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Goodman International Limited

Oakdale Development Site

Water Balance Report Part 2

December 2007

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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1. Introduction

1.1 General

Sustainability is defined as the “capacity for continuance into the long term future” (Wilsdon, 1999). By this definition, anything that can go on being done on an indefinite basis is sustainable. The four short listed servicing strategies for the proposed Oakdale development site have been assessed using Additive and Concordance Multivariable Criteria Analysis (MCA) to help identify the most sustainable scenario(s) considering a range of sustainability criteria incorporating environmental, social/cultural and economic factors.

The Additive and Concordance MCA uses agreed sustainability criteria objectives which are scored for the performance of each short listed servicing option.

1.2 Objectives

The MCA is conducted to help identify the preferred and/or most sustainable water-servicing scenario for the Oakdale development site.

1.3 Background

The preliminary results of the Water Balance Options Report Part 1 (GHD, December 2007) clearly exhibited that the option to prioritise blackwater recycling first, followed by the use of rainwater to help supplement any deficits in non-potable end uses is the preferred servicing strategy.

GHD assessed the preferred water servicing options in detail based on a lot by lot, cluster (group of lots) and centralised scale following the refinement and short-listing of options in a water balance workshop with Goodman International Ltd on the 30 April 2007.

During the 30 April 2007 Workshop, a preliminary list of sustainability criteria and weightings were presented to Goodman International Ltd. Goodman International Ltd reviewed GHD’s preliminary list of sustainability criteria and weightings. Feedback was provided to GHD prior to a subsequent workshop.

The MCA was used to assist Goodman International Ltd with the selection of their preferred servicing strategy option(s).

1.4 Water Balance Scenario Options

The short list of servicing strategies for the Oakdale development consisted of the following three options from the results of the Water Balance (GHD, December 2007) summarised in Table 1.

Table 1 Short Listed of Servicing Strategies with 27 EP / 'Generic Warehouse Facility'

Option Title	Option Brief Description
Lots_27_0	This option represents lot scale servicing with an advanced sewage treatment plant (STP) at each lot, with 27 EP per generic warehouse facility and expected 0% rainfall wet weather inflow/infiltration. The sewage from each generic warehouse facility is conveyed to each local STP by gravity. All sewage is treated to a recycled water standard, stored locally and pumped to service non-potable end uses for reuse on the generic warehouse facility or 'lot'. Roofwater is captured and stored locally (nominally 70kL per generic facility) to supplement any local deficit in recycled water, with excess rainwater being transferred to the Regional Roofwater Harvesting Scheme. An additional emergency storage on each lot is sized to provide up to three days containment of average daily flows to avoid sewage spillages in the event of system malfunction and/or store any unexpected surplus recycled water (no surplus recycled water is expected for this option based on zero inflow/infiltration during wet weather (refer Option Lots_55_1.3 which includes allowance for wet weather inflow/infiltration).
Clust_27_1.3	This option represents cluster scale servicing with an advanced STP to service six development clusters (typically 22 generic warehouse facilities per cluster), with 27 EP per generic facility and 1.27% rainfall wet weather inflow/infiltration. The sewage from a cluster is gravitated/pumped to the corresponding advanced STP. All sewage is treated to a recycled water standard, and pumped to a recycled water reservoir, prior to gravitating as required to meet non-potable end uses within each cluster. Surplus recycled water, not utilised daily, is disposed of in a dedicated irrigation area after temporary storage within the cluster STP emergency storage. Roofwater is captured and stored locally (nominally 70kL per lot) to supplement any cluster deficit in recycled water, with excess rainwater being transferred to the Regional Roofwater Harvesting Scheme. Each cluster STP includes up to 24 hours emergency storage to avoid spillage of sewage during system malfunction and/or to temporarily store any surplus recycled water that cannot be disposed of immediately in the nominated surplus recycled water irrigation area.

Option Title	Option Brief Description
Central_27_2.5	This option includes a single advanced STP to service all of the Oakdale development, with 27 EP per lot and 2.53% rainfall wet weather inflow/infiltration. The sewage from each of the lots is gravitated/pumped to the central advanced STP. All sewage is treated to a recycled water standard and pumped to a central recycled water reservoir prior to gravitating as required to meet non potable end uses. Any surplus recycled water which is not utilised daily across the development is disposed of in a dedicated surplus effluent irrigation area after temporary storage within the central STP emergency storage. Roofwater is stored locally (nominally 70 kL on each generic warehouse facility) to supplement any deficit in recycled water, with excess rainwater being transferred to the Regional Roofwater Harvesting Scheme. The central STP would incorporate up to 24 hours emergency storage to avoid spillage of sewage during system malfunction and/or to temporarily store any surplus recycled water that cannot be disposed immediately off in the nominated surplus recycled water irrigation area.

A fourth servicing strategy option was also investigated, namely ‘Lots_55_1.3’, to assess the effects on the sustainability of an option with a ‘higher end’ of equivalent persons (55EP) per lot with the upper end of expected wet weather inflow/infiltration (1.27%) for lot scale servicing.

This option is configured in the same way as Option Lots_27_0 above, except that the advanced STP capacity and emergency storage volume includes provision for wet weather inflow/infiltration.

As a result, the MCA assessed a total of four short-listed servicing strategies.

2. Summary Water Balance Results

The preliminary results detailed in the Water Balance Options Report Part 1 (GHD, December 2007) clearly exhibited that the option to prioritize blackwater recycling first, followed by the use of roofwater run-off to help meet any deficits in non-potable end uses as the preferred servicing strategy. This strategy maximises potable water savings, reduces effluent generation and provides the most efficient use of resources.

The Water Balance Options Report Part 1- Technical Addendum (GHD, December 2007) further refined the preferred servicing strategy to incorporate:

» Lower rainfall wet weather infiltration to simulate more decentralised strategies. That is, the following wet weather infiltration values were adopted for differing servicing strategies:
  – Centralised: 2.53% of rainfall;
  – Cluster: 1.27% of rainfall;
  – Lot by Lot (fully decentralised): 0% or rainfall (no wet weather inflow/infiltration and 27 EP/ generic warehouse facility); and
  – Lot by Lot with 1.27% inflow/infiltration and 55 EP/ generic warehouse facility.

In summary, the preferred servicing strategies (i.e for 27 EP per generic warehouse facility) would result in the following for the 'average' rainfall year for the total development area:

» **Lot Scale (Fully Decentralised) Servicing**: no surplus recycled water, utilisation of 7.0% of Oakdale's contribution to the Regional Roofwater Harvesting Scheme, and approximately 70% saving in potable water requirements. This equates to a potable water demand of approximately 56ML/year (including 17ML/year of potable substitution to make up non-potable deficits). Non-potable water demands will be serviced by approximately 85ML/year of roof rainwater usage, 46ML/year of recycled water and 17ML/year of potable substitution.

» **Cluster Scale Servicing**: approximately 19 ML/year of surplus recycled water, utilisation of 6.8% Oakdale's contribution to the Regional Roofwater Harvesting Scheme, and approximately 71% saving in potable water requirements. This equates to a potable water demand of approximately 56ML/year (including 17 ML/year of potable substitution to make up non-potable deficits). Non-potable water demands will be serviced by approximately 83 ML/year of roof rainwater, 48ML/year of recycled water and 17 ML/year of potable substitution.

» **Centralised Scale Servicing**: approximately 40 ML/year of surplus recycled water, utilisation of 6.8% of Oakdale's contribution to the Regional Roofwater Harvesting Scheme, and approximately 71% saving in potable water requirements. This equates to a potable water demand of approximately 56ML/year (including 17 ML/year of potable substitution to make up non-potable deficits). Non-potable water demands will be serviced by approximately 83 ML/year of roof rainwater, 48ML/year of recycled water and 17 ML/year of potable substitution.

As discussed in Section 1.4, lot scale (fully decentralised) servicing with 1.27% rainfall inflow/infiltration and 55 EP per generic warehouse facility was also analysed to compare the sustainability of a servicing strategy considering the 'higher end' of EP per 'generic warehouse facility' and test the sensitivity of rainfall inflow/infiltration for lot scale servicing.

The results of this option are summarised as follows:

» Approximately 31ML/year of surplus recycled water, utilisation of 6.6% of Oakdale's contribution to the Regional Roofwater Harvesting Scheme and approximately 68% saving in potable water requirements. This equates to a potable water demand of approximately 76ML/year. Non potable water demands will be serviced by approximately 80ML/year of roof rainwater usage and 79ML/year of recycled water.

Table 2 summarises the results for the Four Servicing Strategy options.

Table 2 Summary of 'Key' Water Balance Results

SP Amended Scenario Description	EP per Generic Proposed Warehouse	Proportion of Infiltration with respect to that Originally Assumed		Potable Saving (%)	Non-Potable Deficit / Substitution				Total Potable			Surplus Recycled Water				Rainwater Usage (for Raintank and Recycled Water Deficit)		
		Stage 1 (% of Rain)	Stage 4 (% of Rain)		Stage 1 %	Stage 1 (ML/pa)	Stage 4 (ML/pa)	Stage 4 %	%	Stage 1 (ML/pa)	Stage 4 (ML/pa)	Stage 1 (% of Flow to Sewer)	Stage 1 (ML/pa)	Stage 4 (ML/pa)	Stage 4 (% of Flow to Sewer)	%	Stage 1 (ML/pa)	Stage 4 (ML/pa)
Lots	27	0.0	0.0	70%	8%	2	17	9%	30%	7.8	56.5	0%	0.0	0.0	0%	7.0%	12.8	84.8
Cluster	27	0.5	1.27	71%	6%	2	17	9%	29%	7.8	56.2	13%	1.1	18.8	28%	6.8%	12.5	82.7
Centralised	27	1.0	2.53	71%	6%	2	17	9%	29%	7.8	56.2	24%	2.3	39.8	45%	6.8%	12.4	82.5
Lots	55	0.0	0.0	68%	3%	1	5.9	3%	32%	11.5	75.9			10.0	11%	6.6%	12.2	80.4
Cluster	55	0.5	1.27	68%	3%	1	5.9	3%	32%	11.5	75.9			31.3	28%	6.6%	12.2	80.4
Centralised	55	1.0	2.53	68%	3%	1	5.9	3%	32%	11.5	75.9	25%	4.1	52.4	40%	6.6%	12.2	80.4

3. Sustainability

3.1 General Methodology

The four short-listed servicing strategies for the Oakdale development area have been assessed using weighted criteria and measures which incorporate environmental, social/cultural and economic factors. Both GHD and Goodman International Ltd have weighted these criteria and measures.

The measures have been scored for each option via allocating either a quantitative value or a scaled rank.

The Multivariable Criteria Analysis (MCA) combined the weightings with the scores for each option to produce the order or preference (or ranking) of the servicing strategy options.

The MCA was compiled via two different statistical methods, being the Concordance method and Additive method.

A brief description of the two different MCA statistical methods used is provided below.

3.1.1 Concordance Method

The Concordance MCA method is a pair-wise comparison, which involves comparing one option against each of the other options in turn, for all combinations or 'pairs' and across all criteria/measures.

The option that performed best of a particular criteria was assigned the full criteria weighting.

The pair-wise comparison is repeated for each criterion, and a total calculated by summing across all criteria, and converted into an order of ranking.

3.1.2 Additive Weighting

The Additive MCA method standardises the scoring for each criteria so the criteria scoring is represented in like, and therefore directly comparable units.

The criteria weightings then multiply the standardised scores. As the scores have been standardised, the impact of each option can be summed across all criteria, providing a ranking of the options.

This method not only provides a rank (as does the concordance method) but also provides information indicating how significant each option is relative to the other.

3.2 Sustainability Criteria (and measures)

The sustainability criteria and measures are listed below in Table 3.

Table 3 Preliminary Criteria and Measures

		Goodman International (GI)						GHD				
		GI	GI	GI WT%	GI Normalised Wts	GI Norm		GHD	GHD	GHD WT%	GHD Normalised Wts	GHD Norm
Weights												
Criteria	**Receiving Water Impacts**	4				0.0%		4				16.7%
	River/ Creek Water Quality - Maintaining waterway quality and manage excess effluent		5	38%	0.0%				5	42%	6.9%	
	Water Dependent Ecosystems- Achieve Natural Flows		4	31%	0.0%				4	33%	5.6%	
	Water Dependent Ecosystems-Maintain Water Quality		4	31%	0.0%				3	25%	4.2%	
	Economically Viable	4				17%		5				21%
	Financial Impacts (OPEX and CAPEX)		4	50%	8.7%				3	38%	7.8%	
	Project Net Present Cost		4	50%	8.7%				5	63%	13.0%	
	Degree of Difficulty	3				13.0%		3				12.5%
	Community Acceptance		3	13%	1.7%				5	25%	3.1%	
	Political Risk- Receiving Support from landowners		4	17%	2.3%				3	15%	1.9%	
	Political Risk- Receiving Support from Local Government		3	13%	1.7%				2	10%	1.3%	
	Political Risk- Receiving Support from State Government		3	13%	1.7%				2	10%	1.3%	
	Regulatory Approvals- Receiving necessary environmental		5	22%	2.8%				4	20%	2.5%	
	Regulatory Approvals- Receiving necessary health approvals		3	13%	1.7%				2	10%	1.3%	
	Regulatory Approvals- Receiving necessary planning approvals		2	9%	1.1%				2	10%	1.3%	
	Resource Utility	4				17.4%		5				20.8%
	Water Reuse		5	19%	3.2%				5	19%	3.9%	
	Water Sensitive Urban Design		4	15%	2.6%				4	15%	3.1%	
	Water Conservation and Efficiency		5	19%	3.2%				5	19%	3.9%	
	Greenhouse Gas Emissions		4	15%	2.6%				4	15%	3.1%	
	Land Take		3	11%	1.9%				3	11%	2.3%	
	Buffers		3	11%	1.9%				3	11%	2.3%	
	Integrated Landuse		3	11%	1.9%				3	11%	2.3%	
	Owner/ Tenant Needs	4				17.4%		4				16.7%
	Public Health		5	33%	5.8%				5	33%	5.6%	
	Regulatory Standards		4	27%	4.6%				4	27%	4.4%	
	Odour		3	20%	3.5%				3	20%	3.3%	
	Noise and visual impact		3	20%	3.5%				3	20%	3.3%	
	Technical Viability	4				17.4%		3				12.5%
	Reliability		5	28%	4.8%				3	19%	2.3%	
	Programme Constraints		3	17%	2.9%				3	19%	2.3%	
	Robustness		4	22%	3.9%				4	25%	3.1%	
	Service Levels		4	22%	3.9%				4	25%	3.1%	
	Technological Risk		2	11%	1.9%				2	13%	1.6%	

Note: Brown (or Light shaded) Sustainability Criteria are quantitative & Red (or Dark shaded) Sustainability Criteria are quantitatively scored criteria.

3.3 Weightings

The weightings were allocated to each of the preliminary sustainability criteria and sub criteria by both Goodman International Ltd and GHD.

Criteria weightings were scored according to how significant the criteria are to the overall sustainability of the Oakdale development. Measures weightings were also allocated and used to determine the relative importance of each measures goal within the indicated criteria category. A scoring system ranging from one to five was used as shown in Table 4, where higher weights place more significance or importance on both criteria categories and measures goals.

The weights as allocated and adopted by both GHD and Goodman International Ltd are shown in Table 3.

Table 4 Range of Sustainability Criteria and Measures Weights

Sustainability Weighting
1 Insignificant
2 Minor Significance
3 Moderate Significance
4 Major Significance
5 Critical Significance

3.3.1 General Differences Between GHD and Goodman International Ltd Weightings

While GHD and Goodman International Ltd weightings varied slightly, generally the weightings were allocated with no significant differences (see Figure 1 and Figure 2).

Figure 1 Sustainability Criteria Weightings – Goodman International Ltd and GHD

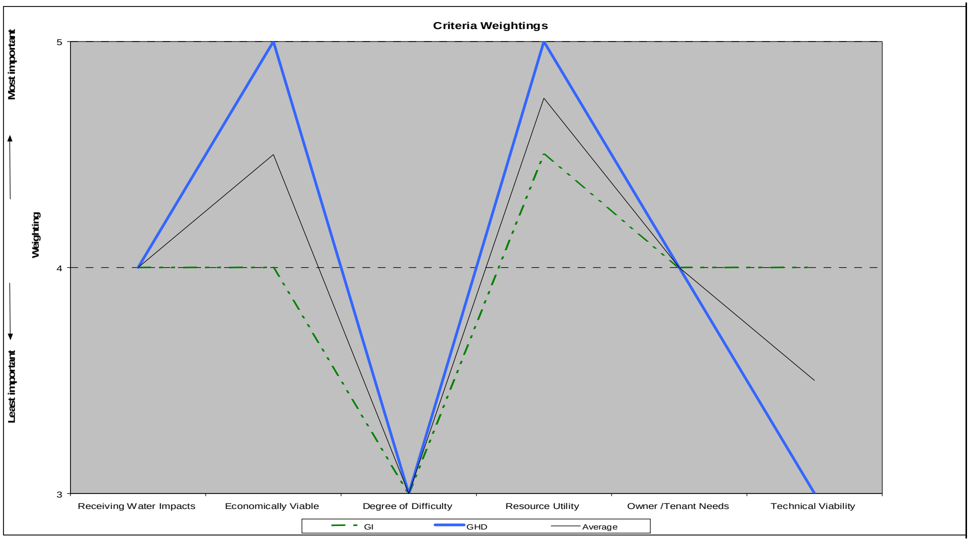
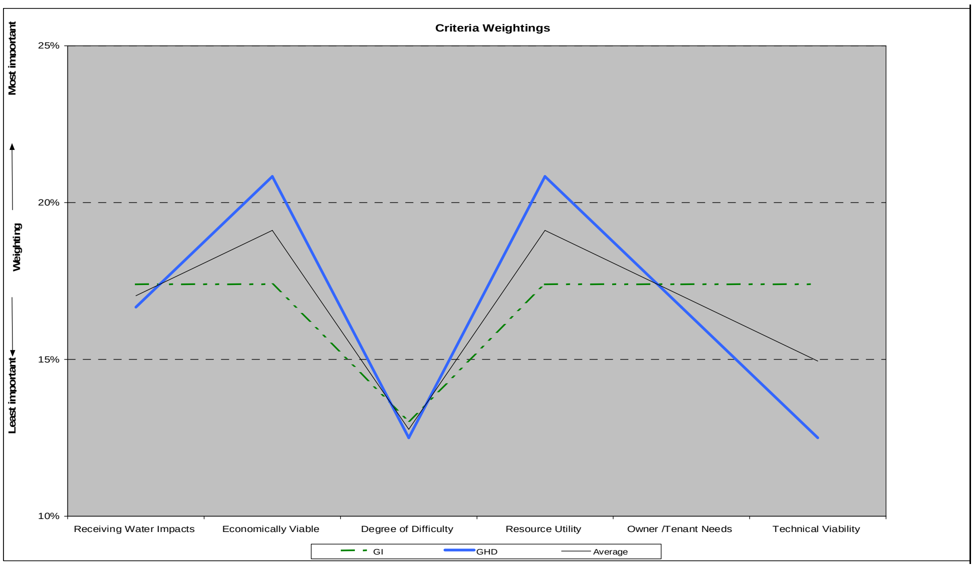


Figure 2 Overall Sustainability Criteria Weightings- Goodman International Ltd & GHD



3.3.2 General Weighting Discussion

The preliminary sustainability criteria "Resource Utility" and "Economic Viability" were allocated the highest weightings of all the criteria (either a '4' or '5' by both GHD and Goodman International Ltd), as the approval for the development depends on sustainable management of resources (known as "Resource Utility"). Similarly, the "Economic Viability" of the development is required for sustainable management of assets.

The preliminary sustainability criteria "Receiving Water Impacts" and "Owner / Tenant Needs" was allocated a weighting of '4' by both Goodman International Ltd and GHD.

GHD ranked “Receiving Water Impacts” and “Owner / Tenant Needs” as major significant, however not of critical significance to the sustainability of supplying water services at the development, as systems and regulations safeguard these criteria. In addition, “Receiving Water Impacts” are of major significance as the management of surplus recycled water at the site is important to maintaining river quality/flows. The requirement to emit to the river system may result in obtaining licences or a breach in the licence, resulting in hefty fines and negative publicity which adds corporate financial and reputation pressures that could jeopardise the provision of sustainable water services.

The preliminary sustainability criteria “Degree of Difficulty” and “Technical Viability” were assigned a ‘moderate significance’ weighting of ‘3’ by GHD, equivalent to an overall weighting of 12.5%. Similarly, Goodman International Ltd allocated a weighting of ‘3’ (equivalent to an overall weighing of 13%) and ‘4’ (equivalent to an overall weighing of 17.4%) for “Degree of Difficulty” and “Technical Viability” respectively.

There is a general recognition for increasingly integrated water management strategies in order to decrease the reliance of potable water via recycling and other methods. This is outlined in the Metropolitan Water Plan (NSW Government, 2006) and via the existence of water saving grants endorsed by the Department of Water and Energy (and others), as such there is reduced risk (or “Degree of Difficulty”) of ‘3’ in implementing the integrated water strategy.

The Barton Report (Barton Group, 2005) demonstrated that the risks to water servicing strategies do not lie in the technology itself, but rather in the maintenance of the technology, as such the “Technological Viability” was allocated a weighing of ‘moderate significance’ by GHD.

In addition to the sustainability criteria, measures were defined under each criterion to avoid duplication of issues which would skew weightings. The results of these weightings are shown in Table 3.

3.4 Scoring

The sustainability assessment scoring was undertaken to assess the four short listed servicing strategy options scenarios (identified in Section 1.4), namely:

- Lots_27_0
- Lots_55_1.3
- Clust_27_1.3
- Central_27_2.5

The results of the scoring process conducted by GHD are shown below for each Criteria measure. There are two main methods of scoring the measures. These are by:

» **A Quantitative Score**

A quantitative score gives a 'scored' numerical value to each measures based on an analysis of each servicing option. The quantitative score may be either in terms of cost ($), land areas ($m^2$ or cost of land), flows (ML/year) or other units as calculated for the particular option.

» **A Scaled Rank**

A scaled rank is a relative scaled rank between 1 and 5 (see Table 5). A scaled score is used where a quantitative score is not available. A larger scaled rank is indicative of a more superior option.

Table 5 Scaled Rank

Scaled Ranking
1 Least Performing Option
2 Moderate Performing Option
3 Median Performing Option
4 Better Performing Option
5 Best Performing Option

3.5 Quantitative Criteria Scoring

3.5.1 Receiving Water Impacts

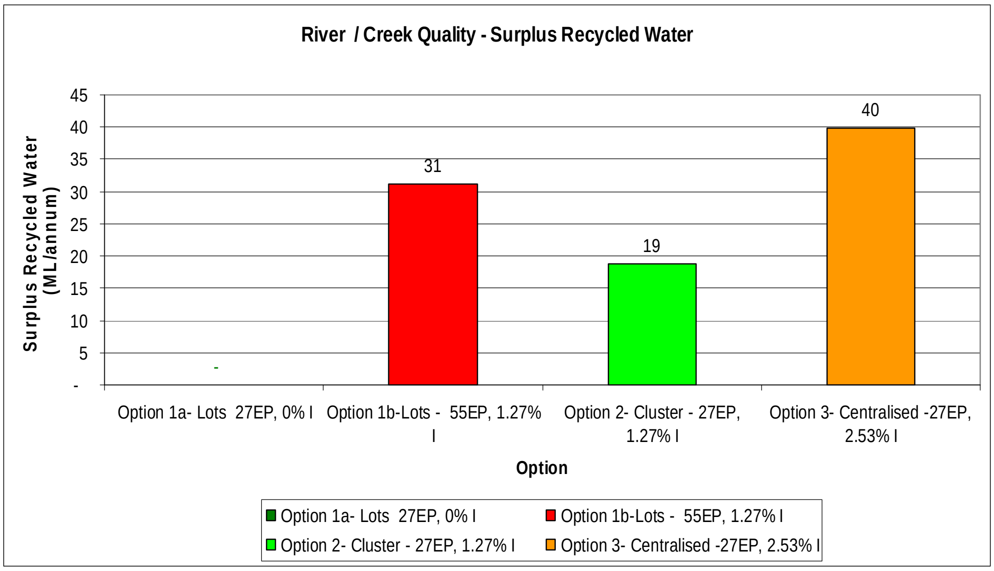
The measures of river/creek water quality would normally be gauged via the volume of effluent that could potentially be discharged to the creek within each servicing option. The objectives of maintaining River/ Creek water quality is via minimising the surplus effluent that is produced. Currently, all servicing strategies assume that all sewage is treated to recycled water standards, and in the case of 'average' rainfall conditions, the surplus recycled water will be managed via irrigation.

Although there is no proposed direct discharge of recycled water to waterways, the volume of surplus recycled water was used as a measure of the potential impact on "Water Dependent Ecosystems". The results are shown in Table 6 and Figure 3.

Table 6 Scoring for "River/Creek - Surplus Recycled Water"

Option	Option 1a- Lots 27EP, 0% I	Option 1b- Lots - 55EP, 1.27% I	Option 2- Cluster - 27EP, 1.27% I	Option 3- Centralised -27EP, 2.53% I
Quantitative Score (ML/year)	0	31	19	40

Figure 3 River / Creek - Surplus Recycled Water for each Option



3.5.2 Economic Viability

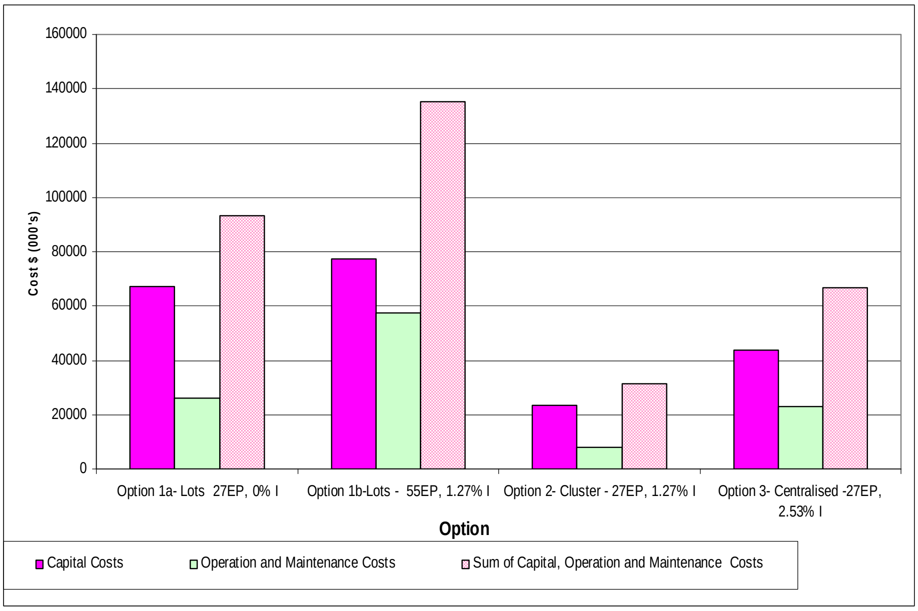
Using the indicative layout, sizing and staging for each option, preliminary cost comparisons of the identified viable options were undertaken. This involved financial analysis of capital works required, as well as estimation of annual operational and maintenance costs. These were combined in a nett present cost value (NPV) analysis, all of which are outlined in this section.

The financial evaluation performed was a comparative cots exercise only and therefore elements that are common to each option (such as rainwater tanks) were not included.

3.5.3 Capital and Operational Expenditure Results & Discussion

The Financial Impacts for the Options (Figure 4) shows the comparative cost for each option.

Figure 4 Financial Impacts ($, 000's) for each option



On the basis of the above results the following trends can been identified:

- Lot scale servicing options (1a and 1b) have higher capital costs than cluster and regional scale options (2 and 3) due to a greater number of smaller-scale plants. The economy of scale and the application of STPs in localised systems outweigh the land cost saving associated with smaller STP's as shown in Figure 4.
- Localised options generally have higher operating and maintenance (O & M) costs than cluster/centralised options due to:
  - An increased number of STP's and associated auxiliary buildings and infrastructure,
  - Increased energy costs and chemical usage.
- The O & M costs increase with increasing number of STP's.
- The O & M expenditure trends display the staging of each option, with regional systems showing a step-like increase in O & M costs in line with the increases in capital investment. The more localised options show a smoother increase in O & M expenses over time, illustrating a shift towards gradual increases in O & M expenses over an increased number of stages.

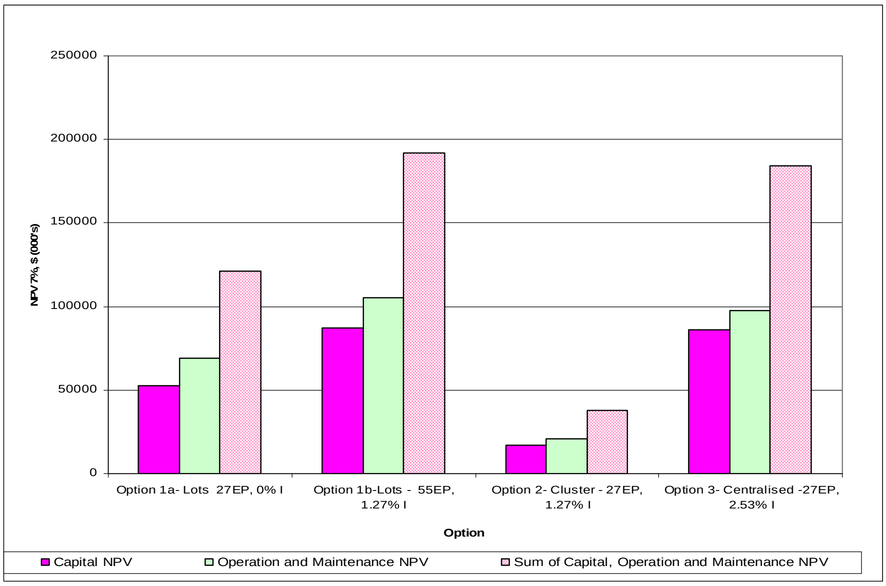
3.5.4 Nett Present Value (NPV) Results and Discussion

The nett present value (NPV) of the four options was calculated using capital, operational and contingency costs over the Oakdale development planning horizon of years 2008 – 2030. The NPV analysis was carried out using a discount factor of 7%, with sensitivity analysis at 4% and 10% included to investigate the effect of an increased or decreased discount rate. Figure 5 shows the 7% NPV for all options

On the basis of the results, the following trends can be identified:

- » The nett present values calculated for each option show that the NPVs of Option 2 (cluster) to be lowest and most cost effective;
- » Options 1a and 1b generally have a higher NPV due to the loss of economy of scale due to increased number of treatment plants treating the same volume of wastewater;
- » Option 1b has a higher NPV than Option 1a due to increased EP and increased effluent treatment cost; and
- » The 4% and 10% NPV sensitivity analysis does not show any significant changes in the ranking of the options.

Figure 5 Nett Present Value ($, 000's) for Each Option



3.5.5 Resource Utility

» **Measures: "Water Reuse" and "Water Conservation and Efficiency"**

The quantitative scoring for the measures of Water Reuse and Water Conversation and Efficiency for each option have been abstracted from the Water Balance (as summarised in Section 2), and shown in Table 7 and Figure 6 and Figure 7.

The measures of Water Reuse gauges the proportion of recycled water which is re-used as a portion of the total water demand for each option. The option which maximises the use of recycled water (i.e Option 1b) scores highest.

The measures of Water Conservation and Efficiency gauges the volume of potable water required by each option. A better performing option would utilise a lower volume of potable water, as such the options with less equivalent persons (i.e Options 1a, 2 and 3) score higher.

Table 7 Scoring for "Water Reuse" and "Water Conservation and Efficiency"

Option à Measures ↓	Option 1a- Lots 27EP, 0% I	Option 1b- Lots - 55EP, 1.27% I	Option 2- Cluster - 27EP, 1.27% I	Option 3- Centralised -27EP, 2.53% I
"Water Reuse" (Recycled Water Utilised as a portion of Total Water Demand, %)	25	34	27	27
"Water Conservation and Efficiency" (ML/year)	56.5	75.9	56.2	56.2

Figure 6 Water Re-use for each Option

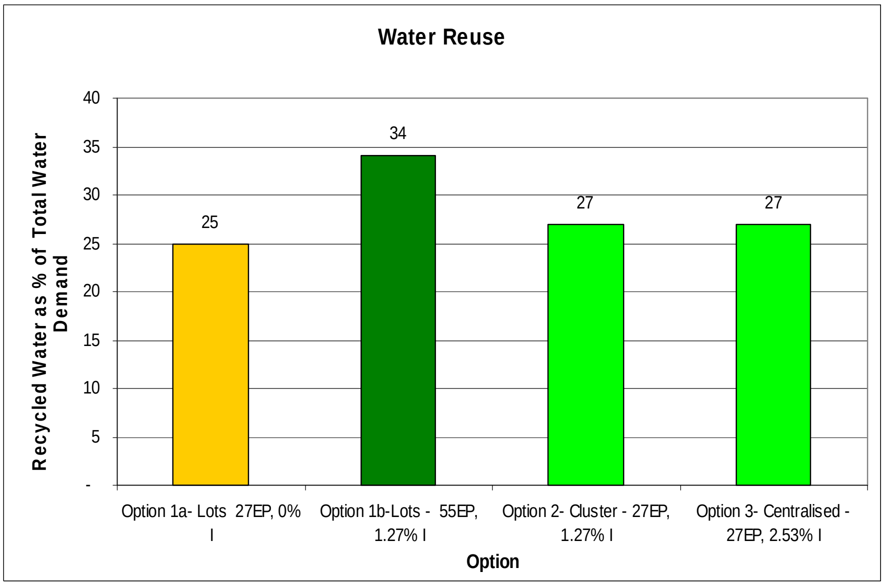
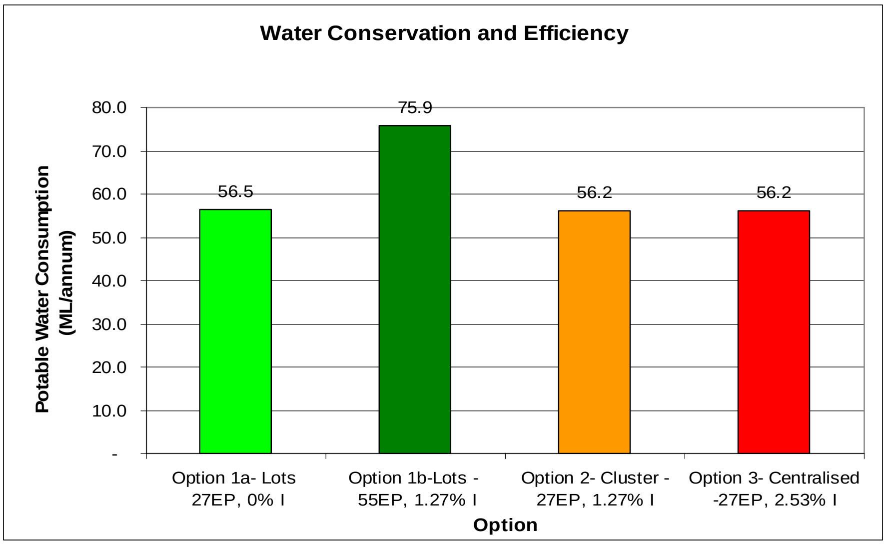


Figure 7 Water Conservation and Efficiency for each Option



3.5.6 Greenhouse Gas Emissions

The Greenhouse Gas Emissions for each option were calculated using the Australian Greenhouse Office, AGO Factors and Methods Workbook (2005).

» **Measure: Municipal Wastewater Treatment Biological Emissions**

Total greenhouse gas emissions from municipal wastewater are the sum of emissions from wastewater treatment and sludge treatment. The following formula is used to measure the CO2-e emissions from treating municipal wastewater as per the AGO handbook:

GHG Emissions (t CO2-e) = [(((P x DCw) x (1 - Fsl) x EFw))+ (P x DCw x Fsl x EFSL)) - R] x 21

The variables and their assumed values are given in Table 8. The assumed values have been sourced from the AGO handbook.

Table 8 Variables and Assumed/Given values

Variable	Description	Given / Assumed
P	EP in thousands (27EP per lot / 55EP per lot)	(As per Option) 3.564 / 7.128
DCw	BOD per capita per year in wastewater	22.5
BODw	BOD in kilograms per year which is the product of DCw and population	(As per Option) 80,190 / 160,380
Fsl	Fraction of BOD removed as sludge.	0.29
Efw	Methane emission factor for wastewater (kg CH4/kg BOD)	0.65

Variable	Description	Given / Assumed
Efsl	Methane emission factor for sludge (kg CH4/kg BOD (sludge))	0.11
CH4	Global Warming Potential of CH4 in terms of CO2	21
kg CH4/m3 CH4	Conversion	0.672
CH4/m3	Energy potential (kJ)	3,3810
CH4/kg	Energy potential (kJ)	5,0312.5
R	Recovered methane from wastewater in a year (tonnes)	0

Using the above assumptions the total CO_2 equivalent emissions for the biological treatment of municipal waste is shown in Table 9;

Table 9 Wastewater Treatment Biological Emissions

Option	Total CO_2 equivalent emissions (tonnes/pa)
Option 1a_Lots27_0_0	792
Option 1b_Lots55_1_3	1,716
Option 2_Clus27_1_3	756
Option 3_Cent27_2_5	831

» **Energy Conversion Assumption**

When electricity is used, it equates to the emissions of greenhouse gasses due to the use of fossil fuels for the pf electricity. The greenhouse gas quantity attributed to the production of electricity is calculated using the following formula:

GHG emissions (t CO2-e) = Q x EF / 1000

Where:

» Q = kWh

» EF = Emission Factor (life-cycle of power). This is dependent on the type of power generation and transportation used. As stated in the AGO handbook, in NSW this factor is 0.985.

» **Measure: Municipal Wastewater Treatment Power Emissions**

Power Consumption at the STPs is calculated by using a power factor conversion from previous experience. It is known that a STP with a treatment capacity of 9000 EP will consume approximately 200,000 kWh per year. Applying the power factor of 0.9 for the scaling of electricity usage to a number of STPs with a total treatment capacity gives the emissions shown in Table 10:

Table 10 Wastewater Treatment Power Emissions

Option	Total CO_2 equivalent emissions (tonnes/pa)
Option 1a_Lots27_0_0	145
Option 1b_Lots55_1_3	264
Option 2_Clus27_1_3	103
Option 3_Cent27_2_5	86

» **Measure: Recycled Water and Sewage Pumping Power Emissions**

The approximate ultimate electrical usage per year for each option is found by applying the energy conversion assumption to give the Wastewater and Recycled Water Pumping CO_2 emission are shown in Table 11:

Table 11 Recycled Water and Wastewater Pumping Power Emissions

Option	Total CO_2 equivalent emissions (tonnes/pa)
Option 1a_Lots27_0_0	66
Option 1b_Lots55_1_3	145
Option 2_Clus27_1_3	70
Option 3_Cent27_2_5	70

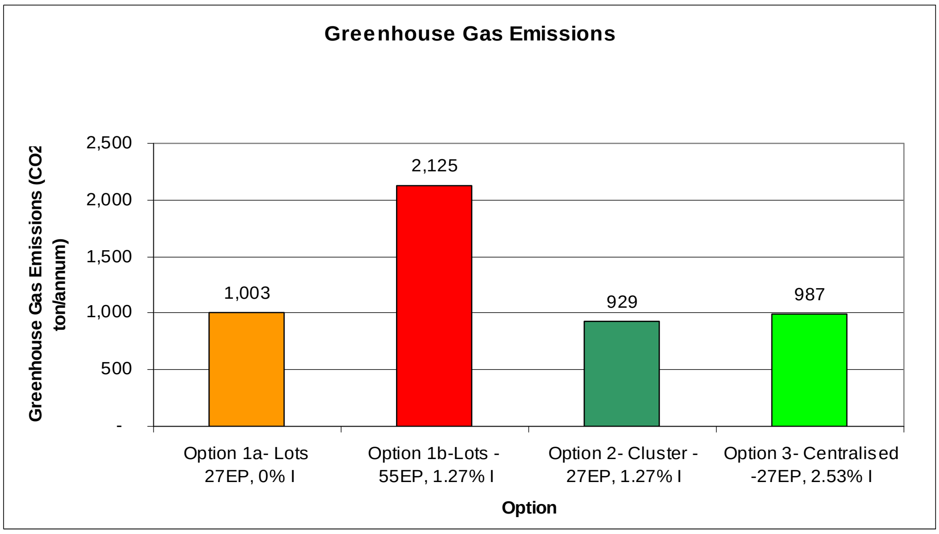
» **Results of total CO2 emissions for each option considered**

As the results in Table 12 (and Figure 8) shows, total CO2 Emission contribution is lowest for cluster treatment option**.**

Table 12 Total CO2 Emissions per option

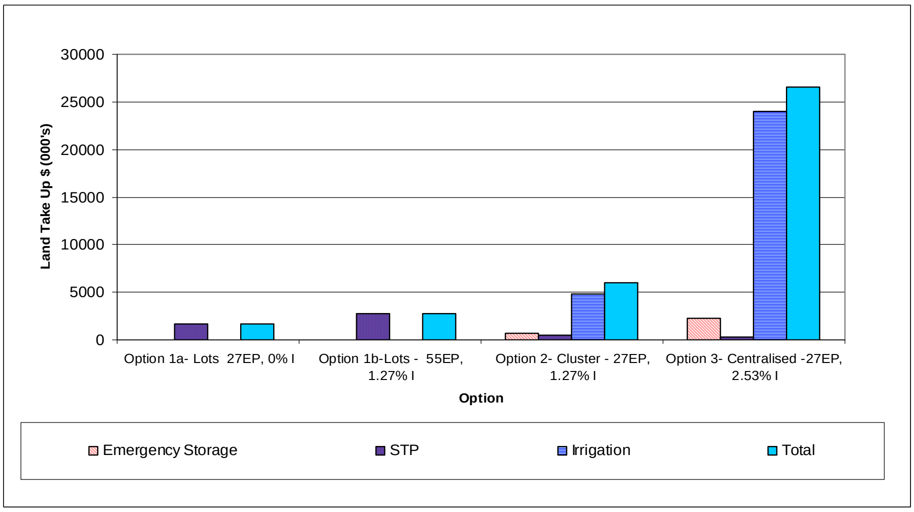
Option	Total CO_2 emissions (tonnes/pa)
Option 1a_Lots27_0_0	1,003
Option 1b_Lots55_1_3	2,125
Option 2_Clus27_1_3	929
Option 3_Cent27_2_5	987

Figure 8 Total CO2 Emissions per option



Land take is simply the comparison between the area taken up by emergency storage, STP and irrigation areas for each option and then multiplied by an assumed land value. The results are presented in Figure 9.

Figure 9 Land Take Up for Emergency Storage, STP and Irrigation for Each Option



3.5.7 Buffers

For the purposes of relative costing (see Section 3.5.2) Membrane Bioreactor (MBR) treatment technology was considered for use in all scenarios. Membrane Bioreactor (MBR) treatment technology is considered to require negligible buffer distances. As such, all servicing strategy options would rank equal for this option (with a quantitative value of approximately 0 hectares).

3.5.8 Integrated Landuse and Water Sensitive Urban Design

The measures "Integrated Landuse" and "Water Sensitive Urban Design" have been allocated scaled ranked scores for each option (albeit, the remainder of the measures in this option are ranked by quantitative scoring).

Generally there is more opportunity to build Integrated Landuse and Water Sensitive Urban Design measures into planning procedures for a more decentralised (or lot scale) servicing strategy. As such, the lot scale option has ranked as better performing than the centralised options (refer Table 13).

Table 13 Integrated Landuse" and "Water Sensitive Urban Design Scores for each Option

Option	Option 1a- Lots 27EP, 0% I	Option 1b- Lots - 55EP, 1.27% I	Option 2- Cluster - 27EP, 1.27% I	Option 3- Centralised -27EP, 2.53% I
Scaled Rank Scoring	4	4	3.5	3

3.5.9 Degree of Difficulty

There is general recognition for the implementation of integrated water management strategies within developments by the local and NSW Government, in addition to growing community acceptance and appreciation. It is considered that a more centralised servicing strategy would be less difficult to implement when compared to the more decentralised options (refer Table 14).

Table 14 Degree of Difficulty Scores of each Option

Option	Option 1a- Lots 27EP, 0% I	Option 1b- Lots - 55EP, 1.27% I	Option 2- Cluster - 27EP, 1.27% I	Option 3- Centralised -27EP, 2.53% I
Scaled Rank	3	3	4	4.5

3.5.10 Owner /Tenant Needs

The "Owner /Tenant Needs" criteria would generally favour a more centralised servicing strategy when compared to the more decentralised options. Centralised systems have less impact on the operations of individual allotments as they will not have to maintain and monitor their own system (refer Table 15).

Table 15 Owner/tenant Needs Scores of each Option

Option	Option 1a- Lots 27EP, 0% I	Option 1b- Lots - 55EP, 1.27% I	Option 2- Cluster - 27EP, 1.27% I	Option 3- Centralised -27EP, 2.53% I
Scaled Rank	3	3	3.5	4

3.5.11 Technical Viability

Measures: Reliability, Robustness and Service Levels

A more centralised option is assumed to be more reliable, being a larger system that is easier to monitor and maintain than several smaller options as the scheme becomes increasingly decentralised. Thus, the measures of “Reliability”, “Robustness” and “Service Levels” under the criteria of “Technical Viability” were ranked higher for the more centralised option.

Measures: Program Constraints

The presence of lot scale servicing would enable a development to proceed with minimal consideration of the presence of external infrastructure or “program constraints”. The implementation of centralised servicing would require a development to consider the status of external or the central infrastructure prior to the development proceeding. As such, a centralised servicing strategy scores lower as it may delay the supply of services.

Measures: Technological Risk

For comparative cost estimating purposes, MBR technology has been assumed. The technological risk was considered for each servicing option. Generally a number of MBR plants treating 5-10 ML/day (similar capacity to cluster scale servicing) have been in operation for several years, while MBR plants up to 45 ML/day (having a slightly lower capacity than the centralised servicing option) have recently been commissioned.

As such, the cluster scale (Option 2) servicing strategy has been ranked the highest of all the options. Option 3 (centralised) ranked next. The lot scale (Option 1a and 1b) servicing strategy ranks the lowest, as the technology at this scale is not as widely used.

The scores for each option are summarised in Table 16.

Table 16 Technical Viability Measures Scoring for Differing Options

Option à	Option 1a- Lots 27EP, 0% I	Option 1b- Lots - 55EP, 1.27% I	Option 2- Cluster - 27EP, 1.27% I	Option 3- Centralised -27EP, 2.53% I
Measures within the " Technical Viability" Criteria				
Reliability- Minimises risk if equipment, system failure and breakdown.	**3.0**	**3.0**	**3.5**	**4.0**
Programme Constraints- Minimise delay of Supply Services	**4.0**	**4.0**	**3.5**	**3.0**
Robustness - Maximises availability of suitably skilled service providers	**3.0**	**3.0**	**3.5**	**4.0**
Service Levels - Maximises potential to meet future changes in service levels, eg. Climate change	**3.0**	**3.0**	**3.5**	**4.0**
Technological Risk - Maximises use of Proven Technology	**2.0**	**2.0**	**3.5**	**3.0**

3.6 Compilation of Scoring Results

A summary of the scores allocated to each measures across the four options is shown in Table 17.

Table 17 Summary of Scoring Results across all Criteria for Each Option

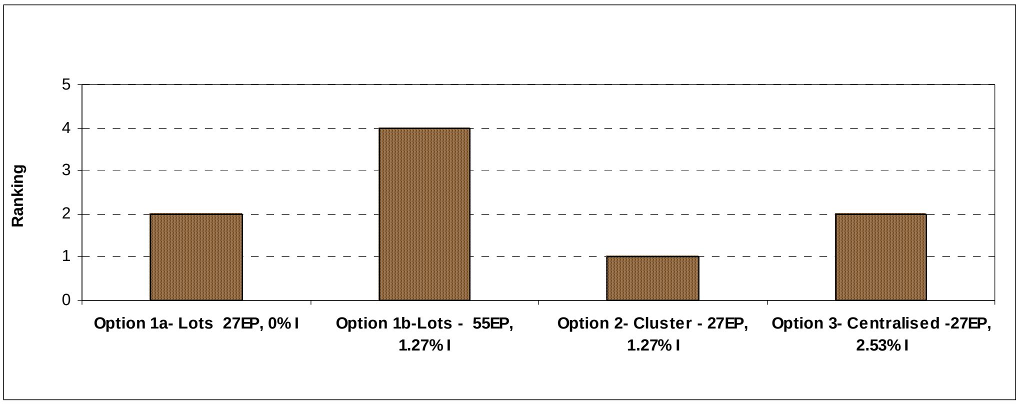
Criteria	Sub-criteria	Unit (quant or scale)	Option 1a- Lots 27EP, 0% I	Option 1b- Lots - 55EP, 1.27% I	Option 2- Cluster - 27EP, 1.27% I	Option 3- Centralised - 27EP, 2.53% I
Receiving Water Impacts	River/ Creek Water Quality - Maintaining waterway quality and manage excess effluent (Excess Effluent)	ML/year	0	31	19	40
	Water Dependent Ecosystems- Achieve Natural Flows	ML/year	0	31	19	40
	Water Dependent Ecosystems-Maintain Water Quality	ML/year	0	31	19	40
Economically Viable	Financial Impacts	$ (000's)	93,159	135,080	31,434	66,645
	Project Net Present Cost	$ (000's)	121,333	191,900	37,800	164,000
Degree of Difficulty	Community Acceptance - Minimises level of controversy expected with the local community	Scale	3.0	3.0	4.0	4.5
	Political Risk- Receiving Support from landowners	Scale	3.0	3.0	4.0	4.5
	Political Risk- Receiving Support from Local Government	Scale	3.0	3.0	4.0	4.5
	Political Risk- Receiving Support from State Government	Scale	3.0	3.0	4.0	4.5
	Regulatory Approvals- Receiving necessary environmental approvals	Scale	3.0	3.0	4.0	4.5
	Regulatory Approvals- Receiving necessary health approvals	Scale	3.0	3.0	4.0	4.5
	Regulatory Approvals- Receiving necessary planning approvals	Scale	3.0	3.0	4.0	4.5
Resource Utility	Water Reuse	(RW as % of total water demand)	25	34	27	27
	Water Sensitive Urban Design	Relative	4.0	4.0	3.5	3
	Water Conservation and Efficiency	ML/yr	56.5	75.9	56.2	56.2
	Greenhouse Gas Emissions	CO_2 tonnes/ year	1,003	2,125	929	987
	Land Take	$ (000's)	1,715	4,034	6,032	26,558
	Buffers	Hectares (assume all MBR)	0.01	0.01	0.01	0.01
	Integrated Landuse	Relative	4.0	4.0	3.5	3
Owner / Tenant Needs	Public Health	Scale	3.0	3.0	3.5	4.0
	Regulatory Standards	Scale	3.0	3.0	3.5	4.0
	Odour	Scale	3.0	3.0	3.5	4.0
	Noise and visual impact	Scale	3.0	3.0	3.5	4.0
Technical Viability	Reliability	Scale	3.0	3.0	3.5	4.0
	Programme Constraints	Scale	5.0	5.0	4.0	3.0
	Robustness	Scale	3.0	3.0	3.5	4.0
	Service Levels	Scale	3.0	3.0	3.5	4.0
	Technological Risk	Scale	2.0	2.0	3.5	3.0

3.7 Results Compiled by Concordance Method

While the weightings allocated to the criteria by GHD and Goodman International Ltd differed slightly, the compilation of the various weightings with the scoring by the Concordance MCA method resulted in the same rankings of each option.

As shown in Figure 10, Option 2 ranked 1st, Option 1a and 3 ranked equal 2nd (and 3rd) and Option 1b ranked last (or 4th).

Figure 10 Ranking of Options by Concordance (GHD and Goodman International Ltd)



3.8 Results Compiled by Additive Method

The general additive scoring of each criteria was similar despite slightly differing weightings allocated across criteria between GHD and Goodman International Ltd as can be seen when comparing the results in Figure 11 with Figure 12.

Figure 11 Additive MCA Results by Measures (using Goodman International Ltd's Weightings)

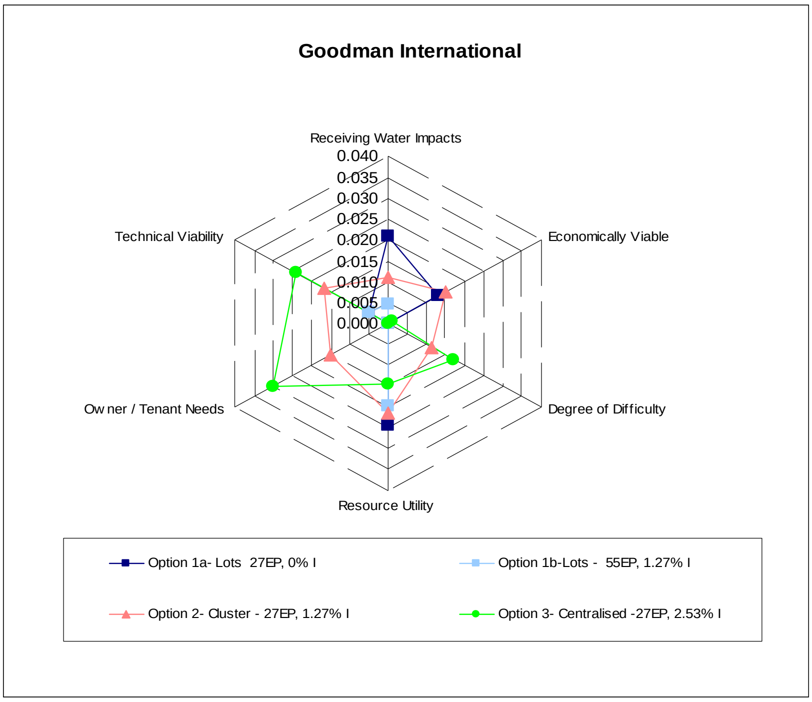
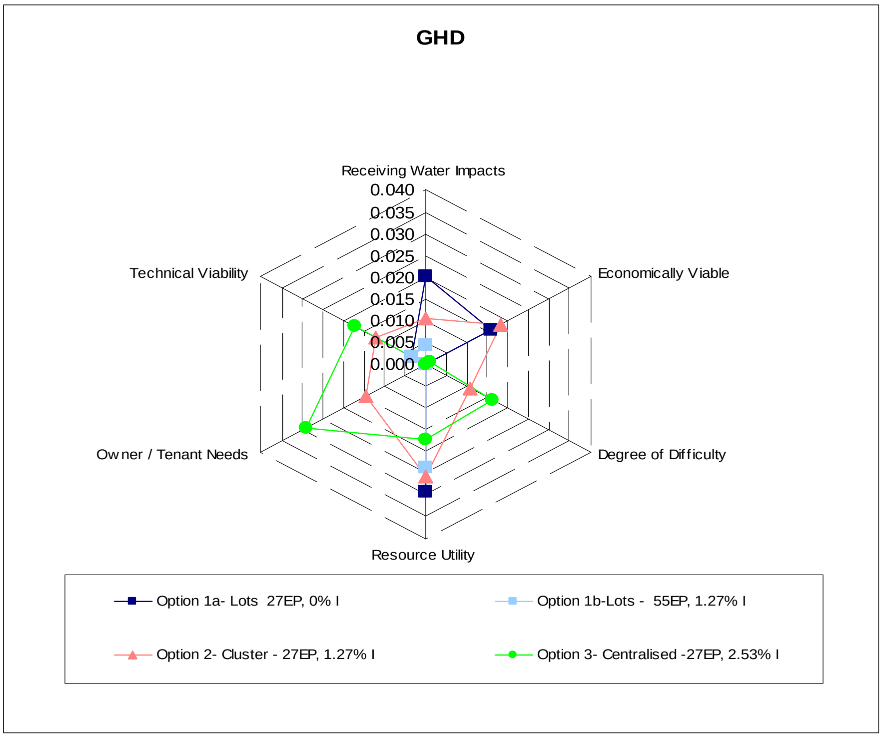


Figure 12 Additive MCA Results by Measures (using GHDs Weightings)



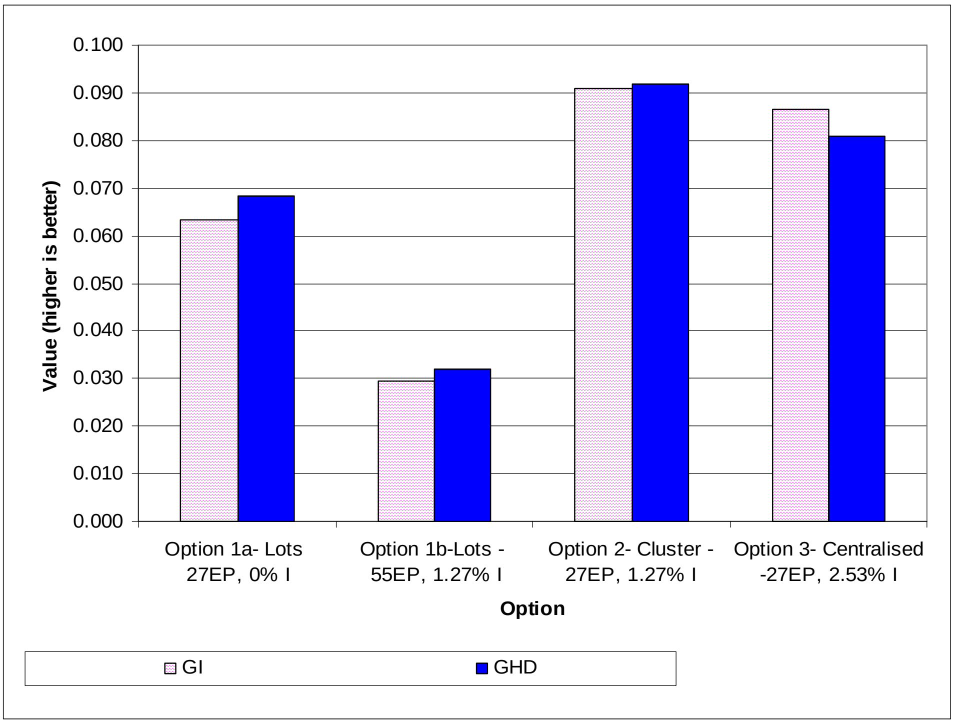
Despite the slightly differing weightings allocated to the criteria by GHD and Goodman International Ltd, the Additive MCA method resulted in the same rankings of each option as shown in Figure 13.

Figure 13 shows the ranking of the options:

- Option 2 ranked 1st (a similar result to the Concordance Method);
- Option 3 ranked 2nd;
- Option 1a ranked 3rd; and
- Option 1b ranked 4th (a similar result to the Concordance Method).

The Additive MCA method allows not only a ranking to be allocated to each option, but also allows the relative differences in rankings to be gauged. In Figure 13 it can be seen that Option 2, 3 and 1a (while ranked 1st, 2nd and 3rd) have a much smaller scoring margin between consecutive rankings than Option 1a has with Option 1b (ranking 3rd and 4th).

Figure 13 GHD and Goodman International Ltd Relative Additive Value of Options



4. Conclusions

The results of the MCA assessment identifies Option 2 Cluster (27 EP, 1.3%) as ranking the highest. However, there is not a significant difference between Option 2 and the 2nd and 3rd ranked options (Option 3 and Option 1a respectively). There is a significant difference in scores when Option 1b is compared to all others reflecting the decreasing viability of lot scale servicing for the higher end of EP's.

In choosing a preferred servicing strategy for the site it is recommended that the developer consider not only the results of the MCA but also such things as the final development staging, potential changes to the rate of expected development and final end-uses of each development site.

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