Water Management Plan for the Town of Merredin

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Summary

The Rural Towns–Liquid Assets (RT–LA) project was established with the aim of integrating salinity, waterlogging and flooding control with development of new water supplies in wheatbelt towns, and where possible, finding ways of putting the excess water to commercial use.

Following the identification of effective integrated water management strategies, these have been applied to the 15 Shires participating in DAFWA's RT–LA project. This report summarises the outcomes from all scientific investigations undertaken for Merredin.
In addition it presents the water management options, a preliminary analysis of those options and the priority recommended ones.

Due to the reduction in rainfall since 2000, Merredin groundwater levels have shown a declining trend below the townsite as a result of reduced infiltration and recharge.

This report documents the results of the drilling programme conducted by Rockwater Consultants, social contexting, water balance, water quality and methodology studies prepared by CSIRO, geophysical surveys organised by the CRC LEME, chemistry analysis undertaken by the WA Chemistry Centre and socio-economic analysis conducted by the University of WA.

The hydrogeologically related investigations performed by these RT–LA project partners, such as a gravity survey and down-hole gamma and electromagnetic induction logging performed by Curtin University Department of Geophysics, and groundwater modelling and water quality analysis performed by CSIRO Division of Land and Water, are reported in the respective appendices attached to this Water Management Plan.

Previous investigations

As a result of major increases in runoff and recharge following the clearing of native vegetation in the wheatbelt of Western Australia, many low-lying rural towns such as Merredin have become adversely affected by flooding, waterlogging, and secondary salinity caused by rising watertables. At Merredin, flooding and waterlogging have been largely controlled by the construction of absorption banks on the valley sides and improved surface drainage within the townsite. Comparatively little has been done to control rising water levels through reducing recharge, much of which arises from within the townsite itself, because of the greater difficulty and expense in doing so. Water level control through enhanced discharge, such as affected by groundwater pumping, is easier to implement and therefore seen as a more attractive method for salinity control, even though this does not address the cause of the problem and problems remain with disposal of the saline groundwater.

Previous hydrogeological investigations at Merredin include drilling and testing of two trial production bores in the west of the town during 1985-1990 (George and Frantom 1990, GSWA unpublished data), and groundwater modelling to predict the effect of groundwater pumping and tree planting on water levels (Matta 2000). Two operational production bores were installed in the centre of the town by the Department of Agriculture in 2000 (Nott 2004). These bores were pumped intermittently between November 2001 and September 2002 to determine the radius of influence of pumping and to supply water to a small scale reverse osmosis (RO) plant for desalination. The project was largely successful on both counts, with the permeate from the RO plant producing high quality water and drawdowns in the watertable being recorded at least 100 m away from the production bores.

1. Introduction

1.1 Background

The Shire of Merredin is located approximately 260 km east north east of Perth in the wheatbelt district of Western Australia (Figure 1). It has a population of around 3060 residents, with the landuse being dominated by agriculture, producing mainly wheat, grains and sheep (Shire of Merredin 2008).

The Shire covers 3372 km^2 and includes the towns of Hines Hill, Burracoppin, South Burracoppin, Goomarin, Korbel, Merredin, Muntadgin, Nangeenan, Nokanning, Tangedin, Nukarni and Norpa (Shire of Merredin 2008). The Merredin town covers approximately 10 km^2.

The town, and consequently most of its high value assets, is located in a valley floor and like many eastern wheatbelt townsites, Merredin is situated in the valley floor of a relatively flat landscape. Rising groundwater is a problem and has been a focus of community activity since the mid-1980s. The depth to groundwater varies throughout the townsite, and until 2000 it had been rising at approximately 0.1 to 0.2 m each year (Dames & Moore 2001).

The Merredin Shire has been part of the Rural Towns Program since 1997 and involved in the Rural Towns–Liquid Assets (RT-LA) project since 2004. The RT–LA project follows on from the success of the original Rural Towns Program. The RT–LA project was established with the aim or integrating salinity, waterlogging and flooding control with the development of new water supplies in wheatbelt towns, and where possible finding ways of putting the excess water to commercial use. In the case of the 15 towns participating in the RT–LA project, integrated water management strategies are partially implemented, following the measures identified to be most effective.

Several water management studies and reports have previously been completed for the Shire of Merredin, including:

- Social contexting study (Appendix A)
- Merredin Council water management priorities (Appendix B);
- Surface water management analysis (Appendix C);
- Merredin water initiatives cost analysis (Appendix D);
- Borefield drilling and test pumping report (Appendix E);
- Evaluation of costs associated with Merredin infrastructure damage caused by salinity (Appendix F);
- Water quality study (Appendix G);
- Water balance study (Appendix H);
- Methodology on saline groundwater recovery, desalination and water use (Appendix I);
- Assessment of groundwater pumping and desalination pilot project (Appendix J); and
- Assessment of the economics of predicted rising groundwater and salinity in Merredin townsite (Appendix K).

This report synthesises all existing data, to present an overall Water Management Plan for Merredin.

1.2 Water Management Plan objectives

The objectives of this Water Management Plan are to:

- Summarise and highlight the water management issues and impacts in Merredin;
- Provide options for the management of surface water and groundwater to prevent waterlogging and salinisation; and
- Identify opportunities for groundwater and surface water resource development, primarily for townsite irrigation.

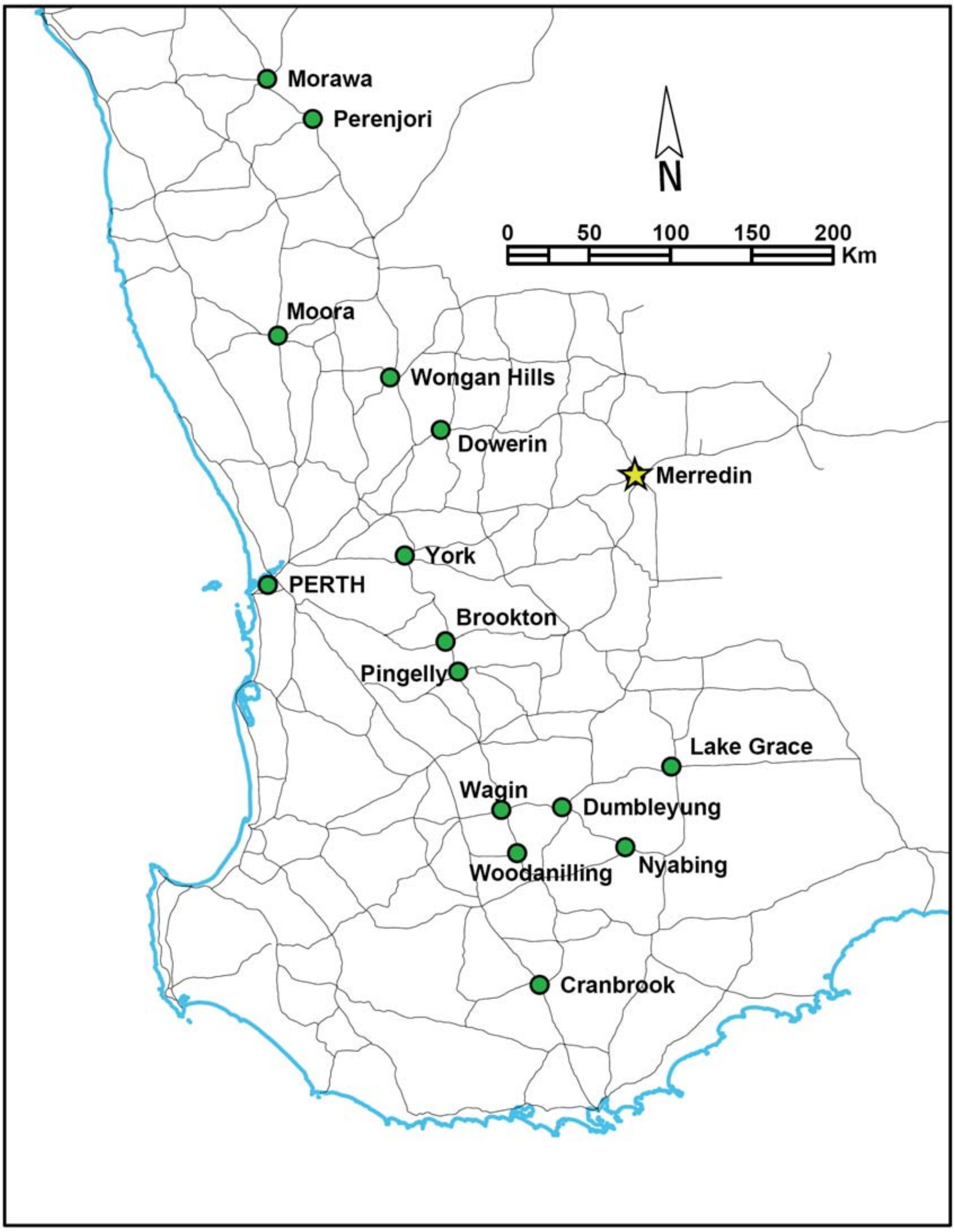

Figure 1 **Location map of Merredin townsite.**

2. Current status

2.1 Climate and rainfall

The Merredin town catchment covers approximately 400 km^2 and comprises a broad, gently sloping valley. The catchment is located east of Perth, and experiences hot, dry summers and cold, relatively dry winters. Annual average rainfall in Merredin is low, with a long term annual average rainfall of 326 mm/yr. Annual pan evaporation is 2630 mm/yr, with potential evapo-transpiration of 1050 mm/yr. Long term average monthly rainfall and maximum temperatures for Merredin are shown in Table 1.

Table 1 **Long term average rainfall at Merredin**

	Average rainfall (mm)	Mean max temperature (°C)
January	13.8	33.7
February	15.6	33.0
March	20.5	30.2
April	23.5	25.3
May	41.2	20.6
June	50.3	17.2
July	51.0	16.2
August	39.0	17.2
September	25.8	20.4
October	18.2	24.6
November	13.9	28.4
December	13.8	31.9
Annual	**326.5**	**-**

* **Source** Bureau of Meteorology Site 'Merredin 010092'.

2.2 Town water resources

The Merredin town water sources include:

- Direct rainfall captured by rainwater tanks attached to residential, commercial and public buildings;
- Harvesting of surface water in Cohn Creek;
- Treated water (permeate), from the desalination plant (when operational);
- Abstracted saline groundwater via the town borefield; and
- Fresh 'scheme' water piped into the town from the Goldfields pipeline, sourced from the Mundaring Weir.

The scheme water supplied piped in through the Goldfields pipeline provides all of the town potable water supplies. Apart from some rainwater tanks, sources of water listed above are utilised mainly for irrigation and other (non-potable) purposes.

The six equipped production well borefield was installed between 2000 and 2005 and was used to supply a desalination plant, which operated in 2006/07. When not used as a feed for desalination, the borefield discharges to a 2 ha evaporation basin located on the western town boundary. Reject water from the desalination plant when in operation was also discharged to the evaporation basin. The borefield has been successful in lowering groundwater levels and preventing the spread of salinity within the town.

Although low salinity water was produced from the desalination plant, it was never intended to be used as a drinking water supply.

Water uses within the Merredin townsite include:

- scheme water used for domestic and commercial purposes
- desalinated water (when operational) for construction and roadwork projects, sourced from groundwater abstraction from the towns borefield
- untreated saline groundwater produced from the borefield used for dust suppression during construction and roadworks projects;
- wastewater – transferred to the Water Corporation waste water treatment plant (WWTP);
- potable supply for irrigation of public amenities (sports fields etc); and
- town dams used for irrigating parks, public gardens and recreational facilities (such as the town oval).

2.3 Landuse

The town of Merredin has a population of around 3060 residents. Landuse in the surrounding district and greater region for that matter, is dominated by agriculture, producing mainly wheat. Over 40 per cent of Western Australia's wheat is produced within a 100 km radius of Merredin (Shire of Merredin 2008). The agricultural land also produces other grains and sheep (Shire of Merredin 2008). The town is located at the centre of a major grain growing area, and supports significant service facilities. Major infrastructure within the town includes:

- around 1100 private dwellings;
- a large Cooperative Bulk Handling (CBH) facility, adjoining the western boundary of the Merredin townsite;
- sports and recreational reserves;
- government, educational and health facilities;
- DAFWA's Dryland Agriculture Research Institute;
- commercial and industrial properties;
- significant railway and road networks;
- Water Corporation WWTP;
- three freshwater dams; and
- a six water production well borefield and 2 ha of evaporation ponds.

The Shire of Merredin has approximately 11 per cent of its original remnant vegetation. Revegetation work has taken place in and around the townsite (Dames & Moore 2001). Much of the surrounding agricultural land has been cleared for cropping, with the only substantial area of remnant native vegetation being located to the northeast of the town, encompassing the golf course and Merredin Peak (Rockwater 2006).

2.4 Surface water hydrology

The Merredin catchment is located in the Swan-Avon drainage basin in a valley and is influenced by catchments to the north, east and up to a lesser extent to the south of the town (Nott et al 2004). The Merredin catchment covers 400 km^2, with surface drainage through the town from east to west via Cohn Creek and a series of intermittent creeks and artificial town drainage systems (Nott et al. 2004). These creeks flow towards the salt lake chains of the Yilgarn River.

The catchment discharges to the Yilgarn River palaeodrainage system at Hines Hill, approximately 20 km west of the town (Nott et al. 2004). The catchment is approximately 34 km long, running from a series of breakaways near Booraan to the east, down to the salt lake drainage west of Hines Hill (Dames and Moore 2001).

Surface water flows originate from the high ground to the east, north and south of the town, flowing through the town along the valley floor to the western boundary of Merredin. Cohn Creek subsequently discharges to the Salt River that flows to the south west (Boyes 2009).

In 1984, 110 km of absorption banks were constructed throughout the catchment, including many upslope of the town to protect it from flooding (generated by intense summer storms), and to reduce catchment soil erosion (Nott et al. 2004). A network of stormwater drains had previously been constructed within the town (Nott et al. 2004).

Prior to 1980, the town of Merredin was subject to occasional inundation and damage by floodwaters, following intense storms in the catchment east of the town. Surface water control structures were implemented in 1984 to prevent further occurrences (Dames & Moore 2001).

2.5 Town water supply

Town water supplies are sourced a combination of imported water via the Goldfields pipeline (supplying potable water), and surface water harvesting from Cohn Creek (supplying non-potable water).

Merredin consumes around 528 ML of scheme water each year (Grant & Sharma 2006), the majority of which (95 per cent) is supplied for domestic purposes. The remainder (5 per cent or 25 ML/yr) is used for irrigation purposes for council parks and ovals, together with water supplies harvested from Cohn Creek. Irrigation supplies are a mixture of mostly surface water harvested from Cohn Creek, and scheme water.

Water harvested from surface water harvesting of Cohn Creek, and scheme water supplies are stored separately in the town due to differences in water quality.

There are currently five existing surface water storage and reticulation facilities located in the town of Merredin for surface water harvesting (Table 2).

Table 2 **Summary of existing surface water storage facilities**

Dam	Capacity* (ML)	Water source	Use
Duff St South Dam (Dam 1)	74	Cohn Creek – surface water harvested adjacent to the western end of the Duff St North Dam (this capture point supplies both Duff St Dams)	All three dams are interconnected. Water is used by Shire of Merredin for irrigation, construction and roadworks
Duff St North Dam (Dam 2)	71		
CBH West Dam (Dam 3)	80	Cohn Creek surface water harvested at the west end of the CBH site plus stormwater runoff from the CBH site	
Railway Dam	25	Runoff from the surrounding sub-catchment, including Merredin Rock	Used by Shire of Merredin for irrigation, construction and roadworks
Sports Dam		Pumped from Dams 1 and 2	Irrigation of adjacent sports ovals

***Source** Shire of Merredin.

Surface water is currently harvested from the Cohn Creek at two locations within the town:

- Adjacent to the western end of the Duff Street North Dam—supplying water to Dams 2 and 3; and
- At the west end of the CBH site—supplying water to Dam 3.

When high flow rates occur in Cohn Creek, the quantity of water harvested is limited by the capacity of the pumps and the efficiency of the sumps to capture the runoff as it flows passed in the channel. In addition to the harvesting equipment limitations, the total storage capacity of approximately 225 ML limits the overall harvesting systems capacity to take advantage of the infrequent high intensity surface water flows (Boyes 2009).

The total volume of the town's major dams is 225 ML, however due to the effects of evaporative losses and the capacity of the existing harvesting infrastructure, there is a calculated shortfall of approximately 25 ML/yr (Boyes 2009). This 25 ML/yr irrigation shortfall is made up by scheme water.

2.6 Groundwater

The town of Merredin, and consequently most of its high value assets, is located in a valley floor and like most eastern wheatbelt catchments, is situated in a landscape which is generally quite flat (Dames & Moore 2001). The depth to groundwater varies seasonally and spatially throughout the townsite. In 1990, for example, depth to groundwater in the town ranged from 2 m to 7 m (Dames & Moore 2001). In other parts of the catchment, it varies from 0 m to 35 m below ground (Nott et al. 2004).

Groundwater modelling (Matta 2000) indicate a groundwater flow direction from east to west with components of flow from the south east and north with respect to the town (Dames & Moore 2001).

Rising groundwater levels are an issue in the town of Merredin, causing inundation, waterlogging and salinity problems. Groundwater levels are rising as a result of wide-scale clearing of agricultural land and the replacement of native vegetation with shallow-rooted crops and pastures. As a result, recharge is increased and groundwater levels rise. In Merredin, groundwater is estimated to be rising by an average of 0.1 to 0.2 m each year (Matta 2000 from Dames & Moore 2001).

Results of a groundwater level monitoring program show that the groundwater levels rise during wet periods (usually winter) and fall during dry periods (Nott et al. 2004). In the upper slopes (recharge areas) where the rate of groundwater recharge is high, water levels are rising by 0.15–0.54 m/yr (Nott 2001 from Nott et al. 2004).

It has been shown that the cause of the rising groundwater is principally generated from within the boundaries of the town (Dames & Moore 2001). Excessive recharge of the groundwater beneath the town is being caused by stormwater infiltration from roads and buildings and with some possible recharge from water imported for domestic gardens and public parks.

Therefore, the focus on reducing the groundwater level rise must be on actions taken within the town and particularly within those areas that will experience damage due to predicted rising watertables over 30 years (Dames & Moore 2001).

Note:

It should be remembered that rates of watertable rise measured during the 1980 to 2000 period were used in the predictive groundwater model. As recharge and watertable rise rates changed post 2000, so too does the validity of the modelling which was based in pre-2000 hydrogeological conditions.

There are four general options to control groundwater rise, these include:

- Reducing the amount of imported water available to enter groundwater (more efficient use of water within the town, mainly irrigation water) (Dames & Moore 2001);
- Intercepting, diverting or capturing the water before it is able to recharge the groundwater (use of improved stormwater drainage and trees) (Dames & Moore 2001);
- Removal of water from groundwater below the areas of town most risk of salinity (pumping) (Dames & Moore 2001); and
- Assessing the condition of the sewage collection systems for leaks.

A combination of these options will be considered as part of this Water Management Plan.

2.7 Wastewater

All properties within the town are connected to a deep sewerage system, with all wastewater being disposed to the Water Corporation wastewater treatment plant (WWTP), located approximately 2 km west of the town centre. The wastewater treatment plant is fully contained, and receives and treats around 155 ML of wastewater each year (Grant & Sharma 2006).

As mentioned previously, approximately 528 ML/yr of scheme water is supplied for domestic purposes. If as expected around 40 per cent (around 211 ML) of this was utilised for outdoor uses (gardening, irrigation and car washing for example), the remaining 316 ML should be transported by the sewerage system to the WWTP. Only 155 ML/yr is treated in the WWTP, indicating that a significant amount of water (around 162 ML/yr) is escaping from the sewerage system. However, if the sewage pipes are below the watertable and are in poor condition (for example, like the Brookton sewerage system), treated volumes should be in excess of the volumes of potable water supplied for domestic purposes. Hence, the sewerage system should be investigated for infiltration/exfiltration.

2.8 Water quality

Groundwater at Merredin is classified as saline, with salinity concentrations ranging from 18 000 mg/L to 22 000 mg/L total dissolved solids (TDS) (Turner 2009). Groundwater salinity generally increases with depth, and there is a general trend of increasing salinity across the town from east to west, with lower salinity in the higher land to the east and north-east, and higher salinity in flatter areas towards the west (Turner 2009). The groundwater is slightly acidic, with an average pH of around 6.3.

Organic compound contamination was detected in several observation and production bores in the vicinity of the railway line near the centre of town. The source of this may have been fuel oil residues remaining from the old railway yards. Pathogen counts were detected in three out of six pumping bores but were at low levels (Turner 2009).

Groundwater quality remains relatively stable during times of groundwater abstraction. Salinity increases from east to west and from upslope to downslope (George & Frantom 1990, from Nott et al. 2004). Shallow bores with lower salinity are generally found in areas of localised recharge, especially from scheme water irrigation (Nott et al. 2004).

Groundwater pH is generally lower in shallow bores than deep bores of the same salinity (Nott et al. 2004). Merredin town groundwater generally has a pH of greater than 6, which is higher (more neutral) than at sites located further downstream (which can be less than 3.5) (Nott et al 2004). Groundwater at Merredin is generally fresher and has a more neutral pH than that of other wheatbelt towns, which may be attributed to scheme water inputs to the shallow groundwater system (Nott et al 2004). Scheme water delivered to the Merredin area is predominately alkaline with a pH of 7–9, and fresh, with salinity of 30–100 mg/L (Nott et al. 2004).

There is a reverse relationship between groundwater pH and EC for the Merredin town, indicating possible ion reactions driven by pH (Matta 2000, from Nott et al. 2004). Groundwater depth also appeared to be a factor in pH/EC relationships.

Concentrations of iron, manganese and silica were found in raw groundwater at concentrations which may lead to fouling of membranes in reverse osmosis (RO) desalination plants (Turner 2009). Because of this, an iron removal unit and potassium permanganate dosing unit were proposed to pre-treat groundwater, to prevent membrane fouling (Turner 2009).

Recent discussions have focussed on the productive uses of groundwater from wheatbelt valleys, particularly the use of groundwater for mineral harvesting, aquaculture, algae production, energy and production of freshwater via desalination. The main physical limitation to the use of each of these technologies appears to be available groundwater supply, and groundwater quality, especially salinity and pH (Nott et al. 2004). The Merredin Shire has expressed an interest in finding alternative productive uses of its groundwater to offset the otherwise high cost of abstraction and disposal (Nott et al. 2004).

2.9 Groundwater pumping and desalination

2001 to 2003

In 2002, a small-scale desalination plant was trialled in Merredin, as part of a joint project between the Department of Agriculture's Rural Towns Program, the Water Corporation and the Merredin Shire. A small trailer mounted Osmoflow® reverse osmosis (RO) desalination plant was installed during the trial and was operational for about a year.

The aim of the desalination plant pilot project was to test the feasibility of pumping water from beneath towns to lower the watertable, and also to process the abstracted water for use for domestic purposes (Nott et al. 2004). The pilot project was largely successful, highlighting that groundwater pumping and desalination has a significant potential for salinity control in Merredin (Nott et al. 2004).

2004 to 2007

With the commencement of the RT–LA project, the production bore network used in the initial trial was expanded in 2004, from two to six production bores, located throughout the parts of the townsite predicted to be at risk of salinity problems (Rockwater 2006). The number and placement of the new production bores was dictated by the need to provide widespread drawdowns in the watertable, as well as the need to supply high yields (Rockwater 2006). These additional four bores increased the total pumping capacity of the production bore network from 2 L/s (173 kL/day or 63 ML/yr) to around 6.9 L/s (596 kL/day or 219 ML/yr).

The infrastructure for the expanded groundwater pumping system comprised:

- six operational production bores equipped with mains power submersible pumps;
- 2 ha of clay lined evaporation ponds, with two main compartments;
- 4.5 km of 80 mm polythene pipe, to transfer abstracted groundwater from the production bores to the evaporation ponds;
- three x 270,000 L steel tanks;
- iron filtration units;
- standpipe and highflow water loading pump; and
- a medium sized Novatron® reverse osmosis (RO) desalination plant mounted in a large sea container. This plant was operational for about seven months during 2006–2007.

The saline groundwater was pumped from the production bores into the desalination plant for treatment via the iron filtration units, producing fresh water and saline effluent (brine). The effluent was discharged to the evaporation ponds, while the fresh treated water was utilised for roadworks and construction projects as and when required. When the desalination plant is not operational, saline groundwater is pumped directly into the evaporation ponds.

With the installation of a large capacity Novatron® reverse osmosis (RO) desalination unit, the production bores supplied saline groundwater to the desalination plant for the upgrade of the Great Eastern Highway roadworks at a rate of 600 kL/day (Rockwater 2006). Untreated saline groundwater was also used for dust suppression and washdown operations.

Apart from being a source of water to supply the RO plant with feed water, the bores were used to lower the groundwater level within much of the townsite. Although there was interest in supplying water for further construction projects, at the time of writing there was no use for the abstracted groundwater or the treated water from the desalination plant. Works are progressing towards establishing alternative uses for treated groundwater.

3. Water management issues

3.1 Waterlogging and salinity

Waterlogging and salinity are both issues in the town of Merredin, and pose a threat to agricultural productivity and town infrastructure. Rising groundwater levels bring dissolved salts to the surface, and can cause salt scalds, vegetation deaths, waterlogging and damage to infrastructure. Managing the watertable by decreasing recharge and increasing groundwater use (either through pumping, drainage or vegetation use) is essential in managing salinity in Merredin.

Two conventional approaches to reducing the damage associated with inundation, waterlogging and salinisation are:

- Diverting water before it reaches an area of inundation, salinisation or waterlogging; and
- Removing or diverting water from the affected area.

In general, it can be expected that the impact can be reduced if the water is diverted before it reaches the problem site. Water quality is also more likely to be maintained if diversion occurs upstream of the affected area.

Inspection of buildings and facilities in Merredin revealed that a considerable amount of stormwater drainage is discharged directly to the ground around buildings (Dames & Moore 2001). This has two compounding impacts. Firstly, damage associated with damp surface soil layers near to point of discharge was noted in several instances. While not a problem associated with the watertable directly, it is an impact caused by excessive water near buildings. Damage to buildings from poor drainage has been attributed to rising groundwater levels, and this damage could be prevented using improved drainage options around infrastructure (Dames & Moore 2001).

Secondly, roof runoff discharging directly onto the ground within the town contributes to groundwater recharge (Dames & Moore 2001). The surface water discharged from sites within the township could be diverted into underground drainage systems to collect paved surface runoff, roof water and subsoil water, and could be introduced into areas that make a significant contribution to the groundwater recharge and in areas where the groundwater is predicted to reach the surface soonest (Dames & Moore 2001).

3.2 Scheme water use

Daily scheme water consumption at Merredin is around 1.4 ML/day, or around 528 ML/year (Grant & Sharma 2006). The water supply of the town of Merredin is sourced from a combination of scheme water supplied via the Goldfields pipeline from Mundaring Weir, and harvesting of surface water flows of Cohn Creek into freshwater dams.

Water used for irrigating Council parks and sports ovals is sourced from surface water captured from Cohn Creek, with top-up from scheme water supplies. Harvested water is stored in the town’s dams, which have a total volume of 225 ML. However due to the effects of evaporative losses and the capacity of the existing harvesting infrastructure, this capacity could be greatly reduced.

The town of Merredin is currently consumes 528 ML of scheme water each year to supply residential properties (Grant & Sharma 2006). In many cases, this high quality water is used for low quality purposes (such as irrigation) when secondary quality ‘fit for purpose’ water would suffice.

Investigating other sources of water for irrigation of public open spaces (race track, sports fields, public gardens etc), would reduce the reliance on, and cost of scheme water.

Utilising current surplus water (stormwater and groundwater) would provide both a self sufficient water supply for irrigation, as well as an improved salinity management option.

3.3 Groundwater disposal

If a higher proportion of the abstracted groundwater could be utilised rather than simply being removed, it would dramatically reduce the area of evaporation basin required. Revenue generated from groundwater, coupled with savings made on preventing damage to infrastructure, might actually generate a positive return on the investment (Nott et al. 2004).

The treated water from the desalination plant is fresh, although it is not suitable as a domestic drinking water supply. The treated water has slightly low pH and slightly high iodide concentrations, which do not meet drinking water quality standards.

There is a network of six production bores within the town of Merredin which can produce up to 600 kL/day of moderately saline (approximately 14 500 mg/L), groundwater. Without desalination, this water has limited uses and is discharged directly to the evaporation ponds for settlement and evaporation. Once desalinated, the water can be utilised for building, construction and roadwork projects.

3.4 Evaporation basins

Monitoring in 2003/04 revealed some leakage from the evaporation ponds into the local groundwater, causing a localised rising of the groundwater (Nott et al. 2004). Acceptable rates of leakage from evaporation basins has been calculated to be between 0.5 – 1.0 mm/day (Leaney & Christen 2000 from Nott et al. 2004). Calculated leakage from the Merredin evaporation ponds ranged from 2.46–4.13 mm/day, with groundwater levels rising at a rate of 2.46–3.10 m/yr below the basin, and over 0.6 m/yr in the Department of Agriculture grounds approximately 80 m away. As this rate of water level rise was not acceptable, the two production bores were shut down in 2004.

Before pumping from the newly expanded borefield recommenced in 2006, leakage rates were reduced to acceptable limits by relining the evaporation basins with higher quality clay and their batters reconstituted by regrading, waterbinding and compacting.

It is important to continue monitor water levels and salinity in the shallow bore network surrounding the evaporation ponds.

4. Water management strategies

It has been identified that the first priority for Merredin in terms of water management should be to reduce groundwater levels in the town, which will reduce the risk of salinisation. The water management priorities for the town, listed in order of priority, are:

1. Reduce groundwater levels within the town. This can be achieved by:
    a. Identifying leaks in sewage infrastructure which may be causing groundwater infiltration;
    b. Reducing groundwater infiltration by improving surface water management. This action will also have the benefit of increasing the amount of water available for irrigation, and also reducing scheme water dependence;
    c. Reducing groundwater infiltration by decreasing irrigation of gardens. This action will also have the benefit of reducing the cost of importing scheme water;
    d. Increasing the use of groundwater by increasing native vegetation; and
    e. Reducing groundwater levels by pumping.
2. Increase amount of water available for irrigation supplies. This can be achieved by:
    a. Increasing surface water harvesting; and
    b. Improving the efficiency of water use.
3. Identify uses for groundwater. This option will allow the continued pumping and desalination of groundwater. Revenue obtained from selling high quality water from the desalination scheme will offset or partially offset costs of water production.

These water management strategies are discussed in greater detail below, with a cost analysis of each option provided in Chapter 5, along with final recommendations for implementation.

4.1 Leaking sewage pipes

Approximately 528 ML of scheme water is utilised each year in Merredin, with 40 per cent of this being used outside, such as irrigation, car washing and gardening (Grant & Sharma 2006). This means that 60 per cent of this water (around 317 ML) each year is transferred to the sewerage treatment plant, via indoor uses, such as toilets, showers, kitchens and laundries. However, only 155 ML/yr is reported to be processed by the WWTP (Grant & Sharma 2006). This highlights that there may be significant leakage in the sewerage system (around 160 ML/yr), which could be responsible for increasing groundwater levels. It is recommended that this be investigated, in order to reduce groundwater infiltration.

Leaks in the sewerage system could be contributing to groundwater level rise within the town. Identifying and repairing major leaks could provide a quick reduction in groundwater recharge and associated groundwater level rise.

Methods of identifying leaks and fixing leaks include:

- gauging studies
- closed circuit television inspection
- gravity cracks and
- relining.

4.2 Improve surface water management

An opportunity exists to increase the harvesting efficiency and the overall reticulation system capability in the town. This option will have the benefit of both increasing the capture of fresh water supplies for irrigation purposes, and decreasing groundwater recharge in areas where high watertables and salinity problems occur.

Monitoring water use and irrigation rates using tensiometers will improve the efficiency of water use and limit the movement of water beyond the root zone to the groundwater. It is estimated that additional irrigation monitoring and control equipment required will cost $10 000/oval (Dames and Moore 2001).

It is recommended that the town of Merredin have a dual supply of surface water, i.e. to harvest surface water from both sealed and non-sealed surfaces (Boyes 2009).

Increased harvesting of surface water runoff can be achieved by the upgrading the current surface water harvesting infrastructure. Recommended upgrades to the current surface water harvesting system include:

- the construction of a new 30 ML capacity storage dam
- construction of a new 5 ML capture dam or sump along Cohn Creek
- increasing the volume of the current Duff Street Sump to 2 ML
- modifying the existing bund at the CBH West Dam and
- conversion of the sports oval dam into 0.5 ML storage tanks to reduce evaporative losses.

The preferred location for the additional sump and dam would be to the east of the treated sewage ponds adjacent to the CBH facility (Figure 2), as this would permit harvesting of surface water from three major sources; the sub-catchments to the east of town, north and south of Merredin (Boyes 2009).

The location of the new sump and dam is subject site investigations, including drilling, geotechnical testing of soil samples and engineering design. Drilling would also check the absence or presence of watertables which had been recorded between 2.0 m and 2.5 m below ground level. In addition to the high watertable constraint, test drilling is required to establish depth to bedrock as this is also a limiting factor in the site suitability.

If no suitable site was found to the west of Merredin, it may be possible to construct a new dam to the east of town. However, the disadvantage of selecting a site on the eastern boundary is that it would not capture all the flow from all three sub-catchments. Ultimately, a compromise will have to be accepted between optimum harvesting opportunity versus practical engineering ability to construct a high efficiency sump and low loss dam (Boyes 2009).

A description of each of the recommended strategies to increase surface water harvesting is provided in Table 3.

Table 3 **Recommended changes to surface water storage facilities**

Strategy	Detail
New 30 ML dam	Construct a new 30 ML dam and a 5 ML sump along Cohn Creek. Captured runoff will then be transferred to either Dam 1 or Dam 2 (the two main storage dams in the town). The additional storage capacity provided by the proposed dam is greater than the town's annual consumption of scheme water and is intended to reduce or eliminate dependency on scheme water. The proposed dam is intended to permit the maximum storage capacity of the dam adjacent to the CBH facility (Dam 3) to be kept for capturing runoff from CBH.
New 5 ML sump	The proposed new town sump to the east of the CBH site takes advantage of surface water flows not captured by the current Duff Street sump. Currently, this water flows into Dam 3 at the western end of the CBH site which reduces the capacity available to capture runoff from CBH. Engineering design is required to establish the optimum combination of sump size, pump capacity and dam capacity to maximise harvesting opportunities. Modelling suggests a sump size of 5 ML and an abstraction rate of 20 L/s to capture and store an additional 40 ML/yr.
Enlarge Duff Street sump	Enlarge the Duff Street sump to 2 ML. This would allow more runoff to be captured and stored in the Duff St Dams (Dams 1 and 2).
Modify bund at existing CBH West Dam	Construct a concrete spillway to better modulate flows from the creek into Dam 3. This will minimise localised flooding at the CBH site.
Construct storage tanks adjacent to sports oval	Replace the Sports Oval Dam with large storage tanks. This will increase the local storage capacity by 0.5 ML and reduce evaporation and seepage losses from the dam
Transfer system between Dam 3 and Dams 1 and 2	Check the capacity of the existing reticulation system to pump sufficient volumes. If required, upgrade pump and pipeline at Dam3 to increase water transfer rates to the Duff Street Dams 1 and 2.

Source Boyes (2009).

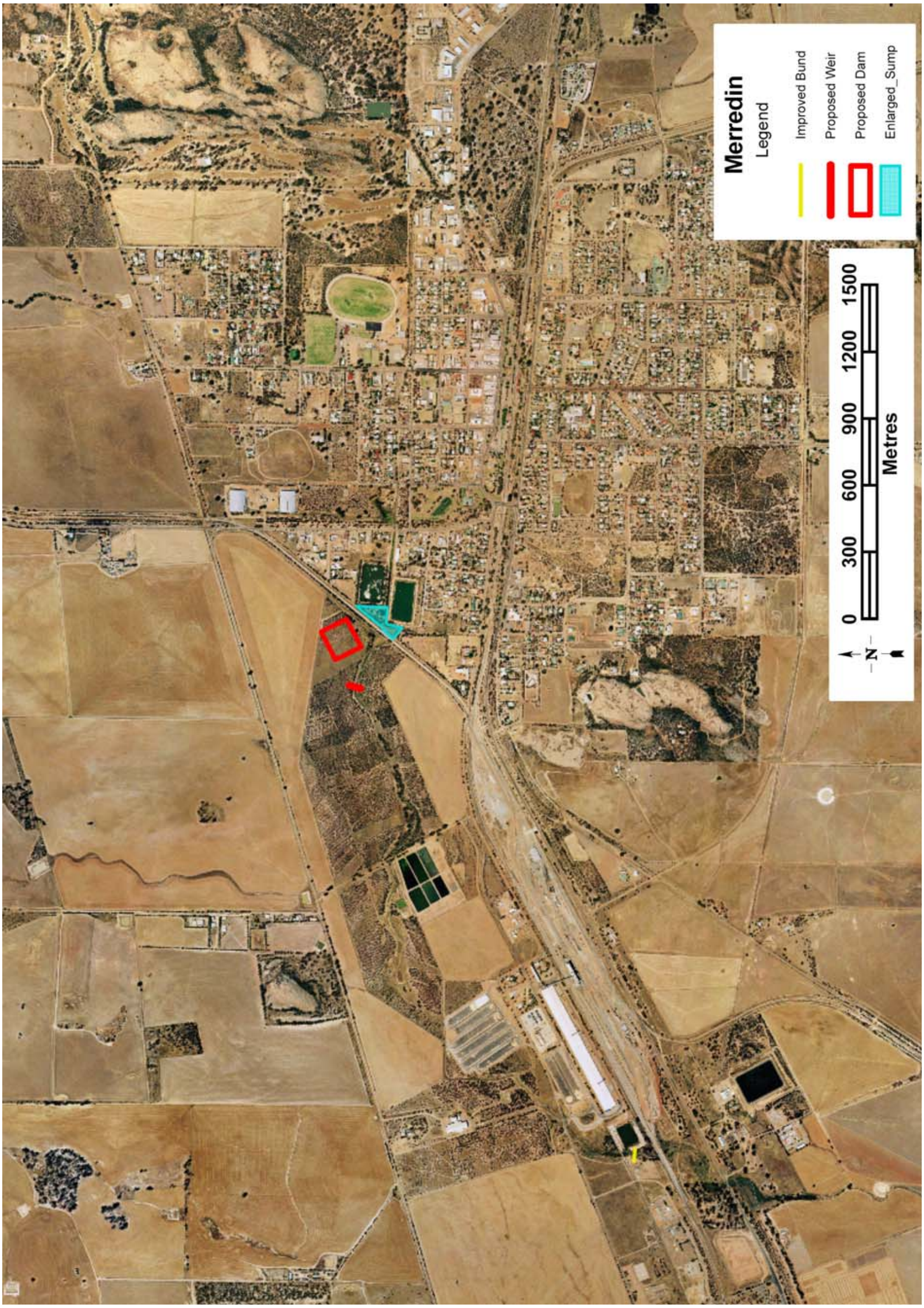

Figure 2 **Sites indicated for proposed surface water upgrades**

4.3 Revegetate with native species

As demonstrated by extensive revegetation to the west of town established in the 1980s, trees grown in plantations are effective at lowering watertables and reducing groundwater recharge rates (Dames and Moore 2001). Even though the effects on the groundwater from tree planting can be localised (up to 10 m to 30 m from the drip-line of the trees), there will be value in planting trees and/or shrubs on vacant land within the townsite. It is recommended vacant public land including existing parks and gardens be revegetated, focusing on those areas of town still affected by rising watertables and at risk of salinity.

4.4 Reduce water use

Community education programs can be implemented to reduce the use of scheme water and reduce irrigation and subsequent groundwater recharge. This can be achieved by:

- Employing a ‘Water Wise’ Officer, to develop and implement community education programs aimed at reducing domestic water use, and assist with domestic stormwater drainage improvements.
- Encouraging the conversion of traditional sprinkler irrigation systems to more efficient units (e.g. trickle and sub-surface systems).
- Encouraging water wise gardening practices, including the use of local indigenous plants and reduced lawn areas.
- Implement education programs such as Waterwise = Saltwise, which recommends the use of rainwater tanks, native vegetation and improved watering regimes. Further information is available from Bulletin 4628 ISSN 1448 – 0352 entitled Wheatbelt waterwise = saltwise, available at: http://www.agric.wa.gov.au/content/HORT/FLOR/BULLETIN4628.PDF
- Encouraging rainwater harvesting for domestic purposes.

The Shire of Merredin may also adopt in areas of the town not implemented, and where it has already been implemented, reinforce existing ‘Water Wise’ strategies to reduce scheme water consumption. Strategies include:

- Conversion to more efficient irrigation systems in public open spaces.
- Hydro-zoning in parks, gardens and public open spaces to decrease lawn areas and increase areas of native gardens.
- Converting gardens, road verges and road reserves to locally native species.
- Implementing Water Wise strategies inside council buildings.

4.5 Groundwater pumping

Groundwater pumping through the established borefield has been successful in lowering the groundwater level beneath the town. Continued groundwater pumping is recommended, in order to effectively manage rising groundwater levels and prevent salinisation. This option may be reduced to periodic or seasonal pumping schedules or eventually phased out if improvements in surface water harvesting and community education programs, which aim to reduce groundwater recharge are effective.

Finding long term uses for the abstracted groundwater is a key element in the long groundwater pumping strategy because it will reduce the costs of operating the system and reduce the pressure on the evaporation ponds. As additional uses for treated groundwater are found, a greater proportion of the abstracted groundwater could be desalinated, leading to an improved cost-benefit of the system, particularly if the water produced meant less reliance on scheme water.

4.6 Potential groundwater uses

A summary of the potential uses for desalinated water are provided below.

4.6.1 Drinking water

Although the quality of the treated water from the desalination plant is high, it is not potable quality and therefore as produced by the Pilot Scheme, has not been suitable for human consumption.

Blending a small quantity of slightly acidic treated desalination water with a large volume of slightly alkaline scheme water will overcome the slightly low pH problem (Nott et al. 2004). Contaminants which prove problematic for desalination plants such as iron oxide or silicate, may be removed before passing through RO membranes (Turner 2008), and iodide concentrations may be reduced by upgrading the RO membranes.

However, many more water quality parameters would need to be addressed before the water was deemed fit for drinking and domestic supply. If portability standards could be met, water intended for drinking would also need to be monitored regularly in order to meet the (high) Health Department WA standards.

4.6.2 Aquaculture

Studies regarding the establishment of aquaculture industries in Merredin have not yet been undertaken. The quality of the groundwater from the production bores appears to be suitable for a range of aquaculture activities, which may generate income to help off-set capital and operating costs (Nott et al. 2004).

Monitoring of both salinity and pH of Merredin groundwater indicates that it may be suitable for growing several fish species, including snapper, bream, trout, giant trigger prawns and possibly barramundi (if temperature can be controlled) (George and Coleman 2001, from Nott et al. 2004). Further trials need to be undertaken to confirm the suitability of the groundwater for these species (Nott et al. 2004).

A great deal of research has been conducted by the Western Australian Colleges of TAFE into the viability and technicalities of inland saline aquaculture (Patridge et al. 2008). The studies have focused on the use of semi intensive floating tank systems (SIFTS), and have examined commercial finfish production using species such as barramundi and rainbow trout. Associated issues including *Artemia* production and managing effluent are also examined in detail.

Further information is available from Dr. Gavin Partridge at Challenger TAFE on
(08) 9239 8032 or: gavin.partridge@challengertafe.wa.edu.au

4.6.3 Irrigation

Townsite recreational areas such as the race track, golf course, sports ovals and council gardens, have the potential to be irrigated by treated desalination plant water. This method would require irrigation infrastructure, and increased capacity of the pilot desalination plant.

Alternatively, untreated bore water could be blended with dam water to extend the capacity of the existing and proposed storages to irrigate grassed areas and gardens within town.

5. Cost analysis

5.1 Groundwater pumping and desalination

A cost analysis of providing saline groundwater and also continuing desalination has been undertaken, and is provided in Table 4.

Table 4 **Estimated costs of providing raw saline water and treated desalinated water**

Cost per kL (at 7.5% discount rate)			
	Saline water supply	**Treated water (hire of RO plant)**	**Treated water (purchase of RO plant)**
1 year	10.06	24.47	20.81
5 years	3.09	11.59	8.24
10 years	2.10	9.25	6.18
20 years	1.46	7.15	4.54

Source Turner et al. 2009.

Over a 20 year period, based on purchasing the desalination plant, the cost of providing treated water from the desalination plant would be approximately $4.50/kL (Turner et al. 2009). This is an expensive option, when compared to the current cost of piping drinking water from Perth to Merredin, at approximately $1/kL (Nott et al. 2004). It has been estimated that additional scheme water supply above the current demand would cost around $2/kL (Nott et al. 2004). Therefore, desalination is an expensive option of water supply, unless other industries can be identified to share costs.

The groundwater abstraction program has the benefit of managing salinity by reducing groundwater levels under the town. Reducing groundwater levels by pumping and my employing various strategies outlined above will alleviate the salinity impacts and damage costs due to salinity and waterlogging. It has been calculated that the damage bill could be approximately $400 000 over 60 years if costed in 2001 dollars (Dames & Moore 2001).

The cost of continuing saline groundwater abstraction, and providing raw saline groundwater for roadworks/construction activities, is around $1.46/kL, over a 20 year timeframe (Turner et al. 2009). Continuing the groundwater abstraction program will continue to manage rising water levels in the town. Ongoing users of the saline groundwater will need to be sourced to remove the pressure on the evaporation ponds. Sourcing ongoing uses of the abstracted groundwater will also assist in reducing operating costs.

5.2 Improved surface water management

The total cost of improving surface water management and harvesting capability has been estimated to be approximately $92 500, plus annual running costs of around $2 400/year (Table 5). The surface water harvesting options would reduce the annual imported water cost, and also aid in salinity prevention by reducing local groundwater recharge. Implementing surface water harvesting strategies should decrease the impacts of waterlogging, inundation and salinity in the town, therefore reducing the need to continue groundwater abstraction in the long term.

Improving water use efficiency at the sports ovals by converting to more efficient sprinkler systems and using tensiometers is estimated to cost around $10 000/oval.

Table 5 **Estimated costs associated with proposed surface water harvesting strategies**

Proposed dams/sumps and pipelines	Volume or length	Estimated capital cost ($)	Operating cost ($/yr)
New Dam (Dam 4) located East of CBH	30 ML	60 000	
New sump east of CBH	5 ML	10 000	2 400
Enlarged existing Duff St Sump	2 ML	5 000	
New pipeline from new CBH East Dam (Dam 4) to Duff St Dams	0.5 km	2 500	
Modified bund at CBH Dam (Dam 3)	15 m	15 000	
TOTAL		**$92 500**	**$2 400/yr**

5.3 Revegetation and community education

Revegetation and community education expenses will be relatively minor, with tree planting costing around $2 000/ha, and the employment of a Water Wise officer around $40 000/yr (0.4 FTE). Benefits of these programs could be significant, reducing imported water use, reducing groundwater recharge and improving salinity, for relatively low ongoing costs.

5.4 Identifying sewerage system leaks

Costs of finding leaks and improving sewerage infrastructure are outlined in Table 6.

Table 6 **Estimated cost of identifying sewerage leaks**

Method	Approximate cost ($)
Gauging studies	$4320
CCTV inspection	$7200

6. Recommendations

Overall, it is recommended that the Shire of Merredin initially focus on improving management of surface water flows and increasing surface water harvesting by implementing the strategies outlined in Table 5. Implementation of low cost options would also prove beneficial, including tree planting and community education strategies. Priorities for management recommendations are provided below, listed in order of highest to lowest priority:

1. Implement stormwater harvesting management strategies, at an approximate capital cost of $92 500, plus annual running costs. This includes strategies outlined in Table 3 and improving management of domestic stormwater.
2. Expand and reinvigorate existing ‘Water Wise’ and community education programs.
3. Continue to pump from production bores to the evaporation ponds at current rates. This pumping may be scaled back then gradually phased out following the completion of improved drainage and surface water harvesting strategies. Implement strategies outlined in Section 4.2 to control the rise of the groundwater around the evaporation ponds.
4. Identify leaks in the town sewerage system.
5. Where high quality (non-potable) water supplies are required for uses such as roadworks, major construction works or for a new industry such as an abattoir, reinstall a desalination plant similar in specification to the Novatron® unit used in 2006/07.

6. Continue revegetation works, particularly focussed around vacant land within the town and around the evaporation ponds.
7. Research suitable industries for abstracted groundwater (e.g. aquaculture, horticulture).

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