Site and Soil Assessment

On-site Wastewater Treatment and Disposal

Lot 222, DP 39689

600 Childowla Road, Bookham, NSW

Applicants: Linn Armour & Orida Armour Lushmoor

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Date of Evaluation: 24 July 2018

Signature:

Executive Summary

An examination of the site and soil characteristics of the proposed site for a domestic on-site wastewater treatment and disposal system was conducted for Linn Armour and Orida Armour Lushmore at Lot 222 DP 39689, 600 Childowla Rd, Bookham, NSW, on 24 July 2018. This evaluation was conducted to determine the suitability of a worm farm rural septic tank system to collect, treat and disperse domestic wastewater at this site, in compliance with the Australian design standard for domestic wastewater management, AS 1547:2012; and the Yass Valley Council (YVC) and the YVC Local Environment Plan (2013).

The applicants propose to construct a concrete floored, metal shed at this site. The applicants advise that the shed will not be used as a dwelling. The shed will be used to facilitate the performance of horticultural and agricultural pursuits. The shed is planned to have toilet and shower facilities. The applicants propose to manage the collection, treatment and dispersal of all domestic wastewater at this site using a worm farm driven rural septic tank system. This system will be supplied and installed by A&A Worm Farms (Victoria) – refer https://www.wormfarm.com.au/.

This report assesses the topography, geology and soil characteristics of the land at this site, in the context of the applicants' proposed domestic wastewater management plan; the relevant AU/NZ standard and YVC operating LEP.

This assessment and report have been conducted for an expected design daily flow allowance consistent with daily use of the toilet/shower facilities by two (2) people. The Australian Design standard, AS1547:2012, provides for the determination of daily flow allowance on a 'per person per day' allowance – refer Appendix H- Table H1. Water supply at this site will be from on-roof collection only, therefore DFA from Table H1 would be 120 litres per person per day. The design daily flow allowance **(DFA) shall be 2 x 120 litres = 240 litres per day.**

The on-site examination indicates that there are no significant, environmental risk factors affecting the proposed on-site management of domestic wastewater treatment and distribution at this site, as proposed by the applicants - refer discussion pages 5-7. Provided our recommendations for system management and application area perimeter drainage management structures are observed, the environmental risk factors will be mitigated, and the proposed system will safely and effectively manage the treatment and dispersal of domestic wastewater at this site.

The physical and chemical characteristics of the soils at the proposed site indicate the extant soil column is suitable for the on-site treatment and disposal of domestic wastewater utilising a worm farm driven rural septic tank system, as proposed by the applicants. Distribution of treated wastewater will be via pumped sub-surface distribution into a Low Pressure Effluent Dosing (LPED) network of specially constructed polyethylene pipes – refer Figure 2 of this report. The indicative permeability of the soil profile of the applicants' land was determined in accord with AS 1547:2012 utilizing the Test Pit Borehole method/constant–head test. Permeability was measured in separate locations at 250mm depth and at 600mm depth. At 600mm depth the indicative soil permeability (Ksat) of the soil column at the proposed application area site was determined to be in the range **0.18-0.19m/day**. At 250mm depth the indicative soil permeability (Ksat) of the soil

column at the proposed application area site was determined to be in the range **0.40-0.41m/day**. Daily Irrigation rate (DIR) in AS1547:2012, is determined from the permeability measurement, soil texture and Table M1 in Appendix M. This table specifies that for the measured permeability at this site (@ 600mm = 0.18-0.19m/day) and soil texture (clay loam) the DIR is **3.0mm per square metre per day**. The **minimum** application area recommended for this site, to ensure reasonable wet weather storage is determined to be **145 square metres**. Adequate space exists on the applicants' land to accommodate primary and reserve application areas of this size.

This report recommends the implementation of the worm farm rural septic tank system as proposed by the applicants, to manage on-site domestic wastewater treatment and disposal at this site. The proposed treatment system, properly maintained, coupled with compliance with manufacturers recommended management practices, will deliver the most environmentally sound method of treatment and disposal of domestic wastewater, at the proposed site, with minimal ecological or environmental impact.

Introduction

This report assesses the suitability of land at Lot 222 DP 39689, 600 Childowla Rd, Bookham, NSW, for the on-site management and disposal of treated domestic wastewater utilising a worm farm rural septic tank system to collect, treat and disperse domestic wastewater at this site, in compliance with the Australian design standard for domestic wastewater management, AS 1547:2012; and the Yass Valley Council (YVC) and the YVC Local Environment Plan (2013). This report includes the specifications of the On-Site Sewage Management for Single Households (Anon, 1998), for on-site domestic wastewater management. This assessment is based upon a detailed examination and description of the proposed site characteristics, and includes detailed assessment of the soil properties at this site, and our recommended installation and operation requirements, to achieve effective and compliant on-site management and disposal of treated domestic wastewater and effluent.

The applicants propose to construct a concrete floored, metal shed at this site. The applicants advise that the shed will not be used as a dwelling. The shed will be used to facilitate the performance of horticultural and agricultural pursuits. The shed is planned to have toilet and shower facilities. The applicants propose to manage the collection, treatment and dispersal of all domestic wastewater at this site using a worm farm driven rural septic tank system. This system will be supplied and installed by A&A Worm Farms (Victoria) – refer https://www.wormfarm.com.au/.

This assessment and report have been conducted for an expected design daily flow allowance consistent with daily use of the toilet/shower facilities by two (2) people. The Australian Design standard, AS1547:2012, provides for the determination of daily flow allowance on a 'per person per day' allowance – refer Appendix H- Table H1. Water supply at this site will be from on-roof collection only, therefore DFA from Table H1 would be 120 litres per person per day. The design daily flow allowance **(DFA) shall be 2 x 120 litres = 240 litres per day.**

The site evaluation was conducted on a clear, cool and dry day. Prevailing winds at the time of evaluation were variable and of moderate strength between 5-15kph from the west/northwest. The

ambient air temperature was 10 degrees C. Climatic conditions in the days immediately before this evaluation were similar to the evaluation day. Very light and variable shower activity had occurred in the evaluation area about 24 hours prior to this evaluation. Wind strength in the days preceding had been variable often of moderate to high strength from the west/northwest. Average temperatures in the evaluation area in the days prior to this evaluation had ranged from maximums of 12-14 degrees to minus 4-6 degrees. The ground surface at the time of evaluation was very slightly moist.

Site Characteristics

Terrain

The applicants' property is situated on a variably sloping, open area of land on the western side of Childowla Road. The property is polygonal in shape and comprises an area of 8.435 hectares (20.8 acres). On the proposed primary application area, the slope is gentle and ranges from 1-4 degrees, with an average slope of 2 degrees.

In the area proposed for the site of the primary application area, the land has an open, northwesterly aspect and is open to all prevailing weather systems. The proposed primary application area has good aspect and exposure for the purposes of maximizing evaporation of dispersed treated wastewater.

The principal drainage pattern on the proposed application area is variable, generally linear and planar, with a slight convergent trending slope to the west. The current drainage patterns and slope on the proposed primary application area indicate this area is at low-moderate risk of inundation and waterlogging during times of heavy or sustained rainfall. However, during such extreme precipitation events, this area is at moderate-high potential risk of impact from surface water accumulating upslope of the primary application area, moving across this area. To prevent impact on the designated application area(s), and potential surface drainage across the application area, we recommend a cut-off drain be constructed upslope of the proposed application area. This cut-off drain should be constructed to direct surface water around the application area. Similarly, due to the existing slope and drainage contours surrounding, and on the proposed application areas, it may be possible for surface water from the proposed application area, to move in a westerly direction, potentially toward the nearby Jugiong Creek. We note that the distance between Jugiong Creek and the most westerly perimeter of the proposed application area is greater than 150 metres. We recommend an earthen embankment be constructed adjacent to the western perimeter of the proposed application area. This embankment should be at least 250mm in height. The ends of the embankment should be curved upslope to reduce the likelihood of unintended bypass of the embankment by surface water.

Site risks:

The most significant environmental risks identified for the proposed wastewater management system are:

1. Potential Surface water contamination:

Potentially nutrient/pathogen enriched surface waters could, if not properly managed, move from the application area toward, and potentially into, the catchment of the nearby Jugiong Creek. This could result in adverse impact on water quality and ecosystem balance of the local watershed catchment. Whilst the consequence of nutrient enriched surface waters entering the Jugiong Creek catchment is high, the **likelihood** of such contamination occurring is very low. This is because of the mitigating effects of the recommended application area construction actions. This wastewater management strategy is designed to ensure that treated wastewater from the applicants' shed and land does not leave the applicants' land or enter the Jugiong Creek catchment. Consistent compliant management and operation of the wastewater system proposed in this report, will ensure the design strategies of the proposed wastewater treatment system are effective in preventing impact on adjoining properties and the local watershed.

2. Potential groundwater contamination:

   There are no bores or wells on the applicants' land. It is not known if there are bores or wells on neighbouring properties. However, given the size of the applicants' land, and the designed daily wastewater flow, we are confident there is no risk to groundwater aquifers in this area from the operation of the proposed wastewater treatment system. The NSW Natural Resource Atlas does not show any known (licensed) groundwater bores within 200 metres horizontal radius of the proposed application area for this development. Having regard to the topography and nature of the bedrock in this location it is reasonable to infer, from the available data, that there is negligible likelihood of contamination of groundwater from the applicant's proposed wastewater treatment system, due to the depth of earth and rock overburden between any groundwater aquifer/s and the ground surface.

To mitigate potential environmental risks associated with this proposed wastewater management plan, we recommend compliance with the following requirements for the effective treatment of domestic wastewater at this site using a worm farm/rural septic tank system with sub-surface distribution of treated wastewater:

- The earthen embankment downslope of the western perimeter of the proposed primary and secondary application areas should be maintained and monitored for effectiveness in preventing escape of surface water into the creek catchment;
- The ends of the embankment should be curved upslope to reduce the potential for unintended surface water bypass of the embankment;
- The entire primary application areas should be planted with a diverse range of grasses, shrubs and other suitable vegetation. This vegetation will assist in the management of wastewater application by increasing evaporation and transpiration losses on this area;
- Surface waters collected upslope of the proposed primary application area should be prevented from draining across the application area. The easiest and most effective method of achieving this would be to construct a surface water cut-off drain above the upslope perimeter of the proposed application area to ensure that surface water is diverted around the proposed primary application area;

- The treated wastewater should be applied beneath the ground surface via an LPED network of pipes;
- The applicants must monitor the application area for evidence of waterlogging. Should waterlogging be evident, the distribution of treated effluent should be directed to the reserve application area. This re-direction process must continue until waterlogging no longer occurs.
- Vehicles should not be driven over the application areas. Driving vehicles on the application areas will lead to compaction of the soil column. Compaction of the soil will lead to a reduction in the ability of the soil to allow vertical infiltration of water through the soil column, and possibly to a reduction in the long-term acceptance rate of the soil column.

Soil Investigation:

Detailed notes on the physical properties of the soil column at the test site are contained in the attached excavation soil profile log (Attachment 2).

The soil profile at the proposed site area comprises a dark-chocolate brown coloured 'A1' horizon typically 50mm in depth of silty loam classification. This horizon has a massive structure and contains infrequent (less than 1% by volume) coarse fragments. These fragments are predominantly subangular to subrounded quartz grains, in the size range 0.5-1mm. This horizon has a fine silty feel. The moist bolus forms a weak cohesive strength ball but will not support a cohesive strength compressed ribbon shape. This horizon was very slightly moist at the time of evaluation. This horizon is classified as a silty loam.

This 'A1' horizon grades sharply into a slightly yellowish, mid-brown coloured A2 horizon. This horizon averages 100-110mm in depth and contains less than 2% coarse particles of similar lithology and size to the A1 layer. The horizon has a massive structure with a slightly higher clay content than the layer above. The moist bolus forms a medium cohesive strength ball and a weak cohesive strength ribbon shape. This horizon is classified as a gritty, silty loam. The horizon was very slightly moist at the time of evaluation.

The A2 horizon grades diffusely into a pale buff light brown B1 horizon. This horizon averages approximately 160-170mm in depth in the evaluation area. It comprises less than 5% coarse fragments of similar lithology to the overlying horizons, although quartz grains up to 5mm occur more frequently in this layer. This horizon displays a pedal structure. The moist bolus forms a high cohesive strength ball and a strong ribbon shape when compressed. This horizon is classified a clay loam. The horizon was dry at time of evaluation.

The B1 horizon grades diffusely into a caramel/bright orange-brown B2 horizon. This horizon is greater than 280-290mm in depth in the evaluation area and displays a pedal structure. It comprises approximately 5% coarse fragments, similar in lithology and size to the B1 layer. These fragments are generally subangular to sub-rounded and range in size from 1-10mm in diameter. The moist bolus forms a strong ball and a high cohesive strength ribbon when compressed. This horizon is classified a light clay loam. The horizon was dry.

The soil profile observed on the applicants' parcel of land may best be described as a yellow podsolic soil (Jenkins, 2000). The soil column at this site is consistent with the soil profile of the Murringo soil landscape described by Hird (1991). The Murringo soil landscapes are common on granitic parent bedrock in the area from Goulburn to Young. Hird notes these soils are generally derived from in situ weathering or parent bedrock as well as colluvial and alluvial vectors. Yellow podzolic soils of the Murringo soil landscape can be susceptible to minor sheet and gully erosion.

The permeability of the soil profile of the applicant's land was determined in accord with AS 1547:2012 utilizing the Test Pit Borehole method/constant–head test. Permeability was measured in separate locations at 250mm depth and at 600mm depth. At 600mm depth the indicative soil permeability (Ksat) of the soil column at the proposed application area site was determined to be in the range **0.18-0.19m/day**. At 250mm depth the indicative soil permeability (Ksat) of the soil column at the proposed application area site was determined to be in the range **0.40-0.41m/day**. Daily Irrigation rate (DIR) in AS1547:2012, is determined from the permeability measurement, soil texture and Table M1 in Appendix M. This table specifies that for the measured permeability at this site (@ 600mm = 0.18-0.19m/day) and soil texture (clay loam) the DIR is **3.0mm per square metre per day**. As discussed in this report at page 4, the daily flow allowance (DFA) is determined from Table H. In this case the DFA is 240 litres per day. As shown above, at 250mm depth in the soil column the measured permeability is greater than double that at 600mm depth. We have used the 600mm calculations to ensure built in conservatism for this design.

Outcropping bedrock occurs commonly in the broad area of the evaluation site. Examination of the bedrock revealed this to be an igneous rock comprising relatively equigranular crystals of quartz, plagioclase feldspar, hornblende and biotite. The relative absence of orthoclase feldspar minerals in the rock leads to a classification of this rock type as granodiorite. The relative hardness of the quartz crystals leads to development of a relatively open and granular (gritty) soil. The openness of the soil structure leads to relatively high permeability, particularly in the upper soil horizons.

From the perimeter of the proposed application area(s) the nearest dam is greater than 80 metres and the nearest permanent watercourse (Jugiong Creek) is greater than 140 metres distant. Compliance with the recommendations for application area overflow structures within this report, will ensure effective mitigation of the risk of contamination of the catchment of Jugiong Creek from distributed treated wastewater. The applicants' proposed shed will be situated to the southeast of the proposed primary application area. It is recommended that the proposed application area be not less than 10 metres from the nearest point of the proposed shed.

The proposed primary and reserve application areas are currently vegetated with native and introduced pasture grasses and scattered mature Eucalyptus *spp* trees. It is recommended that a diverse range of grasses, shrubs and possibly trees, be planted on the application area to increase the uptake of treated wastewater through the processes of evaporation and transpiration.

Following assessment of the existing slope, drainage and permeability of the proposed primary and reserve application areas, we believe there to be negligible risk of nutrient/pathogen enriched water entering the local watershed catchment. Compliance with the recommendations within this report will ensure this risk is managed and adverse environmental outcomes, resulting from domestic wastewater treatment and dispersal at this site, do not occur.

The nearest property boundary, to the proposed primary application area, is greater than 20 metres (downslope) to the south of the southern perimeter of the proposed application areas.

Figure 1: North-northwesterly view across the proposed primary application area. The location of planned shed, septic tank and primary and secondary application areas are shown in the attached site plan – refer Attachment 1. .

Primary application area construction:

Due to the existing topographic features of this site, and the physical and chemical properties of the extant soil column, we recommend the applicants comply with the following recommendations to ensure the efficacy of this wastewater management proposal:

- Treated wastewater should be distributed below the surface of the application area, via a low pressure effluent dosing (LPED) network of pipes as shown in Figure 2;
- Maintain the integrity of the earthen embankment at the downslope perimeter of the proposed primary application area, thus increasing the ability of the soil column to allow vertical rather than lateral movement of water;

LPED distribution network. AS1547:2012 provides design and installation advice for a 'typical' LPED distribution layout as shown below in Figure 2.

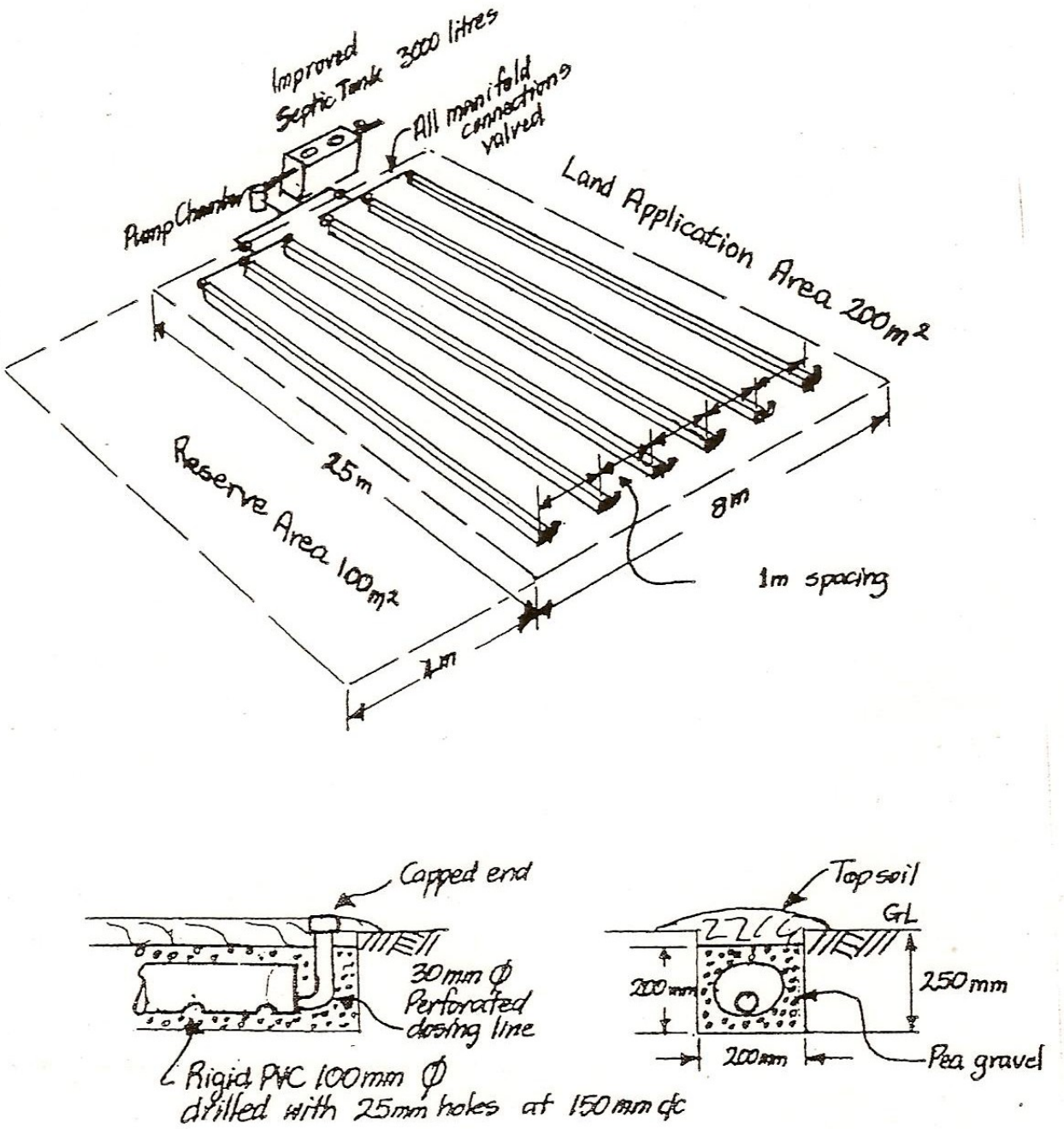

Fig. 2: LPED Primary Effluent Irrigation Layout -from AS1547:2012

Notes:

1. System designed for 3 bedroom dwelling, 5 persons, 600 litres/day design flow.

2. System installed in 250mm depth topsoil over sandy loam soil, DIR 3mm/d for primary effluent.
3. Recommended dosing method is 6-way automatic sequencing valve, or less preferably, the manifold system as illustrated. .
4. By “improved septic tank” is meant septic tank with effluent outlet filter.
4. A 100mm diameter slotted drainage coil line (agricultural pipe)is usually adopted instead of the rigid PVC 100mm diameter distribution line.
5. Not to scale.
6. Application size required is .....not 200 sqm as shown in Fig 2. Refer actual required area size and dimensions in body of this report

Figure 3. The soils at the proposed site display generally sharp, well defined layer boundaries and strong bleaching. The strong reddish orange colouration in the B2 layer is clearly evident.

- The upslope borders of the proposed application areas should be protected from the incursion of surface waters accumulated upslope. Such incursion could exacerbate off-application area environmental issues. We recommend this protection be achieved by constructing a diversion drain upslope of the norther perimeter of the proposed application area. The cut-off drain should direct surface waters away from the application area; and

- Increase the vegetative diversity on the proposed application area, to ensure sufficient uptake of dispersed treated effluent.

Determination of Design Irrigation Rate (DIR) and recommended application area dimensions:

As specified in AS 1547:2012, the design irrigation rate (DIR) determination for worm farm septic tank systems with sub-surface distribution of treated effluent via LPED network method, is dependent on soil permeability, evapo-transpiration (from vegetation on and around the proposed application area), exposure of the application area to prevailing weather systems and upon the long-term acceptance rate (LTAR) of the soils. AS 1547:2012 Table M1, specifies the DIR (in mm/day) for sub-surface LPED discharge systems according to the indicative permeability of the soil column; the soil texture; and the soil structure. At the evaluation site the indicative permeability is 0.18-0.19 metres per day and the subsoil is a light clay with moderately defined structure. This leads to the determination of recommended DIR for the proposed effluent management system on this site to be **3.0mm/day**.

AS1547:2012 also provides guidance and recommendations for determining the appropriate size of the application area(s). The recommended method for determining application area size is given by the equation A= DFA/DIR. Where A = application area (sq. m)

Thus A= 240/3.0 = **80 square metres**.

Wet Weather Capacity allowance:

Calculations and values/symbols for each of the component variables is taken from Appendix 6 of the *On-Site Sewage Management for Single Households (1998).*

This factor is determined by the relationship between inputs and outputs averaged for the lowest output months of winter. It is noted that for the proposed development the likely wastewater daily flow will be 240 litres. We note, as stated earlier in this report, the proposed development will not be used as a dwelling, and the likely daily wastewater load will be significantly lower than the design wastewater load of 240 litres per day.

To determine any required increase in land application area to accommodate wet weather storage, it is necessary to find the equilibrium value of storage (S) period of lowest expected evapotranspiration values, as this will be the lowest expected value of 'outputs'. In this district, this period will be the winter months.

Storage required (S) = inputs – outputs

The wet weather storage adjusted land application area size is determined when S is near, or equal to zero. Therefore, the calculation is:

Inputs is given by Precipitation (P) + Effluent irrigation (W)

Precipitation (P) is taken from BoM data

P = 54mm

Effluent irrigation (W) is determined from the equation (Q x D) / L

Therefore W = (240 (Q) x 31); where D is number of days in the month

W= 7,440 / L where L is the land application area for critical nitrogen load (Sqm)

W = 7440/145

= 51

Outputs is given by Evapotranspiration (ET) + Percolation (B)

Evapotranspiration (ET) -taken from BoM data

ET = 91

B = design load (mm/day) / days in the week x number of days in month

= 3.0/7x31

= 13

So (S) = (P + W) – (92 + B)

= (54+ 51) - (92 + 13)

= 105-105

= 0

To obtain the zero value for S, the land application area size (L) was required to be increased from 80 to 145 square metres.

Therefore, the minimum land application area required at this site, to provide reasonable wet weather storage, is **145 square metres**.

It is important to note that 145 square metres is the recommended minimum area for effective and sustainable permeation, absorption and evaporation of the treated wastewater load at this site. To ensure long term soil health and the sustainability of the wastewater management system at this site, it is recommended that the applicants carefully monitor the application area to ensure that waterlogging of the application area does not occur for any length of time. Should waterlogging of the application area(s) be observed, distribution of treated wastewater should be directed to the reserve application area. We also recommend that a high planting density and diversity on the application area sites be established, to further safeguard and improve the drainage efficacy of the application areas.

Suggested siting of effluent management system components:

We recommend the primary application area be sited in the area to the north of the proposed shed site; with the nearest point of the application area no closer than 10 metres from the proposed shed. We recommend the reserve application be sited in the area to the southwest of the proposed primary application area – refer site plan Attachment 1. The suggested location and shape of the proposed application areas is indicative and suggested only. The application area size and shape are designed to maximise dispersal of treated effluent waters through evaporation, transpiration and permeation, and prevent/minimise surface water accumulation. Long term waterlogging of areas may adversely impact soil structure and will increase the risk of the soils developing a

perched watertable. We recommend the proposed worm driven septic tank be sited in any location suitable to the builder/owner/wastewater system installer. Provided there is fall from the shed to the collection tank, the location of the collection tank is of no direct consequence to the design efficacy of the wastewater management system.

Fig 4: Soil material excavated from borehole during evaluation. A1 topsoil layer is at centre right of frame progressing through the soil profile to B2 (yellow/brown soil) in left foreground.

This evaluation has shown that provided the proposed wastewater treatment system is serviced in accord with manufacturers' recommendations, and the system is not subject to misuse; the structure, texture and chemistry of the soils at this site will support the effective dispersal of all domestic wastewater by a worm farm septic tank treatment system. This report also finds the environmental risk issues prevailing at this site may be safely and effectively overcome, provided recommendations regarding the containment drain/embankment, upslope diversion drainage, and waterlogging monitoring are followed.

Figure 4: Typical appearance of outcropping bedrock on the applicants' land

Water Balance and Hydraulic Conductivity

Water Balance

In relatively simplistic terms, the critical element of water balance requires that, in relation to the treatment and dispersal of effluent in a domestic wastewater situation, treated effluent must not enter the water cycle through precipitation run-off. This is defined in the equation:

P + effluent < or = to Et + RO +IF + DI +^S; that is

Precipitation + effluent applied < or = to Evaporation/transpiration + Run-off + lateral subsurface seepage + deep infiltration + changes in soil water.

Therefore, for this proposal the water balance equation is satisfied wherever the sum of lateral infiltration, deep seepage and evapo-transpiration exceeds **240 litres per day.**

It is important that the operators of this system carefully control the quantity of chemicals, fats and salts introduced into the wastewater management system. Chemicals, fats and particularly salts present in wastewater applied to soils, accumulate in the upper soil layers and can cause a significant reduction in the capacity of the soil to absorb liquids. This will reduce the Long-Term Acceptance Rate (LTAR) of the soils and potentially, lead to a reduction in the efficacy, or failure, of the system.

There have been many studies conducted in relation to appropriate chemicals and detergents to be used in the home where effluent treatment is achieved using on-site treatment. We recommend the operators of the wastewater management system used at this site research this issue and use appropriate chemicals and detergents for a worm farm septic tank treatment system.

In summary, any effluent management system can only be said to be effective where effluent does not enter the catchment through run-off. If effluent does enter the catchment in run-off then the system has failed.

Hydraulic Conductivity

Hydraulic conductivity describes the ease of water flow within a soil. Hydraulic conductivity also depends on the water content and potential of the soil. Thus, in relatively simplistic terms the hydraulic conductivity of a soil determines how quickly or efficiently water may move (laterally or vertically) through a soil column. This soil property therefore has a direct bearing on how capably a soil can disperse treated wastewater.

Factors that reduce the hydraulic conductivity of a soil will also reduce the capacity of that soil to disperse, or allow the passage of treated wastewater, introduced onto or into the soil. Where the hydraulic conductivity of a soil is so affected by chemicals, fats or salts that the soil column becomes saturated with water, or water cannot pass through the soil voids, wastewater in that soil may become available to surface water run-off on the soil, thus leading to the failure of the wastewater management system.

The hydraulic conductivity of a soil is determined by the soil structure, texture and chemistry. Changes to any of these parameters will directly affect the hydraulic conductivity. Salts and fats are particularly harmful to the efficacy of a soil to allow the movement of water through its void spaces. Operators of domestic on-site wastewater treatment systems must also be vigilant in the use of high sodium load chemicals. These are particularly common in some laundry and kitchen detergents. As stated above, we strongly recommend the operators of the effluent system proposed in this examination, research available literature to identify, and use, low sodium (Na) detergents and cleaners.

The apparent (estimated) hydraulic conductivity of the soil column at this site is **low-moderate.**

Nitrogen (N), Phosphorus (P) and nutrient management:

Following careful study of AS1547:2012, including particularly the work of Gerritse (2002) cited in Appendix S5 of the current standard - *Gerritse, R. Movement of nutrients from onsite wastewater systems in soils. Western Australia: Department of Health, 2002;* we do not believe the current standard (AS1547:2012) provides any definitive methodology for reducing and/or removing nitrogen (N) and phosphorus (P) from domestic wastewater. Gerritse (2002) at page 22 noted that "…At densities of septic tanks below 5/ha (i.e. 2000 m^2 lot sizes), inputs of nutrients can become dominated by other sources such as fertilizers, domestic pets, poultry, and particularly horses. In these situations, inputs from wastewater disposal systems should be considered in the context of the overall contribution of the catchment to nutrients". The work of Gerritse (2002) was focussed on septic tanks and his findings reflect this. In the domestic wastewater management system proposed by the applicant, domestic wastewater will be treated to a primary level by the proposed worm farm septic tank/ LPED system.

Notwithstanding Gerritse' work and findings, it is incumbent on occupiers of rural residential lands to ensure that they do not add to the environmental risks associated with the contribution of excess nutrients or pathogens to the environment. The operation of domestic wastewater systems can, if not properly constructed and maintained, lead to elevated nutrient load entering the environment surrounding these systems. If excess phosphorus (P) and nitrogen (N) reach waterways, they can cause eutrophication of the waterways, potential algal blooms and fish-kills.

The most effective method for the applicants to manage phosphorus (P) pollution from their wastewater treatment system is to ensure that washing products are phosphate free, or have low phosphate content and be labelled as being suitable for use in rural /sensitive environments. The management of excess nitrogen output to the environment (as nitrates, ammonia and urea) is more problematic, as nitrogenous compounds are a by-product of the wastewater treatment processes. The most effective steps the applicants should take to reduce nitrogen nutrient loading is to:

- Ensure the wastewater treatment system is managed according to the manufacturers' specifications including the recommended servicing regime;
- Ensure the application area is planted with a diverse range of plants as recommended in this report. Plants will take up nitrogen from the soil as they grow. If vigorous growing plants are planted in the application area, they should be regularly pruned or cut back. This will encourage further growth and uptake of nutrients and wastewater by the plants.

Site constraints, risk assessment and proposed mitigation strategies.

Appendix A of AS1547:2012 provides guidance on the assessment and management of site constraints and risks associated with the operation of domestic wastewater management systems. The Appendix states that the assessment of site and operational risks and the identification of management strategies to address these risks are required in order to prevent adverse impacts on:

(a) Public health, through for example, contamination of drinking or recreational waters, direct or indirect contact with effluent;
(b) Soil or water ecosystems; and
(c) Amenity value, through odours and ponding of wastewater.

The following risk/treatment matrix (Table 1) addresses the site constraints and operational risks for the operation of the proposed domestic wastewater management system at the applicant's site.

Assessment of potential groundwater impact:

There are no bores or wells on the applicants'. The NSW Natural Resource Atlas does not show any known (licensed) groundwater bores within 200 metres horizontal radius of the proposed application area for this development. It is reasonable to conclude that given the size of the applicant's land (8.435 hectares), it is not likely there are any other bores within 200 metres (horizontal distance) of the proposed application area. This is an acceptable horizontal setback distance having regard to Table R1 of AS1547:2012. Having regard to the topography and nature of the bedrock in this location it is reasonable to infer, from the available data, that there is negligible likelihood of contamination of groundwater from the applicant's proposed wastewater treatment system, due to the depth of earth and rock overburden between any groundwater aquifer/s and the ground surface.

The specific issues identified in the current Yass Valley Council LEP's are addressed below:

(a) As discussed above, it is inferred by analysis of available data and assessment of extant topography and lithology, that there is negligible likelihood of contamination of the extant groundwater aquifer in this area. The unknown degree of subsurface fracturing of the bedrock at this location precludes a definitive statement of exclusion of contamination potential. The wastewater system proposed has been designed to maximise retention of wastewater within the root zone and upper 2 metres of the existing soil column where the effects of evaporation and transpiration are maximised.
(b) There are no known groundwater dependent ecosystems near this site.

TABLE 1

DESIGN RISK REDUCTION MEASURES

Cause	Factors that increase likelihood	Recommended risk reduction measures
Low hydraulic gradient in soil column due to permeability characteristics	• Excessive water usage • Fats, salts and other harsh chemicals entering the treatment system	• Use water conservation measures including the installation of water saving taps and toilets to reduce water consumption in the house • Avoid allowing fats and salts to enter the wastewater treatment system • Ensure high planting density on application area; regular tilling or aeration of the soils on this area will further assist
Waterlogging of the application area	• Failing to monitor the application area for signs of waterlogging • Sustained high rainfall • Failure to move irrigation lines from waterlogged areas • Failure to plant sufficient/ effective vegetation plantings on the application area(s)	• Carefully monitor the application area for evidence of waterlogging • Re-direct dispersal to unaffected areas • Construct diversion drainage around the application area to prevent upslope surface water encroachment onto application area(s) • Construct the primary and reserve application area(s) to have a recommended minimum area of 145 square metres • Ensure that a diverse range of plants (grasses and shrubs are planted on the application area(s)
Failure of wastewater treatment system	Failure to maintain specified servicing requirements for the system	Ensure ongoing compliance with servicing requirements recommended by system manufacturer
Surface water run-off from the application area	• Failure to operate the wastewater system in accordance with manufactures recommendations • Failure to construct and maintain the application areas in accordance with the recommendations of this report	• Ensure the wastewater system is operated in accordance with manufactures recommendations • Ensure the application area(s) are constructed and maintained in accord with the recommendations in this report • **Construct the primary and reserve application area(s) to have a recommended minimum area of 145 square metres. Increasing the application area size is recommended to ensure long term efficacy and mitigation of potential catchment impact**
Contamination of the local environment with high levels of nutrients, particularly phosphorus (P) and nitrogen (N)	Failure to observe the recommendations of this report	• Ensure that the application area(s) are constructed and maintained in accordance with the recommendations of this report • Ensure that cleaning products used in the house are phosphate free or have a low phosphate content • Regularly prune or cut plants on the application area(s) to encourage new growth and uptake of nutrients by the plants

(c) The proposed wastewater management system will be sited greater than 200 metres horizontally, of any known (recorded) existing bores (NR Atlas NSW). This horizontal setback distance between the wastewater treatment site and the indicated bore is acceptable having regard to the setback distances given in Table R1 of AS1547:2012. The conformity of the proposed wastewater system setback distances, from known bores, according to AS1547:2012 leads, by inference, to acceptance that there is a negligible risk of cumulative impact from the proposed wastewater treatment system on the groundwater aquifer.

(d) The wastewater system proposed has been designed to maximise retention of wastewater within the root zone and upper 2 metres of the existing soil column, where the effects of evaporation and transpiration are maximised. Furthermore, the earthworks recommended in this report to ensure the management and control of surface water and dispersed treated wastewater, will mitigate potentially adverse environmental and ecological impacts of this development.

SOIL AND SITE SURVEY

On-site evaluation conducted: 24 July 2018

Locality:	Lot 222 DP 39689, 600 Childowla Rd, Bookham, NSW Elevation: 503m
Lat/Long:	34’51”126S/148’36”189E
Owners:	Linn Armour & Orida Armour Lushmoor
Reg. Authority:	Yass Valley Council (YVC)
Block configuration:	polygonal, comprising an area of 8.435 hectares (22 acres)
Site Plan Details Attached:	Attachment 1
Intended water supply:	roof collection of rainwater for all potable supply
Expected wastewater Volume (litres/day):	DFA determined from AS 1547:2012 to be 120 litres per person per day. AS noted in this report, the applicants advise the proposed development will not be used as a dwelling. The development will be used to facilitate horticultural and agricultural activities by the applicants. We have assumed a daily flow allowance of 2 x 120 litres + 240 litres per day.

Soil type:

The soil profile observed on the applicants’ parcel of land may best be described as a yellow podsolic soil (Jenkins, 2000). The soil column at this site is consistent with the soil profile of the Murringo soil landscape described by Hird (1991). The Murringo soil landscapes are common on granitic parent bedrock in the area from Goulburn to Young. Hird notes these soils are generally derived from in situ weathering or parent bedrock as well as colluvial and alluvial vectors. Yellow podzolic soils of the Murringo soil landscape can be susceptible to minor sheet and gully erosion.

The permeability of the soil profile of the applicant's land was determined in accord with AS 1547:2012 utilizing the Test Pit Borehole method/constant–head test. Permeability was measured in separate locations at 250mm depth and at 600mm depth. At 600mm depth the indicative soil permeability (Ksat) of the soil column at the proposed application area site was determined to be in the range **0.18-0.19m/day**. At 250mm depth the indicative soil permeability (Ksat) of the soil column at the proposed application area site was determined to be in the range **0.40-0.41m/day**. Daily Irrigation rate (DIR) in AS1547:2012, is determined from the permeability measurement, soil texture and Table M1 in Appendix M. This table specifies that for the measured permeability at this site (@ 600mm = 0.18-0.19m/day) and soil texture (clay loam) the DIR is **3.0mm per square metre per day**. As discussed in this report at page 4, the daily flow allowance (DFA) is determined from Table H. In this case the DFA is 240 litres per day. As shown above, at 250mm depth in the soil column the measured permeability is greater than double that at 600mm depth. We have used the 600mm calculations to ensure built in conservatism for this design.

Geology of site: Outcropping bedrock occurs commonly in the broad area of the evaluation site. Examination of the bedrock revealed this to be an igneous rock comprising relatively equigranular crystals of quartz, plagioclase feldspar, hornblende and biotite. The relative absence of orthoclase feldspar minerals in the rock leads to a classification of this rock type as granodiorite. The relative hardness of the quartz crystals leads to development of a relatively open and granular (gritty) soil. The openness of the soil structure leads to relatively high permeability, particularly in the upper soil horizons.

Climate: Warm/hot summers with large evaporative deficit and cool to cold winters. The average annual rainfall for nearby Bookham is 847mm and is slightly spring dominant.
Intended water supply source: Roof collected rainwater for all potable supply.
Local experience with existing on-site systems: Correctly maintained and serviced worm farm rural septic treatment and distribution systems operate efficiently without significant limitation in all climatic zones.

ON-SITE EVALUATION

The applicants' property is situated on a variably sloping, open area of land on the western side of Childowla Road. The property is polygonal in shape and comprises an area of 8.435 hectares (20.8 acres). On the proposed primary application area, the slope is gentle and ranges from 1-4 degrees, with an average slope of 2 degrees.

In the area proposed for the site of the primary application area, the land has an open, northwesterly aspect and is open to all prevailing weather systems. The proposed primary application area has good aspect and exposure for the purposes of maximizing evaporation of dispersed treated wastewater.

The principal drainage pattern on the proposed application area is variable, generally linear and planar, with a slight convergent trending slope to the west. The current drainage patterns and slope on the proposed primary application area indicate this area is at low-moderate risk of inundation and waterlogging during times of heavy or sustained rainfall.

Topography

Slope/aspect:	on proposed application area is variable and gentle, 1-4 degrees with mean slope of 2 degrees – open aspect
Ground Cover:	predominantly native and introduced pasture grasses
Drainage patterns:	variable, generally on the proposed application area it is linear and planar with a primary convergent drainage to the west
Clearance:	minimum of not less than 10 metres to building; greater than 70 metres to dam
Boundaries:	nearest boundary (southern) is greater than 20 metres from the southern perimeter of the recommended location of the primary application area.
Waterways:	greater than 100 metres to permanent watercourses
Trees/shrubs:	scattered - common – mature *Eucalyptus* species
Well, bores:	advised nil
Embankment:	recommended– see discussion in body of report (pages 5-7)
Site history (land use):	grazing/ agricultural uses
Site Plan details attached:	Yes – Attachment 1
Site aspect:	open to all prevailing weather systems with good exposure
Pre-dominant wind direction:	northwesterly (summer) and southwesterly (winter)
Presence of shelter belts:	No
Presence of topographical Features or structures:	refer discussion at pages 5-7 of this report

Environmental concerns; Low likelihood but high consequence localised environmental issues prevail at this site – refer discussion in report at pages 5-7 and 15-17. Provided our recommendations regarding the construction and implementation of embankments and diversion drainage, around application areas are observed; and monitoring of the application area to prevent waterlogging are observed, no other environmental issues prevail. Correct use and maintenance of the proposed treatment regime on these soils will be ecologically and environmentally neutral.

Site stability: soils appear generally stable in the evaluation area.

Expert assessment necessary? No

Depth of seasonal water-table: WINTER > 1m; SUMMER:> 2m; EPISODIC:>2m

Need for cut-off drains/diversion banks? Yes - as noted in the body of the report.

Need for surface water collector or cut-off drains? As above

Availability of reserve/setback areas:	available – refer site plan. Reserve area available if necessary
Setback distance between the site development and on-site disposal Design and reserve areas	20 metre minimum setback
Photographs attached:	No, included in body of report

SOIL INVESTIGATION

Soil profile determination method: Test pit Borehole per AS 1547:2012

Type:	yellow podsolic soil –description in body of report
Depth to bedrock or hardpan:	Variable, common outcropping bedrock and rare eroded bedrock in soil column at greater than 200mm depth
Depth to high soil Watertable:	>600mm
Soil texture:	refer attached excavation / soil profile log (Attachment 2)
Soil structure:	Massive A horizons and weakly to moderately pedal B horizons.
Permeability *(Measured)*	indicative permeability of 0.18-0.19m/day at 600mm depth
Coarse fragments	mean = 2% in A horizons; primarily sub angular to subrounded fine quartz grains. In B horizons; mean = 5% quartz crystals generally larger than in A horizons plus rare pebbles/cobbles of heavily eroded granodiorite bedrock, ranging in size from 3mm -12mm.
Bulk density	(estimate 1.7)
pH	surface 6.4; subsurface 6.1

RECOMMENDED DIR: 240 litres per day – (from AS /NZS 1547:2012)
Reasons for DIR recommendations: Development will not be a dwelling. Assume allowance of 240 litres/day for advised horticultural activities. Water supply will be from roof collection.

Groundwater quality issues: Refer to detailed discussion of groundwater vulnerability at page 18-20 of this report. There appear to be no groundwater quality issues of concern, provided the applicants ensure ongoing compliance with the following recommendations:

- adequate vegetative cover is maintained on/around the proposed application areas;
- the minimum primary application area equals or exceeds the recommended area of **145 square metres;**

- an adequate earthen embankment, as discussed in body of report, is constructed around the downslope perimeter(s) of the application area to prevent the egress of surface waters from the application area(s); and
- the upslope borders of the application area should also be protected from the incursion of surface waters from upslope moving across the application area. Suggested means of ensuring this incursion is prevented are given in body of report.

We conclude that the proposed treatment regime will have no adverse impact on groundwater stocks provided these recommendations are observed and the wastewater system is correctly installed, maintained and operated. The management practices discussed in the report are intended to mitigate all potential environmental risks arising from the operation of this wastewater treatment system

Type of land-application system considered best suited to site and why:

All common treatment systems including conventional septic tank/absorption trench, aerated wastewater treatment systems (AWTS), reed bed and worm farm powered systems would effectively manage the treatment and dispersal of treated wastewater at this site. The use of a worm farm rural septic tank system to manage on-site domestic wastewater at this site is recommended as:

- this system requires very low input to operate. The development will be powered by solar panels only;
- worm farm systems produce treated wastewater that is relatively low in pathogen and nutrient counts while also providing minerals and compounds that enrich the soil upon which the wastewater is applied;
- Given the geological, physical and chemical properties of the soils and topography at the proposed site, the use of a worm farm rural septic tank system will allow the efficient management of treated effluent with no, or minimal, environmental and ecological impact.

Overall evaluation of minimum land-application area for the site: at least 145 square metres

Specific health constraints: none apparent

References:

1. Australian/New Zealand Standard AS/NZS 1547:2012. *On-site domestic-wastewater management*
2. Hird, C. (1991) *Soil Landscapes of the Goulburn 1:250,000 sheet*. Soil Conservation Service of NSW, Sydney
3. Jenkins, B.R., 2000. *Soil Landscapes of the Canberra 1:100,000 Sheet Report.* Department of Land and Water Conservation. Sydney

4. McDonald, R.C. (1998 – 2nd Ed). *Australian Soil and Land Survey – Field Handbook.* Department of Primary Industries and Energy and CSIRO Australia.

5. McKenzie, N et al. (2004) Australian *Soils and Landscapes*. CSIRO Publishing.