Legatus Group Regional Community Wastewater Management Scheme (CWMS) Survey and Sludge Processing Plant Viability Investigation

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Executive summary

This report describes life cycle cost estimates for improving sludge treatment by comparing de-watering bags (DWB), mechanical de-watering units (MDU) and septage dewatering ponds (SDP). This initial comparison suggests that the use of SDP is the least cost option, closely followed by DWB. SDPs would provide adequate protection against biological hazards and be fully compliant with current regulations. However, before this option is adopted, further work is required.

First, the preferred option requires that sludge be transported to new processing sites. This will not only impose new costs but will also change current operating procedures and will require capital expenditure. To determine if any change to operating procedures would result in a financial benefit would require a comparison with current costs. However, no Legatus Group Councils currently account for their current sludge management (almost universally they use the very simple option of spreading sludge on nearby agricultural land).

Second, the current method involves hidden costs and benefits. Licenced sludge disposal sites are inadequately monitored at present and there could be issues around environmental pollution, the costs of which are uncounted. Some sites are likely to be sources of improved soil productivity but again there is no accounting of such benefits. These uncounted costs and benefits will change with a move to SDPs.

This report recommends that Councils improve their understanding of current sludge management. In particular, sludge sites need improved monitoring. In addition, sludge management costs need to be determined.

Sludge management is difficult and expensive. The fundamental problem is that Legatus Group Council areas produce relatively little sludge from many small and isolated schemes. Sludge is heavy, bulky and dangerous, so that transporting and aggregating it is expensive. It might be that a decentralised approach, such as that used present, is the best option.

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Glossary

Term	Description
ABS	Australian Bureau of Statistics
AHC	Adelaide Hills Council
BOD	Biological Oxygen Demand
CWMS	Community Wastewater Management Scheme
DCMB	District Council of Mount Barker
DoHA	Department of Health and Ageing
ds	Dry solids
DWB	Dewatering bags
EP	Equivalent population
EPA	Environmental Protection Authority
ESCOSA	Essential Services Commission of South Australia
HDPE	High-density polyethylene
kL	Kilolitres
LCC	Life Cycle Costing
LGA	Local Government Association
m3	Cubic Metre
MDU	Mechanical Dewatering Units
NPV	Net Present Value
PSS	Pressure sewerage system
SA Water	South Australian Water Corporation
SBR	Sequential Batch Reactor
SDP	Sludge Dewatering Ponds
SGW	Sludge and green waste co-composting
SRMTMP	Safety, Reliability, Maintenance, and Technical Management Plan
STED	Septic Tank Effluent Disposal Scheme
STEP	Septic Tank Effluent Pumping Scheme
STP	Sewage Treatment Plant
T	Time
t	Tonnes
TP	Total phosphorus
TSS	Total suspended solids
TN	Total nitrogen
WWTP	Wastewater Treatment Plan

Definitions:

Aerobic digestion	The biochemical decomposition of organic matter in biosolids into carbon dioxide and water by micro-organisms in the presence of air (oxygen).
Anaerobic digestion	The biochemical decomposition of organic matter in biosolids into carbon dioxide, methane and water by micro-organisms in the absence of dissolved oxygen.
Biosolids	Stabilised organic solids derived totally or in part from wastewater treatment processes which can be managed safely to utilise beneficially their nutrient, soil conditioning, energy, or other value. The term biosolid does not include untreated wastewater sludges, industrial sludges or the product produced from the high-temperature incineration of sewage sludge. It should also be noted that many other solid waste materials are not classified as biosolids, e.g., animal manures; food processing or abattoir wastes; solid inorganic wastes; and untreated sewage or untreated wastes from septic systems/sewage wastes.
Community Wastewater Management System (CWMS)	A common drainage system designed to collect, treat, re-use and/or dispose of primary treated effluent from septic tanks on individual properties. The collection system is a network of pipes and pumping stations that transport the effluent from the septic tanks to the treatment site. The treatment system can either be by facultative (oxidation) lagoons where effluent is stored and treated by the aerobic system or by mechanical treatment plants where aerobic action is undertaken in a series of aerated tanks.
Contamination Grade	A grading method used to describe the quality of a biosolids batch according to the concentration of potentially toxic elements contained therein.
Grading	Process of describing biosolids products based on their contaminants (Contamination Grade) and degree of stabilisation (Stabilisation Grade).
Lagoon	A storage facility for sludge
Legatus Group	15 Central local government Councils in South Australia
Septage	Wet sludge was taken from a septic tank for disposal or reuse.
Septic Tank Effluent Disposal (STED) scheme	A common drainage system for the collection of effluent from septic tanks in townships, now known as Community Wastewater Management Systems.
Sewage Sludge	The residual, semi-solid material that is produced as a by-product during sewage treatment of industrial or municipal wastewater.

1 Introduction

1.1 Background

The Legatus Group comprises fifteen Councils in regional South Australia (Figure 1). The Legatus Group Councils all own and operate systems for the collection and management of wastewater generated in small towns, which are commonly known as a Community Wastewater Management Schemes (CWMS). Further details on the basic operation of CWMS can be found in Section 2.1. One of the products of CWMS is sludge and this report considers the viability of treating that sludge to create a usable end-product rather than spreading it on agricultural land, which is the common current practice.   This report has been prepared under the APRIntern program at the University of South Australia.

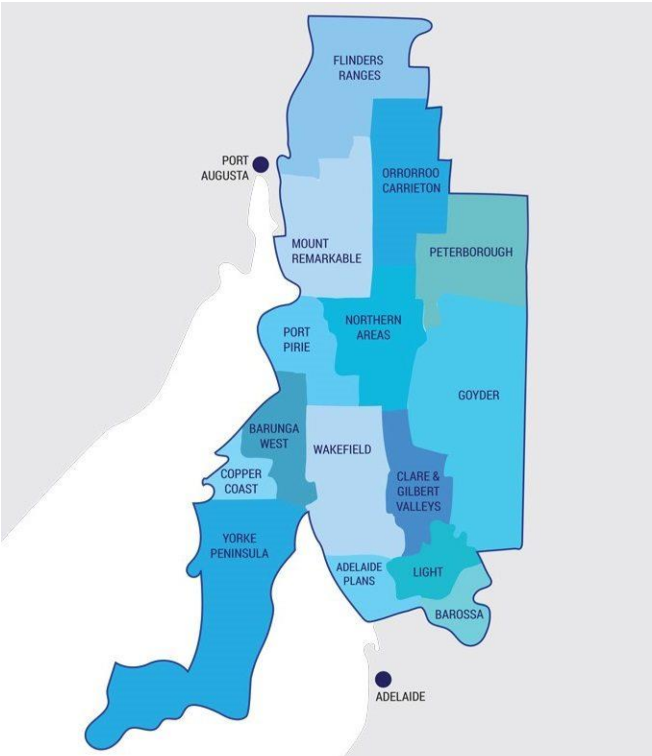

Figure 1 Map of 15 Constituent Councils

1.2 Aims and scope

The following objectives have been outlined for this project:

1. Identify and provide a report on the wastewater and septic facilities in the region, incorporating current and projected figures for the generation of sludge.

2. Undertake a desktop study of current literature and data relevant to regional sludge facilities.
3. Liaise with key industry representatives on the outcomes of the findings from the research.
4. Provide a final report, including key recommendations regarding the viability of a regional sludge facility.

While the report title refers to sludge alone, the scope has been interpreted to include septage pumped from septic tanks attached to CWMS. The scope of this investigation therefore extends to:

- sludge volumes
- current treatment, disposal and management of septage and sludge
- issues and gaps in the disposal of sludge.

The report also aims to estimate the costs for the alternative treatment and disposal of sludge and to determine the most cost-effective option and its environmental impact.

1.3 Report outline

This report begins in Section 2 by considering current practices among Legatus Councils. Section 2 also provides estimates of the quantity and quality of sludge. This work is based on information obtained from Councils by surveys and follow-up telephone interviews. Projections are also provided for future volumes based on extrapolations of Census data.

Section 3 employs a literature review to consider three technologies which can be used to treat sludge in a regional, rural setting. Section 4 considers the issue of viability. It firstly provides cost estimates of the three options. Secondly, it considers the importance of economies of scale and the difficulties in aggregating sludge across Council Schemes. Section 5 provides conclusions and recommendations.

2 Current practices

The first task is to describe these CWMS. Primary information concerning the number of CWMS in each Council area was acquired from the Department of Health and Ageing. A survey questionnaire was developed to collect information on the scale and operation of these schemes, including sludge production and management (Appendix A). This was followed by telephone correspondence. When it was available, additional information was collected from the Safety, Reliability, Maintenance, and Technical Management Plan (SRMTMP), which is part of the regulatory documentation. The results of this information gathering are included in Appendix B. The project framework is outlined in Figure 2.

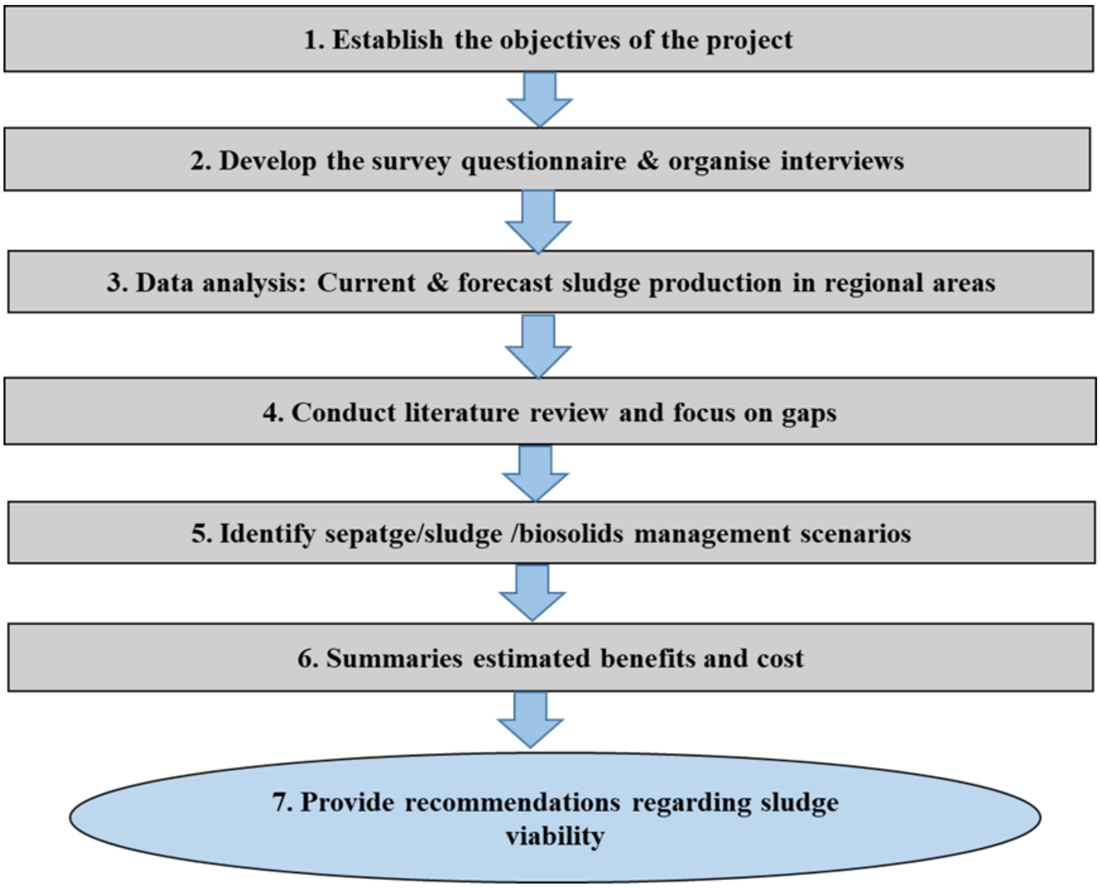

Figure 2 CWMS Sludge Viability Project Framework

2.1 Existing CWMS sludge and septage management

The 15 Legatus Councils use 57 CWMS facilities to treat the effluent from a number of townships ad settlements, as shown in Appendix 3. The effluent is virtually all residential waste. The total area of the 15 Councils is 39,253 km^2, with a total population of 127,216 (ABS, 2018). The population details of the Councils are presented in Appendix C.

The term CWMS refers primarily to systems that receive, transfer and manage wastewater that has been pre-treated in onsite septic tanks that remove solids and provide primary treatment. A schematic of a CWMS is shown in Figure 3 below.

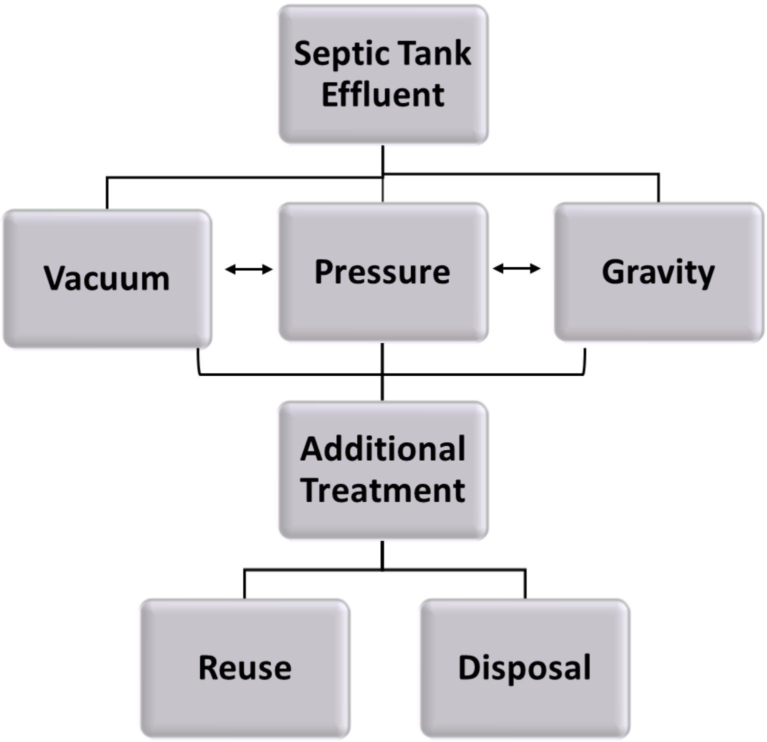

Figure 3 CWMS Schematic Including Collection Network and Treatment

CWMS deal with the effluent from septic tanks on each residential property. A pipe system conveys the wastewater to a treatment facility at the CWMS site. The septic tanks are commonly cleaned to remove solids, which is known as septage, once every four years. The pipe network is categorised as a Septic Tank Effluent Disposal Scheme (STEDS). When the system does not rely only on gravity to move effluent it is known as a Septic Tank Effluent Pumping Scheme (STEPS). The CWMS also include sedimentation and clarifying lagoons followed by a disinfection phase that uses chlorine.

STEDS include a gravity collection system for each property (Figure 3). The Schemes. STEPS consist of a pressurised rising main, which transports the effluent to a treatment and reuse /disposal facility (LGA SA and DoHA, 2019).

The Legatus Group Councils use various treatment methods for the effluent collected by CWMS such as balancing, SBR, aerobic digestion, facultative lagoons, and chlorination. The complete treatment methods are available in a separate worksheet and, where available, the schematic diagrams of CWMS are provided in separate files.

One output of CWMS is recycled wastewater which can be used for local irrigation of golf course, ovals, public gardens and farms. Wastewater safety is maintained by testing at NATA accredited laboratories for heavy metal, pathogen, BOD and TSS analysis.

The other by-product is sludge from the wastewater lagoons which are dredged once every four years or when the lagoons are full. A typical CWMS sludge management system is shown in Figure 4.

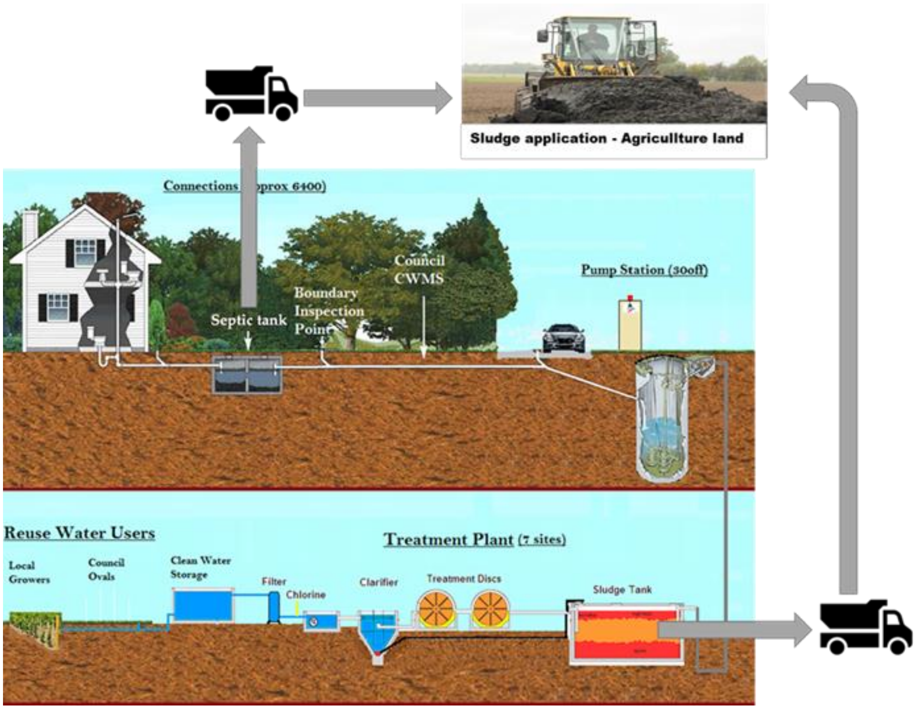

Figure 4 Typical value chain of CWMS

The sludge from Council-run CWMS lagoons is all transported off-site and often spread on agricultural land. However, Councils record very little information on sludge management. Councils provided no information on the:

- quantity of sludge generated in the CWMS facilities
- location of sludge application sites
- number of applications
- quality of sludge

- post-application monitoring of soil or groundwater.

The septic tanks are installed in each property by the owners and are required to follow the design and system criteria developed by the Local Government Association (LGA) of South Australia and the Australian Government Department of Health and Ageing (DoHA) (LGA SA and DoHA, 2019). Septic tanks provide primary treatment such as sedimentation (sludge/solids), flotation (scum), clarification (effluent) and anaerobic digestion (breakdown of organic material). The septage settles at the bottom of the tank and is typically removed once every four years (Figure 4). The contractors pump out septage leaving about 10% in the tank to maintain an appropriate bacterial population for ongoing treatment.

The SA EPA has provided a detailed guideline on septage waste management (EPA, 2017). The SA EPA and DoHA guidelines are listed in Appendix E but the key points relevant here are that:

- Septic tank effluent should only be spread on land with suitable soil properties
- Repeated application of septage to land may cause impacts to soil, groundwater and surface water.

2.2 Estimates of quantities

Estimates of quantities are made firstly for sludge and secondly for septage. Then projections are made for both through to the year 2039.

2.2.1 Quantity of sludge

Without data from the Councils, the quantity of sludge produced in CWMS lagoons was estimated based on the equivalent population connected by CWMS for a year considering 0.04 kg of Biological Oxygen Demand (BOD) per 24 hours (1 day) (LGA SA and DoHA, 2019). A conversion factor of 0.6 is used to estimate sludge volumes based on the combination of aerobic and anaerobic processes and 20 % dry solids (Gujer et al., 1995). The following equation (1) was used:

$$LS_{(Q)} = \frac{EP \times BOD \times D \times 0.6}{0.2} \quad (1)$$

where $LS_{(Q)}$ - the quantity of lagoon Sludge (dry t/year)

EP – equivalent population

BOD – 40 g of BOD per 24 hours (0.04 kg)

D – number of days

0.6 – conversion factor for sludge based on s combination of aerobic and anaerobic processes

20 % – percent dry solids (0.2)

The estimated sludge production in the Legatus Group Councils is presented in Table 1.

Table 1 Estimated sludge production per year in the Legatus Group Councils

No	Councils	No of CWMS	Estimated sludge (t/year)
1	Adelaide Plains	2	34
2	Barossa	7	780
3	Barunga West	2	51
4	Clare and Gilbert Valleys	3	254
5	Copper Coast	3	943
6	Flinders Ranges	1	46
7	Goyder	2	76
8	Light	5	268
9	Mount Remarkable	4	73
10	Northern areas	3	114
11	Orrorroo Carrieton	1	24
12	Peterborough	1	44
13	Port Pirie	2	71
14	Wakefield	4	166
15	Yorke Peninsula	17	421
	Total	57	3,366

The quantity of sludge was categorised into four groups to understand the range of production in the Legatus Group Councils and details are presented in Table 2. This shows that most Legatus CWMS produce quantities of sludge in the range of 10 to 50 t/year. Only 9 townships estimated sludge production that ranged from 100 to 500 t/year.

Table 2 Sludge production range

Sludge from lagoon range (t/year)	No of CWMS	% of total CWMS
100 to 500	9	16
50 to 99	6	11
10 to 49	32	57
1 to 9	10	18
Total	57	100

2.2.2 Septage

Septic tanks are pumped out on the initiative of property owners by contractors who are licenced by the EPA to transport and dispose of septage on approved land sites.

The lack of data regarding septage quantities has meant that an estimate had to be made based on typical septic tank sizes (3000 L) and typical frequency of emptying (once after every 4 years) with a sensitivity analysis also conducted using larger tank sizes (5000 L). The following equation (2) was used to estimate the quantity of sludge:

$$S_{(Q)} = P_{(n)} \times T_{(Q)} \qquad (2)$$

where S(Q) – quantity septage,

P(n) – number of properties,

T(Q) – tank size (L)

The quantity of septage was also categorised into four groups to understand the range of production and details are presented in Table 3. It can be seen that 29 Councils produce sludge in the 100 to 1000 kL/year range and only 4 Councils in the 5000 to 15000 kL/year range.

Table 3 Estimated septage and dry sludge produced per year in the Legatus Group Councils

No	Councils	No of CWMS	Estimated septage (kL/year)	Estimated sludge in septage (t/year)
1	Adelaide Plains	2	159	3
2	Barossa	7	6,141	123
3	Barunga West	2	602	12
4	Clare and Gilbert Valleys	3	1,864	37
5	Copper Coast	3	4,614	92
6	Flinders Ranges	1	75	2
7	Goyder	2	527	11
8	Light	5	1,636	33
9	Mount Remarkable	4	610	12
10	Northern areas	3	1,189	24
11	Orrorroo Carrieton	1	34	1
12	Peterborough	1	806	16
13	Port Pirie	2	540	11
14	Wakefield	4	1,462	29
15	Yorke Peninsula	17	2,798	56
	Total	**57**	**23,055**	**461**

The quantity of septage was categorised into four groups to understand the range of production and details are presented in Table 4. Overall, 29 Councils produce sludge ranging between 100 to 1000 kL/year. Only 4 Councils had high septage production (5000 to 15000 kL/year).

Table 4 Septage production range

Septage range (kL/year)	No of townships	% of the total township
5000 to 14999	4	7
1000 to 4999	21	37
100 to 999	29	51
10 to 99	3	5
Total	57	100

2.3 The quality of sludge and septage

Application of sludge and septage to agricultural land is the traditionally favoured option for disposal. The application of sludge and septage without treatment can cause serious environmental and health issues (Lowman et al., 2013). Sludge and septage contain organics and nutrients and can also contain heavy metals and pathogens (EPA, 2016). When properly treated, sludge is commonly known as biosolids and has many uses including to improve soil fertility and reduce the use of chemical fertilisers (Bruun et al., 2016). This is the primary reason it is spread on agricultural land. However, proper treatment depends on the quality of the sludge and septage, as well as conditions at the spreading sites. For these reasons, information was sought from Councils concerning the quality of sludge from CWMS.

While it is clear that the quality characteristics of sludge and septage are critical to any management regime, this study was unable to discern the characteristics of CWMS sludge from Legatus Councils. This is because the Councils do not comprehensively test the sludge from their ponds and they have no information on the quality of septage. In addition, there is no information from follow up testing. Soil and groundwater monitoring were not conducted after the sludge and septage land application. Therefore it was not possible to collect the information regarding this part of the project.

2.4 Projections for sludge and septage

The estimates made for the quantity of sludge and septage were projected using an arithmetic population forecasting method based on changes at a Council level in each Census since 2001. Sludge was projected based on population growth. Septage projections were based on expected growth in residential dwellings (Bartlett, 1993) using equation (3).

$$P_n = P + n \times C \qquad (3)$$

where P_n *= population/dwellings forecast for the year*

P *= present population/dwellings*

n *= population/dwellings after* n^{th} *decade*

C *= rate of change of population/dwellings with respect to time*

In this method, the average increase in population and dwellings per decade is calculated from past Census reports available at ABS for 2001, 2006, 2011 and 2016. This increase is added to the present population to determine the population for the next decade. Thus, it is assumed that the population is increasing at a rate equal to the average of the last four Censuses. The projected populations for the Legatus Group Councils are shown in Table 5.

Table 5 Predicted population growth

Councils	Predicted population growth				
Year	**2020-21**	**2023-24**	**2028-29**	**2033-34**	**2038-39**
Adelaide Plains	9,089	9,262	9,550	9,838	10,126
Barossa	24,347	24,820	25,609	26,398	27,187
Copper Coast	14,740	15,100	15,701	16,301	16,902
Light	15,500	15,959	16,723	17,488	18,252
Port Pirie	17,415	17,446	17,497	17,548	17,599
Yorke Peninsula	11,059	11,060	11,063	11,065	11,068

Two Wells (Adelaide Plains Council) and Roseworthy (Light Regional Council) were designated as growth areas under a 30-year development plan for Greater Adelaide (Oneighty, 2013). In recent years, population increases have been forecast for this region (Jones and Fuss, 2013).

The total septage and dry sludge production for the Legatus Groups Councils are shown in Table 6 and the total dry tonnage of sludge production for Councils is shown in Table 7.

Table 6 Estimated current and projected septage (kL/year) and sludge production (t/year)

No.	Councils	Year 2018-19		Year 2023-24		Year 2028-29		Year 2033-34		Year 2038-39	
		Current		5 years		10 years		15 years		20 years	
		Septage	Sludge	Septage	Sludge	Septage	Sludge	Septage	Sludge	Septage	Sludge
1	Adelaide Plains	159	34	2,857	406	2,951	423	3,045	431	3,138	444
2	Barossa	6,141	780	8,157	1,087	8,452	1,136	8,748	1,156	9,043	1,191
3	Barunga West	602	51	1,430	112	1,451	113	1,473	113	1,494	113
4	Clare and Gilbert Valleys	1,864	254	3,456	406	3,549	416	3,643	420	3,736	427
5	Copper Coast	4,614	943	7,027	661	7,356	698	7,686	714	8,015	740
6	Flinders Ranges	75	46	739	70	745	68	751	67	757	65
7	Goyder	527	392	1,677	180	1,693	179	1,708	179	1,724	178
8	Light	1,636	268	4,576	699	4,789	746	5,003	766	5,216	799
9	Mount Remarkable	610	73	1,286	125	1,306	125	1,326	125	1,346	125
10	Northern Areas	1,189	114	1,800	198	1,826	198	1,851	197	1,876	197
11	Orrorroo Carrieton	34	24	383	39	388	38	393	38	398	38
12	Peterborough	806	115	812	70	813	68	814	67	815	65
13	Port Pirie	540	71	6,471	764	6,570	767	6,669	769	6,768	771
14	Wakefield	1,462	166	2,480	304	2,528	310	2,576	312	2,624	316
15	Yorke Peninsula	2,798	421	7,560	484	7,728	485	7,895	485	8,063	485

Table 7 Predicted quantity of dry sludge (t/year)

No.	Councils	Estimated current	Year 2023-24 (5 years)	Year 2028-29 (10 years)	Year 2033-34 (15 years)	Year 2038-39 (20 years)
		t/year	t/year	t/year	t/year	t/year
1	Adelaide Plains	34	463	482	492	506
2	Barossa	780	1,250	1,305	1,331	1,372
3	Barunga West	51	141	142	142	143
4	Clare and Gilbert Valleys	254	475	487	493	502
5	Copper Coast	943	802	845	868	901
6	Flinders Ranges	46	84	82	82	80
7	Goyder	392	214	213	213	213
8	Light	268	791	842	866	904
9	Mount Remarkable	73	151	151	151	151
10	Northern areas	114	234	234	235	235
11	Orrorroo Carrieton	24	46	46	46	46
12	Peterborough	115	87	84	83	81
13	Port Pirie	71	894	899	902	906
14	Wakefield	166	354	360	364	368
15	Yorke Peninsula	421	636	639	643	646
	Total	3,752	6,620	6,811	6,910	7,054

This section has focused on the volume and quality of sludge because these are crucial considerations in determining viability, and this is discussed in more detail in Section 4. Viability also depends on the technological solutions that are available and this is the subject for the next section.

3 Technological options for a sludge processing plant

3.1 Introduction

The current practice whereby septage and sludge is applied to agricultural land is conducted in the absence of processing facilities. There are a number of alternative approaches and this section uses a literature review to consider three of the options most likely to be relevant to the scale of operation relevant to this study.

3.2 Dewatering bags

Dewatering bags have the potential to separate water from sludge (Ashworth, 2003) in order to minimize handling costs. Dewatering bags are single-use commercial products that are adopted in many countries, including Australia. Dewatering bags have been used for wastewater treatment plants, aquaculture (Sharrer et al., 2009), paper mills and in mining for ash fly slurry (Khachan et al., 2012). Polymer or alum is often used to enhance the precipitation, coagulation and flocculation processes (Ebeling et al., 2004).

Previous research has reported a significant reduction in the total suspended solids (TSS) (95%) and total phosphorous (TP) (67%) (Sharrer et al., 2009). Based on local experience, it has been shown that dewatering bags have relatively low capital costs, are effective for low flows, but have higher mobilisation costs throughout their life cycle. In South Australia, dewatering bags have been used at Port Lincoln WWTP in an unsuccessful initial trial (Figure 5) (Faulkner, 2015).

Figure 5 Geo dewatering bags at Port Lincoln WWTP (Faulkner, 2015)

Key conclusions

- Handling and transportation costs are high
- Suitable for small-scale decentralised WWTP
- Additional alum and polymer dosing required
- Low capital cost, single use, low environmental impact

3.2.1 Mechanical dewatering units (mobile)

Mechanical dewatering units are often the most effective option for a large quantity of sludge and, because they are transportable, units can be used at multiple locations. The mechanical operational capacity varies with the brand of the unit (Table 8). In the literature, it was indicated that polymers were required in mechanical dewatering units (Al-Muzaini, 2004). The performance of the mechanical dewatering unit can be measured in terms of the dry tonnes of solids (Day and Giles, 2002).

Table 8 Comparative features of mechanical dewatering technologies (Day and Giles, 2002; Young et al., 2006)

	Belt filter press	Centrifuge	V-fold belt
Energy consumption	Moderate	High	Low
Operating cost	High	High	Low
Water usage	High	Low	Low
Polymer (kg/tonne DW of biosolids)	4-10	5-8	Lower than the other two options
Solids dry (%)	10-15	15-20	9-13
Labour (hr/day)	2-3	1-2	1-2

Currently, in South Australia, SPRIAC solid and grit removal screens have been installed at Tea Tree Gully STP and Cadell STP. The Dayco dewatering belt press has been used at Goolwa STP and Wallaroo STP (photographs are attached in Appendix D).

Key Conclusions

- High energy consumption
- Requires labour
- Requires coarse screening of incoming carted wastewater
- Requires bobcat permanently on site to remove dewatered sludge
- Requires clean water for automatic screen backwashing
- Requires enclosure for protection against the elements

- Requires inflow balancing with lift pump to screen

3.2.2 Septage dewatering ponds

Various techniques have been developed to dewater sludge for biosolids production. These include dewatering bags, mechanical belt filter presses, gravity thickeners and centrifuges. Such systems, however, are rarely used in small-scale CWMS as they are relatively expensive and labour intensive. The Septage Dewatering Ponds (SDP) method may be a cost-effective process, having lagoons with HDPE liners allowing natural drying. The sludge dewatering ponds/lagoons process is shown in Figure 6.

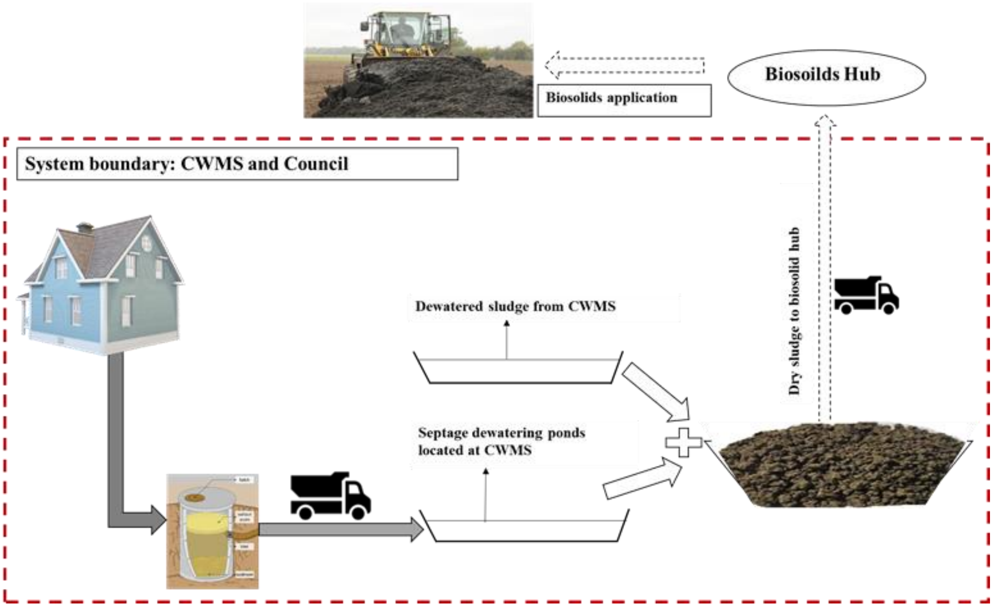

Figure 6: Septage dewatering ponds schematic

SDPs can be constructed at the CWMS site, if land is available. The ongoing septage can be transferred to these ponds but once a lagoon has reached its hydraulic capacity, a second lagoon is required and so on. The dried sludge from dewatering ponds can be transferred and mixed with dewatered sludge from the lagoons. Then the mixed sludge can be transported to a biosolids hub for storage, grading and composting.

In South Australia, Sewage Dewatering Ponds are currently utilised at Loxton, as shown in Figure 7.

Figure 7 Dewatering sewage ponds, Loxton, South Australia

A decentralised dewatering process at a CWMS will reduce the risk of handling and transportation of heavy, bulky septage. Then the dry sludge from the dewatering ponds can be transferred to a centralised biosolids hub for stabilisation and grading. The advantages and disadvantages of this approach are discussed below:

Advantages

- Minimum operation and maintenance required
- There are no technical/skilled operators required to operate a SDP at a CWMS
- Only single phase power is required for the irrigation lift pump and if required power can be provided with solar panels
- Dried sludge can be easily removed from the SDP
- Sludge sampling and analysis costs are reduced
- The potential environmental impact is reduced in terms of soil and groundwater contamination

Disadvantages

- May have occasional odour problems
- Grease and oil may cause blockage of the filter sand
- Requires dried sludge transportation

This section has reviewed three technologies which are suitable for better managing sludge in the Legatus Council areas. By improving management with one of these techniques, the end product can be a biosolid suitable for further processing into soil enhancers and other purposes. The key question is which is the most cost effective option and this is discussed in the next section.

4 The viability of sludge processing plant

4.1 Introduction

The fundamental characteristics of the Legatus Group Council CWMS is that they are small and they are isolated. Also transporting sludge is very expensive and difficult to move safely. In addition, it is bulky material with a very low value to volume ratio. This means that Councils might need to aggregate sludge to achieve economies of scale but are unable to do so cheaply because of the distances.

The viability assessment that follows is based on these facts. It begins with the basics by making a cost comparison of the three technological options considered above. It does so by considering the situation in just one Legatus Council and so looks only at that disaggregated scale and limited transport needs. However, a more complete viability analysis requires consideration of firstly some options for aggregating and secondly consideration of adding other organic waste into the process.

4.2 Cost estimates for the three technologies

The cost of constructing SDPs within each CWMS site will depend on, among other things, site conditions and transportation distances. To simplify matters, this section shows life cycle cost estimates for the three options based on a single Northern Areas Council (covering the towns of Jamestown, Laura and Gladstone, see Table 11; and the details are provided in a separate document).

The method followed involved listing all the costs associated with each option. The categories chosen are shown in Table 9. The life cycle costing was estimated for sludge and septage totalling approximately 2125 m^3 per year over a 20 year time span. The parameters for making the various estimates are derived from previous reports and information provided by stakeholders (GHD, 2018) [1].

[1] Estimated LCC costs

Parameter	Unit cost/basis	Source
Septage cleaning (including transportation and labour)	$ 265 per property for 100 km	Contractor
Sludge dredging	$ 180 /hr	Contractor
Labour cost	$ 52 per hour	Contractor
Maintenance	1.5% of capital cost	
Discount rate	5%	GHD report
Project design cost	15 %	GHD report
Project life	20 years	-
Inflation rate	2%	ABS
Design cost	15%	GHD report
Insurance	0.30 %	GHD report
GHD report: Regional Sludge and Biosolids Management - Northern Region (GHD, 2018)		

Table 9 Costs and benefits of various options

Costs	**New options**
Preliminaries	Applications and permissions from EPA, DoHA, legal work
Site works	<u>Civil works</u> Lagoons construction, road to access lagoons, pump and chemical storage room
Equipment	<u>Mechanical works</u> Valves, piping, pumps
Instruments	Electrical and instrumentation works
Management	Construction management (at each phase) Staff and supervision Project Management
Contractor	Contractor tender, verification
Operation and maintenance	Regular sampling, documentation, auditing
Design Cost	Contractor design
Insurance	Facility insurance
Escalation	NPV escalation
Benefits	**New options**
Environmental benefits	Reduced: odour, carbon footprint, low energy, toxicity potentials, carbon sequestration Reduced negative impact: groundwater, soil contamination
	Increased soil fertility, soil moisture
Biosolid production	Market for biosolids

It can be seen that the costings are incomplete (Table 10). The processing facility will require machinery for screening, grading and handling but these costs are unknown. Many of the costs of services such as design and commissioning are un-estimated. Also, due to a lack of information, transportation costs for sludge are unknown.

Table 10 Cost estimation for septage and sludge management

	Commodity	Option 1	Option 2	Option 3
1	Construction cost ($)	AUD ($)	AUD ($)	AUD ($)
	Preliminaries	Unknown	Unknown	Unknown
	Civil works	1500	49,500	4,000
	Mechanical works	7,400	7,400	7,400
	Construction management	Unknown	Unknown	Unknown
	Testing and commissioning	Unknown	Unknown	Unknown
	Machinery (dewatering unit)	-	Unknown	-
	Contractor fees (10 % profit margin)	11,549	21,797	11,871
2	Fees and allowance	318	599	326
3	Project development cost	Unknown	Unknown	Unknown
4	Project design cost (7 %)	8,893	16,783	9,141
5	Project delivery cost (15%)	19,057	35,964	19,587
6	Transportation	Unknown	Unknown	Unknown
7	Opportunity and risk-based contingency (30%)	46,593	87,933	47,891
8	Septage supply*	105,006	105,006	105,006
9	Sludge supply	1,080	1,080	1,080
10	Insurance (0.30 %)	606	1,143	623
	Total ($)	**202,510**	**365,403**	**199,008**
	*customer paid (include septic tank cleaning, transportation and disposal) **This table provides a template for the costs associated with various options and all costs are subject to change**			

It has not been possible to undertake the detailed work required to make comprehensive estimates within the timeframe of this project. The preliminary work suggests that the major costs are in sourcing septage and sludge. Septage is especially costly to source but it must be noted that these costs are currently incurred by householders and would not be a cost to Councils. However, if the costings move beyond a single Council then the costs of sourcing materials will rise.

Further work is clearly required to make a full assessment of costs. However, based on the tentative LCC analysis, options 3 and 1 ranked 1st and 2nd, respectively (Table 11). The proposed options involve the following considerations:

- Changes to sludge and septage transport
- Permission from SA EPA and DoHA to construct a SDP at CWMS
- Dredging and dewatering of ponds by third party contractor for each site
- Record and maintenance requirements
- Capital costs to build a biosolids hub.

Table 11 Cost estimation for selected scenarios

Options	**Capital cost (AUD) $**	**Per m^3 cost (AUD) $**	**LCC (20 years)**	**Rank**
Option 1	201,984	6.13	243,040	II
Option 2	365,403	11.10	439,677	III
Option 3	199,008	6.04	239,459	I

4.3 Viability and the problem of scale

Economies of scale are a well-established concept in wastewater management (Fraquelli and Giandrone, 2003). Small-scale wastewater treatment facilities are significantly influenced by scale economics (Hernández-Chover et al., 2018). This is important because each Legatus CWMS is small and isolated.

By means of comparison, SA Water has considered the processing of sludge from Adelaide sewers and other SA Water facilities (GHD, 2018). The volumes involved are at least one order of magnitude greater than in the Legatus Councils and yet processing of sludge is non-viable. While the options available to SA Water would generate revenue from reuse, this would only reduce the losses involved. SA Water considered various options for regional processing but found that "none are considered to fit into the category of providing a cost effective regional strategic solution. Transport of liquid unstabilised sludge to a centralised digestion facility, is likely to be costly, and provide inherent risks of community odours / spillages" (GHD, 2018).

These points are important for two reasons. First, sludge processing could be undertaken at a central hub for all Legatus Group Councils. This will reduce the costs of processing but add to the costs of transport and the alternative is to use multiple sites. Second, the viability of processing could improve if other organic material were added to sludge.

The first option is to use SDPs which give a decentralised septage dewatering process, followed by centralised biosolids management. While this would be the preferred combination, it will require complete transformation and control of disposal sites as well as transportation. It will require septage and lagoon sludge from CWMS to be combined and transferred to multiple, small-scale biosolid hubs. The process of dewatering septage at the CWMS site may reduce the transportation costs and reduce the risks associated with transporting bulky and heavy liquid sludge.

Preliminary consideration suggests that small-scale hubs could be located in the Barossa, Mid North, Yorke Peninsula and Southern Flinders. These potential Councils are suggested for biosolid hubs based on their shared boundaries and because they are the highest dry sludge producers in the 5 years to 2023-24. A more detailed GIS matrix study of 57 CWMS is required to better select the location for multiple sludge processing facilities. Selection must also consider the physical characteristics of each site.

Table 12 Groups of Councils and biosolid hubs

Groups	Councils	Biosolid Hubs
1	Adelaide Plains, Barossa, Light	Barossa
2	Wakefield, Northern Areas, Goyder, Clare	Mid North
3	Copper Coast, Yorke Peninsula, Barunga West, Port Pirie	Yorke Peninsula
4	Mount Remarkable, Flinders Ranges, Orrorroo, Peterborough	Southern Flinders

An alternative is to create a single facility for all Legatus Councils. The capital cost for such a hub is likely to be higher than for each of the decentralised facilities but it might still be significant. A biosolid collection, storage and sampling plan will need to be developed for the centralised strategy and a common record sharing facility will also be needed. These centralised biosolid hubs can be managed and maintained by third parties such as composting companies and viticulture farmers.

In a centralised biosolid hub option, the dry sludge can be stockpiled at each CWMS site and then transferred after some interval. The stockpile sludge may reduce the odour problem and reduce other contaminants.

The estimated production of sludge (septage + sludge from a Lagoon) is 3,752 dry t in 2018-19 which will be increased to 6,620 dry t in the next five years. This suggests very strongly that sludge processing is unviable for the Legatus Councils.

However, before it is concluded that sludge processing is unviable because of scale it is possible to enhance scale by making use of other organic waste that exists in Legatus Council areas. For example, residential organic waste is typically disposed of in non-compost waste bins and this may be collected and added to the waste stream. The organic waste contains nitrogen and phosphorous which may be useful for composting and can be mixed with the septage or sludge (Jouraiphy et al., 2005)[2]. Combining these waste streams might offer other benefits too as co-composting reduces the pollutant and bio-availability of heavy metals in sewage sludge (Fourti et al., 2010).

Another potential source of organics is to make use of refuse from agriculture. For example, Almondco producing 35,000 t/year of almond husk and shell which can be added to the sludge to enhance the quality and quantity of the compost (Sánchez et al., 2017; Watteau and Villemin, 2011). In addition, Tarac Technologies treats over 135,000 t of grape marc and this may also be used for co-composting (Tarac Technologies, 2019). Livestock farming also produces a considerable amount of manure which may also be available (Mishima et al., 2017).

These options all involve composting biosolids. Composting is a microbial based aerobic manure and humification process, producing a source of soil fertiliser in an environmentally friendly way to minimise organic waste (Febrisiantosa et al., 2018). The co-composting of sludge, organic waste and livestock waste can provide an optimal C:N ratio, particle density, pH and moisture content (Huang et al., 2004).

In considering all these options, the composting site should be constructed and developed based on EPA and DoHA guidelines and requirements. The ratio of sludge, livestock manure and organic waste will also need to be further investigated.

[2] The application of untreated sludge to agricultural land is limited as it contains pathogens, heavy metals and toxic pollutants (Dudka and Miller, 1999). To reduce these risks, composting is considered to be the best management practice (Ouatmane et al., 2000).

5 Summary and recommendations

The conclusions of this report are tentative. The scope of this project, the lack of pre-existing information and the major role played by private contractors, mean that more resources are required to make firm recommendations. The recommendations that follow are shaped by these limitations.

The first conclusion is that the most cost-effective sludge treatment process that could replace current practices for Legatus Councils, including the private sector management of septage, is Sludge Dewatering Ponds. This conclusion is tentative firstly because full operational costs have not been estimated. In particular, the cost of this treatment depends critically on the cost of transporting sludge to the facility and selection of the environmentally optimal site, neither of which have been considered here in sufficient detail.

Recommendation 1:

A site selection process for a sludge treatment facility be undertaken. The selection is to optimise both transport costs and environmental impacts.

The second conclusion is that establishing sludge treatment facilities will not be viable in the sense of being profitable and self-supporting. The price received for treated sludge will only offset some of the costs of the operation. Of course, it is possible that this will represent a net gain by reducing the current costs, but the next conclusion is pertinent.

The third conclusion is that Councils themselves cannot report their sludge operations in any detail. The sludge quantities are unknown, costs breakdowns are unrecorded and monitoring is not undertaken, at least not systematically with records kept. In addition, virtually all the septage in these systems is managed by private contractors and Councils know almost nothing about these operations.

It follows that it is impossible to determine if the SDP proposal would be an improvement in financial terms. This situation leads to the following recommendation, aimed at generating the information needed:

Recommendation 2:

An indicative costing be undertaken for a selected Council's current sludge management process. This should form a template and a base case for other Councils to then follow with their own costing exercises.

The fourth conclusion is that current arrangements involve uncounted costs and benefits. In particular, Councils are contracting to have sludge spread on agricultural land but are not monitoring the subsequent processes and outcomes. It is not known if current arrangements are imposing unacceptable costs that would justify a shift to the SDP option.

Recommendation 3:

That test monitoring be undertaken and processes identified at selected, current sludge spreading sites to determine the environmental impacts of current arrangements.

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Appendix A: The Survey questionnaire for CWMS and sludge viability investigation

Survey Questionnaire

LEGATUS GROUP

Community Wastewater Treatment Scheme (CWMS) Sludge Processing Plant Viability Investigation

Respondent information

Council:

Contact person name :

Position :

Email :

Phone number :

Introduction
The purpose of this questionnaire is to determine the potential to reduce disposal problems and costs by finding a viable use for wastewater sludge across the Legatus Group region. We are seeking the current and projected volumes and the current and future systems and costs. This will allow comparison to other options, including reuse by major South Australian soil and compost companies. To minimise the time taken to collect the information, PhD Intern Harsha Sapdhare will be in touch with the relevant contact person at each Council to assist. The Legatus Group already holds information about regional CWMS, some of which we will check in this study, but the major purpose is to focus on sludge.

Survey (please indicate 'X' where applicable in box)

Wastewater Treatment Plant (WWTP) general information

WWTP location	:
WWTP Address	:
Total wastewater inflow (m^3/d)	:
Design WWTP treatment capacity (m^3/d)	
No of properties connected	:
Total population equivalent treated (EP)	:
Expected annual population growth (%)	

Wastewater treatment plant operating process flow diagram (please attached site plan if available)

____

____

WWTP

Gravity sewage systems (raw sewage collection, no septic tanks)	☐
Sewage system with pumped and gravity lines in the network	☐
Pumped raw sewage from individual connections to common mains (pressure sewerage)	☐
Septic tank effluent drainage – by gravity	☐
Septic tank effluent drainage –pumped and gravity lines in the network (STEDS)	☐
Vacuum sewerage systems	☐

Types of wastewater treated

Domestic (m^3/day)

Estimated percentage of inflow (trade waste)

WWTP – process

a) Mechanical screen: _______________
b) Raked screen: _______________
c) Grit removal chamber: _______________
d) Screening handling system: _______________
e) Grit classification system: _______________
f) Odour fan and extraction systems: _______________

Attached growth system such as trickling filter, rotating bio-reactor:

____

____

Other biological treatment: ____

____

Filtration system (sand, micro filtration etc.)

____

Lagoon based systems and capacity

a) Aerobic: _____________
b) Facultative: _____________
c) Anaerobic: _____________
d) Aerated lagoon _____________
e) Evaporative lagoons: _____________

Annual sludge production (tonnes of dry solids)

____

Handling and storage

____

____

Quality of sludge

Contamination Grade			
Moisture Content (%)		Chlordane	
Total Cadmium		Dieldrin	
Chromium		Total Nitrogen	
Total Copper		Total Phosphorous	
Total Zinc			
Stabilisation Grade			
Salmonella		PFU Total virus	
Helminth ovum		E. coli	

Costs associated with sludge ($ AUD/annum)

Sludge associated cost (per annum) $ --------------

Sludge Treatment Facility

Lagoon treatment type + thickening + storage

____

____

Emptying time

____

OR

Thickening

a) Rotary disc thickener: ____________________
b) Dissolved air flotation: ____________________
c) Gravity thickener: ____________________

d) Belt thickener: __________________

Dewatering

a) Centrifuge:
   i. Air agitated drying: ______________
   ii. Composting: ______________
b) Sludge drying beds: _______________
c) Other ________________

Storage capacity (tonnes) (Wet/dry)

a) Stockpile: ________________ ___________________% solids
b) Stabilisation lagoons: ________________ ___________________ % solids
c) Sludge lagoons: ________________ ____________________ % solids

Bio solids: _______________ tonnes/year

% dry _______________

Biosolids forms:

Biosolids slurry: _____m^3
Biosolids dewatered cake: ______tonnes
Biosolids pellets: ______
Lime amended biosolids: ______ tonnes
Composted biosolids: _______tonnes
____
____

a) Biosolids reuse (%) in:
Agriculture: ________%
Horticulture: ________%
Landscaping: ________%
Composting: ________%
Land rehabilitation: ________%

b) Transportation for stockpiling to: _______________distance: _________

c) **Biosolids process grade**

Contamination Grade			
Moisture Content (%)		Chlordane	
Total Cadmium		Dieldrin	
Chromium		Total Nitrogen	
Total Copper		Total Phosphorous	
Total Zinc		pH	
Stabilisation Grade			
Salmonella		PFU Total virus	
Helminth ovum		E. coli	

Or Unclassified

____

____

Stockpiling ________________

Time _______________

Biosolid production site _______________________

Application site _______________________

Cost associated with biosolids ($$/annum)

____

____

What are the challenges and problems in wastewater management and treatment?

--

--

Recycling – treated wastewater water

Disinfection

Chlorine use: ___________________

Ozone: _________________________

UV: ____________________________

Recycled water use (m^3/year)

Municipal irrigation (golf course, ovals, public gardens) ☐

Crops and pastures irrigation (vineyards) ☐

Reuse within the process of the WWTP ☐

Other non-potable use ☐

Surface irrigation: Spray ☐ Drip ☐ other ☐

Discharge of treated wastewater

Surface environments (m^3/day): _________________

Managed Aquifer Recharge (m^3/day): _________________

Suspended solids,

____

____

____

Cost associated with water recycling ($$/ annum)

____

____

Notes:

Appendix B: CWMS general information

Council	CWMS	No within Council	CWMS	Wastewater Treatment plant general information				STEDS Types			
				Total wastewater inflow (m3/d)	*Treatment capacity (m3/day)*	*No of property connected*	*Total population equivalent treated (EP)*	*Gravity sewage system*	*Sewage system with pumped and gravity lines*	*Pumped raw sewage from individual connections to common mains*	*Septic tank effluent drainage-by gravity*
Adelaide Plains	**1**	**1**	**Mallala**			160	702	yes	yes	yes	
	2	**2**	**Middle Beach ***	179		52	79				
Barossa	**3**	1	**Lyndoch**	67	160	720	2000	yes	yes		yes
	4	**2**	**Mt Pleasant**	74	560	279	1020	yes	yes	yes	yes
	5	**3**	**Nurioopta**	792	160	3080	6314	yes			yes
	6	**4**	**Springton**	25		820	607	yes	yes	yes	yes
	7	**5**	**Stockwell**	49		149	534	yes	yes		yes

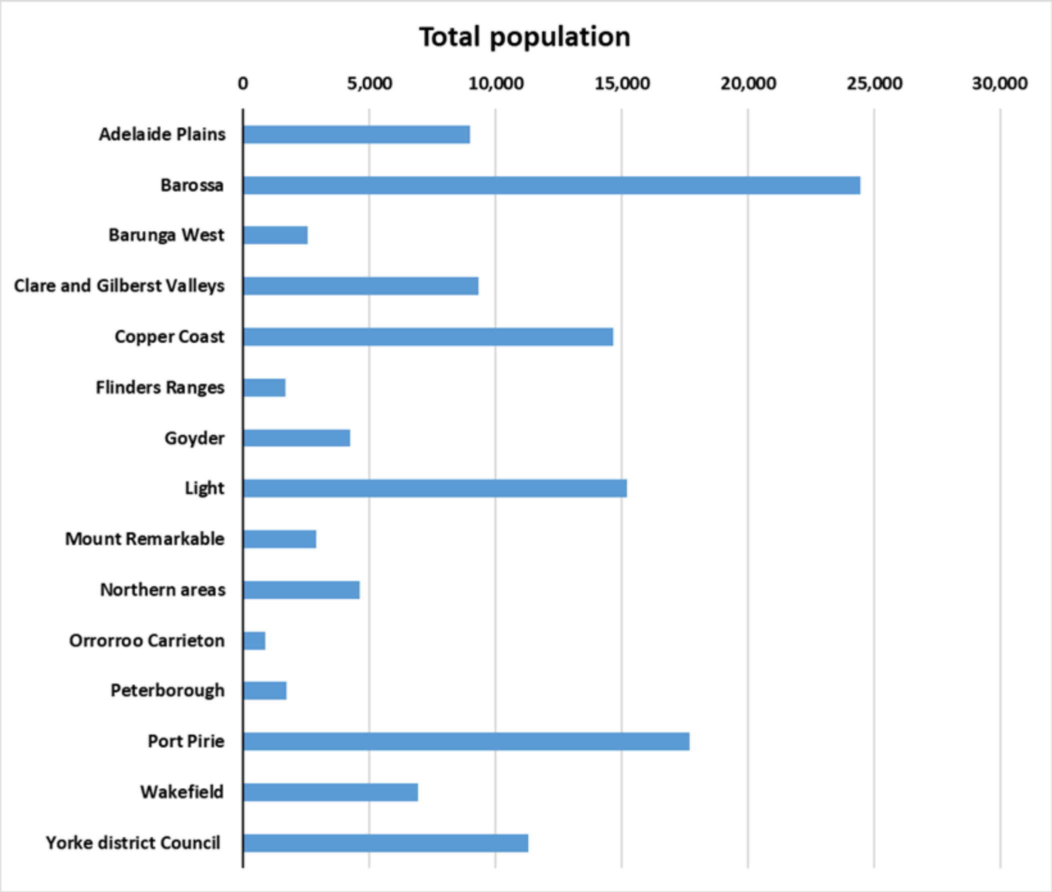
	8	**6**	**Tanunda**	1000		2320	4588	yes			yes
	9	**7**	**Williamstown**	278		820	2755	yes	yes		yes
Barunga West	**10**	**1**	**Port Broughton**	145	159	610	752				yes
	11	**2**	**Bute**	39		192	410				yes
Clare and Gilbert Valleys	**12**	**1**	**Clare**	630	680	1824	4500				yes
	13	**2**	**Riverton**	150	170	422	800				
	14	**3**	**Saddleworth**	40	80	239	500				yes
Copper Coast Council	**15**	**1**	**Kadina***	187.4	425.5	1571	5498	no	yes	no	yes
	16	**2**	**Port Hughes***	587	1200	1556	5446	yes	yes	yes	yes
	17	**3**	**Wallaroo***	862	1000	3025	10,587	yes	yes	No	yes
Flinders Ranges	**18**	**1**	**Quorn**	35	140	100	1050				yes
Goyder	**19**	**1**	**Burra**	Unknown	Unknown	320	1103	Yes			Yes
	20	**2**	**Eudunda**	63	180	382	640				Yes

Light	**21**	**1**	**Kapunda**	400	680	1180	2917	Yes	Yes		yes
	22	**2**	**Freeling**	350	414	465	2214	Yes		yes	yes
	23	**3**	**Roseworthy**			156	994				
	24	**4**	**Nuriootpa**			28					
	25	**5**	**Greenock**			352	1087				
Mount Remarkable	**26**	**1**	**Booleroo**	58.9		185	331				Yes
	27	**2**	**Melrose**	74		151	350				yes
	28	**3**	**Wirrabara**	122.57		251	403				Full sewer
	29	**4**	**Wilmington**	110		226	587				yes
Northern Areas	**30**	**1**	**Jamestown**	258	354	996	1500				yes
	31	**2**	**Laura**	74			499				yes
	32	**3**	**Gladstone**		166	389	600				yes
Orroroo Carrieton	**33**	**1**	**Orrorroo**				557				
Peterborough	**34**	**1**	**Peterborough**	**New**	470	1075	1000				
Pirie	**35**	**1**	**Crystal Brook**	182		585	1185	yes	yes		

	36	**2**	**Napperby**			135	432	yes	yes		
Wakefield Regional Council	**37**	**1**	**Balaklava**	210	290	1034	2048				yes
	38	**2**	**Hamley Bridge**	75	130	299	631				yes
	39	**3**	**Port Wakefield**	95	165	353	636				
	40	**4**	**Snowtown**	50	88	263	467				yes
Yorke district Council	**41**	**1**	**Ardrossan**	175.38	180	896	2688				yes
	42	**2**	**Balgowan**	0.75		20	63	yes			
	43	**3**	**Black Point**	17.77		220	545				yes
	44	**4**	**Bluff Beach**	2.24		59	145	yes			
	45	**5**	**Chinaman Wells**	1.124		37	130	yes			
	46	**6**	**Foul Bays**	0.6		49	80	Yes			yes
	47	**7**	**Hardwicke Bay**	2		52	177	Yes			
	48	**8**	**Maitland**	132	180	475	1425				yes

	49	**9**	**Port Victoria**	60	180	160	465		yes		
	50	**10**	**Port Vincent**	35.5	147	540	1096	yes			yes
	51	**11**	**Point Turton**	31.6		31	109				yes
	52	**12**	**Point Turton # 2**	4.47	167	102	255	yes			
	53	**13**	**Rogues Pt**	1.82	14.06	32.8125	105				yes
	54	**14**	**Point Julia**	0.19	18.75	194	143	yes			
	55	**15**	**Stansbury**	34	249	310	787				yes
	56	**16**	**Sultana Point/ Edithburgh**	4.25	41.48	127	333	yes			yes
	57	**17**	**Yorke Town**	630	147	424	1060				yes
*CWMS with Pressure STEDS, Port Wakefield CWMS with Vacuum STEDS, Wirrabara CWMS in Mount Remarkable – full sewer											

Appendix C: Total population of the Legatus Group Councils



Population in Regional Councils (ABS, 2017)

Appendix D: Photographs of mechanical dewatering units

(a) Belt-filter press

(b) V-fold belt

(c) Centrifuge

Appendix E: Environment Protection Act and Guidelines

The establishment of new CWMS, the modification of current CWMS or the modification of recycled wastewater irrigation systems requires DoHA approval (LGA SA and DoHA, 2019). The disposal and handling of biosolids, composting works, wastewater treatment and recycled water use is a prescribed activity of environmental significance according to the Environment Protection Act 1993 (the EP Act).

The latest available versions of the SA EPA guidelines related to CWMS, septage, sludge and biosolids management were used in this report.

The following guidelines, statistical data, standards or policies referenced in this document are included in following table.

Title	Year	Publisher
The Environment Protection Act 1993	1993	Australian Government and EPA
South Australian Community Wastewater Management System (CWMS) Design Criteria	2019	LGA SA and DoHA,
South Australian Biosolids Guidelines for the safe handling and reuse of biosolids	2017	SA EPA
EPA Guidelines: Liquid biosolids from domestic septic tanks-disposal onto agricultural land	2003	SA EPA