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14 November 2019

Ref: 045500REP02_Rev0

BHP Iron Ore

125 St Georges Terrace

PERTH, WA 6000

Attention: Nicole Romanczuk

Study Specialist - Iron Ore / Asset Projects / Studies

Dear Nicole

RE: MARILLANA CREEK INFILTRATION PROJECT
GEOTECHNICAL MAPPING AND INVESTIGATION REPORT

4DGeotechnics are pleased to present the results of the geotechnical mapping and investigations relating to the Marillana Creek Infiltration Project. This report presents the results of the mapping and investigations and an updated appraisal of the engineering geological materials and conditions within the area of interest. Engineering geological maps and design tables are presented for the purposes of incorporation into your Wetting Front modelling.

It should be noted that as mapping the creek channel itself was the primary goal of the mapping, areas beyond the creek were mapped in limited detail and interpretations have been extrapolated from the areas directly observed in the field. Ground breaking was limited to select accessible locations and has been extrapolated along the wetting front based on mapping observations.

This report supersedes our previous Desktop Study Geotechnical Report (Ref: 045500REP01_Rev0). All the relevant data from the previous desktop report has been carried through and updated for this report with information gathered from the field mapping and ground breaking investigations.

Thank you for the opportunity to provide BHP with this report and 4DG look forward to further assisting you with this, or any other project as required. Please do not hesitate to contact Valdimar Jonsson or myself if you have any queries.

4DGeotechnics Pty Ltd

Ian H Lewis
PRINCIPAL ENGINEERING GEOLOGIST

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BHP IRON ORE

MARILLANA CREEK INFILTRATION PROJECT
GEOTECHNICAL MAPPING AND INVESTIGATION REPORT

REF: 045500REP02_REV0

14 NOVEMBER 2019

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CONTENTS

APPENDICES

1.0 INTRODUCTION

As part of a planned dewatering project for the Mining Area C Mine (MAC), BHP Iron Ore (BHP) plan to pump excess water from mine dewatering into a tributary of the Marillana Creek.

A wetting front is defined as the interface between soil that is unchanged from the initial state of natural moisture and the newly wetted zone resulting from an infiltration or irrigation event. To support calculations of potential allowable discharge rates, volumes and locations, an understanding of the *in situ* geological conditions is required along the potential wetting front, which preliminary hydrological modelling suggests could reach Flat Rocks, west of the current BHP Yandi Mine open pit operations.

BHP have engaged 4DG to conduct a study of the geological conditions in the area of interest to support both the modelling of subsurface conditions and calculations of the wetting front movement along the alluvial channels through which the discharge water will flow.

4DG proposed a three phase approach to gather this information, consisting of a preliminary Desktop Geotechnical Study Phase, followed by a Field Mapping Phase and then a Ground Breaking Investigation (GBI) phase. The Desktop Geotechnical Study Phase created a baseline interpretation of the geological and geomorphological units in the area of interest which formed the base map for the field mapping phase, during which the characteristics of the units and their boundaries have been described in more detail. Updated geological maps have been included as Appendices A and B of this report. Additionally, to assist the assessment of the wetting front development, the streambed material types forming the alluvial channels have been sub-divided into groups (termed Domains for this report) corresponding to their variability in morphology and expected water infiltration and flow characteristics. The GBI phase investigated selected, readily accessible locations to define sub-surface profiles, as well as understand the typical creek bed material properties and permeability characteristics to support the infiltration modelling.

2.0 MAPPING

Mapping of the Marillana Creek and its tributaries through the area of potential saturation was conducted between June 13 and June 25, 2019 by two 4DG Engineering Geologists. The mapping area extended from the beginning of the incised tributary near the intersection of the Yandi Mine Access Road and the Great Northern Highway, through to the Flat Rocks area to the West of the BHP Yandi Mine. Figure 1 provides an overview of the mapped area.

2.1 Methodology

Mapping was carried out on foot, travelling mainly along the creek bed, with limited departures beyond the banks where required to identify rock outcrops where present in the banks, or adjacent hills. Additional observations of geology within the area of interest were made by vehicle traverse along existing accessible tracks.

As part of the mapping, particular attention was paid to the following:

- Identification of primary and secondary channels;
- Variations of creek bed materials along the primary and secondary channels, particularly variations with potential to influence permeability;
- Morphology of the channels and apparent typical flow conditions;
- Bedrock units intersected by the primary and secondary channels;
- Creek bed materials;
- Presence of vegetation;

- Indications for turbulent water flow;
- Signs of calcite precipitation; and
- Orientation of geological structural bedding and defects where suitable outcrop was encountered.

2.2 Engineering Geological Overview

The engineering geological units interpreted during the desktop study are presented on Engineering Geological Maps in Appendices A and B. The summary of encountered engineering geological units and their association with morphological forms are presented in a generalised stratigraphic column (Table 1) where interpreted units are listed generally from youngest to oldest.

2.2.1 Surficial Engineering Geological Units

Surficial unconsolidated material, including transported sediments, duricrust and decomposed weathered bedrock, varies significantly and may directly relate to the topography. Typically, coarse grained deposits occur on the steeper toe-slopes beneath cliffs (talus deposits) or adjacent to residually weathered hills. Coarser grained surficial materials are most common on steep terrain and have been deposited mainly by gravity and less so by water, and are typically mapped as colluvial slope deposits (Cg, Plate 1). Grainsizes typically decrease as the terrain becomes flatter and slopes are gentler. Slope deposits also include a gradation from residual soils (developed in place from weathering) to transported deposits such as colluvium and alluvial wash material. Surficial deposits also occur in alluvial / drainage features with adjacent flatter areas frequently comprising floodplain and older alluvial deposits.

Gravel-rich material in a fine grained matrix encountered on lower gradient downslope areas are produced mainly by slope wash and less so by gravity. These colluvial wash (Cw, Plate 2) deposits generally become finer towards the distal part of wash slopes due to preferential transportation of fines. Variations across wash slopes may accrue and include localised coarse gravel-rich areas, commonly on minor interfluves; and localised fines-rich areas, near wash channels and where surface flow is concentrated. Surface gravel lags of variable thickness are also common.

Low-lying areas can be wash-plains, with poorly developed drainage lines, dominated by distal slope wash material (Aw, Plate 3). The material is formed mainly by slow water wash processes sub-parallel to the main river channel. Surface gravel lags become rarer and accrue along areas where surface flow is concentrated.

Floodplain alluvial proximal (Fp, Plate 4) and distal (FpD, Plate 5) deposits are encountered adjacent to dominant primary alluvial (Al, Plate 6) and secondary (AlS, Plate 7) alluvial channels of the Marillana Creek and its tributaries. Floodplain deposits comprise mainly fine grained alluvial material, although coarser materials may be encountered where older active channels have been buried, or left behind by erosive channel migration. Gravel and sand material of Al and AlS dominate in seasonally active drainage lines, whereas channel margin and in-channel bars (AlB, Plate 8) typically comprise residual alluvial deposits which are no longer part of the typically active alluvial channels. Where alluvial channels intersect and expose duricrust and bedrock in the base of the channel these have been mapped as AlR (Plate 9).

The exposed bedrock surface along the corridor has been weathered and altered over geological time. This has resulted in the development of a secondary cemented duricrust in some areas. The presence of the duricrust obscures the underlying weathered rock characteristics. The main types of duricrust encountered in the area are:

- Calcrete (Czk, Plate 10) is sheet carbonate material that mainly comprises gravel and sand cemented together by calcium carbonate. It is red, pink, brown or white in colour. The material sometimes forms tabular rock and often contains voids and cavities. The calcrete outcrops are frequently overlain or fringed by calcrete soil deposits (Plate 11) thought to be either poorly developed or more likely weathered calcrete deposits. In some areas ancient alluvial gravels (Aa, Plate 12) form partially consolidated rounded mounds. Run off and collection of fine calcareous silts and clays presumed to originate from dolerite gravels in low lying areas on the calcrete produces some areas described as Calcareous Gilgai (C_Gilgai, Plate 13) characterised by frequent crab holes, dark brown appearance and frequent calcrete cobble float. The unit occasionally intersects the major active drainage lines but primarily forms elevated erosional surfaces, commonly overlying Robe Pisolite (Tp, Plate 14). The strength of the calcrete may vary from low to high depending on weathering and the degree of cementation.

- Robe Pisolite (Tp), often referred to more generally as Channel Iron Deposits (CID), originated as deposits within palaeochannels incised into the older bedrock. The material comprises iron-cemented, pisolitic limonite and haematite deposits, with minor scattered fossil wood and thin clay layers. Dependent on the degree of weathering, it can have low (extremely weathered Tp) to high strength (distinctly weathered Tp). The rock mass has weakly cemented zones and voids, and contains occasional thin clay layers.

It is important to note that the duricrust materials have the potential for strength inversion in the geological profile, with higher strength, cemented materials overlying lower strength units, uncemented superficial soils or weathered rock mass. The degree of cementation can vary widely over short distances and also has an impact on the mass permeability / porosity of the rock mass.

2.2.2 Bedrock Engineering Geological Units

The bedrock geology of the area comprises metamorphosed sedimentary and volcanic rocks of Weeli Wolli Formation in the eastern part of the area of interest, and localised Brockman Formation in the western part.

Banded Iron Formation (BIF, Plate 15) units within the Weeli Wolli and Brockman Formations comprise banded iron, chert, pelite, and jaspilite. The rock strength usually ranges from low to high. These are sedimentary units originally and the bedding forms a pervasive fabric through the rock mass, which, when combined with at least three sub-vertical defect sets, typically results in a poor rock mass quality. Many of the joints are open near surface and may be infilled with clay, gravel and rootlets. Shaly BIF (Plate 16) within the Weeli Wolli Formation consist mainly of pelite and is typically medium strength and subject to preferential erosion.

The dolerite units (Plate 17) are intruded within the Weeli Wolli Formation and form multiple sills between BIF units and may vary from very low strength when extremely weathered, to high strength when slightly to distinctly weathered. Dolerite can produce high plasticity fines and can be highly prone to erosion when extremely weathered. Where areas of fresh dolerite appear, the rock may range from high to very high strength and may exhibit a high resilience to weathering.

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TABLE 1: GENERALISED STRATIGRAPHIC COLUMN

Geological Time / Supergroup / Group	EGU[1] Name	EGU[2] Code	Description[3]	Reference to WA Geological Survey Map (SF50-12)
Quaternary	Active Alluvial Deposits of Dominant/Main Channels	Al	Well-defined channels of ephemeral rivers, creeks and drainage lines subject to periodic water flow during seasonal rainfall events. In general, alluvial deposits consist of unconsolidated/loose silt (minor to none), sand, gravel and cobbles. Coarse material (boulders and cobbles) occur where rock sources are nearby. The deposits are formed mainly by high velocity flow. In some cases, shallow ponds of water may be encountered.	Qa
	Active and Stable Bars and Island Alluvial Deposits (i.e. heavy vegetated elevated areas)	AlB	Raised sediment deposits within channels and in some cases floodplains. These comprise: • "channel margin" deposits in forms of various bars and banks to channels; and • "in-channel deposits" forming islands and mid channel bars. The deposits mainly consist of unconsolidated/loose sand, and gravel. Fines (including silt) and sand/gravel material content varies and depends on morphology of the channel, sources of the material and flow regime.	
	Active Alluvial Deposits of Secondary Channels	AlS	Secondary channel deposits occur: • Along outside/elevated parts of dominant/main channels; • Within proximal floodplains/flood ways; and • Along tributary channels. The deposits mainly consist of unconsolidated/loose sand, and gravel, in some cases of the coarser material, where rock sources are near. In general, deposits are formed under high flow conditions where the water flow exceeds the capacity of the primary channel and flow spreads across the greater alluvial channel area. Secondary channels are not flooded as frequently as the dominant channels.	
	Rock in Primary and Secondary Alluvial Channels	AlR	This unit is used to highlight where rock is encountered in dominant/main channels, as well as within secondary channels and rarely in proximal floodplains. The deposit comprises localised areas of exposed duricrust, bedrock and/or continuous rock exposures. It may form high points in the channels or be associated with permanent to semi-permanent deep rock pools. The rock is exposed under high velocity flow with limited sediment deposition.	
	Proximal Floodplain Alluvial Deposits	Fp	Floodplain deposits border the dominant channel(s) along the main flow path and are formed by variable, but mostly lower velocity flow areas on the outskirts of primary and secondary channels during seasonal floods. The deposits include loose silt, sand and gravel lag. The latter mainly occurs in areas of higher energy flow. The deposits include weakly consolidated silt, clay and sand with occasional areas of gravel content. The material often contains organic matter such as woody debris. Proximal floodplain is often highly vegetated compared to other parts of the alluvial system such as secondary channels.	
	Distal Floodplain Alluvial Deposits	FpD	Fine-grained alluvial deposits of distal floodplain/backplain typically accrue in flat areas distant from dominant channel(s). In some cases it could be affected by distal slope wash processes and grades into Alluvial Wash (Aw). The deposits include weakly consolidated silt, clay and sand with gravel lag. In general, FpD deposits are formed under lesser flow or / and under stagnation conditions, and flooding of these areas is not as frequent as the proximal floodplain.	
	Distal Slope Wash (Alluvial Wash)	Aw	Fine grained, wash deposits, which generally occur on relatively level to gently sloping areas dominated by sheetflow parallel to the main local channels. The unit comprises unconsolidated to medium dense silts, clays, sands and gravels. The surface is typically silt and silty sand dominated with local gravel lag. Alluvial wash areas tend to be broad and lack a defined alluvial channel.	Qw

TABLE 1: GENERALISED STRATIGRAPHIC COLUMN

Geological Time / Supergroup / Group	EGU[1] Name	EGU[2] Code	Description[3]	Reference to WA Geological Survey Map (SF50-12)
Quaternary	Colluvial Slope Wash Deposit (Colluvial Wash)	Cw	Unconsolidated to medium dense clay, sand and gravel mixtures with variable occurrence of cobbles. Down slope colluvial deposits, typically with increased fines content relative to Colluvial Gravel (Cg), often grading into Alluvial Wash (Aw). Localised iron cementation may occur. Colluvial Wash is typically located in the lower to mid parts of the colluvial slope, dominantly formed by sheet wash down-slope processes.	Qw
	Proximal Slope Gravel Deposits (Colluvial Gravel)	Cg	Loose to cohesive deposits formed from a combination of gravity and water flow (sheetwash down slope). The deposits are sourced from adjacent hills and ridges, and typically occur on intermediate parts of the slope. The characteristics of the colluvial materials are heavily dependent on the nature of the parent rock, but typically comprise sandy clayey gravels, often with cobbles, and sometimes with a degree of cementation at depth.	Qc
Tertiary	Ancient Alluvium	Aa	Partially consolidated alluvial deposits forming elevated gravelly hills overlying calcrete deposits.	Czk
	Calcrete Soil	Calcrete_Soil	Unconsolidated weathered calcrete comprising calcareous gravels, sands and silts with minor pisolitic gravels. Typically a brown cream colour	
	Calcrete	Calcrete	Calcrete is sheet carbonate material that mainly comprises gravel and sand cemented together by calcium carbonate. It is red, pink, brown or white in colour. The material sometimes forms tabular rock and often has semi-continuous voids and cavities. The calcrete typically overlies Robe Pisolite/Channel Iron Deposits with variable thickness of up to 30 metres in some areas. The strength of the unit may vary from low to high depending on weathering degree of the cementation.	
	Robe Pisolite	Tp	Massive pisolitic and oolitic goethite and haematite ironstone deposits (CID). The materials are iron-cemented, pisolitic limonite and haematite deposits, with minor scattered fossil wood. The unit may contain occasional thin clay layers. Where exposed at the surface it can be distinctly weathered, and exhibit low to high strength.	Czp
	Goethitic Conglomerate	ConG	Goethitic conglomeritic rock typically exposed in the creek margins, underlying calcrete deposits. The unit may be similar to basal CID units but appear poorly developed and may represent the weathered surface from which the CID is derived. Upper exposed and weathered surfaces of the goethitic conglomerate present as a ferruginous cap, which whilst not dissimilar in appearance to CID, is typically less than one metre thick and quickly transitions to the more lateritic appearing goethitic conglomerate.	Czp

TABLE 1: GENERALISED STRATIGRAPHIC COLUMN

Geological Time / Supergroup / Group	EGU[1] Name	EGU[2] Code	Description[3]	Reference to WA Geological Survey Map (SF50-12)
Mount Bruce Super Group / Hamersley Group	Weeli Wolli Formation	BIF	Banded iron-formation, commonly jaspilitic, encountered predominantly within the eastern half of the area of interest. Typically appears as cuesta-landforms and massive hills. Due to several dominant defects sets the unit frequently exhibits a poor rock mass quality. Joints are commonly open near surface and infilled with clay, gravel and rootlets;	Phj
		Shaly BIF	Dominantly Pelite overlain by Chert, encountered predominantly within the eastern half of the area of interest. The unit forms the lower parts of cuesta-landforms and massive hills, with low angle slopes. It typically is of medium strength and subject to preferential weathering and erosion.	
		Dolerite	Metadolerite sills interbedded with Shaly BIF, encountered predominantly within the eastern half of the area of interest. Rock strength may vary from very low strength in extremely weathered forms, to high strength in fresh to distinctly weathered materials.	
	Brockman Formation	BIF	The Brockman Formation BIF rock unit is encountered in the far western part of the area of interest. It comprises banded iron-formation, chert, and pelite. The Brockman Formation BIF may form high rounded hills, with drainage gullies and gorges characterised by near vertical cliff edges formed parallel to pervasive jointing, often with unstable blocks / pillars of rock along the edges. Large blocks, which have fallen from the cliffs, are common at the base of slopes (tallus).	Phb

[1] EGU – Engineering Geological Unit

[2] EGU codes listed in Table 1 are consistent with Engineering Geological Maps provided in Appendix A and Appendix B.

[3] The report N RR17 has been used as the reference for description of alluvial units in Table 1. (Ref 2)

2.3 Geomorphology

2.3.1 Terrain Geomorphology

The Marillana Creek drainage corridor crosses three main geomorphological areas (shown on Figure 1), which have distinct relationships between lithology, surficial materials and topography:

- Western Part – from near the Great Northern Highway where the channel first becomes incised to where several other tributary channels join and the channel flows in more of an easterly direction. The western part is surrounded by low calcrete rises and broad colluvial wash areas with localised calcrete and BIF. The Western Part river channel is dominated by high hydraulic conductivity sandy gravels with frequent grassy low flow channels;
- Central part – from where the significant tributaries join then easterly downstream to a point just upstream from the "Flat Rocks" area. The central part is underlain by calcrete with localised Dolerite and BIF. These rocks control the terrain for this part of the corridor and commonly present as a relatively low elevation erosional surface continuously underlain by calcrete, Dolerite or BIF. The area is dominated by Calcrete capped CID to the north, and weathered Weeli Wolli Formation to the south. The Central Part river channel is typically broad, frequently braided and dominated by high hydraulic conductivity sandy gravels, frequently with cobbles, regular exposures of goethitic conglomerate and BIF with some dolerite, grassy low flow sections and regular gum trees; and
- Eastern part – downstream and surrounding the "Flat Rocks" area, including the outskirts of the BHP Yandi Mine developments. The eastern part of the area of interest around 'Flat Rocks' is dominated by BIF, Shaley BIF and hills of Dolerite. Locally, the old valley infill caps Shaly BIF and forms low, standalone table hills. Here, Marillana Creek and its tributaries cross the dolerite units exposing rock along and within the channels, resulting in damming to form near permanent water pools. The Eastern Part river channel is dominated by high hydraulic conductivity cobbly gravels, shallow BIF and dolerite with patchy gravels and silty clay deposits, frequent to dense gum trees and paper barks.

Further to the east, through the BHP Yandi mine areas, the terrain comprises low flat areas underlain by Robe Pisolite surrounded by moderate to low sharp hills comprising BIF/Shaley BIF and rounded dolerite hills along the periphery areas of Yandi mine developments. The hills are dissected by incised drainage channels of various depths. The majority of the Marillana Creek within the eastern part of the corridor runs through the Yandi mine developments, where the natural flow is intercepted and deviated by cut-off and deviation channels as part of the mine development.

2.3.2 Channel Geomorphology

Creek flow throughout the area is sporadic and influenced by the semi-arid Pilbara climate. Rainfall amounts and intensities are highly variable and irregular due to periodic cyclonic events, thunderstorms and localised intense rainfall. Average annual rainfall varies from 300 to 400 mm. High rainfall events can occur in a short period of time, and over a relatively small area, leading to localised flooding along affected watercourses. Such events can lead to high velocity flows concentrating in dominantly seasonal channels of Marillana Creek and its main tributaries.

Vegetation cover through the area of interest generally comprises spinifex grasses and shrubs in colluvial and wash areas, with "snappy gum" trees growing on elevated areas of rock. White gums typically occur along significant drainage lines, with shrubby and grassy vegetation covering floodplain areas.

The primary channel as mapped does not follow what might be considered a typical river morphology whereby surface flow capacity increases downstream as various tributaries enter the main channel. Rather, it is typically observed that the entering tributaries frequently provide a significant boost to apparent flow which then dissipates and the channel appears to return to normal flow conditions. However, normal flow conditions for the wetting front are highly variable along the creek.

The creek bed frequently switches between open gravelly channels and heavily vegetated irregular channels. It is assessed that the variability in channel morphology can be attributed to two primary factors; depth to rock and isolated nature of the rainfall. Depth to rock is generally expected to be in the order of no more than 1 to 4 metres, and typically 1 to 2 m, although the thickness of gravels is highly dependent on channel position. Local hollows ~2m deeper than surrounding gravels were seen in several locations, and these typically contained calcrete or other rock exposures in the base, but were often associated with local channel narrowing and sharp channel direction changes, so the differential is exacerbated by the creation of a point bar.

Inconsistencies in creek morphology observed in the field, whereby an entering channel would frequently appear to carry more water than the main channel, is attributed to typical Pilbara rainfall events, whereby rainfall events are isolated to parts of the drainage catchment such that high rainfall may fall on one tributary to the primary channel, but not the primary channel itself. It is frequently observed on project sites that one area will see significant rainfall and water flow where nearby areas receive no rainfall. These events would cause “flash flooding” of a tributary or tributaries with an initial unsustained surcharge of water flowing into the creek system which then dissipates into small flows in the low flow channels and/or subsurface flow through the river gravels.

It is expected that the only time the entire creek system would likely see rainfall in the same period would be during cyclonic events where widespread rainfall is common and as such the full creek system would flow. During such events, surface water flow would likely cover the full primary channel as well as extending into secondary channels and floodplains during peak flow, before eventually reducing to flow through low flow channels and then to subsurface flow through gravels.

The broader primary channel is considered to be erosional, with older terrace alluvial deposits frequently seen in the river banks. For this reason the creek bed is dominated by gravels with ~20-30% gravels and little to no fines, whereas the terrace alluvial banks are typically quite silty with coarser gravel bands.

The primary flow channel identified through mapping as presented in the Engineering Geological Maps (Appendices A and B) is typically characterised by a low flow channel within the broader higher flow primary channel. The domains and chainages as presented in the Domain Maps (Appendix C) and the Wetting Front Design Table (Appendix D) are based on this primary flow channel. It is assessed that this primary flow channel is where dewatering water pumped into the creek system will most likely be exposed surficially when the water volume exceeds the capacity of the creek gravels. For modelling purposes, it is expected that an average depth of gravels of 1m below the base of the primary / low flow channel would be a reasonable assumption, with the obvious exception of AIR areas where duricrust or bedrock is exposed in the base of the channel. Sub surface water flow through the river bed gravels could be expected to be carried for the full width of the primary channel, and potentially also extending below the secondary channel.

The creek channel has been broken down into typical morphological “types” for modelling purposes, consisting of the following:

- Vee (Plate 18)– A standard Vee shaped incised channel, relatively narrow with central flow;
- Trapezoidal (Plate 19) – A typical creek shape with relatively steep, well defined banks on both sides and a relatively flat base, low flow channels tend to meander from one side to the other due to development of minor lateral bars;

- Trapezoidal Convex (Plate 20) - A typical creek shape with relatively steep, well defined banks on both sides and a convex base, highest at the centre. low flow channels tend to be present on both sides of the channel;
- Wedge (Plate 21) – Typically occurring on bends in the creek the outer edge is typically steep and erosional with a point bar on the inside forming a gradual shallow bank. The low flow channel is along the steep side however the point bar gravels are loose and permeable;
- Undulating hollowed channel (Plate 22) – Typically occurs where trees are present in the channel forming local hollows with resultant downstream bars causing variability in the low flow channel position;
- Highly vegetated irregular (Plate 23) – Frequent grasses form small bars creating a highly braided channel with poorly defined channels. Water flow through these areas is expected to be predominantly subsurface through gravels, or very shallow at surface. These channels tend to be broad and relatively flat and are often associated with shallow rock and may indicate groundwater connection;
- Rising transition zone (Plate 24) – These sections of the creek channel are distinct in that the creek bed is at a higher elevation downstream than upstream. There is typically a loss of definition for the low flow channel suggesting increased subsurface flows through loose gravels;
- Bowls (Plate 25) – Gentle bowl shaped local lows (typically less than 50 metres) in the channel, typically lacking vegetation in the bed with a relatively regular base, expected to form pools of exposed flow when flow is mostly through the gravel base of surrounding channel areas; and
- Braided zone (Plate 26) – Typically associated with shallow rock and a high water table with frequent trees, channels are highly variable with shallow hollows and resultant bars.

The morphological types are a primary differentiator for the channel domains as described in Section 2.4.

2.4 Channel Domains

To distil mapping information collected in the field into a form that can be used as an input for infiltration and wetting front modelling, a Channel Domain Design Table has been created from the mapping data. The table, presented in Appendix D, references chainages generated to coincide with the defined primary channel centreline and is presented visually in the maps in Appendix C.

2.5 Duricrust and Bedrock Exposures / Channel intersections

Duricrust and bedrock exposures in the channel varied between small exposures in the base of hollows (Plate 27) or the edge of wedge channels (Plate 28); limited bouldery outcrops (Plate 29); or broad dominant outcrops across the full width of the channel (Plate 30), with the latter predominantly found towards the eastern end of the mapped area (Flat rocks).

Where duricrust and bedrock was observed during the mapping, this has been noted within the Channel Domain Design Table in Appendix D.

2.6 Calcite Precipitation

Limited calcite precipitation was observed during the mapping, and it is considered that this would likely be due to the short term, high velocity nature of normal flows in the creek. Where observed, calcite precipitation is noted in the Domain Design Table. In addition, occurrences of hollows indicative of turbulent flow which might facilitate calcite precipitation are noted in the Domain Design Table.

A black precipitate was noted to coat rocks in areas of pooling and low flow (Plate 31) in the eastern parts of the central domain particularly once the wetting front channel joined Marillana Creek

3.0 GROUND BREAKING INVESTIGATIONS

Ground breaking investigations in Marillana Creek and the Tributary that will contain the wetting front were conducted between July 5 and July 11, 2019 and consisted of *in-situ* permeability testing, Panda DCP testing and disturbed material sampling. Eleven potential investigation sites were selected and numbered in order of priority. It was targeted to investigate a minimum of five sites and of the eleven selected potential sites, eight were investigated. At two of the sites, local variability lent itself to performing two *in-situ* permeability tests. Field *in-situ* permeability tests were conducted at ten locations, and nine Panda DCP profiles were conducted. Disturbed bulk samples for laboratory testing were taken at each permeability test location.

3.1 Methodology

3.2 In-Situ Permeability Testing

In-situ permeability testing was conducted using a Guelph Permeameter. Due to the high permeability of the soil, drawdown of the stored water within the permeameter was extremely fast which made obtaining consistent readings difficult. Where consistent readings could not be obtained, multiple tests were conducted at varying heads, and relatively consistent drawdown periods selected based on the drawdown graph and averaged. Video was used to accurately record reservoir levels where drawdown was rapid.

Guelph Permeameter test records are presented in Appendix F and summarised in Appendix E with the laboratory test results.

3.3 Panda DCP Testing

Panda DCP testing was conducted at several locations across the channel at each permeability test location. The goal of the Panda DCP testing was to provide insight to both the depth to rock, and the variability in creek bed materials, such as differing sandy and gravelly layers, and their relative density. In two locations where there was a vertical exposure of terrace alluvials, Panda DCP's were undertaken on the bank to allow correlation with exposed variability.

The Panda DCP is an instrumented variable energy penetrometer which reads cone resistance for each blow of a specially weighted hammer. The Panda DCP gives a precise penetration depth for each blow and the blow force can be varied by the operator to suit conditions. That is, where soils are soft, less force can be used to get a higher resolution of ground density.

Panda DCP logs are presented in Appendix G. Results can be interpreted as follows with respect to cone resistance (MPa) values:

- 0 - 7 MPa – very loose surface materials or loose to medium dense silty sand layers;
- 7 - 20 MPa – Sandy Gravels, loose to medium dense;
- 20 - 40 MPa - Higher ratio of gravels to sand, medium to coarse medium dense to dense gravels;
- >40 MPa – Weakly cemented sandy gravels, or extremely weathered rock; and
- >70 MPa – Rock or well cemented gravels.

A Panda DCP "Traverse" was conducted at each permeability test location to assist with understanding the subsurface creekbed profile across the primary channel. These traverses are visualised as cross sections presented in Appendix J. The creek bed surface profile for these traverses is generated from LIDAR and contour data provided by BHP. Due to the low resolution of this data, the creek bed profile does not accurately represent the actual observed creek bed.

3.4 Material Sampling and Laboratory Testing

Bulk samples were taken by hand excavation using a shovel from locations in the immediate vicinity of field permeability testing. The samples were taken from between 0.05 and 0.25 metres depth. Samples were sent to soils laboratories for characterisation of the material properties (particle size distribution, natural moisture content and compaction) and for permeability testing.

Table 2 summarises the samples taken and testing scheduled. Results are discussed in Section 4.0. Appendix E presents a summary table of test results.

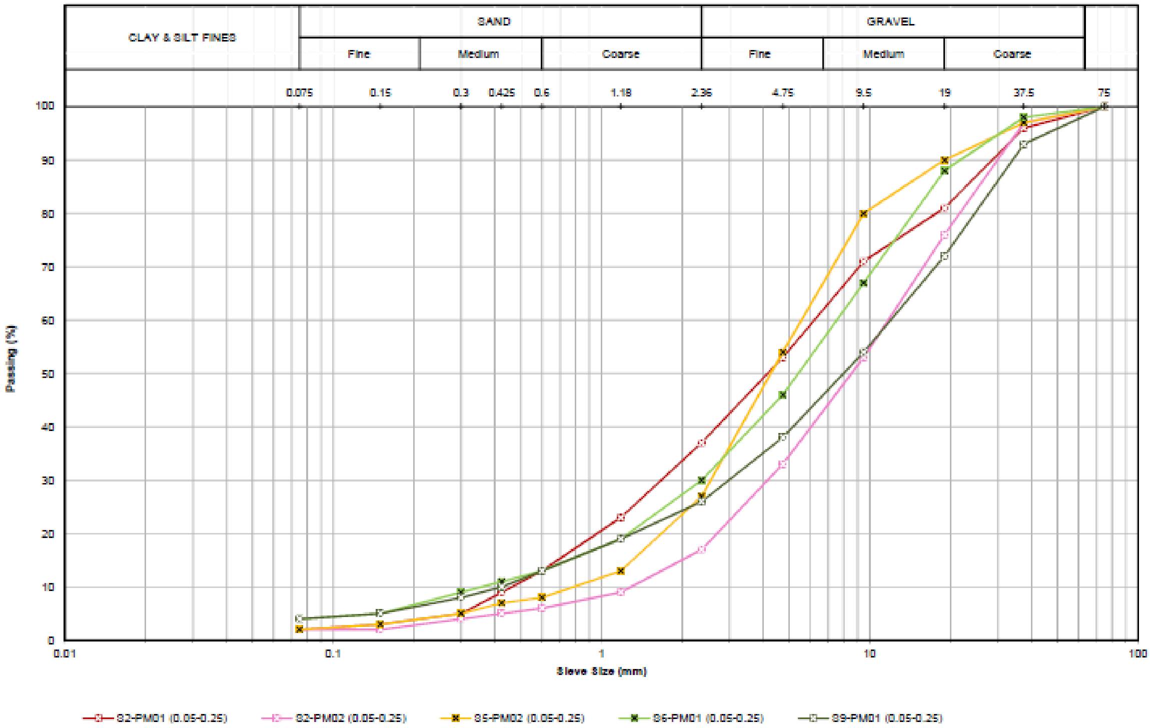
TABLE 2: SCHEDULED LABORATORY TESTING

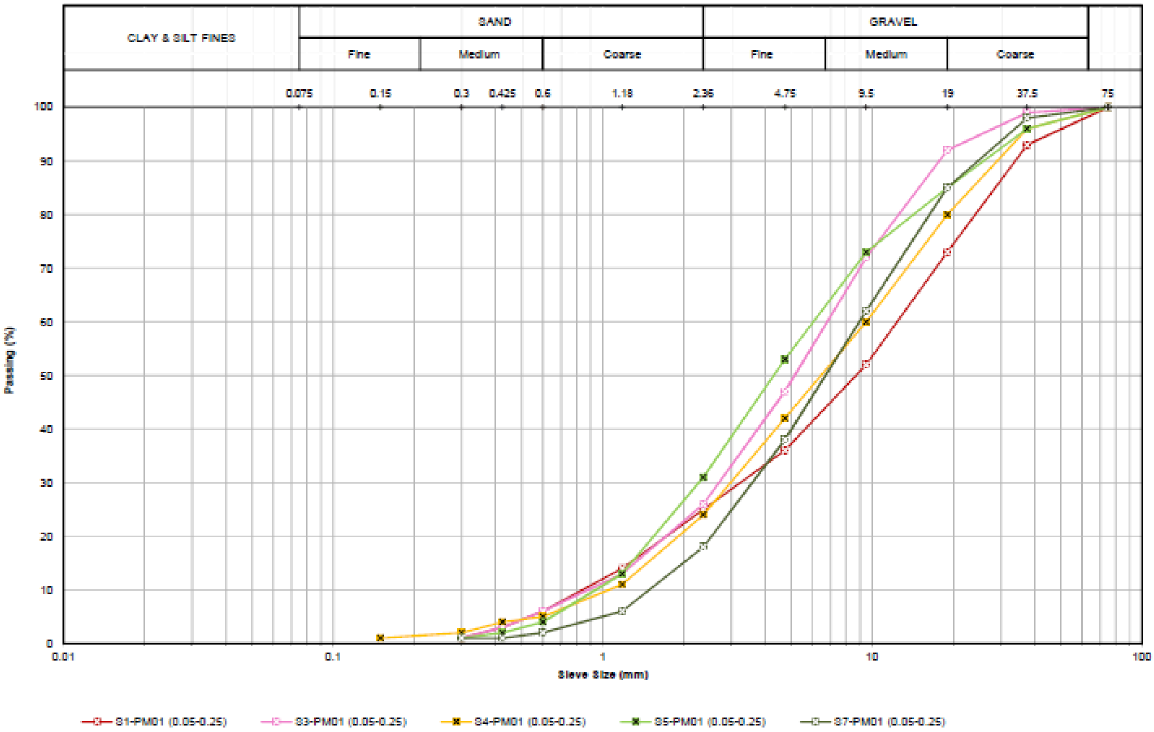
Sample ID	Sample Depth	Natural Moisture Content	Particle Size Distribution	Maximum Dry Density	Calcium Carbonate Content	Soil Void Ratio	Constant Head Permeability
S1-PM01	0.05 - 0.025m		1	1	1	2	1
S2-PM01	0.05 - 0.025m	1	1	1		2	1
S2-PM02	0.05 - 0.025m		1	1		2	1
S3-PM01	0.05 - 0.025m		1	1		2	1
S4-PM01	0.05 - 0.025m		1	1		2	1
S5-PM01	0.05 - 0.025m		1	1		2	1
S5-PM02	0.05 - 0.025m		1	1	1	2	1
S6-PM01	0.05 - 0.025m		1	1		2	1
S7-PM01	0.05 - 0.025m		1	1		2	1
S9-PM01	0.05 - 0.025m		1	1		2	1
Total Tests		**1**	**10**	**10**	**2**	**20**	**10**

4.0 DISCUSSION OF INVESTIGATION RESULTS

4.1 Particle Size Distribution

Of the 10 particle size distribution results 5 contained fines while the other 5 did not. The particle size difference between samples is mostly attributable flow conditions, with coarser materials considered to indicate higher surface flow velocities. Fines, in the form of silt, comprised between 0 and 4% of the creek bed material, with sand comprising between 17 and 37%, and gravel between 63 and 82%. Figure 3 below shows the grading curve plots for those samples with fines present. Figure 4 below shows the grading curve plots for those samples with no fines present.





4.2 Natural Moisture Content

A single natural moisture content (NMC) test was conducted on sample S2-PM01 as this sample was wet from permeability testing conducted prior to sampling. The purpose of this test was to understand the residual moisture remaining in the soil after a saturation event. The NMC result was relatively low considering the material had been soaked, and reflects the non-plastic nature of the fines and high permeability nature of the material overall.

4.3 Permeability

Permeability depends on the particle size of the materials, and to a lesser extent on the void ratio. In the ground, it can vary massively from point to point because of natural inhomogeneity, and be strongly anisotropic (with horizontal k_h much greater than vertical k_v) owing to soil fabric and structure. The potential range of permeability even for uniform soils is very wide and the degree of variation is far greater than for that of almost any other engineering parameter. In ground engineering, it is usual to use a fairly simple model for initial calculations. However, building a reliable picture from small scale tests can be difficult

Field testing was conducted on the upper creek bed materials which were found from the Panda DCP to be typically in a loose to medium dense state. It was established that true saturation could not be achieved during the testing due to the large volume of highly permeable creek bed materials into which the permeameter was releasing its limited supply of water. Whilst local saturation was achieved around the device, true saturation was not considered possible and the results are considered more like unsaturated permeability.

The presence of sand and silt influenced field permeability, with a silty surface typically leading to reduced field permeability. The creek gravels in more vegetated and irregular areas, suggestive of low surface flow, had a tendency towards slightly higher permeability than the more open areas, which is consistent with field observations that suggested flow might be through, rather over the creek bed gravels. More generally, apparent high flow areas had looser surface gravels, leading to higher field permeability which was not reflected as prominently in the laboratory where all samples were compacted to 92% of their maximum dry density.

Laboratory permeability of compacted specimens was typically an order of magnitude lower than field permeability. This is considered to be due to several differential factors between the style and performance of the two tests. The two primary contributing factors to the differences are considered to be compaction (or density of the specimen) and the achieved degree of saturation. Table 3 summarises the permeability results.

Laboratory permeability was conducted on a relatively small volume of fully saturated material, compacted to 92% of its maximum dry density (considered medium dense to dense) which is expected to be similar to the creek bed materials at depth, as indicated by the Panda DCP profiles in Appendix G.

However, it is expected that compaction is the primary reason for the difference between the field and laboratory permeability and as such the field permeability can be used for the materials in the upper 0.2 metres in the base of low flow channels, as well as the adjacent gravels of the broader primary channel, where the creek bed is higher than the low flow channel. It is expected that as the density of the creek bed gravels increases with depth, they will have permeability values similar to the laboratory permeability.

TABLE 3: PERMEABILITY TESTING SUMMARY						
Permeameter Test ID	**Chainage (m)**	**Channel Description**	**Bed Description**	**Gravel Depth (m)**	**Field Permeability (k)**	**Lab Permeability (k)**
S1-PM01	2,250	Highly vegetated irregular	Sandy GRAVEL, cobbly patches	0.6	7.40E-04 m/s	7.44E-05 m/s
S4-PM01	2,725	Undulating Hollowed Channel	GRAVEL with sand and Sandy GRAVEL, trace cobbles	0.7	5.48E-04 m/s	1.13E-04 m/s
S9-PM01	4,165	Highly vegetated irregular	Sandy GRAVEL, trace cobbles	1.2	2.67E-04 m/s	6.78E-05 m/s
S2-PM01	8,100	Highly vegetated irregular	Sandy GRAVEL, trace cobbles	3.6	4.60E-04 m/s	4.91E-05 m/s
S2-PM02	8,150	Wedge	Sandy GRAVEL, trace cobbles, patches of exposed Calcrete	1.2	Field permeability higher than permeameter measuring capability	2.56E-05 m/s
S6-PM01	10,090	Wedge	Sandy GRAVEL, trace cobbles	0.4	1.04E-05 m/s	4.51E-05 m/s
S7-PM01	13,660	Broad and shallow flowing	Sandy GRAVEL	0.9	6.48E-04 m/s	3.43E-05 m/s
S3-PM01	17,840	Highly vegetated irregular	Sandy GRAVEL, trace cobbles and Cobbly GRAVEL, with sand	1.2	6.76E-04 m/s	5.41E-05 m/s
S5-PM01	26,030	Irregular flat	Sandy GRAVEL over rock, cobbles	0.9	4.97E-04 m/s	6.11E-05 m/s
S5-PM02	26,030	Irregular flat (low flow)	Silty Sandy GRAVEL over rock	0.25	1.42E-05 m/s	3.92E-05 m/s

For modelling purposes it could be assumed that field permeability values can be applied to the upper 0.2 to 0.5 m of the creek bed and for short-term permeability as the wetting front passes down the creek. However, once full saturation of the gravel bed occurs after the initial wetting, it may be more appropriate to apply the laboratory permeability to the full creek bed depth.

4.3.1 Soil Void Ratio and Water Capacity

To better understand the water holding capacity of the alluvial gravels in the creek bed, a test was devised to allow direct measurement of the void space / latent water capacity. The goal of this test was to determine how much water the gravels can be expected to 'absorb' before the permeability is expected to reach a steady flow, saturated condition. Material was compacted at two differing moisture contents to achieve differing levels of compaction to better understand the influence of compaction on void space, any changes to which are then inferred to have the potential to similarly influence permeability.

Following compaction, water was added to the compacted sample to fill the available void space. This volume was measured and used to calculate the available void space which has been filled. Based on the results it is appears that void space within the gravels is significantly influenced by density, and density increase can be expected to reduce void space, and in turn hydraulic conductivity. This is in line with the differences between field and laboratory permeability.

TABLE 4: SOIL VOID RATIO RESULTS

Sample ID	Initial Moisture Content (%)	Moisture Added for Compaction (%)	Optimum Moisture Content (%)	Achieved MDD Ratio (%)	Water added to fill voids (g)	Approximate Void Ratio (%)
S1-PM01	2	8.6	10.6	101	25	2
	2	4.6	10.6	97	115	11
S2-PM01	1.3	5.2	6.5	99	49	5
	1.3	3.9	6.5	95	130	13
S2-PM02	1.8	6.6	8.4	102	22	2
	1.8	2.6	8.4	95	148	15
S3-PM01	2.9	6.2	9.1	99	44	4
	2.9	2.2	9.1	96	113	11
S4-PM01	2	8.8	10.8	99	14	1
	2	4.8	10.8	93	123	12
S5-PM01	0.8	6.9	7.7	100	102	10
	0.8	2.9	7.7	96	174	17
S5-PM02	2.5	5.5	8.0	101	28	3
	2.5	1.5	8.0	97	66	7
S6-PM01	2.6	6.8	9.4	99	6	1
	2.6	2.8	9.4	94	56	6

TABLE 4: SOIL VOID RATIO RESULTS

Sample ID	Initial Moisture Content (%)	Moisture Added for Compaction (%)	Optimum Moisture Content (%)	Achieved MDD Ratio (%)	Water added to fill voids (g)	Approximate Void Ratio (%)
S7-PM01	2.9	7.1	10.0	101	69	7
	2.9	3.1	10.0	99	153	15
S9-PM01	1.9	5.9	7.8	100	17	2
	1.9	1.9	7.8	93	86	9

5.0 CONCLUSIONS AND OUTPUTS

The field mapping and subsequent limited ground breaking information have provided insight into the variability of the creek along the potential wetting front. It is apparent that significant influences on the water holding and carrying capacity of the Marillana Creek and its tributaries include:

- The relatively shallow and variable depth of the alluvial deposits;
- The presence of local rock bars where it is expected that the water will be forced to the surface to flow visibly across the ground. In hot times, this will allow some evaporation to occur;
- The potential for changes in vegetation and wildlife in areas such as the rising transition zone, where it is expected that surface water ponding on a semi-permanent basis may occur; and
- The limited permeability of the duricrust and bedrock units, which means that no significant losses should be expected from infiltration into the floor beneath the alluvial materials.

Significant issues beyond the scope of this data collection and assessment study include:

- Understanding the impact of flooding related to natural rainfall or cyclonic events on the system when the alluvial materials are already saturated from the dewatering pumping;
- Understanding the impact of the arrival of the wetting front should it reach the BHP Yandi minesite, and the mine's ability to deal with the on-going flows.

The following digital data will be provided to BHP as an accompaniment to this report:

- The Channel Domain Design Table as an Excel file;
- A primary centreline polyline file in ESRI Shapefile format incorporating the domain design table as attribute data;
- Structural measurement data in Excel format for geological information collected during the mapping for incorporation into BHP's structural database;
- Georeferenced photographs from the field mapping; and
- Engineering geological interpretation of the Area of Interest in ESRI Shapefile format.

6.0 RECOMMENDATIONS FOR FURTHER WORK

Creating a profile along the identified primary channel as presented in the design table based on currently available data produces a saw tooth profile due to the coarseness of the elevation data which limits the vertical accuracy of the creek bed along the wetting front. In the field it was frequently observed that the creek bed would rise in parts, sometimes by as much as one to two metres which may or may not have a corresponding rise in underlying rock. It is recommended that high resolution LIDAR data be captured for the channel to better understand the profile of the creek bed and the potential for local pooling of water.

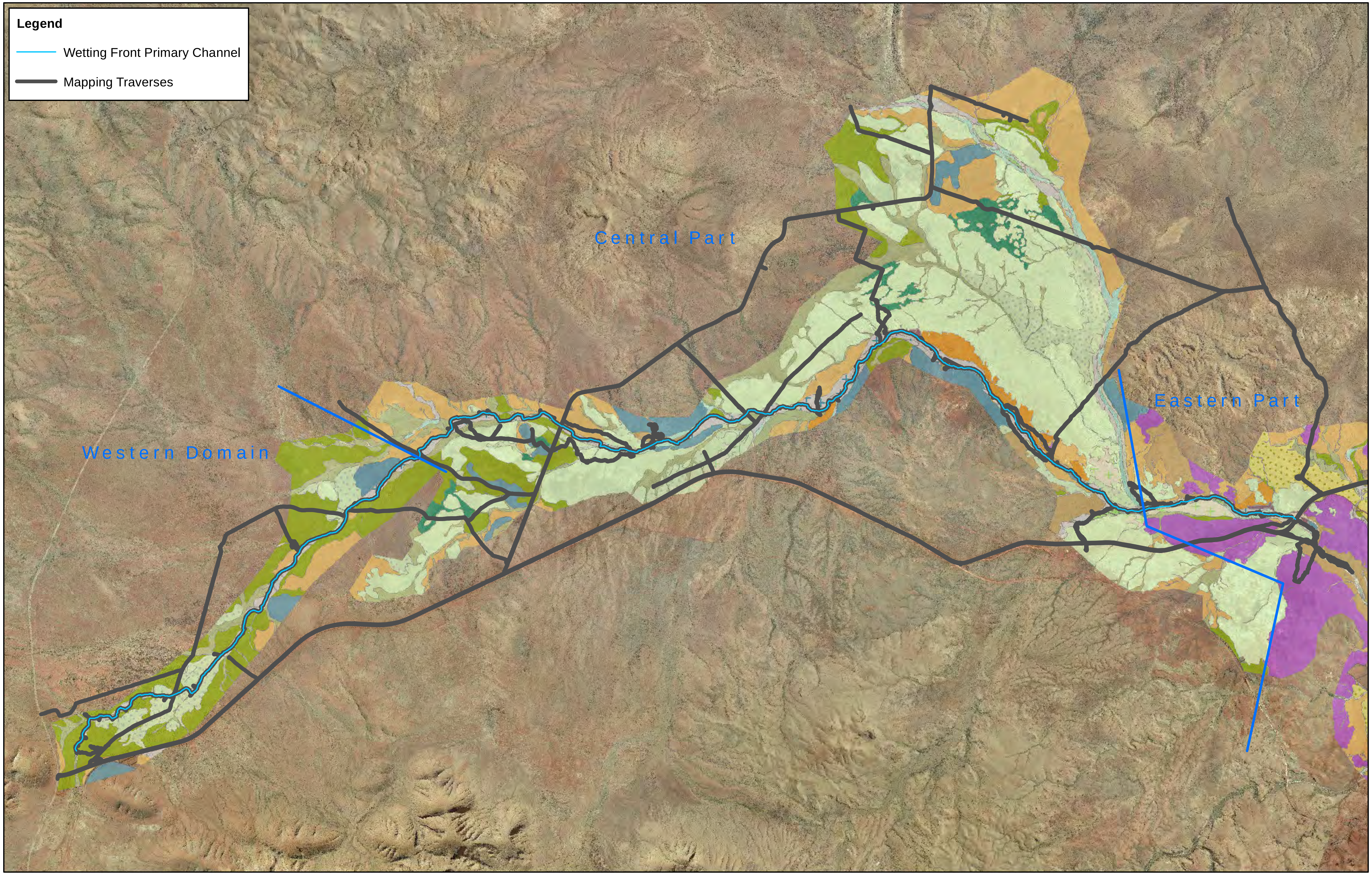
7.0 CLOSURE

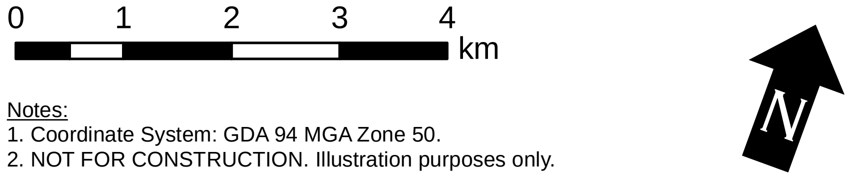
The findings of this report are based on a desk study, field mapping observations, and limited subsurface investigations, as well as interpretation and opinion incorporating experience from previous projects undertaken in the Pilbara region. Since only limited ground-breaking geotechnical investigations have been undertaken, the inherent uncertainty in the findings of this report should be recognised, however within the limitations 4DG believe the information provided should be sufficient to increase accuracy of the wetting front modelling. It will be essential to review and revise the outputs should detailed LIDAR information become available.

REFERENCES

1. Thorne, A. M., and Tyler, I.M., 1996, Roy Hill, W.A. Sheet SF 50-12 (2nd edition): Western Australia Geological Survey, 1:250 000 Geological Series.
2. Water and Rivers Commission (2002) “Recognising Channels and Floodplains Forms”. Water and Rivers Commission River Restoration Report N RR17, Perth, WA.

FIGURES





Notes:
1. Coordinate System: GDA 94 MGA Zone 50.
2. NOT FOR CONSTRUCTION. Illustration purposes only.

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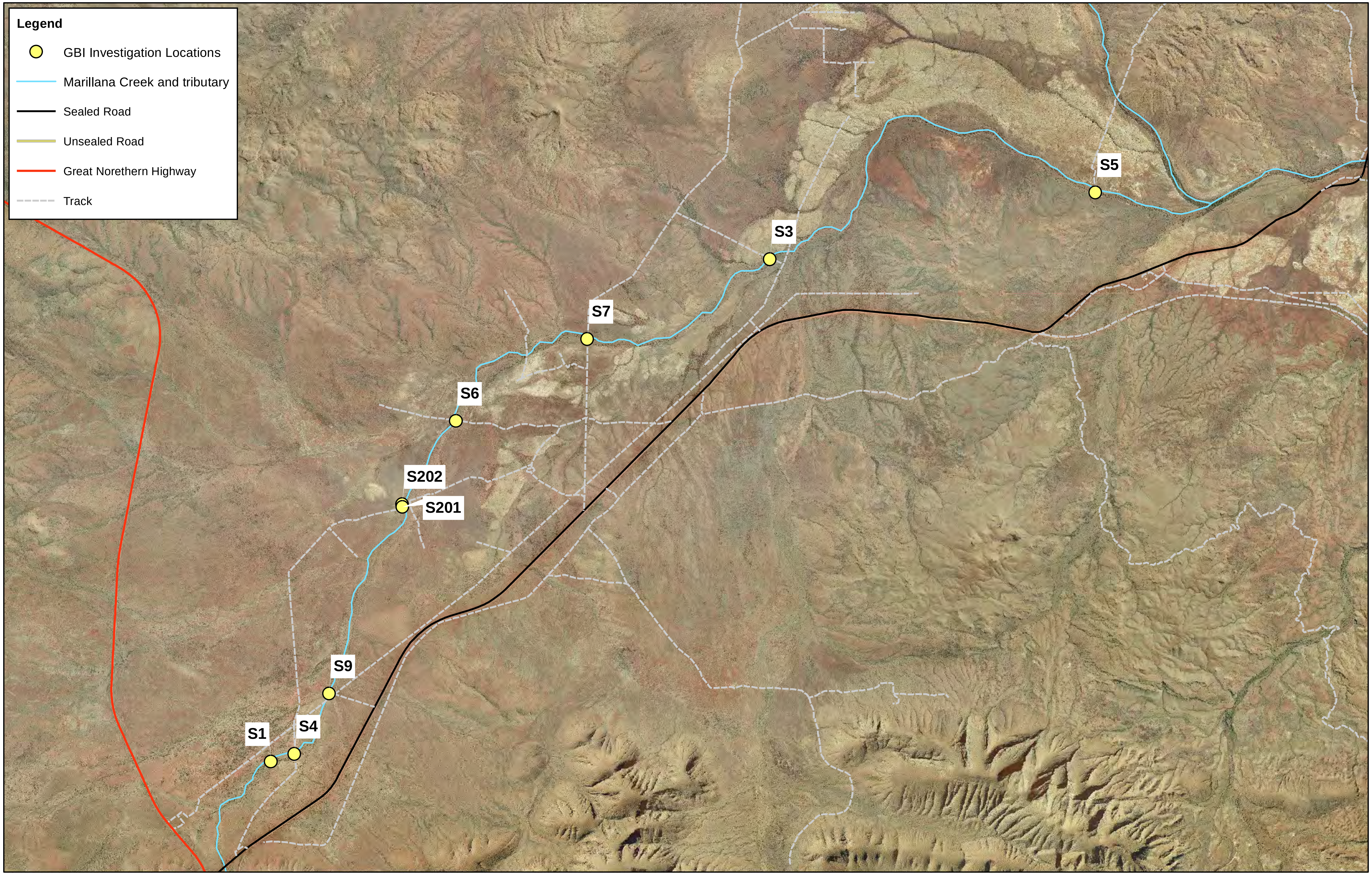
Marillana Creek Infiltration Project

Wetting Front Mapping

Mapping Overview

DRAWN	CNH	DATE	14/11/2019	
CHECKED	VBJ	DATE	14/11/2019	
SCALE	1:70,000	FIGURE No.	1	A3
PROJECT No.	4DG045500			

V:\03 - JobsActive\045500 Marillana Creek Infiltration\05_GIS_Data\01_ArcGIS\WORKING\01M_045500_Figure 1_20190814.mxd - Thursday, 14 November 2019 - 1:08:48 PM



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Notes:
1. Coordinate System: GDA 94 MGA Zone 50.
2. NOT FOR CONSTRUCTION. Illustration purposes only.

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Marillana Creek Infiltration Project
Ground Breaking Investigations
Investigation Location Overview

DRAWN	CNH	DATE	14/11/2019	
CHECKED	VBJ	DATE	14/11/2019	
SCALE	1:65,000	FIGURE No.	2	A3
PROJECT No.	4DG045500			

PLATES

APPENDIX A

AREA OF INTEREST - ENGINEERING GEOLOGICAL MAPS (1:15,000)

APPENDIX B

WETTING FRONT - ENGINEERING GEOLOGICAL MAPS (1:5,000)

APPENDIX C
WETTING FRONT DOMAIN MAPS (1:5,000)

APPENDIX D
WETTING FRONT DESIGN TABLE

4DG

TABLE D-1 - WETTING FRONT DESIGN TABLE

Channel Chainage to (m)	Channel Chainage from (m)	Channel Physiology	Primary Channel Width Min (m)	Primary Channel Width Max (m)	Primary Max Depth (m)	Low Flow Channel Location within Primary	Estimated max bank to bank distance	Secondary Channel Location	Entering drainage(s) Entering from	Entering drainage(s) Size	Dominant Creek Bed Material Description: Material Description	Simplified Description	Estimated Hydraulic Conductivity (High >10E⁻³ms⁻¹, Moderate 10E⁻³ - 10E⁻⁶ms⁻¹, Low <10E⁻⁶ms⁻¹)	Occurrence of Hollows	Calcite Precipitations	Rock Outcropping	Dominant Rock Unit	Vegetation Within Primary Channel
0	20	Vee	2	4	0.5	Mid Channel	4				Gravelly silty SAND, trace cobbles	Gravelly silty SAND	Moderate				Calcrete	Patches of grasses and dense spinifex, patches of shrubs and occasional trees (<10m)
20	50	Undulating Hollowed Channel	3	5	0.5	Mid Channel	5				Gravelly silty SAND, trace cobbles	Gravelly silty SAND	Moderate					Patches of grasses and dense spinifex, patches of shrubs and occasional trees (<10m)
50	80	Vee	2	4	0.5	Mid Channel	4				GRAVEL, with sand	GRAVEL	High					Patches of grasses and dense spinifex, patches of shrubs and occasional trees (<10m)
80	600	Trapezoidal	3	12	1.5	Mid Channel	12		South	Minor	Sandy GRAVEL trace cobbles. Gravel and cobble lag. Low flow gravelly SAND.	Sandy GRAVEL	High	Yes	Possible Minor accretions			Sporadic grasses, transitioning to spinifex
600	660	Wedge	6	12	1.5	South bank	12	South bank			Sandy GRAVEL trace cobbles. Gravel and cobble lag. Low flow gravelly SAND.	Sandy GRAVEL	High	Yes		Ferricrete of limited extent		Scattered grasses
660	910	Highly vegetated irregular	8	20	0.5	Undefined	35	South bank	North	Moderate	Sandy GRAVEL, with patches of exposed Ferricrete	Sandy GRAVEL over rock	Low			Ferricrete		Moderate to dense grasses, occasional trees (<10m)
910	940	Trapezoidal	3	5	1	Mid Channel	40	South bank			Sandy GRAVEL	Sandy GRAVEL	High			Weathered Calcrete		Moderate to dense grasses
940	985	Wedge	4	8	0.5	North bank	50	South bank			Sandy GRAVEL	Sandy GRAVEL	High					Moderate to dense grasses
985	1,070	Undulating Hollowed Channel	6	8	1.5	Variable	60	South bank			Sandy GRAVEL	Sandy GRAVEL	High	Yes				Scattered grasses
1,070	1,440	Highly vegetated irregular	3	12	1	Undefined	60	South bank	Two from South.	Minor	Sandy GRAVEL, patches of Clayey Silty SAND	Sandy GRAVEL	High	Yes		Weathered Calcrete		Moderate grasses becoming dense
1,440	1,840	Highly vegetated irregular	10	20	0.5	Undefined	100	North bank	South	Minor	Silty SAND, Gravelly SAND, and Sandy GRAVEL	Gravelly SAND	High					Dense grasses
1,840	1,920	Trapezoidal	5	7	0.5	Undefined	7				Sandy GRAVEL	Sandy GRAVEL	High					Dense grasses
1,920	1,980	Highly vegetated irregular	5	10	0.5	Undefined	10				Sandy GRAVEL	Sandy GRAVEL	High					Dense grasses
1,980	2,080	Wedge	8	20	1.5	North bank	20				Cobbly GRAVEL, with sand, trace boulders	Cobbly GRAVEL	High			Weathered Calcrete		Dense grasses
2,080	2,120	Highly vegetated irregular	15	20	0.5	Undefined	20				Sandy GRAVEL	Sandy GRAVEL	High			Weathered Calcrete		Dense grasses
2,120	2,160	Undulating Hollowed Channel	4	8	1	Variable	8		North	Minor	Sandy GRAVEL, cobbly patches	Sandy GRAVEL	High	Yes				Dense grasses
2,160	2,320	Highly vegetated irregular	8	12	0.5	Undefined	20	North bank	South	Minor	Sandy GRAVEL, cobbly patches	Sandy GRAVEL	High					Dense grasses
2,320	2,400	Wedge	2	8	1	South bank	30	North bank			Sandy GRAVEL	Sandy GRAVEL	High					Dense grasses
2,400	2,440	Trapezoidal	2	8	1	North and south banks	10				Sandy GRAVEL	Sandy GRAVEL	High					Dense grasses
2,440	2,550	Highly vegetated irregular	20	30	0.5	Undefined	30				Silty SAND with patches of Sandy GRAVEL	Silty SAND	Moderate			Weathered Calcrete		Dense grasses
2,550	2,600	Vee	1	2	0.5	Mid Channel	2				Sandy GRAVEL	Sandy GRAVEL	High	Yes				No Vegetation
2,600	2,630	Trapezoidal	3	5	1	Mid Channel	5				Sandy GRAVEL	Sandy GRAVEL	High			Weathered Calcrete		Scattered grasses
2,630	2,690	Highly irregular rock and boulder channel	6	10	1	Undefined	10				Sandy GRAVEL with patches of exposed Calcrete	Sandy GRAVEL over rock	Low			Weathered Calcrete		Moderate grasses
2,690	2,880	Undulating Hollowed Channel	8	15	2	North bank switching to south bank	15				GRAVEL with sand and Sandy GRAVEL, trace cobbles	GRAVEL	High			Weathered Calcrete		Dense grasses
2,880	3,040	Highly vegetated irregular	7	20	1	Undefined	20				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes		Weathered Calcrete		Dense grasses
3,040	3,080	Trapezoidal	8	10	1	North bank	10				GRAVEL with sand, trace cobbles	GRAVEL	High					Moderately spaced grasses
3,080	3,230	Wedge	8	20	1	South bank	20		South	Minor	GRAVEL with sand, trace cobbles and Sandy GRAVEL	GRAVEL	High			Weathered Calcrete		Moderately to densely spaced grasses becoming absent
3,230	3,300	Highly vegetated irregular	15	20	1	Undefined	20				GRAVEL with sand, trace cobbles and Sandy GRAVEL	GRAVEL	High			Weathered Calcrete		Moderate grasses
3,300	3,380	Trapezoidal	4	8	0.5	North bank	8				GRAVEL with sand, trace cobbles and Sandy GRAVEL	GRAVEL	High	Yes				Moderate grasses
3,380	3,480	Wedge	5	10		South bank	10				Sandy GRAVEL, patches of gravelly SAND	Sandy GRAVEL	High					Sparse grasses
3,480	3,520	Highly vegetated irregular	8	12		Undefined	12				Sandy GRAVEL, patches of gravelly SAND	Sandy GRAVEL	High					Dense grasses
3,520	3,560	Vee	1	3	0.5	Mid Channel	3				Sandy GRAVEL with trace cobbles	Sandy GRAVEL	High					Moderate grasses
3,560	3,620	Undulating Hollowed Channel	4	8	0.5	Variable	8				Sandy GRAVEL with trace cobbles	Sandy GRAVEL	High	Yes				Moderate grasses
3,620	3,720	Highly vegetated irregular	15	25	0.5	Becoming defined on north bank	25				Sandy GRAVEL	Sandy GRAVEL	High					Moderate to dense grasses
3,720	3,860	Trapezoidal	8	12	1	South bank	12				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes		Weathered Calcrete		Moderate grasses
3,860	4,040	Undulating Hollowed Channel	10	15	1	Variable	15				Sandy GRAVEL	Sandy GRAVEL	High					Moderate to dense grasses
4,040	4,220	Highly vegetated irregular	15	25	1	South bank	25		North	Major	Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes				Sparse to dense grasses
4,220	4,780	Broad and vegetated	15	25	0.5	Predominantly north bank	25		North	Minor	Sandy GRAVEL, trace cobbles, bouldery patches	Sandy GRAVEL	High	Yes		Goethitic Conglomerate	Calcrete over Goethitic Conglomerate with localised BIF	Dense grasses
4,780	4,980	Undulating Hollowed Channel	8	15	1	Variable	30		South	Moderate	Sandy GRAVEL, trace cobbles, bouldery and cobbly patches	Sandy GRAVEL	High	Yes		Weathered Calcrete		Dense grasses
4,980	5,320	Wedge	4	6	1	North bank	20				Sandy GRAVEL, trace cobbles, bouldery and cobbly patches, with patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low	Yes		Goethitic Conglomerate		Moderate grasses
5,320	5,350	Highly irregular rock and boulder channel	5	8	0.5	Undefined	8				Goethitic Conglomerate with surficial Sandy GRAVEL, trace cobbles bouldery and cobbly patches	Rock with surficial gravels	Low					Moderate grasses
5,350	5,440	Wedge	8	10	1	South bank	40				Sandy GRAVEL, trace cobbles, bouldery and cobbly patches, patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low			Goethitic Conglomerate		Moderate grasses
5,440	5,480	Highly vegetated irregular	15	20	1	Undefined	20		North	Minor	Sandy GRAVEL, trace cobbles, bouldery and cobbly patches	Sandy GRAVEL	High					Dense grasses
5,480	5,690	Highly irregular rock and boulder channel	7	10	1	Variable	10				Sandy GRAVEL, trace cobbles, bouldery and cobbly patches, patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low	Yes		Goethitic Conglomerate, BIF		Moderate grasses
5,690	5,750	Trapezoidal	8	12	1	Variable	12				GRAVEL, with sand and cobbles	GRAVEL	High					Moderate grasses
5,750	5,790	Undulating Hollowed Channel	8	12	0.5	Variable	12				GRAVEL, with sand and cobbles, trace boulders	GRAVEL	High	Yes				Moderate to dense grasses
5,790	5,860	Trapezoidal	6	8	1	South bank	12				Sandy GRAVEL, patches of silt	Sandy GRAVEL	High					No vegetation
5,860	5,950	Broad and shallow flowing	15	30	1	Undefined	30				Sandy GRAVEL, trace cobbles, patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low	Yes		Goethitic Conglomerate		Moderately to spaced grasses and scattered trees (<8m)
5,950	6,320	Highly vegetated irregular	25	40	0.5	Undefined	40				Sandy GRAVEL bouldery patches, patches of exposed Furruginsed BIF	Sandy GRAVEL over rock	Low	Yes		Furruginsed BIF		Dense grasses and scattered large tree (15m)
6,320	6,420	Wedge	9	11	1	South bank	20				Sandy GRAVEL bouldery patches, patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low			Goethitic Conglomerate		Dense grasses and scattered large tree (15m)
6,420	6,520	Trapezoidal	9	11	1	South bank	20				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Dense grasses and scattered large tree (15m)
6,520	6,620	Wedge	5	10	1	South bank	25				Sandy GRAVEL, patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low	Yes		Goethitic Conglomerate		Dense grasses
6,620	6,700	Highly irregular rock and boulder channel	3	5	1	Mid Channel	5				Goethitic Conglomerate, Furruginsed BIF, with surficial boulders	Rock with surficial gravels	Low			Goethitic Conglomerate, Furruginsed BIF		Moderate to dense grasses
6,700	6,750	Wedge	6	12	1	North bank	30	South bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High			Goethitic Conglomerate		Sparse to moderate grasses
6,750	6,840	Highly vegetated irregular	15	25	1	Undefined	25				Sandy GRAVEL, patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low			Goethitic Conglomerate		Dense grasses
6,840	6,860	Incoming drainage depositional zone	10	20	1	South bank switching to north	25				Sandy GRAVEL, patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low			Goethitic Conglomerate		Sparse to moderate grasses
6,860	6,940	Wedge	8	12	1	North bank	20				Sandy GRAVEL, patches of silt and exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low			Goethitic Conglomerate		Sparse to dense grasses
6,940	7,040	Highly irregular rock and boulder channel	8	12	1	Mid Channel	15				Sandy GRAVEL, patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low			Goethitic Conglomerate		Moderate grasses
7,040	7,090	Trapezoidal	10	20	2	Undefined	20				Sandy GRAVEL, trace boulders, small patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low			Goethitic Conglomerate / Ferricrete		Sparse to moderate grasses and scattered shrubs
7,090	7,140	Wedge	8	15	0.5	North bank	15				Sandy GRAVEL	Sandy GRAVEL	High					Sparse to moderate grasses and scattered shrubs
7,140	7,320	Trapezoidal	15	20	1	North and south banks	20				Sandy GRAVEL, with cobbly and bouldery patches	Sandy GRAVEL	High	Yes				Sparse to moderate grasses, scattered trees and large tree
7,320	7,560	Trapezoidal convex	10	20	1	North and south banks	20				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Moderate grasses and scattered shrubs
7,560	7,660	Highly vegetated irregular	20	30	0.5	Undefined	30				Sandy GRAVEL, trace cobbles, with bouldery patches, patches of exposed Calcrete	Sandy GRAVEL over rock	Low			Goethitic Conglomerate, Calcrete		Dense grasses, scattered shrubs and occasional large trees
7,660	7,780	Wedge	8	12	0.5	South bank	30				Sandy GRAVEL, trace cobbles, patches of exposed Calcrete	Sandy GRAVEL over rock	Low	Yes		Calcrete		Moderate to scattered grasses
7,780	7,840	Trapezoidal	8	12	0.5	Undefined	25				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Moderate to scattered grasses
7,840	7,940	Rising transition zone	15	25	0.5	Undefined	25				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High			Calcrete		Dense grasses
7,940	8,100	Wedge	8	12	1	South bank	30				Sandy GRAVEL, trace cobbles, with bouldery patches and patches of exposed Calcrete	Sandy GRAVEL over rock	Low	Yes				Moderate to dense grasses
8,100	8,130	Highly vegetated irregular	6	10	0.5	North bank	25				Sandy GRAVEL, trace cobbles, patches of exposed Calcrete	Sandy GRAVEL over rock	Low					Moderate grasses
8,130	8,220	Wedge	8	12	1	North bank	15		North	Minor	Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes		Calcrete / Ferricrete		Sparse to moderate grasses
8,220	8,380	Trapezoidal convex	20	30	0.5	North and south banks	30		North	Minor	Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Dense grasses and scattered shrubs
8,380	8,560	Trapezoidal	5	10	1	South bank	30				Sandy GRAVEL	Sandy GRAVEL	High			Calcrete		Moderate to sparse grasses, sporadic large trees
8,560	8,630	Trapezoidal convex	10	20	1	North and south banks	40		South	Minor	Sandy GRAVEL	Sandy GRAVEL	High					Moderate to sparse grasses, sporadic large trees
8,630	8,890	Wedge	10	20	1	South bank	30				Sandy GRAVEL	Sandy GRAVEL	High	Yes		Calcrete / Goethitic Conglomerate		Moderate to sparse grasses, sporadic large trees
8,890	8,910	Rising transition zone	10	20	0.5	Mid Channel	20				Sandy GRAVEL	Sandy GRAVEL	High	Yes				Moderate to sparse grasses
8,910	9,070	Wedge	8	12	1	North bank	20				Sandy GRAVEL, silt veneer in low flow	Sandy GRAVEL	High	Yes				Dense grasses
9,070	9,100	Undulating hollowed channel	12	18	0.5	North bank	30				Sandy GRAVEL	Sandy GRAVEL	High	Yes				Moderate grasses, occasional large trees
9,100	9,180	Trapezoidal convex	12	18	0.5	North and south banks	25		North	Minor	Sandy GRAVEL	Sandy GRAVEL	High					Moderate grasses, occasional large trees
9,180	9,240	Undulating hollowed channel	10	15	1	Variable	30				Sandy GRAVEL, patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low	Yes		Goethitic Conglomerate		Moderate to dense grasses occasional large trees
9,240	9,370	Broad and shallow flowing	25	35	0.5	Undefined	35				Sandy GRAVEL, patches of exposed BIF	Sandy GRAVEL over rock	Low			BIF		Moderate to dense grasses
9,370	9,510	Trapezoidal convex	10	15	0.5	North bank	20				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes		Goethitic Conglomerate		Scattered to moderate grasses
9,510	9,600	Broad and shallow flowing	10	15	0.5	North bank	25				Sandy GRAVEL	Sandy GRAVEL	High					Moderate grasses and scattered large trees
9,600	9,750	Trapezoidal convex	1	5	0.5	North and south banks	80	South bank			Sandy GRAVEL	Sandy GRAVEL	High			BIF		Dense grasses scattered shrubs
9,750	9,810	Undulating hollowed channel	5	15	1	North bank	70	South bank			Sandy GRAVEL, with silt	Sandy GRAVEL	High	Yes				Moderate grasses, occasional shrubs and large trees
9,810	9,895	Broad and shallow flowing	10	15	0.5	South bank	70	South bank			GRAVEL, with sand, trace cobbles	GRAVEL	High					Moderate grasses, occasional shrubs
9,895	9,940	Trapezoidal	5	7	1	South bank	60				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes				Scattered grasses
9,940	9,980	Wedge	7	9	1	South bank	30				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered grasses
9,980	10,010	Wedge	7	9	1	North bank	80		North	Minor	Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered to moderate grasses
10,010	10,145	Wedge	7	9	1	South bank	80				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered grasses
10,145	10,170	Rising transition zone	10	20	0.5	South bank	40				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered grasses
10,170	10,340	Wedge	7	9	1	North bank	15		South	Minor	Sandy GRAVEL, trace cobbles, patches of exposed Calcareous Conglomerate	Sandy GRAVEL over rock	Low	Yes		Calcareous Conglomerate		Moderate grasses
10,340	10,370	Rising transition zone	10	15	0.5	Undefined	15				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Moderate grasses
10,370	10,430	Wedge	4	6	1	North bank	25				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered to moderate grasses
10,430	10,470	Trapezoidal	4	6	1	North bank	25				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered grasses
10,470	10,575	Wedge	8	12	0.5	North bank	15				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High		Calcite deposits in bank			Scattered grasses
10,575	10,665	Trapezoidal	8	12	0.5	South bank	15				Sandy GRAVEL	Sandy GRAVEL	High	Yes		Calcrete soils		Scattered grasses
10,665	10,770	Trapezoidal	12	18	0.5	Undefined	18				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Moderate grasses and shrubs
10,770	10,830	Highly vegetated irregular	12	18	0.5	Undefined	18				Sandy GRAVEL	Sandy GRAVEL	High					Moderate dense grasses and shrubs
10,830	10,980	Wedge	12	18	0.5	South bank switching to North bank	40				Sandy GRAVEL	Sandy GRAVEL	High					Scattered to moderate grasses
10,980	11,160	Undulating hollowed channel	8	10	1	Variable	30		North, north	Major, minor	Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes		Calcrete soils		Scattered grasses and occasional large trees
11,160	11,290	Wedge	8	15	1	North bank	35		North	Moderate	Sandy GRAVEL	Sandy GRAVEL	High					Scattered grasses and occasional large trees
11,290	11,340	Trapezoidal	10	15	1	North bank switching to south bank	17		North	Minor	Sandy GRAVEL	Sandy GRAVEL	High	Yes				Scattered grasses and occasional large trees
11,340	11,440	Wedge	10	15	1	South bank	30				Sandy GRAVEL	Sandy GRAVEL	High					Moderate grasses
11,440	11,490	Broad and shallow flowing	12	18	0.5	Variable	30				Sandy GRAVEL	Sandy GRAVEL	High					Moderate to dense grasses, occasional large trees
11,490	11,545	Undulating hollowed channel	3	5	0.5	South bank	20				Sandy GRAVEL, patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low	Yes		Goethitic Conglomerate		Vegetation absent
11,545	11,820	Trapezoidal	10	15	1	North bank	20				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High		Possible minor accretions	Goethitic Conglomerate / Ferricrete, calcrete		Vegetation absent grasses becoming scattered
11,820	11,890	Wedge	8	10	1	North bank	30				Sandy GRAVEL, trace cobbles, small patches of exposed Calcrete	Sandy GRAVEL over rock	Low		Calcite deposits in bank	Calcrete		Scattered grasses
11,890	11,965	Trapezoidal	8	10	1	South bank	15				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered grasses
11,965	11,985	Undulating hollowed channel	5	8	1	South bank	10		North	Major	Sandy GRAVEL, with cobbles	Sandy GRAVEL	High	Yes				Scattered grasses and sporadic large trees
11,985	12,110	Trapezoidal	15	20	1	North bank	20		North	Minor	Sandy GRAVEL, with cobbles	Sandy GRAVEL	High	Yes		Calcareous Conglomerate		Scattered grasses and sporadic large trees
12,110	12,150	Trapezoidal	3	5	1	North bank switching to south bank	15				Sandy GRAVEL with cobbles	Sandy GRAVEL	High					Scattered grasses and sporadic large trees
12,150	12,265	Undulating hollowed channel	5	7	1	South bank	25		South, south	Minor	Sandy GRAVEL with cobbles, with cobbly patches	Sandy GRAVEL	High	Yes		Calcrete		Scattered grasses and sporadic large trees
12,265	12,450	Trapezoidal	10	15	1	Undefined	15				Sandy GRAVEL, trace cobbles, small patches of exposed Calcrete	Sandy GRAVEL over rock	Low			Calcrete		Scattered grasses
12,450	12,550	Highly vegetated irregular	15	20	0.5	Undefined	20				Sandy GRAVEL, trace cobbles, with small patches of exposed Calcrete and Goethitic Conglomerate	Sandy GRAVEL over rock	Low			Calcrete, Goethitic Conglomerate		Moderate grasses
12,550	12,570	Undulating hollowed channel	10	15	0.5	Variable	20				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes				Moderate grasses
12,570	12,710	Wedge	10	15	0.5	North bank	25				Sandy GRAVEL, trace cobbles, Gravelly COBBLES in low flow	Sandy GRAVEL	High					Scattered grasses
12,710	12,770	Highly vegetated irregular	8	12	0.5	Undefined	25	North bank			Calcrete, with patches of Cobbly GRAVEL with sand.	Rock with surficial gravels	Low			Calcrete		Moderate to dense grasses, occasional large trees
12,770	12,820	Trapezoidal convex	5	10	0.5	South bank	60	North bank	South	Minor	Cobbly GRAVEL with sand	Cobbly GRAVEL	High					Moderate grasses, scattered shrubs
12,820	12,850	Undulating hollowed channel	5	10	0.5	North bank	50				Cobbly GRAVEL with sand	Cobbly GRAVEL	High	Yes		Calcrete		Scattered grasses and shrubs
12,850	13,065	Wedge	10	15	1	North bank switching to south bank	30				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Sparse to dense grasses, scattered shrubs
13,065	13,160	Highly vegetated irregular	30	40	0.5	South bank	40	South bank			Cobbly GRAVEL with sand and patches of silt veneer	Cobbly GRAVEL	High					Moderate to dense grasses, moderate large trees
13,160	13,285	Wedge	10	15	1	North bank	60	South bank	North	Moderate to major	Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes		Calcrete		Moderate to dense grasses becoming scattered, scattered shrubs
13,285	13,380	Trapezoidal convex	8	12	0.5	North bank	50	South bank			Sandy GRAVEL	Sandy GRAVEL	High					Scattered grasses
13,380	13,550	Trapezoidal	10	15	1	Variable	45				Sandy GRAVEL	Sandy GRAVEL	High	Yes		Goethitic Conglomerate		Moderate grasses occasional large trees
13,550	13,665	Broad and shallow flowing	10	20	0.5	South bank	50	North bank			Sandy GRAVEL	Sandy GRAVEL	High					Moderate grasses and sporadic shrubs
13,665	13,670	Road crossing	15	20	0.5	South bank	40	North bank			Sandy GRAVEL	Sandy GRAVEL	High					Vegetation absent
13,670	13,930	Wedge	4	15	1	North bank	60	ank switching to south bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High			Goethitic Conglomerate		Moderate grasses becoming scattered and sporadic shrubs
13,930	13,985	Highly vegetated irregular	8	12	0.5	Undefined	45	South bank			Sandy GRAVEL, trace cobbles, with small patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low			Goethitic Conglomerate		Moderate grasses
13,985	14,030	Wedge	10	20	0.5	South bank	45	South bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered to dense grasses
14,030	14,070	Trapezoidal	8	12	0.5	South bank	40	South bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High			Calcrete		Scattered grasses
14,070	14,090	Undulating hollowed channel	8	12	0.5	South bank	35	South bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes				Scattered grasses, scattered shrubs
14,090	14,400	Highly vegetated irregular	20	40	0.5	Undefined	40	South bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Dense to moderate grasses becoming dense
14,400	14,590	Wedge	4	6	0.5	North bank	70	South bank			Sandy GRAVEL, trace cobbles, with cobbly patches	Sandy GRAVEL	High					Moderate grasses
14,590	14,680	Undulating hollowed channel	10	20	1.5	South bank	70	South bank	South	Moderate	Sandy GRAVEL, trace cobbles, with cobbly patches	Sandy GRAVEL	High	Yes		Calcrete / silcrete		Scattered grasses becoming moderate
14,680	14,750	Wedge	6	8	1	Undefined	70	North bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Moderate grasses
14,750	14,800	Trapezoidal	10	15	0.5	South bank	70	North bank			Sandy GRAVEL	Sandy GRAVEL	High			Calcrete / silcrete		Scattered grasses
14,800	14,840	Undulating hollowed channel	8	15	0.5	South bank	70	North bank			Sandy GRAVEL	Sandy GRAVEL	High	Yes				Scattered grasses and large trees
14,840	15,060	Broad and shallow flowing	15	20	0.5	Undefined	70	North bank	South	Minor	Calcrete with surficial Sandy GRAVEL	Rock with surficial gravels	Low			Calcrete		Moderate to dense grasses, occasional large trees becoming moderate
15,060	15,200	Broad and shallow flowing	12	18	0.5	Undefined	40				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High			Goethitic Conglomerate		Moderate grasses
15,200	15,310	Trapezoidal convex	25	35	1	North and south banks	35				Sandy GRAVEL, trace cobbles, patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low			Calcrete, Goethitic Conglomerate		Dense grasses, scattered shrubs
15,310	15,370	Wedge	5	12	0.5	South bank	50	North bank			Sandy GRAVEL, trace cobbles, patches bouldery, and small patches of exposed Dolerite	Sandy GRAVEL over rock	Low			Dolerite		Moderate grasses and large trees
15,370	15,420	Undulating hollowed channel	8	10	0.5	Variable	50	North bank			Sandy GRAVEL trace cobbles	Sandy GRAVEL	High	Yes		Goethitic Conglomerate		Scattered grasses
15,420	15,485	Highly vegetated irregular	12	18	0.5	South bank	35	North bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Moderate to dense grasses
15,485	15,580	Wedge	8	12	0.5	South bank	35	North bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High			Calcareous conglomerate, Goethitic Conglomerate		Scattered grasses
15,580	15,790	Highly vegetated irregular	5	15	0.5	Undefined	70	North bank	North	Major	Sandy GRAVEL, trace cobbles, patches bouldery, and patches of exposed Dolerite	Sandy GRAVEL over rock	Low			Dolerite, Shale, BIF, Goethitic Conglomerate		Scattered grasses becoming moderate
15,790	15,845	Wedge	4	6	0.5	North bank	30	North bank			Cobbly GRAVEL with sand, with bouldery patches	Cobbly GRAVEL	High			Dolerite, Calcrete		Moderate grasses
15,845	15,910	Trapezoidal	10	15	1	Mid Channel	100				Sandy GRAVEL, with bouldery patches	Sandy GRAVEL	High					Scattered grasses
15,910	15,935	Incoming drainage depositional zone	10	15	0.5	South bank switching to north	75		North	Moderate to Major	Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered grasses
15,935	15,995	Wedge	10	15	0.5	North bank	80				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered grasses
15,995	16,080	Trapezoidal convex	10	15	0.5	North bank	35		South	Minor	Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High			Dolerite		Scattered to moderate grasses and scattered large tree
16,080	16,140	Broad and shallow flowing	10	15	0.5	South bank	35				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes		Cherty BIF, dolerite		Scattered grasses
16,140	16,190	Wedge	10	15	0.5	South bank	60				Dolerite overlain by sandy GRAVEL	Rock with surficial gravels	Low			Dolerite		Scattered grasses
16,190	16,270	Highly irregular rock and boulder channel	10	20	0.5	South bank	90				Sandy GRAVEL, with cobbly patches and patches of exposed Dolerite and cherty BIF	Sandy GRAVEL over rock	Low			Cherty BIF, dolerite		Moderate grasses becoming scattered, scattered trees become present
16,270	16,340	Trapezoidal	10	20	0.5	North bank switching to south	60				Sandy GRAVEL	Sandy GRAVEL	High					Scattered grasses and large trees
16,340	16,420	Trapezoidal convex	10	20	0.5	South bank	60	North bank			Sandy GRAVEL	Sandy GRAVEL	High					Scattered grasses and large trees
16,420	16,475	Trapezoidal	10	20	0.5	Mid Channel	50				Sandy GRAVEL	Sandy GRAVEL	High					Scattered grasses and large trees
16,475	16,550	Trapezoidal convex	5	7	0.5	North bank	50	South bank			Sandy GRAVEL with cobbles	Sandy GRAVEL	High					Moderate grasses

TABLE D-1 - WETTING FRONT DESIGN TABLE

Channel Chainage		Channel Physiology	Primary Channel Width		Primary Max Depth (m)	Low Flow Channel Location within Primary	Estimated max bank to bank distance	Secondary Channel Location	Entering drainage(s)		Dominant Creek Bed Material Description		Estimated Hydraulic Conductivity (High >10E^{-5}ms^{-1}, Moderate 10E^{-5} - 10E^{-6}ms^{-1}, Low <10E^{-6}ms^{-1})	Occurrence of Hollows	Calcite Precipitations	Rock Outcropping	Dominant Rock Unit	Vegetation Within Primary Channel
to (m)	from (m)		Min (m)	Max (m)					Entering from	Size	Material Description	Simplified Description						
16,550	16,600	Broad and shallow flowing	12	18	0.5	Mid Channel	20				Sandy GRAVEL with cobbles, bouldery patches	Sandy GRAVEL	High					Scattered grasses
16,600	16,690	Undulating hollowed channel	12	18	1	Variable	40				Sandy GRAVEL with cobbles	Sandy GRAVEL	High	Yes				Scattered grasses, scattered large trees become present
16,690	16,765	Broad and shallow flowing	15	25	0.5	South bank	60				Sandy GRAVEL with cobbles, patches of Gravelly COBBLES and patches of exposed Cherty BIF	Sandy GRAVEL over rock	Low			Cherty BIF		Scattered bars of grasses
16,765	17,010	Trapezoidal convex	12	18	0.5	North and south banks	35		North	Minor	Sandy GRAVEL	Sandy GRAVEL	High			Shale, Calcrete soil, Goethitic Conglomerate		Scattered grasses and large trees
17,010	17,040	Incised transition zone	2	6	0.5	Mid Channel switching to north	30				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered grasses
17,040	17,210	Wedge	6	10	0.5	North bank	25				Sandy GRAVEL	Sandy GRAVEL	High					Scattered grasses
17,210	17,230	Rising transition zone	15	25	0.5	Undefined	30				Sandy GRAVEL	Sandy GRAVEL	High					Scattered grasses
17,230	17,315	Trapezoidal convex	6	8	0.5	North bank	40		North	Minor	Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered grasses
17,315	17,425	Trapezoidal convex	15	25	0.5	Undefined	40	North bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Moderate grasses
17,425	17,505	Broad and shallow flowing	15	25	0.5	Undefined	30	North bank	South	Minor	Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High			Calcrete		Moderate to dense grasses
17,505	17,590	Wedge	15	20	0.5	South bank	22				Sandy GRAVEL	Sandy GRAVEL	High					Scattered grasses
17,590	17,640	Highly vegetated irregular	15	20	0.5	South bank indistinct	22		North	Moderate	Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Dense grasses
17,640	17,700	Trapezoidal convex	3	6	0.5	South bank, secondary to north	30				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes				Moderate grasses, large tree on island
17,700	17,860	Highly vegetated irregular	10	15	0.5	Mid Channel	30	South bank			Sandy GRAVEL, trace cobbles and Cobbly GRAVEL, with sand	Sandy GRAVEL	High			Calcrete, Calcrete soil, Dolerite,		Moderate to dense grasses
17,860	17,900	Wedge	8	12	1	South bank	40	South bank			Sandy GRAVEL, with cobbles, trace boulders	Sandy GRAVEL	High					Moderate to dense grasses and scattered shrubs
17,900	17,950	Undulating hollowed channel	8	12	1	Variable	35	South bank	North	Minor	Sandy GRAVEL, with cobbles, trace boulders	Sandy GRAVEL	High	Yes				Scattered grasses, occasional trees
17,950	17,970	Wedge	8	12	1	North bank	25	South bank			Sandy GRAVEL, with trace cobbles	Sandy GRAVEL	High			Calcrete		Scattered grasses
17,970	18,015	Undulating hollowed channel	4	6	1	Variable	25	South bank			Sandy GRAVEL, with trace cobbles, silt veneer in local lows	Sandy GRAVEL	High	Yes				Scattered grasses, occasional trees
18,015	18,060	Trapezoidal convex	2	4	0.5	North bank	30	South bank	North	Minor	Sandy GRAVEL	Sandy GRAVEL	High			Calcrete		Scattered to moderate grasses
18,060	18,100	Undulating hollowed channel	2	6	0.5	North bank switching to south	30	South bank			Sandy GRAVEL	Sandy GRAVEL	High	Yes				Scattered grasses moderate large trees
18,100	18,115	Wedge	6	10	0.5	South bank	30	South bank			Sandy GRAVEL	Sandy GRAVEL	High					Scattered grasses
18,115	18,240	Trapezoidal	3	10	0.5	South bank switching to north	25	South bank			Sandy GRAVEL, in places with silt	Sandy GRAVEL	High			Calcrete		Scattered grasses, large trees become present
18,240	18,390	Incoming drainage depositional zone	3	8	1	North bank switching to mid channel	30	South bank			Sandy GRAVEL, in places cobbly	Sandy GRAVEL	High					Scattered to moderate grasses becoming sporadic, scattered large trees
18,390	18,430	Cobbly bowl	6	10	0.5	North bank	50	South bank			Cobbly GRAVEL, with sand	Cobbly GRAVEL	High					Scattered grasses, trees and shrubs on bars
18,430	18,475	Wedge	8	12	0.5	North bank	50	South bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered grasses and shrubs
18,475	18,505	Undulating hollowed channel	8	12	0.5	South bank	60	South bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High	Yes				Scattered grasses
18,505	18,515	Trapezoidal	12	18	1	South bank	70	South bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered grasses
18,515	18,740	Wedge	8	12	1	South bank	80	South bank			Sandy GRAVEL, in places cobbly	Sandy GRAVEL	High			Calcrete		Scattered to moderate grasses
18,740	18,800	Trapezoidal	10	15	1	Mid Channel	70	North bank			Sandy GRAVEL, in places cobbly	Sandy GRAVEL	High					Scattered to moderate grasses
18,800	18,865	Wedge	15	20	0.5	South bank	70	North bank			Sandy GRAVEL, in places cobbly	Sandy GRAVEL	High					Scattered grasses and large trees
18,865	18,885	Undulating hollowed channel	4	8	0.5	South bank switching to north	80	North bank			Sandy GRAVEL, in places cobbly	Sandy GRAVEL	High	Yes				Scattered grasses and large trees
18,885	18,900	Rising transition zone	6	10	0.5	Mid Channel switching to north	80	North bank			Sandy GRAVEL, in places cobbly	Sandy GRAVEL	High					Scattered grasses
18,900	19,160	Wedge	8	12	0.5	North bank	80	North bank			Sandy GRAVEL, in places cobbly	Sandy GRAVEL	High					Scattered grasses
19,160	19,215	Rising transition zone	20	25	0.5	North bank switching to south	90	North and South bank	North	Minor floodplain drai	Sandy GRAVEL, trace cobbles, occasional silt veneer in low flow	Sandy GRAVEL	High		Calcite deposits in bank			Scattered grasses
19,215	19,260	Wedge	10	15	0.5	South bank	100	South bank			Cobbly Sandy GRAVEL	Cobbly GRAVEL	High					Scattered grasses
19,260	19,325	Highly vegetated irregular	15	25	0.5	Undefined	100	South bank			Goethitic Conglomerate with surficial Cobbly Sandy GRAVEL	Rock with surficial gravels	Low			Goethitic Conglomerate		Moderate to dense grasses
19,325	19,360	Undulating hollowed channel	8	15	0.5	Variable	120	North bank			Cobbly Sandy GRAVEL	Cobbly GRAVEL	High	Yes				Scattered to moderate grasses
19,360	19,420	Cobbly bowl	10	15	0.5	Mid channel	120	North bank			Cobbly Sandy GRAVEL, patches of exposed Goethitic Conglomerate	Cobbly sandy GRAVEL over rock	Low			Goethitic Conglomerate		Scattered grasses
19,420	19,450	Highly vegetated irregular	10	15	0.5	South bank	120	North bank			Cobbly Sandy GRAVEL, patches of exposed Goethitic Conglomerate	Cobbly sandy GRAVEL over rock	Low					Moderate to dense grasses
19,450	19,630	Wedge	6	8	0.5	South bank	120	North bank			Sandy GRAVEL, in places cobbly, silt veneer in low flow	Sandy GRAVEL	High		Minor accretions			Scattered to moderate grasses
19,630	19,760	Undulating hollowed channel	8	14	0.5	North bank switching to north then to south	120	North bank			Sandy GRAVEL, in places cobbly, silt veneer in low flow	Sandy GRAVEL	High	Yes				Grasses becoming absent
19,760	19,970	Trapezoidal convex	5	15	0.5	South bank	100	North bank			Sandy GRAVEL, trace cobbles, in places bouldery, silt veneer in low flow	Sandy GRAVEL	High			Goethitic Conglomerate		Moderate grasses becoming scattered
19,970	19,980	Incoming drainage depositional zone	6	12	0.5	Variable	100		South	Major	Sandy GRAVEL with thin silt veneer	Sandy GRAVEL	High					Scattered to moderate grasses
19,980	20,000	Highly vegetated irregular	4	6	0.5	Undefined	100				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High			Shaley BIF		Moderate to dense grasses, scattered large trees
20,000	20,050	Broad and shallow flowing	10	15	0.5	Undefined	100				Sandy GRAVEL, trace cobbles, patches of silty SAND	Sandy GRAVEL	High					Scattered grasses
20,050	20,170	Wedge	8	12	0.2	South bank	70				Sandy GRAVEL, with patches of cobbly GRAVEL, patches of silt veneer	Sandy GRAVEL	High					Scattered grasses and shrubs
20,170	20,230	Incised transition zone	4	6	0.5	South bank switching to north	65	South bank			Cobbly GRAVEL, with sand	Cobbly GRAVEL	High					Scattered grasses
20,230	20,320	Wedge	8	12	0.5	North bank	65	South bank			Bouldery Cobbly Sandy GRAVEL, with silt veneer	Cobbly GRAVEL	High			Cherty BIF		Scattered grasses
20,320	20,350	Rising transition zone	30	50	0.5	Undefined	65	South bank			Sandy GRAVEL with patches of Cobbly GRAVEL	Sandy GRAVEL	High					Dense grasses, moderate shrubs and trees
20,350	20,430	Incised transition zone	10	20	0.5	South bank, high flow to north	70	South bank			Cobbly Sandy GRAVEL	Cobbly GRAVEL	High			Goethitic Conglomerate		Scattered grasses
20,430	20,490	Wedge	8	12	0.5	South bank	70	North bank			Cherty BIF with surficial Sandy GRAVEL and silt veneer	Rock with surficial gravels	Low		Minor accretions	Cherty BIF, Goethitic Conglomerate		Scattered grasses
20,490	20,590	Animal bog	20	30	0.5	Mid channel	80	North bank			Sandy SILT	Sandy SILT	Moderate					Scattered grasses and large trees
20,590	20,760	Highly vegetated irregular	50	70	0.2	Undefined	80	North bank			Sandy GRAVEL, in places bouldery, with large patches of exposed cherty BIF and Ferrunginised BIF, areas of silt veneer	Sandy GRAVEL over rock	Low	Yes	Minor accretions	Cherty BIF, Goethitic Conglomerate		Dense grasses scattered large trees
20,760	20,820	Cobbly bowl	5	10	0.5	Mid channel	120	North bank			Cobbly Sandy GRAVEL	Cobbly sandy GRAVEL	High					Scattered to moderate grasses
20,820	20,870	Highly vegetated irregular	6	12	0.5	Mid channel switching to south	130	North bank			Cobbly Sandy GRAVEL, areas of silt veneer	Cobbly sandy GRAVEL	High					Moderate to dense grasses
20,870	21,090	Wedge	10	15	0.5	South bank	130	North bank	South	Minor	Cobbly Sandy GRAVEL, with boulders, areas of silt veneer	Cobbly sandy GRAVEL	High			Goethitic Conglomerate		Scattered grasses, scattered large trees become present
21,090	21,170	Broad and shallow flowing	15	20	0.5	North bank	120	North bank			Cobbly Sandy GRAVEL	Cobbly sandy GRAVEL	High					Moderate grasses
21,170	21,225	Wedge	12	18	0.5	North bank	100	North bank			Cobbly Sandy GRAVEL	Cobbly sandy GRAVEL	High					Scattered grasses
21,225	21,260	Undulating hollowed channel	6	10	0.5	Mid channel	100	North bank			Cobbly Sandy GRAVEL	Cobbly sandy GRAVEL	High	Yes				Scattered large trees
21,260	21,280	Wedge	4	6	0.5	South bank	100	North bank			Sandy GRAVEL, with patches of Cobbly GRAVEL	Sandy GRAVEL	High					Scattered grasses
21,280	21,330	Incised transition zone	4	6	0.5	Mid channel	100				Sandy GRAVEL, with patches of Cobbly GRAVEL, patches of exposed Ferricrete	Sandy GRAVEL over rock	Low		Possible minor accretions	Ferricrete		Scattered grasses
21,330	21,360	Incoming drainage depositional zone	6	10	0.5	Mid channel	100	ging of secondary from north			Sandy GRAVEL with cobbles	Sandy GRAVEL	High					Scattered grasses
21,360	21,410	Broad and shallow flowing	2	4	0.2	South bank	90				Sandy GRAVEL	Sandy GRAVEL	High					Moderate to dense grasses
21,410	21,525	Wedge	2	8	0.5	South bank	90				Ferricrete with surficial Sandy GRAVEL	Rock with surficial gravels	Low			Ferricrete, Dolerite, Calcrete, Goethitic Conglomerate		Moderate to dense grasses
21,525	21,550	Undulating hollowed channel	4	6	0.5	South bank	80	Mid banks			Goethitic Conglomerate with surficial Sandy GRAVEL with patches of Cobbly GRAVEL	Rock with surficial gravels	Low	Yes		Goethitic Conglomerate		Scattered large trees
21,550	21,640	Highly vegetated irregular	35	45	0.5	Undefined	80	North bank			Goethitic Conglomerate with surficial Sandy GRAVEL with patches of Cobbly GRAVEL	Rock with surficial gravels	Low			Goethitic Conglomerate		Moderate to dense grasses
21,640	21,740	Highly irregular rock and boulder channel	4	8	0.5	Mid channel, multiple secondary channels	80		North	Moderate	Goethitic Conglomerate with surficial Cobbly GRAVEL with patches of Sandy GRAVEL	Rock with surficial gravels	Low					Moderate to dense grasses
21,740	21,790	Incised transition zone	4	6	0.5	Mid channel, multiple secondary channels	80				Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High			Goethitic Conglomerate		Scattered grasses
21,790	21,890	Wedge	2	4	0.5	North bank	100				Cobbly Sandy GRAVEL with areas of trace cobbles	Cobbly sandy GRAVEL	High			Calcrete		Scattered grasses
21,890	21,940	Undulating hollowed channel	2	4	0.5	Mid channel	60				Cobbly Sandy GRAVEL, trace boulders, with areas of trace cobbles	Cobbly sandy GRAVEL	High	Yes				Scattered grasses and large trees
21,940	22,090	Trapezoidal convex	10	20	0.5	North and south banks	70		North	Moderate	Sandy GRAVEL, trace cobbles, with patches of exposed Goethitic Conglomerate	Sandy GRAVEL over rock	Low			Goethitic Conglomerate		Vegetation absent, scattered grasses and trees become present
22,090	22,135	Wedge	10	20	0.5	North bank	80				Sandy GRAVEL with cobbles, areas of silt veneer	Sandy GRAVEL	High					Scattered grasses and trees
22,135	22,230	Broad and shallow flowing	25	35	0.5	Mid channel	100				Sandy GRAVEL with cobbles, areas of silt veneer	Sandy GRAVEL	High			Goethitic Conglomerate		Moderate to dense grasses, becoming scattered
22,230	22,310	Highly vegetated irregular	35	45	0.5	Undefined	110				Sandy GRAVEL with cobbles, patches of exposed Calcrete	Sandy GRAVEL over rock	Low			Calcrete		Dense grasses becoming sparse
22,310	22,385	Highly irregular rock and boulder channel	4	6	0.5	Mid channel, secondary on north	100		North	Moderate	Cobbly GRAVEL, patches of exposed Calcrete	Cobbly GRAVEL over rock	Low			Dolerite, Calcrete		Scattered grasses
22,385	22,480	Wedge	10	20	0.5	South bank	90				Sandy GRAVEL, with patches of exposed Dolerite	Sandy GRAVEL over rock	Low			Ferricrete, Dolerite	Calcrete over Duricrusted Goethitic Conglomerate with Weeli Wolli BIF and Dolerite exposures. CID exposure in parts	Scattered to moderate grasses becoming scattered
22,480	22,550	Rising transition zone	10	15	0.5	South bank switching to north	40				Sandy GRAVEL, with patches of Cobbly GRAVEL	Sandy GRAVEL	High					Scattered to moderate grasses
22,550	22,730	Wedge	3	10	0.5	North bank	120				Sandy GRAVEL, areas of silt veneer	Sandy GRAVEL	High			Goethitic Conglomerate, Shale		Sparse grasses
22,730	22,765	Highly vegetated irregular	6	8	0.5	North bank	120				Cobbly Sandy GRAVEL, areas of silt veneer	Cobbly sandy GRAVEL	High					Dense grasses
22,765	22,840	Cobbly bowl	10	20	0.5	North bank switching to south	120				Sandy GRAVEL, trace cobbles, areas of silt veneer	Sandy GRAVEL	High					Scattered grasses becoming scattered to moderate
22,840	22,895	Undulating hollowed channel	8	12	0.5	South bank	120				Sandy GRAVEL, trace cobbles, areas of silt veneer	Sandy GRAVEL	High	Yes				Scattered live and dead trees
22,895	22,960	Highly vegetated irregular	8	12	0.5	South bank	120				Dolerite with surficial Cobbly GRAVEL, areas of silt veneer	Rock with surficial gravels	Low		Minor accretions	Dolerite		Moderate grasses
22,960	22,990	Broad and shallow flowing	8	12	0.5	Variable	120				Dolerite with surficial by Sandy GRAVEL, areas of silt veneer	Rock with surficial gravels	Low			Dolerite		Scattered grasses
22,990	23,055	Highly vegetated irregular	15	20	0.5	Undefined	120				Dolerite with surficial Bouldery cobbly GRAVEL, areas of silt veneer	Rock with surficial gravels	Low		Minor accretions	Dolerite		Moderate to dense grasses scattered large trees
23,055	23,100	Broad and shallow flowing	15	20	0.5	Mid channel	120				Dolerite with surficial Sandy GRAVEL, areas of silt veneer	Rock with surficial gravels	Low			Dolerite		Scattered grasses
23,100	23,150	Wedge	15	20	0.5	South bank	120				Dolerite with surficial Sandy GRAVEL, areas of silt veneer	Rock with surficial gravels	Low			Dolerite		Scattered grasses
23,150	23,170	Undulating hollowed channel	2	6	0.5	South bank	120				Dolerite with surficial Sandy GRAVEL, areas of silt veneer	Rock with surficial gravels	Low	Yes		Dolerite		Scattered grasses occasional large trees
23,170	23,290	Gentle bowl	2	6	0.5	South bank	120				Dolerite with surficial Sandy GRAVEL, areas of silt veneer	Rock with surficial gravels	Low			Dolerite		Scattered grasses
23,290	23,330	Wedge	4	6	0.5	South bank	110				Shale with surficial Sandy GRAVEL	Rock with surficial gravels	Low			Shale		Scattered grasses
23,330	23,350	Undulating hollowed channel	4	12	0.5	South bank	110				Shale with surficial Sandy GRAVEL	Rock with surficial gravels	Low	Yes		Shale		Scattered grasses
23,350	23,380	Broad and shallow flowing	20	30	0.5	Undefined	110				Sandy GRAVEL	Sandy GRAVEL	High					Scattered grasses
23,380	23,560	Cobbly bowl	8	12	0.5	South bank	110	North bank			Sandy GRAVEL, with bouldery patches and thick silt veneer	Sandy GRAVEL	High			Shaley BIF, Goethitic Conglomerate		Scattered grasses
23,560	23,625	Broad and shallow flowing	8	12	0.5	Mid channel	110	North bank			Sandy GRAVEL	Sandy GRAVEL	High					Moderate grasses
23,625	23,700	Gentle bowl	5	7	0.5	Mid channel	110	North and south bank			Sandy GRAVEL, areas of silt veneer	Sandy GRAVEL	High					Scattered grasses
23,700	23,780	Undulating hollowed channel	1	3	1	Secondary to north	110	North and south bank			Sandy GRAVEL	Sandy GRAVEL	High	Yes				Scattered large trees
23,780	23,840	Cobbly bowl	1	3	0.5	Undefined	90	North and south bank			Cobbly Sandy GRAVEL	Cobbly sandy GRAVEL	High					Scattered grasses
23,840	23,875	Gentle bowl	5	7	0.5	Undefined	90	North and south bank			Cobbly Sandy GRAVEL	Cobbly sandy GRAVEL	High					Scattered to moderate grasses, scattered large trees
23,875	23,885	Undulating hollowed channel	5	7	0.5	Undefined	100	North bank			Cobbly Sandy GRAVEL	Cobbly sandy GRAVEL	High	Yes				Scattered large trees
23,885	23,920	Gentle bowl	5	7	0.5	Undefined	100	North bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High		Minor accretions			Scattered grasses
23,920	24,530	Highly irregular rock and boulder channel	5	10	0.5	Undefined	120	North bank			BIF, Shale, Goethitic Conglomerate and Dolerite with surficial Cobbly Bouldery Sandy GRAVEL	Rock with surficial gravels	Low		Minor accretions	Jaspalitic BIF, Shale, Goethitic Conglomerate, Dolerite		Dense grasses becoming scattered then once again dense
24,530	24,740	Cobbly bowl	5	20	1	South bank switching to north	90	North bank			Cobbly Sandy GRAVEL, with patches of exposed Goethitic Conglomerate	Cobbly GRAVEL over rock	Low					Scattered grasses
24,740	24,800	Broad and shallow flowing	15	25	0.5	Undefined	90	North bank			Sandy GRAVEL, trace cobbles	Sandy GRAVEL	High					Scattered to moderate grasses large trees become scattered
24,800	24,880	Wedge	15	25	0.5	North bank	90	North bank			Sandy GRAVEL, trace cobbles, areas of silt veneer	Sandy GRAVEL	High			Calcrete, Dolerite		Scattered grasses
24,880	24,960	Broad and shallow flowing	30	40	0.5	South bank	90	Secondary Northward			Sandy GRAVEL, areas of silt veneer	Sandy GRAVEL	High					Dense grasses and scattered large trees
24,960	25,020	Gentle bowl	5	10	0.5	Mid channel	90				Sandy GRAVEL, areas of silt veneer with patches of exposed Dolerite	Sandy GRAVEL over rock	Low			Dolerite		Dense grasses occasional shrubs
25,020	25,045	Incoming drainage depositional zone	8	12	0.5	South bank	90				Sandy GRAVEL, trace cobbles areas of silt veneer	Sandy GRAVEL	High					Scattered grasses
25,045	25,075	Highly vegetated irregular	10	15	0.5	Undefined	90				Sandy GRAVEL, patches cobbly, with areas of silt veneer	Sandy GRAVEL	High					Dense grasses
25,075	25,165	Broad and shallow flowing	10	15	0.5	South bank	90				Sandy GRAVEL, patches bouldery, with areas of silt veneer	Sandy GRAVEL	High					Scattered to dense grasses and shrubs
25,165	25,285	Highly vegetated irregular	20	40	0.5	Undefined	90	North bank			Sandy GRAVEL, patches cobbly, with areas of silt veneer	Sandy GRAVEL	High					Dense grasses, large trees become present
25,285	25,305	Cobbly bowl	4	6	0.5	North bank	70				Cobbly GRAVEL with sand with areas of silt veneer	Sandy GRAVEL	High					Scattered grasses
25,305	25,370	Wedge	5	10	0.5	North bank switching to north	70				Sandy GRAVEL with areas of silt veneer	Sandy GRAVEL	High			Dolerite		Scattered grasses
25,370	25,465	Gentle bowl	5	15	0.5	Mid channel	55				Sandy GRAVEL, patches bouldery, with areas of silt veneer	Sandy GRAVEL	High					Scattered grasses
25,465	25,570	Highly vegetated irregular	15	25	0.2	Undefined	70	North bank			Bouldery Cobbly Sandy GRAVEL, with silt veneer	Bouldery cobbly sandy GRAVEL	High					Dense grasses, scattered large trees
25,570	25,590	Cobbly bowl	5	10	0.5	Mid channel	70	North bank			Bouldery Cobbly Sandy GRAVEL, with silt veneer	Bouldery cobbly sandy GRAVEL	High					Scattered grasses
25,590	25,615	Highly irregular rock and boulder channel	4	8	0.5	Mid channel	70	North bank			BIF with surficial Bouldery Cobbly Sandy GRAVEL, with silt veneer	Rock with surficial gravels	Low			BIF		Scattered grasses
25,615	25,675	Highly vegetated irregular	15	25	0.5	Undefined	70	North bank			Dolerite with surficial Bouldery Cobbly Sandy GRAVEL, with silt veneer	Rock with surficial gravels	Low			Dolerite		Moderate to dense grasses, scattered shrubs
25,675	25,770	Highly irregular rock and boulder channel	3	10	0.5	Mid channel	70	North bank			Bouldery Cobbly Sandy GRAVEL, with silt veneer, with patches of exposed Dolerite and BIF	Bouldery cobbly sandy GRAVEL over rock	Low			Dolerite, BIF		Scattered grasses and shrubs
25,770	25,870	Gentle bowl	2	20	0.5	Mid channel	60				Sandy GRAVEL, patches bouldery, areas of silt veneer, with patches of exposed BIF	Sandy GRAVEL over rock	Low			BIF		Scattered grasses
25,870	25,950	Braided zones	15	25	0.5	Undefined	40				Sandy Cobbly GRAVEL, trace boulders, with patches of exposed Dolerite	Sandy cobbly GRAVEL over rock	Low			Dolerite		Moderate grasses and shrubs
25,950	26,030	Undulating hollowed channel	10	20	0.5	Variable	40	North bank			Sandy GRAVEL with patches of exposed BIF, areas of silt veneer	Sandy GRAVEL over rock	Low	Yes		BIF		Scattered grasses and shrubs
26,030	26,070	Irregular flat	5	10	0.5	North and south banks	40	North bank			Sandy GRAVEL patches bouldery, with patches of exposed Dolerite, areas of silt veneer	Sandy GRAVEL over rock	Low					Scattered grasses and shrubs
26,070	26,150	Cobbly bowl	1	2	0.5	Mid channel	50	North bank			Sandy GRAVEL patches bouldery, with patches of exposed Dolerite, areas of silt veneer	Sandy GRAVEL over rock	Low			Calcrete, Dolerite		Scattered to moderate grasses and shrubs, scattered trees
26,150	26,210	Broad and shallow flowing	5	10	1	Undefined	45	North bank			Sandy GRAVEL patches bouldery, with patches of exposed BIF, areas of silt veneer	Sandy GRAVEL over rock	Low			BIF, Dolerite		Scattered grasses
26,210	26,390	Braided zones	10	25	0.5	Undefined	70	North bank			Sandy GRAVEL with areas of silt veneer	Sandy GRAVEL	High			Calcrete, Dolerite, BIF		Moderate grasses and trees
26,390	26,480	Incised transition zone	2	5	0.5	Mid channel	70	South bank			Sandy Cobbly GRAVEL with areas of silt veneer	Sandy cobbly GRAVEL	High					Scattered grasses and trees, reed patches
26,480	26,530	Highly irregular rock and boulder channel	3	10	0.5	North bank	70	South bank			Calcrete Conglomerate and BIF with surficial Sandy Cobbly GRAVEL	Rock with surficial gravels	Low			Calcrete, Dolerite, BIF		Sparse shrubs and reed patches, dense bush on bars
26,530	26,685	Swampy bowl with reed patches?	10	15	1	Mid channel	50	South bank			Sandy GRAVEL, with thick silt veneer	Sandy GRAVEL	High			BIF		Dense grasses, trees and reeds
26,685	26,720	Rising transition zone	15	25	0.5	Undefined	50				Sandy GRAVEL, trace cobbles, with patches of exposed BIF	Sandy GRAVEL over rock	Low			BIF		Scattered grasses
26,720	26,770	Trapezoidal	4	6	0.8	South bank	60	North bank			Cobbly GRAVEL with sand, with patches of exposed Calcareous Dolerite and BIF	Sandy GRAVEL	High			Calcareous Dolerite and BIF		Scattered grasses
26,770	26,935	Irregular flat	5	15	1	Variable	70	North bank			Calcareous BIF, BIF with surficial Cobbly Sandy GRAVEL	Rock with surficial gravels	Low					Scattered grasses and shrubs, patches of trees become present
26,935	27,180	Gentle bowl	2	4	0.5	South bank	90	Mid banks			Sandy GRAVEL patches bouldery with areas of silt veneer	Sandy GRAVEL	High					Moderate grasses, sparse large trees
27,180	27,230	Broad and shallow flowing	20	30	0.5	North bank	90	Mid banks			Sandy GRAVEL patches cobbly, with areas of silt veneer	Sandy GRAVEL	High					Dense grasses, occasional large trees
27,230	27,250	Highly vegetated irregular	20	30	0.5	North bank	80	Mid banks			Cobbly sandy GRAVEL, with areas of silt veneer	Cobbly sandy GRAVEL	High					Scattered to moderate grasses
27,250	27,330	Wedge	10	20	0.5	North bank	50	Mid banks			Sandy GRAVEL with cobbles, with areas of silt veneer	Sandy GRAVEL	High			BIF		Vegetation absent
27,330	27,560	Broad and shallow flowing	2	10	0.5	ndefined, switching to the north then to sou	50	North bank			Sandy GRAVEL, patches cobbly, with areas of silt veneer	Sandy GRAVEL	High			BIF, Calcrete, Calcrete soil		Scattered grasses and shrubs
27,560	27,605	Cobbly bowl	2	3	0.5	South bank	70	North bank			Cobbly sandy GRAVEL	Cobbly sandy GRAVEL	High					Scattered grasses and shrubs
27,605	27,700	Irregular flat	5	15	1	Secondary to north	70	North bank			Bouldery Cobbly Sandy GRAVEL with areas of silt veneer	Bouldery cobbly sandy GRAVEL	High	Yes				Moderate grasses, shrubs and large trees
27,700	27,775	Gentle bowl	8	12	0.5	North bank	80	South bank			Cobbly Sandy GRAVEL, trace boulders, with areas of silt veneer	Cobbly sandy GRAVEL	High					Scattered grasses and shrubs
27,775	27,860	Wedge	10	15	0.5	South bank switching to north	90	South bank			Sandy GRAVEL, trace cobbles, trace boulders, with areas of silt veneer	Sandy GRAVEL	High	Yes				Scattered grasses and large trees
27,860	27,890	Rising transition zone	10	15	0.5	North bank switching to south	100	South bank			Sandy GRAVEL, trace cobbles, trace boulders, with areas of silt veneer	Sandy GRAVEL	High					Scattered grasses
27,890	27,925	Irregular flat	5	10	0.5	South bank	100	South bank			CID? With surficial Sandy GRAVEL, areas of silt veneer	Rock with surficial gravels	Low			CID?		Scattered grasses
27,925	27,980	Gentle bowl	12	18	0.5	Undefined	90				Sandy GRAVEL, patches cobbly, areas of silt veneer	Sandy GRAVEL	High	Yes				Scattered reed patches and large trees
27,980	28,040	Irregular flat	15	20	0.5	North bank secondary channel on south	100				Sandy GRAVEL, trace cobbles, areas of silt veneer	Sandy GRAVEL	High			CID?		Scattered grasses, trees and large trees
28,040	28,120	Broad and shallow flowing	15	20	0.5	South bank	100				Sandy GRAVEL, trace cobbles, areas of silt veneer	Sandy GRAVEL	High					Scattered grasses and large trees, first appearance of Paperbark
28,120	28,155	Gentle bowl	8	12	1	Mid channel	100				Sandy GRAVEL, areas of silt veneer	Sandy GRAVEL	High					Scattered grasses, trees separate channels
28,155	28,790	Braided zones	30	50	0.5	Undefined (south bank)	50		North	Marillana Creek	Sandy GRAVEL, patches bouldery, large patches of exposed cemented gravels and BIF, areas of silt veneer	Sandy GRAVEL over rock	Low	Yes	Minor accretions	BIF, Calcrete		Moderate large trees, patches of dense shrubs and reeds
28,790	28,860	Rock bowl channels	5	15	1	Mid channel	60				BIF with surficial Cobbly GRAVEL, patches bouldery, areas of silt veneer	Rock with surficial gravels	Low		Minor accretions			Scattered shrubs
28,860	28,935	Cobbly bowl	5	15	1	Mid channel	60				Cobbly GRAVEL, with sand, patches bouldery	Cobbly GRAVEL	High					Scattered shrubs
28,935	28,970	Braided zones	30	60	0.5	Undefined	60		North	Minor	Cobbly GRAVEL, with sand, patches bouldery	Cobbly GRAVEL	High					Patches of dense reeds
28,970	29,280	Swampy bowl	5	15	1	Mid channel	70				Dolerite with surficial Sandy GRAVEL, and thick silt veneer	Rock with surficial gravels	Low			Dolerite		Patches of dense reeds, giving way to dense grasses, shrubs and trees
29,280	29,400	Irregular flat	3	8	0.5	North and south banks	70				Dolerite with surficial Sandy GRAVEL, with cobbles, areas of silt veneer	Rock with surficial gravels	Low			Calcrete, Dolerite		Dense grasses, moderate shrubs and trees
29,400	29,440	Gentle bowl	10	15	0.5	Secondary to north	60				Sandy GRAVEL with silt and cobbly patches	Sandy GRAVEL	High					Scattered grasses and reed patches, dense bush on braided bars
29,440	29,600	Irregular flat	10	15	0.5	Switching towards north	80	South bank	North	Minor	Sandy GRAVEL with silt and bouldery patches, with patches of exposed Cemented GRAVEL	Sandy GRAVEL over rock	Low		Minor accretions	Dolerite		Scattered trees
29,600	29,650	Cobbly bowl	5	10	0.5	Mid channel	90	South bank			Cobbly GRAVEL with sand, trace boulders	Cobbly GRAVEL	High					Scattered grasses and shrubs
29,650	29,880	Wedge	5	20	1	North bank, secondary on south	100	South bank			Sandy GRAVEL with cobbles and silt	Sandy GRAVEL	High			BIF, Calcrete		Dead patches of reeds, line of trees separating channels, small patch of dense grasses and shrubs
29,880	29,940	Undulating hollowed channel	10	20	0.5	Mid channel	100	South bank			Sandy GRAVEL trace cobbles and silt	Sandy GRAVEL	High	Yes				Scattered large trees

TABLE D-1 - WETTING FRONT DESIGN TABLE

Channel Chainage		Channel Physiology	Primary Channel Width		Primary Max Depth (m)	Low Flow Channel Location within Primary	Estimated max bank to bank distance	Secondary Channel Location	Entering drainage(s)		Dominant Creek Bed Material Description		Estimated Hydraulic Conductivity (High >10E^{-5}ms^{-1}, Moderate 10E^{-5} - 10E^{-6}ms^{-1}, Low <10E^{-6}ms^{-1})	Occurrence of Hollows	Calcite Precipitations	Rock Outcropping	Dominant Rock Unit	Vegetation Within Primary Channel
to (m)	from (m)		Min (m)	Max (m)					Entering from	Size	Material Description	Simplified Description						
29,940	30,110	Wedge	2	15	1	North bank	100	South bank			Sandy GRAVEL	Sandy GRAVEL	High		Possible minor accretions	CID?, BIF, Calcrete soil		Scattered grasses and reed patches
30,110	30,180	Undulating hollowed channel	2	5	0.5	North bank	90	South bank			Sandy GRAVEL, trace cobbles, areas of thick silt veneer	Sandy GRAVEL	High	Yes	Minor accretions			Moderate grasses and shrubs, scattered reed patches
30,180	30,200	Braided	10	20	0.5	Mid channel	100	South bank			Silty sandy GRAVEL	Silty sandy GRAVEL	Low					Dense grasses and shrubs
30,200	30,290	Swampy bowl	10	15	2	Secondary to south	90	South bank			Silty sandy GRAVEL, patches bouldery	Silty sandy GRAVEL	Low			Goethitic Conglomerate		Dense patches of reeds
30,290	30,350	Rock bowl channels	10	15	2	Secondary to south	100	South bank			Shale with surficial Sandy GRAVEL	Rock with surficial gravels	Low			Shale		Dense patches of reeds
30,350	30,550	Highly irregular rock and boulder channel	5	15	1.5	Variable	110	South bank			BIF with surficial Bouldery Cobbly Sandy GRAVEL	Rock with surficial gravels	Low			BIF, Dolerite		Dense patches of reeds become absent
30,550	30,590	Braided zones	35	45	0.5	Undefined	110	South bank			Silty cobbly sandy GRAVEL with boulders	Silty cobbly sandy GRAVEL	Moderate					Dense grasses, shrubs, and trees
30,590	30,680	Cobbly bowl	5	15	0.5	Mid channel	120	South bank			Sandy GRAVEL, trace silt with patches of boulders and cobbles	Sandy GRAVEL	High					Dense patches of reeds
30,680	30,800	Braided zones	35	45	0.5	Undefined	130	South bank			Silty GRAVEL	Silty GRAVEL	Moderate					Dense grasses, shrubs and trees
30,800	30,860	Cobbly bowl	5	10	1	Mid channel	130	South bank			Silty Sandy GRAVEL with bouldery patches	Silty sandy GRAVEL	Moderate			BIF		Dense reed patches and scattered grasses
30,860	30,890	Braided zones	25	30	0.5	Undefined	120	South bank			Silty Sandy GRAVEL with bouldery patches	Silty sandy GRAVEL	Moderate					Dense grasses, shrubs and trees
30,890	30,960	Highly irregular rock and boulder channel	25	30	0.5	Undefined	120				CID with surficial Sandy GRAVEL, areas of silt veneer	Rock with surficial gravels	Low		Minor accretions (joint infill)	CID		Moderate shrubs and trees
30,960	31,145	Gentle bowl	15	60	1.5	Mid channel	70		South	Moderate to major	Sandy GRAVEL and Sandy SILT	Sandy GRAVEL	High			CID		Scattered trees and patches of reeds
31,145	31,398	Braided zones	80	100	1	Undefined	170				CID with surficial Silty SAND and patches of Silty Sandy GRAVEL	Rock with surficial gravels			Minor accretions (joint infill)	CID		Live and dead large trees, and shrubs on braided bars

APPENDIX E

SUMMARY OF LABORATORY TEST RESULTS

TABLE E-1: SUMMARY OF LABORATORY TEST RESULTS

Sample ID (Ordered by centreline chainage)	Primary Channel Chainage	Channel type	Sample Depth		Field Saturated Hydraulic Conductivity (m/s)								Laboratory Hydraulic Conductivity (m/s)	Gravel Depth (m)	Composition (Dry)			Compaction Related		Calcium Carbonate Content (%)
					Test A		Test B		Test C		Test D				Percentage (%)					
			From (m)	To (m)	Head (cm)	Conductivity (m/s)	Head (cm)	Conductivity (m/s)	Head (cm)	Conductivity (m/s)	Head (cm)	Conductivity (m/s)			Gravel	Sand	Fines	MDD (t/m3)	OMC (%)	
S1-PM01	2,250	Highly vegetated irregular	0.05	0.25	14	5.36E-04	14	5.00E-04	5	8.44E-04	8	7.40E-04	7.44E-05	0.6	75	25	0	2.322	10.6	50.3
S4-PM01	2,725	Undulating Hollowed Channel	0.05	0.25	12	5.48E-04	9	6.69E-04					1.13E-04	0.7	76	24	0	2.42	11.0	
S9-PM01	4,165	Highly vegetated irregular	0.05	0.25	4	2.67E-04	5	3.62E-04					6.78E-05	1.2	70	26	4	2.60	8.0	
S2-PM01	8,100	Highly vegetated irregular	0.05	0.25	14	3.81E-04	14	4.45E-04	8	4.60E-04			4.91E-05	3.6	63	37	2	2.51	6.5	
S2-PM02	8,150	Wedge	0.05	0.25	Not obtainable, permeability exceeded permeameter capabilities								2.56E-05	1.2	81	17	2	2.59	8.5	
S6-PM01	10,090	Wedge	0.05	0.25	7	1.04E-05							4.51E-05	0.4	66	30	4	2.66	9.5	
S7-PM01	13,660	Broad and shallow flowing	0.05	0.25	7	6.76E-04	10	6.48E-04					3.43E-05	0.9	82	18	0	2.25	10.0	
S3-PM01	17,840	Highly vegetated irregular	0.05	0.25	8	6.76E-04	8	6.12E-04					5.41E-05	1.2	74	26	0	2.57	9.0	
S5-PM01	26,030	Irregular flat	0.05	0.25	7	4.97E-04	5	5.38E-04					6.11E-05	0.9	69	31	0	2.33	7.5	
S5-PM02	26,030	Irregular flat (low flow)	0.05	0.25	8	1.48E-05	5	2.19E-05					3.92E-05	0.25	71	27	2	2.60	8.0	59

APPENDIX F
FIELD PERMEABILITY RESULTS

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**	9/07/2019	
Project Number	045500				**Tested By**	MAS/VBJ	
Project	Marillana Creek Infiltration				**Checked By**	IHL	
Site Location	Yandi				**Test ID Number**	S1-PM01	
Test Location	Easting	682680	Northing	7475704	RL	NA	

Subsurface Profile

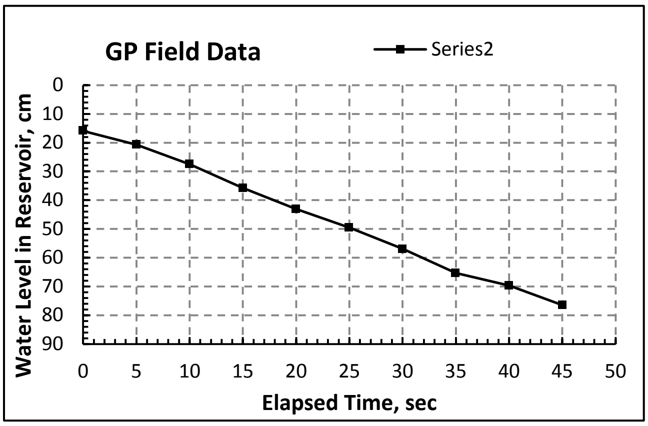
Depth	Description
0 - 0.10 m	Sandy GRAVEL, trace silt; orangish brown, loose to medium
	dense, dry, well graded; gravel, fine to coarse, rounded to
	sub angular; sand, fine to coarse
	Test conducted in the middle of a trapazoidal primary
	channel, moderately spaced grasses and slight riffling.

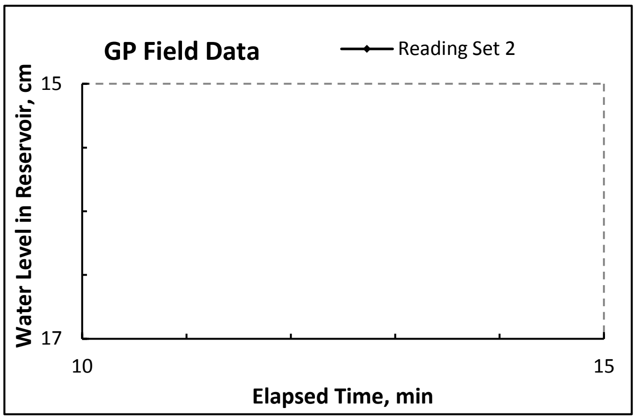
Soil Type	α*	C1	C2
4	0.36	1.597	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.1	m
Well water height - Set 1	H_1	14	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	15.9	0	0					
5	0.083	20.7	4.8	57.6					
10	0.083	27.5	6.8	81.6					
15	0.083	35.8	8.3	99.6					
20	0.083	43.1	7.3	87.6					
25	0.083	49.5	6.4	76.8					
30	0.083	56.9	7.4	88.8					
35	0.083	65.3	8.4	100.8					
40	0.083	69.7	4.4	52.8					
45	0.083	76.5	6.8	81.6					
Steady Rate for 3 readings R_1 (cm/min)				86.9	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity | K_{fs} = **5.36E-02** cm/s **OR** **5.36E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**	9/07/2019	
Project Number	045500				**Tested By**	MAS/VBJ	
Project	Marillana Creek Infiltration				**Checked By**	IHL	
Site Location	Yandi				**Test ID Number**	S1-PM01A	
Test Location	Easting	682680	Northing	7475704	RL	NA	

Subsurface Profile

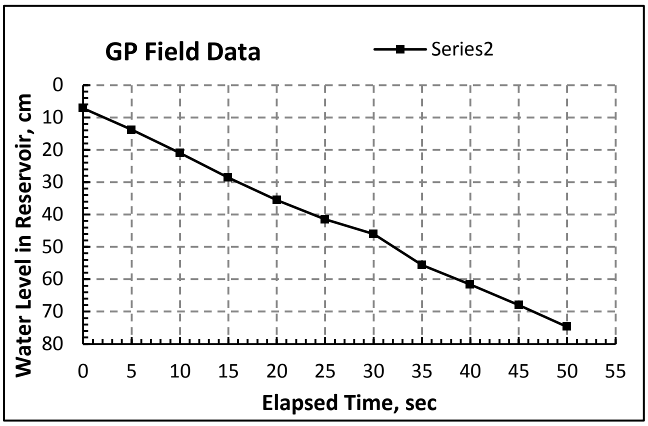
Depth	Description
0 - 0.10 m	Sandy GRAVEL, trace silt; orangish brown, loose to medium
	dense, dry, well graded; gravel, fine to coarse, rounded to
	sub angular; sand, fine to coarse.
	Test conducted in the middle of a trapazoidal primary
	channel, moderately spaced grasses and slight riffling.

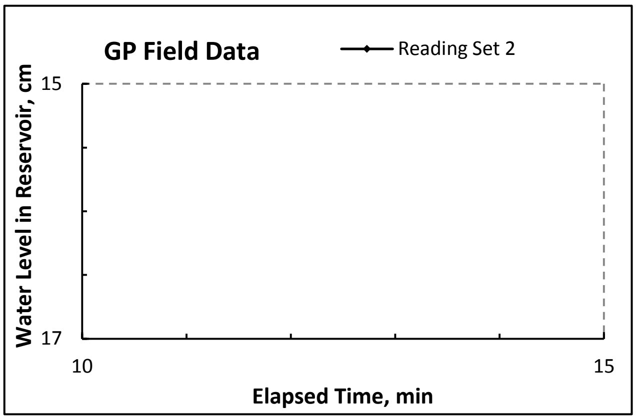
Soil Type	α*	C1	C2
4	0.36	1.597	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.1	m
Well water height - Set 1	H_1	14	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	7.1	0	0					
5	0.083	13.8	6.7	80.4					
10	0.083	21	7.2	86.4					
15	0.083	28.6	7.6	91.2					
20	0.083	35.5	6.9	82.8					
25	0.083	41.5	6	72					
30	0.083	46	4.5	54					
35	0.083	55.6	9.6	115.2					
40	0.083	61.6	6	72					
45	0.083	68	6.4	76.8					
50	0.083	74.7	6.7	80.4					
Steady Rate for 3 readings R_1 (cm/min)				81.12	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **5.00E-02** cm/s OR **5.00E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**	9/07/2019	
Project Number	045500				**Tested By**	MAS/VBJ	
Project	Marillana Creek Infiltration				**Checked By**	IHL	
Site Location	Yandi				**Test ID Number**	S1-PM01B	
Test Location	Easting	682680	Northing	7475704	RL	NA	

Subsurface Profile

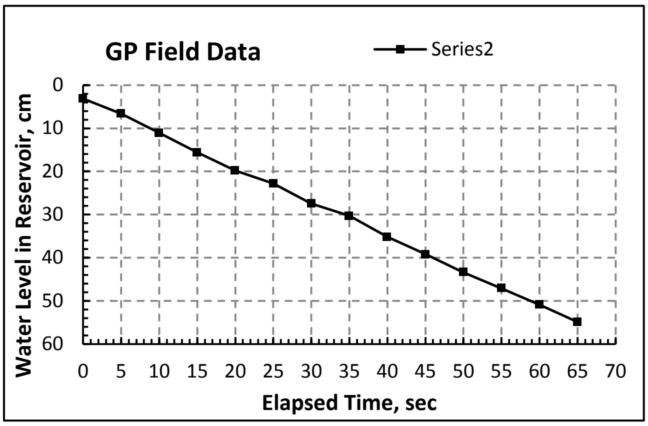
Depth	Description
0 - 0.10 m	Sandy GRAVEL, trace silt; orangish brown, loose to medium
	dense, dry, well graded; gravel, fine to coarse, rounded to
	sub angular; sand, fine to coarse.
	Test conducted in the middle of a trapazoidal primary
	channel, moderately spaced grasses and slight riffling.

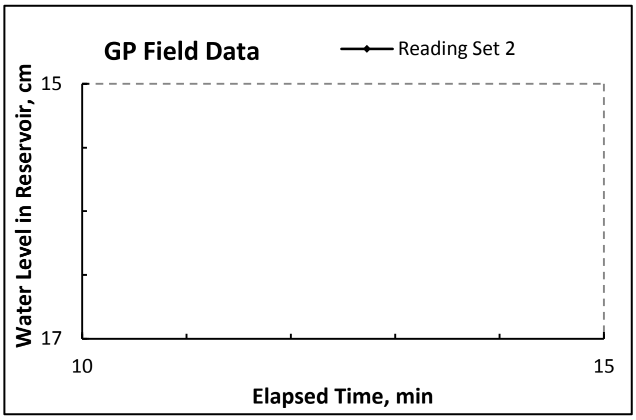
Soil Type	α^*	C1	C2
4	0.36	0.803	0

GP Field Data

Type of Reservoir used	Inner		**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3 cm	**Depth of Well hole**	d	0.05	m
Well water height - Set 1	H_1	5 cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	3.1	0	0					
5	0.083	6.6	3.5	42					
10	0.083	11.1	4.5	54					
15	0.083	15.6	4.5	54					
20	0.083	19.8	4.2	50.4					
25	0.083	22.8	3	36					
30	0.083	27.5	4.7	56.4					
35	0.083	30.3	2.8	33.6					
40	0.083	35.2	4.9	58.8					
45	0.083	39.2	4	48					
50	0.083	43.4	4.2	50.4					
55	0.083	47.1	3.7	44.4					
60	0.083	50.9	3.8	45.6					
65	0.083	54.9	4	48					
Steady Rate for 3 readings R_1 (cm/min)				47.8153846	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **8.44E-02** cm/s OR **8.44E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**	9/07/2019
Project Number	045500				**Tested By**	MAS/VBJ
Project	Marillana Creek Infiltration Project				**Checked By**	IHL
Site Location	Yandi				**Test ID Number**	S1-PM01C
Test Location	Easting	682680	Northing	7475704	RL	NA

Subsurface Profile

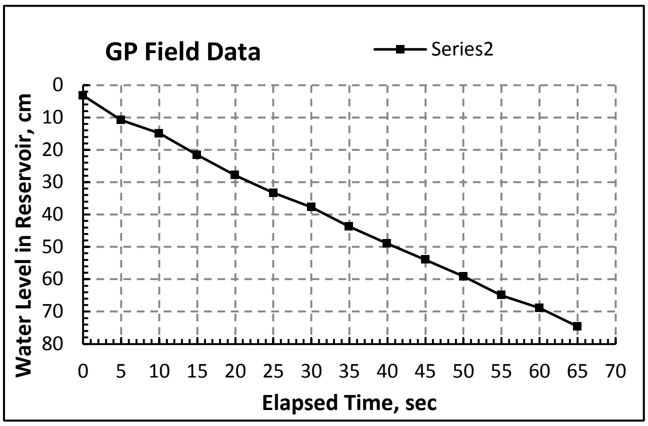
Depth	Description
0 - 0.10 m	Sandy GRAVEL, trace silt; orangish brown, loose to medium
	dense, dry, well graded; gravel, fine to coarse, rounded to
	sub angular; sand, fine to coarse.
	Test conducted in the middle of a trapazoidal primary
	channel, moderately spaced grasses and slight riffling.

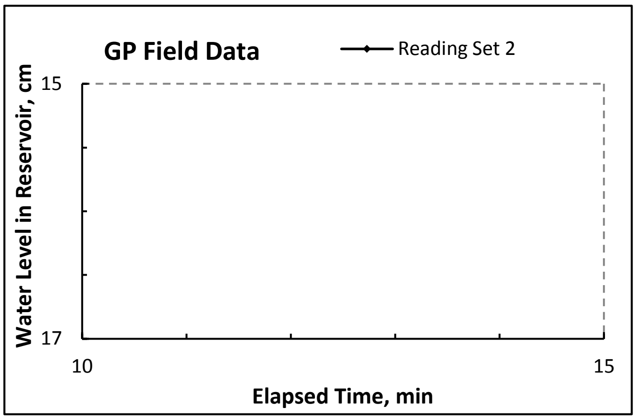
Soil Type	α*	C1	C2
4	0.36	1.11	0

GP Field Data

Type of Reservoir used	Inner		**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3 cm	**Depth of Well hole**	d	0.1	m
Well water height - Set 1	H_1	8 cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	3.2	0	0					
5	0.083	10.8	7.6	91.2					
10	0.083	14.9	4.1	49.2					
15	0.083	21.6	6.7	80.4					
20	0.083	27.9	6.3	75.6					
25	0.083	33.3	5.4	64.8					
30	0.083	37.7	4.4	52.8					
35	0.083	43.7	6	72					
40	0.083	49	5.3	63.6					
45	0.083	54	5	60					
50	0.083	59.1	5.1	61.2					
55	0.083	65	5.9	70.8					
60	0.083	68.9	3.9	46.8					
65	0.083	74.6	5.7	68.4					
Steady Rate for 3 readings R_1 (cm/min)				61.92	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **7.04E-02** cm/s **OR** **7.04E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**	6/07/2019	
Project Number	045500				**Tested By**	MAS	
Project	Marillna Creek Infiltration GBI				**Checked By**	IHL	
Site Location	S2				**Test ID Number**	S2-PM01	
Test Location	Easting	685007	Northing	7480216	RL	NA	

Subsurface Profile

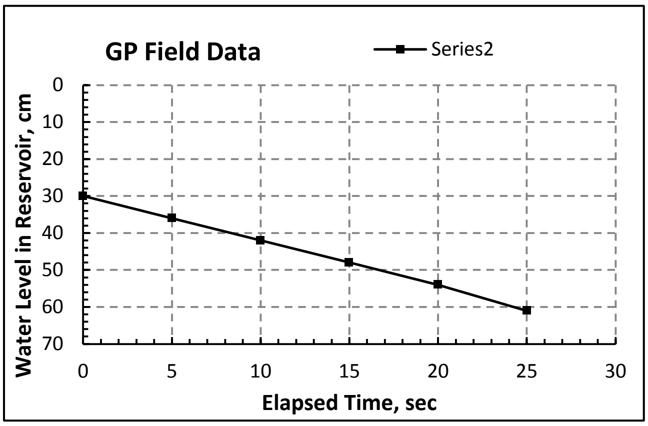
Depth	Description
0 - 0.25 m	GRAVEL with sand, trace silt
	Fine to coarse gravels
	Rounded to sub angular gravels
	Red Brown, dry, loose to medium dense.
	Test conducted in low flow of a riffled channel

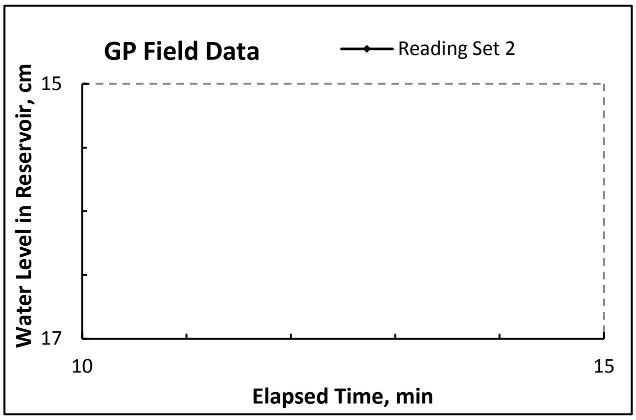
Soil Type	α*	C1	C2
4	0.36	1.386	0

GP Field Data

Type of Reservoir used	Inner		**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3.75 cm	**Depth of Well hole**	d	0.075	m
Well water height - Set 1	H_1	14 cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0	30	0	0					
5	0.083	36	6	72.3					
10	0.083	42	6	72.3					
15	0.083	48	6	72.3					
20	0.083	54	6	72.3					
25	0.083	61	7	84.3					
Steady Rate for 3 readings R_1 (cm/min)				72	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **3.81E-02** cm/s OR **3.81E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**	6/07/2019	
Project Number	045500				**Tested By**	MAS	
Project	Marillna Creek Infiltration GBI				**Checked By**	IHL	
Site Location	Yandi				**Test ID Number**	S2-PM01A	
Test Location	Easting	685007	Northing	7480216	RL	NA	

Subsurface Profile

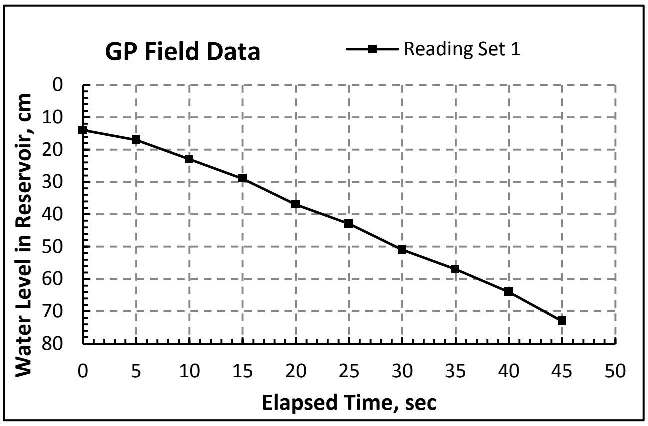
Depth	Description
0 - 0.25 m	GRAVEL with sand, trace silt
	Fine to coarse gravels
	Rounded to sub angular gravels
	Red Brown, dry, loose to medium dense.
Site Description	*Test conducted in low flow of a riffled channel (test not* videoed).

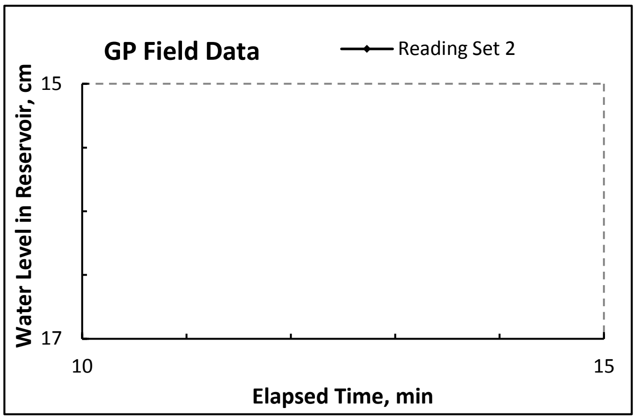
Soil Type	α^*	C1	C2
4	0.36	1.386	0

GP Field Data

Type of Reservoir used	Inner		**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3.75 cm	**Depth of Well hole**	d	0.075	m
Well water height - Set 1	H_1	14 cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0	14	0	0					
5	0.083	17	3	36					
10	0.083	23	6	72					
15	0.083	29	6	72					
20	0.083	37	8	96					
25	0.083	43	6	72					
30	0.083	51	8	96					
35	0.083	57	6	72					
40	0.083	64	7	84					
45	0.083	73	9	108					
Steady Rate for 3 readings R_1 (cm/min)				84	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **4.45E-02** cm/s OR **4.45E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**	6/07/2019	
Project Number	045500				**Tested By**	MAS	
Project	Marillna Creek Infiltration GBI				**Checked By**	IHL	
Site Location	Yandi				**Test ID Number**	S2-PM01B	
Test Location	Easting	685007	Northing	7480216	RL	NA	

Subsurface Profile

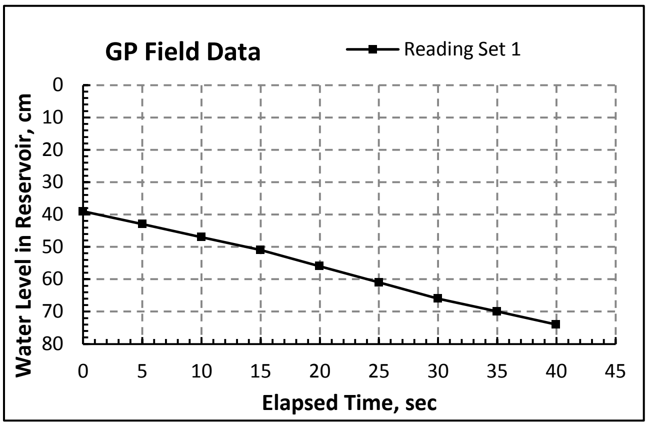
Depth	Description
0 - 0.25 m	GRAVEL with sand, trace silt
	Fine to coarse gravels
	Rounded to sub angular gravels
	Red Brown, dry, loose to medium dense.
Site Description	*Test conducted in low flow of a riffled channel*

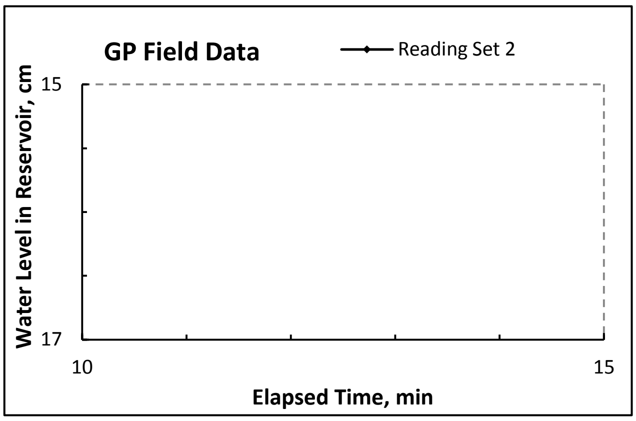
Soil Type	α*	C1	C2
4	0.36	0.954	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3.75	cm	**Depth of Well hole**	d	0.05	m
Well water height - Set 1	H_1	8	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0	39	0	0					
5	0.083	43	4	48					
10	0.083	47	4	48					
15	0.083	51	4	48					
20	0.083	56	5	60					
25	0.083	61	5	60					
30	0.083	66	5	60					
35	0.083	70	4	48					
40	0.083	74	4	48					
Steady Rate for 3 readings R_1 (cm/min)				48	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **4.60E-02** cm/s **OR** **4.60E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP					**Test Date**	6/07/2019
Project Number	045500					**Tested By**	MAS/VBJ
Project	Marillana Creek Infiltration Project					**Checked By**	IHL
Site Location	Yandi					**Test ID Number**	S2-PM02
Test Location	Easting	685000	Northing	7480266	RL	NA	

Subsurface Profile

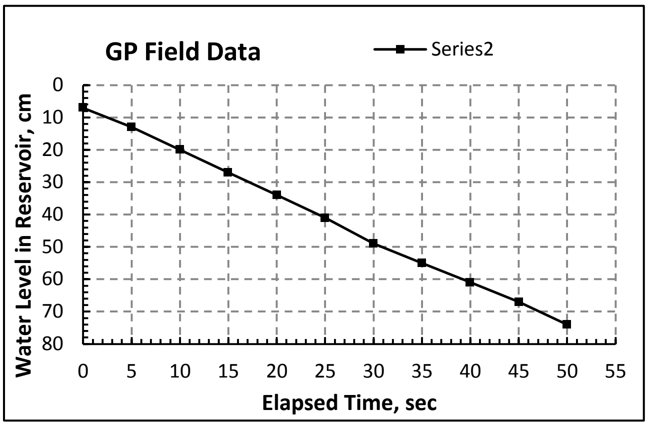
Depth	Description
0 - 0.05 m	Silt veneer
0.05 - 0.1 m	Sandy GRAVEL, trace silt; orangey brown, loose, dry;
	well graded, gravel, fine to coarse, rounded to sub
	angular; sand, fine to coarse.
Site Description	*Test conducted in the low flow seperated from primary by*
	gravel bar, localised silt veneer.

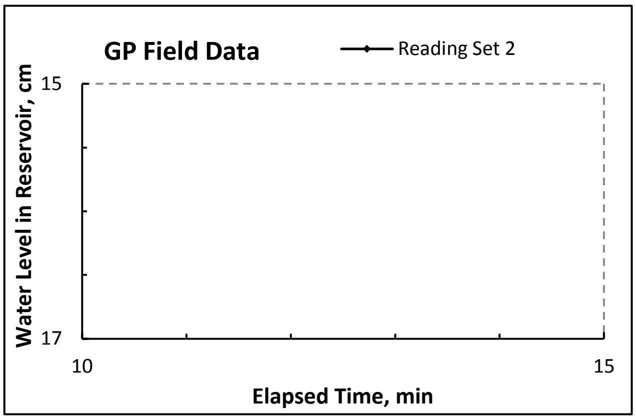
Soil Type	α^*	C1	C2
4	0.36	2.246	0

GP Field Data

Type of Reservoir used	Inner		**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3 cm	**Depth of Well hole**	d	0.01	m
Well water height - Set 1	H_1	25 cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0	7	0	0					
5	0.083	13	6	72					
10	0.083	20	7	84					
15	0.083	27	7	84					
20	0.083	34	7	84					
25	0.083	41	7	84					
30	0.083	49	8	96					
35	0.083	55	6	72					
40	0.083	61	6	72					
45	0.083	67	6	72					
50	0.083	74	7	84					
Steady Rate for 3 readings R_1 (cm/min)				84	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **2.50E-02** cm/s OR **2.50E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**	7/07/2019	
Project Number	045500				**Tested By**	MAS/VBJ	
Project	Marillana Creek Infiltration				**Checked By**	IHL	
Site Location	Yandi				**Test ID Number**	S3-PM01	
Test Location	Easting	691535	Northing	7484604	RL	NA	

Subsurface Profile

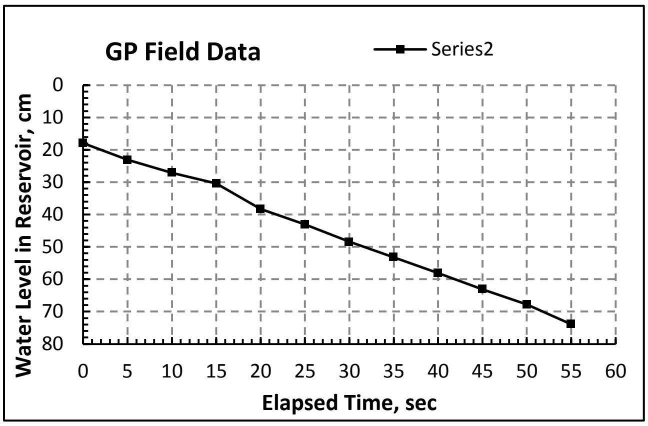
Depth	Description
0 - 0.10 m	Sandy GRAVEL, with cobbles; red to brown, loose to
	medium dense, well graded; dry; gravel, fine to coarse,
	rounded to subangular; sand fine to coarse; cobbles 6%.
	Test conducted in low flow channel of wedge, base is riffled
	with scattered trees and grasses

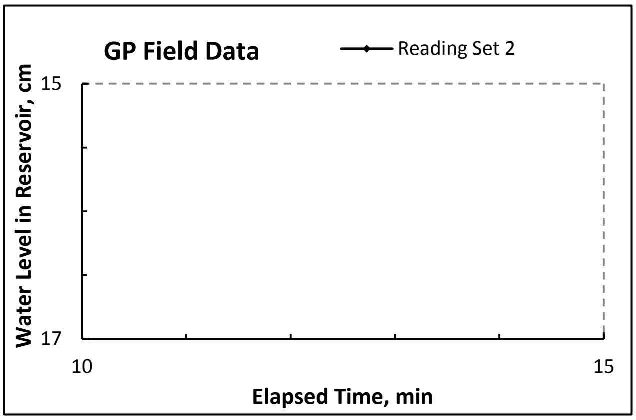
Soil Type	α*	C1	C2
4	0.36	1.11	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.1	m
Well water height - Set 1	H_1	8	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	17.9	0	0					
5	0.083	23.1	5.2	62.4					
10	0.083	27.1	4	48					
15	0.083	30.4	3.3	39.6					
20	0.083	38.3	7.9	94.8					
25	0.083	43.1	4.8	57.6					
30	0.083	48.4	5.3	63.6					
35	0.083	53.2	4.8	57.6					
40	0.083	58.1	4.9	58.8					
45	0.083	63.1	5	60					
50	0.083	67.8	4.7	56.4					
55	0.083	73.9	6.1	73.2					
Steady Rate for 3 readings R_1 (cm/min)				59.5	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **6.76E-02** cm/s **OR** **6.76E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**		7/07/2019
Project Number	045500				**Tested By**		MAS/VBJ
Project	Marillana Creek Infiltration				**Checked By**		IHL
Site Location	Yandi				**Test ID Number**		S3-PM01A
Test Location	Easting	691535	Northing	7484604	RL	NA	

Subsurface Profile

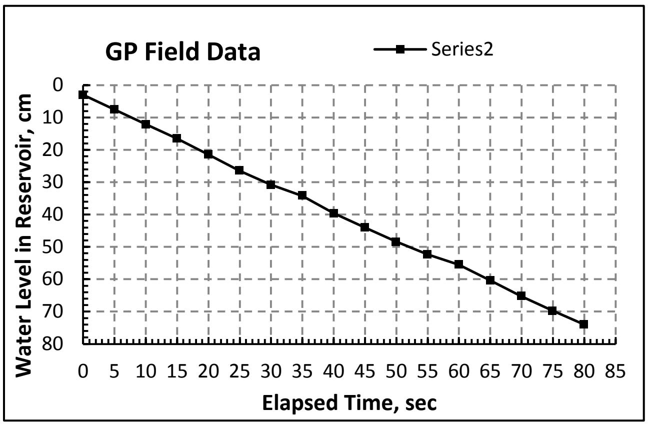
Depth	Description
0 - 0.10 m	Sandy GRAVEL, with cobbles; red - brown, loose to
	medium dense, well graded; dry; gravel, fine to coarse,
	rounded to subangular; sand fine to coarse; cobbles 6%
	Test conducted in low flow channel of wedge, base is riffled
	with scattered trees and grasses

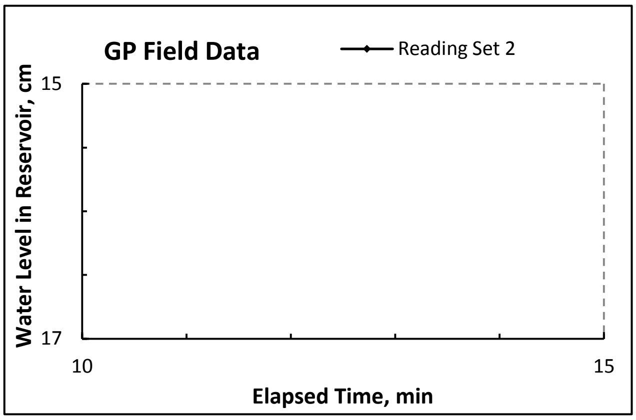
Soil Type	α^*	C1	C2
4	0.36	1.11	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.12	m
Well water height - Set 1	H_1	8	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	3	0	0					
5	0.083	7.5	4.5	54					
10	0.083	12.1	4.6	55.2					
15	0.083	16.5	4.4	52.8					
20	0.083	21.5	5	60					
25	0.083	26.5	5	60					
30	0.083	30.8	4.3	51.6					
35	0.083	34.2	3.4	40.8					
40	0.083	39.6	5.4	64.8					
45	0.083	44	4.4	52.8					
50	0.083	48.4	4.4	52.8					
55	0.083	52.3	3.9	46.8					
60	0.083	55.5	3.2	38.4					
65	0.083	60.4	4.9	58.8					
70	0.083	65.3	4.9	58.8					
75	0.083	69.8	4.5	54					
80	0.083	74	4.2	50.4					
Steady Rate for 3 readings R_1 (cm/min)				53.8	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **6.12E-02** cm/s OR **6.12E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP					**Test Date**	8/07/2019
Project Number	045500					**Tested By**	MAS/VBJ
Project	Marillana Creek Infiltration					**Checked By**	IHL
Site Location	Yandi					**Test ID Number**	S4-PM01
Test Location	Easting	683098	Northing	7475839	RL	NA	

Subsurface Profile

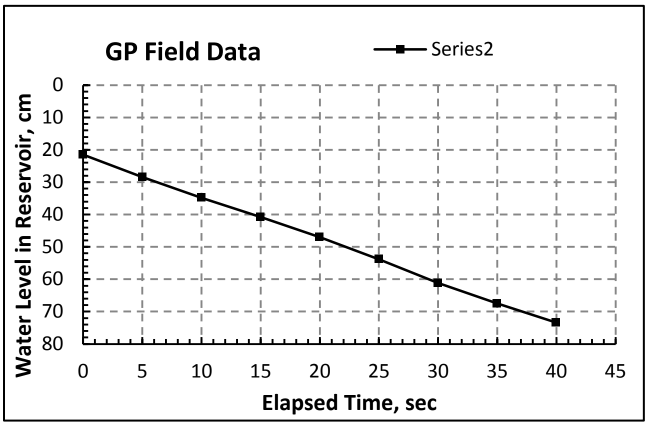
Depth	Description
0 - 0.10 m	Sandy GRAVEL, trace silt; reddish brown, loose to medium
	dense, dry, well graded; gravel, fine to coarse, rounded to
	sub angular; sand, fine to coarse
Site Description	*Test conducted irregular riffled trapazoidal channel*

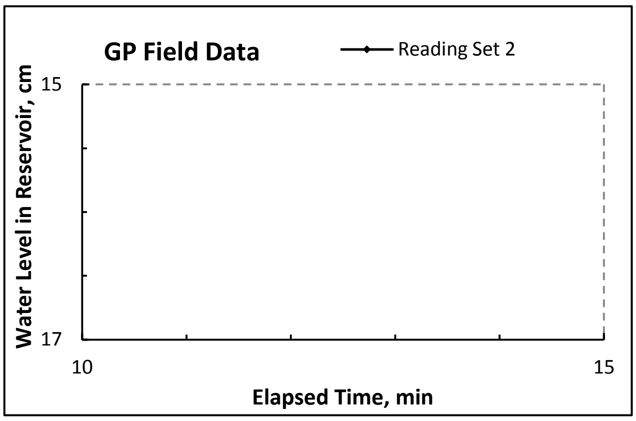
Soil Type	α*	C1	C2
4	0.36	1.449	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.1	m
Well water height - Set 1	H_1	12	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	21.5	0	0					
5	0.083	28.4	6.9	82.8					
10	0.083	34.8	6.4	76.8					
15	0.083	40.8	6	72					
20	0.083	47	6.2	74.4					
25	0.083	53.8	6.8	81.6					
30	0.083	61.2	7.4	88.8					
35	0.083	67.5	6.3	75.6					
40	0.083	73.4	5.9	70.8					
Steady Rate for 3 readings R_1 (cm/min)				74.4	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **5.48E-02** cm/s **OR** **5.48E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**		8/07/2019	
Project Number	045500				**Tested By**		MAS/VBJ	
Project	Marillana Creek Infiltration				**Checked By**		IHL	
Site Location	Yandi				**Test ID Number**		S4-PM01A	
Test Location	Easting	683098	Northing	7475839	RL	NA		

Subsurface Profile

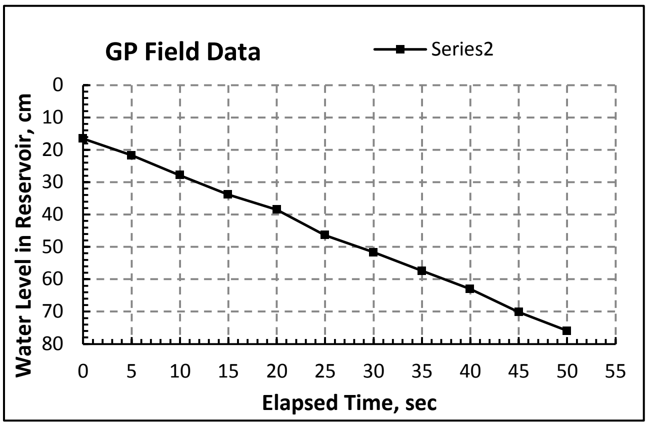
Depth	**Description**
0 - 0.10 m	Sandy GRAVEL, trace silt; reddish brown, loose to medium
	dense, dry, well graded; gravel, fine to coarse, rounded to
	sub angular; sand, fine to coarse
Site Description	*Test conducted irregular riffled trapazoidal channel*

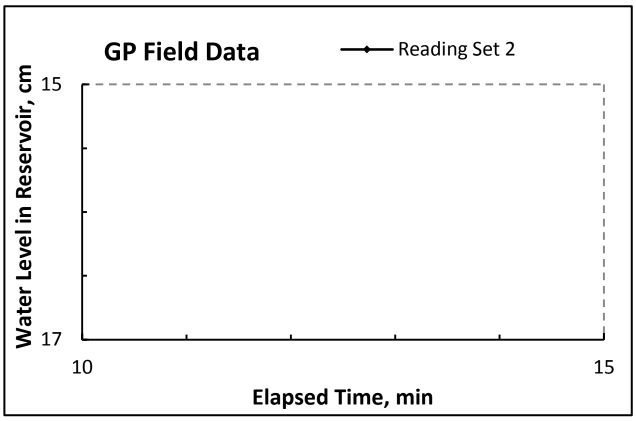
Soil Type	α*	C1	C2
4	0.36	1.201	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.1	m
Well water height - Set 1	H_1	9	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	16.5	0	0					
5	0.083	21.7	5.2	62.4					
10	0.083	27.9	6.2	74.4					
15	0.083	33.9	6	72					
20	0.083	38.5	4.6	55.2					
25	0.083	46.4	7.9	94.8					
30	0.083	51.7	5.3	63.6					
35	0.083	57.4	5.7	68.4					
40	0.083	63	5.6	67.2					
45	0.083	70.2	7.2	86.4					
50	0.083	75.9	5.7	68.4					
Steady Rate for 3 readings R_1 (cm/min)				66.4	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **6.69E-02** cm/s **OR** **6.69E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP					**Test Date**	10/07/2019
Project Number	045500					**Tested By**	MAS/VBJ
Project	Marillana Creek Infiltration					**Checked By**	IHL
Site Location	Yandi					**Test ID Number**	S5-PM01
Test Location	Easting	697291	Northing	7485802	RL	NA	

Subsurface Profile

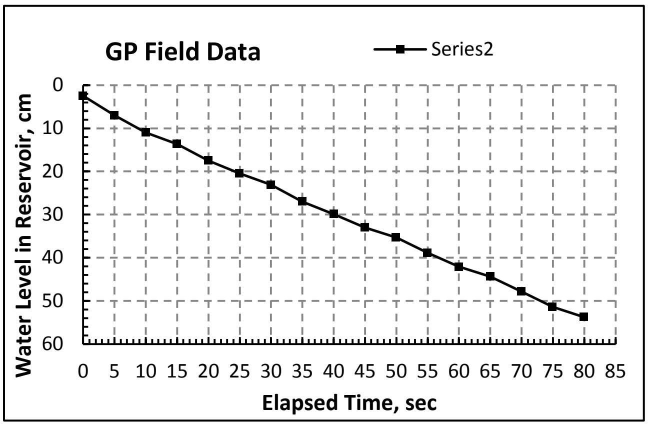
Depth	Description
0 - 0.10 m	Sandy GRAVEL, trace silt; orangish brown, loose, dry,
	well graded; gravel, fine to coarse, rounded to sub angular;
	sand, fine to coarse
	Test in broad uniform primary channel, central gravel bar
	seperates primary from low flow channel on the southern
	bank

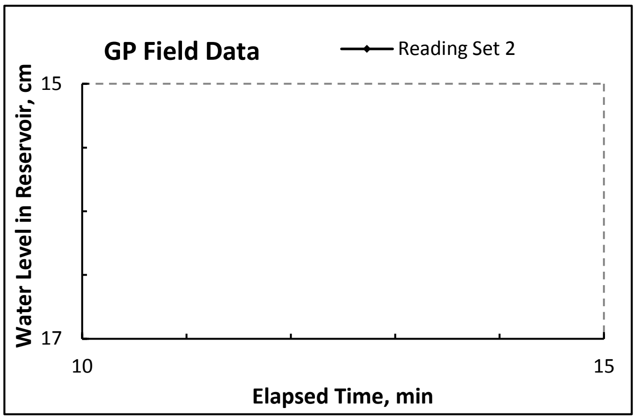
Soil Type	α*	C1	C2
4	0.36	1.014	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.75	m
Well water height - Set 1	H_1	7	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	2.5	0	0					
5	0.083	7	4.5	54					
10	0.083	11	4	48					
15	0.083	13.7	2.7	32.4					
20	0.083	17.5	3.8	45.6					
25	0.083	20.5	3	36					
30	0.083	23.1	2.6	31.2					
35	0.083	27	3.9	46.8					
40	0.083	29.9	2.9	34.8					
45	0.083	33	3.1	37.2					
50	0.083	35.3	2.3	27.6					
55	0.083	38.9	3.6	43.2					
60	0.083	42.1	3.2	38.4					
65	0.083	44.4	2.3	27.6					
70	0.083	47.9	3.5	42					
75	0.083	51.4	3.5	42					
80	0.083	53.8	2.4	28.8					
Steady Rate for 3 readings R_1 (cm/min)				38.3	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **4.97E-02** cm/s **OR** **4.97E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**		10/07/2019	
Project Number	045500				**Tested By**		MAS/VBJ	
Project	Marillana Creek Infiltration				**Checked By**		IHL	
Site Location	Yandi				**Test ID Number**		S5-PM01A	
Test Location	Easting	697291	Northing	7485802	RL	NA		

Subsurface Profile

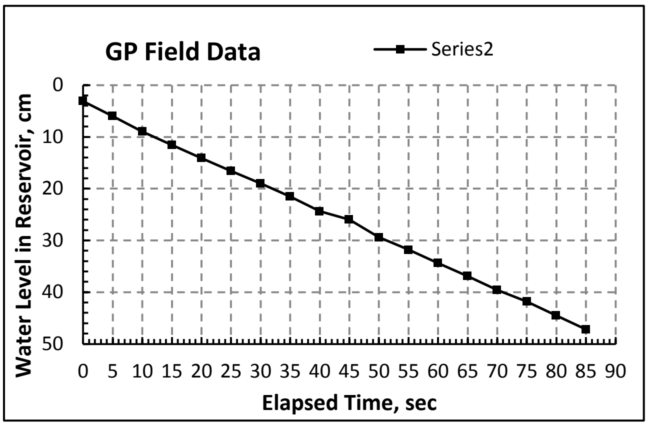
Depth	Description
0 - 0.10 m	Sandy GRAVEL, trace silt; orangish brown, loose, dry,
	well graded; gravel, fine to coarse, rounded to sub angular;
	sand, fine to coarse
	Test in broad uniform primary channel, central gravel bar
	seperates primary from low flow channel on the southern
	bank

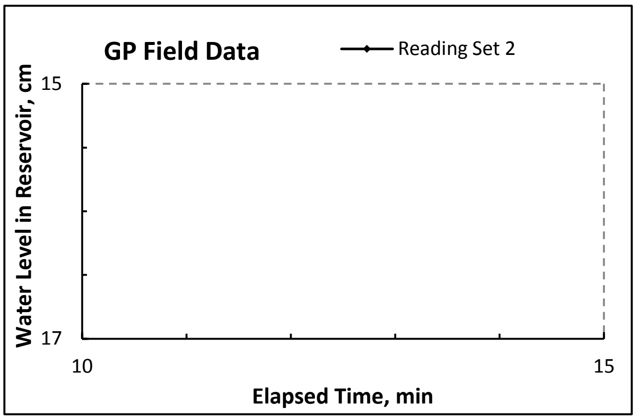
Soil Type	α*	C1	C2
4	0.36	0.803	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.75	m
Well water height - Set 1	H_1	5	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	3.1	0	0					
5	0.083	6	2.9	34.8					
10	0.083	9	3	36					
15	0.083	11.6	2.6	31.2					
20	0.083	14.1	2.5	30					
25	0.083	16.6	2.5	30					
30	0.083	19	2.4	28.8					
35	0.083	21.5	2.5	30					
40	0.083	24.4	2.9	34.8					
45	0.083	26	1.6	19.2					
50	0.083	29.4	3.4	40.8					
55	0.083	31.8	2.4	28.8					
60	0.083	34.4	2.6	31.2					
65	0.083	36.9	2.5	30					
70	0.083	39.6	2.7	32.4					
75	0.083	41.8	2.2	26.4					
80	0.083	44.5	2.7	32.4					
85	0.083	47.2	2.7	32.4					
Steady Rate for 3 readings R_1 (cm/min)				30.5	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **5.38E-02** cm/s **OR** **5.38E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**	10/07/2019	
Project Number	045500				**Tested By**	MAS/VBJ	
Project	Marillana Creek Infiltration				**Checked By**	IHL	
Site Location	Yandi				**Test ID Number**	S5-PM02	
Test Location	Easting	697290	Northing	7485774	RL	NA	

Subsurface Profile

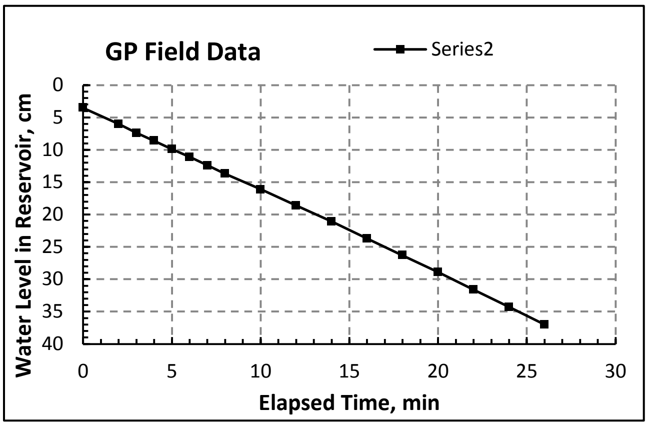
Depth	Description
0 - 0.05 m	Silt veneer
0.05 - 0.1 m	Silty sandy GRAVEL; orangey brown, loose, dry, well graded;
	gravel, fine to medium with minor coarse, rounded to sub
	angular; sand, fine to coarse; fines low to non plastic.
Site Description	*Test conducted in the low flow seperated from primary by*
	gravel bar, localized silt veneer.

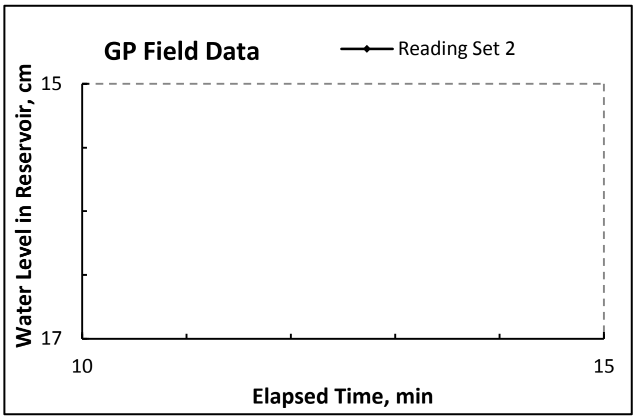
Soil Type	α*	C1	C2
4	0.36	1.11	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.1	m
Well water height - Set 1	H_1	8	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0	3.5	0	0					
2	2	6	2.5	1.25					
3	1	7.4	1.4	1.4					
4	1	8.6	1.2	1.2					
5	1	9.9	1.3	1.3					
6	1	11.1	1.2	1.2					
7	1	12.4	1.3	1.3					
8	1	13.7	1.3	1.3					
10	2	16.1	2.4	1.2					
12	2	18.6	2.5	1.25					
14	2	21.1	2.5	1.25					
16	2	23.7	2.6	1.3					
18	2	26.3	2.6	1.3					
20	2	28.9	2.6	1.3					
22	2	31.6	2.7	1.35					
24	2	34.3	2.7	1.35					
26	2	37	2.7	1.35					
Steady Rate for 3 readings R_1 (cm/min)				1.3	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **1.48E-03** cm/s OR **1.48E-05** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP					**Test Date**	10/07/2019
Project Number	045500					**Tested By**	MAS/VBJ
Project	Marillana Creek Infiltration					**Checked By**	IHL
Site Location	Yandi					**Test ID Number**	S5-PM02A
Test Location	Easting	697290	Northing	7485774		RL	NA

Subsurface Profile

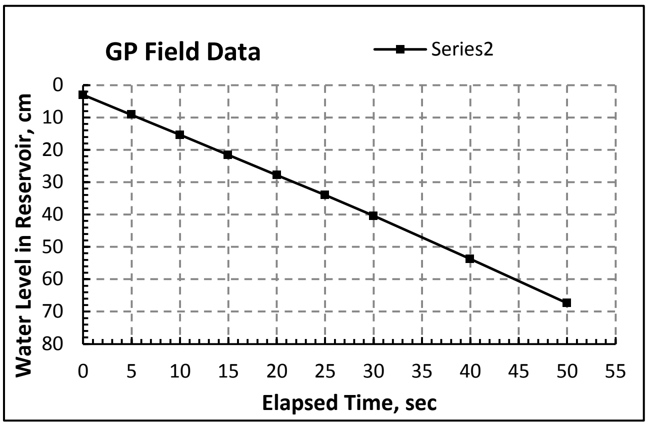
Depth	Description
0 - 0.05 m	Silt veneer
0.05 - 0.1 m	Silty sandy GRAVEL; orangey brown, loose, dry, well graded;
	gravel, fine to medium with minor coarse, rounded to sub
	angular; sand, fine to coarse; fines low to non plastic.
Site Description	*Test conducted in the low flow seperated from primary by*
	gravel bar, localized silt veneer. Minor calc precipatation

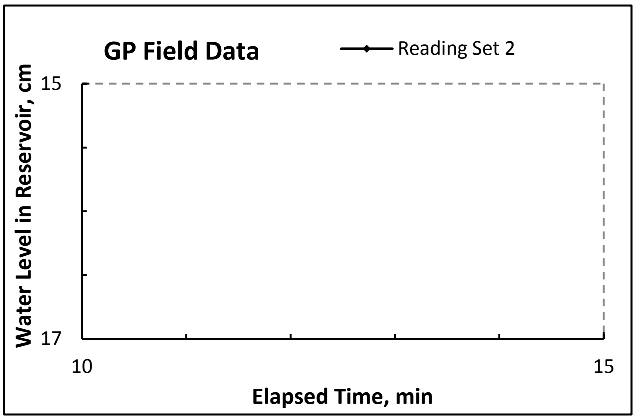
Soil Type	α*	C1	C2
4	0.36	0.803	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.1	m
Well water height - Set 1	H_1	5	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0		3	0	0					
5	5	9.2	6.2	1.24					
10	5	15.4	6.2	1.24					
15	5	21.6	6.2	1.24					
20	5	27.8	6.2	1.24					
25	5	34	6.2	1.24					
30	5	40.4	6.4	1.28					
40	10	53.7	13.3	1.33					
50	10	67.4	13.7	1.37					
Steady Rate for 3 readings R_1 (cm/min)				1.24	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **2.19E-03** cm/s **OR** **2.19E-05** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**	8/07/2019	
Project Number	045500				**Tested By**	MAS/VBJ	
Project	Marillana Creek Infiltration				**Checked By**	IHL	
Site Location	Yandi				**Test ID Number**	S6-PM01	
Test Location	Easting	685961	Northing	7481740	RL	NA	

Subsurface Profile

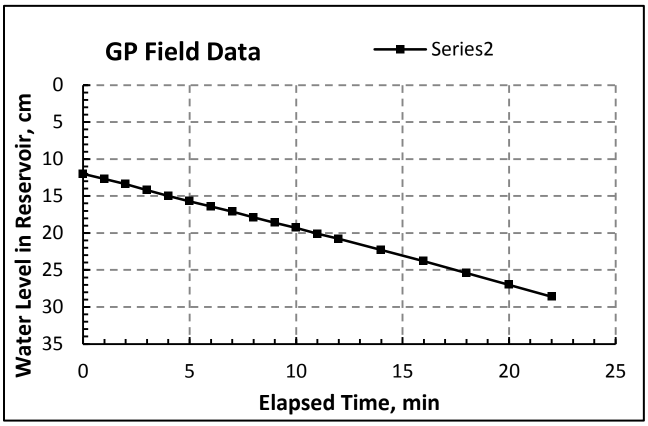
Depth	Description
0 - 0.05 m	Silt veneer
0.05 - 0.1 m	Silty sandy GRAVEL; orangey brown, loose, dry, well graded;
	gravel, fine to coarse, rounded to sub angular; sand, fine to
	coarse; fines low to non plastic.
Site Description	*Test conducted in low flow of a wedge channel, silt sourced*
	from bank erosion forming localized silt veneer.

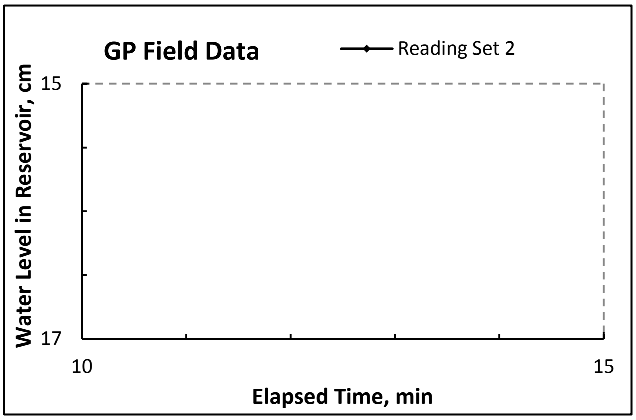
Soil Type	α^*	C1	C2
4	0.36	1.014	0

GP Field Data

Type of Reservoir used	Inner		**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3 cm	**Depth of Well hole**	d	0.1	m
Well water height - Set 1	H_1	7 cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0	12	0	0					
1	1	12.7	0.7	0.7					
2	1	13.4	0.7	0.7					
3	1	14.2	0.8	0.8					
4	1	15	0.8	0.8					
5	1	15.7	0.7	0.7					
6	1	16.4	0.7	0.7					
7	1	17.1	0.7	0.7					
8	1	17.9	0.8	0.8					
9	1	18.6	0.7	0.7					
10	1	19.3	0.7	0.7					
11	1	20.1	0.8	0.8					
12	1	20.8	0.7	0.7					
14	2	22.3	1.5	0.75					
16	2	23.8	1.5	0.75					
18	2	25.4	1.6	0.8					
20	2	27	1.6	0.8					
22	2	28.6	1.6	0.8					
Steady Rate for 3 readings R_1 (cm/min)				0.8	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **1.04E-03** cm/s OR **1.04E-05** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**		9/07/2019	
Project Number	045500				**Tested By**		MAS/VBJ	
Project	Marillana Creek Infiltration				**Checked By**		IHL	
Site Location	Yandi				**Test ID Number**		S7-PM01	
Test Location	Easting	688288	Northing	7483198	RL	NA		

Subsurface Profile

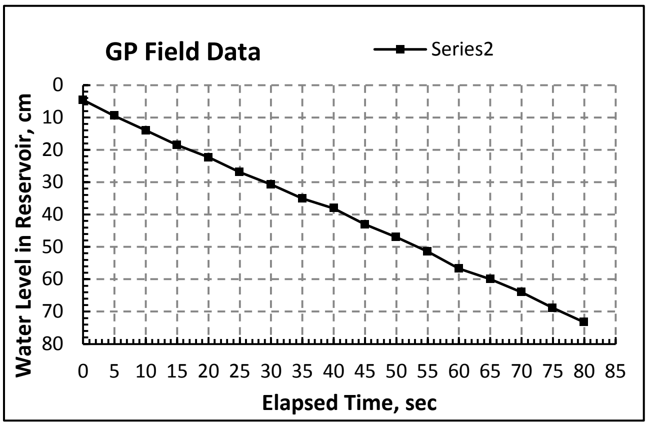
Depth	Description
0 - 0.10 m	Sandy GRAVEL, trace silt; orangish brown, loose, dry,
	well graded; gravel, fine to coarse, rounded to sub angular;
	sand, fine to coarse
	Test in broad uniform primary channel, central gravel bar
	seperates primary from secondary channel

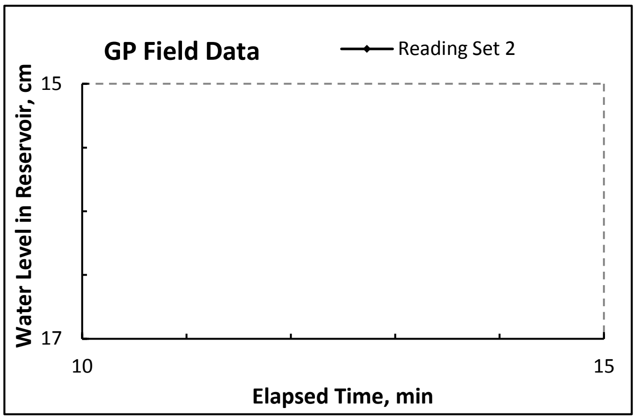
Soil Type	α^*	C1	C2
4	0.36	1.014	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.9	m
Well water height - Set 1	H_1	7	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	4.6	0	0					
5	0.083	9.5	4.9	58.8					
10	0.083	14	4.5	54					
15	0.083	18.5	4.5	54					
20	0.083	22.3	3.8	45.6					
25	0.083	26.9	4.6	55.2					
30	0.083	30.7	3.8	45.6					
35	0.083	35	4.3	51.6					
40	0.083	38.1	3.1	37.2					
45	0.083	43.1	5	60					
50	0.083	47	3.9	46.8					
55	0.083	51.5	4.5	54					
60	0.083	56.7	5.2	62.4					
65	0.083	60	3.3	39.6					
70	0.083	64	4	48					
75	0.083	68.9	4.9	58.8					
80	0.083	73.3	4.4	52.8					
Steady Rate for 3 readings R_1 (cm/min)				52.1	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity | K_{fs} = **6.76E-02** cm/s OR **6.76E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				Test Date	9/07/2019
Project Number	045560				Tested By	MAS/VBJ
Project	Marillana Creek Infiltration				Checked By	IHL
Site Location	Yandi				Test ID Number	S7-PM01A
Test Location	Easting	688288	Northing	7483198	RL	NA

Subsurface Profile

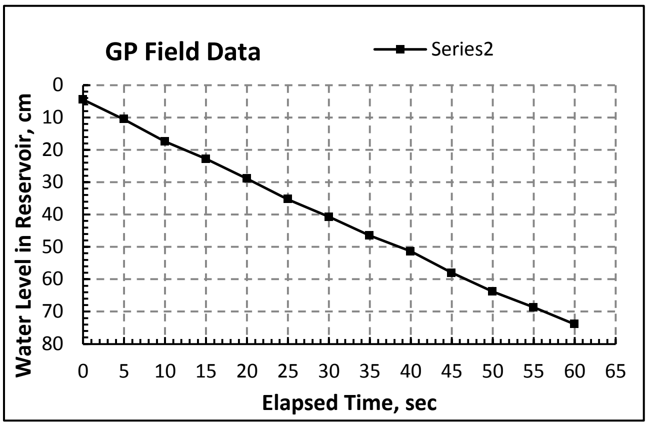
Depth	Description
0 - 0.10 m	Sandy GRAVEL, trace silt; orangish brown, loose, dry,
	well graded; gravel, fine to coarse, rounded to sub angular;
	sand, fine to coarse
	Test in broad uniform primary channel, central gravel bar
	seperates primary from secondary channel

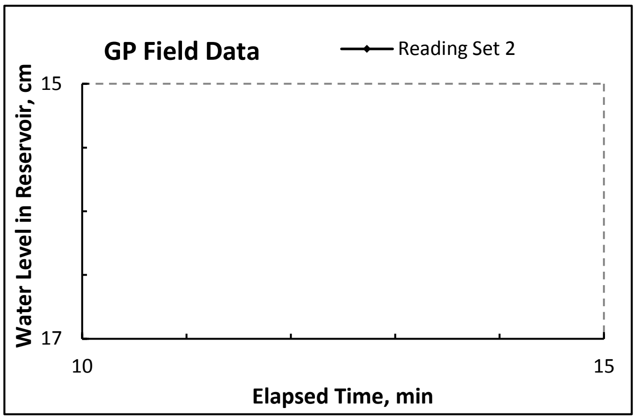
Soil Type	α*	C1	C2
4	0.36	1.288	0

GP Field Data

Type of Reservoir used	Inner			Reservoir Constant	RC	35.22	cm^2
Radius of Well hole	r	3	cm	Depth of Well hole	d	0.9	m
Well water height - Set 1	H_1	10	cm	Well Water Height - Set 2	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.083	4.5	0	0					
5	0.083	10.6	6.1	73.2					
10	0.083	17.4	6.8	81.6					
15	0.083	22.8	5.4	64.8					
20	0.083	28.9	6.1	73.2					
25	0.083	35.3	6.4	76.8					
30	0.083	40.7	5.4	64.8					
35	0.083	46.5	5.8	69.6					
40	0.083	51.4	4.9	58.8					
45	0.083	58	6.6	79.2					
50	0.083	63.8	5.8	69.6					
55	0.083	68.7	4.9	58.8					
60	0.083	73.9	5.2	62.4					
Steady Rate for 3 readings R_1 (cm/min)				72	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **6.48E-02** cm/s OR **6.48E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**	11/07/2019	
Project Number	045500				**Tested By**	MAS/VBJ	
Project	Marillana Creek Infiltration Project				**Checked By**	IHL	
Site Location	Yandi				**Test ID Number**	S9-PM01	
Test Location	Easting	683702	Northing	7476910	RL	NA	

Subsurface Profile

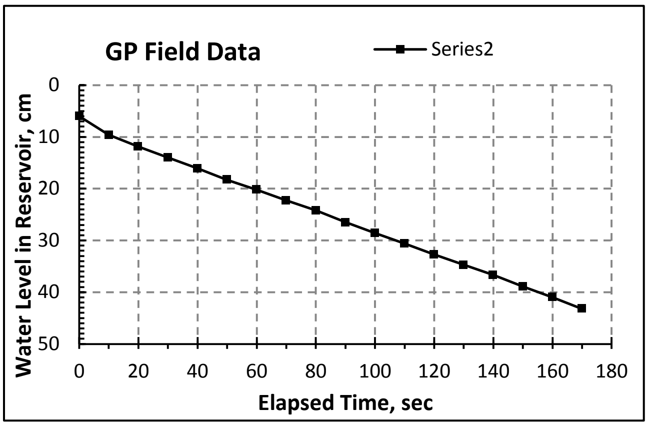
Depth	Description
0 - 0.10 m	Sandy GRAVEL, trace cobbles, trace silt; reddish brown,
	loose, dry, well graded; gravel, fine to coarse,
	rounded to sub angular; sand, fine to coarse
Site Description	*Test conducted in low flow of broad vegatated riffled*
	channel

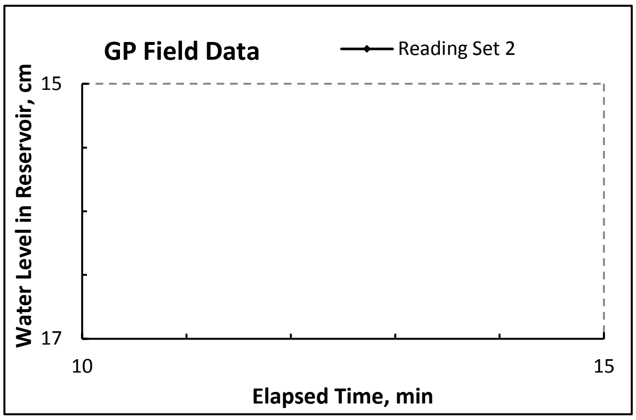
Soil Type	α^*	C1	C2
4	0.36	0.686	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.9	m
Well water height - Set 1	H_1	4	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.167	6	0	0					
10	0.167	9.6	3.6	21.6					
20	0.167	11.9	2.3	13.8					
30	0.167	14	2.1	12.6					
40	0.167	16.1	2.1	12.6					
50	0.167	18.3	2.2	13.2					
60	0.167	20.2	1.9	11.4					
70	0.167	22.3	2.1	12.6					
80	0.167	24.2	1.9	11.4					
90	0.167	26.5	2.3	13.8					
100	0.167	28.6	2.1	12.6					
110	0.167	30.6	2	12					
120	0.167	32.7	2.1	12.6					
130	0.167	34.7	2	12					
140	0.167	36.7	2	12					
150	0.167	38.9	2.2	13.2					
160	0.167	41	2.1	12.6					
170	0.167	43.2	2.2	13.2					
Steady Rate for 3 readings R_1 (cm/min)				12.6	Steady Rate for 3 readings R_2 (cm/min)				





Field Saturated Hydraulic Conductivity K_{fs} = **2.67E-02** cm/s **OR** **2.67E-04** m/s

Guelph Permeameter Field Data
Field Saturated Hydraulic Conductivity

Client	BHP				**Test Date**		11/07/2019	
Project Number	045500				**Tested By**		MAS/VBJ	
Project	Marillana Creek Infiltration Project				**Checked By**		IHL	
Site Location	Yandi				**Test ID Number**		S9-PM01A	
Test Location	Easting	683702	Northing	7476910	RL	NA		

Subsurface Profile

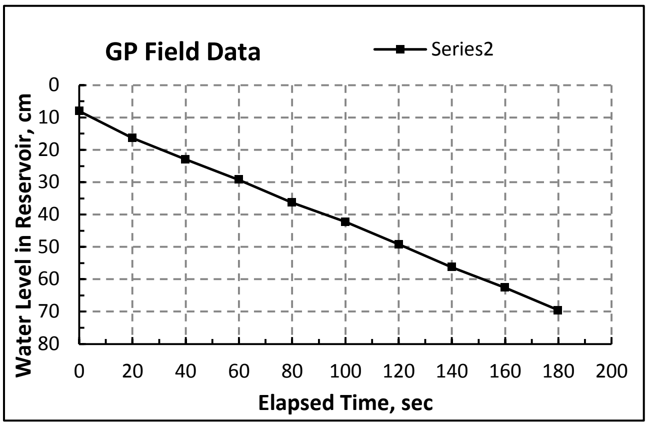
Depth	Description
0 - 0.10 m	Sandy GRAVEL, trace cobbles, trace silt; reddish brown,
	loose, dry, well graded; gravel, fine to coarse,
	rounded to sub angular; sand, fine to coarse
Site Description	*Test conducted in low flow of broad vegatated riffled*
	channel

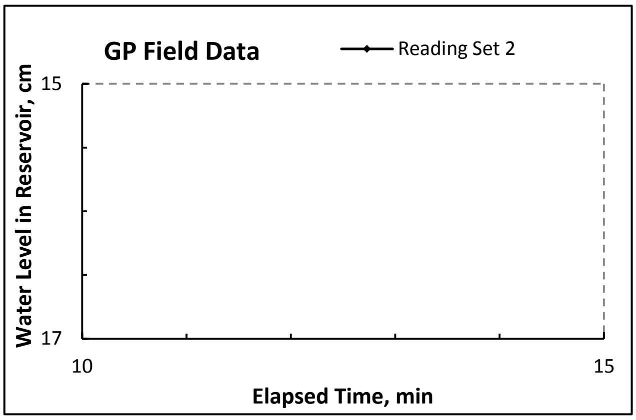
Soil Type	α*	C1	C2
4	0.36	0.803	0

GP Field Data

Type of Reservoir used	Inner			**Reservoir Constant**	RC	35.22	cm^2
Radius of Well hole	r	3	cm	**Depth of Well hole**	d	0.1	m
Well water height - Set 1	H_1	5	cm	**Well Water Height - Set 2**	H_2		cm

Elapsed time (sec)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)	Elapsed time (min)	Time interval (min)	Water level in reservoir (cm)	Change in Water level	Rate of water level change, R (cm/min)
0	0.333	8	0	0					
20	0.333	16.3	8.3	24.9					
40	0.333	23	6.7	20.1					
60	0.333	29.3	6.3	18.9					
80	0.333	36.3	7	21					
100	0.333	42.3	6	18					
120	0.333	49.2	6.9	20.7					
140	0.333	56.3	7.1	21.3					
160	0.333	62.6	6.3	18.9					
180	0.333	69.6	7	21					
Steady Rate for 3 readings R_1 (cm/min)				20.5	Steady Rate for 3 readings R_2 (cm/min)				



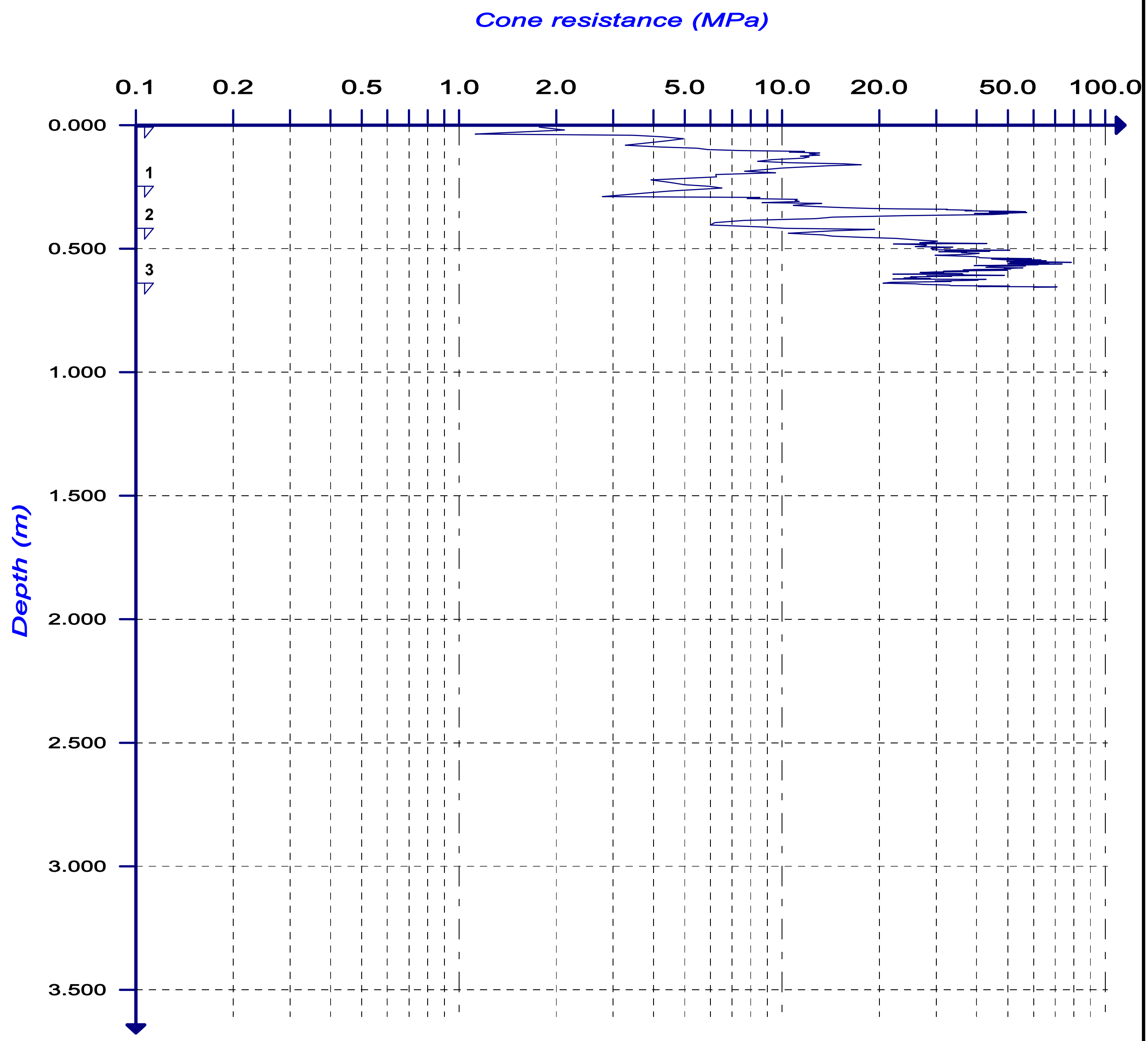


Field Saturated Hydraulic Conductivity | K_{fs} = **3.62E-02** cm/s **OR** **3.62E-04** m/s

APPENDIX G
PANDA DCP LOGS

Ground investigation with variable energy dynamic penetrometer

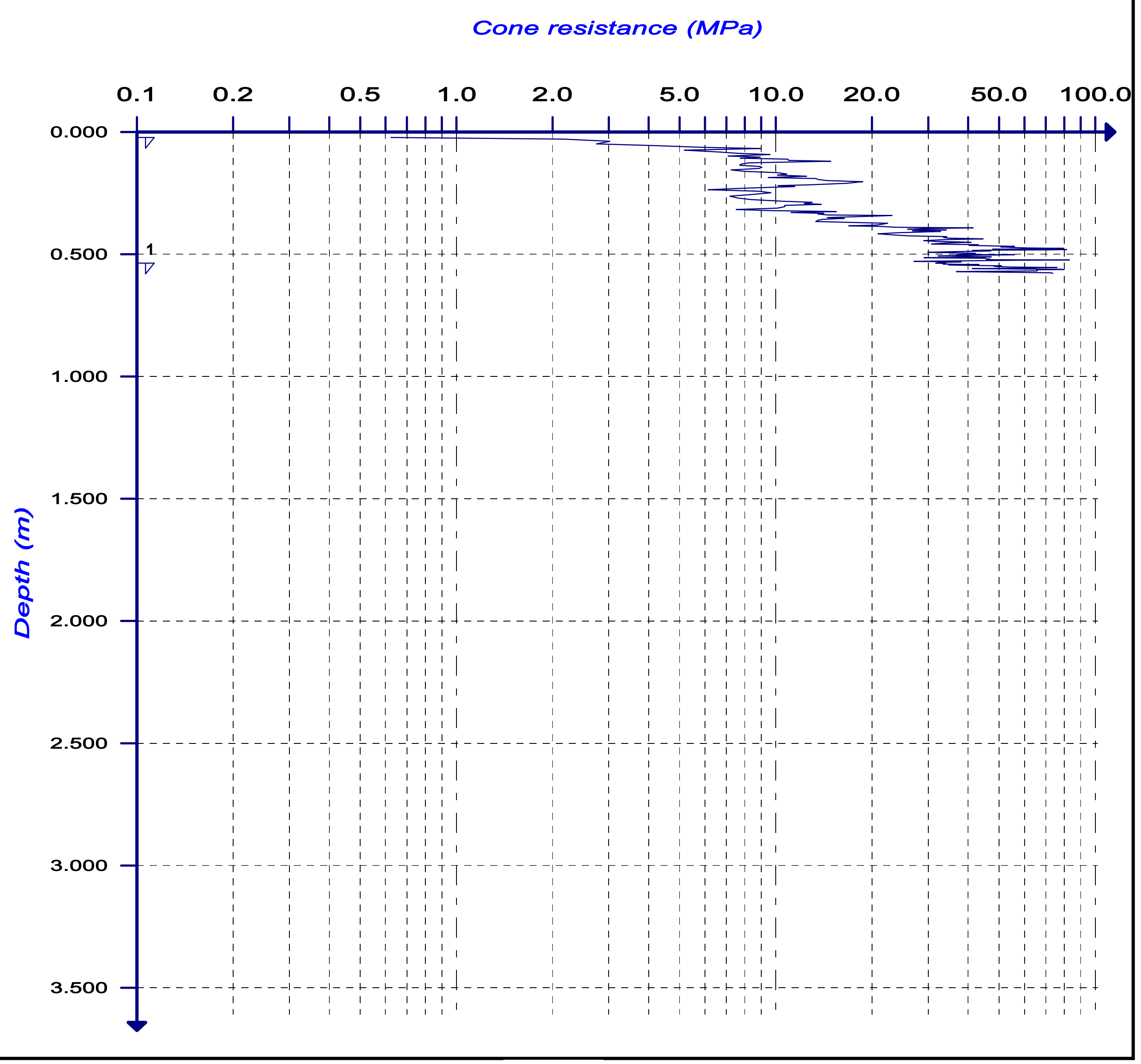
Marillana Creek Infiltration Project			
Sounding : S1-PM01 PDCP01			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 9/07/2019	



4DGeotechnics pty ltd

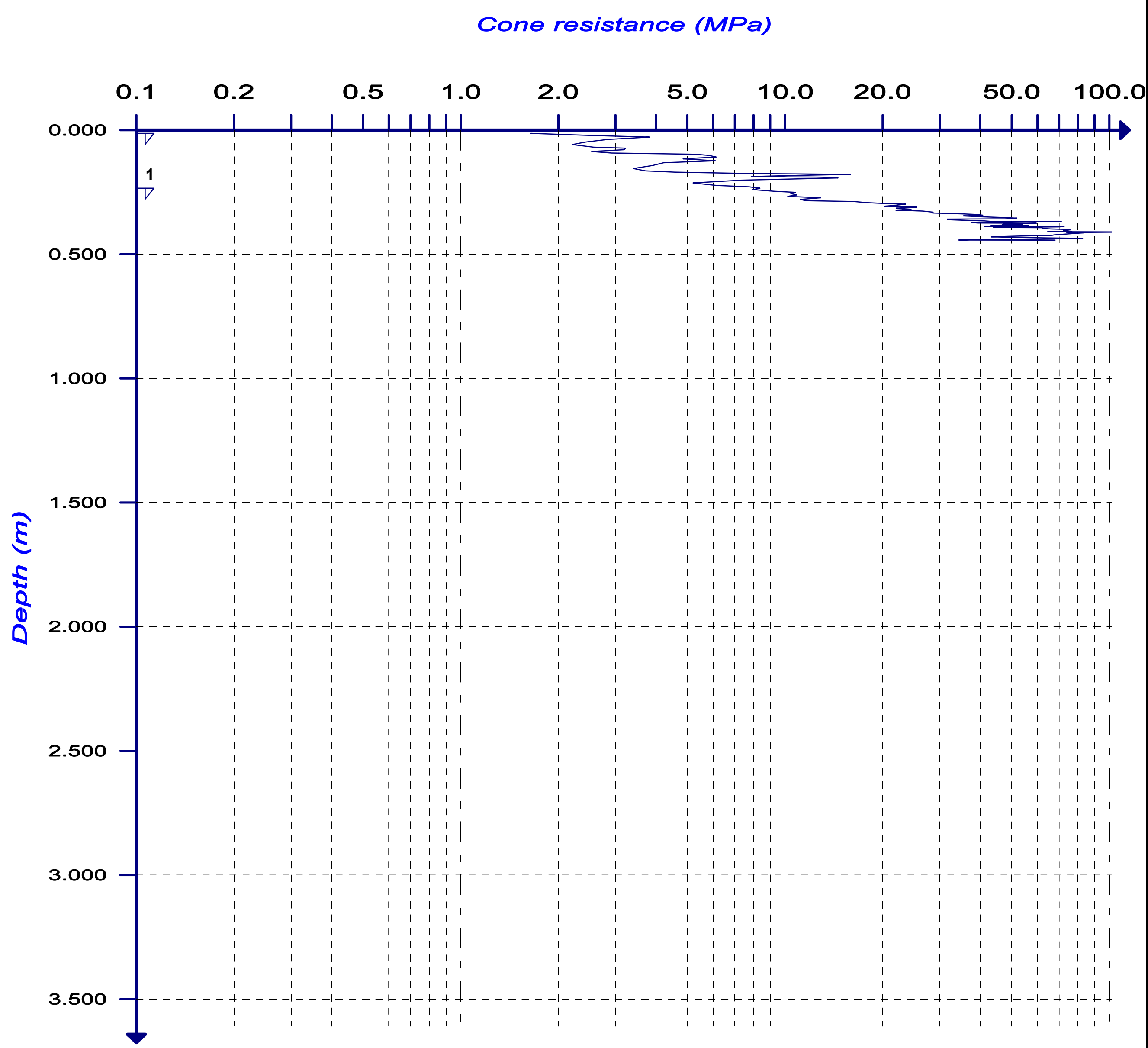
Ground investigation with variable energy dynamic penetrometer

Marillana Creek Infiltration Project			
Sounding : S1-PM01 PDCP02			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 9/07/2019	



Ground investigation with variable energy dynamic penetrometer

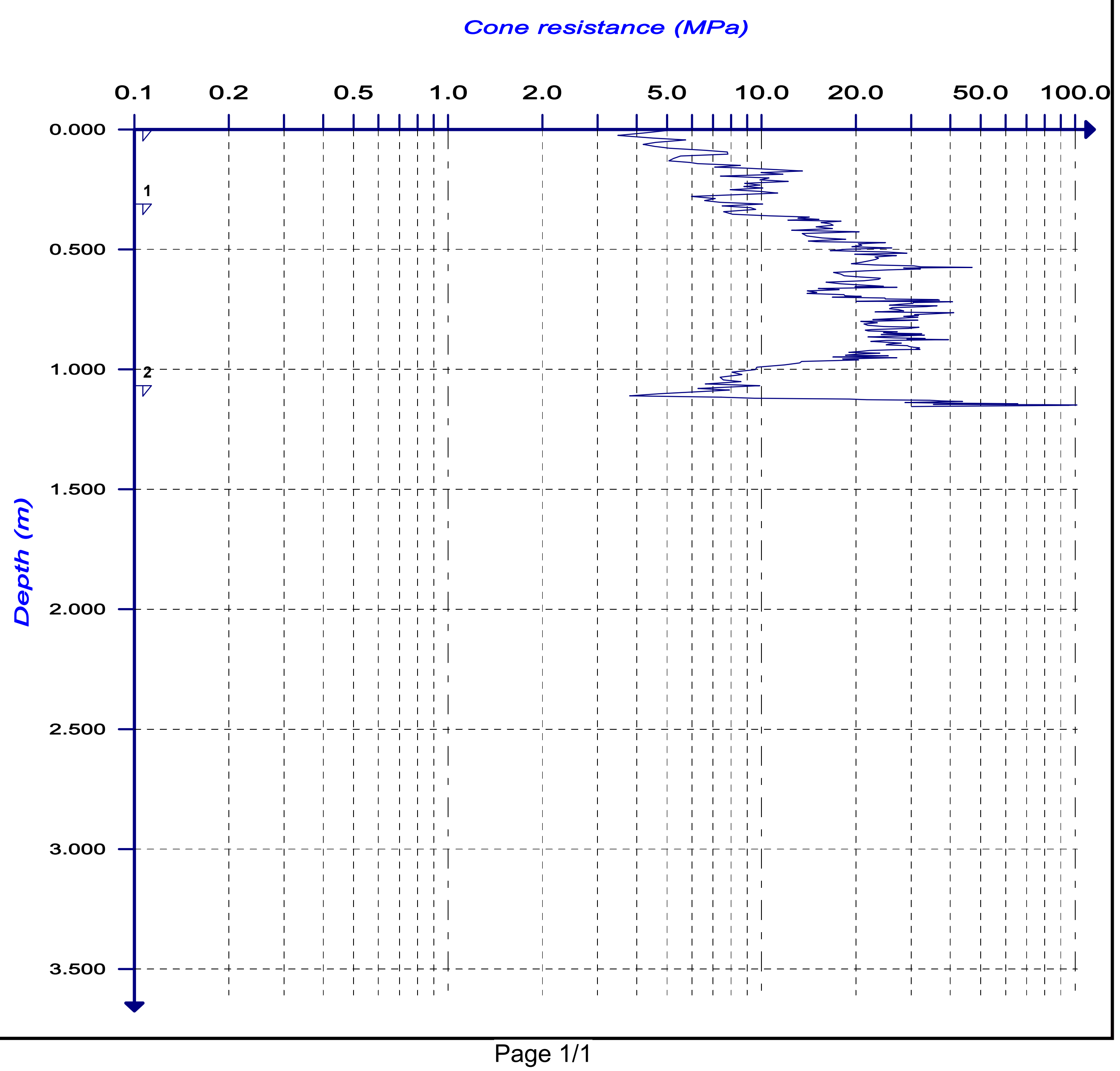
Marillana Creek Infiltration Project			
Sounding : S1-PM01 PDCP03			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 9/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

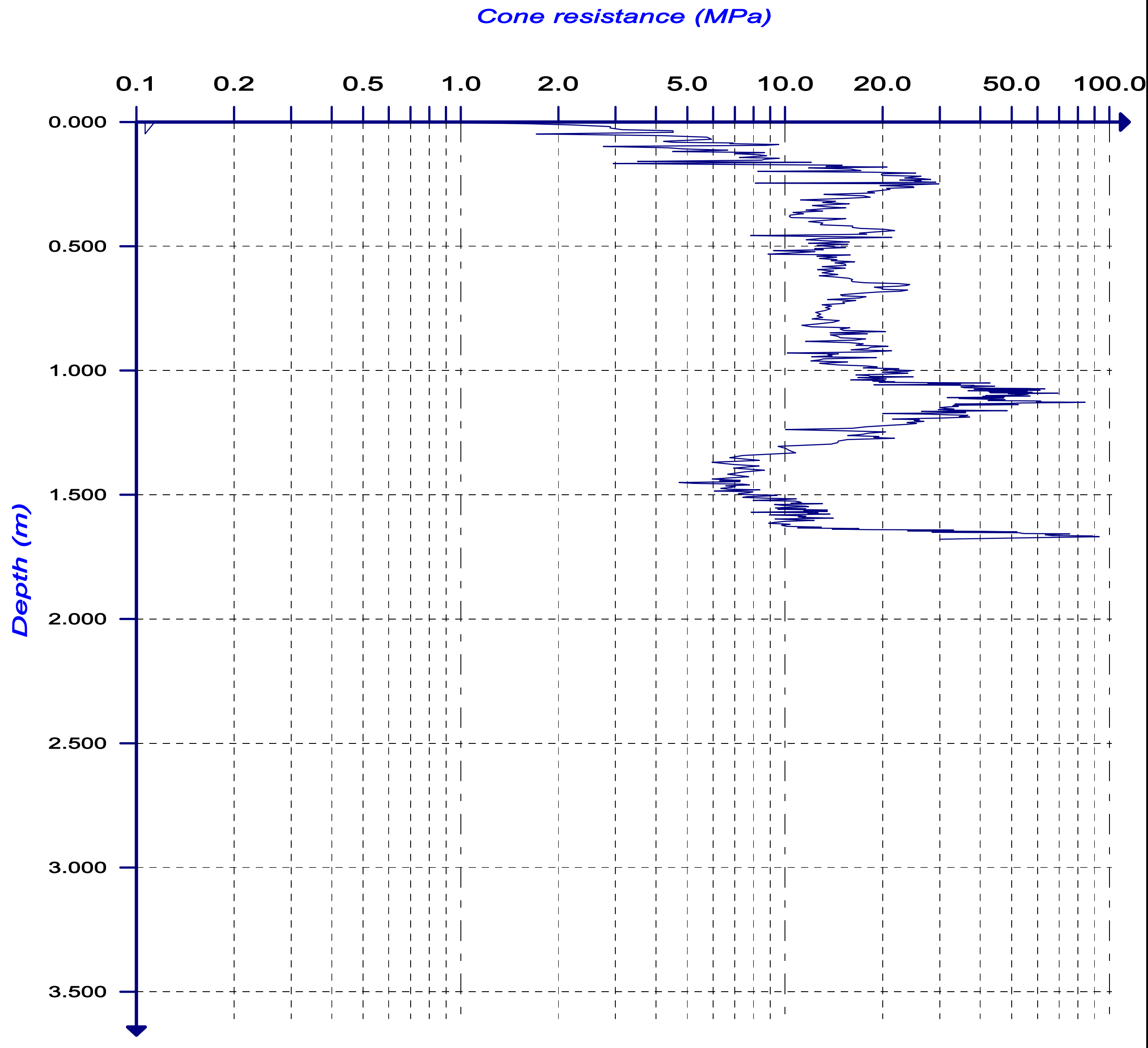
Marillana Creek Infiltration Project			
Sounding : S1-PM01 PDCP04			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 9/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

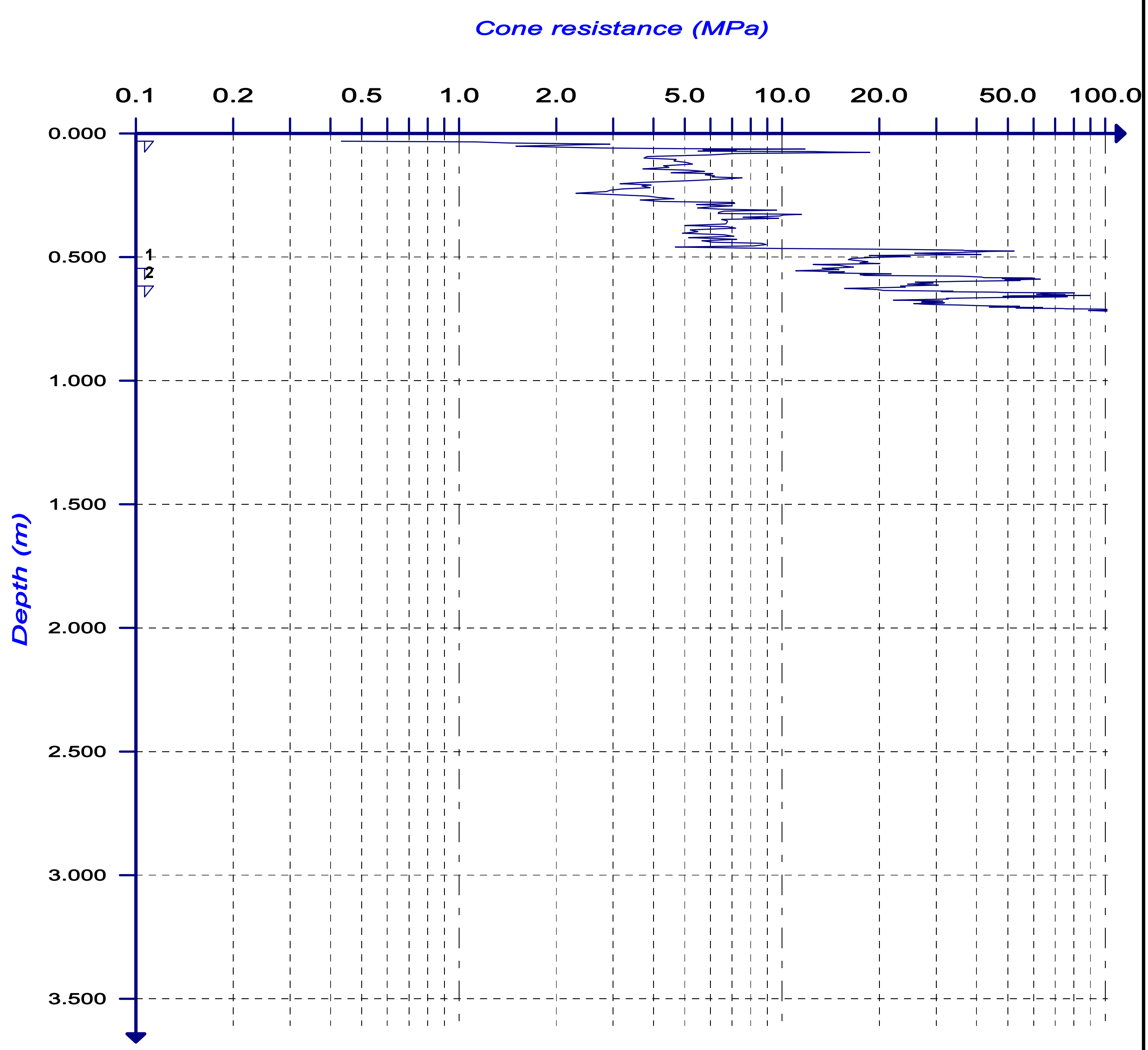
Marillana Creek Infiltration Project			
Sounding : S2-PM01 PDCP01			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 7/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

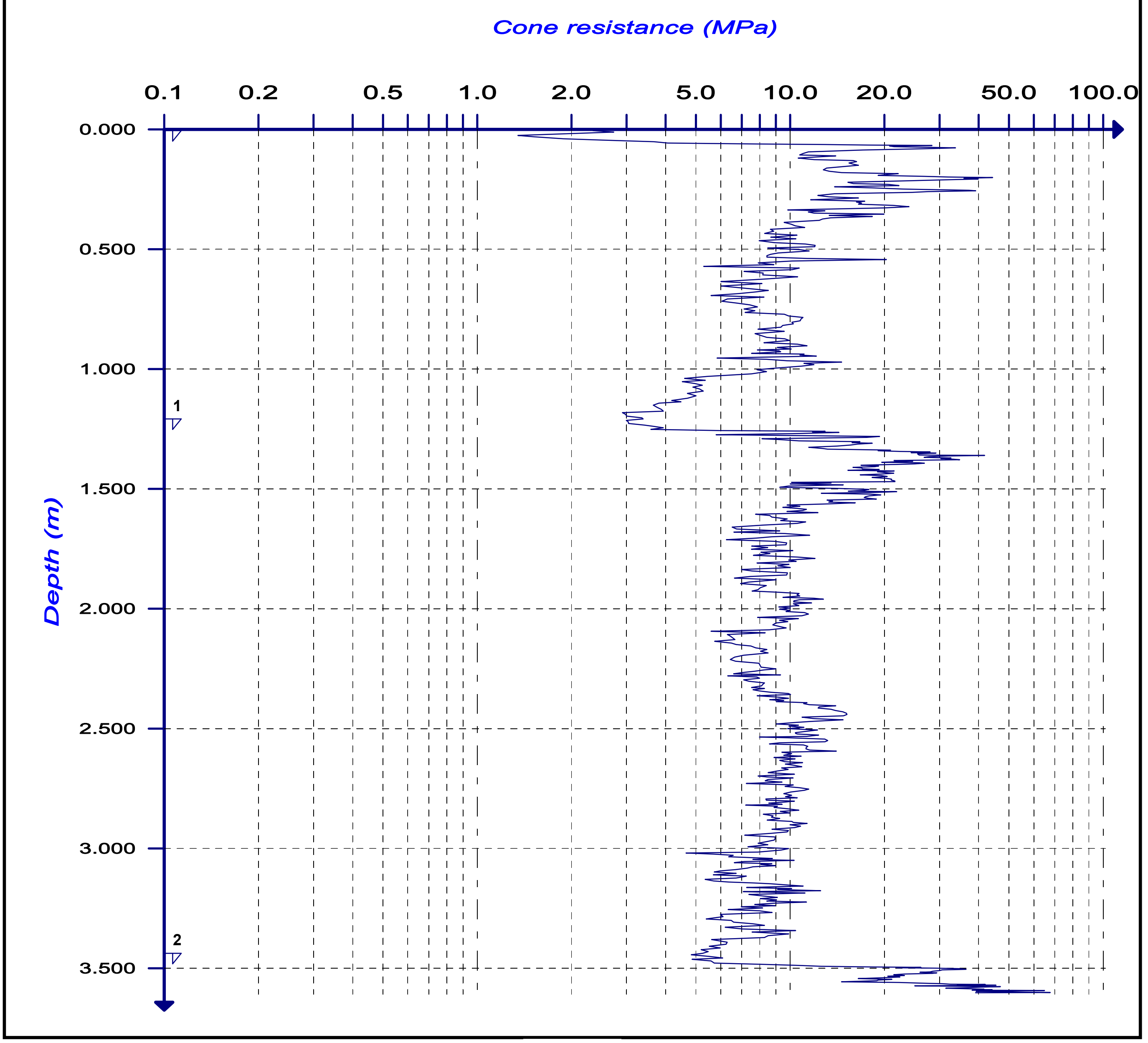
Marillana Creek Infiltration Project			
Sounding : S2-PM01 PDCP02			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 7/07/2019	



4DGeotechnics pty ltd

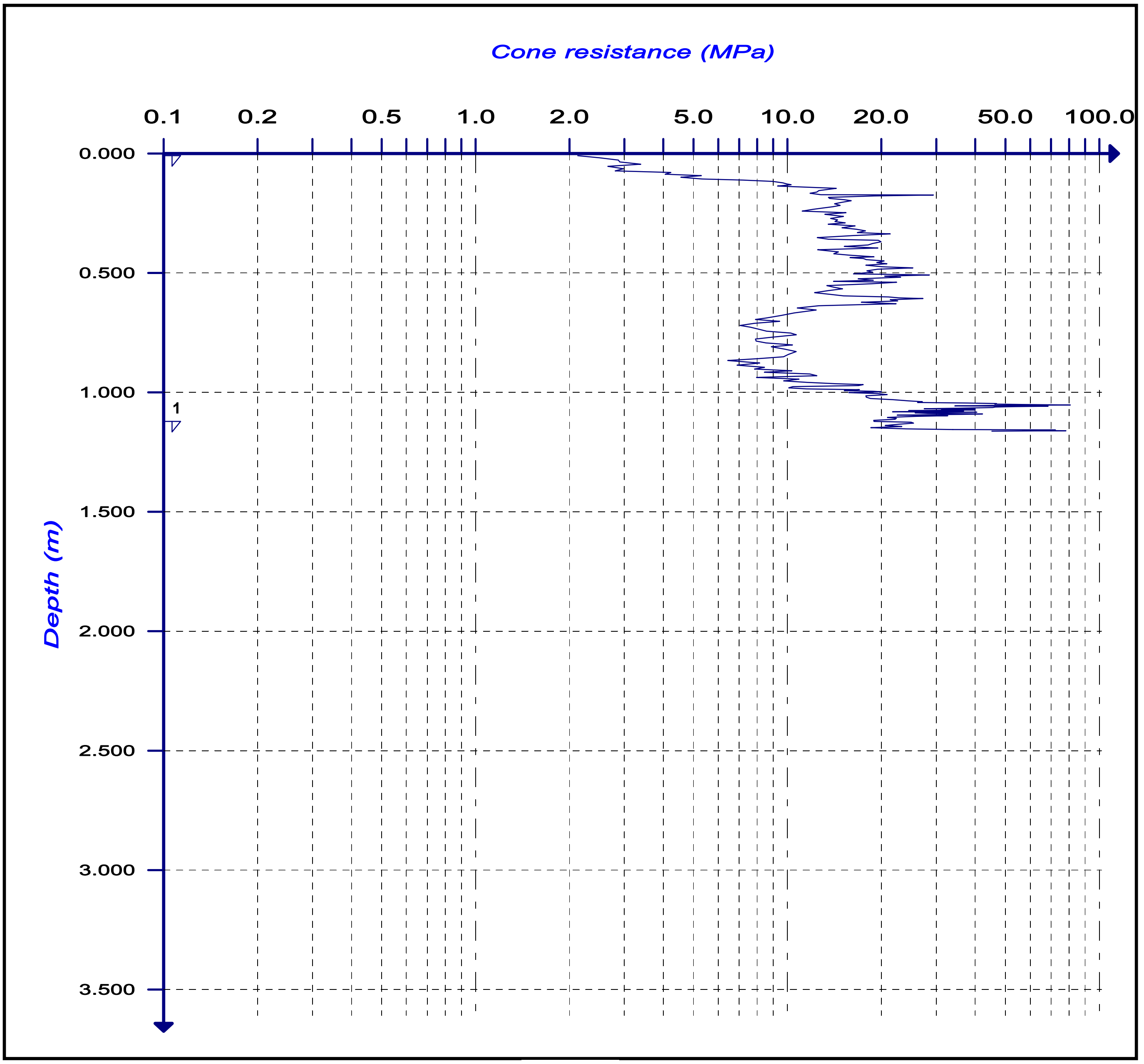
Ground investigation with variable energy dynamic penetrometer

Marillana Creek Infiltration Project			
Sounding : S2-PM01 PDCP03			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 7/07/2019	



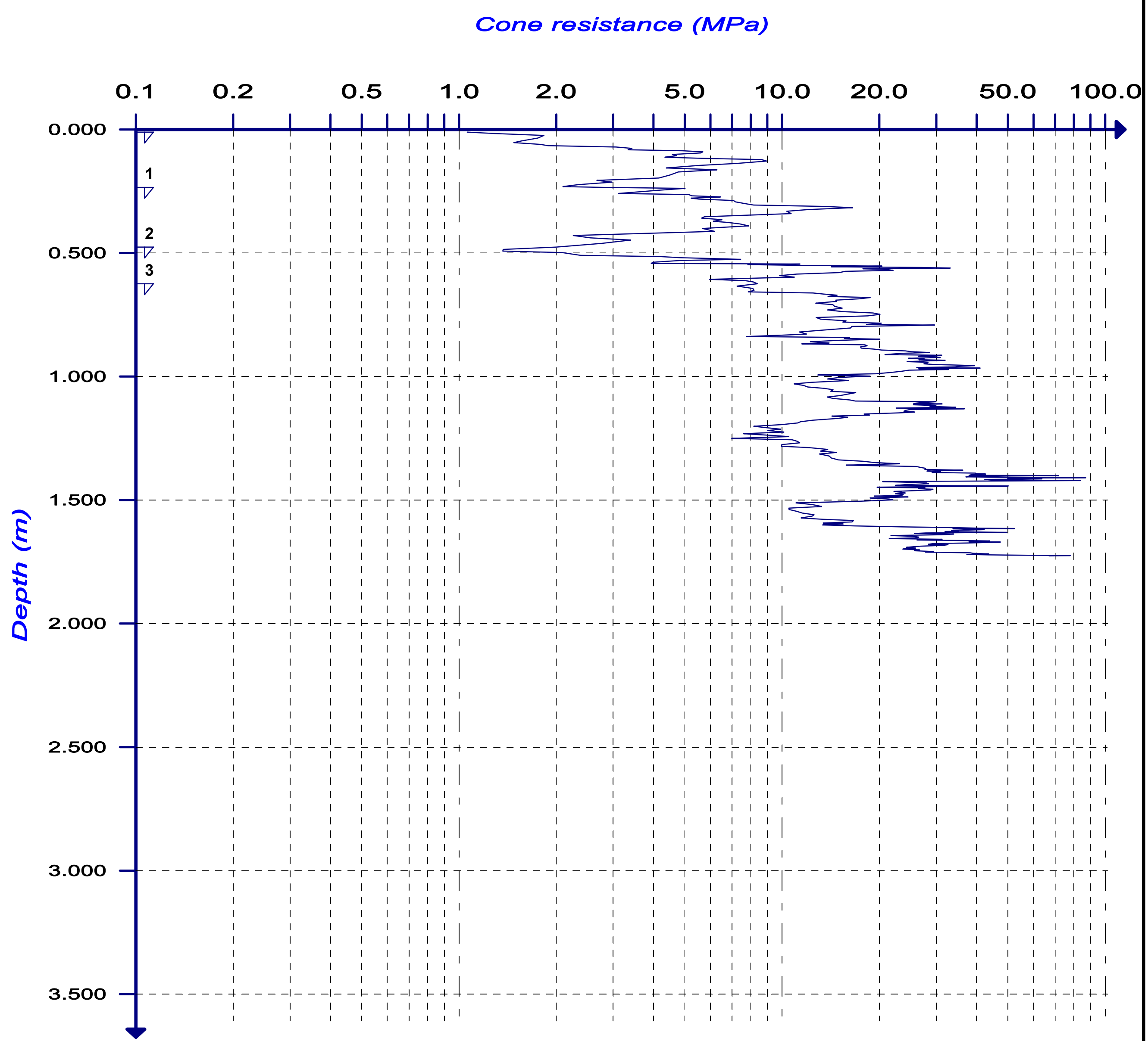
Ground investigation with variable energy dynamic penetrometer

Marillana Creek Infiltration Project			
Sounding : S2-PM02 PDCP01			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 11/07/2019	



Ground investigation with variable energy dynamic penetrometer

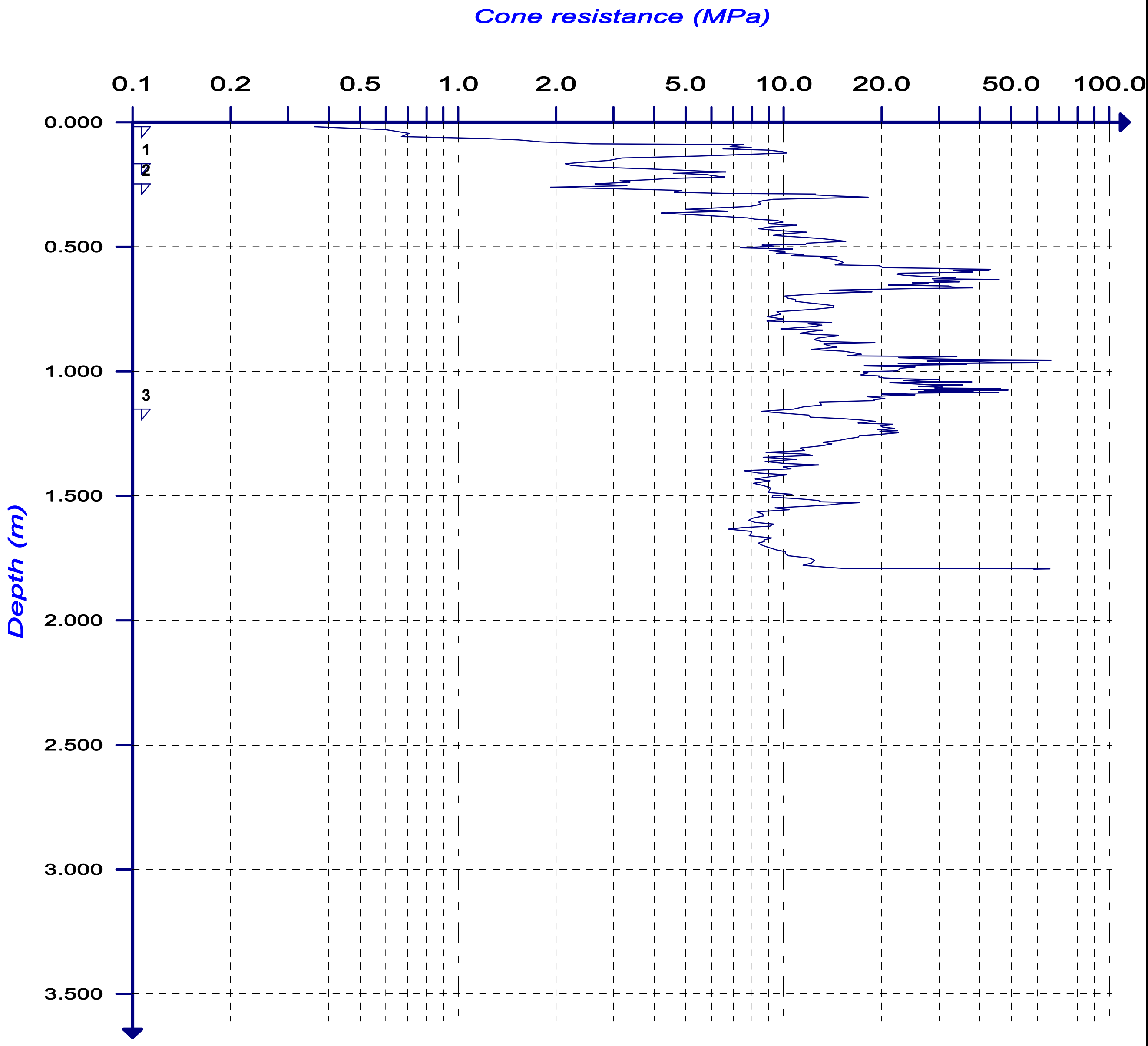
Marillana Creek Infiltration Project			
Sounding : S2-PM02 PDCP02			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 11/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

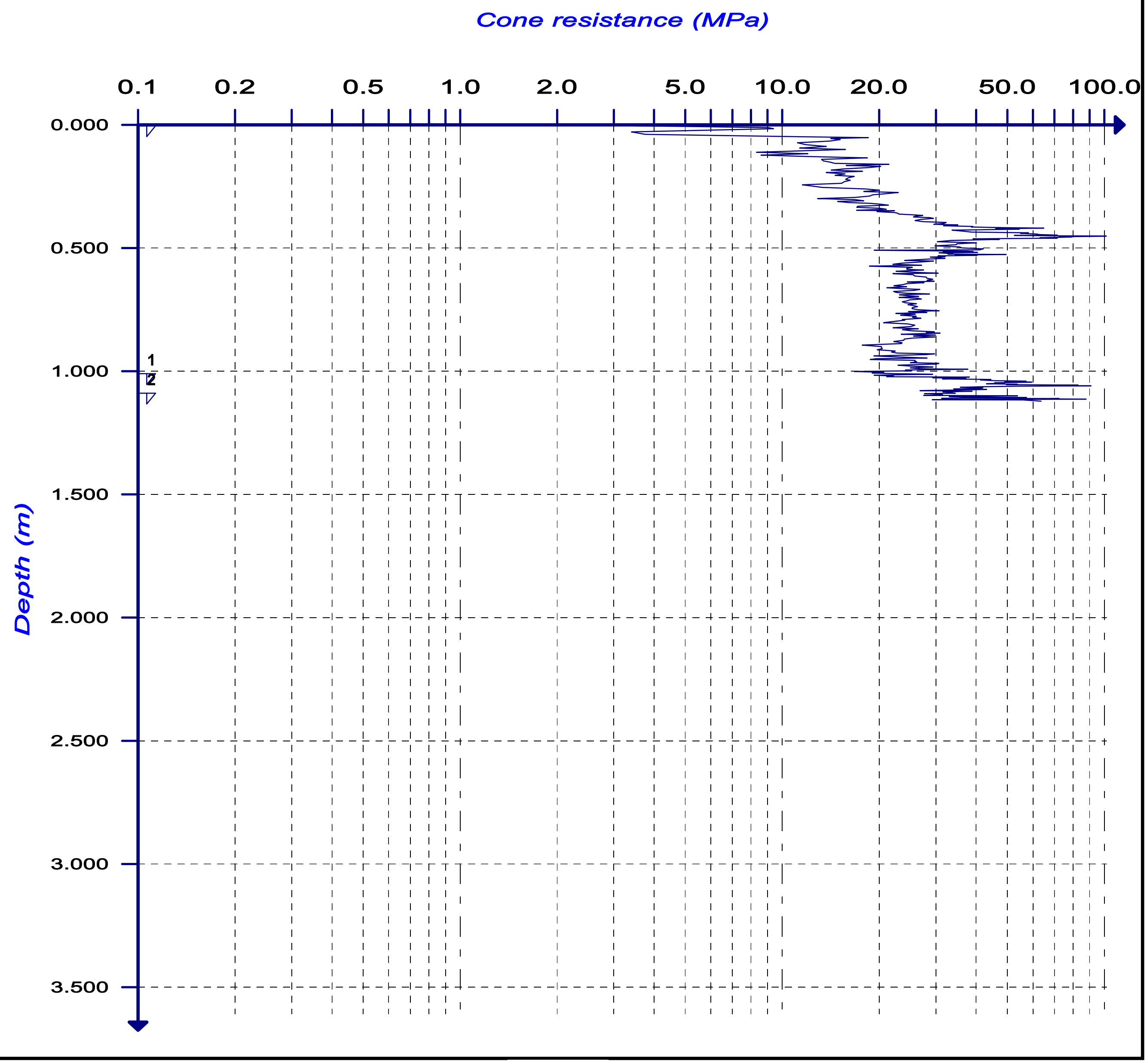
Marillana Creek Infiltration Project			
Sounding : S2-PM02 PDCP03			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 11/07/2019	



4DGeotechnics pty ltd

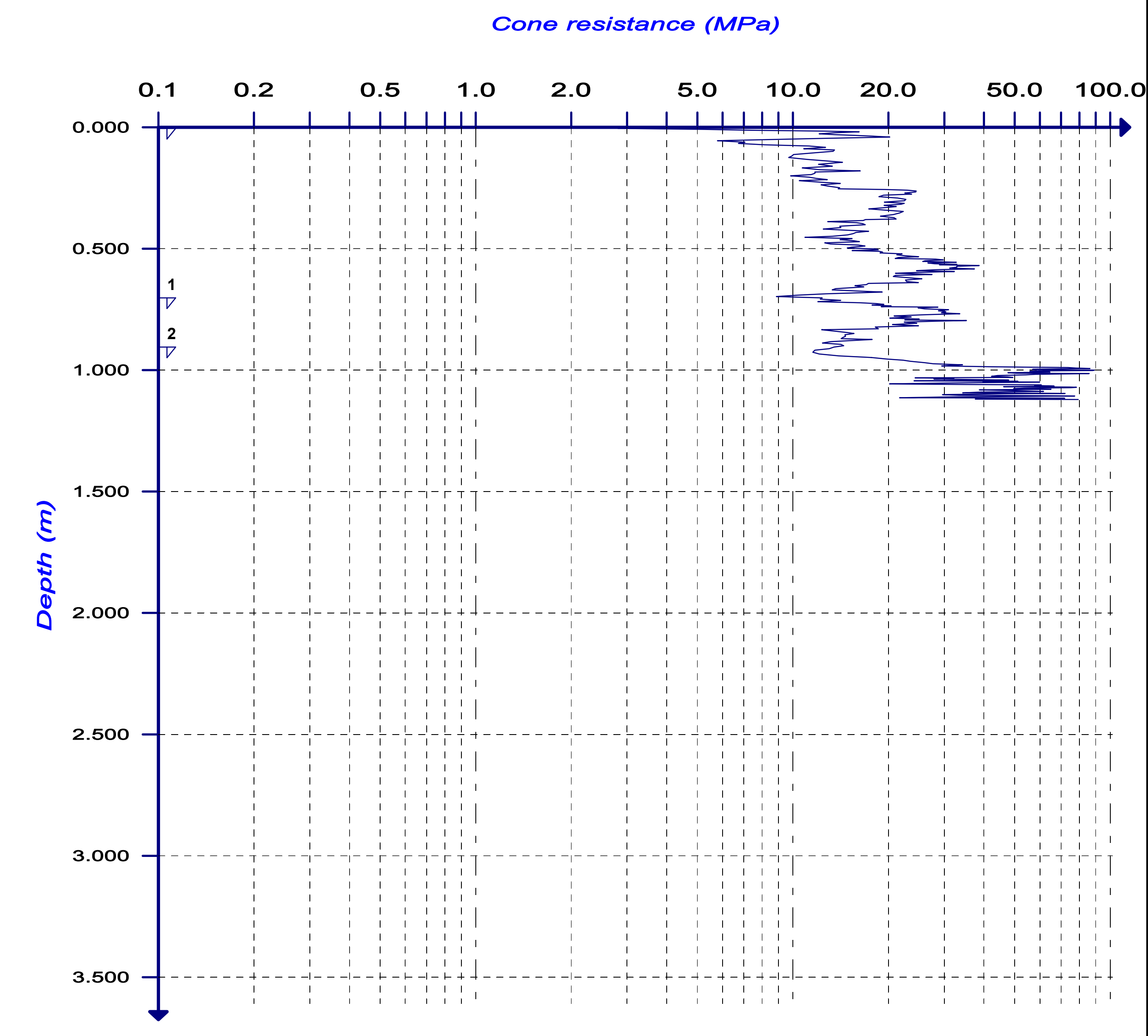
Ground investigation with variable energy dynamic penetrometer

Marillana Creek Infiltration Project			
Sounding : S3-PM01 PDCP01			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 7/07/2019	



Ground investigation with variable energy dynamic penetrometer

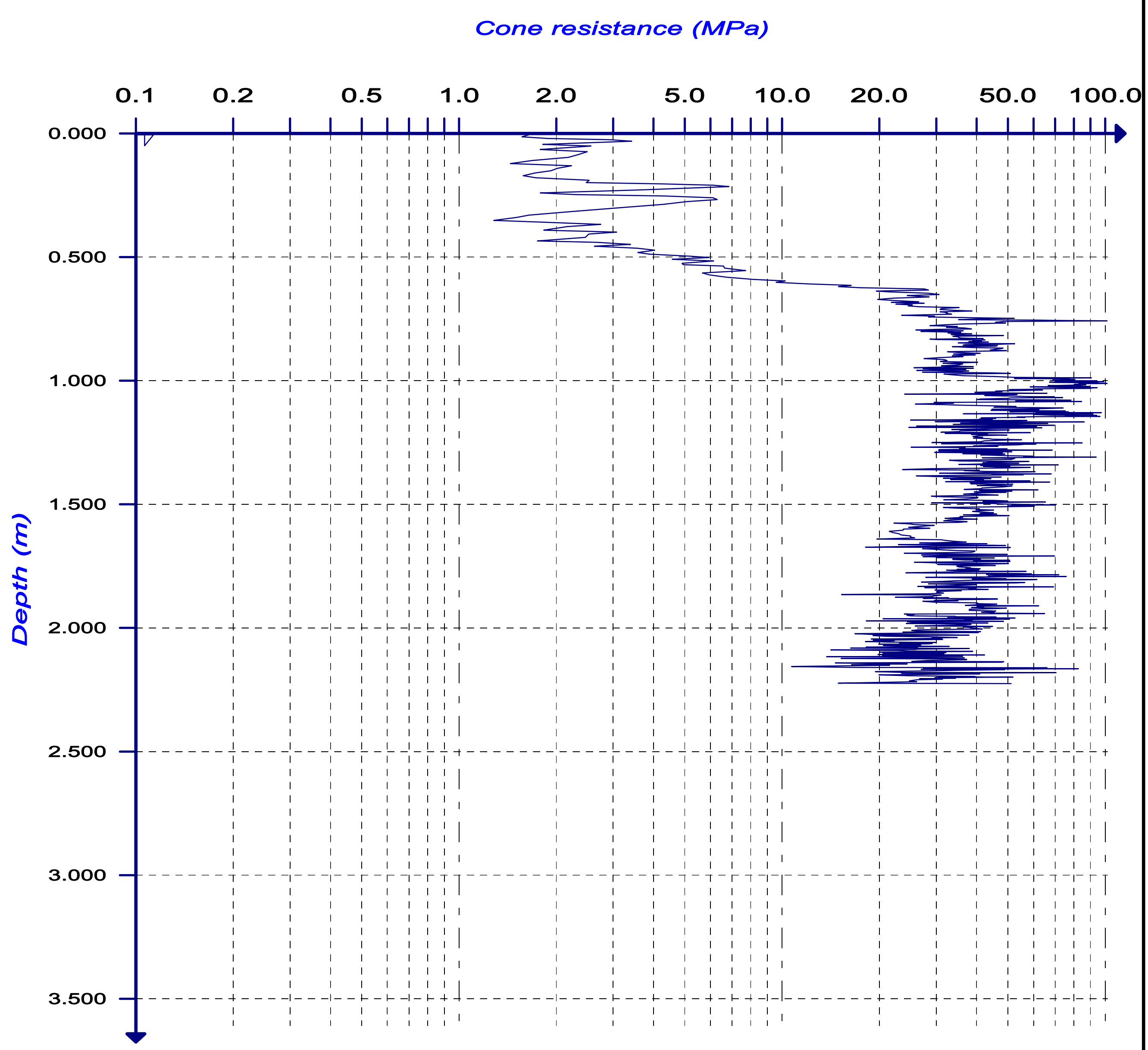
Marillana Creek Infiltration Project			
Sounding : S3-PM01 PDCP02			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 7/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

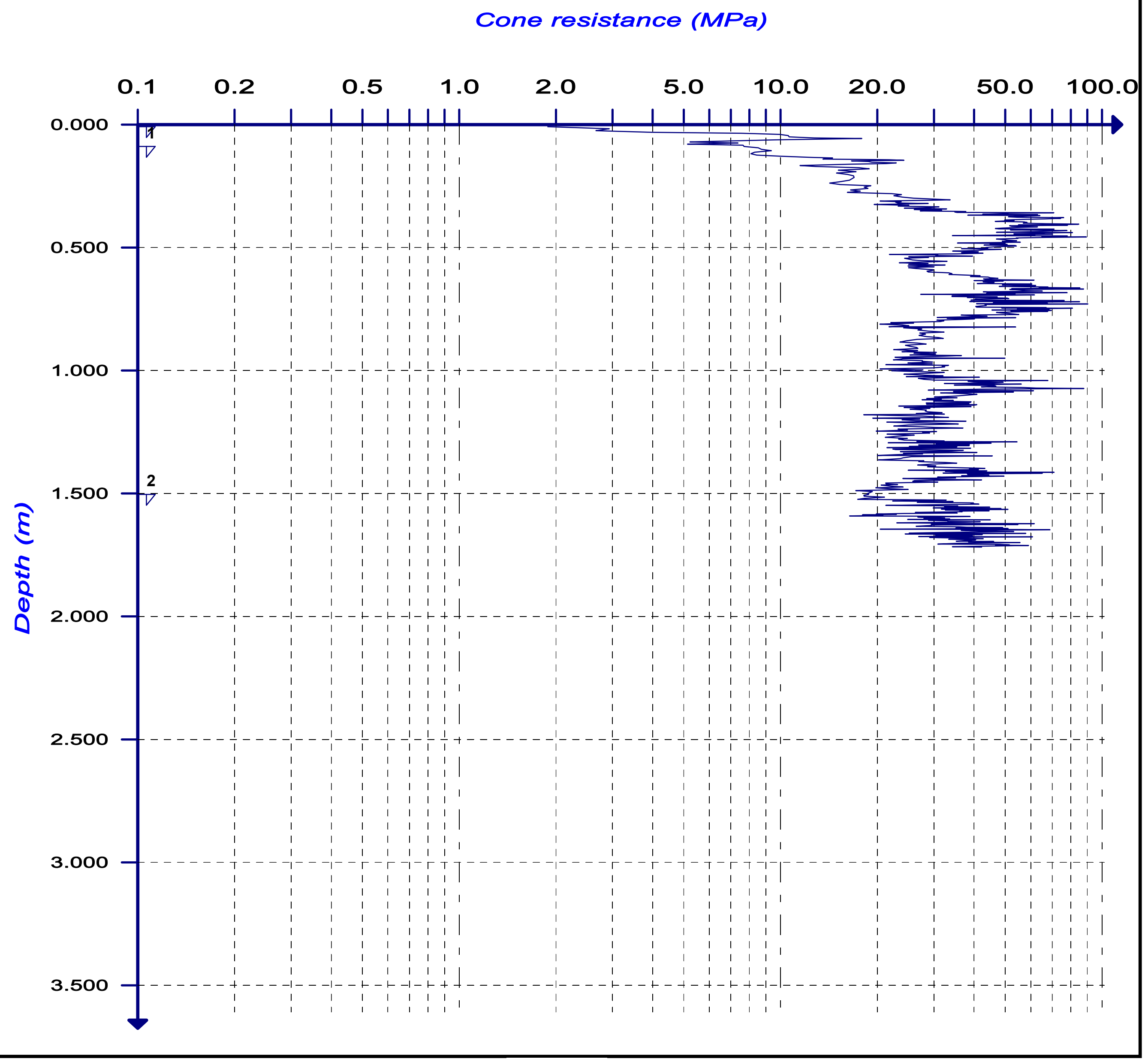
Marillana Creek Infiltration Project			
Sounding : S3-PM01 PDCP03			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 7/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

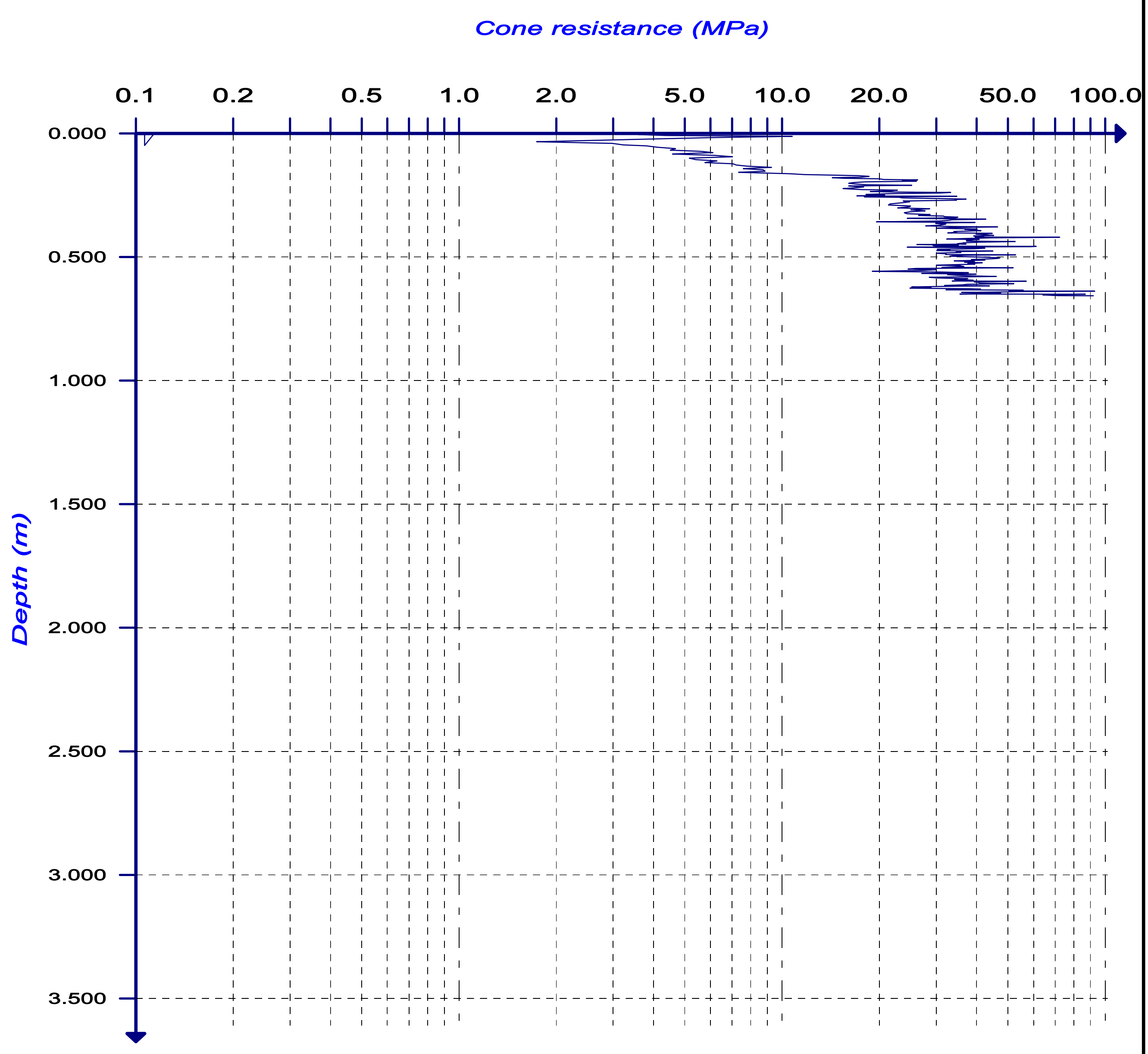
Marillana Creek Infiltration Project			
Sounding : S4-PM01 PDCP01			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 8/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

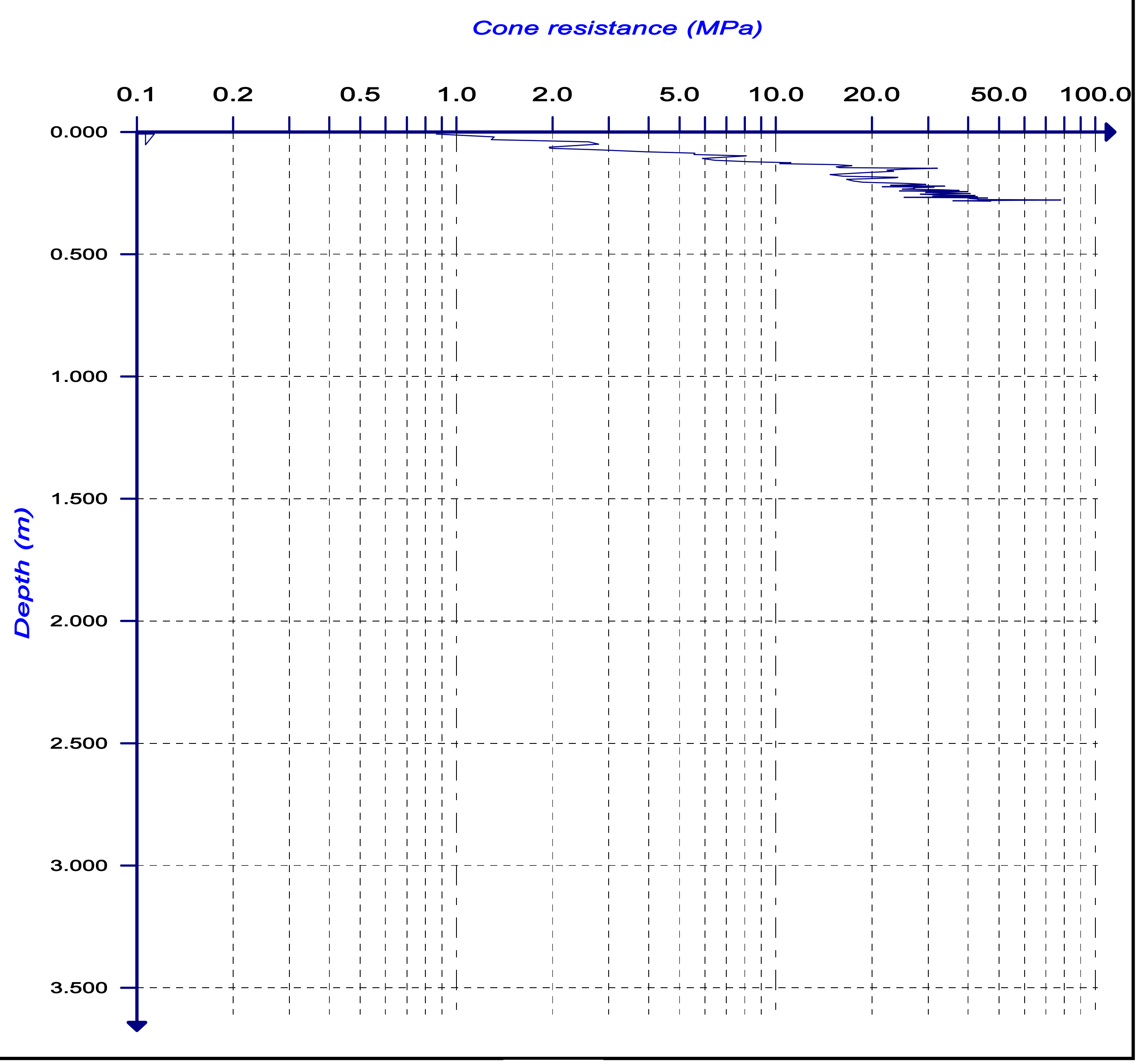
Marillana Creek Infiltration Project			
Sounding : S4-PM01 PDCP02			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 8/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

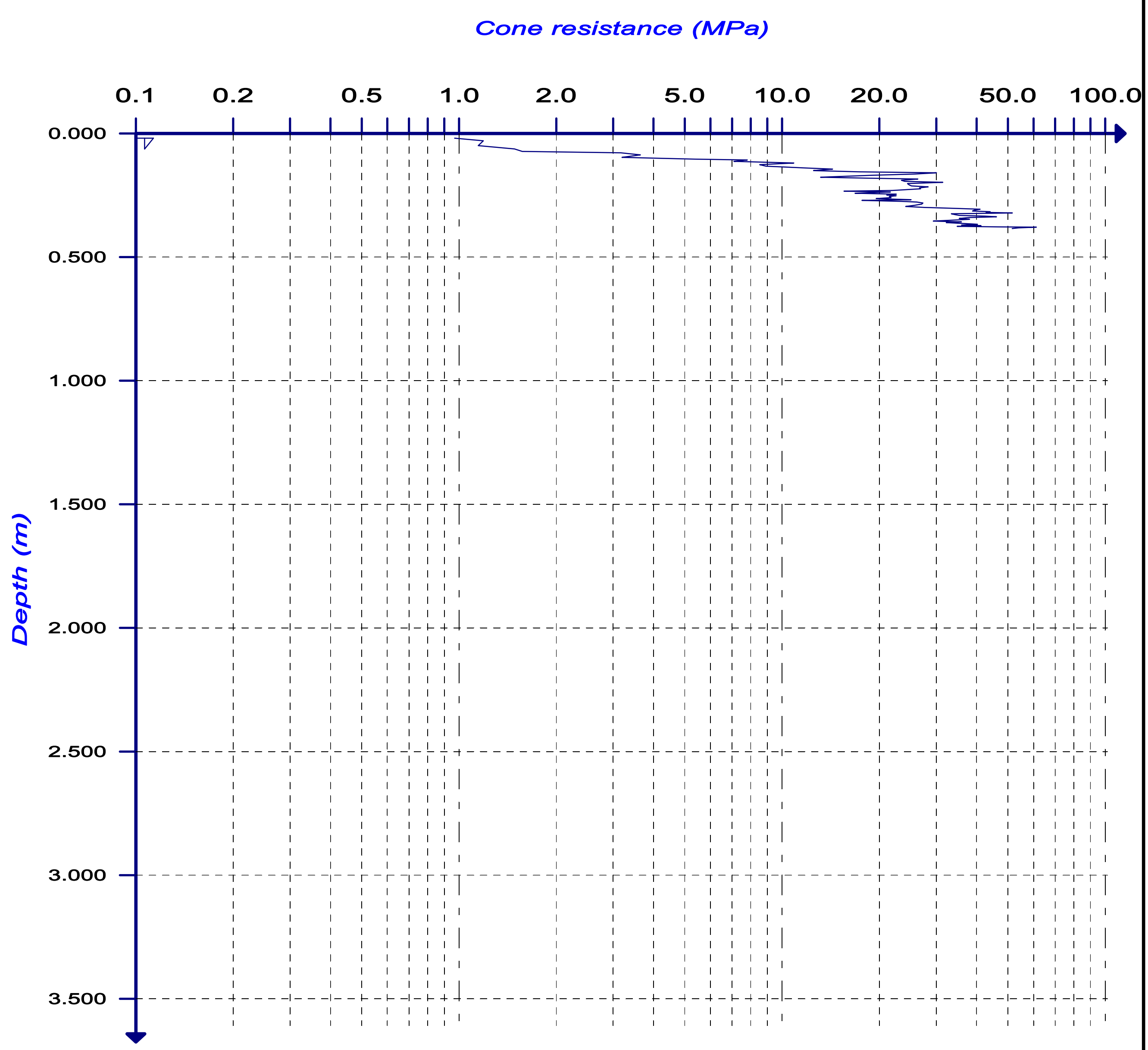
Marillana Creek Infiltration Project			
Sounding : S4-PM01 PDCP03			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 8/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

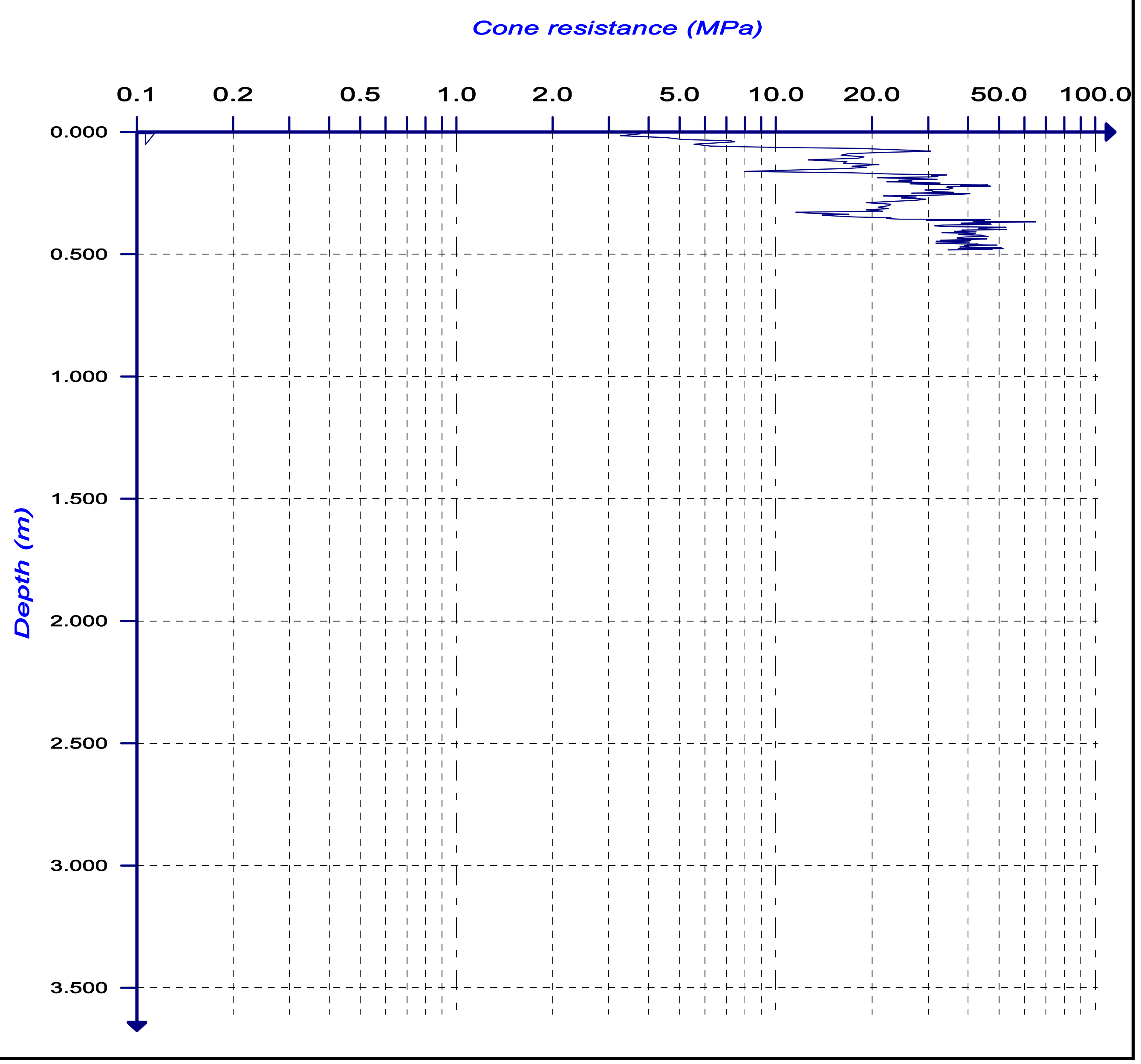
Marillana Creek Infiltration Project			
Sounding : S4-PM01 PDCP03A			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 8/07/2019	



4DGeotechnics pty Ltd

Ground investigation with variable energy dynamic penetrometer

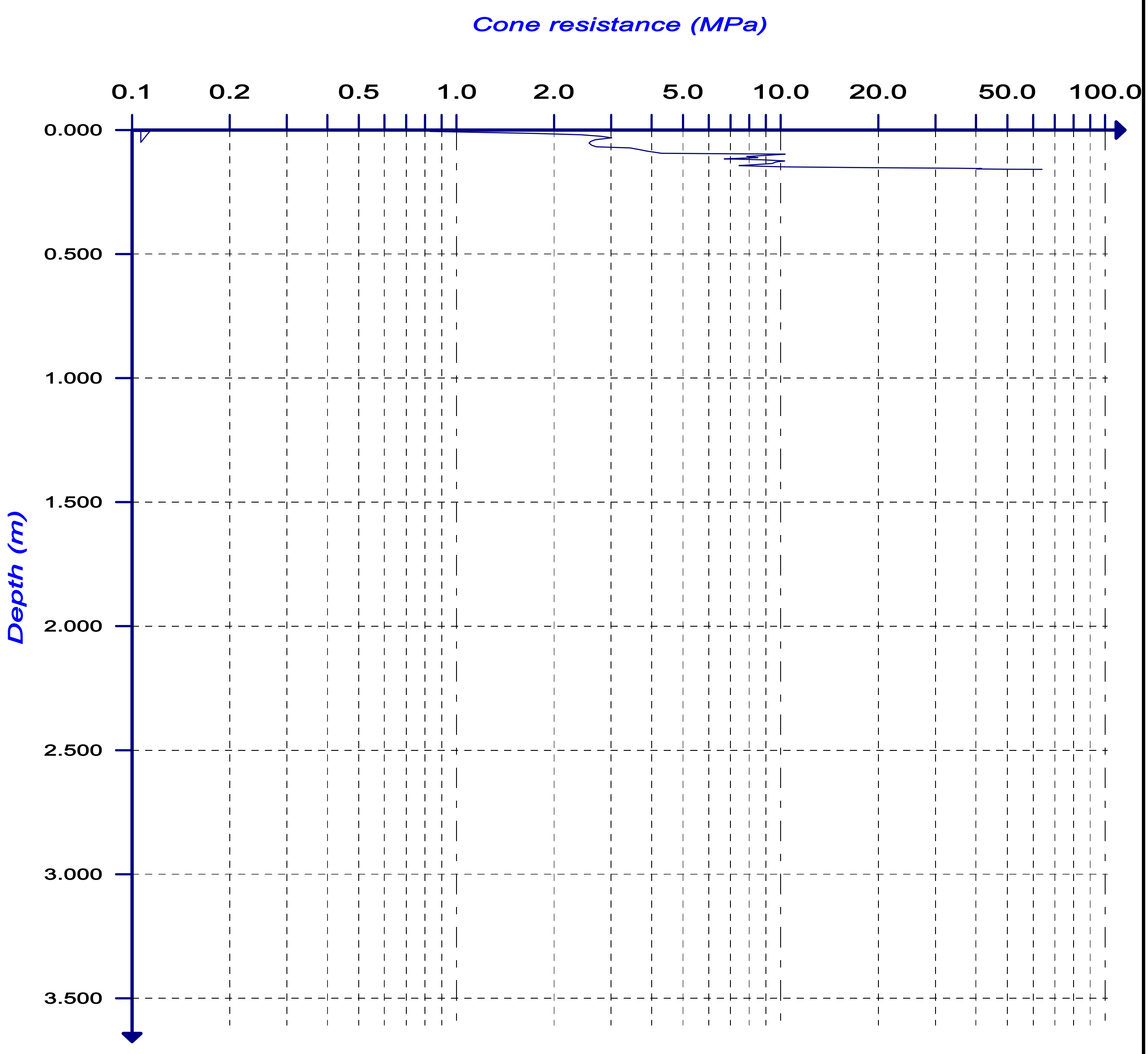
Marillana Creek Infiltration Project			
Sounding : S4-PM01 PDCP04			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 8/07/2019	



4DGeotechnics pty ltd

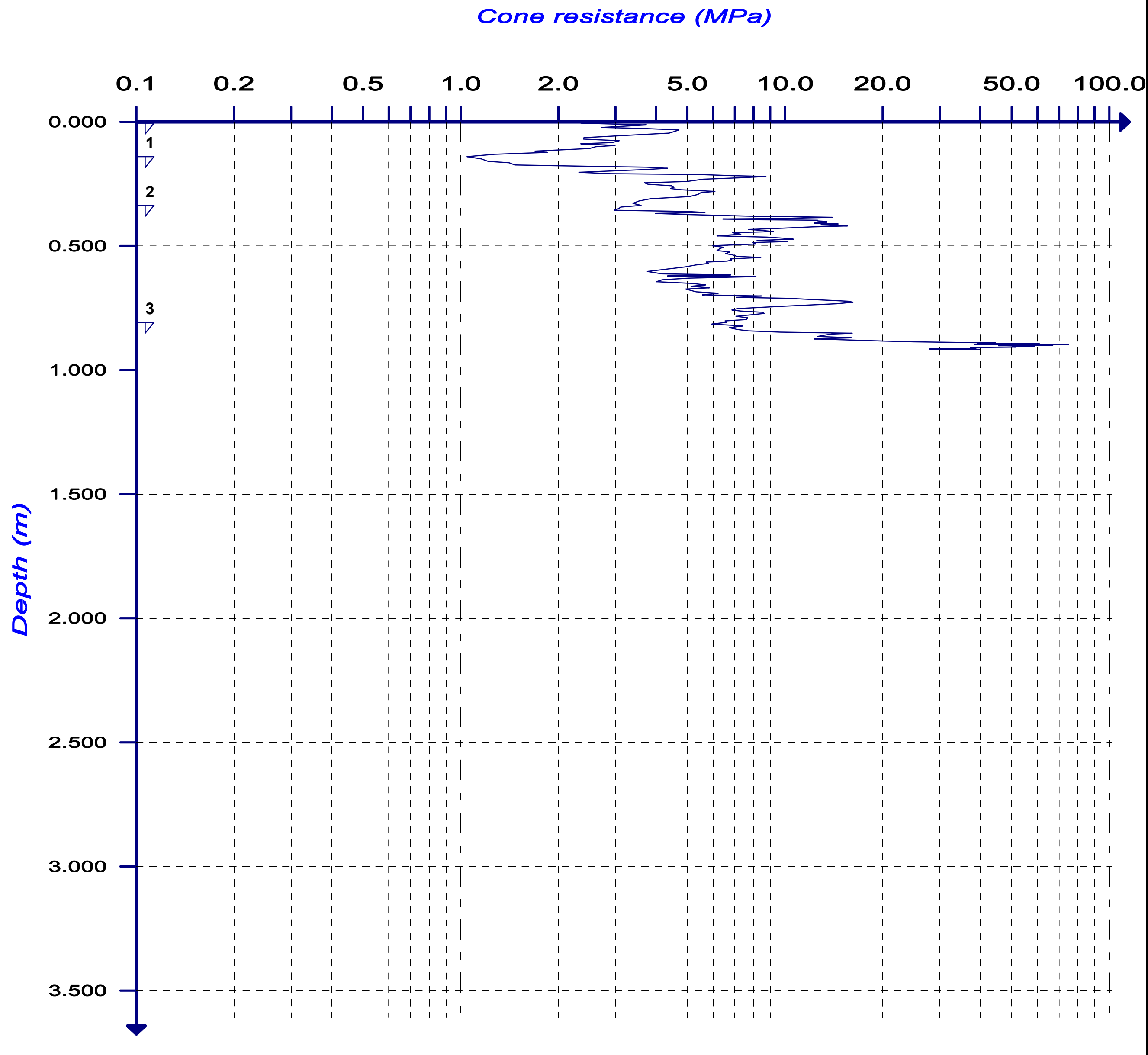
Ground investigation with variable energy dynamic penetrometer

Marillana Creek Infiltration Project			
Sounding : S5-PM01 PDCP01			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 10/07/2019	



Ground investigation with variable energy dynamic penetrometer

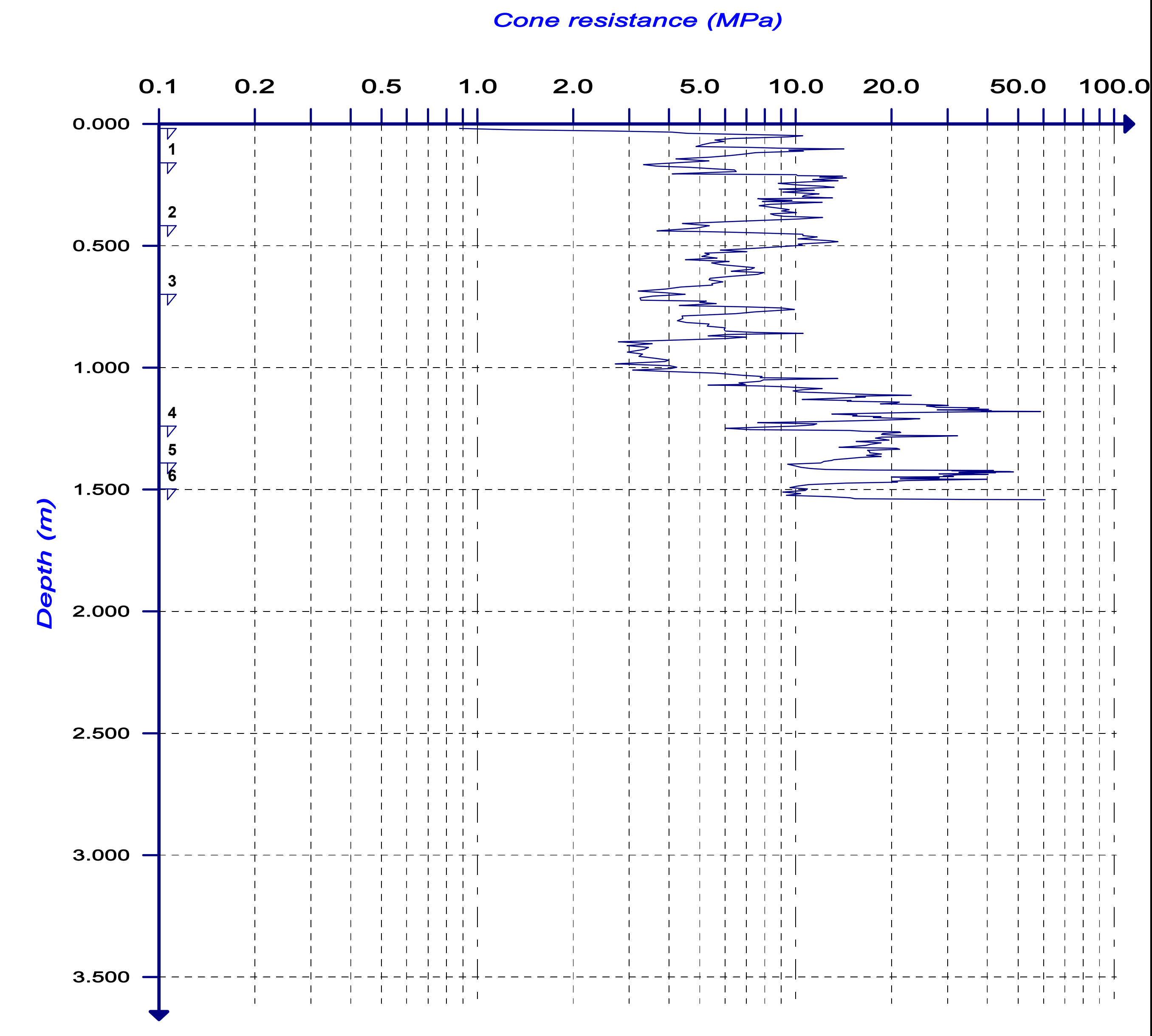
Marillana Creek Infiltration Project			
Sounding : S5-PM01 PDCP02			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 10/07/2019	



4DGeotechnics pty ltd

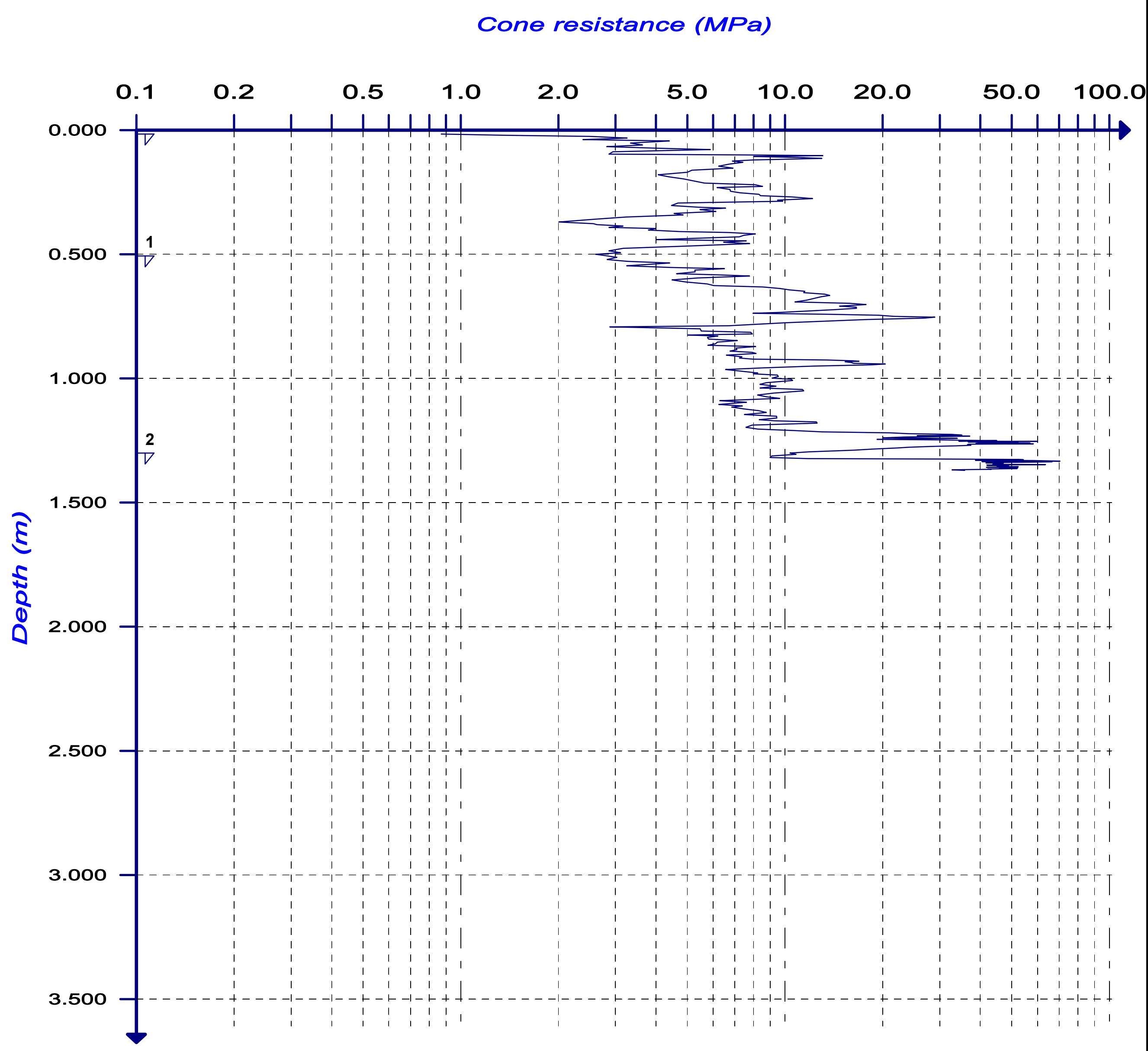
Ground investigation with variable energy dynamic penetrometer

Marillana Creek Infiltration Project			
Sounding : S5-PM01 PDCP03			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 10/07/2019	



Ground investigation with variable energy dynamic penetrometer

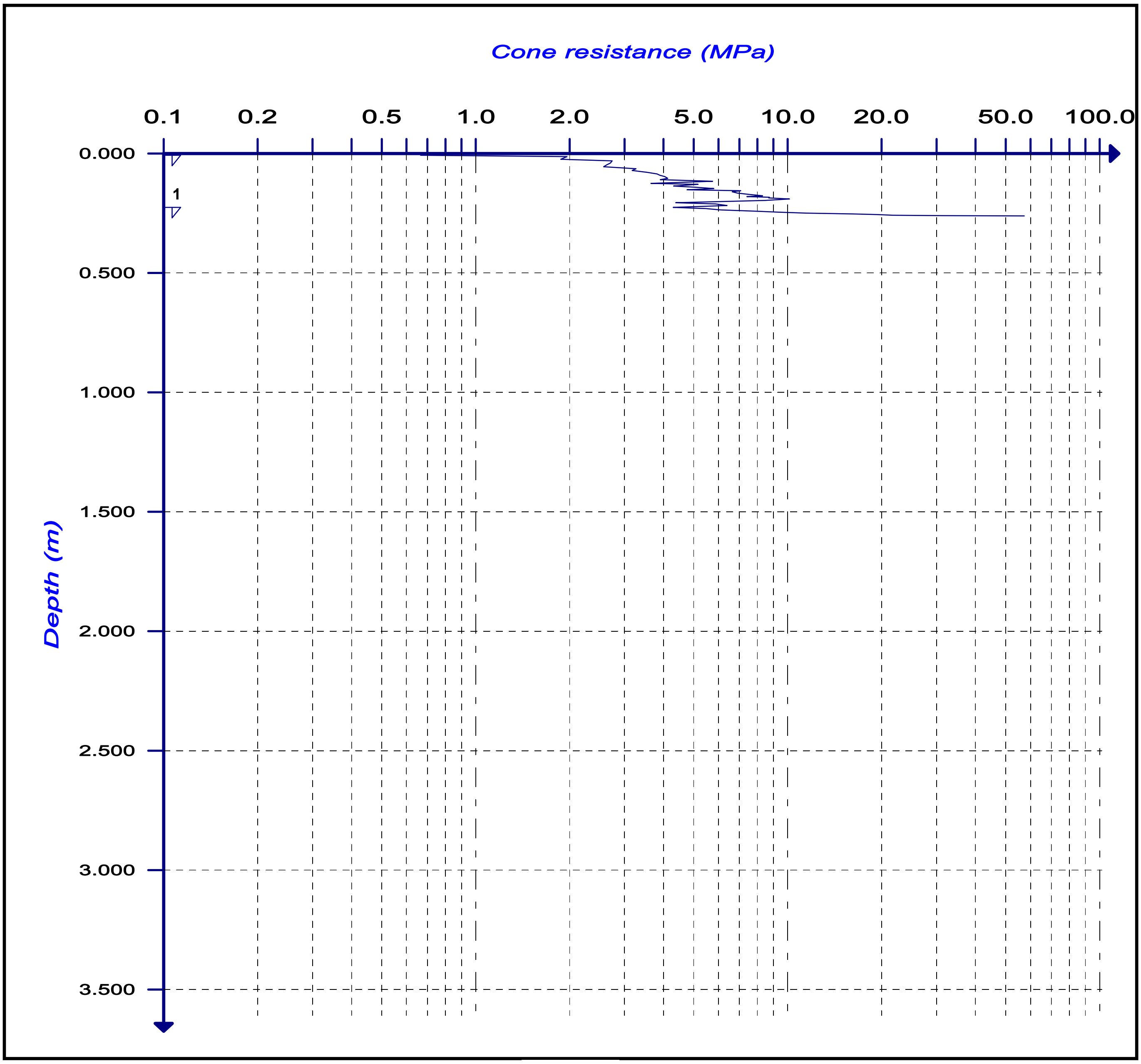
Marillana Creek Infiltration Project			
Sounding : S5-PM01 PDCP04			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 10/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

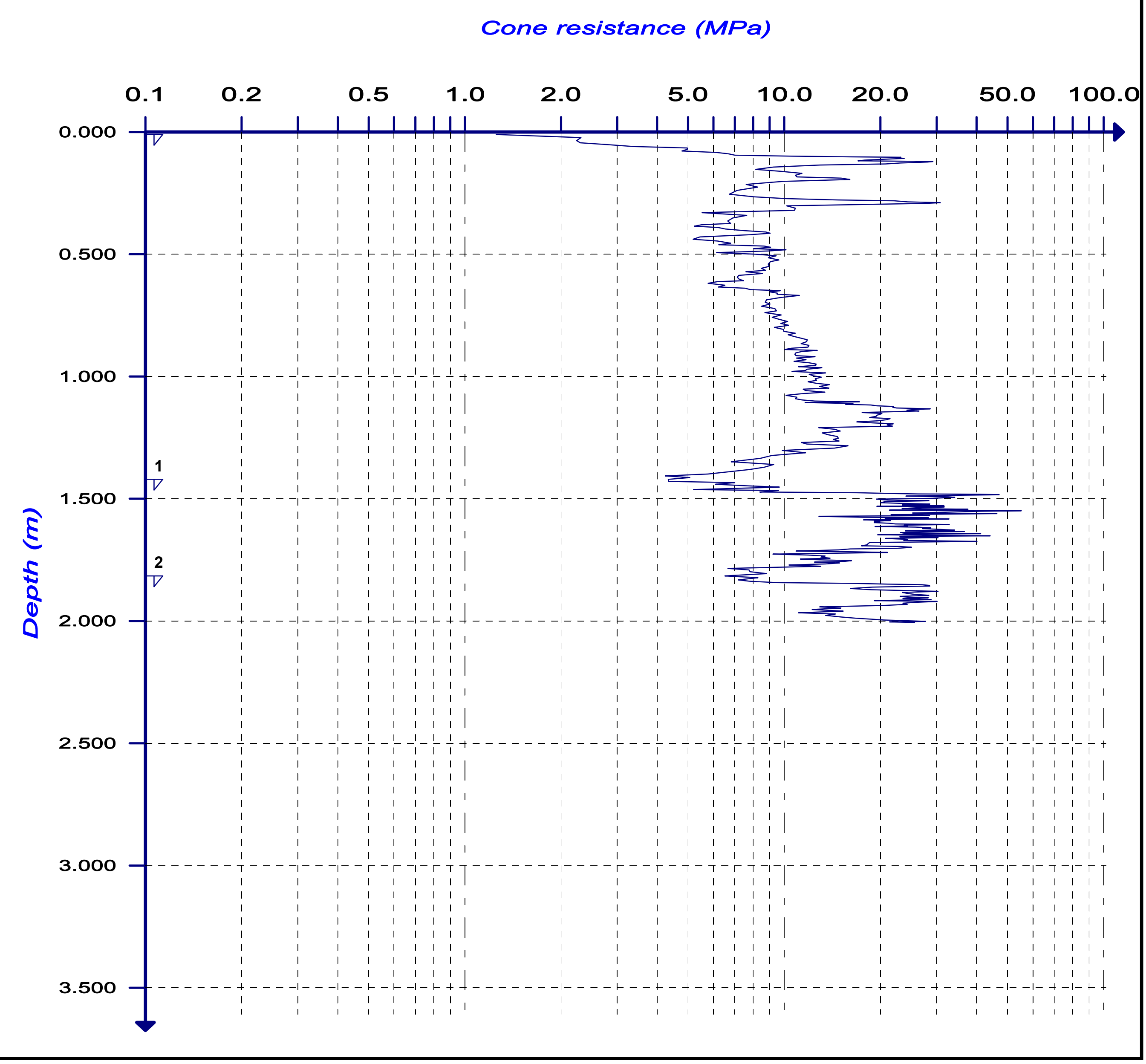
Marillana Creek Infiltration Project			
Sounding : S5-PM01 PDCP05			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 10/07/2019	



4DGeotechnics pty Ltd

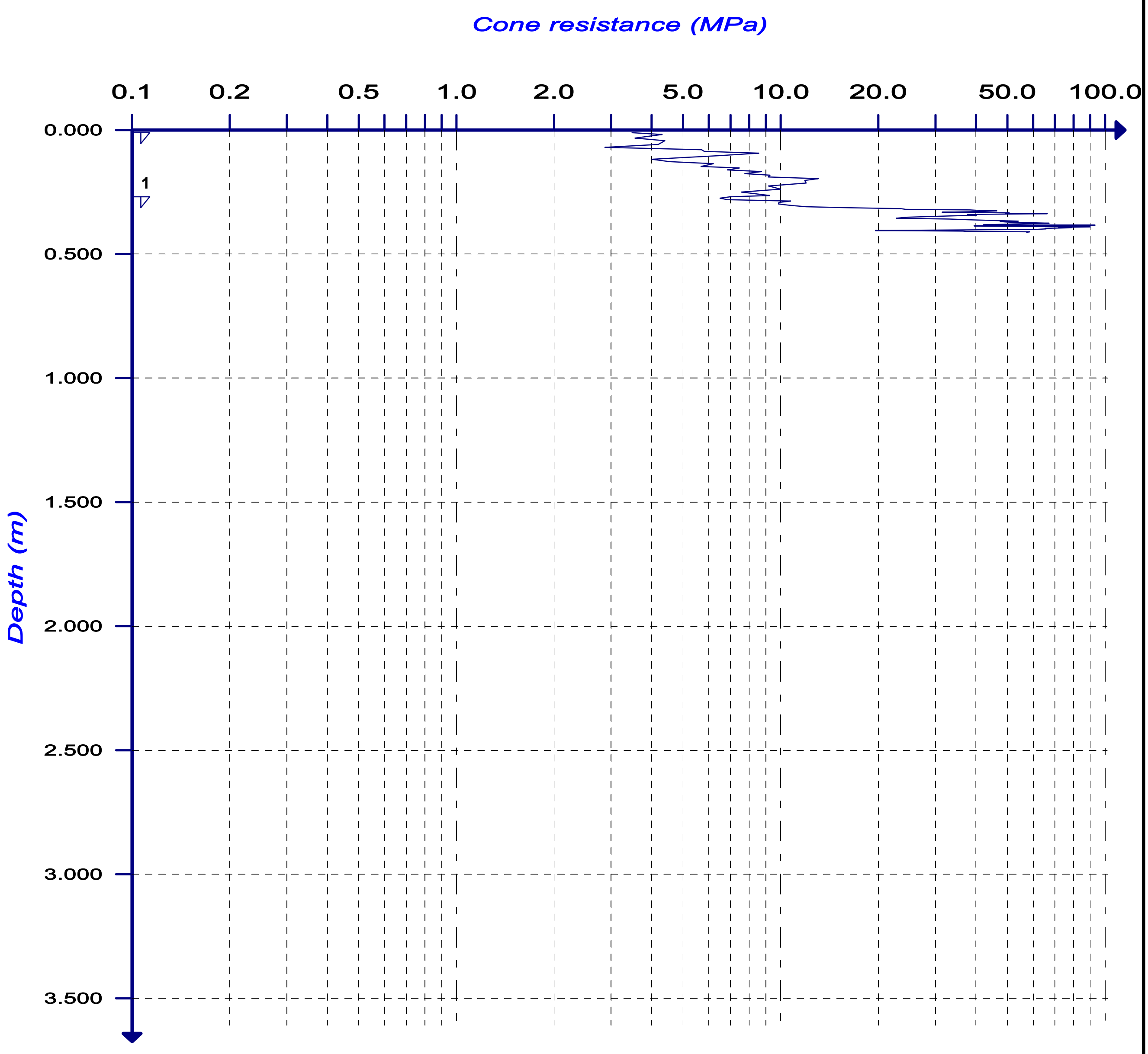
Ground investigation with variable energy dynamic penetrometer

Marillana Creek Infiltration Project			
Sounding : S6-PM01 PDCP01			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 8/07/2019	



Ground investigation with variable energy dynamic penetrometer

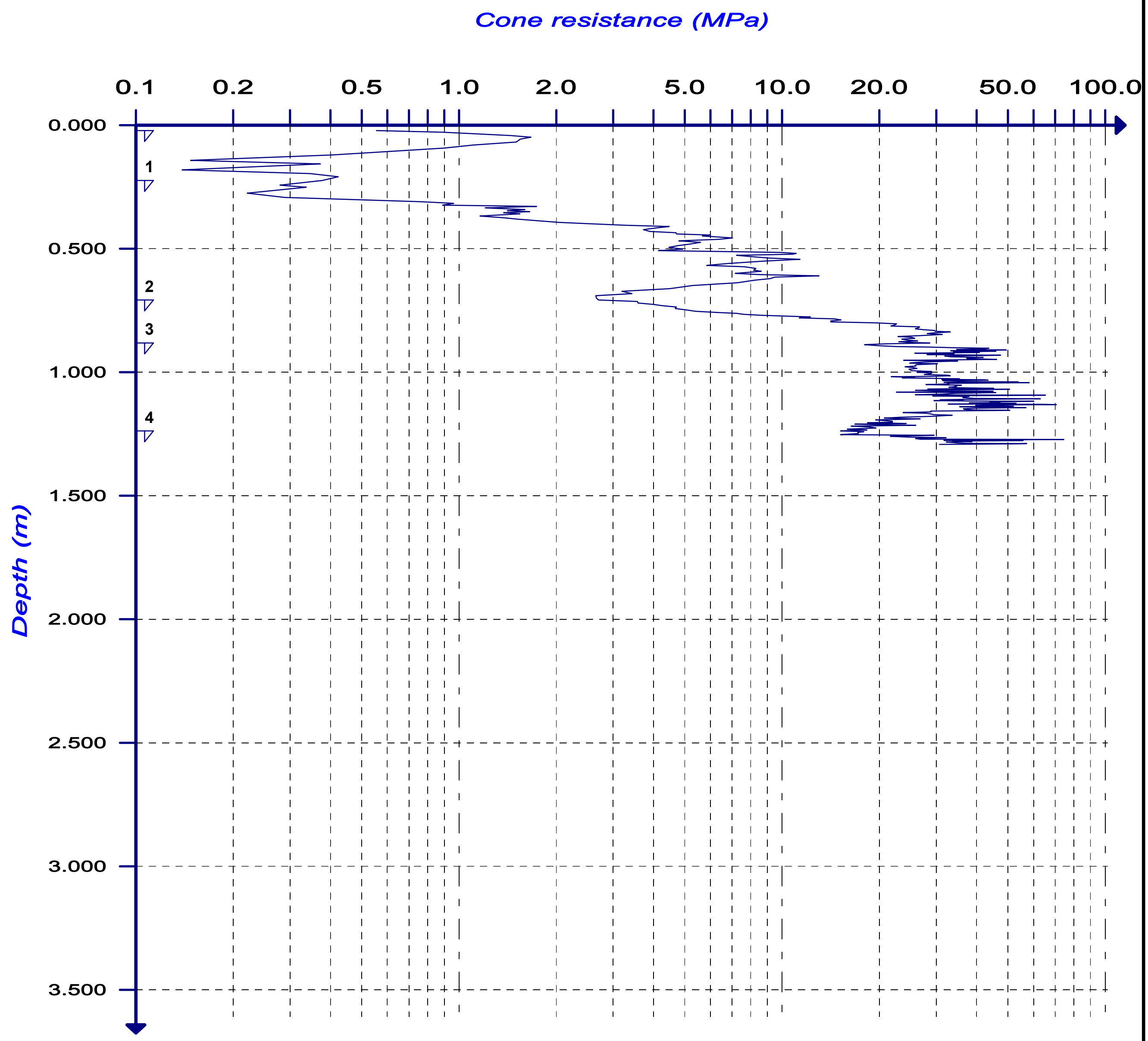
Marillana Creek Infiltration Project			
Sounding : S6-PM01 PDCP02			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 8/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

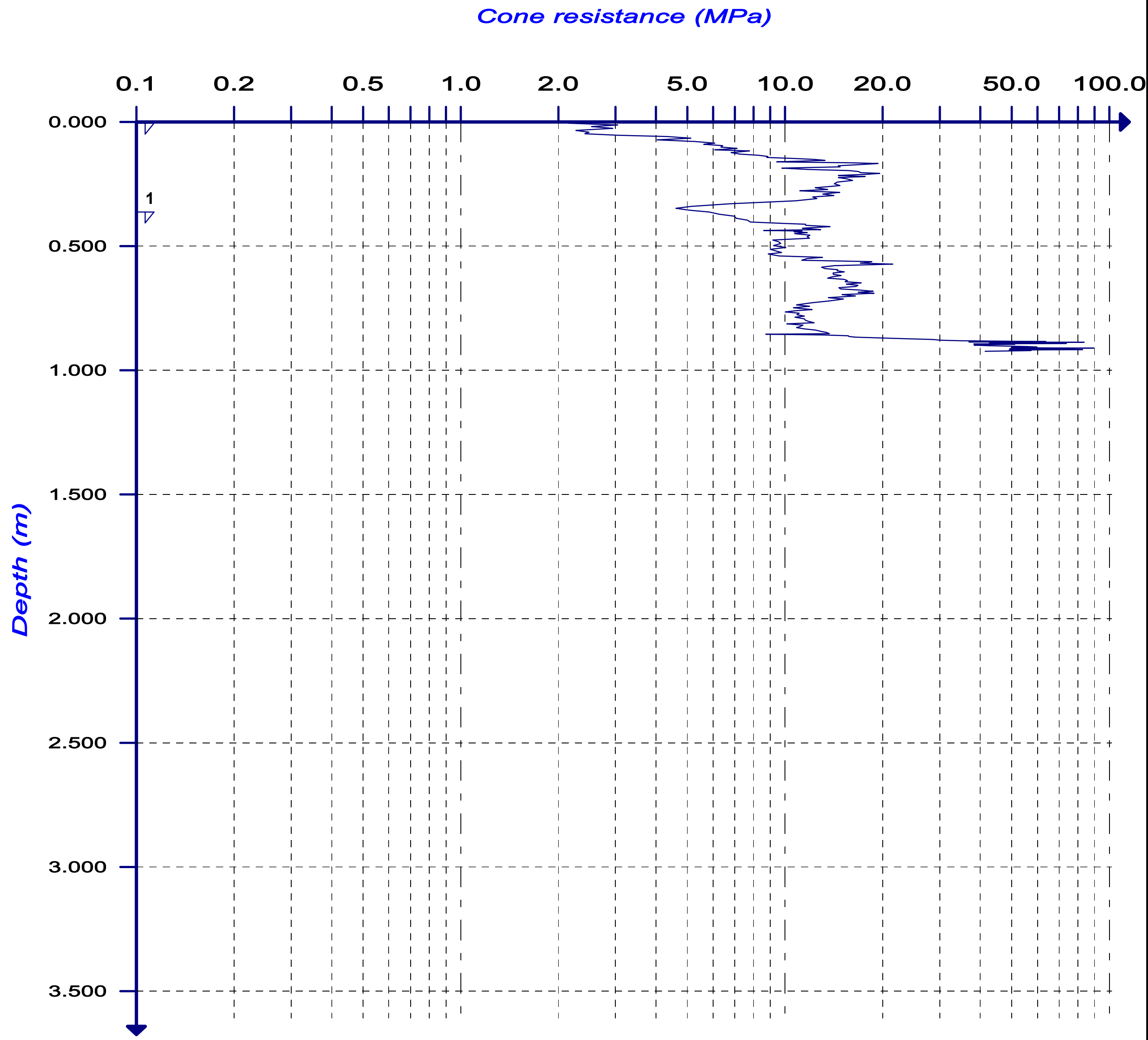
Marillana Creek Infiltration Project			
Sounding : S6-PM01 PDCP03			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 8/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

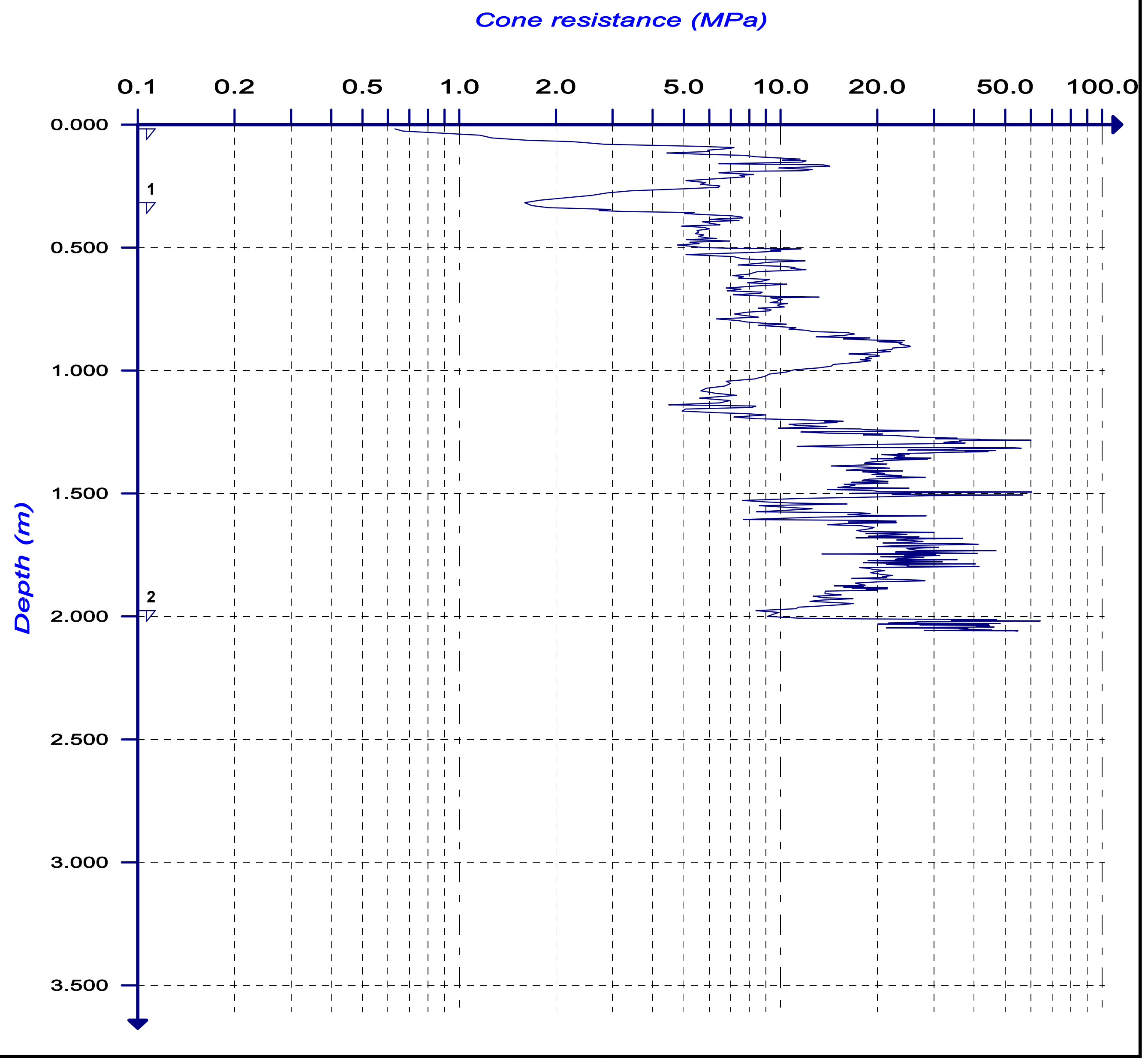
Marillana Creek Infiltration Project			
Sounding : S7-PM01 PDCP01			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 9/07/2019	



4DGeotechnics pty ltd

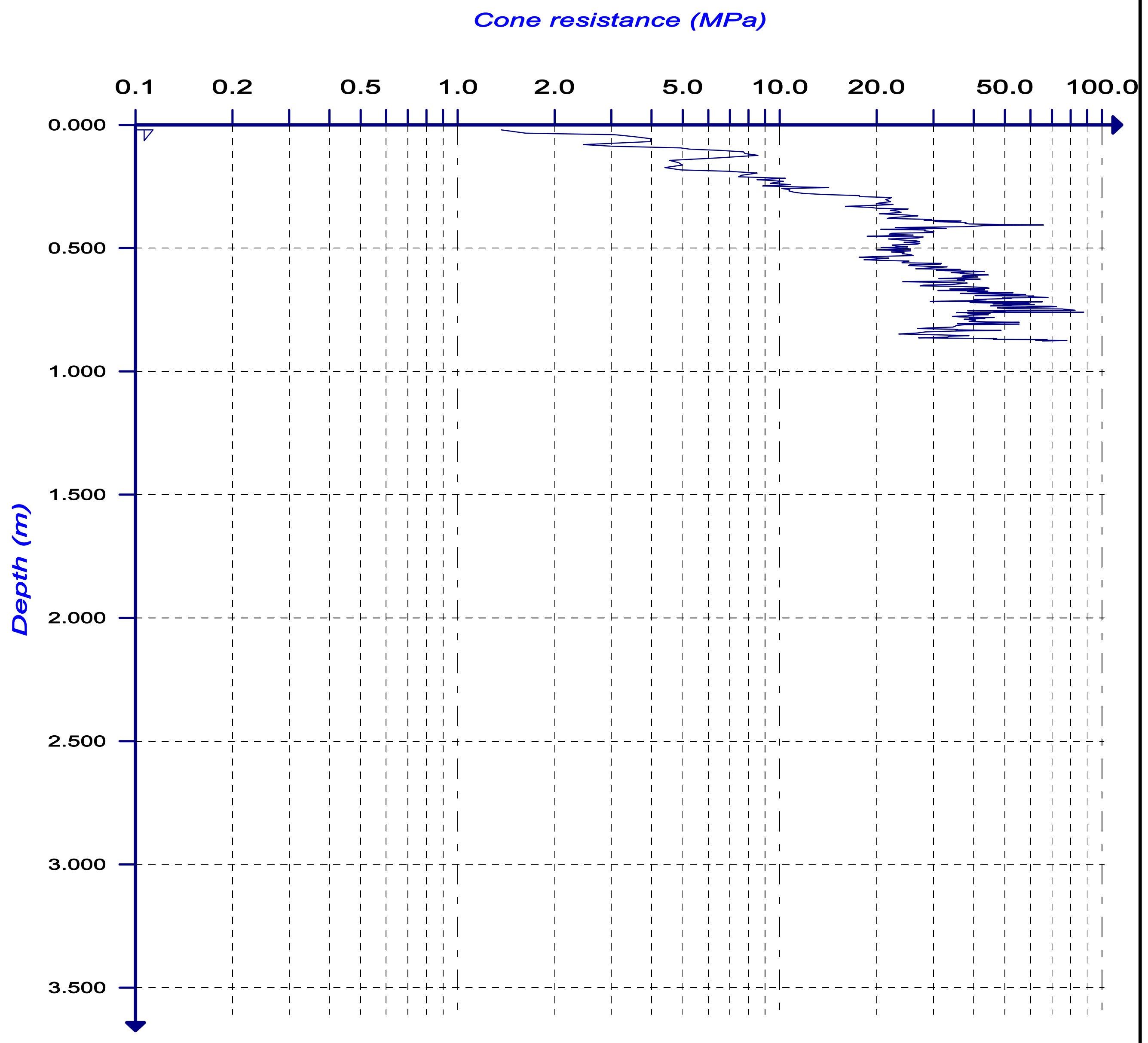
Ground investigation with variable energy dynamic penetrometer

Marillana Creek Infiltration Project			
Sounding : S7-PM01 PDCP02			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 9/07/2019	



Ground investigation with variable energy dynamic penetrometer

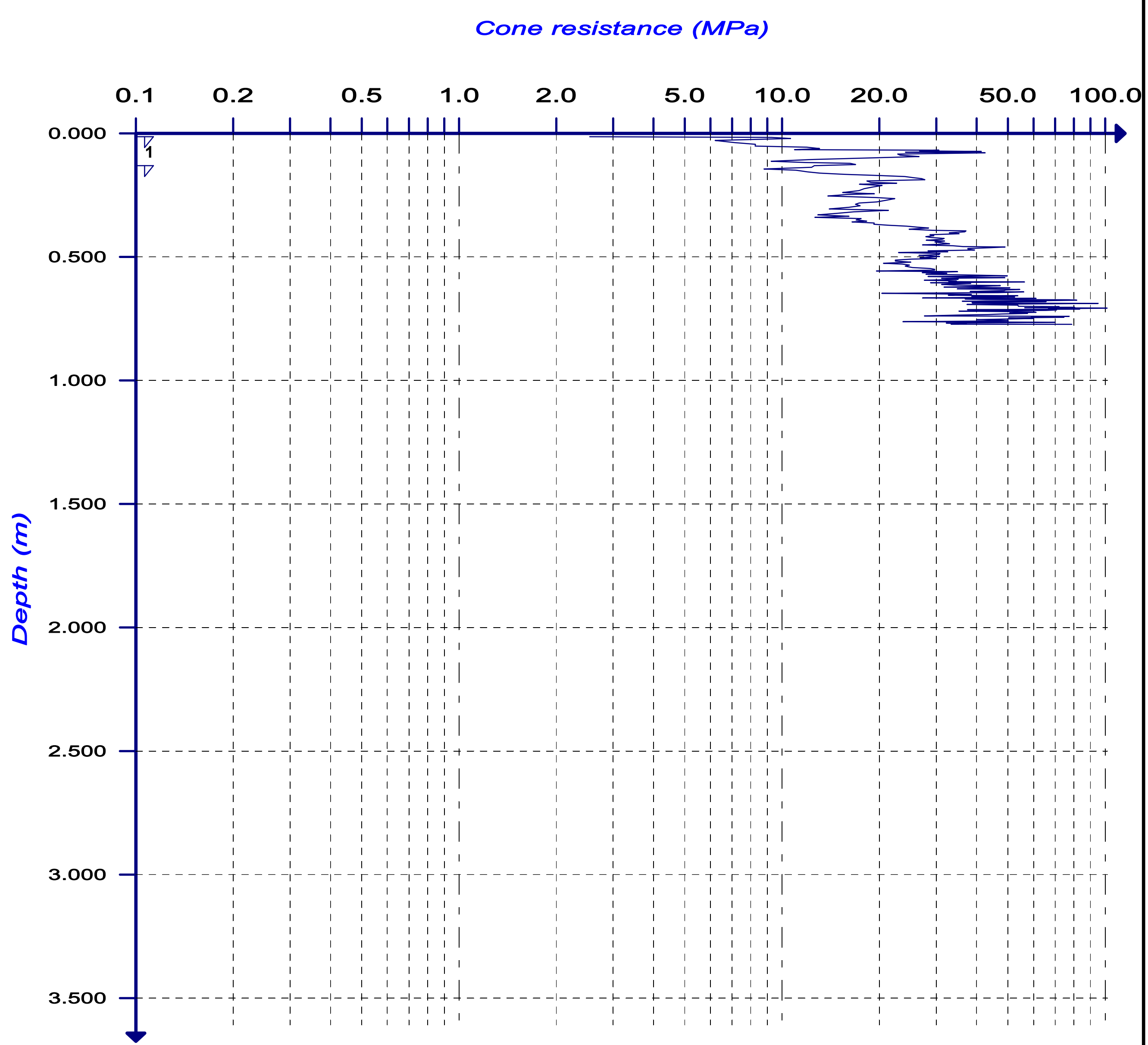
Marillana Creek Infiltration Project			
Sounding : S7-PM01 PDCP03			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 9/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

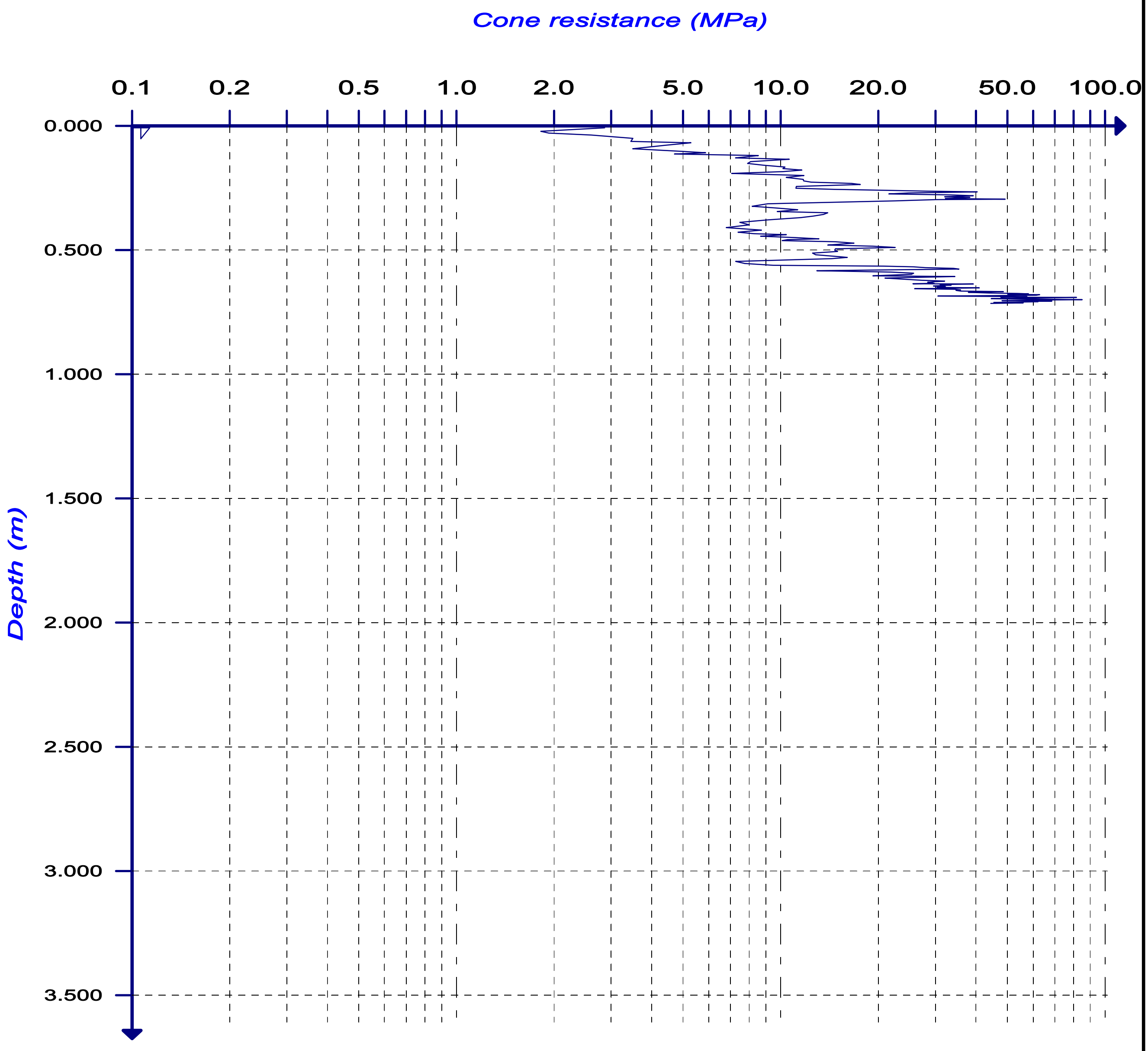
Marillana Creek Infiltration Project			
Sounding : S9-PM01 PDCP01			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 10/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

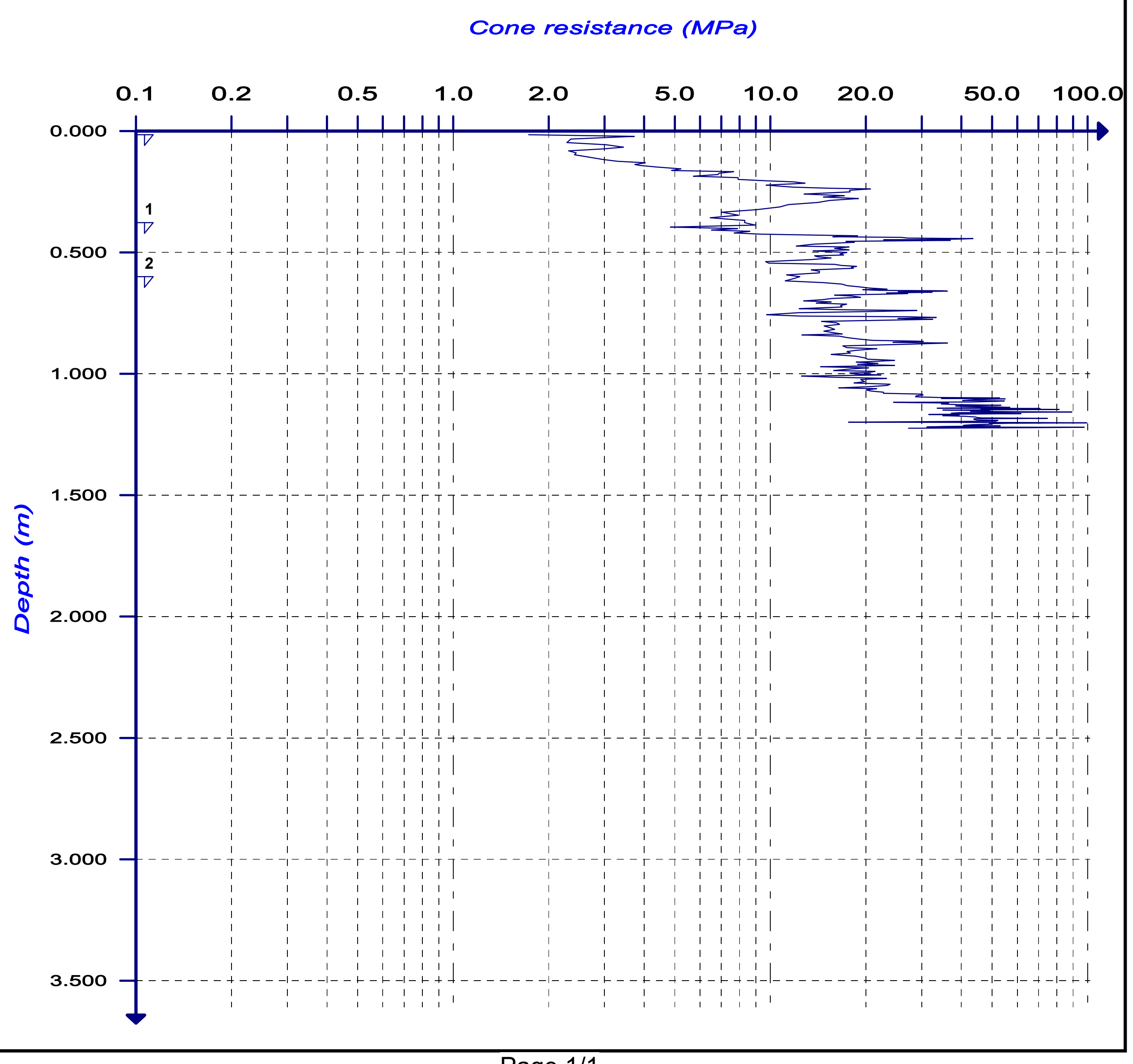
Marillana Creek Infiltration Project			
Sounding : S9-PM01 PDCP02			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 10/07/2019	



4DGeotechnics pty ltd

Ground investigation with variable energy dynamic penetrometer

Marillana Creek Infiltration Project			
Sounding : S9-PM01 PDCP03			
Weight : Panda 2 hammer	Pre-sounding depth : 0.000 m	Area : 2 cm²	Water table : Not encountered
Operator : MAS	Breaking cond. : Refusal	Date : 10/07/2019	



APPENDIX H
LABORATORY TEST RESULTS – SOIL TESTING

TEST REPORT

Client: **BHP**

SAMPLE ID: **S1-PM01**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

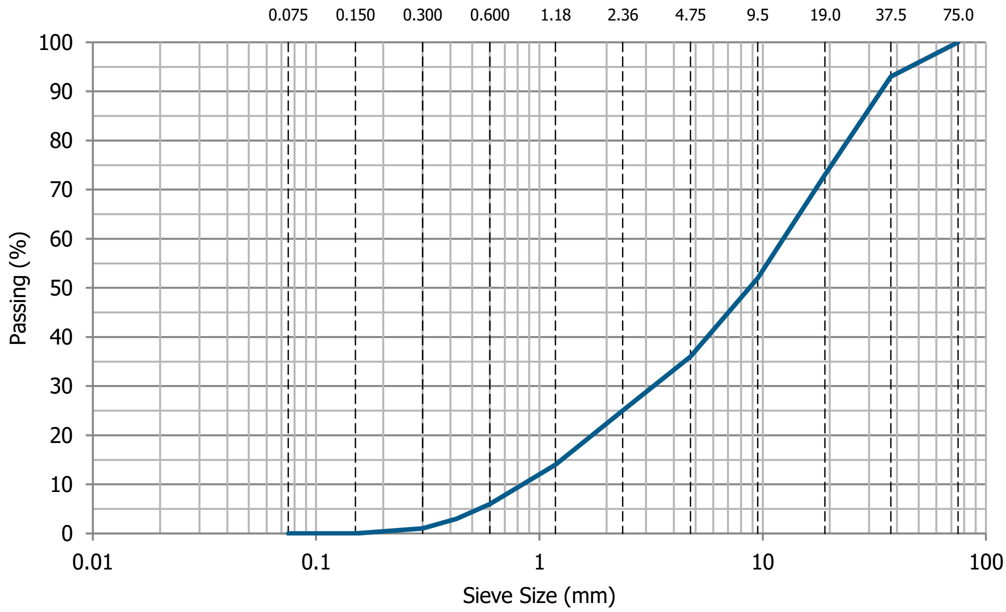
Lab test request: 19-032
Lab location: Wangara
Date tested: 31/07/2019 to 01/08/2019
Lab sample ID: WG19-0556

Earth Materials Classification Trust
Unit 6 / 5 Beneficial Way
Wangara, WA 6065

P (08) 9303 2775
W www.emclabs.com.au
E lab@emclabs.com.au

AS1289.3.6.1

Particle Size Distribution



SIEVE SIZE (mm)	PASSING (%)	SIEVE SIZE (mm)	PASSING (%)
75.0	100	1.18	14
37.5	93	0.600	6
19.0	73	0.425	3
9.5	52	0.300	1
4.75	36	0.150	0
2.36	25	0.075	0

TEST NOTES:
1. Material was sampled and supplied by the client.

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 01/08/2019
Accreditation number: 18548
Test Report No.: 19-032-0556 PSD
Page: 1 of 1

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These results apply only to the material tested, as received. Please refer to 'EMC Terms and Conditions'.

NATA
WORLD RECOGNISED ACCREDITATION

TEST REPORT

Client: **BHP**

SAMPLE ID: **S1-PM01**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 25/07/2019
Lab sample ID: WG19-0556

Earth Materials Classification Trust
Unit 6 / 5 Beneficial Way
Wangara, WA 6065

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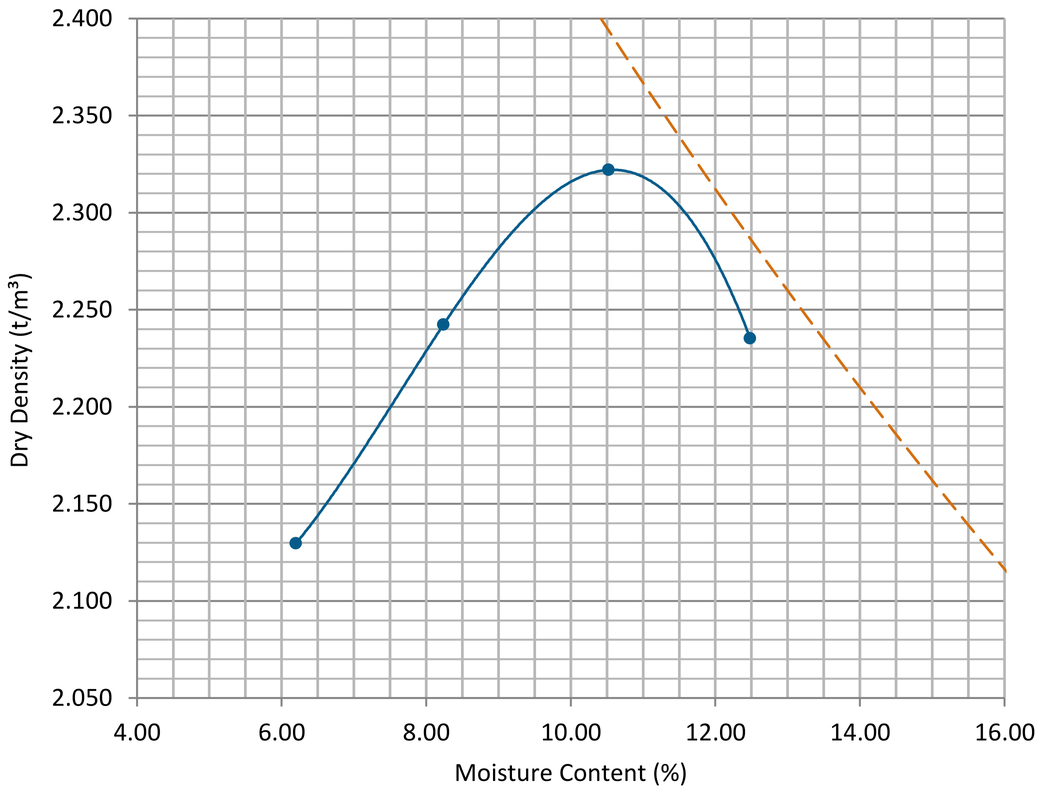
Dry Density / Moisture Content Relationship

Standard Compactive Effort (Mould A)



STANDARD MAXIMUM DRY DENSITY:	**2.32**	(t/m³)
STANDARD OPTIMUM MOISTURE CONTENT:	**10.5**	(%)
RETAINED ON 19.0mm SIEVE:	27	(%)
RETAINED ON 37.5mm SIEVE:	7	(%)
AIR VOIDS LINE:	0	(%)

TEST NOTES:

1. Zero air void line calculated from an assumed particle density of 3.20
2. Where further analysis is required, MDD and OMC values of 2.322t/m³ and 10.6% may be used.
3. Material was sampled and supplied by the client.
4. The sample was cured for 48 hours. Liquid Limit was determined by visual assessment

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 26/07/2019

Test Report No.: 19-032-0556 SMDD
Page: 1 of 1

Deviation from Standard: Insufficient material to perform the required 'Mould B' compaction. 'Mould A' was used and only material <19mm was tested, as directed by the Client.

These results apply only to the material tested, as received.
Please refer to 'EMC Terms and Conditions'.

TEST REPORT

Client: **BHP**

SAMPLE ID: **S1-PM01**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 31/07/2019
Lab sample ID: WG19-0556

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WA915.1 Calcium Carbonate Content

CALCIUM CARBONATE CONTENT ($CaCO_3$): **50.3** (%)

TEST NOTES:
1. Material was sampled and supplied by the client.

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 1/08/2019
Accreditation number: 18548
Test Report No.: 19-032-0556 CCC
Page: 1 of 1

TEST REPORT

Client:	**BHP**
SAMPLE ID:	**S2-PM01**
DEPTH:	**0.05m - 0.25m**
Project:	Marillana Creek Infiltration GBI
Location:	Pilbara, WA
Lab test request:	19-032
Lab location:	Wangara
Date tested:	31/07/2019 to 01/08/2019
Lab sample ID:	WG19-0557

Earth Materials Classification Trust
Unit 6 / 5 Beneficial Way
Wangara, WA 6065

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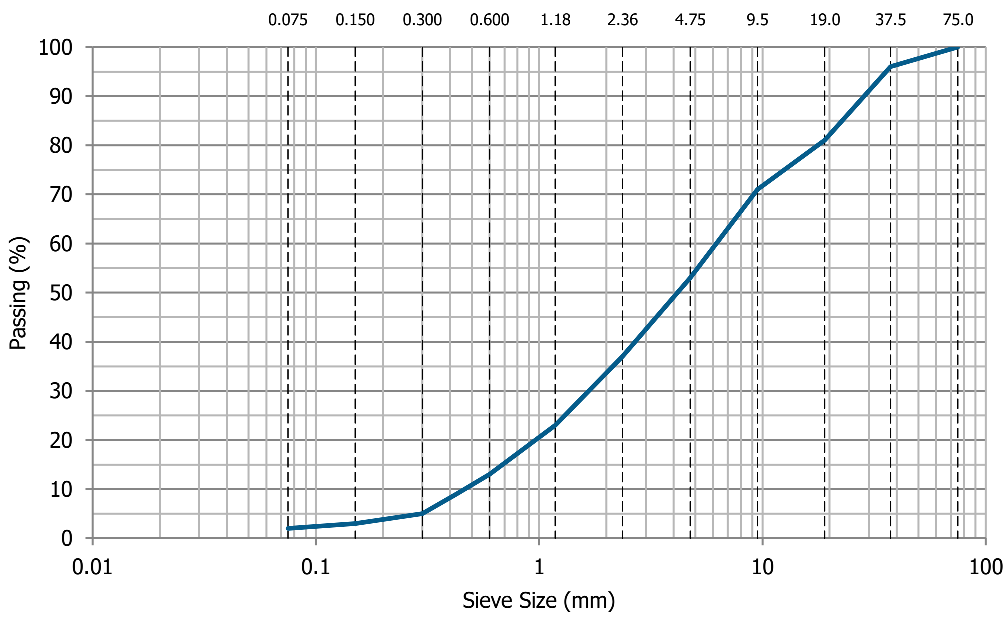
AS1289.3.6.1 | Particle Size Distribution



SIEVE SIZE (mm)	PASSING (%)	SIEVE SIZE (mm)	PASSING (%)
75.0	100	1.18	23
37.5	96	0.600	13
19.0	81	0.425	9
9.5	71	0.300	5
4.75	53	0.150	3
2.36	37	0.075	2

TEST NOTES:

1. Material was sampled and supplied by the client.

Approved signatory:	
Name:	Mick Rose
Position:	Laboratory Manager
Date:	01/08/2019
Accreditation number:	18548
Test Report No.:	19-032-0557 PSD
Page:	1 of 1

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TEST REPORT

Client: **BHP**

SAMPLE ID: **S2-PM01**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 24/07/2019
Lab sample ID: WG19-0557

Earth Materials Classification Trust
Unit 6 / 5 Beneficial Way
Wangara, WA 6065

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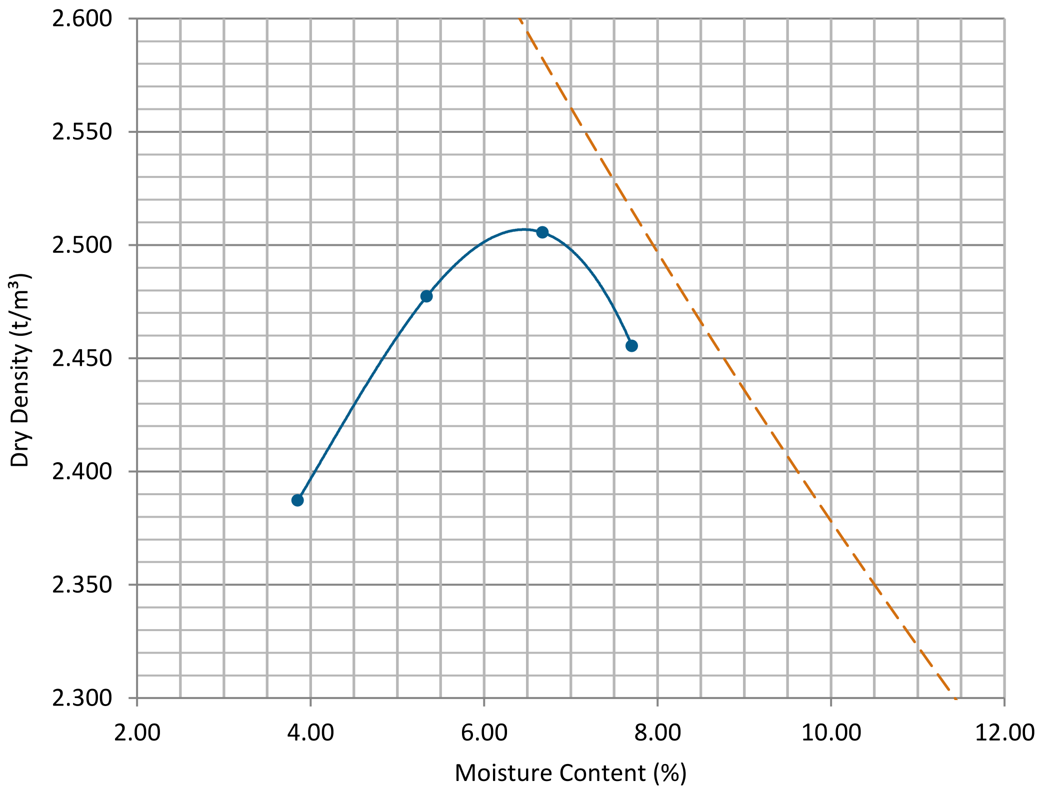
AS1289.5.1.1

Dry Density / Moisture Content Relationship

Standard Compactive Effort (Mould A)



STANDARD MAXIMUM DRY DENSITY:	**2.51**	(t/m³)
STANDARD OPTIMUM MOISTURE CONTENT:	**6.5**	(%)
RETAINED ON 19.0mm SIEVE:	19	(%)
RETAINED ON 37.5mm SIEVE:	4	(%)
AIR VOIDS LINE:	0	(%)

TEST NOTES:

1. Zero air void line calculated from an assumed particle density of 3.12
2. Where further analysis is required, MDD and OMC values of 2.507t/m³ and 6.5% may be used.
3. Material was sampled and supplied by the client.
4. The sample was cured for 2 hours. Liquid Limit was determined by visual assessment

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 25/07/2019
Accreditation number: 18548
Test Report No.: 19-032-0557 SMDD
Page: 1 of 1

The results of the tests and/or measurements included in this document are traceable to Australian/National standards. Accredited for compliance with ISO/IEC 17025 – Testing

These results apply only to the material tested, as received. Please refer to 'EMC Terms and Conditions'.

NATA
WORLD RECOGNISED ACCREDITATION

TEST REPORT

Client: **BHP**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 22/07/2019
Lab sample ID: WG19-0557

Earth Materials Classification Trust
Unit 6 / 5 Beneficial Way
Wangara, WA 6065

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AS1289.2.1.1

Moisture Content

Oven Method

CLIENT SAMPLE ID	DEPTH	MOISTURE CONTENT (%)	LAB SAMPLE ID
S2-PM01	0.05m - 0.25m	**5.0**	WG19-0557

TEST NOTES:

1. Material was sampled and supplied by the client.

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 01/08/2019
Accreditation number: 18548
Test Report No.: 19-032-0557 MC
Page: 1 of 1

TEST REPORT

Client: **BHP**

SAMPLE ID: **S2-PM02**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 31/07/2019 to 01/08/2019
Lab sample ID: WG19-0558

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Wangara, WA 6065

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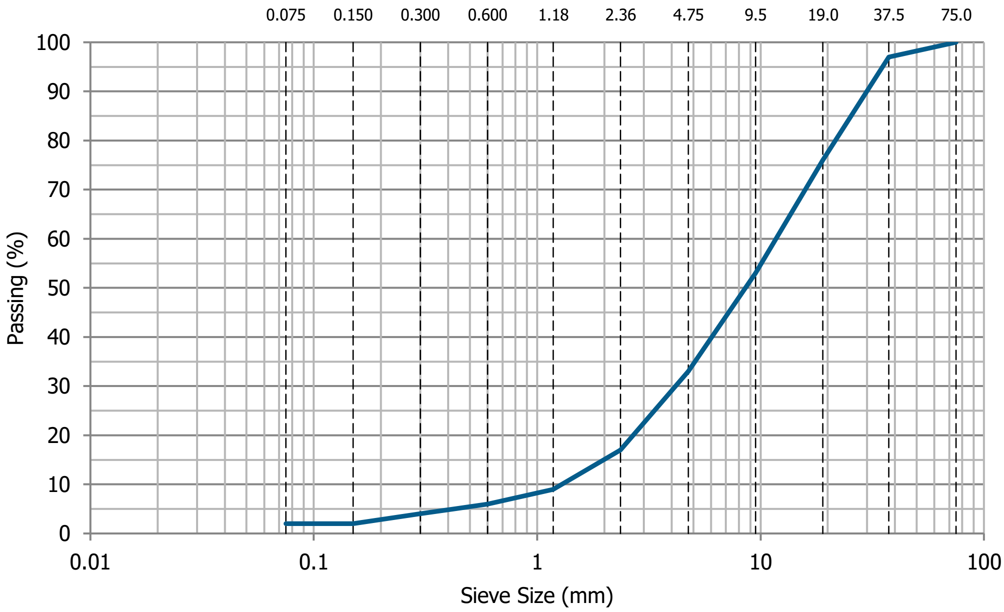
AS1289.3.6.1

Particle Size Distribution



SIEVE SIZE (mm)	PASSING (%)	SIEVE SIZE (mm)	PASSING (%)
75.0	100	1.18	9
37.5	97	0.600	6
19.0	76	0.425	5
9.5	53	0.300	4
4.75	33	0.150	2
2.36	17	0.075	2

TEST NOTES:
1. Material was sampled and supplied by the client.

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 01/08/2019
Accreditation number: 18548
Test Report No.: 19-032-0558 PSD
Page: 1 of 1

TEST REPORT

Client: **BHP**

SAMPLE ID: **S2-PM02**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 25/07/2019
Lab sample ID: WG19-0558

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Wangara, WA 6065

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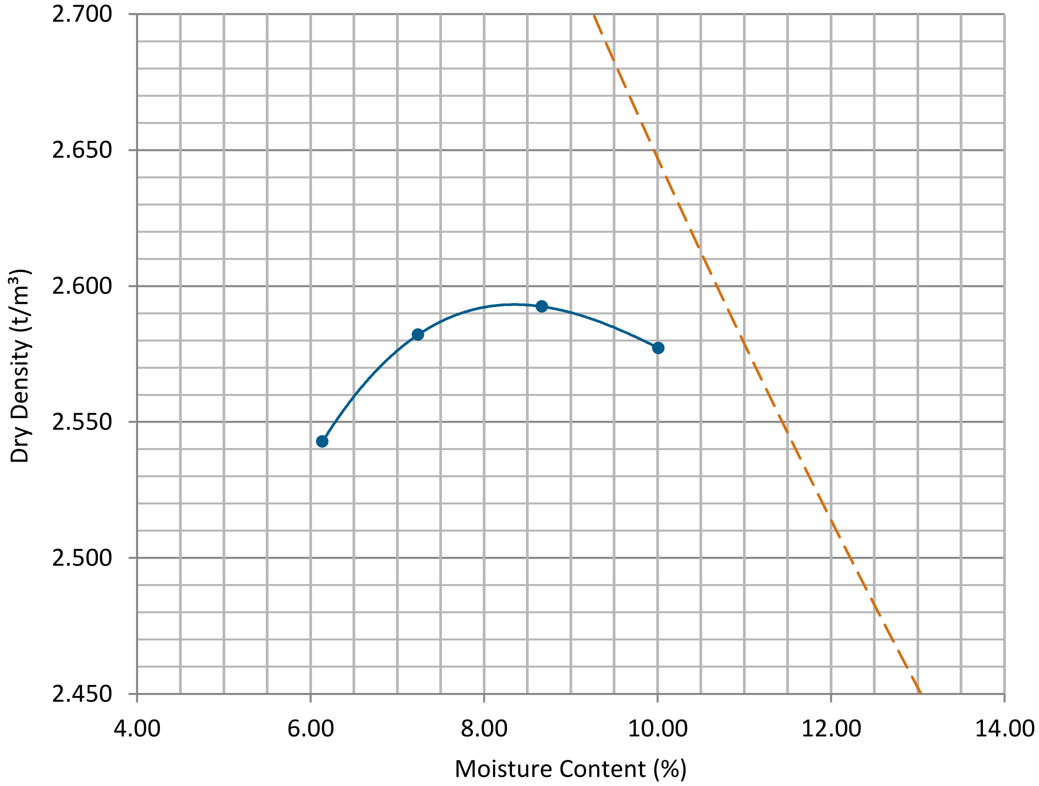
Dry Density / Moisture Content Relationship

Standard Compactive Effort (Mould A)



STANDARD MAXIMUM DRY DENSITY:	**2.59**	(t/m^3)
STANDARD OPTIMUM MOISTURE CONTENT:	**8.5**	(%)
RETAINED ON 19.0mm SIEVE:	24	(%)
RETAINED ON 37.5mm SIEVE:	3	(%)
AIR VOIDS LINE:	0	(%)

TEST NOTES:

1. Zero air void line calculated from an assumed particle density of 3.60
2. Where further analysis is required, MDD and OMC values of 2.593t/m³ and 8.4% may be used.
3. Material was sampled and supplied by the client.
4. The sample was cured for 2 hours. Liquid Limit was determined by visual assessment

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 26/07/2019

Test Report No.: 19-032-0558 SMDD
Page: 1 of 1

Deviation from Standard: Insufficient material to perform the required 'Mould B' compaction. 'Mould A' was used and only material <19mm was tested, as directed by the Client.

These results apply only to the material tested, as received. Please refer to 'EMC Terms and Conditions'.

TEST REPORT

Client: **BHP**

SAMPLE ID: **S3-PM01**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 31/07/2019 to 01/08/2019
Lab sample ID: WG19-0559

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Wangara, WA 6065

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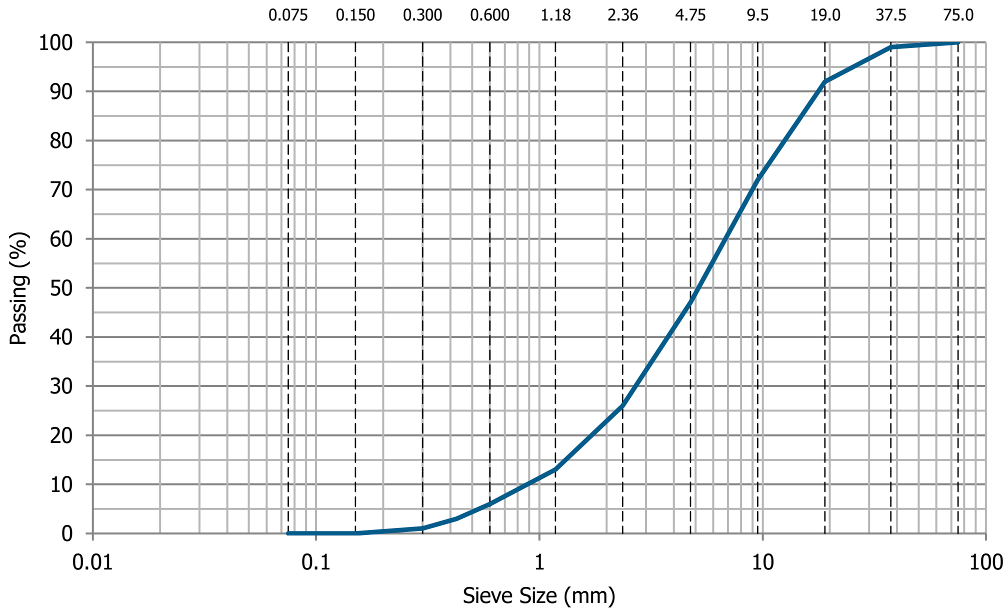
AS1289.3.6.1

Particle Size Distribution



SIEVE SIZE (mm)	PASSING (%)	SIEVE SIZE (mm)	PASSING (%)
75.0	100	1.18	13
37.5	99	0.600	6
19.0	92	0.425	3
9.5	72	0.300	1
4.75	47	0.150	0
2.36	26	0.075	0

TEST NOTES:
1. Material was sampled and supplied by the client.

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 01/08/2019
Accreditation number: 18548
Test Report No.: 19-032-0559 PSD
Page: 1 of 1

TEST REPORT

Client:	**BHP**
SAMPLE ID:	**S3-PM01**
DEPTH:	**0.05m - 0.25m**
Project:	Marillana Creek Infiltration GBI
Location:	Pilbara, WA
Lab test request:	19-032
Lab location:	Wangara
Date tested:	24/07/2019
Lab sample ID:	WG19-0559

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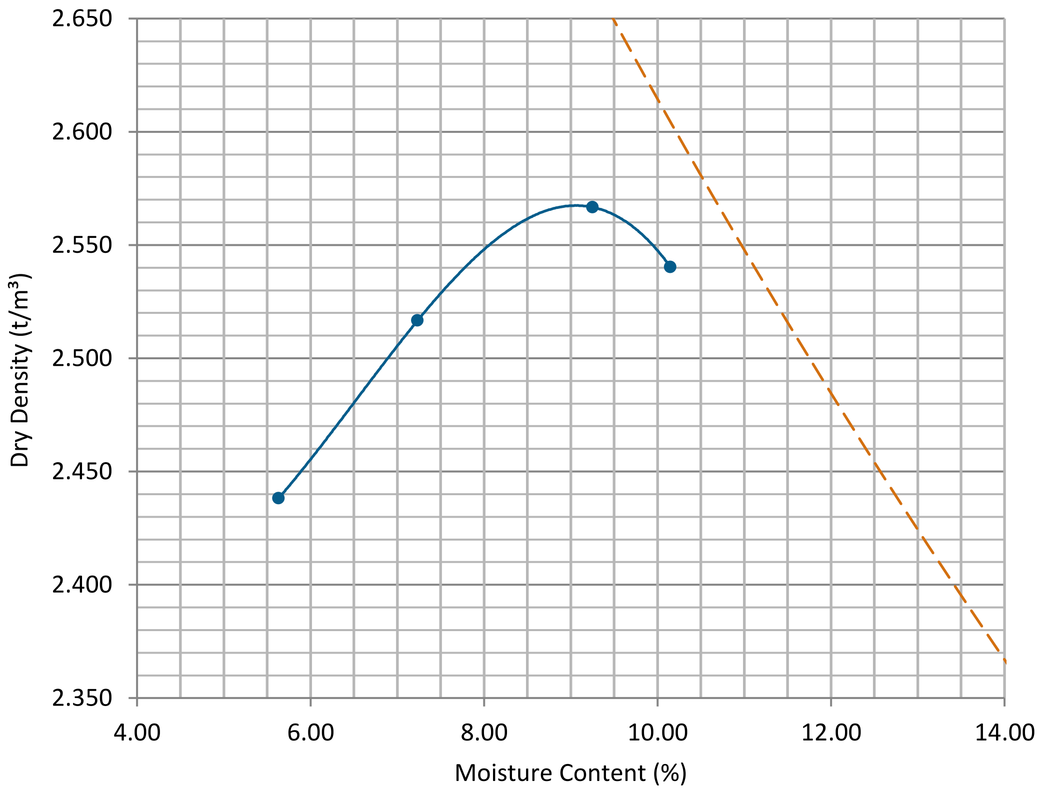
Dry Density / Moisture Content Relationship

Standard Compactive Effort (Mould A)



STANDARD MAXIMUM DRY DENSITY:	**2.57**	(t/m³)
STANDARD OPTIMUM MOISTURE CONTENT:	**9.0**	(%)
RETAINED ON 19.0mm SIEVE:	8	(%)
RETAINED ON 37.5mm SIEVE:	1	(%)
AIR VOIDS LINE:	0	(%)

TEST NOTES:

1. Zero air void line calculated from an assumed particle density of 3.54
2. Where further analysis is required, MDD and OMC values of 2.567t/m³ and 9.1% may be used.
3. Material was sampled and supplied by the client.
4. The sample was cured for 2 hours. Liquid Limit was determined by visual assessment

Approved signatory:	
Name:	Mick Rose
Position:	Laboratory Manager
Date:	25/07/2019
Accreditation number:	18548
Test Report No.:	19-032-0559 SMDD
Page:	1 of 1

TEST REPORT

Client:	**BHP**
SAMPLE ID:	**S4-PM01**
DEPTH:	**0.05m - 0.25m**
Project:	Marillana Creek Infiltration GBI
Location:	Pilbara, WA
Lab test request:	19-032
Lab location:	Wangara
Date tested:	31/07/2019 to 01/08/2019
Lab sample ID:	WG19-0560

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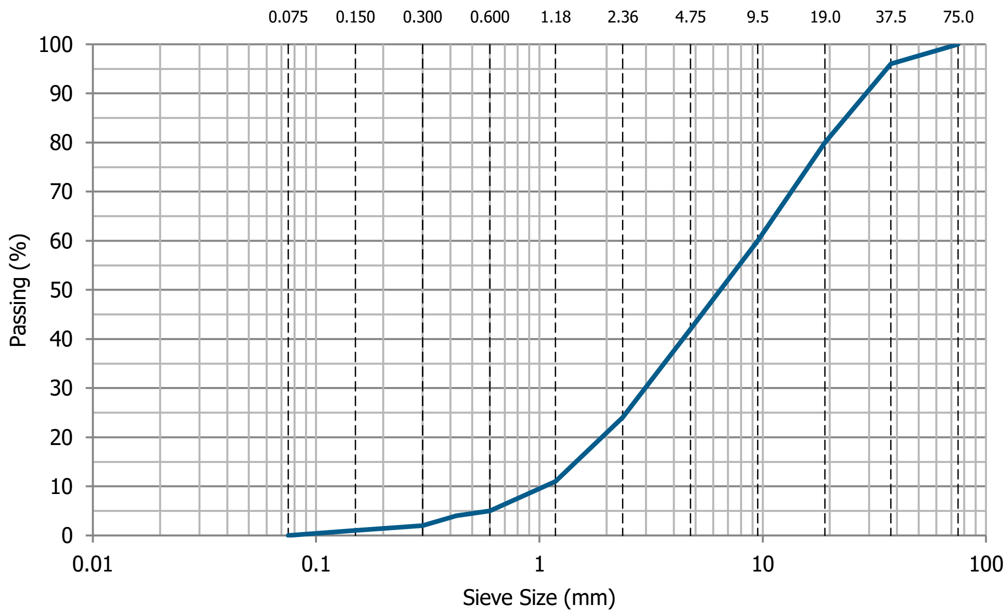
AS1289.3.6.1

Particle Size Distribution



SIEVE SIZE (mm)	PASSING (%)	SIEVE SIZE (mm)	PASSING (%)
75.0	100	1.18	11
37.5	96	0.600	5
19.0	80	0.425	4
9.5	60	0.300	2
4.75	42	0.150	1
2.36	24	0.075	0

TEST NOTES:

1. Material was sampled and supplied by the client.

Approved signatory:	
Name:	Mick Rose
Position:	Laboratory Manager
Date:	01/08/2019
Accreditation number:	18548
Test Report No.:	19-032-0560 PSD
Page:	1 of 1

TEST REPORT

Client: **BHP**

SAMPLE ID: **S4-PM01**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 24/07/2019
Lab sample ID: WG19-0560

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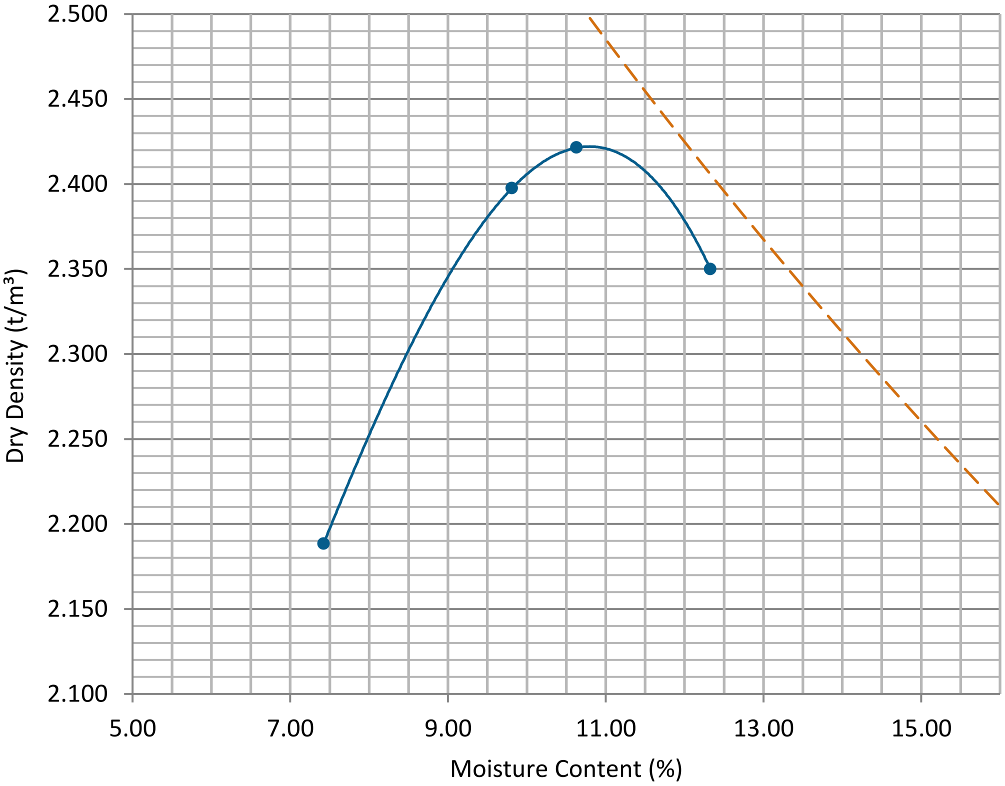
Dry Density / Moisture Content Relationship

Standard Compactive Effort (Mould A)



STANDARD MAXIMUM DRY DENSITY:	**2.42**	(t/m³)
STANDARD OPTIMUM MOISTURE CONTENT:	**11.0**	(%)
RETAINED ON 19.0mm SIEVE:	20	(%)
RETAINED ON 37.5mm SIEVE:	4	(%)
AIR VOIDS LINE:	0	(%)

TEST NOTES:

1. Zero air void line calculated from an assumed particle density of 3.42
2. Where further analysis is required, MDD and OMC values of 2.422t/m³ and 10.8% may be used.
3. Material was sampled and supplied by the client.
4. The sample was cured for 2 hours. Liquid Limit was determined by visual assessment

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 25/07/2019
Accreditation number: 18548
Test Report No.: 19-032-0560 SMDD
Page: 1 of 1

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TEST REPORT

Client: **BHP**

SAMPLE ID: **S5-PM01**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 31/07/2019 to 01/08/2019
Lab sample ID: WG19-0561

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Wangara, WA 6065

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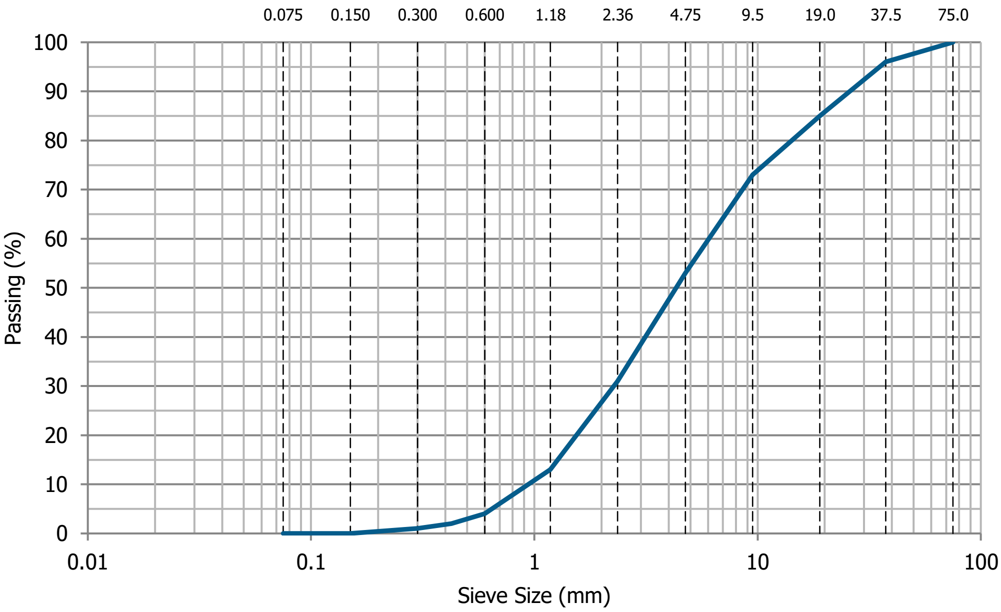
AS1289.3.6.1

Particle Size Distribution



SIEVE SIZE (mm)	PASSING (%)	SIEVE SIZE (mm)	PASSING (%)
75.0	100	1.18	13
37.5	96	0.600	4
19.0	85	0.425	2
9.5	73	0.300	1
4.75	53	0.150	0
2.36	31	0.075	0

TEST NOTES:
1. Material was sampled and supplied by the client.

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 1/08/2019
Accreditation number: 18548
Test Report No.: 19-032-0561 PSD
Page: 1 of 1

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NATA
WORLD RECOGNISED ACCREDITATION

TEST REPORT

Client: **BHP**

SAMPLE ID: **S5-PM01**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 25/07/2019
Lab sample ID: WG19-0561

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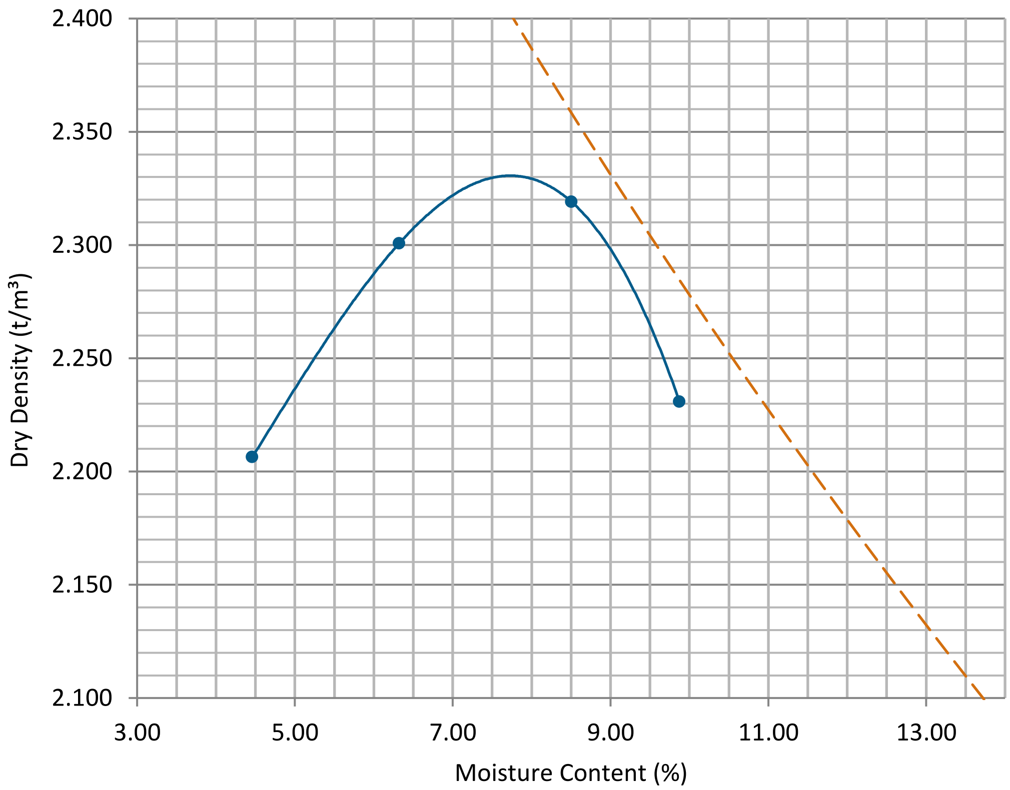
AS1289.5.1.1

Dry Density / Moisture Content Relationship

Standard Compactive Effort (Mould A)



STANDARD MAXIMUM DRY DENSITY:	**2.33**	(t/m³)
STANDARD OPTIMUM MOISTURE CONTENT:	**7.5**	(%)
RETAINED ON 19.0mm SIEVE:	15	(%)
RETAINED ON 37.5mm SIEVE:	4	(%)
AIR VOIDS LINE:	0	(%)

TEST NOTES:

1. Zero air void line calculated from an assumed particle density of 2.95
2. Where further analysis is required, MDD and OMC values of 2.331t/m³ and 7.7% may be used.
3. Material was sampled and supplied by the client.
4. The sample was cured for 2 hours. Liquid Limit was determined by visual assessment

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 26/07/2019
Accreditation number: 18548
Test Report No.: 19-032-0561 SMDD
Page: 1 of 1

TEST REPORT

Client: **BHP**

SAMPLE ID: **S5-PM02**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 31/07/2019 to 01/08/2019
Lab sample ID: WG19-0562

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Wangara, WA 6065

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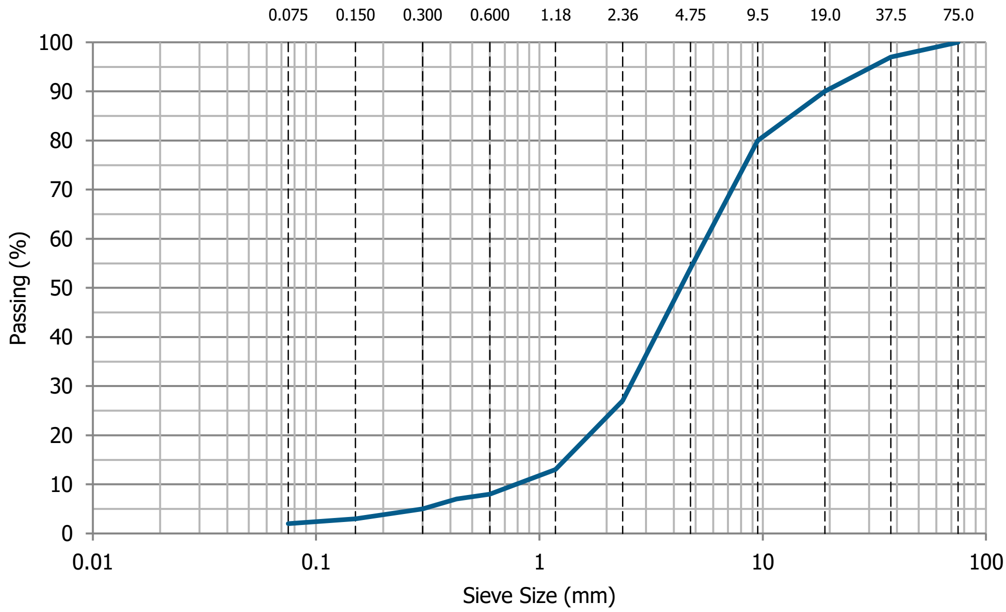
AS1289.3.6.1

Particle Size Distribution



SIEVE SIZE (mm)	PASSING (%)	SIEVE SIZE (mm)	PASSING (%)
75.0	100	1.18	13
37.5	97	0.600	8
19.0	90	0.425	7
9.5	80	0.300	5
4.75	54	0.150	3
2.36	27	0.075	2

TEST NOTES:
1. Material was sampled and supplied by the client.

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 01/08/2019
Accreditation number: 18548
Test Report No.: 19-032-0562 PSD
Page: 1 of 1

TEST REPORT

Client:	**BHP**
SAMPLE ID:	**S5-PM02**
DEPTH:	**0.05m - 0.25m**
Project:	Marillana Creek Infiltration GBI
Location:	Pilbara, WA
Lab test request:	19-032
Lab location:	Wangara
Date tested:	25/07/2019
Lab sample ID:	WG19-0562

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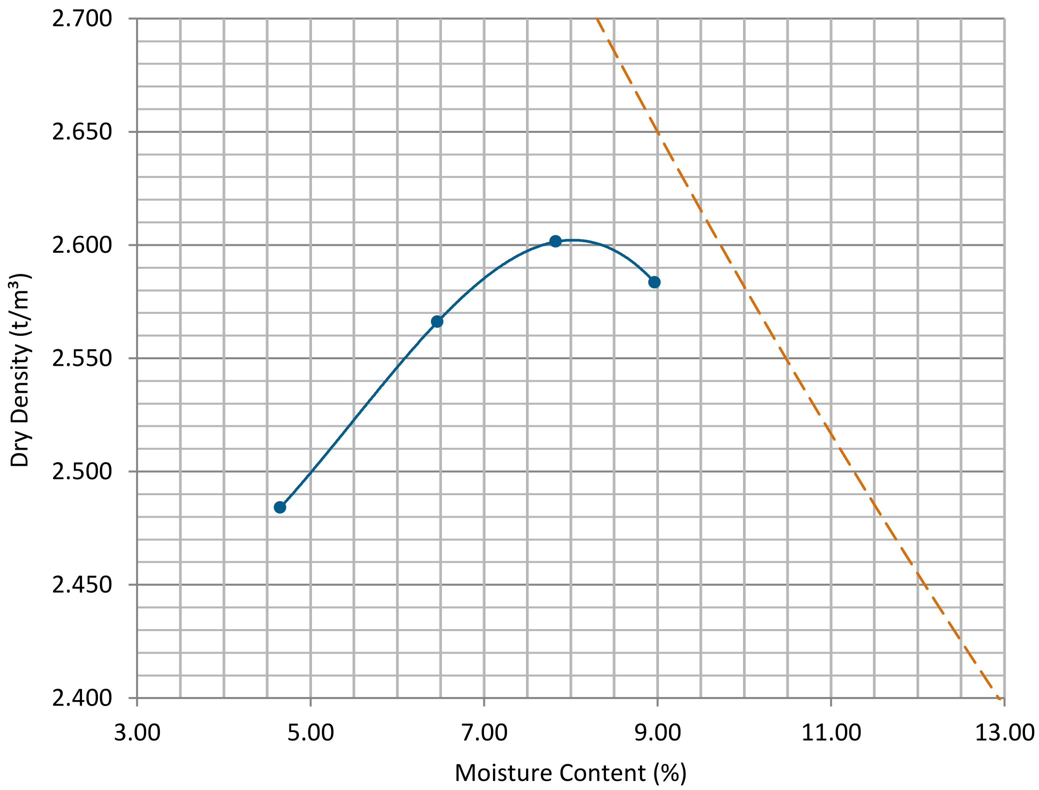
Dry Density / Moisture Content Relationship

Standard Compactive Effort (Mould A)



STANDARD MAXIMUM DRY DENSITY:	**2.60**	(t/m³)
STANDARD OPTIMUM MOISTURE CONTENT:	**8.0**	(%)
RETAINED ON 19.0mm SIEVE:	10	(%)
RETAINED ON 37.5mm SIEVE:	3	(%)
AIR VOIDS LINE:	0	(%)

TEST NOTES:

1. Zero air void line calculated from an assumed particle density of 3.48
2. Where further analysis is required, MDD and OMC values of 2.602t/m³ and 8.0% may be used.
3. Material was sampled and supplied by the client.
4. The sample was cured for 2 hours. Liquid Limit was determined by visual assessment

Approved signatory:	
Name:	Mick Rose
Position:	Laboratory Manager
Date:	26/07/2019
Accreditation number:	18548
Test Report No.:	19-032-0562 SMDD
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TEST REPORT

Client: **BHP**
SAMPLE ID: **S5-PM02**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 31/07/2019
Lab sample ID: WG19-0562

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WA915.1 Calcium Carbonate Content

CALCIUM CARBONATE CONTENT ($CaCO_3$): **58.6** (%)

TEST NOTES:
1. Material was sampled and supplied by the client.

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 1/08/2019
Accreditation number: 18548
Test Report No.: 19-032-0562 CCC
Page: 1 of 1

TEST REPORT

Client:	**BHP**
SAMPLE ID:	**S6-PM01**
DEPTH:	**0.05m - 0.25m**
Project:	Marillana Creek Infiltration GBI
Location:	Pilbara, WA
Lab test request:	19-032
Lab location:	Wangara
Date tested:	31/07/2019 to 01/08/2019
Lab sample ID:	WG19-0563

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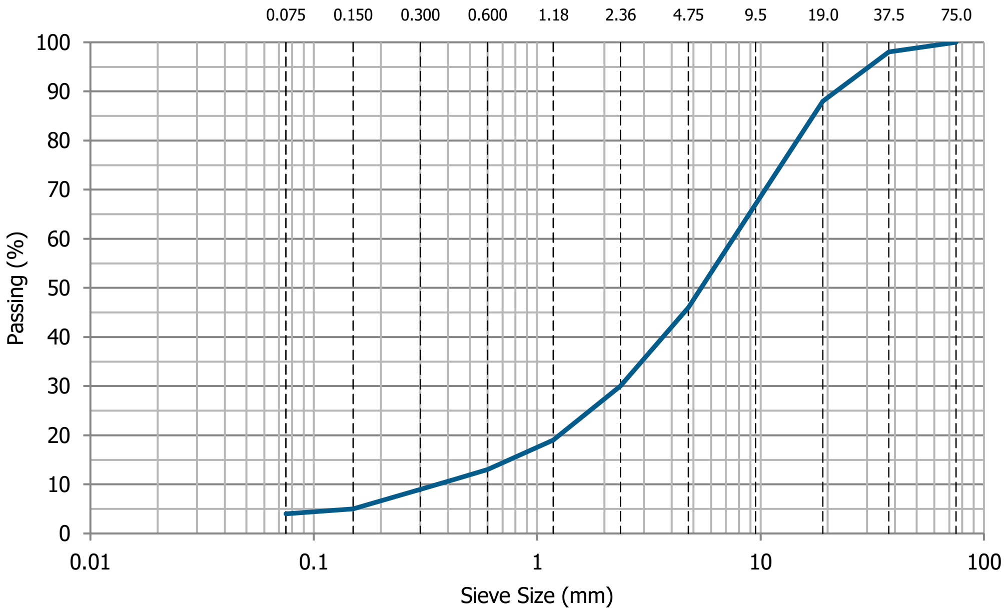
AS1289.3.6.1

Particle Size Distribution



SIEVE SIZE (mm)	PASSING (%)	SIEVE SIZE (mm)	PASSING (%)
75.0	100	1.18	19
37.5	98	0.600	13
19.0	88	0.425	11
9.5	67	0.300	9
4.75	46	0.150	5
2.36	30	0.075	4

TEST NOTES:

1. Material was sampled and supplied by the client.

Approved signatory:	
Name:	Mick Rose
Position:	Laboratory Manager
Date:	01/08/2019
Accreditation number:	18548
Test Report No.:	19-032-0563 PSD
Page:	1 of 1

TEST REPORT

Client: **BHP**

SAMPLE ID: **S6-PM01**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 24/07/2019
Lab sample ID: WG19-0563

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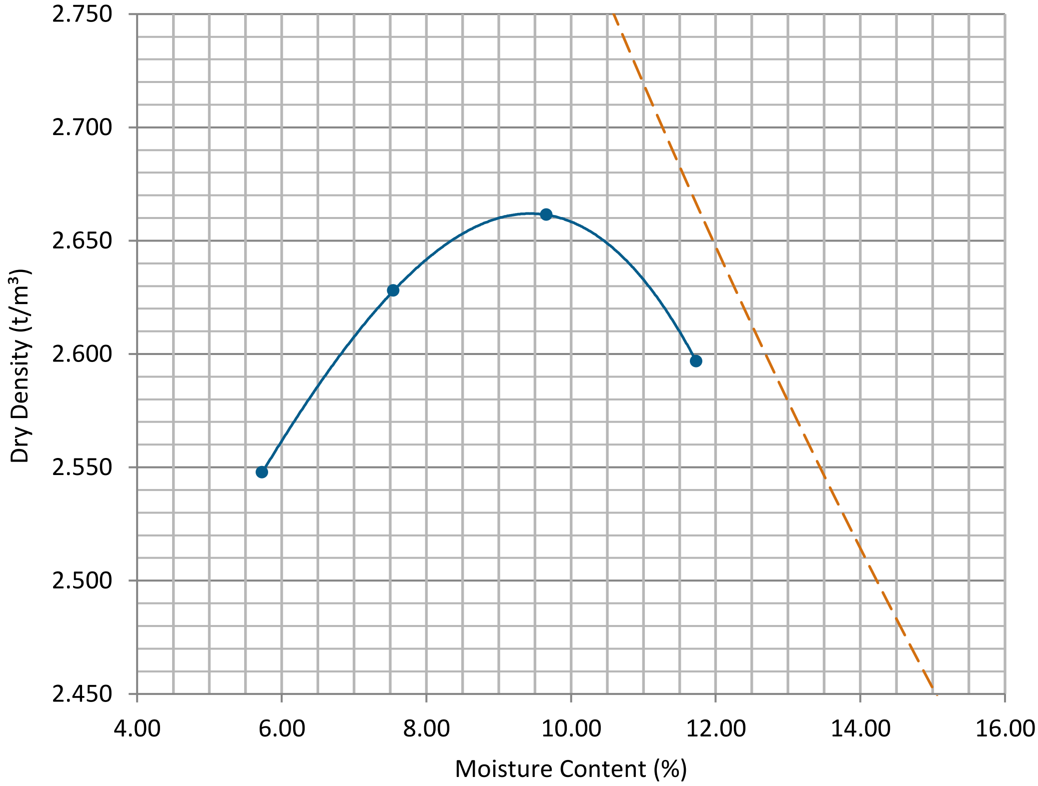
Dry Density / Moisture Content Relationship

Standard Compactive Effort (Mould A)



STANDARD MAXIMUM DRY DENSITY:	**2.66**	(t/m³)
STANDARD OPTIMUM MOISTURE CONTENT:	**9.5**	(%)
RETAINED ON 19.0mm SIEVE:	12	(%)
RETAINED ON 37.5mm SIEVE:	2	(%)
AIR VOIDS LINE:	0	(%)

TEST NOTES:

1. Zero air void line calculated from an assumed particle density of 3.88
2. Where further analysis is required, MDD and OMC values of 2.662t/m³ and 9.4% may be used.
3. Material was sampled and supplied by the client.
4. The sample was cured for 2 hours. Liquid Limit was determined by visual assessment

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 25/07/2019
Accreditation number: 18548
Test Report No.: 19-032-0563 SMDD
Page: 1 of 1

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These results apply only to the material tested, as received. Please refer to 'EMC Terms and Conditions'.

WORLD RECOGNISED ACCREDITATION

TEST REPORT

Client: **BHP**

SAMPLE ID: **S7-PM01**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 31/07/2019 to 01/08/2019
Lab sample ID: WG19-0564

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Wangara, WA 6065

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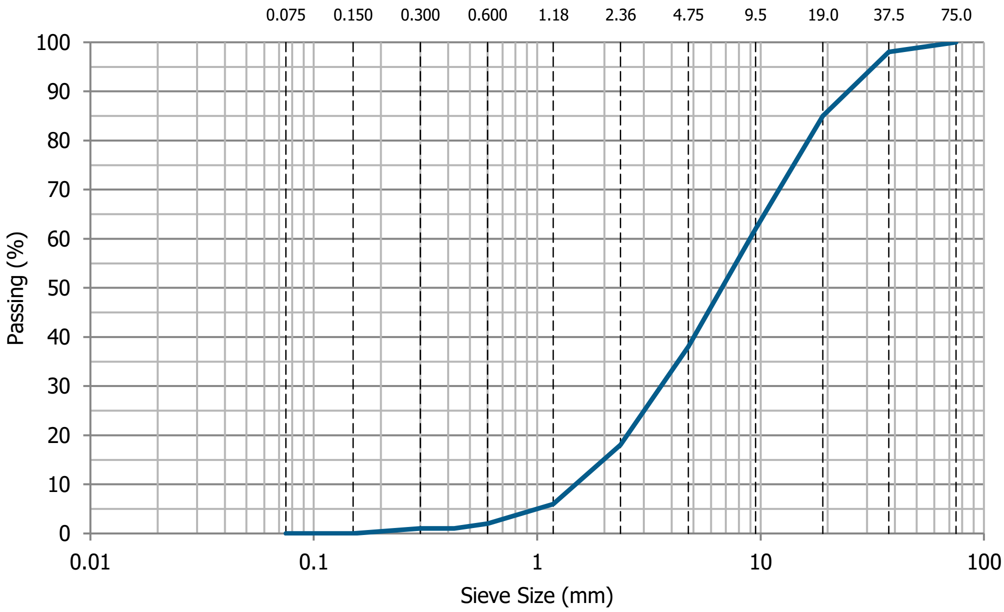
AS1289.3.6.1

Particle Size Distribution



SIEVE SIZE (mm)	PASSING (%)	SIEVE SIZE (mm)	PASSING (%)
75.0	100	1.18	6
37.5	98	0.600	2
19.0	85	0.425	1
9.5	62	0.300	1
4.75	38	0.150	0
2.36	18	0.075	0

TEST NOTES:
1. Material was sampled and supplied by the client.

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 01/08/2019
Accreditation number: 18548
Test Report No.: 19-032-0564 PSD
Page: 1 of 1

TEST REPORT

Earth Materials Classification Trust
Unit 6 / 5 Beneficial Way
Wangara, WA 6065

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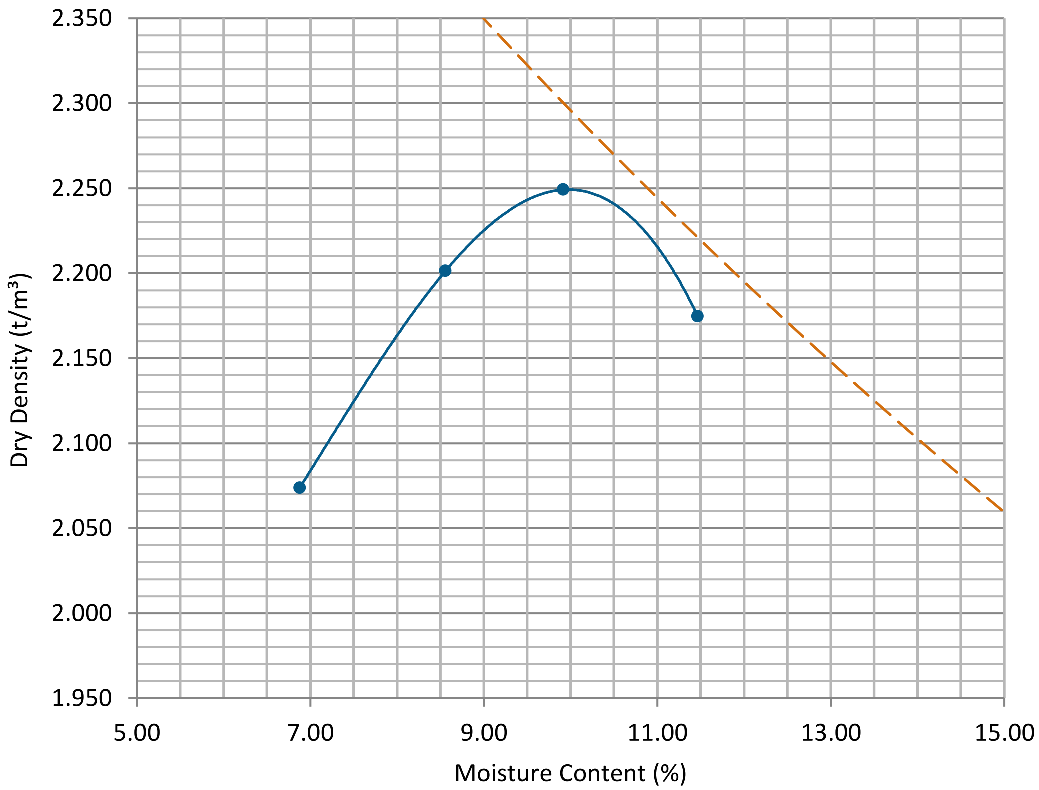
Client:	**BHP**
SAMPLE ID:	**S7-PM01**
DEPTH:	**0.05m - 0.25m**
Project:	Marillana Creek Infiltration GBI
Location:	Pilbara, WA
Lab test request:	19-032
Lab location:	Wangara
Date tested:	25/07/2019
Lab sample ID:	WG19-0564

AS1289.5.1.1

Dry Density / Moisture Content Relationship

Standard Compactive Effort (Mould A)



STANDARD MAXIMUM DRY DENSITY:	**2.25**	(t/m³)
STANDARD OPTIMUM MOISTURE CONTENT:	**10.0**	(%)
RETAINED ON 19.0mm SIEVE:	15	(%)
RETAINED ON 37.5mm SIEVE:	2	(%)
AIR VOIDS LINE:	0	(%)

TEST NOTES:

1. Zero air void line calculated from an assumed particle density of 2.98
2. Where further analysis is required, MDD and OMC values of 2.249t/m³ and 10.0% may be used.
3. Material was sampled and supplied by the client.
4. The sample was cured for 2 hours. Liquid Limit was determined by visual assessment

Approved signatory:	
Name:	Mick Rose
Position:	Laboratory Manager
Date:	26/07/2019
Accreditation number:	18548
Test Report No.:	19-032-0564 SMDD
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WORLD RECOGNISED ACCREDITATION

TEST REPORT

Client: **BHP**

SAMPLE ID: **S9-PM01**
DEPTH: **0.05m - 0.25m**

Project: Marillana Creek Infiltration GBI
Location: Pilbara, WA

Lab test request: 19-032
Lab location: Wangara
Date tested: 31/07/2019 to 01/08/2019
Lab sample ID: WG19-0565

Earth Materials Classification Trust
Unit 6 / 5 Beneficial Way
Wangara, WA 6065

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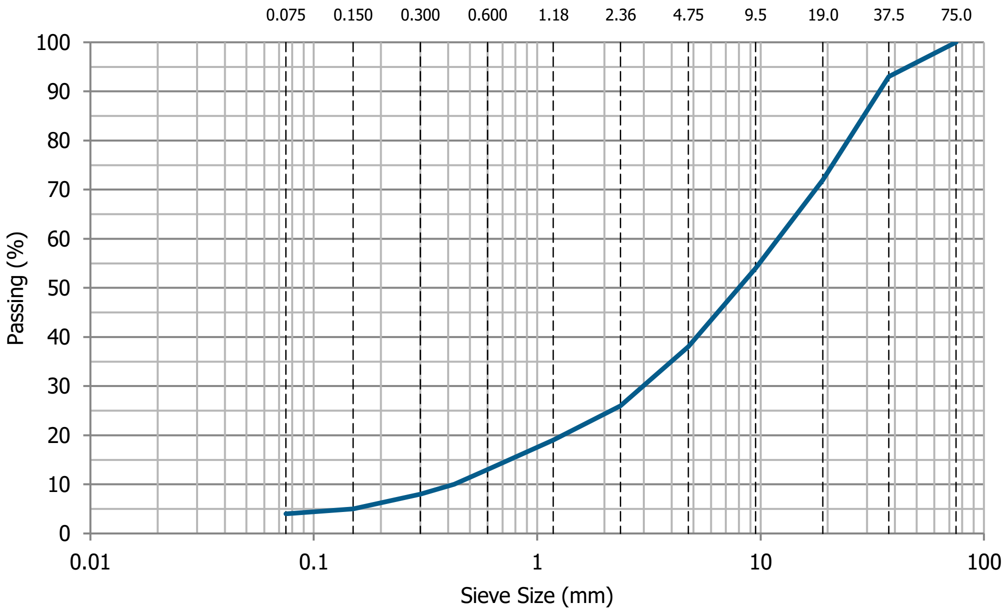
W www.emclabs.com.au
E lab@emclabs.com.au

AS1289.3.6.1

Particle Size Distribution



SIEVE SIZE (mm)	PASSING (%)	SIEVE SIZE (mm)	PASSING (%)
75.0	100	1.18	19
37.5	93	0.600	13
19.0	72	0.425	10
9.5	54	0.300	8
4.75	38	0.150	5
2.36	26	0.075	4

TEST NOTES:
1. Material was sampled and supplied by the client.

Approved signatory:
Name: Mick Rose
Position: Laboratory Manager
Date: 01/08/2019
Accreditation number: 18548
Test Report No.: 19-032-0565 PSD
Page: 1 of 1

The results of the tests and/or measurements included in this document are traceable to Australian/National standards. Accredited for compliance with ISO/IEC 17025 – Testing

These results apply only to the material tested, as received. Please refer to 'EMC Terms and Conditions'.

NATA
WORLD RECOGNISED ACCREDITATION

TEST REPORT

Client:	**BHP**
SAMPLE ID:	**S9-PM01**
DEPTH:	**0.05m - 0.25m**
Project:	Marillana Creek Infiltration GBI
Location:	Pilbara, WA
Lab test request:	19-032
Lab location:	Wangara
Date tested:	24/07/2019
Lab sample ID:	WG19-0565

Earth Materials Classification Trust
Unit 6 / 5 Beneficial Way
Wangara, WA 6065

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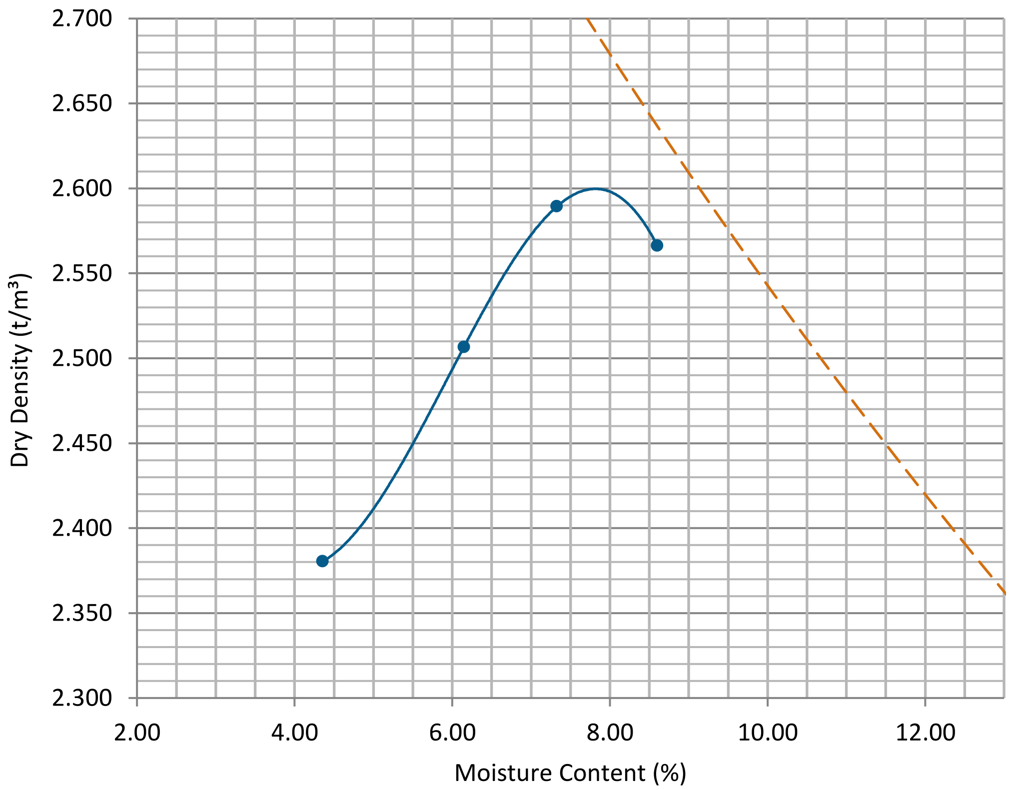
Dry Density / Moisture Content Relationship

Standard Compactive Effort (Mould A)



STANDARD MAXIMUM DRY DENSITY:	**2.60**	(t/m^3)
STANDARD OPTIMUM MOISTURE CONTENT:	**8.0**	(%)
RETAINED ON 19.0mm SIEVE:	28	(%)
RETAINED ON 37.5mm SIEVE:	7	(%)
AIR VOIDS LINE:	0	(%)

TEST NOTES:

1. Zero air void line calculated from an assumed particle density of 3.41
2. Where further analysis is required, MDD and OMC values of 2.600t/m³ and 7.8% may be used.
3. Material was sampled and supplied by the client.
4. The sample was cured for 2 hours. Liquid Limit was determined by visual assessment

Approved signatory:	
Name:	Mick Rose
Position:	Laboratory Manager
Date:	25/07/2019
Test Report No.:	19-032-0565 SMDD
Page:	1 of 1

Deviation from Standard: Insufficient material to perform the required 'Mould B' compaction. 'Mould A' was used and only material <19mm was tested, as directed by the Client.

APPENDIX I

LABORATORY TEST RESULTS – PERMEABILITY TESTING

WESTERN GEOTECHNICAL & Laboratory Services

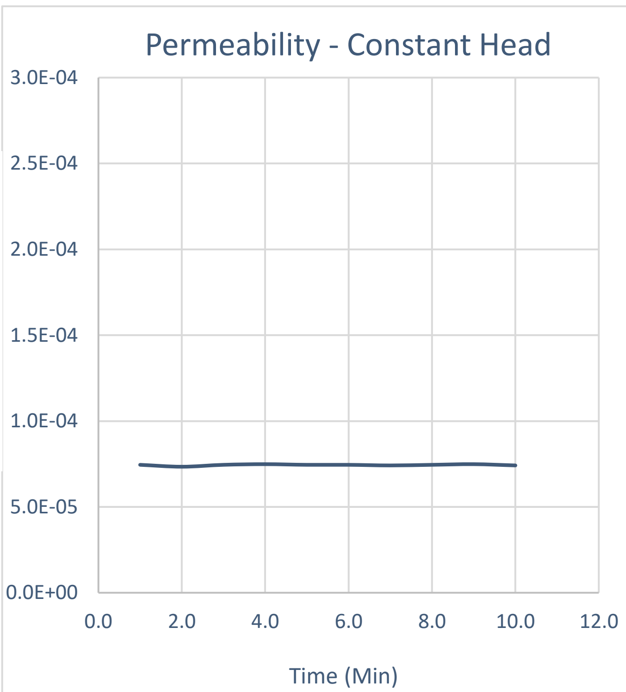
SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.7.1

Client:	EMC	*Ticket No.*	S228
Client Address:	6/5 Beneficial Way, Wanagara WA 6065	*Report No.*	WG19/2140_1_CHPERM
Project:	Marillana Creek Infiltration GBI	*Sample No.*	WG19/2140
Location:	Pilbara WA	*Date Sampled:*	Not Specified
Sample Identification:	S1-PM01 (WG19-0556) 0.05-0.25m	*Date Tested:*	29-07-2019

TEST RESULTS - CONSTANT HEAD PERMEABILITY

Sampling Method: **Sampled by Client, Tested as Received**



Compaction Details	
Compaction Method	AS 1289.5.1.1
Hammer Type	Standard
% Retained on 19.0mm	27
Maximum Dry Density (t/m3)	2.322
Optimum Moisture (%)	10.6
Target Dry Density Ratio	92
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	92.1
Laboratory Moisture Ratio (%)	99.7
Surcharge (kPa)	3.0
Hydraulic Gradient	0.6

Coefficient of Permeability K_{20} (m/s): 7.44E-05

Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 31-July-2019

NATA WORLD RECOGNISED ACCREDITATION

Accreditation No. 20599
Accredited for compliance with ISO/IEC 17025 - Testing

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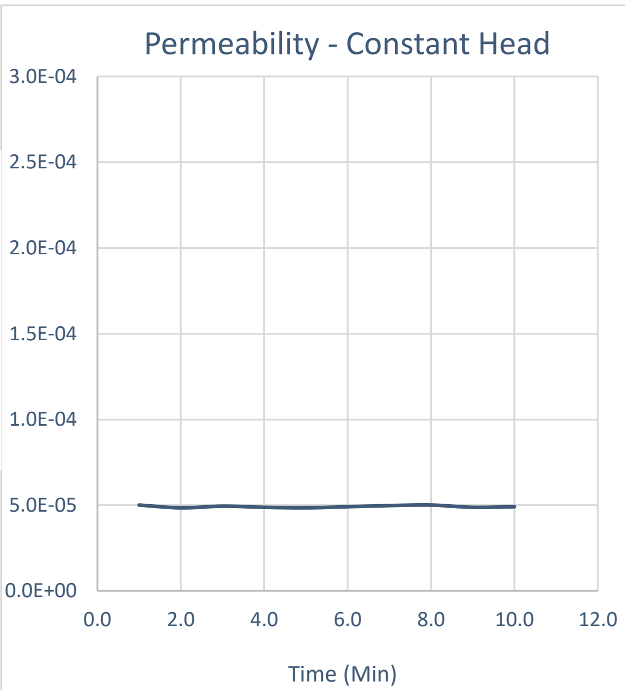
SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.7.1

Client:	EMC	*Ticket No.*	S228
Client Address:	6/5 Beneficial Way, Wanagara WA 6065	*Report No.*	WG19/2141_1_CHPERM
Project:	Marillana Creek Infiltration GBI	*Sample No.*	WG19/2141
Location:	Pilbara WA	*Date Sampled:*	Not Specified
Sample Identification:	S2-PM01 (WG19-0557) 0.05-0.25m	*Date Tested:*	27-07-2019

TEST RESULTS - CONSTANT HEAD PERMEABILITY

Sampling Method: **Sampled by Client, Tested as Received**



Compaction Details	
Compaction Method	AS 1289.5.1.1
Hammer Type	Standard
% Retained on 19.0mm	18.5
Maximum Dry Density (t/m3)	2.507
Optimum Moisture (%)	6.5
Target Dry Density Ratio	92
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	92.0
Laboratory Moisture Ratio (%)	99.4
Surcharge (kPa)	3.0
Hydraulic Gradient	0.7

Coefficient of Permeability K_{20} (m/s): 4.91E-05

Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 31-July-2019

Accreditation No. 20599
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WESTERN GEOTECHNICAL & Laboratory Services

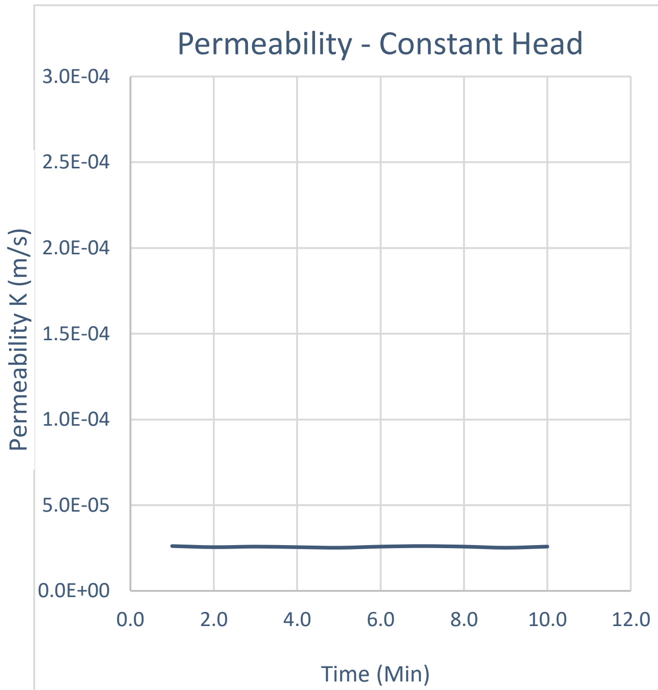
SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.7.1

Client:	EMC	*Ticket No.*	S228
Client Address:	6/5 Beneficial Way, Wanagara WA 6065	*Report No.*	WG19/2142_1_CHPERM
Project:	Marillana Creek Infiltration GBI	*Sample No.*	WG19/2142
Location:	Pilbara WA	*Date Sampled:*	Not Specified
Sample Identification:	S2-PM02 (WG19-0558) 0.05-0.25m	*Date Tested:*	31-07-2019

TEST RESULTS - CONSTANT HEAD PERMEABILITY

Sampling Method: **Sampled by Client, Tested as Received**



Compaction Details	
Compaction Method	AS 1289.5.1.1
Hammer Type	Standard
% Retained on 19.0mm	23.5
Maximum Dry Density (t/m3)	2.593
Optimum Moisture (%)	8.4
Target Dry Density Ratio	92
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	91.9
Laboratory Moisture Ratio (%)	99.5
Surcharge (kPa)	3.0
Hydraulic Gradient	0.7

Coefficient of Permeability K_{20} (m/s): 2.56E-05

Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 01-August-2019

Accreditation No. 20599
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WESTERN GEOTECHNICAL & Laboratory Services

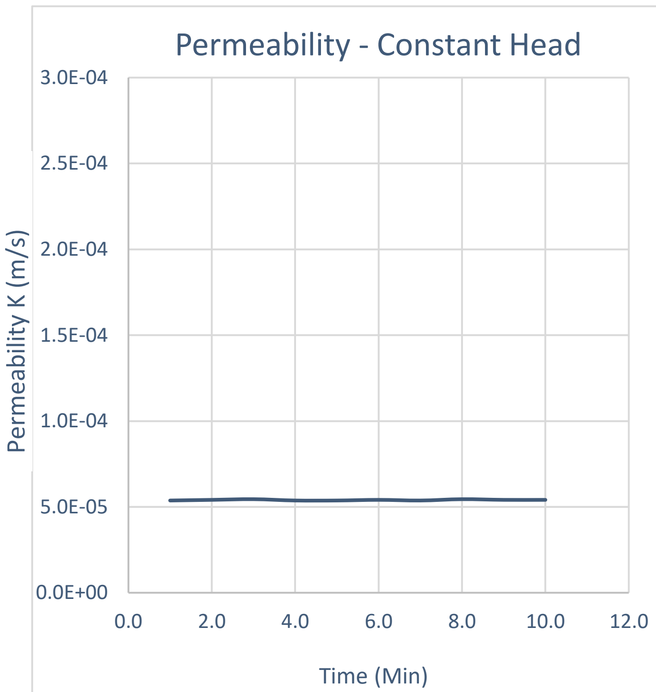
SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.7.1

Client:	EMC	*Ticket No.*	S228
Client Address:	6/5 Beneficial Way, Wanagara WA 6065	*Report No.*	WG19/2143_1_CHPERM
Project:	Marillana Creek Infiltration GBI	*Sample No.*	WG19/2143
Location:	Pilbara WA	*Date Sampled:*	Not Specified
Sample Identification:	S3-PM01 (WG19-0559) 0.05-0.25m	*Date Tested:*	26-07-2019

TEST RESULTS - CONSTANT HEAD PERMEABILITY

Sampling Method: **Sampled by Client, Tested as Received**



Compaction Details	
Compaction Method	AS 1289.5.1.1
Hammer Type	Standard
% Retained on 19.0mm	8.3
Maximum Dry Density (t/m3)	2.567
Optimum Moisture (%)	9.1
Target Dry Density Ratio	92
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	92.2
Laboratory Moisture Ratio (%)	98.7
Surcharge (kPa)	3.0
Hydraulic Gradient	0.6

Coefficient of Permeability K_{20} (m/s): 5.41E-05

Comments:

Approved Signatory:

Name: Matt van Herk

Function: General Manager

Date: 31-July-2019

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WESTERN GEOTECHNICAL & Laboratory Services

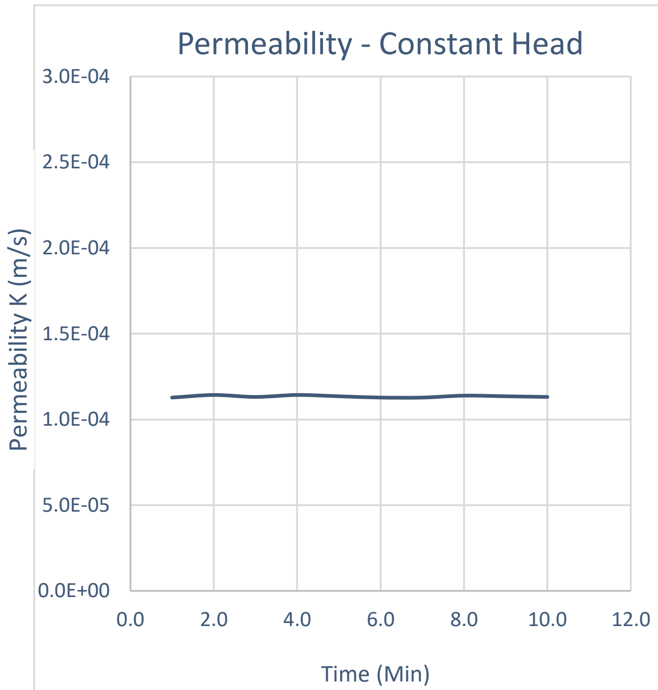
SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.7.1

Client:	EMC	*Ticket No.*	S228
Client Address:	6/5 Beneficial Way, Wanagara WA 6065	*Report No.*	WG19/2144_1_CHPERM
Project:	Marillana Creek Infiltration GBI	*Sample No.*	WG19/2144
Location:	Pilbara WA	*Date Sampled:*	Not Specified
Sample Identification:	S4-PM01 (WG19-0560) 0.05-0.25m	*Date Tested:*	30-07-2019

TEST RESULTS - CONSTANT HEAD PERMEABILITY

Sampling Method: **Sampled by Client, Tested as Received**



Compaction Details	
Compaction Method	AS 1289.5.1.1
Hammer Type	Standard
% Retained on 19.0mm	0
Maximum Dry Density (t/m3)	2.422
Optimum Moisture (%)	10.8
Target Dry Density Ratio	92
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	92.1
Laboratory Moisture Ratio (%)	99.0
Surcharge (kPa)	3.0
Hydraulic Gradient	0.6

Coefficient of Permeability K_{20} (m/s): 1.13E-04

Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 31-July-2019

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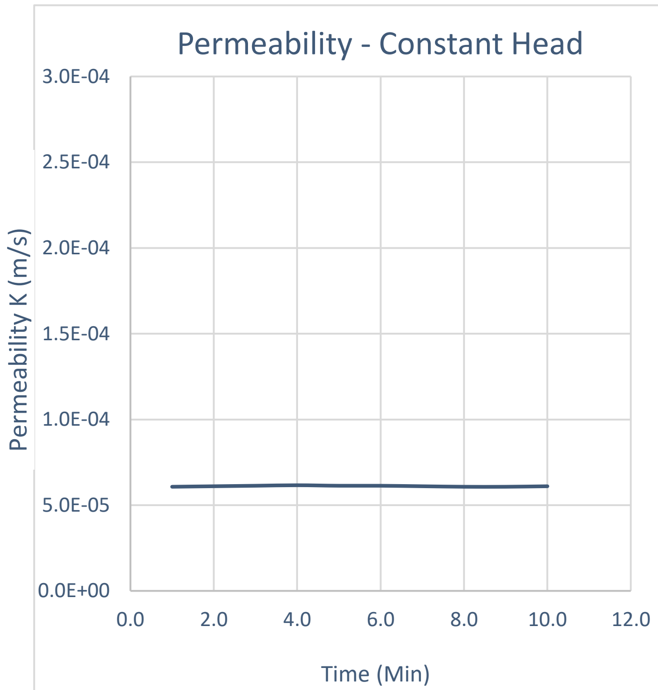
SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.7.1

Client:	EMC	*Ticket No.*	S228
Client Address:	6/5 Beneficial Way, Wanagara WA 6065	*Report No.*	WG19/2145_1_CHPERM
Project:	Marillana Creek Infiltration GBI	*Sample No.*	WG19/2145
Location:	Pilbara WA	*Date Sampled:*	Not Specified
Sample Identification:	S5-PM01 (WG19-0561) 0.05-0.25m	*Date Tested:*	1-08-2019

TEST RESULTS - CONSTANT HEAD PERMEABILITY

Sampling Method: **Sampled by Client, Tested as Received**



Compaction Details	
Compaction Method	AS 1289.5.1.1
Hammer Type	Standard
% Retained on 19.0mm	14.7
Maximum Dry Density (t/m3)	2.331
Optimum Moisture (%)	7.7
Target Dry Density Ratio	92
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	91.9
Laboratory Moisture Ratio (%)	101.5
Surcharge (kPa)	3.0
Hydraulic Gradient	0.7

Coefficient of Permeability K_{20} (m/s): 6.11E-05

Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 01-August-2019

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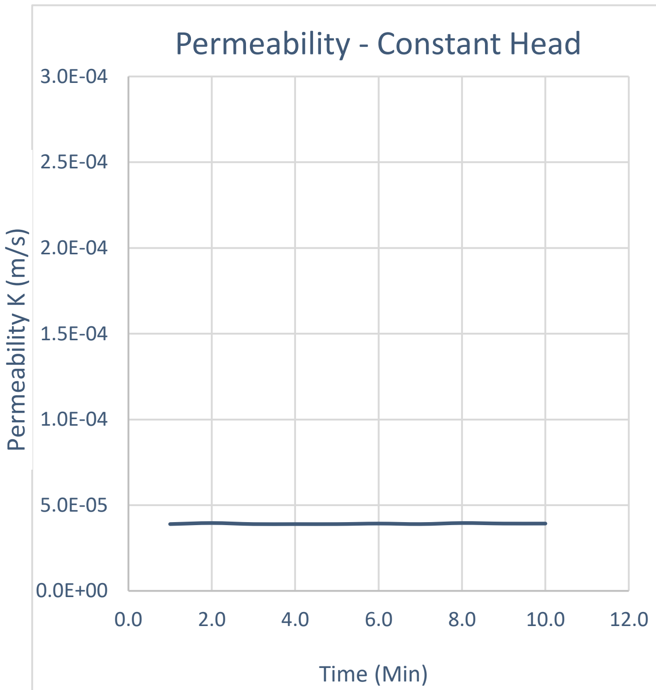
TEST REPORT - AS 1289.6.7.1

Client:	EMC	*Ticket No.*	S228
Client Address:	6/5 Beneficial Way, Wanagara WA 6065	*Report No.*	WG19/2146_1_CHPERM
Project:	Marillana Creek Infiltration GBI	*Sample No.*	WG19/2146
Location:	Pilbara WA	*Date Sampled:*	Not Specified
Sample Identification:	S5-PM02 (WG19-0562) 0.05-0.25m	*Date Tested:*	31-07-2019

TEST RESULTS - CONSTANT HEAD PERMEABILITY

Sampling Method: Sampled by Client, Tested as Received



Compaction Details	
Compaction Method	AS 1289.5.1.1
Hammer Type	Standard
% Retained on 19.0mm	10
Maximum Dry Density (t/m3)	2.602
Optimum Moisture (%)	8
Target Dry Density Ratio	92
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	92.1
Laboratory Moisture Ratio (%)	100.3
Surcharge (kPa)	3.0
Hydraulic Gradient	0.7

Coefficient of Permeability K_{20} (m/s): 3.92E-05

Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 01-August-2019

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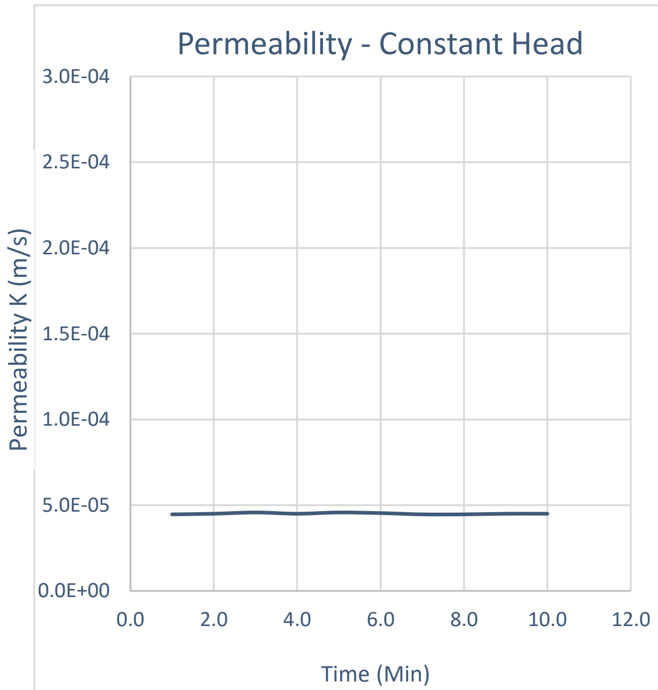
TEST REPORT - AS 1289.6.7.1

Client:	EMC	*Ticket No.*	S228
Client Address:	6/5 Beneficial Way, Wanagara WA 6065	*Report No.*	WG19/2147_1_CHPERM
Project:	Marillana Creek Infiltration GBI	*Sample No.*	WG19/2147
Location:	Pilbara WA	*Date Sampled:*	Not Specified
Sample Identification:	S6-PM01 (WG19-0563) 0.05-0.25m	*Date Tested:*	29-07-2019

TEST RESULTS - CONSTANT HEAD PERMEABILITY

Sampling Method: Sampled by Client, Tested as Received



Compaction Details	
Compaction Method	AS 1289.5.1.1
Hammer Type	Standard
% Retained on 19.0mm	11.8
Maximum Dry Density (t/m3)	2.662
Optimum Moisture (%)	9.4
Target Dry Density Ratio	92
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	92.2
Laboratory Moisture Ratio (%)	102.1
Surcharge (kPa)	3.0
Hydraulic Gradient	0.6

Coefficient of Permeability K_{20} (m/s): 4.51E-05

Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 31-July-2019

Accreditation No. 20599
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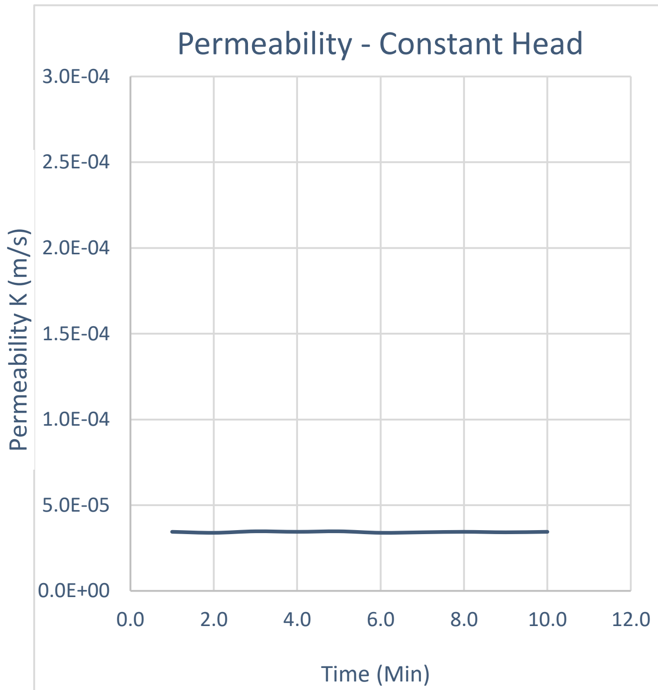
SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.6.7.1

Client:	EMC	*Ticket No.*	S228
Client Address:	6/5 Beneficial Way, Wanagara WA 6065	*Report No.*	WG19/2148_1_CHPERM
Project:	Marillana Creek Infiltration GBI	*Sample No.*	WG19/2148
Location:	Pilbara WA	*Date Sampled:*	Not Specified
Sample Identification:	S7-PM01 (WG19-0564) 0.05-0.25m	*Date Tested:*	31-07-2019

TEST RESULTS - CONSTANT HEAD PERMEABILITY

Sampling Method: **Sampled by Client, Tested as Received**



Compaction Details	
Compaction Method	AS 1289.5.1.1
Hammer Type	Standard
% Retained on 19.0mm	14.7
Maximum Dry Density (t/m3)	2.249
Optimum Moisture (%)	10
Target Dry Density Ratio	92
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	91.8
Laboratory Moisture Ratio (%)	102.8
Surcharge (kPa)	3.0
Hydraulic Gradient	0.7

Coefficient of Permeability K_{20} (m/s): 3.43E-05

Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 01-August-2019

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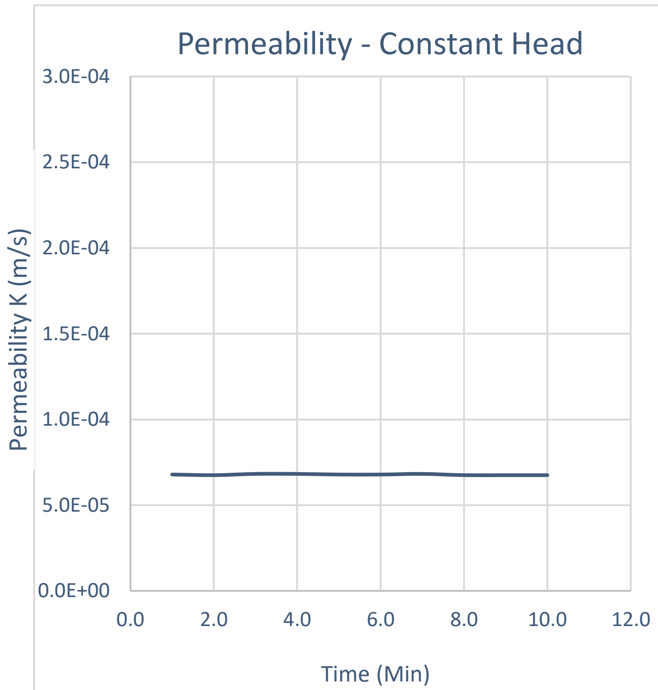
TEST REPORT - AS 1289.6.7.1

Client:	EMC	*Ticket No.*	S228
Client Address:	6/5 Beneficial Way, Wanagara WA 6065	*Report No.*	WG19/2149_1_CHPERM
Project:	Marillana Creek Infiltration GBI	*Sample No.*	WG19/2149
Location:	Pilbara WA	*Date Sampled:*	Not Specified
Sample Identification:	S9-PM01 (WG19-0565) 0.05-0.25m	*Date Tested:*	30-07-2019

TEST RESULTS - CONSTANT HEAD PERMEABILITY

Sampling Method: **Sampled by Client, Tested as Received**



Compaction Details	
Compaction Method	AS 1289.5.1.1
Hammer Type	Standard
% Retained on 19.0mm	0
Maximum Dry Density (t/m3)	2.6
Optimum Moisture (%)	7.8
Target Dry Density Ratio	92
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	91.8
Laboratory Moisture Ratio (%)	103.9
Surcharge (kPa)	3.0
Hydraulic Gradient	0.6

Coefficient of Permeability K_{20} (m/s): 6.78E-05

Comments:

Approved Signatory:

Name: Matt van Herk

Function: General Manager

Date: 31-July-2019

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APPENDIX J
PANDA DCP CROSS SECTION INTERPRETATIONS