Appendix E

Soils Assessment (Whitehead & Associates)

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Soils Assessment

Riverside

Tea Gardens

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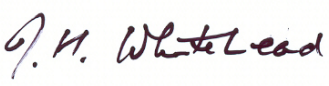
Checked by:	***Issued by:***
3.8.11 	***16.9.11*** 

Disclaimer

- The information contained in this report is based on independent research undertaken by Bridget Whitehead of Whitehead & Associates Environmental Consultants Pty Ltd. To my knowledge, it does not contain any false, misleading or incomplete information. Recommendations are based on an honest appraisal of the site's opportunities and constraints, subject to the limited scope and resources available for this project, and follow relevant best practice standards and guidelines where applicable.

Copyright Note

Table of Contents

1.0 Introduction

Previous studies of the Riverside site (ERM 2011) have identified the occurrence of Swamp Sclerophyll Floodplain Forest as an Endangered Ecological Community (EEC) on the basis of vegetation studies. The occurrence and extent of an EEC is significant for the proposed development of a site as it may limit the permitted development.

A review of the Extent of Endangered Ecological Communities, Riverside, Tea Gardens (Conacher Environmental Group 2011) identifies that the classification of EECs with respect to the Threatened Species Act (1995) and the Environmental Planning and Assessment Act (1979) is dependant on location, vegetation characteristics and soil characteristics. This report concludes that the vegetation communities in question are not classified as EECs due to the absences of identified alluvial soil types and alluvial landforms.

The aim of this study is to determine the origin of the site soils, in order to clarify the possible occurrence of Coastal Floodplain EECs. The differences in soil profile and physical and chemical characteristics of the soils is used to determine the origin of the soil.

This document reports on both the preliminary field work stage of the investigations and the laboratory analyses of the soils.

2.0 Previous studies

Review of the Extent of Endangered Ecological Communities, Riverside Tea Gardens Conacher Environmental Group Feb 2011

This report reviewed the soil and landform requirements for Coastal Floodplain EECs and available soil and soil landscape mapping. As part of the study a series of 20 test pits were used to investigate the soil profile characteristics, and hence determine the depositional origin of the soils. The report concluded that the soils displayed the strong profile development characteristic of a sandy podzol of sand plain origin. No evidence of alluvial soils was encountered during the soil investigation.

Proposed Subdivision – Riverside Estate Project Application and Master Plan Area, Tea Gardens Coffey Geotechnics Pty Ltd July 2008

Proposed Subdivision Riverside Estate Project Application and Concept Plan area, Tea Gardens Coffey Geotechnics Pty Ltd April 2011

These reports provide comments on acid sulphate soils conditions and preliminary geotechnical information for the design and construction of road pavements and residential footings. The Coffey 2008 borelogs of test pits 43, 44 and 45 (the eastern side of the site) identify the sand at these locations as being of aeolian origin. This report identifies the presence of clay soils in the western part of the site but does not comment on their origin.

The conclusions of these two reports do not relate directly to the origins of the soils of the study area, but both reports contain detailed logs of test pits undertaken across the site. While these test pits have been undertaken for a different purpose they may be used to expand the data collected specifically for this study.

The Coastal Geomorphology and Quaternary Geology of the Port Stephens – Myall Lakes area has been described by Thom et al. 1992. The site is located in the Fens embayment which extends from Port Stephens northwards. During the Pleistocene the hills to the north of the site would have formed the shoreline, with a sand barrier and beach ridges extending south and east. The margin of this sand barrier merges with the gently sloping valley fill of the Carboniferous rocks and swamp deposits. Thoms refers to the inner third of the southern part of the Pleistocene beach ridge plain being covered with a veneer of clay up to 2 m thick.

The Department of Land and Water Conservation have published soil landscape maps for the east coast of NSW which map the physical attributes and origins of the soils. Soil Landscapes of the Port Stephens 1:100 000 sheet (CL Murphy 1995) describes the soil landscapes of the site as being of the Tea Gardens and Pindimar Road soil landscape units. This mapping is carried out at a regional scale, so small areas of a soil landscape will not be shown.

3.0 Definitions and Determinations

The NSW Scientific Community Final determination on Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions identifies this EEC as associated with humic clay loams and sandy loams, on waterlogged or periodically inundated alluvial flats and drainage lines associated with coastal floodplains.

The NSW Land and Environment Court has considered two cases in which the definition of Swamp Sclerophyll Floodplain Forest as an EEC has been central to the determination of the case. Gale Holdings Pty Limited v Tweed Shire Council (2008) NSWLEC 209 provides a clear indication that the classification of a vegetation community as an EEC requires the ecological community to meet the final determination of the Scientific Community for that EEC. Hence, to be classified as an EEC a vegetation community must meet the edaphic (soils), locational, floristic and structural criteria for that community.

In the case of the Swamp Sclerophyll Floodplain Forest these are:

- Edaphic - Humic clay loams and sandy loams.
- Locational - Waterlogged or periodically inundated alluvial flats and drainage lines associated with coastal floodplains. Floodplains are level landform patterns on which there may be active erosion and aggradation by channelled and overbank stream flow with an average recurrence interval of 100 years or less.
- Floristic and structural criteria define the characteristic species assemblage and the range of community structures that can occur.

This study looks specifically at the soil characteristics of the site in relation to the definition of an EEC of Swamp Sclerophyll Forest on Coastal Floodplains.

4.0 Site investigation

The Riverside site is located at Tea Gardens, to the east of Myall Way, south of the existing Shearwater Estate and north of Myall Quays subdivision.

On 28 and 29 June 2011 twenty three test pits were excavated to a maximum depth of 2m using a tracked excavator. The location of the excavated test pits is shown in Figure 3. The test pits were logged and soils were characterised by textural field grade (Australian Soils and Land Survey: Field Handbook McDonald et al. 1990). Samples were taken of each horizon for possible further analysis. Test Pit field logs are provided in Appendix 1.

5.0 Discussion

The site soil profiles have been compared with typical soil profiles for soils of different origins, as described in the Soil Landscapes of the Port Stephens 1:100 000 sheet. Figure 1 shows profiles for soils of erosional, aeolian, estuarine and alluvial origin as they typically occur in the Tea Gardens area. According to the Soil Landscape map erosional and aeolian soils (Pindimar Road and Tea Gardens soil landscape units respectively) occur on the site and estuarine soils (Bobs Farm soil landscape unit) occur adjacent to the site. The nearest alluvial soil landscapes (Myall River soil landscape unit) are found over 15km to the north of the adjacent to the Myall River upstream of Bombah Broadwater.

Erosional soil landscapes have been primarily sculpted by the erosive action of running water. Soil may either be absent, derived from water washed parent material or derived from in-situ weathered bedrock. Alluvial soils landscapes are formed by deposition along rivers and streams. Soil parent material is alluvium. Alluvial soil landscapes include floodplains and alluvial deposits. Estuarine soil landscapes occur where rivers and streams enter large bodies of water such as the sea or inland lakes. Aeolian soil landscapes have accumulated by deposition of sand sized particles by wind action.

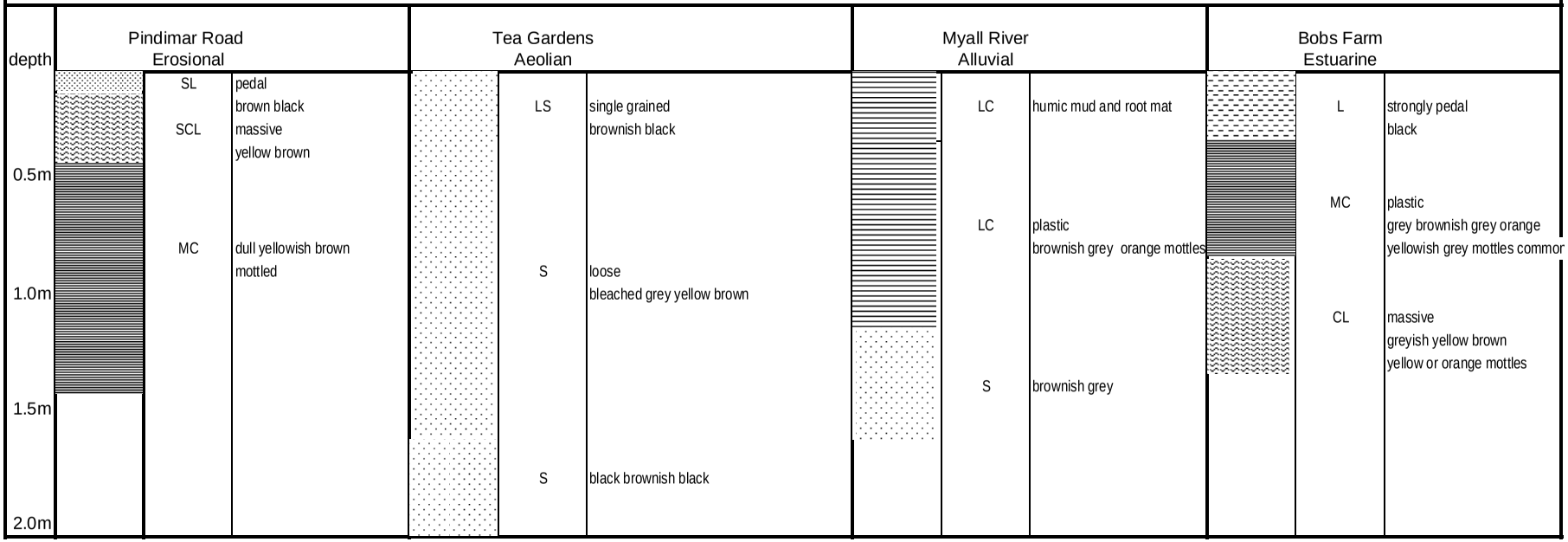
Comparison of the test pits profiles with the typical soil profiles allows an assessment to be made of the origin of the soil at each location, as presented in Table 1.

Table 1 Origin of soil

Soil landscape unit	Occurrence	Origin	Test pit number
Pindimar Road	Poorly drained areas on mudstone	Erosional	15, 20
Tea Gardens	Swales	Aeolian	1, 2, 3, 5, 8, 9, 10, 16, 17, 21, 22
Bobs Farm	Swampy estuarine plain	Estuarine	12, 18, 19
Myall River	Floodplain/ backswamp	Alluvial	

No test pit exhibits a soil profile that perfectly matches the Myall River soil landscape floodplain/ backswamp profile.

Figure 1 Typical soil profiles for Erosional, Aeolian, Alluvial and Estuarine environments



Six test pits (4, 6, 7, 11, 13 and 14) do not fit either the aeolian profile or the estuarine profile but display elements of both, and are interpreted as transitional between the two environments. The soil profile of test pit 23 displays elements of the estuarine and erosional soil profiles.

The Scientific Community determination on Sclerophyll Swamp Floodplain Forest refers to humic clay loams and sandy loams. The soils in test pits 4, 6, 7, 11, 13, 14, 20 and 23 have been described as loam on the basis of the field texture characteristics.

Soil is classified into clay, loam and sand based on the proportion of different sized grains within the soil. A loam is a soil with roughly equal proportions of clay sized, silt sized and sand sized grains. Soil is routinely characterised in the field, based on the behaviour of a sample of soil when manipulated in the hand. Laboratory analysis of the particle size distribution of the soil can be used to more precisely define the texture grade of a soil, by reference to the Australian soil texture triangle.

The soil texture grade does not provide any indication of the origin of the soil. Thus a clay loam may develop on a residual, colluvial or erosional landscape as well as an estuarine, alluvial or lacustrine environment.

6.0 Laboratory analyses

Samples from 6 test pits (7, 11, 15, 16, 18and 23) were submitted for more detailed laboratory analysis. Test pits 15, 16 and 18 are considered representative of soil landscape units Pindimar Road, Tea Gardens and Bobs Farm respectively, so samples from these test pits provide a reference point for the test pits characterised as transitional environments.

Quantitative determination of particle size distribution was made according to wet and dry sieve analysis (AS 1289.3.6.1) and hydrometer analysis for particles finer than the 0.075 sieve (AS 1289.3.6.3), where more than 10% of the sample by mass passed the 0.075 sieve.

A qualitative assessment of the grain shape and petrography of the 0.125mm to 1.0mm fraction of samples was made, using a petrographic microscope.

6.1 Grain analysis

The results of the grain analysis are summarised in Table 2.

Table 2 Grain characteristics		
Test pit	Soil landscape	Description
16	Tea Gardens soil landscape unit Aeolian	Frosted rounded or subrounded quartz grains. The finer sand fraction contains around 5% clear red brown grains, probably rutile
15	Pindimar Road soil landscape unit Residual	No sand sized grains analysed
18	Bobs Farm soil landscape unit Estuarine	Predominantly frosted rounded quartz grains, some with red brown surface coating, 20% clear brown grains in fine fraction
7		Frosted subrounded and rounded quartz grains with brown surface coating
11		Frosted rounded quartz grains. The fine fraction contains clear red brown grains, probably rutile
23		Sub rounded to sub angular elongate pale grey lithic siltstone grains and brown translucent grains. Minor quantities of clear angular quartz grains. Very occasional frosted rounded quartz grains

The sand fraction of the soils in test pits 7 and 11 are very similar to those of beach barrier sand in test pit 16. They both display the rounded or subrounded frosted quartz grains characteristic of the beach barrier sand and the soil in test pit 11 contains the small red brown rutile grains found in the fine fraction of the soil in test pit 16. These features suggest that the sands of test pits 7 and 11 have a similar origin to those of test pit 16.

The grains in the soil from test pit 23 are noticeably different to those of test pits 16 and 18. The grains are predominantly lithic fragments of mudstone and siltstone with minor quantities of quartz grains and brown translucent grains. The majority of quartz grains are clear and angular and do not display the frosted surface exhibited in soils from test pits 16 and 18. There are very occasional rounded frosted quartz grains. The presence of mudstone and siltstone grains suggests that these grains have not been transported a great distance, as these materials are relatively easily abraded during transportation.

6.2 Particle size distribution

The results of the laboratory analyses are summarized in Table 3 and presented in Appendix 2.

Table 3 Particle size distribution				
Sample number	Clay (< 0.002mm) % by mass	Silt (0.002 to 0.02mm % by mass	Sand (> 0.02mm % by mass	Classification according to Australian Soil texture triangle
7.1	89.2	2.7	8.2	Sand
7.2	89.8	2.2	8.0	Sand
7.3	91.1	Not assessed*		Sand
11.1	93.5	3.0	3.5	Sand
11.2	92.3	1.5	6.2	Sand
11.3	92.1	0.5	7.4	Sand
15.1	32.6	18.8	48.6	Clay
15.2	72.6	11.2	16.2	Loam
16.1	93.6	Not assessed*		Sand
16.2	95.1	Not assessed*		Sand
16.3	97.7	0.6	1.7	Sand
18.1	56.6	4.9	38.4	Clay
18.2	93.2	1.2	5.6	Sand
23.1	75.1	13.6	11.3	Loam
23.2	79.3	10.9	9.4	Loamy sand
23.3	96.1	1.2	2.7	Sand

* where more than 90% of the sample is retained on the 0.075mm sieve, future analysis is not required to classify the soil as a sand, so no assessment has been made of the silt or clay sized fractions.

Soil is classified as clay, loam or sand based on the proportion of different sized grains within the soil. A loam is a soil with roughly equal proportions of clay sized, silt sized and sand sized grains. Soil is routinely characterised in the field, based on the behaviour of a sample of soil when manipulated in the hand. Laboratory analysis of the particle size distribution of the soil can be used to more precisely define the texture grade of a soil, by reference to the Australian soil texture triangle.

A preliminary analysis of the Riverside soils was made on field texture characteristics, as described in Section 4.0 above. Laboratory analysis of the soil particle size distribution

has been undertaken to determine the soil texture category of the soils in test pits 7, 11, 15, 16, 18 and 23. The results are presented in Figure 2.

These results have been used to refine the assessment of the origin of the soils.

Test pit 7 field log records the soils as sandy loam overlying a clay loam sand over a sand. The laboratory analysis classifies all these horizons as sands. The grain analysis demonstrates that the sands have characteristics comparable with the beach barrier sands of test pit 16. Test pit 7 is therefore considered to fall into the Tea Gardens soil landscape unit.

Test pit 11 field log records the soils as loamy sand overlying a clay loam sand, over a sand and a clay loam sand. The laboratory analysis classifies these horizons as sand. The grain analysis demonstrates that these sands have characteristics of the beach barrier sand of test pit 16. Test pit 11 is therefore considered to fall into the Tea Gardens soil landscape unit.

Test pit 23 field log records the soils as loam overlying a clay loam sand, overlying a clayey sand. The laboratory analysis classifies these horizons as loam, sandy loam and sand respectively. Test pit 23 does not fit the profile of any of the proposed soil landscape units exactly. The grain analysis indicates that sand fraction of this soil is significantly different to the sands of the Tea Gardens and Bobs Farm soils landscape units. The predominance of mudstone and siltstone grains indicates that these grains have not been transported a significant distance. Pindimar Road soil landscape is an erosional soil developed on mudstone and siltstone parent rock. The presence of grains of these materials in the soil at test pit 23 leads to this soil profile being considered to form part of the Pindimar Road soil landscape unit.

The results of the analyses of test pits 7 and 11 have been interpolated to the adjacent test pits. Hence, test pits 4, 6, 11 and 14 are considered to be of the Tea Gardens soils landscape unit. Test pit 13 exhibits a very thick surface loam horizon compared with the Tea Gardens soil landscape unit but the underlying sands demonstrate the same frosted rounded quartz grains that are characteristic of the Tea Gardens soil landscape unit. Hence test pit 13 is considered to be of the Tea Gardens soil landscape unit.

The soil landscapes of the site are presented in Figure 3.

The soil profiles of test pits 12, 13, 18, 19, 20 and 23 contain loam or sandy loam. The soil texture grade does not provide any indication of the origin of the soil. Comparison of the soil profiles at these test pits with soil profiles of know origin, as in Table 1 shows that the soils of test pits 12, 18 and 19 are of estuarine origin and test pits 20 and 23 of erosional origin.

7.0 Discussion

The classification of a vegetation community as an EEC requires the ecological community to meet the final determination of the Scientific Community for the EEC with respect to edaphic, location, floristic and structural criteria. Swamp Sclerophyll Floodplain Forest on Coastal Floodplains of NSW North Coast are associated with humic clay loams and sandy loams on waterlogged or periodically inundated alluvial flats and drainage lines associated with coastal plains. This report considers the nature of the soils at the Riverside Tea Gardens site; it does not consider floristic or structural considerations.

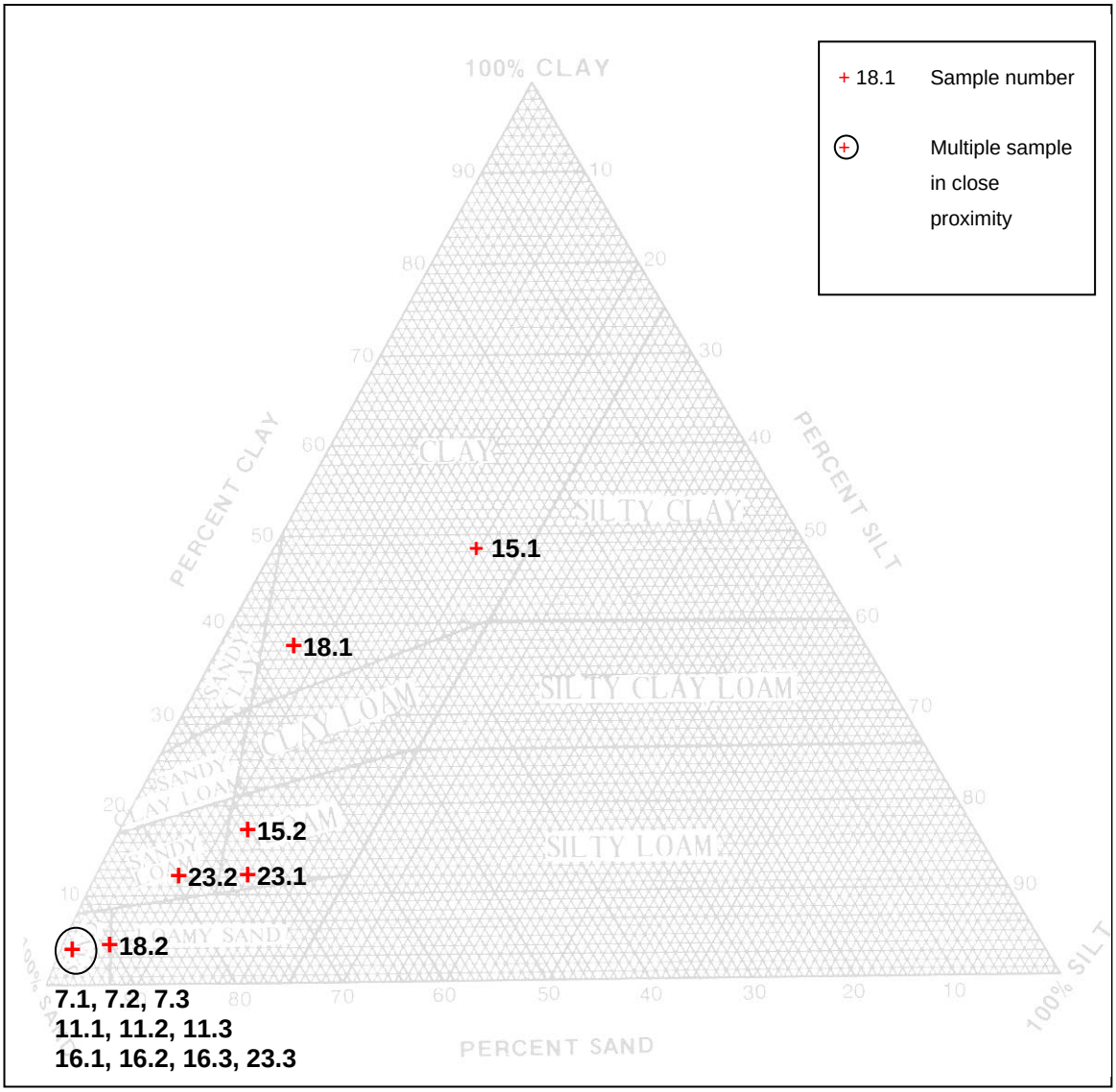


Figure 2 Soil Textures

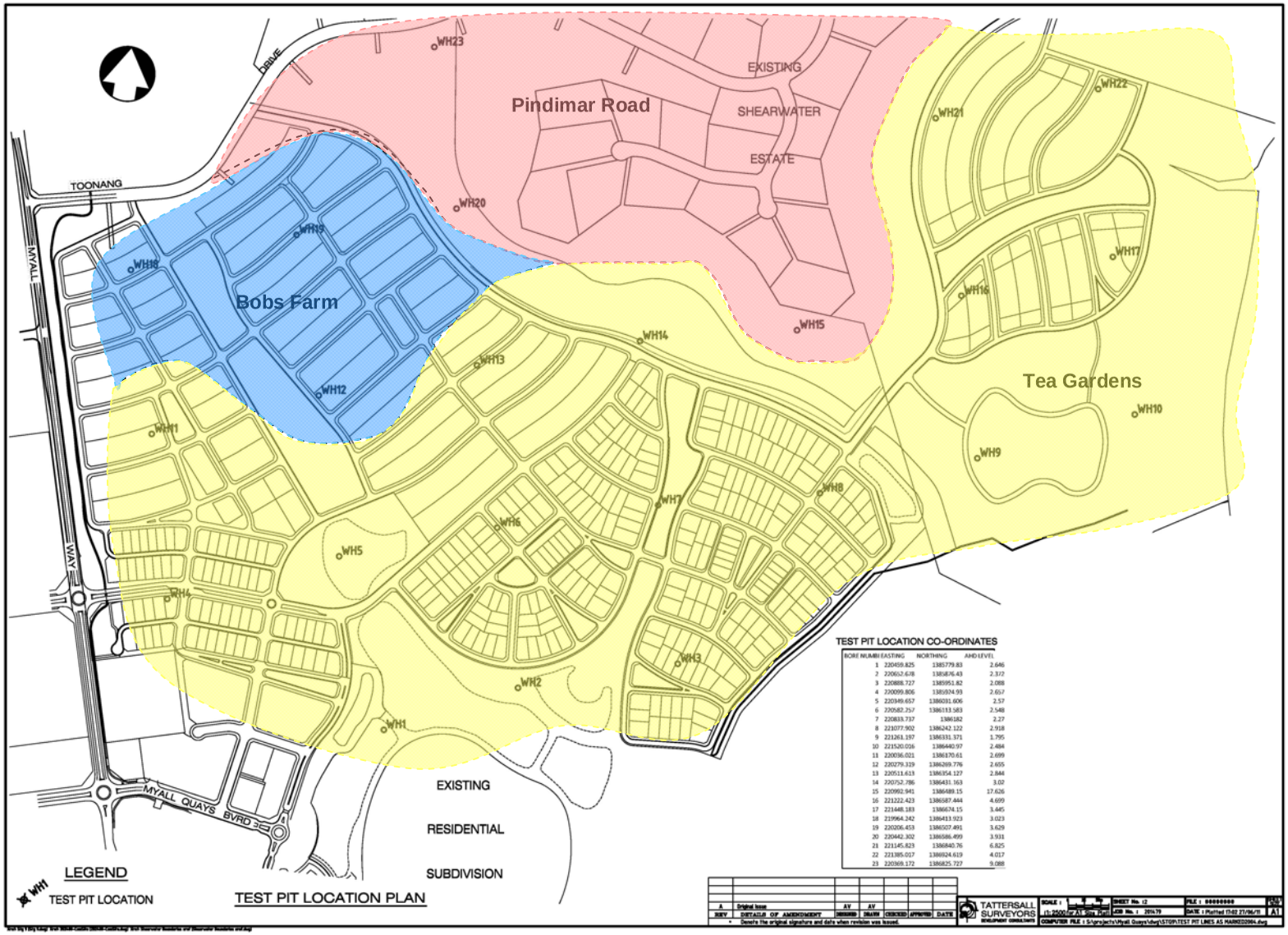


Figure 3 Soil Landscape Unit

The majority of the site is of the Tea Gardens soil landscape unit, which comprises sandy soils of marine (beach barrier) or aeolian origin. The sandy nature of the soils in this soil landscape unit does not meet the edaphic conditions for the Swamp Sclerophyll Floodplain Forest EEC.

The sloping ground adjacent to the existing Shearwater estate to the north of the site is part of the Pindimar soil landscape unit. This erosional soil profile is largely clay at test pit 15, but contains clay loam at test pits 20 and 23. The development of an erosional soil indicates that this is an area subject to erosion rather than deposition as would occur on an alluvial flat. Soils on an erosional soil landscape would therefore not meet the edaphic and locational conditions for the Swamp Sclerophyll Floodplain Forest ECC.

The north western portion of the site adjacent to Toonang Drive is of the Bobs Farm soil landscape unit. The Bobs Farm soil landscape is an estuarine soil landscape formed on a drained Holocene estuarine flat on the coastal sand plain. Alluvial soils landscapes are formed by deposition along rivers and streams whereas estuarine soil landscapes occur where rivers and streams enter large bodies of water such as the sea or inland lakes. The soils of test pits 12, 19 and 20 comprise up to 0.4m of sandy loam overlying a medium clay. While these soils meet the edaphic conditions for the Swamp Sclerophyll Floodplain Forest EEC they have been formed under estuarine conditions. The Scientific community definition does not differentiate between the current locational conditions and those prevailing at the time of deposition of the soils. In this case a clear distinction can be made between soils which have been deposited in an estuarine setting as opposed to those deposited in an alluvial setting. While the soils of this area have edaphic characteristics that meet the Swamp Sclerophyll Floodplain Forest EEC definition and this area is waterlogged at times the soils represent those of a distinctly different depositional setting.

8.0 Conclusions

This report considers the soils at Riverside Tea Gardens with respect to the classification of a vegetation community as an EEC according to the final determination of the Scientific Community for the EEC, it does not consider the floristic or structural characteristics of the vegetation at Riverside Tea Gardens.

While the NSW Scientific Community Final determination on Swamp Sclerophyll Floodplain Forest identifies this EEC as associated with humic clay loams and sandy loams, the presence of these soils types does not indicate alluvial conditions. Indeed soil texture grade does not provide any indication of the origin of the soil. Thus a clay loam may develop on a residual, colluvial or erosional landscape as well as an estuarine, alluvial or lacustrine environment

The southern and eastern part of the site comprises sandy soils of marine (beach barrier) or aeolian origin (Tea Gardens soil landscape). This soil landscape does not meet the conditions for the Swamp Sclerophyll Floodplain Forest EEC.

The northern section of the site comprises clay and clay loam soils of erosional origin (Pindimar Road soil landscape) Soils of an erosional nature would not meet the edaphic and locational conditions for the Swamp Sclerophyll Floodplain Forest EEC

The northwest portion of the site comprises sandy loam formed under estuarine conditions on a drained Holocene estuarine flat on a coastal sand plain. While the soils of this area have edaphic characteristics that meet the Swamp Sclerophyll Floodplain Forest EEC definition and this area is waterlogged at times the soils represent those of a distinctly different depositional setting to an alluvial environment.

9.0 References

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Appendix 1

Test pit logs

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP 1**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32 39.097 152 09.129	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
1.1	0.1 – 0.6		S	single grained	dark black humic		roots	M	moist to base no mottles-uniform
	0.6								black humus on base
1.2	0.7 – 1.0		S	single grained	brown paler to base			M	
	0.9								hard pan at base
	1.0								base of hole 1.0m
	1.1 – 2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP2**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:		Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
2.1	0.1		S	single grained	black			M	
	0.2								
	0.3								
	0.4								
	0.5								
2.2	0.6		SC	pedal	grey yellow			M	
	0.7								
	0.8								
2.3	0.9		S	single grained	yellow brown			M	appears to be beach sand
	1.0								
	1.1								
	1.2								base of hole 1.15m
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP3**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.39.008 152.09.403	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
2.1	0.1		S	single grained	blackish brown brown to base		roots	W	medium sand
	0.2								
	0.3								
	0.4								
	0.5								
	0.6								
2.2	0.7		S	single grained	grey white	orange (rust) some black		W	coarser sand water seeping into hole
	0.8								
	0.9								base of hole 0.9 m
	1.0								
	1.1								
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP4**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32 39.013 152 08.895	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
4.1	0.1		LS	single grains	dark brown			M	roots
	0.2								
4.2	0.3		CS	single grains	brown			M	medium grained some clay lenses
	0.4								
	0.5								
4.3	0.6		SCL	pedal	mid grey brown	orange		M	
	0.7								
	0.8								
4.4	0.9		S	single grains	biscuit white			W	seepage
	1.0								base of hole 1.0m
	1.1								
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP5**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.956 152.09.060	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
5.1	0.1 – 0.3		SCL	moderately pedal	dark brown		roots	M	fine sand
5.2	0.4 – 0.6		SC	weakly pedal	grey brown	orange		M	fine-medium sand heavy-medium clay
5.3	0.7 – 1.0		S	single grained	biscuit white			W	water seepage at 1.0 m
5.4	1.1 – 1.3		SC	weakly pedal	grey	orange		M	medium-heavy clay
5.5	1.4 – 1.8		S	single grained	white/grey biscuit dark black to base			M	humic at base odour at base acidic? soil collapsing at base base of hole 1.8 m
	1.9 – 2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP6**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32 38.915 152 09.209	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
6.1	0.1		L						
6.2	0.2		LS	fine pedal	mid to dark brown			M	
	0.3								
	0.4								
	0.5								
	0.6		CS	single grains	biscuit brown	orange		M	
	0.7								
	0.8							M	
6.3	0.9		SCL		biscuit brown	grey and rust orange			
	1.0								
6.4	1.1		S	single grains	pale brown			W W	seepage base of hole 1.1m
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP7**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32 38.876 152 09.371	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
7.1	0.1								
	0.2		SL	strongly pedal	black brown humic		roots	M	
	0.3								
	0.4								
7.2	0.5		CLS	pedal	grey brown			M	
	0.6								
	0.7								
7.3	0.8		S	massive	biscuit brown darker to top			W	medium grained
	0.9								seepage into hole base of hole at 0.9m
	1.0								
	1.1								
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP8**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.843	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
8.1	0.1–0.4		S	single grained	dark grey/brown		roots	W	wet fine-medium sand
8.2	0.5–0.7		S	single grained	biscuit white			W	wet collapsing hole medium-coarse sand water seepage base of hole 0.75 m
	0.8–2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP9**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.790 152.09.623	Date:	29.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
9.1	0.1		SL	pedal	dark brown/black to grey yellow		roots	M	humic material medium sand
	0.2								
	0.3								
	0.4								
	0.5								
	0.6								
9.2	0.7		S	sinlge grained	biscuit white			W	medium-coarse sand
	0.8								
	0.9								
	1.0								hole collapsing-water seepage base of hole 1.0 m
	1.1								
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP10**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.749 152.09.810	Date:	29.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
10.1	0.1		SL	pedal	grey brown			M	topsoil
	0.2								fine-medium sand
	0.3				grading to			M	
	0.4								
	0.5								
	0.6								
	0.7								
10.2	0.8		S	single grained	biscuit white			W	
	0.9								
	1.0								
	1.1								
	1.2								
	1.3								
	1.4				orange/brown at base				hole collapsing base of hole 1.4 m
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP11**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32 38.879 152 08.857	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
11.1	0.1		LS	Strongly pedal	dark brown			M	water on surface
	0.2								
11.2	0.3		CLS	pedal	mid grey brown			M	
	0.4								
	0.5								
	0.6								
11.3	0.7		S	single grained	biscuit brown	orange			rapid inflow of water
	0.8							W	
	0.9				brown				
	1.0		CLS						base of hole 1.0m
	1.1								
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP12**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.833 152.09.016	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
12.1	0.1		CL	pedal	dark brown		roots	M	plastic no sand
	0.2								
	0.3								hydrogen sulfide anaerobic conditions
	0.4								no sand
	0.5								
12.2	0.6		MC	blocky	medium grey brown	orange		M	
	0.7								
	0.8								
	0.9								
	1.0								
	1.1		HC	blocky	dark grey			M	water dripping into hole from surface no water table at 1.2 m base of hole 1.2 m
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP13**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32 38.787 152 09.172	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
	0.1		SL		dark brown		roots		
	0.2								
13.1	0.3		SL	strongly pedal	dark grey brown				organic
	0.4								
	0.5								
13.2	0.6		LS		coffee brown				black cemented in parts
	0.7								
	0.8								
	0.9								
13.3	1.0		CS	single grained	brown pale brown to base			M	fine grained more sandy to base
	1.1								
	1.2							W	seepage
	1.3		CLS	strongly pedal	browngrey				base of hole 1.3m
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP14**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:		Date:	29.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
	0.1		SCL	moderately pedal	dark grey brown			W	medium sand
	0.2								wet
	0.3								seepage at 0.3 m
	0.4								
14.1	0.5		SCL	pedal	biscuit brown dark grey brown to top			M	medium sand
	0.6								
	0.7								
	0.8								
	0.9								
	1.0		SCL	pedal	medium brown	orange		M	stiff slightly cemented
14.2	1.1								
	1.2								
	1.3								
	1.4								
	1.5								
14.3	1.6		CS	pedal	medium brown			M	medium sand
	1.7								
	1.8								
	1.9								
	2.0								base of hole 2.0m

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP15**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.746 152.09.467	Date:	29.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
	0.1		L	moderately pedal blocky	dark brown			W	water at surface
	0.2								
	0.3								
15.1	0.4		MC	massive	brown	minor orange mottles	occasional rock fragments	M	
	0.5								
	0.6								
	0.7		HC	massive coarse peds up to 2cm	medium brown	minor orange mottles	frequent weathered rock fragments up to 10cm	M	
15.2	0.8								base of hole 0.8 m
	0.9		Parent material weathered		biscuit brown	orange			weathered siltstone
	1.0								
	1.1								
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP16**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.637 152.09.637	Date:	29.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
16.1	0.1		LS	weakly pedal	dark brown grey			M	humic loamy grading to sand
	0.2								
	0.3								
	0.4								
16.2	0.5		S	single grained	dark brown grey			W	very wet well sorted medium sand
	0.6								
	0.7								
	0.8								
	0.9								water at surface
	1.0								
	1.1		S	single grained	biscuit white/grey	brown/orange	brown/orange cemented fragments (humic)		finer sand less well sorted
16.3	1.2								
	1.3								water flow through humic acid
	1.4								
	1.5					black cemented wet nodules			base of hole 1.5 m
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP17**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.637 152.09.756	Date:	29.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
17.1	0.1		LS	weakly pedal	medium grey brown		roots	M	
	0.2								
	0.3								
	0.4								
17.2	0.5		S	single grained	biscuit white			M	medium sand
	0.6								
	0.7								
	0.8								
	0.9								
	1.0								
	1.1								
17.3	1.2		S	single grained	dark coffee brown	orange	cemented	M	hard pan on top fine sand no water in hole base of hole 1.3 m
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								slow seepings at 2.0 m

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP18**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.742 152.08.813	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
	0.1		SL	pedal	brown			M	sandy to base
	0.2								
	0.3								
	0.4								
	0.5								
	0.6		MC	pedal	brown	orange		VM	very sticky
	0.7								
18.1	0.8								
	0.9								
	1.0								
	1.1								
18.2	1.2		CLS	pedal	grey brown				water seeping from underneath odour-hydrogen sulfide anaerobic conditions
	1.3								base of hole 1.3 m
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP19**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.700 152.08.972	Date:	28.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
	0.1		SCL	blocky peds	grey brown			M	
	0.2								
	0.3								
	0.4								slight hydrogen sulfide odour anaerobic conditions
	0.5								
	0.6								(difficult to see structure as rain smearing side of hole)
19.1	0.7								
	0.8								
	0.9								
	1.0		MC	blocky peds	yellow grey brown	orange			
	1.1								
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
19.2	1.8		MC	strong peds	dark grey brown				no water in hole clay crumbly base of hole 1.8 m
	1.9								
	2.0								

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP20**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.659 152.09.117	Date:	29.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
	0.1		CL	strongly pedal	brown		roots	M	
	0.2								
20.1	0.3		CLS	strongly pedal	brown		roots	W	fine sand
	0.4								
	0.5								
	0.6								
	0.7								
20.2	0.8		MC	massive pedal	yellow brown	orange		W	stiff/heavy
	0.9								
	1.0								
	1.1								no water in hole base of hole 1.1 m
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP21**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.526 152.09.573	Date:	29.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
21.1	0.1		LS	pedal	grey brown			W	roots
	0.2								
	0.3								
	0.4								
21.2	0.5		S	single grained	medium grey			M	
	0.6								
	0.7								water flowing onto top from 0.5 m to 0.7 m
21.3	0.8		S	single grained	coffe brown	orange/brown		W	
	0.9								base of hole 0.9 m
	1.0								
	1.1								
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Project	918	**Borehole No.:**	**TP22**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.482 152.09.733	Date:	29.6.11

PROFILE DESCRIPTION

Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
	0.1		LS	pedal	dark grey			W	wet odour-hydrogen sulfide anaerobic
	0.2								
22.1	0.3		S	single grained	pale grey			M	
	0.4								
	0.5								
22.2			S	single grained	grey yellow			M	medium sand
	0.6								
	0.7								
	0.8								
	0.9								
	1.0								water flowing into hole causing collapsing
22.3	1.1		S	single grained	dark coffee brown humic			M	base of hole 1.1 m on weathered siltstone
	1.2								
	1.3								
	1.4								
	1.5								
	1.6								
	1.7								
	1.8								
	1.9								
	2.0								

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

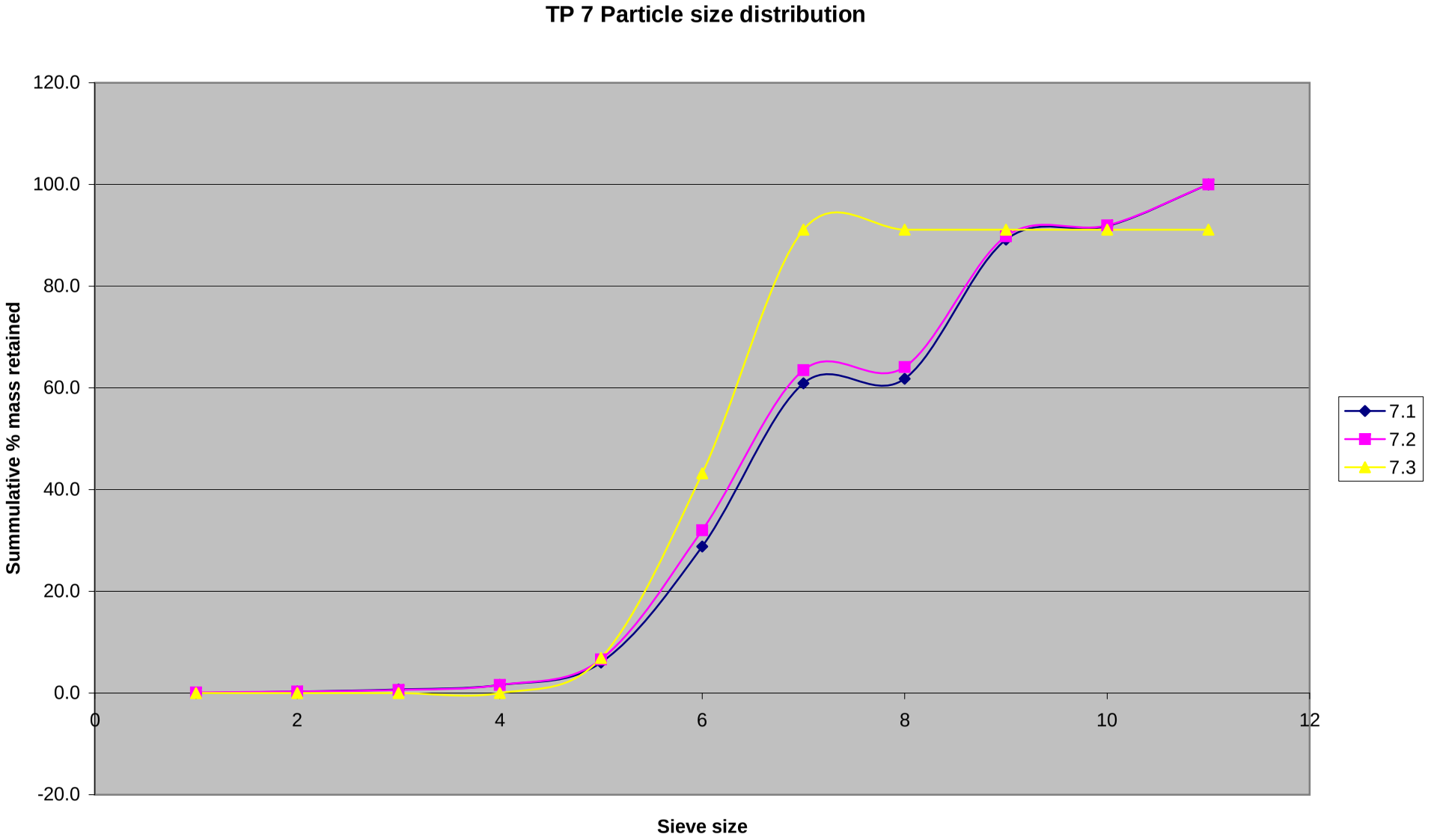
Project	918	**Borehole No.:**	**TP23**
Client:	Crighton Properties	Logged by:	BW
Site:	Riverside Tea Gardens	Excavation method:	Backhoe Test pit
Loc:	32.38.530 152.09.074	Date:	29.6.11

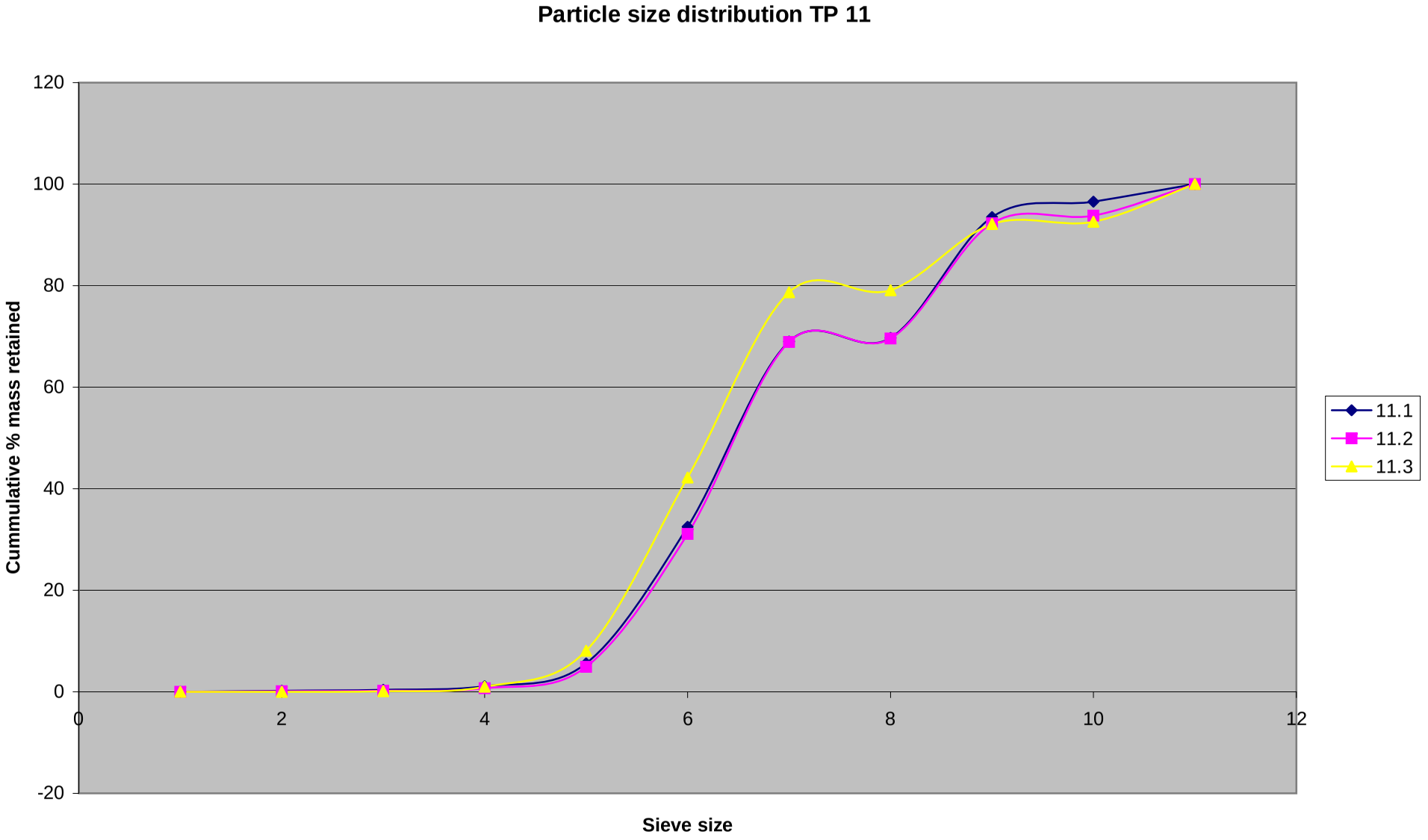
PROFILE DESCRIPTION

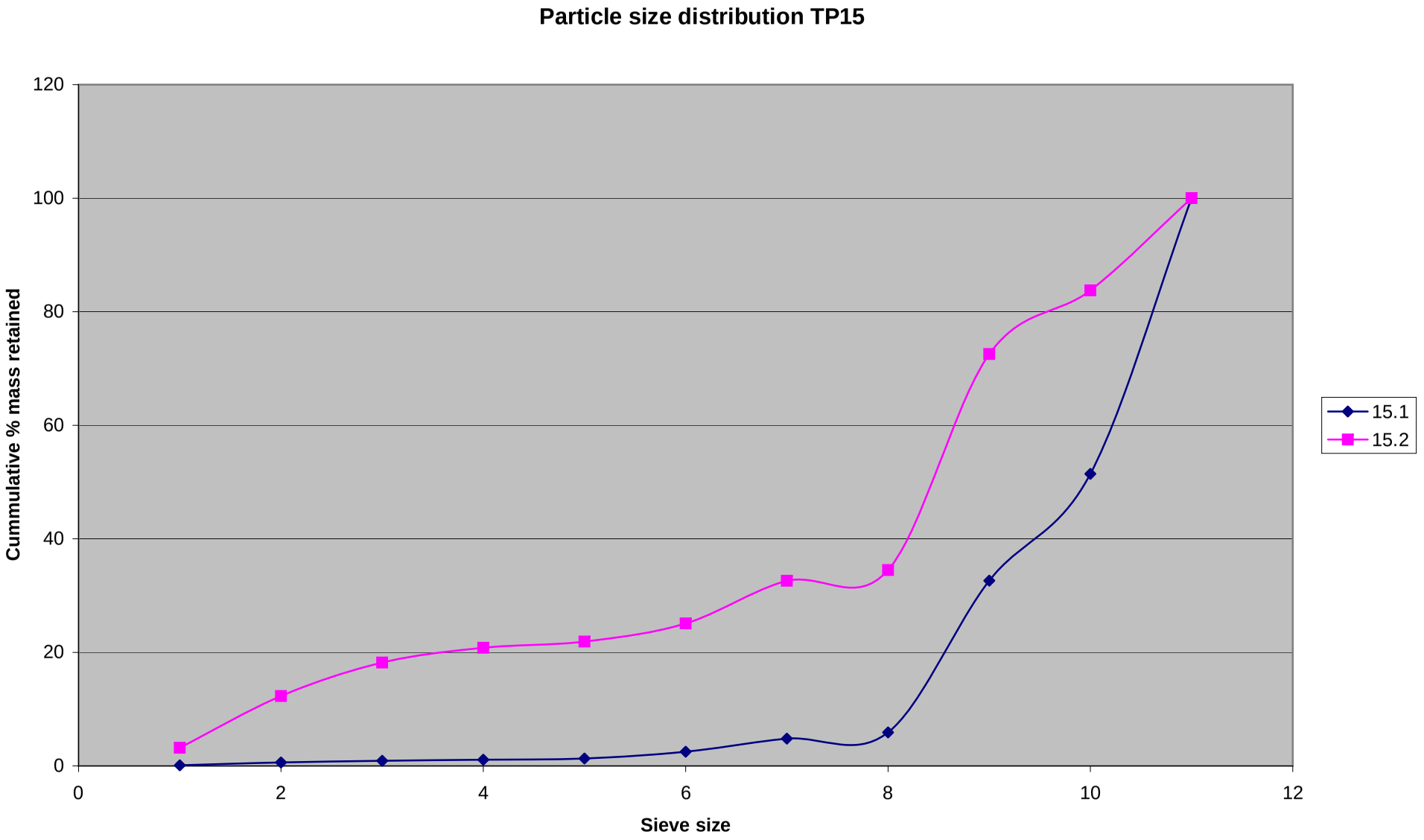
Samples	Depth (m)	Graphic Log	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture	Comments
	0.1		L	pedal	dark brown				
	0.2								
	0.3		CLS	small peds	brown				
23.1	0.4								
	0.5								
	0.6		CLS	pedal	brown				some water seepage
	0.7								
	0.8								
	0.9								
	1.0		CS	medium peds blocky	paler brown				medium sand
23.2	1.1								
	1.2								
	1.3								
	1.4								
	1.5		CS	strongly pedal	light medium brown	orange			coarse sand
	1.6								
23.3	1.7								
	1.8								
	1.9								
	2.0								water in hole base of hole 2.0 m

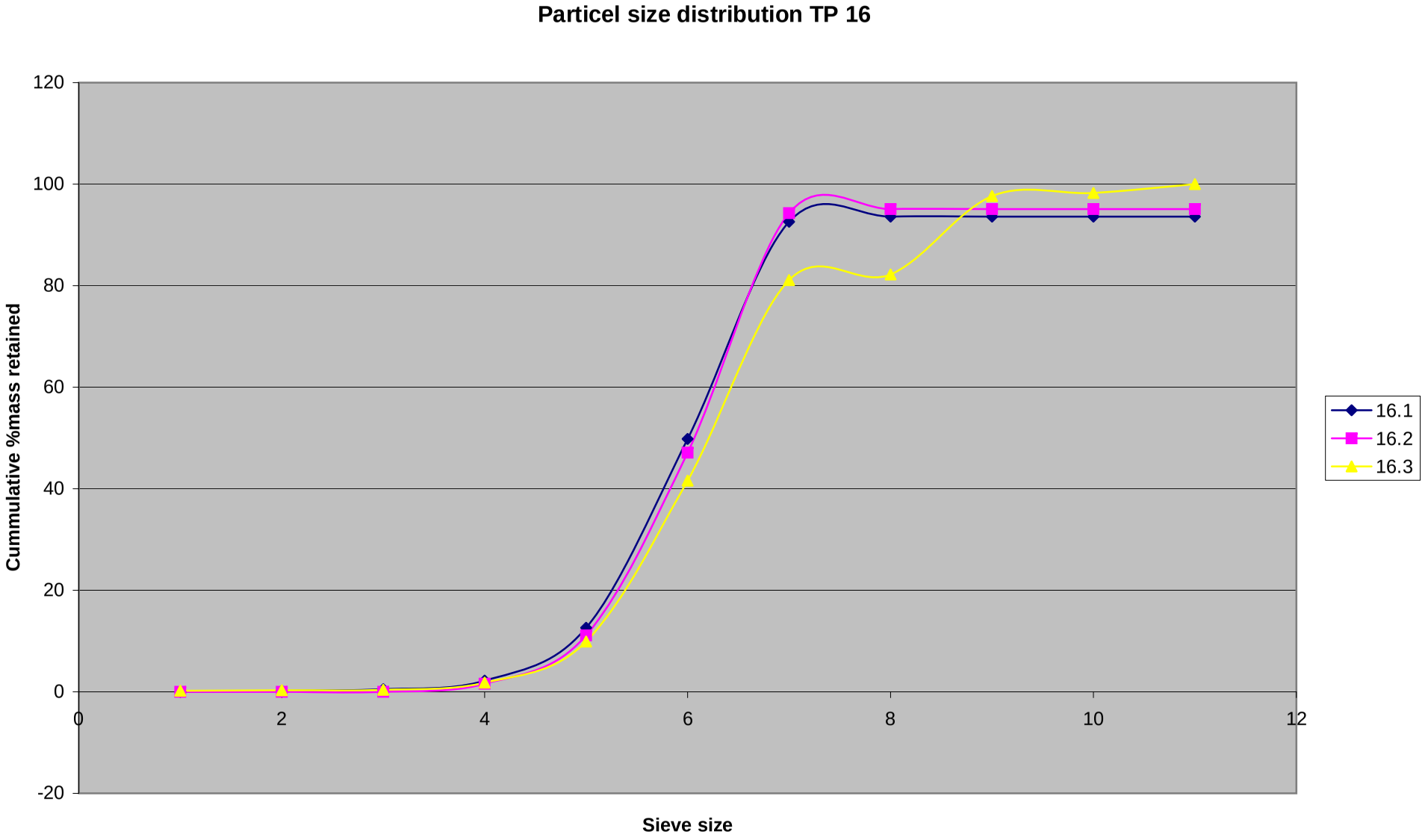
Appendix 2

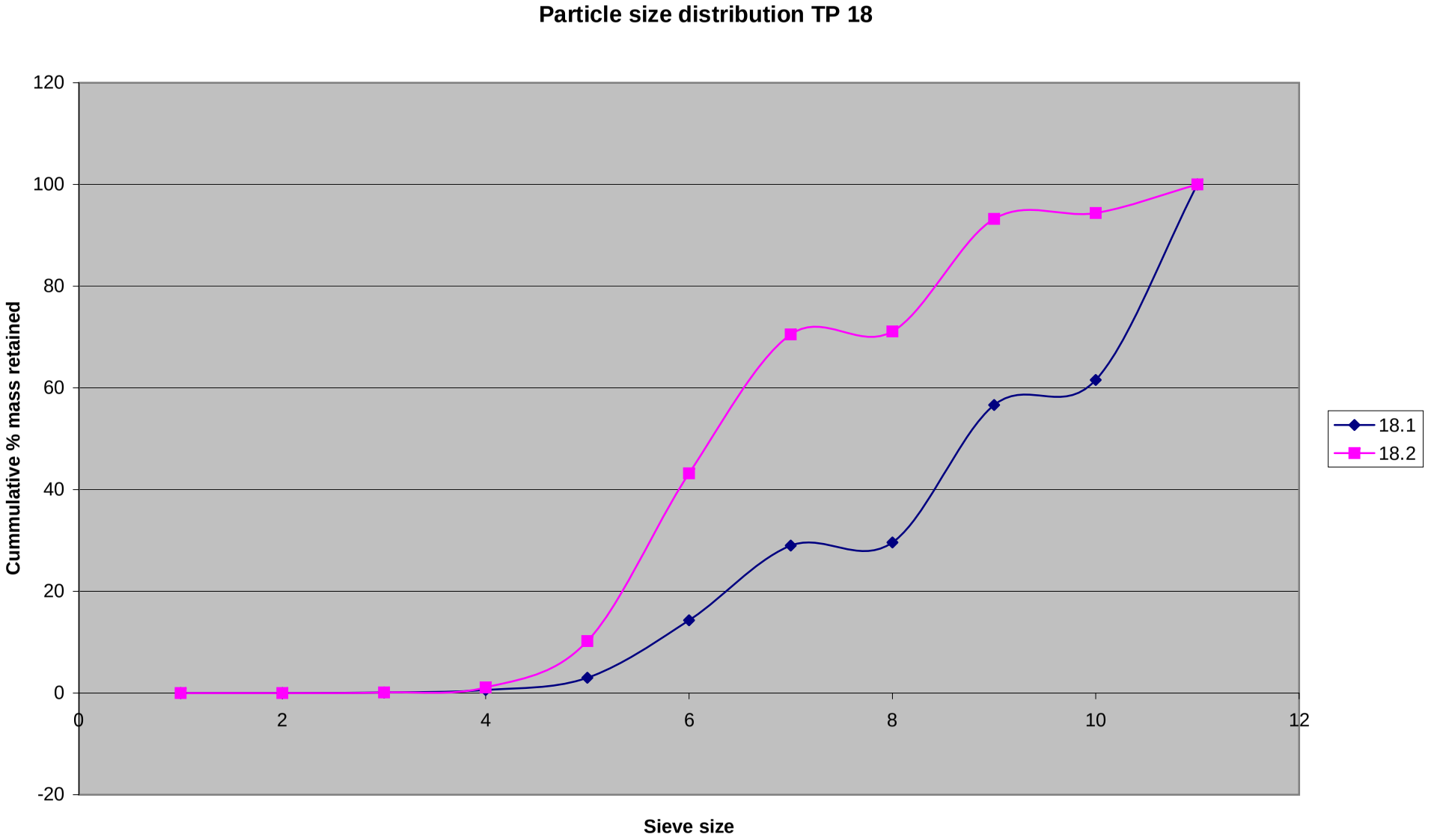
Laboratory results

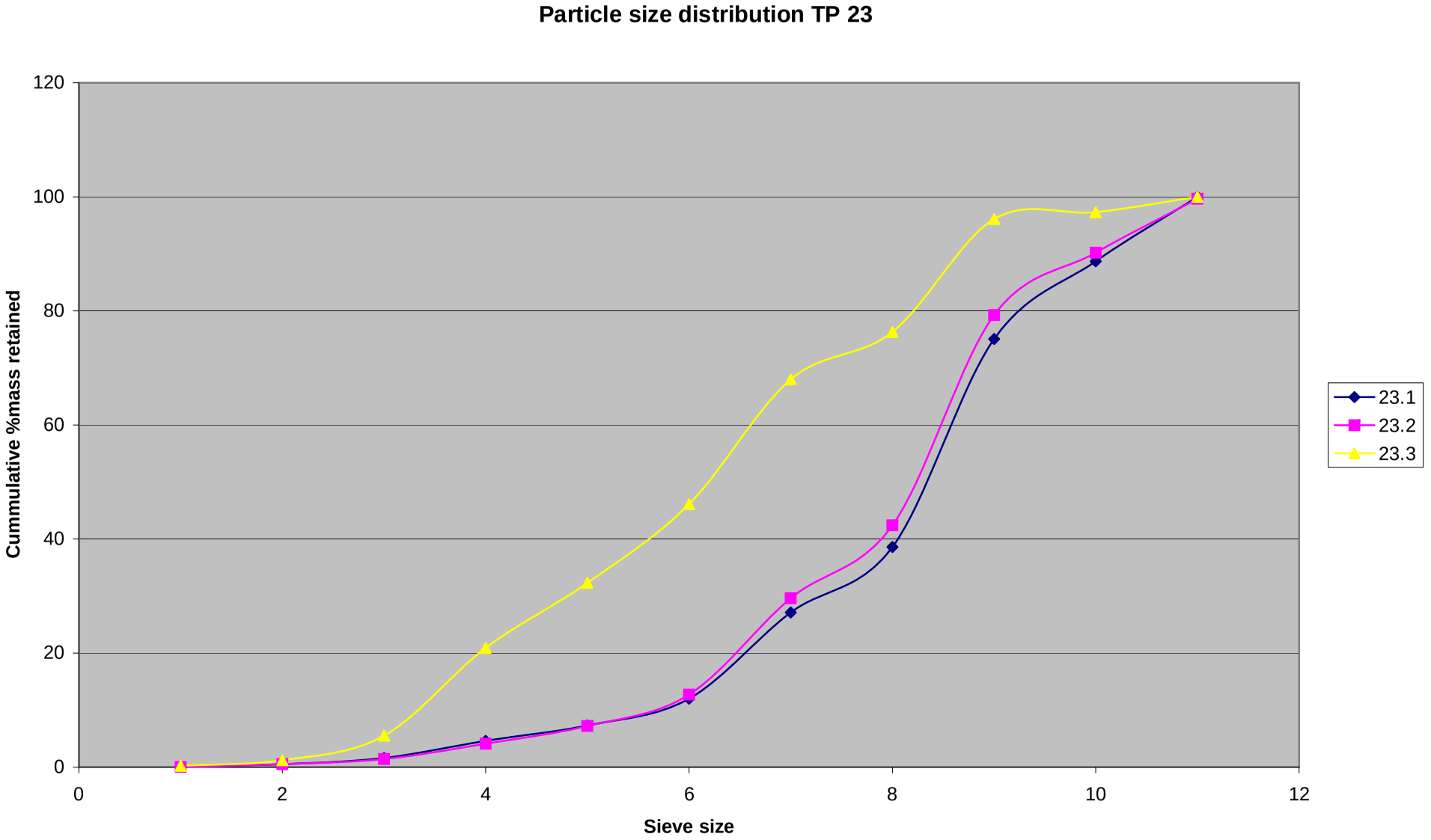

TP 7 Particle size distribution
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
Summulative % mass retained
0
2
4
6
8
10
12
Sieve size
7.1
7.2
7.3


Particle size distribution TP 11
Cummulative % mass retained
120
100
80
60
40
20
0
-20
0
2
4
6
8
10
12
Sieve size
11.1
11.2
11.3


Particle size distribution TP15
Cummulative % mass retained
120
100
80
60
40
20
0
0
2
4
6
8
10
12
Sieve size
15.1
15.2


Particel size distribution TP 16
Cummulative %mass retained
120
100
80
60
40
20
0
-20
0
2
4
6
8
10
12
Sieve size
16.1
16.2
16.3


Particle size distribution TP 18
Cummulative % mass retained
120
100
80
60
40
20
0
-20
0
2
4
6
8
10
12
Sieve size
18.1
18.2


Particle size distribution TP 23
Cummulative %mass retained
120
100
80
60
40
20
0
0
2
4
6
8
10
12
Sieve size
23.1
23.2
23.3