LORD HOWE ISLAND BOARD

On-Site Wastewater Management

Strategy

DESIGN GUIDELINES

December 2015

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1 Introduction

The Lord Howe Island Board (the Board) has identified sustainable on-site wastewater treatment with irrigation of secondary treated, disinfected effluent as their preferred wastewater management strategy for the Island. The aims and objectives of this Strategy have been documented in the Lord Howe Island On-site Wastewater Management Strategy (2015).

These Design Guidelines outline the considerations for selecting, designing and positioning on-site sewage systems on Lord Howe Island.

The considerations fall into two categories – general considerations to be undertaken by the Board on behalf of all residents and considerations for individual Leaseholds.

1.1 Considerations for the Board

The following activities, to be undertaken by the Board, will have a significant impact in reducing risks associated with the management of effluent on-site on an 'Island wide' basis.

1. Instigate an application and approval process for installation of, or upgrades to, on-site sewage systems.
2. For residential/domestic systems, mandate the use of on-site treatment systems that have been accredited by NSW Health, except where exemptions are provided by NSW Health.
3. Ensure that a pump-out vehicle is available to remove effluent or sewage from individual Leaseholds where not doing so has the potential to cause health or environmental harm.
4. Consider the impact of any proposals for significant population growth (including tourists) on the sustainability of Island wide on-site treatment of sewage.
5. Encourage detergents containing low levels of phosphorus and sodium chloride.
6. Encourage all landholders to not use fertilisers or other chemicals within treated effluent irrigation areas.
7. Encourage use of locally made fertilisers in non-effluent irrigation areas.
8. Encourage local food production thereby minimising the importation of additional nitrogen and phosphorus in food to the Island.
9. Where required and feasible, make available land for sustainable irrigation of treated effluent.

1.2 General considerations for Leaseholders

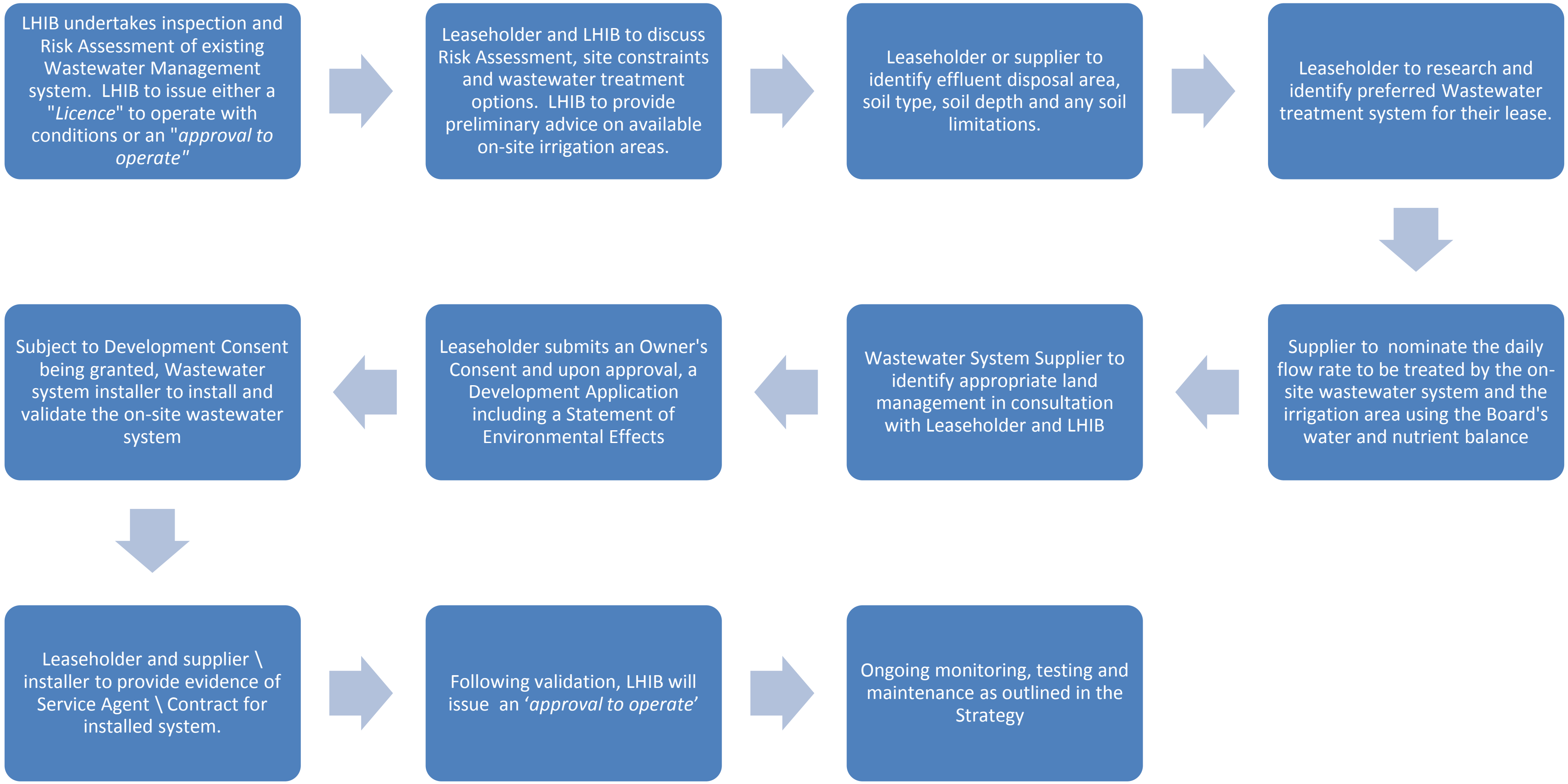
1. Leaseholders will be required to have access to an irrigation area that can be used for the sustainable irrigation of treated effluent.
2. Leaseholders will be required to confirm with the Board, the soil type(s) within their proposed irrigation area.
3. Subsurface drip irrigation is the preferred option for land application of treated effluent. Where Significant Native Vegetation, or other vegetation, prevents the installation of subsurface drip irrigation, surface drip irrigation should be installed.
4. A 20 metre buffer must occur between irrigation areas and residences on an adjacent block unless there is an agreement with affected Leaseholders.
5. Any irrigation system should be at least 35 metres from a perennially flowing water course.
6. Any irrigation system should be at least 20 metres from non-permanent water ways (drainage channels, gullies etc).
7. Where possible, irrigation of designated Significant Native Vegetation or habitat should be avoided. Irrigation in Significant Native Vegetation is considered a last resort and is subject to rigorous analysis as part of the planning process.

8. All irrigation systems will be sized using the Board’s water and nutrient balance, where possible, to avoid the requirement for wet weather storage.

1.3 Upgrade Process

Figure 1 below outlines the procedure for Leaseholders to upgrade on-site wastewater systems. Some on-site wastewater systems may be exempt from the requirement to submit a Development Consent application.

Figure 1: Process Flowchart for wastewater system upgrade



2 Approval process

2.1 Special requirements for commercial properties and domestic situations treating more than 2000L per day

For Commercial properties and in domestic situations where one wastewater treatment system is required to treat more than 2,000L of effluent per day, an appropriately qualified wastewater system designer is to be engaged to design a treatment system appropriate to meet the requirements of the Strategy. This document can be used to assist the wastewater system designer with designing an on-site wastewater system and irrigation area.

2.2 Pre DA meeting with the Board

Before an application is made, the Leaseholder should hold discussions with Board staff regarding planning, environmental, heritage and system design issues. The Leaseholder should discuss with the Board their existing wastewater system, site constraints, potential effluent disposal areas and seek clarification on what they need to do to ensure their system is upgraded to meet the requirements of the Strategy.

The Board can provide each Leaseholder with a map of their lease showing areas where treated effluent irrigation will not be permitted or will be difficult to achieve.

2.2.1 Information to be collected by the Leaseholder before an application is made

Initially the Board's Leasehold maps can be used as a guide to determine which soil type is likely to occur on particular Leaseholds as described in the preceding section.

The Board will provide a set of GIS generated plans which identify the lease and any buildings upon it. The plans will also show details of the soils and any constraints to land application of treated effluent. Land falling outside of the relevant buffers will then potentially be available for land application.

It is essential to confirm the soil type and determine the presence of groundwater or indurated (hard) layers by digging or augering a test pit to a depth greater than 1m. A sample of soil(s) is to be provided to the Board for all soil types within the proposed irrigation area.

The depth to groundwater will vary depending on seasonal conditions and there is a need to ascertain the maximum seasonal water table. Seasonal water tables or restricted drainage will be characterised by mottling and dark colourations that reflect low oxygen environments.

2.2.2 Flow rate scenarios

Each Leaseholder will need to consider their likely daily treated effluent flow rate.

The design wastewater flow is determined for residential properties by a flow allowance of 120 litres/person/day based on occupancy. Occupancy is calculated by assuming two persons for the first bedroom and one for each subsequent bedroom.

Commercial properties will be required to justify their flow estimates. These will be based on licenced occupancy rates and established guidelines such as AS/NZS1547:2012 and will make due consideration for the hydraulic and organic loads generated by commercial kitchens. Wastewater treatment systems must demonstrate capacity to manage peak flows.

Where there is a high degree of variability in flow rate, consideration will be given to designs which incorporate flow balancing before treatment and/or land application.

Utilising the data available in AS/NZS 1547:2012, combined with consultation from industry experts and historical use data for Lord Howe Island, the Board has set definitive wastewater design flows for commercial systems. These values are at Appendix 2: Commercial Wastewater Design Flows. Any departure from the above basis for calculation of daily design wastewater flows would need to be supported by flow meter data for a minimum of 3 months over the peak tourist season.

2.2.3 Using the water and nutrient balance to size land application areas

The Board has developed a water and nutrient balance to assist with sizing of land application areas. The water and nutrient balance is based on established principles as outlined in AS/NZS 1547:2012 On-site Domestic Wastewater Management.

2.3 Application for approval to install or upgrade

In assessing the application to install an on-site wastewater system, the Board will make a determination as to the viability of the proposal with regard to:

- System design and site suitability;
- Cumulative public health and environmental impacts within the area or wider catchment; and
- Expectations for future development in the area.

Requirements for an application are shown in the Board's *Onsite Wastewater Management Strategy - Checklist for Applicants* available on the Board's website. In addition, the following information should be included:

- Plan and Lot number of Lease(s)
- Number of dwellings to be serviced by the system
- If Commercial, number of beds or restaurant / cafe seats occupied in peak season and in 'low season' and the operating period
- Provide sample of soil from 1m to 1.5 metres deep. The depth of any impediment (water table, bleached or mottled sand, heavy clay or indurated rock) to be recorded
- Describe use of irrigation area (e.g. turf, garden beds, grazing lands, palm plantations, re-establishment native vegetation)
- Detail the verification program undertaken by the manufacturer off-site as well as tests that will be undertaken on-site to demonstrate the system is operating to specification
- Detail the maintenance program recommended by the manufacturer and as required by the Strategy
- Describe the proposed monitoring in line with the Strategy

2.4 Installation and Validation of new or upgraded wastewater treatment systems

Following Development Consent, and the issuing of an "Approval to Operate without a Licence", the Leaseholder will be required to show evidence that their system is working according to the manufacturer's claims and the requirements of the Strategy with regard to effluent quality.

The supplier or installer must validate all components of the process, such as treatment technology, balancing tanks, storages, any on-line monitoring, disinfection and the irrigation system.

2.4.1 Validation of the sewage treatment system

Domestic Systems

Because of the difficulties of validating sewage treatment systems on the Island, in most cases, Leaseholders will select a system that has been validated by the manufacturer elsewhere and has thus gained NSW Health accreditation

New systems will be tested periodically to confirm compliance with the Strategy.

For NSW Health accredited systems, testing will be based around the number of new or upgraded domestic systems installed by each supplier per calendar year. For each supplier, a minimum of 1 system / year or 10% of installed systems (whichever is greater), will be required to be tested on a quarterly basis as per Table 5.2.1 of the Strategy for the first 12 months of operation at the supplier's cost. The system(s) tested for each supplier will be selected by the LHIB. If, the testing results for the system(s) meet the criteria, no further testing will be required for that batch of installations for that supplier. If the testing results for 1 or more system(s) fails to meet the criteria for the first 2 quarters, all installed systems for that 12 month period will then need to be tested quarterly for a 12 month period or until the testing results for the system(s) demonstrate compliance with Table 5.2.1. These testing arrangements will continue until all domestic systems have been upgraded.

Where, a non-accredited domestic/residential system has been approved as outlined in Section 4.4 of the Strategy, the system will be required to be tested on a quarterly basis as per Table 5.2.1 of the Strategy for the first 12 months of operation at the Leaseholder's cost. If, the testing results for the system meet the criteria, no further testing will be required for that installation. If the testing results fail to meet the criteria for the first 2 quarters, appropriate rectification, upgrade or replacement of the system will be required and the system will then need to be tested quarterly for a further 12 month period to show that the testing results for the system demonstrate compliance with Table 5.2.1.

Commercial Systems

For commercial systems designed to meet Table 5.2.2, 5.2.3 or 5.2.4 of the Strategy, the system designer needs to develop a validation and verification schedule that will demonstrate to the satisfaction of the Board the proposed system meets the requirements of the Strategy.

Where validation occurs off-site, the test treatment system must be the same as the system proposed and the influent treated by the validation process of equivalent quality to the proposed influent. Nonetheless, some validation tests should be undertaken on site once the unit is installed.

Specification of the operating range and critical limits for each variable of the wastewater treatment process (e.g. flow rate, pressure, chlorine residual, etc.) that will produce treated effluent of sufficient quality to meet the effluent treatment standards, is required to be tested and confirmed during the verification period. The nitrogen and phosphorus content is also required to be established.

Whether or not validation tests are taken off-site or on-site, appropriately trained personnel should collect all water quality samples from the sewage treatment system. A laboratory accredited for the specified tests by an independent body acceptable to NSW Health, such as the National Association of Testing Authorities (NATA) or equivalent, are to carry out manufacturer's analyses.

Test results consistent with the effluent treatment standards in the Strategy should be produced for a continuous, minimum period of four (4) weeks to be considered validated.

Where sample results are collected from an online sampler, a schedule of online calibrations shall be developed and records of the online calibrations shall be maintained.

It is acknowledged that the treated effluent that fails a validation test during its initial operation will still need to be irrigated as there are no alternative disposal options available on the Island. However approval for a system that is not operating properly will not be given by the Board until the system is validated.

2.4.2 Validation of the irrigation system

Similarly, the irrigation system must demonstrate that it is capable of achieving an even distribution of treated effluent over the required area.

When installing subsurface systems, advice should be sought from the manufacturer on how to verify and maintain these to ensure even distribution and avoidance of blockages. The Board is to be provided with an opportunity to verify the irrigation area's operation before it is covered over.

2.4.3 Back-flow prevention

Where there is concurrent potable water supply to the recycled water scheme (e.g. where recycled water is used for toilet flushing), there is a requirement to install testable double check backflow prevention devices on water and wastewater connections of the property with the recycled water system. In this case recycled water shall not be provided for end use until a licensed plumber with accreditation in backflow testing and maintenance, has verified there are no cross-connections at that point in time.

2.5 Approval

Following the validation process, results showing that the system is operating as described in the application process are to be given to the Board for review and consideration. If the system is operating in compliance with the Strategy, the LHIB will issue an "*Approval to operate without a licence*". If the system does not meet the requirements of the Strategy the LHIB will issue a "*licence to operate a wastewater system*" with conditions.

The conditions of the Licence will reflect the Board's consideration of the risks posed by the system on the site. For example, on-site wastewater systems with irrigation in close proximity to shallow water tables or neighbouring residences may require a more extensive monitoring program than described below with results regularly reported to the Board.

2.6 Ongoing monitoring to determine the success of the on-site Strategy

The following Table (Table 2) illustrates day to day measurements that can be taken and the management response if limits are exceeded. These are provided for guidance of system owners and operators. Proactive management of systems is most likely to minimise operational problems, but equally prompt reaction to problems as they are identified minimises the likelihood of adverse environmental or public health impacts. These are also aspects of systems which the Board expects system owners and operators to demonstrate are managed effectively and which system owners and operators can expect the Board to monitor and inspect periodically.

Table 2: Available critical control points that can be measured on Wastewater Management Systems

Item to be measured	Frequency	Critical limits	Management responses to significant exceedances
Total flow rate - Commercial systems	Daily for first 3 months then weekly	As defined by the capability of the selected on-site system	Effluent quality testing to determine whether guidelines still being met. If not upgrade of treatment system will be required
Variability in flow rate - Commercial systems	Daily for first 3 months then weekly	As above	As above
Irrigation area condition	Daily during 1 Nov to 30 April, then weekly	No water logging or flooding	If waterlogged increase or temporarily change the location of the irrigation area. If site is waterlogged, any available storage is full and there are no alternative irrigation sites pumping out of the storage may be required.
	Daily during 1 Nov to 30 April, then weekly	No localised water logging	Check operation of irrigation system and rectify
Effluent quality	During validation period then quarterly - commercial and three yearly - domestic	Limits defined for pH, SS, BOD, TDS, total N and total P, E.coli	Investigate cause and remedy by qualified expert
	Daily	Acceptable odour	Engage a suitable qualified contractor to identify and rectify cause of odour

3 Effluent Reuse by land irrigation

3.1 Hydraulic Loading

The amount of liquid applied to the disposal area must not be greater than the area's capability to handle the water. To ensure that the disposal site is not overloaded, resulting in ponding on the surface or short circuiting with concentrated flows, particularly relevant in sandy soils, the Board's water and nutrient balances (Appendix 1) should be used for land application area sizing. Water and nutrient balances have been undertaken on soil types from the three dominant geologies on the Island – sands, calcareous earths formed from Ned's Beach Calcarenite, and volcanic soils. The water balance shows that typical residential Leaseholds will require between approximately 250 and 600 square metres of irrigation land and that in some locations, particularly on sandy soils, a wastewater treatment system which requires significant nutrient removal will be required to comply with the Strategy.

3.2 Nutrient Loading

Treated effluent (irrespective of treatment technology) contains concentrations of nitrogen and phosphorus that could adversely impact on local ground and surface waters and native eco-systems if simply discharged to an absorption trench or water body. Irrigation of vegetation (that uses these nutrients for plant growth) provides a mechanism for removal of these nutrients to acceptable levels. However, the irrigation scheme must be designed so that the amount of nutrient applied is less than or equal to the amount taken up by the growing plants and assimilated by the soil. The management of vegetation is also critical. For example, by mowing lawns without clippings removal, or grazing animals that excrete the nutrients back to the environment, means that the nutrients are recycled within the irrigation area increasing the load. Nonetheless, even if there is total recycling of the plant there is still some loss of nutrients. Some nitrogen is lost through nitrification by soil organisms. Phosphorus becomes absorbed (immobilised) by reactive clay particles in the soil.

3.3 Irrigation systems

3.3.1 Sub-Surface and drip irrigation

All treatment systems must achieve secondary treatment standard with disinfection.

The **pump** (or dosing siphon) is to be large enough to handle the design irrigation flow rates. A minimum dose of 200L, or three times the fill volume of the lines (whichever is the greater), is recommended. All irrigation systems must incorporate an adequate level of hydraulic design to demonstrate that even distribution can be achieved. Where irrigation areas exceed 400 square metres in area, they should be divided into zones, each of which should not exceed 400 square metres and distribution should be sequentially to each zone using a sequencing valve. This should ensure that the capacity of the pump to deliver even distribution is not exceeded.

Irrigation lines are to be **purple** in colour and designed to deliver an **even flow** over the entire application area. Irrigation lines should be pressure compensating and able to **regulate the flow** from each emitter, particularly if installed on sloping ground.

Irrigation lines need to be **maintained** to ensure that they do not clog. When used in garden beds care must be taken not to cut the lines with garden implements. In this case they must be repaired immediately.

If chlorine is used as the disinfecting agent it will assist in keeping the lines clear. A **filter** should be installed after the pump to ensure that fines do not block the emitters. A **root inhibitor** is recommended to stop roots entering the emitters.

All irrigation systems should incorporate a **flushing mechanism**. The flushing valve should be set up so that the whole line can be flushed. Flushing valves can be operated manually during inspections or automatic valves can be installed. These valves flush the line every time the pump starts.

3.3.1.1 Subsurface

In turf, the treated effluent is irrigated through perforated pipes spaced 500 to 800 mm apart and covered by up to 150mm of topsoil. Effluent is applied in regular pulses along the root zone of plants. Sub-surface systems should not be located too close to building foundations as water logging and chemicals in the effluent may corrode some types of building materials.

3.3.1.2 Drip irrigation

Surface drip irrigation is to be utilised in areas where installation of subsurface irrigation lines has the potential to cause damage to Significant Native Vegetation or other vegetation.

4 Pumps and Dosing Siphons

In the treatment and irrigation of wastewater pumps are often required to transfer the effluent from one area to another, and to deliver effluent to the irrigation area.

It is important that the **correct pump** is selected. Pumps need to be carefully selected to ensure even distribution of effluent to the irrigation area(s). It is imperative that pumps are hydraulically matched to the requirements of the irrigation area(s) they serve. Pumps must be able to deliver at the required flow rate and pressure to ensure even distribution. A common failing of domestic on-site wastewater systems is poor matching of pumps to the requirements of irrigation systems.

Similarly, the pump out chamber prior to irrigation should be sized to deliver a volume of at least **three times the pipe volume** or a **minimum of 200 litres** (whichever is the greater).

Note that this volume is the **operating volume**, between the top water level and the bottom water level, NOT the total volume of the chamber.

Maintenance on pumps will be required. Suppliers and service agents should coordinate as much as possible to ensure the pump provided can be serviced on the Island and / or adequate supplies of replacements are available quickly if required.

Dosing Siphons can be used as an alternative to pumps if there is sufficient fall between the collection tank and the delivery area. A dosing siphon requires **no power** to operate. Siphons are well suited for distributing water to sand and peat filters.

Dosing siphons cannot generally adequately dose irrigation lines.

Appendix 1: Guidance on System Design and Sizing

Following review of a number of both residential and commercial on-site wastewater system designs for the Lord Howe Island Board in 2014, it has become apparent that problems exist in determining a standardised basis for land application area sizing which results in acceptable outcomes for Leaseholders and the Board.

Over the period of 2014, in collaboration with Board staff and with some input from some system suppliers a standardised approach to water and nutrient balance sizing has evolved.

This approach is outlined in the attached water and nutrient balance spreadsheet.

The spreadsheet is used by the Board to size land application areas or check land application area sizes. To minimise time spent with system suppliers in establishing minimum acceptable land application area sizes, the Board may use the spreadsheet to define the minimum acceptable area for individual properties.

To assist with system sizing using the water and nutrient balance a series of tables are presented below to show the water and nutrient (nitrogen and phosphorus) requirements for irrigation areas based on typical house sizes of 4, 3 and 2 bedrooms, on each of the three soil types; sand, calcareous earth and volcanic soil and typical vegetation types; kikuyu and significant native vegetation/tropical rainforest/kentia palm plantation.

The individual elements and inputs to the spreadsheet are described below:

Water Balance

The water balance establishes the minimum area required for sustainable management of the hydraulic component of the treated effluent.

Occupancy

For all residential properties the basis of occupancy is the number of bedrooms + 1.

Design flow

The design flow for all residential properties is 120L/person/day.

For non-residential commercial premises, flow allowances may be determined on the basis of other established guidelines such as AS/NZS1547:2012. See Appendix 2: Commercial Wastewater Design Flows for LHIB set commercial flow rate values.

At commercial properties, where there is a variable pattern of wastewater generation it is expected that the wastewater system will have the capacity to treat the peak load to the appropriate standard. The Board will give appropriate consideration to systems designed to treat variable loads only where suitably sized flow balancing has been incorporated into the design prior to treatment and/or land application.

For any departure from the above basis of hydraulic load calculation to be considered, flow meter records of actual wastewater generation over a minimum of a full twelve month period would be required.

Daily Design Percolation Rate

The Daily Design Percolation Rate, appropriate for subsurface or surface drip irrigation of secondary treated effluent, is based on soil type.

Three main soil types are identified on Lord Howe Island and Daily Design Percolation Rates are based on their respective hydraulic conductivities as follows:

Sand:	5.0 mm/day
Calcareous earth:	4.0 mm/day
Volcanic soils:	3.0 mm/day

Effective Rainfall/Rainfall Runoff Coefficient

Effective Rainfall/Rainfall Runoff Coefficient is the proportion of rainfall that remains on-site and infiltrates. It is a function of slope and cover, allowing for any runoff. Effective Rainfall/Rainfall Runoff Coefficients are set to correspond to soil type as follows:

Sand:	0.8
Calcareous earth:	0.75
Volcanic soils:	0.7

Crop Factor

The Crop Factor varies with season and crop type and allows for the conversion of pan evaporation to evapotranspiration. Typical values for grasses (e.g. kikuyu) vary from 0.7 to 0.8 throughout the year.

Rainfall Data

Mean monthly rainfall data, derived from Lord Howe Island Aero BoM 200839 is used in the water balance.

Evaporation Data

Mean monthly evaporation data, derived from Norfolk Island BoM 200288 is used in the water balance.
The water balance is populated with appropriate data as outlined above. The water balance automatically calculates the minimum land application area required for zero wet weather storage.

If the minimum land application area for zero wet weather storage is not available, it is possible to iterate lesser land application areas and determine the requirement for wet weather storage (the volume of storage required). It is preferable that wet weather storage not be required as wet weather storage management is challenging. Storage and soil moisture monitoring are both expensive and automation of irrigation of stored effluent is difficult. In addition, there is potential for effluent quality to deteriorate whilst stored, generating unpleasant odours and additional public health risk when it is subsequently irrigated.

Nutrient balance

The nutrient balance establishes the minimum area required for sustainable management of the nitrogen and phosphorus components of the treated effluent.

Approved secondary wastewater treatment system types

A number of secondary wastewater treatment system suppliers have been approved by the Lord Howe Island Board. The NSW Health approved secondary treatment systems supplied by these approved suppliers are listed along with effluent nutrient concentrations included in their NSW Health approval documents or otherwise considered by the Lord Howe Island Board to be appropriate for use in a nutrient balance. If specific data for a particular system is not included, the generic Secondary Treatment (AWTS) data should be used unless other validated data can be provided to the Board. The appropriate effluent nutrient concentration figures should be used as input into the nutrient balance.

Crop Nutrient Uptake

Crop nutrient uptake figures for typical vegetation types found on Lord Howe Island are listed. Appropriate crop nutrient uptake figures for both nitrogen and phosphorus, for the vegetation type in the land application area, should be used as input into the nutrient balance.

Soil Phosphorus Sorption

Soil phosphorus sorption values are listed for typical Lord Howe Island soils. These values have been derived from limited soil sampling and testing undertaken in 2014 and represent appropriate values for input into the nutrient balance in the absence of site specific data.

The values are as follows:

Sand:	170 mg/kg
Calcareous earth:	400 mg/kg
Volcanic soils:	700 mg/kg

Soil Bulk Density

Soil bulk density values are listed for typical Lord Howe Island soils. These values are appropriate for input into the nutrient balance.

The values are as follows:

Sand:	1.8 g/cm^3
Calcareous earth:	1.6 g/cm^3
Volcanic soils:	1.4 g/cm^3

Depth of Soil

Soil depths on Lord Howe Island vary. If site specific data is available it should be used, but soil depth data must be representative of the soil phosphorus sorption data used in the nutrient balance. In the absence of site specific data a depth of no greater than 0.8 metres should be used.

Percentage (%) of Predicted Phosphorus Sorption

This is a conservative estimate based on work by Geary & Gardner (1996) and Patterson (2002) and is in recognition of the various soil physical and chemical characteristics which contribute to phosphorus sorption. Values can range from a low value of 0.25 (for a soil where phosphorus sorption would be taken up less readily) to a high value of 0.75 (for a soil where phosphorus sorption would be taken up readily). It is recommended that this value be 0.5 unless there is compelling evidence to suggest otherwise.

With suitable inputs, the nutrient balance then calculates the minimum areas required for sustainable nitrogen and phosphorus assimilation, the predicted nitrogen and/or phosphorus export from the nominated land application area required for the hydraulic load (where this area is smaller than one or both of the nutrient areas), the phosphorus longevity for the land application area (target longevity is 50 years) and the minimum buffer required for excess nutrient (again where the area required for the hydraulic load is less than one or both of the nutrient areas). This latter area can be used to estimate an appropriate nutrient setback distance from a nutrient sensitive receptor (water body).

It is recommended that the maximum area required to sustainably manage the hydraulic, nitrogen or phosphorus load is considered the required area for land application and that the effluent be uniformly distributed over that area by drip irrigation.

Nominated Area Water Balance & Storage Calculations

Site Address:

OCCUPANCY

Flow Allowance	120	L/p/d
No. of bedrooms	4	
Occupancy	5	Beds + 1
Design Flow	600	L/d

SOILS

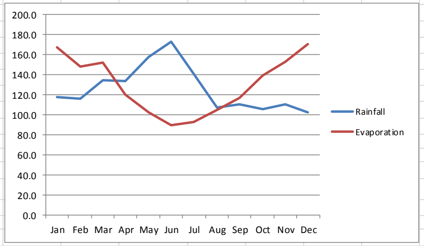
LHI Soils	Daily DPR	units	Effective rainfall	units
Sand	5.0	mm/day	0.8	number
Calcareous earth	4.0	mm/day	0.75	number
Volcanic soil	3.0	mm/day	0.7	number

INPUT DATA

Design Wastewater Flow	Q	600	L/day	
Daily Design Percolation Rate	DPR	5.0	mm/day	Equivalent to litres per m^2 per day - based on LHI Strategy for secondary effluent
Nominated Land Application Area	L	242	m^2	
Crop Factor	C	0.7-0.8	unitless	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Effective Rainfall/Runoff Coefficient	R_C	0.8	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data	Lord Howe Island Aero BoM 200839			Mean Monthly Data
Evaporation Data	Norfolk Island BoM 200288			Mean Monthly Data

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Days in month	D	\	days	31	28	31	30	31	30	31	31	30	31	30	31	**365**
Rainfall	R	\	mm/month	117.5	116.2	134.9	134.2	157.7	173.1	141.0	107.7	110.7	106.1	110.3	102.4	**1,512**
Evaporation	E	\	mm/month	167.4	148.4	151.9	120	102.3	90	93	105.4	117	139.5	153	170.5	**1,558**
Daily Evaporation			mm/day	5.4	5.3	4.9	4.0	3.3	3.0	3.0	3.4	3.9	4.5	5.1	5.5	
Crop Factor	C		unitless	0.80	0.80	0.80	0.70	0.70	0.70	0.70	0.70	0.70	0.80	0.80	0.80	
OUTPUTS																
Evapotranspiration	ET	ExC	mm/month	133.9	118.7	121.5	84.0	71.6	63.0	65.1	73.8	81.9	111.6	122.4	136.4	**1184.0**
Percolation	B	(DPR/7)xD	mm/month	155.0	140	155.0	150.0	155.0	150.0	155.0	155.0	150.0	155.0	150.0	155.0	**1825.0**
Outputs		ET+B	mm/month	288.9	258.72	276.5	234.0	226.6	213.0	220.1	228.8	231.9	266.6	272.4	291.4	**3009.0**
INPUTS																
Retained Rainfall	RR	R_C	mm/month	94	92.96	107.92	107.36	126.16	138.48	112.8	86.16	88.56	84.88	88.24	81.92	**1209.4**
Effluent Irrigation	W	(QxD)/L	mm/month	76.9	69.4	76.9	74.4	76.9	74.4	76.9	76.9	74.4	76.9	74.4	76.9	**905.0**
Inputs		RR+W	mm/month	170.9	162.4	184.8	181.7	203.0	212.9	189.7	163.0	162.9	161.7	162.6	158.8	**2114.4**
STORAGE CALCULATION																
Storage remaining from previous month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the month	S	(RR+W)-(ET+B)	mm/month	-118.1	-96.3	-91.7	-52.3	-23.6	-0.1	-30.4	-65.8	-69.0	-104.9	-109.8	-132.6	
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Maximum Storage for Nominated Area	N		mm	0.00												
	V	NxL	L	0												
LAND AREA REQUIRED FOR ZERO STORAGE			m^2	95	101	110	142	185	242	173	130	126	102	98	89	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: 242 m^2



1. Enter the property address in Cell B2.
2. For domestic premises, determine number of bedrooms and enter number in Cell P5. This will then calculate the daily design wastewater flow on the basis of occupancy of two persons for the first bedroom and one person for each subsequent bedroom. The daily hydraulic load will then be displayed in Cell Q6. This value should then be transferred to Cell C4.
3. For non-domestic premises determine the daily hydrauic load. This value should represent maximum potential occupancy and should take into consideration all possible wastewater generating activities. For non-domestic premises this value should be transferred to Cell C4.
4. Determine the soil type in the proposed land application area. Depending on the soil type, select the appropriate value for Daily Design Percolation Rate (Daily DPR) from Cells U4, U5 or U6. Enter the selected Daily DPR value in Cell C5.
5. Again depending on the soil type, select the appropriate value for Effective Rainfall (Rainfall Runoff Coefficient) from Cells W4, W5 or W6. Enter the selected Rainfall Runoff Coefficient value in Cell C8.
6. Mean monthly rainfall data for Lord Howe Island Aero and daily evaporation data for Norfolk Island are used in the water balance spreadsheet. The spreadsheet is already populated with these values.
7. The spreadsheet is also already populated with appropriate Crop Factor values used to convert Evaporation data to Evapotranspiration.
8. The spreadsheet automatically calculates the land application area required to avoid the need for wet weather storage in all months. This is the maximum value of Cells E33 to P33. This value should be inserted in Cell C6. If this area cannot be achieved, it is possible to enter lesser values in Cell C6, in which case the words "Storage Required" appear in Cell E35 and the required "wet weather" storage volume will be shown in Cell E32.

Nutrient Balance

Site Address: 0

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 443 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake				
Hydraulic Load	600	L/Day	Crop N Uptake	260	kg/ha/yr	which equals	71 mg/m^2/day
Effluent N Concentration	30	mg/L	Crop P Uptake	25	kg/ha/yr	which equals	7 mg/m^2/day
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	**Phosphorus Sorption**				
Total N Loss to Soil	3,600	mg/day	P-sorption result	170	mg/kg	which equals	2,448 kg/ha
Remaining N Load after soil loss	14,400	mg/day	Bulk Density	1.8	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	202	m^2	Nominated LAA Size	242	m^2
Phosphorus	443	m^2	Predicted N Export from LAA	-1.04	kg/year
			Predicted P Export from LAA	0.99	kg/year
			Phosphorus Longevity for LAA	19	Years
			Minimum Buffer Required for excess nutrient	201	m^2

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	242	m^2			
Daily P Load	0.006	kg/day	Phosphorus generated over life of system	109.5	kg
Daily Uptake	0.0016575	kg/day	Phosphorus vegetative uptake for life of system	0.125	kg/m^2
Measured p-sorption capacity	0.2448	kg/m^2			
Assumed p-sorption capacity	0.122	kg/m^2	Phosphorus adsorbed in 50 years	0.122	kg/m^2
Site P-sorption capacity	29.62	kg	Desired Annual P Application Rate	1.197	kg/year
			which equals	0.00328	kg/day
P-load to be sorbed	1.59	kg/year			

EFFLUENT NUTRIENT CONCENTRATION

System type	Nitrogen	Phosphorus	units
Secondary treatment (AWTS)	30	10	mg/L
Fuji Clean CE1500EX	18.11	1.33	mg/L
Fuji Clean CRX1500	8.29	0.24	mg/L
Rootzone Model 1200	20	10	mg/L

CROP NUTRIENT UPTAKE

Vegetation type	Nitrogen	Phosphorus	units
Kikuyu	260	25	kg/ha/yr
Significant natural vegetation	200	20	kg/ha/yr
Coastal rainforest	200	20	kg/ha/yr
Kentia palm plantation	200	20	kg/ha/yr

SOIL PHOSPHORUS SORPTION

LHI Soils	P-sorption	units
Sand	170	mg/kg
Calcareous earth	400	mg/kg
Volcanic soil	700	mg/kg

Based on analysis of LHI soils 2014

SOIL BULK DENSITY

LHI Soils	Bulk Density	units
Sand	1.8	g/cm^3
Calcareous earth	1.6	g/cm^3
Volcanic soil	1.4	g/cm^3

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]. Conservative estimate based on work by Geary & Gardner (1996) and Patterson (2002).

[3]. 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.

1. Select the appropriate effluent nutrient concentration for the chosen treatment system type and enter the respective values for nitrogen and phosphorus in Cells C9 and C13.
2. Select the appropriate crop nutrient uptake rates for the vegetation type in the land application area and enter the respective values for nitrogen and phosphorus in Cells G8 and G9.
3. Select the appropriate soil phosphorus sorption value for the soil type in the land application area and enter the value in Cell G11.
4. Select the appropriate soil bulk density value for the soil type in the land application area and enter the value in Cell G12.
5. Set the appropriate depth of soil in the land application area in Cell G13. It is recommended that this depth not exceed 0.8 metres unless site specific data has been obtained and the soil is of uniform character for the whole depth of the soil.
6. The minimum required land application area to meet the requirements of the water and nutrient balance is identified in Cell J4.

Irrigation area requirements (m^2) calculated by water and nutrient balance

Limiting values are highlighted in yellow

Soil type	Sand						
Vegetation type	Kikuyu						
	Water balance	Secondary treatment AWTS		Fuji Clean CE1500 EX		Rootzone Model 1200 Reed Bed	
		Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
House size							
4 bedroom	242	202	443	122	59	135	443
3 bedroom	193	162	354	98	47	108	354
2 bedroom	145	121	266	73	35	81	266

Soil type	Sand						
Vegetation type	SNV Kentia palm						
	Water balance	Secondary treatment AWTS		Fuji Clean CE1500 EX		Rootzone Model 1200 Reed Bed	
		Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
House size							
4 bedroom	242	263	492	159	65	175	492
3 bedroom	193	210	394	127	52	140	394
2 bedroom	145	158	295	95	39	105	295

Soil type	Calcareous earth						
Vegetation type	Kikuyu						
	Water balance	Secondary treatment AWTS		Fuji Clean CE1500 EX		Rootzone Model 1200 Reed Bed	
		Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
House size							
4 bedroom	339	202	287	122	38	135	287
3 bedroom	271	162	230	98	31	108	230
2 bedroom	203	121	172	73	23	81	172

Soil type	Calcareous earth						
Vegetation type	SNV Kentia palm						
	Water balance	Secondary treatment AWTS		Fuji Clean CE1500 EX		Rootzone Model 1200 Reed Bed	
		Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
House size							
4 bedroom	339	263	308	159	41	175	308
3 bedroom	271	210	246	127	33	140	246
2 bedroom	203	158	185	95	25	105	185

Soil type	Volcanic soil						
Vegetation type	Kikuyu						
	Water balance	Secondary treatment AWTS		Fuji Clean CE1500 EX		Rootzone Model 1200 Reed Bed	
		Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
House size							
4 bedroom	566	202	212	122	28	135	212
3 bedroom	452	162	169	98	23	108	169
2 bedroom	339	121	127	73	17	81	127

Soil type	Volcanic soil						
Vegetation type	SNV Kentia palm						
	Water balance	Secondary treatment AWTS		Fuji Clean CE1500 EX		Rootzone Model 1200 Reed Bed	
		Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
House size							
4 bedroom	566	263	223	159	30	175	223
3 bedroom	452	210	178	127	24	140	178
2 bedroom	339	158	134	95	18	105	134

Appendix 2: Commercial Wastewater Design Flows

The Lord Howe Island On-Site Wastewater Management Strategy December 2015 and accompanying Design Guidelines require leaseholders to calculate their daily effluent flow rate. The Australian and New Zealand Standard AS/NZS 1547:2012 has been used to determine the design flow allowance.

This standard sets the flow rate for domestic systems in Australia at 120litres/EP*/day. The standard has no definitive flow rates for commercial systems in Australia. The standard has flow rates set for New Zealand domestic and commercial systems.

Utilising the data available in the standard, combined with consultation from industry experts and historical use data for Lord Howe Island, the Lord Howe Island Board has set definitive wastewater design flows for commercial systems. These values take into consideration increased levels of laundering and the balance between the leaseholder's focus on water conservation and the generally higher usage from visitors.

Source	**Wastewater Design Flows** (L/person/day)
Accommodation Providers	
- Guests	150
- Live-in staff (fully catered for by the facility)	150
- Staff with self-contained accommodation	As per domestic
- Non-resident staff	15
Restaurants/Cafés incl. toilets (per diner per sitting)	30
Tearooms/Lunch bars/Takeaways (per customer)	
- Without restroom facilities	10
- With restroom facilities	15
Bar Trade (per customer)	20
Community Halls/Churches	
- Meetings/gatherings	10
- Banqueting	20
School (pupils plus staff)	20
Public Toilets (per person)	10
Offices, factories, shops (per staff member)	20

These flows should be used for design purposes. Any departure from the above basis for calculation of daily design wastewater flows will need to be supported by flow data for a minimum of 3 months over the peak tourist season.

*EP = Equivalent Population. This is calculated as the number of bedrooms in the house plus one for the dwelling, eg. A three bedroom house has an EP of 4.