Emirates Luxury Resort, Wolgan Valley

Water and Wastewater Master Plan

DA Issue

October, 2004

Prepared by:
Sustainable Solutions International Pty Ltd
in association with Steve Paul & Partners Pty Ltd

ABN: 78 094 501 185
Level 1, 19 Hope Street
P.O. Box 3064 South Brisbane
Queensland 4101 Australia
Ph: +61 7 3255 0000
Fax: +61 7 3255 0066
Email: office@sustainablesolutionsinternational.com

Prepared for:
Emirates Resorts and Hotels
C/-Clifton Coney Group

Quality Assurance

Revision		Author	Checked	Document Status	Amendments
No.	Date				
0	28/07/05	VT,BI	BI	D	Partial Draft Released
1	10/08/05	VT, BI	TM	D	Changes incorporated, revised rainfall data incorporated
2	16/08/05	DX, BI, VT	TM	D	Changes to section 5 and 5.1
3	17/08/05	DX, BI, VT		D	Changes to section 5 and 3 to incorporate comments from Urbis JHD
4	10/10/05	BI	BI	F	Labelled DA Issue

Document Status			
D – Draft	P – Preliminary	F – Final	A - Amended

Table of Contents

1 Introduction

1.1 Background

Sustainable Solutions International Pty. Ltd. as part of Steve Paul & Partners Pty. Ltd. have been engaged by Clifton Coney Group Pty. Ltd on behalf of Emirates Hotels and Resorts to develop a Water and Wastewater Master Plan for the proposed ecologically sustainable luxury resort development in Wolgan Valley, New South Wales.

This Water and Wastewater Master Plan report has been developed based on the preliminary design brief prepared by consultant architects Conybeare Morrison Pty. Ltd. dated ***18 July 2005***, and may be subject to minor variation as the development master plan progresses through consultation with relevant stakeholders. The report will outline the estimated water demands and wastewater generation at the resort and the preferred water supply strategy based on the available water sources at the site.

Conceptual information on the wastewater treatment plant and effluent irrigation area will also be provided to accompany the development application.

1.2 Scope

The scope of works for this Water and Wastewater Master Plan is as follows:

- Estimate water demands and wastewater generation on the site based on the various resort facilities, expected population and occupancy data;
- Evaluate potential yields and quality of all site water sources, including town water, ground water, rainwater and recycled water;
- Develop the optimal water balance for the site by matching water supply sources with water demands in the most efficient and sustainable manner;
- Estimate wastewater hydraulic and pollutant loadings for the resort;
- Size the effluent irrigation area and wet weather storage using MEDLI (Model for Effluent Disposal by Land Irrigation);
- Document effluent quality requirements based on the intended use;
- Select an appropriate wastewater treatment process(es) that can reliably achieve the required effluent quality;
- Provide a conceptual layout of the wastewater treatment plant; and
- Document the outcomes in a Water and Wastewater Master Plan report.

1.3 Emirates Resort Development Objectives

The Emirates Luxury Resort will be designed to reduce the environmental impact of its operation and provide a balance between resort user activities and its natural environment. Conybeare Morrison Pty. Ltd. (Resort Architects) documented the major design objectives in developing the resort as to:

- Showcase best practices in reducing ecological impacts by hospitality operations;
- Highlight historically relevant rural architecture while blending harmoniously with the natural environment;
- Demonstrate architecture that is timeless and will be appreciated now and in the future;
- Set the standard for luxury accommodation worldwide ;
- Induce memorable experience for the guests; and
- Make a positive impact on the visitors and the surrounding community.

1.4 Water & Wastewater Management Objectives

The following objectives have been developed for water and wastewater management at the resort and are based on the Ecological Sustainable Development goals outlined in the design brief for the resort, as well as additional objectives set by SSI.

Emirates ESD design goals:

- Manage site water to harvest and reuse rain water;
- Reduce off-site treatment of wastewater;
- Use biological waste treatment systems;
- Conserve building water– low flow toilets & automatic sensors for public lavatories;
- Maintain appropriate level of water quality on the site and in the buildings;
- Use rainwater capturing systems and grey-water recycling for irrigation; and
- Use newest methods available for sewage treatment.

SSI project specific objectives for water and wastewater management:

- Develop a reliable, safe and sustainable water supply system;
- Minimise the demand placed on the town water supply system by maximising the use of rainwater and recycled water;
- Ensure all water used on site is of appropriate quality for its intended use;
- Ensure no direct discharge of effluent to natural water bodies;
- Protect ground and surface waters, soil systems and natural vegetation from potential impacts of wastewater disposal;
- Minimise energy consumption of the scheme as a whole and in particular in wastewater treatment processes;
- Ensure there are no odour impacts on resort guests;
- Minimise the aesthetic impacts of the system;

2 Development Description

2.1 Site Description

The 1,457 hectare site is located on Wolgan Road, 35 kilometres north of Lithgow, and 3 kilometres south of Newnes. The site is located near The Greater Blue Mountains World Heritage area and is bordered by Gardens of Stone National Park, Wollemi National Park and licensed crown land, as shown in Figure 1.

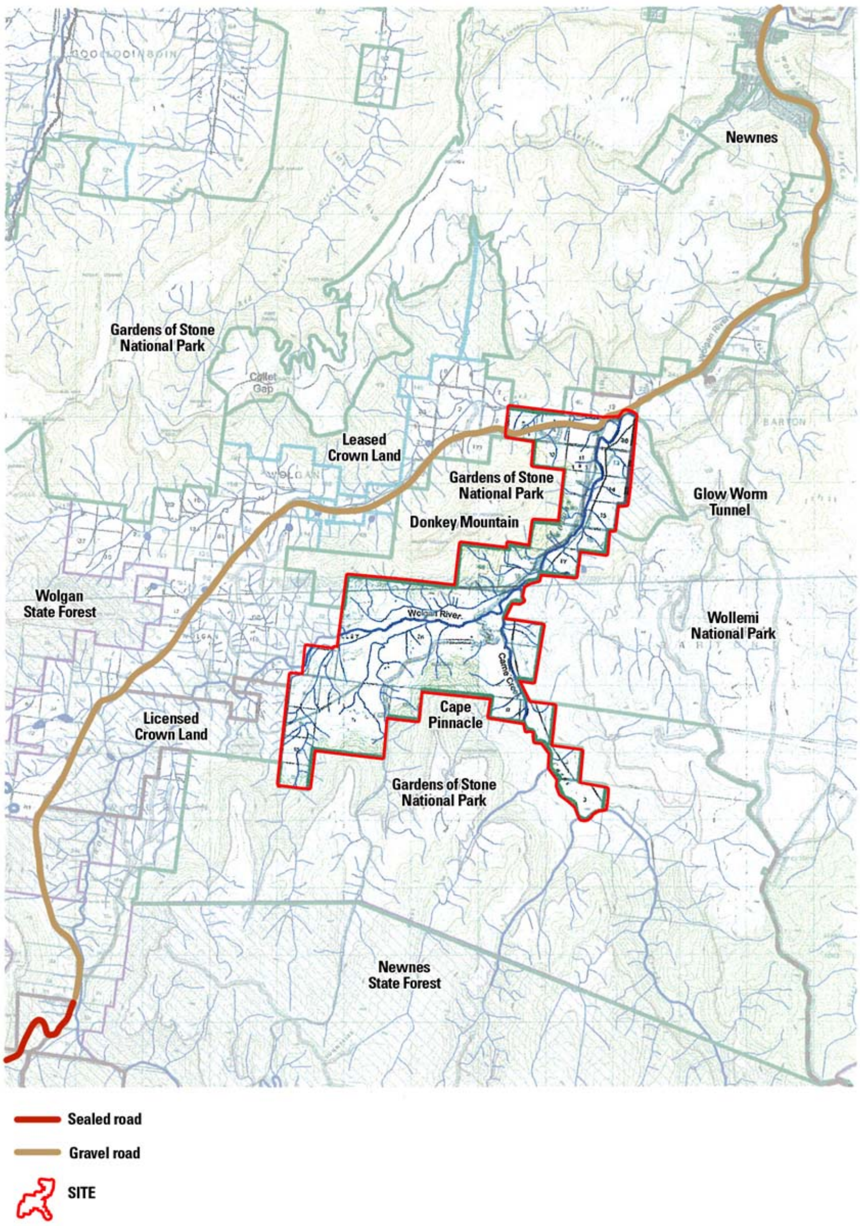


Figure 1: Locality map of proposed resort site

The site is comprised of a gently sloping valley floor traversed by two intersecting watercourses, known as the eastern and western branches of the Wolgan River. Immediately adjacent to all sides of the site are steep, heavily vegetated foot slopes to the sandstone cliffs of the western escarpment of the Blue Mountains plateau. The two watercourses, Wolgan River and Carne Creek, show localised signs of erosion.

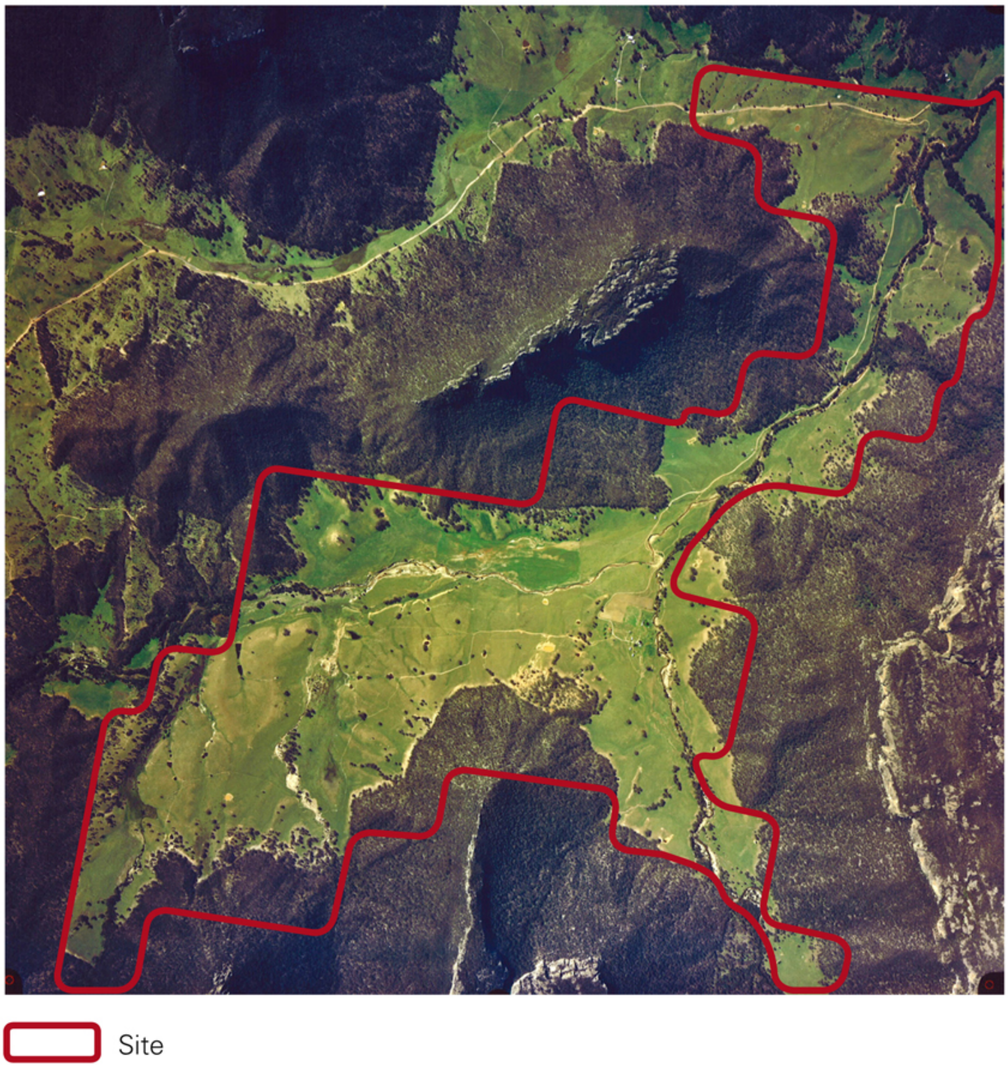


Figure 2: Aerial photograph of subject site

The majority of the site is located on the valley floor of alluvial soils. Specific soil characteristics were observed to vary widely across small areas of the site. In general, brown silty topsoils have been recorded, with varying degrees of clay and sand across the site. Top soils typically overlay silty sands, with varying degrees of clay and gravel across the site. Gravely sands were generally observed below this soil horizon. Siltstone from the Berry formation was observed below this in some test pits. Saturated hydraulic conductivity readings were low at between 0.02 m/d and 1 m/d (Douglas Partners, 2005).

2.2 Proposed Resort Facilities

The resort will be designed and constructed to provide the following facilities onsite:

1. Accommodation villas to accommodate up to 90 people, 108 ultimate.
    a. 35 Standard suites
    b. 3 Royal suites
    c. 2 Presidential suites
2. Main Building
    a. Restaurant to seat up to 90 people, 108 ultimate.
    b. Bar to seat up to 90 people, 108 ultimate.
    c. Administrative services
    d. Miscellaneous facilities, e.g. library, cigar room, medical etc
3. Spa Facilities, 40 people per day
4. Conference Centre to house up to 80 resort guests, 96 ultimate.
5. Picnic Areas
6. Maintenance Facilities
7. Horse Stables with 20 horses (***Non included in the concept plan stage***)

A maximum of 120 resort staff will be accommodated on-site to maintain a 3:1 staff to villa ratio; this will increase to 144 at ultimate development. The facilities to be provided on this on-site staff accommodation are:

1. Accommodation rooms
    - 18 Single/Double rooms
    - 22 Quad rooms
    - 4 visitor rooms
2. Pool
3. Dining, kitchen and laundry facilities

The above is based on the preliminary design brief for the resort prepared by architects Conybeare Morrison Pty. Ltd. dated 18 July 2005.

3 Site Water Demands

The draft design brief provided a list of various resort facilities and available areas for each of those facilities. The sections below estimate the water demand for various resort facilities onsite. Wherever appropriate, the underlying assumptions made in estimating water demand have been included.

It should be noted that the proposed concept plan does not include horse stables; this would be part of the development in latter stages. However, the site water demand has included the horse stables with an allocation for 20 horses to enable the calculation of the total site water demand and wastewater pollutant and hydraulic generation rates.

3.1 Water Demand Management

The proposed development will have a strong focus on demand management within the scope of its intended operations as a 6-star resort.

The following water efficiency measures will be incorporated into the development:

- All tap outlets at sinks in villas will be fitted with AAAAA rated flow restriction devices with a maximum flow of 6L/min;
- All laundry equipment will be a minimum of AAAA rated;
- All toilets will be a minimum of AAAA rated;
- All showers will be a minimum of AAA rated with a maximum flow of 9 L/min;
- Waterless urinals will be used in all high trafficked areas; and
- All other fixtures & appliances installed should be a minimum of AAA if practical.

Smart water metering will also be implemented for leak detection and as an ongoing monitoring and feedback process.

3.2 Building Water Demand

The resort site will provide various facilities such as guest accommodation, a restaurant and bar, spa and conference hall and office and accommodation sites for resort operations and maintenance staff. Water demands for the site have been estimated for each of these facilities based on an expected population and estimated per capita water usage rates. The water demands have been derived from state environmental protection agencies, state health agencies, state water authorities and SSI in-house reference data from suppliers of water appliances.

Emirates Group intends to increase the resort occupancy by 20% in future. The future water demand due to this increase has also been included in the sections below.

3.2.1 Guest Accommodation Villas

Water use in guest accommodation villas has been estimated based on a per capita water demand within the villa of 130 L/guest/day, which is based on the following water use breakdown:

- Shower, 63 L/guest/day;
- Toilet, 12 L/guest/day;
- Basins, 15 L/guest/day; and
- Pool Top Up, 40 L/guest/day.

Stage 1 guest population is expected to be 90 persons and the Ultimate guest population is expected to be approximately 108 persons, this corresponds to a total peak day water demand for the villas of 11,700 L/day and 14,040 L/day for Stage 1 and Ultimate development respectively.

An annual occupancy rate of 80% has been assumed for resort villas.

Table 1 contains a summary of water use in the resort.

3.2.2 Main Building

The main building consists of a restaurant, a bar and a staff and administration centre. Water usage in the main building has been estimated based on contribution from resort guests and staff.

Water usage by resort guests has been estimated based on a per capita water demand of 122 L/person/day, which is based on the following assumptions:

- 100% of resort guests will use the restaurant and bar every day;
- Waterless urinals will be installed in all male toilets;
- Restaurant water demand, 100 L/guest/day for 4 meals; and
- Bar water demand, 22 L/guest/day.

Water usage by resort staff in the main building has been estimated based on a per capita water demand of 23 L/staff/day.

Based on a Stage 1 population of 90 guests and 120 staff, the peak day water demand in the main building is expected to be around 13,770 L/day and 16,524 L/day for Stage 1 and Ultimate development respectively.

An average annual occupancy of 80% has been assumed for resort guests using the main building. No reduction in staff has been assumed and an average annual occupancy of 100% has been assumed for staff in the main building.

Table 1 contains a summary of water use in the resort.

3.2.3 Conference Centre

The conference centre will cater for a maximum of 80 people per day at Stage 1 and 96 people per day at Ultimate capacity, all of which will be resort guests.

Water usage in the conference centre has been estimated based on a per capita water demand of 27 L/person/day. Peak day water use in the conference centre has been estimated to be approximately 2192 L/day at Stage 1 and 2630 L/day at Ultimate capacity.

An average annual occupancy of 50% has been assumed for the conference centre, meaning one conference every 2 days on average.

Table 1 contains a summary of water use in the resort.

3.2.4 Spa Centre

Water usage in the Spa Centre has been estimated based on the following assumptions:

- 40 resort guests will use each of the various spa facilities each day;
- Spa water use, 12 L/guest/day;
- Hydrotherapy, 24 L/guest/day;
- Cold plunge pool, 40 L/guest/day;
- Indoor/outdoor pool, 40 L/guest/day; and
- Amenities, 76 L/guest/day.

Peak day water demands for the Spa Centre have been estimated at 7,717 L/day. No allowance has been made for expansion of the spa at ultimate development.

Average annual occupancy in the spa centre has been assumed to be 80%, in line with guest occupancy rates.

Table 1 contains a summary of water use in the resort.

3.2.5 Staff & Manager Accommodation

Staff accommodation will be divided into two separate areas. The managers' accommodation will cater for 12 people and the remaining 108 staff will be housed in the general staff accommodation area.

Water usage in staff accommodation has been estimated based on the following assumptions:

- Staff water usage within building; 120 L/staff/day;
    - Shower, 63 L/staff/day;
    - Toilet, 12 L/staff/day;
    - Basins, 15 L/staff/day; and
    - Kitchen, 30 L/staff/day.
- All 120 staff will use the central staff laundry located within the general staff accommodation building at 26 L/staff/day;
- All 120 staff will use the central staff pool located within the general staff accommodation building once per week at 40 L/staff/usage;

Peak day water demands in the general staff accommodation building have been estimated to be approximately 16,802 L/day and 20,515 L/day at Stage 1 and Ultimate development respectively.

Peak day water demands in the managers' accommodation building have been estimated to be approximately 1,441 L/day and 1,681 L/day at Stage 1 and Ultimate development respectively.

Average annual occupancy rates for all staff have been assumed to be 100%.

Table 1 contains a summary of water use in the resort.

3.2.6 Miscellaneous Facilities

Miscellaneous facilities at the resort include a horse stable with 20-horse capacity and a vehicle wash down area to cater for 20 vehicle cleanings per week.

Water usage in these facilities has been estimated based on the following assumptions:

- Horse stable water use, 70 L/horse/day;
    - 30 L/horse/day for stable cleaning;
    - 40 L/horse/day for stock water;
- Wash down water use, 30 L/vehicle/week;

Average annual occupancy rates for all horse stables and wash down has been assumed to be 100%.

Table 1 contains a summary of water use in the resort.

3.2.7 Landscaping

SSI discussed the landscape irrigation demands with Context Landscape Design Pty Ltd, the resort's landscape architects. Context Landscape Design informed SSI that native and endemic vegetation will be used on the site and as a result there is expected to be no irrigation demands for the entire site. For this reason no allowances have been made for landscape irrigation water supply at this stage.

Although not explicitly accounted for, there will be surplus recycled water available for irrigation that can not be more beneficially reused within the resort for uses like toilet flushing etc. An effluent irrigation system will be designed to cope with this surplus water. This surplus recycled water would be the primary source for irrigation water within the development should it be required.

3.3 Summary of Water Demands

Water demands for the site have been summarised in Table 1. Total peak day water demands for the site have been estimated to be approximately 55 kL/day and 65 kL/day at Stage 1 and Ultimate development. This accounts for increase in gross water demand of approximately 15%.

Average annual water demands are slightly lower than peak day water demands to account for periods of reduced resort occupancy. The reduced occupancy was assumed to be 80% for guests and related facilities, and 100% for staff and maintenance facilities.

Total water use per capita based a population of 210, i.e. 90 guests + 120 staff for stage 1, is approximately 280 L/person/day.

A breakdown of ultimate potable and non-potable demands are contained in Appendix 1.

Table 1: Summary of peak day and average annual water demands for Stage 1 and Ultimate development.

Building Type	Stage 1 Development							
	No. of buildings/ facilities	Persons/ building	Population	Peak Day Water Demands			Average Annual Occupancy	Average Annual Water
				Per Capita	Per Building	Total for Building		
				L/person/ day	L/building/day	L/building	%	L/building type/day
Villas								
Standard Suites	35	2	70	130	260	9100	80%	7280
Royal Suites	3	4	12	130	520	1560	80%	1248
Presidential Suites	2	4	8	130	520	1040	80%	832
TOTAL VILLAS	***40***		***90***			***11700***		***9360***
Main Building								
Restaurant	1	90	90	100	8982	8982	80%	7186
Bar	1	90	90	22	2016	2016	80%	1613
Staff & Admininstration	1	120	120	23	2772	2772	100%	2772
TOTAL MAIN BUILDING	***1***					***13770***		***11570***
Spa Centre								
Spa	1	40	40	12	490	490	80%	392
Hydrotherapy	1	40	40	24	980	980	80%	784
Cold Plunge Pool	1	40	40	40	1600	1600	80%	1280
Steam Room	1	40	40	0.2	8	8	80%	6
Indoor/Outdoor Pool	1	40	40	40	1600	1600	80%	1280
Toilets/Showers	1	40	40	76	3040	3040	80%	2432
TOTAL SPA CENTRE	***1***					***7717***		***6174***
Conference Centre	***1***	***80***	***80***	***27***	***2192***	***2192***	***50%***	***1096***
Managers Accommodation	***1***	***12***	***12***	***120***	***1441***	***1441***	***100%***	***1441***
Staff Building								
Staff Accommodation	1	108	108	120	12971	12971	100%	12971
Staff Laundry	1	120	120	26	3150	3150	100%	3150
Staff Pool	1	120	120	40	681	681	100%	681
TOTAL STAFF BUILDING	***1***					***16802***		***16802***
Horse Stables	***1***	***20***	***20***	***70***	***1400***	***1400***	***100%***	***1400***
Vehicle Wash Down	***1***	***20***	***20***	***4***	***86***	***86***	***100%***	***86***
TOTAL FOR ENTIRE SITE	***47***		***210***	***262***		***55109***		***47929***

Building Type	Ultimate Development							
	No. of buildings/ facilities	Persons/ building	Population	Peak Day Water Demands			Average Annual Occupancy	Average Annual Water Demand
				Per Capita	Per Building	Total for Building Type		
				L/person/ day	L/building/day	L/building	%	L/building type/day
Villas								
Standard Suites	42	2	84	130	260	10920	80%	8736
Royal Suites	4	4	16	130	520	2080	80%	1664
Presidential Suites	2	4	8	130	520	1040	80%	832
TOTAL VILLAS	***48***		***108***			***14040***		***11232***
Main Building								
Restaurant	1	108	108	100	10778	10778	80%	8623
Bar	1	108	108	22	2419	2419	80%	1935
Staff & Admininstration	1	146	146	23	3373	3373	100%	3373
TOTAL MAIN BUILDING	***1***					***16570***		***13931***
Spa Centre								
Spa	1	40	40	12	490	490	80%	392
Hydrotherapy	1	40	40	24	980	980	80%	784
Cold Plunge Pool	1	40	40	40	1600	1600	80%	1280
Steam Room	1	40	40	0.2	8	8	80%	6
Indoor/Outdoor Pool	1	40	40	40	1600	1600	80%	1280
Toilets/Showers	1	40	40	76	3040	3040	80%	2432
TOTAL SPA CENTRE	***1***					***7717***		***6174***
Conference Centre	***1***	***96***	***96***	***27***	***2630***	***2630***	***50%***	***1315***
Managers Accommodation	***1***	***14***	***14***	***120***	***1681***	***1681***	***100%***	***1681***
Staff Building								
Staff Accommodation	1	132	132	120	15853	15853	100%	15853
Staff Laundry	1	146	146	26	3833	3833	100%	3833
Staff Pool	1	146	146	40	829	829	100%	829
TOTAL STAFF BUILDING	***1***					***20515***		***20515***
Horse Stables	***1***	***20***	***20***	***70***	***1400***	***1400***	***100%***	***1400***
Vehicle Wash Down	***1***	***20***	***20***	***4***	***86***	***86***	***100%***	***86***
TOTAL FOR ENTIRE SITE	***55***		***254***	***254***		***64640***		***56334***

4 Site Water Sources

4.1 Rain Water

Climate data for the site was obtained from the Queensland Department of Natural Resources data drill service for location 33.15 S, 150.25 E. This data is derived from climate observations at nearby weather stations and interpolated to estimate site specific climate data.

The average annual rainfall and pan evaporation for Wolgan Valley site is estimated to be approximately 640 mm/yr and 1453 mm/yr respectively. This data compares well with other nearby weather stations with the exception of Newnes Forest Weather Station, which has recorded an average annual rainfall in the order of 1,140 mm/yr. This weather station is located approximately 30 km to the north of the resort site and is higher in altitude, which may explain its relatively elevated rainfall.

To be conservative in assessing the rainwater harvesting system from the site, the lower average rainfall of 640 mm/yr was assumed and is represented graphically in Figure 3.

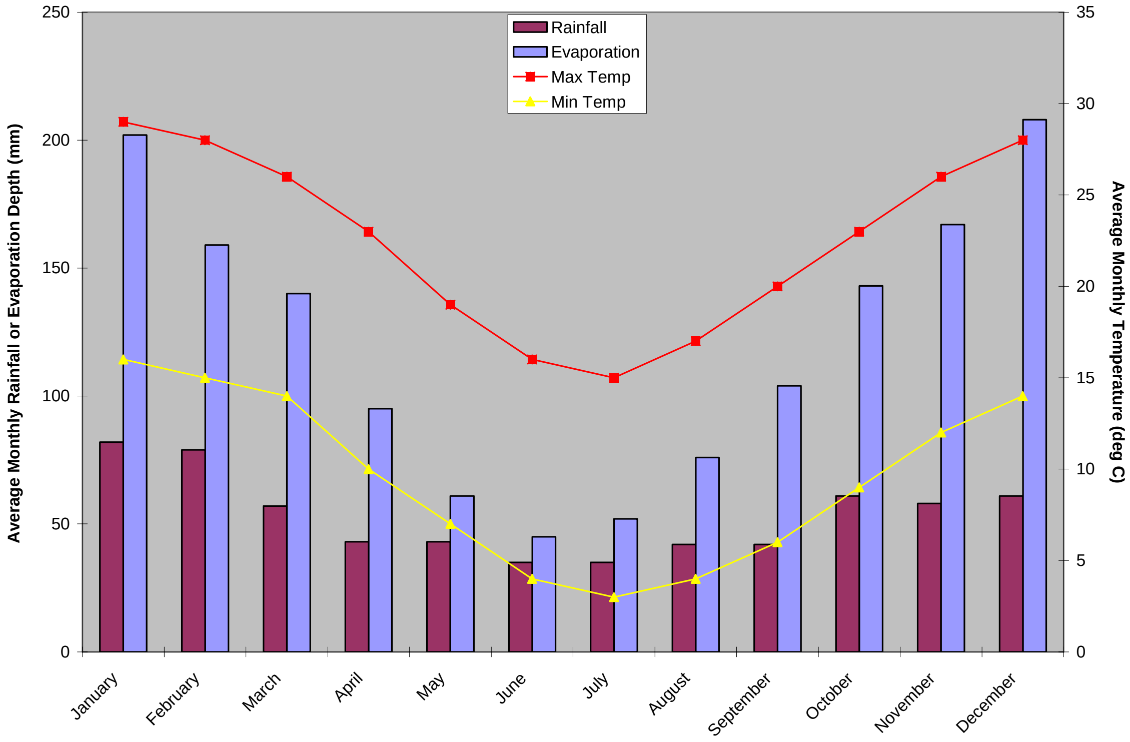


Figure 3: Average Monthly Rainfall for Wolgan Valley location 33.15 S, 150.25 E (DNR, 2005)

Due to the relatively low rainfall in the area, it is unlikely that rainwater harvesting will supply 100% of water demands for the resort; however it will provide a valuable alternate source that should be maximised. This will also provide additional benefits in reducing stormwater runoff volumes and peak flows from impervious roof surfaces.

4.1.1 Rainwater Modelling

SSI conducted a rainwater feasibility modelling for the site using over 50 years of historic daily rainfall data for the region from 1954 to 2004. A daily water balance was conducted based on roof catchment areas, the rainwater tank capacities and the rainwater demands, a schematic of the rain water balance is illustrated below in Figure 4.

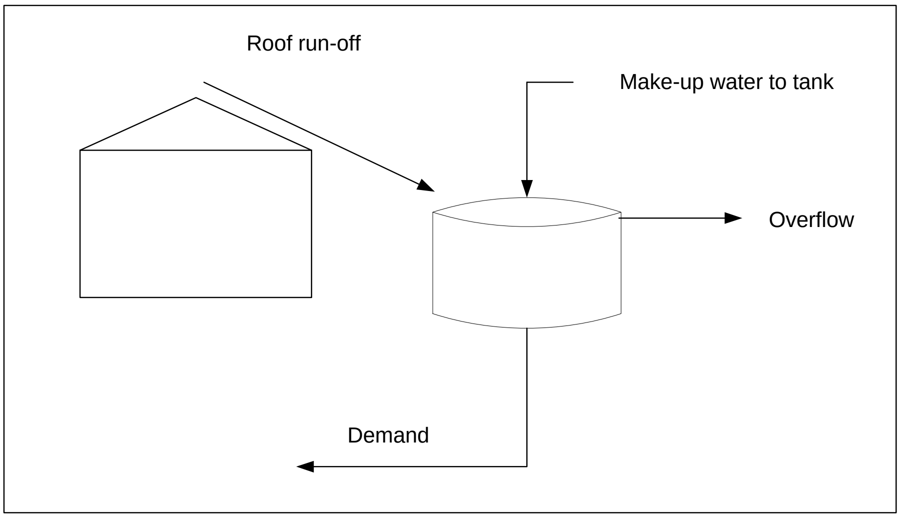


Figure 4: Water balance for estimation of rainwater storage capacity

The daily water balance model determines the average annual rainwater yield from the catchment for given tank volumes. Plots were then developed of tank size verses annual demand satisfied to determine the optimum tank sizes for the various site buildings.

4.2 Town Water

The nearest town water supply system to proposed resort site is the Fish River Water Supply Scheme (FRWS). The nearest connection point to this scheme is at Baal Bone Point approximately 6 kilometres to the west of the site.

The Department of Commerce were engaged by Clifton Coney Group to prepare an options report for the provision of a water supply pipeline to the site. The pipeline was sized to a maximum daily flow of 1 ML/day, or 11.6 L/s, to supply the following peak day water demands:

- Potable Water 150 kL/day;
- Fire sprinkle system 550 kL/ day; and
- Fire hydrants 300 kL/ day.

It was identified from this report that the preferred option would involve construction of a 12.5 km DN 160 mm polyethylene and DN 100 mm DICL pipeline, a pump station and a balancing tank. Total capital cost of this option was estimated to be around $4 M.

The majority of the capacity provided in the pipeline is for fire fighting flows in order to meet the requirement of filling the fire storage tanks within a 24 hour period. During normal site operation, i.e. when fire flows are not being provided, the total water demand of the site is expected to be only 52 kL/day, as discussed in Section 3.3.

At an average total demand of 52 kL/day, detention time in this pipeline will be around 4-5 days, and could be in the order of 8 -12 days following the implementation of water reuse and recycling strategies at the resort.

Such long detention times may result in a decline in water quality and it is likely that additional treatment will be required at the resort. Water quality would also be expected to vary between seasons as changes in temperature and pipeline flow will impact on water quality.

The type of water treatment processes likely to be required are:

- Activated carbon adsorption to remove bad tastes, odours and colour; and
- Chlorination to provide residual disinfection. “Point of use” ultraviolet irradiation could be used as an alternative disinfection process to avoid chemical use onsite.

The main advantage of the town water supply system is that is a reliable supply with service guarantees during normal operating conditions. The resort will however be subject to water restrictions whenever they are imposed by the water authority.

It is also likely that supply reliability during bush fires will be low due to large demands on the system; hence it may not be possible to fill the fire tanks within 24 hours under these conditions.

4.2.1 Sustainability

SSI held discussions with Mr. Warrack Batty Smith of State Water, Operations Manager of the Fish River Water Supply Scheme, to discuss issues of long term sustainable water extraction regimes for the resort.

Discussions revealed the sustainable yield that had already been determined for the Fish River Water Supply Scheme was allocated to cities and towns in the region. To enable the resort to proceed Lithgow City Council made an in principle agreement to relinquish up to 92 ML/year of their existing water allocation.

As discussed in Section 3, the total annual water demand from the resort at ultimate development has been estimated to be approximately 22 ML/year, which is about 25% of the in principle water allocation given to the resort. Based on this, extraction of town water for the resort development is considered to be sustainable as it is within the existing extraction limits defined for the scheme.

Through the implementation of rainwater harvesting, water recycling and investigation into other alternate water sources, annual extraction rates on the FRWS can be further reduced, thus improving the overall sustainability of the resort.

4.3 Ground Water

A desktop evaluation of potential groundwater sources in the area was undertaken by Douglas Partners (2005).

This assessment suggested that general area of the resort site is regarded as having brackish groundwater. A disused bore was noted in the assessment that was abandoned due to high salinity.

Preliminary geotechnical test pit investigations in the alluvial sequences on the site revealed varying TDS values, some of which were in the acceptable range for drinking water.

Further investigation is required to assess the feasibility of groundwater. In order to achieve the requirement to fill fire fighting tanks within 24 hours, a sustainable yield of approximately 10 L/s is required.

The feasibility of reverse osmosis for desalination of brackish groundwater should also be investigated. The power requirements of such a system are likely to significantly less than that required for sea water desalination due to the lower osmotic pressures.

Considering the high cost of the town water supply option ($4 M), there is potential for a brackish water desalination system to more economical.

4.4 Recycled Water

It has been estimated that the resort will generate approximately 18 ML/year of wastewater that will need to be treated and managed onsite in a sustainable manner.

From a sustainability perspective, wastewater recycling has dual benefits in that it reduces demands on the potable water supply systems, and reduces the amount of effluent that needs to be discharged to the environment.

There is potential to use recycled water within the resort for a number of non-potable uses provided the water quality requirements can be achieved, these are outlined below in Table 2. In general it can be seen that the higher the level of potential contact with recycled water, the higher the level of treatment required, and hence the more energy and treatment process chemicals that are consumed during water treatment.

Table 2: Recycled water quality requirements based on intended use

Recycled Water Use	Indicative Water Quality Requirements	Comments
Subsurface Irrigation	Secondary Treatment with disinfection to <100 c.f.u./100 mL Class B Recycled Water	Secondary treatment typically requires less energy consumption and chemical use. Nutrients contained in effluent are managed by plant uptake and full nutrient removal at the WWTP is not required. Full nutrient removal processes typically require more energy consumption and chemicals use. Sustainable irrigation practices mean effluent will not reach water bodies in significant volumes. Subsurface irrigation reduces chance of runoff.
Unrestricted Surface Irrigation	Tertiary Treatment with disinfection to <10 c.f.u./100 mL Class A+ Recycled Water	Tertiary treatment typically requires more energy consumption and chemical use. Nutrients contained in effluent are managed by plant uptake and full nutrient removal at the WWTP is not required. Full nutrient removal processes typically require more energy consumption and chemicals use.
Toilet Flushing	Tertiary Treatment with disinfection to <10 c.f.u./100 mL Class A+ Recycled Water	Tertiary treatment typically requires more energy consumption and chemical use. Toilet reuse reduces the amount of effluent requiring disposal.
Central Laundry Facility	Tertiary Treatment with disinfection to <10 c.f.u./100 mL Class A+ Recycled Water	Tertiary treatment typically requires more energy consumption and chemical use. Laundry reuse reduces the amount of effluent requiring disposal.
Wash Down Water	Tertiary Treatment with disinfection to <10 c.f.u./100 mL Class A+ Recycled Water	Tertiary treatment typically requires more energy consumption and chemical use. Wash down water reuse reduces the amount of effluent requiring disposal. Wash down water should be returned back to sewer following pre treatment to remove gross pollutants and oils.

5 Water Supply Scheme

The primary potable water supply for the proposed development shall be from the towns' water supply from the Fish River System. This potable water supply shall be supplemented by the utilisation of rainwater harvesting. Firefighting water supply will be provided by town water. Non-potable water for the development shall be sourced from the on site wastewater treatment system which shall produce Class A+ recycled water suitable for toilet flushing and other acceptable uses. On site ground water may also be utilised in the development should investigations deem the volume and water quality to be acceptable. A schematic of the proposed integrated water supply scheme is shown below in Figure 5. A more detailed description of the scheme is provided in the following sections.

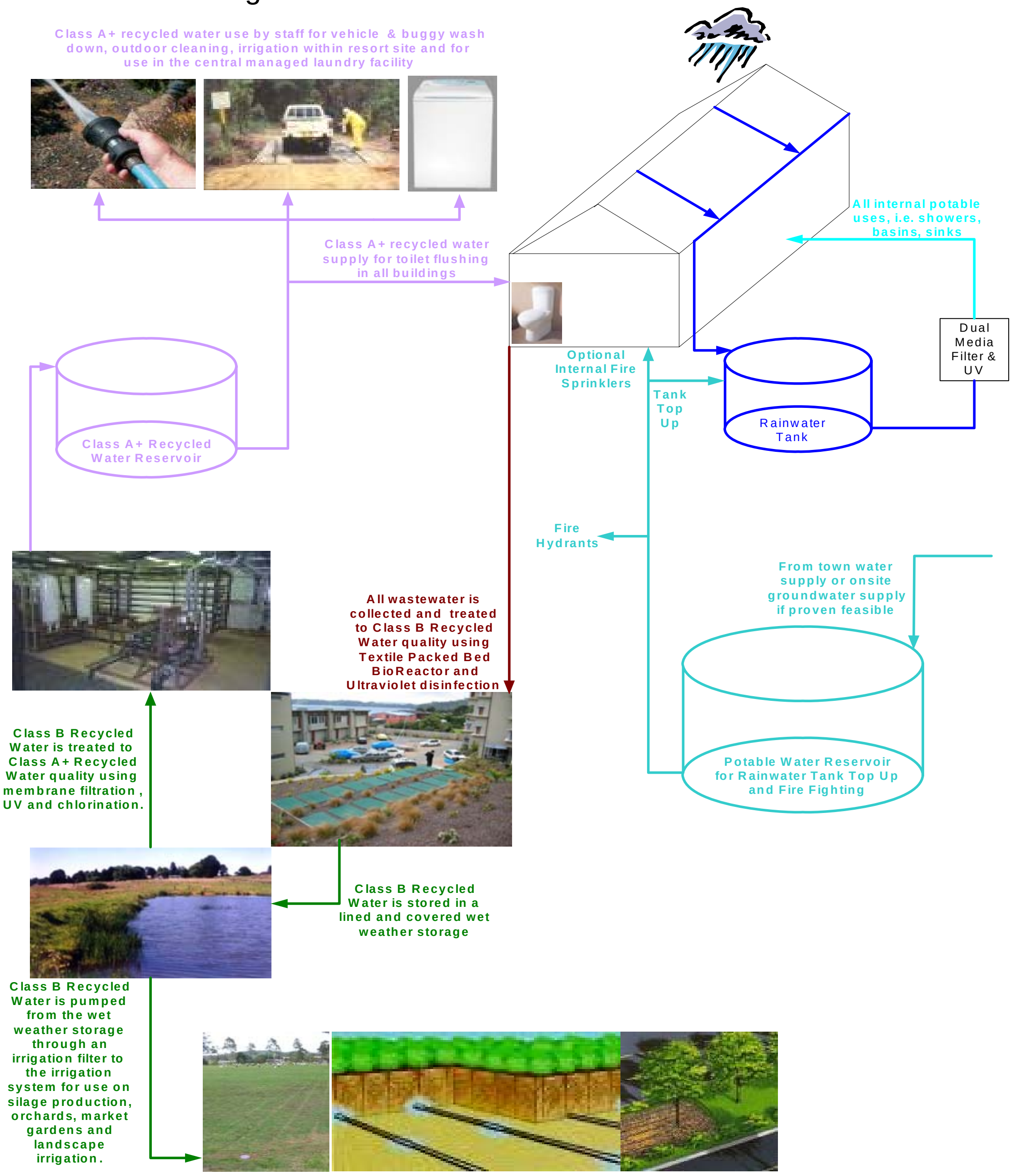


Figure 5: Schematic of integrated water supply scheme for proposed resort

5.1 Rainwater Tanks – Potable Water Supply

It is proposed to use water from rainwater tanks as feasibly possible for potable water source for all buildings at the resort.

A brief overview of the rainwater harvesting system is outlined below:

- Each building is supplied with potable water from a rainwater tank;
- Treatment of rainwater is provided at each tank using dual media filtration (sand, mesh or fibre physical filtration followed by activated carbon adsorption) as well as ultraviolet disinfection;
- Rainwater tanks will be topped up with town water (or onsite groundwater if this proves feasible);
- Rainwater tank overflows will be directed away from buildings to the site stormwater system.

5.1.1 Rainwater Yields & Supply Reliability

Water balance modelling of the rainwater system was undertaken to determine rainwater tank sizes and expected reliability based on historic rainfall data. The modelling was undertaken using potable water demands with non-potable recycled water demands subtracted as indicated by Appendix 1. The results of this modelling are outlined below in Table 3 and shown graphically in Appendix 2.

Table 3: Rainwater modelling results

Building	Roof Area	Ultimate Average Day Rainwater Demand	Minimum Rainwater Storage Volume	Average Day Total Rainwater Supplied	% Reliability
	sqm	L/Building/ Day	kL	L/day	% demand satisfied
Standard Suites	90	260	15	134	51%
Royal Suites	175	520	15	250	48%
Presidential Suites	375	520	30	442	85%
Main Building	4620	11900	200	5856	49%
Spa & Conference Centre	3700	7200	200	4594	64%
Staff Accomodation	3900	14250	200	5320	37%
Managers Residence	600	1150	30	796	69%
Horse Stables	400	800	30	550	69%
Total for Whole Site	18450	49340	1410	24614	50%

* - Spa and conference centre were modelled as one to minimise spa storage. The storage should be proportioned between buildings and an interconnecting pipe work installed for water level equalisation in tanks.

Smaller tanks for the resort villas, horse stable and managers' accommodation are likely to be domestic type concrete or polyethylene tanks. The larger tanks for the main buildings are most likely to be concrete. These can be either stand alone above ground, below ground or partially buried, or alternately these could be integrated into the design of the building.

5.1.2 Assumptions used for rainwater modelling:

- Modelling was undertaken using climate data supplied by the Queensland Department of Natural Resources & Mines data drill service for location 33.15 S, 150.25 E as discussed in Section 4.1;
- 95% of catchment efficiency;
- The first 1mm of all rainfall events over the entire catchment is diverted by a first flush device to stormwater;
- Suites were modelled at 100% average annual occupancy as site operators may prefer to shut down specific villas during low occupancy periods;
- Main building and spa modelled at 80% average annual occupancy; and
- Staff facilities and horse stables were modelled at 100% average annual occupancy.

5.1.3 Limitations with the rain water modelling conducted

It should be noted that the rainwater modelling undertaken by SSI was based on the best available daily rainfall data for the site collected over 50 years. It should be noted that the impact of climate change on temperature, evaporation rates and rainfall patterns have not been addressed in the rainwater feasibility modelling conducted by SSI.

5.1.4 Water Quality Control

Water quality control from the rainwater system will be controlled by proper design and preventative maintenance programs to ensure roof catchment areas are clean and made of suitable materials, and that storage tanks are sealed to protect from vermin and water ingress. In general the tanks will be designed and operated in accordance the *Commonwealth Government Enhealth Guideline* (2004).

The rainwater harvesting system will incorporate the following pre-treatment measures to ensure water entering the tank is relatively free of contamination:

- Leaf gutter guards;
- Rain head screens; and
- First flush device.

Additional water treatment will be provided at each tank in the form of:

- Pressurised dual media filtration using physical filtration and activated carbon adsorption for removal of potential tastes and odours; and
- Ultraviolet disinfection to control microbial quality.

5.2 Recycled Water – Non Potable Supply

It is proposed to Class A+ Recycled Water for the following uses within the resort:

- Toilet flushing in all buildings;
- Vehicle wash down water;
- Outdoor water and cleaning; and
- Central managed laundry facility.

These uses represent the high priority use of recycled water and preference will be given to these water uses.

Class B Recycled Water will be used for subsurface irrigation of resort landscaped areas and grasslands provided the Class A+ recycled water demands can be met.

5.2.1 Recycled Water Demands

At ultimate development the demand for Class A+ recycled water is estimated to be approximately 10 kL/day, this represents approximately 18% of the total water demand for the site.

5.2.2 Water Quality Control

When using recycled water it is imperative that the water quality is matched to the intended final use of the resource. Recycled water quality requirements were based on the *NWQMS Use of Reclaimed Water Guidelines (2000)* and the *NSW Health Interim Guidance for Greywater and Sewage Recycling in Multi Unit Dwellings and Commercial Premises (2004)*. Wastewater treatment processes have been selected that can reliably achieve the required water quality.

All wastewater produced at the site will be treated to Class B Recycled Water quality through the use of a Textile Packed Bed Reactor treatment system and ultraviolet disinfection. On a demand basis, a portion of this water will be treated using membrane filtration, additional ultraviolet disinfection and chlorination to achieve Class A+ Recycled Water quality.

More information on the wastewater treatment process is included in Section 6 – Wastewater Management.

5.3 Rainwater Tank Top-Up

The rain water harvesting system proposed for the site is expected to achieve around 50% reliability on an average annual basis. For the proposed resort to achieve 99% reliability from rainwater, would require either rainwater storages or roof catchment areas to be increased, particularly in the main buildings and staff accommodation areas.

Considering town water supply is required at the site for fire fighting purposes, provision of extraneously large rainwater storages is not required. The rainwater storages proposed will achieve around 50% reliability on average and will therefore require top-up to ensure a reliable water supply to resort patrons.

At this stage it is assumed that top-up will be provided from the town water supply system, however should an onsite bore water supply prove feasible, this would be the source of top-up water.

5.3.1 Top-Up Water Demands

The supply reliability for the entire site at ultimate development is estimated to be approximately 50% on an average annual basis. A preliminary breakdown of this is shown below in Table 4.

Table 4: Estimated rainwater tank top up requirements

Building	Average Day Rainwater Demand	Average Day Rainwater Supplied	% Reliability	Average Day Topup Required	Average Annual Top Up Required
	L/day	L/day	% demand satisfied	L/day	ML/yr
Standard Suites	10920	5614	51%	5306	1.94
Royal Suites	2080	1000	48%	1080	0.39
Presidential Suites	1040	884	85%	156	0.06
Main Building	11900	5856	49%	6044	2.21
Spa & Conference Centre	7200	4594	64%	2606	0.95
Staff Accomodation	14250	5320	37%	8930	3.26
Managers Residence	1150	796	69%	354	0.13
Horse Stables	800	550	69%	250	0.09
Total for Whole Site	49340	24614	50%	24726	9.03

It can be seen that the average day rainwater demand for the site is approximately 49 kL/day and of which approximately 25 kL/day can be supplied with rain water on average. Top-up requirements are approximately 25 kL/day.

Top-up requirements from the town water supply system are therefore around 9 ML/yr, which represents a reasonable reduction in demand on the town water system.

5.3.2 Water Quality Control

As discussed in Section 4.2, the proposed 11 km long water supply pipeline from the Fish River Water Supply Scheme has been designed to fill onsite fire tanks within 24 hours while maintaining potable water supply to the resort, which equates to flow of 1 ML/day.

The flows likely to be extracted from the pipeline are significantly lower than this proposed design value. At an average annual extraction rate of 9 ML/yr or 25 kL/day, average detention times in this pipeline will be in the order of 10 days and would be significantly longer following wet periods when rainwater tanks are full. Such long detention times are likely to result in a decline in water quality that will require treatment. At peak extraction rates, i.e. when all rainwater tanks are empty, detention times are expected to be lower at around 5 days, which is still likely to require treatment.

It is proposed to use the existing rainwater treatment systems provided at each building to treat top up water on demand. As previously stated, these treatment processes are proposed to include dual media filtration with sand/fibre and activated carbon followed by UV disinfection, which are suitable treatment processes for potentially stagnant water. In combination with this, clever positioning of tank inlet and top up pipes to maximise passive aeration of water as it enters the tank will also help to improve water quality.

More detailed evaluation will determine whether individual tanks, or cluster based tanks servicing 2 – 4 villas are used to maximise cost efficiency of the system.

6 Wastewater Management

6.1 Wastewater Loads

6.1.1 Hydraulic Loads

The estimated hydraulic wastewater loads for Stage 1 and Ultimate development are shown below in Table 5. Peak day wastewater generation is approximately 48 kL/d for Stage 1 and 57 kL/d at ultimate development.

Table 5: Estimate Peak Day Stage 1 and Ultimate Hydraulic Wastewater Loads

Building	Stage 1 - Peak Day			Ultimate - Peak Day		
	Persons	L/P/day	L/d	Persons	L/P/day	L/d
Villas	90	103	9309	108	103	11171
Main Building						
Restaurant	90	100	8982	108	100	10778
Bar	90	22	2016	108	22	2419
Non Resident Staff	120	23	2772	144	23	3326
Spa	40	113	4536	40	113	4536
Conference Centre	80	27	2192	96	27	2630
Horse Stables	20	30	600	20	30	600
Vehicle Wash Down	20	4	86	20	4	86
Managers Accommodation	12	120	1441	14	120	1729
Staff Accommodation	108	120	12984	132	120	15867
Laundry	120	26	3150	144	26	3780
TOTAL PEAK DAY(L/d)			**48068**			**56923**
TOTAL AVERAGE DAY (L/d) Assumed Annual Occupancy 80% Guests, 50% conferences, 100% staff			**41630**			**49382**

Average day loads were estimated using annual occupancy rates of 80% for resort guests, 50% for conferences and 100% for staff and maintenance facilities.

Average day wastewater production was estimated to be around 42 kL/day in Stage 1 and 49 kL/day at Ultimate development.

6.1.2 Pollutant Loads

Pollutant loads have been estimated for the resort based on the following per capita pollutant loading rate assumptions, which were adapted from VIC EPA (1997), US EPA (2002) and SA Health (1995):

- Biochemical Oxygen Demand (BOD)
  - 30 g/guest/day for guests in villas;
  - 40 g/guest/day for guests meals at the restaurant;
  - 10 g/guest/day for guests bar use;
  - 20 g/guest/day for guests spa use;
  - 15 g/guest/day for conference centre;
  - 40 g/staff/day in staff accommodation;
  - 15 g/staff/day in resort;
  - 9 g/staff/day for laundry;
  - 15 g/horse/day in stable wash down water following pre-treatment; and
  - 2 g/buggy/day in wash down water following pre-treatment.

BOD loads were totalled and converted to an equivalent load using 70 g BOD/EP/day. From this assumed "equivalent population", the following per EP loading rates were used for other pollutants:

- Total Suspended Solids, 70 g/EP/day;
- Total Phosphorus, 2 g/EP/day; and
- Total Nitrogen, 15 g/EP/day.

Mass pollutant loads and concentrations for the resort were estimated based on the above assumptions and are shown for Stage 1 and Ultimate peak days below in Table 6. As can be seen, the ultimate peak day BOD load is approximately 21 kg BOD/day. The pollutant concentrations shown in Table 6 are within the range typically expected for domestic wastewater.

Table 6: Peak day pollutant loads and concentrations for Stage 1 and Ultimate Development

Building	Peak Day Pollutant Loads (g/day)								Pollutant Concentrations (mg/L)			
	Stage 1 - Peak Day				Ultimate - Peak Day							
	BOD	SS	TN	TP	BOD	SS	TN	TP	BOD	SS	TN	TP
Villas	2700	2700	579	77	3240	3240	694	93	290	290	62	8
Main Building												
Restaurant	3600	3600	771	103	4320	4320	926	123	401	401	86	11
Bar	900	900	193	26	1080	1080	231	31	446	446	96	13
Non Resident Staff	1800	1800	386	51	2160	2160	463	62	649	649	139	19
Spa	800	800	171	23	800	800	171	23	176	176	38	5
Conference Centre	1200	1200	257	34	1440	1440	309	41	547	547	117	16
Horse Stables	300	300	64	9	300	300	64	9	500	500	107	14
Vehicle Wash Down	43	43	9	1	43	43	9	1	500	500	107	14
Managers Accommodation	480	480	103	14	576	576	123	16	444	444	95	13
Staff Accommodation	4320	4320	926	123	5280	5280	1131	151	333	333	71	10
Laundry	1114	1114	239	32	1337	1337	287	38	354	354	76	10
TOTAL PEAK DAY (kg/day)	17.3	17.3	3.7	0.49	20.6	20.6	4.4	0.59	364	364	78	10
TOTAL AVG DAY (kg/day)	15.1	15.1	3.2	0.43	18.0	18.0	3.9	0.51				

6.2 Effluent Management Strategy

As discussed in Section 5.2 and represented schematically in Figure 5, it is proposed to use Class A+ Recycled Water for the following non-potable uses:

- Toilet flushing in all buildings;
- Vehicle wash down water;
- Outdoor watering and cleaning; and
- Central managed laundry facility.

The demand for recycled water from these uses has been estimated to be around 10 kL/day during full ultimate development, which is approximately 18% of the total wastewater generated at the resort, as shown in Table 7.

Wastewater that is generated in surplus of these demands will be used for subsurface irrigation of landscaped areas and grass lands. Water used for subsurface irrigation is required to achieve a Class B Recycled Water quality.

It is possible to treat all wastewater at the resort to a Class A+ standard; however the types of treatment processes required to achieve this, i.e. membrane filtration, chlorine and UV, consume relatively large amounts of energy and treatment process chemicals.

For this reason only a portion of the wastewater produced onsite will be treated to Class A+ recycled water quality, and the remainder will be treated to Class B recycled water quality suitable for sub surface irrigation.

Table 7: Recycled Water Balance at Ultimate Development.

Ultimate Development	Hydraulic Load (L/d)		Class A+ Reuse (L/d)		Surplus Class B for Land Irrigation	
Building	**Peak Day**	**Avg Day**	**Peak Day**	**Avg Day**	**Peak Day**	**Avg Day**
Villas	11171	8937	1307	1045	9864	7891
Main Building						
Restaurant	10778	8623	864	691.2	9914	7932
Bar	2419	1935	432	345.6	1987	1590
Non Resident Staff	3326	3326	432	432	2894	2894
Spa	4536	3629	160	128	4376	3501
Conference Centre	2630	1315	384	192	2246	1123
Horse Stables	600	600	600	600	0	0
Vehicle Wash Down	86	86	86	86	0	0
Managers Accommodation	1729	1729	174	174	1555	1555
Staff Accommodation	15867	15853	1597	1597	14269	14256
Laundry	3780	3780	3780	3780	0	0
TOTAL ULTIMATE (L/d)	**56923**	**49814**	**9816**	**9071**	**47107**	**40742**
TOTAL STAGE 1 (L/d)	**48068**	**41990**	**8297**	**7671**	**39771**	**34319**
% Breakdown	**100%**		**18%**		**82%**	

6.3 Effluent Irrigation System

As discussed Section 6.2, the preferred management strategy for surplus effluent that can not be reused as Class A+ recycled water within the resort is land irrigation.

This strategy will provide a number of benefits to the scheme including:

- Effluent is not discharged directly to water bodies;
  - Reduced potential for water quality impacts on the Wolgan River;
  - Reduced potential for ecological impacts on the Wolgan River ecosystem;

- The effluent irrigation area has a natural capacity to assimilate and absorb nutrients and other pollutants, hence full advanced nutrient removal at the WWTP is not required, which means;
  - Reduced consumption of energy in the treatment process;
  - Reduced consumption of treatment process chemicals;
  - Reduced WWTP complexity, with reduced operation and maintenance requirements;
  - More realistic and achievable effluent quality for the site considering there will be a 'package' type WWTP being operated by resort staff;

- Reduced need to import fertilisers to the site, which in turn need to be sourced, manufactured and transported to the site.

The effluent irrigation system has been designed to apply effluent at low loading rates to ensure the irrigation area does not become overloaded from either a hydraulic or pollutant loading perspective.

This was determined by modelling of the effluent irrigation system using MEDLI (Model for Effluent Disposal by Land Irrigation) to determine the size of the effluent irrigation area and wet weather storage required for sustainable effluent irrigation.

The underlying assumptions used in the MEDLI modelling were:
- Ultimate average daily irrigation water flow: 40.7 kL/day ***plus***
  10% allowance for wet weather infiltration (4 kL/d) = 45 kL/day;
- Temperate pasture crop;
- Sand soil type;
- Derived daily meteorological data from QLD Department of Natural Resources and Mines for Wolgan Valley at location 33.15^0 South, 150.25^0 East; and
- Simulation period: 1/1/1954 – 31/12/2004, 50 years.

6.3.1 Hydraulic Loading - Irrigation Area & Wet Weather Storage

The MEDLI model was used to determine the irrigation area and wet weather storage required for sustainable irrigation. The assessment was undertaken in line with the design objectives shown in Table 8.

Table 8: Hydraulic design objectives for effluent irrigation system

Hydraulic Loading Design Objectives	How objective was achieved
Discharge from the wet weather storage in less than 50% of years (NSW EPA, 2004)	Water balance modelling in MEDLI to maintain overflow events to less than 50% of years i.e. once every 2 years on average
Minimise potential for deep percolation of effluent into groundwater	5/10 deficit irrigation strategy, that irrigates a maximum application rate of 5 mm/day when the soil water deficit reaches 10 mm. Field capacity is theoretically never exceeded during irrigation, hence water is held within soil profile by capillary forces.
Minimise potential for surface runoff of effluent	5/10 deficit irrigation strategy leaves a 5 mm soil water deficit for rainfall infiltration. 5 mm/day application rate is lower than the measured saturated hydraulic conductivity of the site, which varies from 0.02 – 1 m/day.
Minimise potential for saturated soil conditions and water logging	5/10 deficit irrigation strategy, that irrigates a maximum application rate of 5 mm/day when the soil water deficit reaches 10 mm. Field capacity is theoretically never exceeded during irrigation, hence saturated soil conditions do not occur as a result of irrigation.

Figure 6 shows a graph of the irrigation area and wet weather storage combinations capable of achieving the design objectives outlined in Table 8. The curve is based on a discharge event in less than 50% of years using a 5/10 irrigation strategy, as indicated in Table 8.

The minimum storage/maximum area combination is approximately 2.2 ML storage with a 9 hectare irrigation area, as indicated by the bright green point on the curve in Figure 6. This corresponds to approximately 49 days storage and a hydraulic loading rate of approximately 1.8 ML/ha/yr. Minimum storage is determined in MEDLI by the maximum consecutive days where irrigation is not possible due to elevated soil moisture conditions.

The maximum storage/minimum area combination is approximately 10 ML storage with a 3.9 hectare irrigation area. This corresponds to approximately 222 days storage and a hydraulic loading rate of approximately 4.2 ML/ha/yr. Minimum area is estimated as being the point where an increase in storage size does not result in a reduction in irrigation area, as shown by the red point on the curve in Figure 6.

Any irrigation area/storage combination that sits on this curve achieves largely the same performance outcome from a hydraulic loading perspective.

From a nutrient loading perspective however, smaller irrigation areas have higher pollutant loading rates. This issue is discussed further in 6.3.2.

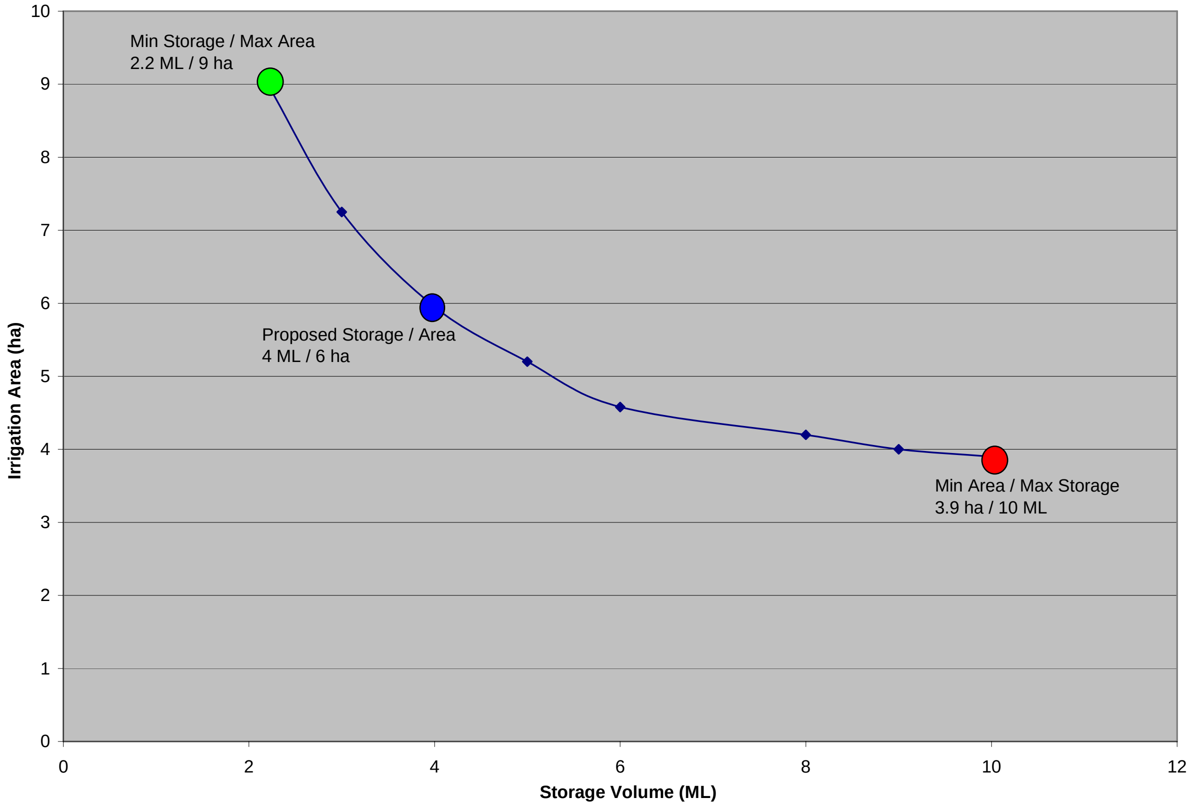


Figure 6: Effluent Irrigation area and storage combinations capable of achieving the hydraulic design objectives

6.3.2 Pollutant Loadings

An assessment of pollutant loadings for all irrigation area / storage combinations shown in Figure 6 was undertaken using MEDLI to identify the minimum irrigation area required to avoid excessive accumulation or export of pollutants from the site. The assessment was undertaken with the following assumed effluent quality:

- Total Nitrogen – 15 mg/L
- Total Phosphorus – 10 mg/L
- Total Dissolved Solids – 1000 mg/L

The performance objectives used for this analysis are contained in Table 9.

Table 9: Pollutant loading objectives for effluent irrigation system

Pollutant Loading Design Objectives	How objective was achieved
Avoid excessive accumulation of nutrients within the irrigation area	Nutrient balance modelling in MEDLI was undertaken for each potential irrigation area to ensure nutrient accumulation was not excessive. Low phosphorous detergent use will be mandated through purchasing policies.
Avoid excessive export of nutrients from the irrigation area	Nutrient balance modelling in MEDLI was undertaken for each potential irrigation area to ensure nutrient export was not excessive.
Avoid irrigation of sodic soils	Geotechnical testing conducted by Douglas Partners (2005) indicated that there was some potential for sodic soils to be present in certain areas of the site. More detailed testing of the selected irrigation area will identify the appropriate management strategies, including avoidance of specific problem areas. Low sodium detergents will be mandated through purchasing policies.
Minimise potential impacts on vegetation from salt accumulation	Conservative TDS concentration of 1000 mg/L was modelled with **no vegetation impacts** recorded in MEDLI.

A summary of the nutrient loading output from MEDLI for each of the irrigation area in Figure 6 is shown below in Table 10.

The table shows that the crop is removing more nitrogen than is being applied in effluent.

It was also shown that the phosphorus applied in effluent is always in excess of what can be absorbed by vegetation, which is typical for most effluent irrigation schemes. Phosphorus accumulation rates in soil are however low, and considering the remaining phosphorus adsorption capacity in the top 150 mm of soil is around 2300 kg P/ha (Douglas Partners, 2005), all areas provide in excess of 130 years of phosphorus retention.

Table 10: Nutrient loadings on potential irrigation areas

Descriptor	Irrigation Area	Wet Weather Storage	Hydraulic Loading Rate	Days Storage	N added by irrigation	N plant uptake	P added by	P plant uptake	Change in adsorbe	P life of soil
	ha	ML	ML/ha/yr	Days	kg/ha/yr	kg/ha/yr	kg/ha/y	kg/ha/yr	kg/ha/yr	yrs
Min Storage / Max Area	9	2.2	1.83	49	22.7	49.2	17.7	13	4.8	493
	7.25	3	2.27	67	27	53.6	22	15.5	6.6	358
Proposed area	6	4	2.74	89	31.3	57.9	27	17.4	9.7	244
	5.2	5	3.16	111	34.2	60.8	31.1	19	12.2	194
	4.6	6	3.57	133	37.1	63.6	35.7	20.9	14.9	159
	4.2	8	3.91	178	36.3	63.1	38.7	22.2	16.6	142
	4	9	4.11	200	36.3	63.1	40.6	23.1	17.6	134
Min Area / Maximum Storage	3.9	10	4.21	222	35.8	62.7	41.8	23.5	18.3	129

The nutrient loading rates on all irrigation areas shown in Table 10 are considered sustainable as accumulation of phosphorous and export of nitrate from the site has been modelled to be low.

Considering there is no shortage of area available on the site, it is proposed to use the larger area of 6 hectares with a 4 ML wet weather storage. This corresponds to a loading rate of 2.7 ML/ha/yr and about 90 days storage.

6.3.3 Effluent Irrigation Area

The resort site has been divided into a number of precincts with separate management objectives and targets. The proposed precincts are discussed in the Landscape Plan prepared by Context Landscape Architects (2005) and summarised below in terms of their relationship with effluent irrigation practices:

- *Precinct1: Managed Resort Area and Asset Protection Zones*;
  - Some minor irrigation of landscaped areas using Class A+ recycled water within resort zone.
- *Precinct 2: Managed Open Park Land;*
  - The main 6 hectare effluent irrigation area will be located within this precinct and to the north of the site near Wolgan Valley Road.
- *Precinct 3: Riparian Corridors 50 metres either side of top of bank of water course;*
  - No effluent irrigation will occur within this precinct.
- *Precinct 4: Nature Conservancy; and*
  - No effluent irrigation will occur within this precinct.
- *Precinct 5: Main Site Access Corridor.*
  - Some minor effluent irrigation may occur within this precinct.

All effluent irrigation areas will comply with the following set back and buffering requirements:

Water Courses and Riparian Zones:

No effluent irrigation within the 50 metre of top of bank of water courses.

Topography:

Slope should be less than 15% to minimise potential for slope instability, surface runoff and soil erosion. Surface runoff and erosion are not a significant issue where subsurface irrigation is used.

Groundwater:

Minimum depth to groundwater should be 0.6 metres to maintain unsaturated soil conditions below the irrigation area.

Flooding Levels:

Irrigation areas should be located above the 100 year ARI flood line.

Soils:

Areas containing significant rocky outcrops should not be irrigated. Specific areas of highly sodic soils will not be irrigated with recycled water following more detailed soil testing of actual irrigation area.

There are a number of potential options available for the 6 hectare effluent irrigation area, which could solely include or be a combination of:

- Pasture production for on or off site cattle and horse feed;
- Fruit orchard to supplement resort food requirements;
- Vegetable garden to supplement resort food requirements;
- Vineyard; and
- Managed grass and parkland areas for visual amenity.

Class B recycled water would be suitable for pasture, orchard, vineyard and grass land irrigation; while Class A+ recycled water would be required for vegetable garden irrigation.

The current proposal is for subsurface irrigation of managed open grass and parklands, however the potential to incorporate any or all of the above land uses into the resort architecture will be analysed at a later stage.

The preferred irrigation area will be situated within precinct 2. The irrigation area will occupy 6-hectares of an approximate 50 hectare area of cleared land in the north of the site near Wolgan Road as indicated in Appendix 3. More detailed soil and site assessment will be carried out to identify the optimum location for the 6-hectare irrigation area within this approximate 50-hectare allotment to ensure ell environmental impacts are minimised in line with the above requirements.

6.4 Effluent Quality Requirements

The proposed effluent quality requirements for Class B and Class A+ Recycled Water are shown in Table 11. These quality requirements are based on the recycled water guidelines produced by NWQMS (2000) and NSW Health (2004) and the results of the MEDLI modelling assessment of the effluent irrigation area.

Table 11: Effluent quality requirements for Class B and Class A+ recycled water

Parameter	Class B Recycled Water	Class A+ Recycled Water
Biochemical Oxygen Demand (BOD5)	< 10 mg/L	< 10 mg/L
Suspended Solids	< 10 mg/L	< 10 mg/L
pH	6.5-8.0	6.5-8.0
Total Nitrogen	< 15 mg/L	< 15 mg/L
Total Phosphorus	< 10 mg/L	< 10 mg/L
E. coli or Thermotolerant Coliforms*	< 100/100 mL	< 10/100 mL
Turbidity	N/A	2 NTU (5 max)
Residual Chlorination	N/A	0.5 mg/L free chlorine
Virus*	N/A	5 Log Reduction

* Additional testing during validation period may be required.

6.5 Wastewater Treatment Plant

A wastewater treatment plant will be constructed that can reliably achieve the effluent quality requirements in Table 11. The most suitable process for this site has been determined to be a Textile Packed Bed Reactor with UV disinfection to produce irrigation quality Class B Recycled Water.

A portion of this water will be given tertiary treatment and triple disinfection to produce Class A+ Recycled Water using membrane microfiltration, UV disinfection and residual chlorination.

A conceptual process description is provided in Section 7.

6.6 Wastewater Collection System

Wastewater collection will be via vacuum sewerage system. This has benefits of reducing detention time and septicity during low occupancy periods and minimising wet weather sewerage system flows.

6.7 Environmental Management

A Site Based Environmental Management Plan (SBEMP) for the wastewater management system will be developed during the next phase of the project. The SBEMP uses a risk management framework to identify, assess, control and monitor all actual and potential environmental and public health risks relating to the wastewater management system.

Mechanisms for achieving continuous improvement are incorporated into the management plan to ensure the wastewater management system remains up to date and responds to any potential impacts that may be identified during monitoring processes.

Table 12 provides a brief summary of potential environmental impacts and how they have been addressed in this proposal. The information contained in this table is preliminary and will be further refined during preparation of the SBEMP for the wastewater management system.

Table 12: Preliminary Environmental Impacts and Mitigation Measures

Potential Environmental Impact	Mitigation Measure	Monitoring
Surface water impacts	Irrigate using deficit irrigation strategy and store effluent in wet weather storage during wet periods.	Surface water monitoring program. Monitor effluent application rates.
Ground water impacts	Irrigate using deficit irrigation strategy and do not over apply effluent	Groundwater monitoring program. Monitor effluent application rates.

Potential Environmental Impact	Mitigation Measure	Monitoring
Soil impacts	Do not irrigate higher than designed loading rates. Purchasing policy to control use of detergents and cleaning chemicals.	Soil monitoring program. Monitor effluent application rates.
Vegetation impacts	Do not irrigate higher than designed loading rates. Select appropriate vegetation species for irrigation areas. Purchasing policy to control use of detergents and cleaning chemicals.	Vegetation monitoring program. Monitor effluent application rates.
Public health impacts	Ensure treatment processes are achieving water quality requirements. Ensure recycled water is only being used for its designed uses.	Recycled water quality monitoring program.
Odour impacts	Treatment process uses activated carbon filters on all tank outlets. Soil bed filter or activated carbon will be used on collection system where required.	Monitor odours and odour complaints.
Noise impacts	Membrane filtration unit located in shed. Textile filters are low in noise.	Monitor noise and noise complaints.
Aesthetic impacts	Vegetative buffers around WWTP.	Maintain vegetation buffers and monitor complaints.
Energy Use	Textile packed bed reactor uses passive aeration - attached growth technology with low energy requirements. Aeration requirements minimised as advanced nitrogen removal was not required, as nutrients will be managed by sustainable irrigation. Membrane filtration is highest energy user for WWTP and only the required portion of the flow will be treated to Class A+ Recycled Water quality.	Monitor energy consumption.
Chemical Use	Alum dosing and potentially pH correction chemicals not required as advanced phosphorus removal was not required as nutrients will be managed by sustainable irrigation. Chlorine requirements minimised as only the required portion of the flow will be treated to Class A+ Recycled Water quality, which requires. UV disinfection used as primary disinfectant.	Monitor chemical consumption.
Sludge & Screenings Management	Passive management of sludge and screenings through primary treatment and anaerobic digestion. Primary sludge and foreign matter will be removed via licensed road tanker pump out from primary tanks every 3-5 years. Initial proposal involves pump out to the nearest capable council WWTP, however considering the first pump out will not be for around 5 years	Monitor sludge levels and pump out frequency.
Sewerage system inflow & infiltration	Use vacuum sewerage system. Welded polyethylene pipes will be used where appropriate. Locating top of vacuum pods above 100 year ARI level where feasible Contour ground around vacuum pods to avoid water ponding Using vacuum sewerage laid at minimum depth to avoid groundwater infiltration during dry weather	Monitor pump run times and WWTP flows

The above will be developed in more detail during the next stage of the project.

7 Wastewater Treatment Plant Concept

The wastewater treatment system proposed for the resort consists of two main treatment trains;

- Textile Packed Bed Reactor with UV to produce Class B Recycled Water, 100% of wastewater flow; and
- Continuous Microfiltration, with UV and residual chlorination to produce Class A+ Recycled Water, around 20-30% of wastewater flow.

A schematic of the proposed WWTP is shown below in Figure 7.

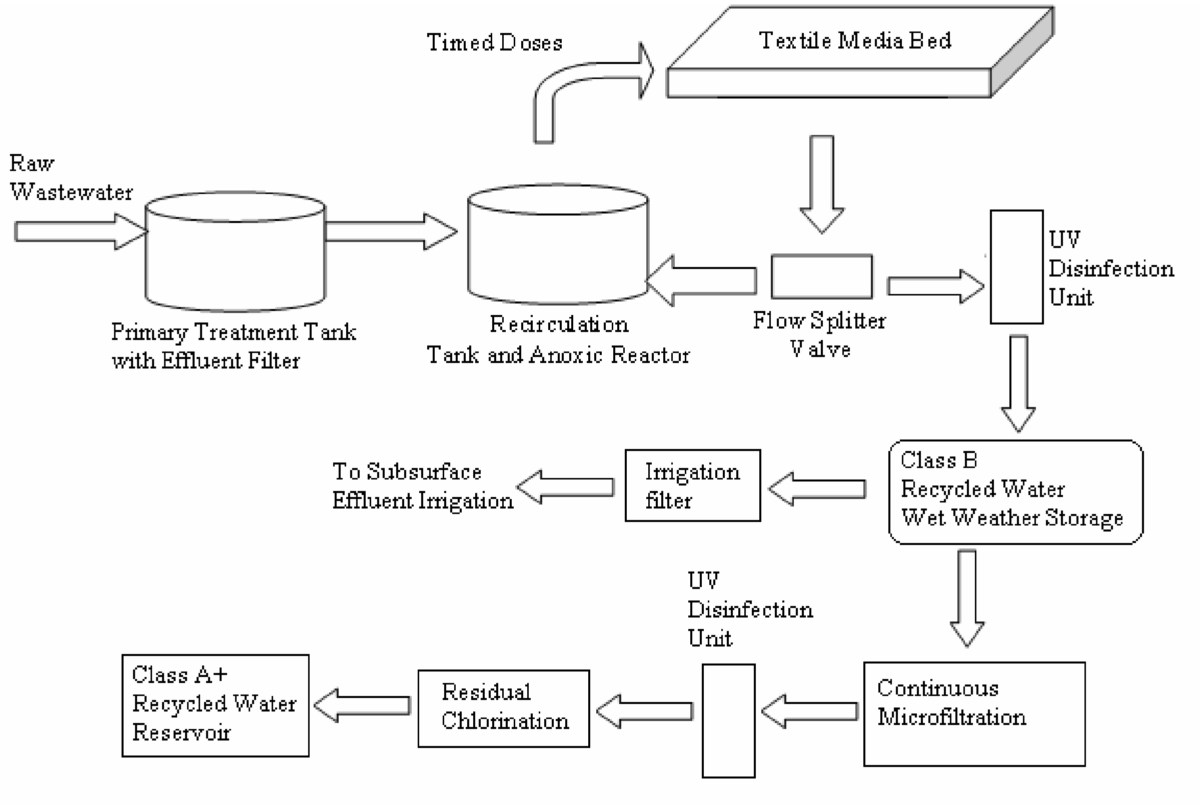


Figure 7: Schematic of proposed WWTP

7.1 Class B Recycled Water Treatment Plant – Textile Packed Bed Reactor

7.1.1 Primary Treatment & Sludge Management

A series of primary settling tanks will be used to provide a cost effective and passive primary treatment of wastewater. The settling tanks provide a quiescent environment to enable solids to settle.

- All tanks will be sealed with specially designed air-tight lids provided and fitted with activated carbon filters to absorb all odour;
- Filters will be fitted to outlet of the tanks to further reduce suspended solids carry over to the wastewater treatment plant; and
- There is no need for handling of any screenings (foreign matter). All sludge and screenings will be contained in the tank where it naturally biodegrades.

Accumulated sludge will be periodically removed every 3 - 5 years by tanker. In time alternative processes may be developed to enable the sludge to be beneficially reused at the resort.

7.1.2 Recirculation Tank

Effluent from the primary tanks gravity flows to a recirculation tank. Periodically the water in the recirculation tank is dosed to the packed bed reactor using submersible pumps. Small reliable turbine pumps are used to minimise operating and maintenance costs. The pumps will be fitted into screened pump vaults to ensure that no gross solids are pumped onto the textile filter.

The dosing pumps operate on a timer sequence to buffer incoming and recycle flows, and uniformly apply effluent to the textile filter bed. Level indicators installed inside the pump vaults control and override the timer for high water on, and alarm in the unlikely event of timer failure.

A recirculation/splitter valve assembly ensures that the optimal recycle ratio is maintained at all times, maximising treatment efficiency for a consistently high quality effluent.

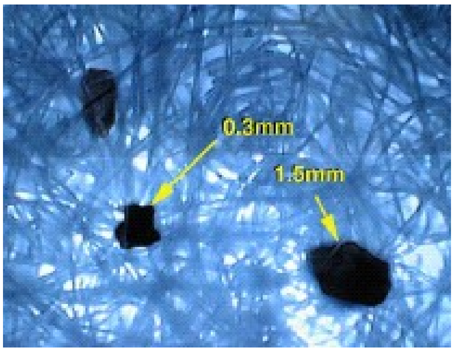
The recirculation tank ensures that the packed bed reactor receives a continuous source of oxygen and food during periods of little or no flow, ensuring that the microorganisms are maintained at peak condition, ready to receive shock or varying loads. This is particularly important for a resort development where there will be periods of very low occupancy.

A portion of the recirculation tank will be used to provide an anoxic zone to enable denitrification to occur where nitrified return water is mixed with carbon rich feed water..

7.1.3 AdvanTex® Recirculation Textile Packed Bed Reactor

Orenco's research and development has refined and optimised the Textile filter processes to produce a design that is unsurpassed for efficiency, reliability, future expansion capabilities, and low maintenance requirements.

The sand and pebble aggregates used in sand filters has been replaced by an internationally patented textile media that can accept a loading rate up to 10 times higher. This produces a reactor basin with a footprint only a fraction of the size of conventional sand filters.



The unique complex fibre structure of the textile media has an immense surface area for biomass colonisation, (up to 5 times greater than sand) and a much greater void space (~3 times higher than sand) to ensure free flow of oxygen through the media interstices. Its high field moisture capacity ensures long, intimate, contact times of the wastewater with the biomass for almost complete renovation.

The AdvanTex® textile filter is essentially a bed of this highly specialised textile nestled in a pre-made pod. The pods are completely enclosed with green textured air-tight fibreglass lids and are installed at ground level. This means that the entire treatment plant is below ground with very low visual impact.

The textile filters are fitted with a small ventilation fan to provide adequate air flow through the system for aerobic conditions to be maintained. The fan outlet uses an activated carbon filter to absorb all odours.

Treated effluent from the textile packed bed reactor receives UV disinfection to achieve a Class B Recycled Water quality before being stored in the covered and lined effluent wet weather storage until it is either irrigated or pumped to the Class A+ Recycled Water treatment plant.

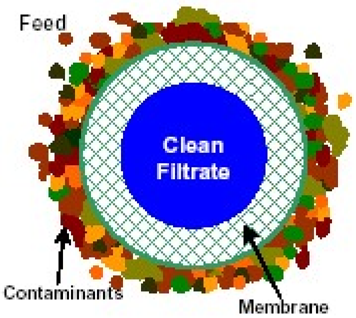
7.2 Class A+ Recycled Water Treatment Plant – Membrane Filtration, UV Disinfection & Residual Chlorination

7.2.1 Continuous Microfiltration

The Pressurised Continuous Micro-Filtration (CMF) process uses hollow fibre membranes to produce high quality treated water. Memcor have been using this CMF process to treat the secondary effluent from trickle filters since 1990.

The packaged Memcor continuous microfiltration plant known as the AXIM 3 is a simple to install and easy to operate membrane filtration system. It is automatic in operation and requires minimal operator assistance.

7.2.2 Filtration



Raw water is fed to the CMF process from an above ground feed tank using gravity. The raw water will be Class B Recycled Water wet weather storage.

Water from the feed tank enters the filtration modules and flows along the length of the hollow fibre membranes. The difference in pressure pushes clean water to the inside of the hollow membrane. Suspended solids, bacteria and some viruses are blocked at the membrane surface.

7.2.3 Gas backwash

Filtered contaminants are periodically removed from the membranes using a gas backwash. The gas backwash forces high pressure air into the membrane and through the wall of the fibres to dislodge build up on the outside of the fibres. Feed liquid is used to flush the dislodged particles out of the module to the backwash outlet.

Backwashing is carried out automatically for approximately 150 seconds every 15 – 60 minutes depending on the feed water quality. The backwash water is collected and returned to the primary tank of the wastewater treatment plant.

7.2.4 Clean in place

Chemical cleaning of the membranes is needed to remove the built-up of contaminants that can not be completely removed by backwashing alone. After the manual addition of cleaning chemicals, the unit automatically runs through a cleaning and rinsing process without further operator attention. The CIP interval will depend upon the raw water quality and type of fouling, with a minimum of 2 hours for each chemical clean. Typical CIP frequency is around 3-4 weeks. Chemical cleaning for the membranes will likely to require the use of citric acid and chlorine.

7.2.5 Compressed air system

Compressed air for the gas backwash is provided by an air compressor.

Key features and benefits of the CMF Unit:

- It is a barrier filtration system that provides positive physical retention of suspended solids and microorganisms
- Proven performance with secondary quality effluent
- Filtrate quality provides consistent high quality even over wide variations in feed water quality conditions.
- The membrane integrity is automatically monitored.
- Extensive diagnostic plant alarms detect possible faults before they compromise plant operation.
- Operator input is minimal.
- The units are robust in design and intended for unattended remote area operation.

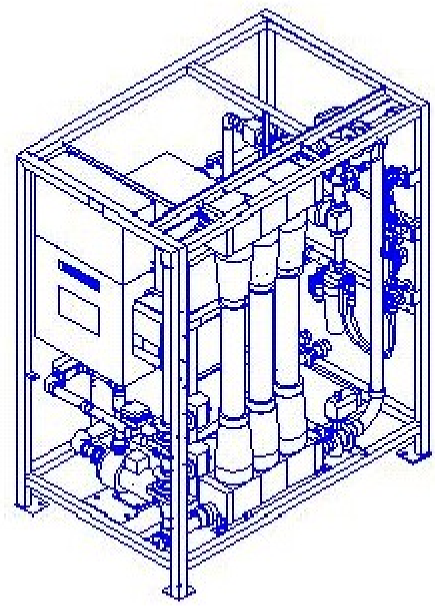


Figure 8: Diagram of Memcor AXIM 3 packaged continuous microfiltration unit

7.2.6 UV disinfection

A UV unit will be installed to provide 90 mW.s/cm^2 of UV intensity. The UV unit will provide effective disinfection and ensure Class A+ recycled water requirements are met by the plant. The UV unit will be fitted with UV intensity monitors.

7.2.7 Residual chlorine disinfection

Residual chlorine disinfection dosing equipment is required to achieve the Class A+ Recycled Water quality. It is likely that sodium hypochlorite will be used to provide the required 1 mg/L residual.

References

enHealth, *Guidance on the Use of Rainwater Tanks*, The Commonwealth Government enHealth Council, 2004.

NWQMS *Use of Reclaimed Water Guidelines* (2000)

NSW Health, *Interim Guidance for Greywater and Sewage Recycling in Multi Unit Dwellings and Commercial Premises* (2004).

Douglas Partners, *Geotechnical Investigation Proposed Emirates Luxury Resort Wolgan Road Wolgan Valley* (2005)

NSW EPA *Guidelines for Land Irrigation of Effluent* (2004)

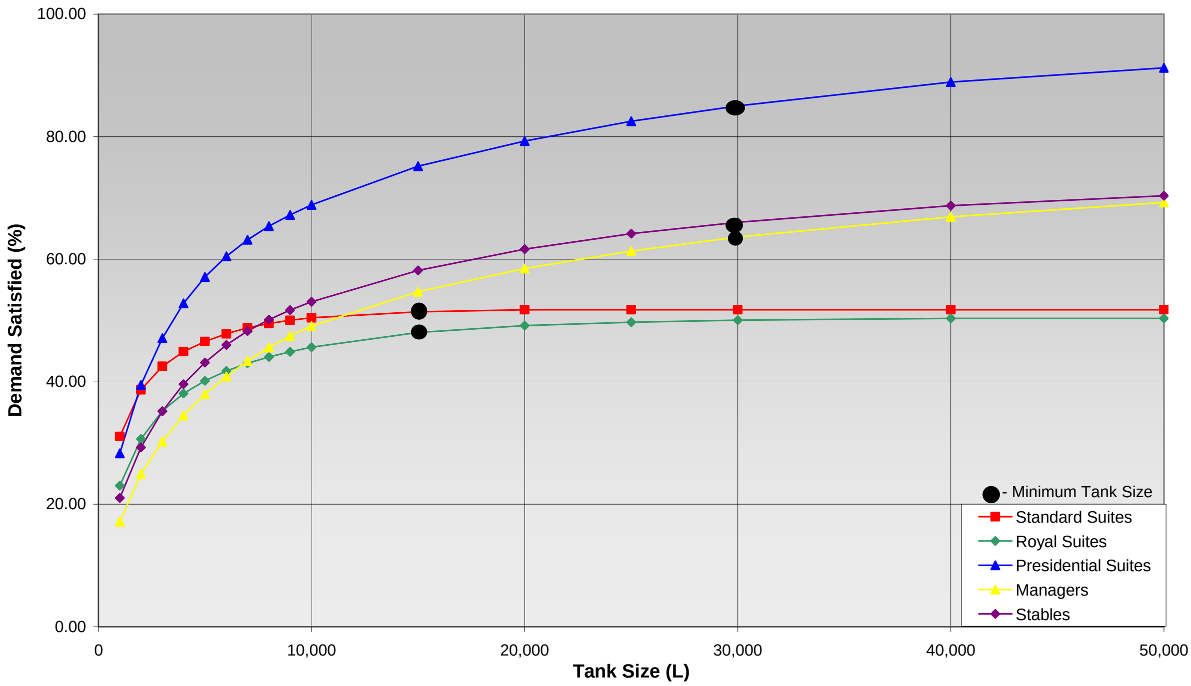
Appendix 1:
Breakdown of Ultimate Potable and Non-Potable Water Demands

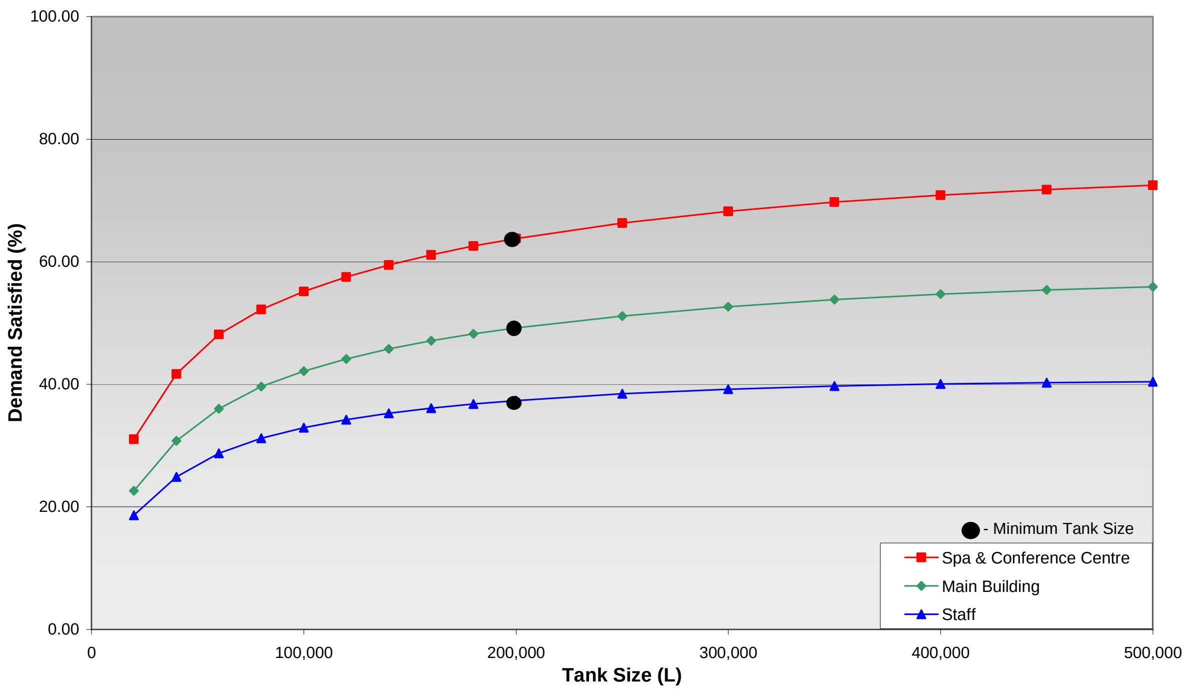
Facility	Occupancy/No. of Users/Quantity			Water Usage (L/person/day)			Total Water Usage (L/day)			Average day water demand L/day		
									occupancy	accom 0.8	conf 0.5	staff etc 1
Villas	Dwellings	Occupancy	Population	Total	Potable	Reuse	Total	Potable	Reuse	Total	Potable	Reuse
Standard	42	2	84	130	118	12	10907	9891	1016	8726	7913	813
Royal	4	4	14	130	118	12	1870	1696	174	1496	1356	139
Presendential	2	4	10	130	118	12	1247	1130	116	997	904	93
Total							**14024**	**12717**	**1307**	**11219**	**10174**	**1045**
Main Building												
Restaurant	1	108	108	100	92	8	10778	9914	864	8623	7932	691
Bar	1	108	108	22	18	4	2419	1987	432	1935	1590	346
Non-Resident Staff	1	144	144	23	20	3	3326	2894	432	2661	2316	432
Total							**16524**	**14796**	**1728**	**13219**	**11837**	**1469**
Conference Centre	1	96	96	27	23	4	**2630**	**2246**	**384**	**1315**	**1123**	**192**
Spa												
Spa	1	40	40	12	12	0	490	490	0	392	392	0
Hydrotherapy	1	40	40	24	24	0	980	980	0	784	784	0
Cold Plunge Pool	1	40	40	40	40	0	1600	1600	0	1280	1280	0
Steam Room	1	40	40	0	0.2	0	8	8	0	6	6	0
Indoor/Outdoor Pool	1	40	40	40	40	0	1600	1600	0	1280	1280	0
Toilets/Showers	1	40	40	76	72	4	3040	2880	160	2432	2304	128
Total							**7717**	**7557**	**160**	**6174**	**6046**	**128**
Horse Stables	1	20	20	70	40	30	**1400**	**800**	**600**	**1400**	**800**	**600**
Manager's Accommodatio	1	14	14	120	108	12	**1729**	**1555**	**174**	**1729**	**1555**	**174**
Vehicle Wash Bay	1	20	20	4	0	4	**86**	**0**	**86**	**86**	**0**	**86**
Overall Total							**44111**	**39672**	**4439**	**35143**	**31535**	**3694**

Staff Accommodation

Facility	Occupancy/No. of Users/Quantity			Water Usage (L/person/day)			Total Water Usage (L/day)			Average day water demand L/day		
	Dwellings	Occupancy	Population	Total	Potable	Reuse	Total	Potable	Reuse	Total	Potable	Reuse
Single Room	16	1	16	90	78	12	1442	1248	194	1442	1248	194
Double Room	14	2	28	90	78	12	2523	2184	339	2523	2184	339
Quad rooms	22	4	88	90	78	12	7929	6864	1065	7929	6864	1065
Pool	1	144	144	40	0	40	654	0	654	654	0	654
Kitchen	1	132	132	30	30	0	3960	3960	0	3960	3960	0
Staff Laundry	1	144	144	26	0	26	3780	0	3780	3780	0	3780
Total							**20287**	**14256**	**6031**	**20287**	**14256**	**6031**

Appendix 2:
Rainwater Modelling Curves: Tank Sizes Verses % Demand Satisfied.





Appendix 3: Irrigation Area