Whitehead & Associates
Environmental Consultants

PJE MANAGEMENT PTY LTD
(via email)

Ref: Letter_2641_002

11 January 2022

On-site Wastewater Management Report for proposed rural subdivision at 256 Lennoxton Road, Vacy NSW

Whitehead and Associates Environmental Consultants Pty Ltd (“W&A”) were engaged by PJE MANAGEMENT PTY LTD (the “Client”) to prepare an On-site Wastewater Management Report (WMR) for a proposed 24-lot rural residential subdivision at 256 Lennoxton Road, Vacy NSW (the “Site”).

The Site, identified as Lot 8 DP739338 and Lot 94 DP788016, are zoned E3 (Environmental Management) and R5 (Large Lot Residential) under the Dungog LEP (2014). The total area of the Site is approximately 60.97ha. An existing dwelling is located within the centre of the Site (proposed Lot 13), which is to remain. The proposed subdivision will create 24 new lots ranging in size from 1.07ha to 20.64ha, with access to the created lots via a newly constructed road running east-west through the centre of the Site.

The Site is largely cleared, comprised mostly of open pasture with scattered vegetation throughout the paddocks and along riparian zones. A number of surface water features are observable on the property, including multiple intermittent drainage channels and dams. Rodney’s Gully is located in the west of the Site, draining into Paterson River that bounds the Site to the north. The property is marginally bushfire prone (Vegetation Category 1) in the southwest, and is flood impacted in the areas adjacent Rodney’s Gully and the Paterson River.

Dungog Shire Council (“DSC” or “Council”) have adopted a comprehensive Development Assessment Framework (DAF, 2015) for on-site sewage management (OSSM), which sets out required standards for investigation, acceptable solutions and minimum standards for sewage management in unsewered areas of the Dungog Local Government Area (LGA).

The DSC DAF (2015) identifies each allotment within the LGA as having Low, Medium, High or Very High hazard for OSSM. Council have confirmed the Site to be a “High Hazard” allotment for an unsewered subdivision. As such, Council requires that a comprehensive WMR is to be provided with the Development Application (DA), in accordance with the minimum standards for a “High Hazard” property as set out in Section 2.3 of the DSC DAF (2015) in order to assess the capability for sustainable OSSM at the Site.

A critical component in the assessment of subdivisions in “High Hazard” areas is that created lots must demonstrate that ≥4,000m^2 of ‘useable land’ is available for effluent management. Given the proposed lot sizes, and the identified surface water features, this requirement cannot be achieved within five (5) of the created lots. Therefore, a standard Cumulative Impact Assessment (CIA) is provided as part of the application to support the design and demonstrate compliance with environment and health protection (E&HP) targets. This approach is supported by the DSC DAF (2015) for 'High Hazard' allotments. The following table presents the minimum standards required to comply with the DSC DAF (2015) for the subdivision of a "High Hazard" allotment.

DSC Minimum Standards for WMR (Medium Hazard – Subdivision)		
Report Element	**Minimum Standard**	**Completed**
Introduction and Background	• Name, contact details and qualifications of author(s); • Site location and owner; • Allotment size (m² or ha); • Proposed/ existing water supply; • Number of new building entitlements; • Availability of sewer;	✓ ✓ ✓ ✓ ✓ ✓
Site and Soil Assessment	• Broad overview of locality and landscape characteristics; • Details of the date of assessment in addition to statements confirming the methods used to complete the assessment; • Site assessment that considers all parameters listed in Table 28 of the DAF in accordance with *AS/NZS 1547:2012*; • Detailed review of available published soils information for the Site; • Soil assessment that considers all parameters listed in Table 6-1 of the DAF in accordance with *AS/NZS 1547:2012*; • Where multiple soil facets are present the site plan should show the approximate boundary between facets; • Detailed explanation of the implications of observed site and soil features for system design and performance; • Assessment of the existing condition of the receiving environment and sensitivity to on-site system impacts;	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
System Selection and Design	• Summarise potential treatment and land application systems considered including advantages and limitations; • Brief statement justifying selection of potential treatment and land application systems; • Sizing of land application systems using the most limiting of soil water and annual nutrient balances (see *Technical Manual*);	✓ ✓ ✓
Site Plan	• Survey plan; • Location of soil test pits; • Proposed allotment boundaries, dimensions and area; • Location of existing buildings, swimming pools, paths, groundwater bores, dams and waterways; • Location of exclusion zones (e.g. setback distances and unsuitable site and soil conditions) and useable land; • Location of EMAs and an indicative LAA and reserves (where applicable) to clearly demonstrate viability; • Two (2) metre elevation contours; • Location of existing and proposed drainage pipework (centreline);	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
Cumulative Impacts (where required)	• Summary of approach taken and confirmation of compliance with the Minimum Standards documented in Section 2.7; • Results demonstrating compliance with local water quality objectives and adequate management of health risk as defined and demonstrated in Section 10.1.1 of the Technical Manual; • Brief discussion of long-term risks to health and environment and recommended management measures to address impacts;	✓ ✓ ✓
Appendices	• Soil bore logs for all test pits; • Raw laboratory results for soil analysis; and • All design calculations and assumptions including screenshots of cumulative impact spreadsheets/models.	✓ ✓ ✓

1 Author Statement

This WMR was prepared by Connor Morton. Connor is an Environmental Consultant with W&A, holding a B. EnvSc. and Mgmt. from the University of Newcastle (2019). Connor has completed the On-site Wastewater Management professional short-course with the Centre for Environmental Training (CET) and has completed multiple WMR's across the Cessnock, Central Coast and MidCoast regions.

2 Introduction

This assessment has been undertaken in reference to the assessment and design principles of:

- *AS/NZS 1547:2012* On-site Domestic Wastewater Management (Standards Australia/ Standards New Zealand, 2012);
- Environment & Health Protection Guidelines: On-site Sewage Management for Single Households (Department of Local Government, 1998);
- DSC (2015) On-site Sewage Development Assessment Framework (DAF), dated 4th June 2015; and
- DSC (2015) On-site Sewage Management Technical Manual, dated 4th June 2015.

The following table presents information on the property investigated.

Feature	Description
Site Address	256 Lennoxton Road, Vacy NSW
Lots	Lot 8 in DP739338 and Lot 94 in DP788016
Local Government Area	Dungog Shire Council
Land Zoning	E3 (Environmental Management); and R5 (Large Lot Residential)
Site Size (ha)	60.97 (combined)
Climate Zone	(1) Southern Rainfall Zone
Sewer Connection Available (within 75m)	No
Potable Water Supply	On-site (tank) water supply

3 Site and Soil Assessment

The Site investigation was undertaken by Connor Morton, Charyssa Lawrence and Nicholas Banbrook of W&A on the 29th of November 2021. The following tables present the results of our site and soil investigation for the property.

A description of the Site physical constraints and the degree of limitation they pose to OSSM is provided in the table below. Reference is made to the rating scale in NSW DLG (1998) and, where appropriate, the DSC DAF (2015).

SITE ASSESSMENT			
Parameter	**Data / Observation**	**Reference**	**Classification/ Outcome**
Climate	Temperate climate with median annual rainfall of 943.2mm; minimum of 30.1mm (August), maximum of 109.2 (March).	Paterson Tocal AWS (BoM Station 061250)	Minor limitation
	Mean annual evaporation of 1,570.6mm. Potential evaporation exceeds rainfall for all months of the year.		
Sizing			
Hydraulic modelling attached:	Yes	per DSC DAF (2015) procedures	
Nutrient modelling attached:	Yes		
Land application area (LAA) sizing attached:	Yes		
Wet weather storage requirement:	N/A	N/A	
Flooding			
Land application areas above 1:20 ARI flood level:	Yes	Paterson River Flood Study Vacy to Hinton (2017) indicates the Site is marginally flood	Moderate limitation
Land application areas above 1:100 ARI flood level:	No		
Electrical components above 1:100 ARI flood level:	Yes	Achievable at construction stage	
Exposure and Aspect	The Site is primarily cleared with scattered trees located in paddocks and along permanent waterways (riparian areas). Aspect is primarily south-west to north-west; high exposure to sun and prevailing wind.	Minor limitation	
Slope	~1-10% slope within the available effluent management area (EMA).	Minor limitation	
Landform	The landform of the Site is generally mixed between convex convergent and convex divergent slope configurations, dependent upon location in relation to drainage features.	Minor to Moderate limitation	
Run-on and Seepage	No run-on or up-slope seepage observed in the vicinity of the preferred land application areas (LAAs) for each lot at the time of the Site inspection. Stormwater from upslope areas and roof run-off must be directed away from the LAAs (refer Section 9.3).	Minor limitation	
Erosion Potential	No erosion evident within EMA, with good vegetation cover observed.	Minor limitation	

<table>
<tr><th colspan="5">SITE ASSESSMENT</th></tr>
<tr><th>Parameter</th><th colspan="2">Data / Observation</th><th>Reference</th><th>Classification/ Outcome</th></tr>
<tr><td>Site Drainage</td><td colspan="2">Moderately well drained.
Some signs of surface saturation (ponding) due to extended rainfall in two (2) week period prior to the Site visit.</td><td colspan="2">Minor to Moderate limitation</td></tr>
<tr><td>Fill</td><td colspan="2">None observed or apparent.</td><td colspan="2">Minor limitation</td></tr>
<tr><td>Groundwater</td><td colspan="2">No shallow groundwater encountered during soil survey.
NSW Office of Water groundwater bore registry indicates no registered ‘domestic’ bores are located within 250m of the Site.</td><td colspan="2">Minor limitation</td></tr>
<tr><td>Flood Potential</td><td colspan="2">The Site is bound to the north by the Paterson River.
1% AEP flood level: 21.8mAHD
5% AEP flood level: 20.5mAHD
Both the 1% AEP and 5% AEP flood levels are associated with the overbank areas of the Paterson River and Rodney’s Gully (refer Figure 3, Appendix A).</td><td>Paterson River Flood Study Vacy to Hinton (2017): Paterson River Upstream of Vacy</td><td>Moderate limitation</td></tr>
<tr><td colspan="3">Applicable Buffers</td><td colspan="2" rowspan="2">Not achievable in Lots 1, 2, 11, and 12
Reduced setbacks proposed, with mitigation (refer Section 8)</td></tr>
<tr><td colspan="2">Permanent rivers and creeks (100m):</td><td>Yes</td></tr>
<tr><td colspan="2">Intermittent creeks, drainages and dams (40m):</td><td>Yes</td><td colspan="2">Not achievable in Lot 6.
Reduced setbacks proposed, with mitigation (refer Section 8)</td></tr>
<tr><td colspan="2">Domestic groundwater bore (250m):</td><td>N/A</td><td colspan="2"></td></tr>
<tr><td colspan="2">Lot boundaries (3m if EMA downslope-6m if EMA upslope):</td><td>Yes</td><td colspan="2">Achievable</td></tr>
<tr><td colspan="2">Buildings, driveways and swimming pools (3m if EMA downslope-6m if EMA upslope):</td><td>Yes</td><td colspan="2">Achievable</td></tr>
<tr><td colspan="2">Limiting horizon (groundwater, bedrock etc.) (0.6m):</td><td>Yes</td><td colspan="2">Achievable</td></tr>
<tr><td colspan="2">Other sensitive receptors:</td><td>N/A</td><td colspan="2"></td></tr>
<tr><td>Surface Rock/ Outcrop</td><td colspan="2">Localised area of surface rock observed during the Site investigations (refer Figure 1, Appendix A).</td><td colspan="2">Minor limitation</td></tr>
<tr><td>Useable Land</td><td colspan="2">Available ‘useable land’ calculated for each created lot (refer Figure 1, Appendix A):</td><td colspan="2">Major limitation</td></tr>
</table>

SITE ASSESSMENT				
Parameter	**Data / Observation**		**Reference**	**Classification/ Outcome**
	Lot 1 ~379m^2;	Lot 13 ~10,174m^2;		
	Lot 2 ~3,310m^2;	Lot 14 ~5,769m^2;		
	Lot 3 ~6,419m^2;	Lot 15 ~11,065m^2;		
	Lot 4 ~14,154m^2;	Lot 16 ~12,845m^2;		
	Lot 5 ~9,105m^2;	Lot 17 ~12,243m^2;		
	Lot 6 ~2,401m^2;	Lot 18 ~9,180m^2;		
	Lot 7 ~11,768m^2;	Lot 19 ~5,561m^2;		
	Lot 8 ~13,759m^2;	Lot 20 ~11,585m^2;		
	Lot 9 ~10,216m^2;	Lot 21 ~15,085m^2;		
	Lot 10 ~5,829m^2;	Lot 22 ~10,864m^2;		
	Lot 11 ~2,503m^2;	Lot 23 ~5,345m^2; and		
	Lot 12 ~0m$^{2;}$	Lot 24 ~10,028m^2.		

Concluding Remarks

Landform, site drainage and flood potential pose a moderate constraint to OSSM at the Site; however, identified limitations can be mitigated or avoided through conservative LAA location, design and installation.

The proposed subdivision cannot satisfy the DSC DAF (2015) ‘deemed to comply’ minimum standard of >4,000m^2 of ‘useable’ land on all proposed lots.

Additional modelling and justification is provided in this WMR for a reduction in the available buffer to intermittent drainage lines and dams for proposed Lots 1, 2, 6, 11 and 12 to achieve the required useable land criteria for each lot (refer Section 8).

SOIL ASSESSMENT (physical)			
Parameter	**Data/ Observation**	**Reference**	**Classification/ Outcome**
Soil Depth	450mm – 1,200mm		Minor to Major limitation
Soil Profile	**<u>BHs 1-3, 5-7 and 12:</u>** A: 0 - 200/400mm, moderately structured, sandy clay loam / silty clay loam / clay loam (Cat 4). B: 200/400mm - 450/1,200mm, weakly to moderate structured, sandy clay (Cat 5). **<u>BHs 4 and 9:</u>** A: 0 - 200/300mm, moderately structured, sandy clay / silty clay (Cat 5). B: 200/300mm - 900/1,000mm, weakly to moderately structured, medium clay (Cat 6).		Minor to Major limitation

SOIL ASSESSMENT (physical)

Parameter	**Data/ Observation**	**Reference**	**Classification/ Outcome**
	<u>BH 8:</u> A: 0 - 200mm, moderately structured, sandy clay loam (Cat 4). B$_1$: 200mm - 650mm, moderately structured, sandy clay (Cat 5). B$_2$: 650mm - 800mm, moderately structured, medium clay (Cat 6). **<u>BHs 10 and 11:</u>** A: 0 - 250/500mm, moderately structured, sandy clay loam (Cat 4). B$_1$: 250/500 - 500/700mm, moderately structured, medium clay (Cat 6). B$_2$: 500/700 - 600/1,100mm, weakly to moderately structured, sandy clay (Cat 5). *Locations of boreholes shown in Figure 1, Appendix A.* *Soil borelogs and laboratory results presented as Appendix B.*		
Depth to Water Table	Shallow (episodic) water table not encountered.	Minor limitation	
Coarse Fragments (%)	~2-20% (<2-20mm).	Minor limitation	
Soil Permeability	**<u>BHs 1-3, 5-7 and 12:</u>** <0.06 – 0.12m/day (indicative). **<u>BHs 4 and 8-11:</u>** <0.06mm/day (indicative).	Based on moderately to weakly structured sandy and medium clay (Cat 5 / 6).	Moderate to Major limitation
Modified Emerson Aggregate Class (EAT)	Topsoil: 2(1) – 5 (moderate / high to stable) Subsoil: 1 – 5 (very high to stable)	Minor to Major limitation	
Soil Landscape	The Site is located across four (4) Soil Landscapes (refer Figure 4, Appendix A): **<u>BHs 1, 2 and 8-12</u>** *<u>Vacy ('va'):</u>* Slope gradients are commonly 2–10%, local relief is 10–40m, and elevation is 20–100m. Long concave footslopes (10–1,500m) with slopes of 2–10%, low hills have flat, moderately broad (200m) crests and gentle (5–10%) sideslopes. Soils are typically dark brown to bleached sandy clay loam over yellow sandy to medium clays.		

SOIL ASSESSMENT (physical)

Parameter	Data/ Observation	Reference	Classification/ Outcome
	BHs 5-7 *Brecon (‘br’):* Undulating rises to low hills. Slopes are commonly 2–10%; local relief is up to 30m, elevation to 70m. Crests are broad (>300m), sideslopes are long (>300m) and gently inclined with slopes of 2–10%. Soils are typically brown sandy / silty loam to bleached sandy clay loam over brown light to medium clay. **BH 3** *Paterson River (‘pa’):* Level to gently undulating, narrow (100–500m) alluvial plain. Slope gradients are <3% and local relief is <10m. Small, dissected terrace remnants up to 300 m wide and 10 m high occur. Other landform elements include ox-bows and low (<1m), narrow (<10m) levee banks. Occasional small alluvial fans (to 700m) occur. Soils are typically dark brown commonly loamy sand to sandy loam over brown sand to clayey sand. **BH 4** *Welshmans Creek (‘we’):* Rolling hills. Slopes are 10–25%; local relief is 90–240m, and elevation of 140–400m. Crests are often broad (300–500m) with occasional narrow (<100m) ridges. Slopes are long (>400m), with some short (<50m), steep sideslopes into drainage lines, which often display terracing and occasional narrow (3–5m) benches. Soils are typically brownish black sandy loam to bleached sandy clay loam over brown sandy to medium clay or bright brown sandy clay to light clay. *Soil Landscapes of the Newcastle 1:100,000 Sheet, Matthei (1995) and Soil Landscapes of the Dungog 1:100,000 Sheet, Henderson (2000).*		

Concluding Remarks

Soil conditions are generally good in the available EMA; however, available soil depth, permeability and soil stability limitations are present.

Permeability limitations will be addressed through conservative LAA location, sizing and design.

Stability limitations and available soil depth can be mitigated through soil improvement recommendations (refer Section 9.1).

SOIL ASSESSMENT (chemical)				
Parameter	**Data/ Observation**		**Reference**	**Classification / Outcome**
Vacy Soil Landscape (BHs 1, 2 and 8-12)				
pH	Topsoil: 4.7 – 6.2 Subsoil: 4.6 – 5.8	Very strongly acidic to slightly acidic	Minor to Moderate limitation	
EC (EC$_e$)	Topsoil: 0.25 – 0.88 Subsoil: 0.35 – 2.09	Non-saline to slightly saline	Minor limitation	
ESP (%)	2.7	Non-sodic	From prior laboratory analysis on Vacy Soil Landscape	Minor limitation
CEC (me/100g)	6.1	Low fertility		Moderate limitation
P-sorption (mg/kg)	420	High		Minor limitation
Brecon Soil Landscape (BHs 5-7)				
pH	Topsoil: 4.9 – 5.2 Subsoil: 4.7 – 5.2	Strongly to very strongly acidic	Moderate limitation	
EC (EC$_e$)	Topsoil: 0.24 – 0.39 Subsoil: 0.19 – 2.54	Non-saline to slightly saline	Minor limitation	
ESP (%)	2.7	Non-sodic	From prior laboratory analysis on Brecon Soil Landscape	Minor limitation
CEC (me/100g)	21.0	Moderate fertility		Minor limitation
P-sorption (mg/kg)	186	Low		Moderate limitation
Paterson River Soil Landscape (BH 3)				
pH	Topsoil: 5.6 Subsoil: 5.7 – 5.8	Moderately acidic	Moderate limitation	
EC (EC$_e$)	Topsoil: 0.22 Subsoil: 0.31 – 0.39	Non-saline	Minor limitation	
ESP (%)	2.0	Non-sodic	Soil Landscapes of the Dungog 1:100,000 Sheet, Henderson (2000): 326/2	Minor limitation
CEC (me/100g)	10.9	Low fertility		Moderate limitation
P-sorption (mg/kg)	188	Low		Moderate limitation
Welshmans River Soil Landscape (BH 4)				

<table>
<tr><th colspan="5">SOIL ASSESSMENT (chemical)</th></tr>
<tr><th>Parameter</th><th colspan="2">Data/ Observation</th><th>Reference</th><th>Classification / Outcome</th></tr>
<tr><td>pH</td><td>Topsoil: 5.7
Subsoil: 5.7 – 5.8</td><td>Moderately acidic</td><td colspan="2">Moderate limitation</td></tr>
<tr><td>EC (EC_e)</td><td>Topsoil: 0.31
Subsoil: 1.39 – 2.59</td><td>Non-saline to slightly saline</td><td colspan="2">Minor limitation</td></tr>
<tr><td>ESP (%)</td><td>7.0</td><td>Slightly sodic</td><td rowspan="3">Soil Landscapes of the Newcastle 1:100,000 Sheet,
Matthei (1995): 368/3/72</td><td>Moderate limitation</td></tr>
<tr><td>CEC (me/100g)</td><td>15.6</td><td>Moderate fertility</td><td>Minor limitation</td></tr>
<tr><td>P-sorption (mg/kg)</td><td>230</td><td>Moderate</td><td>Moderate limitation</td></tr>
<tr><td colspan="5">Concluding Remarks
Vacy: The pH and cation exchange capacity (CEC) of the Site soils within the Vacy soil landscape pose a moderate constraint to OSSM.
Brecon: The pH and p-sorption capacity of the Site soils within the Brecon soil landscape pose a moderate constraint to OSSM.
Paterson River: The pH, cation exchange capacity (CEC) and the low P-sorption capacity for the Site soils within the Paterson River soil landscape pose a moderate to major constraint to OSSM.
Welshmans River: The pH, sodicity (ESP %) and low P-sorption capacity of the Site soils within the Welshmans River soil landscape pose a moderate to major constraint to OSSM.
Identified limitations can be mitigated through soil improvement recommendations (refer Section 9.1).
Limiting P-sorption values can be mitigated through conservative LAA selection, sizing and design.
<i>Site soil test results and soil chemistry data is presented in Appendix B.</i>
<i>Explanatory notes on soil chemistry parameters are presented in Appendix E.</i></td></tr>
</table>

4 Wastewater Generation

4.1 Wastewater Quantity

The assumed wastewater hydraulic load associated with the existing 3-bedroom dwelling on proposed Lot 13 is presented in the following table.

	Value	Description
Number of bedrooms	3	Existing 3-bedroom dwelling
Occupancy Rate (persons per bedroom	1.6	Section 6.2 of the DSC DAF (2015)
Design Occupancy (EP)	5	3-bedroom x 1.6EP, rounded
Wastewater generation (L/person/day)	120	Table 30 DSC DAF (2015) for roof water supply

	Value	Description
Design hydraulic load (L/day)	**600** (existing)	(5EP x 120L/person/day)

Once subdivided, each created lot (proposed Lots 1-12 and 14-24) is required to have a separate OSSM system, with on-site (tank) water supply. For assessment, we have assumed a (maximum) 5-bedroom dwelling on each lot. The assumed wastewater hydraulic load associated with proposed lots is presented in the following table.

	Value	Description
Number of bedrooms	5	Assumed 5-bedroom dwelling
Occupancy rate (persons per bedroom)	1.6	Section 6.2 of DSC DAF (2015)
Design Occupancy (EP)	8	
Wastewater generation (L/person/day)	120	Table 6-2 of DSC DAF (2015) for roof (on-site) water supply
Design hydraulic load (L/day)	**960**	(5 bedrooms x 1.6 persons per bedroom x 120 L/person/day)

4.2 Wastewater Quality

The contaminants in wastewater have the potential to create undesirable public health concerns and pollute waterways unless managed appropriately. As a result, domestic wastewater must be treated to remove the majority of pollutants and enable attenuation of the remaining pollutants through soil processes and plant uptake.

Wastewater generated by the existing and future dwellings is expected to be of ‘typical’ domestic nature, with combined wastewater; blackwater (toilet) and greywater (kitchen, laundry and shower) streams. As such, untreated wastewater is expected to have characteristics similar to that described in the table below; which incorporates information taken from the NSW DLG (1998).

Parameter	Loading	Greywater %	Blackwater %
Daily Flow		65	35
Biochemical Oxygen Demand	200-300mg/L	35	65
Suspended Solids	200-300mg/L	40	60
Total Nitrogen	20-100mg/L	20-40	60-80
Total Phosphorus	10-25mg/L	50-70	30-50
Faecal Coliforms	10^3 – 10^{10}cfu/100ml	Medium – High	High

5 Existing OSSM

Wastewater generated from the existing three (3) bedroom dwelling on proposed Lot 13 is currently displaced into an old concrete septic tank; with no identifiable effluent disposal area.

5.1 OSSM System Condition

During the Site investigation the existing septic tank was found to be in poor structural condition, with no manhole cover; multiple surface cracks within the lid; and heavy vegetation growth within the tank. The specifications of the tank could not be identified due to its poor condition.

The area around the tank was overgrown by tall grass, assumed to be a consequence of effluent leakage from the septic tank. No effluent disposal area could be identified during the Site visit.

5.1.1 Recommendation

Due to the existing OSSM system's condition and unknown age, it is recommended that the existing treatment system be decommissioned and replaced with a new OSSM system as in Section 6.

To prevent the redundant septic tank from causing public health, safety or environmental problems, it should be decommissioned and removed in accordance with NSW Health Advisory Note 3.

http://www.health.nsw.gov.au/environment/domesticwastewater/Documents/adnote3.pdf

6 Proposed Wastewater Treatment

Given the identified Site and soil limitations, primarily proximity to surface water features and low permeability subsoils, primary treatment systems (i.e. septic tanks) are not recommended as they significantly limit effluent disposal and reuse options and pose a higher risk to human and environmental health compared to secondary or tertiary treatment systems.

6.1 Recommended Wastewater Treatment System

A minimum effluent quality standard of 'secondary' treatment (with disinfection) is recommended. Secondary treatment is aimed at the removal of dissolved and suspended organic material by a combination of physical and biological methods, usually incorporating both aerobic and anaerobic phases. Secondary treatment presents a significantly lower risk to human health and the environment, when compared to conventional primary (septic tank) systems.

The NSW Ministry of Health (NSW Health) provides accreditation for domestic secondary treatment systems in NSW. The system selected for use on each lot must hold such an accreditation. Appropriate secondary treatment technologies include (but are not limited to) the following:

- Aerated wastewater treatment systems (AWTS);
- Media / textile filter systems; and
- Aerobic sand filters (accredited or site-specific design required).

A detailed list of suitable NSW Health accredited systems can be found at:

http://www.health.nsw.gov.au/environment/domesticwastewater/Pages/default.aspx

Disinfection units are typically installed as a standard component of proprietary secondary treatment systems, or can be installed as an add-on by the system supplier. W&A recommend that a disinfection unit is installed with the chosen system. Domestic systems typically use one or a combination of the following disinfection methods:

- Ultra violet (UV) irradiation; and/or
- Chlorination.

Final system selection will be the responsibility of individual property Owners; however, selection and installation of the system must follow the requirements of Section 6.3 of the DSC DAF (2015) and the recommendations of this WMR.

6.1.1 Treated Effluent Quality

Section 6.3.1 of the DSC DAF (2015) describes the minimum effluent quality standards for secondary treatment systems (reproduced below). The nominated treatment system supplier must warrant the selected system by providing a ‘Producer Statement’ that illustrates the system layout and configuration, describes and quantifies the hydraulic design, as well as provides confirmation that the desired effluent standards can be met.

The expected effluent quality of all NSW Health accredited OSSM systems are provided in the associated accreditation certificates.

Parameter	Loading
Biochemical Oxygen Demand	≤20mg/L (>90% of samples)
Suspended Solids	≤30mg/L (>90% of samples)
Faecal Coliforms	≤30cfu/100mL (>90% of samples)
Total Nitrogen	≤30mg/L
Total Phosphorus	≤10mg/L

The listed phosphorus and nitrogen concentration values are targets and have been adopted for nutrient balance modelling.

6.1.2 System Siting

The exact positioning of the treatment systems will depend on the local gradient and level controls and can be determined in consultation with a licensed plumber and Council prior to obtaining consent for the installation of the systems.

Final plumbing design will be the responsibility of a certified plumber and must adhere to relevant codes and standards as described in Section 6.3.8 of the DSC DAF (2015).

6.1.3 Flood Mitigation

A large portion of land for potential treatment system positioning within proposed Lots 1 and 24 are located under the 1% AEP flood level.

Section 6.3.9 of the DSC DAF (2015) requires the lid of the treatment system to be located at or above the 1% AEP flood level. Alternatively, a pressure sealed lid may be installed and all electrical components, such as the pump controller and blower, must be above the 1% AEP flood level.

6.1.4 System Operation and Management

Successful performance of wastewater treatment systems relies on periodic monitoring and maintenance, which will be the responsibility of individual property Owners. The selected treatment systems should be serviced by a suitably qualified technician at the prescribed intervals.

7 Proposed Effluent Management

This section describes the Site's capability for effluent management and provides design details, including sizing of the required LAAs for each of the proposed lots. As detailed above, secondary treatment is considered the most appropriate wastewater treatment option for the proposed lots.

7.1 Buffers

Buffer distances from LAAs are recommended to minimise risk to public health, maintain public amenity and protect sensitive environments. Buffer (or setback) distances are recommended to provide a form of mitigation against unidentified hazards and reduce potential pathways of human and environmental exposure.

The following 'standard' environmental buffers are required for secondary SSI systems, based on Table 6-8 of the DSC DAF (2015):

- 250m from domestic groundwater bores;
- 100m from permanent watercourses;
- 40m from intermittent watercourses, drainage channels and dams;
- 15m to retaining walls, embankments, escarpments and cuttings; and
- 6m if area up-gradient and 3m if area down-gradient of dwellings and buildings, swimming pools, property boundaries and driveways.

All of the recommended buffer distances are achievable on the Site with the exception of the available setback to Rodney's Gully (proposed Lots 1, 2, 11 and 12; the Paterson River (proposed Lot 12), and the dam and associated drainage channel within proposed Lot 6 (refer Figures 1 and 2, Appendix A).

7.1.1 Buffer Reduction

In order to achieve a minimum 4,000m² of 'useable' land on each of the created lots, the buffer distances to surface water features must be reduced, as below:

- 55m to Rodney's Gully within Lots 1, 2, 11 and 12;
- 70m to the Paterson River within Lot 12; and
- 20m to the dam and 30m to the associated drainage channel within Lot 6.

Therefore, as prescribed in Table 2-13 of the DSC DAF (2015), a standard Cumulative Impact Assessment (CIA) has been undertaken to demonstrate that the reduction in the available setback will not significantly increase OSSM risk and effluent land application can be adequately managed on each lot (refer to Section 8).

7.2 On-site Effluent Management Options

W&A have considered the suitability of various land application systems with regard to the identified Site and soil limitations. In determining the suitability of the various options, we have assessed the Site constraints and the relative environmental and public health risks associated with each.

The table below provides a summary analysis of the effluent land application options considered for subdivision lots, and presents recommendation for the preferred approach to be used in conjunction with the proposed secondary treatment system selected.

Land Application Option	Suitable	Reasoning
Absorption Trenches/ Beds	Possible	Subsoil absorption systems are not supported by *AS/NZS 1547:2012* for a majority of the Site due to available soil depth, slope, and low permeability of subsoils. Secondary subsoil absorption systems, with adequate engineered design, may be feasible within select lots; however, other LAA options are considered more suitable.
ETA Beds	No	Considered unsuitable for Cat 5-6 soils due to (variably) low permeability and the very large bed lengths required (*AS/NZS 1547:2012*).
Mounds	Possible	Considered suitable in areas where slope is <15%; however, option discounted due to substantial cost and availability of suitable alternative.
Surface Irrigation	No	Surface spray irrigation generally not permitted for new OSSM systems (refer Section 6.6.1 DSC DAF, 2015).
Subsurface Irrigation (SSI)	Yes	SSI considered suitable as effluent is able to be applied high in the soil profile, maximising evapotranspiration and vegetation uptake. Treated effluent must be disinfected.

Based on the above analysis, SSI is the preferred option for all proposed lots. A description of the preferred effluent management method and (nominal) sizing are presented below.

7.3 Subsurface Irrigation

SSI is the preferred method of effluent disposal for each of the proposed lots within the subdivision. SSI is suitable within lawn and landscaped areas and applies effluent within the root-zone of plants for optimum irrigation efficiency. It is an ideal option for ensuring even, widespread coverage of the proposed irrigation area. SSI installation does not require any bulk materials or heavy machinery; irrigation lines can be simply installed with a small trench digger or “ditch-witch”.

Proprietary, pressure-compensating subsurface drip (PCSD) irrigation pipe designed for use with treated effluent should be used that will ensure distribution of effluent at uniform, controlled application rates. These products have been specifically designed for use with effluent and allow for the higher BOD5, suspended solids, nutrient and biological loads usually present in effluent compared to potable water. They contain specially designed emitters that reduce the risk of blockage, typically incorporating chemicals that provide protection against root intrusion and biofilm development (e.g. Trifluralin or copper). The dripper lines are coloured lilac to clearly identify that they are irrigating treated effluent.

7.4 LAA Sizing

Preliminary sizing of the required SSI LAAs for proposed lots have been determined using the DSC DAF (2015) procedures and relevant guidelines.

To allow for consistent sizing of LAAs, lots have been assigned to an associated soil classification (as outlined in Section 3) by means of proximity, elevation and soil landscape. The table below outlines borehole allocation, along with the attributed design irrigation rate (DIR) and P-sorption capacity.

BH	**1**	**2**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Proposed Lot	13, 23	1, 24	2-5	6-9	10-12	14-15, 22	16-17	18-19	20-21	13, 23
DIR (mm/day)	3	3	3	3	3	2	2	2	2	3
P-sorption (mg/kg)	420	420	186	186	186	420	420	420	420	420

For simplicity, this approach is further consolidated into three (3) separate groups based on assigned DIR and P-sorption values, as below:

Lots 1, 13, 23, 24 are sized on a DIR of 3mm/day, and a P-sorption value of 420mg/kg;

Lots 2-12 are sized on a DIR of 3mm/day, and a P-sorption value of 186mg/kg; and

Lots 14-22 are sized on a DIR of 2mm/day, and a P-sorption value of 420mg/kg.

7.4.1 Hydraulic Sizing

Section 6.4.3 of the DSC DAF (2015) and Section 9.2 of the DSC DAF Technical Manual (2015) provide a simplified hydraulic sizing equation, with a climate adjustment factor (CAF) for use in sizing LAAs for residential developments on low, medium and high hazard allotments. The Site is situated in the Southern Rainfall Zone (Climate Zone 1), as identified in Figure 8-1 of the DSC DAF Technical Manual (2015). As such, a CAF of 0mm/day has been adopted for use in LAA sizing, as shown:

$$LAA = Q / (DIR - CAF)$$

Where;

LAA = Land Application Area (basal area in m^2);

Q = Design Wastewater Generation Rate (L/day);

DIR = Design Irrigation Rate (mm/day); and

CAF = Climate Adjustment Factor (mm/day).

The total SSI LAA required to assimilate the estimated hydraulic loads from each of the created lots is:

Proposed Lot	LAA Sizing	Reference
Existing Dwelling (Lot 13)	200	(600L/day) / (3mm/day – 0mm/day)
1-12, 23 and 24	320	(960L/day) / (3mm/day – 0mm/day)
14-22	480	(960L/day) / (2mm/day – 0mm/day)

7.4.2 Nutrient Sizing

Nutrient balance modelling was also undertaken to determine the area required to sustainably manage the expected nutrient loads from the proposed lots within the subdivision. Nutrient sizing requirements are outlined in Section 9.3 of the DSC DAF Technical Manual (2015) which generally follows the NSW DLG (1998) procedure.

The nutrient balance calculates the minimum area required to enable nutrients to be assimilated by the soils and vegetation. The nutrient balance used here is based on the simplistic NSW DLG (1998) methodology, but improves this by more accurately accounting for natural nutrient cycles and processes. It acknowledges that a proportion of nitrogen will be retained in the soil through processes such as ammonification (the conversion of organic nitrogen to ammonia) and a certain amount will be lost by denitrification, microbial digestion and volatilisation (Patterson, 2003). Patterson (2002) estimates that these processes may account for up to 40% of total nitrogen lost from soil. In this case, a more conservative estimate of 20% is adopted for the nitrogen losses due to soil processes.

The nutrient balance was modelled using a design hydraulic load of 600L/day (existing 3-bedroom dwelling) and 960L/day (proposed future 5-bedroom dwellings) and the expected ‘minimum’ standards for secondary effluent. Due to low P-sorption values of some Site soils (Section 3), LAAs are proposed to be located on the Vacy and Brecon soil landscapes only.

The inputs and results are presented in the table below. Full nutrient balance results are presented in Appendix C.

Parameter	Units	Value	Comments
Design (daily) hydraulic load	L/day	600	Based on existing 3-bedroom dwelling (Lot 13).
		960	Based on assumed 5-bedroom dwelling (all other Lots).
Effluent total nitrogen concentration	mg/L	30	Target effluent quality following secondary treatment in accredited STS.
Effluent total phosphorus concentration	mg/L	10	Target effluent quality following secondary treatment in accredited STS.
Nitrogen conversion rate (soil processes)	annual percentage	20	Conservative estimate of in-soil conversion processes.
Nitrogen plant uptake	kg/ha/yr	260	Section 9.3 of DSC Technical Manual (2015).
Phosphorus plant uptake	kg/ha/yr	30	

Parameter	Units	Value	Comments
Soil phosphorus sorption capacity	mg/kg	Vacy: 420	From prior soil laboratory analysis on ‘va’ soil landscape; Lots 1 and 13-24.
		Brecon: 186	From prior soil laboratory analysis on ‘br’ soil landscape; Lots 2-12.
Design life of system	Years	50	Reasonable service life for system.
Results			
	Nitrogen Balance (m^2)		**Phosphorus Balance (m^2)**
Existing Dwelling	202		250
Lots 1 and 14-24	323		400
Lots 2-12	323		687

7.4.3 Final LAA Size

Based on the preliminary hydraulic sizing and nutrient modelling outcomes, the hydraulic load is the limiting factor for LAA sizing on proposed Lots 14-22, while the phosphorus load is the limiting factor for all other proposed lots.

The following table summarises the preliminary LAA sizing requirements for each lot. Values have been rounded for simplicity.

Lot	Lot 13 (Existing Dwelling)	Lots 1 and 23-24	Lots 2-12	Lots 14-22
Limiting Balance	Phosphorus			Hydraulics
Sizing (m^2)	250	400	690	480

7.5 Installation and Detail

A critical element of the design process is hydraulic design including selection of appropriate dripline, dosing and flush manifold pipe, lateral and emitter spacing and pump performance. Dripline typically needs an operating pressure at the emitter of 10-40m (head) to maintain pressure compensation. As such, higher head, low flow pumps are required to service drip irrigation systems that differ from pumps traditionally used in OSSM.

Lateral pipes should be spaced to provide good and even coverage of the area they service. Generally, they should be no more than 1m apart, roughly parallel and along the contour as close as possible. SSI shall be installed at a depth of 100 - 150mm into the topsoil as per *AS/NZS 1547:2012*. The DSC DAF (2015) also requires a minimum depth of 600mm of soil to exist from the bottom of the irrigation laterals to the limiting layer (bedrock or weathered rock) or water table.

General specifications for SSI land application systems are as follows:

- Effluent must be applied evenly across the LAA. If necessary, it is recommended that larger LAAs are split evenly into separate zones (no more than 400m^2) using hydraulic indexing valves (or similar);
- PCSD line specifically designed for effluent irrigation (e.g. Toro Drip-in, Netafim Dripnet PC AS XR or Safe-T-Flo) shall be installed. 1.6 – 2.1 litres per hour emitters should be used;
- An in-line 120µm disc filter may be installed to minimise the amount of solids entering the pipelines and emitters. This must be removed and cleaned regularly (at least at 3-monthly intervals). Alternately, a flush main may be installed to periodically clean-out the irrigation lines to provide effective long-term performance. Either manual or automatic flush valves may be installed, with flush water directed back to the treatment system;
- Air release valves will be installed at the high points in individual irrigation areas to prevent soil particles being sucked into the lines at the end of pump cycles as pipelines depressurise; and
- An 'as-built' layout of the OSSM system (treatment and LAA) shall be provided to Council and the system Owner upon completion.

Figure 5 in Appendix A provides a schematic representation of a generic SSI system. Specialist advice must be obtained for designing and installing the irrigation systems.

7.6 LAA Positioning

Available and suitable areas for effluent application are shown on the Site Plan (Figure 3, Appendix A) as 'Available EMA'. These areas exclude minimum setback distances as described in Section 7.1 in addition to areas that are unsuitable for effluent application due to ground conditions (i.e. rock outcrop) or other identified limitations (soil P-sorption or slope >20%).

The required LAA can be located anywhere within the available EMA on each lot. However, the final LAA location will need to incorporate the minimum setbacks to future lot improvements, such as a dwelling, driveway and swimming pool.

Nominal SSI LAA locations are shown on the Site Plan provided as Figure 3 in Appendix A of this WMR.

7.7 Reserve LAA

Land application areas dosed with secondary effluent do not require provision of a reserve area, as per Section 6.4.4 of the DSC DAF (2015). However, it is expected that sufficient area will be available on each lot for a reserve LAA (if required).

8 Cumulative Impact Assessment

Section 2.3 (Table 2-5) of the DSC DAF (2015) specifies mandatory completion of a CIA if <4,000m² of 'useable land' is achievable on each lot created by the subdivision. As shown in Figure 1 of Appendix A, <4,000m² of 'useable land' is available on Lots 1, 2, 6, 11 and 12 with standard buffer distances to surface water features applied.

A <50% reduction of standard buffer distances to surface water features is required to ensure >4,000m^2 of 'useable land' is available, therefore, as per Section 2.7 (Table 2-13) of the DSC DAF (2015), a 'standard' CIA is required.

CIA is an indicative risk assessment tool that involves the use of continuous daily soil/water modelling to maximise potential to achieve a sustainable design and provide a high level of assurance when assessing potential impacts on receiving environments. The adopted methodology involves establishing background pollutant loads and contaminant concentrations, calculation of catchment surface and subsurface discharge characteristics, and integration of site-specific OSSM inputs using the Land Application Mass balance (LAM) model to estimate the potential for human health and environmental impacts from OSSM systems.

Preliminary LAA sizing has been determined in Section 7.4.3 and is compared to DSC's E&HP targets. Table 2-14 in the DSC DAF (2015) outlines the minimum assessment requirements for a CIA and are reproduced in the following table.

Risk Assessment Component	Minimum Standard
On-lot Land Application Area (LAA) Assessment	Daily water and nutrient mass balance modelling for each general on-site system LAA type within the subject site used to derive average annual hydraulic and pollutant loads to surface and subsurface export routes. Also used to estimate frequency of hydraulic failure (surcharge).
Rainfall-Runoff	Average annual estimate of runoff volume using a volumetric coefficient of rainfall. Recommend use of Figure 2.3 (and subsequent equations) from Fletcher *et al.* (2004).
Surface and Subsurface Pollutant Export	Application of catchment attenuation factor (provided in Table 10-7 of the Technical Manual for 'Inland / Rolling Hills') to combined surface and subsurface on-site loads based on broad characteristics of the receiving environment. Mass balance combining attenuated on-site system flows and loads with catchment inputs.
Background Pollutant Loads / Concentrations	Sourced from Tables 2.44 - 2.45 or Figures 2.15 – 2.23 of Fletcher *et al.* (2004). Acceptable export rates/ concentrations sourced from published local studies.
Environment and Health Protection Targets	No more than 10% increase in average annual nitrogen and phosphorus loads (kg/year) based on existing undeveloped background loads. Average virus concentration <1 MPN/100ml at receiving water or exposure point after application of attenuation rates. All land application areas sized to ensure hydraulic failure (surcharging) accounts for only 5% of total wastewater generated (i.e. 95% containment via evapotranspiration and deep drainage).

8.1 Existing (Baseline) Condition

The effective impervious area of the Site was set to 1% for the existing condition, a conservative value which takes into consideration the rural land use on mostly cleared, unimproved pasture with a driveway, dwelling and two (2) sheds. To estimate the average annual background pollutant load for the Site, the annual rainfall runoff coefficient was first obtained using the calculation provided in Section 2.2 of Fletcher *et al.* (2004):

$$C = (0.83 - 0.00018R) \times Imp + 0.0013R^{0.8} – 0.095$$

Where;

C = Annual Runoff Fraction

R = Mean Annual Rainfall (mm/year)

Imp = Impervious Fraction.

Average annual rainfall for the Site is 929mm (Paterson (Tocal AWS)) which equates to an annual runoff fraction of 0.22.

The average annual runoff volume is then calculated using the Rational Method:

$$Q = C \times I \times A$$

Where;

Q = Annual Runoff Volume (ML/year)

I = Average Annual Rainfall (mm/year)

A = Site Area (m^2).

Given that the total area of the Site is approximately 609,700m^2, the expected runoff volume equates to 124.32ML/year.

8.1.1 Pollutant Generation and Export

Background nutrient (N and P) export concentrations were derived using recommended ‘typical’ values from Tables 2.44 and 2.45 of Fletcher *et al.* (2004) for ‘Rural’ land use.

Section 10.1.1.4 of the DSC DAF Technical Manual (2015) recommends applying dry weather concentrations for 20% of the run-off volume and wet weather concentrations to the remaining 80%. A summary of the background nutrient export loads and average concentrations is provided in the table below.

Parameter	Average Background Loads (kg/ year)	Average Concentration (mg/ L)
Total Phosphorus (TP)	23.4	0.14
Total Nitrogen (TN)	221.3	1.45

8.2 Daily Modelling Overview

The LAM is a Microsoft Excel based daily water, nutrient and pathogen mass balance model developed by BMT WBM for predicting the performance of OSSM systems under varying environmental conditions. The algorithms in the model have been derived from the Decentralised Sewer Model (DSM) and tailored to suit a single site application. It can assess long-term environmental and human health performance of wastewater systems.

The LAM requires a range of bio-physical parameters as inputs to determine whether a LAA option would be sustainable at the Site. The model predicts OSSM performance by simulating the movement of pollutants within the effluent load as it travels from the point source (on-site or community-scale systems) as surface or subsurface flows. The LAM does not predict the minimum area required to achieve zero surface runoff or deep drainage, instead, like the nominated area approach of the monthly water balance, the model predicts the surface and subsurface discharges based on a set of nominated conditions such as receptor sensitivity, soil, slope, climate, wastewater input and available area.

A summary of the model processes, inputs and results is provided below.

8.2.1 Model Inputs

The simulation was run for a data period of 61.9 years (1960-2021) and represents a conservative estimate of long-term performance based on available information and a set of assumptions as detailed within this WMR.

Simulations were carried out for the preferred land application options for each lot, as follows:

- Lot 13 – secondary treated effluent to 250m^2 of SSI in (limiting) Cat 5 soil;
- Lots 1, 23, and 24 – secondary treated effluent to 400m^2 of SSI in (limiting) Cat 5 soil;
- Lots 2-10 – secondary treated effluent to 690m^2 of SSI in (limiting) Cat 5 soil, with >700mm of available soil depth;
- Lots 11 and 12 – secondary treated effluent to 690m^2 of SSI in (limiting) Cat 5 soil, with <700mm of available soil depth; and
- Lots 14-22 – secondary treated effluent to 480m^2 of SSI in (limiting) Cat 6 soil.

Daily climate data used in the model was sourced from 'SILO Data Drill' information available through the QLD Department of Environment and Science. The adopted SILO data set uses ‘grid’ point rainfall data and the (FAO56) Penman-Monteith methodology to estimate reference evapotranspiration (ET_0), which is a function of both evaporation and transpiration factors, based on a specific reference crop planted in the LAA (assumes turf).

Rather than simplistic loading rates, as utilised in monthly modelling, the LAM inputs include a more detailed estimation of the soils ability to receive, store and transmit water by approximating parameters such as effective saturation, field capacity, and the infiltration exponent. Soil input data was based on soil test pit data for the Site, presented in Appendix B.

Soil phosphorus sorption capacity was based on 5-point isotherm analytical results for a composite soil sample taken from the W&A database for the nearest soil sample location of the same landform and soil texture. For reference, a copy of the laboratory report is included in Appendix B. The input data sheets used in the modelling are presented in Appendix D.

8.2.2 Pollutant Attenuation Factors

Natural attenuation of excess effluent nutrient loads from a LAA will occur within the underlying soil and groundwater, providing reductions in contaminant concentrations to mitigate off-site export.

Established pollutant attenuation rates for hydraulics, pathogens, nitrogen and phosphorus are adopted from Table 10-7 in the DSC DAF Technical Manual (2015). These attenuation rates have been established through modelling undertaken in several case studies for both ‘Inland / Rolling Hills’ and ‘Coastal / Estuarine’ catchment scenarios and depending on whether DSC prescribed setbacks are achievable.

Based on the location and soil characteristics of the property, the ‘Inland / Rolling Hills’ catchment scenario has been adopted, with attenuation rates of 40% for hydraulics, 90% for nitrogen, 98% for phosphorus and 99% for pathogens considered appropriate based on achieving >50% of standard setbacks.

8.3 LAM Results and Compliance

Hydraulic and nutrient generation is divided into surplus loads discharged to the ground surface as ‘surface surcharge’ or draining below the root zone with subsequent (eventual) groundwater migration to surface water bodies or aquifers as ‘deep drainage’. The following sections outline the results of the modelling and their compliance with the required acceptance criteria.

The model was run to confirm that the proposed OSSM system options for each lot can sustainably assimilate the projected wastewater loads.

Modelling of the preliminary LAA sizing outputs demonstrates compliance with the performance targets of the DSC DAF (2015). Sensitive receptors are not expected to be impacted, with pathogen assimilation occurring well within the available setbacks.

To further refine the OSSM design, a second (optimisation) simulation was completed to quantify the minimum acceptable SSI LAA required for each proposed lot, with the following results:

- RUN001 (Lot 13), secondary treated effluent to 250m^2 of SSI;
- RUN002 (Lots 1, 23, and 24), secondary treated effluent to 400m^2 of SSI;
- RUN003 (Lots 2-10), secondary treated effluent to 600m^2 of SSI, with >700mm of available soil depth;
- RUN004 (Lots 11 and 12), secondary treated effluent to 600m^2 of SSI, with <700mm of available soil depth; and
- RUN005 (Lots 14-22), secondary treated effluent to 500m^2 of SSI.

Copies of all LAM inputs and output results for all FINAL model runs are presented in Appendix D.

8.3.1 Hydraulic Loads

Modelling of the movement of water, from both applied effluent and rainfall, through the soil is a key component of the LAM, ultimately determining the nutrient movement throughout the LAAs.

The table below presents the surface surcharge and deep drainage predicted for the 60-year modelling period.

Parameter	RUN001	RUN002	RUN003	RUN004	RUN005
Run Description	Secondary to SSI	Secondary to SSI	Secondary to SSI	Secondary to SSI	Secondary to SSI
Site	Lot 12	Lots 1, 23, and 24	Lots 2-10	Lots 11 and 12	Lots 14-22
Total LAA (m²)	250	1,200	5,000	1,200	4,500
Wastewater Generation (L/day)	600	2,880	8,640	1,920	8,640
Surface Surcharge Frequency (days/year)	0	0	0	0	0

Parameter	RUN001	RUN002	RUN003	RUN004	RUN005
Surface Surcharge as (%) total WWF	0	0	0	0	0
Deep Drainage (mm/day)	0.8	3.9	13.3	2.7	15.2
Deep Drainage (mm/day)	35.9				

The modelling results show that surface surcharge is not expected to occur for either OSSM system during the ~62-year modelling period. Thus, the DSC DAF (2015) requirement of 95% containment via deep drainage and evapotranspiration is achieved.

Additionally, following application of the specified hydraulic attenuation factor (40%), the total daily deep drainage from the LAAs is expected to be <3.71mm/day.

8.3.2 Nutrient and Pathogen Results

The table below summarises the predicted mean annual nutrient and pathogen loads generated by the proposed LAA designs and released beyond the LAA footprints.

Parameter	TP (kg/year)				
	RUN001	RUN002	RUN003	RUN004	RUN005
Deep Drainage Output	0.8	3.9	13.3	2.7	15.2
Surface Surcharge Output	0.0				
Combined OSSM System Output	35.9				
Parameter	**TN (kg/year)**				
	RUN001	RUN002	RUN003	RUN004	RUN005
Deep Drainage Output	0.0	0.1	0.1	0.0	0.2
Surface Surcharge Output	0.0				
Combined OSSM System Output	0.4				
Parameter	**Total Virus (MPN/L)**				
	RUN001	RUN002	RUN003	RUN004	RUN005
Deep Drainage Output	5.1	5.1	3.5	3.1	3.9
Surface Surcharge Output	0.0				
Combined OSSM System Output	20.7				

LAM modelling shows that nutrient export through surface surcharge is not expected to occur. Deep drainage is the principal pathway for nutrient export beyond the LAA footprints.

Based on this, the combined output expected from proposed subdivision is estimated as 35.9kg (P) and 0.4kg (N) annually, with an associated pathogen concentration of ~20.7 (average) MPN/L.

8.3.3 Catchment Pollutant Attenuation

Pollutant (nutrient and pathogen) loads generated at the LAAs will continue to undergo assimilation (capture, conversion, destruction etc.) within the soil environment as treated effluent moves away from the LAA.

The extent to which this occurs is based generally on the area available for assimilation (applied buffers) and the nature of the soil environment (landform/morphology). The attenuation factors specified in Section 8.2.2 have been applied for nitrogen, phosphorus and pathogen loads from the combined LAAs. The resulting pollutant export concentrations are presented in the table below.

Parameter	TP (kg/yr)	TN (kg/yr)	T_{Virus} (MPN/L)
Background Load (Site)	23.40	221.30	N/A
Total (Combined) OSSM Export	35.90	0.40	20.70
Attenuation Factor (%)	98	90	99
Attenuated Export Load (All Lots)	0.72	0.02	**0.21**
Background Load + Attenuated Export Load	24.12	221.32	N/A
Increase from Background Export Load (%)	**3.1**	**0.01**	N/A

As shown, attenuated nutrient export loads are expected to achieve the required E&HP target of <10% increase over (background) average annual nitrogen (0.01%) and phosphorus (3.1%) loads (kg/year). The pathogen export target of <1MPN/100ml (<10MPN/L) is also readily achievable.

Taking into consideration the proposed LAA locations and application methods, sensitive receptors are not expected to be impacted, with pathogen assimilation occurring well within the available setbacks.

8.4 CIA Summary

The CIA addressed the various risks on each lot by confirming that the proposed OSSM system designs presented in this WMR are sustainable and the potential for contaminant migration away from the LAAs is low.

Modelling shows that predicted hydraulic loads are manageable, with no surface surcharge expected. Nutrients will also be retained within the LAAs and surrounding setbacks, with no appreciable increase in nutrient export concentrations over background conditions, and pathogens will be effectively attenuated well before they can reach property boundaries or sensitive receptors.

Based on our analysis, the risk of hydraulic, nutrient and pathogen export to surface waters and groundwater posed by the proposed OSSM systems will not be significant. Furthermore, the human and environmental health risk to neighbouring properties is considered negligible.

9 Mitigation Measures

9.1 Soil Improvement

9.1.1 Soil Depth

To increase available soil depth within observed shallow soil profiles on proposed Lots 1, 10-13, 18, 19, 23 and 24, the addition of ~200-300mm of good-quality topsoil (sandy loam) is recommended throughout the LAA footprint prior to the installation of the SSI system.

This will ensure that SSI laterals can achieve a (minimum) 600mm separation from the most-limiting soil horizon, as per the recommendations of *AS/NZS 1547:2012,* Table M1.

The ‘raised’ irrigation area on these lots should have a (maximum) batter slope of 3 (horizontal): 1 (vertical) around the perimeter of the LAA to minimise erosion potential and ensure a stable incline for mowing.

9.1.2 Soil Chemistry

Given that Site soils are identified as dispersive with very low fertility, there is a risk of structural decline and dispersion leading to crusting and impeded effluent infiltration. To mitigate against the impacts of dispersibility, gypsum application is recommended. Gypsum application adds calcium to the soil to improve the soil CEC and Ca/Mg ratio, improving fertility, while reducing the potential for soil structural degradation.

Gypsum is only slowly soluble in water, so simply broadcasting at the surface can be of limited benefit as it can take a long time for the calcium to penetrate the soil and reach the deeper soil layers. Therefore, it is recommended to incorporate the amendment into the soil during construction of the land application system on the proposed lots. A suitable gypsum application rate of approximately 0.5kg/m^2 should be applied.

9.2 Vegetation Establishment

Vegetation that is suited to the application of effluent, preferably with high water and nutrient requirements (such as turf) should be established over the LAAs following construction. A complete vegetation cover is important to reduce the erosion hazard and optimise water and nutrient uptake.

It is recommended to establish and maintain a vegetated buffer around the LAAs. It should be planted with moisture-tolerant vegetation and remain well maintained to maximise moisture uptake. Plants must be selected that will not be so large as to shade the LAAs once fully grown. It is important that the LAAs receive maximum exposure to sun and wind to maximise evapotranspiration.

To maximise assimilation of effluent-borne nutrients within the LAAs, vegetation clippings should be removed from the LAAs and mulched elsewhere on-site for use in other landscaped areas that are not used for wastewater application. Mulching the clippings back onto the area from which they were cut is not recommended. An alternative is to dispose clippings in the general waste bin, or green waste bin collection service, if provided.

9.3 Stormwater Management

The performance of LAAs (and potentially treatment systems) can be adversely affected if stormwater is allowed to run onto these areas. Stormwater diversion devices should be designed and constructed to collect, divert and dissipate collected run-on away from the LAAs.

The structure(s) should be designed and installed by a suitably qualified professional and be compliant with relevant guidelines and standards.

A diagram of a ‘typical’ stormwater diversion, which would be appropriate for this purpose, is provided in Appendix A, Figure 6. The outlet must be stabilised and must discharge water in a safe location where it will not create an erosion hazard or impact on structures or neighbouring properties.

9.4 Water Saving Measures

To minimise wastewater generation, it is recommended that all domestic water use fixtures in the proposed dwellings be installed in accordance with BASIX requirements, including installation of ‘standard’ water reduction fittings.

Standard water reduction fixtures for internal and external water use include:

- Taps – WELS 4-star (or better) rated;
- Toilets – 4.5/3.0 litre dual flush pan and cistern;
- Showers – WELS 3-star (or better) rated; and
- Dishwashers (if used) – AAA rated using as little as 18 litres per wash.

Implementation of these measures is expected to reduce water use, and thereby wastewater generation, by as much as 10-15%.

10 Conclusions and Recommendations

This completes our assessment of the Site's capability for sustainable OSSM in relation to the proposed 24-lot subdivision. Specifically, we recommend the following:

- Generated wastewater from the existing dwelling (Lot 13) is to be treated in an appropriately sized and located NSW Health accredited STS with disinfection. Secondary treated effluent will be dispersed on-site via pressure compensating SSI within a LAA is to be a minimum area of 250m^2;
- Generated wastewater from the future dwelling in the proposed Lots 1 – 12, 14 – 24 it to be treated in an appropriately sized and located NSW Health accredited STS with disinfection.
- Secondary treated effluent is to be dispersed on-site via pressure compensating SSI within a LAA of;
    - 400m^2 for proposed Lots 1, 23 and 24;
    - 500m^2 for proposed Lots 14-22;
    - 600m^2 for proposed Lots 2-12;
- The proposed LAAs must be located within the available EMA as in Figure 2, Appendix A;
- Addition of good quality topsoil (sandy loam) to allow for 600mm of separation from the limiting layer within proposed Lots 1, 10-13, 18, 19, 23 and 24;
- A suitable lime application rate of approximately 0.5kg/m^2 should be applied at the base of the land application systems during installation;
- Vegetation must be established over the LAAs immediately after installation;
- Stormwater run-on must be directed away from the proposed LAAs; and
- Vehicles and grazing animals must be prevented from entering the designated LAAs.

Yours Sincerely,

Cmorton

Connor Morton

Environmental Consultant

Whitehead and Associates Environmental Consultants Pty Ltd

Appendix A

Figures

Figure 1: Site Plan Showing Useable Land

2641: Lennoxton Road, Vacy NSW - WMR for Subdivision

N

Whitehead & Associates
Environmental Consultants

0 200 400 600 800 1,000 1,200 m

(Approx Scale)

Revision	001
Drawn	CM
Approved	MS

Figure 2: Site Plan Showing Useable Land

2641: Lennoxton Road, Vacy NSW - WMR for Subdivision

W Whitehead & Associates Environmental Consultants

0 200 400 600 800 1,000 1,200 m

(Approx Scale)

Revision	001
Drawn	CM
Approved	MS

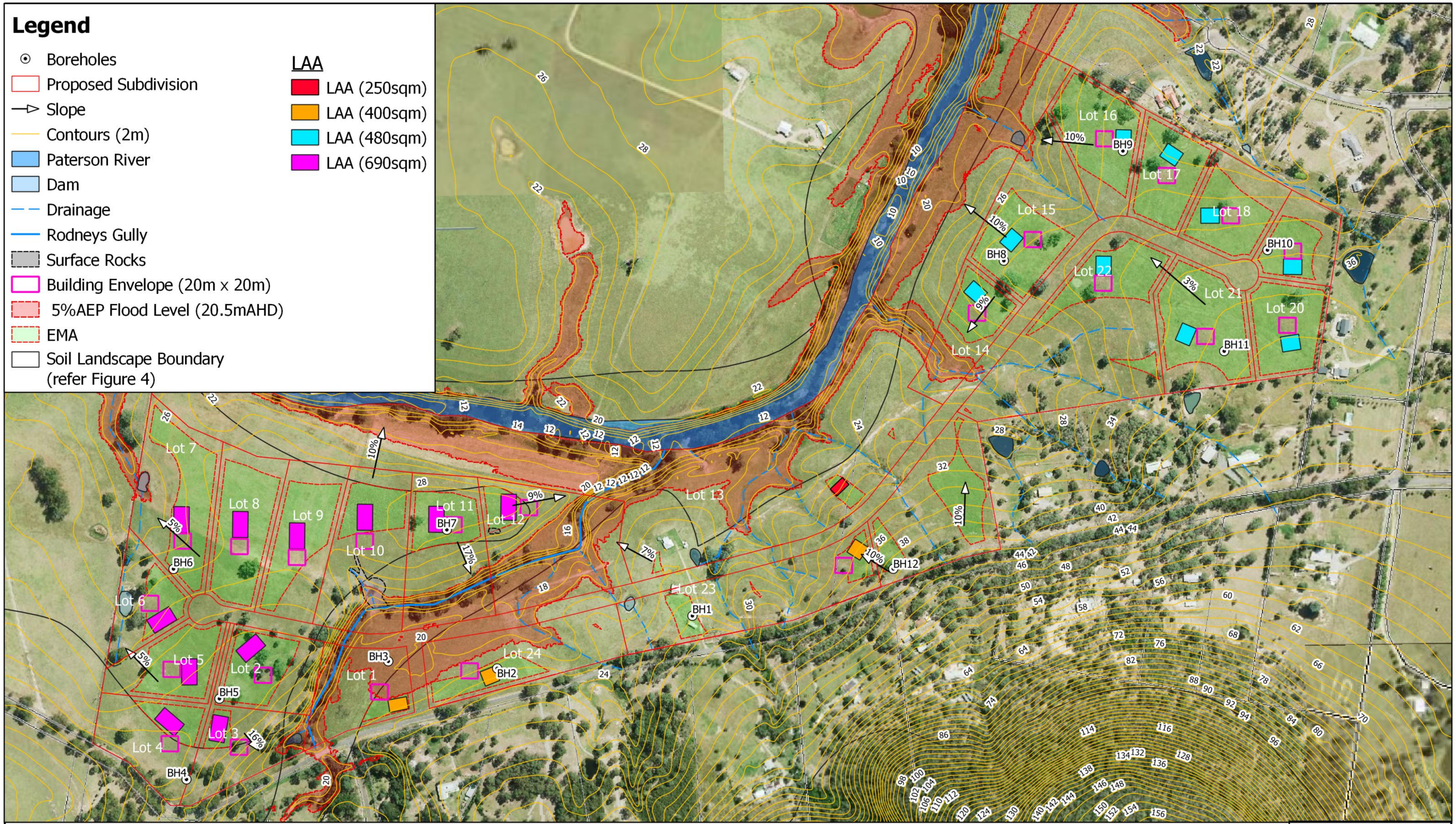

Figure 3: Site Plan Showing LAA

2641: Lennoxton Road, Vacy NSW - WMR for Subdivision

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Revision	001
Drawn	CM
Approved	MS

Figure 4: Site Plan Showing Soil Landscapes

2641: Lennoxton Road, Vacy NSW - WMR for Subdivision

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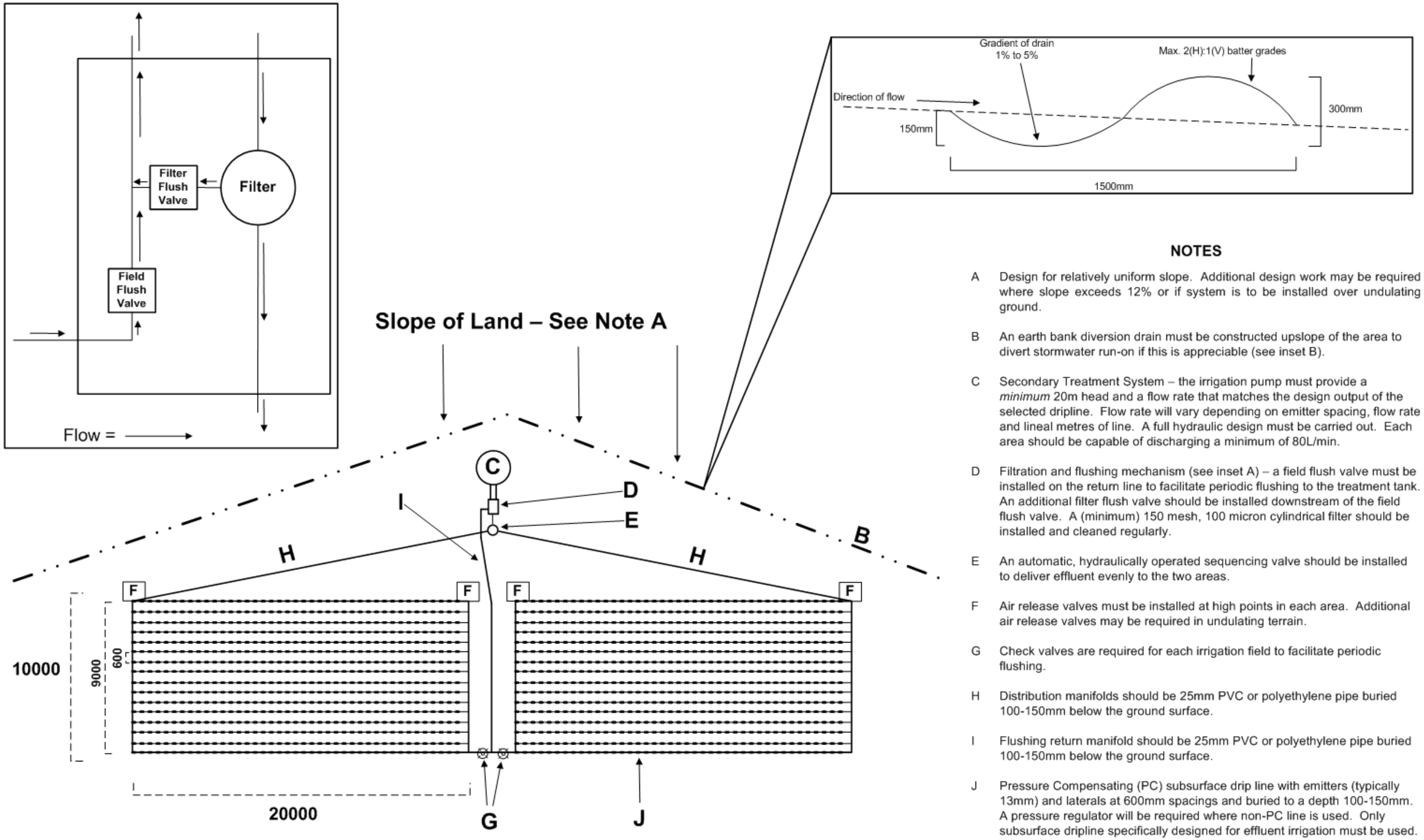
Whitehead & Associates
Environmental Consultants

0 200 400 600 800 1,000 1,200 m
(Approx Scale)

Revision	001
Drawn	CM
Approved	MS



NOTES

A	Design for relatively uniform slope. Additional design work may be required where slope exceeds 12% or if system is to be installed over undulating ground.
B	An earth bank diversion drain must be constructed upslope of the area to divert stormwater run-on if this is appreciable (see inset B).
C	Secondary Treatment System – the irrigation pump must provide a *minimum* 20m head and a flow rate that matches the design output of the selected dripline. Flow rate will vary depending on emitter spacing, flow rate and lineal metres of line. A full hydraulic design must be carried out. Each area should be capable of discharging a minimum of 80L/min.
D	Filtration and flushing mechanism (see inset A) – a field flush valve must be installed on the return line to facilitate periodic flushing to the treatment tank. An additional filter flush valve should be installed downstream of the field flush valve. A (minimum) 150 mesh, 100 micron cylindrical filter should be installed and cleaned regularly.
E	An automatic, hydraulically operated sequencing valve should be installed to deliver effluent evenly to the two areas.
F	Air release valves must be installed at high points in each area. Additional air release valves may be required in undulating terrain.
G	Check valves are required for each irrigation field to facilitate periodic flushing.
H	Distribution manifolds should be 25mm PVC or polyethylene pipe buried 100-150mm below the ground surface.
I	Flushing return manifold should be 25mm PVC or polyethylene pipe buried 100-150mm below the ground surface.
J	Pressure Compensating (PC) subsurface drip line with emitters (typically 13mm) and laterals at 600mm spacings and buried to a depth 100-150mm. A pressure regulator will be required where non-PC line is used. Only subsurface dripline specifically designed for effluent irrigation must be used.

This standard design has been based on a generic area of 400m² for irrigation based on typical conditions. It does not eliminate the need for a site and soil evaluation to be carried out or any additional consideration of site specific issues. It should be used as a generic guide only.

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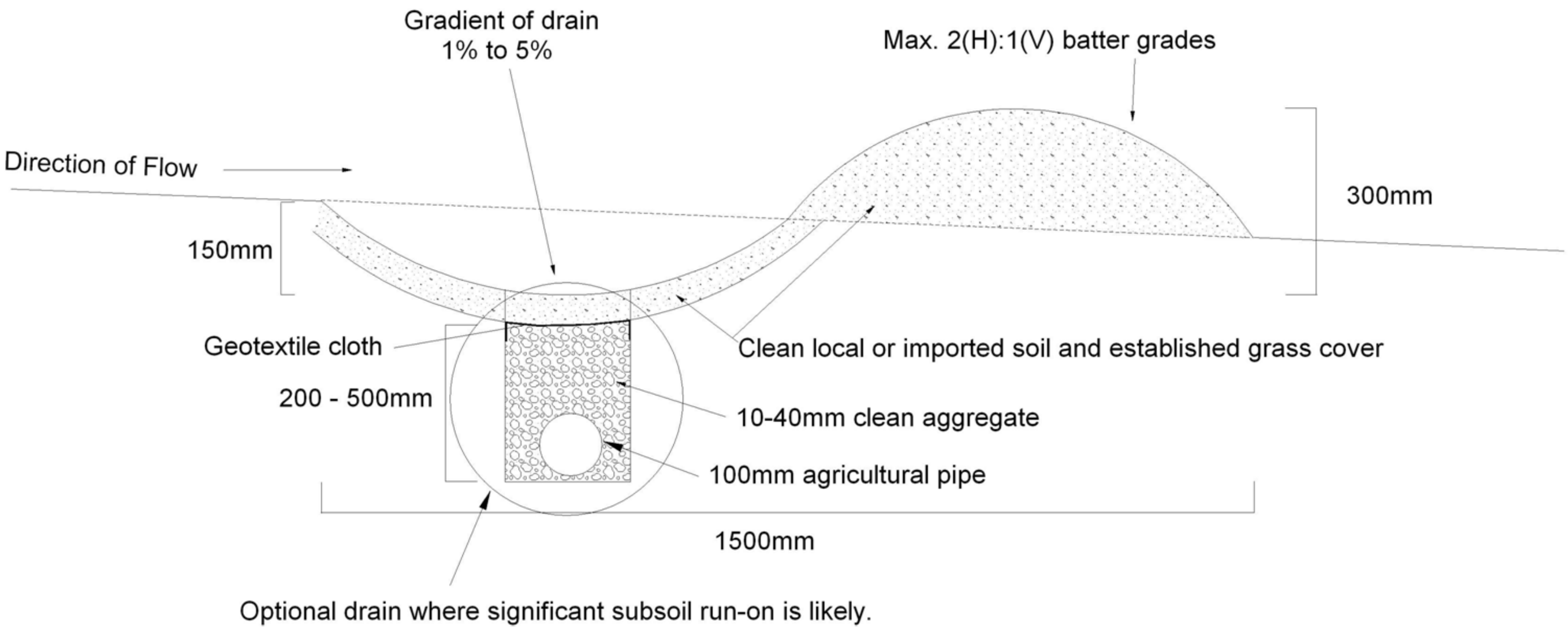
FIGURE 5:
SUBSURFACE IRRIGATION OF EFFLUENT

Project: 2641
Drawn: CM
Approved: MS
Scale: NTS

Cross Section: Upslope Diversion Drain



Whitehead & Associates Environmental Consultants	**FIGURE 6:** **UPSLOPE DIVERSION DRAIN**	**Project: 2641** **Scale: NTS** **Drawn: CM** **For visualisation purposes only, not for construction use**

Appendix B

Soil Borelogs and Laboratory Results

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Key to Soil Borelogs

Symbols

W	Watertable depth	●	Sample collected
X	Depth of refusal		

Moisture condition

D	Dry
SM	Slightly moist
M	Moist
VM	Very moist
W	Wet / saturated

Graphic Log and Textures

⁙	S - Sand LS - Loamy sand CS - Clayey sand	▓	CL - Clay loam SCL - Sandy clay loam SiCL - Silty clay loam	▩	Gravel (G)
░	SL - Sandy loam	▤	LC - Light clay SC - Sandy clay	▦	Parent material (stiff)
▒	L - Loam LFS - Loam fine sandy SiL - Silty loam	☰	MC - Medium clay HC - Heavy clay	▧	Parent material (weathered)

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH1**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1	▒	BH1/1	A	SCL	Moderate	Very dark brown	No	2 - 10%	2-6mm	M	
0.2	▒										
0.3	≡	BH1/2	B	SC	Moderate	Dark brown	Red (minor)	2 - 10%	2-6mm	M	
0.4	≡										
0.5	≡										
	~ Refusal										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH2**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1	▩	BH2/1	A	CL	Moderate	Black	No	2 - 10%	2-6mm	M	
0.2	▩										
0.3	▤	BH2/2	B	SC	Moderate	Dark brown	Orange (minor)	2 - 10%	2-6mm	M	
0.4	▤										
0.5	▤										
0.6	▤										
	~ Refusal										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH3**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1 0.2 0.3 0.4 0.5 0.6	▒	BH3/1	A1	SCL	Moderate	Dark brown	No	2 - 10%	2-6mm	VM	
0.7 0.8 0.9 1.0	▒	BH3/2	A2	SCL	Moderate	Dark yellowish brown	Orange (minor)	2 - 10%	2-6mm	M	
1.1 1.2	▤	BH3/3	B	SC	Moderate	Brown	Gley (minor)	2 - 10%	6-20mm	M	

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH4**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1		BH4/1	A	SC	Moderate	Dark reddish brown	No	2 - 10%	6-20mm		
0.2											
0.3											
0.4		BH4/2	B1	MC	Weak	Reddish brown	Red / yellow (minor)	2 - 10%	2-6mm		
0.5											
0.6											
0.7											
0.8											
0.9		BH4/3	B2	MC	Weak	Reddish brown	Red / yellow (minor)	2 - 10%	2-6mm		
1.0											
	~ Refusal										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH5**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1	▒	BH5/1	A	SCL	Moderate	Dark brown	No	2 - 10%	6-20mm	M	
0.2	▒										
0.3	▒										
0.4	▒										
0.5	▤	BH5/2	B1	SC	Moderate	Brown	Red / yellow (minor)	2 - 10%	6-20mm	M	
0.6	▤										
0.7	▤	BH5/3	B2	SC	Weak	Brown	Orange (minor)	2 - 10%	6-20mm	M	
0.8	▤										
0.9	▤										
1.0	▤										
	~ Refusal on compated material										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH6**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1 0.2	▒	BH6/1	A	SCL	Moderate	Vey dark greyish brown	No	10 - 20%	20-60mm		
0.3 0.4 0.5	▤	BH6/2	B1	SC	Moderate	Dark yellowish	Orange (minor)	2 - 10%	6-20mm		
0.6 0.7 0.8 0.9	▤	BH6/3	B2	SC	Moderate	Stong Brown	Orange (minor)	2 - 10%	6-20mm		
	~ Refusal on compated material										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH7**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1	▒	BH7/1	A1	SiCL	Moderate	Brown	No	2 - 10%	6-20mm	M	
0.2 0.3	▒	BH7/2	A2	SCL	Moderate	Brown	No	2 - 10%	6-20mm	M	
0.4	☰	BH7/3	B	SC	Weak	Reddish brown	Red (minor)	10 - 20%	6-20mm	M	
	~ Refusal on compated material										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH8**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1	▒	BH8/1	A	SCL	Moderate	Very dark greyish brown	No	2 - 10%	6-20mm		
0.2	▒										
0.3	☰	BH8/2	B1	SC	Moderate	Brown	Orange (minor)	2 - 10%	2-6mm		
0.4	☰										
0.5	☰										
0.6	☰										
0.7	☰	BH8/3	B2	MC	Moderate	Dark yellowish brown	Orange (minor)	2 - 10%	2-6mm		
0.8	☰										
	~ Refusal on compated material										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH9**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1	▩	BH9/1	A	SiC	Moderate	Very dark greyish brown	No	2 - 10%	2-6mm	M	
0.2	▩										
0.3	▤	BH9/2	B1	MC	Moderate	Very dark greyish brown	No	2 - 10%	2-6mm	M	
0.4	▤										
0.5	▤										
0.6	▤	BH9/3	B2	MC	Moderate	Dark greyish brown	No	< 2%	2-6mm	M	
0.7	▤										
0.8	▤										
0.9	▤										
	~ Refusal on compated material										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH10**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1		BH10/1	A	SCL	Moderate	Very dark grey	No	2 - 10%	6-20mm	M	
0.2											
0.3											
0.4											
0.5											
0.6		BH10/2	B1	MC	Moderate	Dark greyish brown	No	2 - 10%	6-20mm	M	
0.7											
0.8		BH10/3	B2	SC	Moderate	Brown	Orange (minor)	2 - 10%	6-20mm	M	
0.9											
1.0											
1.1											

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH11**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1	▨	BH11/1	A	SCL	Moderate	Dark brown	No	2 - 10%	6-20mm	M	
0.2	▨										
0.3	☰	BH11/2	B1	MC	Moderate	Dark greyish brown	No	2 - 10%	2-6mm	M	
0.4	☰										
0.5	☰										
0.6	☰	BH11/3	B2	SC	Weak	Brown	Orange (minor)	10 - 20%	2-6mm	M	
	~ Refusal on compated material										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Peter Evans	**Test Pit No:**	**BH12**
Site:	256 Lennoxton Road, Vacy	Excavated/logged by:	CM, CL, NB
Date:	29 December 2021	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Size of Coarse Fragments	Moisture Condition	Comments
0.1	▒	BH12/1	A1	SCL	Moderate	Dark brown	No	2 - 10%	6-20mm	M	
0.2	▒	BH12/2	A2	SCL	Moderate	Greyish brown	No	2 - 10%	6-20mm	VM	
0.3	▒										
0.4	▒										
0.5	▤	BH12/3	B	SC	Weak	Yellowish brown	No	2 - 10%	6-20mm	M	
0.6	▤										
	~ Refusal on compated material										

Project 2641: 256 Lennoxton Road, Vacy

Sheet 1 - Soil Sampling Schedule and Results of pH, EC and Emerson Aggregate Test Analysis

Site	Sample Name	Sample Depth (mm)	Texture Class	EAT [1]	Rating [2]	pH f [3]	pH 1:5 [4]	Rating	EC 1:5 (µS/cm)	ECe (dS/m) [5]	Rating
BH1	1/1	200	SCL	2(1)	Mod-High	n/a	6.2	Slightly acid	46	0.41	Non-saline
	1/2	500	SC	5	Slight	n/a	5.8	Moderately acid	39	0.39	Non-saline
BH2	2/1	200	CL	5	Slight	n/a	5.6	Moderately acid	32	0.29	Non-saline
	2/2	600	SC	5	Slight	n/a	5.7	Moderately acid	44	0.35	Non-saline
BH3	3/1	650	SCL	5	Slight	n/a	5.6	Moderately acid	22	0.20	Non-saline
	3/2	1000	SCL	5	Slight	n/a	5.7	Moderately acid	34	0.31	Non-saline
	3/3	1200	SC	1	Very High	n/a	5.8	Moderately acid	49	0.39	Non-saline
BH4	4/1	300	SC	5	Slight	n/a	5.7	Moderately acid	39	0.31	Non-saline
	4/2	850	MC	5	Slight	n/a	5.7	Moderately acid	199	1.39	Non-saline
	4/3	1000	MC	2(2)	High	n/a	5.8	Moderately acid	370	2.59	Slightly saline
BH5	5/1	400	SCL	5	Slight	n/a	5.2	Strongly acid	27	0.24	Non-saline
	5/2	600	SC	1	Very High	n/a	5.1	Strongly acid	73	0.58	Non-saline
	5/3	1000	SC	2	Very High	n/a	4.7	Very strongly acid	318	2.54	Slightly saline
BH6	6/1	250	SCL	5	Slight	n/a	4.8	Very strongly acid	30	0.27	Non-saline
	6/2	500	SC	1	Very High	n/a	5.0	Very strongly acid	49	0.39	Non-saline
	6/3	900	SC	2(2)	High	n/a	5.2	Strongly acid	27	0.19	Non-saline
BH7	7/1	150	SiCL	5	Slight	n/a	4.9	Very strongly acid	43	0.39	Non-saline
	7/2	350	SiC	5	Slight	n/a	5.0	Very strongly acid	43	0.34	Non-saline
	7/3	450	SC	5	Slight	n/a	5.1	Strongly acid	68	0.54	Non-saline
BH8	8/1	200	SCL	2(2)	High	n/a	5.0	Very strongly acid	32	0.29	Non-saline
	8/2	650	SC	5	Slight	n/a	5.3	Strongly acid	104	0.83	Non-saline
	8/3	800	MC	2(1)	Mod-High	n/a	5.5	Strongly acid	299	2.09	Slightly saline
BH9	9/1	200	SiC	5	Slight	n/a	5.6	Moderately acid	29	0.26	Non-saline
	9/2	500	MC	2(1)	Mod-High	n/a	5.6	Moderately acid	169	1.18	Non-saline
	9/3	900	MC	2(2)	High	n/a	5.8	Moderately acid	541	3.79	Slightly saline
BH10	10/1	500	SCL	5	Slight	n/a	5.5	Strongly acid	28	0.25	Non-saline
	10/2	700	MC	1	Very High	n/a	4.8	Very strongly acid	332	2.32	Slightly saline
	10/3	1100	MC	2(3)	Very High	n/a	4.6	Very strongly acid	504	3.53	Slightly saline
BH11	11/1	250	SCL	1	Very High	n/a	5.1	Strongly acid	53	0.48	Non-saline
	11/2	500	MC	1	Very High	n/a	4.9	Very strongly acid	135	0.95	Non-saline
	11/3	600	SC	2(2)	High	n/a	4.9	Very strongly acid	170	1.36	Non-saline
BH12	12/1	150	SCL	5	Slight	n/a	4.7	Very strongly acid	98	0.88	Non-saline
	12/2	400	SCL	2(3)	Very High	n/a	5.1	Strongly acid	49	0.44	Non-saline
	12/3	600	SC	2(3)	Very High	n/a	5.1	Strongly acid	81	0.65	Non-saline

Notes:- (also refer Interpretation Sheet 1)

n/a not available

n/t not tested

[1] The modified Emerson Aggregate Test (EAT) provides an indication of soil susceptibility to dispersion.

[2] Ratings describe the likely hazard associated with land application of treated wastewater.

[3] pH measured in the field using Raupac Indicator.

[4] pH measured on 1:5 soil:water suspensions using a *Hanna Combo* hand-held pH/EC/temp meter.

[5] Electrical conductivity of the saturated extract (Ece) = $EC_{1:5}$(µS/cm) x MF / 1000. Units are dS/m. MF is a soil texture multiplication factor.

[6] External laboratories used for the following analyses, if indicated:

- CEC (Cation exchange capacity)
- Psorb (Phosphorus sorption capacity)
- Bray Phosphorus
- Organic carbon
- Total nitrogen

Vacy Soil Landscape

Project 2641: Lennoxton Road, Vacy NSW

Sheet 2

Site	**Depth (mm)**	**CEC** (me/100g)	Rating	**Ca** (mg/kg)	Rating	**Mg** (mg/kg)	Rating	**Na** (mg/kg)	Rating	**K** (mg/kg)	Rating	**ESP** (%)	Rating	**P-sorp.** (mg/kg)	Rating
207 Lennoxton Road, Vacy	-	6.1	L		n/a		n/a		n/a		n/a	2.7	NS	420	H

Notes:- (also refer Interpretation Sheet 2)

n/a	not available
n/t	not tested

Brecon Soil Landscape

Project 2641: Lennoxton Road, Vacy NSW

Sheet 2

Site	**Depth (mm)**	**CEC** (me/100g)	Rating	**Ca** (mg/kg)	Rating	**Mg** (mg/kg)	Rating	**Na** (mg/kg)	Rating	**K** (mg/kg)	Rating	**ESP** (%)	Rating	**P-sorp.** (mg/kg)	Rating
77 Black Rock Road, Martins Creek		21.0	M		n/a		n/a		n/a		n/a	8.6	S	186	M

Notes:- (also refer Interpretation Sheet 2)

n/a	not available
n/t	not tested

Paterson River Soil Landscape

Project 2641: Lennoxton Road, Vacy NSW

Sheet 2

Sample Name	**Depth (mm)**	**CEC** (me/100g)	Rating	**Ca** (mg/kg)	Rating	**Mg** (mg/kg)	Rating	**Na** (mg/kg)	Rating	**K** (mg/kg)	Rating	**ESP** (%)	Rating	**P-sorp.** (mg/kg)	Rating
326/2		10.9	L		n/a		n/a		n/a		n/a	2.0	NS	188	M

Notes:- (also refer Interpretation Sheet 2)

n/a	not available
n/t	not tested

Welshmans River Soil Landscape

Project 2641: Lennoxton Road, Vacy NSW

Sheet 2

Sample Name	**Depth (mm)**	**CEC** (me/100g)	Rating	**Ca** (mg/kg)	Rating	**Mg** (mg/kg)	Rating	**Na** (mg/kg)	Rating	**K** (mg/kg)	Rating	**ESP** (%)	Rating	**P-sorp.** (mg/kg)	Rating
368/3/72		15.6	M		n/a		n/a		n/a		n/a	7.0	S	230	M

Notes:- (also refer Interpretation Sheet 2)

n/a	not available
n/t	not tested

Appendix C

Nutrient Balance Modelling

Nutrient Balance (Vacy Soil Landscape, Existing Dwelling)

Whitehead & Associates
Environmental Consultants

Project 2641: Lennoxton Road, Vacy NSW

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = **350 m^2**

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	840	L/day	Crop N Uptake	260	kg/ha/yr	which equals	71.23	$mg/m^2/day$
Effluent N Concentration	30	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8.22	$mg/m^2/day$
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	5,040	mg/day	P-sorption result	514	mg/kg	which equals	5,757	kg/ha
Remaining N Load after soil loss	20,160	mg/day	Bulk Density	1.4	g/cm^3			
Effluent P Concentration	10	mg/L	Depth of Soil	0.8	m			
Design Life of System	50	yrs	% of Predicted P-sorp.[2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer			Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)		
Nitrogen	283	m^2	Nominated LAA Size	320	m^2
Phosphorus	350	m^2	Predicted N Export from LAA	-0.96	kg/year
			Predicted P Export from LAA	0.26	kg/year
			Phosphorus Longevity for LAA	44	Years
			Minimum Buffer Required for excess nutrient	30	m^2

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	**320**	m^2				
Daily P Load	0.0084	kg/day	→	Phosphorus generated over life of system	153.3	kg
Daily Uptake	0.0026301	kg/day	→	Phosphorus vegetative uptake for life of system	0.150	kg/m^2
Measured p-sorption capacity	0.57568	kg/m^2				
Assumed p-sorption capacity	0.288	kg/m^2	→	Phosphorus adsorbed in 50 years	0.288	kg/m^2
Site P-sorption capacity	92.11	kg	→	Desired Annual P Application Rate	2.802	kg/year
				which equals	0.00768	kg/day
P-load to be sorbed	2.11	kg/year				

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Whitehead & Associates
Environmental Consultants

Nutrient Balance (Vacy Soil Landescape, Proposed Dwelling)

Project 2641: Lennoxton Road, Vacy NSW

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 400 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	960	L/day	Crop N Uptake	260	kg/ha/yr	which equals	71.23	$mg/m^2/day$
Effluent N Concentration	30	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8.22	$mg/m^2/day$
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	5,760	mg/day	P-sorption result	514	mg/kg	which equals	5,757	kg/ha
Remaining N Load after soil loss	23,040	mg/day	Bulk Density	1.4	g/cm^3			
Effluent P Concentration	10	mg/L	Depth of Soil	0.8	m			
Design Life of System	50	yrs	% of Predicted P-sorp.[2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer

Nitrogen	323	m^2
Phosphorus	400	m^2

Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)

Nominated LAA Size	320	m^2
Predicted N Export from LAA	0.09	kg/year
Predicted P Export from LAA	0.70	kg/year
Phosphorus Longevity for LAA	36	Years
Minimum Buffer Required for excess nutrient	80	m^2

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	**320**	m^2				
Daily P Load	0.0096	kg/day	→	Phosphorus generated over life of system	175.2	kg
Daily Uptake	0.0026301	kg/day	→	Phosphorus vegetative uptake for life of system	0.150	kg/m^2
Measured p-sorption capacity	0.57568	kg/m^2				
Assumed p-sorption capacity	0.288	kg/m^2	→	Phosphorus adsorbed in 50 years	0.288	kg/m^2
Site P-sorption capacity	92.11	kg	→	Desired Annual P Application Rate	2.802	kg/year
				which equals	0.00768	kg/day
P-load to be sorbed	2.54	kg/year				

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Nutrient Balance (Brecon Soil Landscape)

Project 2641: Lennoxton Road, Vacy NSW

Whitehead & Associates
Environmental Consultants

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 361 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	960	L/day	Crop N Uptake	260	kg/ha/yr	which equals	71.23	mg/m^2/day
Effluent N Concentration	30	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8.22	mg/m^2/day
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	5,760	mg/day	P-sorption result	599	mg/kg	which equals	6,709	kg/ha
Remaining N Load after soil loss	23,040	mg/day	Bulk Density	1.4	g/cm^3			
Effluent P Concentration	10	mg/L	Depth of Soil	0.8	m			
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer

Nitrogen	323	m^2
Phosphorus	361	m^2

Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)

Nominated LAA Size	480	m^2
Predicted N Export from LAA	-4.07	kg/year
Predicted P Export from LAA	-1.16	kg/year
Phosphorus Longevity for LAA	78	Years
Minimum Buffer Required for excess nutrient	0	m^2

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	**480**	m^2				
Daily P Load	0.0096	kg/day	→	Phosphorus generated over life of system	175.2	kg
Daily Uptake	0.0039452	kg/day	→	Phosphorus vegetative uptake for life of system	0.150	kg/m^2
Measured p-sorption capacity	0.67088	kg/m^2				
Assumed p-sorption capacity	0.335	kg/m^2	→	Phosphorus adsorbed in 50 years	0.335	kg/m^2
Site P-sorption capacity	161.01	kg	→	Desired Annual P Application Rate	4.660	kg/year
				which equals	0.01277	kg/day
P-load to be sorbed	2.06	kg/year				

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Nutrient Balance (Paterson River Soil Landscape)

Project 2641: Lennoxton Road, Vacy NSW

Whitehead & Associates
Environmental Consultants

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = **686 m^2**

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	960	L/day	Crop N Uptake	260	kg/ha/yr	which equals	71.23	mg/m^2/day
Effluent N Concentration	30	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8.22	mg/m^2/day
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	5,760	mg/day	P-sorption result	188	mg/kg	which equals	2,106	kg/ha
Remaining N Load after soil loss	23,040	mg/day	Bulk Density	1.4	g/cm^3			
Effluent P Concentration	10	mg/L	Depth of Soil	0.8	m			
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer

Nitrogen	323	m^2
Phosphorus	686	m^2

Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)

Nominated LAA Size	320	m^2
Predicted N Export from LAA	0.09	kg/year
Predicted P Export from LAA	1.87	kg/year
Phosphorus Longevity for LAA	13	Years
Minimum Buffer Required for excess nutrient	366	m^2

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	**320**	m^2			
Daily P Load	0.0096	kg/day	→ Phosphorus generated over life of system	175.2	kg
Daily Uptake	0.0026301	kg/day	→ Phosphorus vegetative uptake for life of system	0.150	kg/m^2
Measured p-sorption capacity	0.21056	kg/m^2			
Assumed p-sorption capacity	0.105	kg/m^2	→ Phosphorus adsorbed in 50 years	0.105	kg/m^2
Site P-sorption capacity	33.69	kg	→ Desired Annual P Application Rate	1.634	kg/year
			which equals	0.00448	kg/day
P-load to be sorbed	2.54	kg/year			

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Nutrient Balance (Welshmans River Soil Landscape)

Project 2641: Lennoxton Road, Vacy NSW

Whitehead & Associates
Environmental Consultants

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = **628 m^2**

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	960	L/day	Crop N Uptake	260	kg/ha/yr	which equals	71.23	mg/m^2/day
Effluent N Concentration	30	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8.22	mg/m^2/day
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	5,760	mg/day	P-sorption result	230	mg/kg	which equals	2,576	kg/ha
Remaining N Load after soil loss	23,040	mg/day	Bulk Density	1.4	g/cm^3			
Effluent P Concentration	10	mg/L	Depth of Soil	0.8	m			
Design Life of System	50	yrs	% of Predicted P-sorp.[2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer		
Nitrogen	323	m^2
Phosphorus	628	m^2

Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)		
Nominated LAA Size	480	m^2
Predicted N Export from LAA	-4.07	kg/year
Predicted P Export from LAA	0.83	kg/year
Phosphorus Longevity for LAA	30	Years
Minimum Buffer Required for excess nutrient	148	m^2

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	**480**	m^2			
Daily P Load	0.0096	kg/day	→ Phosphorus generated over life of system	175.2	kg
Daily Uptake	0.0039452	kg/day	→ Phosphorus vegetative uptake for life of system	0.150	kg/m^2
Measured p-sorption capacity	0.2576	kg/m^2			
Assumed p-sorption capacity	0.129	kg/m^2	→ Phosphorus adsorbed in 50 years	0.129	kg/m^2
Site P-sorption capacity	61.82	kg	→ Desired Annual P Application Rate	2.676	kg/year
			which equals	0.00733	kg/day
P-load to be sorbed	2.06	kg/year			

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

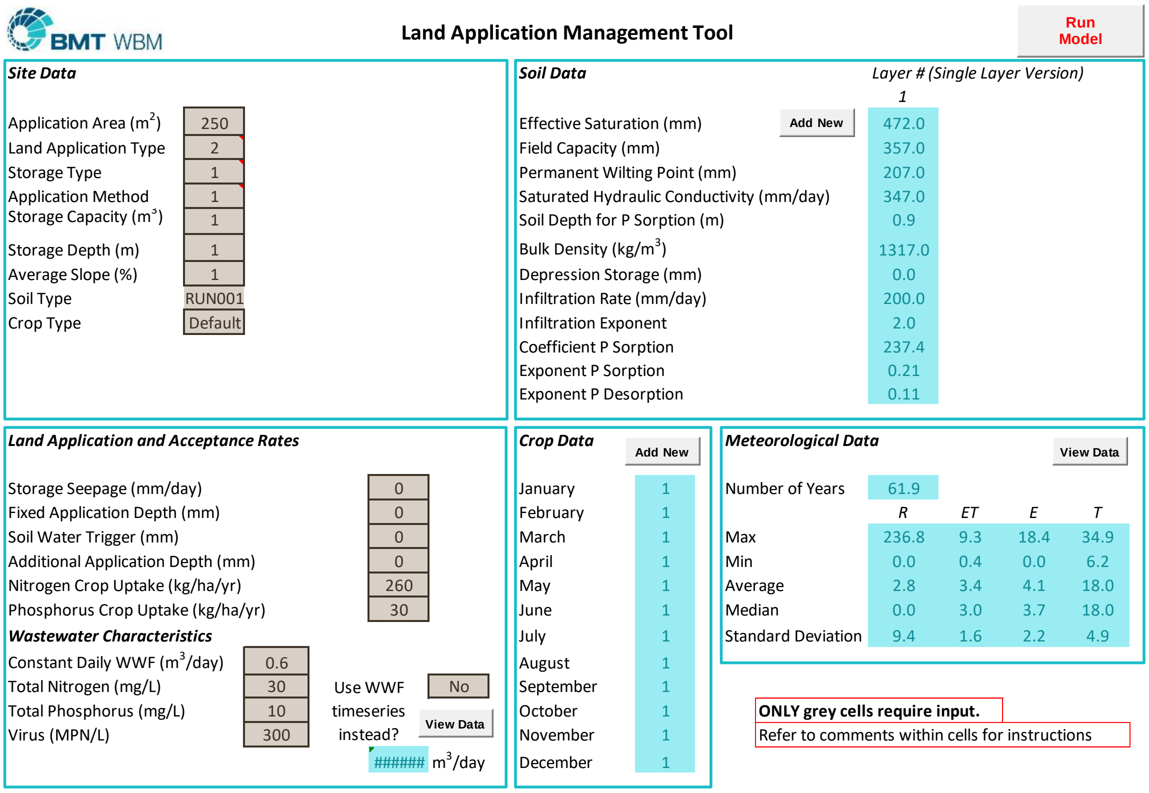
- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Appendix D

LAM Modelling Inputs / Results

RUN001



Land Application Management Tool

Site Data

Application Area (m^2)	250
Land Application Type	2
Storage Type	1
Application Method	1
Storage Capacity (m^3)	1
Storage Depth (m)	1
Average Slope (%)	1
Soil Type	RUN001
Crop Type	Default

Soil Data

	Layer # (Single Layer Version) *1*
Effective Saturation (mm)	472.0
Field Capacity (mm)	357.0
Permanent Wilting Point (mm)	207.0
Saturated Hydraulic Conductivity (mm/day)	347.0
Soil Depth for P Sorption (m)	0.9
Bulk Density (kg/m^3)	1317.0
Depression Storage (mm)	0.0
Infiltration Rate (mm/day)	200.0
Infiltration Exponent	2.0
Coefficient P Sorption	237.4
Exponent P Sorption	0.21
Exponent P Desorption	0.11

Land Application and Acceptance Rates

Storage Seepage (mm/day)	0
Fixed Application Depth (mm)	0
Soil Water Trigger (mm)	0
Additional Application Depth (mm)	0
Nitrogen Crop Uptake (kg/ha/yr)	260
Phosphorus Crop Uptake (kg/ha/yr)	30

Wastewater Characteristics

Constant Daily WWF (m^3/day)	0.6
Total Nitrogen (mg/L)	30
Total Phosphorus (mg/L)	10
Virus (MPN/L)	300

Use WWF timeseries instead? No

m^3/day

Crop Data

January	1
February	1
March	1
April	1
May	1
June	1
July	1
August	1
September	1
October	1
November	1
December	1

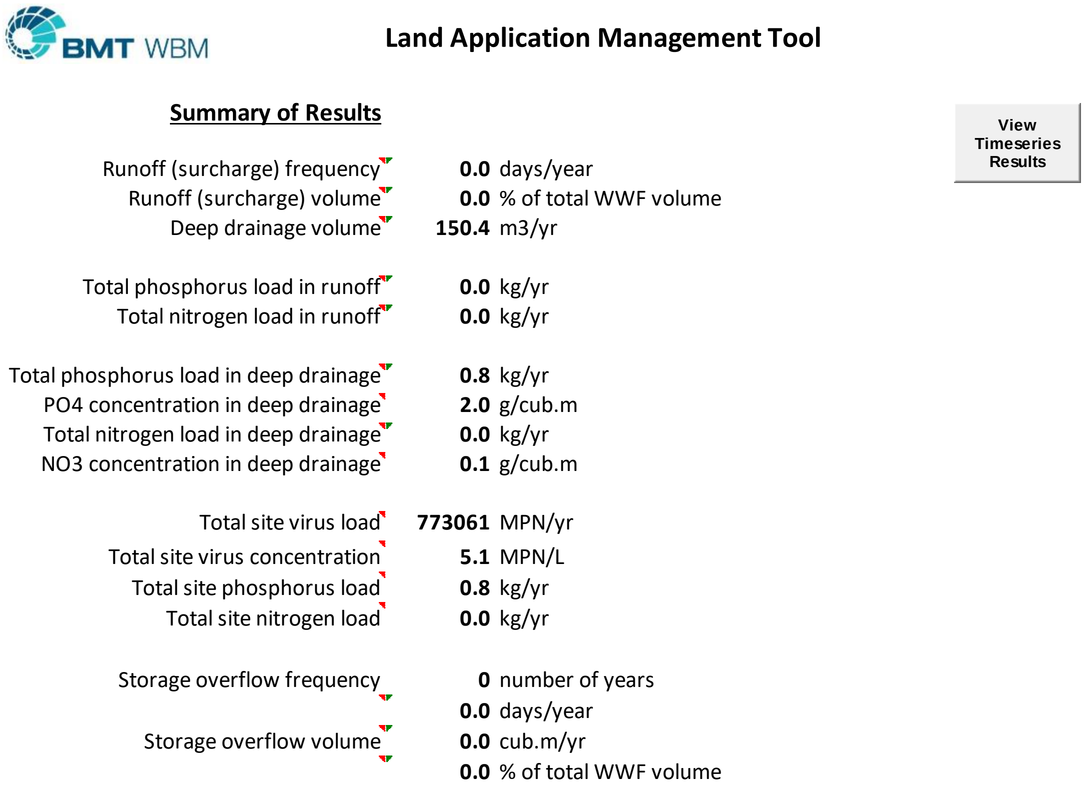
Meteorological Data

Number of Years 61.9

	R	*ET*	*E*	*T*
Max	236.8	9.3	18.4	34.9
Min	0.0	0.4	0.0	6.2
Average	2.8	3.4	4.1	18.0
Median	0.0	3.0	3.7	18.0
Standard Deviation	9.4	1.6	2.2	4.9

ONLY grey cells require input.

Refer to comments within cells for instructions

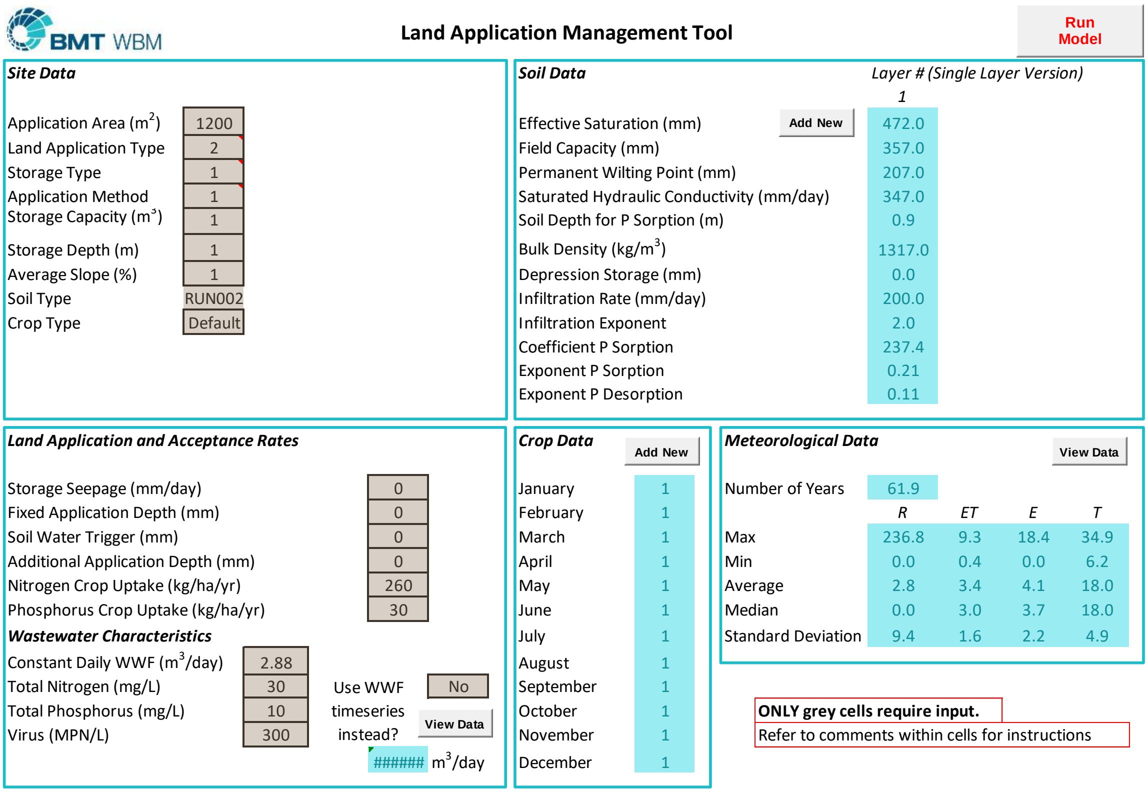


Land Application Management Tool

Summary of Results

Runoff (surcharge) frequency	**0.0**	days/year
Runoff (surcharge) volume	**0.0**	% of total WWF volume
Deep drainage volume	**150.4**	m3/yr
Total phosphorus load in runoff	**0.0**	kg/yr
Total nitrogen load in runoff	**0.0**	kg/yr
Total phosphorus load in deep drainage	**0.8**	kg/yr
PO4 concentration in deep drainage	**2.0**	g/cub.m
Total nitrogen load in deep drainage	**0.0**	kg/yr
NO3 concentration in deep drainage	**0.1**	g/cub.m
Total site virus load	**773061**	MPN/yr
Total site virus concentration	**5.1**	MPN/L
Total site phosphorus load	**0.8**	kg/yr
Total site nitrogen load	**0.0**	kg/yr
Storage overflow frequency	**0**	number of years
	0.0	days/year
Storage overflow volume	**0.0**	cub.m/yr
	0.0	% of total WWF volume

RUN002



Land Application Management Tool

Site Data

Application Area (m^2)	1200
Land Application Type	2
Storage Type	1
Application Method	1
Storage Capacity (m^3)	1
Storage Depth (m)	1
Average Slope (%)	1
Soil Type	RUN002
Crop Type	Default

Soil Data

	Layer # (Single Layer Version) *1*
Effective Saturation (mm)	472.0
Field Capacity (mm)	357.0
Permanent Wilting Point (mm)	207.0
Saturated Hydraulic Conductivity (mm/day)	347.0
Soil Depth for P Sorption (m)	0.9
Bulk Density (kg/m^3)	1317.0
Depression Storage (mm)	0.0
Infiltration Rate (mm/day)	200.0
Infiltration Exponent	2.0
Coefficient P Sorption	237.4
Exponent P Sorption	0.21
Exponent P Desorption	0.11

Land Application and Acceptance Rates

Storage Seepage (mm/day)	0
Fixed Application Depth (mm)	0
Soil Water Trigger (mm)	0
Additional Application Depth (mm)	0
Nitrogen Crop Uptake (kg/ha/yr)	260
Phosphorus Crop Uptake (kg/ha/yr)	30

Wastewater Characteristics

Constant Daily WWF (m^3/day)	2.88
Total Nitrogen (mg/L)	30
Total Phosphorus (mg/L)	10
Virus (MPN/L)	300

Use WWF timeseries instead? No

m^3/day

Crop Data

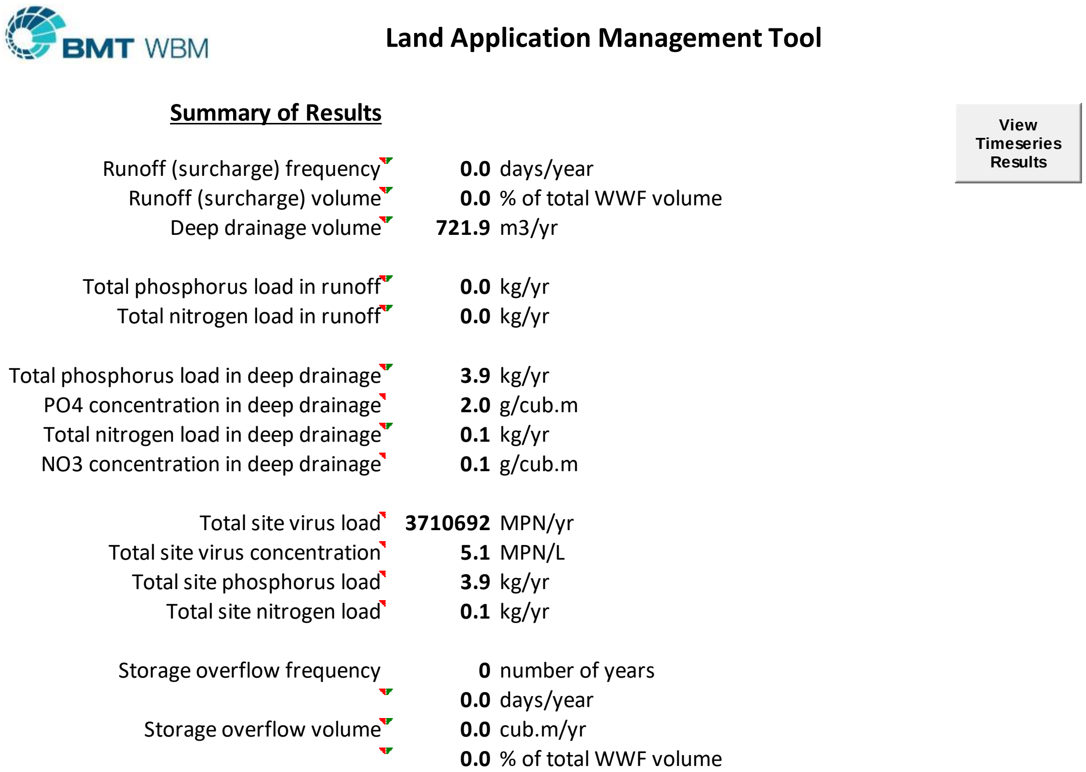
January	1
February	1
March	1
April	1
May	1
June	1
July	1
August	1
September	1
October	1
November	1
December	1

Meteorological Data

Number of Years 61.9

	R	*ET*	*E*	*T*
Max	236.8	9.3	18.4	34.9
Min	0.0	0.4	0.0	6.2
Average	2.8	3.4	4.1	18.0
Median	0.0	3.0	3.7	18.0
Standard Deviation	9.4	1.6	2.2	4.9

ONLY grey cells require input.
Refer to comments within cells for instructions

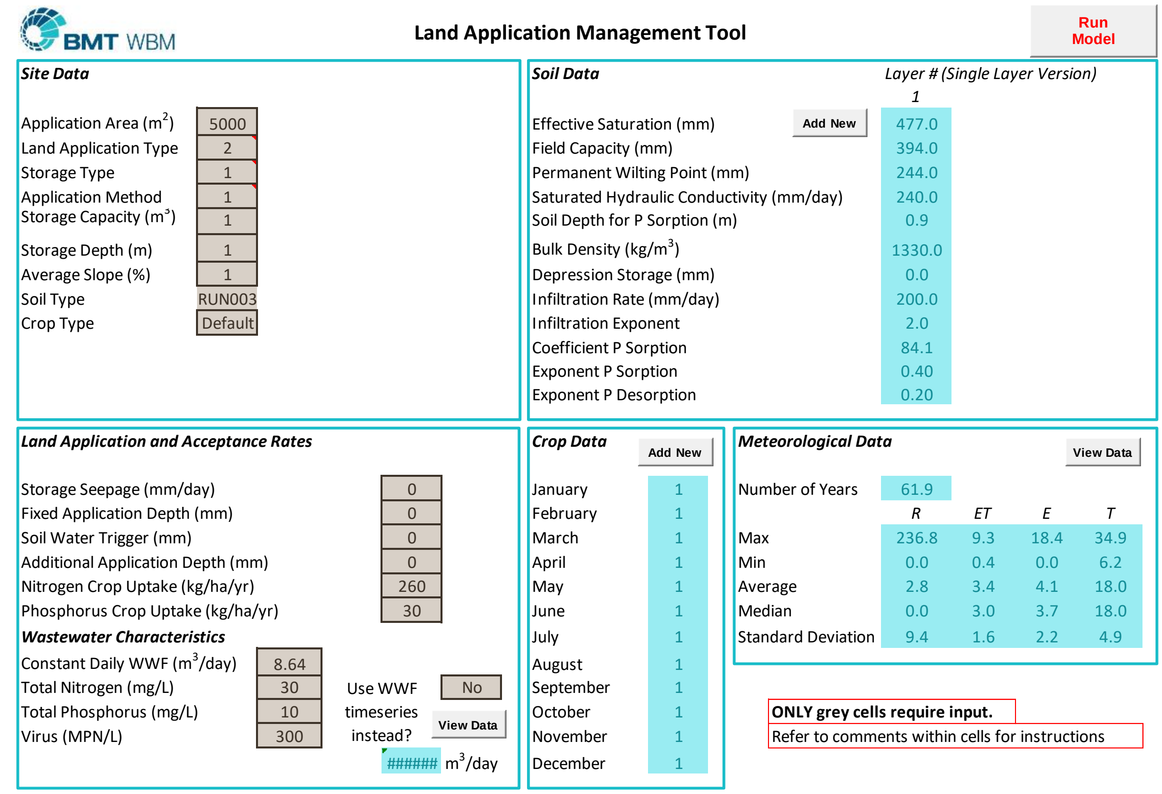


Land Application Management Tool

Summary of Results

Runoff (surcharge) frequency	**0.0**	days/year
Runoff (surcharge) volume	**0.0**	% of total WWF volume
Deep drainage volume	**721.9**	m3/yr
Total phosphorus load in runoff	**0.0**	kg/yr
Total nitrogen load in runoff	**0.0**	kg/yr
Total phosphorus load in deep drainage	**3.9**	kg/yr
PO4 concentration in deep drainage	**2.0**	g/cub.m
Total nitrogen load in deep drainage	**0.1**	kg/yr
NO3 concentration in deep drainage	**0.1**	g/cub.m
Total site virus load	**3710692**	MPN/yr
Total site virus concentration	**5.1**	MPN/L
Total site phosphorus load	**3.9**	kg/yr
Total site nitrogen load	**0.1**	kg/yr
Storage overflow frequency	**0**	number of years
	0.0	days/year
Storage overflow volume	**0.0**	cub.m/yr
	0.0	% of total WWF volume

RUN003



Land Application Management Tool

Site Data

Application Area (m^2)	5000
Land Application Type	2
Storage Type	1
Application Method	1
Storage Capacity (m^3)	1
Storage Depth (m)	1
Average Slope (%)	1
Soil Type	RUN003
Crop Type	Default

Soil Data

	Layer # (Single Layer Version) *1*
Effective Saturation (mm)	477.0
Field Capacity (mm)	394.0
Permanent Wilting Point (mm)	244.0
Saturated Hydraulic Conductivity (mm/day)	240.0
Soil Depth for P Sorption (m)	0.9
Bulk Density (kg/m^3)	1330.0
Depression Storage (mm)	0.0
Infiltration Rate (mm/day)	200.0
Infiltration Exponent	2.0
Coefficient P Sorption	84.1
Exponent P Sorption	0.40
Exponent P Desorption	0.20

Land Application and Acceptance Rates

Storage Seepage (mm/day)	0
Fixed Application Depth (mm)	0
Soil Water Trigger (mm)	0
Additional Application Depth (mm)	0
Nitrogen Crop Uptake (kg/ha/yr)	260
Phosphorus Crop Uptake (kg/ha/yr)	30

Wastewater Characteristics

Constant Daily WWF (m^3/day)	8.64
Total Nitrogen (mg/L)	30
Total Phosphorus (mg/L)	10
Virus (MPN/L)	300

Use WWF timeseries instead? No

m^3/day

Crop Data

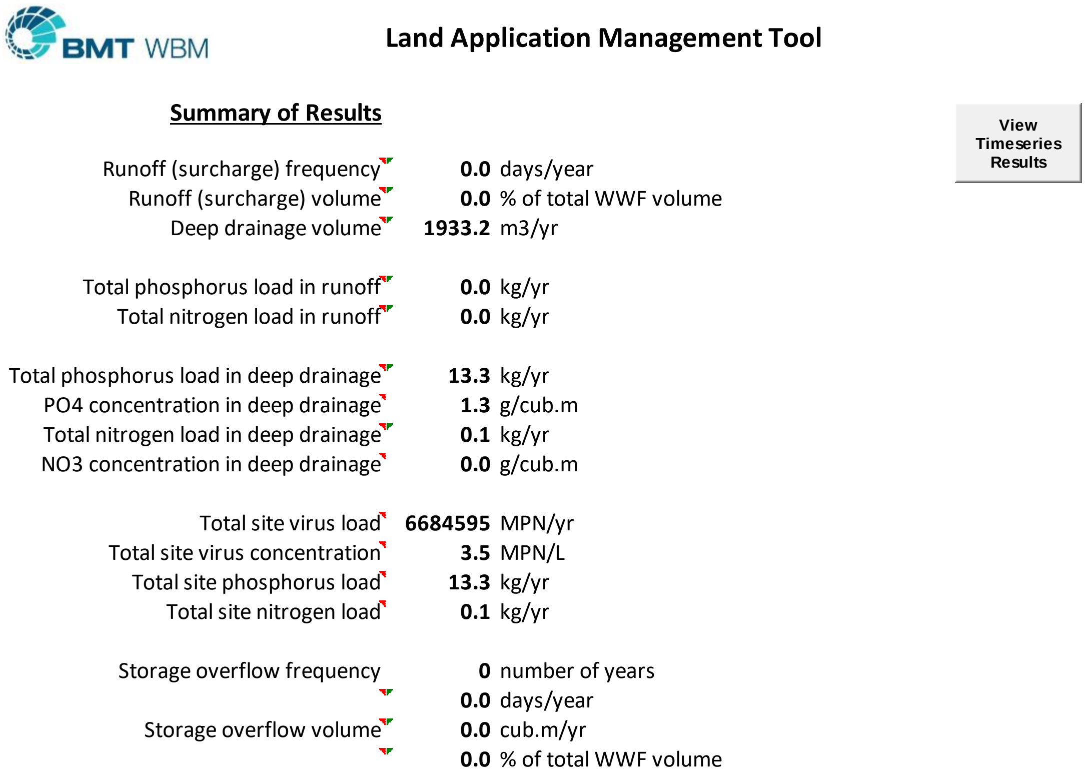
January	1
February	1
March	1
April	1
May	1
June	1
July	1
August	1
September	1
October	1
November	1
December	1

Meteorological Data

Number of Years 61.9

	R	*ET*	*E*	*T*
Max	236.8	9.3	18.4	34.9
Min	0.0	0.4	0.0	6.2
Average	2.8	3.4	4.1	18.0
Median	0.0	3.0	3.7	18.0
Standard Deviation	9.4	1.6	2.2	4.9

ONLY grey cells require input.
Refer to comments within cells for instructions

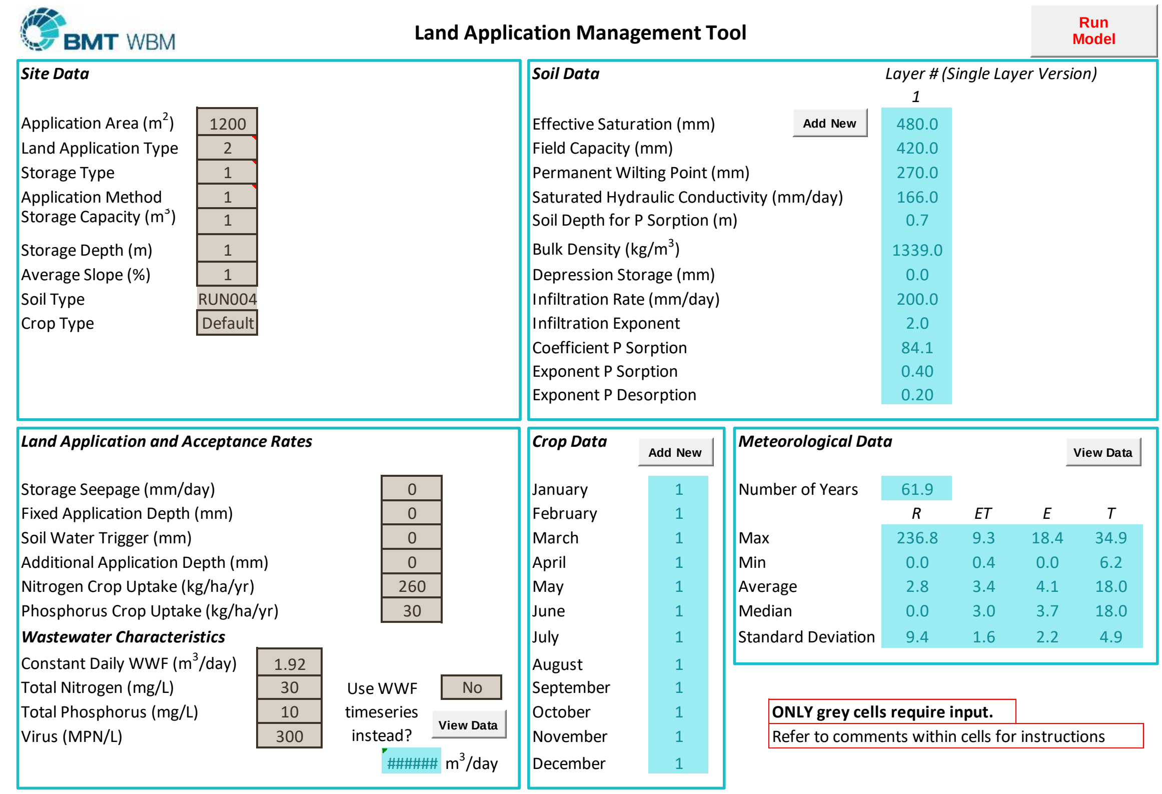


Land Application Management Tool

Summary of Results

Runoff (surcharge) frequency	**0.0**	days/year
Runoff (surcharge) volume	**0.0**	% of total WWF volume
Deep drainage volume	**1933.2**	m3/yr
Total phosphorus load in runoff	**0.0**	kg/yr
Total nitrogen load in runoff	**0.0**	kg/yr
Total phosphorus load in deep drainage	**13.3**	kg/yr
PO4 concentration in deep drainage	**1.3**	g/cub.m
Total nitrogen load in deep drainage	**0.1**	kg/yr
NO3 concentration in deep drainage	**0.0**	g/cub.m
Total site virus load	**6684595**	MPN/yr
Total site virus concentration	**3.5**	MPN/L
Total site phosphorus load	**13.3**	kg/yr
Total site nitrogen load	**0.1**	kg/yr
Storage overflow frequency	**0**	number of years
	0.0	days/year
Storage overflow volume	**0.0**	cub.m/yr
	0.0	% of total WWF volume

RUN004



Land Application Management Tool

Site Data

Application Area (m^2)	1200
Land Application Type	2
Storage Type	1
Application Method	1
Storage Capacity (m^3)	1
Storage Depth (m)	1
Average Slope (%)	1
Soil Type	RUN004
Crop Type	Default

Soil Data

	Layer # (Single Layer Version) *1*
Effective Saturation (mm)	480.0
Field Capacity (mm)	420.0
Permanent Wilting Point (mm)	270.0
Saturated Hydraulic Conductivity (mm/day)	166.0
Soil Depth for P Sorption (m)	0.7
Bulk Density (kg/m^3)	1339.0
Depression Storage (mm)	0.0
Infiltration Rate (mm/day)	200.0
Infiltration Exponent	2.0
Coefficient P Sorption	84.1
Exponent P Sorption	0.40
Exponent P Desorption	0.20

Land Application and Acceptance Rates

Storage Seepage (mm/day)	0
Fixed Application Depth (mm)	0
Soil Water Trigger (mm)	0
Additional Application Depth (mm)	0
Nitrogen Crop Uptake (kg/ha/yr)	260
Phosphorus Crop Uptake (kg/ha/yr)	30

Wastewater Characteristics

Constant Daily WWF (m^3/day)	1.92
Total Nitrogen (mg/L)	30
Total Phosphorus (mg/L)	10
Virus (MPN/L)	300

Use WWF timeseries instead? No

m^3/day

Crop Data

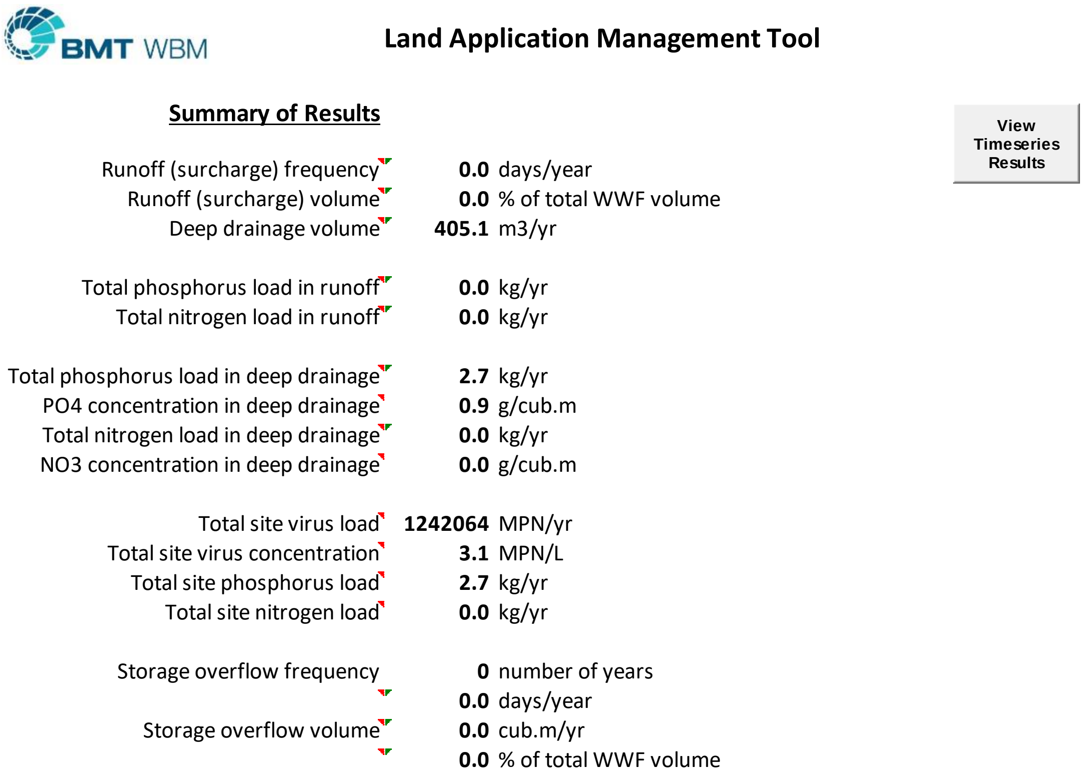
January	1
February	1
March	1
April	1
May	1
June	1
July	1
August	1
September	1
October	1
November	1
December	1

Meteorological Data

Number of Years 61.9

	R	*ET*	*E*	*T*
Max	236.8	9.3	18.4	34.9
Min	0.0	0.4	0.0	6.2
Average	2.8	3.4	4.1	18.0
Median	0.0	3.0	3.7	18.0
Standard Deviation	9.4	1.6	2.2	4.9

ONLY grey cells require input.
Refer to comments within cells for instructions

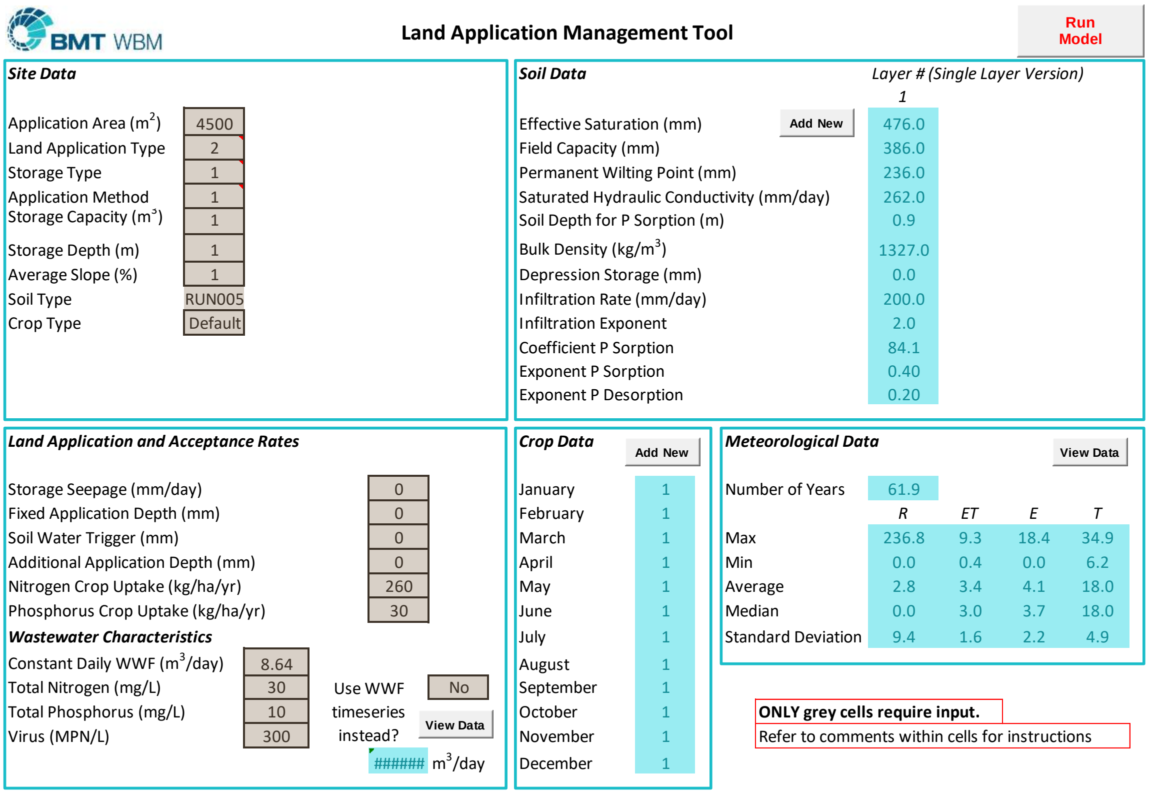


Land Application Management Tool

Summary of Results

Runoff (surcharge) frequency	**0.0** days/year
Runoff (surcharge) volume	**0.0** % of total WWF volume
Deep drainage volume	**405.1** m3/yr
Total phosphorus load in runoff	**0.0** kg/yr
Total nitrogen load in runoff	**0.0** kg/yr
Total phosphorus load in deep drainage	**2.7** kg/yr
PO4 concentration in deep drainage	**0.9** g/cub.m
Total nitrogen load in deep drainage	**0.0** kg/yr
NO3 concentration in deep drainage	**0.0** g/cub.m
Total site virus load	**1242064** MPN/yr
Total site virus concentration	**3.1** MPN/L
Total site phosphorus load	**2.7** kg/yr
Total site nitrogen load	**0.0** kg/yr
Storage overflow frequency	**0** number of years
	0.0 days/year
Storage overflow volume	**0.0** cub.m/yr
	0.0 % of total WWF volume

RUN005



Land Application Management Tool

Site Data

Application Area (m^2)	4500
Land Application Type	2
Storage Type	1
Application Method	1
Storage Capacity (m^3)	1
Storage Depth (m)	1
Average Slope (%)	1
Soil Type	RUN005
Crop Type	Default

Soil Data

	Layer # (Single Layer Version) *1*
Effective Saturation (mm)	476.0
Field Capacity (mm)	386.0
Permanent Wilting Point (mm)	236.0
Saturated Hydraulic Conductivity (mm/day)	262.0
Soil Depth for P Sorption (m)	0.9
Bulk Density (kg/m^3)	1327.0
Depression Storage (mm)	0.0
Infiltration Rate (mm/day)	200.0
Infiltration Exponent	2.0
Coefficient P Sorption	84.1
Exponent P Sorption	0.40
Exponent P Desorption	0.20

Land Application and Acceptance Rates

Storage Seepage (mm/day)	0
Fixed Application Depth (mm)	0
Soil Water Trigger (mm)	0
Additional Application Depth (mm)	0
Nitrogen Crop Uptake (kg/ha/yr)	260
Phosphorus Crop Uptake (kg/ha/yr)	30

Wastewater Characteristics

Constant Daily WWF (m^3/day)	8.64
Total Nitrogen (mg/L)	30
Total Phosphorus (mg/L)	10
Virus (MPN/L)	300

Use WWF timeseries instead? No

m^3/day

Crop Data

January	1
February	1
March	1
April	1
May	1
June	1
July	1
August	1
September	1
October	1
November	1
December	1

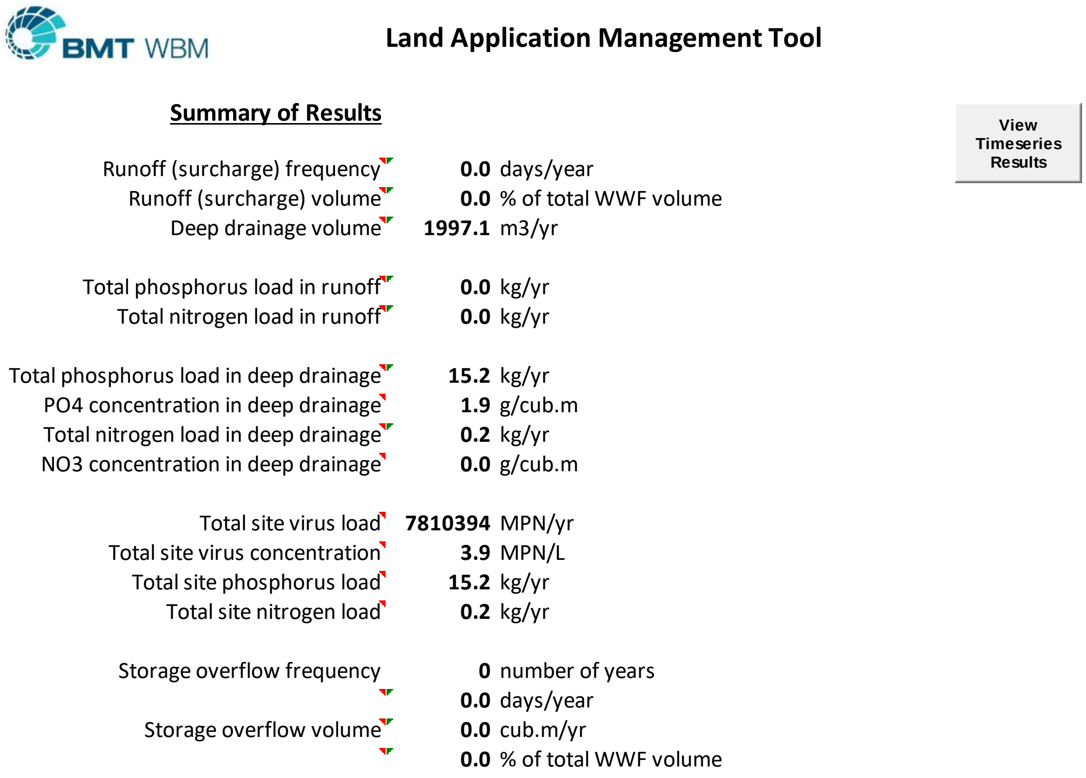
Meteorological Data

Number of Years 61.9

	R	*ET*	*E*	*T*
Max	236.8	9.3	18.4	34.9
Min	0.0	0.4	0.0	6.2
Average	2.8	3.4	4.1	18.0
Median	0.0	3.0	3.7	18.0
Standard Deviation	9.4	1.6	2.2	4.9

ONLY grey cells require input.

Refer to comments within cells for instructions



Land Application Management Tool

Summary of Results

Runoff (surcharge) frequency	**0.0**	days/year
Runoff (surcharge) volume	**0.0**	% of total WWF volume
Deep drainage volume	**1997.1**	m3/yr
Total phosphorus load in runoff	**0.0**	kg/yr
Total nitrogen load in runoff	**0.0**	kg/yr
Total phosphorus load in deep drainage	**15.2**	kg/yr
PO4 concentration in deep drainage	**1.9**	g/cub.m
Total nitrogen load in deep drainage	**0.2**	kg/yr
NO3 concentration in deep drainage	**0.0**	g/cub.m
Total site virus load	**7810394**	MPN/yr
Total site virus concentration	**3.9**	MPN/L
Total site phosphorus load	**15.2**	kg/yr
Total site nitrogen load	**0.2**	kg/yr
Storage overflow frequency	**0**	number of years
	0.0	days/year
Storage overflow volume	**0.0**	cub.m/yr
	0.0	% of total WWF volume

Appendix E

General Notes

Soil Physical Properties / Chemistry

pH

This test is used to determine the acidity or alkalinity of native soils. pH is measured on a scale of 0 to 14, with 7 being neutral. Results below 7 are considered acid, while those above 7 are alkaline. For land application of effluent, soil with a pH of 4.5 to 8.5 should typically pose no constraints. Soil pH affects the solubility and fixation of some nutrients; this in turn reduces soil fertility and plant growth. By correcting soil pH beneficial plant growth is improved, assisting in the assimilation of nutrient and improving evapotranspiration of effluent. Most Australian soils are naturally acidic.

Electrical Conductivity

Electrical conductivity (EC) is a measure of a soil or soil/water extracts ability to conduct an electrical current. It is used as an indirect measure of a soil's accumulation of water-soluble salts, mainly of sodium, with minor potassium, calcium and magnesium. High EC within a land application area reflects general soil salinity and is undesirable for vegetation growth. The tolerance of vegetation species to soil salinity varies among plant types. Typically, EC readings of <4dS/m pose no constraints. There are a number of measures available to counter high soil EC values for land application of effluent; however, the most important measure relates to the conservative selection of application rates and appropriate application area sizing.

Emerson Aggregate Test

The Emerson Aggregate Test (EAT) is a measure of soil dispersibility and susceptibility to erosion and structural degradation. It assesses the physical changes that occur in a single ped of soil when immersed in water, specifically whether the soil slakes and falls apart or disperses and clouds the water. Dispersive soils pose limitations to on-site sewage management because of the potential loss of soil structure when effluent is applied. Soil pores can become smaller or completely blocked, causing a decrease in soil permeability, which can lead to system failure.

Cation Exchange Capacity

The cation exchange capacity (CEC) is the capacity of the soil to hold and exchange cations (positively charged molecules). Because some soils have a dominant negative charge, they can adsorb cations. Soils bind cations such as calcium, magnesium, potassium and sodium, preventing them from being leached from the soil profile and making them available as plant nutrients. CEC is a major controlling agent for soil structural stability, nutrient availability for plants and the soils' reaction to fertilisers and other ameliorants. A CEC of greater than 15 cmol+/kg or me/100g is recommended for land application systems. Adding organic matter (compost/humus) to soil can greatly increase its CEC.

Exchangeable Sodium Percentage

The exchangeable sodium percentage (ESP) is an important indicator of soil sodicity, which affects soil structural stability and overall susceptibility to dispersion. Sodic soils tend to have a low infiltration capability, low hydraulic conductivity, and a high susceptibility to erosion. When sodium dominates the exchangeable cation complex, soil structural stability declines significantly. Soil ESP is considered acceptable for effluent application areas when it is below 5%, marginal between 5% – 10% and limiting >10%. The ESP of application area soils can be improved by the measured application of calcium (lime/gypsum).

Phosphorus Sorption Capacity

Phosphorus sorption (P-sorption) capacity is a direct measure of a soils ability to adsorb phosphorus. Phosphorus is an important plant nutrient and is the limiting available nutrient in many aquatic environments. Excess phosphorus can increase the production of nuisance vegetative growth such as algae. The P-sorption capacity of the soil in an effluent application area relates to its ability to assimilate the phosphorus in the wastewater for the design life of the application area. P-sorption values greater than 400mg/kg is considered acceptable for land application of effluent, while values below 150mg/kg present a constraint.