Ark Angel Pty. Ltd.
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Earth's Manager

LAND CAPABILITY ASSESSMENT
GRAHAM & HENDERSON ROADS
TOONGABBIE

12/09/23

ADVERTISED
PLAN

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1.0 Introduction

The author has **been commissioned to conduct a land capability assessment** for a proposed onsite sewerage system **for a Bio-Gas generation facility within a Farming Zoned Property**, refer Figure 2. A land capability assessment is required to ensure that in any future development, an approved onsite sewage management system can successfully maintain all treated effluent onsite in accordance with EPA, 2016, *Code of Practice - Onsite Wastewater Management*, Publication 891.4. It is expected that the assessment will accompany a septic tank permit application to **Wellington Shire Council**. This application will be undertaken by the owner, developer, or their representative, e.g. a plumber or drainer.

This report recommends the best practical assessment known to the author who is a fully qualified engineer, IEA Registration Number 6680, experienced and insured to undertake such assessments. However, the author cannot guarantee the assessment will be approved by Council. The proprietary information contained in this report is also site specific and is not to be used outside the bounds of the property.

2.0 Summary

The best chance of maintaining all effluent onsite requires that **a primary treatment system be installed.** The limiting site conditions are such that the following onsite wastewater management system is recommended:

1. **A suitable EPA approved 3000 L septic tank primary treatment system can be installed at this site, refer Figures 1, 5-10 and Section 6.2 for more details. This tanks must be desludged at least every 14 years.**
2. **All primary treated effluent is to be disposed of by an arched trench irrigation system that is shown in Figures 1, 5, 6, 11 & 12.**
3. **Due to the flat nature of the site, the depth of the septic tank should be set in the ground at least 200 mm higher than normal to allow for gravity flow of effluent to the effluent distribution system. Alternatively the base of the trench system should be set at least 200 mm lower than normal to allow for gravity flow to the trench systems.**
4. **The effluent dispersal area should be fenced off from vehicular traffic.**
5. **The effluent dispersal area should be located at least 20 away from any proposed water bore.**
6. **Minimum buffer distances described in Section 8.0 from the effluent dispersal area to salient features are to be adhered to.**
7. **The soils in the proposed trench effluent dispersal area are to be amended, refer Section 6.4 for details.**
8. **It is recommended that water conservation appliances and practices are to installed and maintained, refer Section 9 for more details.**

9. All other services (e.g. Gas, water telecom, underground power, etc. are to be determined by others before beginning system construction.
10. It is recommended that the onsite sewage system be maintained like that discussed in Section 9 and the attached management information file.
11. All other details regarding the construction and management of the proposed effluent management system are to be compliant with the recommendations of this report and regulatory authority directives where appropriate.

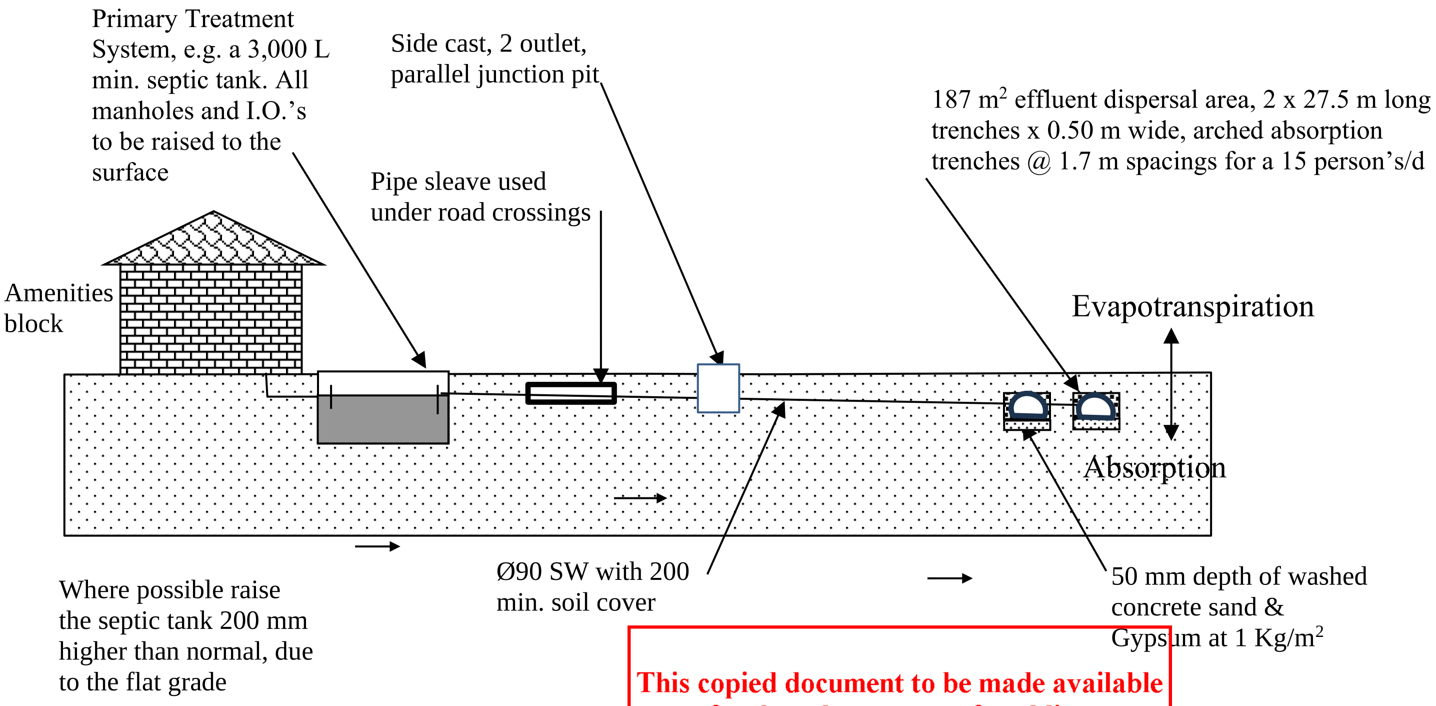


Figure 1B:
Typical Section of Side Cast Proposed Gravity Flow Trench Effluent Management System

Table 1:
Required Residential Effluent Management System Characteristics

ITEM	Sewage Influent (L/d)	Maximum number of people	Minimum trench base area (m^2)	Minimum trench length (m)	Effluent dispersal area (m^2)	Minimum septic tank size, without a partition (L)
Trench System	10 L/p		DLR = 5.4 mm/d	Width = 500 mm under arch	EFF = 1.6 mm/d	
Workers	150	15	72	55	187	3,000

NB:

1. The sewage influent and absorption area in this table is calculated on the basis of average effluent production rate of 10 L/p.d of blackwater sewage being used. However, I also recommend that any proposed amenities facilities have water conservation fixtures. These include 3-4 star flush toilets, 3 star shower roses, 4-5 star dishwashers (or no dishwashers).
2. The maximum number of design people is 15/d.
3. Minimum septic tank size is 3,000 L, and this is to be desludged every 14 years..
4. It is recommended that a septic tank system without an internal 2/3's partition system be installed; refer attached system management notes.

3.0 Method

The author Scott McFarlane undertook an **onsite investigation on the 10/09/23**. In the past it has been common practice by many practitioners in this field to use blind rule of thumb and trial and error assessment procedures and simply increase the length of trench or area of the drip irrigation system to help ensure a safer onsite sewage system, e.g. from stopping the dangerous pathogen laden effluent from coming to the surface and coming in contact with owners, neighbours and the environment alike. This has often been carried out without due consideration of the nature of the underlying soils, consequently onsite sewage system designed in this way have in the past, and will in the future often fail prematurely.

However when a land capability assessment is conducted by an experienced assessor, a relatively new phenomenon; the assessor will conduct a soil profile analysis and then appropriately design the onsite effluent management system to meet the soil condition found at the site. As a consequence of this. The onsite system may not look like a traditional trench or drip irrigation system, which did not take into account the nature of the soil profile at all.

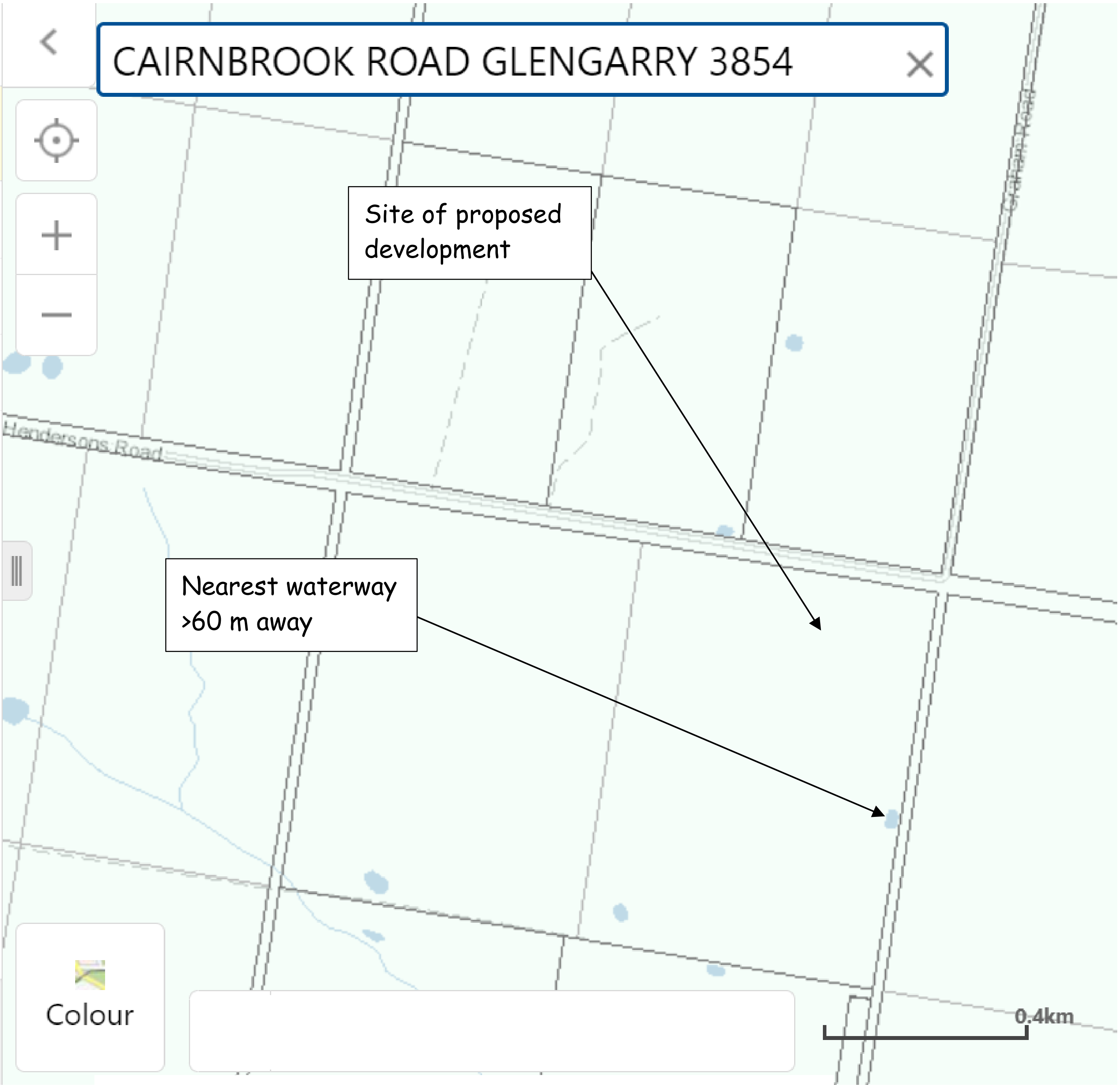
For example, the assessor may determine that the site has, or is likely to have a perched water table with the addition of effluent; in which case no amount of increasing the size of the size of a traditional effluent management system will make the system safer, e.g. the applied effluent will come to the surface regardless of size. In addition to this, the author will use other soil classification parameters (e.g. bearing capacity, and micro-soil structure) not covered by AS/NZS1547 to help make an assessment for a more reliable onsite effluent management system.

As a consequence of the author's approach; instead of a traditional system, the assessor may recommend that deep cut-off drains be installed, the effluent be applied to a more permeable underlying soil horizon via a sand – permeable clay lined shallow or deep trench system, or by a deep ripped, or evenly applied pre-treated effluent application system that by-passes the shallow offending poor permeable soil horizon, or improves the quality of treatment and vegetation evapotranspiration rate by appropriate horticultural measures.

At this site the author has used a hand auger to determine the texture and the structure of the soil ped structure (refer Table 5.2 of AS/NZS1547:2012) to a minimum depth of 1.2 m in deep or to bedrock, whichever comes first. When taking into consideration the deep red volcanic Geology of the local area, **2 investigative boreholes showed that this site has good permeable Category 6 Clay soils that are suitable for an arcched trench effluent dispersal systems.** No more boreholes are likely to improve this design outcome.

4.0 Location

Figure 2 provides a locality plan and indicates the location of the site of the proposed development. **Figure 2** provides a typical existing site plan describing the sites key site features. **Figures 5-12** below will provide information on the proposed effluent management system, including any effluent dispersal envelope/s.



Site of proposed development

Nearest waterway >60 m away

FIGURE 1
LOCALITY PLAN OF PROPOSED SITE
NB:

1. To scale as shown
2. Metre dimensions unless stated otherwise.
3. To be read in conjunction with attached report.

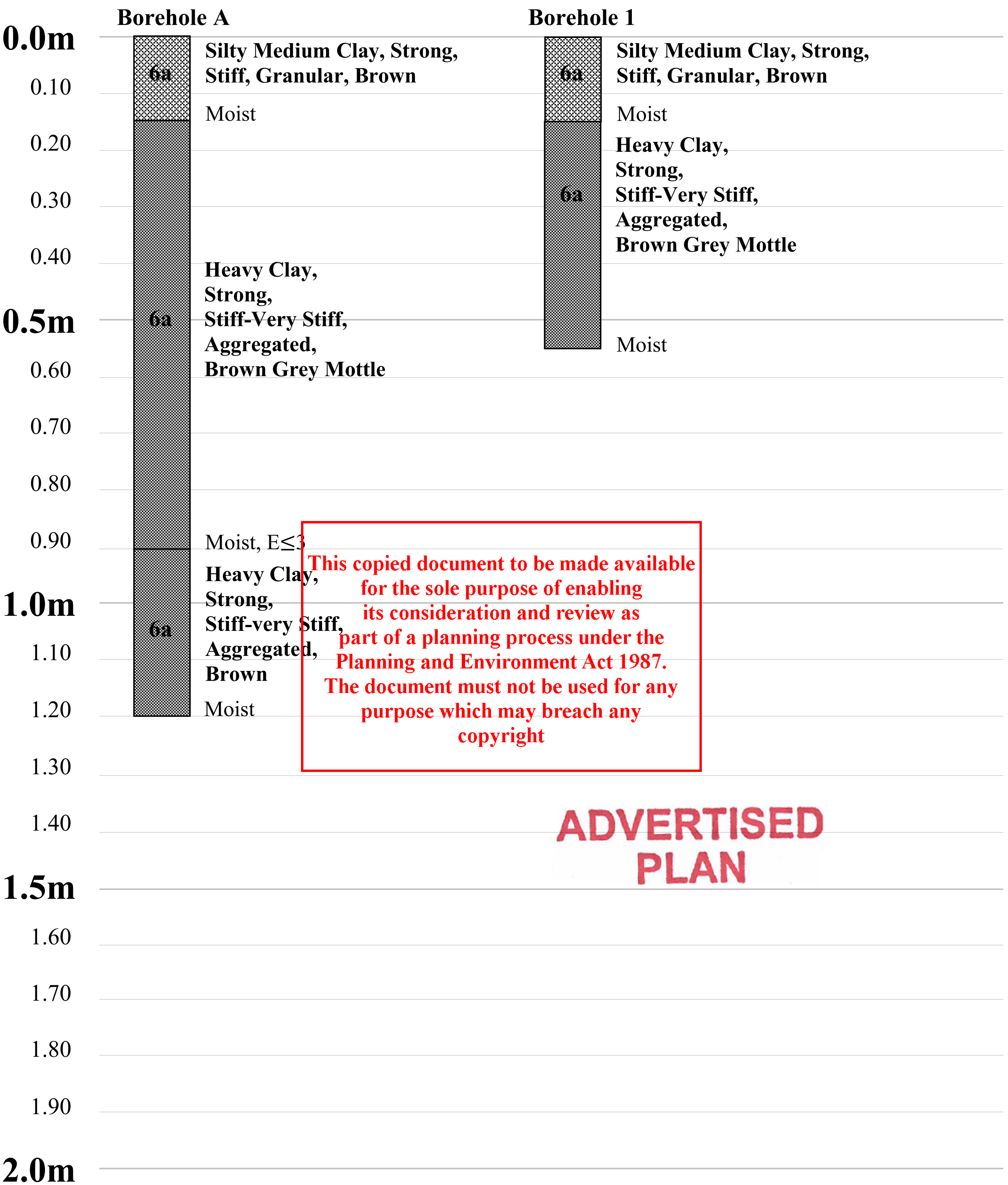
FIGURE 2
DETAIL PLAN OF THE EXISTING SITE

NB:

1. To scale as shown
2. Alphanumeric dots are borehole locations.
3. Numeric dots are soil permeability assessment locations.
4. Metre dimensions unless stated otherwise.
5. 10m contours shown.
6. To be read in conjunction with attached report.

BOREHOLE LOG

DATE: 10/09/23



LEGEND

▤ Fill
■ Rock
▩ Gravel
⬚ Sand
⬚ Sandy Loam
⬚ Loam
▨ Clay Loam
▨ Light Clay
▨ Medium Clay
▩ Heavy Clay

5.0 Land Capability Assessment

The land at this site is primarily assessed and designed from the information shown in Table 2. The proposed risk assessment method and their meanings are outlined in MAV, 2014, *Victorian Land Capability Assessment Framework*. Some parameters are determined from site observation. The method of soil and permeability assessment is consistent with AS/NZS 1547:2012, Tables E1, E4, B2, 5.2, and Appendix G where relevant. Field measured soil qualities are taken from hand augured borehole samples within 50mm of a soil horizon change, or at 400 mm depth where trenches are considered.

Table 2: Land Capability Assessment Parameter Risk Check and Resulting Design Strategy

Land Features	**Risk Assessment** **Minor, Moderate, Major**	**Observation & Remarks**
GENERAL SITE		
Aspect	Minor	OK
Climate	Minor	OK
Erosion	Minor	Well grassed.
Exposure	Minor	OK
Fill	Minor	OK
Flood Frequency	Minor	OK
Groundwater Bores	?	None at the moment. However, any proposed bore for this site should be at least 20 m away from the proposed effluent dispersal system.
Available Land Area	Minor	Enough for a primary treatment system with trenches, including a reserve area, refer Figure 2.
Land Slip	Minor	None likely.
Rock Outcrops	Minor	None
Slope	Moderate	The proposed effluent management sites have relatively flat slope of <1 %. Consequently, it is recommended that the proposed effluent management systems have an overall effluent application rate of 1.6 mm/d, as is recommended for drip and trench irrigation systems of this nature on flat sites, refer to Table M1 of AS/NZS1547 and MAV model for recommendations on flat sites, and Appendix C. This approach will ensure that the eventual deep effluent application rates for drip and trench systems have approximately same level of effluent application and risk. It should be noted that the above recommended method for determining the overall effluent application rate shall be used instead of the Water Balance method recommended in the MAV LCA model, refer Appendix B for more information.
Soil Drainage	Major	This site has relatively good vegetation coverage. This indicates that good quality drainage is present, refer Figure 2. Consequently the effluent dispersal system can be located anywhere close to the proposed office and amenities block. The soil profile at Borehole A supports indicates that the site has strongly structured soils to 1.2m depth, even though the soils below 0.15 m depth are heavy clays. A soil permeability test was conducted in accordance with Appendix G of AS/NZS1547, and this determined that the soils have a permeability Of ~0.07 m/d. Referring to Figure 4, a soil permeability of 0.07

m/d (refer Appendix D) coincides with a Blackwater DLR of 3.4 /mm/d, refer Figure 4 below. Consequently the best way to manage the dispersal of effluent at this site is to install a trench effluent dispersal system with a 50 mm thick, sand lined absorption/evapotranspiration trench system with an arched drain. As the soils are sodic in nature, it is also recommended that gypsum be applied to the base of the trench system at a rate of 1 Kg/m^2. It should be noted that this is a combined absorption/evapotranspiration trench system.

Therefore the following trench systems are considered potentially suitable for this site:

A Trench Irrigation System

1. A 3,000 L min. primary treatment system approved by AS/NZS1546.1 can be installed here.
2. A water balance assessment is not proposed for this site as there are problems associated with this method, refer Appendix B. The alternate method of adopting DIR shown in Table M1 & M2, as recommended by Section M6.2 of AS/NZS1542 will be used instead for the design of this proposed trench system total irrigation area. It should be noted that the author recommends that DIR for drip irrigation systems be interchangeable for trench irrigation systems. In this case, the author recommends that a conservative equivalent DIR of 1.6 mm/d be used. This will give the trench system the same level of failure risk as a drip irrigation system. Refer to the slope section above for more information.
3. It is recommended that a low DLR of 3.4 mm/d be used for the proposed deep sand lined trench system. **However because an arched drain is recommended, it is recommended that an allowance be made for the lack of aggregate contact area in the base of the arched trench system.** Research by Siegrist R., McCray J. and Lowe K. (2004): *Wastewater infiltration into soil and the effects of infiltrative surface architecture*, showed that the effective absorption surface in traditional trench systems is only the contact area between the aggregate distribution layer in the base of the trench. Most distribution aggregate in the base of trenches take up 60% of the contact area in the base of the trench, hence all applied effluent is only being absorbed through 40% of the trench's base area.

   Consequently for arched drains, the effective base absorption area is now 100% of a trench base area. Hence the effective DLR for an arched drain trench is equal to:

   DLR_{AT} = [1 + (1-0.4)] DLR_{TT}
   = 1.6 DLR_{TT} mm/d

   Where:
   DLR_{AT} = primary treated effluent Design Loading Rate of an arched trench… mm/d
   DLR_{TT} = primary treated effluent Design Loading Rate of an traditional trench… mm/d
   0.4 = the free contact area of the distribution aggregate layer, i.e. the void ratio.
   Therefore for this site:
   DLR_{AT} = 1.6 DLR_{TT} mm/d
   = 1.6 x 3.4
   = 5.4 mm/d

   NB: it should be noted that a typical arched drain is only 500 mm wide once it is installed in a 600 mm wide trench system. It is however

		recommended that the effluent dispersal system be protected by a vehicle barrier in order to protect the arched drain from being crushed, e.g. a fence or surrounding 300 mm high aggregate mound around the perimeter if the effluent dispersal system. 4. If required, it is recommended that the spacing of proposed trench irrigation lines be estimated from known information about these soil, refer Section 6.3.1. It should be noted that once the effluent leaves the base of a trench system (as with drip irrigation systems) it will continue to gravitate downwards until a poor permeable soil horizon is encountered. When this occurs the percolate will begin to mound up and move laterally between the trenches. The driving head for determining the trench separation distance of the proposed trench system in this case, is the depth is 0.50 m, i.e. the depth to the C soil horizon below the base of the trench system. The proposed trench design must have a driving head that is less than this. In this design process it is recommended that the soil below the trench will have a low design permeability of only 0.02 m/d, which is considered to be the limit for trench systems by the author. 5. It is recommended that the base of the trench system be lined with 50 mm of washed sand. This design is allowed by Table K2 (p.137) of AS/NZS1547. This approach to trench design will help prefilter the applied primary treated effluent to secondary treatment quality (refer Appendix A), improve the longevity and reliability of the treatment system, and help it overcome any variation in soil permeability across the site. However, at this site no allowance will be made for secondary treatment as an extra safety precaution. 6. It is recommended that an upslope spoon drain be installed. This will help minimise any upslope runoff water from running onto the effluent dispersal area and competing with the trench systems for the deep absorption of effluent, refer Figure 12. 7. Due to the flat nature of the site, the depth of the septic tank should be set in the ground at least 200 mm higher than normal to allow for gravity flow of effluent to the effluent distribution system. Alternatively the base of the trench system should be set at least 200 mm lower than normal to allow for gravity flow to the trench systems.
Stormwater run on and off	Major	It is recommended that an upslope, 200 mm deep spoon drain be installed. This will help to divert upslope surface runoff away from the effluent dispersal area, this is shown in Figures 5, 6 & 12.
Waterway Set Back	Minor	This site is not located within a declared catchment region, refer Figure 2. Therefore it is recommended that the proposed effluent dispersal area be located at least 60 m away from the local declared waterway; which it is quite capable of doing, refer Figure 2.
Vegetation Coverage and Aspect	Moderate	The site is covered by relatively good-medium quality grass; thus it will provide good evapotranspiration to any applied effluent.
SOIL PROFILE		
Electrical Conduct.	Minor	The Clay topsoils and grass quality indicates that this is not a problem.
Emerson (Simple)	Minor	The underlying soils in the E soil horizon have $E \leq 3$. Consequently it is recommended that Gypsum be applied at a rate of 1 Kg/m^2 of trench base area.
Gleying	Minor	None
Mottling	Minor	Some, however not considered to be a problem with the sand lined arched trench arrangement.

pH	Minor	The vegetation quality indicates that this is not a problem, and therefore has no effect on the overall size of the effluent dispersal system.
Rock Fragments	Minor	None
Sodicity	Minor	Refer to the Emerson section above, as this potential problem is managed in the same manor.
Soil Depth to Rock	Minor	> 1.20 m, therefore this is not a problem.
Soil Texture	Moderate	The soils at this site are all medium-heavy Category 6 Clay soils. Refer to borehole assessment. At this particular site, these soils are best managed by the design recommendations made in the Slope and Soil Drainage sections above.
Soil Structure	Moderate	The structure of the soils at this site are all strongly structured. As a consequence, these soil are best managed by the design recommendations made in the Slope and Soil Drainage sections above.
Water Table Depth	Minor	None observed.
TREATMENT SYSTEMS		
Suitable Treatment System	Moderate	A suitable EPA approved primary treatment system is recommended; refer Figures 1, 5-10.
Suitable Effluent Dispersal System	Moderate	A suitable arched trench irrigation system is recommended; refer Figures 1, 5, 6, 11 & 12.
Special Management	Major	Refer to attached management information sheet.
Land Features	**Assessment**	**Remarks**

6.0 The Onsite Effluent Management System

This Land Capability Assessment has been prepared to accompany a development application to the local Council for the management of onsite wastewater. A detailed design of the proposed effluent management system, based on the assessed site information in Table 2 is discussed in the following Sections of this report.

6.1 Estimated Quantity and Quality of Sewage and Other Influential Parameters

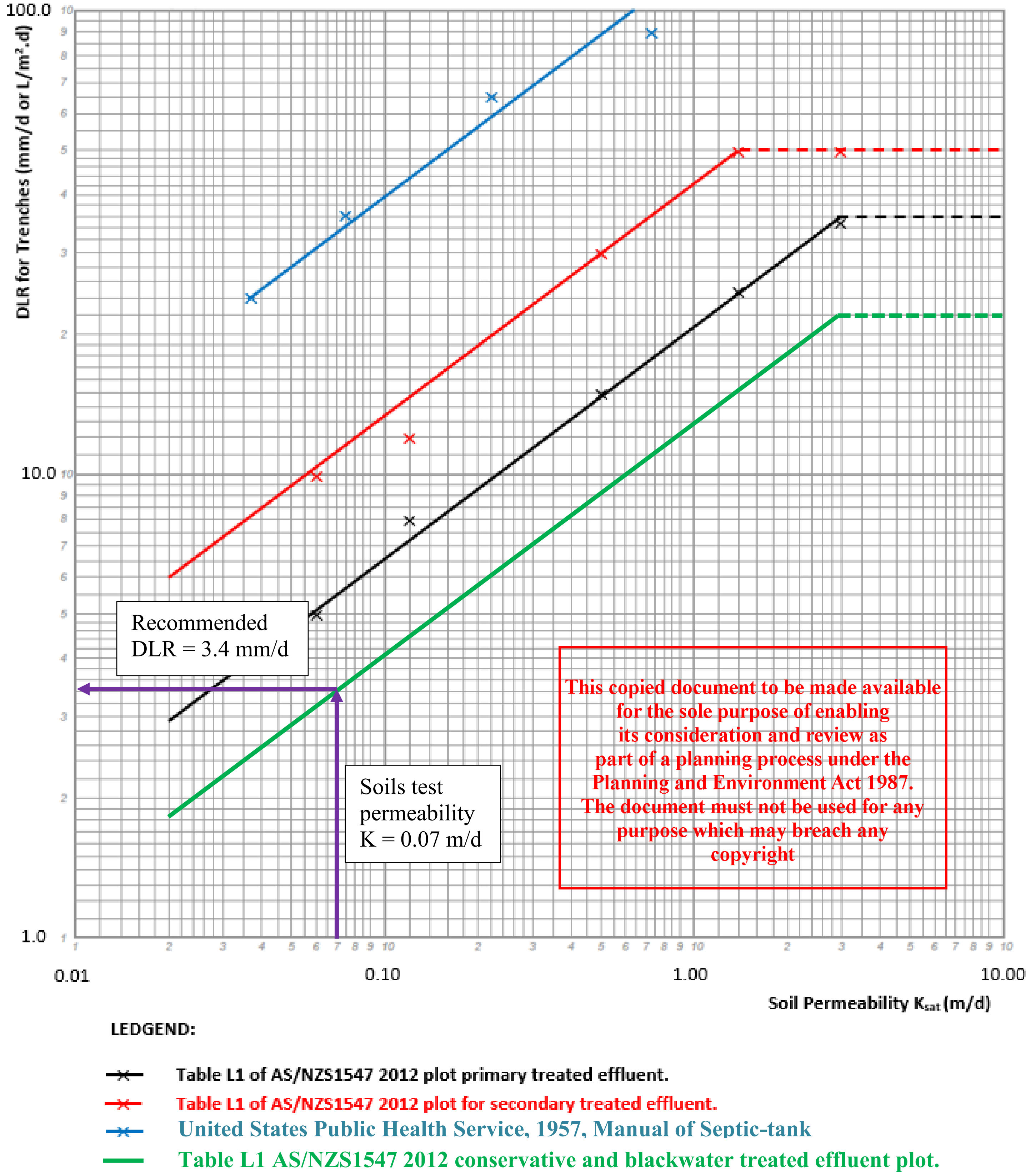
It is estimated that when fully developed, ~10 people will be working at the site. An allowance of 5 additional people will be made for delivery drivers and temporary maintenance crew. Hence a total design loading rate for this site will be the sewage generated by at least 15 people. Instead of using the out of date figures in Appendix A of AS/NZS1547 to estimate the daily effluent quantity, Table 3 below will be used by the author. This table has in the author's experience resulted in a more accurate assessment of these values when compared to actual measured water consumption data.

Sewage Production Rate Estimate

1. This is a commercial facility that will produce what is essentially known as black water sewage. It should be noted that all toilets at this facility are/will be water conservative 6/3 L flush toilets (i.e. 4 L average per visit), or there are low flush urinals in place. Using the following basic assessment procedure, the average estimated sewage production rate Q for a factory sewage system is: 2 toilet visits per day (e.g. 2 x 4 /flush = 8 L/d), plus a 2 L/d for washing

FIGURE 4

Trench DLR Versus Soil Permeability K_{sat} Plots



2. hands and kitchen usage. This amounts to 8+2 =10 L/person.d. For 15 people this amounts to an effluent production rate of 15 x 10 = 150 L/d.

TABLE 3:
Typical household water and BOD_5, daily sewage production rates

ITEM	Reticulated water supply (L/p.d)	Rainwater Tank Supply (L/p.d)	Untreated Average $UBOD_5$ Quality (g/p.d)
Toilet Blackwater	20	20	23
Bathroom	90	60	9
Laundry	30	30	9
Kitchen	10	10	9
Subtotal Greywater	100	100	27
Black & Greywater TOTAL	150	120	50

Notes:

1. Household water consumption figures taken from Table H1 of Appendix H of AS/NZS1547 2012, UWRAA 1989 and current day WELS water consumption star rating system.
2. Typical household BOD_5 figures adapted from Table 1.3 of Mara, 2004, *Domestic Wastewater Treatment in Developing Countries.*

Treatment Plant Requirements

6.2 The Proposed Treatment System Requirements

A primary treatment system will be analysed for use at this site. The following treatment system requirements are recommended for low risk- and trouble-free service:

1. If the proposed treatment process requires a 3000 L primary treatment tank.
2. The accumulation of sludge in a septic tank from blackwater sewage is about 20 L/person.year after taking into account partial daily and weekly usage, refer Section 5.4.2.2.1 of

AS/NZS1547. The volume allowed for the accumulation of sludge and scum is ~2/3 of the 3000 L storage volume of a septic tank. Consequently for a facility with 10 people, the septic tank will need to be desludged every:
2,000/ (20 x 10 x (5/7)) = 14 years.

3. Though not mandatory, it is recommended that septic tank treatment system be constructed like that shown in Figures 7 & 8.

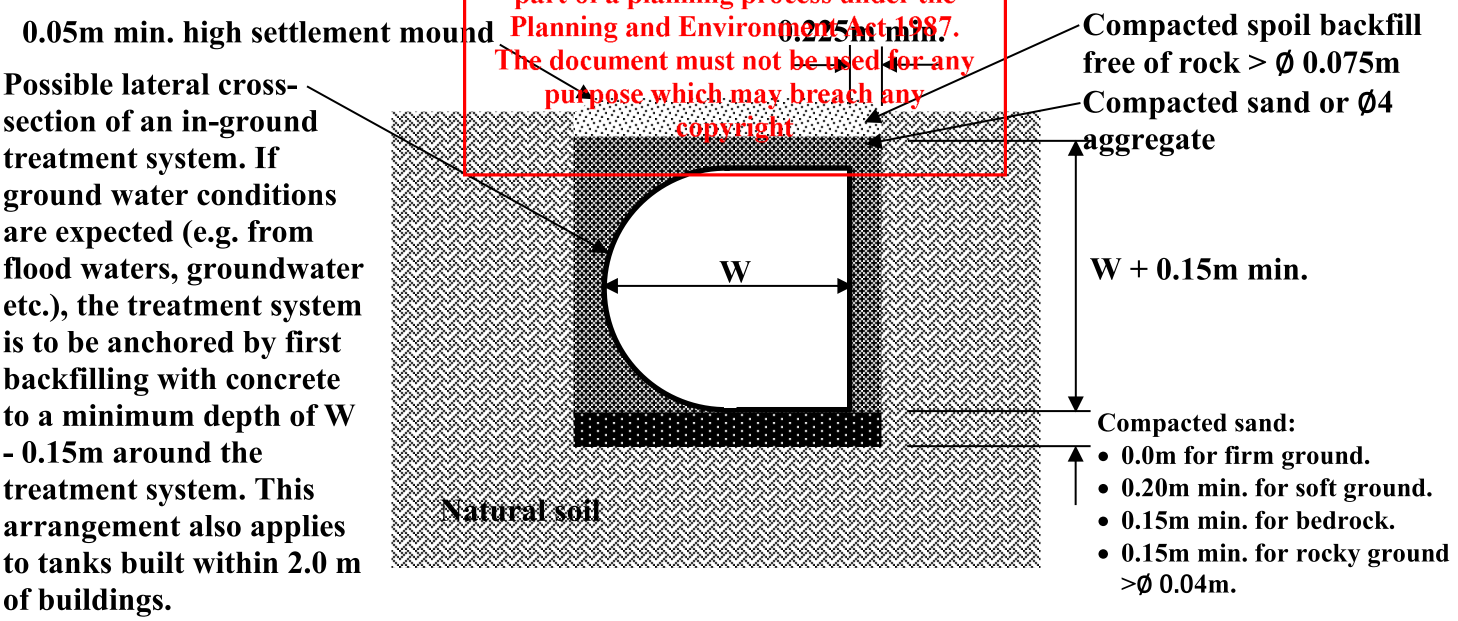
   It should be strongly noted that the septic tank design shown in these Figures will:

   1. Provide natural anchorage against groundwater buoyancy forces,
   2. Provide security against the tank's operation being compromised (e.g., by scum layer overflow to the absorption lines) when the area is inundated by heavy rainfall and the tank becomes flooded. It should be noted that this is particularly relevant to a flat site installation where the ingress of rainwater runoff via backflow along the absorption lines is ever present,
   3. Provide 1 days backup storage in the event when the tank is used in combination with a pumped irrigation system (refer to Section B 5.4.2.2.1 of AS/NZS1547:2012),
   4. The design length to width ratio will help ensure adequate storage detention and treatment of sewage.
   5. Provide good foundation support against ongoing settlement under load,
   6. Reduce start up smells by allowing the scum blanket to cover all exposed septic water surfaces,
   7. Increase the time between desludgings by 1/3 over and above a tank with a partition (i.e. will reduce the long-term desludging operating cost by 1/3).
   8. Provide an ever reminding presence (i.e. due to the tank being constructed ~200 mm above ground level) that the tank needs to be desludged on a regular basis.
   9. Provide a simple 5 min. cost effective method for determining when the septic tank needs to be desludged.
   10. Make it easy and less time consuming for desludgers to find and desludge the tank.
   11. Prevent the ingress of storm water into the top of the tank under normal operating conditions; refer Section 2.2 of AS/NZS1546.1:2008.

4. Where primary or secondary treated effluent is required, only EPA approved treatment systems are recommended. Primary treatment systems are expected to reduce the influent BOD_5 loading rate by ½, refer page 304 of Crites & Tchobanoglous, 1998, *Small and Decentralized Wastewater Management Systems*. Secondary treatment systems are expected to reduce the organic BOD_5 effluent loading rate to at least 20 mg/L. If a secondary treatment system is being considered, and it is proposed to use the property on an intermittent basis (e.g. as a retreat, or holiday house); then it is recommended that a sand filter treatment system be installed.

5. **For any proposed trench irrigation system at this site all effluent must be delivered evenly to all absorption lines, otherwise the Design Loading Rate (DLR), as recommended by Section L4.1 and Table L1 of AS/NZS1547:2012 will not be achieved. This can be achieved by the use of a parallel junction pit system like that shown in Figures 1, 5-10, and Figure T1 of AS/NZS1547. It should be noted that when the effluent is applied at, or less than the specified DLR, the percolate undergoes optimum unsaturated flow and aerobic treatment before reaching the underlying water table, refer Table K2 of AS/NZS1547. The longevity of the trench system will also be optimised; anything less is therefore an environmental health, and wealth hazard. <u>Conventional serial distribution pits are not to be used under any circumstance.</u>**

6. Treatment systems are typically constructed to high structural performance standards for their intended service; however, the structural performance of the foundations in which they are placed is often overlooked in the installation process. Consequently, all treatment systems, including pump wells are to be installed on firm ground foundations so that they do not adversely move and cause failure in service; e.g. either to the treatment system or to the unyielding pipes that they are connected to, refer Section B2.2 of AS/NZS1546.1. Alternatively used the recommended pipe backfill provisions of AS3500, which all plumbers and drainers are familiar with. Unless otherwise advised by the manufacturer, the following installation conditions are to be followed:



Possible lateral cross-section of an in-ground treatment system. If ground water conditions are expected (e.g. from flood waters, groundwater etc.), the treatment system is to be anchored by first backfilling with concrete to a minimum depth of W - 0.15m around the treatment system. This arrangement also applies to tanks built within 2.0 m of buildings.

Compacted sand:
- **0.0m for firm ground.**
- **0.20m min. for soft ground.**
- **0.15m min. for bedrock.**
- **0.15m min. for rocky ground >Ø 0.04m.**

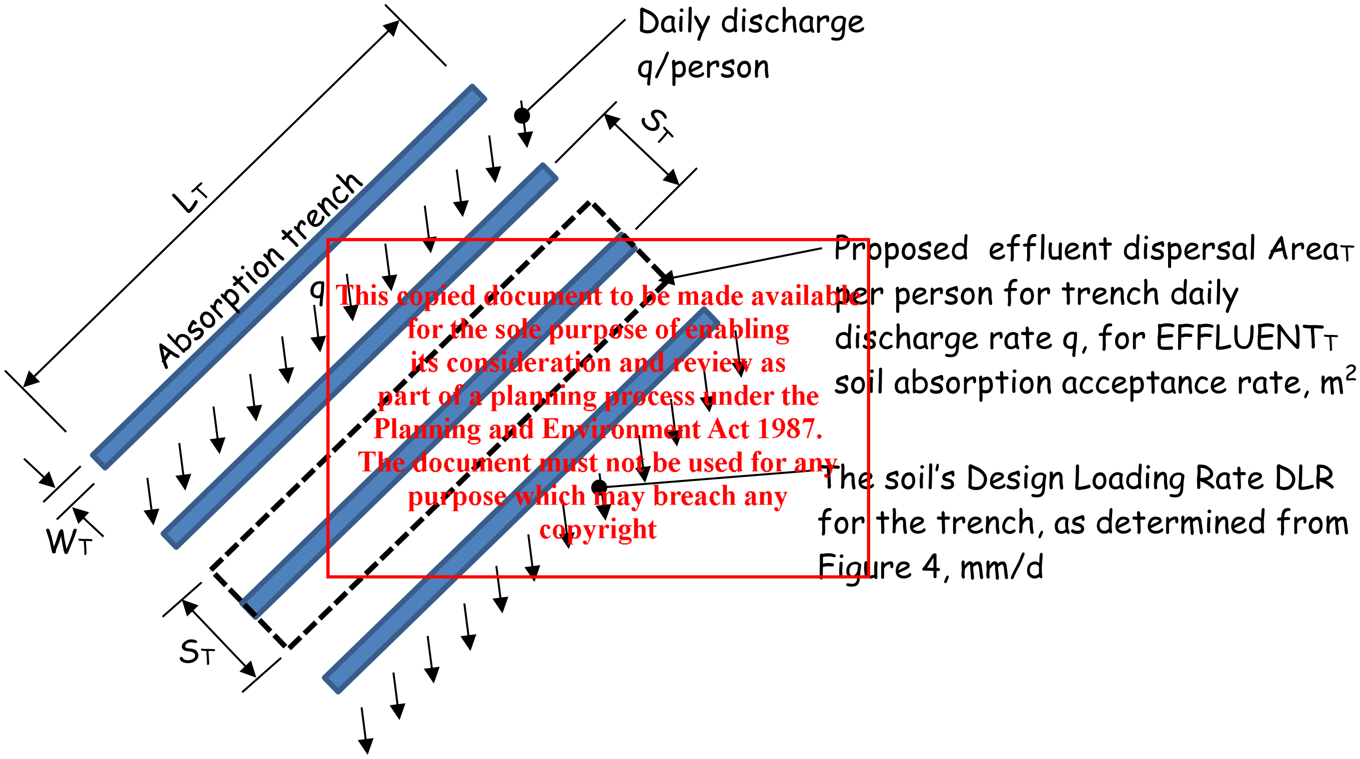
6.3 Land Application

After the site investigation and desktop analysis of the soil conditions, the author has determined that a **primary treatment and corresponding arched trench irrigation system** is suitable for this site, refer Table 2. However, in order to determine the proposed trench irrigation area characteristics, an effluent application rate assessment is to be determined. In this assessment the author has not used the recommended MAV water balance assessment as it is deeply flawed, refer Appendix B. Instead the author has adopted a conservative, equivalent drip effluent application rate of 1.6 mm/d for both the proposed trench and drip irrigation system, as it recommended by Sections M6.2 and Tables M1 & M2 of AS/NZS1547. Also refer to Appendix C. It should be further noted that this effluent application rate offers each system the same level of deep infiltration failure risk. This irrigation information is summarised in Table 1 at the start of the report.

6.3.1

Trench Effluent Dispersal area, Trench Design and Construction

Effluent Application rate, $EFFLUENT_T$ = 1.6 mm/d … as recommended in Table 2 above. A typical trench system layout is shown below.



In this arrangement the households effluent is applied to the trenches in an even manner, where it is then absorbed through the base of the trench. The effluent percolate continues to travel downwards until it meets a poor permeable barrier, where it then spreads out laterally until it is all absorbed vertically in conjunction with rainfall percolate. The salient trench irrigation dimensions that are capable of meeting these basic trench requirements are determined as follows:

$Area_T = q / EFFLUENT_T \ m^2$ Equation 6

$S_T = DLR \times W_T / EFFLUENT_T \ m$ Equation 7

$L_T = Area_T / S_T \ m$ Equation 8

Where:

Area_T = Total effluent dispersal area of any Trench system. m^2
q = Peak week, average daily discharge. L/d.p
= **150 L/d**
EFFLUENT_T = Total average effluent application rate for the Trench system. mm/d
= **1.6 mm/d**
DLR = Effluent design loading rate over the trench basal area. mm/d, or $L/m^2.d$
= **5.4 mm/d refer Table 2**.
W_T = Width of trench; excavation bucket widths of 0.2, 0.3, 0.45 and 0.6m is typical.
= **0.50 m** for the permeable soils in this area, refer Table 2.
L_T = Total trench length. m
S_T = Trench centreline spacing. m

Therefore:
Area_T = 150/1.6
= 94 m^2 irrigation area with centrally located trench.
S_T = 5.4 x 0.5 / 1.6
= 1.7 m
L_T = 94/1.7
= 55 m

Lateral Distribution and Driving Head Analysis

Check that the Trench Separation Distance and Width are Suitable for this Soil Profile

Within the assessed constraints of this site, check that the recommended trench separation distance S_T is achievable with the available driving head (H) constraints of the site. The Darcy equation that defines the relationship between soil permeability, effluent application and trench separation distance is derived as follows:

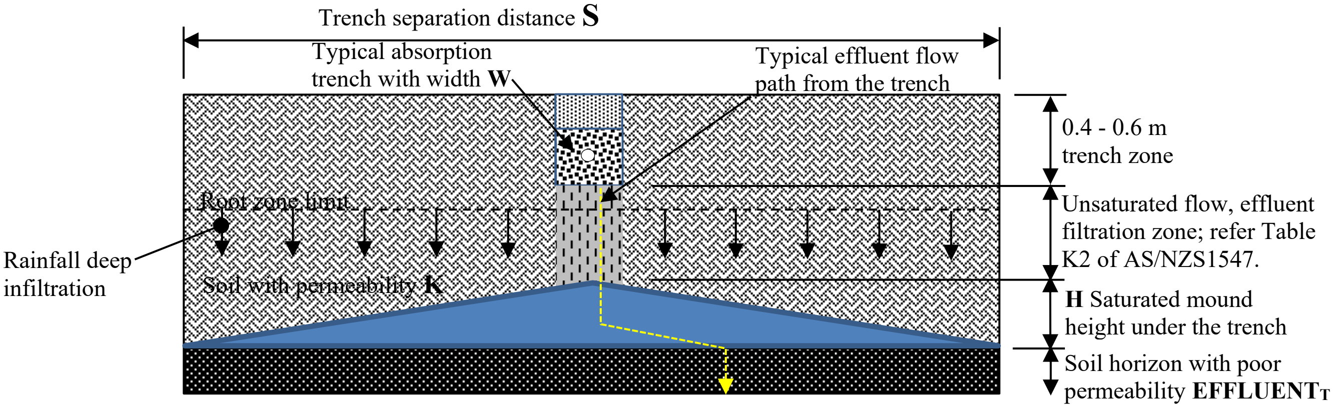
Q = KIA - Darcey's equation $m^3/m^2.d$
= DLR x W / S - per m run of trench
= $K \times H \times (H + S/2) / (FS \times (H^2 + (S/2)^2)^{0.5})$ - per m run of trench
= EFFLUNT_T

These equations can be solved by equating them together to equal 0, which in turn is solved by an iterative approach to determine the trench driving head "H" in an Excel spread sheet:

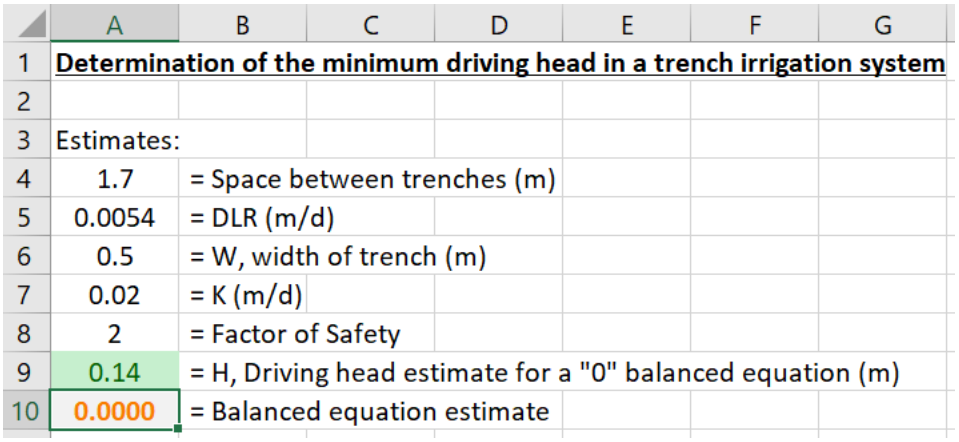
$$0 = (DLR \times W / S) - (K \times H \times (H + S/2) / (FS \times (H^2 + (S/2)^2)^{0.5}) \quad \text{Equation 9}$$

Where the parameters are described and depicted below:
S = Trench centreline spacing as determined from water balance assessment above (m)

= **1.7** m
W = Width of trench (m)
= **0.5** (m)
I = hydraulic gradient $\Delta h/\Delta L$
A = Area through which the effluent passes (m)
Q = The applied effluent quantity per metre run of trench. (m^3/d)
H = The available saturated mound Height under the trench that drives the effluent percolate to the margins, in between the trenches.
= **0.50** (m) as determined from field assessment, refer Table 2. (m)
= To be determined ≤ required in an iterative trial and error approach using an Excel spreadsheet, refer below.
FS = Factor of Safety that allows for variation in soil permeability over the dispersal area, non-isotropic properties of the soil, and due to the fact that non pure water is being considered in this analysis.
= **2.0**
K = Assumed worst case soil permeability between trenches. (m/d)
= **0.02** m/d, NB: In the authors opinion, trenches are not suitable in soils with a permeability that is < 0.02 m/d.
DLR = The trench Design Loading Rate. (m/d)
= **0.0054** m/d



Therefore:



	A	B
1	**Determination of the minimum driving head in a trench irrigation system**	
2		
3	Estimates:	
4	1.7	= Space between trenches (m)
5	0.0054	= DLR (m/d)
6	0.5	= W, width of trench (m)
7	0.02	= K (m/d)
8	2	= Factor of Safety
9	0.14	= H, Driving head estimate for a "0" balanced equation (m)
10	0.0000	= Balanced equation estimate

NB: The estimated driving head H = 0.14 m, as H = 0.50 m is required as derived above in Table 2, therefore adopt W_T = 0.5 m, S_T = 1.7 m, DLR = 5.3 mm/d, and L_T = 55 m.

The above calculation shows that only a 0.14 m of hydraulic head is required to drive the effluent from the trenches to the centre space between the trenches, while being absorbed into a poor permeable underlying soil layer at an overall application rate of 1.6 mm/d. This trench irrigation information is summarised in Table 1 at the start of the report.

6.4 Dispersal Area Soil Amendments

- Proposed Trench Irrigation System
  - It is recommended that 50 mm of washed sand prefilter be installed in the base of the trench system, refer Figure 11.
  - Gypsum be applied at a rate of 1 Kg/m^2 to the base of the initial 600 mm wide base of the trench system.

7.0 Configuration of the Land Application Area

The full potential effluent dispersal areas for this property are shown in Figures 1, 5 & 6 for the for proposed trench systems. It is recommended that the effluent dispersal systems be located approximately where and how they are shown in these Figures. The final shape of treatment system of the effluent dispersal area does not matter, provided the minimum required irrigation area and setback distances are achieved, refer Table 1, and Figures 5, 6 for more details. There is enough area on the property for a reserve area if a trench system is used.

8.0 Buffer Distances

The recommended key buffer distances for this development in accordance with Table 5 of EPA's, 2016, *Septic Tanks Code of Practice* are as follows:

1. There is a minimum effluent disposal system offset distance of 3.0 m to gas and water pipes and salient features such as upslope buildings and boundary lines.

2. There is a minimum effluent disposal system offset distance of 6.0m to salient features such as drains, downslope boundaries and buildings.

3. There is to be a minimum waterway offset of **60 m** to any effluent management system.

4. **All the above buffer distances can be halved where secondary treatment systems are used.**

5. All sewer pipes built under roads and tracks are to have at least 600mm of soil cover or are to be placed in a suitable protective metal or concrete pipe sleeves.

6. All in-ground treatment systems, including septic tanks, pump wells, or other treatment systems are to have a minimum setback distance of 2m to buildings and effluent dispersal systems.

7. It is recommended that the minimum offset distance from a trench system to a tree trunk be at least 0.75 x Tree Height, or 1.0 x Clump of Tree Heights, otherwise a drip irrigation system is to be used. The minimum offset distance for a drip line (with anti-root intrusion properties) to a small tree trunk is 2.1 m.

9.0 Monitoring, Operation and Maintenance

In each case it is assumed that the onsite sewage system is managed in such a way that the system has a long life, e.g., at least 30 years. However, this does not mean that the onsite sewage system can be left to look after itself without maintenance.

It is recommended that water conservation appliances be installed throughout the staff amenities facility. These include 3-4 star flush toilets, 3 star shower roses, 4-5 star dishwashers (or no dishwashers), and 4-5 star washing machines. It is also recommended **that the onsite wastewater management system be monitored and operated in the manner outlined in the attached operation and maintenance sheet.**

10.0 Stormwater Management

It is recommended that an upslope spoon and 200 mm deep spoon drain be installed to divert all upslope surface runoff away from the trench effluent dispersal area, refer Figures 5, 6.

11.0 Conclusion and Recommendations:

The best chance of maintaining all effluent onsite requires that **a primary treatment system be installed.** The limiting site conditions are such that the following onsite wastewater management system is recommended:

1. **A suitable EPA approved 3000 L septic tank primary treatment system can be installed at this site, refer Figures 1, 5-10 and Section 6.2 for more details. This tanks must be desludged at least every 14 years.**
2. **All primary treated effluent is to be disposed of by an arched trench irrigation system that is shown in Figures 1, 5, 6, 11 & 12.**
3. **Due to the flat nature of the site, the depth of the septic tank should be set in the ground at least 200 mm higher than normal to allow for gravity flow of effluent to the effluent distribution system. Alternatively the base of the trench system should be set at least 200 mm lower than normal to allow for gravity flow to the trench systems.**
4. **The effluent dispersal area should be fenced off from vehicular traffic.**
5. **The effluent dispersal area should be located at least 20 away from any proposed water bore.**

6. **Minimum buffer distances described in Section 8.0 from the effluent dispersal area to salient features are to be adhered to.**
7. **The soils in the proposed trench effluent dispersal area are to be amended, refer Section 6.4 for details.**
8. **It is recommended that water conservation appliances and practices are to installed and maintained, refer Section 9 for more details.**
9. **All other services (e.g. Gas, water telecom, underground power, etc. are to be determined by others before beginning system construction.**
10. **It is recommended that the onsite sewage system be maintained like that discussed in Section 9 and the attached management information file.**
11. **All other details regarding the construction and management of the proposed effluent management system are to be compliant with the recommendations of this report and regulatory authority directives where appropriate.**

12.0 Limitations

Unless otherwise employed, the author is not responsible for choosing the treatment system subtype, the final location of the disposal system, the quality of construction, or determining the location of any essential services (e.g. power, gas, telephone, water lines etc.) that may be built over in the course of this proposals construction. Where construction details are not mentioned in this report, it is recommended that information in relevant Septic Tank Codes of Practice or Certificates of Conformity be adopted. While every care has been taken to design the proposed effluent dispersal system for the observed site and soil conditions in this report, Ark Angel P/L is not responsible for the performance of the proposed systems due to conditions beyond that observed in this report. It is recommended that appropriately qualified plumbers or drainers carry out all construction work. It is suggested that the owners (or their representative) of this property pass their landscape design, that includes an onsite sewage system, and building envelope proposal documentation onto the Council for approval.

Scott McFarlane

Scott McFarlane Ba. Eng. (Civil)
Earth's Manager

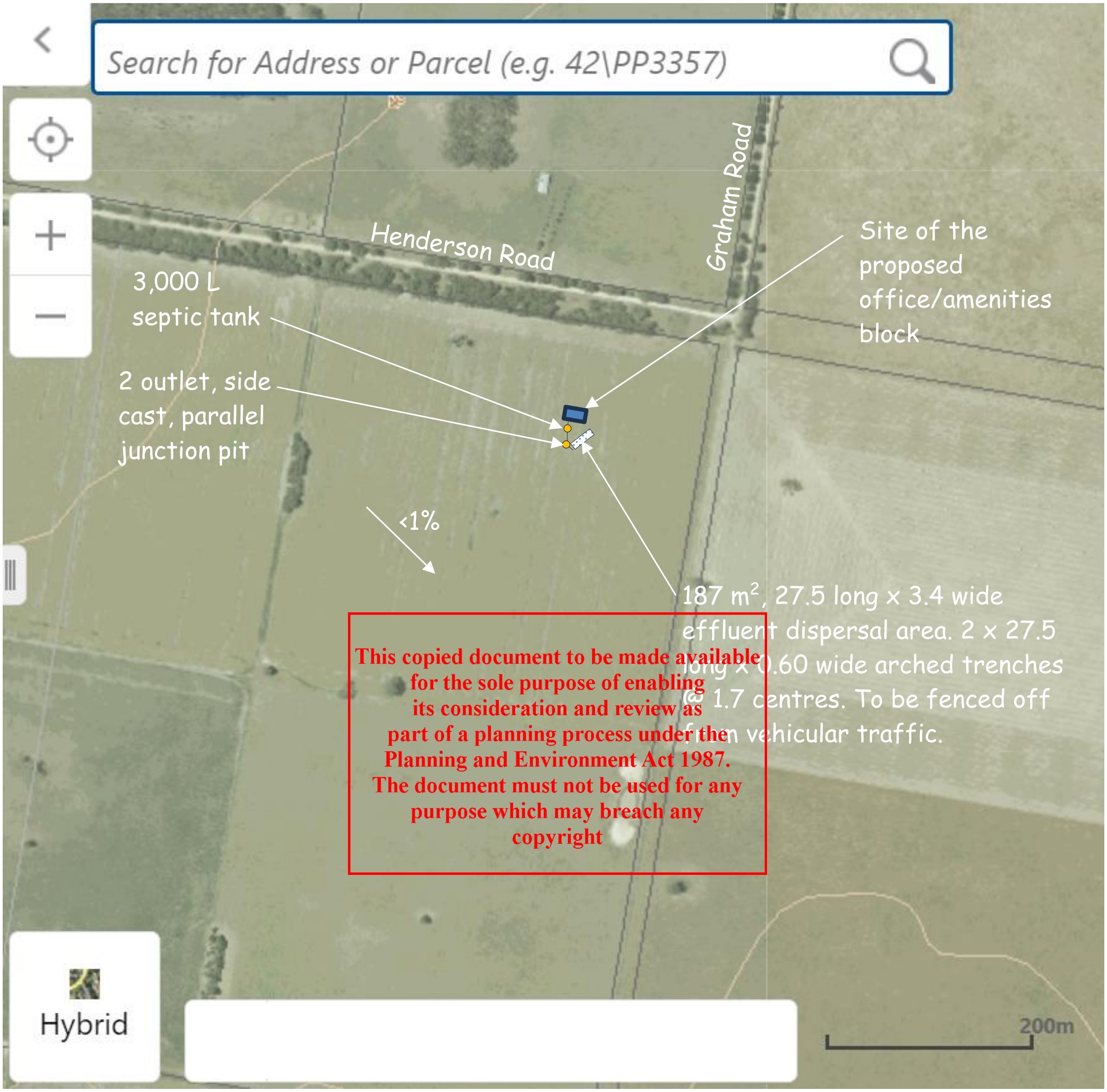


FIGURE 5:
PLAN OF TYPICAL TRENCH EFFLUENT MANAGEMENT AREA
NB:

1. Metre dimensions unless stated otherwise.
2. In all cases the minimum sized envelope and required setback distances, as discussed in Section 2, Table 1; and offset distances discussed in Section 8.0 must be achieved.
3. To be read in conjunction with attached report.

NOTE:
At this site there are only 2 x 27.5 m long trenches

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Slope %	A (m)	B (m)
1	13.8	46.0
2	9.4	23.0
3	7.1	15.3
4	5.7	11.5
5	4.8	9.2
6	4.1	7.7
7	3.6	6.6
8	3.2	5.8
9	2.9	5.1
10	2.6	4.6
11	2.4	4.2
12	2.2	3.8
13	2.1	3.5
14	2.0	3.3
15	2.0	3.1
16	2.0	2.9
17	2.0	2.7
18	2.0	2.6
19	2.0	2.4
20	2.0	2.3
21	2.0	2.2
22	2.0	2.1
≥ 23	2.0	2.0

ADVERTISED PLAN

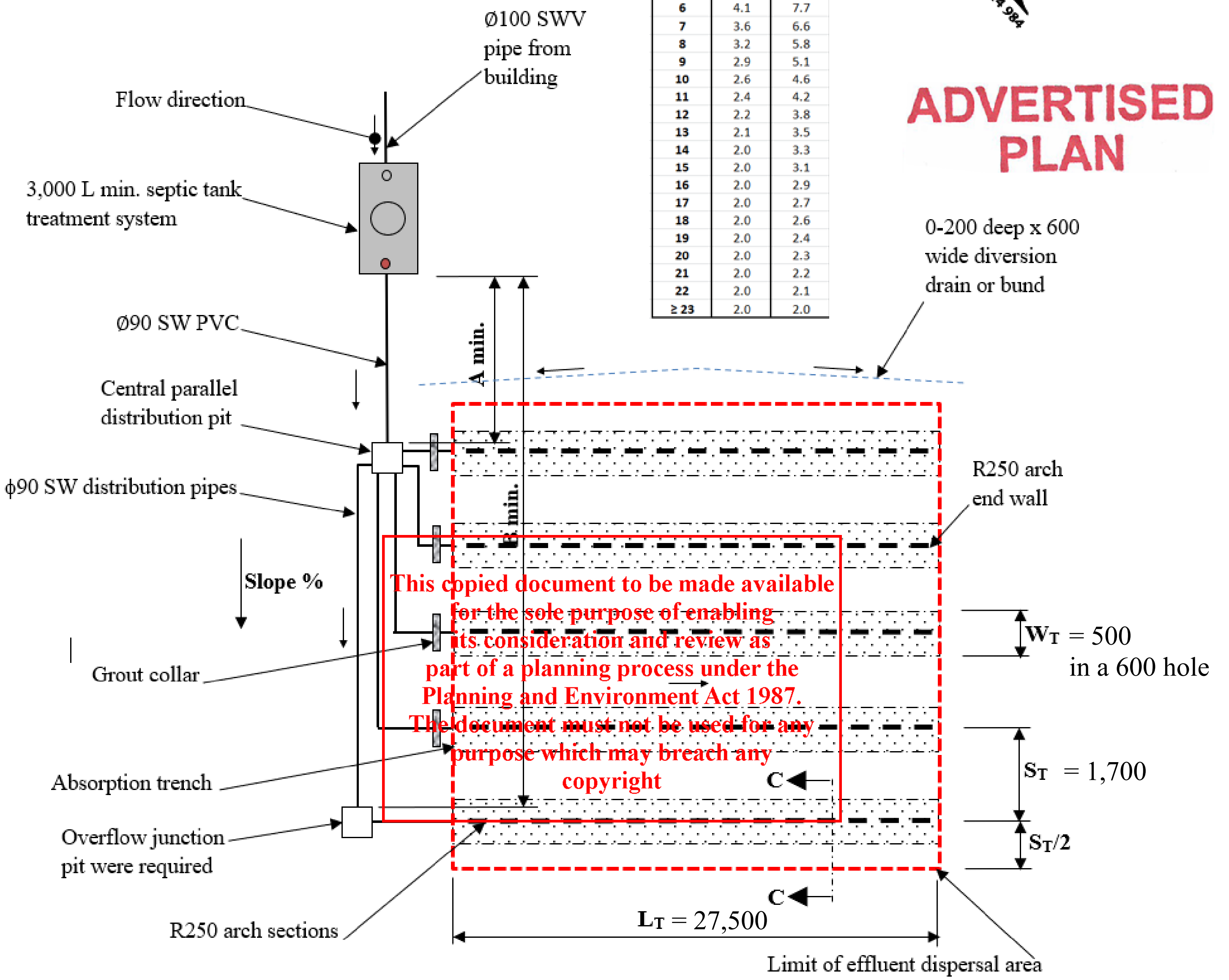

FIGURE 6
TYPICAL PLAN OF GRAVITY FLOW TRENCH SYSTEM WITH PARALLEL DISTRIBUTION

NB:

1. Not to scale
2. Unless stated otherwise, millimetre dimensions used.
3. Dimensions A & B are minimum requirements for shallow 400 mm deep absorption trenches. For those flatter down sloping sites where the junction pit offset dimensions A & B cannot be complied with, the deep absorption trench and junction pit option should be considered.
4. If the space is available, then the overflow junction pit can be done away with by adopting the "B" dimension from the septic tank outlet to the central parallel distribution pit, i.e. the distribution pit is also an overflow pit.
5. If for any reason the septic tank cannot be constructed to the minimum depth, or the effluent dispersal area is upslope of the septic tank, then the effluent must be pumped to the absorption trenches.
6. On slopes ≤ 2%, the diversion drain is to be constructed around the entire effluent dispersal area.
7. All minor hills and hollows within the effluent dispersal area are to be cut or filled over.
8. To be read in conjunction with the attached conditions of installation.

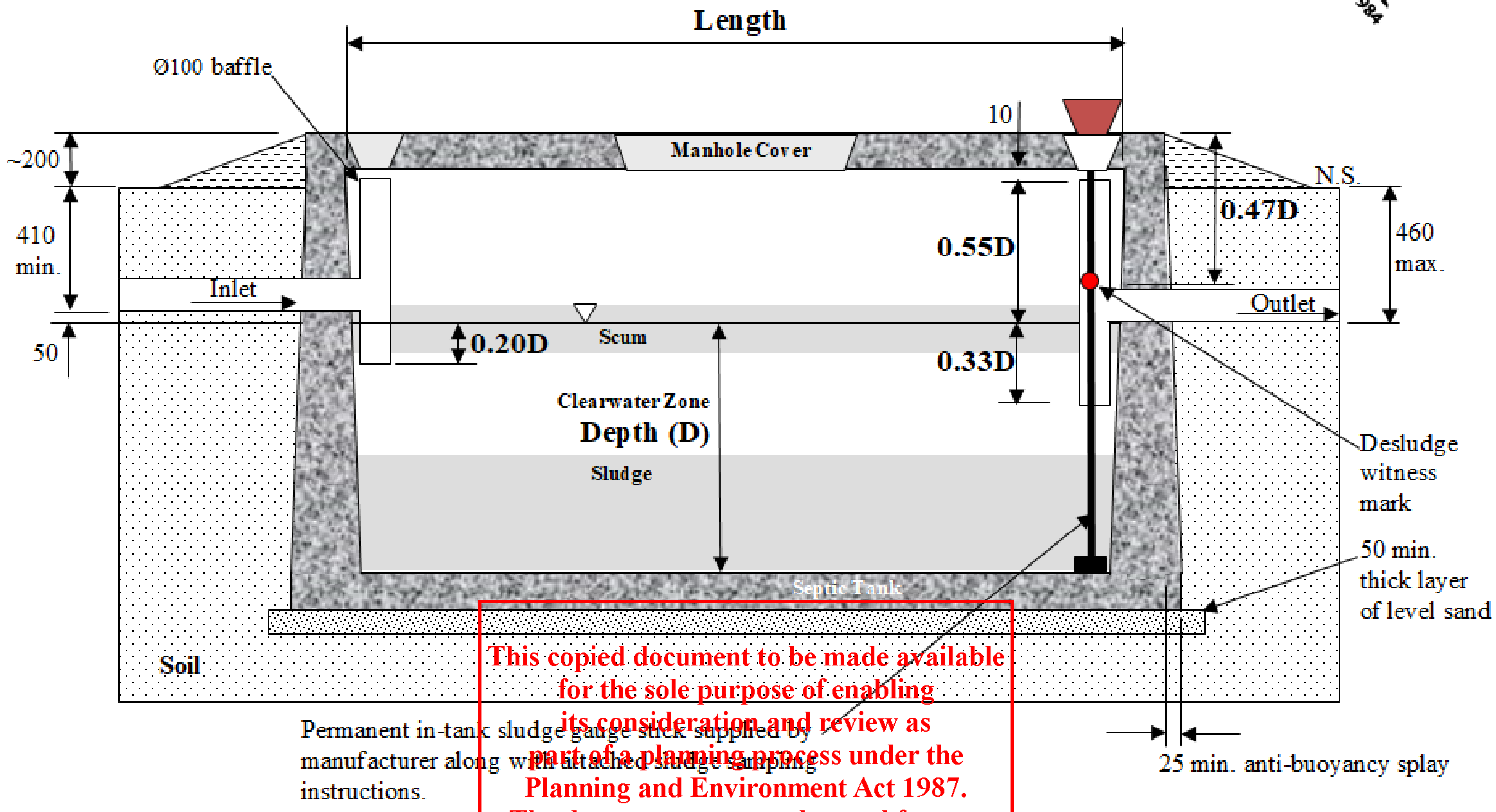

FIGURE 7
TYPICAL LONGITUDINAL CROSS-SECTION OF A SEPTIC TANK
- Minimum Recommended Requirements

NB:

1. Not to scale.
2. Millimetre dimensions used unless stated otherwise.
3. For practical minimum treatment requirements, the septic tank's **Length = 3 x Width**
4. If the top level of the septic tank is below the finished surface level, all manholes and inspection openings (IO) are to be constructed so that they are at least level with the surface.
5. To be read in conjunction with the attached conditions of installation.

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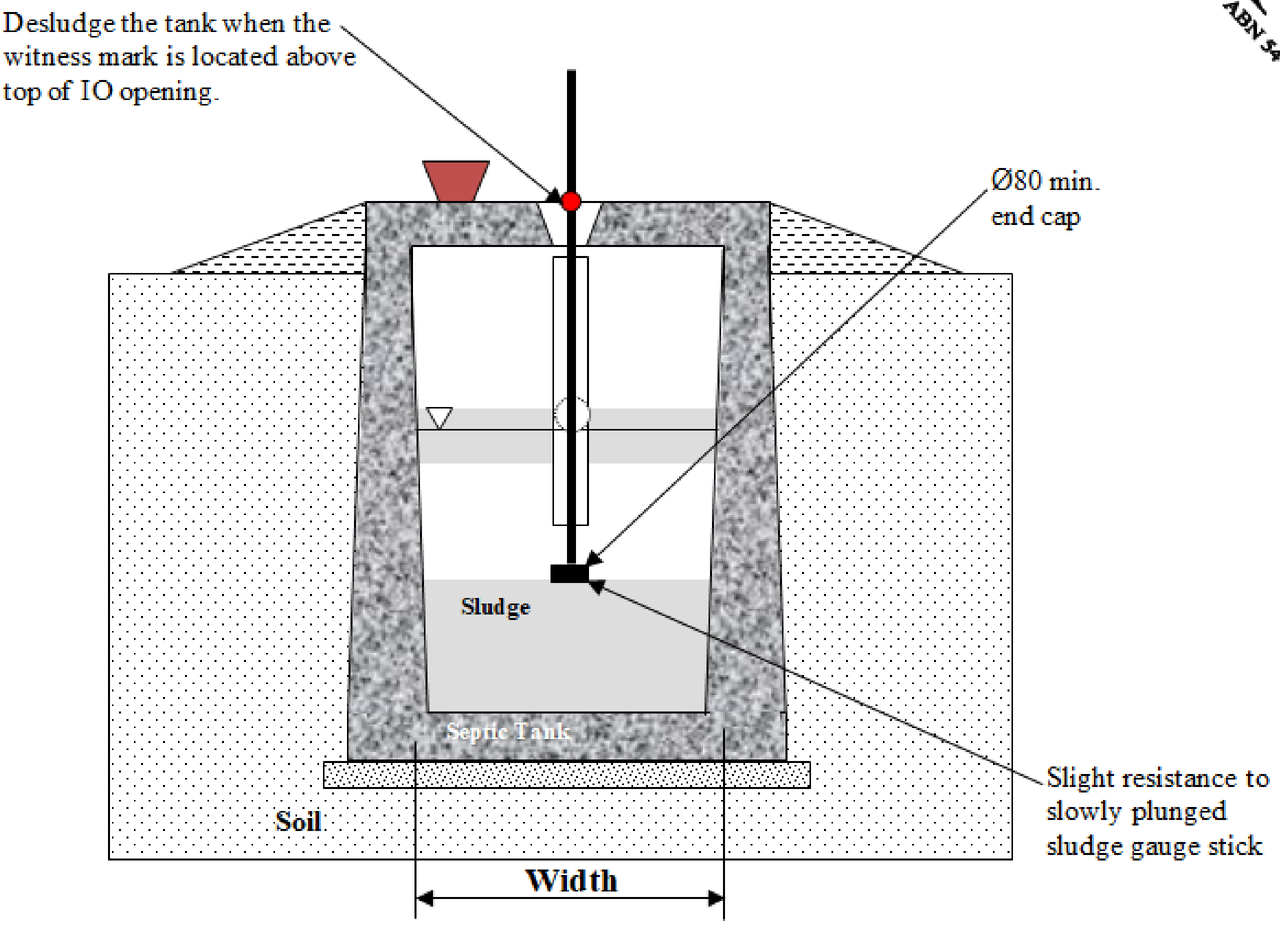

FIGURE 8

TYPICAL CROSS-SECTION OF A SEPTIC TANK

- Minimum Recommended Requirements

NB:

1. Not to scale.
2. Millimetre dimensions used unless stated otherwise.
3. To be read in conjunction with the attached conditions of installation.

ADVERTISED PLAN

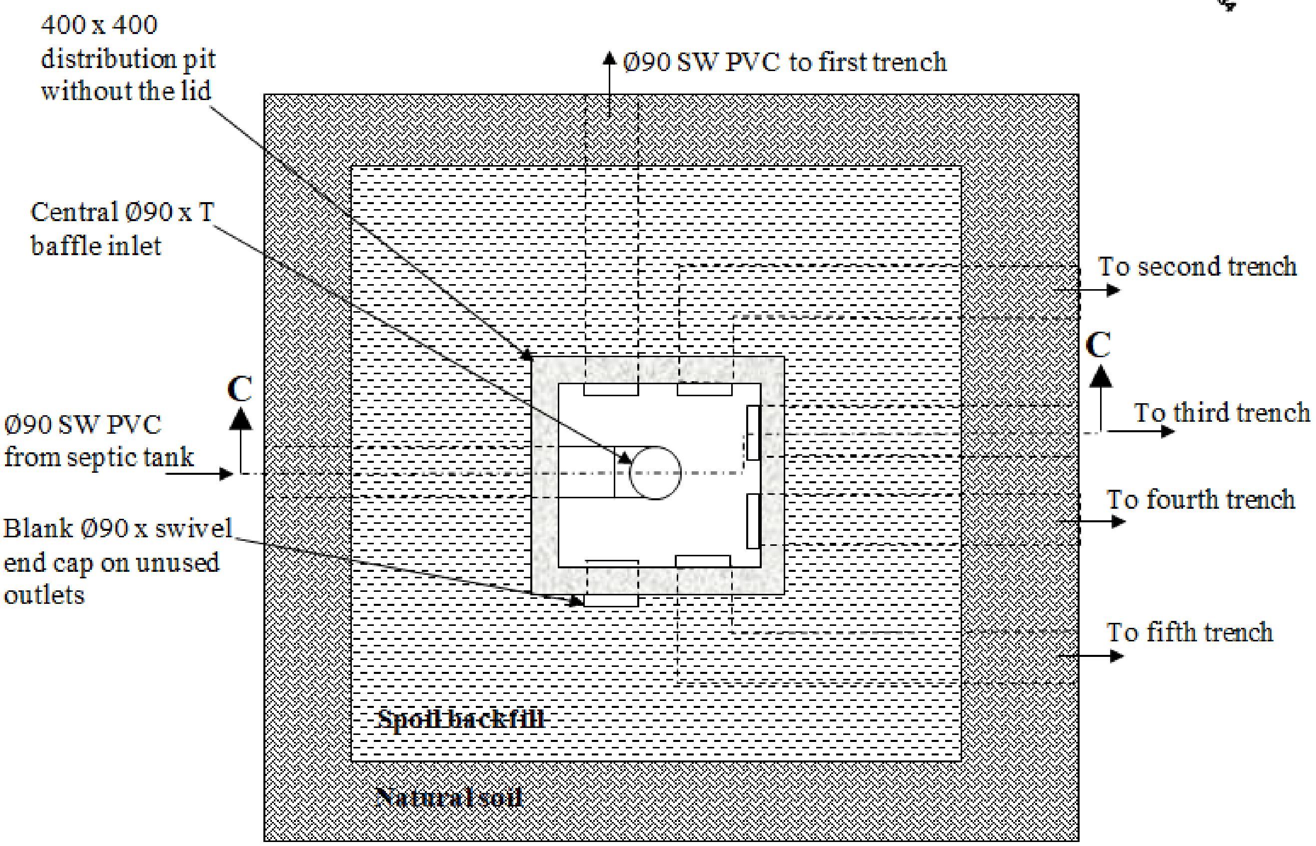

FIGURE 9

TYPICAL PLAN OF GRAVITY FLOW PARRALLEL DISTRIBUTION PIT

NB:

1. Not to scale
2. Unless stated otherwise, millimetre dimensions used.
3. To be read in conjunction with the attached conditions of installation.

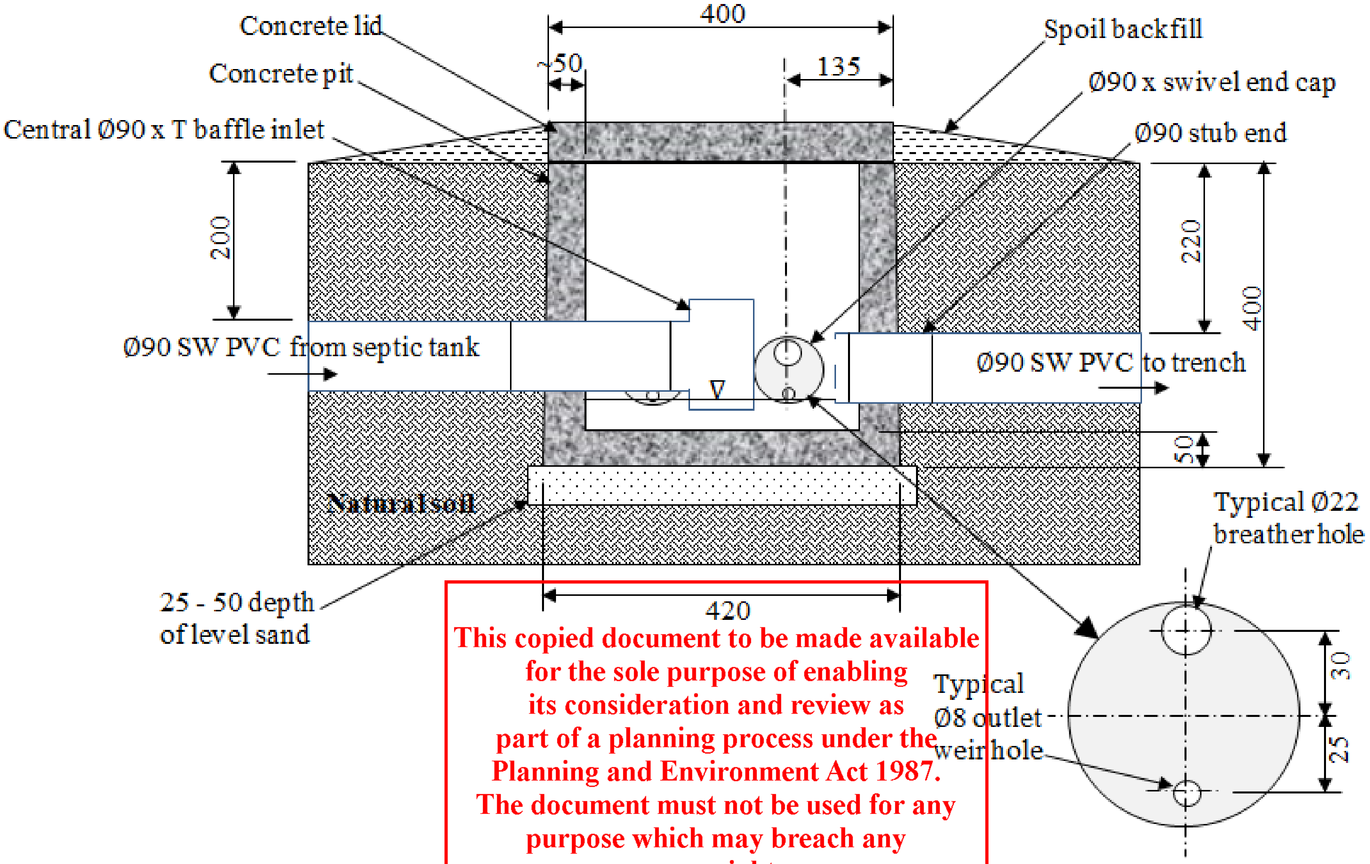

FIGURE 10

TYPICAL SECTION CC OF A SHALLOW GRAVITY FLOW PARRALLEL DISTRIBUTION PIT

NB:

1. Not to scale
2. Unless stated otherwise, millimetre dimensions used.
3. Where possible, shallow distribution pits are to be used in preference to deep distribution pits. Shallow distribution pits are typically used where there are no spatial constraints, on slopes ≥ 2%, where pumping is not required, and where the minimum mean average temperature for any month is > 4°C. Otherwise 600 mm deep junction pits are typically used.
4. The junction pits are supplied with ø90 SW PVC pipe stub ends cast or glued into the sidewalls of the pit.
5. All swivel end caps with outlet weirs are to be set level with the aid of a common water level in the junction pit, on the day of installation.
6. **The simple alternate method of constructing this junction pit system from scratch is to use the following Everhard plastic rainwater management products: a 300 Pit (Part # 84825), a 300 Poly Cover (Part # 84953), a Ø110 mm hole saw, adhesive, and a screwed pit boss for each inlet and outlet pipe (Part # 80080). Also refer to Everhard's pit boss installation sheet. Use a Ø90 mm hole saw to remove the constraining lip in each pit boss. If need be, use a small abrasive grinder to remove excess plastic material to allow the Ø90 SW pipe to be pushed all the way through into the junction pit so that it can be fitted with the Ø90 swivel end cap or baffle inlet pipe arrangement. The pipe is then glued to the pit boss so that a water tight joint is achieved.**
7. To be read in conjunction with the attached conditions of installation.

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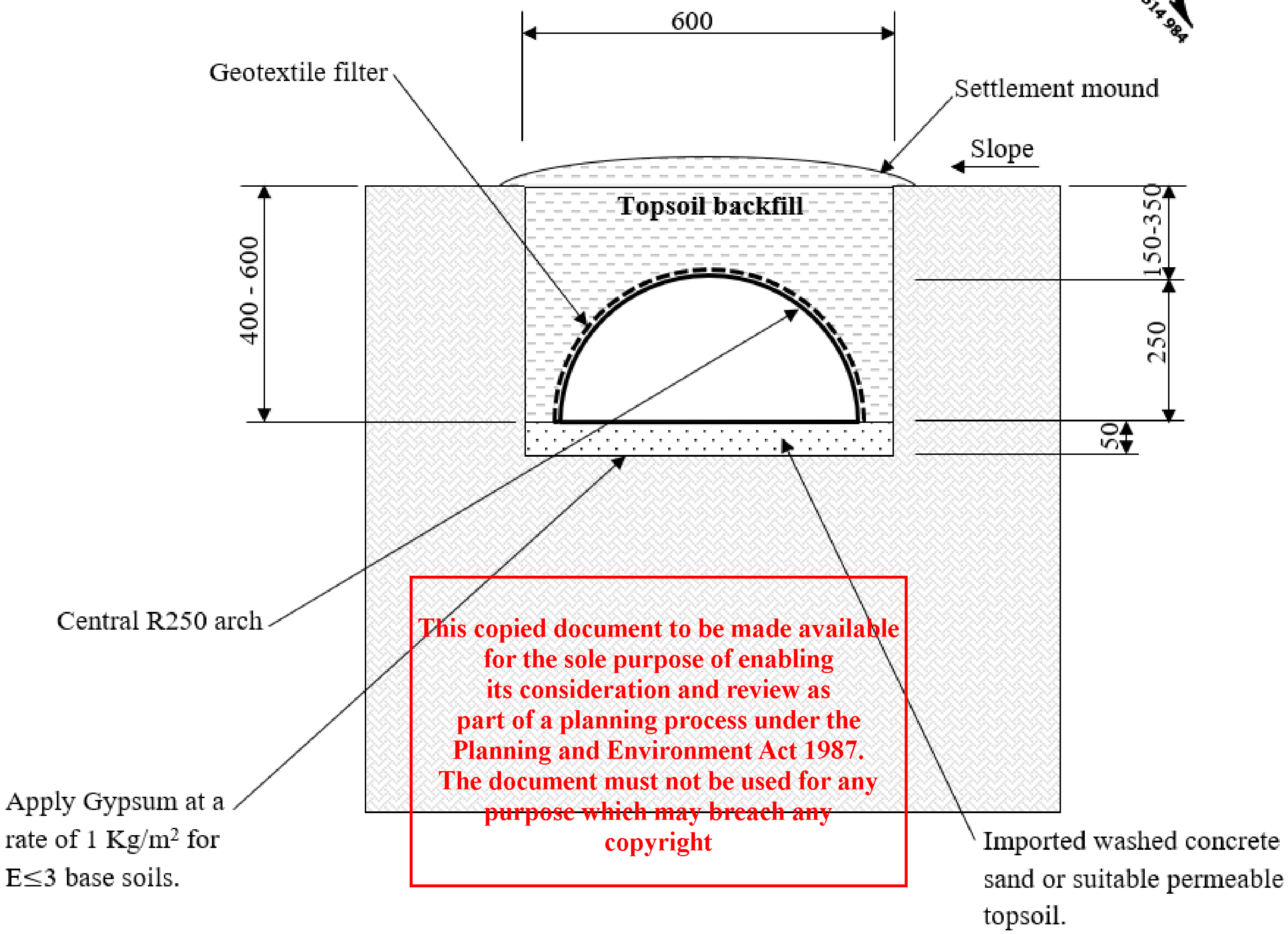


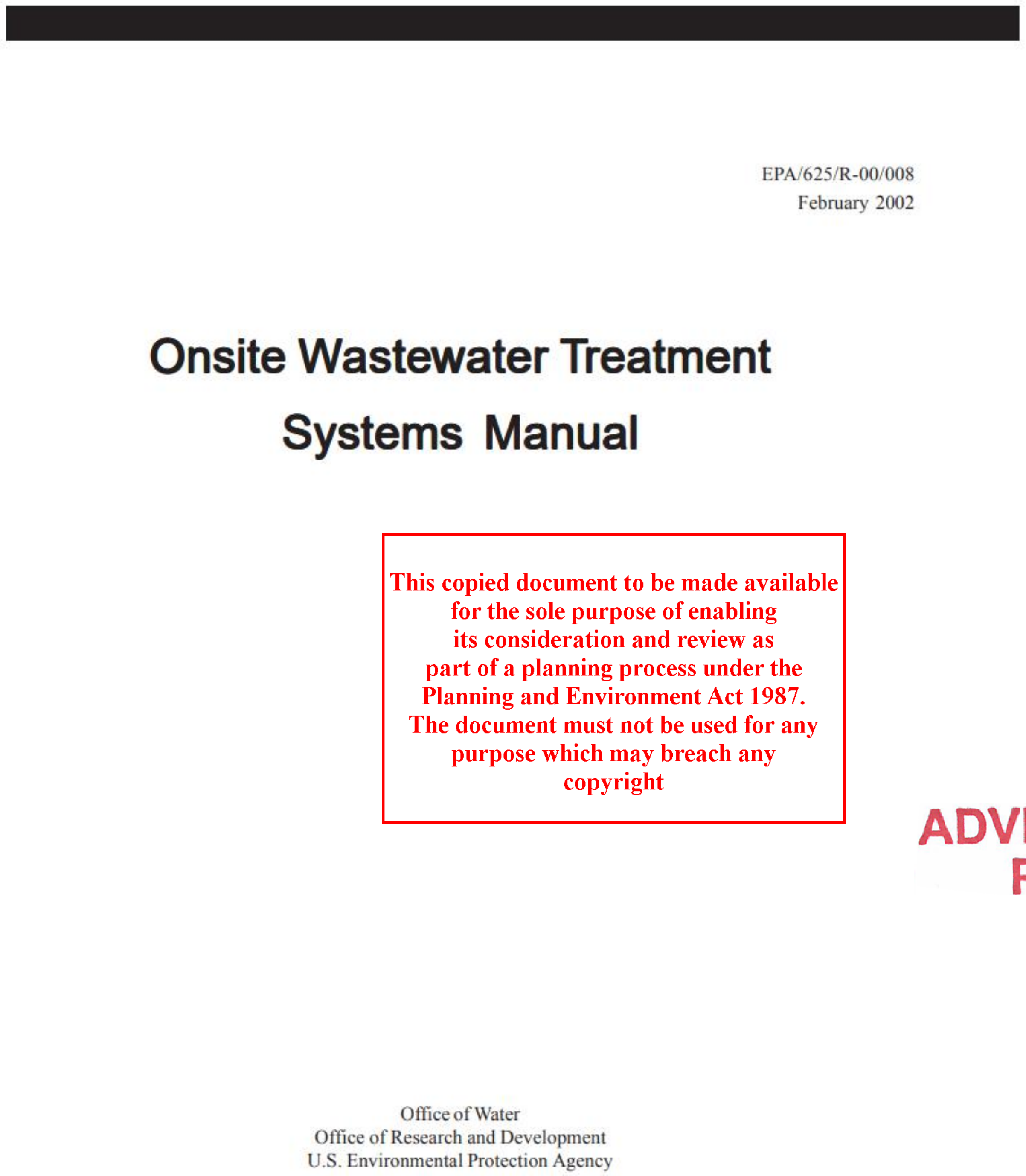
FIGURE 11

TYPICAL CROSS SECTION CC OF AN ARCHED ABSORPTION TRENCH

NB:

1. Not to scale
2. Unless stated otherwise, millimetre dimensions used.
3. The lateral and longitudinal grade of the absorption trench base is level. The trenches are to be set out and checked with a level before backfilling with aggregate.
4. Where possible all trenches are not to be exposed to rainfall during their construction.
5. To be read in conjunction with the attached conditions of installation.

APPENDIX A:
Evidence for Natural Secondary Treatment of Applied Effluent in Trench Systems



EPA/625/R-00/008
February 2002

Onsite Wastewater Treatment Systems Manual

Office of Water
Office of Research and Development
U.S. Environmental Protection Agency

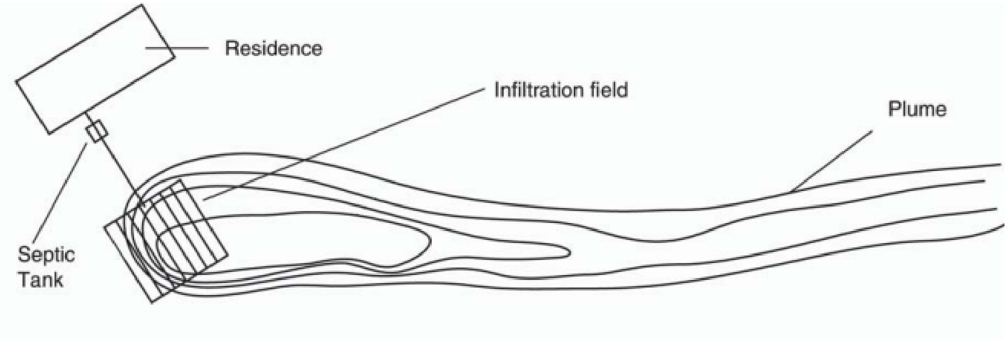


Figure 3-9. An example of effluent plume movement

[illegible] (Florida HRS, 1993). A study that examined SWIS plume movement in a shallow, unconfined sand aquifer found that after 12 years the plume had sharp lateral and vertical boundaries, a length of 426 feet (130 meters), and a uniform width of about 32.8 feet (10 meters) (Robertson, 1991). At another site examined in that study, a SWIS constructed in a similar carbonate-depleted sand aquifer generated a plume with discrete boundaries that began discharging into a river 65.6 feet (20 meters) away after 1.5 years of system operation.

Given the tendency of OWTS effluent plumes to remain relatively intact over long distances (more than 100 meters), dilution models commonly used in the past to calculate nitrate attenuation in the vadose zone are probably unrealistic (Robertson, 1995). State codes that specify 100-foot separation distances between conventional SWIS treatment units and downgradient wells or surface waters should not be expected to always protect these resources from dissolved, highly mobile contaminants such as nitrate (Robertson, 1991). Moreover, published data indicate that viruses that reach groundwater can travel at least 220 feet (67 meters) vertically and 1,338 feet (408 meters) laterally in some porous soils and still remain infective (Gerba, 1995). One study noted that fecal coliform bacteria moved 2 feet (0.6 meter) downward and 50 feet (15 meters) longitudinally 1 hour after being injected into a shallow trench in saturated soil on a 14 percent slope in western Oregon (Cogger, 1995). Contaminant plume movement on the surface of the saturated zone can be rapid, especially under sloping conditions, but it typically slows upon penetration into ground water in the saturated zone. Travel times and distances under unsaturated conditions in more level terrain are likely much less.

Ground water discharge

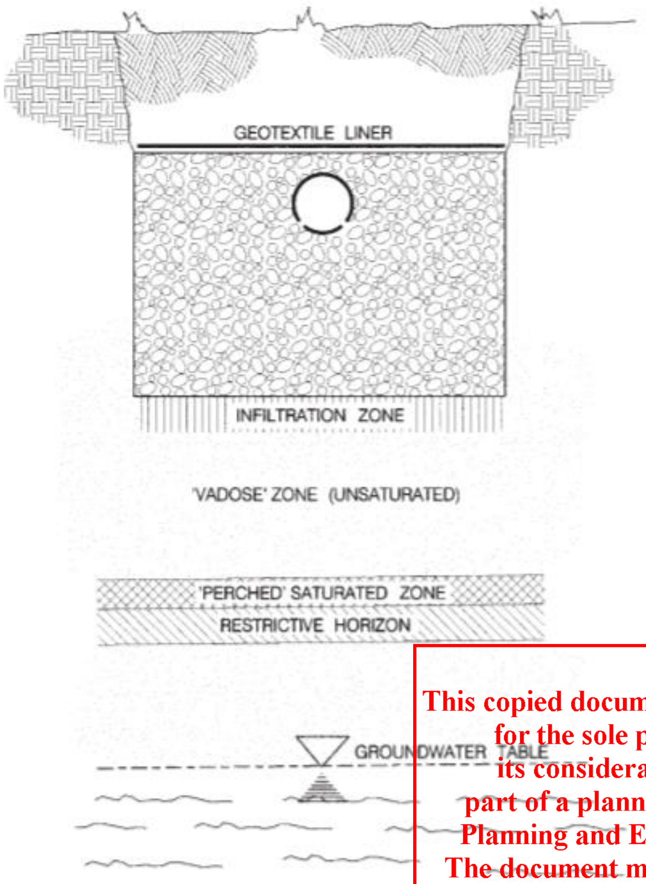
A conventional OWTS (septic tank and SWIS) discharges to ground water and usually relies on the unsaturated or vadose zone for final polishing of the wastewater before it enters the saturated zone. The septic tank provides primary treatment of the wastewater, removing most of the settleable solids, greases, oils, and other floatable matter and anaerobic liquifaction of the retained organic solids. The biomat that forms at the infiltrative surface and within the first few centimeters of unsaturated soil below the infiltrative field provides physical, chemical, and biological treatment of the SWIS effluent as it migrates toward the ground water.

SWIS:
Subsurface
Wastewater
Infiltration
System

Because of the excellent treatment the SWIS provides, it is a critical component of onsite systems that discharge to ground water. Fluid transport from the infiltrative surface typically occurs through three zones, as shown in figure 3-10 (Ayres Associates, 1993a). In addition to the three zones, the figure shows a saturated zone perched above a restrictive horizon, a site feature that often occurs.

Pretreated wastewater enters the SWIS at the surface of the infiltration zone. A biomat forms in this zone, which is usually only a few centimeters thick. Most of the physical, chemical, and biological treatment of the pretreated effluent occurs in this zone and in the vadose zone. Particulate matter in the effluent accumulates on the infiltration surface and within the pores of the soil matrix, providing a

Figure 3-10. Soil treatment zones



Source: Ayres Associates, 1993a.

source of carbon and nutrients to the active biomass. New biomass and its metabolic by-products accumulate in this zone. The accumulated biomass, particulate matter, and metabolic by-products reduce the porosity and the infiltration rate through them. Thus, the infiltration zone is a transitional zone where fluid flow changes from saturated to unsaturated flow. The biomat controls the rate at which the pretreated wastewater moves through the infiltration zone in coarse- to medium-textured soils, but it is less likely to control the flow through fine-textured silt and clay soils because they may be more restrictive to flow than the biomat.

Below the zone of infiltration lies the unsaturated or vadose zone. Here the effluent is under a negative pressure potential (less than atmospheric) resulting from the capillary and adsorptive forces of the soil matrix. Consequently, fluid flow occurs over the surfaces of soil particles and through finer pores of the soil while larger pores usually remain air-filled. This is the most critical fluid transport zone because the unsaturated soil allows air to diffuse into the open soil pores to supply oxygen to the microbes that grow on the surface of the soil particles. The negative soil moisture potential forces the wastewater into the finer pores and over the surfaces of the soil particles, increasing retention time, absorption, filtration, and biological treatment of the wastewater.

From the vadose zone, fluid passes through the capillary fringe immediately above the ground water and enters the saturated zone, where flow occurs in response to a positive pressure gradient. Treated wastewater is transported from the site by fluid movement in the saturated zone. Mixing of treated water with ground water is somewhat limited because ground water flow usually is laminar. As a result, treated laminar water can remain as a distinct plume at the ground water interface for some distance from its source (Robertson et al., 1989). The plume might descend into the ground water as it travels from the source because of recharge from precipitation above. Dispersion occurs, but the mobility of solutes in the plume varies with the soil-solute reactivity.

Water quality-based performance requirements for ground water discharging systems are not clearly defined by current codes regulating OWTSs. Primary drinking water standards are typically required at a point of use (e.g., drinking water well) but are addressed in the codes only by requirements that the infiltration system be located a specified horizontal distance from the wellhead and vertical distance from the seasonal high water table. Nitrate-nitrogen is the common drinking water pollutant of concern that is routinely found in ground water below conventional SWISs. Regions with karst terrain or sandy soils are at particular risk for rapid movement of bacteria, viruses, nitrate-nitrogen, and other pollutants to ground water. In addition, geological conditions that support "gaining streams" (streams fed by ground water during low-flow conditions) might result in OWTS nutrient or pathogen impacts on surface waters if siting or design criteria fail to consider these conditions.

Surface water discharge

Direct discharges to surface waters require a permit issued under the National Pollutant Discharge Elimination System (NPDES) of the Clean Water

Act. The NPDES permitting process, which is administered by all but a few states, defines discharge performance requirements in the form of numerical criteria for specific pollutants and narrative criteria for parameters like color and odor. The treated effluent should meet water quality criteria before it is discharged. Criteria-based standards may include limits for BOD_5, TSS, fecal coliforms, ammonia, nutrients, metals, and other pollutants, including chlorine, which is often used to disinfect treated effluent prior to discharge. The limits specified vary based on the designated use of the water resource (e.g., swimming, aquatic habitat, recreation, potable water supply), state water classification schemes (Class I, II, III, etc.), water quality criteria associated with designated uses, or the sensitivity of aquatic ecosystems—especially lakes and coastal areas—to eutrophication. Surface water discharges are often discouraged for individual onsite treatment systems, however, because of the difficulty in achieving regulatory oversight and surveillance of many small, privately operated discharges.

Atmospheric discharge

Discharges to the atmosphere also may occur through evaporation and transpiration by plants. Evapotranspiration can release significant volumes of water into the atmosphere, but except for areas where annual evaporation exceeds precipitation (e.g., the American Southwest), evapotranspiration cannot be solely relied on for year-round discharge. However, evapotranspiration during the growing season can significantly reduce the hydraulic loading to soil infiltration systems.

Contaminant attenuation

Performance standards for ground water discharge systems are usually applied to the treated effluent/ground water mixture at some specified point away from the treatment system (see chapter 5). This approach is significantly different from the effluent limitation approach used with surface water discharges because of the inclusion of the soil column as part of the treatment system. However, monitoring ground water quality as a performance measure is not as easily accomplished. The fate and transport of wastewater pollutants through soil should be accounted for in the design of the overall treatment system.

Contaminant attenuation (removal or inactivation through treatment processes) begins in the septic tank and continues through the distribution piping of the SWIS or other treatment unit components, the infiltrative surface biomat, the soils of the vadose zone, and the saturated zone. Raw wastewater composition was discussed in section 3.4 and summarized in table 3-7. Jantrania (1994) found that chemical, physical, and biological processes in the anaerobic environment of the septic tank produce effluents with TSS concentrations of 40 to 350 mg/L, oil and grease levels of 50 to 150 mg/L, and total coliform counts of 10^6 to 10^8 per 100 milliliters. Although biofilms develop on exposed surfaces as the effluent passes through piping to and within the SWIS, no significant level of treatment is provided by these growths. The next treatment site is the infiltrative zone, which contains the biomat. Filtration, microstraining, and aerobic biological decomposition processes in the biomat and infiltration zone remove more than 90 percent of the BOD and suspended solids and 99 percent of the bacteria (University of Wisconsin, 1978).

As the treated effluent passes through the biomat and into the vadose and saturated zones, other treatment processes (e.g., filtration, adsorption, precipitation, chemical reactions) occur. The following section discusses broadly the transport and fate of some of the primary pollutants of concern under the range of conditions found in North America. Table 3-18 summarizes a case study that characterized the septic tank effluent and soil water quality in the first 4 feet of a soil treatment system consisting of fine sand. Results for other soil types might be significantly different. Note that mean nitrate concentrations still exceed the 10 mg/L drinking water standard even after the wastewater has percolated through 4 feet of fine sand under unsaturated conditions.

Biochemical oxygen demand and total suspended solids

Biodegradable organic material creates biochemical oxygen demand (BOD), which can cause low dissolved oxygen concentrations in surface water, create taste and odor problems in well water, and cause leaching of metals from soil and rock into ground water and surface waters. Total suspended solids (TSS) in system effluent can clog the infiltrative surface or soil interstices, while colloidal solids

APPENDIX A:
Evidence for Natural Secondary Treatment of Applied Effluent in Trench Systems

Assessment of the USEPA Literature Above:

It should be noted from the literature above (refer 1st red box, p.3-25), the biofiltermat layer (i.e. pretreatment layer) in the base of the trench is only ~20 mm thick. Consequently a suitable pretreatment layer of say ≥ 50 mm of Loam - Sandy soil would be adequate to incorportae the initial biofiltermat layer. It is also stated in the 4th red box (p. 3-27) that the biofiltermat layer is capable of removing 90% of the wastewater's BOD_5 and suspended solids from the applied primary treated effluent. In effect, the practice of installing a permeable prefilter helps treat the applied effluent to higher quality, making it better suited to being absorbed by a poorer underlying permeable soil like clay, refer 2nd-3rd red boxes, i.e. the bio-filter-mat layer controls the trench absorption rate rather that the smaller pored underlying claysoils.

The next question to ask is: what does this mean in terms of the residual BOD_5 in treated percolate? In order to estimate this, an assessment of the BOD_5 in primary treated effluent must be made. For Australian sewage, the estimated level of BOD_5 in raw sewage is shown in Table 1 below:

TABLE 1:
Typical household water and BOD_5, daily sewage production rates

ITEM	Reticulated water supply (L/p.d)	Rainwater Tank Supply (L/p.d)	Untreated Average $UBOD_5$ Quality (g/p.d)
Toilet Blackwater	20	20	23
Bathroom	90	60	9
Laundry	30	30	9
Kitchen	10	10	9
Subtotal Greywater	100	100	27
Black & Greywater TOTAL	150	120	50

Notes:

3. Household water consumption figures taken from Table H1 of Appendix H of AS/NZS1547 2012, UWRAA 1989 and current day WELS water consumption star rating system.
4. Typical household BOD_5 figures adapted from Table 1.3 of Mara D., 2004, *Domestic Wastewater Treatment in Developing Countries.*

Primary Treatment

The level of BOD_5 in primary treated sewage is half that of untreated raw sewage, refer to Figure 5-35 of Crites & Tchobanoglous, (1998).

Therefore:

The BOD_5 concentration of primary treated sewage:
$= 0.5 \times UBOD_5 \times 1000/q$ mg/L ...Equation 2
$= 0.5 \times 50 \times 1{,}000 / 150$
$= 167$ mg/L

A 90% reduction in the bio-filter-mat filtered percolate, reduces the BOD concentration to:
$= 0.9 \times 167$
$= 16.7$ mg/L

Note that this level of natural treatment is <20 mg/L requirement for secondary treated effluent. Consequently, the use of a permeable Sand type soil as a trench base prefilter improves the quality and longevity of the trench system. This practice therefore allows trench systems the opportunity to be installed in poorer permeable clay soils (including those with dispersive (i.e., E≤3) or high shrink swell clays) at a higher effluent application rate than that recommended by AS/NZS1547; where the effluent is applied directly to the surface of the clay soil. However, the overall deep infiltration also has to be considered, hence the higher effluent application rates do not always apply.

In order to achieve a good and better environmentally friendly aerobic outcome in the base of the trench's bio-filter-mat zone, it is recommended that all effluent be applied evenly to the base of the trench system. This can be achieved by the use of a gravity flow parallel distribution pit system, or a pumped system.

In most cases, cost and competitive conscious plumbers will not install then unless directed otherwise by environmental health officers as they are slightly more expensive to install than traditional serial distribution systems. However, the proposed parallel distribution systems will enable the trench systems to easily achieve secondary treatment at a far cheaper cost than purpose built secondary treatment systems.

References:

Crites R., Tchobanoglous G. 1998: Small and Decentralized Wastewater Management Systems, McGraw Hill.

Mara D., (2004): *Domestic wastewater treatment in developing countries*, Earthscan.

United States EPA, (USEPA), 2002: Onsite Wastewater Treatment Systems, Manual EPA/625/R-00/008.

Urban Water Research Association of Australia, (UWRAA), 1989: Water Use Efficiency of Domestic Appliances, Report No. WSAA7, Melbourne and Metropolitan Board of Works

APPENDIX B:

Demonstrating the requirement for a better design effluent irrigation rate for drip and trench irrigation systems

One of the standards recommended for assessing the effluent irrigation rates for drip irrigation systems in Victoria is the water balance recommended in the MAV, 2014, *Victorian Land Capability Assessment Framework*. This assessment method unfortunately has inherent errors. The main errors include:

1. The assumption that the deep infiltration rate is equal to the drip irrigation rates DIR value for the soil category in which system is located. In fact, the derivation of DIR has more to do with the absorption of applied secondary treated effluent around the thin drip irrigation tube, and little to do with the soil's deep infiltration rate at all. Hence the use of this parameter as the deep infiltration rate is totally bogus.
2. The proposed water balance equation lacks the soil storage component Δs, as described in Appendix Q of AS/NZS1547. Consequently, the water balance equation is only accurate during the wintertime when the soil profile is near full field capacity all the time. Hence there is little to no influence on the deep infiltration rate. Therefore, 12 monthly assessments as recommended by the MAV model are a total waste of time.
3. In the Gippsland region, the naturally high rainfall and low evapotranspiration rate during the wintertime is such that the recommended deep infiltration rate is achieved and often exceeded by the natural rainfall alone, without any additional input by the applied effluent. Hence the MAV water balance analysis often recommends that no effluent be applied during the winter months of the year, or the size of the effluent dispersal area is absurdly too large.

In practice, many absorption systems are working fine in this region during the winter months of the year. This is mainly due to the fact that the soils in which they are placed are quite permeable and able to absorb the deep infiltrating rainfall and applied effluent at the same time. However, there are still many soil types where this does not apply. These problematic poor draining soils (e.g., Vertisols, high shrink swell soils, shallow heavy clays, sodic soils, soils with shallow groundwater, etc.) are best assessed and managed by an experienced and qualified Land Capability Assessor.

Unfortunately, instead of understanding this problem and admitting that there is an error in the assessment method, many Land Capability Assessors still try to use the MAV water balance assessment method by trying to grossly exaggerating the rainfall runoff figures (i.e., the author has seen grossly exaggerated rainfall runoff rates of ≥60% instead of a more realistic run-off rate of 25-35% being used) in order to achieve an acceptable effluent application rate result.

Fortunately, recent changes to EPA Act, has made it easier for local Environmental Health Officers to adopt changes for managing onsite sewage systems in their local area; which I strongly encourage in this regard. The alternative to using the MAV water balance assessment is to use the design irrigation rate (DIR) method recommended in Section M6.2 of AS/NZS1547. However, this method also has to be used with caution as there are some soil types where this method does not apply. However, this method can also be used for the design of trenches; in which case an equivalent design outcome (i.e., deep infiltration rate), with the same level of failure risk as that of drip irrigation systems.

APPENDIX D

- **Soil Permeability Test Records in accordance with Appendix G of AS/NZS15475:2012**

PREAMBLE

ITEM	**DESCRIPTION**
Tester	Scott McFarlane
Site Location	Near borehole A, refer Figure 3
Vegetation quality	Good
Test water quality	Salted to match typical domestic sewage of ~0.8 dS/m.
Pre-Soaking Time	~1.0 hour by which time the absorption rate had settled by observation, i.e. notice that the difference in ΔH values is less than 10%, and then tested to confirm this.
Antecedent Soil Moisture	Moist and suitable for testing.
Depth to Impermeable Layer (S)	>0.5m
Additional Remarks	Soil conditions are suitable for testing.

Measured Permeability with an Auger Hole Radius = 5.75 cm, Tube Radius = 2.70 cm

Hole No.	Depth (cm)	H (cm)	H1 (cm)	T1 (Min:Sec)	H2 (cm)	T2 (Min:Sec)	ΔT (Min:Sec)	ΔH (cm)	K_{SAT} (m/d)
1	65.0	27.5	324.7	0.00	322.3	5.00	5.00	2.4	
1	**65.0**	**27.5**	**322.3**	**5.00**	**320.0**	**10.00**	**5.00**	**2.3**	**0.07**

NB:

1. **K_{SAT} is determined from a spread sheet analysis using Equation G1 in AS/NZS1547:2012.**
2. **Adopt the more conservative soil permeability K_{SAT} for test hole 1, i.e. K = 0.07 m/d.**