

QUALIFIED GEOTECHNICAL ENGINEERS



Aitken Rowe
TESTING LABORATORIES

SITE CLASSIFICATION & LAND CAPABILITY ASSESSMENT

CLIENT:

PROJECT DESCRIPTION: PROPOSED RESIDENTIAL DWELLING & EFFLUENT DISPOSAL SYSTEM

LOCATION:

ACCREDITED CONSTRUCTION MATERIALS
TESTING LABORATORIES



SE26-000

1 JANUARY 2000

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SITE CLASSIFICATION

FIELD INVESTIGATION

At your request, a subsurface exploration was performed at the above location to assess the nature of the underlying soils in order to classify the site in accordance with AS 2870 - 2011 “Residential Slab and Footings”. The following classification is derived from information gained in regard to the history of the site, the description of the natural material and the amount of swell and shrinkage the natural soils experience with variations of water content.

On 20 February 2026, our Geotechnical staff excavated two boreholes (BH1 to 3.0m and BH2 to 2.3m) using a powered drilling rig at the locations shown in the attached sketch. Disturbed samples were taken at various depths to represent various strata. The soil and groundwater conditions in these boreholes were assessed and the boreholes were logged in the field. Visual descriptions of moisture, plasticity and strength were also noted. The soil samples were tested at our NATA accredited laboratory in Wagga Wagga. Dynamic Cone Penetrometer (DCP) testing was performed at the location of BH1 and BH2 to assess the strength of the underlying material. The borehole logs with test results and DCP test reports are attached to this report.

PROPOSED STUDIO

The site of the proposed studio is situated on the northern side of the road, approximately 20m east of the existing dwelling. It should be noted that a cottage was recently demolished/removed within the footprint of the proposed construction in Circa 2025 as advised by the client.



Figure 1 – Google Earth Aerial Imagery (11/04/2023)



Site Photo 1 – BH1 Looking West (20/02/2026)

The borehole investigation performed for the proposed studio (BH1) revealed that the site is underlain by fill material comprising low plasticity sandy silt to 0.1m, overlying natural alluvial and residual material comprising various medium, medium to high and high plasticity clays and sandy silty clays to 1.9m, which is then underlain by extremely weathered, extremely low strength siltstone bedrock extending to the borehole termination depth at 3.0m in BH1. The fill material encountered at the site appeared to have been placed “uncontrolled” and “moderately” compacted.

The moisture condition of the underlying material was generally less than plastic limit throughout the clay-based profile and dry throughout the siltstone bedrock at the time of the investigation. The underlying clays are considered “poorly drained” which may result in significant volume changes during the wet and dry climatic cycles. No groundwater or seepage was encountered during the drilling, however it should be noted that variations to the water table level could fluctuate with changes to the season, temperature and rainfall.

The DCP test results in BH1 (DCP1) indicate the underlying natural clay-based material (below fill) to be very stiff consistency to the shallow DCP refusal depth of 0.3m in BH1 at the time of the investigation.

It is noted that the fill material encountered at the site is considered “uncontrolled and not suitable” for any structural element of the footing system in its current state. It should also be noted that due to the recent demolition of the existing cottage, and presence of the existing large sized tree near the footprint of the proposed dwelling (refer to Figure 1 and Site Photo 1 above), the site is considered to

have “abnormal moisture” conditions. Therefore, based on available data, laboratory test results and estimated characteristic surface movements (γ_s), the site shall be classified as **“P-Problem site”** in accordance with the Australian Standard AS 2870. We recommend that all the footings shall be designed similar to those as recommended in the Standard for “Class P” and the footing shall be designed by engineering principles. However, if one of the following 3 options is adopted and followed then **“Class ‘H1-D’ – Highly reactive deep drying”** classification may be adopted.

- 1) Allow the foundation material to achieve equilibrium moisture condition throughout the soil profile by removing the affecting tree or by installing a heavy-duty root barrier to isolate the tree roots. The root barrier should be installed to the minimum depth of 1.5m below the existing surface level or below the tree root system (whichever is greater). **Any tree roots within the building footprint are to be removed and backfilled in a controlled manner such that it can be used as “controlled fill” as required. It is anticipated that equilibrium moisture conditions may be achieved within a minimum period of 12 months from the date of the tree removal (or installation of a heavy-duty root barrier) provided abnormal moisture ingress does not affect the underlying foundation material during this period.** Once the foundation has achieved equilibrium moisture condition throughout the soil profile, based on the type and condition of the subsoil at the time of the field investigation;
 - The footing shall be founded on the **stiff consistency or better natural orange brown clay or “controlled fill” material at or below the minimum depth of 0.35m** measured from the existing surface (refer to attached borehole logs), for which an allowable bearing capacity of **100kPa may be adopted**, provided proper drainage measures are incorporated in the design, during and after the construction, and provided the fill material is certified under level 1 supervision as “controlled fill”.
 - The slab panel, internal beams and load support thickenings may be founded on the underlying **natural brown sandy silty clay or “controlled fill” material** for which an allowable bearing capacity of **50kPa may be adopted**, provided the fill material is certified under level 1 supervision as “controlled fill” and the final fill surface and exposed subgrade is **proof rolled to detect any soft, loose or heaving areas**. If such areas exist, they shall be excavated and replaced and compacted with granular select fill as required.

It is highly recommended to undertake additional drilling and field moisture content determination tests at or after the minimum 12 month period or;

- 2) Position the proposed studio such that it remains outside the influence zone of the large sized tree. **The applicable minimum setback distance for this site is 100% of the mature tree height.** Depending on the distance from the current borehole drilled, additional boreholes and DCP testing may be required at the new location of the proposed studio in order to assess the suitability of the founding material and recommended founding depths.
- 3) All footings are founded below the anticipated moisture affected upper profile (1.5m from the existing surface level) and the slab is fully suspended on a pier footing system. **The pier footing system** shall be founded on the **very stiff consistency or better natural clay at or below 1.5m** from the existing surface (refer borehole logs) for which an allowable bearing capacity of 250kPa and allowable side adhesion of 25kPa may be adopted provided the slab is fully suspended on the pier footing system. The side adhesion within uncontrolled fill and the top 1.5m of the natural material should be ignored.

PROPOSED OUTDOOR KITCHEN

The site of the proposed outdoor kitchen is situated approximately 20m north of the existing dwelling. It is understood that an existing timber shed will be removed from within the footprint of the proposed construction, however there are no slab or footings to remove. Several trees are also situated in close proximity to the proposed construction.



Site Photo 2 – BH2 Looking South (20/02/2026)

The borehole investigation performed for the proposed outdoor kitchen (BH2) revealed that the site is underlain by natural alluvial and residual material comprising topsoil to 0.1m overlying various medium, medium to high and high plasticity clays, silty clays and sandy silty clays to 2.0m, which is then underlain by extremely weathered, extremely low strength siltstone bedrock extending to the borehole termination depth at 2.3m in BH2.

The moisture condition of the underlying material was generally less than plastic limit throughout the clay-based profile and dry throughout the siltstone bedrock at the time of the investigation. The underlying clays are considered “poorly drained” which may result in significant volume changes during the wet and dry climatic cycles. No groundwater or seepage was encountered during the drilling, however it should be noted that variations to the water table level could fluctuate with changes to the season, temperature and rainfall.

The DCP test results in BH2 (DCP2) indicate the underlying natural clay-based material (below topsoil) to be very stiff consistency to the shallow DCP refusal depth of 0.2m in BH2 at the time of the investigation.

It should be noted that due to the presence of the existing trees near the footprint of the proposed structure, the site is considered to have “abnormal moisture” conditions. Therefore, based on available data, laboratory test results and estimated characteristic surface movements (γ_s), the site shall be classified as **“P-Problem site”** in accordance with the Australian Standard AS 2870. We recommend that all the footings shall be designed similar to those as recommended in the Standard for “Class P” and the footing shall be designed by engineering principles. However, if one of the following 3 options is adopted and followed then **“Class ‘H1-D’ – Highly reactive deep drying”** classification may be adopted.

- 1) Allow the foundation material to achieve equilibrium moisture condition throughout the soil profile by removing the affecting tree or by installing a heavy-duty root barrier to isolate the tree roots. The root barrier should be installed to the minimum depth of 1.5m below the existing surface level or below the tree root system (whichever is greater). **Any tree roots within the building footprint are to be removed and backfilled in a controlled manner such that it can be used as “controlled fill” as required. It is anticipated that equilibrium moisture conditions may be achieved within a minimum period of 12 months from the date of the tree removal (or installation of a heavy-duty root barrier) provided abnormal moisture ingress does not affect the underlying foundation material during this period.** Once the foundation has achieved equilibrium moisture condition throughout the soil profile, based on the type and condition of the subsoil at the time of the field investigation;
 - The footing shall be founded on the **stiff consistency or better natural yellow orange sandy silty clay or “controlled fill” material at or below the minimum depth of 0.35m** measured from the existing surface (refer to attached borehole logs), for which an allowable bearing capacity of **100kPa may be adopted**, provided proper drainage measures are incorporated in the design, during and after the construction, and provided the fill material is certified under level 1 supervision as “controlled fill”.
 - The slab panel, internal beams and load support thickenings may also be founded on the underlying **natural yellow orange sandy silty clay or “controlled fill” material** for which an allowable bearing capacity of **50kPa may be adopted**, provided the fill material is certified under level 1 supervision as “controlled fill” and the final fill surface and exposed subgrade is **proof rolled to detect any soft, loose or heaving areas**. If such areas exist, they shall be excavated and replaced and compacted with granular select fill as required.

It is highly recommended to undertake additional drilling and field moisture content determination tests at or after the minimum 12 month period or;

- 2) Position the proposed outdoor kitchen such that it remains outside the influence zone of the large sized tree. **The applicable minimum setback distance for this site is 100% of the mature tree height.** Depending on the distance from the current borehole drilled, additional boreholes and DCP testing may be required at the new location of the proposed structure in order to assess the suitability of the founding material and recommended founding depths.

- 3) All footings are founded below the anticipated moisture affected upper profile (1.5m from the existing surface level) and the slab is fully suspended on a pier footing system. **The pier footing system shall be founded on the very stiff consistency or better natural clay at or below 1.5m** from the existing surface (refer borehole logs) for which an allowable bearing capacity of 250kPa and allowable side adhesion of 25kPa may be adopted provided the slab is fully suspended on the pier footing system. The side adhesion within uncontrolled fill and the top 1.5m of the natural material should be ignored.



ADDITIONAL SITE RECOMMENDATIONS

It should be noted that the minimum footing depths for various footing systems are determined by the type of construction selected for the proposed dwelling and are presented in Section 3 of AS 2870 – 2011. **It is highly recommended to undertake Dynamic Cone Penetrometer testing at the time of construction to ensure the required bearing capacity can be achieved at the base of the footing system.**

The applicable minimum setback distance for existing and future trees at this site is 100% of the mature tree height. If trees are to be retained or planted in close proximity, the site shall be classified as “Class P – Problem site” in accordance with the Australian Standard AS 2870. Alternatively, a heavy-duty tree root barrier may be installed to the minimum depth of 1.5m along the perimeter of the construction or surrounding the affecting trees.

To assist the structural design of the footing system, the “estimated tree induced characteristic surface movement” (y_t) was calculated based on a range of possible tree heights and distances from the proposed construction, based on the current subsoil profile. The calculated y_t values are presented in Table 1 below.

Table 1 Estimated y_t Values

Distance to Building (m)	Individual Trees – Mature Height (m)							Groups of Trees – Mature Height (m)						
	4	6	8	10	12	15	20	4	6	8	10	12	15	20
2	12.4	12.4	12.4	12.4	12.4	12.4	12.4	19.6	19.6	19.6	19.6	19.6	19.6	19.6
5	NIL	4.1	9.3	12.4	12.4	12.4	12.4	9.8	15.2	18.0	19.6	19.6	19.6	19.6
8	NIL	NIL	NIL	5.0	8.3	11.6	12.4	NIL	8.7	13.1	15.7	17.4	19.2	19.6
10	NIL	NIL	NIL	NIL	4.1	8.3	12.4	NIL	4.4	9.8	13.1	15.2	17.4	19.6
15	NIL	NIL	NIL	NIL	NIL	NIL	6.2	NIL	NIL	1.6	6.5	9.8	13.1	16.3

If any additional fill placement is required on site during the site preparation, it is highly recommended to remove the existing topsoil, fill, silt-based material, and unsuitable material, if any, and place granular fill comprising mainly sand and well graded gravel, but caution shall be exercised not to select a ‘raw’ or non-plastic material that may induce erosion. The fill shall be placed in accordance with Clauses 2.5.3 & 6.4.2 of AS2870, or otherwise the site classification shall be reviewed.

The controlled fill is to be prepared in such a way that it achieves 95% of Standard Maximum Dry Density in every 150mm thick compacted layer. The placed fill shall be certified by a relevant NATA accredited testing laboratory for which a safe allowable bearing pressure of 100kPa may be adopted, provided proper drainage measures are incorporated in the design, during and after the construction.

Care should be taken when selecting material for use as controlled fill. Clay-based fill material is reactive to seasonal changes in moisture content which may result in shrink/swell problems and therefore should be avoided where possible. It should be noted that the placement of reactive clay-based fill material can reduce the cracking zone and adversely affect the estimated characteristic surface movements (γ_s) of the subject site. Similarly, the cracking zone can be reduced when site cuts are undertaken. **If greater than 0.4m of clay-based fill is placed, or greater than 0.5m of cut is undertaken, the site classification shall be reviewed in accordance with Clauses 2.3.2 and 2.5.2 of AS2870.**



WIND SPEED CLASSIFICATION

The following has been assessed for this site as per AS4055-2021 – Wind loads for housing:

- Region - A
- Topographic Classification - T0
- Shielding Classification - PS
- Terrain Category Classification - TC2.5

Based on the above classifications, the wind classification for this site as per AS4055-2021 is: **N1**.

LAND CAPABILITY ASSESSMENT

INTRODUCTION

Aitken Rowe Testing Laboratories Pty Ltd were also engaged to undertake a Land Capability Assessment (LCA) at the site. It is the purpose of this report to assess the above site for the suitability of an onsite treated wastewater management system. The current property owners are proposing to construct a new septic system to service the existing three-bedroom dwelling and the proposed one-bedroom studio at the site. As the site is not connected to Council's reticulated sewer network, on-site treated effluent disposal will be required.

The field investigation including detailed site visit, excavation of one borehole (BH3) to the depth of 1.5m (termination depth) and constant head permeability testing (using a Talsma-Hallam Permeameter) was carried out on 20 February 2026. Laboratory testing (Emerson Class, pH, ECe and Soil Grading) was completed on recovered samples at our NATA accredited laboratory in Wagga Wagga, NSW. A site plan showing borehole and permeameter test locations, borehole logs with explanatory note, and laboratory test reports are attached to this report. The LCA was undertaken in accordance with AS1547:2012 and the NSW Onsite Wastewater Management Guidelines (2025).



Site Photo 3 – BH3 Looking South (20/02/2026)



SITE KEY FEATURES

Table 2 summarises the key features of the site in relation to the effluent management proposed for the site.

Table 2: Site Assessment

Site Feature	Relevant System	Site Limitation			Level of Constraint	Mitigation Measures
		Minor	Moderate	Major		
Geology	All Systems	N/A	N/A	Fractured or highly porous bedrock	Minor	NN*
Shallow Bedrock	All Systems	N/A	N/A	Bedrock depth < 1.2m	Minor	NN*
Rock Outcrops	All Systems	<10% Floaters	10% to 20% Floaters	>20% Floaters	Minor	NN*
Fill	All Systems	No Fill	Controlled Fill Present	Uncontrolled Fill Present	Major	Conservative loading rates adopted
Landform	All Systems	Hill crests, divergent slopes and plains	Convergent slopes and foot slopes	Drainage plains and incised channels	Minor	NN*
Slope %	Absorption Trench	0% to 10%	10% to 20%	>20%	Minor	NN*
	ETA Bed	0% to 5%	5% to 10%	>10%	Minor	NN*
	Subsurface Irrigation	0% to 20%	20% to 30%	>30%	Minor	NN*
	LPED Irrigation	0% to 5%	5% to 10%	>10%	Minor	NN*
	Constructed Mound	0% to 10%	10% to 15%	>15%	Minor	NN*
Erosion Potential	All Systems	No signs of erosion present and well vegetated	Absence of vegetation	Signs of erosion and slope failure present	Moderate	Consider subsurface irrigation with planted turf
Run-on and Upslope Seepage	All Systems	No run-on	Some run-on: diversion possible	High run-on: diversion not practical	Minor	NN*
Flood Potential	Septic Tank	Vents, opening and electrical components above 1 in 100-year flood contour	N/A	Vents, opening and electrical components below 1 in 100-year flood contour	Minor	NN*
	All Systems	Above 1 in 20-year floor contour	N/A	Below 1 in 20-year floor contour	Minor	NN*

Table 2: Site Assessment (Continued)

Site Feature	Relevant System	Site Limitation			Level of Constraint	Mitigation Measures
		Minor	Moderate	Major		
Site Drainage	All Systems	No visible signs of surface dampness	N/A	Visible signs of surface dampness or seepage	Minor	NN*
Exposure	All Systems	High sun and wind exposure	N/A	Low sun and wind exposure	Major	Remove existing trees
Land Area	All Systems	Area is available	N/A	Area is not available	Minor	NN*

*NN – Not needed

SOIL KEY FEATURES

The site's soils have been assessed for their suitability for onsite wastewater management by a combination of soil survey and laboratory testing as outlined below.

The site is generally underlain by fill material comprising clay loam topsoil to 0.1m, overlying fill material comprising moderately structured clay loam to 0.3m, which is then underlain by highly structured light clay fill material to 1.2m underlain by natural weakly structured heavy clay within the investigation depth of 1.5m.

The permeability of the underlying clay-based fill material from 0.3 to 0.55m was assessed by carrying out a constant head permeameter test at the site. The test indicated an average permeability of 0.69m/day on the underlying material. This classifies the underlying soil as "Category 5A" as per AS1547:2012 – "On-site domestic-wastewater management".

Soil gradings were performed on the underlying material and confirms the upper 0.3 to 1.2m of soil to be a "Category 5A". Emerson Class testing was also performed and indicated the material to be "potentially highly dispersive" in the upper profile and "potentially moderately dispersive" in the lower profile. Due to the dispersive nature of the underlying clays, it is highly recommended to ameliorate the soil with an initial dose of 0.8kg/m² of gypsum before constructing the effluent disposal system. Annual dosing at a lower rate (0.5kg/m²) should be applied to prevent structural degradation of the soil. The annual treatment may be applied to the disposal surface (for irrigation systems) or directly to the septic tank in the form of liquid gypsum (for trench and bed systems).

Therefore, based on the field investigation and laboratory test results, Category 5A will be adopted for all disposal systems at this site. The constant head permeability, grading and Emerson Class test reports are herewith attached.

Table 3 below provides an assessment of the physical and chemical characteristics of the soil profile.

Table 3: Soil Assessment

Soil Feature	Relevant System	Soil Limitation			Level of Constraint	Mitigation Measures
		Minor	Moderate	Major		
Depth to Bedrock or Groundwater	Absorption Trench	> 1.5m	1.2 – 1.5m	< 1.2m	Minor	NN*
	ETA Bed	> 1.35m	1.05 – 1.35m	< 1.05m	Minor	NN*
	Subsurface Irrigation	> 1.0m	0.7 – 1.0m	< 0.7m	Minor	NN*
	LPED Irrigation	> 1.1m	0.8 – 1.1m	< 0.8m	Minor	NN*
Soil Category	Absorption Trench	3 and 4	N/A	1, 2, 5 and 6	Major	Conservative DLR adopted
	ETA Bed	4 and 5	6	1, 2 and 3	Minor	NN*
	Subsurface Irrigation	2B, 3 and 4	1, 2A, 5 and 6	N/A	Moderate	Appropriate DIR adopted
	LPED Irrigation	2, 3 and 4	5	1 and 6	Moderate	Appropriate DIR adopted
Coarse Fragments	All Systems	< 20%	20 – 40%	> 40%	Minor	NN*
Bulk Density (g/cm ³)	Cat 2, 3	< 1.8	N/A	> 1.8	Minor	NN*
	Cat 4	< 1.6	N/A	> 1.6	Minor	NN*
	Cat 5	< 1.4	N/A	> 1.4	Minor	NN*
pH	All Systems	> 6.0	4.5 – 6.0	< 4.5	Minor	NN*
ECe (dS/m)	All Systems	< 4	4 – 8	> 8	Minor	NN*
Sodicity (ESP)	All Systems	< 5	5 – 10	> 10	Not tested (single site)	Ongoing monitoring recommended
Cation Exchange Capacity (cmol/kg)	Subsurface and LPED irrigation	> 15	5 – 15	< 5	Not tested (single site)	Ongoing monitoring recommended
Phosphorus Sorption (kg/ha)	All Systems	> 6,000	2,000 – 6,000	< 2,000	Moderate	Nutrient balance required
Emerson Class	All Systems	Class 3, 4, 5, 6, 7 and 8	Class 2	Class 1	Moderate	Gypsum dosing recommended

*NN – Not needed



DISPOSAL AREA SIZING

It is assumed the proposed septic system will service the existing three-bedroom dwelling and the proposed one-bedroom studio as advised by the client. Therefore, the calculation rates are based on 150L/bedroom+2/day (allow 6 persons). This assumption is based on Table 6-1 of the NSW Onsite Wastewater Management Guidelines (2025).

It should be noted that if the above design flow rates are adopted then the minimum design capacity for the septic tank shall be determined by:

- Providing for around 24 hours settling volume
- Providing for sludge accumulation over a 5 year pump out cycle using the following rates;

- 1) All waste 80L/person/year
- 2) Greywater 40L/person/year
- 3) Blackwater 50L/person/year

Table 4: Minimum Septic Tank Capacity (All Waste) – 5 Year Pump Out

Design Occupancy	Design Flow Rate (L/day)	Minimum Septic Tank Capacity (L)
3	450	1,650
4	600	2,200
5	750	2,750
6	900	3,300
7	1,050	3,850
8	1,200	4,400
9	1,350	4,950
10	1,500	5,500

It is highly recommended to install an outlet filter in the septic tank. Outlet filters can extend the lifetime of disposal systems and protect irrigation fields from clogs. The outlet filter should be removed and cleaned every 5 years.

The following minimum disposal areas for various systems have been calculated based on the above laboratory test results, design flow rate assumptions, and SILO climatic data for Wagga Wagga.

1. Absorption Trench (Primary & Secondary Treated Effluent)

Absorption trenches can be used for primary and secondary treated wastewater. The wastewater will exit through the side walls of the trench as well as the base, but only the base of the trench is used to calculate the application area.

Absorption trenches are not recommended in sandy soils (soil categories 1 and 2a) due to the high infiltration rates that can carry pathogens, salts and nutrients to groundwater. They are also not recommended for use in heavy clay soils (soil categories 5b, 5c and 6) as dispersal rates in these soils are limited.

However, in some circumstances, the use of absorption trenches/beds (with special design and distribution techniques or soil modification procedures) may be used in sandy soils or heavy clay soils. Where groundwater quality is at risk, secondary treatment is required and consideration should also be given to disinfection, nutrient removal, soil modification or distribution over a large application area.

The suitability of a soil for a trench bed can also depend on the composition of sandy loam and climate and other factors. Depending on the soil type, the spacing between trenches will vary between 1m (for sandy loams) to 2m (for clay soils) and may be greater where required. The minimum spacing of 1m is in accordance with AS/NZS 1547:2012.

The absorption trench may comprise conventional distribution pipes or self-supporting arch. The preferred construction method using 'ReIn' trench is shown in Figure 2 below. The following figure is appropriated from Appendix L of AS1547:2012 and should be used as a visual aid.

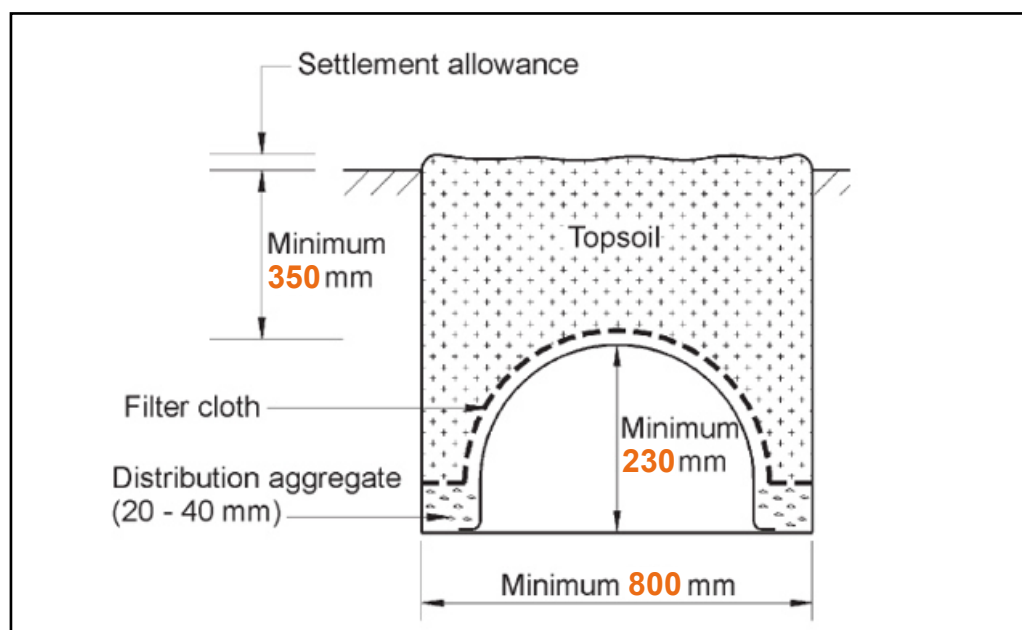


Figure 2 – Absorption Trench System Visual Aid (Figure L2, AS 1547, 2012)

The preferred construction method for a wick trench is shown in Figure 3 below. The following figure is appropriated from the EPA Victoria Code of Practice 891.4 (2016) and should be used as a visual aid.

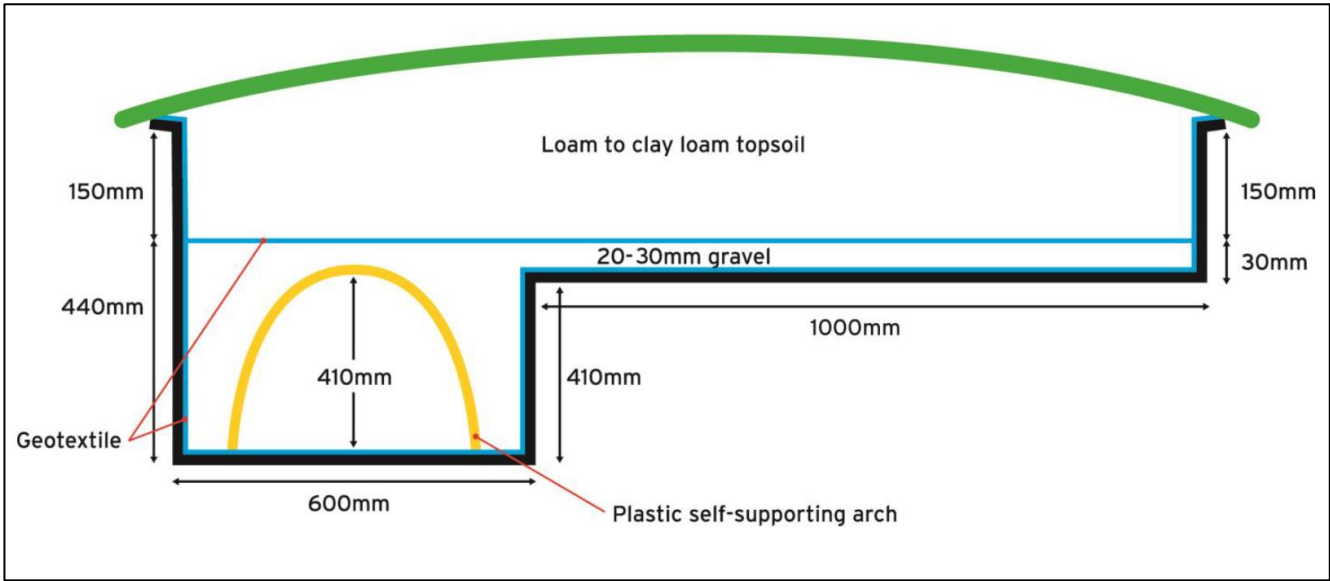


Figure 3 – Wick Trench & Bed System Visual Aid (EPA Victoria Code of Practice 891.4, 2016)

Based on the above assumptions, the following minimum dimensions for the disposal area for the absorption trench disposal system are recommended. The trenches shall have a maximum base gradient of 5%, and **maximum individual trench length of 20m**. If the site is sloping, the trenches shall be constructed along the contours. **It is highly recommended to incorporate a syphon flush system to ensure even distribution across the entire absorption trench.**

- | | | |
|---------------------------------------|---------------------|------------------------------------|
| • Effluent Treatment Quality | - Primary | - Secondary |
| • Minimum Absorption Area (Standard) | - 180m ² | - 75m ² |
| • Minimum Trench Length (Standard) | - 225m | - 94m (width 0.8m, depth 0.6m) |
| • Minimum Trench Length (Wick Trench) | - 135m | - 56m (width 0.6/1.0m, depth 0.6m) |

As stated in AS1547:2012 and the NSW Onsite Wastewater Management Guidelines (2025), a suitable “reserve area” equivalent to the minimum disposal areas stated above shall be reserved in the case of early system failure. Reserve areas are typical required for primary treated effluent only, however may also be required for secondary treated effluent at the discretion of the local authority.

Due to the impermeable nature of the underlying clay-based fill material and resulting excessive lengths of trench required, the absorption trench disposal method is not considered feasible for this site.

2. Evapotranspiration Bed (Primary Treated Effluent)

Evapotranspiration beds rely on subsurface absorption as well as evaporation and transpiration by plants to further treat the effluent in the subsurface. As such, they perform best when installed in a position with good sun and wind exposure. Evapotranspiration beds are generally constructed below ground with a slightly mounded surface to direct run-off.

As effluent is dosed to the distribution manifold by either pressure, low pressure or gravity, capillary action draws effluent up through the sand in the upper part of the bed from the storage in the void spaces between the gravel aggregate underneath. This supplies the root zone of the vegetation (turf) to optimise evapotranspiration. For this reason, it is crucial to develop a slight clogging layer to ensure there is effluent available, however if the clogging layer becomes moderate to severe, the system may fail. Therefore, for Category 1 to 5 soils, primary treated effluent is recommended, however for Category 6 soils, secondary treated effluent is required to prevent severe clogging. Additionally, a fine sand layer should be incorporated into the bed construction to maintain a slight clogging layer.

Variation in aggregate and sand sizing can cause upper soil to settle into the lower aggregate, further clogging the lower layers of the bed. It is therefore recommended to construct an additional layer of fine aggregate above the standard gravel aggregate, as shown in Figure 4 below. The following figure is appropriated from the NSW Onsite Wastewater Management Guidelines (2025) and should be used as a visual aid.

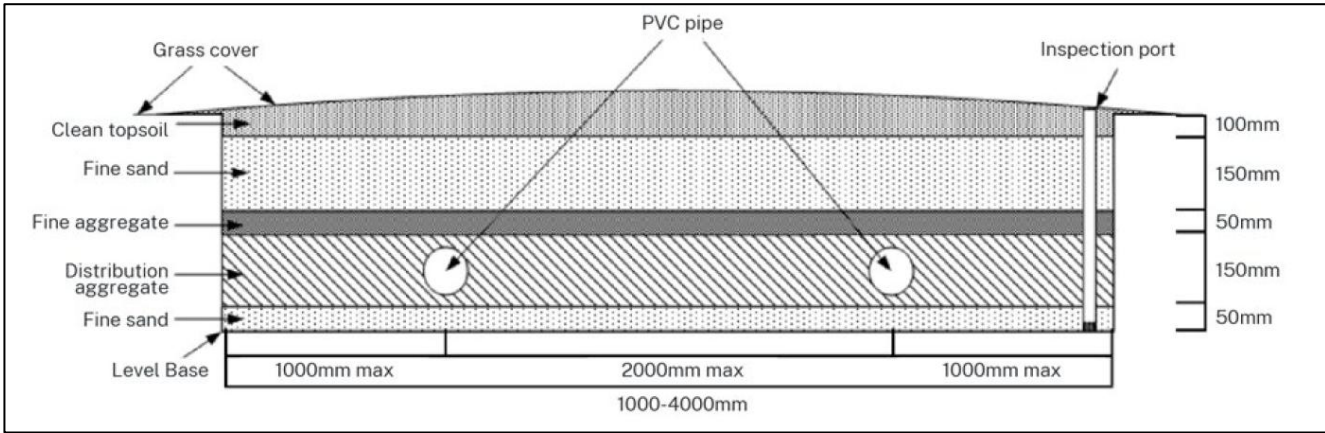


Figure 4 – Evapotranspiration Bed System Visual Aid (Figure 5-16, NSW OWMG, 2025)

Based on the above assumptions, water balance analysis (allowing 250mm of effluent storage) and soil data available, the following minimum dimensions for the evapotranspiration bed disposal system are recommended provided that the Design Loading Rate (DLR) does not exceed 8.0mm/day. The beds shall have a maximum base gradient of 5%, and **maximum individual bed length of 20m**. If the site is sloping, the beds shall be constructed along the contours. It should be noted that this system is considered suitable for primary treated effluent only. **It is highly recommended to incorporate a syphon flush system to ensure even distribution across the entire evapotranspiration bed.** The water balance calculations assume vegetation planting (turf) will occur on-site to allow evapotranspiration.

- Water Balance Area - 99m²
- Minimum Bed Length - 25m (width 4.0m, depth 0.45m)

As stated in AS1547:2012 and the NSW Onsite Wastewater Management Guidelines (2025), a suitable “reserve area” equivalent to the minimum disposal areas stated above shall be reserved in the case of early system failure. Reserve areas are typical required for primary treated effluent only, however may also be required for secondary treated effluent at the discretion of the local authority.

3. Pressurised Subsurface Irrigation System (Secondary Treated Effluent)

Consideration through consultation with the local authority will be required prior to choosing this method of disposal because the treatment system will need to conform to effluent quality standards to ensure protection of public health as such:

- Five days biochemical oxygen demand (BOD5) not greater than 20mg/L.
- Suspended solids not greater than 30mg/L.
- Thermotolerant coliforms not greater than 10 per 100mL.
- Where chlorine is used as a disinfectant, free residual chlorine measured by a field test at the first irrigation outlet, is not less than 0.5mg/L after a 30min contact period.
- All other requirements are to be met as per Part 5 and Appendix M of AS1547:2012.

Subsurface irrigation comprises a network of drip-irrigation lines that are specially designed for use with wastewater. The pipe contains pressure compensating emitters (drippers) that employ a biocide to prevent build-up of slimes and inhibit root penetration. The lateral pipes are usually 0.6 to 1.0m apart, installed parallel along the contour, utilising the topsoil (in-situ or imported) for even distribution to the underlying soil. Due to the limiting soil texture class of Category 5A, the site may utilise the existing in-situ topsoil, and therefore only requires the importation of 50mm of additional topsoil across the entire irrigation area, and the lateral pipes should be spaced 0.6m apart. The lateral pipe installation depth is 100mm below the existing surface level in accordance with AS/NZS 1547:2012. It is critical that the irrigation pump be sized properly to ensure adequate pressure and delivery rate to the irrigation network.

A filter should be installed in the main line to remove fine particulates that could block the emitters. This must be cleaned regularly following manufacturer's instructions. Vacuum breakers should be installed at the high point/s in the system to prevent air and soil being sucked back into the drippers when the pump shuts off. Flushing valves are an important component and allow periodic flushing of the lines, with the flush water then returned to the treatment system.

Any trenching used to install the pipes must be backfilled properly with good quality topsoil to prevent preferential subsurface flows along trench lines. Irrigation areas must not be subject to high foot traffic movement, and vehicles and livestock must not have access to the area otherwise compaction around emitters can lead to premature system failure.

Based on the above assumptions, water balance analysis and soil data available, the following minimum subsurface irrigation area is recommended provided proper control of the effluent is maintained and the rate of irrigation does not exceed 3.0mm/day. The water balance calculations assume vegetation planting (turf) will occur on-site to allow evapotranspiration.

- Area - 380m²

In addition to the water balance, nutrient balances (nitrogen and phosphorus) were also undertaken which determined a minimum nutrient uptake area of **424m²**. Therefore, in addition to the above irrigation area, a **minimum 44m² nutrient buffer** shall be allocated downslope of the irrigation area to allow for nutrient uptake. If the disposal area is flat, the nutrient uptake area shall be allocated evenly around the perimeter of the irrigation area.

4. Low Pressure Effluent Distribution (LPED) Irrigation System (Secondary Treated Effluent)

Alternatively, LPED Irrigation may be considered for this site, and if adopted, will require secondary treatment to the same quality standards detailed above for subsurface irrigation. The pressure distribution lines shall comprise 25-40mm PVC with 3-6mm drilled holes distributed evenly along each length of pipe. The system should incorporate capacity for flushing. The pipes shall be placed in shallow trenches 200mm wide by 200mm deep (minimum 1.0m spacing between trenches). A clean water test should be observed before covering to ensure even squirt height. The distribution line should then be sleeved in ag-pipe or slotted 100mm PVC and the trenches backfilled with gravel. A mound of topsoil should be constructed above the completed LPED irrigation area in order to shed rainfall.

Based on the above assumptions, water balance analysis and soil data available, the following minimum LPED irrigation area is recommended provided proper control of the effluent is maintained and the rate of irrigation does not exceed 2.5mm/day. The water balance calculations assume vegetation planting (turf) will occur on-site to allow evapotranspiration.

- Area - 482m²

In addition to the water balance, nutrient balances (nitrogen and phosphorus) were also undertaken which determined a minimum nutrient uptake area of 424m². Therefore, no additional nutrient buffer is required to allow for nutrient uptake.

BUFFER DISTANCES

The following buffer distances are based on information provided in AS1547:2012 and the NSW Onsite Wastewater Management Guidelines (2025). The following distances should be used as a guide, however council may approve lower buffer distances, particularly on small lots if no suitable alternative application area is available. Proper drainage systems should be incorporated with the land application system design to ensure surface run-off does not enter into the system.

Table 5: Minimum Buffer Distances

Sensitive Receptor		Minimum Horizontal Buffer Distance (m)	
		Primary Treatment	Secondary Treatment
Property Boundary	Downslope	15	6
	Upslope	2	1.5
Buildings	Downslope	6	4
	Upslope	4	2
Swimming Pool	Downslope	15	10
	Upslope	6	3
In-Ground Water Tank	Downslope	15	10
	Upslope	6	3
Permanent Water (Rivers & Lakes)		100	50
Intermittent Water (Dams & Channels)		40	15
Water Bore (Residential Supply)		100	15
Water Bore (Town/Commercial Supply)		250	250

Should you have any queries, please do not hesitate to contact us.

Yours Faithfully,



Peter Forbes-Taber
Geotechnical Engineer / Environmental Manager

Attachments:

- Addendum
- Site Diagram showing Borehole and Permeameter Test Locations
- Borehole Logs with Explanatory Note
- Dynamic Cone Penetrometer Test Reports
- Permeameter, Emerson Class, and Soil Grading Reports
- Water & Nutrient Balance Calculations

GENERAL COMMENT

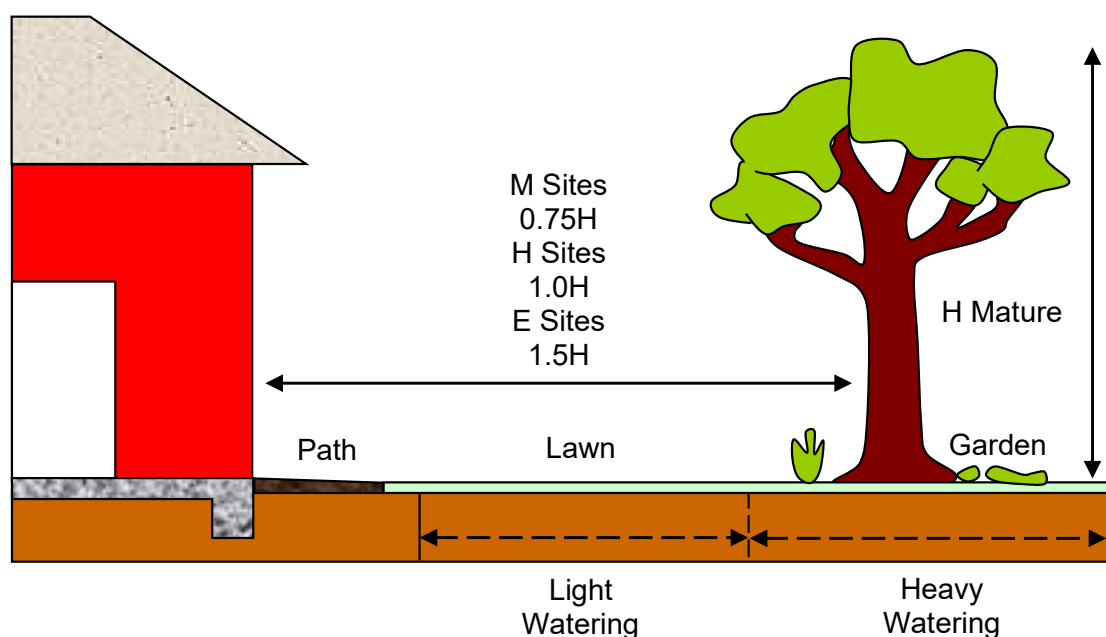
GARDENS AND TREES

Just as the building of a house changes the moisture conditions of the soil, so does the planting and establishment of a garden. The watering of the gardens increases moisture in the soil which can cause it to swell. Plants also draw moisture out of the soil, especially in long dry spells, causing the soil to shrink.

To avoid excessive moisture fluctuations around the home it is necessary to plan the garden so that only lightly watered areas such as lawns and small garden beds be located in close proximity to the house. Garden beds containing larger shrubs and trees should be kept well away from the building. Heavy watering of gardens near the house should be avoided, although uniform consistent watering of the gardens can be beneficial to prevent damage during long dry periods. Australian native plants generally require less water than exotic varieties. In any case, it is recommended to obtain information about the species to be planted in the garden prior to establishing the area.

If trees exist on site, it is highly recommended to site the proposed residential dwelling away from these trees at a distance equivalent to at least 75% (for Class M sites), 100% (for Class H sites) and 150% (for Class E sites) of the mature height of the tree. If the tree is to be removed, it is highly recommended to remove the entire tree including root system and allow the ground to achieve equilibrium moisture condition prior to construction. To assist with achieving equilibrium moisture content, the material used to backfill the removed tree site should be similar to the surrounding soil. If any trees are to be retained and the dwelling is to be built within the distance equivalent to 75% (for Class M sites), 100% (for Class H sites) and 150% (for Class E sites) of the mature height of the tree, then the footing system shall be designed for “**Class P – Problem site**” classification.

There are no recommendations within the standard for Class A and Class S sites for trees. To ensure that trees do not have a detrimental effect on the underlying materials of the dwelling it is recommended to take care when designing gardens for all soil classifications.





FOUNDATION EXCAVATION

The foundation excavation at times may expose soft or heaving areas at the base of the footing construction particularly if they are excavated after prolonged periods of rainfall. If such areas are encountered within the footing excavation, then such areas shall be excavated and treated before pouring the concrete. It is highly recommended to incorporate proper drainage measures around the perimeter of the building to ensure surface run-off does not ingress into the founding material.



RECOMMENDED FOUNDATION MATERIAL

Soil layer variations are common; we have therefore provided a description of the “Recommended foundation material” as a guide to the builder as to the correct foundation depths outside our test sites. In all cases the foundation soil chosen should have a similar consistency and strength to that recommended but need not be of the same type. The depth of the recommended foundation material may vary outside the test locations if the site is excavated or filled in any way after the date of our investigation. It is often difficult to distinguish fill from natural ground during investigation. If any significant variation from the borehole logs is noted during footing excavation i.e. 200mm or more, Aitken Rowe Testing Laboratories Pty Ltd should be consulted. Some allowances should be made for the removal of topsoil, organic matter, roots etc, which may be found in small, localised areas in the footing trenches. Also the effect of past and future trees should be considered in the selection of a design value for differential movement.



UNEXPECTED GROUND CONDITIONS

It is highly recommended to have experienced Geotechnical personnel inspect the site once the topsoil and unsuitable materials, if any, have been stripped to ensure that the exposed subgrade is consistent across the site. It is also recommended to proof roll the exposed subgrade. Isolated areas of “uncontrolled fill”, silt-based material, tree roots, existing services trenches, tile drainage etc, may be identified and may require removal prior to construction. Care should be given to the site history, particularly where orchards/vineyards/trees or existing structures have been removed.



SITE ESTABLISHMENT

It is important to establish the site as soon as possible around the home as this will assist in stabilising the moisture content in the surrounding soil. The majority of soils expand (increase in volume) when wet, and shrink (decrease in volume) again when they dry out. The change in moisture and volume of soil can cause movement sufficient to damage the home. The more swelling and shrinkage the particular soil types on a site are likely to experience from changing moisture content, the more reactive that site will be. By quickly completing the stormwater drainage and paving around the home the moisture content in the vicinity of the home can be partially stabilised. With careful planting of trees, shrubs and garden beds and well planned watering, the expected soil movement and risk of damage to the home can be minimised.

SITE DRAINAGE

When initially drawing a plan it is recommended to include the general layout of the site and garden areas. This enables the required levels to be established and ensures that adequate drainage is provided to all areas. This site drainage includes roof stormwater and ground water that may accumulate around the site and result in a change of soil conditions that could cause damage to the building. Retaining walls generally require drainage provisions to be made around and behind the wall. These drains need to be co-ordinated with the total drainage system on the site.

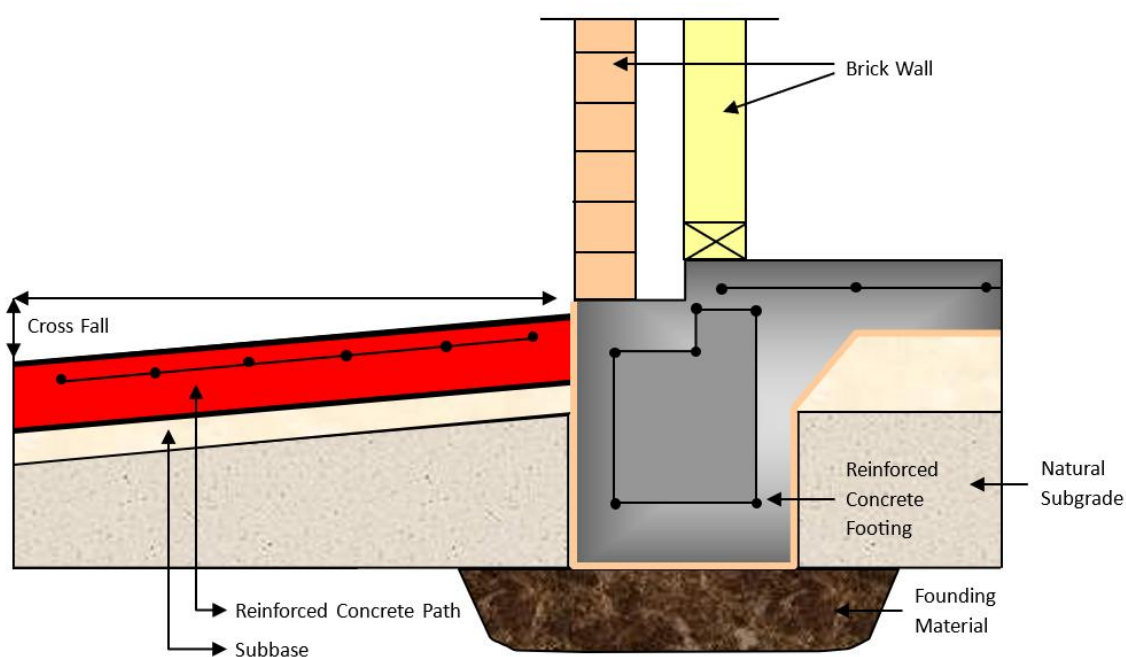
Paved areas also require adequate provision for stormwater runoff and should be graded to collection points that are both accessible for cleaning and connected to the stormwater system. All drains should be designed to prevent surface and subsurface water draining towards the house.

PAVING

The finished ground level (soil) around the home should be graded away from the house footing with a minimum fall of 50mm over the first metre. Any fill that has been placed during construction should also have the same fall and be well compacted.

Paving provides an excellent “buffer zone” around the house that assists in reducing fluctuations in the moisture conditions adjacent to the footings. If possible this paving should extend outwards from the building line a minimum of 900mm or more for highly reactive soils. It is essential that paving has the right crossfall for the expected reactivity (ground movement) of the site and all surface water is adequately drained. Care needs to be taken if laying pavements in the summer to ensure the crossfalls will not be reduced due to soils swelling in the winter. If it is not possible to construct paving immediately, plastic sheeting with gravel spread on top provides a practical temporary alternative to protect the home until concrete paths can be placed.

For Class A, S, M sites, a minimum 30mm cross fall per metre is advised. For Class H and E sites, a minimum 50mm cross fall per metre is advised.





DEFINITIONS OF SITE CLASSES

- A** Most sand or 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.
- M-D** Moderately reactive clay or silt sites with deep moisture changes.
- H1** Highly reactive clay sites, which can experience high ground movement from moisture changes.
- H2** Highly reactive clay sites, which can experience high ground movement from moisture changes.
- H1-D** Highly reactive clay sites with deep moisture changes.
- H2-D** Highly reactive clay sites with deep moisture changes.
- E** Extremely reactive sites, which can experience extreme ground movement from moisture changes.
- E-D** Extremely reactive sites with deep moisture changes.
- P** Sites which include “uncontrolled” fill; 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 with large trees adjacent to the footings or sites which cannot be classified otherwise.



MAINTENANCE

As it is important for the homeowner to maintain the building, it is also important to maintain the site around the home. The primary objective of the site and house footing maintenance is to prevent the soil from becoming too wet or too dry. By keeping the moisture content of the soil under and adjacent to the footing reasonably constant, the potential for the soil to experience significant movement that may damage the building will be limited.

Good site establishment and management is a vital part of the maintenance and protection of the home. Careful planning and detailing of the site around the concrete footing will protect your investment in the home and provide a low maintenance concrete footing for many years.

ADDENDUM



LIMITS OF INVESTIGATION

The recommendations made in this report are based on the assumption that the test results are representative of the overall subsurface conditions. However, it should be noted that even under optimum circumstances, actual conditions in some parts of the building site may differ from those said to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal all that is hidden by earth, rock and time. Because the investigation procedure generally includes sampling from either one, two or three boreholes, it may not be possible to conclusively establish the presence or extent the condition of the underlying soil and rock over the whole block until site work commences for the construction.

The client should also be aware that our recommendations refer only to our test site locations and the ground level at the time of testing.

The recommendations in this report are based on the following: -

- a) The information gained from our investigation.
- b) The present "state of the art" in testing and design.
- c) The building type and site treatment conveyed to us by the client.
- d) Historical Information

Should the client or their agent have omitted to supply us with the correct relevant information, or make significant changes to the building type and/or building envelope, our report may not take responsibility for any consequences and we reserve the right to make an additional charge if more testing is necessary.

Not withstanding the recommendations made in this report, we also recommend that whenever footings are close to any excavations or easements, that consideration should be given to deepening the footings.

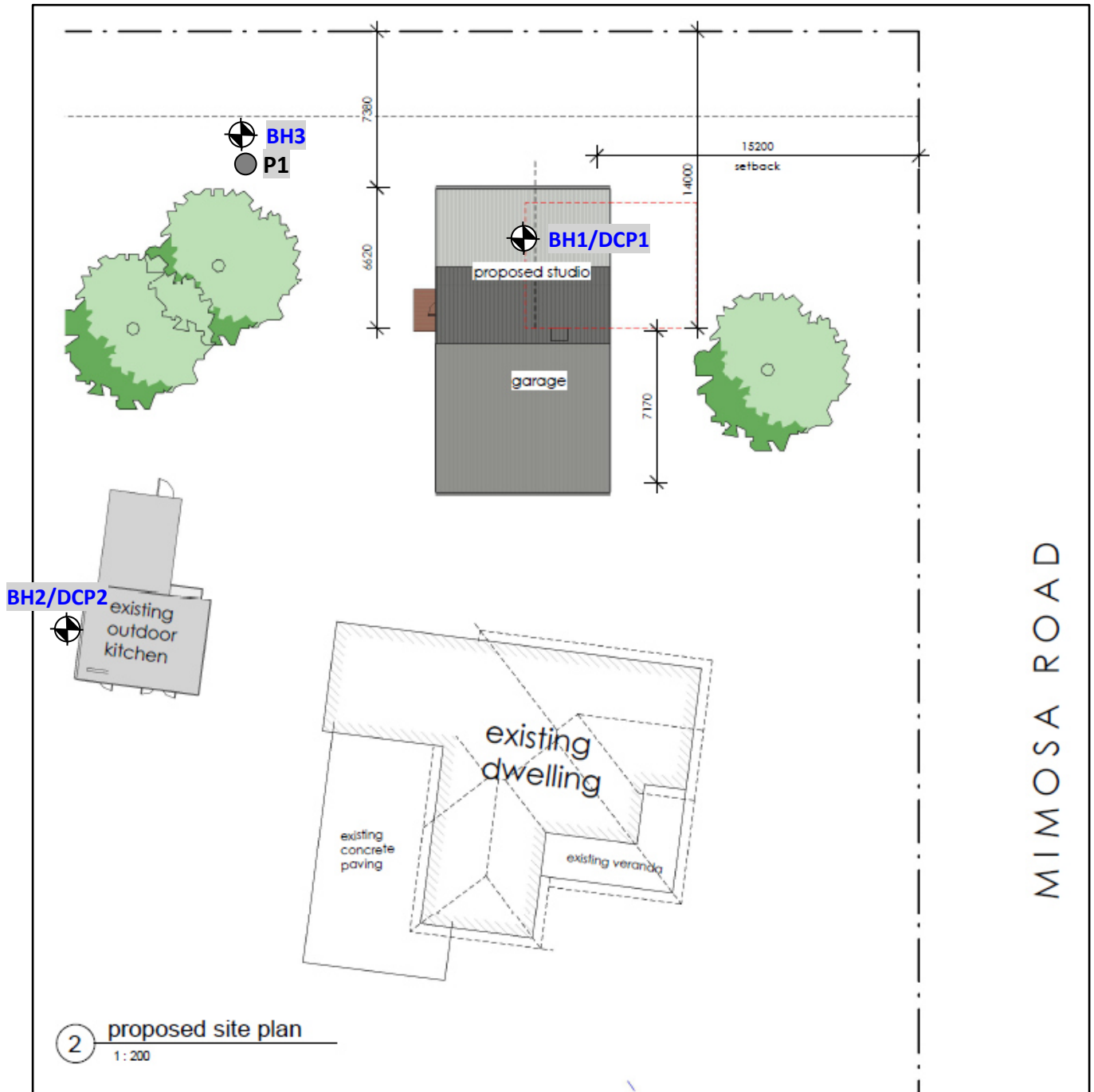
Unless otherwise stated in our commission, any dimensions or slope direction and magnitude should not be used for any building costing calculations and/or positioning. Any sketch supplied should be considered as only an approximate pictorial evidence of our work.



ADDITIONAL INFORMATION

Refer also to the CSIRO Information Sheet: - BTF18 "Foundation Maintenance and Footing Performance: A Home Owner's Guide, which can be accessed through <https://www.publish.csiro.au/book/7942/>.

SITE PLAN



MIMOSA ROAD

NOT DRAWN TO SCALE

Form R7 V1 24/09/2025

AITKEN ROWE TESTING LABORATORIES PTY LTD

Borehole No.: 3
Sheet No.: 1 of 1

Ground Level: Existing
Method: Auger Drilling with TC Bit

Date:
GPS N:
E:

Soil Category	Description/Soil Texture Class	Depth (m)	Soil Structure (H/M/W/S)	Moisture Condition	Mottled	Bleached	Sample		pH (1:5)	ECe (dS/m)	Emerson Class (Distilled Water)	Remarks & Field Records	
							Type	No.					
4A	FILL/TOPSOIL: Clay LOAM; brown	0.5	M	MC<PL	N	Y		3A	7.14	0.90	2	FILL: Appears moderately compacted, "Uncontrolled"	
4A	FILL: Clay LOAM; yellow orange		M	MC<PL	N	N							
5A	FILL: Light CLAY; orange		H	MC<PL	N	N							D
5A	FILL: Light CLAY; orange brown	1.0	H	MC<PL	N	N	D	3B	7.23	2.99	4	trace rubbish	
6C	Heavy CLAY; brown	1.5	W	MC<PL	N	N						NATURAL	
	End of Borehole (BH3) @ 1.5m	2.0											

Site Soil Profile Photo

Registration No.:
Location:
Client:

Logged By:
Scale: As shown
Dry on completion



AITKEN ROWE TESTING LABORATORIES PTY LTD

LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION				
Groundwater Record		Standing water level. Time delay following completion of drilling may be shown.				
		Groundwater seepage into borehole or excavation noted during drilling or excavation.				
Samples	D	Disturbed bag sample taken between the depths indicated by lines.				
	U	Undisturbed 50mm diameter tube sample taken between the depths indicated by lines				
Field Tests	4, 7, 10 N=17	Standard Penetration Test (S.P.T.) performed between depths indicated by lines. Individual figures show blows per 150mm penetration driven by SPT hammer.				
	5	Dynamic Cone Penetration Test performed between depths indicated by lines.				
	7	Individual figures show blows per 100mm penetration for 60 degree solid cone driven by 9 kg hammer.				
	3					
Moisture Condition (Silt or Clay based)	MC<PL	Moisture content estimated to be less than plastic limit.				
	MC=PL	Moisture content estimated to be approx. equal to plastic limit.				
	MC>PL	Moisture content estimated to be greater than plastic limit.				
Moisture Condition (Gravel or Sand based)	D	DRY – runs freely through fingers.				
	M	MOIST – does not run freely but no free water visible on soil surface.				
	W	WET – free water visible on soil surface.				
Consistency (Silt or Clay based)	VS	VERY SOFT – unconfined compressive strength less than 25kPa.				
	S	SOFT – unconfined compressive strength 25-50 kPa.				
	F	FIRM – unconfined compressive strength 50-100kPa.				
	St.	STIFF – unconfined compressive strength 100-200kPa.				
	VSt.	VERY STIFF – unconfined compressive strength 200-400kPa.				
	H	HARD – unconfined compressive strength greater than 400kPa.				
Relative Density (Gravel or Sand based)		Description	Density Index Range %	'N' Value Range Blows/300mm		
	VL	VERY LOOSE	<15	0-5		
	L	LOOSE	15-35	6-10		
	MD	MEDIUM DENSE	35-65	11-30		
	D	DENSE	65-85	31-50		
	VD	VERY DENSE	>85	>50		
Hand Penetrometer Readings	300 250 280	Numbers indicate individual test results in kPa on representative undisturbed material.				
Laboratory Test	L.S. %	Linear Shrinkage (As per TfNSW Method T113)				
	M.C. %	Field Moisture Content (As per Australian Standard AS1289.2.1.1 or TfNSW Method T120)				
	Iss	Shrink-Swell Index (As per Australian Standard AS1289.7.1.1)				
Remarks	'V' bit	Hardened steel 'V' shaped bit.				
	'TC' bit	Tungsten Carbide wing bit.				
Piezometer Construction	Backfill Materials			Piezometer		
		Bentonite		Concrete		Solid Pipe
		Washed Fine Graded Gravel		General Fill		Slotted Screen



AITKEN ROWE TESTING LABORATORIES PTY LTD

LOG SYMBOLS - ROCK FORMATION

DEGREES OF WEATHERING

TERM	SYMBOL	DEFINITION
Extremely Weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties. i.e. 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 chemicals 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 fresh rock substances 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 substances in the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics & AS 1726 - 2017 (Reference).

TERM	Is (50) MPa	FIELD GUIDE	SYMBOL
Extremely Low: —	0.03	Easily remoulded by hand to a material with soil properties.	XL
Very Low: —	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable.	VL
Low: —	0.3	A piece of core 150mm long x 50mm dia. can be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	L
Medium: —	1	A piece of core 150mm long x 50mm dia. can be broken by hand with considerable difficulty. Readily scored with knife.	M
High: —	3	A piece of core 150mm long x 50mm dia. cannot be broken by unaided hands, can be slightly scratched or scored with knife.	H
Very High: —	10	A piece of core 150mm long x 50mm dia. may be broken readily with hand held hammer. Cannot be scratched with pen knife.	VH
Extremely High: —		A piece of core 150mm long x 50mm dia. is difficult to break with hand held hammer. Rings when struck with hammer.	EH

DEGREES 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 exclude known artificial 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 the 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 10mm -- 300mm.
Unbroken:	The core does not contain any fractures.



AITKEN ROWE TESTING LABORATORIES PTY LTD

LOG SYMBOLS (LCA)

LOG COLUMN	SYMBOL	DEFINITION	
Groundwater Record		Standing water level. Time delay following completion of drilling may be shown.	
		Groundwater seepage into borehole or excavation noted during drilling or excavation.	
Samples	D	Disturbed bag sample taken between the depths indicated by lines.	
	U	Undisturbed 50mm diameter tube sample taken between the depths indicated by lines	
Soil Structure	H	Highly structured peds of soil.	
	M	Moderately structured peds of soil.	
	W	Weakly structured peds of soil.	
	S	Structureless soil.	
Moisture Condition (Silt or Clay based)	MC<PL	Moisture content estimated to be less than plastic limit.	
	MC=PL	Moisture content estimated to be approx. equal to plastic limit.	
	MC>PL	Moisture content estimated to be greater than plastic limit.	
Moisture Condition (Gravel or Sand based)	D	DRY – runs freely through fingers.	
	M	MOIST – does not run freely but no free water visible on soil surface.	
	W	WET – free water visible on soil surface.	
Soil Category		Soil Texture Class	Indicative Permeability (Ksat) m/s
	1	Structureless Gravel/Sand	> 3.0
	2A	Weakly Structured Sandy Loam	> 3.0
	2B	Structureless Sandy Loam	1.4 - 3.0
	3A	Moderately Structured Loam	1.5 - 3.0
	3B	Weakly Structured Loam	0.5 - 1.5
	4A	Moderately Structured Clay Loam	0.5 - 1.5
	4B	Weakly Structured Clay Loam	0.12 - 0.5
	4C	Structureless Clay Loam	0.06 - 0.12
	5A	Highly Structured Light Clay	0.12 - 0.5
	5B	Moderately Structured Light Clay	0.06 - 0.12
	5C	Weakly Structured Light Clay	< 0.06
	6A	Highly Structured Medium to Heavy Clay	0.06 - 0.5
	6B	Moderately Structured Medium to Heavy Clay	< 0.06
	6C	Weakly Structured Medium to Heavy Clay	< 0.06
	HL	Hydraulically Limiting Bedrock or Groundwater	< 0.06
Laboratory Tests	pH (1:5)	pH tested in a 1:5 suspension (soil:distilled water).	
	Ece	EC tested in a 1:5 suspension (soil:distilled water), then converted to Ece using soil texture factors.	
	Emerson Class	Emerson Class aggregate dispersion test carried out with distilled water.	
Remarks	'V' bit	Hardened steel 'V' shaped bit.	
	'TC' bit	Tungsten Carbide wing bit.	



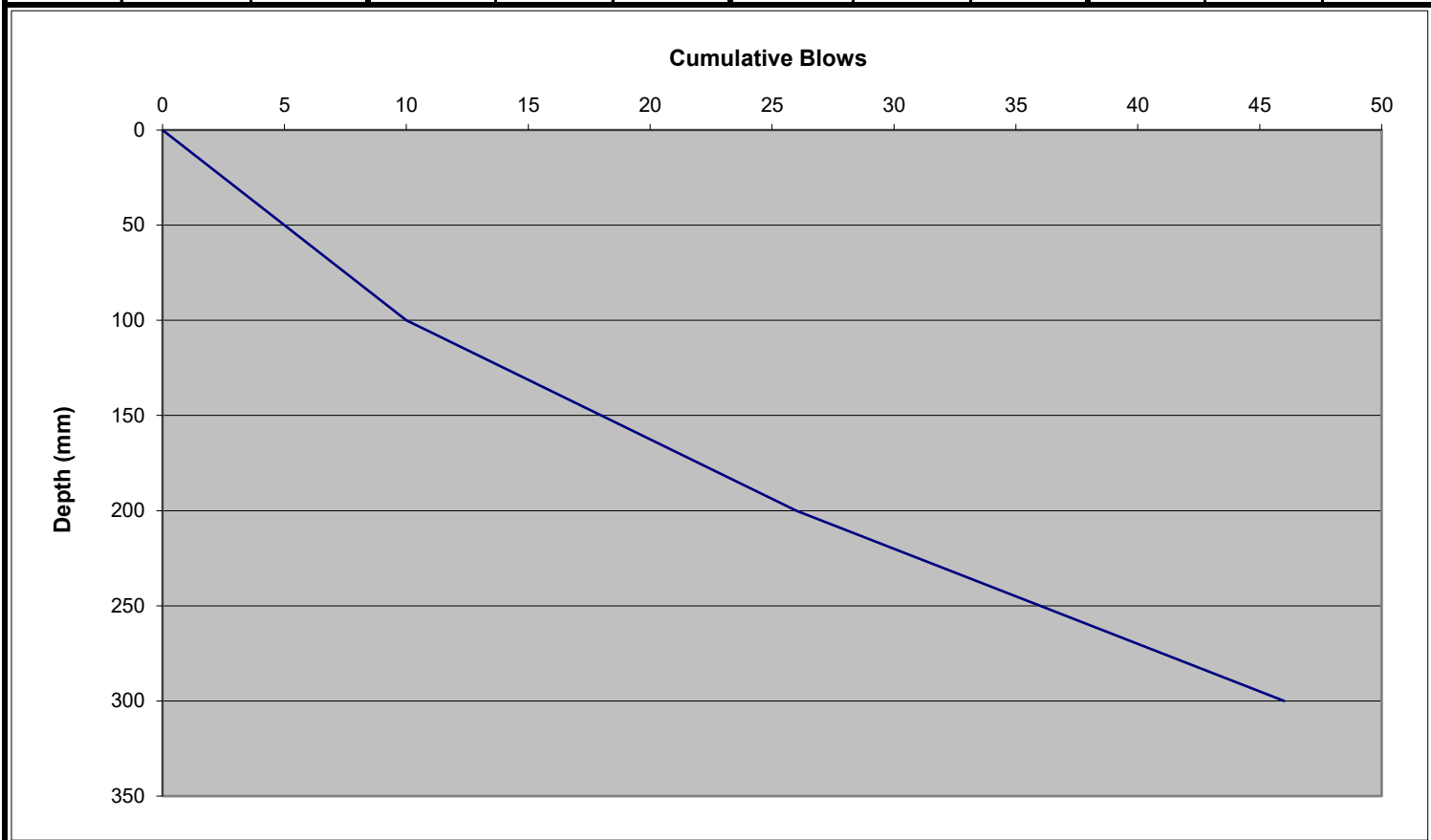
Aitken Rowe Testing Laboratories Pty Ltd

ARTL Wagga: 1/5 Dangar Place, East Wagga Wagga NSW 2650

DYNAMIC CONE PENETROMETER TEST REPORT

CLIENT:						PAGE: 1 OF: 2					
PROJECT:						REGISTRATION NO:					
LOCATION:						DATE OF TEST:					
SOIL DESCRIPTION: REFER TO BOREHOLE LOGS						DEPTH BELOW ESL (mm): NIL					
DEPTH OF GROUND WATER TABLE IF INTERSECTED: N/A						MOISTURE CONDITION: REFER TO LOGS					
						TEST METHOD: AS 1289.6.3.2					

Depth(m)	Blows	Est. CBR	Depth(m)	Blows	Est. CBR	Depth(m)	Blows	Est. CBR	Depth(m)	Blows	Est. CBR
0.0 - 0.1	10	23	1.5 - 1.6	*	*	3.0 - 3.1	*	*	4.5 - 4.6	*	*
0.1 - 0.2	16	41	1.6 - 1.7	*	*	3.1 - 3.2	*	*	4.6 - 4.7	*	*
0.2 - 0.3	20	55	1.7 - 1.8	*	*	3.2 - 3.3	*	*	4.7 - 4.8	*	*
0.3 - 0.4	END	*	1.8 - 1.9	*	*	3.3 - 3.4	*	*	4.8 - 4.9	*	*
0.4 - 0.5	*	*	1.9 - 2.0	*	*	3.4 - 3.5	*	*	4.9 - 5.0	*	*
0.5 - 0.6	*	*	2.0 - 2.1	*	*	3.5 - 3.6	*	*	5.0 - 5.1	*	*
0.6 - 0.7	*	*	2.1 - 2.2	*	*	3.6 - 3.7	*	*	5.1 - 5.2	*	*
0.7 - 0.8	*	*	2.2 - 2.3	*	*	3.7 - 3.8	*	*	5.2 - 5.3	*	*
0.8 - 0.9	*	*	2.3 - 2.4	*	*	3.8 - 3.9	*	*	5.3 - 5.4	*	*
0.9 - 1.0	*	*	2.4 - 2.5	*	*	3.9 - 4.0	*	*	5.4 - 5.5	*	*
1.0 - 1.1	*	*	2.5 - 2.6	*	*	4.0 - 4.1	*	*	5.5 - 5.6	*	*
1.1 - 1.2	*	*	2.6 - 2.7	*	*	4.1 - 4.2	*	*	5.6 - 5.7	*	*
1.2 - 1.3	*	*	2.7 - 2.8	*	*	4.2 - 4.3	*	*	5.7 - 5.8	*	*
1.3 - 1.4	*	*	2.8 - 2.9	*	*	4.3 - 4.4	*	*	5.8 - 5.9	*	*
1.4 - 1.5	*	*	2.9 - 3.0	*	*	4.4 - 4.5	*	*	5.9 - 6.0	*	*



Accredited for compliance with
ISO/IEC 17025 - Testing.

ACCREDITATION NUMBER: 4679

REMARKS:

APPROVED SIGNATORY:  Peter Forbes-Taber

DATE:



Aitken Rowe Testing Laboratories Pty Ltd

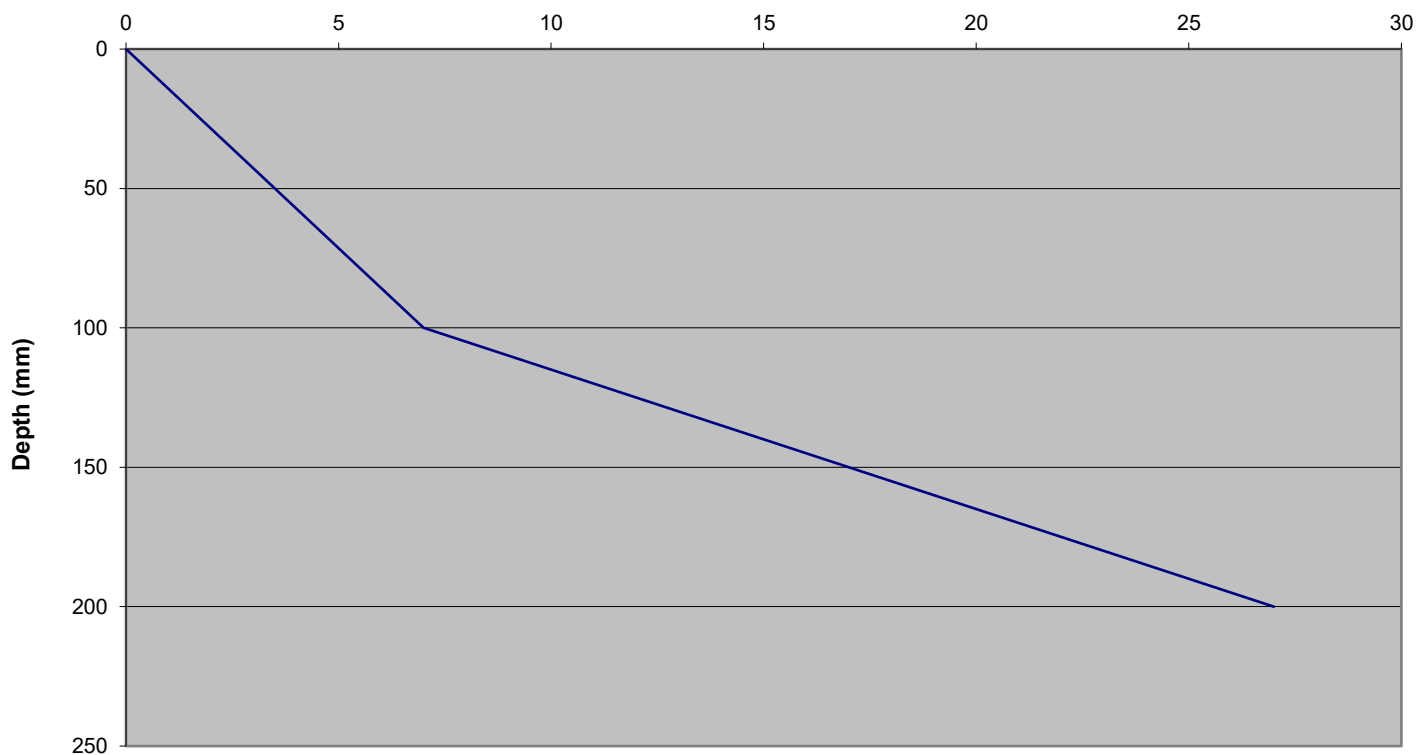
ARTL Wagga: 1/5 Dangar Place, East Wagga Wagga NSW 2650

DYNAMIC CONE PENETROMETER TEST REPORT

CLIENT:						PAGE: 2 OF: 2					
PROJECT:						REGISTRATION NO:					
LOCATION:						DATE OF TEST:					
SOIL DESCRIPTION: REFER TO BOREHOLE LOGS						DEPTH BELOW ESL (mm): NIL					
DEPTH OF GROUND WATER TABLE IF INTERSECTED: N/A						MOISTURE CONDITION: REFER TO LOGS					
						TEST METHOD: AS 1289.6.3.2					

Depth(m)	Blows	Est. CBR	Depth(m)	Blows	Est. CBR	Depth(m)	Blows	Est. CBR	Depth(m)	Blows	Est. CBR
0.0 - 0.1	7	14	1.5 - 1.6	*	*	3.0 - 3.1	*	*	4.5 - 4.6	*	*
0.1 - 0.2	20	55	1.6 - 1.7	*	*	3.1 - 3.2	*	*	4.6 - 4.7	*	*
0.2 - 0.3	END	*	1.7 - 1.8	*	*	3.2 - 3.3	*	*	4.7 - 4.8	*	*
0.3 - 0.4	*	*	1.8 - 1.9	*	*	3.3 - 3.4	*	*	4.8 - 4.9	*	*
0.4 - 0.5	*	*	1.9 - 2.0	*	*	3.4 - 3.5	*	*	4.9 - 5.0	*	*
0.5 - 0.6	*	*	2.0 - 2.1	*	*	3.5 - 3.6	*	*	5.0 - 5.1	*	*
0.6 - 0.7	*	*	2.1 - 2.2	*	*	3.6 - 3.7	*	*	5.1 - 5.2	*	*
0.7 - 0.8	*	*	2.2 - 2.3	*	*	3.7 - 3.8	*	*	5.2 - 5.3	*	*
0.8 - 0.9	*	*	2.3 - 2.4	*	*	3.8 - 3.9	*	*	5.3 - 5.4	*	*
0.9 - 1.0	*	*	2.4 - 2.5	*	*	3.9 - 4.0	*	*	5.4 - 5.5	*	*
1.0 - 1.1	*	*	2.5 - 2.6	*	*	4.0 - 4.1	*	*	5.5 - 5.6	*	*
1.1 - 1.2	*	*	2.6 - 2.7	*	*	4.1 - 4.2	*	*	5.6 - 5.7	*	*
1.2 - 1.3	*	*	2.7 - 2.8	*	*	4.2 - 4.3	*	*	5.7 - 5.8	*	*
1.3 - 1.4	*	*	2.8 - 2.9	*	*	4.3 - 4.4	*	*	5.8 - 5.9	*	*
1.4 - 1.5	*	*	2.9 - 3.0	*	*	4.4 - 4.5	*	*	5.9 - 6.0	*	*

Cumulative Blows



Accredited for compliance with
ISO/IEC 17025 - Testing.

ACCREDITATION NUMBER: 4679

REMARKS:

APPROVED SIGNATORY:  Peter Forbes-Taber

DATE:

**AITKEN ROWE Testing Laboratories Pty Ltd**

ARTL Wagga: 1/5 Dangar Place, East Wagga Wagga NSW 2650

*

TEST REPORT: GEOTECHNICAL INVESTIGATION - SOIL ANALYSIS

CLIENT :

JOB DESCRIPTION : SITE CLASSIFICATION & LAND CAPABILITY ASSESSMENT

PAGE 1 OF 1

SAMPLED BY: ARTL

DATE SAMPLED:

DATE SUBMITTED:

SAMPLING METHOD: AS1289.1.2.1

SAMPLING CLAUSE: 6.5.3

DATES TESTED:

ORDER No.: *

MATERIAL SOURCE : IN-SITU BOREHOLES

PROPOSED USE :

MATERIAL TYPE : REFER TO BOREHOLE LOGS

REGISTRATION No : R28

SAMPLE NUMBER :		3A	3B	*	*	*	*
SAMPLING LOCATION :		BH3	BH3	*	*	*	*
DEPTHS BETWEEN WHICH SAMPLES TAKEN (mm) :		400-600	1000-1200	*	*	*	*
TESTS	TEST ELEMENT	*	*	*	*	*	*
AS1289.3.6.1	PASS 100.0mm SIEVE %	*	*	*	*	*	*
	PASS 75.0mm SIEVE %	*	*	*	*	*	*
	PASS 53.0mm SIEVE %	*	*	*	*	*	*
	PASS 37.5mm SIEVE %	*	*	*	*	*	*
	PASS 26.5mm SIEVE %	*	100	*	*	*	*
	PASS 19.0mm SIEVE %	*	95	*	*	*	*
	PASS 13.2mm SIEVE %	*	95	*	*	*	*
	PASS 9.50mm SIEVE %	*	95	*	*	*	*
	PASS 6.70mm SIEVE %	*	94	*	*	*	*
	PASS 4.75mm SIEVE %	100	94	*	*	*	*
	PASS 2.36mm SIEVE %	99	93	*	*	*	*
AS1141.19	WHOLE SAMPLE	PASS 425 µm SIEVE %	88	79	*	*	*
		PASS 75 µm SIEVE %	81	68	*	*	*
		LESS THAN 13.5 µm %	59	43	*	*	*
AS1141.19	-2.36mm	PASS 425 µm SIEVE %	89	85	*	*	*
		PASS 75 µm SIEVE %	82	73	*	*	*
		LESS THAN 13.5 µm %	60	46	*	*	*
		OBSERVATIONS	*	*	*	*	*
AS1289.3.8.1 (AIR DRIED)	EMERSON CLASS	2	4	*	*	*	*
	TYPE OF WATER	DISTILLED	DISTILLED	*	*	*	*

Accredited for compliance
with ISO/IEC 17025 - Testing.ACCREDITATION NUMBER:
4679*
*
*

All samples are oven dried and dry sieved during prep. unless otherwise stated

APPROVED SIGNATORY :

Peter Forbes-Taber

DATE:



WATER & NUTRIENT BALANCE: WAGGA WAGGA

REGISTRATION:
SITE LOCATION:



ABSORPTION TRENCH

DESIGN FLOW RATE (Q_d): 900 L/day

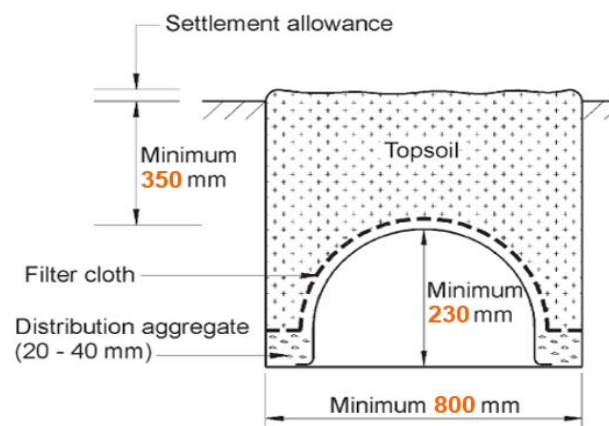
INSTALLATION DEPTH: 600mm
LIMITING SOIL TEXTURE CLASS: 5A
SOIL INFLUENCE DEPTH: 1200mm
HIGHLY STRUCTURED LIGHT CLAY

STANDARD ABSORPTION TRENCH

PRIMARY TREATMENT	SECONDARY TREATMENT
AS1547:2012	AS1547:2012
$A_w = Q_d / \text{DLR}$	$A_w = Q_d / \text{DLR}$
$Q_d = 900$	$Q_d = 900$
$\text{DLR} = 5$	$\text{DLR} = 12$
$A_w = 180\text{m}^2$	$A_w = 75\text{m}^2$
$L = A_w / W$	$L = A_w / W$
$W = 800\text{mm}$	$W = 800\text{mm}$

Length, $L = 225\text{m}$

Length, $L = 94\text{m}$



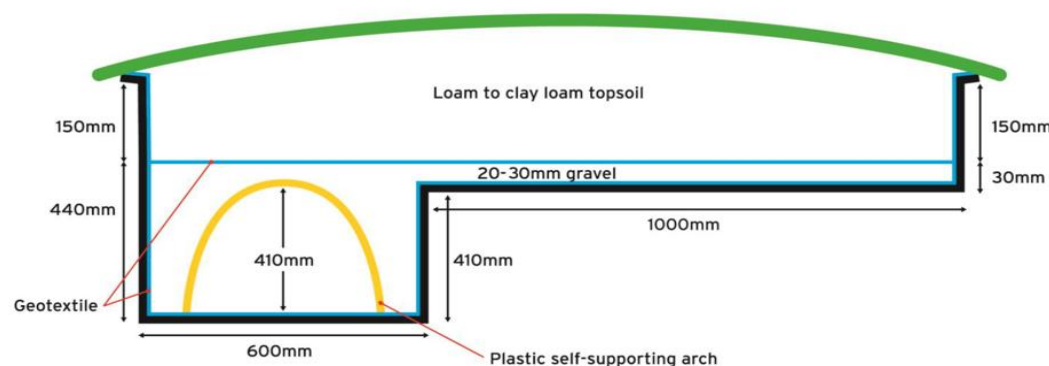
Absorption Trench System Visual Aid (Figure L2, AS 1547, 2012)

WICK TRENCH

PRIMARY TREATMENT	SECONDARY TREATMENT
VIC EPA 891.4:2016	VIC EPA 891.4:2016
$L = Q_d / (\text{DLR} \times (W/F))$	$L = Q_d / (\text{DLR} \times (W/F))$
$Q_d = 900$	$Q_d = 900$
$\text{DLR} = 5$	$\text{DLR} = 12$
$W = 1600\text{mm}$	$W = 1600\text{mm}$
$F = 1.2$	$F = 1.2$

Length, $L = 135\text{m}$

Length, $L = 56\text{m}$



Wick Trench & Bed System Visual Aid (EPA Victoria Code of Practice 891.4, 2016)

EVAPOTRANSPIRATION BED (PRIMARY TREATMENT ONLY)

DESIGN FLOW RATE (Q_d):

900 L/day

INSTALLATION DEPTH: 450mm

SOIL INFLUENCE DEPTH: 1050mm

LIMITING SOIL TEXTURE CLASS: 5A

HIGHLY STRUCTURED LIGHT CLAY

AS1547:2012

WATER BALANCE

$$A_w = Q_d / \text{DLR}$$

$$A_w = \text{ET} - \text{Rr} + \text{DLR}$$

Run off Coefficient 0.75 (75% Retained)

DLR = 8

DLR = 8

Soil Porosity 0.4 (40% Voids)

$$A_w = 112.5\text{m}^2$$

$$A_w = 99\text{m}^2$$

$$L = A_w / W$$

$$L = A_w / W$$

$$W = 4000\text{mm}$$

$$W = 4000\text{mm}$$

Length, L = 28m

Length, L = 25m

SIZE OF PRIMARY TREATMENT EVAPOTRANSPIRATION BED BASAL AREA (A_w) FOR EACH MONTH (ALLOWING 250mm EFFLUENT STORAGE)

Month	Days per month	Pan Evaporation (mm)	Crop Factor $S = 0.8$ $W = 0.6$	Evapotranspiration (mm)	Rainfall (mm)	Retained Rainfall	DLR per day (mm)	DLR per month (mm)	Disposal Rate per month (mm)	Effluent Applied per Month (L)	Size of Area (m^2)
	N	E_o	C_f	ET	R	R_r	P	Pm	ET-Rr+Pm	QxN	
Jan.	31	272.1	0.8	217.7	46.3	34.7	8	248	431.0	27900	65
Feb.	28	209.2	0.8	167.4	50.6	38.0	8	224	353.4	25200	71
Mar.	31	171.0	0.8	136.8	46.9	35.2	8	248	349.6	27900	80
Apr.	30	97.0	0.6	58.2	34.2	25.7	8	240	272.6	27000	99
May.	31	54.2	0.6	32.5	38.9	29.2	8	248	251.3	27900	111
Jun.	30	34.5	0.6	20.7	53.0	39.8	8	240	221.0	27000	122
Jul.	31	36.9	0.6	22.1	49.1	36.8	8	248	233.3	27900	120
Aug.	31	55.5	0.6	33.3	48.2	36.2	8	248	245.1	27900	114
Sep.	30	91.6	0.6	54.9	45.4	34.0	8	240	260.9	27000	103
Oct.	31	147.1	0.8	117.6	47.7	35.7	8	248	329.9	27900	85
Nov.	30	194.2	0.8	155.4	61.8	46.4	8	240	349.0	27000	77
Dec.	31	248.3	0.8	198.7	46.0	34.5	8	248	412.2	27900	68
Sum		1611.5		1215.3	568.1					Average Area	93
Month	Days per month	First Trial Area (m^2)	Effluent Applied per Month (L)	Disposal Rate per month (mm)	Application Rate (mm)	Gain/Loss (mm)	Evaporation Deficit (mm)	Starting depth of Effluent (mm)	Increase in depth of stored effluent (mm)	Computed depth of Effluent (mm)	
Jan.	31	99	27900	431.0	281.8	-149.2	-183.0	0.0	-372.9	0.0	
Feb.	28		25200	353.4	254.5	-98.9	-129.4	0.0	-247.2	0.0	
Mar.	31		27900	349.6	281.8	-67.8	-101.6	0.0	-169.5	0.0	
Apr.	30		27000	272.6	272.7	0.2	-32.6	0.0	0.4	0.4	
May.	31		27900	251.3	281.8	30.5	-3.3	0.4	76.3	76.7	
Jun.	30		27000	221.0	272.7	51.8	19.0	76.3	129.4	205.7	
Jul.	31		27900	233.3	281.8	48.5	14.7	129.4	121.3	250.7	
Aug.	31		27900	245.1	281.8	36.7	2.9	121.3	91.7	213.0	
Sep.	30		27000	260.9	272.7	11.8	-20.9	91.7	29.6	121.3	
Oct.	31		27900	329.9	281.8	-48.1	-81.9	29.6	-120.2	0.0	
Nov.	30		27000	349.0	272.7	-76.3	-109.0	0.0	-190.7	0.0	
Dec.	31		27900	412.2	281.8	-130.3	-164.2	0.0	-325.8	0.0	

SUBSURFACE IRRIGATION (SECONDARY TREATMENT ONLY)

DESIGN FLOW RATE (Q_d): 900 L/day

INSTALLATION DEPTH: 100mm
LIMITING SOIL TEXTURE CLASS: 5A

SOIL INFLUENCE DEPTH: 700mm
HIGHLY STRUCTURED LIGHT CLAY

AS1547:2012

$$A_w = Q_d / \text{DIR}$$

DIR = 3

$$A_w = 300\text{m}^2$$

WATER BALANCE

$$A_w = \text{ET} - \text{Rr} + \text{DLR}$$

Run off ^x = 0.75 (75% Retained)

Soil Porosity = 0.4 (40% Voids)

DIR = 3

$$A_w = 380\text{m}^2$$

NUTRIENT MASS BALANCE

$$\text{Total N} = 30\text{mg/L}$$

Daily N Load = 27000mg/day

Annual N Load = 9.86kg/year

20% Loss (Denitrification) = 7.88kg/year

Turf N Uptake = 240kg/ha/year

$$A_n = 329\text{m}^2$$

$$\text{Total P} = 12\text{mg/L}$$

Daily P Load = 10800mg/day

Annual P Load = 3.94kg/year

P Sorption (mg/kg) = 500

Bulk Density (B) = 1.4

Soil P Sorption = 0.315kg/m²

Turf P Uptake = 30kg/ha/year

$$A_p = 424\text{m}^2$$

SIZE OF SECONDARY TREATMENT SUBSURFACE IRRIGATION AREA (A_w) FOR EACH MONTH (NO ALLOWANCE FOR EFFLUENT STORAGE)

Month	Days per month	Pan Evaporation (mm)	Crop Factor S = 0.8 W = 0.6	Evapotranspiration (mm)	Rainfall (mm)	Retained Rainfall	DIR per day (mm)	DIR per month (mm)	Disposal Rate per month (mm)	Effluent Applied per Month (L)	Size of Area (m ²)
	N	E _o	C _f	ET	R	R _r	P	Pm	ET-Rr+Pm	QxN	
Jan.	31	272.1	0.8	217.7	46.3	34.7	3	93	276.0	27900	101
Feb.	28	209.2	0.8	167.4	50.6	38.0	3	84	213.4	25200	118
Mar.	31	171.0	0.8	136.8	46.9	35.2	3	93	194.6	27900	143
Apr.	30	97.0	0.6	58.2	34.2	25.7	3	90	122.6	27000	220
May.	31	54.2	0.6	32.5	38.9	29.2	3	93	96.3	27900	290
Jun.	30	34.5	0.6	20.7	53.0	39.8	3	90	71.0	27000	380
Jul.	31	36.9	0.6	22.1	49.1	36.8	3	93	78.3	27900	356
Aug.	31	55.5	0.6	33.3	48.2	36.2	3	93	90.1	27900	310
Sep.	30	91.6	0.6	54.9	45.4	34.0	3	90	110.9	27000	243
Oct.	31	147.1	0.8	117.6	47.7	35.7	3	93	174.9	27900	160
Nov.	30	194.2	0.8	155.4	61.8	46.4	3	90	199.0	27000	136
Dec.	31	248.3	0.8	198.7	46.0	34.5	3	93	257.2	27900	108
Sum		1611.5		1215.3	568.1					Max Area	380
Month	Days per month	First Trial Area (m ²)	Effluent Applied per Month (L)	Disposal Rate per month (mm)	Application Rate (mm)	Gain/Loss (mm)	Evaporation Deficit (mm)	Starting depth of Effluent (mm)	Increase in depth of stored effluent (mm)	Computed depth of Effluent (mm)	
Jan.	31	380	27900	276.0	73.3	-202.7	-183.0	0.0	-506.6	0.0	
Feb.	28		25200	213.4	66.2	-147.2	-129.4	0.0	-368.0	0.0	
Mar.	31		27900	194.6	73.3	-121.3	-101.6	0.0	-303.2	0.0	
Apr.	30		27000	122.6	71.0	-51.6	-32.6	0.0	-129.0	0.0	
May.	31		27900	96.3	73.3	-23.0	-3.3	0.0	-57.4	0.0	
Jun.	30		27000	71.0	71.0	0.0	19.0	0.0	0.0	0.0	
Jul.	31		27900	78.3	73.3	-5.0	14.7	0.0	-12.5	0.0	
Aug.	31		27900	90.1	73.3	-16.8	2.9	0.0	-42.0	0.0	
Sep.	30		27000	110.9	71.0	-39.9	-20.9	0.0	-99.9	0.0	
Oct.	31		27900	174.9	73.3	-101.6	-81.9	0.0	-253.9	0.0	
Nov.	30		27000	199.0	71.0	-128.0	-109.0	0.0	-320.1	0.0	
Dec.	31		27900	257.2	73.3	-183.8	-164.2	0.0	-459.6	0.0	



LPED IRRIGATION (SECONDARY TREATMENT ONLY)

DESIGN FLOW RATE (Q_d):

900 L/day

INSTALLATION DEPTH: 200mm

SOIL INFLUENCE DEPTH: 800mm

LIMITING SOIL TEXTURE CLASS: 5A

HIGHLY STRUCTURED LIGHT CLAY

AS1547:2012

WATER BALANCE

NUTRIENT MASS BALANCE

Total P = 12mg/L

$$A_w = Q_d / \text{DIR}$$

$$A_w = \text{ET} - \text{Rr} + \text{DLR}$$

$$\text{Total N} = 30\text{mg/L}$$

$$\text{Daily P Load} = 10800\text{mg/day}$$

$$\text{DIR} = 2.5$$

$$\text{Run off}^x = 0.75 \text{ (75\% Retained)}$$

$$\text{Daily N Load} = 27000\text{mg/day}$$

$$\text{Annual P Load} = 3.94\text{kg/year}$$

$$A_w = 360\text{m}^2$$

$$\text{Soil Porosity} = 0.4 \text{ (40\% Voids)}$$

$$\text{Annual N Load} = 9.86\text{kg/year}$$

$$\text{P Sorption (mg/kg)} = 500$$

$$\text{DIR} = 2.5$$

$$20\% \text{ Loss (Denitrification)} = 7.88\text{kg/year}$$

$$\text{Bulk Density (B)} = 1.4$$

$$\text{Turf N Uptake} = 240\text{kg/ha/year}$$

$$\text{Soil P Sorption} = 0.315$$

$$A_n = 329\text{m}^2$$

$$\text{Turf P Uptake} = 30\text{kg/ha/year}$$

$$A_p = 424\text{m}^2$$

SIZE OF SECONDARY TREATMENT LPED IRRIGATION AREA (A_w) FOR EACH MONTH (NO ALLOWANCE FOR EFFLUENT STORAGE)

Month	Days per month	Pan Evaporation (mm)	Crop Factor $S = 0.8 \text{ } W = 0.6$	Evapotranspiration (mm)	Rainfall (mm)	Retained Rainfall	DIR per day (mm)	DIR per month (mm)	Disposal Rate per month (mm)	Effluent Applied per Month (L)	Size of Area (m^2)
	N	E_o	C_f	ET	R	R_r	P	Pm	ET-Rr+Pm	QxN	
Jan.	31	272.1	0.8	217.7	46.3	34.7	2.5	77.5	260.5	27900	107
Feb.	28	209.2	0.8	167.4	50.6	38.0	2.5	70	199.4	25200	126
Mar.	31	171.0	0.8	136.8	46.9	35.2	2.5	77.5	179.1	27900	156
Apr.	30	97.0	0.6	58.2	34.2	25.7	2.5	75	107.6	27000	251
May.	31	54.2	0.6	32.5	38.9	29.2	2.5	77.5	80.8	27900	345
Jun.	30	34.5	0.6	20.7	53.0	39.8	2.5	75	56.0	27000	482
Jul.	31	36.9	0.6	22.1	49.1	36.8	2.5	77.5	62.8	27900	444
Aug.	31	55.5	0.6	33.3	48.2	36.2	2.5	77.5	74.6	27900	374
Sep.	30	91.6	0.6	54.9	45.4	34.0	2.5	75	95.9	27000	282
Oct.	31	147.1	0.8	117.6	47.7	35.7	2.5	77.5	159.4	27900	175
Nov.	30	194.2	0.8	155.4	61.8	46.4	2.5	75	184.0	27000	147
Dec.	31	248.3	0.8	198.7	46.0	34.5	2.5	77.5	241.7	27900	115
Sum		1611.5		1215.3	568.1					Max Area	482
Month	Days per month	First Trial Area (m^2)	Effluent Applied per Month (L)	Disposal Rate per month (mm)	Application Rate (mm)	Gain/Loss (mm)	Evaporation Deficit (mm)	Starting depth of Effluent (mm)	Increase in depth of stored effluent (mm)	Computed depth of Effluent (mm)	
Jan.	31	482	27900	260.5	57.8	-202.7	-183.0	0.0	-506.6	0.0	
Feb.	28		25200	199.4	52.2	-147.2	-129.4	0.0	-368.0	0.0	
Mar.	31		27900	179.1	57.8	-121.3	-101.6	0.0	-303.2	0.0	
Apr.	30		27000	107.6	56.0	-51.6	-32.6	0.0	-129.0	0.0	
May.	31		27900	80.8	57.8	-23.0	-3.3	0.0	-57.4	0.0	
Jun.	30		27000	56.0	56.0	0.0	19.0	0.0	0.0	0.0	
Jul.	31		27900	62.8	57.8	-5.0	14.7	0.0	-12.5	0.0	
Aug.	31		27900	74.6	57.8	-16.8	2.9	0.0	-42.0	0.0	
Sep.	30		27000	95.9	56.0	-39.9	-20.9	0.0	-99.9	0.0	
Oct.	31		27900	159.4	57.8	-101.6	-81.9	0.0	-253.9	0.0	
Nov.	30		27000	184.0	56.0	-128.0	-109.0	0.0	-320.1	0.0	
Dec.	31		27900	241.7	57.8	-183.8	-164.2	0.0	-459.6	0.0	



SOIL CATEGORIES & RECOMMENDED DESIGN IRRIGATION/LOADING RATES

Appropriated from Table 5.2 of AS1547:2012

SOIL CATEGORY	SOIL STRUCTURE	SOIL TEXTURE	INDICATIVE PERMEABILITY	ABSORPTION TRENCH		ETA BED	IRRIGATION	LPED	MOUNDS	DENSITY (B) (g/cm ³)	P SORPTION (mg/kg)
				DLR (P)	DLR (S)	DLR (P/S)	DIR	DIR	DLR (P)		
1	STRUCTURELESS	GRAVEL/SAND	> 3.0	N/R	N/R	N/R	5	N/R	32	2	50
2A	WEAKLY STRUCTURED	SANDY LOAM	> 3.0	N/R	N/R	N/R	5	4	24	1.8	100
2B	STRUCTURELESS	SANDY LOAM	1.4 - 3.0	15	50	N/R	5	4	24	1.8	100
3A	MODERATELY STRUCTURED	LOAM	1.5 - 3.0	15	50	N/R	4	3.5	24	1.7	200
3B	WEAKLY STRUCTURED	LOAM	0.5 - 1.5	10	30	N/R	4	3.5	16	1.7	200
4A	MODERATELY STRUCTURED	CLAY LOAM	0.5 - 1.5	10	30	12	3.5	3	16	1.6	400
4B	WEAKLY STRUCTURED	CLAY LOAM	0.12 - 0.5	6	20	8	3.5	3	8	1.6	400
4C	STRUCTURELESS	CLAY LOAM	0.06 - 0.12	4	10	5	3.5	3	5	1.6	400
5A	HIGHLY STRUCTURED	LIGHT CLAY	0.12 - 0.5	5	12	8	3	2.5	8	1.4	500
5B	MODERATELY STRUCTURED	LIGHT CLAY	0.06 - 0.12	4	10	5	3	2.5	N/R	1.4	500
5C	WEAKLY STRUCTURED	LIGHT CLAY	< 0.06	3	8	4	3	2.5	N/R	1.4	500
6A	HIGHLY STRUCTURED	MEDIUM TO HEAVY CLAY	0.06 - 0.5	3	8	8	2	N/R	N/R	1.4	600
6B	MODERATELY STRUCTURED	MEDIUM TO HEAVY CLAY	< 0.06	2.5	6	6	2	N/R	N/R	1.4	600
6C	WEAKLY STRUCTURED	MEDIUM TO HEAVY CLAY	< 0.06	N/R	N/R	4	2	N/R	N/R	1.4	600
HL	HYDRAULICALLY LIMITING	BEDROCK OR GROUNDWATER	< 0.06	N/R	N/R	N/R	N/R	N/R	N/R	2.5	50

Foundation Maintenance and Footing Performance: A Homeowner's Guide



PUBLISHING

BTF 18-2011
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 2870-2011, 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, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Notes

1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class P is used for sites which include soft fills, such as clay or silt or loose sands; landslide; mine subsidence; collapsing soils; soil subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater, further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).

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 perpend).

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

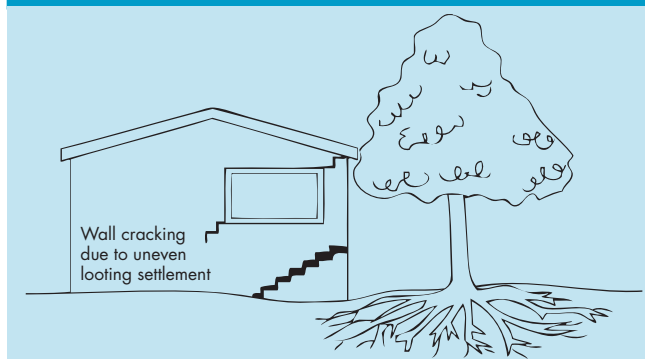
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the 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.

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

Trees can cause shrinkage and damage



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 causes 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 2870-2011.

AS 2870-2011 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.

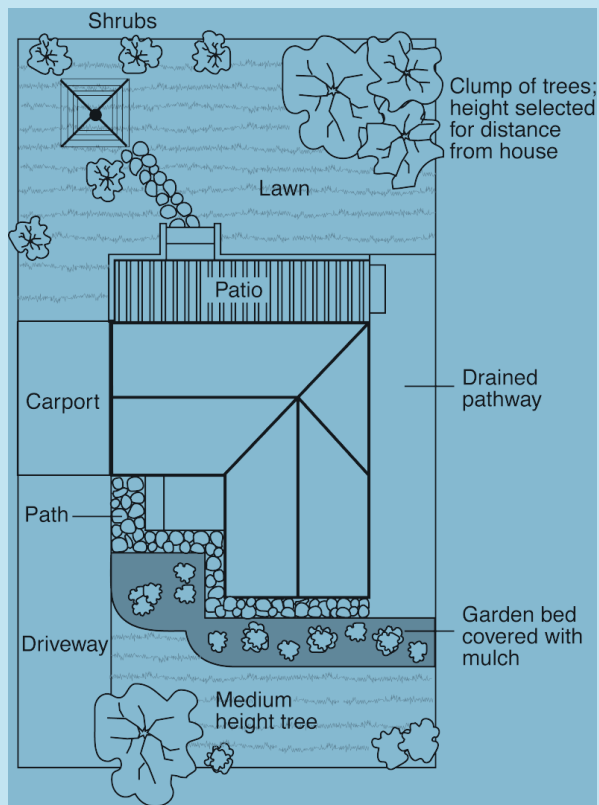
Protection of the building perimeter

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 should

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 depends on number of cracks	4

Gardens for a reactive site



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.

The information in this and other issues in the series was derived from various sources and was believed to be correct when published.

The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject.

Further professional advice needs to be obtained before taking any action based on the information provided.

Distributed by

CSIRO PUBLISHING PO Box 1139, Collingwood 3066, Australia

Tel (03) 9662 7666 Fax (03) 9662 7555 www.publish.csiro.au

Email: publishing.sales@csiro.au

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