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1 Introduction

1.1 BACKGROUND

The Department of Agriculture (DAWA) together with a number of project partners, which include: CSIRO, CRC LEME, UWA Agriculture Resources Economics, UWA CWR, the WA Chemistry Centre and Wheatbelt Enterprise Technologies is delivering the $6 million project *Rural Towns-Liquid Asset (RT-LA)*.

The project is funded by the Western Australian State Government, 16 Local Government Authorities and the National Action Plan for Salinity and Water Quality (NAP). The other major stakeholders are the Avon Catchment Council, the Northern Agricultural Catchment Council, the South West Catchment Council and the South Coast Regional Initiative Planning Team (SCRIPT).

The aim of the project is to devise solutions to potential and existing townsite salinity problems as well as developing new locally based water resources, for the sixteen rural towns participating in the RT-LA. New research and existing knowledge of groundwater systems will be used to identify water management options and construct townsite Water Management Plans (WMPs) that focus on improved and integrated water management strategies.

Lake Grace is one of the sixteen towns participating in the RT-LA project. Lake Grace is located approximately 275km south-east of Perth (Figure 1.1 and Figure 1.2) and has a population of 650 residents. The Lake Grace shire has been involved in the Rural Towns project since its introduction in 1999.

1.2 WATER MANAGEMENT OBJECTIVES

In a socio-economic survey conducted as part of the RT-LA project (Appendix A), it was identified that issues surrounding water management at Lake Grace are associated with available water resources for the town and for creating opportunities for new industry to attract more people to the town, and salinity issues.

The water management objectives for Lake Grace and for the RT-LA project are to devise a water management plan:

- To identify opportunities for ground and surface water resource development, primarily for irrigation purposes;
- For salinity and waterlogging management; and
- To identify socio-economic opportunities associated with water resources.

A workshop was held with the Shire and Project Planning Team in June 2005 to identify specific water management priorities for Lake Grace which was used to guide the direction and focus of this Water Management Plan. A summary of the workshop outcomes is located in Appendix G. The priorities and issues identified at the workshop were:

- Achieving a self-sufficient supply system for parks, gardens and recreational areas by addressing the issues of:
- Reliability of runoff from the existing dam catchment;
- Harvesting of stormwater runoff from town;
- Construction of a large new community dam;
- Townsite flooding/waterlogging management possibly through integration with the local wastewater treatment scheme; and
- Quantifying the cost/benefit of feasible stormwater management options.

1.3 PURPOSE OF THE WATER MANAGEMENT PLAN

This document is the water management plan for Lake Grace, which outlines:

- a summary of outcomes from all the scientific investigations undertaken, which synthesises contents of the following technical reports:
  - Lake Grace Geophysics Summary Report;
  - Water balance study of Lake Grace;
  - Evaluation of cost associated with the townsite infrastructure damage caused by salinity;
  - Methodology for assessment of options;
  - Lake Grace water quality report;
  - Groundwater levels and associated impacts on salinity and infrastructure, Lake Grace Township, WA;
  - Lake Grace surface water management plan;
  - A brief socioeconomic report for the town of Lake Grace;
- recommended water management options;
- preliminary engineering analysis of water management options;
- cost/benefit analysis for the recommended water management options; and
- specific recommended priority water management options in Lake Grace.

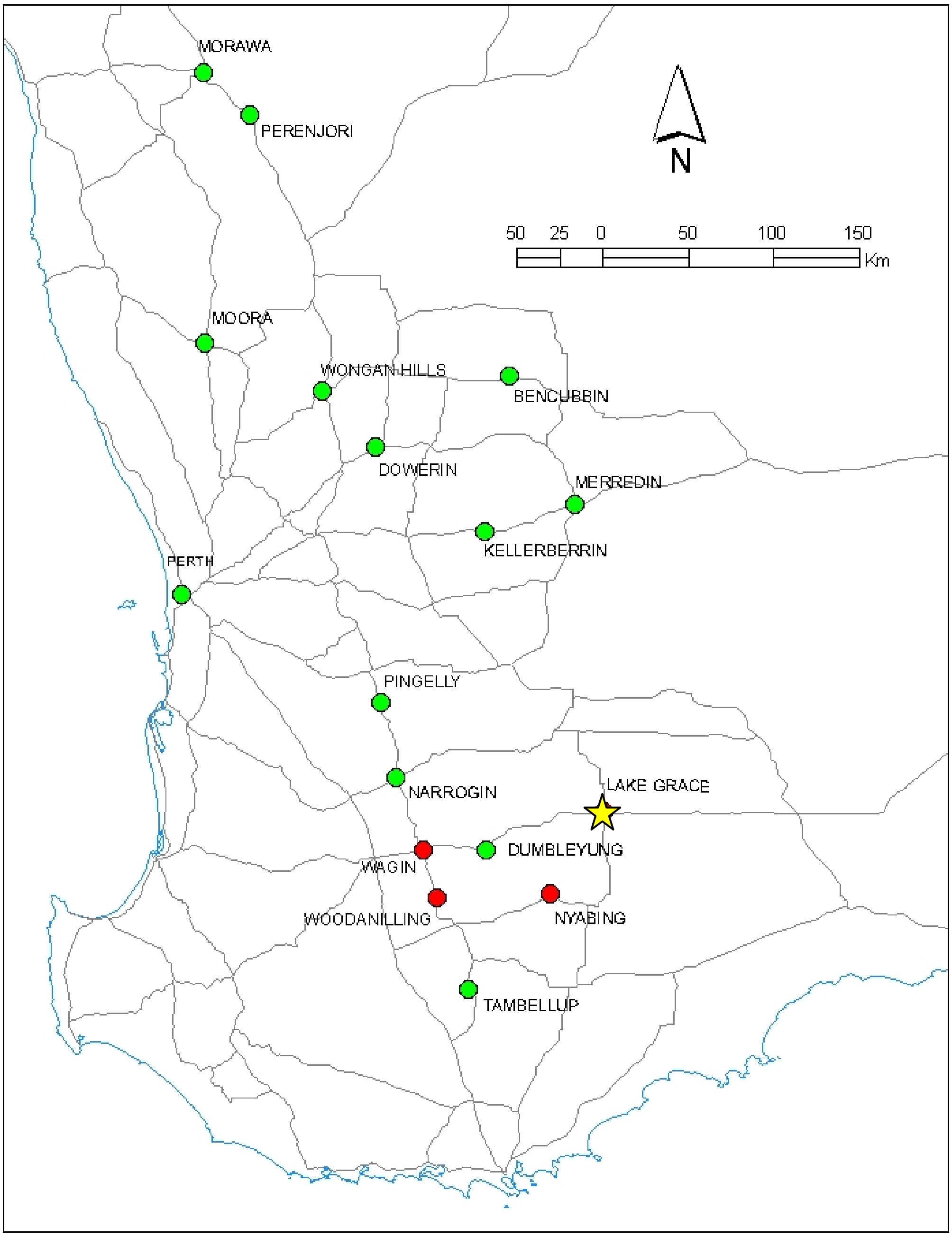

Figure 1.1- Lake Grace locality map

Figure 1.2 - Lake Grace townsite and key water management features

2 Current Town Status

2.1 SCIENTIFIC STUDIES AND INVESTIGATIONS

A number of scientific studies and investigations were carried out to identify the current water management status at Lake Grace and hence make appropriate recommendations for water management options that will reflect the town's objectives. The investigations which were undertaken include:

- Surface water investigation to assess risks of salinity an waterlogging in Lake Grace due to surface runoff process, and to identify existing water resources and potential sources of water for Lake Grace (Appendix C);
- Geophysics investigation to understand the underlying geology of Lake Grace, particularly the underlying basement rocks and the regolith material that lies between the bedrock and ground surface, which is important in understanding the hydrogeology, salinity risks and its management (Appendix D);
- Groundwater investigation for aquifer characteristics such as recharge and yield to assess salinity risk from rising water table at Lake Grace, and to determine the feasibility of dewatering to lower the water table for salinity management (Appendix E);
- Infrastructure damage cost associated with salinity and waterlogging (Appendix F);
- Investigate the viability or commercial utilisation of additional water resources or cultural improvements derived from water use or reuse options;
- Groundwater quality investigations to determine feasibility of using dewatering as either potable water supply or as potable substitute water following treatment. If dewatering is feasible, determine the appropriate level of treatment (eg reverse osmosis, desalination, nanofiltration or evaporative desalination), assess the potential for bulk mineral harvesting from saline water and water disposal options (Appendix G);
- Assess groundwater quality and its spatial and temporal distribution and variation which could provide key information on groundwater and surface water interactions, and interconnection within groundwater systems when integrated with hydrogeology, groundwater modelling, geophysics and surface hydrology (Appendix G); and
- Urban water balance to identify existing water usage in town and volumes of other sources of water within town which can be developed (Appendix H).

The outcomes of the above investigations are summarised in this chapter as the current status for Lake Grace. For more information on each technical investigation refer to the relevant appendices in this report.

2.2 SALINITY RISK ASSESSMENT

It was identified in a telephone survey undertaken by RT-LA (Appendix A) that residents at Lake Grace acknowledge that there is a salinity problem in the town particularly in the eastern and southern ends of town. There is anecdotal evidence of salinity damage to brickwork in the lower walls of the older buildings such as the post office and shire hall.

Groundwater investigations reveal that the eastern part and western part of town is on lower to mid-slopes of the valley, where depth of the shallow groundwater is greater than 2m (Figure 2.1). The 2m depth is the approximate maximum depth to which groundwater can be expected to passively discharge to the land surface as a result of evaporation during summer. Therefore, the eastern and western part of town has low risk of salinity development. The central part of town is situated just above the valley floor, and the depth to the shallow groundwater level is less than 2m. Therefore, there is high risk of developing secondary salinity in the central part of town. The salinity risk mapping for Lake Grace is shown in Figure 2.2.

Salinity is often exacerbated where ponding of surface water occurs, leading to high rates of infiltration where there is a prolonged connection between the watertable and the land surface. Waterlogging/inundation is a hydrological process often associated with the break of slope or soil profile changes from permeable to less permeable thus discharging at the soil interface, and where rainfall recharge occurs. Assessment of landmonitor data and soil landscape units showed that a break of slope is present at the centre of town, corresponding to the valley floor (Figure 2.3). This low-lying area of the landscape is already saline due to the soils being prone to salinity.

Geophysical, drilling and aquifer test data indicate that it is feasible to alleviate salinity risk in the central part of town through lowering the shallow groundwater level by pumping. The most favourable location for the pumping bore is within a semi-circular area bounded by the Stubbs Street to the north, post office to the west and Vernon Street to the east (Figure 2.4). The radius of influence of any production bore in the area is likely to be within 100m. This dewatering zone would protect structures in town with high historical value of the Post Office and Shire Hall.

Groundwater quality investigation showed that the shallow groundwater at Lake Grace has salinity level between 13,600mg/L and 61,200mg/L (2000-9000mS/m). Salinity in the deep bores is in excess of 110,000mg/L (15,000mS/m). There are also trends of spatial variability in shallow groundwater. Areas in town where there is recharge-infiltration, the observed salinity is lower. This indicates that surface water management should be a key focus in managing groundwater levels and infiltration in the townsite.

2.2.1 Infrastructure Damage Through Salinity

The extent of damage to townsite infrastructure resulting from shallow water levels and attendant increases in soil moisture and salt contents is poorly known. However, evaluation of the cost associated with the townsite infrastructure damage caused by salinity and shallow water tables was undertaken. The assessment was done based on groundwater level in the shallow observation bores, and confined to the part of town where these bores exist. The level of risk was estimated in accordance with soil saturation level at the 1m depth below the ground level. Furthermore, this information was used in conjunction with the land tenure data to arrive at an infrastructure damage cost caused by salinity.

Salinity risk for Lake Grace is confined to the south east of town. The estimated damage cost for the different landuse zones as described in the town planning scheme is $22000/year and the project NPV (net present value) cost over the next 20 years is $233000 if the do-nothing option is adopted. This information is also shown in Table 2.1.

Table 2.1 - Estimated infrastructure damage due to shallow water table and salinity

Land Use Type	Damage Cost in Year 1 ($)	Projected NPV over 20 years (@ 7%) ($)
Industrial	2,584	27,375
Parkland and Recreation	552	5,848
Public purposes	414	4,386
Railway	43	456
Residential	14,889	157,734
Rural	0	0
Special Use	193	2,045
Town Centre	2,478	26,252
Roads	907	9,609
Total	**22,060**	**233,704**

2.3 URBAN WATER

2.3.1 Urban Water Balance

The urban water balance for Lake Grace was determined by analysis of several key components, namely:

- existing scheme water consumption provided by the Water Corporation and billing records;
- wastewater outflow from the existing wastewater ponds; and
- modelled stormwater runoff from a series of assumptions about the surface runoff characteristics using AQUACYCLE.

The urban water balance based upon the last 50 years of historical meteorological data and recent scheme water consumption records from the Western Australian Water Corporation are summarised in Table 2.2. Further explanations for the derivation these figures are provided in Appendix H.

Table 2.2 - Urban water balance for Lake Grace

Items	Indoor use (ML/year)	Outdoor use (ML/year)	Total (ML/year)
Total scheme water use	69.4	67.9	137.3
Scheme water - residential	44.3	41.3	85.6
Scheme water use - commercial	12.8	12.1	24.9
Scheme water use - industry	12.0	11.9	23.9
Scheme water use - other	0.3	2.58	2.9
Wastewater			161.3
Modelled stormwater runoff			70.1

The current demand for scheme water at Lake Grace is 137.3ML/year, and is being supplied by the Water Corporation. As shown in Table 2.2 approximately 50% of the total scheme water usage is for outdoor use, which is mostly for watering of lawns and gardens.

The urban water balance study further identified that a large potential water resource for the town is collection of stormwater runoff (approximately 70ML/year could be collected based on modelling results). The other potential water resource is reusing treated wastewater from the treatment ponds, which has been estimated at 161ML/year.

2.3.2 Water Demand for Irrigation on Community Open Spaces

The Shire of Lake Grace also uses water for irrigation of parks and oval, which is a total of 50.4ML/year, as shown in Table 2.3. It is reported that water for irrigation is supplied by the local dam catchments. Demand is augmented by scheme water when the dam is dry. Reportedly the Shire spends up to $40,000/year, which is equivalent to approximately 30ML/year.

Some scheme water use for irrigation for parks and ovals is being accounted for in the urban water balance in Table 2.2 as outdoor use of ‘Scheme water use - other’, which is 2.58ML/year.

Table 2.3 - Water demand for irrigation on parks and gardens (Source: DAWA)

Location of demand	Area (hectares)	Watering rate/day (kL/day)	Watering depth (mm/week)	Frequency per week	Watering months per year	Annual volume (ML/year)
Oval	4.0	200	35	7	9 (Sept - May)	50.4
Total	**4.0**					**50.4**

The Shire of Lake Grace has also indicated that if more water was available it could be used for beautification of the townsite.

2.3.3 Rainwater Tanks

Some rainwater tanks are currently being used by residents to reduce scheme water usage.

Installation of rainwater tanks at every residential house for residential outdoor use and for toilet flushing was also modelled as part of the urban water balance study to investigate the effectiveness of rainwater tanks at substituting scheme water usage. It was found that adoption of rainwater tanks would reduce scheme water consumption by 8.7% or approximately 11.9ML/year.

Rainwater tanks would reduce stormwater runoff within the townsite by 16.5% or 11.6ML/year. This may also alleviate potential waterlogging and salinity at the town site as recharge-infiltration to shallow groundwater is reduced.

Detailed description of the derivation of the above modelling results may be found in Appendix A.

2.4 TOWN WATER RESOURCES

The existing water storages of natural runoff in Lake Grace include the sports dam located south east of town. The town dam has a capacity of 65ML and collects runoff from a roaded catchment of 27.8 hectares. Currently, water is being pumped out of the sports dam to the oval tanks (202kL capacity) and used for irrigation. The dam yield is reported to be unreliable and scheme water augmentation for irrigation of parks and ovals is required.

2.5 SOCIO-ECONOMIC FACTORS

The Shire of Lake Grace has reported that if additional water supplies were developed, they would like to see water used to beautify the township in order to attract more people to the town, to aid in drought proofing farms, or to fill up salt lakes for recreational purposes and water sports.

If there was excess water, The Shire of Lake Grace would also like to develop water related industries such as aquaculture, nurseries, viticulture/olives, salt tolerant plant industries, solar technology and reusable energy and hydroponics industries.

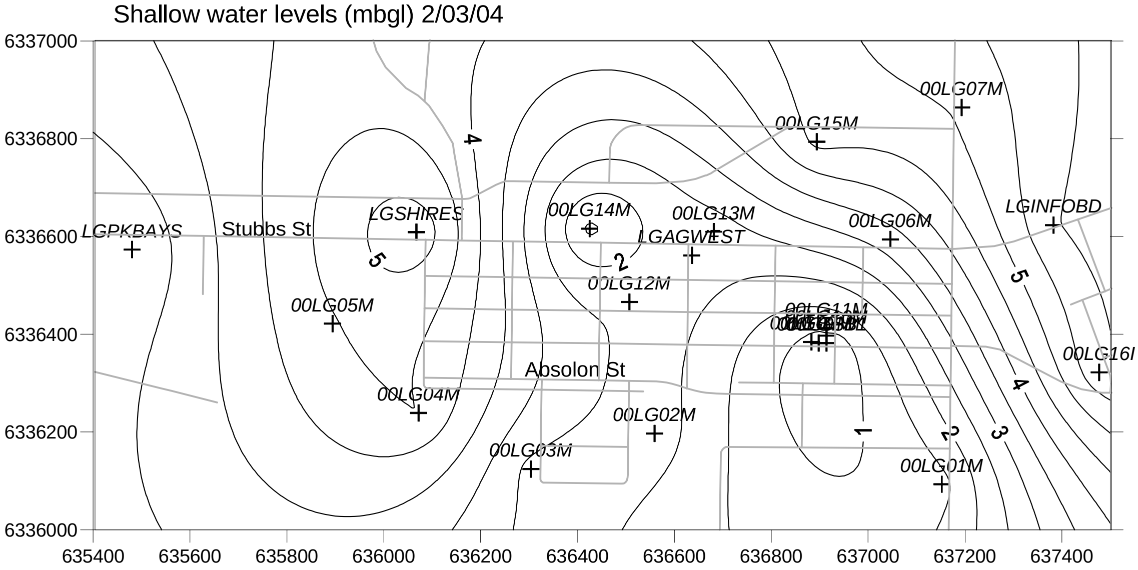

Figure 2.1 - Contour map of shallow groundwater depth at Lake Grace

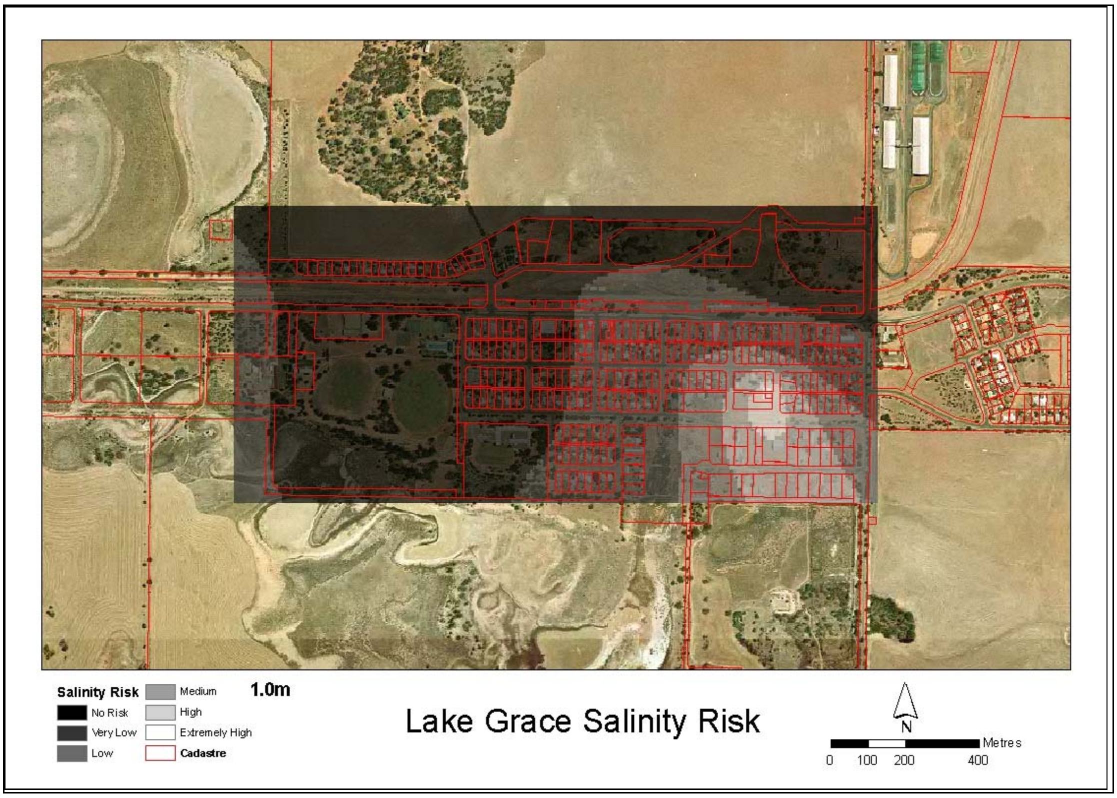

Figure 2.2 - Salinity risk mapping at Lake Grace

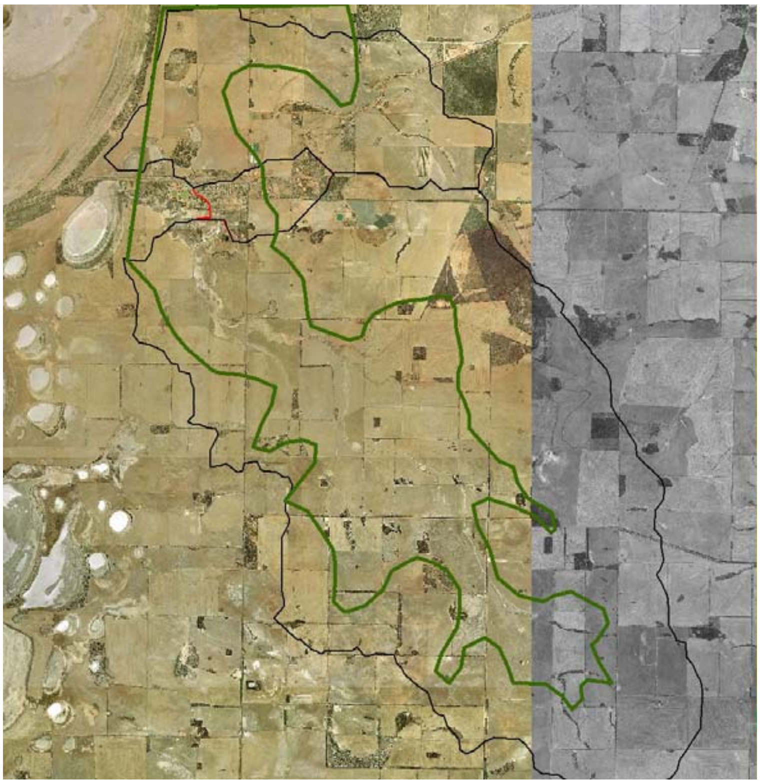

Figure 2.3 - Salinity risk mapping from break of slope surface water process

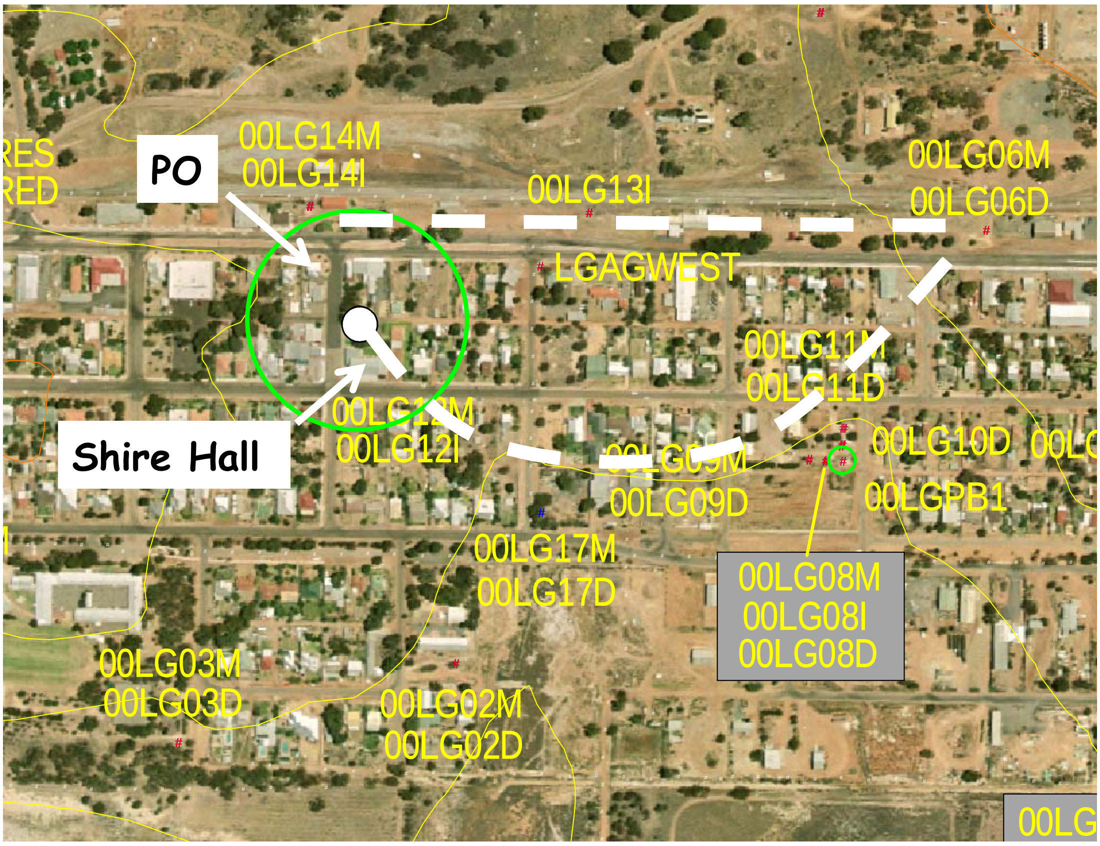

Figure 2.4 - Feasible area in Lake Grace for pumping via a production bore to lower water tables

3 Water Management Options

Water management options were formulated following investigations of the existing town water management practices, governing scientific processes and the Shire's planning priorities and objectives. The Shire's priorities and objectives were identified through discussions between the RT-LA planning team and Shire of Lake Grace representatives.

Water management options for Lake Grace are outlined below. These options address water resources development, salinity management and socio-economic development objectives. Refer to Figure 1.2 of Lake Grace townsite for location of the key water management features.

3.1 OPTIONS IDENTIFIED

3.1.1 Option 1: Sports Dam

Upgrade the existing sports dam and roaded catchment to increase runoff reliability and performance of the existing town dam.

This option would satisfy the objective of water resource development for socio-economic improvement purposes.

3.1.2 Option 2: Capturing Surface Runoff to Dam

Capturing surface water runoff from the catchment east of town via the existing sump and pump it to the existing sports dam or a new dam for storage. This will supply irrigation demand on parks and ovals.

This option satisfies the objectives: water resource development and alleviation of townsite salinity and waterlogging.

3.1.3 Option 3: Capturing Surface Runoff for Water Logging Management

Capturing of surface runoff from the catchments north and east of town and redirect stormwater runoff around the town into the natural drainage system that eventually discharges at the salt lakes.

This option satisfies the objectives: water resource development and alleviation of townsite salinity and waterlogging.

3.1.4 Option 4: Roof Runoffs

In this option it is proposed that runoff from roofs is to be directed to road drainage.

This option would satisfy the objective of waterlogging and salinity management by reducing recharge and infiltration at the townsite and to the shallow groundwater table.

3.1.5 Option 5: Wastewater Blended with Catchment Water

In this option it is proposed that wastewater from the treatment plant could be blend with catchment water and use for irrigation of parks and ovals.

This option would satisfy the objective of water resources development.

3.2 OPTIONS FOR FURTHER INVESTIGATION

From the above options, only Option 1, Option 2 and Option 3 have been designed as part of the RT-LA project as they have been identified as major priorities for the town, and have the highest potential to meet the water management objectives in Lake Grace. Further discussions of these options are outlined in Section 4.

The process of option selection involved discussions with the Shire of Lake Grace and all stakeholders in the project. The method for assessment of options, and selection of recommended option informally adopted the method outlined in Appendix I.

Water management Options 4 and 5 were considered second order priorities. These Options, whilst being recognised as preferences, require further investigation before they can be implemented. The issues which still need to be resolved include the blending of waste water and catchment water, consultation with the Water Corporation for reuse of treated wastewater, and assessing the wastewater quality and treatment required by the guidelines for reuse on parks and ovals by the Department of Health.

4 Engineering Analysis of Water Management Options

Kellogg Brown and Root Pty Ltd (KBR) was commissioned to undertake preliminary engineering analysis of the options identified as priority for water management at Lake Grace. The options and their sub-options (based on engineering alternatives) which were analysed are:

- Option 1: Utilise the existing sports dam and sports dam catchment for irrigation within Lake Grace town.
- Option 2a: Capture stormwater runoff from the town and farmland east of Kulin-Lake Grace Rd (east of townsite) via a sump then pump it to the existing dam for storage.
- Option 2b: Capture stormwater runoff from the town and farm farmland east of Kulin-Lake Grace Rd (east of townsite) via a sump then pump it to a new dam for storage.
- Option 3: Capture stormwater runoff from two catchments, east of Kulin-Lake Grace Rd (east of townsite) and north of Stubbs Rd (north of townsite) into drainage channels by-passing the townsite to alleviate waterlogging/inundation problem in town.

The engineering analysis included identification of potential water yield from each option, capital requirements, and associated capital and operation and maintenance cost. This section summarises the engineering details as outlined for each option. More information on methodology of the engineering analysis and assumptions is in Appendix I.

The engineering analysis is preliminary, based upon limited, site specific data supplied by RT-LA. Accordingly, further engineering design would have to be undertaken at a later stage prior to implementation of any of the options.

The cost estimates on capital requirements are based on the following:

- Work contractors are fully insured and have total liability for construction and accept risks for completion eg material and labour conditions;
- Work contractors will conduct testing and commissioning of installed equipment (eg pressure testing of pipes);
- All works are quality controlled and adhere to construction and engineering standards for quality assurance of the product;
- Works will be fully supervised and comply with Work Safe regulations;

- All estimates are based on the current commercial construction rates in Western Australia and assume a competitive tender process.

Costs may be further refined when options are further optimised at the detailed engineering design stage.

There may be opportunity for the Shire of Lake Grace or other local contractors to price and undertake the works which may lead to reduced costs against the cost estimates. However, comparison of the cost estimate given here and any cost estimate obtained from the Shire, or others must give attention and comparison to the respective quality, delivery, construction and liability risks.

4.1 OPTION 1 – EXISTING TOWN DAM

4.1.1 Description of Option

In this option water demand for irrigation at the oval is being supplied by the existing sports dam, which has a capacity 65ML. The dam is fed by a roaded catchment with an area of 27.8 hectares. There is an existing pipe (90mm) and pump that supply water to the demand points. Site inspection by RT-LA and discussions with the Shire of Lake Grace identified that the inlet, outlet and overflow structures at the dam require an upgrade to ensure structural integrity and performance. A schematic of this option is shown in Figure 4.1.

The objectives for this option are to:

- Undertake yield analysis at the existing dam
- Improve runoff reliability from the catchment size and surface type; and
- Undertake a preliminary engineering design to allow for costing of inlet, outlet and overflow structures.

4.1.2 Water Yield

Results from the water balance analysis reveal that dam has an average annual yield of 19ML based on the last 10 years of rainfall record. This yield represents 38% of the current water demand, which is 50ML/year. This yield is consistent with the reported augmentation of scheme water of 30ML/year to satisfy complete demand. The annual yield from the dam is less than the 65ML capacity of the existing sports dam.

Another analysis was performed on the size of catchment to achieve a dam yield that would satisfy demand. At a catchment threshold of 8mm, it was found that at a catchment size of 50 hectares (that is an additional 22.2 hectares), there was an average yield of 35ML/year. Beyond 50 hectares, the size of the dam becomes deficient. Therefore, it would not be cost effective to increase the size of the catchment larger than 50 hectares as the dam will overflow and yield is not maximised beyond 35ML/year.

4.1.3 Capital Requirements and Costs

Existing Pipe and Pump

It is reported that the existing pipeline is 90mm in size. At this size, it was found that it is only feasible to produce 3L/s at 84m head. At peak demand the flow rate required is 13L/s and would require a 150mm pipe. However, there are storage tanks available at the ovals with a total capacity of 202kL. Thus it is possible to feed the tank at the existing maximum pumping rate of 3L/s. This would require 18 hours of pumping per day to fill the tank to later supply the 13L/s demand.

Existing Town Dam Structure

It has been reported that the inlet, outlet and overflow structures at the sports dam require upgrades. Allowance will be made in the cost estimate for upgrades of the dam to restore it to reasonable integrity.

The capital requirements and costs for this option are shown in Table 4.1. The basis for the cost estimate has been outlined earlier and the assumptions and exclusions associated with this option have also been included with the table.

Capital Requirements and Costs

The capital requirements and costs for this option are shown in Table 4.1. The cost estimates on capital requirements are provided for KBR commercial rates and DAWA/Shire rates. The assumptions and cost details for these rates is supplied in Appendix J.

Costs may be further refined when options are further optimised at the detailed engineering design stage

Table 4.1 - Capital requirements and costs, and operation and maintenance costs for Option 1

Capital items	Details	KBR Commercial Rates ($) 20%+30%	DAWA/Shire Rates ($)
Increase size of town dam roaded catchment	Additional 18.3 hectares	109,800	91,500
Upgrade inlet structure for existing town dam		2,800	500
Upgrade outlet structure for existing town dam		4,283	500
Upgrade overflow structure for existing town dam		14,310	2,960
Location allowance (30%)	Adjustment for regional location factor eg transportation etc as costs are based on metro rates	39,358	-
	Sub-total capital costs	***170,551***	***95,640***
Additional project costs			
General contractors prelims (20%)	For mobilisation/demobilisation, site set-up, site clean-up etc	34,110	-

Capital items	Details	KBR Commercial Rates ($) 20%+30%	DAWA/Shire Rates ($)
EPCM fees (@10% of cost)	Engineering, Procurement, Construction and Management fees	20,466	-
Contingency (@10% of cost)		20,466	-
	Sub-total for additional project costs	***75,042***	**-**
	Total for capital investment	***245,594***	***65,460***
Operation and Maintenance items	**Details**	**Cost ($/year)**	
Pump operation (3L/s @ 85m head)	18hrs/day, 7days/week, 9months/year of 7.5kW pump and $0.17/kWh	5,783	
Maintenance personnel & repairs	$80/hr 2hrs/week 7months/year	4,480	
	Total for operation and maintenance	***10,263***	

4.2 OPTION 2A – TOWN RUNOFF TO EXISTING DAM

4.2.1 Description of Option

Town surface runoff is to be collected at a new sump and pumping it in the existing Residential and farmland surface runoff to the east of Kulin-Lake Grace Rd (east of townsite) is to be collected at the location of an existing sump and pumped into the existing sports dam for storage for irrigation of the town ovals. The existing sump would need to be resized.

It is also reported that some flooding occurs in the town site due to runoff from this catchment. RT-LA believed that flooding is caused mainly due to a culvert at the intersection of Stubbs St and Kulin-Lake Grace Rd, which conveys runoff from the catchment into a piped-open drain section toward the sump, being undersized. The size of the culvert was reported to be 1x900x450mm. The size of this piped-open drain from the culvert to the sump is not known. As such, investigation into the drainage arrangement for this section is also required in this option.

The requirements for this option are as follows:

- Determine volume of surface runoff which can be captured
- Upgrade the existing sump;
- Assess the drainage arrangement at the culvert and piped-open drain; and
- Yield analysis for the existing sports dam with the augmentation of town and farm surface runoff.

All features discussed in each sub-option are shown in the schematic in Figure 4.2.

4.2.2 Water Yield

Based on the last 10 years of rainfall record the average annual surface runoff which could be collected from the residential and farmland catchment is 59ML/year.

The residential and farmland surface runoff, and yield from the existing sports dam produce a combined average annual yield of 50ML/year, and would supply 100% of the current water demand, which is 50ML/year.

Results from the dam water balance also suggest that there is water in excess of demand in the dam. As such, a separate analysis was undertaken to determine the maximum yield from the dam. It was found that the dam can produce annual average of 69ML/year provided that all available water is withdrawn, and the dam is kept at its minimum depth. Thus after satisfying the existing demand of 50ML/year, there is an excess of 19ML/year available for future use.

4.2.3 Capital Requirements and Costs

The capital requirements and costs for this option are shown in Table 4.2. The cost estimates on capital requirements are provided for KBR commercial rates and DAWA/Shire rates. The assumptions and cost details for these rates is supplied in Appendix J.

Costs may be further refined when options are further optimised at the detailed engineering design stage.

As per Option 1, allowance for upgrades of inlet, outlet and overflow structures at the existing town dam has been made, as the town dam is currently not in good structural condition, and to ensure that more water can be added to the dam without worsening its structural integrity.

A check was performed on the capacity of the existing culverts at the railway at CBH and DAWA office at the intersection of Kulin-Lake Grace Road and Stubbs Road. With limited knowledge of the invert levels of the culvert a slope of 1% was assumed. It was found that the 2x440mm pipe culvert and the 900mmx450mm box culvert are under capacity to cater for the 1 in 5 year rainfall event (1357L/s peak flow). It was assumed that these culverts would need to be upgraded.

The capital requirements and costs for this option are shown in Table 4.2. The cost estimates on capital requirements are provided for KBR commercial rates and DAWA/Shire rates. The assumptions and cost details for these rates is supplied in Appendix J.

Costs may be further refined when options are further optimised at the detailed engineering design stage

Table 4.2 - Capital requirements and costs, and operation and maintenance costs for Option 2a

Capital items	Details	KBR Commercial Rates ($) 20%+30%	DAWA/Shire Rates ($)
Upgrade inlet structure for existing sports dam		3,200	500
Upgrade outlet structure for existing sports dam		4,283	500
Upgrade overflow structure for existing sports		14,310	2,960
Upgrade drainage channel along Kulin-Lake Grace Road for 1:10year peak flow	400m long, 2m bottom width, 1:4 side slope, 1m deep	48,500	1,000
New culverts at CBH	2x750mm 10m long	57,906	57,906
New culverts outside DAWA office	1x900mmx450mm 10m long		
New sump	71×71×2.5m fully lined	220,980	28,727
Pump from new sump to existing sports dam	1×3 L/s @ 95m head	30,770	26,980
Pipe to connect from new sump to existing pipe route to sports dam	Extra 260m of 90mm main with class 9 pressure rating	22,110	12,874
Location allowance (30%)	Adjustment for regional location factor eg transportation etc as costs are based on metro rates	122,718	-
	Sub-total capital costs	*531,777*	*131,447*
Additional project costs			
General contractors prelims (20%)	For mobilisation/demobilisation, site set-up, site clean-up etc	106,355	-
EPCM fees (@10% of cost)	Engineering, Procurement, Construction and Management fees	63,813	-
Contingency (@10% of cost)		63,813	-
	Sub-total for additional project costs	*223,981*	-
	Total for capital investment	*765,759*	*131,447*
Operation and Maintenance items	**Details**	**Cost ($/year)**	
Operation of pump from existing sports dam to oval (3L/s @ 85m head)	18hrs/day, 7days/week, 9months/year of 7.5kW pump and $0.17/kWh	5,783	
Operation of pump from sump to sports dam (3L/s @ 95m head)	Nominal operation: 12hrs/day, 3days/week, 6months/year of 7.5kW pump and $0.17/kWh	1,102	
Maintenance personnel & repairs	$80/hr 2hrs/week 7months/year	4,480	
	Total for operation and maintenance	***11,526***	

4.3 OPTION 2B – TOWN RUNOFF TO NEW DAM

4.3.1 Description of Option

This option is similar to Option 2a except the surface runoff from the eastern catchment would be collected and stored at a new dam instead of the existing sports dam.

The location of the new dam is in a farmer's paddock and the land is assumed to be obtainable.

A schematic of this option is shown in Figure 4.3.

4.3.2 Water Yield

As per Option 2a, the average annual town and farm site surface runoff was estimated to be 59.4ML/year.

The size of the new dam required is 77ML assuming a geometry of 126x126x6m at a 1:3 side slope. The yield from the new dam is 36ML/year representing approximately 72% of the existing water demand, which is 50ML/year.

The yield from Option 2b is less than 2a, as augmentation from the sports dam is not included.

As per Option 2a, it was found that the 2x440mm pipe culvert and the 900mmx450mm box culvert at the CBH and outside DAWA office are under capacity to cater for the 1 in 5 year rainfall event (1357L/s peak flow). It is assumed that these culverts would need to be upgraded.

4.3.3 Capital Requirements and Costs

The capital requirements and costs for this option are shown in Table 4.3. The cost estimates on capital requirements are provided for KBR commercial rates and DAWA/Shire rates. The assumptions and cost details for these rates is supplied in Appendix J.

Costs may be further refined when options are further optimised at the detailed engineering design stage

Table 4.3 - Capital requirements and costs, and operation and maintenance costs for Option 2b

Capital items	Details	KBR Commercial Rates ($) 20%+30%	DAWA/Shire Rates ($)
Upgrade drainage channel along Pingrup-Lake Grace Road for 1:10year peak flow	400m long, 2m bottom width, 1:4 side slope, 1m deep	48,500	1,000
New culverts at CBH	2x750mm 10m long	57,906	57,906
New culverts outside DAWA office	1x900mmx450mm 10m long		
New dam	77ML capacity 126m×126m×6m with 1:3 side slope	303,550 (fully lined)	269,458 (with liner) 169,758 (without liner)
Reticulation line from new dam to oval	Extra 100m of 90mm main with class 9 pressure rating	11,550	7,690
Pump from new dam to oval	6L/s @ 22m head	30,770	27,230
New sump	71×71×2.5m fully lined	227,980	28,727
Pump from new sump to new dam	1×6 L/s @ 31m head	30,770	27,230
Pipe to connect from new sump to new dam	700m of DN90mm PVC with class 9 pressure rating	30,700	27,130
Location allowance (20%)	Adjustment for regional location factor eg transportation etc as costs are based on metro rates	228,653	-
	Sub-total capital costs	*1,188,995*	*446,370 (with liner)* *346,670 (without liner)*
Additional project costs			
General contractors prelims (20%)	For mobilisation/demobilisation, site set-up, site clean-up etc	198,166	-
EPCM fees (@10% of cost)	Engineering, Procurement, Construction and Management fees	118,899	-
Contingency (@10% of cost)		118,899	-
	Sub-total for additional project costs	*435,964*	-
	Total for capital investment	*1,426,793*	*446,370 (with liner)* *346,670 (without liner)*
Operation and Maintenance items	**Details**	**Cost ($/year)**	
Operation of pump from existing sports dam to oval (6L/s @ 22m head)	9hrs/day, 7days/week, 9months/year of 7.5kW pump and $0.17/kWh	2,892	
Operation of pump from sump to sports dam (6L/s @ 31m head)	Nominal operation: 6hrs/day, 3days/week, 6months/year of 7.5kW pump and $0.17/kWh	551	
Maintenance personnel & repairs	$80/hr 2hrs/week 7months/year	4,480	
	Total for operation and maintenance	***7,923***	

4.4 OPTION 3 - MANAGEMENT OF SURFACE RUNOFF

4.4.1 Description of Option

It has been that reported that the inundation/waterlogging at the Lake Grace townsite is due to runoff coming from the farmland catchments to the north and east of the townsite. Thus, to alleviate waterlogging, and hence reduce salinity risks, surface runoff from the two catchments is to be collected via drainage channels and discharged into natural drainage pathways which will eventually drain into the salt lake system west of the town. Some upgrades of the existing drainage systems along Kulin-Lake Grace Road, particularly a series of culverts at the CBH and outside DAWA office, are proposed to cope with the 1 in 5 year storm event. A new cut-off drain is proposed along Boulton Street and Dewar Street to collect surface runoff from the northern catchment.

The requirements for this option are as follows:

- Determine volume of surface runoff which can be captured from the eastern and northern catchments;
- Upgrade the existing sump and drainage along Kulin-Lake Grace Road;
- Install a new cut-off drain; and
- Sizing of all drainage features.

This option would only satisfy the objective of waterlogging and salinity management.

A schematic for the option is shown in Figure 4.4.

4.4.2 Volume of Surface Runoff Diverted

Based on the last 10 years of rainfall record the average annual surface runoff which can be collected is 60ML/year and 16ML/year from the catchment east of town and north of town, respectively. Detailed outputs of town surface runoff analysis are shown in Appendix B.

This suggests that 60ML/year and 16ML/year of surface runoff is diverted away from the townsite, and hence reduce the quantity of shallow groundwater recharge via the surface water process accordingly.

4.4.3 Existing Drainage

As per Option 2a and 2b, at the eastern catchment, it was found that the 2x440mm pipe culvert and the 900mmx450mm box culvert at the CBH and outside DAWA office are under capacity to cater for the 1 in 5 year rainfall event (1357L/s peak flow).

These culverts would need to be upgraded to alleviate flooding at the town site caused by choking at these culverts, and to prevent this overflow from reaching the townsite as it is currently the case.

4.4.4 Capital Requirements

The capital requirements and costs for this option are shown in Table 4.4. The cost estimates on capital requirements are provided for KBR commercial rates and

DAWA/Shire rates. The assumptions and cost details for these rates is supplied in Appendix J.

Costs may be further refined when options are further optimised at the detailed engineering design stage.

Table 4.4 - Capital requirements and costs, and operation and maintenance costs for Option 3

Capital items	Details	KBR Commercial Rates ($) 20%+30%	DAWA/Shire Rates ($)
Upgrade drainage channel along Kulin-Lake Grace Road for 1:10year peak flow	400m long, 2m bottom width, 1:4 side slope, 1m deep	48,500	1,000
New culverts at CBH	2x750mm 10m long	57,906	57,406
New culverts outside DAWA office	1x900mmx450mm 10m long		
Install drainage channel along Boulton Street and Dewar Street for 1:10year peak flow	1600m long, 2m bottom width, 1:4 side slope, 1m deep	176,500	4,000
Location allowance (30%)	Adjustment for regional location factor eg transportation etc as costs are based on metro rates	84,872	-
	Sub-total capital costs	*367,778*	*62,406*
Additional project costs	**Details**	**Cost ($) (-20%+30%)**	
General contractors prelims (20%)	For mobilisation/demobilisation, site set-up, site clean-up etc	73,556	-
EPCM fees (@10% of cost)	Engineering, Procurement, Construction and Management fees	44,133	-
Contingency (@10% of cost)		44,133	-
	Sub-total for additional project costs	*161,822*	-
	Total for capital investment	*529,600*	*62,406*
Operation and Maintenance items	**Details**	**Cost ($/year)**	
Maintenance personnel & repairs	$80/hr 2hrs/week 7months/year	4,480	
	Total for operation and maintenance	***4,480***	

4.5 SUMMARY OF ALL OPTIONS

The yield for all options is summarised in Table 4.5 and the capital, operation and maintenance costs for all options are summarised in Table 4.6 for comparison.

Table 4.5 - Summary of yield, capital, operation and maintenance costs for all options

Option	Average annual water yield (ML/year)	% of demand (%)	Excess water (ML/year)
1	35	70	-
2a	50[1]	100	19
2b	36[2]	72	-
3	-	-	-

1. Yield combines runoff of 59.4ML/year town surface and 19ML/year from existing sports dam

2. Yield combines runoff of 59.4ML/year town surface.

Table 4.6 - Capital, operation and maintenance costs for all options

Option	KBR Commercial Rates ($) (Including location allowance) (-20%+30%)	Additional Cost ($) (-20%+30%)	TOTAL KBR Commercial Rates[1] Capital Investment Costs ($) (-20%+30%)	TOTAL DAWA/Shire Rates[1] Capital Investment Costs ($)	O & M Cost ($)
1	170,551	75,042	245,594	65,460	10,263
2a	531,777	223,981	765,759	131,447	11,526
2b	1,188,995	435,964	1,426,793	446,370 (with liner) 346,670 (without liner	7,923
3	367,778	161,822	529,600	62,406	4,480

1. See Capital Investment and Costs for calculation methodology and assumptions.

4.6 COST/BENEFIT ANALYSIS

To be included when results from UWA cost/benefit analysis are available

Figure 4.1 - Schematic for Option 1 - Existing Sports Dam to Oval

Figure 4.2 - Schematic for Option 2a - Surface runoff and to existing dam

Figure 4.3 - Schematic for Option 2b - Surface runoff to new dam

Figure 4.4 - Schematic for Option 3 - Management of surface runoff

5 Conclusion

As part of the Rural Towns-Liquid Assets (RT-LA) project, DAWA and its partners have undertaken scientific investigations, and in consultation with the Shire of Lake Grace have devised solutions for water management at Lake Grace.

The objectives of water management at Lake Grace are: to provide water resources development; for salinity management and for identifying socioeconomic opportunities associated with water resources.

This document is the Water Management Plan for Lake Grace, which synthesises outcomes from all scientific investigations and reports, and presents the recommended water management options for Lake Grace.

The outcomes of all scientific investigations suggest that:

- Salinity risk for most part of the town is low, except at the central and south eastern edge of town. Anecdotal evidence of salinity in town is at the post office and town hall;
- Water logging is reported due to discharges of surface runoff at the break of slope, and from the catchments north and east of town;
- It is feasible to lower the shallow groundwater table via pumping from a production bore at the centre of town to protect places with high historical value eg the post office and town hall from waterlogging and salinity damage;
- Salinity management through surface water processes would be more effective than through pumping of groundwater;
- The total scheme water consumption is 137.3ML/year, which is being supplied by the Water Corporation. There is potential to reuse treated wastewater, (approximately 161ML/year). The modelled surface runoff which could be captured off the townsite is 70ML/year, which could be a potential water resource;
- The current demand for irrigation on parks and ovals is approximately 50.4ML/year. This demand is being supplied by the local sports dam owned by the Shire. Approximately 30ML/year of demand is further augmented by scheme water when the dam is dry.

The recommended water management options outlined below are a result of the above scientific outcomes and in consultation with the Shire:

- Option 1: Utilise the existing sports dam and sports dam catchment for irrigation within Lake Grace town.

- Option 2a: Capture stormwater runoff from the town and farmland east of Kulin-Lake Grace Rd (east of townsite) via a sump then pump it to the existing dam for storage.
- Option 2b: Capture stormwater runoff from the town and farm farmland east of Kulin-Lake Grace Rd (east of townsite) via a sump then pump it to a new dam for storage.
- Option 3: Capture stormwater runoff from two catchments, east of Kulin-Lake Grace Rd (east of townsite) and north of Stubbs Rd (north of townsite) into drainage channels by-passing the townsite to alleviate waterlogging/inundation problem in town.

Preliminary engineering analysis was undertaken to quantify water yield for each option and the associated capital requirements and costs, operation and maintenance costs. It is important to note that further engineering analysis would be required prior to implementation of any of these options. The results of the analysis are summarised below with assumptions included.

The yield for all options is summarised in Table 5.1 and the capital, operation and maintenance costs for all options are summarised in Table 5.2 for comparison.

Table 5.1 - Yield and cost for all options

Option	Average annual water yield (ML/year)	% of demand (%)	Excess water (ML/year)
1	35	70	-
2a	50[1]	100	19
2b	36[2]	72	-
3	-	-	-

1. Yield combines runoff of 59.4ML/year town surface and 19ML/year from existing sports dam

2. Yield combines runoff of 59.4ML/year town surface.

Table 5.2- Capital, operation and maintenance costs for all options

Option	KBR Commercial Rates ($) (Including location allowance) (-20%+30%)	Additional Cost ($) (-20%+30%)	TOTAL KBR Commercial Rates[1] Capital Investment Costs ($) (-20%+30%)	TOTAL DAWA/Shire Rates[1] Capital Investment Costs ($)	O & M Cost ($)
1	170,551	75,042	245,594	65,460	10,263
2a	531,777	223,981	765,759	131,447	11,526
2b	1,188,995	435,964	1,426,793	446,370 (with liner) 346,670 (without liner	7,923
3	367,778	161,822	529,600	62,406	4,480

1. See Capital Investment and Costs for calculation methodology and assumptions.

The cost/benefit analysis for each option shows that….. *to be included when results from UWA cost/benefit analysis are available*

6 References

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