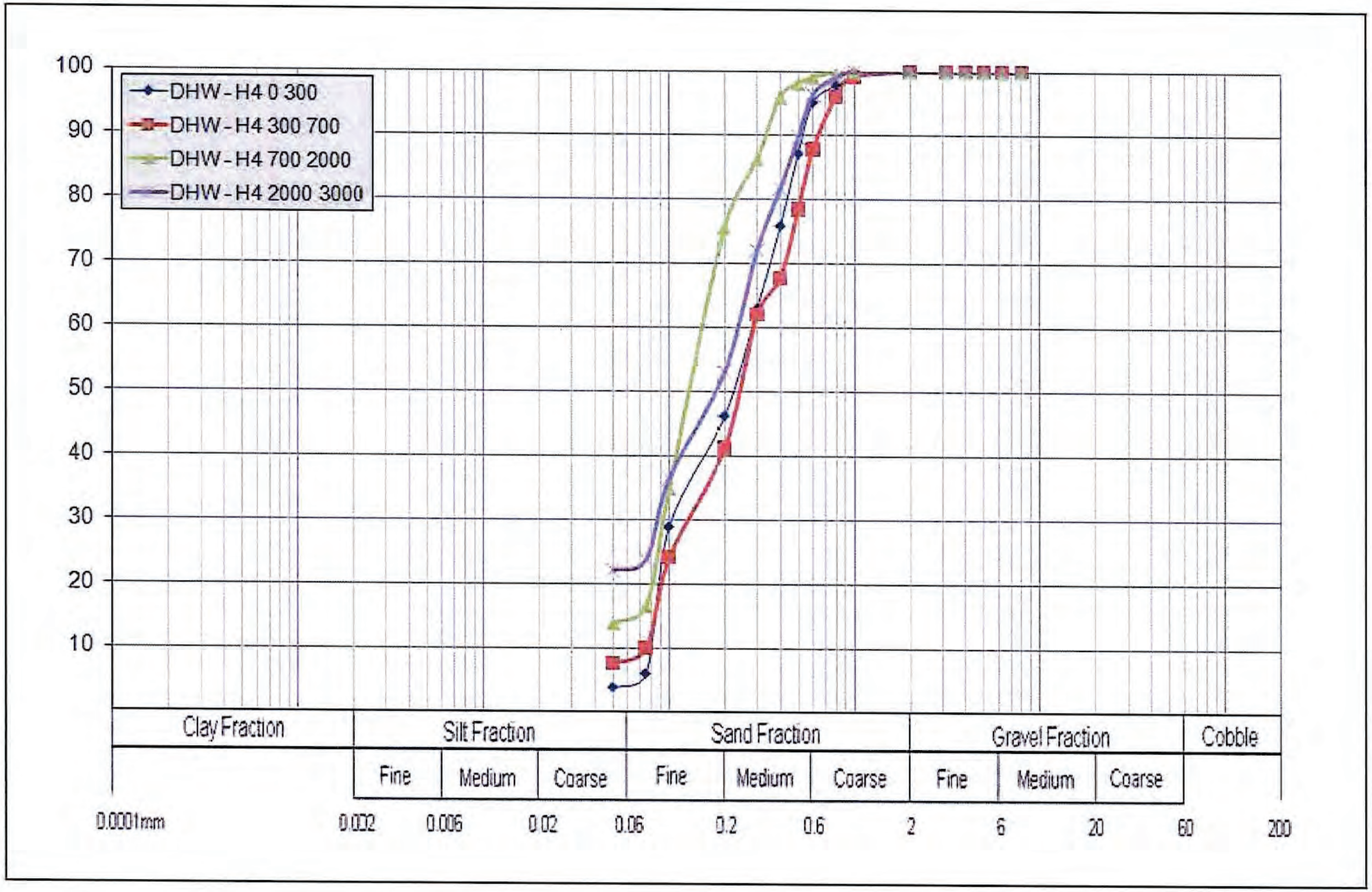
Appendix 7 – Particle Size Distribution

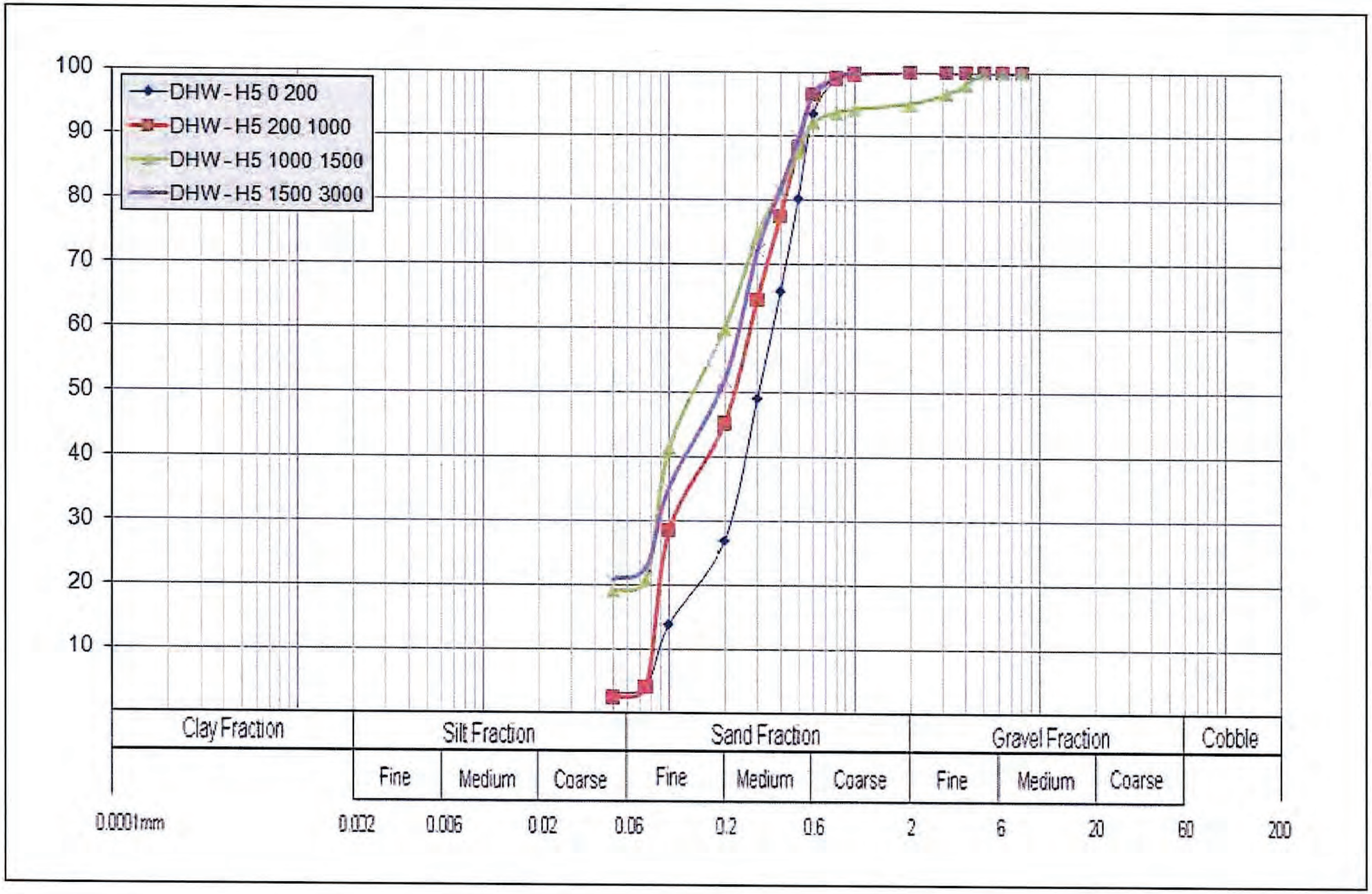



100
90
80
70
60
50
40
30
20
10
DHW - H2 0 200
DHW - H2 200 400
DHW - H2 400 1600
DHW - H2 1600 2000
DHW - H2 2000 3000
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200

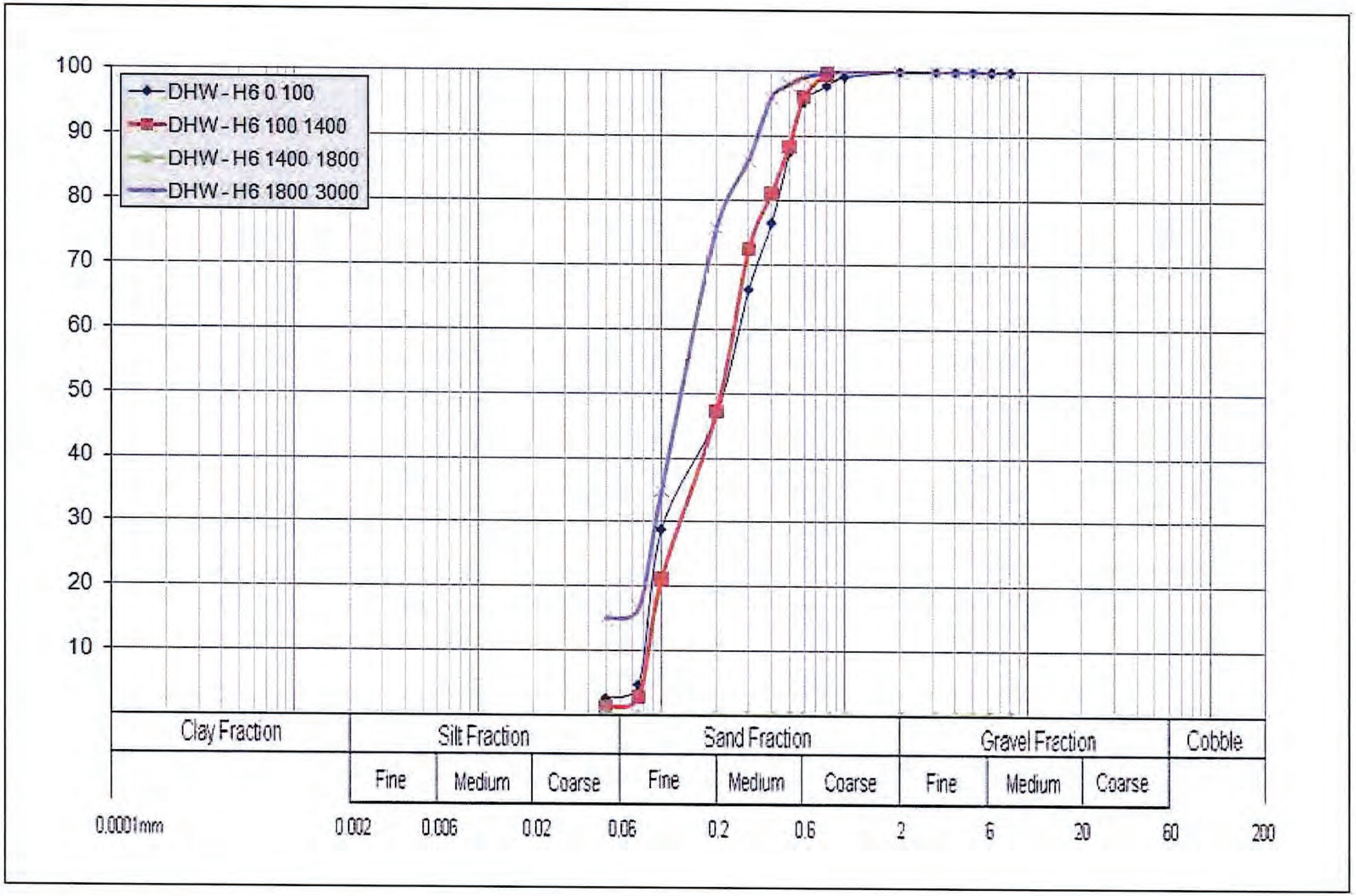


100
90
80
70
60
50
40
30
20
10
DHW - H3 0 300
DHW - H3 300 1500
DHW - H3 1800 3000
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200

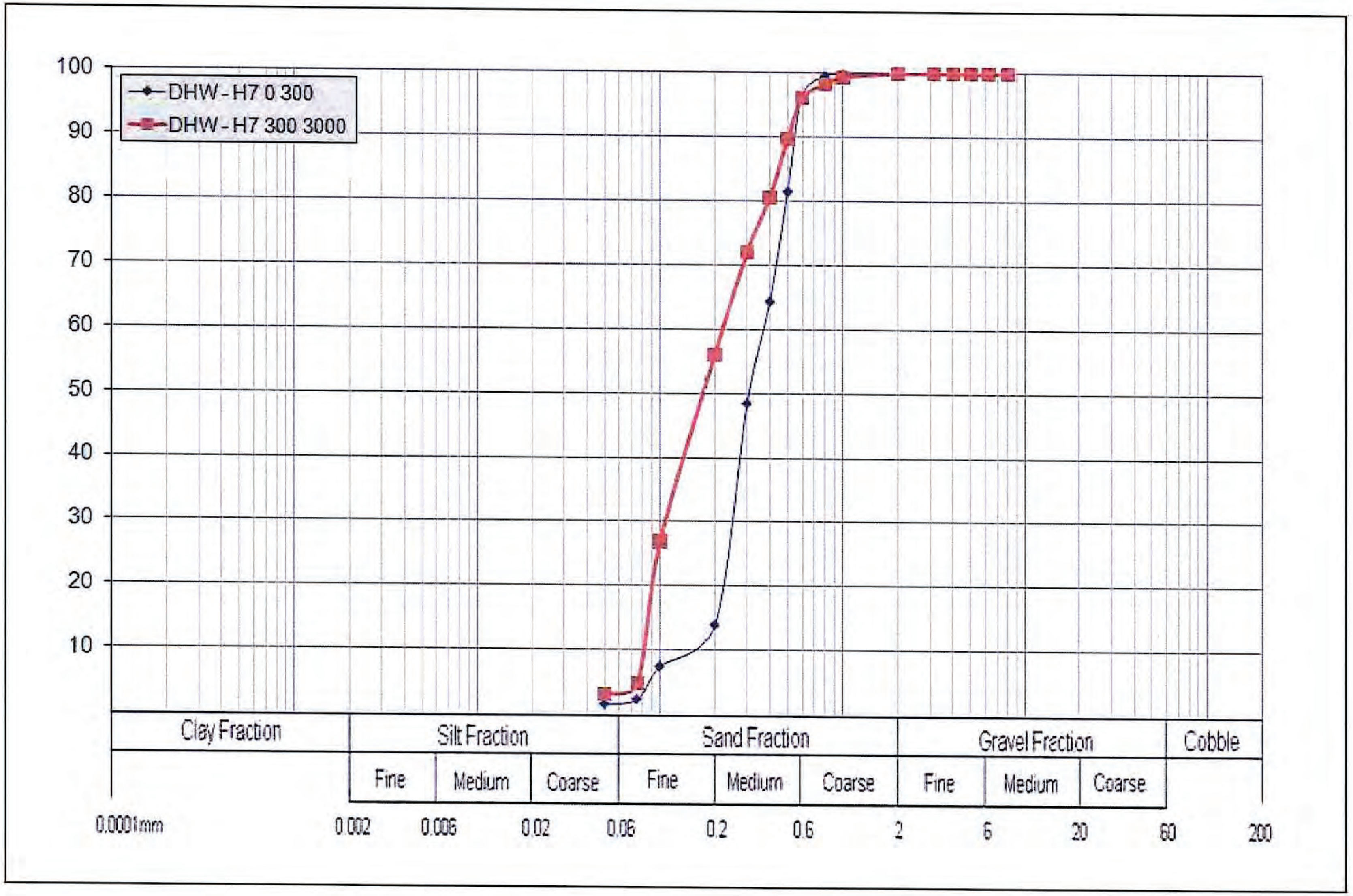

100
90
80
70
60
50
40
30
20
10
DHW - H4 0 300
DHW - H4 300 700
DHW - H4 700 2000
DHW - H4 2000 3000
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200

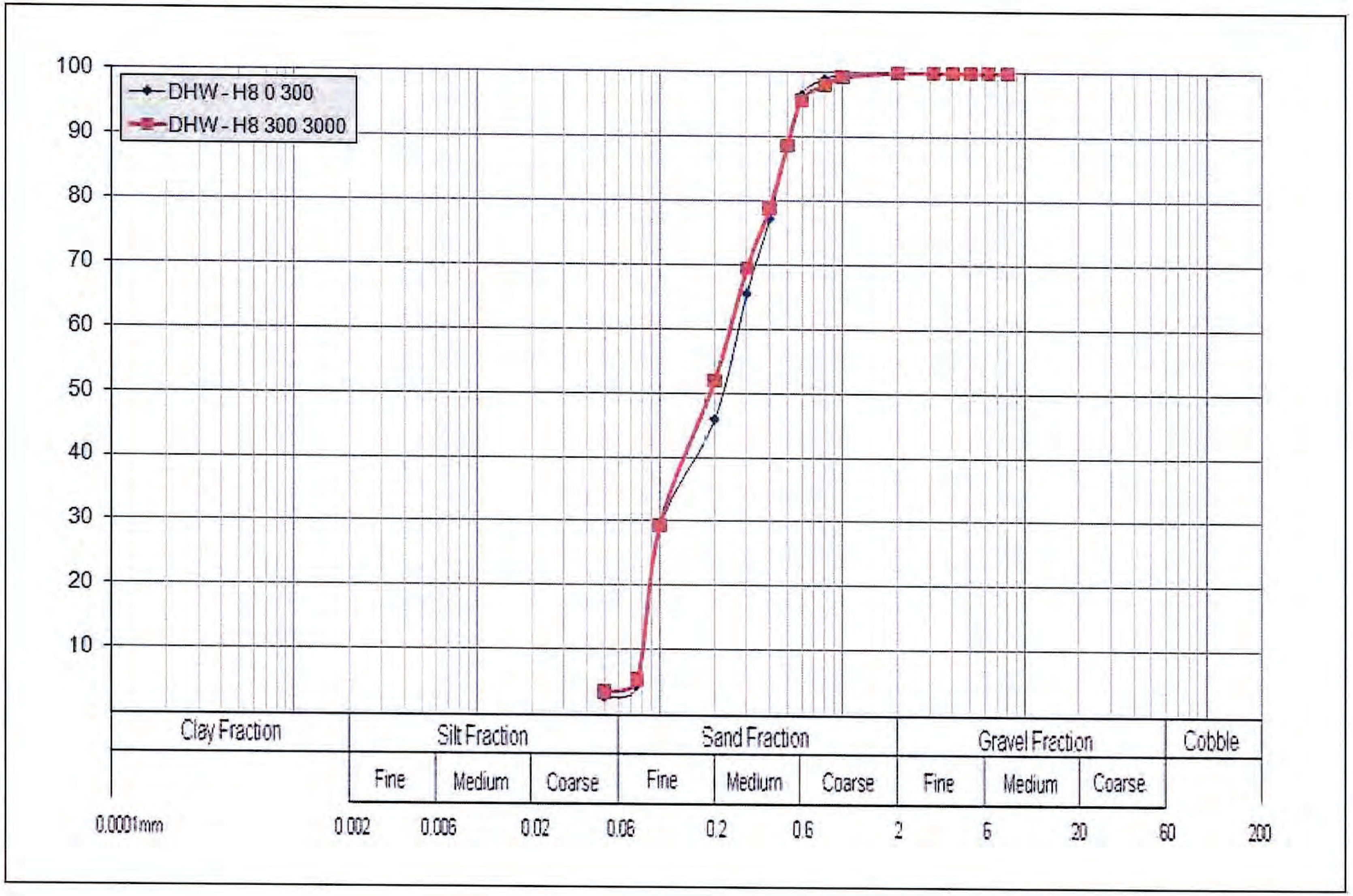


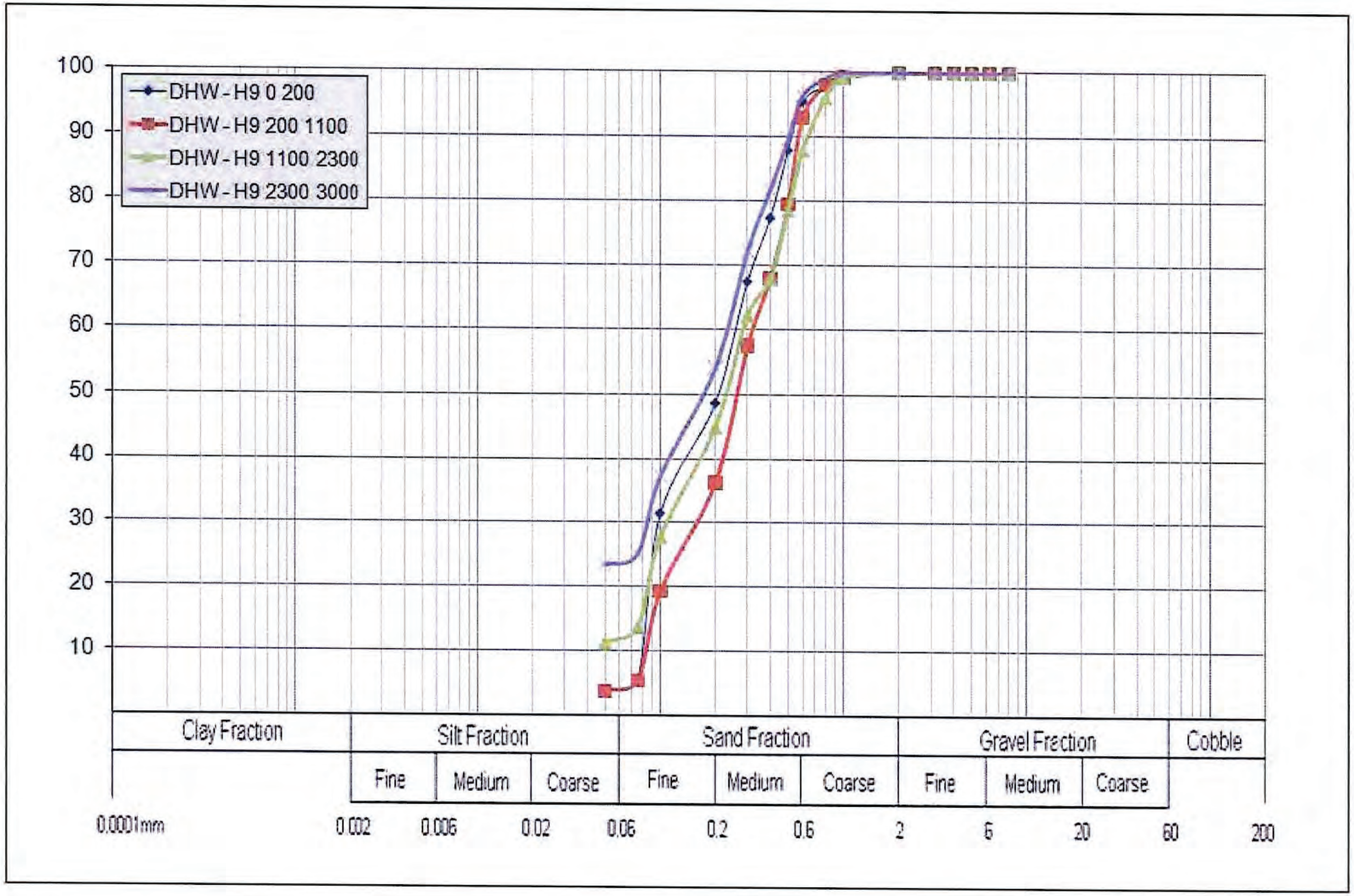
100
90
80
70
60
50
40
30
20
10
DHW - H5 0 200
DHW - H5 200 1000
DHW - H5 1000 1500
DHW - H5 1500 3000
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200



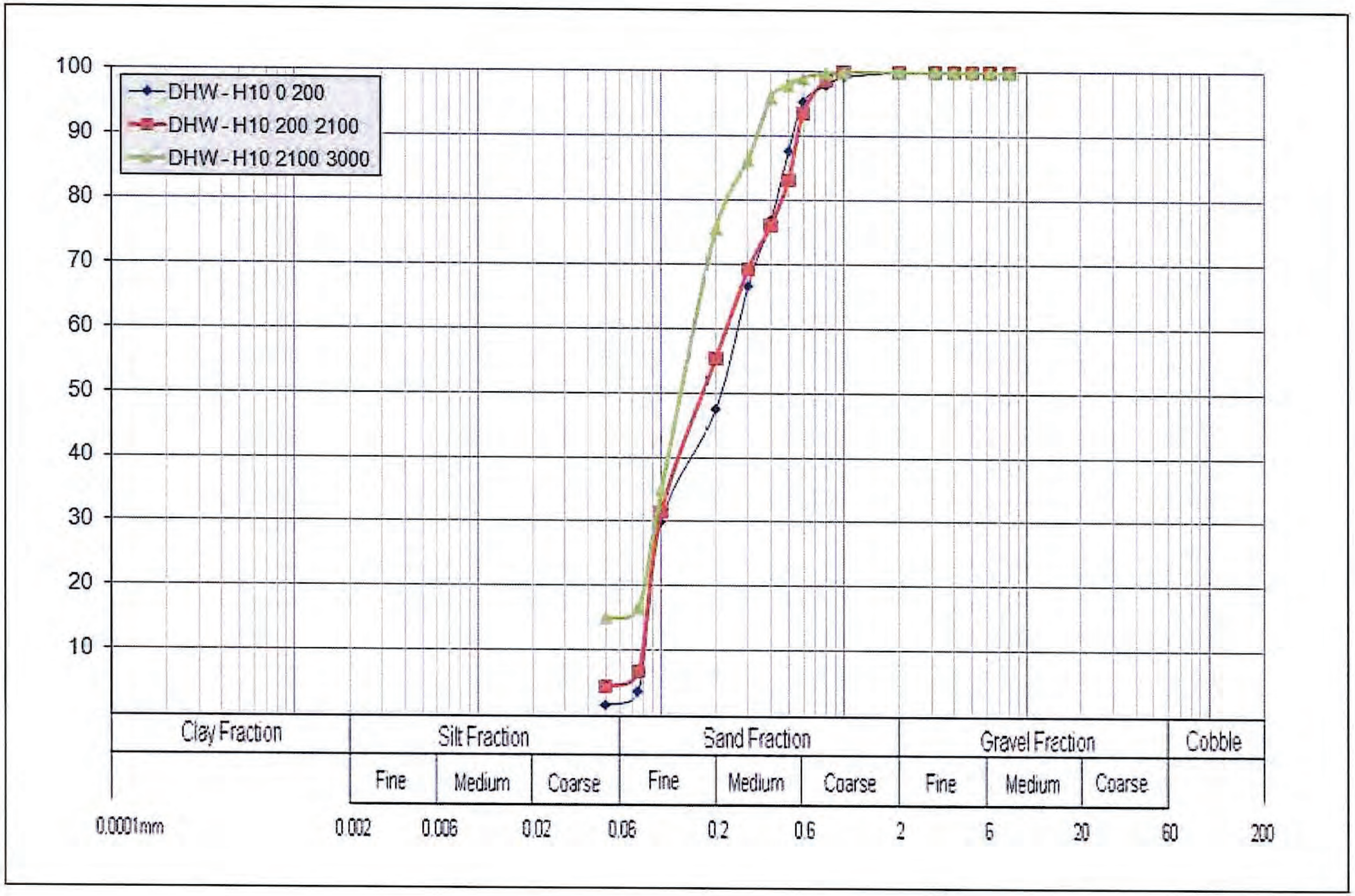
100
90
80
70
60
50
40
30
20
10
DHW - H6 0 100
DHW - H6 100 1400
DHW - H6 1400 1800
DHW - H6 1800 3000
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200


DHW - H7 0 300
DHW - H7 300 3000
100
90
80
70
60
50
40
30
20
10
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200

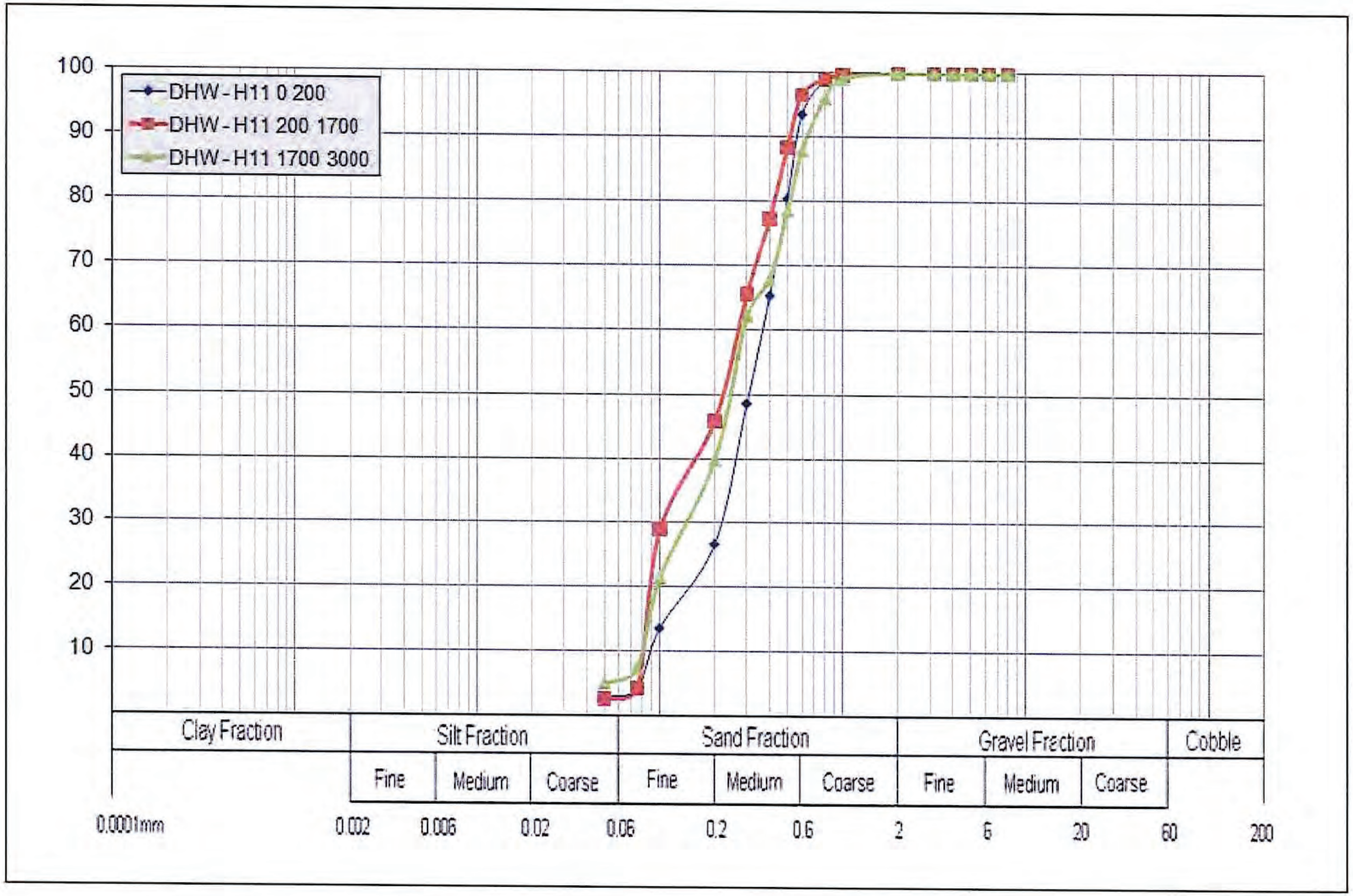

100
90
80
70
60
50
40
30
20
10
DHW - H8 0 300
DHW - H8 300 3000
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200



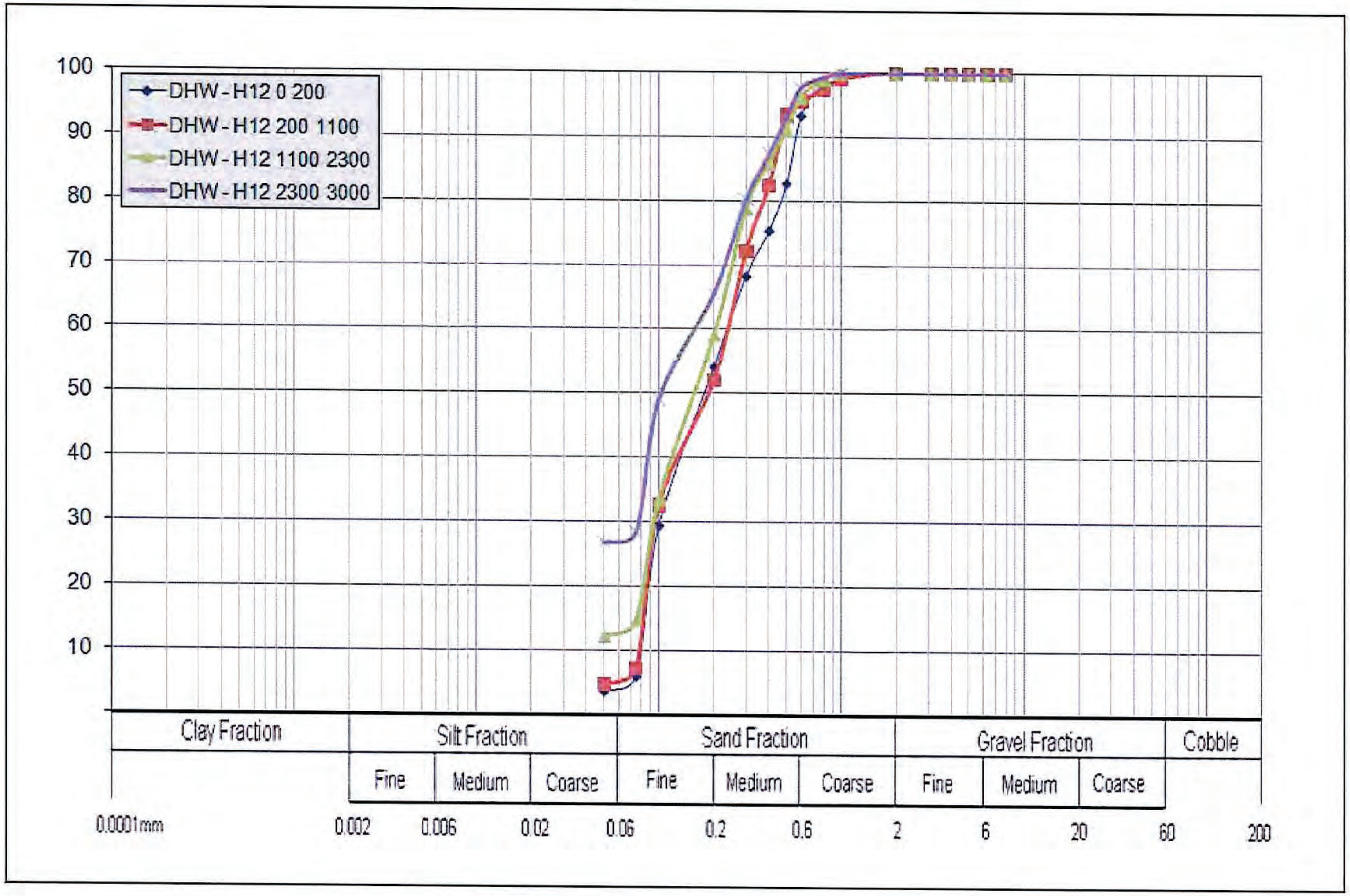
100
90
80
70
60
50
40
30
20
10
DHW - H9 0 200
DHW - H9 200 1100
DHW - H9 1100 2300
DHW - H9 2300 3000
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200



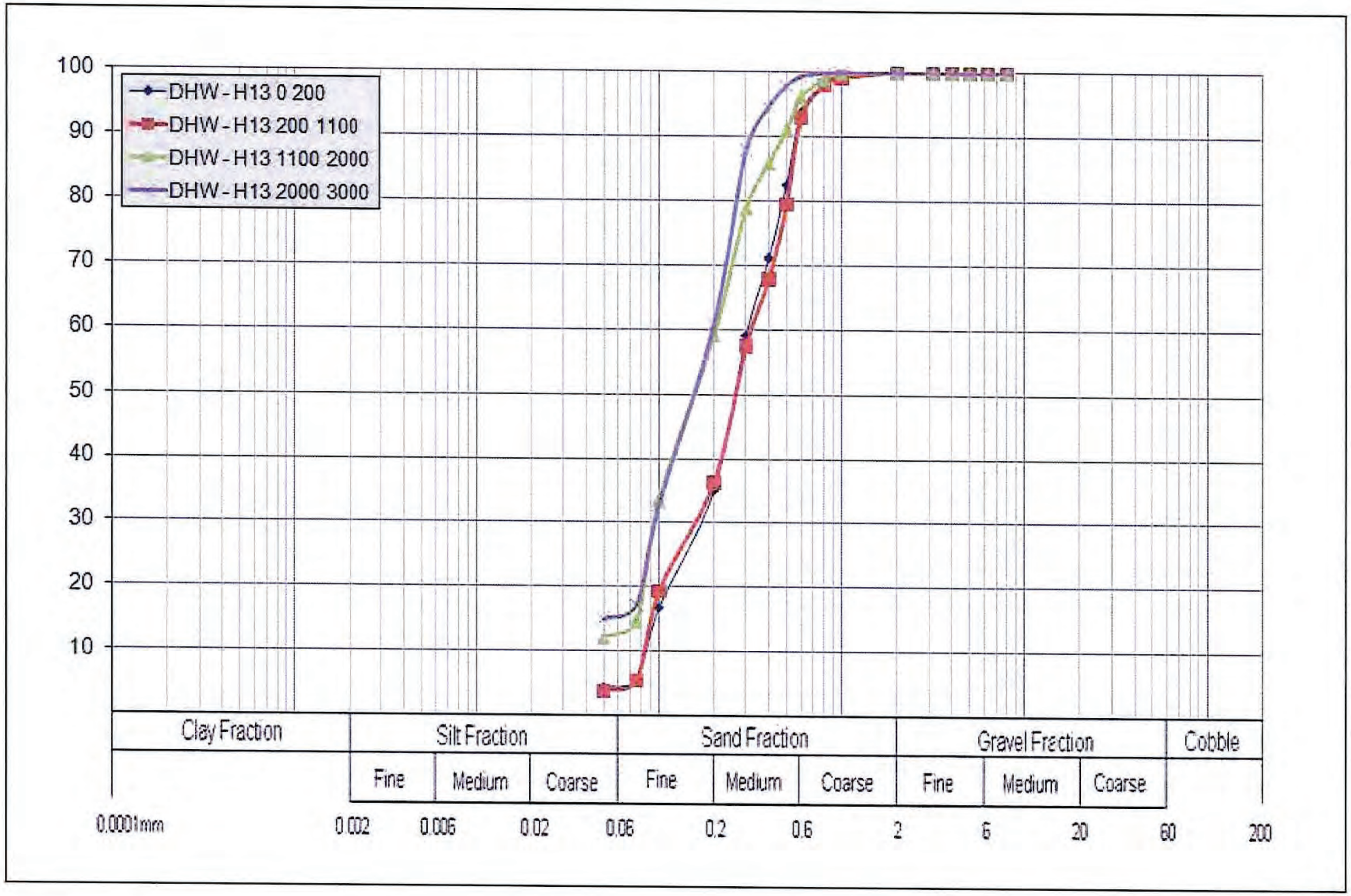
DHW - H10 0 200
DHW - H10 200 2100
DHW - H10 2100 3000
100
90
80
70
60
50
40
30
20
10
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200

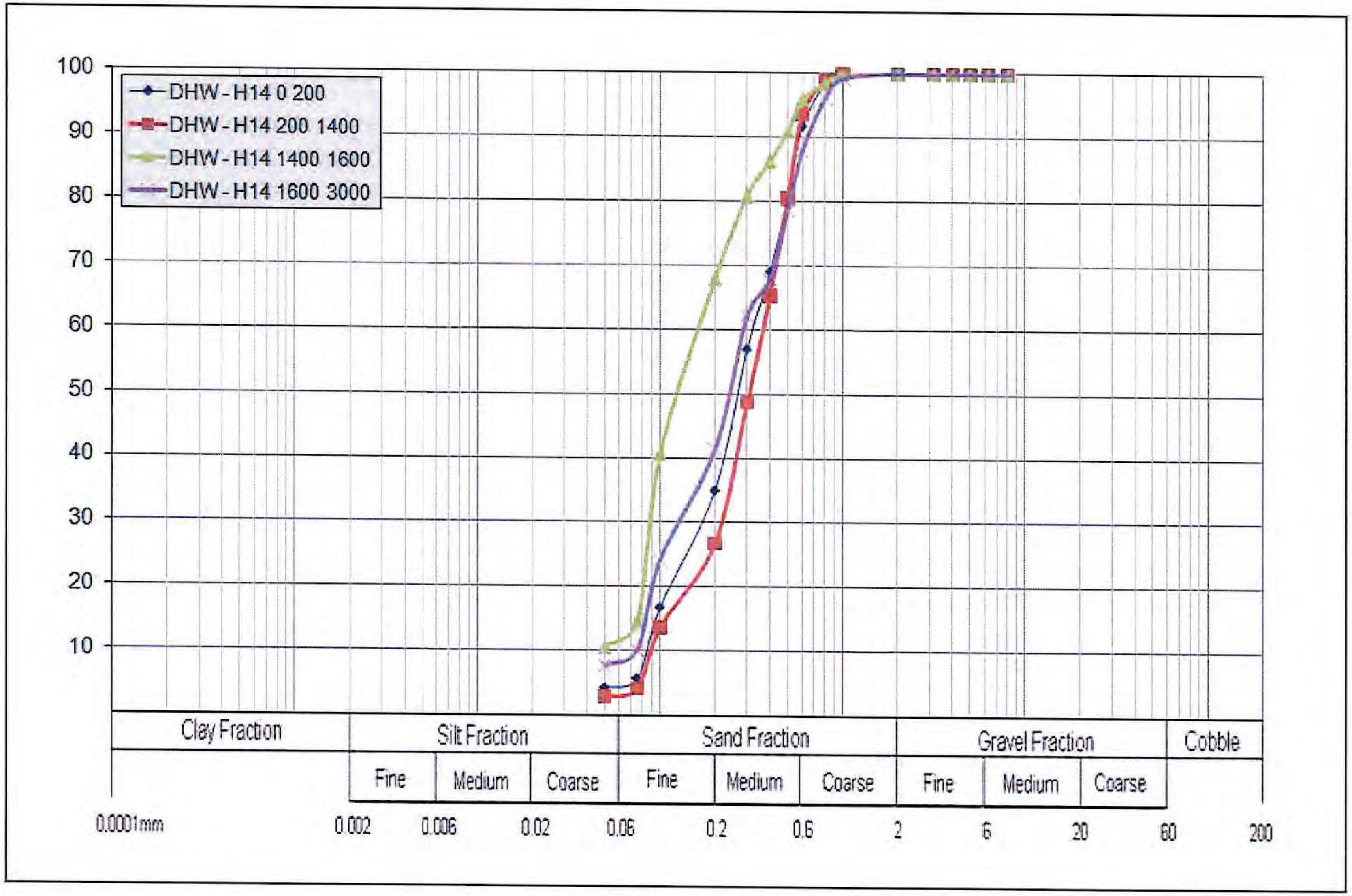


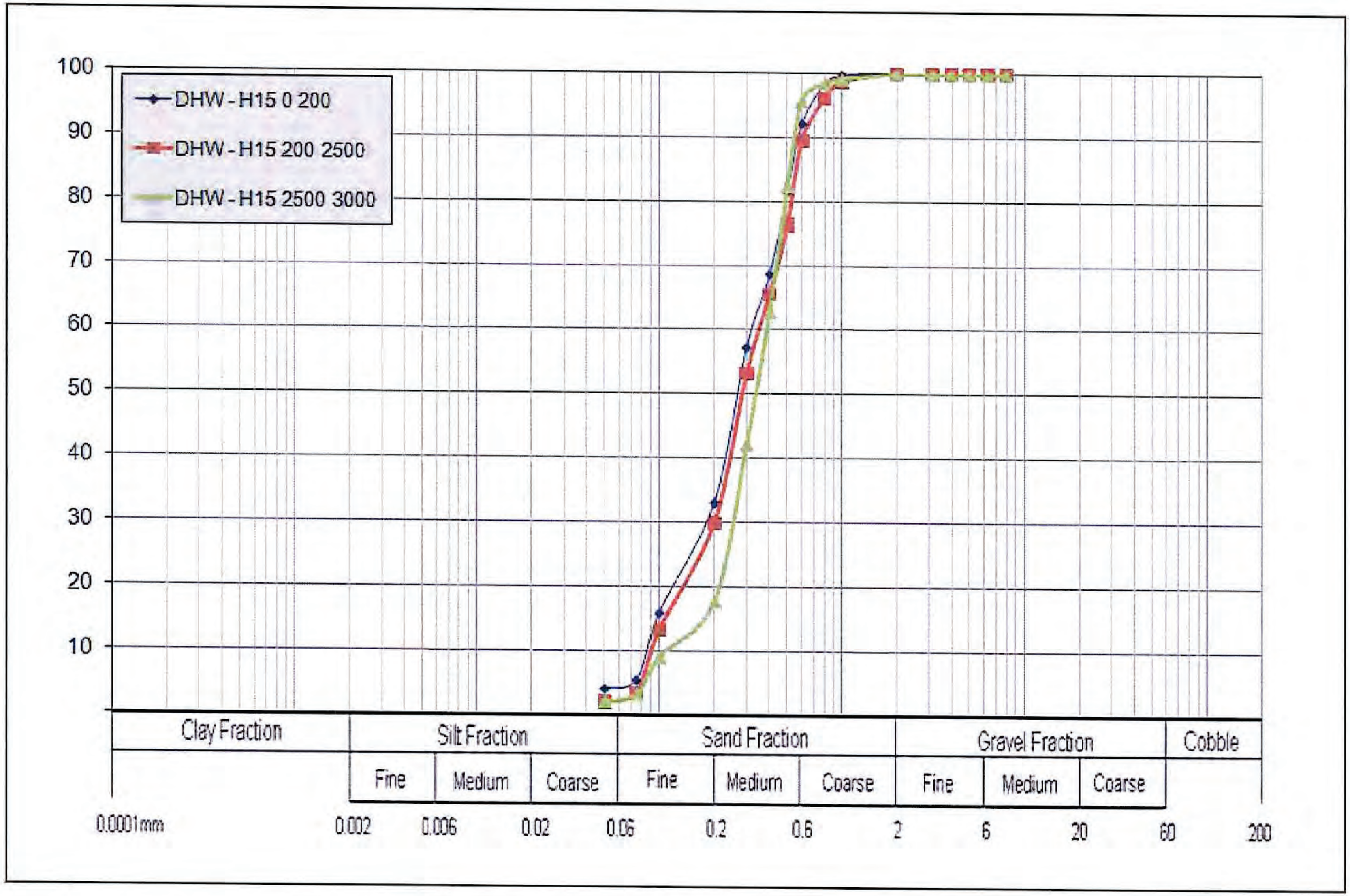
100
90
80
70
60
50
40
30
20
10
DHW - H11 0 200
DHW - H11 200 1700
DHW - H11 1700 3000
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200



100
90
80
70
60
50
40
30
20
10
DHW - H12 0 200
DHW - H12 200 1100
DHW - H12 1100 2300
DHW - H12 2300 3000
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200


DHW - H13 0 200
DHW - H13 200 1100
DHW - H13 1100 2000
DHW - H13 2000 3000
100
90
80
70
60
50
40
30
20
10
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200


DHW - H14 0 200
DHW - H14 200 1400
DHW - H14 1400 1600
DHW - H14 1600 3000
100
90
80
70
60
50
40
30
20
10
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200


100
90
80
70
60
50
40
30
20
10
DHW-H15 0 200
DHW-H15 200 2500
DHW-H15 2500 3000
Clay Fraction
Silt Fraction
Sand Fraction
Gravel Fraction
Cobble
Fine
Medium
Coarse
Fine
Medium
Coarse
Fine
Medium
Coarse
0.0001mm
0.002
0.006
0.02
0.06
0.2
0.6
2
6
20
60
200

Appendix 8 – SPOCAS Acid Sulfate Soil Results

Sample Name		*DHW1 300-400*	*DHW1 400-700*	*DHW1 700-800*	*DHW1 800-1500*	*DHW1 3200*	*DHW9 3800-3900*	*DHW12 1700-2500*	*DHW13 600-1600*	*DHW13 1600-2400*	*DHW13 2400-2900*	*DHW15 1800-2200*
pH	KCl	8.96	8.52	6.86	6.46	6.60	5.42	6.57	6.46	6.71	5.99	5.57
	mol H+/t	<0.01	<0.01	<0.01	0.53	<0.01	8.58	<0.01	0.75	<0.01	0.91	64.44
TAA	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.10
	Mg	3.15	3.11	2.18	2.68	3.61	2.36	2.85	3.94	3.47	5.46	2.53
	Ca	0.46	0.53	0.28	0.32	0.57	0.25	0.64	0.81	0.87	0.85	0.48
pH	OX	5.57	5.48	5.36	5.09	4.40	2.46	2.43	3.43	5.39	5.15	2.01
	mol H+/t	<0.01	<0.01	<0.01	<0.01	<0.01	81.77	44.20	<0.01	<0.01	<0.01	55.58
TPA	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01	0.13	0.07	<0.01	<0.01	<0.01	0.09
	Mg	3.48	3.70	2.00	2.92	6.34	2.76	1.78	3.73	2.95	4.72	3.60
	Ca	0.49	0.41	0.26	0.49	0.75	0.21	0.83	0.98	1.30	1.97	1.05
	mol H+/t	<0.01	<0.01	<0.01	<0.01	<0.01	73.19	44.20	<0.01	0.00	<0.01	<0.01
TSA	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01	0.12	0.07	0.00	0.00	0.00	<0.01
	Mg	0.32	0.59	<0.01	0.24	2.73	0.41	<0.01	<0.01	<0.01	<0.01	1.07
	Ca	0.03	<0.01	<0.01	0.17	0.18	<0.01	0.19	0.17	0.42	1.11	0.57
Sulphate	S (T)	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	0.02	<0.01	<0.01	0.04	0.18
Carbon	C (T)	0.12	0.15	0.51	0.04	0.05	0.68	0.50	0.03	0.01	0.04	2.85