University of Southern Queensland

Faculty of Engineering and Surveying

To determine if there is a correlation between the shrink swell index and atterberg limits for soils within the Shepparton Formation

A dissertation submitted by

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Abstract

Currently there is a belief within the Engineering Profession that there is not any form of correlation between the shrink swell index and the atterberg limits or linear shrinkage properties for a soil.

This research project will concentrate on soils from one particular Geological structure which is known as the Pleistocene Quaternary Shepparton Formation. The soils in this formation have been placed using sedimentary techniques and predominately consist of clays, silts, sands and gravels.

The analysis to determine if there is a relationship between this index and any of the atterberg limits or linear shrinkage results was undertaken using a sampling and testing program for 29 soils that had different characteristics. The soils that were tested all originated from this formation and are located in the Goulburn Valley and Murray Valley Regions in Northern Victoria. The soils that were tested ranged from silts with sands and extended through to highly reactive clays.

All these samples were subjected to the same testing program and included shrink swell index, atterberg limits, linear shrinkage and particle size distribution. Upon completion of the testing program the atterberg limits and linear shrinkage results were plotted against the shrink swell index. An analysis of modified atterberg limits and linear shrinkage results which were multiplied by the percentage of clay contained within the soil sample was performed as well. This data was then graphed and the strongest trendline was fitted to it and the corresponding equation calculated.

For a correlation to be considered a useful estimating tool the strength of this relationship must exceed $R^2 = 0.80$. There were four correlations which met the requirement of $R^2 > 0.8$. Two of these were for where the plasticity index and linear shrinkage had been modified using the percentage of clay contained within the sample. The other two acceptable correlations were where the plasticity index

and linear shrinkage had been modified using both the percentage of clay and silt particles present in the soil. The equations for these correlations could be used to estimate the possible shrink swell index of a soil.

This research work has indicated that further work could be undertaken which may improve these correlations by separating the soils into each of their clay types and performing the same analysis.

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Limitations of Use

Certification

I certify that the ideas, designs and experimental work, results, and analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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Signature

24.10.2005

Date

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Chapter 1: Introduction

1.1 Background

In order to calculate the potential ground movement in accordance with AS 2870-1996 Residential slabs and footings – Construction Standard, one of the parameters that is required to be known is the Instability index (I_{pt}) for the soil. To classify a residential building site in accordance with this standard it is required to know the shrink swell index for the soils within the suction profile. By using this index the potential seasonal ground movement for that site can be calculated.

The Australian Standard for residential footing design also allows sites to be classified by using methods other than that of the shrink swell index. The code allows the site to be classified using a correlation factor that they have determined through data analysis or relevant experience.

During the assessment of a site it is not always possible to collect an undisturbed soil sample to undertake the shrink swell test for a number of reasons which include:

- Unable to collect an undisturbed sample as the appropriate equipment may not be available.

- Soils that have been collected can crumble when extruded from the sampling tube as they are too dry.

If a correlation could be found between the shrink swell index and any of the atterberg limits or linear shrinkage results this would prove a useful tool for the Engineering Profession in allowing them to calculate the potential ground movement for a site if only disturbed samples could be collected.

1.2 Development of Project

The initial proposal for this dissertation was to investigate whether a correlation existed between the shrink swell index and any of the atterberg limits for soils located within the Geological profile known as the Pleistocene Quaternary Shepparton Formation. A copy of the signed Project Specification can be found in Appendix A.

However after conducting research into previous studies it was identified that the shrink swell characteristics of a soil is based on the percentage of clay present in the soil. Investigations also discovered that previous works had found that the linear shrinkage test could be a possible indicator of the soils ability to shrink and swell. It was decided based on this information that the scope of this project should be enlarged, to incorporate whether a correlation existed for the linear shrinkage of the soil and the percentage of clay contained within the soil.

1.3 Overview of Research

1.3.1 Aim of Project

The broad aim of this project is to determine if there is a correlation between the shrink swell index and various soil properties as detailed previously. It aims to assist in providing an alternative method to calculate the shrink swell index for a soil by using properties that can be determined from a disturbed sample and not reliant on having an undisturbed sample to test.

1.3.2 Specific Objectives of Research

The specific objectives of this research project is to determine if a correlation exists between the shrink swell index and various soil properties that are located within the top 3 metres of the surface.

For a correlation to be considered a useful tool for estimating the shrink swell index of a soil the strength the least squares regression or R^2 of this trendline will have to exceed 0.8.

1.4 Structure of Dissertation

The Background Information for this project is covered in Chapter 2 and provides a summary of previous works that have been undertaken in this area. The various soil properties appropriate for this research project are described in this section of the report. In this chapter a brief outline of the assessment of the consequential effects from the research is covered.

Chapter 3 outlines the sampling rationale adopted to obtain a suitable number of samples. It outlines how the soils were sampled and the procedure used to ensure a variety of different soil types are collected. Finally this chapter goes into some detail of how the tests were performed.

The results from the testing program are contained within Chapter 4. Contained in Chapter 5 is the analysis of results which has been performed and the different comparisons shown. The relationship between each of the properties compared to the shrink swell index is graphically represented with the equation and R^2 of the best trendline shown.

The conclusion is contained within Chapter 6. This chapter provides a summary of which properties can be used to estimate the shrink swell index for a soil from within the Shepparton Formation. It provides information of possible work that could be undertaken to expand on the work performed in this research project.

Chapter 2: Background Information

2.1 Previous Works

2.1.1 Methods used to calculate the Instability Index

To be able to calculate the design surface movement as stated in AS 2870-1996 Residential slabs and footings – Construction, one of the parameters that is required to be known is the Instability index (I_{pt}) for the soil. This standard recommends three direct methods to calculate this index. The three methods are the shrink swell index (I_{ss}), loaded shrinkage index (I_{ls}) and the core shrinkage index (I_{cs}). The shrinkage index for the soil (I_{ps}) can be determined using any one of these methods with this result then being used to calculate I_{pt}. The three test methods are outlined and include their advantages and disadvantages for each method are as follows:

2.1.1.1 Core Shrinkage Test

The core shrinkage test requires an undisturbed core sample of a nominal diameter of between 38 to 50mm to be trimmed to a length not exceeding twice its diameter. A drawing pin is placed in the centre of the core at each end to provide a reference mark for measurements to be taken. The specimen is allowed to be air dried for a minimum of three days with mass and length measurements taken throughout this period. After a three day drying period, the core is then oven dried to a constant mass to allow the final moisture content to be calculated. When the sample has reached a constant mass a measurement of the distance between the drawing pins is taken. The strain moisture relationship is then plotted. The core shrinkage index is then calculated using the formula for the initial linear section of the graph:

$$I_{cs} = \frac{\varepsilon}{\Delta w} \text{ x } \frac{\Delta w}{\Delta u}$$

where: ε = strain (%).

Δw = change in moisture content of the dry weight of the soil (%).

Δu = is the change in the total soil suction (pF).

The moisture characteristic for the soil is $\Delta w / \Delta u$ and is determined with the use of a psychrometer and taking readings of the suction on thin discs of soil during different conditions of wetting and drying.

2.1.1.2 Loaded Shrinkage Test

For the loaded shrinkage test a small core sample is secured in an apparatus as outlined by Pile *et al*. (1984). A surcharge of 25kPa is normally applied to the perforated shrinkage cell as this is representative of the load that is applied by a residential dwelling footing system. It is required to determine the initial suction, moisture content and length of the specimen.

This cell is placed in a desiccator that contains a solution to provide a final suction similar to the design dry condition. The mass and length of the sample is monitored until it reaches the point where the readings are stable. At this point the final length is determined and the strain is calculated as a percentage. The loaded shrinkage index is calculated by using the formula:

$I_{ls} = \varepsilon / (u_f - u_i)$

where: ε = strain (%).

u_f = final suction.

u_i = initial suction.

The shrinkage index can be calculated by reducing the result from the above equation by 10% due to the effect of the load.

2.1.1.3 Shrink Swell Test

The shrink swell test is performed by undertaking two separate tests which have been obtained from one undisturbed core sample. The shrink swell index is calculated by combining the results from these two tests, which are the core shrinkage test and the loaded swell test.

The first part of the test is to undertake a simplified core shrinkage test as outlined in Clause 2.1.1.1 of this report except that the suction readings are not required to be performed. The second part of this test is to undertake a swell test with a 25 kPa surcharge applied to the specimen. This test is similar to that of the one outlined in Clause 2.1.1.2 of this report except that there is no requirement to calculate the suction profile.

This test has two main advantages over the other tests and this is due to the fact that it does not require any form of suction testing. The other benefit is that this test can be used to calculate the reactivity of the soil and is not dependent on the initial moisture content of the sample.

Cameron (1989) believes that from these three tests, the shrink swell approach appears to provide the best method for the calculation of the shrinkage index. The shrink swell index method results are slightly better than of the loaded shrinkage method and do not require the suction to be measured.

2.1.2 Previous studies undertaken on correlations

Cameron (1989) indicates that there is a relationship between the shrink swell index and the linear shrinkage, but this is only satisfactory r = 0.76 and was for a broad range of soils. He concludes that despite the lack of success of these broad scale correlation studies, it is most probable that greater success would be achieved if investigations were confined to a single soil type.

A study undertaken by Wan et al. (2002) indicates that there is a correlation between the shrink swell of a soil and liquid limit. This relationship was found to be dependent on the clay content. This study was undertaken on volcanic soils from Honolulu and these soils would be quite different to that of soils found in the Shepparton Formation but a similar type of relationship may exist to the one that Wan et al. found.

Chen (1988) found a correlation existed between the swelling potential and plasticity index for undisturbed soil samples. He proposed:

$$S = Be^{A(PI)}$$

where: S = swelling potential.

B = 0.2558.

A = 0.0838.

e = the natural number 2.718.

PI = the plasticity index of the soil.

A number of researchers have attempted to determine if a correlation exists between the swelling potential and plasticity index of a soil. In this research the percentage of swell was determined for a laterally confined soil sample that has been compacted at the optimum moisture content. The level of compaction required for this test is 100% standard compaction effort.

It has been established that the swelling properties, liquid limit and plastic limit for a soil is dependent on both the type and quantity of clay minerals present.

Due to this fact it is reasonable to assume that some type of correlation does exist. Seed et al (1962) established that a relationship between the PI and swelling potential for a soil exists:

$$S = 60K(PI)^{2.44}$$

where: S = the swelling potential.

PI = the plasticity index of the soil.

K = a constant equal to 3.6×10^{-5}.

This formula is only valid for soils with a clay mineral content of between 8% and 65%, with the predicted swelling potential only having an accuracy of around 33% of the laboratory value. These results have been calculated using artificial mixtures containing various percentages of clay and sand.

It could be assumed that soils with a high plasticity index would have a greater swelling potential to that of one with a lower PI. Studies undertaken have confirmed that this is not the case, so the plasticity index should only be used as a rough estimate of the swelling potential for the soil.

Based on the soil properties it would seem logical to assume that there would be a relationship between the resulting shrink swell of a soil and that of the linear shrinkage. The reasoning behind this rationale is that both of these tests are measurements of volume change of the soil. Previous research indicates that there is no conclusive evidence to suggest that there is a correlation between these two properties. However the linear shrinkage can be used as an indication of possible volume change.

A correlation was established by works undertaken by Seed et al. (1962) for the swell potential and the percentage of clay content. This relationship requires not only the percentage of clay but also the type of clay to be known to determine the swell potential. They therefore offered an alternative method using the above concept where by using the percent of clay and soil activity to calculate the swelling potential using the appropriate graph. The formula that was developed to calculate the soil activity is:

$$A_c = \frac{PI}{C - 5}$$

where: A_c = Soil Activity.

PI = Plasticity Index.

C = Percentage of Clay.

This relationship is close to Skempton's definition for soil activity which is:

$$\text{Activity} = \frac{PI}{C}$$

2.2 Material Properties

2.2.1 General Properties of Soils

Soils can behave very differently and this is usually dependant on the geotechnical construction of the soil. When soils are deemed to be coarse grained, this is an indication that the majority of the particles in the soil are greater than 75µm in size. The behaviour of the soils in relation to the engineering properties is mainly influenced by the comparative proportions of the different shape and size of particles present. Soils which predominately consist of grains greater than 75µm can also be defined as granular soils.

Fine grained soils are where the major percentage of particles in the soil is less than 75µm in size. The engineering behaviour of this soil type is dependent on the mineralogy of the fine soil particles and water content. Generally the smallest particle size which can be distinguished with the naked eye is one of about 75µm.

To be able to classify soils in accordance with AS 1726-1993: Geotechnical site investigations, it is required to use the size of the grains as its base to group soils into a particular type. In this code, clays have a particle size of less than 2μm, silts 2μm-75μm, sands 75μm-2.36mm, gravels 2.36-63mm, cobbles 63-200mm and boulders greater than 200mm. Soils that are in these major groups can still behave quite differently, so some systematic methods have been developed to classify them into distinct sub-groups.

2.2.2 Grain Size Distribution

The particle size distribution of a coarse grained soil is generally determined using a sieve analysis where a prepared dry soil sample is shaken thoroughly through a stack of sieves that consist of different apertures. The mass of particles retained on each sieve is calculated as a percentage of the total dry sample mass.

The grain size distribution of the fines less than 75μm is determined using hydrometer analysis where the fines are combined with distilled water to form a 1000 ml of suspension. The hydrometer is used to measure the density of this solution for specific times. This time-density data is then used to calculate the percentage of different particle sizes for the required 48 hour period where observations are required to be made.

It is quite common for soils to contain both coarse and fine grains and it is necessary to undertake both a sieve and hydrometer analysis to obtain the complete particle size distribution. The usual method followed is to initially carry out a sieve analysis, which is then followed by the hydrometer test on the particles that pass the 75μm sieve. The percentage passing each sieve is generally treated cumulatively to determine the entire particle size distribution.

2.2.3 Particle Shape

For a coarse grained soil the shape of the particles can be angular, sub angular, sub rounded or rounded. If the grains are angular this provides an increase of the interlocking between the particles thus the strength and stiffness of the soil will be greater. As the shape of the grains increases in roundness, this provides less surface friction between particles and cause the strength and stiffness of the soil to be less than one with angular particles.

2.2.4 Shrinkage and Swelling Characteristics

For soils to illustrate shrinkage and swelling characteristics they will demonstrate a noticeable volume change with variations in the moisture content. When soils behave in this manner they contain clay minerals that are prone to the infiltration of water molecules, which effects there chemical structure. Soils which are susceptible to this type of movement can be termed as expansive soils. When these soils are subjected to climatic conditions of prolonged periods of wetting or drying this will in turn generate the maximum ground movement due to the moisture gain or loss.

2.2.5 General overview of Clay Particles

The particles in a soil which are less than 2μm in size are commonly referred to as clay minerals. Clays are derived from the weathering and decomposition of rock and can be classified as sedimentary or residual clays depending on its proximity to the parent rock.

A sedimentary clay is formed from a parent rock and then these clay particles are transported some distance to a new location. These particles are usually deposited to this new location by being transported in water or as dust particles and carried by the wind. This type of clay has finer particles than that of residual clay and therefore tends to be more plastic of the two types. Residual clays are found in the place of their source material and contain larger-sized particles. Both sedimentary and residual clays are formed through surface weathering through chemical processes.

Some of the chemical processes include:

- Oxidation and reduction which is the predominate type of reactions for minerals which contain iron minerals.
- Carbonation is the dissolution of minerals in water that has been made acidic by carbon dioxide.
- Hydrolysis is when water splits into hydrogen and hydroxide, and one or both components participate directly in the chemical process.
- Hydration occurs when water is incorporated into the crystal structure of a mineral that causes the mineral properties to change.

The chemical composition of clays is based on hydrated silicates of aluminum and will usually contain impurities which can consist of potassium, sodium, calcium, magnesium, or iron, in small amounts.

While gravels, sands and silts are equi-dimensional or have the same order of magnitude in all three directions, clay particles are like plates or needles. The surface of the clay particles carries an electrical charge due to an imbalance between the cations and anions within the atomic structure. The microstructure or microfabric of clay relies on the mineralogy of the clay, valence, concentration and type of cations present in the pore water.

The mineralogy and microfabric of a clay structure can be studied by x-ray diffraction, differential thermal analysis or scanning electron microscope. All of these techniques are very sophisticated and are not usually used for routine geotechnical works.

There are three types of clay minerals, being kaolinite, illite and montmorillonite. As these clays are of plate like appearance, they have a significant surface area to mass ratio. Due to their structure this has a major impact on their properties due to the forces which act on the surfaces.

The majority of clay minerals will consist of silica tetrahedron or alumina octahedron as there structural platform. The various types of clays will be formed using these basic structural units in different stacking sheets and the type of bond between these sheets.

The clay mineral known as kaolinite is a bonded combination of a single sheet of silca tetrahedrons with a single sheet of alumina octahedrons to form a stack. This strong bond provided by the hydrogen molecule minimises the interlayer space for the absorption of water cations and causes the resultant expansion rate of this clay mineral to be minimal.

The Illite clay mineral has a structure where a single sheet of alumina octahedrons is sandwiched between single sheets of silca tetrahedrons. Potassium ions provide the bond between the combined sheets to form a stack, with this link being relatively weak. As this bond is not as strong as the hydrogen bond it allows for a greater number of water cations to be absorbed and causes this mineral to have an increased expansion rate than that of kaolinite.

Montmorillonite clay minerals have a very similar structure to that of illite, except that there is no potassium ion bond between the combined sheets. The space between the combined sheets is now occupied with water molecules and various types of cations. Out of the three clay types this has the weakest bond and substantial swelling can occur due to the extra water cations that can be absorbed between the combined sheets.

Table 2.1 provides a summary of the typical ranges of the liquid limit and plastic limit for each of the clay minerals for two the dominant pore water cation.

Table 2.1 - Typical ranges of liquid and plastic limits for each of the clay types.

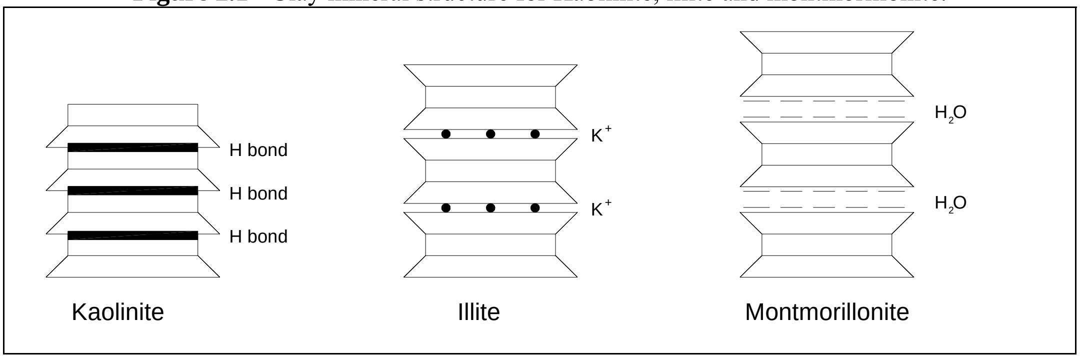
Clay Mineral	Dominant pore water cation			
	Ca^{2+}		Na^{+}	
	Liquid Limit (%)	Plastic Limit (%)	Liquid Limit (%)	Plastic Limit (%)
Kaolinite	34 – 73	26 – 36	29 – 52	26 – 28
Illite	69 – 100	36 – 42	61 – 75	34 – 41
Montmorillonite	123 – 177	65 – 79	280 – 700	86 – 97

Source (Carter and Bentley)

The swell potential for a clay mineral is based on the charge distribution and cation species. The clay mineral particle surfaces contain residual negative charges which results in cations present in the water in the void space being attracted to the particles. If the configuration of the water changes the cations can be replaced as they are not held in position with any strength. This process where the cations are replaced is known as cation exchange.

In Figure 2.1 the typical structures for the clay minerals kaolinite, illite and montmorillonite are shown.

Figure 2.1 - Clay mineral structure for Kaolinite, illite and montmorillonite.



Source: Craig (1997)

2.2.6 General overview of Silt Particles

Silt predominantly consists of quartz mineral particles and is greater in size than that of the clay particles. The test method AS 1289.3.6.1-1995 indicates that particles which pass through the 75µm sieve and are greater than 2µm in size are deemed to be silt. This particle is similar to clay and sand as it is a product of the weathering and decomposition of rock.

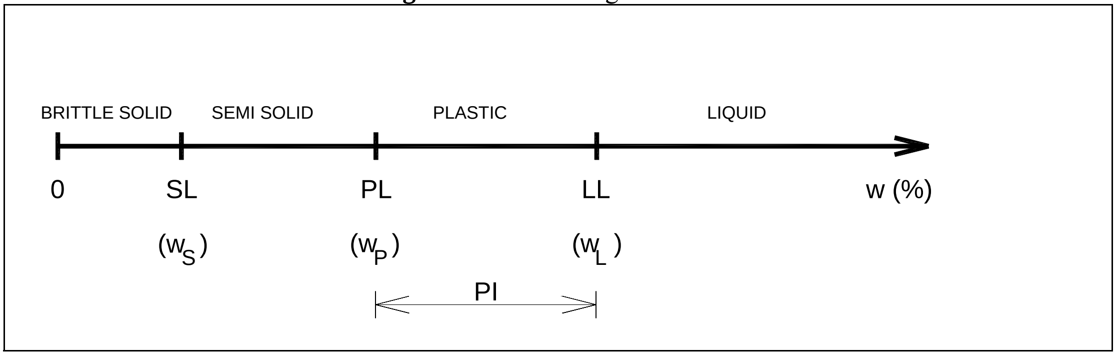
If silt is allowed to harden it can form a sedimentary rock called siltstone, which tends to be deposited in thin layers. Silt is formed through the mechanical weathering of rock, as opposed to the chemical weathering which results in the formation of clays. The most common types of mechanical weathering are grinding and wind erosion for rocks exposed to the atmosphere. Water erosion can take place where rocks are located on the beds of rivers and streams.

When silt occurs as a residual deposit this signifies that the source material where the weathering process was performed is in close proximity. Silt can be transported great distances by the water in a creek, river or an ocean current. As silt particles are very fine they can be even deposited long distances away from their original source material by winds in the form of dust. Where the transportation of the silt particles happens this causes the silt to be termed as sedimentary.

2.2.7 Atterberg Limits

The degree of firmness for a fine grained soil varies significantly with the moisture content. As the percentage of water increases gradually from 0%, it progresses through different phases namely, brittle solid, semi-solid, plastic and liquid states (Figure 2.2). Atterberg limits are the boundary line between the level of water contents for two such states. These limits were developed in the early 1900's by a Swedish soil scientist A. Atterberg, who worked in the ceramics industry. In the late 1920's K.Terzaghi along with A. Casagrande in the early 1930's modified these parameters to suit geotechnical works.

Figure 2.2 - Atterberg Limits.



2.3 Hand Classification of Soils

For hand classification of soils, the two techniques used in conjunction with each other are to feel the soil with the hand whilst visually inspecting the soil. The identification of coarse grained soil is quite easy to classify as they predominately consist of particles greater than 75μm in size.

To enable fine grained soils to be classified additional properties are identified on the basis of some simple tests for dry strength, dilatancy and toughness. Dry strength is a qualitative measure of the effort that is required to crush a dry mass of soil between the fingers. Clays have a very high dry strength where as silts have a very low dry strength.

Dilatancy is an indicator of how rapidly the moisture contained in a wet soil can be brought to the surface through vibration. This is achieved by placing a pat of moist clay on the palm of one hand and striking it against the other hand several times. For soils with a high silt content the moisture comes to the surface within a few strikes and causes the surface to shine. For clays to have a shiny surface it may require a greater effort to make the water come to the surface. The dilatancy can be considered to be quick for silts and slow for clays with a mixture of the two being somewhere between these levels.

Toughness is a qualitative indicator of how tough it is when the soil is near its plastic limit. As the plasticity of a soil increases the toughness will also increase.

This implies that there is a direct relationship between the plasticity and toughness of a soil. At the plastic limit clays are quite hard and rigid whereas silts are soft and friable.

The fines contained in a soil can also be detected by feeling a moist pat. If the pat feels sticky, then it will consist predominately of clay. The stickiness is due to the cohesive properties of the clay particles and this provides an indication of its plasticity. Clays are commonly known as cohesive soils and if the soil has a gritty feel to it then it can be considered to have a significant percentage of silt present. Although silt particles are smaller than gravel and sand the gritty feel of silt lends it to be defined as a granular soil.

2.4 Soil Classification Systems

The formal soil classification system is a universal description which all the geotechnical engineers understand. It is a rational and systematic approach to classify and describe them by grouping soils together that exhibit similar behaviour or properties. When soils are classified in this manner with the use of such standard and precise terms it assists in eliminating any ambiguity in communicating the soil characteristics.

There is several classification systems currently used to describe soils. The Unified Soil Classification System (USCS) is one of the most popular methods and is currently used in many parts of the world. For materials used in road works the various soils are grouped according to their suitability as embankment or subgrade materials. This type of system is known as the American Association of State Highway and Transportation Officials (AASHTO) classification system. For geotechnical works the most widely used system in Australia is outlined in AS 1726-1993: Geotechnical site investigations.

2.4.1 AS 1726-1993: Geotechnical site investigations

In the Australian Standard AS 1726-1993, it requires the soil to be placed in a limited number of groups which is primarily based on the grading and plasticity characteristics of the soil. Soils are usually described in terms of its mass characteristics and are independent of how the soil is formed.

A fine grained soil is either classified as a clay or silt but this depends on the Atterberg limits of the soil and not on the percentage of the particle present in the soil. Casagrande proposed the PI-LL chart shown in Figure 2.3, and on this chart the A-line is used to separate the clay soils from the silt soils.

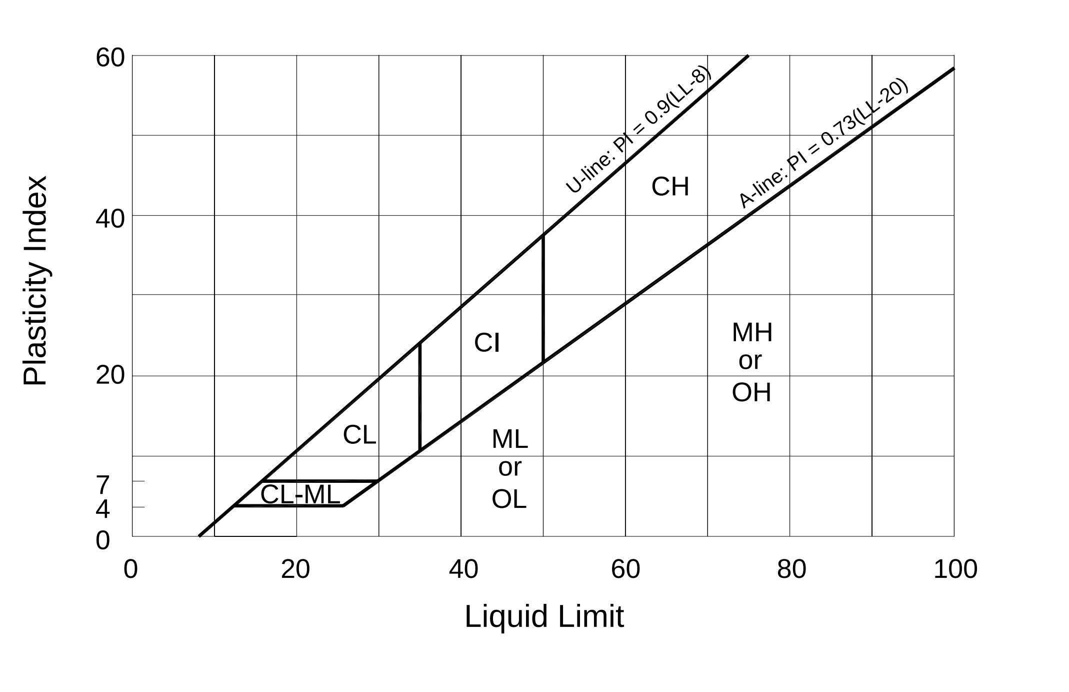
When the value of the LL and PI for a soil is plotted on the chart and both values are above the A-line it is predominately clay. If these same properties are plotted and they fall below the A-line it can be considered as some form of silt. Soils that are located above the A-line are described as CL, CI, or CH type of clays. Clay can occur below the A-line in the form of organic clay and this is symbolised as either OL or OH. Silts are symbolised as ML or MH and only occur below the A-line. In Table 2.2 both the major soil group and descriptor that is used in the plasticity chart is defined.

Table 2.2 - Soil Group and Descriptor Symbols for fine grained soils.

Major Soil Group	Descriptor	Range of liquid limit (%)
C - Clay	L - Low Plasticity	≤ 35
M - Silt	M – Medium Plasticity	$> 35 \leq 50$
O - Organic	H – High Plasticity	> 50

On the plasticity chart shown in Figure 2.3 there is a U-line which is approximately the upper limit for where the plasticity index and liquid limit relationship should be used. If the plotted value is above the U-line then the classification should be carefully considered.

Figure 2.3 - Plasticity chart for classification of fine grained soils.



The geotechnical characteristics of a soil are significantly influenced by the percentage of fines present. When classifying soils this must be taken into consideration. For a fine grained soil the percentage of fines must be at least 50% smaller than 75µm. Table 2.3 shows the descriptive terms for material proportions for a fine grained soil that should be included when classifying a soil.

Table 2.3 - Descriptive terms for material proportions.

% Coarse	Modifier
≤ 15	Omit, or use ‘trace’
> 15 ≤30	Describe as ‘with sand/gravel’ as applicable
> 30	Prefix soil as ‘sandy/gravelly’ as applicable

2.4.2 Unified Soil Classification System

The Unified Soil Classification System (USCS) is very similar to the one outlined in AS 1726-1993. The main difference between the two classification systems is the border line between sands and gravels is 4.75mm and not 2.36mm as stated in AS 1726-1993. When classifying soils based on the fine content the USCS requires if the fine content equals 45-55%, the soil is assigned a symbol of XY-YZ, where X and Y are the symbols for the coarse and fine grained soils respectively. Z is the descriptor of the fines L or H and USCS does not recommend the use of 'I' as a descriptor for fines.

2.5 Geological Formation

The Geological soil type known as the Quaternary Pleistocene Shepparton Formation within the Murray Basin consists predominately of sand, silts and clays. Douglas *et al*. (1988) indicates that this formation is bounded to the north, east and south by folded Palaeozoic sediments and intrusives. The western boundary coincides with Aeolian landforms developed in the Woorinen Formation. The Shepparton Formation is supported on the weathered and eroded surface of the Calivil Formation and Palaeozoic bedrock.

The Murray Basin was created when massive land subsidence occurred during the Tertiary period prior to the sediments being deposited and is part of the Riverine Plain. The Shepparton Formation represents the most recent major phase of fluvatile deposition during the Tertiary and Quaternary periods. This process occurred around 1.6 million years ago and continued up to the recent geological times. The soil particles in the area were deposited by prior river or stream systems in the Quaternary Period.

The sediments within the Shepparton Formation were deposited by low energy streams and rivers. The waterways throughout this area are of meandering nature. During seasonal flooding of the plains when the water broke through the river, stream or creek banks this allowed gradual build up of the silt and clay over large areas. Included in this profile there are traces of windblown deposits consisting of fine calcareous material which were spread over the basin during drier climatic conditions. The depth of the sediment deposits within the Shepparton Formation ranges from 50 to 125 metres.

The clayey sediments throughout this Formation consist of different colors which include mottled grey orange brown, mottled grey red brown and shades of brown. The deeper the clays are found in the Formation, tends to result in the colors becoming darker. During the process of deposition when the soil was being formed, the effect of mottling has been caused through the redistribution of iron minerals and subsequent water percolation.

Although the soils in this Formation consist mainly of clay and silty clay there are also many irregular shaped sand seams. The sand beds predominately consist of quartz minerals along with minor percentages of lithic, limonite and mica particles. The composition of the beds ranges from clean sand to sandy clay and a various range of colors which include orange, brown, grey, and white. Throughout this Formation the seams are scattered and are usually flowing thin narrow seams. These seams are generally between 2 to 5 metres in depth but greater depths can occasionally be found. The quantity of sand in a particular area is dependent on the proximity of the plain to the parent river and the size of the river.

The size of the sand grains in a bed can range from fine sand to coarse sand and even gravel can be found sometimes. At the downstream end of these past streams there is a lack of sand and comprise more of silts, silty clays and sandy clays. The sand and gravel deposits are usually found to be deposited by streams in there last phase. These deposits are located close to the surface and in narrow belts and are not strongly related to the surface topography.

2.6 Assessment of consequential effects

2.6.1 Aspects of Sustainability

The investigation and findings of this report will not have an impact on the development and environmental needs of future generations as it is only determining if there is a relationship between various soil parameters.

The development of a correlation may provide assistance to the engineering profession who currently estimate potential ground movements for residential sites using atterberg limits and not the shrink swell index. By using the recommended correlations, it may allow the calculation of the potential seasonal ground movement for the residential building site to be more accurate if sites are being classified using atterberg limits.

If a site can be more accurately classified, then this will help the design engineer to provide the most efficient footing appropriate for the site. If the footing design is more precise then the possible problems due to ground movement will be minimised. As the design is able to be more precise, and with the minimisation of the ongoing problems, it could provide an economical benefit to the community as resources do not have to be spent on remedial works. Another benefit of providing a more accurate classification is that the footing system maybe designed less conservatively thus saving on natural resources and construction costs that are used to construct the footing system.

The environmental protection practices that will be incorporated into the investigation work is when samples are collected that every effort will be made to leave the environment in the same condition as it was found. When samples were collected they were positioned on the site so they were located within the footprint of the dwelling.

As this project is only looking at a particular Geological soil type that only occurs in Australia it is envisaged that the global impact of this work will be insignificant.

The people or organisations that maybe impacted or be able to utilise these results are people who use the atterberg limits to estimate the shrink swell index for soils within the Shepparton Formation.

As this project is only determining if there is a correlation between the atterberg limits and shrink swell index it is envisaged that this will not have a major impact on the general public. For people who currently use atterberg limits to classify residential building sites and are prepared to utilise a correlation factor to estimate the shrink swell index of a soil it may improve living standards. People's living standards may improve because they may not have to spend money on remedial works on their dwelling resulting from ground movement which was not designed for. By not spending money on these works they are able to utilise this money in other areas.

The findings in this project are to be treated as very limited and only appropriate for a particular Geological Formation type and would not have any impact on developed or undeveloped countries throughout the world.

2.6.2 Aspects of Ethical Responsibility

This project is going to try and establish if a correlation does exist between the shrink swell index and any atterberg limits. The sampling program and locations will not be extensive and this report should only be treated as a preliminary investigation to determine if further detailed investigation work is justified.

The sample location and types will be chosen to eliminate any bias from the outcome. It is intended to sample a broad range of soils with varying properties that occur within the top 3 metres of the profile. If one soil type was used then the results could be bias and not be a true reflection of what actually does occur.

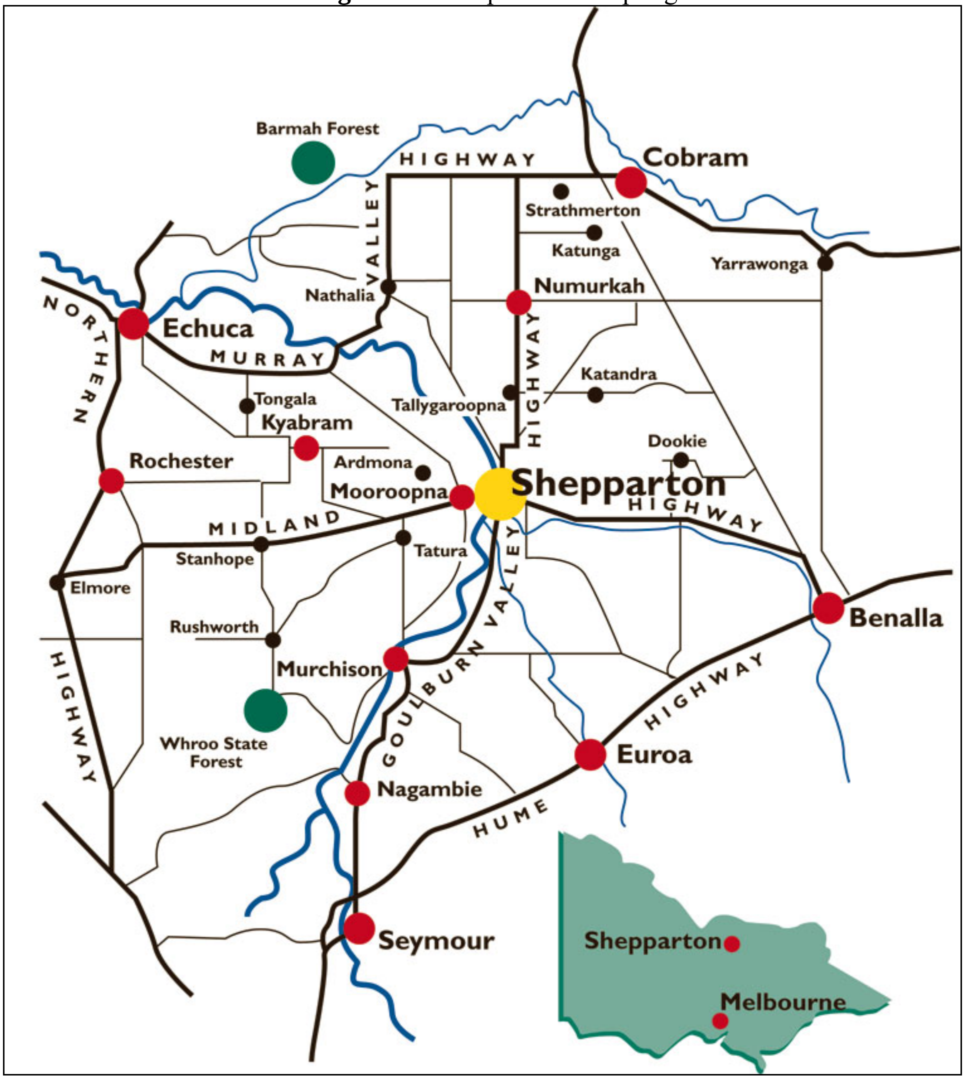
Chapter 3: Sampling and Testing Methodology

3.1 Selection of Sampling Sites

To select possible sampling sites, Geological maps published by the Department of Natural Resources and Environment for Bendigo and Wangaratta were examined to identify the location of the Shepparton Formation. These maps are produced at a scale of 1:250,000 and a copy of these two plans can be found in Appendix B. As this is an initial investigation it was decided to limit the possible sampling sites to the Goulburn Valley and Murray Valley regions.

When selecting possible sampling sites the major factor that was considered extremely important was that the site to be definitely located in the Shepparton Formation. To ensure samples covered a sufficient area of this Formation, sites were identified covering both the Goulburn and Murray Valley regions. Some of the towns identified as possible sampling sites included Echuca, Shepparton, Yarrawonga and Benalla. The total area that these sites represented is approximately 10,000 km^2. Once possible sites were selected and confirmed to lie within the Formation, arrangements were made to gain access to the site. A map covering the area which samples were obtained from is shown in Figure 3.1.

Figure 3.1 - Map of the Sampling area.



It was decided to collect approximately 30 samples for testing to determine if a correlation does exist. This was considered an adequate number of samples for an initial investigation. The number of samples selected was based on previous studies undertaken by Cameron (1989) and Wan et al. (2002) which is similar to this research and had sample sizes of between 16 and 14 respectively.

It was required to identify additional sites due to the fact that some of the original sites chosen when visited did not allow undisturbed samples to be collected, because the soils were to dry too perform the shrink swell test as they crumbled when they were extruded from the sampling tube. The main reason why the soils are currently in such a dry condition is due to the drought which has been experienced in these regions over the past few years.

3.2 Collection of Soil Samples

To undertake the collection of the soil samples the physical site was identified by using the appropriate subdivision plan or residential address before the hydraulic drilling rig was set up as in Figure 3.2. Prior to setting up the drilling rig a risk assessment was undertaken for the site to ensure that it was safe to proceed. A copy of the risk assessment used to ensure that drilling rig was operated in a safe manner can be found in Appendix C. The drilling plant used is capable of creating a 100mm diameter bore. The rig can achieve bores up to 12 metres deep by utilising 1.5 metre lengths of 100mm diameter continuous flight auguring.

Figure 3.2 - Hydraulic Drilling Rig set up.

An initial borehole was drilled to ascertain the depth of each soil type within the 3 metre profile. During this process the disturbed soils were brought to the surface by the flight on the auger and each soil type was hand classified. The depth at which the soil changed from one type to another was recorded. An assessment of the moisture content was also hand classified to ensure that the soils were at an acceptable moisture content to perform the shrink swell test.

3.2.1 Collection of Disturbed Samples

After the soils were hand classified the appropriate soil type/s were sampled from a second bore which was drilled adjacent to the first. For this second borehole, it was required to drill down to the depth at which the soil to be sampled was located. Prior to the collection of the disturbed sample, both the auger and borehole were required to be cleaned to remove all loose material. This was done to avoid the possibility of contaminating the sample being collected. To collect a disturbed sample the auger was drilled into the layer at intervals of 300mm with the auger being removed after each 300mm penetration and the disturbed soil collected. The soil on the auger was removed and placed in a clean plastic tray. These samples were collected as outlined in AS 1289.1.2.1-1998.

Figure 3.3 - Collection of a disturbed sample.

To be able to undertake this part of the designed testing program, it was required to collect a disturbed soil sample. The mass of soil which was required to undertake all of these tests is around 10 kilograms. This disturbed soil was placed in an air tight plastic bag with a reference tag to describe the location of the sample. Figure 3.3 shows the collection of a disturbed sample using the drilling rig.

3.2.2 Collection of Undisturbed Samples

The collection of undisturbed samples was undertaken using a nominal 50mm diameter thin walled steel tube 450mm long and performed in accordance with the method outlined in AS 1289.1.3.1-1999. To enable the tube to be pushed into the soil a third borehole was drilled to the required depth. When the required sample depth was achieved the auger was removed from the borehole. A hand auger was then used to remove any loose soil that remained in the borehole after the continuous flight auger was removed from the bore.

The sampling tube was fastened to an extension rod by using an adaptor. To provide a sufficient force to push the tube into the soil a hydraulic jack hammer mounted on the drilling rig was utilised. The rod was fixed into the jack hammer and lowered this assembly into position. When the tube was resting on top of the soil which was to be sampled, it was driven in with the jack hammer until a sample of at least 200mm was achieved.

The sampling tube was then removed from the hole and the ends of the tube filled with loose soil to minimise the loss of any moisture. This sample tube was then placed into an air tight plastic bag with a reference tag enclosed. Figure 3.4 shows the setup of the jack hammer, extension rod and sampling tube used to collect the undisturbed sample.

Figure 3.4 - Setup for the collection of an undisturbed sample.

3.3 Laboratory Testing

For this project all testing was undertaken in a laboratory accredited by the National Association of Testing Authorities (NATA). The laboratory testing was carried out in the soil laboratory of BM Consulting Civil Engineers, accreditation number 5023.

This laboratory is accredited for the following tests:

- AS 1289.3.1.2-1995 Determination of the liquid limit of a soil – One point Casagrande method.
- AS 1289.3.2.1-1995 Determination of the plastic limit of a soil – Standard method.
- AS 1289.3.3.1-1995 Calculation of the plastic index of a soil.
- AS 1289.3.4.1-1995 Determination of the linear shrinkage of a soil – Standard method.

- AS 1289.3.6.1-1995 Determination of the particle size distribution of a soil – Standard method of analysis by sieving.

The balance of the required tests required for this project were undertaken in this laboratory even though it is not accredited for these tests. The tests for which the laboratory is not accredited for were all performed in accordance with the relevant test methods as set out in the Australian Standards. When undertaking the testing in the laboratory a risk analysis was undertaken to identify potential risks so these could be treated to minimise the impact of injury. A copy of this assessment can be found in Appendix D.

As part of the NATA requirements all samples have to be identified with a unique identification. This laboratory provides a different prefix for each type of report produced, but the numerical portion of the report identifies that the sample tested could be part of a larger sample. If a report has an identical numerical segment in the report number, then it can be assured that the sample is part of a larger sample or has been derived from the same location and can be treated as one sample.

All samples that were collected, whether they comprised disturbed or undisturbed samples, were allocated a sample number prior to any preparation work on them. It should be understood that although the disturbed and undisturbed samples originated from separate bores, they should be treated as one sample.

3.4 Shrink Swell Index Testing

In order to calculate the potential seasonal ground movement as outlined in AS 2870-1996 Residential slabs and footings - Construction Standard, it is required to know the shrinkage index. Cameron (1989) concluded that the shrink swell test appears to provide the most accurate method of the three methods listed in AS2870-1996 for determining the shrinkage index.

One of the main advantages of using this method is that soil suction determinations are not essential for this method. This method allows soil to be sampled and tested irrespective of its initial moisture content. It was found that this was not the case as samples that were very dry did not allow the core shrinkage sampled to be prepared, as this sample crumbled when extruded from the sampling tube.

The shrink swell index (I_{ss}) performed in accordance with AS1289.7.1.1-2003, requires the collection of an undisturbed soil sample and to prepare both a sample for the swell test and simplified core shrinkage test from this undisturbed sample.

The swell test is performed by preparing a swell specimen from the 50mm nominal diameter undisturbed sample recovered. When the sample was extruded from the sample tube, a specimen was achieved by extruding it through the consolidation ring. The dimensions for this ring used throughout for this test was nominally 48mm in diameter and 24mm in height.

Once a specimen had been placed into the consolidation ring (Figure 3.5) it is then assembled between dry porous stone plates. This assembly is known as the consolidation cell. This cell is then placed into the loading device where a 5kPa seating load is applied for 30 minutes. After this time the load is then increased to 25kPa and the sample is inundated with distilled water. Once the cell is inundated in the water the extent of swelling is monitored and recorded with the use of a dial gauge. Figure 3.6 shows the cell inundated in the loading device.

Testing is continued until the difference in the movement of the specimen is less than 5% between the last reading and the one previously done 3 hours prior.

Figure 3.5 - Specimen in consolidation ring.

Figure 3.6 - Consolidation cell in the loading device.

The simplified core shrinkage test is prepared from the undisturbed sample which has been extruded from the sampling tube with the length of this specimen being within the range of 1.5 to 2 times the diameter of the sample. For this test samples were between 75 and 100mm long and a prepared sample is shown in Figure 3.7.

Figure 3.7 - Prepared core shrinkage specimen.

The average length of this specimen is calculated by taking two measurements of the sample and also the initial mass of this core is recorded. The mass of two drawing pins are determined and recorded before being placed firmly into the centre of each end of the specimen. The distance between the rounded heads of the drawing pins is measured with vernier callipers. The samples were then placed on a smooth surface in the atmosphere and measurements of the distance between the pins were taken twice daily. Cracking and crumbling of the specimen was observed during this process and noted.

When the shrinkage ceased, the sample was then placed in a drying oven with the temperature in the range of 105°C to 110°C. Once the specimen reached a constant mass, the distance between the two drawing pins was measured.

The final part of the simplified core shrinkage test is to break the specimen apart and visually inspect it for uniformity and also for rock, gravel and/or organic inclusions. If there are any significant inert inclusions this was estimated as a percentage of the volume and recorded on the worksheet.

For both the swell test and shrinkage test the initial moisture contents of both these samples were required to be determined.

To enable the swelling strain (ε_{sw}) to be calculated, it was performed by using the total swell less any initial settlement that occurs prior to inundation of the sample. This result is expressed as a percentage of the average initial height of the specimen.

$$\varepsilon_{sw} = \frac{D_s - D_i}{H_a}$$

where: ε_{sw} = the total swelling strain in percentage.

D_s = the total swell of the sample after inundation in millimetres.

D_i = the initial settlement observed prior to inundation.

H_a = the average initial length of the specimen in millimetres.

To calculate the shrinkage strain (ε_{sh}) to the constant mass condition the following equation is used:

$$\varepsilon_{sh} = \frac{100(D_o - D_d)}{H_o}$$

where: ε_{sh} = the total shrinkage strain to a constant mass condition in percent.

D_o = the distance between the heads of the drawing pins in millimetres after their placement.

D_d = the distance between the heads of the drawing pins in millimetres after removal from the oven.

H_o = the average initial length of the specimen in millimeters.

The calculation for the shrink swell index is undertaken in accordance with the following equation:

$$I_{ss} = \frac{(\varepsilon_{sw}/2) + \varepsilon_{sh}}{1.8}$$

where: I_{ss} = the shrink swell index, percentage strain per pF change in suction.

ε_{sw} = the total swelling strain in percentage and if $\varepsilon_{sw} < 0$ then $\varepsilon_{sw} = 0$.

ε_{sh} = the total shrinkage strain to a constant mass condition in percent.

A copy of the shrink swell test results for all of the tested samples can be found in Appendix E.

3.5 Preparation of Disturbed Soil Samples

The disturbed samples recovered were used to determine results for the Atterberg Limits, Linear Shrinkage, Particle Size Distribution for both the sieving method and hydrometer test. For these tests to be undertaken they were required to be prepared in accordance with AS 1289.1.1-2001.

For ease and productivity it was decided to dry all disturbed samples to a constant mass in a drying oven at 45°C to 50°C.

The preliminary preparation of the soil sample was to take the dry sample and reduce all of the clods in the sample to pass through a 10mm screen. To achieve the required size, the clods were initially chopped up with a shovel and then made to crumble by lightly tapping the clods with a sledge hammer. During this process of chopping and crumbling extreme care was taken to ensure that individual particles were not crushed.

3.5.1 Preparation of soil for liquid limit, plastic limit and linear shrinkage

The method adopted for all of these tests was the dry preparation method using a mechanical device. This method requires a sample of around 1000 grams to be subdivided from the total sample.

This sample was placed in the 2.36mm sieve and shaken until the only particles retained on this sieve were greater than 2.36mm. The material that passed through the sieve was collected and rubbed down using a mechanical device as shown in Figure 3.8.

Figure 3.8 - Soil being rubbed down in the mechanical device.

The material that has been rubbed down is then sieved through a 425µm sieve. After the entire sample has been sieved, the material which has passed through the sieve is then split to obtain a mass of at least 300 grams so all three tests can be performed.

3.5.2 Preparation of the soil for particle size distribution test using sieves

From the total dry soil sample a smaller sample is obtained with the use of a riffle box to achieve the minimum mass as specified in Table 1 of AS 1289.1.1-2001. The minimum mass is based on the nominal maximum size of particle present in the sample.

3.5.3 Preparation of the soil for the particle size distribution using the hydrometer

With the use of a riffle box a representative sub sample is obtained from the total sample with this sub sample containing at least 50 grams of material passing through the 75µm sieve.

3.5.4 Preparation of the soil for particle density analysis

For this test it is required to subdivide the total sample by splitting it through the riffle box until this sample is of sufficient mass that will allow around 200 grams to be collected once it passes through the 2.36mm sieve.

3.6 Determination of the Atterberg Limits of a soil

The atterberg limits for a soil consists of three tests which determines different properties for the soil. The three tests which make up the atterberg limits are the Liquid Limit, Plastic Limit and Plasticity Index.

3.6.1 Determination of the Liquid Limit of a soil

The liquid limit (LL) for a soil is the moisture content at which the soil begins to flow. This is the point at where the soil is said to change from a solid state to a liquid state.

This test has been performed in accordance with AS 1289.3.1.2-1995. To undertake this test, a disturbed sample which was prepared in accordance with

AS 1289.1.1-2001 is required. From the prepared soil it was required to obtain at least 250 grams of material which passes through the 425µm sieve.

This dry sample of soil was then placed on a glass mixing plate and water added to the soil in increments and thoroughly mixed through with a palette knife. Water is continued to be added and mixed until the soil becomes a consistent paste mixture and is close to 25 blows at closure when tested in the liquid limit apparatus. After this had been obtained the soil was then placed in an air tight container and allowed to cure for a minimum of 12 hours at room temperature.

After the soil had cured it was then thoroughly reworked for at least 1 minute on a clean glass plate. A portion of this mixture was placed into the cup which rested on the base of the liquid limit apparatus. This mixture was then leveled off parallel to the base so the depth of the soil in the cup was around 10mm but did not exceed this depth. A groove is cut through this mixture along the centreline using the appropriate grooving tool. A prepared test is shown in Figure 3.9.

The crank handle of the apparatus was turned at 2 rev/s so that the cup is raised and lowered until the bottom of groove comes together for a distance of 10mm. A typical closure of the groove can be seen in Figure 3.10. The desired number of revolutions for this test was 25 with a tolerance of ±3 revs. This tolerance was required so the mixture could be used for the linear shrinkage test.

If this was not achieved then the sample required the addition of extra water if it was greater than 28 blows and to be air dried if less than 22 blows. This sample was then required to be reworked for a minimum of 3 minutes and tested again as described above, until the number of revolutions for closure was between 22 and 28.

Figure 3.9 - Sample ready for the liquid limit test.

Figure 3.10 - Completed liquid limit test with groove closed.

When the sample was between 22 and 28 blows a second sample was tested after the mixture had been reworked for at least 30 seconds. If this sample was within 1 blow of the previous test, the number of blows was then recorded.

If the second test is not within the 1 blow tolerance it was reworked and retested until the two consecutive tests are within 1 blow of each other and between the specified tolerances of 22 to 28 blows.

A sample of approximately 10 grams was taken from the mixture in the bowl where closure occurred. This sample was then used to determine the moisture content at which this event occurred. This moisture content is known as the liquid limit for the soil. A copy of all the liquid limit test results for the tested samples can be found in Appendix F.

3.6.2 Determination of the Plastic Limit of a soil

The plastic limit (PL) is a measurement of the moisture content where the soil stiffens from the plastic condition to a semi rigid friable state.

This test has been performed in accordance with AS 1289.3.2.1-1995. To undertake this test, a disturbed sample which was prepared in accordance with AS 1289.1.1-2001 is required. From the prepared soil it was required to obtain at least 40 grams of material which passed through the 425µm sieve.

The preparation for this test was done in conjunction with the liquid limit. Whilst undertaking the initial mixing phase of the liquid limit test a sample of approximately 40 grams was put aside when the mixture was in the plastic limit range. If the sample was too wet it was allowed to air dry until the desired uniformity was obtained.

When the sample was at the required moisture content it was placed in an air tight container and allowed to cure for a minimum of 12 hours at room temperature.

After the sample had cured, around an 8 gram ball of soil was taken and moulded between the fingers. This was followed by rolling the ball of soil between the palm of the hands until minor cracks appeared on the surface of the sample. With the use of a hand and applying slight pressure to the ball it was rolled backwards and forwards along a glass plate until 3mm diameter thread crumbles.

If the thread crumbles prior to reaching 3mm in diameter, additional water was applied and the entire sample reworked. Alternatively if the thread did not crumble when the diameter reached 3mm the sample was collected, combined and reworked. This new ball was then rolled out again until it crumbled and the thread was 3mm in diameter. In Figure 3.11 the 3mm diameter crumbled threads can be seen.

Figure 3.11 - 3mm diameter threads that have crumbled.

The 3mm crumbled threads were collected and placed in a container and covered until a total mass of 8 grams is obtained. A second test was undertaken using another 8 gram ball in the same manner.

The moisture content for both samples was determined and provided they were within 2 percent of each other the test is complete. If the results are greater than 2 percent apart the test is required to be repeated until this criteria is attained.

The plastic limit was calculated by averaging the two moisture contents of the samples. A copy of all the plastic limit test results for the tested samples can be found in Appendix F.

3.6.3 Determination of the Plasticity Index of a soil

The plastic index (PI) of a soil is the difference between the liquid limit and the plastic limit and is one of the most commonly used measurements to indicate the reactivity of the soil. This result was calculated in accordance with the test method as specified in AS 1289.3.3.1-1995. A copy of all the plasticity index test results for the tested samples can be found in Appendix F.

3.7 Determination of the Linear Shrinkage of a soil

The linear shrinkage (LS) of a soil is the measurement of the horizontal shrinkage of a soil at its liquid limit.

This test was performed in accordance with AS 1289.3.4.1-1995 except that a separate 250 gram soil was not prepared but the soil sample that was prepared and tested for the liquid limit was utilised for this test.

When undertaking the linear shrinkage test it was necessary to ensure that the liquid limit was within the tolerance of 25 ± 3 blows of the closure of the groove in the liquid limit apparatus so this sample could be used for the linear shrinkage test.

With the sample thoroughly mixed and of uniform consistency it was then placed in a lightly greased clean shrinkage mould. The mixture was levelled off with the top of the mould and any trapped air in this mixture was removed by lightly tapping the base of the mould on a solid object. The sample was then levelled off again with the top of the mould and if required additional mixture was added to replace the air which had been removed. The mould was then cleaned to remove any excess material that may have adhered to the outside of the mould.

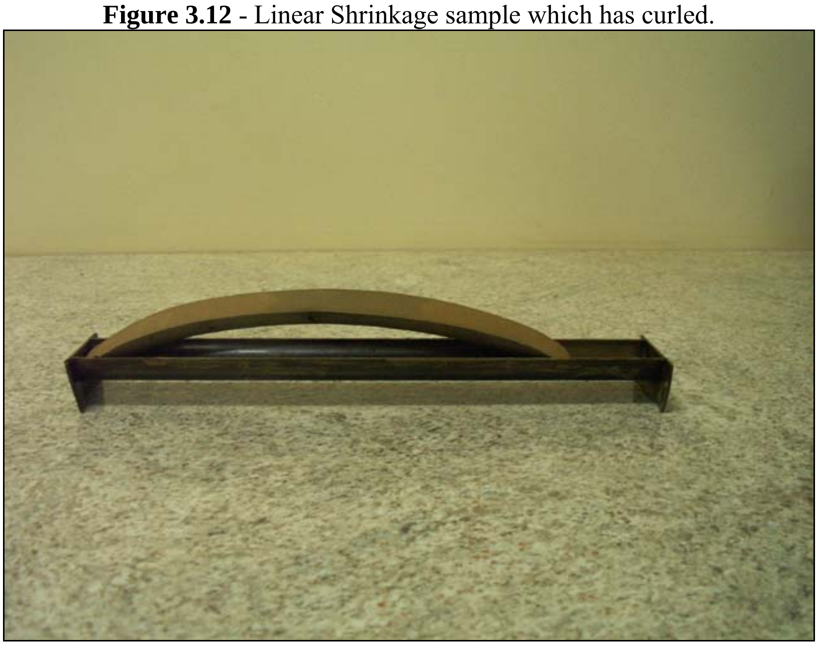
The sample was then allowed to dry at room temperature for at least 24 hours prior to placing it into a drying oven with the temperature in the range of 105ºC to 110ºC. Before the sample was allowed to cool it was checked to ensure that all moisture was removed from the specimen.

Once the specimen was completely dry it was allowed to cool and a measurement of the longitudinal shrinkage was taken to the nearest millimetre. If the sample curled as shown in Figure 3.12 it was removed from the mould and a measurement of the top and bottom surfaces of the specimen was taken.

To calculate the longitudinal shrinkage for this curled sample the average of these two lengths was calculated and subtracted from the mould length. To calculate the shrinkage length for a sample which is said to have crumbled, the cracked pieces are pushed firmly together to one end of the mould. A measurement of the gap between the end of the specimen and the mould was taken to determine the longitudinal shrinkage for the specimen.

To calculate the linear shrinkage of the specimen it is required to divide the longitudinal shrinkage of the specimen by the length of the mould and convert this result to a percentage. A copy of all the linear shrinkage test results for the tested samples can be found in Appendix F.

Figure 3.12 - Linear Shrinkage sample which has curled.



3.8 Determination of the gravel and sand particles in a soil

The method adopted to determine the percentage of gravel and sand contained within the soil was performed as outlined in AS 1289.3.6.1-1995. This method covers the determination of the particle size distribution within a soil down to a particle size of 75µm. This method does not determine the combined clay and silt percentages contained in the soil and the method chosen to calculate this is the fine analysis method using a hydrometer.

All samples were initially treated as if they contained particles greater than 2.36mm so the intermediate sieving approach was initiated. A sample was prepared in accordance with AS 1289.1.1-2001 for this test.

This sample was placed in a tray and the initial mass of the soil was determined. A dispersing solution was then poured over the soil until it was inundated and completely wet by stirring the sample. The dispersing solution or reagent used was sodium hexametaphosphate and this mixture was allowed to soak for at least 1 hour.

After the soaking process had taken place the sample was then washed through a 2.36mm washing sieve which protected a 75µm washing sieve from the larger particles. The water that passed through this finer sieve contained clay and silt particles, and this dirty water mixture was allowed to run to waste. The washing process was continued until the water that ran to waste was basically clear and the entire sample had been washed.

The washed material retained on both sieves was then returned to the tray and excess water is decanted. The washed sample was then placed in a drying oven set between 105°C and 110°C and dried to a constant mass. This dry sample was then weighed and the mass recorded.

This sample was then placed in a set of 300mm diameter sieves with varying apertures ranging from 4.75mm to 19mm. The set of sieves were then shaken for the prescribed time and the mass of material retained on each sieve was recorded.

The material that was retained in the pan of the 300mm diameter sieves was then prepared for sieve analysis by riffling so a sub sample of approximately 100 grams was available for analysis.

This sub sample was then placed in a set of 200mm diameter sieves with the apertures ranging from 2.36mm to 75µm. After the sample had been shaken the material retained on each sieve and pan was recorded. Figure 3.13 shows the 200mm sieves in the shaker.

The percentage of material retained on each sieve is then calculated as a percentage of the initial dry mass. A copy of all the particle size distribution analysis greater than 75µm in size for the tested samples can be found in Appendix F.

Figure 3.13 - 200mm diameter sieves in the shaker.

3.9 Percentage of silt and clay particles in a soil

The procedure that was adopted for this section of the research was the test method as outlined in AS 1289.3.6.3-1994. This publication provides the method of how to determine the particle soil distribution of a soil by the standard method for fine analysis using a hydrometer. This test determines the distribution of particles contained within a soil less than 75µm in size. The hydrometer used for this test has previously been calibrated in accordance with the method specified in this standard.

To undertake this test it was first required to obtain a soil sample of at least 300 grams which had passed through the 2.36mm sieve and was prepared in accordance with AS 1289.1.1-2001. From this sample two sub samples were prepared with the aid of the riffle box, to achieve a sample of approximately 200 grams and the other one approximately 50 grams.

The 200 gram sample was used to calculate the soil particle density as outlined in AS 1289.3.5.1-1995: Determination of the soil particle density of a soil – Standard method. The 50 gram sample was then tested to determine whether the soil contained calcium compounds or soluble salts. All of the samples tested did not require pretreatment for either of these compounds. The soil was also assessed for organic materials but all of the samples contained less than the required 2%.

As no pretreatment was required the sample was then placed in a bowl and 100mL of dispersing agent was added and the mixture allowed too soak for a minimum of 12 hours with the bowl being made air tight. This mixture was then transferred to the mechanical dispersion device and thoroughly mixed for 15 minutes.

This mixture was then placed in the 75µm washing sieve and washed clean using distilled water. The waste from this sieve was caught in a dish and transferred to a 1000mL measuring cylinder and topped up to exactly 1000mL with distilled water. This suspension was then placed in a room where the temperature was constant and allowed to stand until it had achieved the ambient temperature.

Prior to the insertion of the hydrometer a rubber stopper was placed in the end of the cylinder and the mixture was shaken for approximately 1 minute. Immediately after the shaking process had finished the hydrometer was immersed into the liquid. It remained in the cylinder for the first four minutes with readings taken throughout this period at 0.5, 1, 2 and 4 minutes. At the end of 4 minutes the hydrometer was removed, rinsed with distilled water and placed in a cylinder of distilled water which was at the same temperature as that of the sample.

For the elapsed times of 8, 15, 30, 60, 120 and 240 minutes the hydrometer was inserted, readings taken and then removed. After the 240 minute reading further readings were taken once daily until the 48 hour period was attained. A completed hydrometer test is shown in Figure 3.14. The temperature of the suspension was taken once in the first 15 minutes and then at each subsequent measurement.

The material that was retained on the 75µm washing sieve was transferred to a dish using a jet of water and dried to a constant mass in an oven at 105°C to 110°C. The dry mass was weighed and recorded as the fine sand percentage of the soil. This retained sample was not sieved to determine the distribution of particle sizes as this was done when the sieve analysis was performed.

The particle size analysis using this method uses the sedimentation process based on the velocity that the particles settle out of the soil water mixture. The effective particle size is calculated using Stoke's Law which is:

$v = (g/1.8) \times [(\rho_s - \rho_w)/\mu] \times (D^2 \times 10^{-4})$

where: v = terminal velocity, in millimetres per second.

g = gravitational acceleration, in metres per second squared.

ρ_s = soil particle density, in grams per cubic centimetre.

ρ_w = density of water, in grams per cubic centimetre.

μ = dynamic viscosity of water, in megapascal second.

D = particle diameter, in micrometres.

To calculate the distribution of particle sizes the hydrometer readings, temperature, particle density, mass of soil and soil retained on the 75µm were imputed into a spreadsheet which performed the required calculations in accordance with Clause 7.3 of AS 1289.3.6.3-1994. A copy of the hydrometer test results for all of the tested samples can be found in Appendix G.

Figure 3.14 - Completed Hydrometer test.

3.10 Calculation of the Particle Density of the soil

The particle density for a soil was performed in accordance with the following procedure as outlined in AS 1289.3.5.1-1995.

A volumetric flask was washed and dried prior to the flask being filled with 500 grams of distilled water. With the flask filled with 500 grams of water the bottom of the meniscus was accurately marked on the surface of the flask with this mark now representing a volume of exactly 500mL.

To start the test a clean and dry volumetric flash was weighed to determine the mass of the flash. A sample which was prepared earlier of approximately 200 grams was added to the flask and the combined mass recorded.

Distilled water was then added to this dry mixture ensuring that it was less than the 500mL mark. A rubber stopper was placed in the end of the flask to which a hand vacuum pump was attached. All of the air was removed from the water and soil mixture using this pump. De-aired water was then added to top the mixture up to the 500mL mark. The mass of the flask, soil and water was then taken.

The total mass of water and soil was now able to be calculated. The soil volume was calculated by subtracting the mass of water away from the 500mL mark.

The particle density of the soil was calculated by dividing the mass of the soil by the volume of soil.

3.11 Classification of Soil Samples

Apart from the hand classification of the soils which was done onsite, soils were also classified in accordance with Table A1 of AS 1726-1993 Geotechnical Investigation. This method of classification was adopted because it is the most commonly used method in Australia for Geotechnical works. When classifying a soil using this table the liquid limit, plasticity index and particle size distribution is required. After the required tests were completed and the above properties were determined, the classification of the soil using the Table A1 in this standard was able to be undertaken.

3.12 Analysis Method Used

The method used to analyse the results to determine if there is a correlation between the shrink swell index and the various soil properties is to use a 'xy' scatter plot and fit the best trendline to the plotted data. The process that was undertaken to carry out this analysis was for the results to be graphed using the computer program Microsoft Excel.

To be able to achieve a graph from this program the results were tabulated against the corresponding shrink swell index. Once all the results were tabulated the results were then graphed as a 'xy' scatter graph. A scatter chart has two axes with the x–axis showing one set of numerical data and the other value along the y-axis. This graph combines these two values into single data point and displays them on the graph where ever they occur.

Scatter charts are frequently used for displaying and comparing numeric values, such as engineering, statistical, and scientific data. The advantage of a scatter plot for this situation is that this chart allows different comparisons to be made. Scatter charts can be displayed with or without lines to connect the data points or fitted with a trendline that fits the data best. A trendline is a graphical representation of the trend or direction of data in a series. Trendlines are used generally to predict a value on the y axis from data on the x axis.

The data was tested for different trendlines which consisted of the following relationships:

- Linear
- Logarithmic
- Polynomial
- Power
- Exponential

For each trendline both the equation and R^2 value of the trendline was determined using the facility provided in the Excel program.

To determine the strength of each correlation the R^2 value for the trendline was calculated. The R^2 value for a trendline is sometimes referred to as the proportion of explained variation. Put another way, R^2 is the square of the correlation between the response values and the predicted response values. In brief R^2 is the relative predictive power of a model and is a descriptive measure between 0 and 1. The closer it is to one the greater the ability for the equation to predict an outcome. For example an R^2 value of 0.8645 means that the fit explains 86.45% of the total variation in the data about the average. Overall the R^2 statistic indicates how much of the behavior of y is captured by the model.

R^2 is defined as the ratio of the sum of squares of the regression (SSR) and the total sum of squares (SST). SSR is defined as

$$SSR = \sum_{i=1}^{n} w_i (\hat{y}_i - \bar{y})^2$$

SST is also called the sum of squares about the mean, and is defined as

$$SST = \sum_{i=1}^{n} w_i (y_i - \bar{y})^2$$

Given these definitions, R^2 is expressed as

$$R^2 = \frac{SSR}{SST} = \frac{\sum_{i-1}^{n} w_i (\hat{y}_i - \bar{y})^2}{\sum_{i-1}^{n} w_i (y_i - \bar{y})^2}$$

Chapter 4: Test Results

4.1 Classification of the Soils

At the end of the sampling program a total of 29 samples had been collected from across the Goulburn Valley and Murray Valley regions. This was in accordance with the intended number to be collected which was around 30. Although these samples were hand classified at the time of collection, to ensure a variety of soils were gathered the soils were classified using the appropriate laboratory results.

To classify the samples in accordance with Table A1 of AS 1726-1993 the liquids limit, plasticity index and particle size percentages are required. Although it is not a requirement of the soil classification system to describe the soils color, it was included as a descriptive measure to assist in identifying the soils.

The classification and description of each sample collected can be examined in Table 4.1. The report number which was allocated to each sample is unique for each particular soil. This table provides both the location and depth of where each sample was retrieved from.

Table 4.1 - Classification of Samples by soil properties.

Report No.	Location	Depth	Soil Description	Classification
050476	393 Walsh's Bridge Road Kaarimba	200 - 600mm	Orange Brown Silty Clay with traces of sand	CL
050477	393 Walsh's Bridge Road Kaarimba	600 - 1000mm	Grey Brown Clay	CH
050489	Lot 84 McLahlan Road, Echuca	400 - 1100mm	Brown Silty Clay with traces of sand	CH
050490	Lot 84 McLahlan Road, Echuca	1200 - 1800mm	Light Brown Silty Clay with traces of sand	CH
050493	Lot 42 Sir Edward Drive, Benalla	600 - 1300mm	Brown Orange Silty Clay	CI
050494	Lot 42 Sir Edward Drive, Benalla	1300 - 2000mm	Light Brown Silty Clay with traces of sand	CI
050503	Lot 2 Peppernell Road, Toorumbarry	300 - 800mm	Orange Brown Silty Clay with traces of sand	CH
050504	Lot 2 Peppernell Road, Toorumbarry	1100 - 2000mm	Mottled Orange Light Brown Silty Clay with traces of sand	CH
050507	Lot 16 Wesley Court, Shepparton	300 - 700mm	Orange Brown Silty Clay with sand	CI
050518	Lot 765 Narran Court, Kialla Lakes	1200 - 1500mm	Yellow Light Brown Silty Clay with sand	CI
050519	Lot 6 Bluebird Court, Kialla	700 - 1100mm	Orange Brown Silty Clay with traces of sand	CI
050526	62 Mason Street, Shepparton	300 - 800mm	Orange Brown Silty Clay with traces of sand	CI
050527	62 Mason Street, Shepparton	1700 - 2300mm	Orange Silty Clay with traces of sand	CI
050530	365 Mitchell Road, Kialla	400 - 1000mm	Brown Silty Clay with traces of sand	CH
050531	365 Mitchell Road, Kialla	1000 - 1600mm	Mottled Grey Orange Light Brown Clay	CH
050541	Lot 105 Taig Avenue, Kialla	1500 - 2000mm	Mottled Grey Orange Light Brown Silty Clay	CH
050542	Lot 765 Narran Court, Kialla Lakes	600 - 1000mm	Yellow Light Brown Clay	CH
050544	8 Gray Street, Benalla	1500 - 2000mm	Mottled Red Orange Brown Silty Clay with sand	CI
050545	Lot 3 Murrays Road, Benalla	500 - 1000mm	Mottled Light Brown Silty Clay with sand	CL
050547	Lot 3 Murrays Road, Benalla	100 - 500mm	Light Brown Silt with sand	ML
050548	Lot 1 Ruttles Road, Strathmerton	300 - 800mm	Mottled Grey Brown Orange Sandy Clay	CI
050549	Lot 1 Ruttles Road, Strathmerton	100 - 300mm	Grey Light Brown Silt with sand	ML
050550	5 Lincoln Street, Katandra West	200 - 700mm	Orange Silty Clay with sand	CL
050551	Lot 404 Linda Crescent, Yarrawonga	250 - 600mm	Orange Brown Silty Clay with traces of sand	CI
050561	34 Orr Street, Shepparton	300 - 700mm	Orange Brown Silty Clay with sand	CI
050562	Lot 404 Linda Crescent, Yarrawonga	1300 - 1800mm	Yellow Light Brown Silty Clay with sand	CI
050577	Lot 41 Boyd Avenue, Shepparton	400 - 700mm	Red Orange Silty Clay with traces of sand	CI
050578	Lot 41 Boyd Avenue, Shepparton	700 - 1300mm	Mottled Orange Brown Silty Clay with traces of sand	CI
050579	Lot 41 Boyd Avenue, Shepparton	1300 - 3000mm	Brown Silty Clay with sand	CL

The majority of the soils collected were classified as silty clays with the plasticity of these samples ranging from CL to CH. These samples generally had some percentage of sand contained in them. Two of the samples collected were classified as ML with both of these samples being described as silt with sand.

The samples that were collected are very typical of the soils which make up this Formation and predominately consist of clay minerals. The range of colors for the collected samples was consistent with previous investigations that have been undertaken in this Geological Formation.

4.2 Results for the Shrink Swell Index Test

The Shrink Swell Index for the soils ranged from 0.1 to 4.0% with the results providing a relatively even spread throughout this range. The two silt samples had shrink swell indexes of 0.1 and 0.6%. It would be expected that the index for this soil type should be low as soils mainly comprised of silt particles demonstrate low plasticity characteristics.

The silty clay samples covered the plasticity range from CL to CH. The shrink swell index for these soils ranged from 0.5 to 4.0%. The results for these silty clays indicate that there is not any relationship between the classification and the corresponding shrink swell index. For the three group symbols that are above the A line in the plasticity chart, the range of shrink swell index values are:

CL – 0.4 to 1.8%.
CI – 0.5 to 3.0%.
CH – 1.0 to 4.0%.

These results indicate that there is an overlap of the actual shrink swell index when compared to the classification of the soil. Table 4.2 provides the results of all the tests for the shrink swell index and compares them to the soil classification.

Table 4.2 - Shrink Swell index for each soil.

Report No.	Classification	Shrink Swell Index (%)
050547	ML	0.1
050549	ML	0.6
050579	CL	0.4
050545	CL	0.7
050476	CL	1.2
050550	CL	1.8
050527	CI	0.5
050578	CI	0.5
050518	CI	0.6
050544	CI	0.8
050562	CI	0.8
050577	CI	1.1
050551	CI	1.4
050493	CI	1.6
050507	CI	1.6
050548	CI	1.7
050519	CI	2.1
050526	CI	2.3
050561	CI	2.3
050494	CI	3.0
050504	CH	1.0
050541	CH	1.1
050503	CH	1.6
050490	CH	2.3
050531	CH	2.5
050530	CH	3.0
050542	CH	3.5
050489	CH	3.6
050477	CH	4.0

4.3 Results for the Atterberg Limits

The atterberg limits for a soil consists of the liquid limit, plastic limit and plasticity index. In Table 4.3 the atterberg limits for all of the soils tested are shown.

4.3.1 Liquid Limit

The liquid limit for the samples ranged from 17% to 65% for the soils collected. The two soils classified as ML had liquid limits of 17% and 21%. The liquid limit for the soils in the CL category ranged from 25% to 29% and the CI soils spanned from 35% to 47%. The CH classified soils had liquid limits starting from 52% and ending at 65%.

The liquid limits for each classification did not extend beyond one classification to the next. It can be seen when the classification increases in plasticity the liquid limit also increases. As the soils have been classified in accordance with AS 1726-1993 and it utilises the liquid limit as one of its parameters to classify the soil, it would be logical that there would not be an overlap.

Although there is a relationship between the classification and liquid limit this does not mean that there is one between the liquid limit and the shrink swell index.

4.3.2 Plastic Limit

The two soils classified as ML both had the same plastic limit of 16%. The CL soils had moisture contents from 14% to 17% and the CI soils ranged from 13% to 17%. The clays that had a high plasticity and were classified as CH soils had plastic limits commencing at 16% and finishing at 21%.

These results indicate that for the different soil classifications, there is not necessarily a relationship between the plastic limit and the classification. This is due to the fact that the same plastic limit could occur in any of the classifications.

4.3.3 Plasticity Index

For each of the soil classifications the plasticity index was found to cover the following moisture contents:

ML – 1% to 5%.

CL – 11% to 15%.

CI – 22% to 31%.

CH – 36% to 44%.

Table 4.3 - Atterberg Limits for each soil.

Report No.	Classification	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
050547	ML	17	16	1
050549	ML	21	16	5
050545	CL	25	14	11
050550	CL	26	11	15
050476	CL	28	13	15
050579	CL	29	17	12
050548	CI	35	13	22
050527	CI	36	14	22
050577	CI	36	13	23
050561	CI	36	13	23
050494	CI	36	13	23
050544	CI	37	14	23
050578	CI	38	15	23
050551	CI	42	14	28
050507	CI	43	15	28
050518	CI	45	15	30
050493	CI	45	15	30
050562	CI	46	16	30
050519	CI	46	15	31
050526	CI	47	16	31
050541	CH	52	16	36
050542	CH	53	17	36
050504	CH	54	16	38
050490	CH	54	16	38
050503	CH	57	18	39
050530	CH	59	16	43
050531	CH	60	18	42
050477	CH	62	20	42
050489	CH	65	21	44

From these results it can be determined as the plasticity increased so did the plasticity index. It was also observed that there is no overlap of moisture levels for each type of classification.

4.4 Results of the Linear Shrinkage Test

During the preparation and testing of the liquid limit for a soil, it was decided to undertake linear shrinkage tests on each sample. The decision to undertake this test also, is because it is a measure of volume change of the soil at the liquid limit. As this test is a measure of volume change it was thought that this may provide a correlation with the shrink swell index. The results from this testing indicates that there is a relationship between the classification and the resulting linear shrinkage. The test results imply that there is not an overlap of linear shrinkage test results and the classification. Results for the linear shrinkage test and the corresponding classification can be examined in Table 4.4.

The results for each of the soil classification can be summarised as follows:

ML – 0.5% to 2.5%.
CL – 5% to 9%.
CI – 10.5% to 15.5%.
CH – 13.5% to 20%.

These results demonstrate that there is no overlap for each classification except between the CI and CH soil types. For all of the samples there was only one soil type that overlapped into a different classification. This occurred for the soil in Report No. 050542 which had a liquid limit of 13.5% and was classified as a CH soil, which appears to be in the range of a CI soil.

Table 4.4 - Linear Shrinkage Test Results.

Report No.	Classification	Linear Shrinkage (%)
050547	ML	0.5
050549	ML	2.5
050545	CL	5
050550	CL	9
050476	CL	9
050579	CL	6
050548	CI	10.5
050527	CI	11.5
050577	CI	11
050561	CI	11
050494	CI	13
050544	CI	10.5
050578	CI	13
050551	CI	15
050507	CI	14.5
050518	CI	14
050493	CI	13.5
050562	CI	13
050519	CI	14
050526	CI	15.5
050541	CH	16
050542	CH	13.5
050504	CH	16.5
050490	CH	17.5
050503	CH	17
050530	CH	17.5
050531	CH	18
050477	CH	15
050489	CH	20

4.5 Results of the Particle Size Analysis

By undertaking a sieve analysis and a hydrometer test on each sample the percentage of sand, silt and clay was able to be determined. The percentage of the three different particle types for each of the samples is tabulated in Table 4.5. These results demonstrate that there is no obvious relationship between the classification of the soil and any of the various particle sizes.

The sand fraction was determined using both the sieve analysis and hydrometer test. The results from both of these tests to measure the percentage of sand contained in a sample yielded identical results for the sand fraction.

To determine the percentage of silt and clay in each sample the hydrometer test was performed. Table 4.6 provides a summary of the mineral types and the range that they covered for each of the soil classifications.

Table 4.5 - Particle Analysis for the samples.

Report No.	Classification	Sand Fraction (%)	Silt Fraction (%)	Clay Fraction (%)
050547	ML	25	61	14
050549	ML	36	45	19
050545	CL	18	56	26
050550	CL	27	40	33
050476	CL	6	69	24
050579	CL	18	73	10
050548	CI	31	35	34
050527	CI	17	75	8
050577	CI	10	51	39
050561	CI	23	39	38
050494	CI	9	67	23
050544	CI	16	52	32
050578	CI	8	80	12
050551	CI	14	45	40
050507	CI	24	31	45
050518	CI	21	71	8
050493	CI	2	49	49
050562	CI	16	76	9
050519	CI	13	53	33
050526	CI	9	34	56
050541	CH	5	59	36
050542	CH	4	16	80
050504	CH	15	71	14
050490	CH	7	62	31
050503	CH	7	76	17
050530	CH	7	68	25
050531	CH	5	24	71
050477	CH	3	24	72
050489	CH	6	51	43

Table 4.6 - Summary of Particle Analysis for the samples.

Classification	Sand Fraction (%)	Silt Fraction (%)	Clay Fraction (%)
ML	25 - 36	45 - 61	14 - 19
CL	6-27	40 - 73	10 - 33
CI	2-31	31 - 80	8 - 56
CH	3 - 15	16 - 76	17 - 80

4.6 Summary of Results

A summary of all the results can be found in Table 4.7. In Chapter 5 an analysis of the results is undertaken to determine if there is a correlation between the shrink swell index and any of the atterberg limits, linear shrinkage or the percentage of clay contained within a soil.

Table 4.7 - Summary of Test Results.

Report No.	Classification	Shrink Swell Index (%)	LL (%)	PL (%)	PI (%)	LS (%)	Sand Fraction (%)	Silt Fraction (%)	Clay Fraction (%)
050547	ML	0.1	17	16	1	0.5	25	61	14
050549	ML	0.6	21	16	5	2.5	36	45	19
050545	CL	0.7	25	14	11	5	18	56	26
050550	CL	1.8	26	11	15	9	27	40	33
050476	CL	1.2	28	13	15	9	6	69	24
050579	CL	0.4	29	17	12	6	18	73	10
050548	CI	1.7	35	13	22	10.5	31	35	34
050527	CI	0.5	36	14	22	11.5	17	75	8
050577	CI	1.1	36	13	23	11	10	51	39
050561	CI	2.3	36	13	23	11	23	39	38
050494	CI	3.0	36	13	23	13	9	67	23
050544	CI	0.8	37	14	23	10.5	16	52	32
050578	CI	0.5	38	15	23	13	8	80	12
050551	CI	1.4	42	14	28	15	14	45	40
050507	CI	1.6	43	15	28	14.5	24	31	45
050518	CI	0.6	45	15	30	14	21	71	8
050493	CI	1.6	45	15	30	13.5	2	49	49
050562	CI	0.8	46	16	30	13	16	76	9
050519	CI	2.1	46	15	31	14	13	53	33
050526	CI	2.3	47	16	31	15.5	9	34	56
050541	CH	1.1	52	16	36	16	5	59	36
050542	CH	3.5	53	17	36	13.5	4	16	80
050504	CH	1.0	54	16	38	16.5	15	71	14
050490	CH	2.3	54	16	38	17.5	7	62	31
050503	CH	1.6	57	18	39	17	7	76	17
050530	CH	3.0	59	16	43	17.5	7	68	25
050531	CH	2.5	60	18	42	18	5	24	71
050477	CH	4.0	62	20	42	15	3	24	72
50489	CH	3.6	65	21	44	20	6	51	43

Chapter 5: Analysis of Results

5.1 Analysis Rationale

5.1.1 Aim of Analysis

The aim of the analysis was to determine if there is a correlation between the shrink swell index and any of the atterberg limits for soils within the Geological soil structure known as the Shepparton Formation.

Cameron (1989) indicates that there is a relationship between the shrink swell index and the linear shrinkage but this is only satisfactory $r = 0.76$. Based on this information it was decided for a correlation to be of any beneficial use it had to have a predicting outcome of at least $R^2 = 0.80$. If the correlation was less than this, it is considered not accurate enough to estimate a shrink swell index.

5.1.2 Method adopted to determine if a correlation exists

For a correlation to exist an analysis of the results was undertaken to determine if a relationship is present between the shrink swell index and any of the atterberg limits. To determine if a correlation exists, the results of the shrink swell test were plotted against each of the atterberg limits in the form of a 'xy' scatter graph.

To determine the best fitting trendline several types of lines were fitted on the graph which included linear, numerous polynomial equations, logarithm, exponential and power functions. From previous studies conducted by Chen (1988) and Seed et al (1962) into correlations using shrink swell properties of the soil and the atterberg limits it was found that these relationships were not linear.

By graphing these results using the computer program Microsoft Excel this enabled the scatter graph to be easily fitted with a trendline for the particular type of equation used. This program provided a quick and easy way to calculate the equation of the fitted trendline and the corresponding R^2 value. For each analysis against the shrink swell index the best fitting trendline, equation and R^2 results were recorded on the scatter graph.

5.1.3 Additional Correlations to be evaluated

Initially it was only planned to determine if a correlation existed with any of the atterberg limits. After evaluating the research into previous studies undertaken in this area it was decided that a comparison should also be performed against the linear shrinkage for the soil. The logic behind this decision is that the shrink swell test is a measurement of the volume change for a soil, as it moves from a dry condition to a moist condition. It was thought that as the linear shrinkage test is a measurement of volume change for a soil there may in fact be some form of correlation between these two properties.

During the testing process the sand, silt and clay percentages were determined so the laboratory classification of the soils could be completed. As these results were available for all samples it was decided to investigate if any relationship existed between the shrink swell index and the percentage of clay. The rationale behind this is that the clay minerals in the soil structure have a major influence of the shrink swell characteristics for the soil.

For soils to shrink and swell they will show a noticeable volume change with changes in the moisture content. When soils behave in this manner they contain clay minerals that are prone to the infiltration of water. As the atterberg limits and linear shrinkage are an indicator of the reactivity of the soil it may not necessarily be an indicator of the particular clay present in the soil.

Whilst undertaking the testing program, the samples were tested to determine the percentage of clay present in each sample. It was thought that this might be a factor that could be used to modify the atterberg and linear shrinkage properties to improve the strength of these correlations. The basis behind using the percentage of clay as a modifier is that this mineral is the predominate one in the soil which absorbs water and causes the soil to shrink and swell. The liquid limit, plastic limit and linear shrinkage were all prepared from samples where the soil had passed through the 425μm sieve. With clay particles being less than 2μm in size and being a major factor in causing the soils to shrink and swell, it was thought that by using the percentage of clay particles present it could improve the correlation.

Another modification factor that was performed was to multiply each of the liquid limit, plastic limit, plasticity index and linear shrinkage by the percentage of clay and then dividing this result by the total sum of the silt and clay fractions. The results for all of these different analyses are contained in this chapter.

5.2 Shrink Swell Index against the Liquid Limit

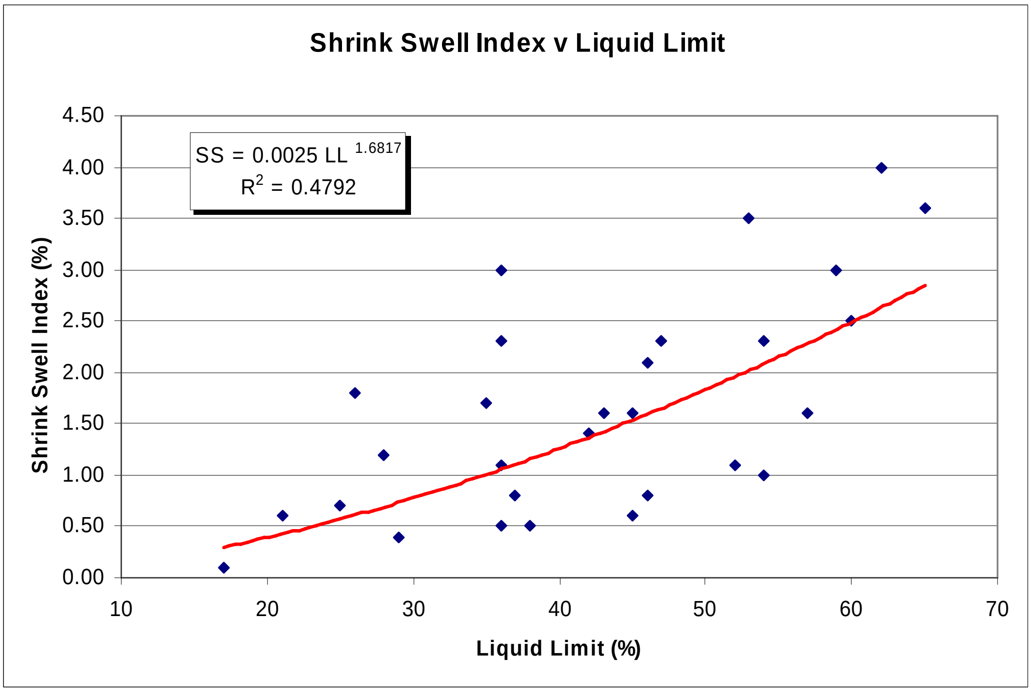
5.2.1 Relationship with the Liquid Limit

The relationship between the shrink swell index and the liquid limit for all of the tested samples is shown in Figure 5.1. The best fitting trendline for this relationship is one where the liquid limit is multiplied by a constant and also has a power applied to it.

The formula for this trendline to predict the shrink swell index (SS) from a liquid limit (LL) is $SS = 0.0025\ LL^{1.6817}$. The strength of this equation in predicting an outcome from the liquid limit is around 48% or has an $R^2 = 0.48$.

As the strength of this correlation is only 48% it is deemed not reliable enough to be used as a predictor for the estimation of the shrink swell index.

Figure 5.1 – Graph of Shrink Swell Index versus the Liquid Limit.



5.2.2 Relationship with the Liquid Limit factored by the Clay Fraction

The relationship between the liquid limit and shrink swell index has been found not to be reliable enough to be used as a predictor. It was decided to investigate whether by multiplying the liquid limit by the percentage of clay would provide a stronger correlation.

The calculations of the liquid limit by the fraction of clay are shown in Table 5.1 with Figure 5.2 showing the resultant graph and trendline. The trendline for this correlation is an improvement on the previous one with a level of accuracy of 69.9%. The equation of this trendline is a polynomial equation with:

$$SS = 0.1849\ FL^{0.8114}$$

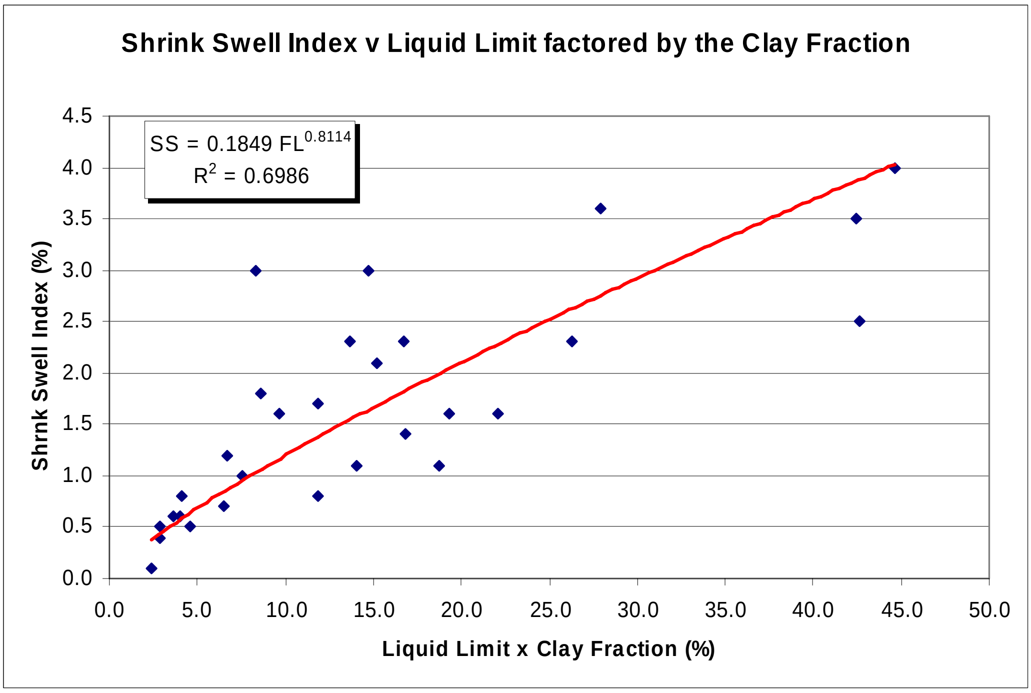
where: SS = Shrink Swell Index.

FL = Liquid Limit x Clay Fraction.

Table 5.1 - Calculation of the Liquid Limit factored by the Clay Fraction.

Report No.	Shrink Swell Index (%)	Liquid Limit (%)	Clay Fraction (%)	LL x C (%)
050547	0.1	17	14	2.4
050579	0.4	29	10	2.9
050527	0.5	36	8	2.9
050578	0.5	38	12	4.6
050518	0.6	45	8	3.6
050549	0.6	21	19	4.0
050545	0.7	25	26	6.5
050544	0.8	37	32	11.8
050562	0.8	46	9	4.1
050504	1.0	54	14	7.6
050541	1.1	52	36	18.7
050577	1.1	36	39	14.0
050476	1.2	28	24	6.7
050551	1.4	42	40	16.8
050493	1.6	45	49	22.1
050503	1.6	57	17	9.7
050507	1.6	43	45	19.4
050548	1.7	35	34	11.9
050550	1.8	26	33	8.6
050519	2.1	46	33	15.2
050490	2.3	54	31	16.7
050526	2.3	47	56	26.3
050561	2.3	36	38	13.7
050531	2.5	60	71	42.6
050494	3.0	36	23	8.3
050530	3.0	59	25	14.8
050542	3.5	53	80	42.4
050489	3.6	65	43	28.0
050477	4.0	62	72	44.6

Figure 5.2 – Graph of Shrink Swell Index versus Liquid Limit factored by the Clay Fraction.



5.2.3 Relationship with the Liquid Limit factored by the Clay and Silt Fraction

After the previous two analyses, a third one was undertaken by multiplying the Liquid Limit by the clay fraction and dividing this value by the sum of the silt and clay fraction. The results for these calculations are contained within Table 5.2.

The trendline for these results is a power function with the:

Shrink Swell Index = $0.1743\ SL^{0.8114}$

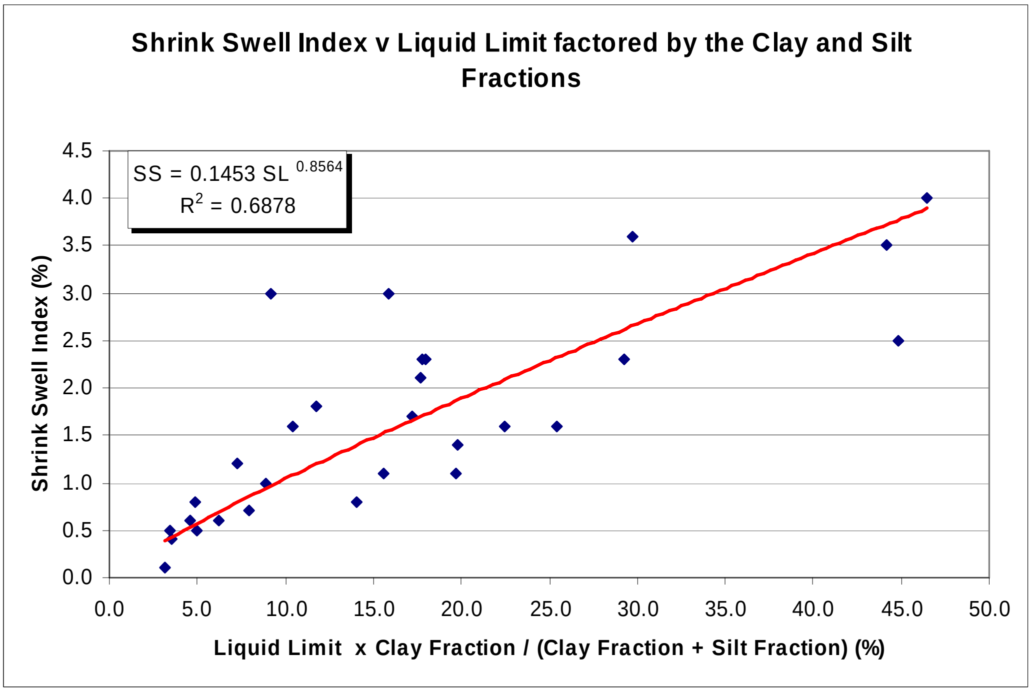
where: SL = Liquid Limit x Clay Fraction / (Clay Fraction + Silt Fraction).

The strength of this correlation has an $R^2 = 0.699$ which is very similar to that of the trendline for the liquid limit x clay fraction. The graph of this relationship is in Figure 5.3.

Table 5.2 - Calculation of the Liquid Limit factored by the Clay and Silt Fractions.

Report No.	Shrink Swell Index (%)	Liquid Limit (%)	Silt Fraction (%)	Clay Fraction (%)	LL x C/(C+S) (%)
050476	1.2	28	69	24	7.2
050477	4.0	62	24	72	48.0
050489	3.6	65	51	43	30.1
050490	2.3	54	62	31	18.0
050493	1.6	45	49	49	23.7
050494	3.0	36	67	23	8.9
050503	1.6	57	76	17	10.4
050504	1.0	54	71	14	8.1
050507	1.6	43	31	45	20.8
050518	0.6	45	71	8	3.9
050519	2.1	46	53	33	16.3
050526	2.3	47	34	56	28.3
050527	0.5	36	75	8	3.1
050530	3.0	59	68	25	15.9
050531	2.5	60	24	71	45.8
050541	1.1	52	59	36	20.1
050542	3.5	53	16	80	45.6
050544	0.8	37	52	32	12.7
050545	0.7	25	56	26	7.0
050547	0.1	17	61	14	2.6
050548	1.7	35	35	34	12.8
050549	0.6	21	45	19	4.3
050550	1.8	26	40	33	9.2
050551	1.4	42	45	40	18.1
050561	2.3	36	39	38	14.7
050562	0.8	46	76	9	4.5
050577	1.1	36	51	39	15.1
050578	0.5	38	80	12	4.9
050579	0.4	29	73	10	3.1

Figure 5.3 - Graph of Shrink Swell Index versus Liquid Limit factored by the Clay and Silt Fractions.



5.3 Shrink Swell Index against the Plastic Limit

5.3.1 Relationship with the Plastic Limit

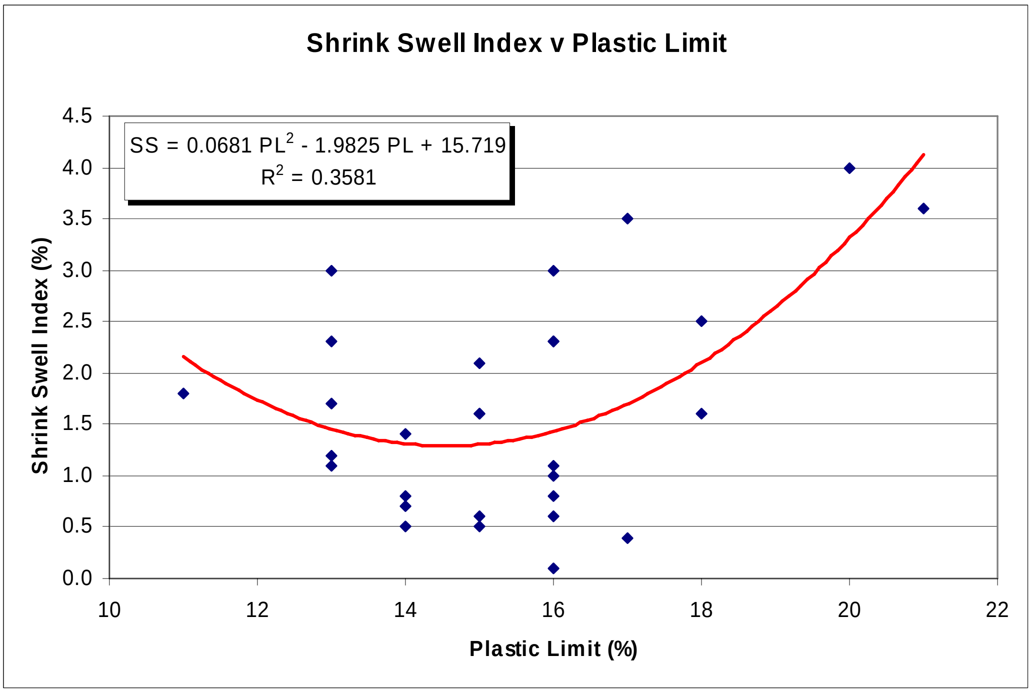
The correlation between the shrink swell index and the plastic limit for all of the tested samples is shown in Figure 5.4. The most appropriate trendline to fit the plotted data is a polynomial which provides a predicted outcome for the plastic limit of 36%. The formula of this line is:

$$SS = 0.068\ PL^2 - 1.983\ PL + 15.719$$

where: SS = Shrink Swell Index.

PL = Plastic Limit.

Figure 5.4 - Graph of Shrink Swell Index versus the Plastic Limit.



5.3.2 Relationship with the Plastic Limit factored by the Clay Fraction

The relationship between the plastic limit and shrink swell index has been found to be poor and could not be used as a possible correlation for determining a shrink swell index. As for the liquid limit a comparison will be made by multiplying the plastic limit by the percentage of clay which could provide a better correlation.

The calculation of the plastic limit by the fraction of clay is shown in Table 5.3 with Figure 5.5 showing the trendline for these results. The trendline for this correlation is significantly improved but is still not strong, as the R^2 value is 0.567. The linear equation of this trendline is:

$$SS = 0.2203\ FP + 0.5186$$

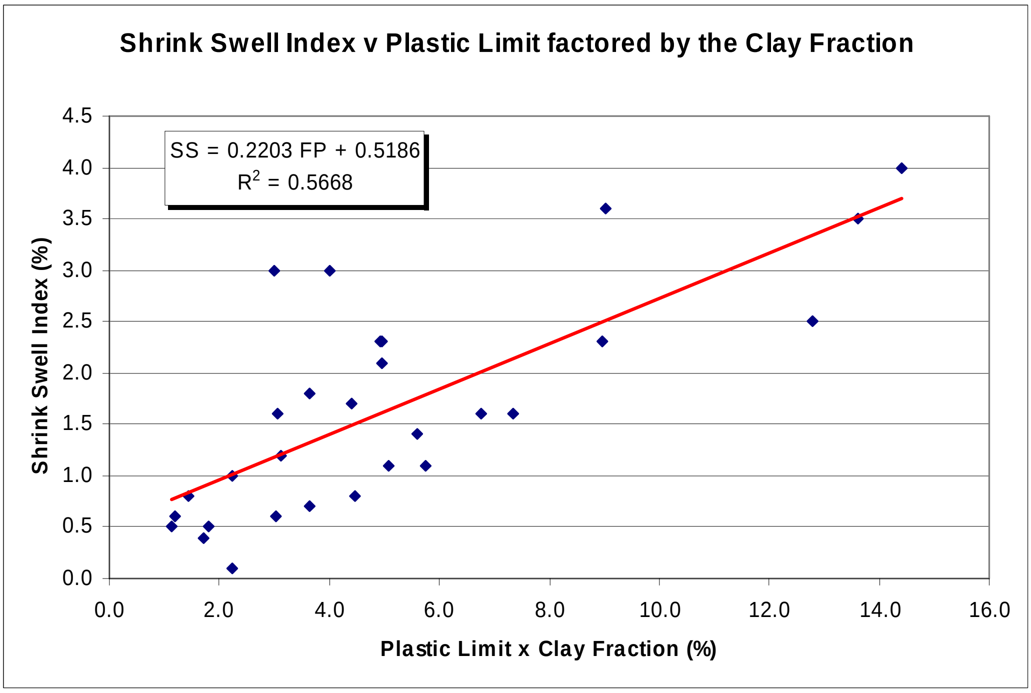
where: SS = Shrink Swell Index.

FP = Plastic Limit x Clay Fraction.

Table 5.3 - Calculation of the Plastic Limit factored by the Clay Fraction.

Report No.	Shrink Swell Index (%)	Plastic Limit (%)	Clay Fraction (%)	PL x C (%)
050547	0.1	16	14	2.2
050579	0.4	17	10	1.7
050527	0.5	14	8	1.1
050578	0.5	15	12	1.8
050518	0.6	15	8	1.2
050549	0.6	16	19	3.0
050545	0.7	14	26	3.6
050544	0.8	14	32	4.5
050562	0.8	16	9	1.4
050504	1.0	16	14	2.2
050541	1.1	16	36	5.8
050577	1.1	13	39	5.1
050476	1.2	13	24	3.1
050551	1.4	14	40	5.6
050493	1.6	15	49	7.4
050503	1.6	18	17	3.1
050507	1.6	15	45	6.8
050548	1.7	13	34	4.4
050550	1.8	11	33	3.6
050519	2.1	15	33	5.0
050490	2.3	16	31	5.0
050526	2.3	16	56	9.0
050561	2.3	13	38	4.9
050531	2.5	18	71	12.8
050494	3.0	13	23	3.0
050530	3.0	16	25	4.0
050542	3.5	17	80	13.6
050489	3.6	21	43	9.0
050477	4.0	20	72	14.4

Figure 5.5 - Graph of Shrink Swell Index versus Plastic Limit factored by the Clay Fraction.



5.3.3 Relationship with the Plastic Limit factored by the Clay and Silt Fractions

The results for the calculation of the plastic limit multiplied by the clay fraction and divided by the total of clay and silt fraction can be found in Table 5.4. The resulting trendline is a linear relationship and has a predictive accuracy of 54.1%. This correlation strength is slightly less than if the plastic limit is multiplied just by the clay fraction so there appears not to be any benefit of using this correlation. The linear equation determined for these results is:

SS = 0.2089 SP + 0.4294

where: SS = Shrink Swell Index.

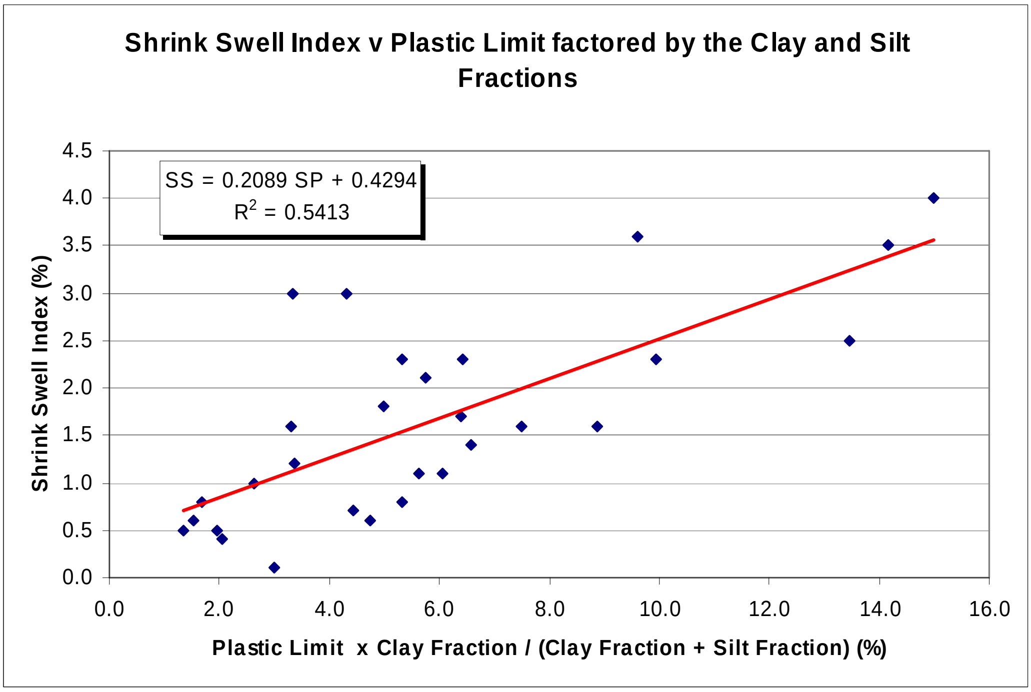
SP = Plastic Limit x Clay Fraction / (Clay Fraction + Silt Fraction).

Table 5.4 - Calculation of the Plastic Limit factored by the Clay and Silt Fractions.

Report No.	Shrink Swell Index (%)	Plastic Limit (%)	Silt Fraction (%)	Clay Fraction (%)	PL x C/(C+S) (%)
050476	1.2	13	69	24	3.4
050477	4.0	20	24	72	15.5
050489	3.6	21	51	43	9.7
050490	2.3	16	62	31	5.3
050493	1.6	15	49	49	7.9
050494	3.0	13	67	23	3.2
050503	1.6	18	76	17	3.3
050504	1.0	16	71	14	2.4
050507	1.6	15	31	45	7.3
050518	0.6	15	71	8	1.3
050519	2.1	15	53	33	5.3
050526	2.3	16	34	56	9.6
050527	0.5	14	75	8	1.2
050530	3.0	16	68	25	4.3
050531	2.5	18	24	71	13.7
050541	1.1	16	59	36	6.2
050542	3.5	17	16	80	14.6
050544	0.8	14	52	32	4.8
050545	0.7	14	56	26	3.9
050547	0.1	16	61	14	2.4
050548	1.7	13	35	34	4.8
050549	0.6	16	45	19	3.3
050550	1.8	11	40	33	3.9
050551	1.4	14	45	40	6.0
050561	2.3	13	39	38	5.3
050562	0.8	16	76	9	1.5
050577	1.1	13	51	39	5.5
050578	0.5	15	80	12	1.9
050579	0.4	17	73	10	1.8

This plotted data and the resulting trendline relationship is shown in Figure 5.6.

Figure 5.6 - Graph of Shrink Swell Index versus Plastic Limit factored by the Clay and Silt Fractions.



5.4 Shrink Swell Index against the Plasticity Index

5.4.1 Relationship with the Plasticity Index

The last atterberg limit to be analysed is the plasticity index. The plasticity index of a soil is the difference between the liquid limit and the plastic limit. The strongest trendline that was fitted to the data is shown in Figure 5.7 with the equation for this relationship being:

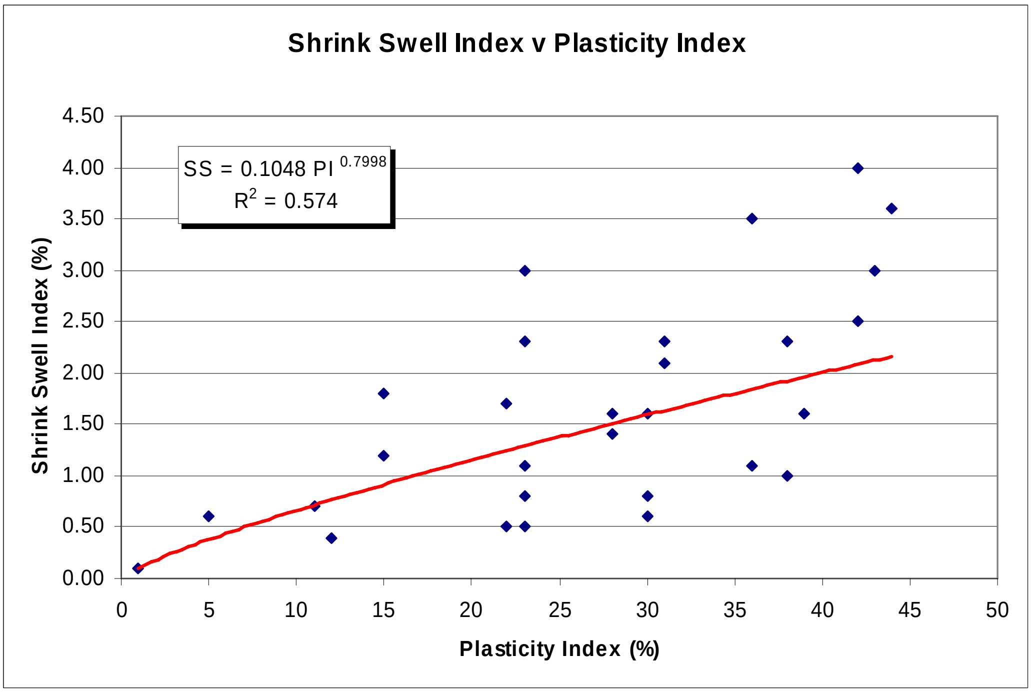
$$SS = 0.1048\ PI^{0.7998}$$

where: SS = Shrink Swell Index.

PI = Plasticity Index.

This formula has the capacity to predict the shrink swell index by using the plastic limit and is in the order of 57.4% being correct. This strength could be regarded as weak and should be avoided to calculate the shrink swell index.

Figure 5.7 - Graph of Shrink Swell Index versus the Plasticity Index.



5.4.2 Relationship with the Plasticity Index factored by the Clay Fraction

In Table 5.5 the calculation of the plasticity index multiplied the clay fraction is shown. The trendline that fits this data the best is $SS = 0.4119\ FPI^{0.6251}$ and is displayed in Figure 5.8. In this equation the following abbreviations were used:

SS = Shrink Swell Index.

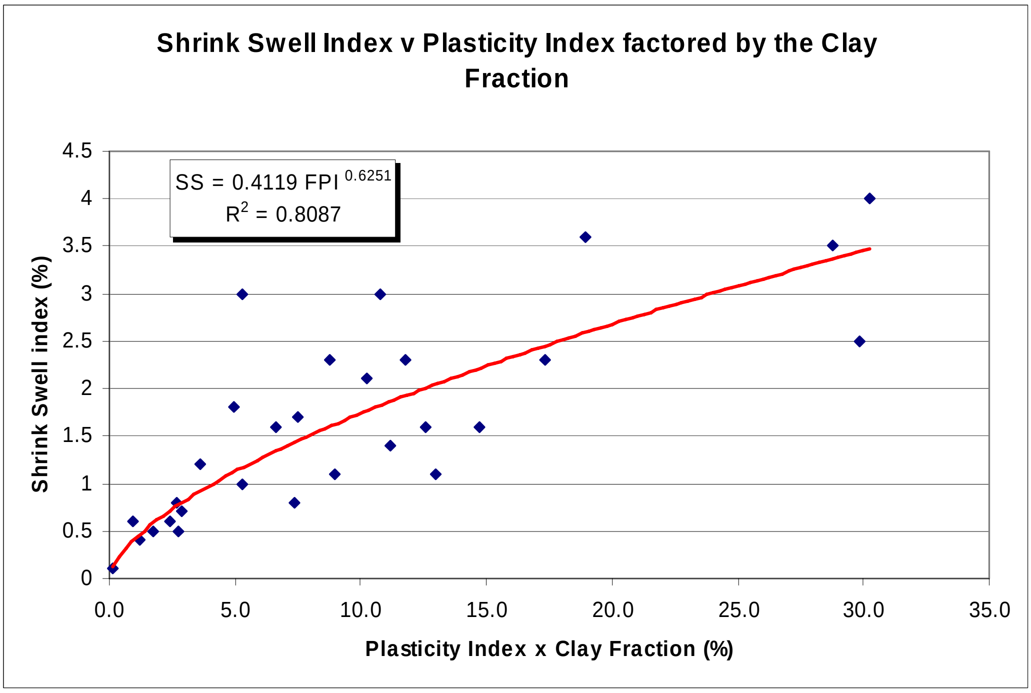
FPI = Plasticity Index x Clay Fraction.

The strength of this correlation is good with an accuracy rate of 80.9%. This relationship has exceeded the criteria initially set for an equation to provide reliable results. As the strength is reasonably strong, this equation could be considered a useful tool to assist in estimating the shrink swell index for a soil using this atterberg limit.

Table 5.5 - Calculation of the Plasticity Index factored by the Clay Fraction.

Report No.	Shrink Swell Index (%)	Plasticity Index (%)	Clay Fraction (%)	PI x C (%)
050547	0.1	1	14	0.1
050579	0.4	12	10	1.2
050527	0.5	22	8	1.8
050578	0.5	23	12	2.8
050518	0.6	30	8	2.4
050549	0.6	5	19	1.0
050545	0.7	11	26	2.9
050544	0.8	23	32	7.4
050562	0.8	30	9	2.7
050504	1.0	38	14	5.3
050541	1.1	36	36	13.0
050577	1.1	23	39	9.0
050476	1.2	15	24	3.6
050551	1.4	28	40	11.2
050493	1.6	30	49	14.7
050503	1.6	39	17	6.6
050507	1.6	28	45	12.6
050548	1.7	22	34	7.5
050550	1.8	15	33	5.0
050519	2.1	31	33	10.2
050490	2.3	38	31	11.8
050526	2.3	31	56	17.4
050561	2.3	23	38	8.7
050531	2.5	42	71	29.8
050494	3.0	23	23	5.3
050530	3.0	43	25	10.8
050542	3.5	36	80	28.8
050489	3.6	44	43	18.9
050477	4.0	42	72	30.2

Figure 5.8 - Graph of Shrink Swell Index versus Plasticity Index factored by the Clay Fraction.



The equation for this correlation has been used to calculate the predicted values in Table 5.6. This table shows the actual shrink swell index value compared to the predicted value as calculated using the equation SS = 0.4119 $FPI^{0.6251}$. The table also contains the difference between the actual value and the predicted one.

It can be observed from the values in this table that there is no pattern to the size of the difference and where it occurs.

Table 5.6 - Difference between the Shrink Swell Index and the Plasticity Index factored by the Clay Fraction.

Report No.	Classification	Shrink Swell Index (%)	$0.4119\ FPI^{0.6251}$	Difference
050547	ML	0.1	0.1	0.0
050579	CL	0.4	0.5	-0.1
050527	CI	0.5	0.6	-0.1
050578	CI	0.5	0.8	-0.3
050518	CI	0.6	0.7	-0.1
050549	ML	0.6	0.4	0.2
050545	CL	0.7	0.8	-0.1
050544	CI	0.8	1.4	-0.6
050562	CI	0.8	0.8	0.0
050504	CH	1.0	1.2	-0.2
050541	CH	1.1	2.0	-0.9
050577	CI	1.1	1.6	-0.5
050476	CL	1.2	0.9	0.3
050551	CI	1.4	1.9	-0.5
050503	CH	1.6	1.3	0.3
050507	CI	1.6	2.0	-0.4
050493	CI	1.6	2.2	-0.6
050548	CI	1.7	1.4	0.3
050550	CL	1.8	1.1	0.7
050519	CI	2.1	1.8	0.3
050490	CH	2.3	1.9	0.4
050561	CI	2.3	1.6	0.7
050526	CI	2.3	2.5	-0.2
050531	CH	2.5	3.4	-0.9
050530	CH	3.0	1.8	1.2
050494	CI	3.0	1.2	1.8
050542	CH	3.5	3.4	0.1
050489	CH	3.6	2.6	1.0
050477	CH	4.0	3.5	0.5

5.4.3 Relationship with the Plastic Index factored by the Clay and Silt Fractions

The results for the calculation of the plasticity index multiplied by the clay fraction and divided by the total of clay and silt fraction are in Table 5.7. The resulting trendline is a power function and has a predictive accuracy of 81.6%.

The trendline to predict the shrink swell index can be found in Figure 5.9 and the equation of this line is:

$$SS = 0.3486\ PC^{0.6604}$$

where: SS = Shrink Swell Index.

PC = Plasticity Index x Clay Fraction / (Clay Fraction + Silt Fraction).

The strength of this correlation can be considered satisfactory and has exceeded the criteria initially set for an equation to provide reliable results. As the strength is reasonably strong, this equation could be considered a useful tool to assist in estimating the shrink swell index for a soil using this atterberg limit.

Figure 5.9 - Graph of Shrink Swell Index versus Plasticity Index factored by the Clay and Silt Fractions.

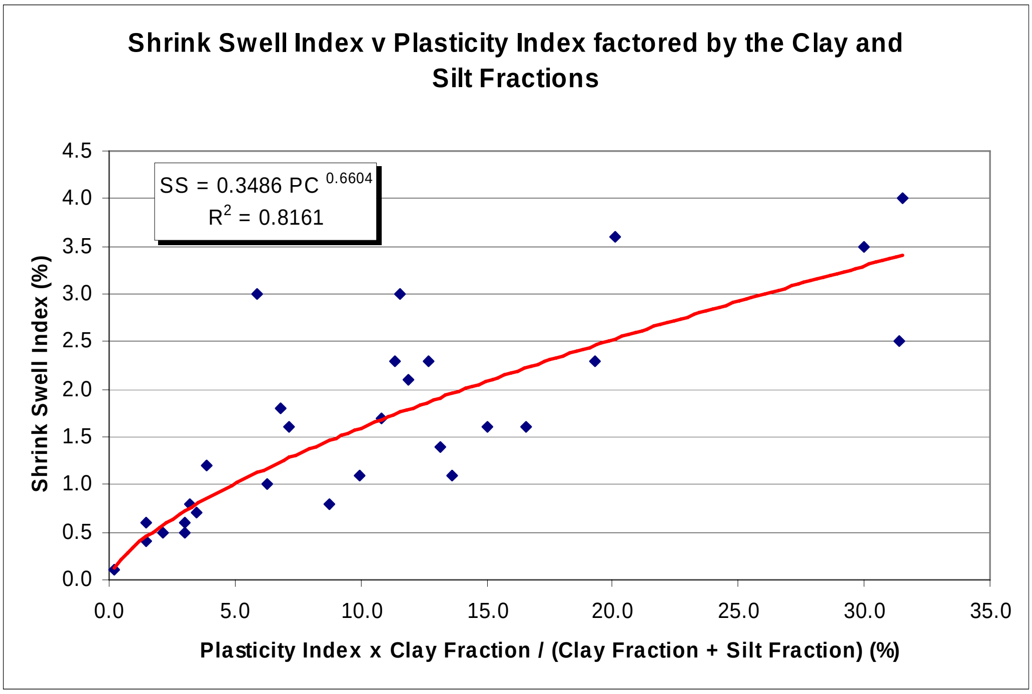


Table 5.7 - Calculation of the Plasticity Index factored by the Clay and Silt Fractions.

Report No.	Shrink Swell Index (%)	Plasticity Index (%)	Silt Fraction (%)	Clay Fraction (%)	PI x C/(C+S) (%)
050476	1.2	15	69	24	3.9
050477	4.0	42	24	72	32.5
050489	3.6	44	51	43	20.3
050490	2.3	38	62	31	12.7
050493	1.6	30	49	49	15.8
050494	3.0	23	67	23	5.7
050503	1.6	39	76	17	7.1
050504	1.0	38	71	14	5.7
050507	1.6	28	31	45	13.5
050518	0.6	30	71	8	2.6
050519	2.1	31	53	33	11.0
050526	2.3	31	34	56	18.7
050527	0.5	22	75	8	1.9
050530	3.0	43	68	25	11.6
050531	2.5	42	24	71	32.1
050541	1.1	36	59	36	13.9
050542	3.5	36	16	80	31.0
050544	0.8	23	52	32	7.9
050545	0.7	11	56	26	3.1
050547	0.1	1	61	14	0.2
050548	1.7	22	35	34	8.0
050549	0.6	5	45	19	1.0
050550	1.8	15	40	33	5.3
050551	1.4	28	45	40	12.0
050561	2.3	23	39	38	9.4
050562	0.8	30	76	9	2.9
050577	1.1	23	51	39	9.6
050578	0.5	23	80	12	3.0
050579	0.4	12	73	10	1.3

The equation for this correlation has been used to calculate the predicted values in Table 5.8. This table shows the actual shrink swell index value compared to the predicted value as calculated using the equation SS = 0.3486 $PC^{0.6604}$. The table also contains the difference between the actual value and the predicted one.

It can be observed from the values in this table that there is no pattern to the size of the difference and where it occurs.

Table 5.8 - Difference between the Shrink Swell Index and the Plasticity Index factored by the Clay and Silt Fractions.

Report No.	Classification	Shrink Swell Index (%)	0.3486 $PC^{0.6604}$	Difference
050547	ML	0.1	0.1	0.0
050579	CL	0.4	0.4	0.0
050527	CI	0.5	0.6	-0.1
050578	CI	0.5	0.7	-0.2
050518	CI	0.6	0.7	-0.1
050549	ML	0.6	0.5	0.1
050545	CL	0.7	0.8	-0.1
050544	CI	0.8	1.5	-0.7
050562	CI	0.8	0.7	0.1
050504	CH	1.0	1.2	-0.2
050541	CH	1.1	2.0	-0.9
050577	CI	1.1	1.6	-0.5
050476	CL	1.2	0.9	0.3
050551	CI	1.4	1.9	-0.5
050503	CH	1.6	1.3	0.3
050507	CI	1.6	2.2	-0.6
050493	CI	1.6	2.1	-0.5
050548	CI	1.7	1.7	0.0
050550	CL	1.8	1.2	0.6
050519	CI	2.1	1.8	0.3
050490	CH	2.3	1.9	0.4
050561	CI	2.3	1.7	0.6
050526	CI	2.3	2.5	-0.2
050531	CH	2.5	3.4	-0.9
050530	CH	3.0	1.8	1.2
050494	CI	3.0	1.1	1.9
050542	CH	3.5	3.3	0.2
050489	CH	3.6	2.5	1.1
050477	CH	4.0	3.4	0.6

5.5 Shrink Swell Index against the Linear Shrinkage

5.5.1 Relationship with the Linear Shrinkage

The relationship between the linear shrinkage properties and the shrink swell index for the samples tested are shown in Figure 5.10. The equation of the relationship is a power function and is:

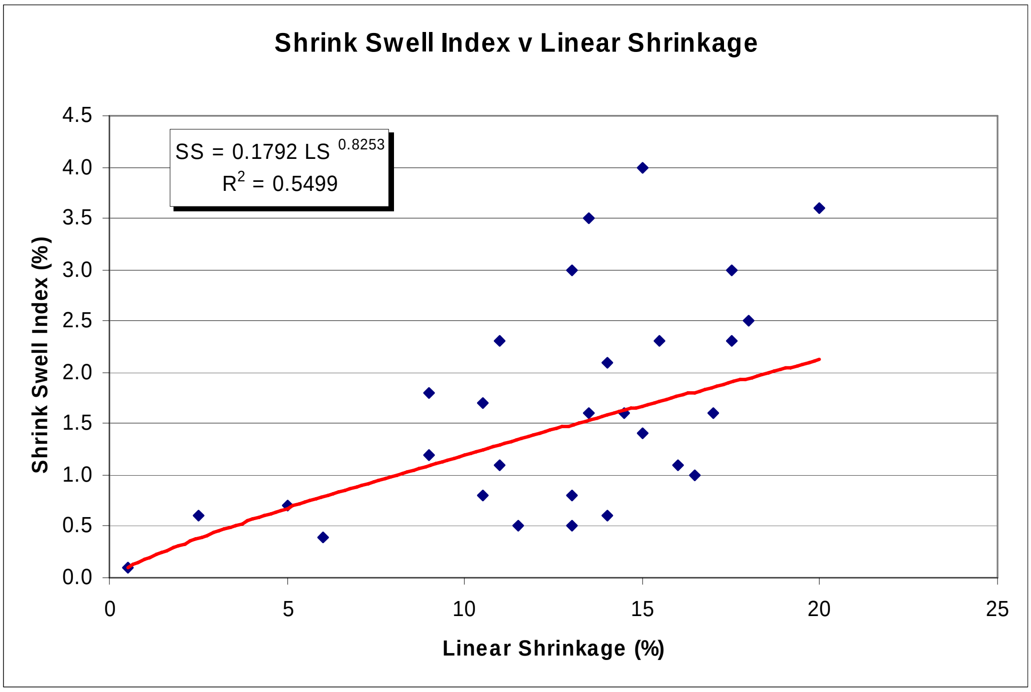
$$SS = 0.1792\ LS^{0.8253}$$

where: SS = Shrink Swell Index.

LS = Linear Shrinkage.

The strength of this correlation has a R^2 value of 0.55. This result can be considered poor and this equation should be avoided to estimate a shrink swell index.

Figure 5.10 - Graph of Shrink Swell Index versus the Linear Shrinkage.



5.5.2 Relationship with the Linear Shrinkage factored by the Clay Fraction

The calculation of the linear shrinkage multiplied by the clay fraction can be found in Table 5.9. The best trendline that fitted the plotted data is a power function. The equation of this function is:

$$SS = 0.6373\ LC^{0.6535}$$

where: SS = Shrink Swell Index.

LC = Linear Shrinkage x Clay Fraction.

The strength of this correlation is good with an accuracy rate of 81.2%. This relationship exceeds the criteria set for an equation to provide reliable results. As the strength is reasonably strong this equation could be considered a useful tool to assist in estimating the shrink swell index for a soil using these test results.

Figure 5.11 - Graph of Shrink Swell Index versus Linear Shrinkage factored by the Clay Fraction.

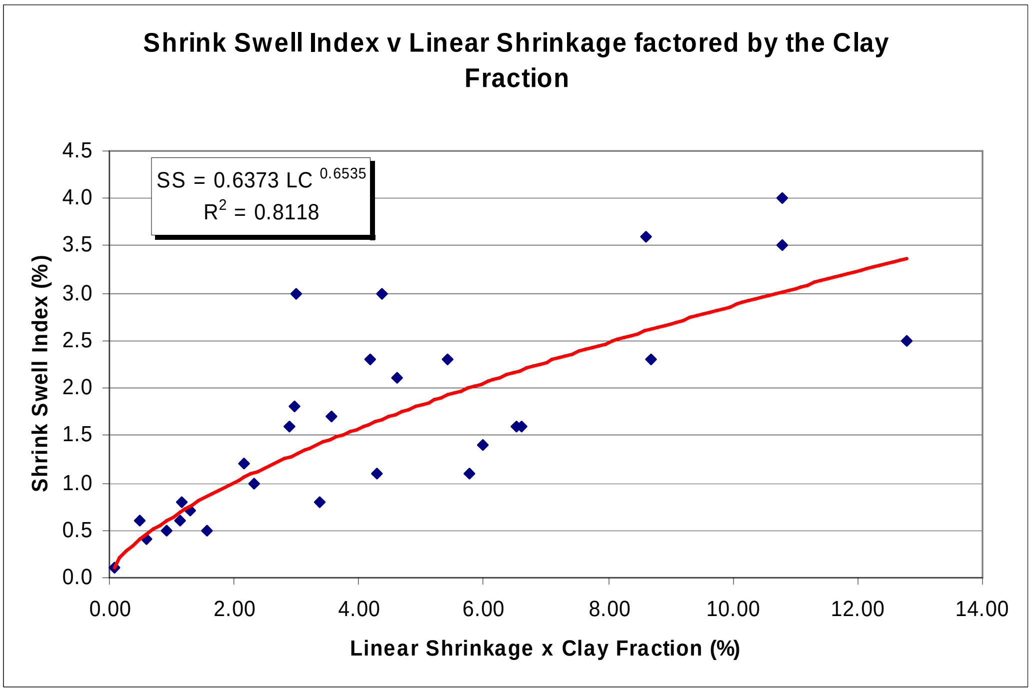


Table 5.9 - Calculation of the Linear Shrinkage factored by the Clay Fraction.

Report No.	Shrink Swell Index (%)	Linear Shrinkage (%)	Clay Fraction (%)	LS x C (%)
050476	1.2	9	24	2.2
050477	4.0	15	72	10.8
050489	3.6	20	43	8.6
050490	2.3	17.5	31	5.4
050493	1.6	13.5	49	6.6
050494	3.0	13	23	3.0
050503	1.6	17	17	2.9
050504	1.0	16.5	14	2.3
050507	1.6	14.5	45	6.5
050518	0.6	14	8	1.1
050519	2.1	14	33	4.6
050526	2.3	15.5	56	8.7
050527	0.5	11.5	8	0.9
050530	3.0	17.5	25	4.4
050531	2.5	18	71	12.8
050541	1.1	16	36	5.8
050542	3.5	13.5	80	10.8
050544	0.8	10.5	32	3.4
050545	0.7	5	26	1.3
050547	0.1	0.5	14	0.1
050548	1.7	10.5	34	3.6
050549	0.6	2.5	19	0.5
050550	1.8	9	33	3.0
050551	1.4	15	40	6.0
050561	2.3	11	38	4.2
050562	0.8	13	9	1.2
050577	1.1	11	39	4.3
050578	0.5	13	12	1.6
050579	0.4	6	10	0.6

The equation for this correlation has been used to calculate the predicted values in Table 5.10. This table shows the actual shrink swell index value compared to the predicted value as calculated using the equation SS = 0.6373 $LC^{0.6535}$. The table also contains the difference between the actual value and the predicted one.

It can be observed from the values in this table that there is no pattern to the size of the difference and where it occurs.

Table 5.10 - Difference between the Shrink Swell Index and the Linear Shrinkage factored by the Clay Fraction.

Report No.	Classification	Shrink Swell Index (%)	0.3486 $LC^{0.6535}$	Difference
050547	ML	0.1	0.1	0.0
050579	CL	0.4	0.5	-0.1
050527	CI	0.5	0.6	-0.1
050578	CI	0.5	0.9	-0.4
050518	CI	0.6	0.7	-0.1
050549	ML	0.6	0.4	0.2
050545	CL	0.7	0.8	-0.1
050544	CI	0.8	1.4	-0.6
050562	CI	0.8	0.7	0.1
050504	CH	1.0	1.1	-0.1
050541	CH	1.1	2.0	-0.9
050577	CI	1.1	1.7	-0.6
050476	CL	1.2	1.1	0.1
050551	CI	1.4	2.1	-0.7
050503	CH	1.6	1.3	0.3
050507	CI	1.6	2.2	-0.6
050493	CI	1.6	2.2	-0.6
050548	CI	1.7	1.5	0.2
050550	CL	1.8	1.3	0.5
050519	CI	2.1	1.7	0.4
050490	CH	2.3	1.9	0.4
050561	CI	2.3	1.6	0.7
050526	CI	2.3	2.6	-0.3
050531	CH	2.5	3.4	-0.9
050530	CH	3.0	1.7	1.3
050494	CI	3.0	1.3	1.7
050542	CH	3.5	3.0	0.5
050489	CH	3.6	2.6	1.0
050477	CH	4.0	3.0	1.0

5.5.3 Relationship with the Linear Shrinkage factored by the Clay and Silt Fractions

The results for the calculations of the linear shrinkage multiplied by the clay fraction and divided by the total of clay and silt fraction are in Table 5.11. The resulting trendline is a power function and has a predictive accuracy of 81.7%.

The trendline to predict the shrink swell index can be found in Figure 5.12 and the equation of this line is:

$$SS = 0.5508\ LCS^{0.6894}$$

where: SS = Shrink Swell Index.

LCS = Linear Shrinkage x Clay Fraction / (Clay Fraction + Silt Fraction).

The strength of this correlation can be considered satisfactory and has exceeded the criteria initially set for an equation to provide reliable results. As the strength is reasonably strong this equation could be considered a useful tool to assist in estimating the shrink swell index for a soil using these test results.

Figure 5.12 - Graph of Shrink Swell Index versus Linear Shrinkage factored by the Clay and Silt Fractions.

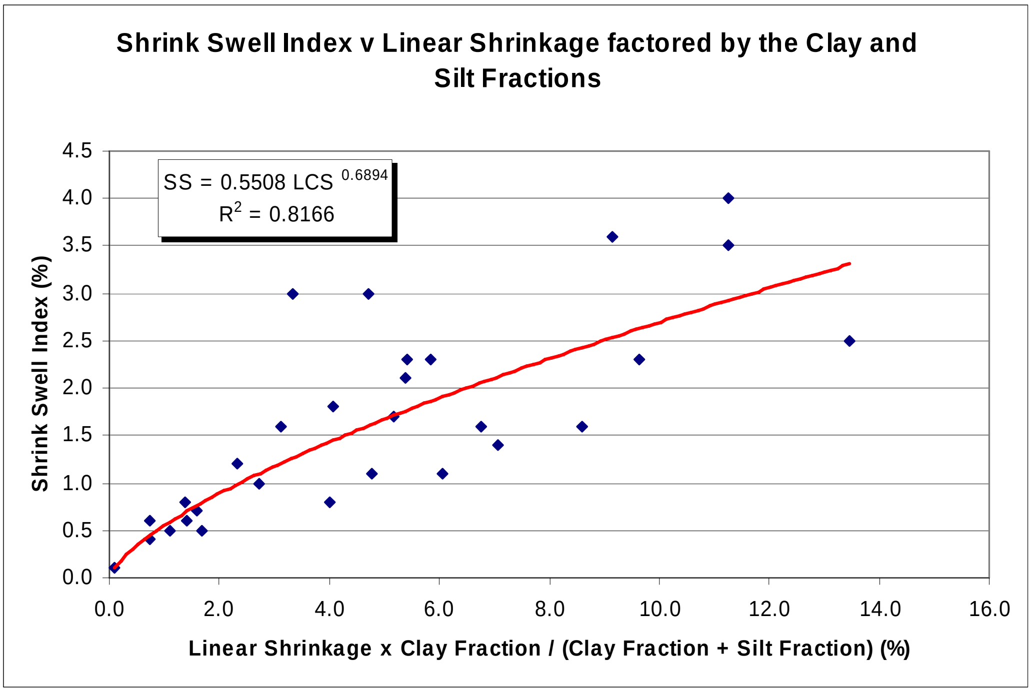


Table 5.11 - Calculation of the Linear Shrinkage factored by the Clay and Silt Fractions.

Report No.	Shrink Swell Index (%)	Linear Shrinkage (%)	Silt Fraction (%)	Clay Fraction (%)	LS x C/(C+S) (%)
050476	1.2	9	69	24	2.3
050477	4.0	15	24	72	11.3
050489	3.6	20	51	43	9.1
050490	2.3	17.5	62	31	5.8
050493	1.6	13.5	49	49	6.8
050494	3.0	13	67	23	3.3
050503	1.6	17	76	17	3.1
050504	1.0	16.5	71	14	2.7
050507	1.6	14.5	31	45	8.6
050518	0.6	14	71	8	1.4
050519	2.1	14	53	33	5.4
050526	2.3	15.5	34	56	9.6
050527	0.5	11.5	75	8	1.1
050530	3.0	17.5	68	25	4.7
050531	2.5	18	24	71	13.5
050541	1.1	16	59	36	6.1
050542	3.5	13.5	16	80	11.3
050544	0.8	10.5	52	32	4.0
050545	0.7	5	56	26	1.6
050547	0.1	0.5	61	14	0.1
050548	1.7	10.5	35	34	5.2
050549	0.6	2.5	45	19	0.7
050550	1.8	9	40	33	4.1
050551	1.4	15	45	40	7.1
050561	2.3	11	39	38	5.4
050562	0.8	13	76	9	1.4
050577	1.1	11	51	39	4.8
050578	0.5	13	80	12	1.7
050579	0.4	6	73	10	0.7

The equation for this correlation has been used to calculate the predicted values in Table 5.12. This table shows the actual shrink swell index value compared to the predicted value as calculated using the equation SS = 0.5508 $LCS^{0.6894}$. The table also contains the difference between the actual value and the predicted one.

It can be observed from the values in this table that there is no pattern to the size of the difference and where it occurs.

Table 5.12 - Difference between the Shrink Swell Index and the Linear Shrinkage factored by the Clay and Silt Fractions.

Report No.	Classification	Shrink Swell Index (%)	0.5508 $LCS^{0.6894}$	Difference
050547	ML	0.1	0.1	0.0
050579	CL	0.4	0.4	0.0
050527	CI	0.5	0.6	-0.1
050578	CI	0.5	0.8	-0.3
050518	CI	0.6	0.7	-0.1
050549	ML	0.6	0.4	0.2
050545	CL	0.7	0.8	-0.1
050544	CI	0.8	1.4	-0.6
050562	CI	0.8	0.7	0.1
050504	CH	1.0	1.1	-0.1
050541	CH	1.1	1.9	-0.8
050577	CI	1.1	1.6	-0.5
050476	CL	1.2	1.0	0.2
050551	CI	1.4	2.1	-0.7
050503	CH	1.6	1.2	0.4
050507	CI	1.6	2.4	-0.8
050493	CI	1.6	2.1	-0.5
050548	CI	1.7	1.7	0.0
050550	CL	1.8	1.4	0.4
050519	CI	2.1	1.8	0.3
050490	CH	2.3	1.9	0.4
050561	CI	2.3	1.8	0.5
050526	CI	2.3	2.6	-0.3
050531	CH	2.5	3.3	-0.8
050530	CH	3.0	1.6	1.4
050494	CI	3.0	1.3	1.7
050542	CH	3.5	2.9	0.6
050489	CH	3.6	2.5	1.1
050477	CH	4.0	2.9	1.1

5.6 Shrink Swell Index against the Clay Fraction

During the testing regime the percentage of clay was determined using the hydrometer test. The shrink swell index of a soil is strongly dependent on the type and percentage of clay present in the soil.

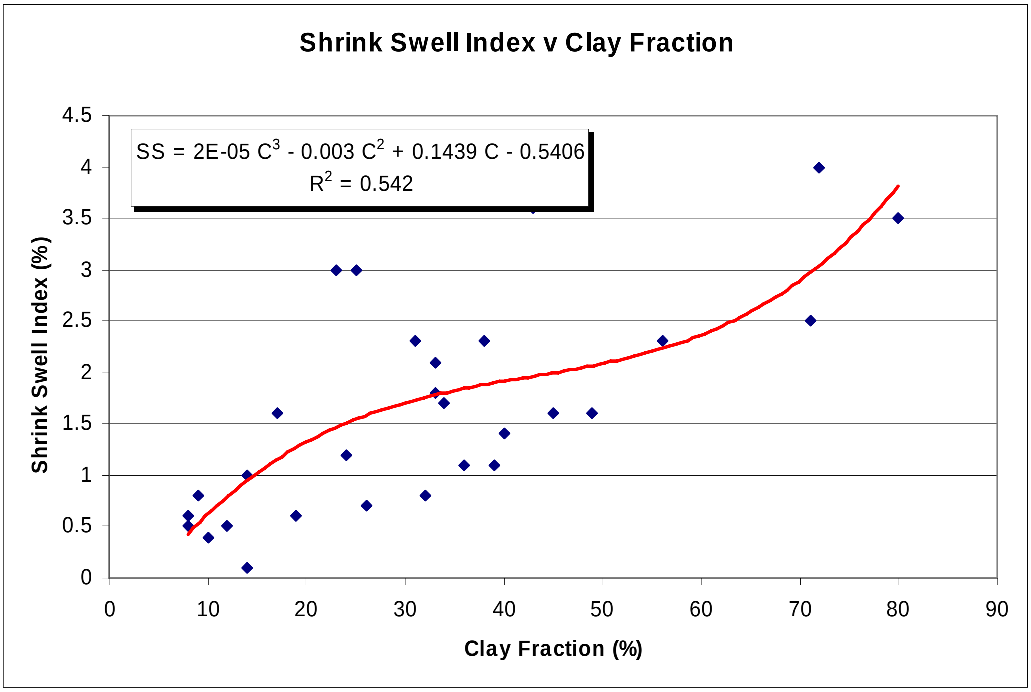
Although clay is not an atterberg limit it was decided to determine if a correlation does exist between these two properties for the soil. The plotted data can be found in Figure 5.13 and the trendline for this data is poor with prediction strength of 0.542. The equation for this relationship is:

$$SS = 2 \times 10^{-5}\, C^3 - 0.003\, C^2 + 0.1439\, C - 0.5406$$

where: SS = Shrink Swell Index.

C = Clay Fraction.

Figure 5.13 - Graph of Shrink Swell Index versus the Clay Fraction.



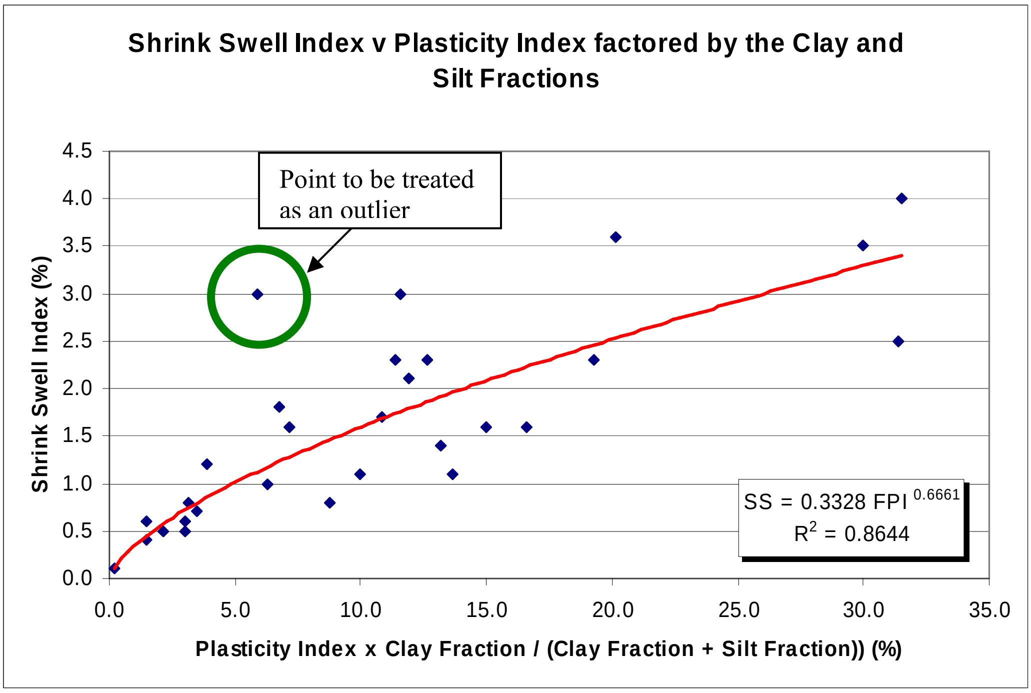
5.7 Improving Correlations

As this research is trying to determine if there is a correlation between the shrink swell index and the atterberg limits it was decided to analyse the data and trendline of the strongest correlation to investigate whether this result could be improved.

Looking at the spread of the data one point appeared to be an outlier. It was decided to re-calculate the trendline and not include this point, which is deemed to be an outlier to determine if this had a major effect on the relationship. The graph of this correlation is shown in Figure 5.14 and with the outlier removed the strength of the relationship has increased to a R^2 value of 0.864. The strength of the correlation with this outlier included was 0.816. By treating this point as an outlier has improved the correlation substantially.

For this point to be treated as an outlier it is recommended that the test for this site be undertaken again to confirm the results found for this soil. If the retested results are the same as the current results, then this point should remain and this point included in the analysis. If the retest indicates that there is a variation in the results then the new results should be included and the previous results be discarded.

Figure 5.14 - Graph ignoring one outlier.



Chapter 6: Conclusion

6.1 Major Outcomes and Key Findings

The preceding chapters have outlined the sampling, testing and analysis methods undertaken to determine if a correlation exists between the shrink swell index and any of the atterberg limits, linear shrinkage and percentage of clay for soils within the Geological profile known as the Pleistocene Quaternary Shepparton Formation.

This investigation should be considered as only an initial investigation as it is based on 29 soil samples that have been collected and tested originating from the Goulburn and Murray Valley Regions of North Central Victoria. It should be noted that in this research for a correlation to be deemed as a useful estimating tool for the engineering profession the R^2 criteria of 0.80 had to be achieved.

The two properties that provide an acceptable correlation is the plasticity index and linear shrinkage which have been modified by both the percentage of clay and silt particles present in the soil. The correlation against the liquid limit, plastic limit and percentage of clay should not be used to estimate the shrink swell index for a soil.

There are four equations which can be used to estimate the shrink swell index which are:

1. $SS = 0.4119\ FPI^{0.6251}$ ($R^2 = 0.81$)

   where: SS = Shrink Swell Index.
   FPI = Plasticity Index x Clay Fraction.

2. $SS = 0.3486\ PC^{0.6604}$ ($R^2 = 0.82$)

   where: SS = Shrink Swell Index.
   PC = Plasticity Index x Clay Fraction / (Clay Fraction + Silt Fraction).

3. $SS = 0.6373\ LC^{0.6535}$ ($R^2 = 0.81$)

   where: SS = Shrink Swell Index.
   LC = Linear Shrinkage x Clay Fraction.

4. $SS = 0.5508\ LCS^{0.6894}$ ($R^2 = 0.82$)

   where: SS = Shrink Swell Index.
   LCS = Linear Shrinkage x Clay Fraction / (Clay Fraction + Silt Fraction).

6.2 Recommendations for Further Work

Through this research it has become apparent that it may be possible to improve these correlations and a summary of topics for further research and study is provided below.

- If a greater accuracy of $R^2 = 0.80$ is required then additional sampling and testing should be performed to minimise the effect of any possible outliers that may be present.

- An investigation into whether a correlation exists between the shrink swell index and the plasticity index or linear shrinkage using each particular clay type as the basis for this analysis.

One possible research project that could be undertaken as result of this project is to determine whether a correlation exists for reworked samples of soils from within this formation as this project concentrated on only natural undisturbed samples.

This project has concentrated on soils from the Shepparton Formation in regards to determining if any correlations existed. Future work could be taken using similar analysis techniques for other Geological Formations.

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Appendix A – Project Specification

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

ENG 4111/4112 Research Project
PROJECT SPECIFICATION

FOR:	**DAVID EARL**
TOPIC:	DETERMINE IF THERE IS A CORRELATION BETWEEN THE SHRINK/SWELL TEST AND ATTERBERG TEST FOR SOILS FROM THE SHEPPARTON FORMATION
SUPERVISOR:	Dr. Richard Merifield
ASSOCIATE SUPERVISOR:	Mr. Damien Byrne
PROJECT AIM:	This project seeks to investigate and determine if there is a relationship between the results from the shrink/swell test and atterberg test for soils within the Shepparton formation.
SPONSORSHIP:	BM Consulting Civil Engineers Pty Ltd.

PROGRAMME: **Issue A, 11 March 2005**

1. Research the background information relating to any comparisons between shrink/swell test and atterberg test.
2. Design a sampling program for the collection of various soil types.
3. Conduct laboratory tests on the soil samples to determine shrink/swell value, atterberg limits and particle sieve analysis.
4. Classify each of the soil types in accordance with Table A1 of AS 1726-1993.
5. Analyse and evaluate the test results to determine if there is any correlation between the shrink/swell test and any of the atterberg properties.

As time permits:

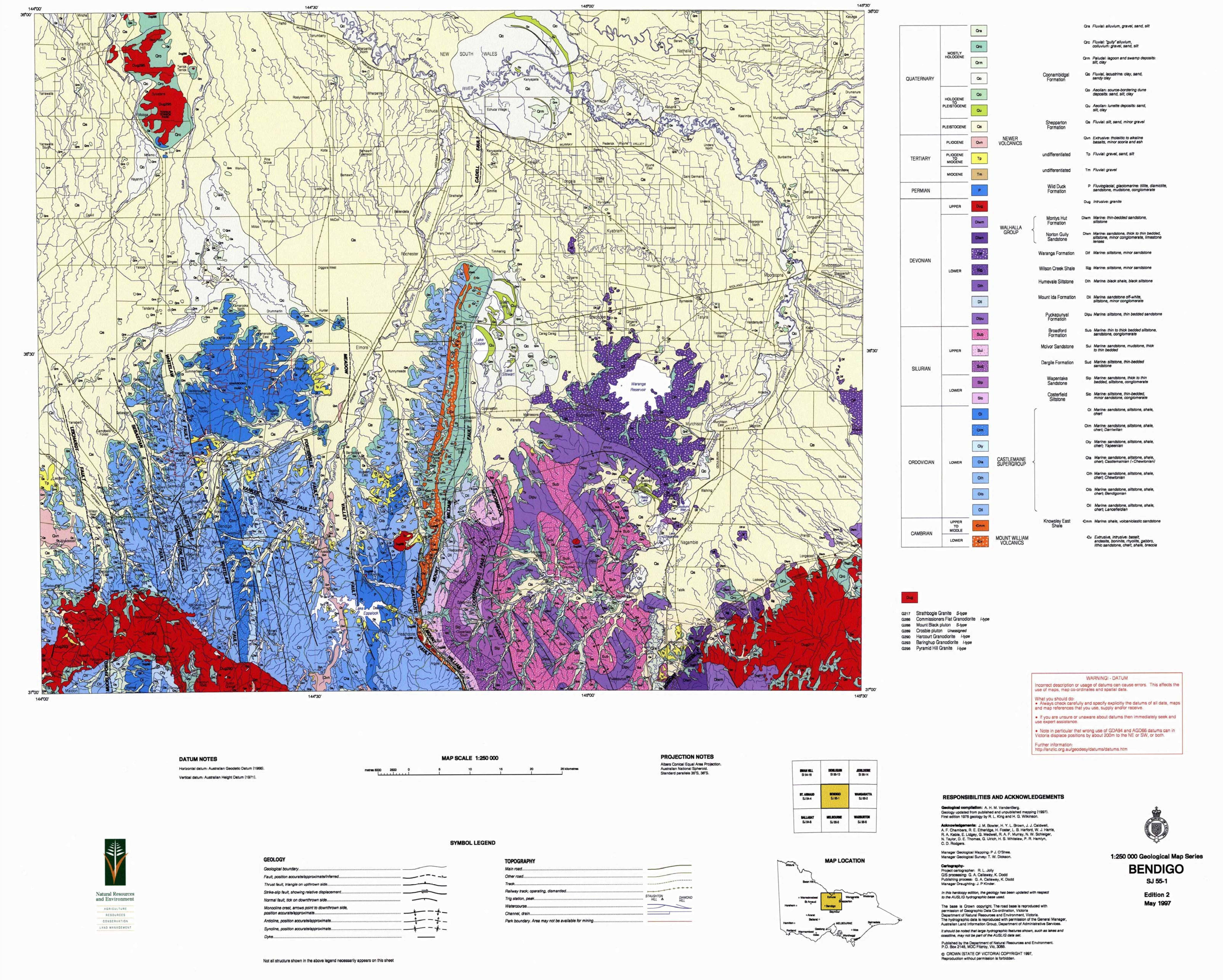
6. Obtain additional samples to be tested and analyised.
7. Using the information from the sieve analysis determine if this has an impact on the relationship between the two tests being compared.

AGREED:

_______________ (Student) _______________ (Supervisor)

21 / 3 / 05 7 / 4 / 05

Appendix B – Geological Maps



144°00'
144°30'
145°00'
145°30'
36°00'
36°30'
37°00'
NEW SOUTH WALES
Warranga Reservoir
QUATERNARY
MOSTLY HOLOCENE
HOLOCENE TO PLEISTOCENE
PLEISTOCENE
TERTIARY
PLIOCENE
PLIOCENE TO MIOCENE
MIOCENE
PERMIAN
DEVONIAN
UPPER
LOWER
SILURIAN
ORDOVICIAN
CAMBRIAN
UPPER TO MIDDLE
Qra Fluvial: alluvium, gravel, sand, silt
Qrc Fluvial: "gully" alluvium, colluvium: gravel, sand, silt
Qrm Paludal: lagoon and swamp deposits: silt, clay
Coonambidgal Formation
Qc Fluvial, lacustrine: clay, sand, sandy clay
Qo Aeolian: source-bordering dune deposits: sand, silt, clay
Qu Aeolian: lunette deposits: sand, silt, clay
Shepparton Formation
Qs Fluvial: silt, sand, minor gravel
NEWER VOLCANICS
Qvn Extrusive: tholeiitic to alkaline basalts, minor scoria and ash
undifferentiated
Tp Fluvial: gravel, sand, silt
undifferentiated
Tm Fluvial: gravel
Wild Duck Formation
P Fluvioglacial, glaciomarine: tillite, diamictite, sandstone, mudstone, conglomerate
Dug Intrusive: granite
WALHALLA GROUP
Montys Hut Formation
Dlwm Marine: thin-bedded sandstone, siltstone
Norton Gully Sandstone
Dlwn Marine: sandstone, thick to thin bedded, siltstone, minor conglomerate, limestone lenses
Waranga Formation
Dlf Marine: siltstone, minor sandstone
Wilson Creek Shale
Slg Marine: siltstone, minor sandstone
Humevale Siltstone
Dlh Marine: black shale, black siltstone
Mount Ida Formation
Dli Marine: sandstone off-white, siltstone, minor conglomerate
Puckapunyal Formation
Dlpu Marine: siltstone, thin bedded sandstone
Broadford Formation
Sub Marine: thin to thick bedded siltstone, sandstone, conglomerate
McIvor Sandstone
Sui Marine: sandstone, mudstone, thick to thin bedded
Dargile Formation
Sud Marine: siltstone, thin-bedded sandstone
Wapentake Sandstone
Slp Marine: sandstone, thick to thin bedded, siltstone, conglomerate
Costerfield Siltstone
Slc Marine: siltstone, thin-bedded, minor sandstone, conglomerate
CASTLEMAINE SUPERGROUP
Ol Marine: sandstone, siltstone, shale, chert
Olm Marine: sandstone, siltstone, shale, chert; Darriwilian
Oly Marine: sandstone, siltstone, shale, chert; Yapeenian
Ola Marine: sandstone, siltstone, shale, chert; Castlemainian (+Chewtonian)
Olh Marine: sandstone, siltstone, shale, chert; Chewtonian
Olb Marine: sandstone, siltstone, shale, chert; Bendigonian
Oll Marine: sandstone, siltstone, shale, chert; Lancefieldian
Knowsley East Shale
Ꞓmm Marine: shale, volcaniclastic sandstone
MOUNT WILLIAM VOLCANICS
Ꞓv Extrusive, intrusive: basalt, andesite, boninite, rhyolite, gabbro, lithic sandstone, chert, shale, breccia
Dug
G217 Strathbogie Granite S-type
G286 Commissioners Flat Granodiorite I-type
G288 Mount Black pluton S-type
G289 Crosbie pluton Unassigned
G290 Harcourt Granodiorite I-type
G293 Baringhup Granodiorite I-type
G295 Pyramid Hill Granite I-type
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Further information:
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DATUM NOTES
Horizontal datum: Australian Geodetic Datum (1966).
Vertical datum: Australian Height Datum (1971).
MAP SCALE 1:250 000
metres 5000 2500 0 5 10 15 20 25 kilometres
PROJECTION NOTES
Albers Conical Equal Area Projection.
Australian National Spheroid.
Standard parallels 35°S, 38°S.
MAP LOCATION
Natural Resources and Environment
AGRICULTURE
RESOURCES
CONSERVATION
LAND MANAGEMENT
SYMBOL LEGEND
GEOLOGY
Geological boundary
Fault, position accurate/approximate/inferred
Thrust fault, triangle on upthrown side
Strike-slip fault, showing relative displacement
Normal fault, tick on downthrown side
Monocline crest, arrows point to downthrown side, position accurate/approximate
Anticline, position accurate/approximate
Syncline, position accurate/approximate
Dyke
TOPOGRAPHY
Main road
Other road
Track
Railway track; operating, dismantled
Trig station, peak
STAUGHTON HILL
DIAMOND HILL
Watercourse
Channel, drain
Park boundary. Area may not be available for mining
Not all structure shown in the above legend necessarily appears on this sheet
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Geological compilation: A. H. M. VandenBerg.
Geology updated from published and unpublished mapping (1997).
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Manager Geological Mapping: P J. O'Shea.
Manager Geological Survey: T. W. Dickson.
Cartography-
Project cartographer: R. L. Jolly
GIS processing: G. A. Callaway, K. Dodd
Publishing process: G. A. Callaway, K. Dodd
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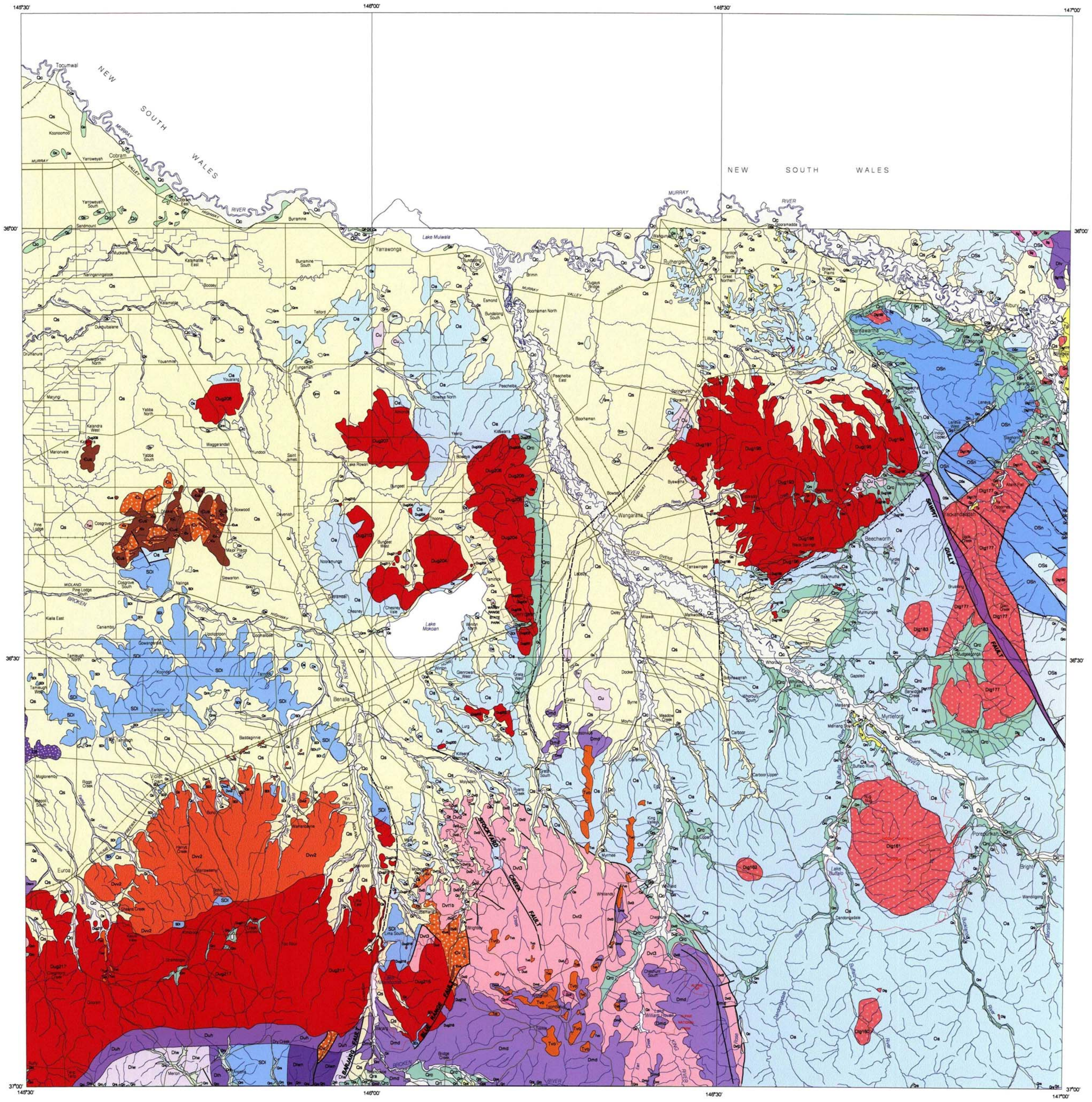
1:250 000 Geological Map Series
BENDIGO
SJ 55-1
Edition 2
May 1997



QUATERNARY	MOSTLY HOLOCENE	Qra			Qra *Fluvial: alluvium, gravel, sand, silt*
		Qrc			Qrc *Fluvial: "gully" alluvium, colluvium: gravel, sand, silt*
		Qrm			Qrm *Paludal: lagoon and swamp deposits: silt, clay*
		Qrt			Qrt *Fluvial: alluvial terraces: gravel, sand, silt*
		Qc		Coonambidgal Formation	Qc *Fluvial, lacustrine: clay, sand, sandy clay*
	HOLOCENE TO PLEISTOCENE	Qo			Qo *Aeolian: source-bordering dune deposits: sand, silt, clay*
	PLEISTOCENE	Qpa			Qpa *Fluvial: gravel, sand, silt*
		Qs		Shepparton Formation	Qs *Fluvial: silt, sand, minor gravel*
TERTIARY	PLIOCENE	Qvn	NEWER VOLCANICS		Qvn *Extrusive: tholeiitic to alkaline basalts, minor scoria and ash*
	PLIOCENE TO MIOCENE	Tp		undifferentiated	Tp *Fluvial: gravel, sand, silt*
	EOCENE TO OLIGOCENE	Tvo	OLDER VOLCANICS		Tvo *Extrusive: tholeiitic and minor alkaline basalts*
CARBONIFEROUS	UPPER	Cu		Boorhaman Conglomerate	Cu *Fluvioglacial, glaciomarine: tillite, diamictite, sandstone, mudstone, conglomerate*
DEVONIAN	UPPER	Dmd	MANSFIELD GROUP	Devils Plain Formation	Dmd *Fluvial: red mudstone, sandstone, conglomerate*
		Dmt		Timbertop Conglomerate	Dmt *Fluvial: cobble conglomerate, pebbly sandstone cross bedded sandstone*
		Duh			Duh *Metamorphic: hornfels*
		Dud			Dud *Intrusive: felsic dykes*
		Dug			Dug *Intrusive: granite*
		Dvt3	TOLMIE IGNEOUS COMPLEX	Toombullup Formation	Dvt3 *Extrusive: rhyolite and rhyodacite ignimbrite, welded*
		Dvt2		Ryans Creek Rhyolite	Dvt2 *Extrusive: rhyolite ignimbrite, welded to recrystallized*
		Dvt1b		Hollands Creek Rhyodacite	Dvt1b *Extrusive: rhyolite to rhyodacite ignimbrite, welded*
		Dvv2	VIOLET TOWN VOLCANICS	unnamed	Dvv2 *Extrusive: rhyodacite ignimbrite*
		Dvv1		unnamed	Dvv1 *Extrusive: rhyolite ignimbrite*
	LOWER	Dlw	WALHALLA GROUP		Dlw *Marine: undifferentiated: sandstone, mudstone, minor conglomerate*
		Dlwm		Montys Hut Formation	Dlwm *Marine: thin-bedded sandstone siltstone*
		Dlwn		Norton Gully Sandstone	Dlwn *Marine: sandstone, thick to thin bedded, siltstone, minor conglomerate, limestone lenses*
		Dlh		Humevale Siltstone	Dlh *Marine: siltstone, minor sandstone*
		Dlv		unnamed	Dlv *Extrusive/fluvial: rhyolitic ignimbrite, lava, quartzite*
		Dlf		Waranga Formation	Dlf *Marine: siltstone, minor sandstone*
		Dlg		unnamed	Dlg *Intrusive: granite*
SILURIAN TO DEVONIAN		SDl		undifferentiated	SDl *Marine: sandstone, siltstone*
SILURIAN	LOWER	Sg		unnamed	Sg *Intrusive: granite*
		Sy			Sy *mylonite, fault rock*
ORDOVICIAN	LOWER	OSn	OMEO METAMORPHIC COMPLEX		OSn *Metamorphic: gneiss*
		OSs			OSs *Metamorphic: schist, spotted schist, phyllite*
		Oa	ADAMINABY GROUP	Pinnak Sandstone	Oa *Marine: sandstone, mudstone, siltstone, minor chert*
CAMBRIAN	UPPER TO MIDDLE	Ꞓus		undifferentiated sediments	Ꞓus *Marine: chert, volcaniclastic sandstone, mudstone, limestone*
	LOWER	Ꞓv			Ꞓv *Extrusive, intrusive: basalt, andesite, gabbro, lithic sandstone, chert, shale, breccia*

Dug

G193	Woolshed Valley Granite	*I-type*
G194	Morilla Granite	*I-type*
G195	Beechworth Granite	*I-type*
G196	Golden Ball Adamellite	*I-type*
G197	Byawatha Granite	*I-type*
G198	Everton Granodiorite	*I-type*
G199	Murmungee Granite	*I-type*
G200	Lurg Granite	*Unassigned*
G201	Kelly Gap Granite	*Unassigned*
G202	Glenrowan Granite	*Unassigned*
G203	Warby Springs Granite	*S-type*
G204	Taminick Gap Granite	*Unassigned*
G205	Mount Bruno Granite	*I-type*
G206	Killawarra Granite	*Unassigned*
G207	Almonds Granite	*I-type*
G208	Youarang Granite	*Unassigned*
G209	Katandra Granite	*Unassigned*
G210	Bungeet West Granite	*Unassigned*
G211	Chesney Vale Granite	*Unassigned*
G215	Swanpool Granite	*Unassigned*
G216	Barjarg Granodiorite	*S-type*
G217	Strathbogie Granodiorite	*S-type*

Dlg

G160	Mount Angus	*I-type*
G161	Mount Buffalo	*Unassigned*
G162	Mount Emu Adamellite	*Unassigned*
G176	Baranduda Granite	*Unassigned*
G177	Yackandandah Granite	*I-type*
G180	Kergunyah Granite	*Unassigned*
G182	Lady Franklin Granite	*Unassigned*
G183	Mount Stanley Granite	*Unassigned*

Sg

G175	Bethanga Gneiss

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metres 5000 2500 0 5 10 15 20 25 kilometres

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Standard parallels 35°S, 38°S.

INDEX TO ADJOINING MAPS

DENILIQUIN SI 55-13	JERILDERIE SI 55-14	WAGGA WAGGA SI 55-15
BENDIGO SJ 55-1	WANGARATTA SJ 55-2	TALLANGATTA SJ 55-3
MELBOURNE SJ 55-5	WARBURTON SJ 55-6	BAIRNSDALE SJ 55-7

Natural Resources and Environment
AGRICULTURE
RESOURCES
CONSERVATION
LAND MANAGEMENT

SYMBOL LEGEND

GEOLOGY

- *Geological boundary*
- *Fault, position accurate/approximate/inferred*
- *Thrust fault, triangle on upthrown side*
- *Strike-slip fault, showing relative displacement*
- *Normal fault, tick on downthrown side*
- *Monocline crest, arrows point to downthrown side, position accurate/approximate*
- *Anticline, position accurate/approximate*
- *Syncline, position accurate/approximate*

TOPOGRAPHY

- *Main road*
- *Other road*
- *Track*
- *Railway track; operating, dismantled*
- *Trig station, peak* (STAUGHTON HILL, DIAMOND HILL)
- *Watercourse*
- *Channel, drain*
- *Park boundary. Area may not be available for mining*

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MAP LOCATION

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Manager Geological Mapping: P. J. O'Shea.
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WANGARATTA

AND PART OF JERILDERIE

SJ 55-2

Edition 2
May 1997

Appendix C – Risk Assessment for Drilling Rig

Risk Assessment using the Drilling Rig

In assessing a risk for a hazard table C.1 provides a legend that is used for assessing a risk.

Table C.1: Risk Classification Legend

Level of Risk	Consequences		
	Major	**Moderate**	**Minor**
Conceivable but very unlikely	L	L	L
Possible but unlikely	M	L	L
Possible	H	M	L
Might well be expected	H	H	M

L =Business as usual M = Heightened action H = Immediate action

Table C.2: Risk Assessment whilst using the drilling rig.

Work Description	Potential Hazardous Outcomes	Risk Classification	Controls to be Implemented
Towing drilling Rig and equipment to site	Road Accident	**M**	Maintain towing vehicle and drilling-trailers. Lights and trailer brakes to comply with VicRoads Regulations. Driver of adequate driving and towing experience. Road Laws to be adhered to and defensive driving techniques used.
Drilling Rig: Fuelling	Fire	**L**	Fuel up in clear areas. Operational Fire extinguisher on board both rigs. Engines switched off. Fuel up at service station. Use rig with long range tank with gauge and refuel off site. Engines switched off
Drilling Rig: Setting up	Electrocution	**L**	Working to cease during electrical storms. Site has been inspected for overhead powerlines and there are none in the drilling area. Travel between drill sites with the mast lowered.
Drilling Rig: Setting up	Unstable ground support	**L**	Site has been cultivated but drill support rams and connection to vehicle will provide adequate support.
Drilling Rig: Setting up	Crushing during raising of mast	**L**	Body parts clear of machinery during mast raising. No spectators within 6.0m.

Work Description	Potential Hazardous Outcomes	Risk Classification	Controls to be Implemented
Drilling Rig : Setting Up	Distractions due to livestock	**L**	Confirm absence of livestock on the property. Otherwise drilling is not to proceed.
Drilling and sampling operations: Work area	Loss of footing	**L**	Operator in approved footwear. Work area kept clear of obstacles. Visitors kept clear of work area and inducted as to safe standing areas and setback distances. Clear area of loose debris fill, remove loose timber or debris from the area.
Drilling and sampling operations: Lifting	Back Injury Minor abrasions	**M**	Maximum bit manual lift is 2.0m length. Bits stored and replaced on the trailer deck at waist height. Riggers gloves to be worn. Operators have green card OH&S training.
Drilling and sampling operations: Noise, dust and grit, falling objects.	Harm to drilling personnel	**M**	Operators have green card OH&S training. Operators carry Company Safety Pack containing Ear muffs (class 5), ear plugs, safety glasses, safety vest, sunhat, UV blockout, insect repellent and riggers gloves.
Drilling and sampling operations: Exposure to weather.	Harm to drilling personnel	**M**	As above. Drilling operations cease in heavy rain.
Drilling and sampling operations: Rotation of drill bits.	Entanglement	**L**	Operator has short hair. Company issue clothing is not loose. Loose clothing not to be worn. Loose jewellery and rings recommended not to be worn. Drills are fitted with deadman controls. Operators do not smoke.

Work Description	Potential Hazardous Outcomes	Risk Classification	Controls to be Implemented
			Observe set back for visitors. Remove soil from auger only when rotation has ceased.
Drilling Rig Unattended	Injury to tampering vandals	**L**	Site is remote. Remove key as drill is not startable without key. Only left unattended in instance of severe mechanical failure. Recovery instigated immediately.
Environmental Risk: Interception of aquifer	Contamination or short circuiting of aquifer(s).	**L**	Drilling is shallow and previous in surrounding areas indicates no sign of aquifers. In event plug as per drillers guide using bentonite or cementitious slurry.
Environmental Risk: Petrochemical contamination	Fuel spillage grease /oil leaks.	**L**	Rig kept clean of excess grease and oil leakage. Appropriate pouring devices used for fuel filling in small rig. Larger rig will most likely be used and has large capacity tank requiring no on-site filling.

Appendix D – Risk Assessment for Laboratory Work

Risk Assessment whilst working in the Laboratory

In assessing a risk for a hazard table D.1 provides a legend that is used for assessing a risk.

Table D.1: Risk Classification Legend

Level of Risk	**Consequences**		
	Major	**Moderate**	**Minor**
Conceivable but very unlikely	L	L	L
Possible but unlikely	M	L	L
Possible	H	M	L
Might well be expected	H	H	M

L =Business as usual M = Heightened action H = Immediate action

Table D.2: Risk Assessment whilst performing tests in the laboratory.

Work Description	Potential Hazardous Outcomes	Risk Classification	Controls to be Implemented
Sample Preparation: Moving of samples	Back Injury	**L**	Samples for the required tests should not exceed 5 kg. Use recommended lifting techniques.
Sample Preparation: Work Environment	Inhaling dust and hearing loss	**M**	Prepare samples in an open ventilated area. Wear dust mask when handling dry samples. Wear earmuffs in laboratory to minimise noise.
Sample Preparation: Mixing of water into samples with spatula	Repetitive Strain Injury	**L**	When mixing samples have regular breaks as required. Ensure preparation height is suited to individuals needs.
Sample Preparation: Removing samples from tubes.	Jamming of fingers or hands	**L**	Keep fingers and hands clear of moving parts in the extruder.
Laboratory Testing: Removing and placing samples in oven	Burns	**L**	Wear oven mitts when placing or removing objects from drying ovens.
Laboratory Testing: Using Swell machine	Crushing of hands and feet	**L**	Keep hands and feet clear when placing weights on the machine. Wear safety boots.
Laboratory Testing: Generating computer reports	Repetitive strain injury and eye fatigue	**L**	Ensure that the work station is set up within the ergo-dynamic principles in mind. Take breaks every hour and do stretching exercises in this break.

Appendix E – Shrink Swell Index Test Results

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Ph: (03) 5821 7393
Fax: (03) 5831 3042

SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050476	**Source:**	200 - 600mm	
Date:	20.6.2005	**Location:**	393 Walshs Bridge Road. Kaarimba	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty Clay with traces of sand (CL)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Orange Brown Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**1.2%**

Shrink Speciman Data

Initial Moisture Content (w_3)	8.0%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**0.4%**

Swell Speciman Data

Initial Moisture Content (w_1)	8.0%
Final Moisture Content (w_2)	24.7%
Total Swell (E_{sw})	**3.6%**

Comments:

Approved Signatory: [signature] **Date:** 20.6.2005

D. Earl

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Fax: (03) 5831 3042

SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050477	**Source:**	600 - 1000mm
Date:	20.6.2005	**Location:**	393 Walshs Bridge Road. Kaarimba
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Clay (CH)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Grey Brown Clay

Shrink - Swell Index (I_{ss})	**4.0%**

Shrink Speciman Data

Initial Moisture Content (w_3)	26.1%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**6.7%**

Swell Speciman Data

Initial Moisture Content (w_1)	26.1%
Final Moisture Content (w_2)	28.5%
Total Swell (E_{sw})	**1.1%**

Comments:

Approved Signatory: [signature] **Date:** 20.6.2005

D. Earl

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050489	**Source:**	400 - 1100mm
Date:	25.6.2005	**Location:**	Lot 84 McLahlan Road, Echuca
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Silty Clay with traces of sand (CH)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Brown Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**3.6%**

Shrink Speciman Data

Initial Moisture Content (w_3)	20.5%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**4.0%**

Swell Speciman Data

Initial Moisture Content (w_1)	20.5%
Final Moisture Content (w_2)	27.0%
Total Swell (E_{sw})	**4.9%**

Comments:

Approved Signatory: D. Earl **Date:** 25.6.2005

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Fax: (03) 5831 3042

SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050490	**Source:**	1200 - 1800mm	
Date:	25.6.2005	**Location:**	Lot 84 McLahlan Road, Echuca	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty Clay with traces of sand (CH)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Light Brown Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**2.3%**

Shrink Speciman Data

Initial Moisture Content (w_3)	17.4%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**4.1%**

Swell Speciman Data

Initial Moisture Content (w_1)	17.4%
Final Moisture Content (w_2)	30.7%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: [signature] **Date:** 25.6.2005

D. Earl

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050493	**Source:**	600 - 1300mm
Date:	27.6.2005	**Location:**	Lot 42 Sir Edward Drive, Benalla
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Silty Clay (CI)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Brown Orange Silty Clay

Shrink - Swell Index (I_{ss})	**1.6%**

Shrink Speciman Data

Initial Moisture Content (w_3)	21.1%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Moderate
Total Shrinkage (E_{sh})	**2.8%**

Swell Speciman Data

Initial Moisture Content (w_1)	21.1%
Final Moisture Content (w_2)	26.0%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: D. Earl **Date:** 27.6.2005

D. Earl

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050494	**Source:**	1300 - 2000mm
Date:	27.6.2005	**Location:**	Lot 42 Sir Edward Drive, Benalla
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Silty Clay with traces of sand (CI)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Light Brown Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**3.0%**

Shrink Speciman Data

Initial Moisture Content (w_3)	18.7%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Minor
Total Shrinkage (E_{sh})	**5.5%**

Swell Speciman Data

Initial Moisture Content (w_1)	18.7%
Final Moisture Content (w_2)	19.0%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: D. Earl **Date:** 27.6.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050503	**Source:**	300 - 800mm	
Date:	2.7.2005	**Location:**	Lot 2 Peppernell Road, Toorumbarry	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty Clay with traces of sand (CH)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Orange Brown Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**1.6%**

Shrink Speciman Data

Initial Moisture Content (w_3)	19.0%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**2.6%**

Swell Speciman Data

Initial Moisture Content (w_1)	19.0%
Final Moisture Content (w_2)	26.6%
Total Swell (E_{sw})	**0.4%**

Comments:

Approved Signatory: [signature] **Date:** 2.7.2005

D. Earl

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050504	**Source:**	1100 - 2000mm
Date:	2.7.2005	**Location:**	Lot 2 Peppernell Road, Toorumbarry
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Silty Clay with traces of sand (CH)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Mottled Orange Light Brown Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**1.0%**

Shrink Speciman Data

Initial Moisture Content (w_3)	17.7%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Moderate
Total Shrinkage (E_{sh})	**1.8%**

Swell Speciman Data

Initial Moisture Content (w_1)	17.7%
Final Moisture Content (w_2)	25.7%
Total Swell (E_{sw})	**0.1%**

Comments:

Approved Signatory: D. Earl **Date:** 2.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050507	**Source:**	300 - 700mm
Date:	4.7.2005	**Location:**	Lot 16 Wesley Court, Shepparton
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Silty Clay with sand (CI)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Orange Brown Silty Clay with sand

Shrink - Swell Index (I_{ss})	**1.6%**

Shrink Speciman Data

Initial Moisture Content (w_3)	17.3%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Moderate
Total Shrinkage (E_{sh})	**2.7%**

Swell Speciman Data

Initial Moisture Content (w_1)	17.3%
Final Moisture Content (w_2)	23.8%
Total Swell (E_{sw})	**0.2%**

Comments:

Approved Signatory: [signature] **Date:** 4.7.2005

D. Earl

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050518	**Source:**	1200 - 1500mm
Date:	9.7.2005	**Location:**	Lot 765 Narran Court, Kialla Lakes
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Silty Clay with sand (CI)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Yellow Light Brown Silty Clay with sand

Shrink - Swell Index (I_{ss})	**0.6%**

Shrink Speciman Data

Initial Moisture Content (w_3)	9.4%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Minor
Total Shrinkage (E_{sh})	**1.1%**

Swell Speciman Data

Initial Moisture Content (w_1)	9.4%
Final Moisture Content (w_2)	23.7%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: [signature] **Date:** 9.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050519	**Source:**	700 - 1100mm	
Date:	9.7.2005	**Location:**	Lot 6 Bluebird Court, Kialla	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty Clay with traces of sand (CI	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Orange Brown Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**2.1%**

Shrink Speciman Data

Initial Moisture Content (w_3)	17.2%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Moderate
Total Shrinkage (E_{sh})	**3.3%**

Swell Speciman Data

Initial Moisture Content (w_1)	17.2%
Final Moisture Content (w_2)	22.6%
Total Swell (E_{sw})	**0.7%**

Comments:

Approved Signatory: D. Earl **Date:** 9.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050526	**Source:**	300 - 800mm	
Date:	12.7.2005	**Location:**	62 Mason Street, Shepparton	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty Clay with traces of sand (CI	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Orange Brown Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**2.3%**

Shrink Speciman Data

Initial Moisture Content (w_3)	19.3%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**4.2%**

Swell Speciman Data

Initial Moisture Content (w_1)	19.3%
Final Moisture Content (w_2)	20.9%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: D. Earl **Date:** 12.7.2005

D. Earl

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050527	**Source:**	1700 - 2300mm	
Date:	12.7.2005	**Location:**	62 Mason Street, Shepparton	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty clay with traces of sand (CI)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Orange Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**0.5%**

Shrink Speciman Data

Initial Moisture Content (w_3)	15.5%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Minor
Total Shrinkage (E_{sh})	**1.0%**

Swell Speciman Data

Initial Moisture Content (w_1)	15.5%
Final Moisture Content (w_2)	20.7%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: [signature] D. Earl

Date: 12.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050530	**Source:**	400 - 1000mm	
Date:	16.7.2005	**Location:**	365 Mitchell Road, Kialla	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty Clay with traces of sand (CH)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Brown Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**3.0%**

Shrink Speciman Data

Initial Moisture Content (w_3)	24.8%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Moderate
Total Shrinkage (E_{sh})	**5.1%**

Swell Speciman Data

Initial Moisture Content (w_1)	24.8%
Final Moisture Content (w_2)	27.0%
Total Swell (E_{sw})	**0.6%**

Comments:

Approved Signatory: D. Earl **Date:** 16.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050531	**Source:**	1000 - 1600mm
Date:	16.7.2005	**Location:**	365 Mitchell Road, Kialla
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Clay (CH)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Mottled Grey Orange Light Brown Clay

Shrink - Swell Index (I_{ss})	**2.5%**

Shrink Speciman Data

Initial Moisture Content (w_3)	21.2%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Moderate
Total Shrinkage (E_{sh})	**4.2%**

Swell Speciman Data

Initial Moisture Content (w_1)	21.2%
Final Moisture Content (w_2)	27.0%
Total Swell (E_{sw})	**0.6%**

Comments:

Approved Signatory: [signature] **Date:** 16.7.2005

D. Earl

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050541	**Source:**	1500 - 2000mm
Date:	19.7.2005	**Location:**	Lot 105 Taig Avenue, Kialla
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Silty Clay (CH)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Mottled Grey Orange Light Brown Silty Clay

Shrink - Swell Index (I_{ss})	**1.1%**

Shrink Speciman Data

Initial Moisture Content (w_3)	18.3%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Minor
Total Shrinkage (E_{sh})	**1.8%**

Swell Speciman Data

Initial Moisture Content (w_1)	18.3%
Final Moisture Content (w_2)	26.2%
Total Swell (E_{sw})	**0.2%**

Comments:

Approved Signatory: D. Earl **Date:** 19.7.2005

D. Earl

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050542	**Source:**	600 - 1000mm	
Date:	19.7.2005	**Location:**	Lot 765 Narran Court, Kialla Lakes	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Clay (CH)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Yellow Light Brown Clay

Shrink - Swell Index (I_{ss})	**3.5%**

Shrink Speciman Data

Initial Moisture Content (w_3)	22.9%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**6.0%**

Swell Speciman Data

Initial Moisture Content (w_1)	22.9%
Final Moisture Content (w_2)	26.0%
Total Swell (E_{sw})	**0.5%**

Comments:

Approved Signatory: D. Earl **Date:** 19.7.2005

D. Earl

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050544	**Source:**	1300 - 1800mm	
Date:	21.7.2005	**Location:**	8 Gray Street, Benalla	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty Clay with sand (CI)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Mottled Red Orange Brown Silty Clay with sand

Shrink - Swell Index (I_{ss})	**0.8%**

Shrink Speciman Data

Initial Moisture Content (w_3)	14.2%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Minor
Total Shrinkage (E_{sh})	**1.3%**

Swell Speciman Data

Initial Moisture Content (w_1)	14.2%
Final Moisture Content (w_2)	17.9%
Total Swell (E_{sw})	**0.4%**

Comments:

Approved Signatory: [signature] **Date:** 21.7.2005

D. Earl

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050545	**Source:**	500 - 1000mm
Date:	21.7.2005	**Location:**	Lot 3 Murrays Road, Benalla
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Silty Clay with sand (CL)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Mottled Light Brown Silty Clay with sand

Shrink - Swell Index (I_{ss})	**0.7%**

Shrink Speciman Data

Initial Moisture Content (w_3)	16.4%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**1.2%**

Swell Speciman Data

Initial Moisture Content (w_1)	16.4%
Final Moisture Content (w_2)	17.9%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: [signature] **Date:** 21.7.2005

D. Earl

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050547	**Source:**	100 - 500mm	
Date:	21.7.2005	**Location:**	Lot 3 Murrays Road, Benalla	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silt with sand (ML)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Light Brown Silt with sand

Shrink - Swell Index (I_{ss})	**0.1%**

Shrink Speciman Data

Initial Moisture Content (w_3)	14.2%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**0.2%**

Swell Speciman Data

Initial Moisture Content (w_1)	14.2%
Final Moisture Content (w_2)	15.6%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: [signature] **Date:** 21.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050548	**Source:**	300 - 800mm
Date:	24.7.2005	**Location:**	Lot 1 Ruttles Road, Strathmerton
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Sandy Clay (CI)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Mottled Grey Brown Orange Sandy Clay

Shrink - Swell Index (I_{ss})	**1.7%**

Shrink Speciman Data

Initial Moisture Content (w_3)	13.7%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**3.0%**

Swell Speciman Data

Initial Moisture Content (w_1)	13.7%
Final Moisture Content (w_2)	16.2%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: [signature] **Date:** 24.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050549	**Source:**	100 - 300mm	
Date:	24.7.2005	**Location:**	Lot 1 Ruttles Road, Strathmerton	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silt with sand (ML)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Grey Light Brown Silt with sand

Shrink - Swell Index (I_{ss})	**0.6%**

Shrink Speciman Data

Initial Moisture Content (w_3)	13.5%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Minor
Total Shrinkage (E_{sh})	**1.0%**

Swell Speciman Data

Initial Moisture Content (w_1)	13.5%
Final Moisture Content (w_2)	19.2%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: [signature] **Date:** 24.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050550	**Source:**	200 - 700mm	
Date:	25.7.2005	**Location:**	5 Lincoln Street, Katandra West	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty Clay with sand (CL)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Orange Silty Clay with sand

Shrink - Swell Index (I_{ss})	**1.8%**

Shrink Speciman Data

Initial Moisture Content (w_3)	21.4%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Minor
Total Shrinkage (E_{sh})	**3.2%**

Swell Speciman Data

Initial Moisture Content (w_1)	21.4%
Final Moisture Content (w_2)	23.3%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: [signature] **Date:** 25.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050551	**Source:**	250 - 600mm
Date:	25.7.2005	**Location:**	Lot 404 Linda Crescent, Yarrawonga
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Silty Clay with traces of sand (CL)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Orange Brown Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**1.4%**

Shrink Speciman Data

Initial Moisture Content (w_3)	15.0%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Minor
Total Shrinkage (E_{sh})	**2.5%**

Swell Speciman Data

Initial Moisture Content (w_1)	15.0%
Final Moisture Content (w_2)	21.2%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: [signature] **Date:** 25.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Sheet 1 of 1

Report No.	SS050561	**Source:**	300 - 700mm
Date:	26.7.2005	**Location:**	34 Orr Street, Shepparton
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Silty Clay with sand (CI)	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Orange Brown Silty Clay with sand

Shrink - Swell Index (I_{ss})	**2.3%**

Shrink Speciman Data

Initial Moisture Content (w_3)	22.1%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**4.1%**

Swell Speciman Data

Initial Moisture Content (w_1)	22.1%
Final Moisture Content (w_2)	22.6%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: D. Earl **Date:** 26.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050562	**Source:**	1300 - 1800mm	
Date:	26.7.2005	**Location:**	Lot 404 Linda Crescent, Yarrawonga	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty Clay with sand (CI)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Yellow Light Brown Silty Clay with sand

Shrink - Swell Index (I_{ss})	**0.8%**

Shrink Speciman Data

Initial Moisture Content (w_3)	17.0%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**1.4%**

Swell Speciman Data

Initial Moisture Content (w_1)	17.0%
Final Moisture Content (w_2)	22.3%
Total Swell (E_{sw})	**0.2%**

Comments:

Approved Signatory: [signature] **Date:** 26.7.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050577	**Source:**	400 - 700mm
Date:	7.8.2005	**Location:**	Lot 41 Boyd Avenue, Shepparton
Tested By:	D. Earl	**Client Name:**	D. Earl
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton
Material:	Silty Clay with traces of sar	**Test Methods:**	AS1289.1.1(samp.prep) AS1289.2.1.1(m.c.) AS1289.7.1.1 AS1289.7.1.1

Visual Description of Sample: Red Orange Silty Clay with traces of sand

Shrink - Swell Index (I_{ss})	**1.1%**

Shrink Speciman Data

Initial Moisture Content (w_3)	16.6%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**1.9%**

Swell Speciman Data

Initial Moisture Content (w_1)	16.6%
Final Moisture Content (w_2)	26.3%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: D. Earl **Date:** 7.8.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050578	**Source:**	700 - 1300mm	
Date:	7.8.2005	**Location:**	Lot 41 Boyd Avenue, Shepparton	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty Clay with traces of sand (CI)	**Test Methods:**	**AS1289.1.1(samp.prep)**	**AS1289.2.1.1(m.c.)**
			AS1289.7.1.1	**AS1289.7.1.1**

Visual Description of Sample: Mottled Orange Brown silty clay with traces of sand

Shrink - Swell Index (I_{ss})	**0.5%**

Shrink Speciman Data

Initial Moisture Content (w_3)	18.5%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**0.8%**

Swell Speciman Data

Initial Moisture Content (w_1)	18.5%
Final Moisture Content (w_2)	25.2%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: [signature] **Date:** 7.8.2005

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SHRINK SWELL INDEX REPORT SHEET

Report No.	SS050579	**Source:**	1300 - 3000mm	
Date:	7.8.2005	**Location:**	Lot 41 Boyd Avenue, Shepparton	
Tested By:	D. Earl	**Client Name:**	D. Earl	
Sampled By:	D. Earl	**Client Address:**	41 Ferguson Road, Shepparton	
Material:	Silty Clay with sand (CL)	**Test Methods:**	AS1289.1.1(samp.prep)	AS1289.2.1.1(m.c.)
			AS1289.7.1.1	AS1289.7.1.1

Visual Description of Sample: Brown Silty Clay with sand

Shrink - Swell Index (I_{ss})	**0.4%**

Shrink Speciman Data

Initial Moisture Content (w_3)	22.9%
Significant Inert Inclusions	Nil
Extent of Soil Crumbling	Nil
Extent of Cracking	Nil
Total Shrinkage (E_{sh})	**0.6%**

Swell Speciman Data

Initial Moisture Content (w_1)	22.9%
Final Moisture Content (w_2)	24.1%
Total Swell (E_{sw})	**0.0%**

Comments:

Approved Signatory: D. Earl **Date:** 7.8.2005

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Appendix F – Atterberg Limits, Linear Shrinkage and Particle Size Distribution Test Results

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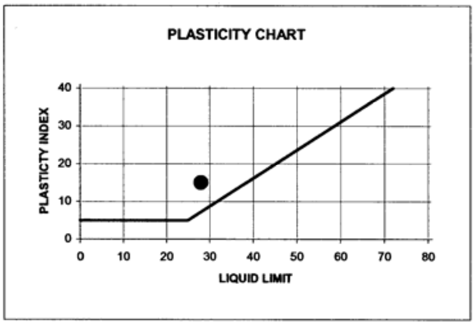
R012-1/2

Client	D. Earl 41 Ferguson Road. Shepparton	Report No. Sample No.	C050476 050476
Date	25.6.2005	Sheet	1 of 1

Location	393 Walsh's Bridge Road, Kaarimba	Source	**200 - 600mm**
Material	Silty Clay with traces of sand (CL)		

Atterberg Test	
Liquid Limit %	28
Plastic Limit %	13
Plasticity Index %	15
Linear Shrinkage	9.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	100		
600um	100		
425um	100		
300um	99		
150um	98		
75um	94		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: ______________________

Approved Signatory: [signature] Date: 25.6.2005

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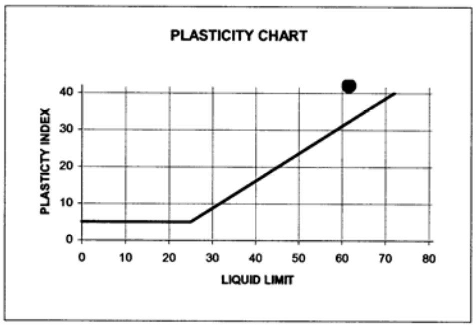
R012-1/2

Client	D. Earl 41 Ferguson Road. Shepparton	Report No.	C050477
		Sample No.	050477
Date	25.6.2005	Sheet	1 of 1

Location	393 Walshs Bridge Road, Kaarimba	Source	**600 - 1000mm**
Material	Clay (CH)		

Atterberg Test	
Liquid Limit %	62
Plastic Limit %	20
Plasticity Index %	42
Linear Shrinkage	15.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis			
Sieve Size mm	Percentage Passing	Specification Limits	
		Upper	Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	100		
600um	99		
425um	99		
300um	99		
150um	98		
75um	97		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.		
Water Type	Distilled	Tap
Water Temperature ºC	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 25.6.2005

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R012-1/2

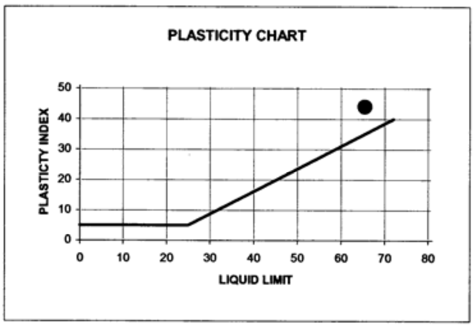
Client	D. Earl 41 Ferguson Road. Shepparton	Report No.	C050489
		Sample No.	050489
Date	8.7.2005	Sheet	1 of 1

Location	Lot 84 McLahlan Rd. Echuca	Source	**400 - 1100mm**
Material	Silty Clay with traces of sand (CH)		

Atterberg Test

Liquid Limit %	65
Plastic Limit %	21
Plasticity Index %	44
Linear Shrinkage	20.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred

Test Methods Used
AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	99		
600um	99		
425um	98		
300um	98		
150um	96		
75um	94		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 8.7.2005

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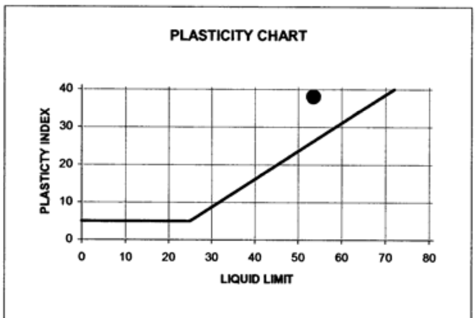
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050490
		Sample No.	050490
Date	8.7.2005	Sheet	1 of 1

Location	Lot 84 McLahlan Road, Echuca	Source	**1200 - 1800mm**
Material	Silty Clay with traces of sand (CH)		

Atterberg Test

Liquid Limit %	54
Plastic Limit %	16
Plasticity Index %	38
Linear Shrinkage	17.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	100		
600um	99		
425um	99		
300um	98		
150um	96		
75um	93		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 8.7.2005

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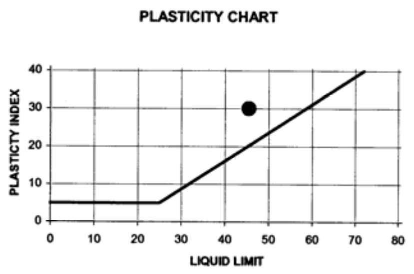
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050493
		Sample No.	050493
Date	6.7.2005	Sheet	1 of 1

Location	Lot 42 Sir Edward Drive, Benalla	Source	**600 - 1300mm**
Material	Silty Clay (CI)		

Atterberg Test

Liquid Limit %	45
Plastic Limit %	15
Plasticity Index %	30
Linear Shrinkage	13.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	100		
600um	100		
425um	99		
300um	99		
150um	99		
75um	98		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: ______________________

Approved Signatory: [signature] Date: 6.7.2005

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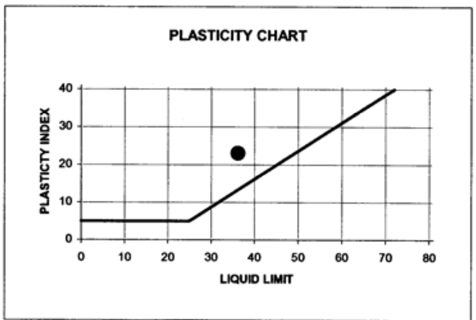
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050494
		Sample No.	050494
Date	6.7.2005	Sheet	1 of 1

Location	Lot 42 Sir Edward Drive, Benalla	Source	**1300 - 2000mm**
Material	Silty Clay with traces of Sand (CI)		

Atterberg Test	
Liquid Limit %	36
Plastic Limit %	13
Plasticity Index %	23
Linear Shrinkage	13.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis			
Sieve Size mm	Percentage Passing	Specification Limits	
		Upper	Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	99		
4.75mm	98		
2.36mm	96		
1.18mm	95		
600um	95		
425um	94		
300um	94		
150um	93		
75um	91		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.		
Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 6.7.2005

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R012-1/2

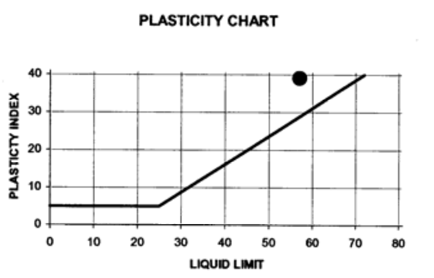
Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C 050503
		Sample No.	050503
Date	6.7.2005	Sheet	1 of 1

Location	Lot 2 Peppernell Road, Toorumbarry	Source	**300 - 800mm**
Material	Silty Clay with traces of sand (CH)		

Atterberg Test

Liquid Limit %	57
Plastic Limit %	18
Plasticity Index %	39
Linear Shrinkage	17.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred

Test Methods Used
AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	100		
600um	100		
425um	100		
300um	99		
150um	97		
75um	93		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature ºC	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 6.7.2005

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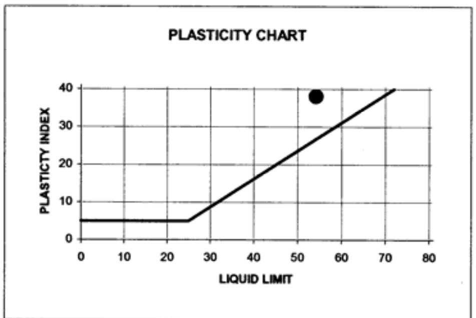
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C 050504
		Sample No.	050504
Date	6.7.2005	Sheet	1 of 1

Location	Lot 2 Peppernell Road, Toorumbarry	Source	**1100 - 2000mm**
Material	Silty Clay with traces of sand (CH)		

Atterberg Test	
Liquid Limit %	54
Plastic Limit %	16
Plasticity Index %	38
Linear Shrinkage	16.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis			
Sieve Size mm	Percentage Passing	Specification Limits Upper	Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	99		
6.70mm	98		
4.75mm	97		
2.36mm	97		
1.18mm	96		
600um	96		
425um	96		
300um	95		
150um	93		
75um	85		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.		
Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: ______________________

Approved Signatory: [signature] Date: 6.7.2005

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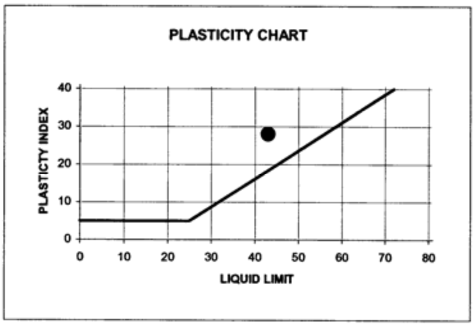
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C 050507
		Sample No.	050507
Date	6.7.2005	Sheet	1 of 1

Location	Lot 16 Wesley Court, Shepparton	Source	**300 - 700mm**
Material	Silty Clay with sand (CI)		

Atterberg Test

Liquid Limit %	43
Plastic Limit %	15
Plasticity Index %	28
Linear Shrinkage	14.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	99		
1.18mm	98		
600um	95		
425um	93		
300um	91		
150um	85		
75um	76		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: Date: 6.7.2005

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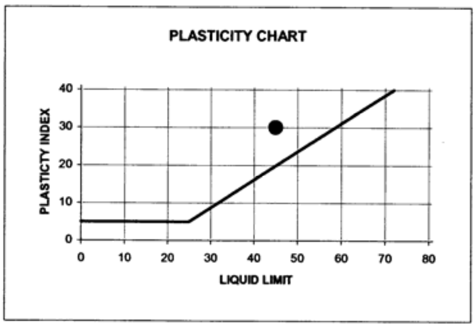
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050518
		Sample No.	050518
Date	17.7.2005	Sheet	1 of 1

Location	Lot 765 Narran Court, Kialla Lakes	Source	**1200 - 1500mm**
Material	Silty Clay with sand (CI)		

Atterberg Test

Liquid Limit %	45
Plastic Limit %	15
Plasticity Index %	30
Linear Shrinkage	14.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	99		
600um	97		
425um	89		
300um	88		
150um	85		
75um	79		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 17.7.2005

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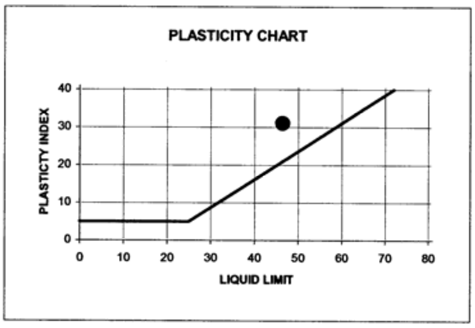
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050519
		Sample No.	050519
Date	17.7.2005	Sheet	1 of 1

Location	Lot 6 Bluebird Court, Kialla	Source	**700 - 1100mm**
Material	Silty Clay with traces of sand (CI)		

Atterberg Test	
Liquid Limit %	46
Plastic Limit %	15
Plasticity Index %	31
Linear Shrinkage	14.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	99		
600um	98		
425um	97		
300um	95		
150um	91		
75um	87		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: __________

Approved Signatory: [signature] Date: 17.7.2005

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R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No. Sample No.	C050526 050526
Date	16.7.2005	Sheet	1 of 1

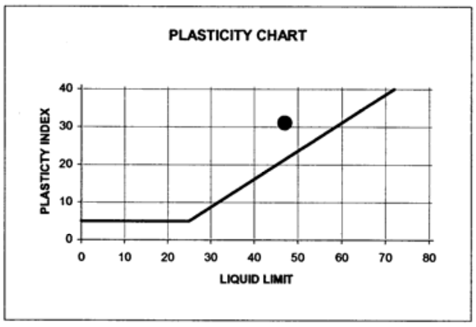
Location	62 Mason Street, Shepparton	Source	**300- 800mm**
Material	Silty Clay with traces of sand (CI)		

Atterberg Test

Liquid Limit %	47
Plastic Limit %	16
Plasticity Index %	31
Linear Shrinkage	15.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred

Test Methods Used

AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	99		
600um	99		
425um	98		
300um	98		
150um	95		
75um	91		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature ºC	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 16.7.2005

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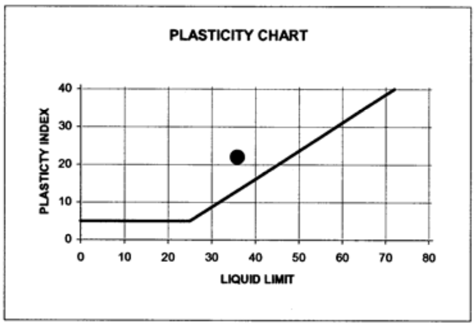
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050527
		Sample No.	050527
Date	16.7.2005	Sheet	1 of 1

Location	62 Mason Street, Shepparton	Source	**1700- 2300mm**
Material	Silty clay with traces of sand (CI)		

Atterberg Test	
Liquid Limit %	36
Plastic Limit %	14
Plasticity Index %	22
Linear Shrinkage	11.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis			
Sieve Size mm	Percentage Passing	Specification Limits	
		Upper	Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	100		
600um	99		
425um	98		
300um	97		
150um	91		
75um	83		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.		
Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: ______________________

Approved Signatory: [signature] Date: 16.7.2005

D. Earl

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R012-1/2

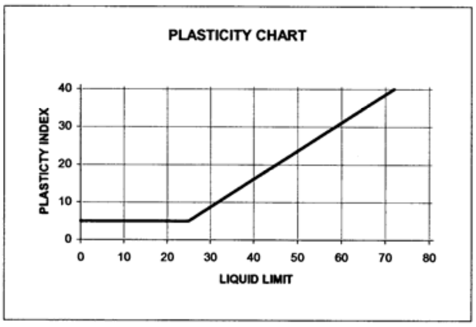
Client	D. Earl 41 Ferguson Road, Shepparton	Report No. Sample No.	C050530 050530
Date	19.7.2005	Sheet	1 of 1

Location	365 Mitchell Road, Kialla	Source	**400 - 1000mm**
Material	Silty Clay with traces of sand (CH)		

Atterberg Test

Liquid Limit %	59
Plastic Limit %	16
Plasticity Index %	43
Linear Shrinkage	17.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred

Test Methods Used
AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	99		
1.18mm	99		
600um	98		
425um	98		
300um	97		
150um	96		
75um	93		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: ______________________

Approved Signatory: [signature] Date: 19.7.2005

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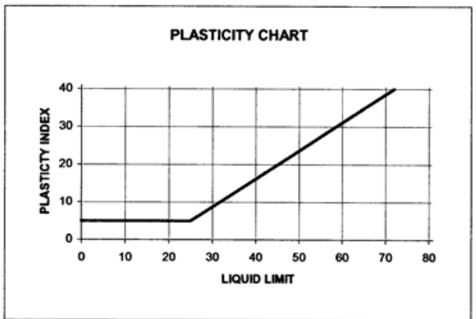
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No. Sample No.	C050531 050531
Date	19.7.2005	Sheet	1 of 1

Location	365 Mitchell Road, Kialla	Source	**1000 - 1600mm**
Material	Clay (CH)		

Atterberg Test	
Liquid Limit %	60
Plastic Limit %	18
Plasticity Index %	42
Linear Shrinkage	18.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	100		
600um	99		
425um	99		
300um	99		
150um	97		
75um	95		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 19.7.2005

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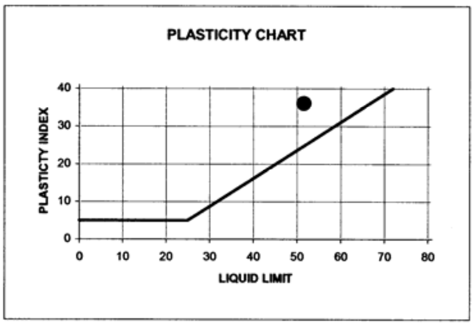
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No. Sample No.	C050541 050541
Date	21.7.2005	Sheet	1 of 1

Location	Lot 105 Taig Avenue, Kialla	Source	**1500 - 2000mm**
Material	Silty Clay (CH)		

Atterberg Test	
Liquid Limit %	52
Plastic Limit %	16
Plasticity Index %	36
Linear Shrinkage	16.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	99		
2.36mm	99		
1.18mm	98		
600um	98		
425um	98		
300um	97		
150um	96		
75um	95		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.		
Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

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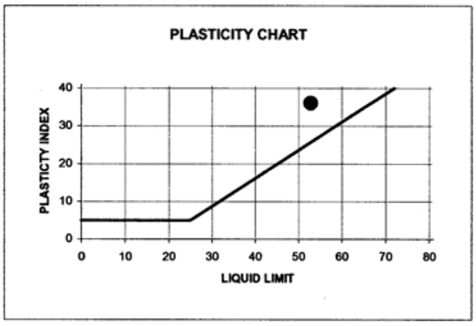
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050542
		Sample No.	050542
Date	21.7.2005	Sheet	1 of 1

Location	Lot 765 Narran Court, Kialla Lakes	Source	**600 - 1000mm**
Material	Clay (CH)		

Atterberg Test	
Liquid Limit %	53
Plastic Limit %	17
Plasticity Index %	36
Linear Shrinkage	13.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	100		
600um	99		
425um	99		
300um	98		
150um	97		
75um	96		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: ______________________

Approved Signatory: [signature] Date: 21.7.2005

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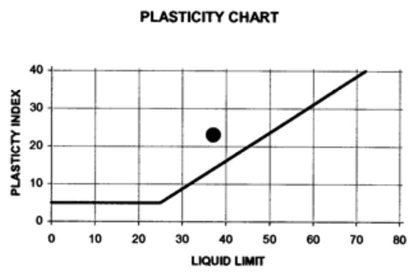
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No. Sample No.	C050544 050544
Date	25.7.2005	Sheet	1 of 1

Location	8 Gray Street, Benalla	Source	**1500 - 2000mm**
Material	Silty Clay with sand (CI)		

Atterberg Test	
Liquid Limit %	37
Plastic Limit %	14
Plasticity Index %	23
Linear Shrinkage	10.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	100		
600um	99		
425um	99		
300um	97		
150um	92		
75um	84		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: ______________________

Approved Signatory: [signature] Date: 25.7.2005

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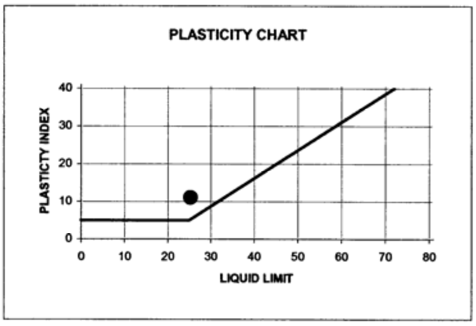
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No. Sample No.	C050545 050545
Date	25.7.2005	Sheet	1 of 1

Location	Lot 3 Murrays Road, Benalla	Source	**500 - 1000mm**
Material	Silty Clay with sand (CL)		

Atterberg Test

Liquid Limit %	25
Plastic Limit %	14
Plasticity Index %	11
Linear Shrinkage	5.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Crumbling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	99		
600um	98		
425um	97		
300um	96		
150um	91		
75um	82		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 25.7.2005

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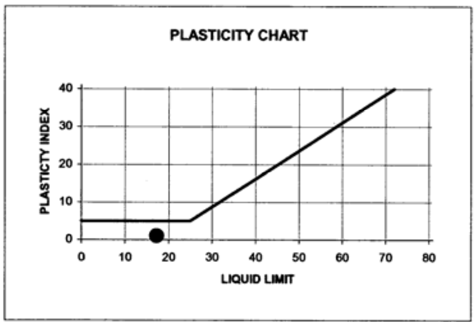
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050547
		Sample No.	050547
Date	26.7.2005	Sheet	1 of 1

Location	Lot 3 Murrays Road, Benalla	Source	**100 - 500mm**
Material	Silt with sand (ML)		

Atterberg Test	
Liquid Limit %	17
Plastic Limit %	16
Plasticity Index %	1
Linear Shrinkage	0.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Crumbling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	99		
1.18mm	97		
600um	95		
425um	93		
300um	91		
150um	85		
75um	75		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 26.7.2005

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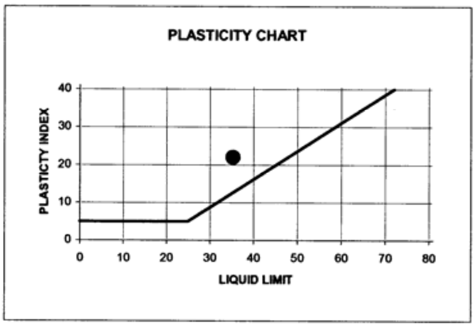
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050548
		Sample No.	050548
Date	25.7.2005	Sheet	1 of 1

Location	Lot 1 Ruttles Road, Strathmerton	Source	**300 - 800mm**
Material	Sandy Clay (CI)		

Atterberg Test

Liquid Limit %	35
Plastic Limit %	13
Plasticity Index %	22
Linear Shrinkage	10.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	99		
1.18mm	98		
600um	96		
425um	95		
300um	92		
150um	82		
75um	69		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature ºC	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 25.7.2005

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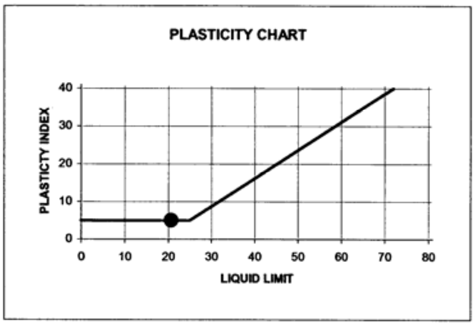
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050549
		Sample No.	050549
Date	26.7.2005	Sheet	1 of 1

Location	Lot 1 Ruttles Road, Strathmerton	Source	**100 - 300mm**
Material	Silt with sand (ML)		

Atterberg Test	
Liquid Limit %	21
Plastic Limit %	16
Plasticity Index %	5
Linear Shrinkage	2.5
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	99		
1.18mm	98		
600um	96		
425um	95		
300um	92		
150um	81		
75um	64		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 26.7.2005

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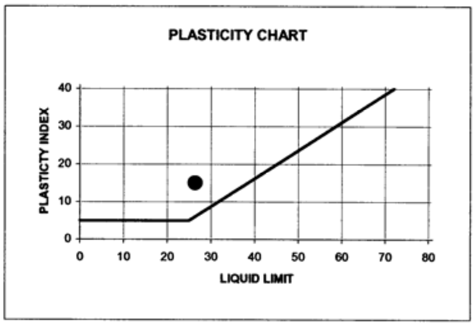
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050550
		Sample No.	050550
Date	22.7.2005	Sheet	1 of 1

Location	5 Lincoln Street, Katandra West	Source	**200 - 700mm**
Material	Silty Clay with sand (CL)		

Atterberg Test

Liquid Limit %	26
Plastic Limit %	11
Plasticity Index %	15
Linear Shrinkage	9.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	98		
4.75mm	96		
2.36mm	94		
1.18mm	91		
600um	87		
425um	85		
300um	83		
150um	78		
75um	73		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: ______________________________

Approved Signatory: [signature] Date: 22.7.2005

D. Earl

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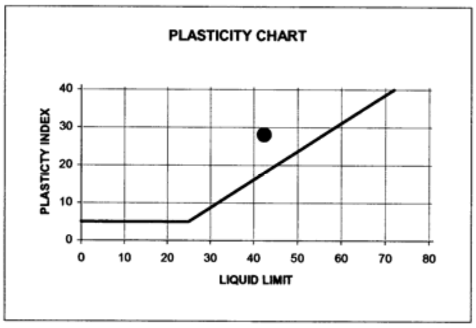
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050551
		Sample No.	0505551
Date	27.7.2005	Sheet	1 of 1

Location	Lot 404 Linda Crescent, Yarrawonga	Source	**250 - 600mm**
Material	Silty Clay with traces of sand (CI)		

Atterberg Test	
Liquid Limit %	42
Plastic Limit %	14
Plasticity Index %	28
Linear Shrinkage	15.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	99		
600um	98		
425um	96		
300um	95		
150um	91		
75um	86		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: ______

Approved Signatory: [signature] Date: 27.7.2005

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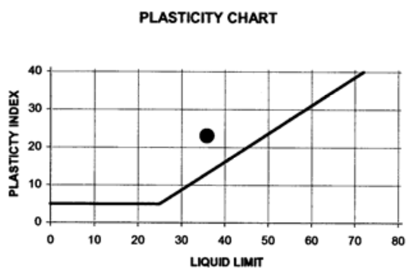
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050561
		Sample No.	050561
Date	1.8.2005	Sheet	1 of 1

Location	31 Orr Street, Shepparton	Source	**300 - 700mm**
Material	Silty Clay with sand (CI)		

Atterberg Test	
Liquid Limit %	36
Plastic Limit %	13
Plasticity Index %	23
Linear Shrinkage	11.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	98		
600um	94		
425um	92		
300um	89		
150um	83		
75um	77		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: ______________________

Approved Signatory: [signature] Date: 1.8.2005

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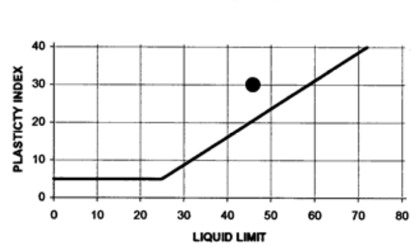
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050562
		Sample No.	050562
Date	1.8.2005	Sheet	1 of 1

Location	Lot 404 Linda Crescent, Yarrawonga	Source	**1300 - 1800mm**
Material	Silty Clay with sand (CI)		

Atterberg Test

Liquid Limit %	46
Plastic Limit %	16
Plasticity Index %	30
Linear Shrinkage	13.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	99		
4.75mm	99		
2.36mm	99		
1.18mm	98		
600um	97		
425um	96		
300um	95		
150um	91		
75um	84		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: Date: 1.8.2005

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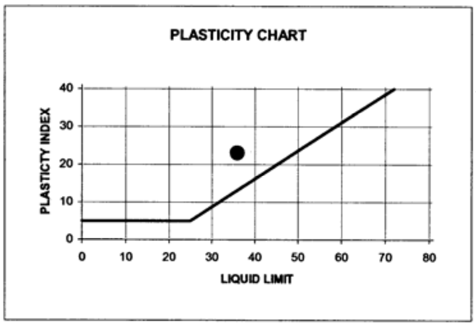
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050577
		Sample No.	050577
Date	9.8.2005	Sheet	1 of 1

Location	Lot 41 Boyd Avenue Shepparton	Source	**400 - 700mm**
Material	Silty Clay with traces of sand (CI)		

Atterberg Test	
Liquid Limit %	36
Plastic Limit %	13
Plasticity Index %	23
Linear Shrinkage	11.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis			
Sieve Size mm	Percentage Passing	Specification Limits Upper	Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	100		
600um	99		
425um	99		
300um	98		
150um	96		
75um	90		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.		
Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 9.8.2005

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R012-1/2

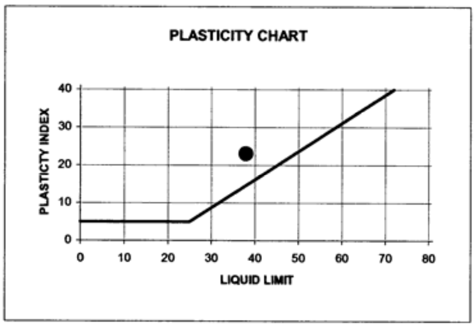
Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050578
		Sample No.	050578
Date	9.8.2005	Sheet	1 of 1

Location	Lot 41 Boyd Avenue Shepparton	Source	**700 - 1300mm**
Material	Silty Clay with traces of sand (CI)		

Atterberg Test

Liquid Limit %	38
Plastic Limit %	15
Plasticity Index %	23
Linear Shrinkage	13.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Curling occurred

Test Methods Used
AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis

Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	100		
1.18mm	99		
600um	99		
425um	99		
300um	99		
150um	98		
75um	92		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.

Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments: ____________________

Approved Signatory: [signature] Date: 9.8.2005

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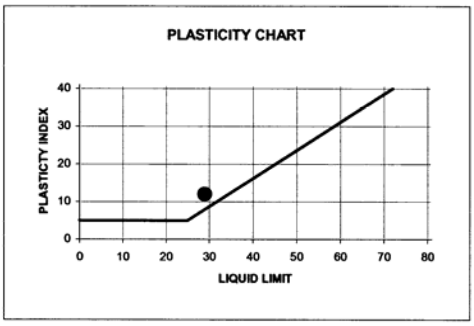
R012-1/2

Client	D. Earl 41 Ferguson Road, Shepparton	Report No.	C050579
		Sample No.	050579
Date	9.8.2005	Sheet	1 of 1

Location	Lot 41 Boyd Avenue Shepparton	Source	**1300 - 3000mm**
Material	Silty Clay with sand (CL)		

Atterberg Test	
Liquid Limit %	29
Plastic Limit %	17
Plasticity Index %	12
Linear Shrinkage	6.0
Preparation Method	Dry Sieved
Sample History	Oven Dried
Comments	Linear Shrinkage - Crumbling occurred
Test Methods Used	AS1289.1.1/1289.1.2.1/1289.2.1.1/1289.3.1.2/1289.3.2.1/1289.3.3.1/1289.3.4.1



Sieve Analysis			
Sieve Size mm	Percentage Passing	Specification Limits Upper	Specification Limits Lower
75.0mm	100		
53.0mm	100		
37.5mm	100		
26.5mm	100		
19.0mm	100		
13.2mm	100		
9.50mm	100		
6.70mm	100		
4.75mm	100		
2.36mm	98		
1.18mm	98		
600um	98		
425um	97		
300um	97		
150um	95		
75um	82		
Wet/Dry sieved	Wet		
Test Methods Used	AS 1289.1.1/1289.2.1.1/1289.3.6.1		

Emerson Class No.		
Water Type	Distilled	Tap
Water Temperature °C	0	0
Sampled Date	0	0
Emerson Class No.	-	-
Test Methods Used	-	

Comments:

Approved Signatory: [signature] Date: 9.8.2005

D. Earl

Appendix G – Hydrometer Test Results

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Ph: (03) 5821 7393
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REPORT NO: HY050476
DATE: 28.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CL)
SOURCE: 200 - 600mm
LOCATION: 393 Walshs Bridge Road, Kaarimba
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	68.44
Total Dry Mass Retained on 75um sieve (grams)	4.40
Fine Sand Proportion	6%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	46	47.65	3.42	1.306	14.14	63	30	70
1	41	42.65	3.53	1.306	10.00	46	37	63
2	37	38.65	3.63	1.306	7.07	33	43	57
4	32.5	34.15	3.73	1.306	5.00	24	50	50
8	28.5	30.15	3.67	1.306	3.54	17	56	44
15	25	26.65	3.75	1.306	2.58	13	61	39
30	23.5	25.15	3.79	1.306	1.83	9	63	37
60	21.5	23.15	3.83	1.306	1.29	6	66	34
120	20	21.65	3.87	1.306	0.91	5	68	32
240	19	20.65	3.89	1.306	0.65	3	70	30
1410	15	16.65	3.99	1.306	0.27	1	76	24

Fine Sand Fraction - 6%
Silt Fraction - 69%
Clay Fraction - 24%

Signed

Date: 28.7.2005

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REPORT NO: HY050477
DATE: 28.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Clay (CH)

SOURCE: 600 - 1000mm
LOCATION: 393 Walshs Bridge Road, Kaarimba
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	53.10
Total Dry Mass Retained on 75um sieve (grams)	1.84
Fine Sand Proportion	3%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	49	50.65	3.35	1.571	14.14	74	-1	101
1	48.5	50.15	3.36	1.571	10.00	53	0	100
2	48	49.65	3.38	1.571	7.07	37	1	99
4	47.5	49.15	3.39	1.571	5.00	27	2	98
8	47	48.65	3.23	1.571	3.54	18	3	97
15	46	47.65	3.25	1.571	2.58	13	5	95
30	45	46.65	3.27	1.571	1.83	9	7	93
60	44	45.65	3.30	1.571	1.29	7	9	91
120	42	43.65	3.35	1.571	0.91	5	13	87
240	40	41.65	3.39	1.571	0.65	3	17	83
1410	34.5	36.15	3.52	1.571	0.27	1	28	72

Fine Sand Fraction - 3%
Silt Fraction - 24%
Clay Fraction - 72%

Signed

Date: 28.7.2005

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REPORT NO: HY050489
DATE: 30.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CH)

SOURCE: 400 - 1100mm
LOCATION: Lot 84 McLahlan Road, Echuca
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	84.64
Total Dry Mass Retained on 75um sieve (grams)	4.87
Fine Sand Proportion	6%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	63	64.65	3.03	1.493	14.14	64	23	77
1	63	64.65	3.03	1.493	10.00	45	23	77
2	63	64.65	3.03	1.493	7.07	32	23	77
4	63	64.65	3.03	1.493	5.00	23	23	77
8	63	64.65	2.85	1.493	3.54	15	23	77
15	63	64.65	2.85	1.493	2.58	11	23	77
30	63	64.65	2.85	1.493	1.83	8	23	77
60	63	64.65	2.85	1.493	1.29	5	23	77
120	63	64.65	2.85	1.493	0.91	4	23	77
240	63	64.65	2.85	1.493	0.65	3	23	77
1410	34.5	36.15	3.52	1.493	0.27	1	57	43

Fine Sand Fraction - 6%
Silt Fraction - 51%
Clay Fraction - 43%

Signed ____________

Date: 30.7.2005

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Ph: (03) 5821 7393
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REPORT NO: HY050490
DATE: 28.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CH)

SOURCE: 1200 - 1800mm
LOCATION: Lot 84 McLahlan Road, Echuca
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	50.81
Total Dry Mass Retained on 75um sieve (grams)	3.42
Fine Sand Proportion	7%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	44	45.65	3.47	1.503	14.14	74	7	93
1	44	45.65	3.47	1.503	10.00	52	7	93
2	44	45.65	3.47	1.503	7.07	37	7	93
4	44	45.65	3.47	1.503	5.00	26	7	93
8	42	43.65	3.35	1.503	3.54	18	11	89
15	41	42.65	3.37	1.503	2.58	13	13	87
30	41	42.65	3.37	1.503	1.83	9	13	87
60	40.5	42.15	3.38	1.503	1.29	7	14	86
120	40	41.65	3.39	1.503	0.91	5	15	85
240	39.5	41.15	3.40	1.503	0.65	3	16	84
1410	13.5	15.15	4.02	1.503	0.27	2	69	31

Fine Sand Fraction - 7%
Silt Fraction - 62%
Clay Fraction - 31%

Signed ______________

Date: 28.7.2005

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REPORT NO: HY050493
DATE: 3.8.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay (CI)

SOURCE: 600 - 1300mm
LOCATION: Lot 42 Sir Edward Drive, Benalla
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	70.86
Total Dry Mass Retained on 75um sieve (grams)	1.64
Fine Sand Proportion	2%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	64	65.65	3.01	1.518	14.14	65	5	95
1	63	64.65	3.03	1.518	10.00	46	7	93
2	61	62.65	3.08	1.518	7.07	33	9	91
4	59	60.65	3.13	1.518	5.00	24	12	88
8	56.5	58.15	3.00	1.518	3.54	16	16	84
15	53	54.65	3.08	1.518	2.58	12	21	79
30	50	51.65	3.15	1.518	1.83	9	25	75
60	45	46.65	3.27	1.518	1.29	6	33	67
120	41.5	43.15	3.36	1.518	0.91	5	38	62
240	38	39.65	3.44	1.518	0.65	3	43	57
1410	32	33.65	3.58	1.518	0.27	1	51	49

Fine Sand Fraction - 2%
Silt Fraction - 49%
Clay Fraction - 49%

Signed

Date: 3.8.2005

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REPORT NO: HY050494
DATE: 31.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CI)

SOURCE: 1300 - 2000mm
LOCATION: Lot 42 Sir Edward Drive, Benalla
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	59.10
Total Dry Mass Retained on 75um sieve (grams)	5.52
Fine Sand Proportion	9%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	46	47.65	3.42	1.531	14.14	74	16	84
1	44	45.65	3.47	1.531	10.00	53	20	80
2	40.5	42.15	3.55	1.531	7.07	38	26	74
4	38	39.65	3.60	1.531	5.00	28	30	70
8	34	35.65	3.54	1.531	3.54	19	37	63
15	32	33.65	3.58	1.531	2.58	14	41	59
30	29.5	31.15	3.64	1.531	1.83	10	45	55
60	26	27.65	3.73	1.531	1.29	7	51	49
120	24	25.65	3.77	1.531	0.91	5	55	45
240	20	21.65	3.87	1.531	0.65	4	62	38
1410	11.5	13.15	4.07	1.531	0.27	2	77	23

Fine Sand Fraction - 9%
Silt Fraction - 67%
Clay Fraction - 23%

Signed ____________

Date: 31.7.2005

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REPORT NO: HY050503
DATE: 3.8.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CH)

SOURCE: 300 - 800mm
LOCATION: Lot 2 Peppernell Road, Toorumbarry
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	59.31
Total Dry Mass Retained on 75um sieve (grams)	3.94
Fine Sand Proportion	7%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	54	55.65	3.24	1.557	14.14	71	1	99
1	52.5	54.15	3.27	1.557	10.00	51	4	96
2	52.5	54.15	3.27	1.557	7.07	36	4	96
4	52.5	54.15	3.27	1.557	5.00	25	4	96
8	52.5	54.15	3.10	1.557	3.54	17	4	96
15	52.5	54.15	3.10	1.557	2.58	12	4	96
30	52.5	54.15	3.10	1.557	1.83	9	4	96
60	52.5	54.15	3.10	1.557	1.29	6	4	96
120	51	52.65	3.13	1.557	0.91	4	6	94
240	45	46.65	3.27	1.557	0.65	3	17	83
1410	8	9.65	4.15	1.557	0.27	2	83	17

Fine Sand Fraction - 7%
Silt Fraction - 76%
Clay Fraction - 17%

Signed D Earl

Date: 3.8.2005

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REPORT NO: HY050504
DATE: 30.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CH)

SOURCE: 1100 - 2000mm
LOCATION: Lot 2 Peppernell Road, Toorumbarry
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	65.14
Total Dry Mass Retained on 75um sieve (grams)	9.89
Fine Sand Proportion	15%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	47.5	49.15	3.39	1.653	14.14	79	17	83
1	47.5	49.15	3.39	1.653	10.00	56	17	83
2	47.5	49.15	3.39	1.653	7.07	40	17	83
4	47.5	49.15	3.39	1.653	5.00	28	17	83
8	47	48.65	3.23	1.653	3.54	19	18	82
15	47	48.65	3.23	1.653	2.58	14	18	82
30	47	48.65	3.23	1.653	1.83	10	18	82
60	46.5	48.15	3.24	1.653	1.29	7	19	81
120	46.5	48.15	3.24	1.653	0.91	5	19	81
240	18.5	20.15	3.90	1.653	0.65	4	66	34
1410	6.5	8.15	4.19	1.653	0.27	2	86	14

Fine Sand Fraction - 15%
Silt Fraction - 71%
Clay Fraction - 14%

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Date: 30.7.2005

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REPORT NO: HY050507
DATE: 30.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with sand (CI)

SOURCE: 300 - 700mm
LOCATION: Lot 16 Wesley Court, Shepparton
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	65.05
Total Dry Mass Retained on 75um sieve (grams)	15.35
Fine Sand Proportion	24%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	45.5	47.15	3.43	1.534	14.14	74	25	75
1	44	45.65	3.47	1.534	10.00	53	28	72
2	41.5	43.15	3.52	1.534	7.07	38	31	69
4	38.5	40.15	3.59	1.534	5.00	28	36	64
8	37	38.65	3.46	1.534	3.54	19	39	61
15	36	37.65	3.49	1.534	2.58	14	40	60
30	35	36.65	3.51	1.534	1.83	10	42	58
60	33	34.65	3.56	1.534	1.29	7	45	55
120	31.5	33.15	3.60	1.534	0.91	5	47	53
240	29.5	31.15	3.64	1.534	0.65	4	51	49
1410	27	28.65	3.70	1.534	0.27	2	55	45

Fine Sand Fraction - 24%
Silt Fraction - 31%
Clay Fraction - 45%

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Date: 30.7.2005

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REPORT NO: HY050518
DATE: 31.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with sand (CI)

SOURCE: 1200 - 1500mm
LOCATION: Lot 765 Narran Court, Kialla Lakes
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	64.72
Total Dry Mass Retained on 75um sieve (grams)	13.55
Fine Sand Proportion	21%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	47	48.65	3.40	1.567	14.14	75	20	80
1	35	36.65	3.67	1.567	10.00	58	40	60
2	28	29.65	3.83	1.567	7.07	42	51	49
4	23.5	25.15	3.93	1.567	5.00	31	59	41
8	22	23.65	3.82	1.567	3.54	21	61	39
15	21	22.65	3.85	1.567	2.58	16	63	37
30	19	20.65	3.89	1.567	1.83	11	66	34
60	17.5	19.15	3.93	1.567	1.29	8	69	31
120	5.5	7.15	4.21	1.567	0.91	6	88	12
240	3	4.65	4.27	1.567	0.65	4	92	8
1410	3	4.65	4.27	1.567	0.27	2	92	8

Fine Sand Fraction - 21%
Silt Fraction - 71%
Clay Fraction - 8%

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Date: 31.7.2005

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REPORT NO: HY050519
DATE: 28.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CI)

SOURCE: 700 - 1100mm
LOCATION: Lot 6 Bluebird Court, Kialla
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	58.54
Total Dry Mass Retained on 75um sieve (grams)	7.86
Fine Sand Proportion	13%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	50	51.65	3.33	1.546	14.14	73	8	92
1	46	47.65	3.42	1.546	10.00	53	15	85
2	43	44.65	3.49	1.546	7.07	38	21	79
4	39.5	41.15	3.57	1.546	5.00	28	27	73
8	37.5	39.15	3.45	1.546	3.54	19	31	69
15	36	37.65	3.49	1.546	2.58	14	33	67
30	33.5	35.15	3.55	1.546	1.83	10	38	62
60	32.5	34.15	3.57	1.546	1.29	7	39	61
120	30	31.65	3.63	1.546	0.91	5	44	56
240	28	29.65	3.68	1.546	0.65	4	47	53
1410	17	18.65	3.94	1.546	0.27	2	67	33

Fine Sand Fraction - 13%
Silt Fraction - 53%
Clay Fraction - 33%

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Date: 28.7.2005

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REPORT NO: HY050526
DATE: 30.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CI)

SOURCE: 300 - 800mm
LOCATION: 62 Mason Street, Shepparton
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	66.84
Total Dry Mass Retained on 75um sieve (grams)	6.30
Fine Sand Proportion	9%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	57	58.65	3.17	1.505	14.14	67	10	90
1	55.5	57.15	3.20	1.505	10.00	48	12	88
2	51.5	53.15	3.30	1.505	7.07	35	18	82
4	18.5	20.15	4.05	1.505	5.00	30	69	31
8	47.5	49.15	3.21	1.505	3.54	17	24	76
15	45	46.65	3.27	1.505	2.58	13	28	72
30	43.5	45.15	3.31	1.505	1.83	9	31	69
60	42	43.65	3.35	1.505	1.29	6	33	67
120	40	41.65	3.39	1.505	0.91	5	36	64
240	37	38.65	3.46	1.505	0.65	3	41	59
1410	35	36.65	3.51	1.505	0.27	1	44	56

Fine Sand Fraction - 9%
Silt Fraction - 34%
Clay Fraction - 56%

Signed ______________

Date: 30.7.2005

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REPORT NO: HY050527
DATE: 31.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CI)

SOURCE: 1700 - 2300mm
LOCATION: 62 Mason Street, Shepparton
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	68.71
Total Dry Mass Retained on 75um sieve (grams)	12.00
Fine Sand Proportion	17%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	51	52.65	3.31	1.584	14.14	74	19	81
1	49	50.65	3.35	1.584	10.00	53	22	78
2	46.5	48.15	3.41	1.584	7.07	38	26	74
4	44	45.65	3.47	1.584	5.00	27	30	70
8	41.5	43.15	3.36	1.584	3.54	19	33	67
15	39	40.65	3.42	1.584	2.58	14	37	63
30	37.5	39.15	3.45	1.584	1.83	10	40	60
60	35.5	37.15	3.50	1.584	1.29	7	43	57
120	25	26.65	3.75	1.584	0.91	5	59	41
240	11.5	13.15	4.07	1.584	0.65	4	80	20
1410	3.5	5.15	4.26	1.584	0.27	2	92	8

Fine Sand Fraction - 17%
Silt Fraction - 75%
Clay Fraction - 8%

Signed D Earl

Date: 31.7.2005

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REPORT NO: HY050530
DATE: 30.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CH)

SOURCE: 400 - 1000mm
LOCATION: 365 Mitchell Road, Kialla
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	57.86
Total Dry Mass Retained on 75um sieve (grams)	3.89
Fine Sand Proportion	7%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	52.5	54.15	3.27	1.582	14.14	73	1	99
1	51.5	53.15	3.30	1.582	10.00	52	3	97
2	51.5	53.15	3.30	1.582	7.07	37	3	97
4	51.5	53.15	3.30	1.582	5.00	26	3	97
8	51.5	53.15	3.12	1.582	3.54	17	3	97
15	51.5	53.15	3.12	1.582	2.58	13	3	97
30	51.5	53.15	3.12	1.582	1.83	9	3	97
60	51	52.65	3.13	1.582	1.29	6	4	96
120	51	52.65	3.13	1.582	0.91	5	4	96
240	49	50.65	3.18	1.582	0.65	3	7	93
1410	12	13.65	4.06	1.582	0.27	2	75	25

Fine Sand Fraction - 7%
Silt Fraction - 68%
Clay Fraction - 25%

Signed ______________

Date: 30.7.2005

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REPORT NO: HY050531
DATE: 30.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Clay (CH)

SOURCE: 1000 - 1600mm
LOCATION: 365 Mitchell Road, Kialla
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	67.04
Total Dry Mass Retained on 75um sieve (grams)	3.65
Fine Sand Proportion	5%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	57	58.65	3.17	1.617	14.14	72	6	94
1	57	58.65	3.17	1.617	10.00	51	6	94
2	57	58.65	3.17	1.617	7.07	36	6	94
4	57	58.65	3.17	1.617	5.00	26	6	94
8	57	58.65	2.99	1.617	3.54	17	6	94
15	57	58.65	2.99	1.617	2.58	12	6	94
30	57	58.65	2.99	1.617	1.83	9	6	94
60	57	58.65	2.99	1.617	1.29	6	6	94
120	56	57.65	3.01	1.617	0.91	4	7	93
240	54.5	56.15	3.05	1.617	0.65	3	10	90
1410	42.5	44.15	3.33	1.617	0.27	1	29	71

Fine Sand Fraction - 5%
Silt Fraction - 24%
Clay Fraction - 71%

Signed

Date: 30.7.2005

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Damien Byrne C.P. Eng. (Civil). M.I.E. (Aus.) EC1605

David Melrose C.P. Eng. (Civil). M.I.E. (Aus.) EC1917

Ph: (03) 5821 7393
Fax: (03) 5831 3042

REPORT NO: HY050541
DATE: 7.8.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay (CH)

SOURCE: 1500 - 2000mm
LOCATION: Lot 105 Taig Avenue, Kialla
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	64.80
Total Dry Mass Retained on 75um sieve (grams)	3.52
Fine Sand Proportion	5%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	57.5	59.15	3.16	1.549	14.14	69	5	95
1	57.5	59.15	3.16	1.549	10.00	49	5	95
2	57.5	59.15	3.16	1.549	7.07	35	5	95
4	57.5	59.15	3.16	1.549	5.00	24	5	95
8	57.5	59.15	2.98	1.549	3.54	16	5	95
15	57.5	59.15	2.98	1.549	2.58	12	5	95
30	57.5	59.15	2.98	1.549	1.83	8	5	95
60	57.5	59.15	2.98	1.549	1.29	6	5	95
120	57.5	59.15	2.98	1.549	0.91	4	5	95
240	57.5	59.15	2.98	1.549	0.65	3	5	95
1410	20.5	22.15	3.86	1.549	0.27	2	64	36

Fine Sand Fraction - 5%
Silt Fraction - 59%
Clay Fraction - 36%

Signed D Earl

Date: 7.8.2005

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REPORT NO: HY050542
DATE: 7.8.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Clay (CH)

SOURCE: 600 - 1000mm
LOCATION: Lot 765 Narran Court, Kialla Lakes
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	70.59
Total Dry Mass Retained on 75um sieve (grams)	3.13
Fine Sand Proportion	4%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	60	61.65	3.10	1.536	14.14	67	10	90
1	60	61.65	3.10	1.536	10.00	48	10	90
2	60	61.65	3.10	1.536	7.07	34	10	90
4	60	61.65	3.10	1.536	5.00	24	10	90
8	60	61.65	2.92	1.536	3.54	16	10	90
15	60	61.65	2.92	1.536	2.58	12	10	90
30	60	61.65	2.92	1.536	1.83	8	10	90
60	60	61.65	2.92	1.536	1.29	6	10	90
120	58.5	60.15	2.95	1.536	0.91	4	12	88
240	58	59.65	2.96	1.536	0.65	3	13	87
1410	53	54.65	3.08	1.536	0.27	1	20	80

Fine Sand Fraction - 4%
Silt Fraction - 16%
Clay Fraction - 80%

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Date: 7.8.2005

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Fax: (03) 5831 3042

REPORT NO: HY050544
DATE: 28.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with sand (CI)

SOURCE: 1500 - 2000mm
LOCATION: 8 Gray Street, Benalla
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	50.07
Total Dry Mass Retained on 75um sieve (grams)	8.27
Fine Sand Proportion	17%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	35	36.65	3.67	1.692	14.14	88	18	82
1	33.5	35.15	3.70	1.692	10.00	63	21	79
2	31.5	33.15	3.75	1.692	7.07	45	26	74
4	29	30.65	3.81	1.692	5.00	32	31	69
8	28	29.65	3.68	1.692	3.54	22	34	66
15	26.5	28.15	3.71	1.692	2.58	16	37	63
30	25	26.65	3.75	1.692	1.83	12	40	60
60	24.5	26.15	3.76	1.692	1.29	8	41	59
120	23	24.65	3.80	1.692	0.91	6	45	55
240	20.5	22.15	3.86	1.692	0.65	4	50	50
1410	12.5	14.15	4.05	1.692	0.27	2	68	32

Fine Sand Fraction - 17%
Silt Fraction - 52%
Clay Fraction - 32%

Signed D Earl

Date: 28.7.2005

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REPORT NO: HY050545
DATE: 3.8.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with sand (CL)

SOURCE: 500 - 1000mm
LOCATION: Lot 3 Murrays Road, Benalla
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	72.51
Total Dry Mass Retained on 75um sieve (grams)	13.16
Fine Sand Proportion	18%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	48	49.65	3.38	1.549	14.14	74	29	71
1	46	47.65	3.42	1.549	10.00	53	32	68
2	42	43.65	3.51	1.549	7.07	38	37	63
4	36	37.65	3.65	1.549	5.00	28	46	54
8	32.5	34.15	3.57	1.549	3.54	20	51	49
15	30	31.65	3.63	1.549	2.58	15	55	45
30	26.5	28.15	3.71	1.549	1.83	11	60	40
60	23.5	25.15	3.79	1.549	1.29	8	64	36
120	21	22.65	3.85	1.549	0.91	5	67	33
240	19.5	21.15	3.88	1.549	0.65	4	70	30
1410	16.5	18.15	3.95	1.549	0.27	2	74	26

Fine Sand Fraction - 18%
Silt Fraction - 56%
Clay Fraction - 26%

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Date: 3.8.2005

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REPORT NO: HY050547

DATE: 3.8.2005

TESTED BY: D. Earl

SAMPLED BY: D. Earl

MATERIAL: Silt with sand (ML)

SOURCE: 100 - 500mm

LOCATION: Lot 3 Murrays Road, Benalla

CLIENT NAME: D. Earl

CLIENT ADDRESS: 41 Ferguson Road, Shepparton

TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	70.02
Total Dry Mass Retained on 75um sieve (grams)	17.52
Fine Sand Proportion	25%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	39.5	41.15	3.57	1.485	14.14	75	41	59
1	36	37.65	3.65	1.485	10.00	54	46	54
2	32.5	34.15	3.73	1.485	7.07	39	51	49
4	27	28.65	3.85	1.485	5.00	29	59	41
8	23.5	25.15	3.79	1.485	3.54	20	64	36
15	20	21.65	3.87	1.485	2.58	15	69	31
30	16.5	18.15	3.95	1.485	1.83	11	74	26
60	15	16.65	3.99	1.485	1.29	8	76	24
120	13	14.65	4.04	1.485	0.91	5	79	21
240	11	12.65	4.08	1.485	0.65	4	82	18
1410	8	9.65	4.15	1.485	0.27	2	86	14

Fine Sand Fraction - 25%
Silt Fraction - 61%
Clay Fraction - 14%

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Date: 3.8.2005

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REPORT NO: HY050548
DATE: 31.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Sandy Clay (CI)

SOURCE: 300 - 800mm
LOCATION: Lot 1 Ruttles Road, Strathmerton
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	58.90
Total Dry Mass Retained on 75um sieve (grams)	18.53
Fine Sand Proportion	31%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	33	34.65	3.72	1.480	14.14	78	40	60
1	31.5	33.15	3.75	1.480	10.00	56	43	57
2	30	31.65	3.78	1.480	7.07	40	45	55
4	29	30.65	3.81	1.480	5.00	28	47	53
8	28.5	30.15	3.67	1.480	3.54	19	48	52
15	27	28.65	3.70	1.480	2.58	14	51	49
30	26	27.65	3.73	1.480	1.83	10	52	48
60	25	26.65	3.75	1.480	1.29	7	54	46
120	23.5	25.15	3.79	1.480	0.91	5	57	43
240	21	22.65	3.85	1.480	0.65	4	61	39
1410	18	19.65	3.92	1.480	0.27	2	66	34

Fine Sand Fraction - 31%
Silt Fraction - 35%
Clay Fraction - 34%

Signed

Date: 31.7.2005

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REPORT NO: HY050549
DATE: 28.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silt with sand (ML)

SOURCE: 100 - 300mm
LOCATION: Lot 1 Ruttles Road, Strathmerton
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	69.76
Total Dry Mass Retained on 75um sieve (grams)	25.12
Fine Sand Proportion	36%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	42	43.65	3.51	1.498	14.14	74	36	64
1	35	36.65	3.67	1.498	10.00	55	46	54
2	29.5	31.15	3.80	1.498	7.07	40	54	46
4	27.5	29.15	3.84	1.498	5.00	29	57	43
8	26	27.65	3.73	1.498	3.54	20	59	41
15	25	26.65	3.75	1.498	2.58	15	61	39
30	23	24.65	3.80	1.498	1.83	10	64	36
60	21	22.65	3.85	1.498	1.29	7	67	33
120	18.5	20.15	3.90	1.498	0.91	5	70	30
240	16.5	18.15	3.95	1.498	0.65	4	73	27
1410	11.5	13.15	4.07	1.498	0.27	2	81	19

Fine Sand Fraction - 36%
Silt Fraction - 45%
Clay Fraction - 19%

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Date: 28.7.2005

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REPORT NO: HY050550
DATE: 31.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with sand (CL)

SOURCE: 200 - 700mm
LOCATION: 5 Lincoln Street, Katandra West
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	48.85
Total Dry Mass Retained on 75um sieve (grams)	13.07
Fine Sand Proportion	27%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	40	41.65	3.56	1.495	14.14	75	14	86
1	35	36.65	3.67	1.495	10.00	55	24	76
2	29	30.65	3.81	1.495	7.07	40	36	64
4	27	28.65	3.85	1.495	5.00	29	41	59
8	25.5	27.15	3.74	1.495	3.54	20	44	56
15	24.5	26.15	3.76	1.495	2.58	15	46	54
30	23	24.65	3.80	1.495	1.83	10	49	51
60	22	23.65	3.82	1.495	1.29	7	51	49
120	21	22.65	3.85	1.495	0.91	5	53	47
240	19.5	21.15	3.88	1.495	0.65	4	56	44
1410	14.5	16.15	4.00	1.495	0.27	2	67	33

Fine Sand Fraction - 27%
Silt Fraction - 40%
Clay Fraction - 33%

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Date: 31.7.2005

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REPORT NO: HY050551
DATE: 28.7.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CL)

SOURCE: 250 - 600mm
LOCATION: Lot 404 Linda Court, Yarrawonga
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	58.57
Total Dry Mass Retained on 75um sieve (grams)	8.35
Fine Sand Proportion	14%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	42	43.65	3.51	1.507	14.14	75	24	76
1	40.5	42.15	3.55	1.507	10.00	53	27	73
2	38.5	40.15	3.59	1.507	7.07	38	30	70
4	36	37.65	3.65	1.507	5.00	27	35	65
8	35	36.65	3.51	1.507	3.54	19	36	64
15	33.5	35.15	3.55	1.507	2.58	14	39	61
30	32.5	34.15	3.57	1.507	1.83	10	41	59
60	30.5	32.15	3.62	1.507	1.29	7	44	56
120	29.5	31.15	3.64	1.507	0.91	5	46	54
240	27.5	29.15	3.69	1.507	0.65	4	49	51
1410	21.5	23.15	3.83	1.507	0.27	2	60	40

Fine Sand Fraction - 14%
Silt Fraction - 45%
Clay Fraction - 40%

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Date: 28.7.2005

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REPORT NO: HY050561
DATE: 3.8.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with sand (CI)

SOURCE: 300 - 700mm
LOCATION: 31 Orr Street, Shepparton
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	54.89
Total Dry Mass Retained on 75um sieve (grams)	12.70
Fine Sand Proportion	23%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	37	38.65	3.63	1.475	14.14	76	29	71
1	35	36.65	3.67	1.475	10.00	54	33	67
2	33	34.65	3.72	1.475	7.07	39	37	63
4	30	31.65	3.78	1.475	5.00	28	42	58
8	28.5	30.15	3.67	1.475	3.54	19	45	55
15	27	28.65	3.70	1.475	2.58	14	48	52
30	26	27.65	3.73	1.475	1.83	10	50	50
60	24.5	26.15	3.76	1.475	1.29	7	52	48
120	23	24.65	3.80	1.475	0.91	5	55	45
240	21.5	23.15	3.83	1.475	0.65	4	58	42
1410	19	20.65	3.89	1.475	0.27	2	62	38

Fine Sand Fraction - 23%
Silt Fraction - 39%
Clay Fraction - 38%

Signed D. Earl

Date: 3.8.2005

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REPORT NO: HY050562
DATE: 3.8.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with sand (CI)

SOURCE: 1300 - 1800mm
LOCATION: Lot 404 Linda Crescent, Yarrawonga
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	56.14
Total Dry Mass Retained on 75um sieve (grams)	8.85
Fine Sand Proportion	16%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	45	46.65	3.44	1.526	14.14	74	15	85
1	45	46.65	3.44	1.526	10.00	53	15	85
2	45	46.65	3.44	1.526	7.07	37	15	85
4	45	46.65	3.44	1.526	5.00	26	15	85
8	44	45.65	3.30	1.526	3.54	18	16	84
15	41.5	43.15	3.36	1.526	2.58	13	21	79
30	39	40.65	3.42	1.526	1.83	10	26	74
60	27.5	29.15	3.69	1.526	1.29	7	47	53
120	8.5	10.15	4.14	1.526	0.91	6	81	19
240	3.5	5.15	4.26	1.526	0.65	4	91	9
1410	3	4.65	4.27	1.526	0.27	2	91	9

Fine Sand Fraction - 16%
Silt Fraction - 76%
Clay Fraction - 9%

Signed ____________

Date: 3.8.2005

NATA

SOIL TESTING LABORATORY • STRUCTURAL & CIVIL DESIGN

B·M CIVIL ENGINEERS

B·M CONSULTING
CIVIL ENGINEERS PTY. LTD.
A.B.N. 36 473 826 551

6 Clarke Street, Shepparton, 3630
P. O. Box 6577, Shepparton, 3632

Damien Byrne C.P. Eng. (Civil). M.I.E. (Aus.) EC1605

David Melrose C.P. Eng. (Civil). M.I.E. (Aus.) EC1917

Ph: (03) 5821 7393
Fax: (03) 5831 3042

REPORT NO: HY050577

DATE: 10.8.2005

TESTED BY: D. Earl

SAMPLED BY: D. Earl

MATERIAL: Silty Clay with traces of sand (CI)

SOURCE: 400 - 700mm

LOCATION: Lot 41 Boyd Avenue, Shepparton

CLIENT NAME: D. Earl

CLIENT ADDRESS: 41 Ferguson Road, Shepparton

TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	59.80
Total Dry Mass Retained on 75um sieve (grams)	6.24
Fine Sand Proportion	10%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	43.5	45.15	3.48	1.493	14.14	73	23	77
1	41.5	43.15	3.52	1.493	10.00	53	26	74
2	38.5	40.15	3.59	1.493	7.07	38	31	69
4	35	36.65	3.67	1.493	5.00	27	37	63
8	32.5	34.15	3.57	1.493	3.54	19	42	58
15	30	31.65	3.63	1.493	2.58	14	46	54
30	28.5	30.15	3.67	1.493	1.83	10	49	51
60	27	28.65	3.70	1.493	1.29	7	51	49
120	25.5	27.15	3.74	1.493	0.91	5	54	46
240	23.5	25.15	3.79	1.493	0.65	4	57	43
1410	21	22.65	3.85	1.493	0.27	2	61	39

Fine Sand Fraction - 10%
Silt Fraction - 51%
Clay Fraction - 39%

Signed D Earl

Date: 10.8.2005

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Ph: (03) 5821 7393
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REPORT NO: HY050578
DATE: 10.8.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with traces of sand (CI)

SOURCE: 700 - 1300mm
LOCATION: Lot 41 Boyd Avenue, Shepparton
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	52.97
Total Dry Mass Retained on 75um sieve (grams)	4.08
Fine Sand Proportion	8%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	43.5	45.15	3.48	1.519	14.14	75	12	88
1	40.5	42.15	3.55	1.519	10.00	54	18	82
2	37	38.65	3.63	1.519	7.07	39	24	76
4	32.5	34.15	3.73	1.519	5.00	28	33	67
8	29.5	31.15	3.64	1.519	3.54	20	39	61
15	26.5	28.15	3.71	1.519	2.58	15	45	55
30	24.5	26.15	3.76	1.519	1.83	10	49	51
60	23.5	25.15	3.79	1.519	1.29	7	51	49
120	21.5	23.15	3.83	1.519	0.91	5	55	45
240	14.5	16.15	4.00	1.519	0.65	4	68	32
1410	4.5	6.15	4.24	1.519	0.27	2	88	12

Fine Sand Fraction - 8%
Silt Fraction - 80%
Clay Fraction - 12%

Signed [signature]

Date: 10.8.2005

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Ph: (03) 5821 7393
Fax: (03) 5831 3042

REPORT NO: HY050579
DATE: 10.8.2005
TESTED BY: D. Earl
SAMPLED BY: D. Earl
MATERIAL: Silty Clay with sand (CL)

SOURCE: 1300 - 3000mm
LOCATION: Lot 41 Boyd Avenue, Shepparton
CLIENT NAME: D. Earl
CLIENT ADDRESS: 41 Ferguson Road, Shepparton
TEST METHODS: AS1289.1, AS1289.2.1.1, AS 1289.3.6.3-1994

Total Dry Mass (grams)	63.95
Total Dry Mass Retained on 75um sieve (grams)	11.24
Fine Sand Proportion	18%

						Diameter (um)	% Retained	% Passing
Elapsed time t	Rh	Corrected reading Rc=Rh+Ct-Ca	F1	F2	F3	D	L	K
0.5	44.5	46.15	3.45	1.452	14.14	71	28	72
1	40.5	42.15	3.55	1.452	10.00	51	34	66
2	35.5	37.15	3.66	1.452	7.07	38	42	58
4	29	30.65	3.81	1.452	5.00	28	52	48
8	26	27.65	3.73	1.452	3.54	19	57	43
15	23	24.65	3.80	1.452	2.58	14	61	39
30	21	22.65	3.85	1.452	1.83	10	65	35
60	20.5	22.15	3.86	1.452	1.29	7	65	35
120	16.5	18.15	3.95	1.452	0.91	5	72	28
240	5.5	7.15	4.21	1.452	0.65	4	89	11
1410	4.5	6.15	4.24	1.452	0.27	2	90	10

Fine Sand Fraction - 18%
Silt Fraction - 73%
Clay Fraction - 10%

Signed [signature]

Date: 10.8.2005

NATA

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