11 Attachment C – Borehole Logs

CLIENT	**Sydney Anglican Schools Corporation, C/- Terrior**	**COMMENCED**	30/9/15	**COMPLETED**	30/9/15	**REF BH101** **Sheet** 1 **of** 1
PROJECT	**Preliminary Salinity & Geotechnical Assessment**	**LOGGED**	BM	**CHECKED**	RE	
SITE	**37 Worcester Road, Rouse Hill, NSW**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.** P1504946
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	Approx. 56.25 mAHD	
EXCAVATION DIMENSIONS	Ø90mm X 1.8m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE** 5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
V	Nil	N	D	0.25			SM	Silty SAND - Fine to medium grained, brown.		L-MD	A	0.2	- TOPSOIL 4946/101/0.2
V	Nil	N	D	0.6			CL	Silty CLAY - low to medium plasticity, brown.	VSt		A B	0.5 0.5-0.95	- RESIDUAL SPT: 0.5m 4, 9, 7 n = 16 4946/101/0.5 4946/101/0.5-0.95
V	Nil	N	D	1.0 1.3			CL-CI	CLAY - Low to medium plasticity, brown/grey, light brown.	H		A B	1.0 1.0-1.3	- RESIDUAL 4946/101/1.0 4946/101/1.0-1.3 SPT: 1.0-1.3m 6, 18, double bounce refusal n = >18 V-bit refusal at 1.3m
TC	Nil	N	D	1.8				SHALE - Dark grey/brown, inferred low strength.			B	1.5-1.7	- ROCK 4946/101/1.5-1.7
				2.0 3.0 4.0 4.5				TC-bit refusal at 1.8m on inferred medium strength shale. End of borehole					1.0 2.0 3.0 4.0 4.5

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
SPT Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	Sydney Anglican Schools Corporation, C/- Terrior	**COMMENCED**	30/9/15	**COMPLETED**	30/9/15	**REF**	**BH102**
PROJECT	Preliminary Salinity & Geotechnical Assessment	**LOGGED**	BM	**CHECKED**	RE	**Sheet** 1 **of** 1	
SITE	37 Worcester Road, Rouse Hill, NSW	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.**	P1504946
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	Approx. 59.85 mAHD		
EXCAVATION DIMENSIONS	Ø90mm X 2.7m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	D	0.2			SM	Silty SAND - Fine to medium grained, brown.		L-MD	A	0.2	4946/102/0.2 - TOPSOIL
V	Nil	N	D	0.4			CL	Silty CLAY - low to medium plasticity, brown.	St-VSt				- RESIDUAL
V	Nil	N	D	0.7			CL-CI	CLAY - Low to medium plasticity, brown/red brown. Grading to	St-VSt		A	0.5	4946/102/0.5 - RESIDUAL
V	Nil	N	D	1.0 1.3			CL	CLAY - Low plasticity, light brown/ brown/grey.	VSt		A	1.0	4946/102/1.0 - RESIDUAL 1.0 V-bit refusal at 1.3m
TC	Nil	N	D	2.0 2.7				SHALE - Light brown/grey, inferred low strength.			A	1.5	4946/102/1.5 - ROCK 2.0
				3.0 4.0 4.5				TC-bit refusal at 2.7m on inferred medium strength shale. End of borehole.					3.0 4.0 4.5

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
WI Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
SPT Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	Sydney Anglican Schools Corporation, C/- Terrior	**COMMENCED**	30/9/15	**COMPLETED**	30/9/15	**REF**	**BH103**
PROJECT	Preliminary Salinity & Geotechnical Assessment	**LOGGED**	BM	**CHECKED**	RE	**Sheet** 1 **of** 1	
SITE	37 Worcester Road, Rouse Hill, NSW	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.**	P1504946
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	Approx. 60 mAHD		
EXCAVATION DIMENSIONS	Ø90mm X 1.5m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	5%

EXCAVATION DATA / MATERIAL DATA / SAMPLING & TESTING

METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	D	0.3			SM	Silty SAND - Fine to medium grained, brown.		L- MD	A	0.2	- TOPSOIL 4946/103/0.2
V	Nil	N	D	0.8			CL- CI	CLAY - Low to medium plasticity, brown/red brown. Grading to	H		A B	0.5 0.5- 0.95	- RESIDUAL 4946/103/0.5 4946/103/0.5-0.95 SPT: 0.5m 5, 11, 15 (bouncing at 0.95m) n = 26
V	Nil	N	D	1.0 1.2			CL	CLAY - Low plasticity, light brown/ brown/grey.	H		A	1.0	- RESIDUAL 4946/103/1.0 V-bit refusal at 1.1m
TC	Nil	N	D	1.5				SHALE - Light brown/grey, inferred low strength.					- ROCK
				2.0 3.0 4.0 4.5				TC-bit refusal at 1.5m on inferred medium strength shale. End of borehole.					

EQUIPMENT / METHOD
- N Natural exposure
- X Existing excavation
- BH Backhoe bucket
- HA Hand auger
- S Spade
- CC Concrete Corer
- V V-bit
- TC Tungsten Carbide Bit
- PT Push tube

SUPPORT
- SH Shoring
- SC Shotcrete
- RB Rock Bolts
- Nil No support

WATER
- N None observed
- X Not measured
- ∇ Water level
- ◁ Water outflow
- ▷ Water inflow

MOISTURE
- D Dry
- M Moist
- W Wet
- Wp Plastic limit
- Wl Liquid limit

DRILLING RESISTANCE
- L Low
- M Moderate
- H High
- R Refusal

CONSISTENCY
- VS Very Soft
- S Soft
- F Firm
- St Stiff
- VSt Very Stiff
- H Hard
- F Friable

DENSITY
- VL Very Loose
- L Loose
- MD Medium Dense
- D Dense
- VD Very Dense

SAMPLING & TESTING
- A Auger sample
- B Bulk sample
- U Undisturbed sample
- D Disturbed sample
- Ux Tube sample (x mm)
- pp Pocket penetrometer
- SPT Standard penetration test
- CBR California Bearing Ratio
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- M Moisture content
- WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
- Y USCS
- N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	**Sydney Anglican Schools Corporation, C/- Terrior**	**COMMENCED**	30/9/15	**COMPLETED**	30/9/15	**REF BH104**
PROJECT	**Preliminary Salinity & Geotechnical Assessment**	**LOGGED**	BM	**CHECKED**	RE	**Sheet** 1 **of** 1
SITE	**37 Worcester Road, Rouse Hill, NSW**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.** P1504946
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	Approx. 63.25 mAHD	
EXCAVATION DIMENSIONS	Ø90mm X 1.8m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE** <5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
V	Nil	N	D	0.2			SM	Silty SAND - Fine to medium grained, brown.		L-MD	A	0.2	- TOPSOIL 4946/104/0.2
V	Nil	N	D	0.6			CL	Silty CLAY - low to medium plasticity, brown.	St		B A	0.4-0.6 0.5	- RESIDUAL 4946/104/0.4-0.6 4946/104/0.5
V	Nil	N	D	1.0 1.2			CL-CI	CLAY - Low to medium plasticity, brown/red brown. Grading to	St-Vst		A B	1.0 1.0-1.2	- RESIDUAL 4946/104/1.0 4946/104/1.0-1.2
V	Nil	N	D	1.45			CL	CLAY - Low plasticity, light brown/ brown/grey.	VSt-H				- RESIDUAL V-bit refusal at 1.45m
TC	Nil	N	D	1.8				SHALE - Light brown/grey, inferred low strength.			A	1.5	- ROCK 4946/104/1.5
				2.0 3.0 4.0 4.5				TC-bit refusal at 1.8m on inferred medium strength shale. End of borehole.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
SPT Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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Engineering Log - Borehole

CLIENT	**Sydney Anglican Schools Corporation, C/- Terrior**	**COMMENCED**	30/9/15	**COMPLETED**	30/9/15	**REF**	**BH105**
PROJECT	**Preliminary Salinity and Geotechnical Assessment**	**LOGGED**	BM	**CHECKED**	RE	**Sheet**	1 of 1
SITE	**37 Worcester Road, Rouse Hill, NSW**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.**	P1504946
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	Approx. 66.1 mAHD		
EXCAVATION DIMENSIONS	Ø90mm X 1.7m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	D	0.2			SM	Silty SAND - Fine to medium grained, brown.		L-MD	A	0.2	- TOPSOIL 4946/105/0.2
V	Nil	N	D	0.8			CL-CI	CLAY - Low to medium plasticity, brown/red brown. Grading to	St-VSt		A B	0.5 0.5-0.95	- RESIDUAL 4946/105/0.5 4946/105/0.5-0.95 SPT: 0.5m-0.95m 5, 8, 10 n = 18
V	Nil	N	D	1.0 1.4			CL	CLAY - Low plasticity, light brown/ brown/grey.	VSt		B	1.0-1.4	- RESIDUAL 1.0 4946/105/1.0-1.4 SPT: 1.0m-1.4m 7, 16, 10/100mm (double bounce) n = >26 V-bit refusal at 1.4m
TC	Nil	N	D	1.7				SHALE - Light brown/grey, inferred low strength.			A	1.5	- ROCK 4946/105/1.5
				2.0 3.0 4.0 4.5				TC-bit refusal at 1.7m on inferred medium strength shale. End of borehole.					2.0 3.0 4.0 4.5

EQUIPMENT / METHOD
- N Natural exposure
- X Existing excavation
- BH Backhoe bucket
- HA Hand auger
- S Spade
- CC Concrete Corer
- V V-bit
- TC Tungsten Carbide Bit
- PT Push tube

SUPPORT
- SH Shoring
- SC Shotcrete
- RB Rock Bolts
- Nil No support

WATER
- N None observed
- X Not measured
- ▽ Water level
- ◁ Water outflow
- ▷ Water inflow

MOISTURE
- D Dry
- M Moist
- W Wet
- Wp Plastic limit
- Wl Liquid limit

DRILLING RESISTANCE
- L Low
- M Moderate
- H High
- R Refusal

CONSISTENCY
- VS Very Soft
- S Soft
- F Firm
- St Stiff
- VSt Very Stiff
- H Hard
- F Friable

DENSITY
- VL Very Loose
- L Loose
- MD Medium Dense
- D Dense
- VD Very Dense

SAMPLING & TESTING
- A Auger sample
- B Bulk sample
- U Undisturbed sample
- D Disturbed sample
- Ux Tube sample (x mm)
- pp Pocket penetrometer
- SPT Standard penetration test
- CBR California Bearing Ratio
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- M Moisture content
- WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
- Y USCS
- N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	**Sydney Anglican Schools Corporation, C/- Terrior**	**COMMENCED**	30/9/15	**COMPLETED**	30/9/15	**REF**	**BH106**
PROJECT	**Preliminary Salinity & Geotechnical Assessment**	**LOGGED**	BM	**CHECKED**	RE	**Sheet** 1 **of** 1	
SITE	**37 Worcester Road, Rouse Hill, NSW**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.**	P1504946
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	Approx. 63.25 mAHD		
EXCAVATION DIMENSIONS	Ø90mm X 2.1m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	5%

EXCAVATION DATA						**MATERIAL DATA**					**SAMPLING & TESTING**		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
V	Nil	N	D	0.2			SM	Silty SAND - Fine to medium grained, brown.		L-MD	A	0.2	4946/106/0.2 - TOPSOIL
V	Nil	N	D	0.8			CL-CI	CLAY - Low to medium plasticity, brown/red brown. Grading to	St-VSt		B A	0.4-0.6 0.5	- RESIDUAL 4946/106/0.4-0.6 4946/106/0.5
V TC	Nil	N	D	1.0 1.4			CL	CLAY - Low plasticity, light brown/ brown/grey.	VSt-H		A B	1.0 1.0-1.2	- RESIDUAL V-bit refusal at 0.9m 4946/106/1.0 4946/106/1.0-1.2
TC	Nil	N	D	2.0 2.1				SHALE - Light brown/grey, inferred low strength.			B B	1.5 2.0	- ROCK 4946/106/1.5 Possible clay band at 1.7-1.9m. 4946/106/2.0
				3.0 4.0 4.5				TC-bit refusal at 2.1m on inferred medium strength shale. End of borehole.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
SPT Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	**Sydney Anglican Schools Corporation, C/- Terrior**	**COMMENCED**	30/9/15	**COMPLETED**	30/9/15	**REF**	**BH107**
PROJECT	**Preliminary Salinity & Geotechnical Assessment**	**LOGGED**	BM	**CHECKED**	RE	**Sheet** 1 **of** 1	
SITE	**37 Worcester Road, Rouse Hill, NSW**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.**	P1504946
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	Approx. 62.40 mAHD		
EXCAVATION DIMENSIONS	Ø90mm X 2.0m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	D	0.4			CI	Silty CLAY - Medium plasticity, dark brown.	F-St		A	0.2	4946/107/0.2 - TOPSOIL
V	Nil	N	D	0.9			CL-CI	CLAY - Low to medium plasticity, brown/red brown. Grading to	VSt		B A B	0.4-0.6 0.5 0.5-0.95	CBR: 0.4-0.6m 4946/107/0.5 4946/107/0.5-0.95 SPT: 0.5m 4, 9, 13 n = 22 - RESIDUAL
V	Nil	N	D	1.0 1.3			CL	CLAY - Low plasticity, light brown/ brown/grey.	VSt		A	1.0	4946/107/1.0 - RESIDUAL V-bit refusal at 1.3m
TC	Nil	N	D	2.0				SHALE - Light brown/grey, inferred low strength.			B	1.5-1.7	4946/107/1.5-1.7 - ROCK
				3.0 4.0 4.5				TC-bit refusal at 2.0m on inferred medium strength shale. End of borehole.					

EQUIPMENT / METHOD
- N Natural exposure
- X Existing excavation
- BH Backhoe bucket
- HA Hand auger
- S Spade
- CC Concrete Corer
- V V-bit
- TC Tungsten Carbide Bit
- PT Push tube

SUPPORT
- SH Shoring
- SC Shotcrete
- RB Rock Bolts
- Nil No support

WATER
- N None observed
- X Not measured
- ▽ Water level
- ◁ Water outflow
- ▷ Water inflow

MOISTURE
- D Dry
- M Moist
- W Wet
- Wp Plastic limit
- Wl Liquid limit

DRILLING RESISTANCE
- L Low
- M Moderate
- H High
- R Refusal

CONSISTENCY
- VS Very Soft
- S Soft
- F Firm
- St Stiff
- VSt Very Stiff
- H Hard
- F Friable

DENSITY
- VL Very Loose
- L Loose
- MD Medium Dense
- D Dense
- VD Very Dense

SAMPLING & TESTING
- A Auger sample
- B Bulk sample
- U Undisturbed sample
- D Disturbed sample
- Ux Tube sample (x mm)
- pp Pocket penetrometer
- SPT Standard penetration test
- CBR California Bearing Ratio
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- M Moisture content
- WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
- Y USCS
- N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	**Sydney Anglican Schools Corporation, C/- Terrior**	**COMMENCED**	30/9/15	**COMPLETED**	30/9/15	**REF**	**BH108**
PROJECT	**Preliminary Salinity & Geotechnical Assessment**	**LOGGED**	BM	**CHECKED**	RE	**Sheet**	1 of 1
SITE	**37 Worcester Road, Rouse Hill, NSW**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.**	P1504946
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	Approx. 65.1 mAHD		
EXCAVATION DIMENSIONS	Ø90mm X 1.7m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	5%

EXCAVATION DATA / MATERIAL DATA / SAMPLING & TESTING

METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	D	0.2			CL	Silty CLAY - low to medium plasticity, brown.	St		A	0.2	- TOPSOIL 4946/108/0.2
V	Nil	N	D	0.8			CL-CI	CLAY - Low to medium plasticity, brown/red brown. Grading to	F-VSt		A	0.5	- RESIDUAL 4946/108/0.5
V	Nil	N	D	1.0 1.1			CL	CLAY - Low plasticity, light brown/ brown/grey.	VSt-H		A	1.0	- RESIDUAL 4946/108/1.0 V-bit refusal at 1.1m
TC	Nil	N	D	1.7				SHALE - Light brown/grey, inferred low strength.			B	1.5	- ROCK 4946/108/1.5
				2.0 3.0 4.0 4.5				TC-bit refusal at 1.7m on inferred medium strength shale. End of borehole.					1.0 2.0 3.0 4.0 4.5

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
∇ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
SPT Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Sydney Anglican Schools Corporation, C/- Terrior**	**COMMENCED**	30/9/15	**COMPLETED**	30/9/15	**REF BH109**
PROJECT	**Preliminary Salinity & Geotechnnical Assessment**	**LOGGED**	BM	**CHECKED**	RE	**Sheet 1 of 1**
SITE	**37 Worcester Road, Rouse Hill, NSW**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.** P1504946
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	Approx. 66 mAHD	
EXCAVATION DIMENSIONS	Ø90mm X 1.4m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE** 5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
V	Nil	N	D	0.2			SM	Silty SAND - Fine to medium grained.		L-MD	A	0.2	4946/109/0.2 - TOPSOIL
V	Nil	N	D	0.7			CL-CI	CLAY - Low to medium plasticity, brown/red brown. Grading to	St-VSt		B A	0.3-0.5 0.5	- RESIDUAL CBR: 0.3-0.5m 4946/109/0.5 V-bit refusal at 0.7m
TC	Nil	N	D	1.0 1.1			CL	CLAY - Low plasticity, light brown/ brown/grey.	VSt		A	1.0	- RESIDUAL 4946/109/1.0
TC	Nil	N	D	1.4				SHALE - Light brown/grey, inferred low strength.					- ROCK
				2.0 3.0 4.0 4.5				TC-bit refusal at 1.4m on inferred medium strength shale. End of borehole.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
SPT Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
☒ Y USCS
☐ N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	**Sydney Anglican Schools Corporation, C/- Terrior**	**COMMENCED**	30/9/15	**COMPLETED**	30/9/15	**REF**	**BH110**
PROJECT	**Preliminary Salinity & Geotechnical Assessment**	**LOGGED**	BM	**CHECKED**	RE	**Sheet** 1 **of** 1	
SITE	**37 Worcester Road, Rouse Hill, NSW**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.**	P1504946
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	Approx. 63.35 mAHD		
EXCAVATION DIMENSIONS	Ø90mm X 2.4m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	5%

EXCAVATION DATA						**MATERIAL DATA**					**SAMPLING & TESTING**		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
V	Nil	N	D	0.4			SM	Silty SAND - Fine to medium grained.		L- MD	A	0.2	4946/110/0.2 - TOPSOIL
V TC	Nil	N	D	0.9			CL	CLAY - Low plasticity, light brown/ brown/grey.	VSt- H		B A	0.4- 0.6 0.5	4946/110/0.4-0.6 - RESIDUAL 4946/110/0.5 V-bit refusal at 0.8m
TC	Nil	N	D	1.0 2.0 2.4				SHALE - Light brown/grey, inferred low strength.			A B	1.0 2.0	- ROCK 4946/110/1.0 4946/110/2.0
				3.0 4.0 4.5				TC-bit refusal at 2.4m on inferred medium strength shale. End of borehole.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
SPT Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Sydney Anglican Schools Corporation, C/- Terrior**	**COMMENCED**	30/9/15	**COMPLETED**	30/9/15	**REF BH111**
PROJECT	**Preliminary Salinity & Geotechnical Assessment**	**LOGGED**	BM	**CHECKED**	RE	**Sheet** 1 **of** 1
SITE	**37 Worcester Road, Rouse Hill, NSW**	**GEOLOGY**	Shale	**VEGETATION**	Grass	**PROJECT NO.** P1504946
EQUIPMENT	Hydraulic Rig	**EASTING**	NA	**RL SURFACE**	Approx. 62 mAHD	
EXCAVATION DIMENSIONS	Ø90mm X 2.2m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE** 5%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
													- RESIDUAL
											A	0.2	4946/111/0.2
V	Nil	N	D				CL	CLAY - Low plasticity, light brown/ brown/grey.	VSt-H		A	0.5	4946/111/0.5
				1.0							A	1.0	4946/111/1.0 V-bit refusal at 1.0m
													- ROCK
											B	1.5	4946/111/1.5
TC	Nil	N	D					SHALE - Light brown/grey, inferred low strength.					
				2.0									
				2.2				TC-bit refusal at 2.2m on inferred medium strength shale. End of borehole.					
				3.0									
				4.0									
				4.5									

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
Ux Tube sample (x mm)
pp Pocket penetrometer
SPT Standard penetration test
CBR California Bearing Ratio
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
M Moisture content
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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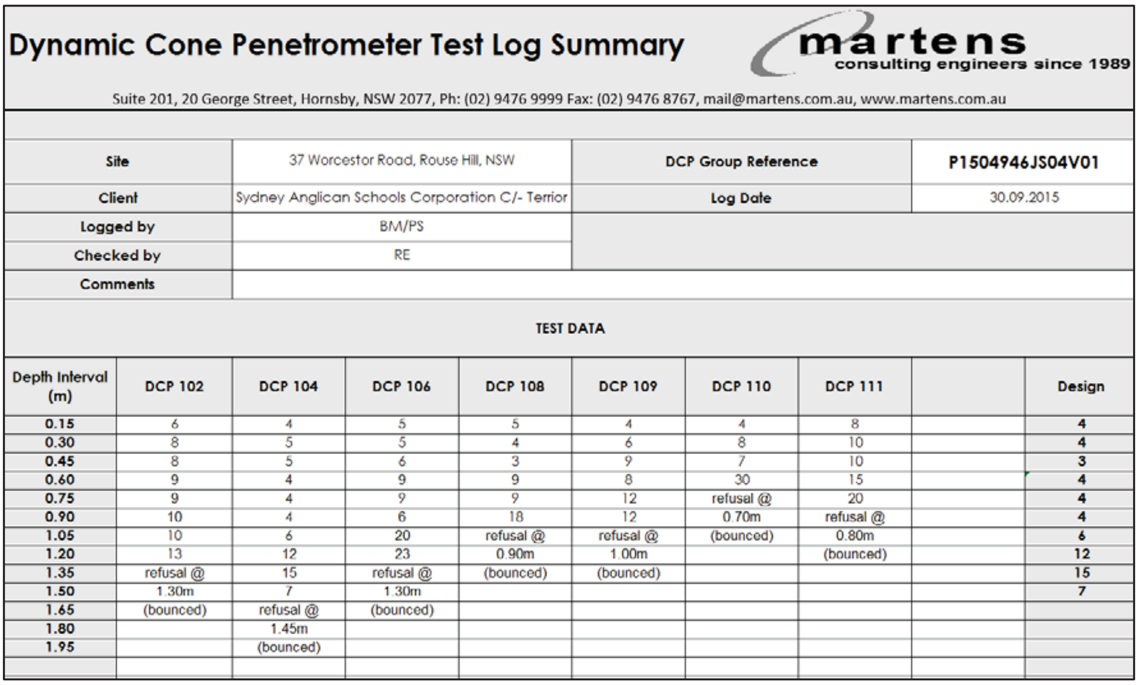
Engineering Log - Borehole

13 Attachment D – DCP ‘n’ Counts



Dynamic Cone Penetrometer Test Log Summary

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Site	37 Worcestor Road, Rouse Hill, NSW	**DCP Group Reference**	**P1504946JS04V01**
Client	Sydney Anglican Schools Corporation C/- Terrior	**Log Date**	30.09.2015
Logged by	BM/PS		
Checked by	RE		
Comments			

TEST DATA

Depth Interval (m)	DCP 102	DCP 104	DCP 106	DCP 108	DCP 109	DCP 110	DCP 111		Design
0.15	6	4	5	5	4	4	8		**4**
0.30	8	5	5	4	6	8	10		**4**
0.45	8	5	6	3	9	7	10		**3**
0.60	9	4	9	9	8	30	15		**4**
0.75	9	4	9	9	12	refusal @	20		**4**
0.90	10	4	6	18	12	0.70m	refusal @		**4**
1.05	10	6	20	refusal @	refusal @	(bounced)	0.80m		**6**
1.20	13	12	23	0.90m	1.00m		(bounced)		**12**
1.35	refusal @	15	refusal @	(bounced)	(bounced)				**15**
1.50	1.30m	7	1.30m						**7**
1.65	(bounced)	refusal @	(bounced)						
1.80		1.45m							
1.95		(bounced)							

14 Attachment E – Salinity Laboratory Report

CERTIFICATE OF ANALYSIS 135528

Client:

Martens & Associates Pty Ltd
Suite 201, 20 George St
Hornsby
NSW 2077

Attention: Ben McGiffin

Sample log in details:

Your Reference:	**P1504946, Rouse Hill Anglican College**
No. of samples:	35 Soils
Date samples received / completed instructions received	02/10/15 / 07/10/15

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	14/10/15 / 13/10/15
Date of Preliminary Report:	Not Issued

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

Misc Inorg - Soil						
Our Reference:	UNITS	135528-1	135528-2	135528-3	135528-4	135528-5
Your Reference	-------------	4946/BH101	4946/BH101	4946/BH101	4946/BH102	4946/BH102
Depth	------------	0.2	0.5	1.0	0.2	0.5
Date Sampled		30/09/2015	30/09/2015	30/09/2015	30/09/2015	30/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	08/10/2015	08/10/2015	08/10/2015	08/10/2015	08/10/2015
Date analysed	-	08/10/2015	08/10/2015	08/10/2015	08/10/2015	08/10/2015
pH 1:5 soil:water	pH Units	5.8	5.8	5.7	5.7	5.7
Electrical Conductivity 1:5 soil:water	µS/cm	41	37	96	39	37
Sulphate, SO4 1:5 soil:water	mg/kg	10	28	<10	20	31

Misc Inorg - Soil						
Our Reference:	UNITS	135528-6	135528-8	135528-9	135528-10	135528-11
Your Reference	-------------	4946/BH102	4946/BH103	4946/BH103	4946/BH103	4946/BH104
Depth	------------	1.0	0.2	0.5	1.0	0.2
Date Sampled		30/09/2015	30/09/2015	30/09/2015	30/09/2015	30/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	08/10/2015	08/10/2015	08/10/2015	08/10/2015	08/10/2015
Date analysed	-	08/10/2015	08/10/2015	08/10/2015	08/10/2015	08/10/2015
pH 1:5 soil:water	pH Units	5.4	6.1	5.8	5.8	5.8
Electrical Conductivity 1:5 soil:water	µS/cm	71	46	38	27	39
Sulphate, SO4 1:5 soil:water	mg/kg	72	20	31	22	20

Misc Inorg - Soil						
Our Reference:	UNITS	135528-12	135528-13	135528-15	135528-16	135528-18
Your Reference	-------------	4946/BH104	4946/BH104	4946/BH105	4946/BH105	4946/BH106
Depth	------------	0.5	1.0	0.2	0.5	0.2
Date Sampled		30/09/2015	30/09/2015	30/09/2015	30/09/2015	30/09/2015
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	08/10/2015	08/10/2015	08/10/2015	08/10/2015	08/10/2015
Date analysed	-	08/10/2015	08/10/2015	08/10/2015	08/10/2015	08/10/2015
pH 1:5 soil:water	pH Units	6.1	5.7	5.7	5.2	5.7
Electrical Conductivity 1:5 soil:water	µS/cm	28	40	31	46	33
Sulphate, SO4 1:5 soil:water	mg/kg	22	34	10	53	10

Misc Inorg - Soil				
Our Reference:	UNITS	135528-19	135528-27	135528-28
Your Reference	-------------	4946/BH106	4946/BH109	4946/BH109
Depth	------------	0.5	0.2	0.5
Date Sampled		30/09/2015	30/09/2015	30/09/2015
Type of sample		Soil	Soil	Soil
Date prepared	-	08/10/2015	08/10/2015	08/10/2015
Date analysed	-	08/10/2015	08/10/2015	08/10/2015
pH 1:5 soil:water	pH Units	5.7	6.6	5.0
Electrical Conductivity 1:5 soil:water	µS/cm	31	63	51
Sulphate, SO4 1:5 soil:water	mg/kg	28	24	47

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B.

QUALITY CONTROL Misc Inorg - Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			08/10/2015	135528-1	08/10/2015 || 08/10/2015	LCS-1	08/10/2015
Date analysed	-			08/10/2015	135528-1	08/10/2015 || 08/10/2015	LCS-1	08/10/2015
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	135528-1	5.8 || 5.8 || RPD: 0	LCS-1	101%
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	135528-1	41 || 36 || RPD: 13	LCS-1	98%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	135528-1	10 || 10 || RPD: 0	LCS-1	105%

QUALITY CONTROL Misc Inorg - Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	135528-12	08/10/2015 || 08/10/2015	135528-2	08/10/2015
Date analysed	-	135528-12	08/10/2015 || 08/10/2015	135528-2	08/10/2015
pH 1:5 soil:water	pH Units	135528-12	6.1 || 6.1 || RPD: 0	[NR]	[NR]
Electrical Conductivity 1:5 soil:water	µS/cm	135528-12	28 || 28 || RPD: 0	[NR]	[NR]
Sulphate, SO4 1:5 soil:water	mg/kg	135528-12	22 || 20 || RPD: 10	135528-2	89%

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

15 Attachment F – CBR and Atterberg Limits Laboratory Reports

resource laboratories
AGGREGATE, ROCK, AND SOIL TESTING
ABN: 25 131 532 020
Sydney: 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145
Ph: (02) 9674 7711 **| Fax:** (02) 9674 7755 **| Email:** info@resourcelab.com.au

Test Report

Customer: Martens & Associates Pty Ltd
Job number: 15-0092
Project: P1504946
Report number: 2
Location: Rouse Hill Anglican College
Page: 1 of 1

California Bearing Ratio

Sampling method: Samples tested as received
Test method(s): AS 1289.1.1, 2.1.1, 5.1.1, 6.1.1

	Results			
Laboratory sample no.	7200	7201		
Customer sample no.	4946/CBR01 0.3-0.5m	4946/CBR02 0.3-0.5m		
Date sampled	30/09/2015	30/09/2015		
Material description	SILTY CLAY, trace of gravel, brown mottled red-brown/orange-brown/pale grey	SILTY CLAY, trace of gravel, brown mottled red-brown/orange-brown/pale grey		
Maximum dry density (t/m^3)	1.70	1.65		
Optimum moisture content (%)	19.5	20.5		
Field moisture content (%)	n/a	n/a		
Oversize retained on 19.0mm sieve (%)	1	0		
Oversize included (Y/N)	N	N		
Dry density before soak (t/m^3)	1.67	1.62		
Dry density after soak (t/m^3)	1.66	1.60		
Moisture content before soak (%)	19.1	20.2		
Moisture content after soak (%)	21.5	22.5		
Moisture content after test - top 30mm (%)	21.6	24.1		
Moisture content after test - remaining depth (%)	20.8	21.8		
Density ratio before soaking (%)	98.5	98.5		
Moisture ratio before soaking (%)	98.0	98.5		
Period of soaking (days)	4	4		
Compactive effort	Standard	Standard		
Mass of surcharge applied (kg)	4.5	4.5		
Swell after soaking (%)	0.5	1.0		
Penetration (mm)	2.5	2.5		
CBR Value (%)	**8**	**6**		

Notes: Specified LDR: 98 ±1%

Approved Signatory: C. Greely **Date:** 04/11/2015

NATA
ACCREDITED FOR TECHNICAL COMPETENCE
Accredited for compliance with ISO/IEC 17025.

NATA Accredited Laboratory Number: **17062**

resource laboratories
AGGREGATE, ROCK, AND SOIL TESTING
ABN: 25 131 532 020
Sydney: 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145
Ph: (02) 9674 7711 | **Fax:** (02) 9674 7755 | **Email:** info@resourcelab.com.au

Test Report

Customer: Martens & Associates Pty Ltd
Project: P1504946
Location: Rouse Hill Anglican College

Job number: 15-0092
Report number: 1
Page: 1 of 1

Soil Index Properties

Sampling method: Samples tested as received

Test method(s): AS 1289.1.1, 2.1.1, 3.1.2, 3.2.1, 3.3.1 .3.4.1

	Results				
Laboratory sample no.	7202	7203	7204		
Customer sample no.	4946/BH101/ 0.8-1.2m	4946/BH104/ 0.4-0.6m	4946/BH104/ 1.0-1.2m		
Date sampled	30/09/2015	30/09/2015	30/09/2015		
Material description	CLAY, with silt, trace of gravel, pale grey mottled orange-brown/ red-brown	SILTY CLAY, trace of gravel, brown mottled pale brown/ orange-brown	CLAY, trace of silt, brown mottled orange-brown/ red-brown		
Liquid limit (%)	42	38	58		
Plastic limit (%)	17	19	20		
Plasticity index (%)	25	19	38		
Linear shrinkage (%)	11.5	8.5	14.0		
Cracking / Curling / Crumbling	-	-	-		
Sample history	Air dried	Air dried	Air dried		
Preparation	Dry sieved	Dry sieved	Dry sieved		

Approved Signatory: C. Greely

Date: 28/10/2015

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025.

NATA Accredited Laboratory Number: **17062**

16 Attachment G – CSIRO Sheet BTF 18

Foundation Maintenance and Footing Performance:

A Homeowner's Guide

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

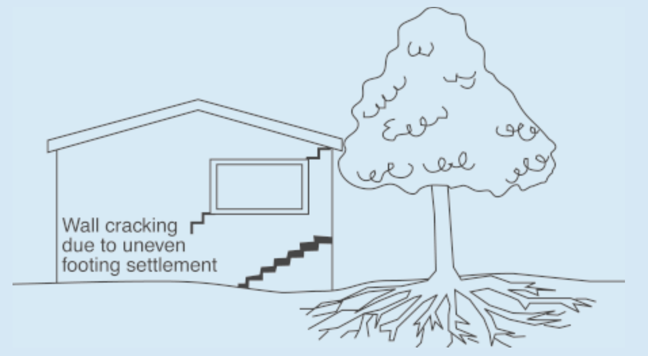
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

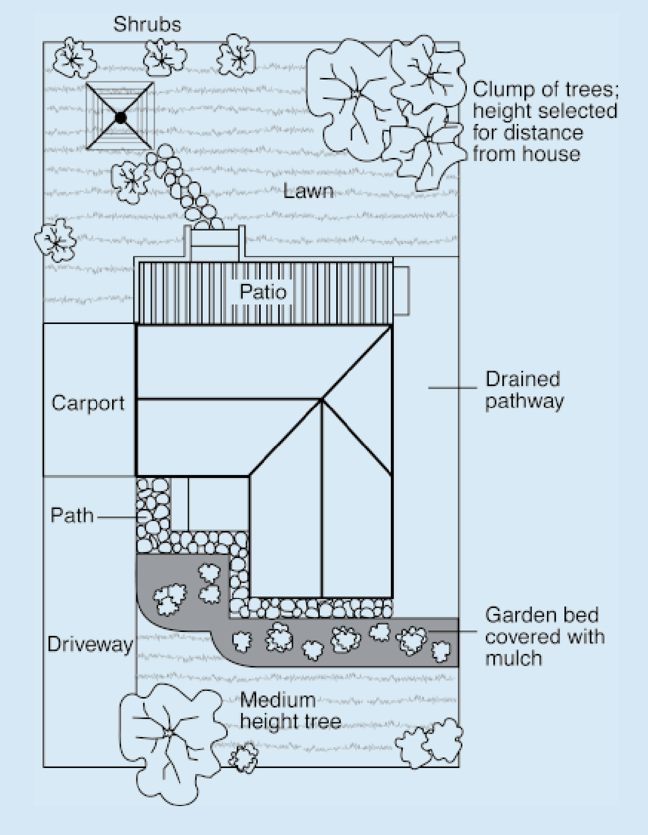
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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17 Attachment H – Notes About This Report

Important Information About Your Report

Subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all of course, are necessarily relevant to all reports, but are included as general reference.

Engineering Reports - Limitations

Geotechnical reports are based on information gained from limited sub-surface site testing and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Engineering Reports – Project Specific Criteria

Engineering reports are prepared by qualified personnel and are based on the information obtained, on current engineering standards of interpretation and analysis, and on the basis of your unique project specific requirements as understood by Martens. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the Client.

Where the report has been prepared for a specific design proposal (eg. a three storey building), the information and interpretation may not be relative if the design proposal is changed (eg. to a twenty storey building). Your report should not be relied upon if there are changes to the project without first asking Martens to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Martens will not accept responsibility for problems that may occur due to design changes if they are not consulted.

Engineering Reports – Recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced and therefore your site investigation report recommendations should only be regarded as preliminary.

Only Martens, who prepared the report, are fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Martens cannot be held responsible for such misinterpretation.

Engineering Reports – Use For Tendering Purposes

Where information obtained from this investigation is provided for tendering purposes, Martens recommend that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. Attention is drawn to the document 'Guidelines for the Provision of Geotechnical Information in Tender Documents', published by the Institution of Engineers, Australia.

The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Engineering Reports – Data

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings *etc* are customarily included in a Martens report and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These data should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Engineering Reports – Other Projects

To avoid misuse of the information contained in your report it is recommended that you confer with Martens before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Subsurface Conditions - General

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects, relevant standards and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions - the potential for will depend partly on test point (eg. excavation or borehole) spacing and sampling frequency which are often limited by project imposed budgetary constraints.

- Changes in guidelines, standards and policy or interpretation of guidelines, standards and policy by statutory authorities.

- The actions of contractors responding to commercial pressures.
- Actual conditions differing somewhat from those inferred to exist, because no professional, no matter how qualified, can reveal precisely what is hidden by earth, rock and time.

  The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions

If these conditions occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Subsurface Conditions - Changes

Natural processes and the activity of man create subsurface conditions. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Reports are based on conditions which existed at the time of the subsurface exploration.

Decisions should not be based on a report whose adequacy may have been affected by time. If an extended period of time has elapsed since the report was prepared, consult Martens to be advised how time may have impacted on the project.

Subsurface Conditions - Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those that were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved at the time when conditions are exposed, rather than at some later stage well after the event.

Report Use By Other Design Professionals

To avoid potentially costly misinterpretations when other design professionals develop their plans based on a report, retain Martens to work with other project professionals who are affected by the report. This may involve Martens explaining the report design implications and then reviewing plans and specifications produced to see how they have incorporated the report findings.

Subsurface Conditions - Geoenvironmental Issues

Your report generally does not relate to any findings, conclusions, or recommendations about the potential for hazardous or contaminated materials existing at the site unless specifically required to do so as part of the Company's proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geoenvironmental or site contamination assessments. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Martens for information relating to such matters.

Responsibility

Geotechnical reporting relies on interpretation of factual information based on professional judgment and opinion and has an inherent level of uncertainty attached to it and is typically far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded.

To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Martens to other parties but are included to identify where Martens' responsibilities begin and end. Their use is intended to help all parties involved to recognize their individual responsibilities. Read all documents from Martens closely and do not hesitate to ask any questions you may have.

Site Inspections

Martens will always be pleased to provide engineering inspection services for aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site. Martens is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction.

Soil Data

Explanation of Terms (1 of 3)

Definitions

In engineering terms, soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material does not exhibit any visible rock properties and can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726 and the S.A.A Site Investigation Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

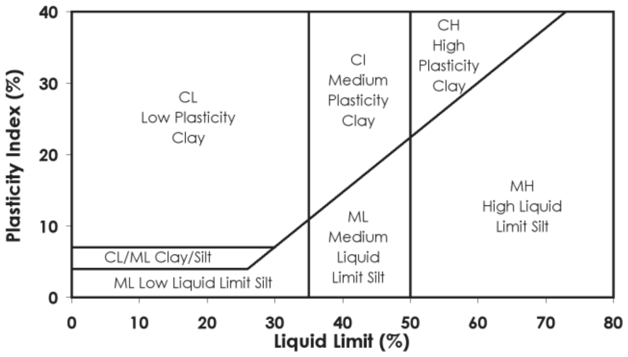
Particle Size

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay). Unless otherwise stated, particle size is described in accordance with the following table.

Division	Subdivision	Size
BOULDERS		>200 mm
COBBLES		60 to 200 mm
GRAVEL	Coarse	20 to 60 mm
	Medium	6 to 20 mm
	Fine	2 to 6 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties

Plasticity properties can be assessed either in the field by tactile properties, or by laboratory procedures.



Moisture Condition

Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and damp and is darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.

Term	C_u (kPa)	Apprx SPT "N"	Field Guide
Very Soft	<12	2	A finger can be pushed well into the soil with little effort. Sample extrudes between fingers when squeezed in fist.
Soft	12 - 25	2 to 4	A finger can be pushed into the soil to about 25mm depth. Easily moulded in fingers.
Firm	25 - 50	4 – 8	The soil can be indented about 5mm with the thumb, but not penetrated. Can be moulded by strong pressure in the figures.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated. Cannot be moulded by fingers.
Very Stiff	100 - 200	15 – 30	The surface of the soil can be marked, but not indented with thumb pressure. Difficult to cut with a knife. Thumbnail can readily indent.
Hard	> 200	> 30	The surface of the soil can be marked only with the thumbnail. Brittle. Tends to break into fragments.
Friable	-	-	Crumbles or powders when scraped by thumbnail

Density of Granular Soils

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration test (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	%	SPT 'N' Value (blows/300mm)	CPT Cone Value (q_c Mpa)
Very loose	< 15	< 5	< 2
Loose	15 – 35	5 - 10	2 -5
Medium dense	35 – 65	10 - 30	5 - 15
Dense	65- 85	30 - 50	15 - 25
Very dense	> 85	> 50	> 25

Minor Components

Minor components in soils may be present and readily detectable, but have little bearing on general geotechnical classification. Terms include:

Term	Assessment	Proportion of Minor component In:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5 % Fine grained soils: < 15 %
With some	Presence easily detectable by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 – 12 % Fine grained soils: 15 – 30 %

Soil Agricultural Classification Scheme

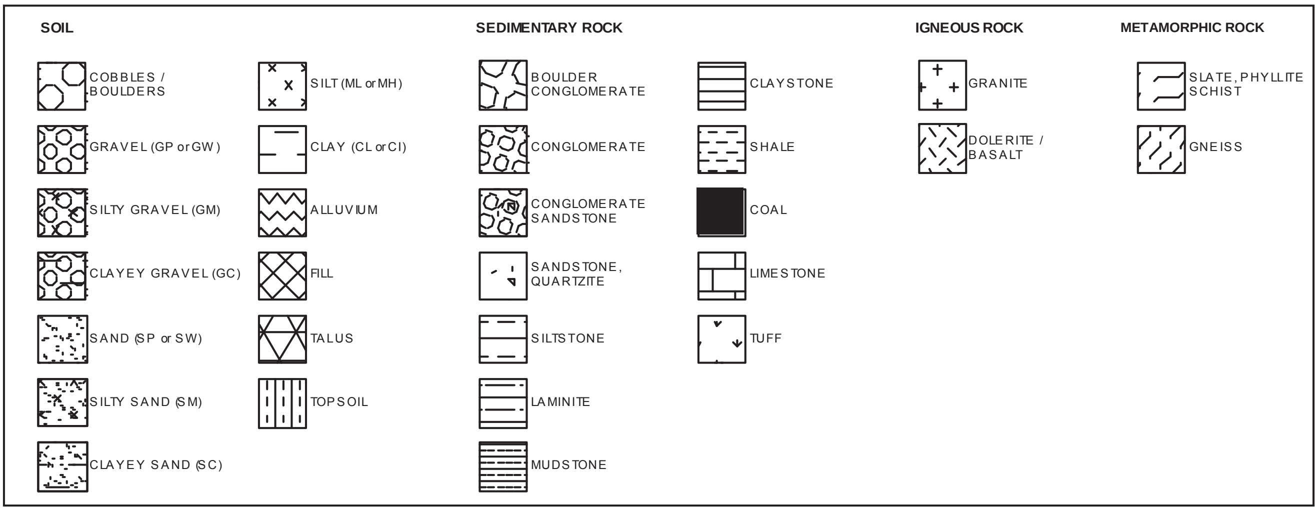
In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions by Northcote, K.H. (1979) *The factual key for the recognition of Australian Soils*, Rellim Technical Publications, NSW, p 26 - 28.

Symbol	Field Texture Grade	Behaviour of moist bolus	Ribbon length	Clay content (%)
S	Sand	Coherence nil to very slight; cannot be moulded; single grains adhere to fingers	0 mm	< 5
LS	Loamy sand	Slight coherence; discolours fingers with dark organic stain	6.35 mm	5
CLS	Clayey sand	Slight coherence; sticky when wet; many sand grains stick to fingers; discolours fingers with clay stain	6.35mm - 1.3cm	5 - 10
SL	Sandy loam	Bolus just coherent but very sandy to touch; dominant sand grains are of medium size and are readily visible	1.3 - 2.5	10 - 15
FSL	Fine sandy loam	Bolus coherent; fine sand can be felt and heard	1.3 - 2.5	10 - 20
SCL^{-}	Light sandy clay loam	Bolus strongly coherent but sandy to touch, sand grains dominantly medium size and easily visible	2.0	15 - 20
L	Loam	Bolus coherent and rather spongy; smooth feel when manipulated but no obvious sandiness or silkiness; may be somewhat greasy to the touch if much organic matter present	2.5	25
Lfsy	Loam, fine sandy	Bolus coherent and slightly spongy; fine sand can be felt and heard when manipulated	2.5	25
SiL	Silt loam	Coherent bolus, very smooth to silky when manipulated	2.5	25 + > 25 silt
SCL	Sandy clay loam	Strongly coherent bolus sandy to touch; medium size sand grains visible in a finer matrix	2.5 - 3.8	20 - 30
CL	Clay loam	Coherent plastic bolus; smooth to manipulate	3.8 - 5.0	30 - 35
SiCL	Silty clay loam	Coherent smooth bolus; plastic and silky to touch	3.8 - 5.0	30- 35 + > 25 silt
FSCL	Fine sandy clay loam	Coherent bolus; fine sand can be felt and heard	3.8 - 5.0	30 - 35
SC	Sandy clay	Plastic bolus; fine to medium sized sands can be seen, felt or heard in a clayey matrix	5.0 - 7.5	35 - 40
SiC	Silty clay	Plastic bolus; smooth and silky	5.0 - 7.5	35 - 40 + > 25 silt
LC	Light clay	Plastic bolus; smooth to touch; slight resistance to shearing	5.0 - 7.5	35 - 40
LMC	Light medium clay	Plastic bolus; smooth to touch, slightly greater resistance to shearing than LC	7.5	40 - 45
MC	Medium clay	Smooth plastic bolus, handles like plasticine and can be moulded into rods without fracture, some resistance to shearing	> 7.5	45 - 55
HC	Heavy clay	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; firm resistance to shearing	> 7.5	> 50

Soil Data

Explanation of Terms (3 of 3)

Symbols for Soil and Rock



Unified Soil Classification Scheme (USCS)

<table>
<tr><th colspan="6">FIELD IDENTIFICATION PROCEDURES
(Excluding particles larger than 63 mm and basing fractions on estimated mass)</th><th>USCS</th><th>Primary Name</th></tr>
<tr><td rowspan="8">COARSE GRAINED SOILS
More than 50 % of material less than 63 mm is larger than 0.075 mm</td><td rowspan="16">(A 0.075 mm particle is about the smallest particle visible to the naked eye)</td><td rowspan="4">GRAVELS
More than half of coarse fraction is larger than 2.0 mm.</td><td rowspan="2">CLEAN GRAVELS (Little or no fines)</td><td colspan="2">Wide range in grain size and substantial amounts of all intermediate particle sizes.</td><td>GW</td><td>Gravel</td></tr>
<tr><td colspan="2">Predominantly one size or a range of sizes with more intermediate sizes missing</td><td>GP</td><td>Gravel</td></tr>
<tr><td rowspan="2">GRAVELS WITH FINES (Appreciable amount of fines)</td><td colspan="2">Non-plastic fines (for identification procedures see ML below)</td><td>GM</td><td>Silty Gravel</td></tr>
<tr><td colspan="2">Plastic fines (for identification procedures see CL below)</td><td>GC</td><td>Clayey Gravel</td></tr>
<tr><td rowspan="4">SANDS
More than half of coarse fraction is smaller than 2.0 mm</td><td rowspan="2">CLEAN SANDS (Little or no fines)</td><td colspan="2">Wide range in grain sizes and substantial amounts of intermediate sizes missing.</td><td>SW</td><td>Sand</td></tr>
<tr><td colspan="2">Predominantly one size or a range of sizes with some intermediate sizes missing</td><td>SP</td><td>Sand</td></tr>
<tr><td rowspan="2">SANDS WITH FINES (Appreciable amount of fines)</td><td colspan="2">Non-plastic fines (for identification procedures see ML below)</td><td>SM</td><td>Silty Sand</td></tr>
<tr><td colspan="2">Plastic fines (for identification procedures see CL below)</td><td>SC</td><td>Clayey Sand</td></tr>
<tr><td rowspan="8">FINE GRAINED SOILS
More than 50 % of material less than 63 mm is smaller than 0.075 mm</td><th colspan="6">IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM</th></tr>
<tr><th>DRY STRENGTH (Crushing Characteristics)</th><th>DILATANCY</th><th>TOUGHNESS</th><th>DESCRIPTION</th><th>USCS</th><th>Primary Name</th></tr>
<tr><td>None to Low</td><td>Quick to Slow</td><td>None</td><td>Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity</td><td>ML</td><td>Silt</td></tr>
<tr><td>Medium to High</td><td>None</td><td>Medium</td><td>Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays</td><td>CL</td><td>Clay</td></tr>
<tr><td>Low to Medium</td><td>Slow to Very Slow</td><td>Low</td><td>Organic slits and organic silty clays of low plasticity</td><td>OL</td><td>Organic Silt</td></tr>
<tr><td>Low to Medium</td><td>Slow to Very Slow</td><td>Low to Medium</td><td>Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts</td><td>MH</td><td>Silt</td></tr>
<tr><td>High</td><td>None</td><td>High</td><td>Inorganic clays of high plasticity, fat clays</td><td>CH</td><td>Clay</td></tr>
<tr><td>Medium to High</td><td>None</td><td>Low to Medium</td><td>Organic clays of medium to high plasticity</td><td>OH</td><td>Organic Silt</td></tr>
<tr><td colspan="2">HIGHLY ORGANIC SOILS</td><td colspan="4">Readily identified by colour, odour, spongy feel and frequently by fibrous texture</td><td>Pt</td><td>Peat</td></tr>
<tr><td colspan="8">Low Plasticity – Liquid Limit W_L < 35 % Medium Plasticity – Liquid limit W_L 35 to 60 % High Plasticity - Liquid limit W_L > 60 %</td></tr>
</table>

Rock Data

Explanation of Terms (1 of 2)

Definitions

Descriptive terms used for Rock by Martens are given below and include rock substance, rock defects and rock mass.

Rock Substance	In geotechnical engineering terms, rock substance is any naturally occurring aggregate of minerals and organic matter which cannot, unless extremely weathered, be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Rock substance is effectively homogeneous and may be isotropic or anisotropic.
Rock Defect	Discontinuity or break in the continuity of a substance or substances.
Rock Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

Degree of Weathering

Rock weathering is defined as the degree in rock structure and grain property decline and can be readily determined in the field.

Term	Symbol	Definition
Residual Soil	Rs	Soil derived from the weathering of rock. The mass structure and substance fabric are no longer evident. There is a large change in volume but the soil has not been significantly transported.
Extremely weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - ie. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly weathered	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decrease compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original rock substance is no longer recognisable.
Moderately weathered	MW	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh	Fr	Rock substance unaffected by weathering

Rock Strength

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance is the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics.

Term	Is (50) MPa	Field Guide	Symbol
Extremely low	≤0.03	Easily remoulded by hand to a material with soil properties.	EL
Very low	>0.03 ≤0.1	May be crumbled in the hand. Sandstone is ‘sugary’ and friable.	VL
Low	>0.1 ≤0.3	A piece of core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	L
Medium	>0.3 ≤1.0	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	M
High	>1 ≤3	A piece of core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife.	H
Very high	>3 ≤10	A piece of core 150mm long x 50mm diameter may be broken readily with hand held hammer. Cannot be scratched with pen knife.	VH
Extremely high	>10	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	EH

Rock Data

Explanation of Terms (2 of 2)

Degree of Fracturing

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but excludes fractures such as drilling breaks.

Term	Description
Fragmented	The core is comprised primarily of fragments of length less than 20mm, and mostly of width less than core diameter.
Highly fractured	Core lengths are generally less than 20mm-40mm with occasional fragments.
Fractured	Core lengths are mainly 30mm-100mm with occasional shorter and longer sections.
Slightly fractured	Core lengths are generally 300mm-1000mm with occasional longer sections and occasional sections of 100mm-300mm.
Unbroken	The core does not contain any fractures.

Rock Core Recovery

TCR = Total Core Recovery

$$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100\%$$

SCR = Solid Core Recovery

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100\%$$

RQD = Rock Quality Designation

$$= \frac{\sum \text{Axial lengths of core} > 100\,\text{mm long}}{\text{Length of core run}} \times 100\%$$

Rock Strength Tests

▼	Point load strength Index (Is50) - axial test (MPa)
▶	Point load strength Index (Is50) - diametrall test (MPa)
●	Unconfined compressive strength (UCS) (MPa)

Defect Type Abbreviations and Descriptions

Defect Type (with inclination given)

BP	Bedding plane parting
X	Foliation
L	Cleavage
JT	Joint
F	Fracture
SZ	Sheared zone (Fault)
CS	Crushed seam
DS	Decomposed seam
IS	Infilled seam
V	Vein

Coating or Filling

Cn	Clean
Sn	Stain
Ct	Coating
Fe	Iron Oxide

Planarity

Cu	Curved
Ir	Irregular
Pl	Planar
St	Stepped
Un	Undulating

Roughness

Po	Polished
Ro	Rough
Sl	Slickensided
Sm	Smooth
Vr	Very rough

Inclination

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

Test Methods

Explanation of Terms (1 of 2)

Sampling

Sampling is carried out during drilling or excavation to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples may be taken by pushing a thin-walled sample tube into the soils and withdrawing a soil sample in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Other sampling methods may be used. Details of the type and method of sampling are given in the report.

Drilling Methods

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Hand Excavation – in some situations, excavation using hand tools such as mattock and spade may be required due to limited site access or shallow soil profiles.

Hand Auger - the hole is advanced by pushing and rotating either a sand or clay auger generally 75-100mm in diameter into the ground. The depth of penetration is usually limited to the length of the auger pole, however extender pieces can be added to lengthen this.

Test Pits - these are excavated with a backhoe or a tracked excavator, allowing close examination of the *in-situ* soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) - the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling - the hole is advanced by pushing a 100mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength *etc.* is only marginally affected.

Continuous Spiral Flight Augers - the hole is advanced using 90 - 115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or *in-situ* testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface or, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling - similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling - a continuous core sample is obtained using a diamond tipped core barrel, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in AS 1289 Methods of Testing Soils for Engineering Purposes - Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

(i) In the case where full penetration is obtained with successive blow counts for each 150mm of say 4, 6 and 7 blows:

as 4, 6, 7
N = 13
(ii) In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm

as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

CONE PENETROMETER TESTING AND INTERPRETATION

Cone penetrometer testing (sometimes referred to as Dutch Cone - abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in AS 1289 - Test F4.1.

In the test, a 35mm diameter rod with a cone tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on separate 130mm long sleeve, immediately behind the cone. Tranducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records.

The information provided on the charts comprises:
Cone resistance - the actual end bearing force divided by the cross sectional area of the cone - expressed in MPA.
Sleeve friction - the frictional force of the sleeve divided by the surface area - expressed in kPa.
Friction ratio - the ratio of sleeve friction to cone resistance - expressed in percent.

There are two scales available for measurement of cone resistance. The lower (A) scale (0 - 5 Mpa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main (B) scale (0 - 50 Mpa) is less sensitive and is shown as a full line.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%-2% are commonly encountered in sands and very soft clays rising to 4%-10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:

q_c (Mpa) = (0.4 to 0.6) N (blows/300mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:

q_c = (12 to 18) c_u

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes *etc*. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

DYNAMIC CONE (HAND) PENETROMETERS
Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods. Two relatively similar tests are used.

Perth sand penetrometer - a 16 mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS 1289 - Test F 3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
Cone penetrometer (sometimes known as the Scala Penetrometer) - a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289 - Test F 3.2). The test was developed initially for pavement sub-grade investigations, with correlations of the test results with California bearing ratio published by various Road Authorities.

LABORATORY TESTING
Laboratory testing is carried out in accordance with AS 1289 Methods of Testing Soil for Engineering Purposes. Details of the test procedure used are given on the individual report forms.

TEST PIT / BORE LOGS
The test pit / bore log(s) presented herein are an engineering and/or geological interpretation of the subsurface conditions and their reliability will depend to some extent on frequency of sampling and the method of excavation / drilling. Ideally, continuous undisturbed sampling or excavation / core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variation between the boreholes.

GROUND WATER
Where ground water levels are measured in boreholes, there are several potential problems:

In low permeability soils, ground water although present, may enter the hole slowly, or perhaps not at all during the time it is left open.
A localised perched water table may lead to an erroneous indication of the true water table.
Water table levels will vary from time to time with seasons or recent prior weather changes. They may not be the same at the time of construction as are indicated in the report.
The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.