WALLBRIDGE GILBERT AZTEC

Shire of Serpentine Jarrahdale

Integrated Water Management Strategy

FINAL REPORT

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Revision History

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1 INTRODUCTION

1.1 BACKGROUND

The Shire of Serpentine Jarrahdale (SSJ) is situated on the fringe of Perth's urban development area and is one of the fastest growing communities in the country. It is predicted that Perth's population will grow by 1.5 million people by 2050 (WAPC), from this growth SSJ is predicted to grow by nearly 100,000 people by 2050 (Shire of Serpentine Jarrahdale, 2016).

In response, SSJ developed the SJ 2050 visioning document (2016) to help plan for the future and maintain the community liveability expectations whilst providing growth opportunities in house and employment. The plan developed a framework of nine outcomes (refer to Figure 1) to maintain and improve the quality of life and create a long-term shared vision.

Figure 1: SJ 2050 Framework (SSJ, 2016)

The predicted increase in population will result in increasing pressure on water supply and wastewater management infrastructure in the region. As a result of climate change and over exploitations, Perth's water resources are under increasing pressure with efficiency of use and reuse of alternative water supplies becoming increasingly important.

Provision and maintenance of green open spaces and vegetation canopy in urban areas is critical to meeting minimum social, health and liveability requirements. SSJ has developed a draft Urban and Rural Forest Strategy 2018-2028 to maintain and improve the tree canopy and vegetation both now and into the future. The awareness of the importance of healthy tree canopy in community environments is increasing as it can help counteract the urban heat island effect and improve mental and physical wellbeing of the community.

As the communities in the project area are changing in response to the increasing population and density, it was realised that a secure water supply and wastewater management infrastructure was required to meet the minimum community expectations, both in the urban environment and agricultural precincts. Water security for the shire is of critical importance in a drying climate. The development of the integrated water management strategy was commissioned to understand the constraints and opportunities to water supplies in the project area and provide a platform for secure water management into the future.

This project considers four main precincts within the SSJ governing boundary, Byford – Oakford, Oldbury – Mundijong, Hopeland – Serpentine – Keysbrook and Jarrahdale township, a site locality plan is presented in Figure 2.

The SJ 2050 strategy document provides guidance on the future land use for the four regions, the land use sectors have been developed to ensure that the rural community focused values remain. The land use zones include, urban residential, equestrian, agriculture intensive agriculture, industrial, conservation and heritage tourism. The future land use zones for each precinct is presented in Figure 2. This report considers elements 1 Wellbeing, 7 Economic Development, 8 Agriculture and 9 Natural Environment of the SJ 2050 framework.

Water demand for council managed infrastructure i.e. parks and reserves, is considered the priority in the demand projections. If surplus water is identified in regions, consideration will be given to other local demands, e.g. school ovals, dual reticulation, industrial demands or agriculture.

1.2 REPORT PURPOSE

This report is the final document outlining the integrated management strategy plan for SSJ. The plan was developed in a staged approach. Information pertaining to the development of the plan and the early stages can be found in:

- WGA, 2019. Integrated Water Management Strategy – Preliminary Water Security Study – Long List of Options. Doc No. WGA181592-RP-CV-001[A].
- WGA, 2019. Integrated Water Management Strategy – Preliminary Water Security Study – Short List of Options. Doc No. WGA181592-RP-CV-002[A].

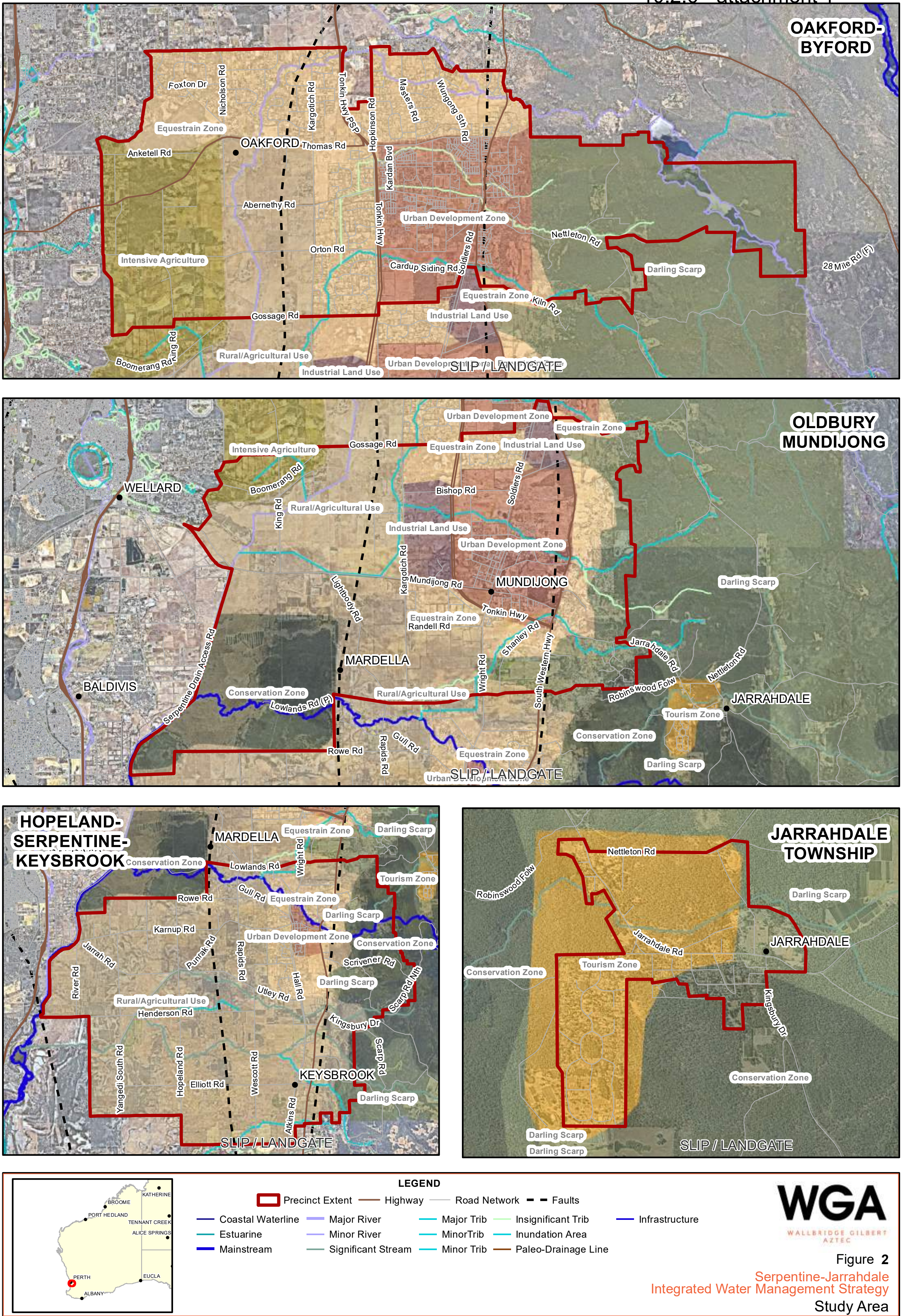


Figure 2
Serpentine-Jarrahdale
Integrated Water Management Strategy
Study Area

1.3 SCOPE OF SERVICES

The scope of services for the plan included:

- Review all relevant background information, including, existing and proposed infrastructure, flood management, local and district structure plans.
- Determine specific drivers and assessment criteria for each precinct.
- Identify potential sources of water.
- Carry out preliminary stakeholder engagement with Department of Parks and Recreation, Department of Water and Environmental Regulation, Water Corporation and Department of Planning, Lands and Heritage.
- Understand a demand analysis for both current and future requirements.
- Carry out a desktop assessment to identify available groundwater resources or high-level feasibility of Managed Aquifer Recharge (MAR).
- Review opportunities for water sensitive design (WSUD), treated wastewater reuse and residential dual reticulation.
- Create a long list of potential opportunities for investigation.
- Review SSJ comments and recommendations of the Long List of Options Assessment to identify a Short List of Options.
- Consider strategic, legislative, policy and cost considerations for each option.
- Undertake a SWOT analysis and rank the overall options.
- Determine the priority / preferred options of up to three per precinct.
- Develop a conceptual design and preliminary cost estimate for each option.
- Identify additional investigations required to determine the IWM opportunity feasibility.
- Assist the SSJ to undertake community consultation to seek feedback from the community for the final plan.
- Produce a final integrated water management strategy plan.

1.4 WATER SUPPLY OPTIONS CONSIDERED

The following water supply options have been considered as part of this assessment.

Groundwater

Groundwater salinity in the area is generally fresh and aquifers are high yielding. Groundwater in the region is proclaimed and is fully or over allocated for viable aquifers and the groundwater resources are in decline. Consultation with Department of Water Environment and Regulation has indicated that reductions in groundwater allocations in the region is likely to ensure sustainable management of the groundwater resource. A licence is required to take water from groundwater under the *Rights in Water and Irrigation Act 1914*. Access to groundwater is via the transfer or purchase of groundwater entitlements.

Surface Water

The taking of water surface water sources including rivers, creeks and drains, in proclaimed and un-proclaimed areas. A licence is required to take water from a surface water course under the *Rights in Water and Irrigation Act 1914*. The Serpentine River and Wugong River are proclaimed within the region; however, significant surface flows are reported during winter in the other creeks and drain systems. Water within these features is a combination of runoff from the Darling Scarp catchment, urban runoff directly or via the sub surface drainage network or groundwater discharge. Discharge from the Serpentine Dam Head into the Serpentine River is also routinely carried out by Water Corporation; however, this is captured in the allocation volumes.

Stormwater or Urban Runoff

The increase in runoff (including via subsurface drainage) from the increasing urbanisation is water considered to be available for harvesting and reuse. The current approach incorporates a series of subsurface drains and drainage basins which ultimately discharge to the regional drain systems (managed by Water Corporation). Only the predicted increase in runoff from predevelopment conditions to the proposed development has been captured in this category to ensure integrity of the water balance.

The concept of rejected recharge has not been considered in this report as the definition and reliable volume determination is still being developed by industry. It is likely that the rejected recharge is somewhat captured under the Stormwater – Urban Runoff analysis, however, it is recommended that the water balance be reviewed in the future.

Wastewater - Sewer Mining

Sewer mining is the practice of extracting wastewater from the sewerage network and treating it to produce recycled water. The regional sewer network (where present) is managed my Water Corporation and would require an access agreement to progress this option. Wastewater in a third-party managed network may include residential sewage and industrial trade waste depending on Water Corporation’s allowable discharges.

Wastewater - Decentralised Wastewater System

The development of decentralised or community wastewater system may limit the waste product to residential sewerage only with industrial trade waste products potentially being excluded. In some areas where there is no regional sewer network the development of a decentralised wastewater system may be more economical than connecting to an existing Water Corporation System. This could be delivered by Water Corporation or a third-party supplier.

2 PRECINCTS

2.1 BYFORD – OAKFORD PRECINCT

The Byford - Oakford precinct is the northern most region of the study area and is located approximately 25 km south of Perth and 11 km east of the coastline and is situated on the fringe of the Perth metropolitan region. The main township of Byford has undergone a significant population growth in recent years, current population is approximately 18,000 and the area is expected to grow to 50,000 residents by 2050. The designated urban development area covers approximately 1,750 Ha (refer to Figure 2).

The land use within the precinct is predominantly urban residential, rural residential, equine properties and agriculture. A portion of the precinct expands into the Darling Scarp, which is of higher elevation and is predominantly state forest, however, the area also includes the Wungong water supply reservoir and several agricultural properties. The Austral Brick quarry and processing facility is located along the scarp in the south eastern section of the precinct. The predicted land use is to be predominantly urban residential, equine, agriculture and an intensive agricultural precinct (refer to Figure 2). The development of the intensive agricultural precinct forms part of the proposed Peel Food Zone which is a 42,000 Ha area across the Shires of Murray, Serpentine – Jarrahdale and north-east of Mandurah. The intensive agricultural precinct extends into the Oldbury-Mundijong precinct.

Potable drinking water is supplied to the region via Water Corporation's Scheme network with the exception of the township of Oakford. Wastewater is managed through a combination of onsite septic systems and Water Corporation's sewer network for more recent developments. The network transfers the wastewater northward through a pressure main to Woodend for treatment, reuse or ocean discharge. Recent residential housing developments have incorporated subsurface drainage, runoff is discharged to the ground using soak wells, water then travels through the surficial sand layer to subsurface drains and then to a surface drainage basin. Water from the drainage basin discharge to the subsurface and ultimately to the regional drain network e.g. Oaklands or Birriga Main Drain.

The major drainage features which transect the precinct are:

- Cardup Brook, Beenyup Brook and Oakland Creek Drain from the scarp through the Byford Township and discharge to the Oakland Drain which ultimately discharges into the Birriga Main Drain in the Oakford – Mundijong Precinct. Square modelling carried out by DoW (2012) reported average annual flows of 33.8 GL in Birriga Main Drain.
- A tributary of the Wungong River runs through the suburb of Darling Downs and tends south and discharges into the Birriga Main Drain. The Wungong River is prescribed with 30 GL of surface water licences held in the precinct, predominantly held by Water Corporation for water supply.

Groundwater is commonly sourced from the Superficial, Leederville and Cattamara Aquifer systems in the region. The groundwater allocation in this precinct is approximately 17.5 GL/a. SSJ hold three groundwater licences in the region, Superficial Aquifer (9 ML/a), Leederville Aquifer (37.125 ML/a) and Cattamarra Aquifer (85 ML/a). A number of groundwater licences are held by property developers and the intent is to transfer ownership to the council, the volume and timing of these proposed transfers is unknown.

Department of Water and Environmental Regulation (DWER) has indicated that the groundwater resource is under pressure and is in decline (refer to Appendix A). In response, there is discussion regarding the reduction of groundwater allocations to ensure responsible and sustainable management of the groundwater resource. A reduction greater than 10% is anticipated, however, the timing is unknown. Groundwater and surface water allocations could be purchased from other third parties. Groundwater allocations for the Serpentine Groundwater Management Area are presented in **Appendix A**

Due to the discrepancy in supply and demand timing, balancing storage is required, this could be in the form of above ground storage (wetlands, lagoons, tanks) or below ground using tanks or Managed Aquifer Recharge (MAR). MAR is the purposeful recharge of water to an aquifer for storage and ultimately reuse. A high-level review for the potential for MAR to be adopted in the region is discussed further in Appendix A, further investigations are required to confirm aquifer storage capacities or sustainable injections rates. MAR is one form of storage that is considered to be feasible in most of this precinct. Table 1 presents a summary of the MAR opportunities and constraints. MAR in the Darling Scarp is not considered feasible due to low yields and potential risk of water logging or surface expression.

Table 1: MAR Opportunities – Byford - Oakford

Aquifer	Opportunity	Limitation
Superficial	Not considered feasible	Insufficient storage capacity with potential impacts of water logging or damage to infrastructure from water level increases.
Leederville	Feasible with the potential for credit transfer	Moderate to high level of storage capacity, however, potential limitation to injection pressures due to connection with the shallower aquifer units or daylighting. Salinity in the aquifer is considered to be fresh and maybe suitable for extraction via a credit transfer system in areas.
Cattamara	Feasible with the potential for credit transfer	Moderate to high level of storage capacity, however, potential limitation to injection pressures due to connection with the shallower aquifer units or daylighting. Salinity in the aquifer is considered to be fresh and maybe suitable for extraction via a credit transfer system in areas.
Fractured Rock Aquifer	Not considered feasible	Insufficient storage capacity with potential impacts of water logging or damage to infrastructure from water level increases.

2.1.1 Future Development

The shire has identified a number of key projects which are required to ensure suitable amenity and facilities for the developing community. These developments are outlined in the SJ 2050 strategy (2016) document and Community Infrastructure Implementation Plan (2017), the information in the following sections are summarised from these documents. In addition, future residential developments are required to incorporate a minimum of 10% of irrigated community space to overcome the urban heat island effects and provide community recreational space. As the public open space regions will depend on the development designs, the increased irrigation associated with these spaces has been based on an area only.

Kalimna Oval Expansion

Expansion and upgrade of the Kalimna sporting reserve is proposed under a shared use agreement with the school. The expansion will include extension of the oval to allow for three soccer fields, an athletics track, carparking and a pavilion. A concept design is presented in **Figure 3: Kalimna Oval Expansion**

Figure 3: Kalimna Oval Expansion

Orton Road District Sporting Facility

The Orton Road District Space is approximately 11 Ha in area and is to accommodate two senior sized sporting ovals, parking and a club facility. The site incorporates a drainage basin for the adjacent residential housing development. A concept design is presented in

Figure 4: Orton Road District Sporting Facility

Figure 4: Orton Road District Sporting Facility

Briggs Park Lower Oval Upgrade

The upgrade of the Briggs Park Recreational facility to include an additional sporting space, equipment, lighting and carpark expansion. **Figure 5: Briggs Park Lower Oval Upgrade** presents the conceptual layout for the sporting facility.

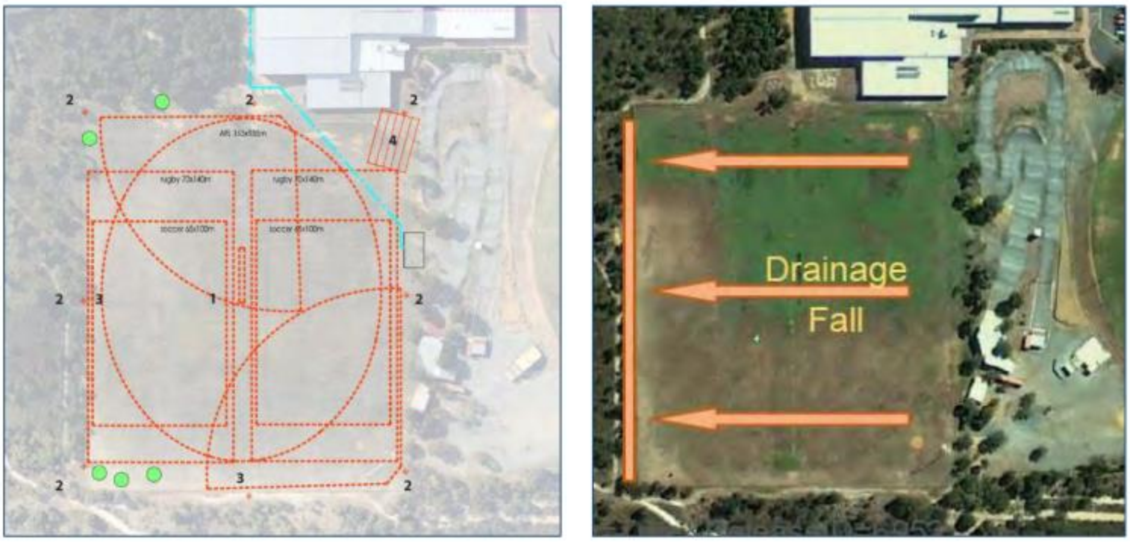


Figure 5: Briggs Park Lower Oval Upgrade

Woodland Grove

The Woodland Grove site includes three drainage basins and a winter creek line which limits the design possibilities. The area can accommodate two senior sized ovals and other functions such as a BMX track or skate park. A conceptual layout is presented in **Figure 6.**

Figure 6: Woodland Grove Expansion

2.2 OLDBURY – MUNDIJONG PRECINCT

The Oldbury-Mundijong precinct is located 35 km south of Perth and 10 km east of the coastline. The precinct has two townships, Mundijong and Oldbury. The land use is predominantly agricultural, equine and rural residential. Mundijong is the largest township which has a population of 2,300 people and is predicted to increase to 50,000 people by 2050. This growth is expected to be in the urban area (refer to Figure 2) which covers approximately 1,850 Ha. The growth strategy is for increased density development rather than urban area expansion. The surrounding land use is expected to remain rural residential, equine facilities or agriculture. An intensive agricultural precinct has been designated in the north-western portion of the precinct, however, is predominantly within the Byford precinct.

Potable drinking water is supplied to the townships via Water Corporation's Scheme network. Wastewater is managed through septic systems. Water Corporation has extended their sewer network to the Mundijong township with a recent small development being serviced. The network transfers the waste northward through a pressure main which transect the township of Byford to Woodend for treatment, reuse or discharge to ocean. There is no stormwater management infrastructure in the existing residential area, however the new housing development incorporates subsurface drainage pipes which discharge to a drainage basin and ultimate to surface drainage channels.

The major drainage features which transect the precinct:

- Serpentine River intersects the south-western portion of the precinct and transects a conservation area, a prescribed river which receives flow from the Serpentine Reservoir and headwall dam which supply drinking water supplies managed by Water Corporation. The Serpentine River discharges to the Serpentine Drain which is located on the western boundary of the precinct. The Serpentine River is fully allocated, in order to source water from this location SSJ would be required to purchase an entitlement from a third party.
- Medulla Brook transects the south-eastern portion of the precinct and discharges into the Serpentine River.
- Manjedal Brook is located north of Mundijong and discharges into the Oaklands Drain and ultimately discharges into the Birriga Main Drain. Square modelling carried out by DoW (2012) reported average annual flows of 33.8 GL in Birriga Main Drain and 18.1 GL in Manjedal. The daily flow rate and quality is unknown.

Groundwater is commonly sourced from the Leederville and Cattamara Aquifer systems in the region. The groundwater allocation in this precinct is approximately 14 GL/a. SSJ hold a groundwater licence in the region which is used to irrigate Mundijong Oval, the volume and target aquifer for this supply is currently unknown. DWER has indicated that the groundwater resource is under pressure and is in decline. In response, there is discussion regarding the reduction of groundwater allocations to ensure responsible and sustainable management of the groundwater resource. A reduction greater than 10% is anticipated, however, the timing is unknown. Groundwater allocations could be purchased from other third parties.

Evidence of quarrying activities are present in the north eastern corner of the precinct. Depending on the activities or closure plan for the site, this may present an opportunity to source water, provide a balancing storage or a water recreational facility.

Due to the discrepancy in supply and demand timing, balancing storage is required, this could be in the form of above ground storage (wetlands, lagoons, tanks) or below ground using tanks or MAR. A high-level review for the potential for MAR to be adopted in the region is discussed further in Appendix A, further investigations are required to confirm aquifer storage capacities or sustainable injections. MAR is one form of storage that is considered to be feasible in most of this precinct. **Table 2** presents a summary of the MAR opportunities and constraints.

Table 2: MAR Opportunities – Oldbury - Mundijong

Aquifer	Opportunity	Limitation
Superficial	Not considered feasible	Insufficient storage capacity with potential impacts of water logging or damage to infrastructure from water level increases.
Leederville	Feasible with the potential for credit transfer	Moderate to high level of storage capacity however potential limitation to injection pressures due to connection with the shallower aquifer units or daylighting. Salinity is the aquifer is considered to be fresh and maybe suitable for extraction via a credit transfer system.
Cattamara	Feasible with the potential for credit transfer	Moderate to high level of storage capacity however potential limitation to injection pressures due to connection with the shallower aquifer units or daylighting. Salinity is the aquifer is considered to be fresh and maybe suitable for extraction via a credit transfer system.

2.2.1 Future Development

The shire has identified a key number of projects which are required to ensure suitable amenity and facilities for the developing community. These developments are outlined in the SJ 2050 strategy (2016) document and Community Infrastructure Implementation Plan (2017), the information in the following sections are summarised from these documents. In addition, future residential developments are required to incorporate a minimum of 10% of irrigated community space to overcome the urban heat island effects and provide community recreational space. As the public open space regions will depend on the development designs, the increased irrigation associated with these spaces has been based on an area only.

Keirnan Park Recreation Centre

A district open space and sporting facility is proposed for Keirnan Street, Mundijong, the 58 Ha facility will consist of 2-3 senior sized ovals, parking and a pavilion. There is also consideration that the facility could include a BMX facility, multi-use indoor sporting facility including 12 indoor basketball courts, 16 netball courts, 8 tennis courts and an aquatic centre. A concept for the development is presented in **Figure 7**

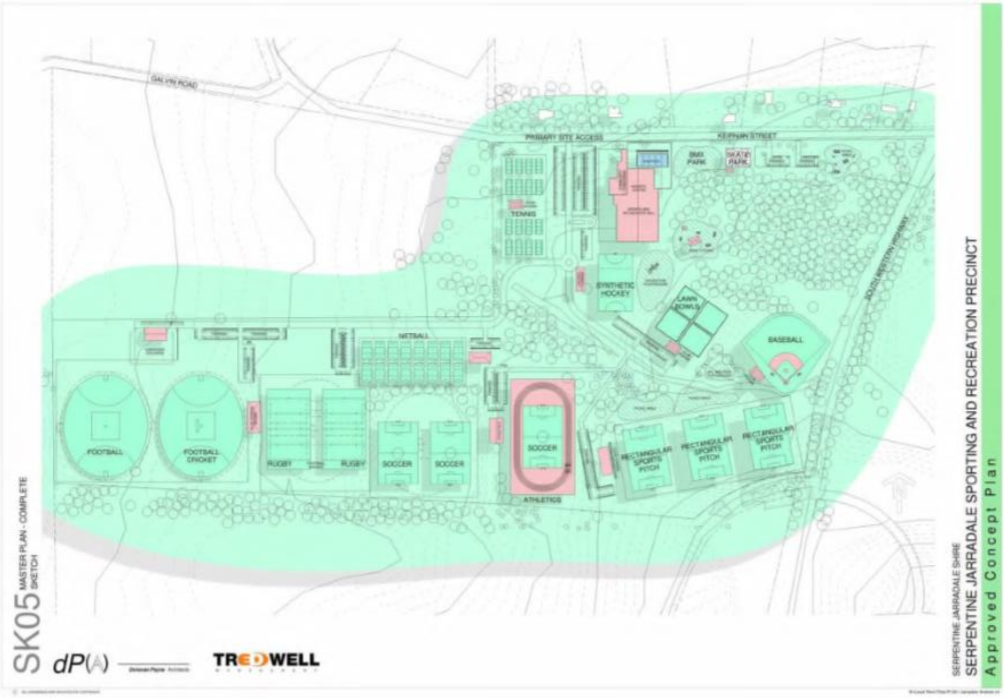


Figure 7: Keirnan Park Recreation Centre

Whitby and Mundijong District Sporting Space

A district sporting facility is required to support the Whitby High School and new Mundijong High School. The 12 Ha facility is to include two senior sized ovals and supporting infrastructure. The proposed location of the facility is unknown.

Figure 8: Whitby and Mundijong District Sporting Space Concept Design

District Equine Facility

Equine activities are prevalent in the precinct, there is the potential to develop a district equine facility at Webb Road Reserve which is currently used as a training ground for trotting and gallopers.

2.3 HOPELAND-SERPENTINE – KEYSBROOK PRECINCT

The Hopeland – Serpentine – Keysbrook precinct is in the southern most area of the SSJ governing area. It is located 40 km south of Perth and 9 km east of the coastline. The precinct has three townships, Serpentine, Keysbrook and Hopeland. The land use is predominantly agricultural and rural residential. Serpentine is the largest township which has a population of 1,800 people and is predicted to increase to 10,000 people by 2050. This growth is expected to be in the urban area (refer to Figure 2) which covers approximately 415 Ha. The growth strategy is for increased density development rather than urban area expansion. The surrounding land use is expected to remain rural residential, equine facilities or agriculture.

Potable drinking water is supplied to the townships via Water Corporation's Scheme network. Wastewater is managed through septic systems; Water Corporation has no plans to expand the wastewater network into this region. There is no stormwater management infrastructure in this region, runoff is directed to natural drainage line by existing topography.

Three major drainage features transect the precinct:

- Serpentine River, a prescribed river which received flow from the Serpentine Reservoir and headwall dam which supply drinking water supplies managed by Water Corporation. The Serpentine River discharges to the Serpentine Drain which is located on the western boundary of the precinct. The Serpentine River is fully allocated, in order to source water from this location SSJ would be required to purchase an entitlement from a third party.

- Kardup and Dirk Brooks are located in the southern portion of the project area. Both drainage lines are catchment and groundwater fed and are not prescribed. Currently extractive supplies are unknown. Predominantly winter flowing, water is drained to the Punrack Drain. Flows at Yangedi Punrack Drain are estimated to be between 35 and 42 GL/a with daily flows up to between 100 and 800 ML/a depending on rainfall. Salinity monitoring at this location (Station 614094, DWER) indicates a winter and summer cycle whereby salinity in winter is in the order of 250-300 mg/L whilst in summer it increases to greater than 1,500 mg/L.

Groundwater is commonly sourced from the Leederville and Cattamara Aquifer system in the region. The groundwater allocation in this precinct is approximately 47 GL/a. SSJ currently hold 110 ML/a of licences from the Leederville Aquifer in the Serpentine region. DWER has indicated that the groundwater resource is under pressure and is in decline. In response, there is discussion regarding the reduction of groundwater allocations to ensure responsible and sustainable management of the groundwater resource. A reduction greater than 10% is anticipated, however, the timing is unknown. Groundwater allocations could be purchased from other third parties.

Due to discrepancy in supply and demand timing, balancing storage is required, this could be in the form of above ground storage (wetlands, lagoons, tanks) or below ground using tanks or MAR. A high-level review for the potential for MAR to be adopted in the region is discussed further in Appendix A, further investigations are required to confirm aquifer storage capacities or sustainable injections. MAR is one form of storage that is considered to be feasible in most of this precinct. **Table 1** presents a summary of the MAR opportunities and constraints.

Table 3: MAR Opportunities – Hopelands – Serpentine – Keysbrook

Aquifer	Opportunity	Limitation
Superficial	Not considered feasible	Insufficient storage capacity with potential impacts of water logging or damage to infrastructure from water level increases.
Leederville	Feasible with the potential for credit transfer	Moderate to high level of storage capacity however potential limitation to injection pressures due to connection with the shallower aquifer units or daylighting. Salinity is the aquifer is considered to be fresh and maybe suitable for extraction via a credit transfer system.
Cattamara	Feasible with the potential for credit transfer	Moderate to high level of storage capacity however potential limitation to injection pressures due to connection with the shallower aquifer units or daylighting. Salinity is the aquifer is considered to be fresh and maybe suitable for extraction via a credit transfer system.

2.3.1 Future Development

No significant community infrastructure projects are planned for this region. In addition, future residential developments are required to incorporate a minimum of 10% of irrigated community space to overcome the urban heat island effects and provide community recreational space. As the public open space regions will depend on the development designs, the increased irrigation associated with these spaces has been based on an area only.

2.4 JARRAHDALE TOWNSHIP

The township of Jarrahdale is located in the Darling Range approximately 45 km south-east of Perth and 8.5 km north-east of the township of Serpentine. The township is located in the Jarrah Forest and houses over 1,000 permanent residents. Land use consists of rural residential and community facilities (e.g. schools, sporting) while the surrounding land use consists of state forest (recreation activities) and agriculture including the Millbrook Winery a world-class facility and popular destination for food and wine. Agricultural properties source water from onsite dam structures. The town was built adjacent to Gooralong Brook which ultimately feeds into the prescribed Serpentine River unfortunately there are no active flow gauging stations. The community consultation process (refer to Section 5.2) highlighted concerns regarding the flows within the creek and the minimum environmental flows, additional environmental assessments and community consultation is recommended.

The fire risk in the region is considered high, a secure water supply is required to manage this risk.

Potable water supply is via a piped network managed by Water Corporation. Wastewater is managed by private septic tank systems. Wastewater from the Millbrook Winery is treated and reused for irrigation of the native woodlot adjacent to the property, the volume of wastewater is estimated at 1-1.5 ML/a. Groundwater use in the area is minimal to none, due to the low yielding nature of the underlying fractured rock aquifer system. There are no recorded groundwater licences in the region.

2.4.1 Future Development

The permanent residential population is not predicted to significantly increase, however, due to the proximity to the state forest and proposed development projects, the short-stay tourist population is expected to increase. The shire has identified a key number of projects which are required to ensure suitable amenity and facilities for the developing community.

These developments are outlined in the SJ 2050 strategy (2016) document and Community Infrastructure Implementation Plan (2017), the information in the following sections are summarised from these documents.

Jarrahdale Oval Facility

The Jarrahdale Oval facility development would allow for increased use by the community (sporting or other community events) or as a camping ground. The site upgrade will include the development of toilet facilities, power and water. The oval is currently not irrigated. Future irrigation of the oval would require approximately 7.5 ML/a based on 1.05 Ha oval space and irrigation rate of 6.5 ML/Ha. The timing of this development is not known.

Tourist Park

The development of a tourist park was identified as part of SSJ tourism strategy (Economic Development Advisory Committee, 2018) to service overnight and holiday visitors. The region is home to a number of accessible trails in the surrounding forest areas for equestrian, bike riding and walking purposes. Figure 9 presents a concept design which formed part of an expression of interest in 2018. The park concept includes 166 accommodation options including camping and caravan sites, cabins, a wellness centre with units and tree houses. A water park has also been included. The facility is designed to accommodate the equestrian community with facilities for stables, float parking and exercise areas.

Provision of potable water to the site is assumed to be sourced from Water Corporations Scheme Water network. In addition to drinking water supplies, water would be required for washdown facilities and irrigation. Wastewater from the site would include the plumbed facilities plus caravan disposal sites. Based on Water Corporations assumption of 180 L/d of wastewater person and a recycling water factor, the facility may generate between 5 and 20 ML/a of wastewater for reuse depending on occupation rates. There is opportunity to capture, treat and reuse the wastewater onsite for irrigation or washdown or supply irrigation water to the Jarrahdale Oval.

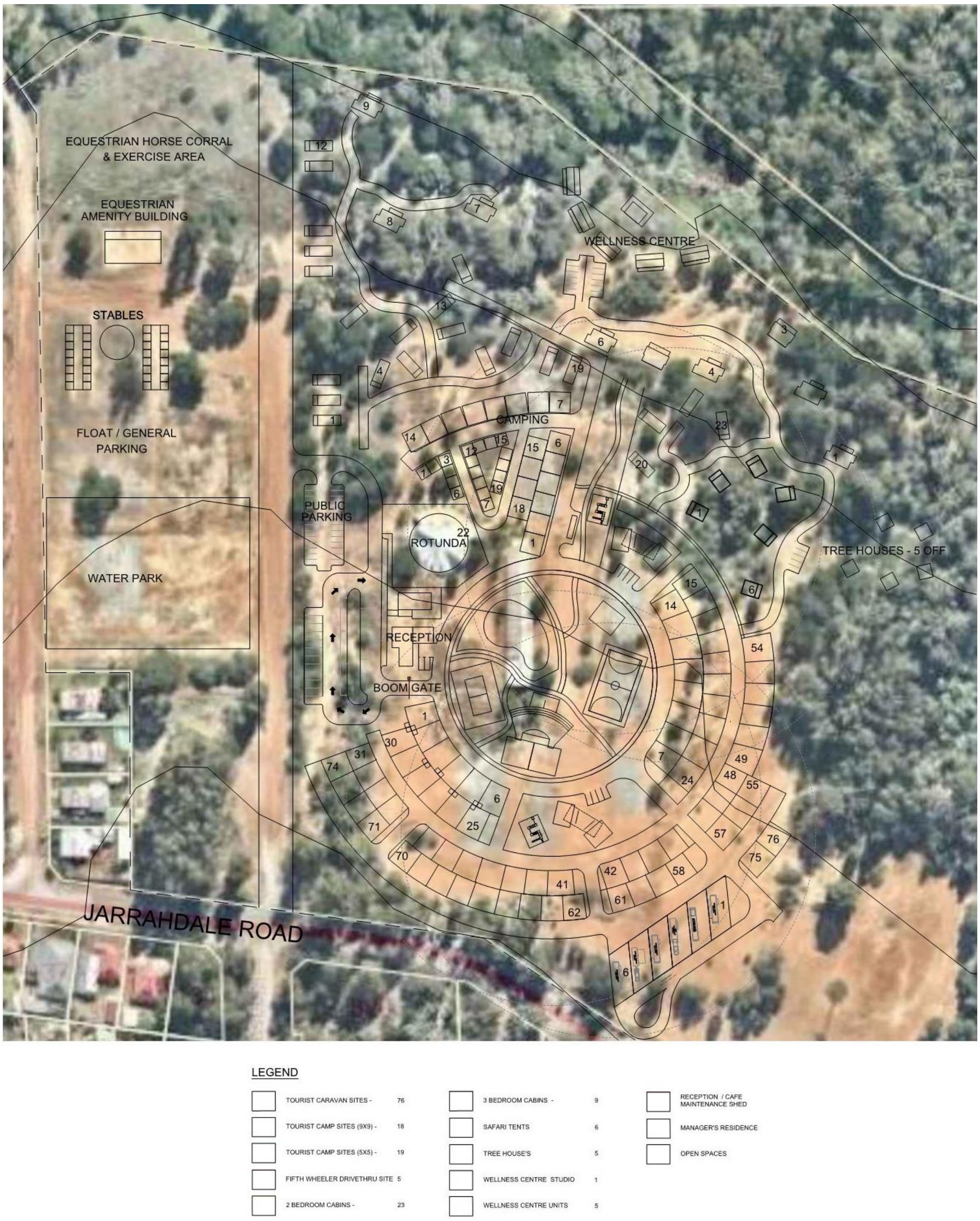


Figure 9: Tourist Park Concept Design

3 WATER BALANCE

The current and predicted water use for irrigation purposes only was calculated and is presented in Table 4 and Appendix B. The current use was based on recorded water use through meters at a large majority of the sites, however, water user for a couple of sites in the township of Jarrahdale were not available so estimates were based on typical water use rates and the area. Groundwater allocations were based on available information at the time of preparation; however, it is recommended that this be routinely reviewed. It is our understanding that the groundwater resource is in decline and that as a result DWER is proposing to reduce groundwater allocation by up to 20%. This potential reduction has not been included in the deficient calculation due to the magnitude of the future demand compared to groundwater allocations (i.e. <20%).

The future demand was based on the following:

- Planned community projects as outlined in the Community Development Plan (SSJ, 2017).
- The urban development areas and population growth as outlined in the SJ 2050 (Urbaqua, 2018).
- A requirement to have 10% of the urban area as irrigated public open space.
- An average irrigation rate of 6.5 ML/Ha/a for the irrigation area, acknowledging that there will likely be varying irrigation rates depending on the community use of the area and seasonal conditions. Irrigation of high amenity sporting ovals or gardens with introduced species may require irrigation at a rate of over 9 ML/Ha/a. Low amenity or areas vegetated with native species may only require an irrigation rate in the order of 3 ML/Ha/a. At this stage of the project, use of seasonal water storage means an average irrigation rate is considered appropriate.

Table 4: Current and Predicted Water Demand (rounded) for Irrigation of Public Open Space

Precinct	Current Demand (ML/a)	Future Demand (ML/a)	Current Groundwater Allocation (ML/a)	Deficit (ML/a)
Byford - Oakford	110	555	131	424
Oldbury-Mundijong	25	750	20*	730
Hopeland-Serpentine-Keysbrook	63	340	157	183
Jarrahdale	3	32	0	32
Total	**201**	**1,677**	**308**	**1,369**

Note:*Groundwater allocation requires confirmation.

4 SYNOPSIS OF LONG LIST OF OPTIONS

Further information pertaining to the long list options assessment can be found in WGA, 2019 titled Integrated Water Management Strategy – Preliminary Water Security Study – Long List of Options. A summary of the options identified is provided in this section.

The long options assessment included a review of available background information to identify potential sources of water, current and future demands based on the SJ 2050 plan, a preliminary Managed Aquifer Recharge feasibility assessment and stakeholder consultation. The water source options considered included groundwater, surface water, stormwater or urban runoff and wastewater (sewer mining or a decentralised wastewater system).

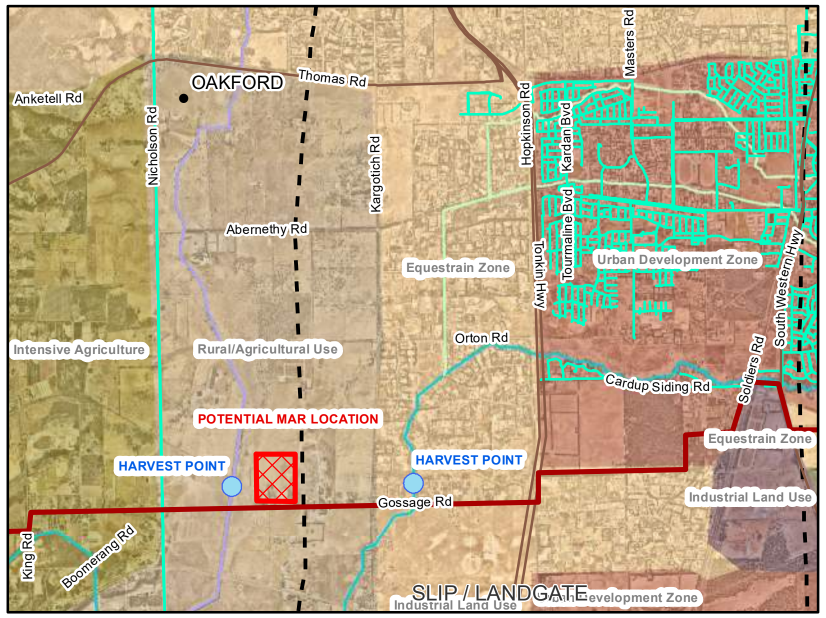
MAR is the purposeful recharge of water to an aquifer for storage and subsequent reuse, this can provide an alternative storage solution in place of above ground storages. There are different approaches for MAR, two techniques considered in this report include Aquifer Storage and Recovery (ASR) whereby water is recharged and extracted from the same recharge bore and infiltration to the unconfined Superficial Aquifer via galleries. A preliminary feasibility assessment in the project area identified that recharge to the Leederville, Yarragadee Formation and Cattamara Coal Measures is technically feasible. A number of unknowns or risks have been identified and a detailed MAR feasibility assessment would be required to determine if the concepts are viable, or design components such as treatment requirements, number of bores are appropriate etc. This is further discussed in **Appendix A** For the purpose of this assessment, the technique is deemed feasible.

Table 5 provides a summary of the options identified for each area with conceptual options presented in **Figure 10** - **Figure 13**.

Table 5: Summary of Long List of Options

Area	Future Demand / Deficit (ML/a)	#	Description	Potential Supply Volumes (ML/a) ±50%
Byford - Oakford	555 / 424	1	Harvest of surface water flows from Oakland and / or Barriga Main Drain during winter.	5,000-10,000
		2	Sewer mining from Water Corporation's sewer network or development of a decentralised wastewater treatment facility.	1,000-2,000
		3	Integrated approach for Opportunities 1 and 2 to increase security of supply.	6,000-12,000
		4	Orton Road District Sporting Facility – harvesting of surface runoff from Cardup Brook and urban runoff.	100-200
		5	Woodland Grove Sporting Facility – harvesting surface runoff from drainage line and urban runoff.	20-100
		6	Briggs Park Sporting Facility - harvesting of surface runoff.	10-50
		7	Austral Brick Quarry - Potential source of water from dewatering activities on site. There is the potential to integrate any supply with surface flows from Cardup Brook.	<20
Oldbury - Mundijong	750 / 730	8	Harvest of surface water flows from Manjedal Brook during winter.	3,000-5,000
		9	Harvest of surface water flows from Oakland and / or Barriga Main Drain during winter.	5,000-10,000
		10	Sewer mining from Water Corporation's sewer network or development of a decentralised wastewater treatment facility.	1,000-2,000
		11	Integrated approach for Opportunities 8 and 10 to increase security of supply.	3,000-6,000
		12	Keirnan District Sporting Facility - harvesting of surface runoff.	50-50
		13	Whitby and Mundijong District Sporting Facility – Potential to harvest surface runoff from the sporting facility and surrounding school buildings.	20-100
		14	Quarry - Potential source of water from dewatering activities on site.	<20
Hopeland Serpentine - Keysbrook	340 / 183	15	Harvest of surface water flows from Punrack Drain during winter.	5,000-10,000
		16	Harvesting of urban runoff through subsurface drainage network and a series of drainage basins.	<100
		17	Development of a decentralised wastewater treatment facility.	100-300
Jarrahdale	32 / 32	18	Harvest of surface water flows from Gooralong Brook during winter.	20-200
		19	Development of a decentralised wastewater treatment facility and retrofit the existing septic system.	20-50
		20	Development of a decentralised wastewater treatment facility for the proposed Tourist Park.	10
		21	Transfer of treated wastewater from Millbrook Winery via a piped network.	1

OPPORTUNITY 1



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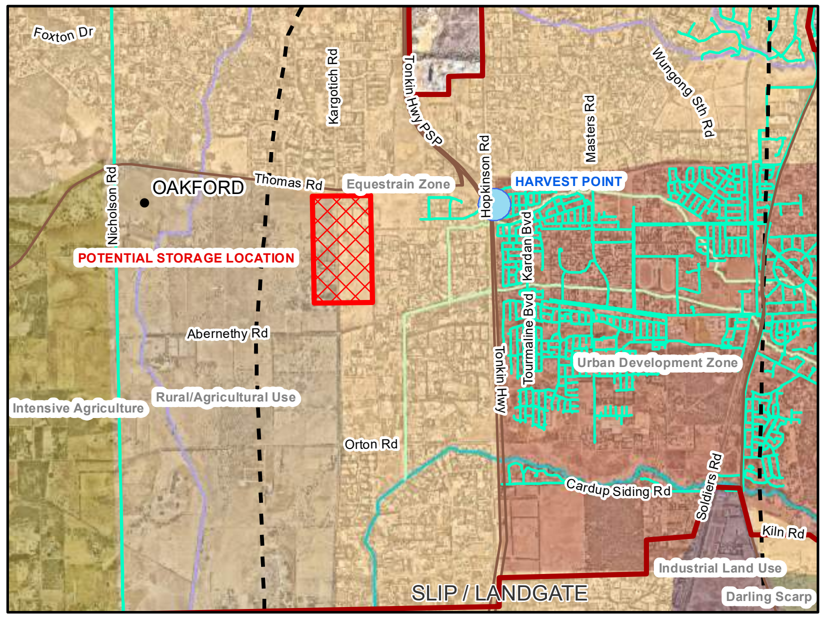

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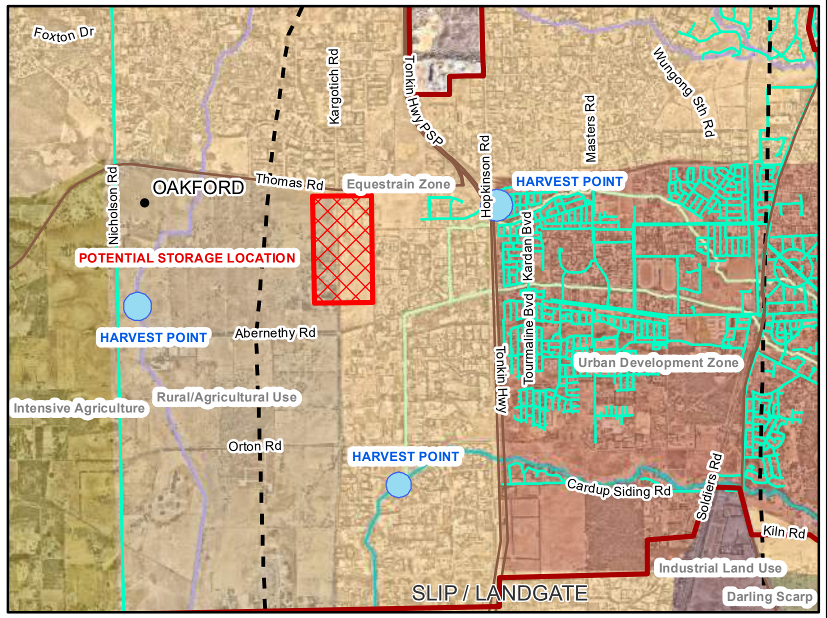

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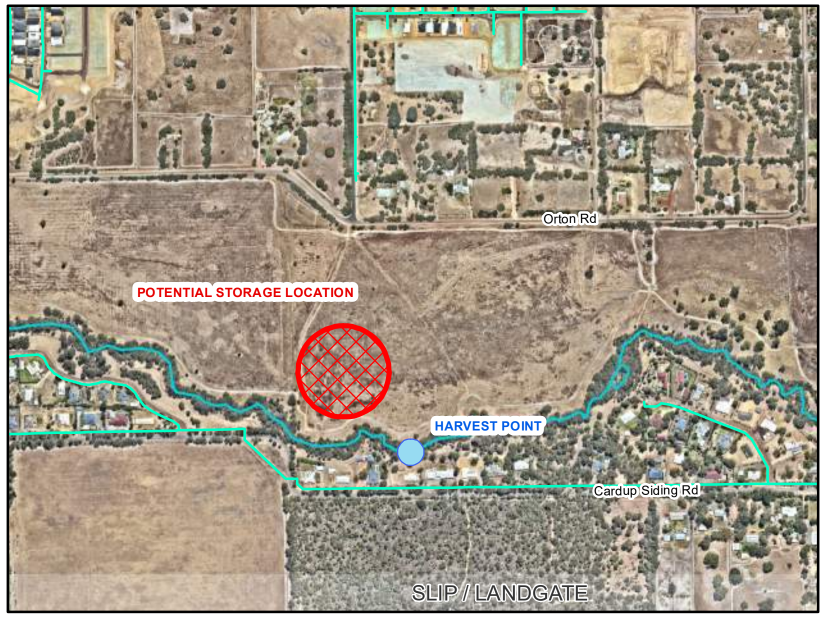
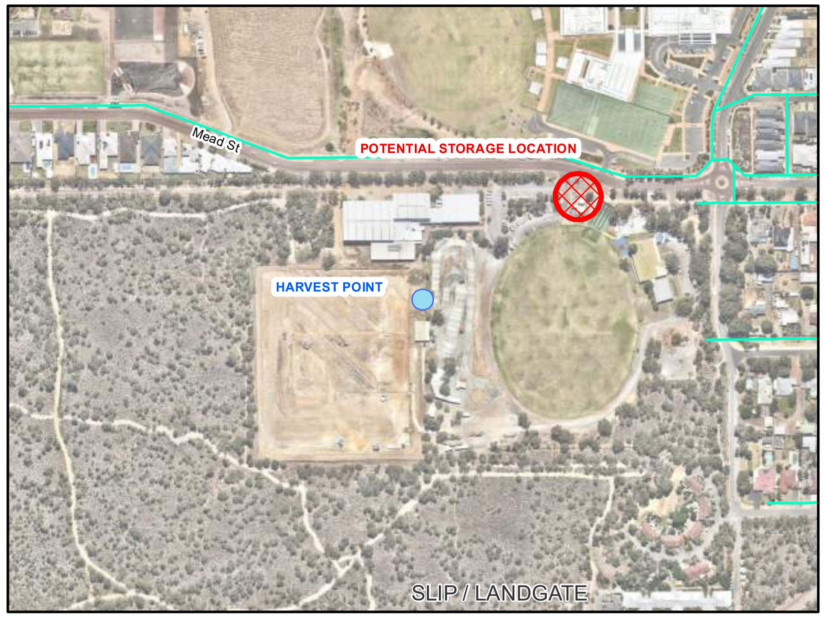


OPPORTUNITY 5

OPPORTUNITY 6



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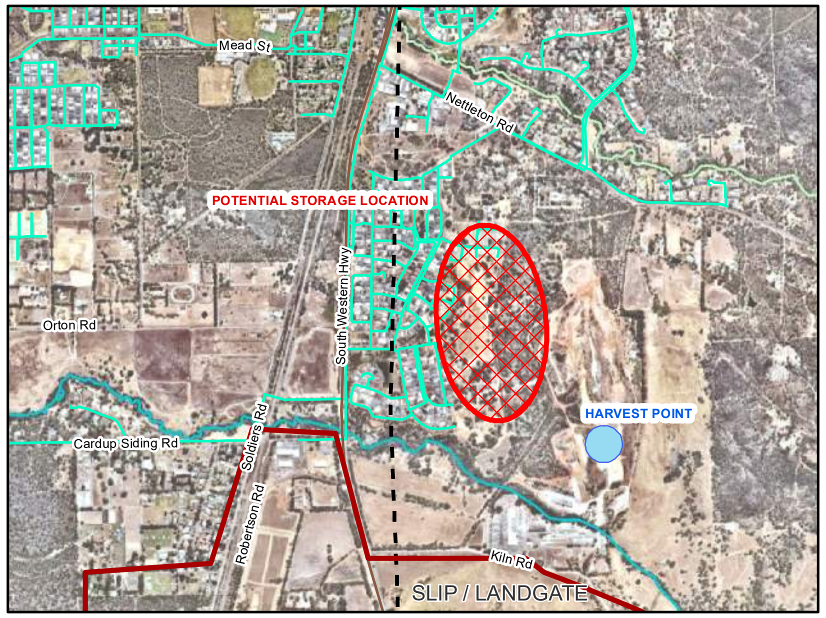
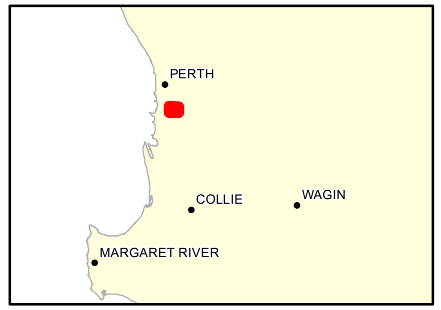


Area	Future Demand / Deficit (ML/a)	Option #	Description	Potential Supply Volumes (ML/a) ±50%
Byford - Oakford	555/424	1	Harvest of surface water flows from Oakland and / or Barriga Main Drain during winter. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	5,000-10,000
		2	Sewer mining from Water Corporations sewer network or development of a decentralised wastewater treatment facility. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	1,000-2,000
		3	Integrated approach for Opportunities 1 and 2 to increase security of supply.	6,000-12,000
		4	Orton Road District Sporting Facility – harvesting of surface runoff, surface water from Cardup Brook and urban runoff captured in the drainage basin. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	100-+200
		5	Woodland Grove Sporting Facility – harvesting of surface runoff, surface water from drainage line and urban runoff captured in the drainage basin. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	20-+100
		6	Briggs Park Sporting Facility - harvesting of surface runoff. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	10-+50
		7	Austral Brick Quarry Potential source of water from dewatering activities on site. There is the potential to integrate any supply with surface flows from Cardup Brook.	<20



Precinct Extent
Potential Storage Location
Harvest Point
Highway
Faults
Water Delivery Pipe
Coastal Waterline
Estuarine
Mainstream
Major River
Minor River
Significant Stream
Major Trib
MinorTrib
Minor Trib
Insignificant Trib
Inundation Area
Paleo-Drainage Line
Infrastructure

SJ2050 Proposed Landuse

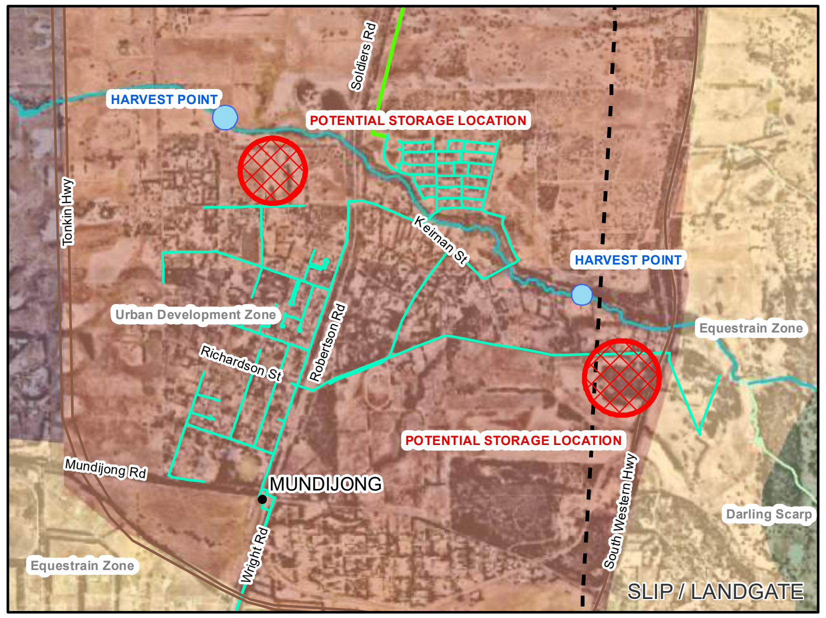
Equestrain Zone
Intensive Agriculture Zone
Conservation Zone
Darling Scarp
Urban Development Zone
Tourism Zone
Rural/Agricultural Use
Industrial Land Use

WGA
WALLBRIDGE GILBERT AZTEC

Figure **10**

Summary of Long List of Opportunities – Byford-Oakford

OPPORTUNITY 8



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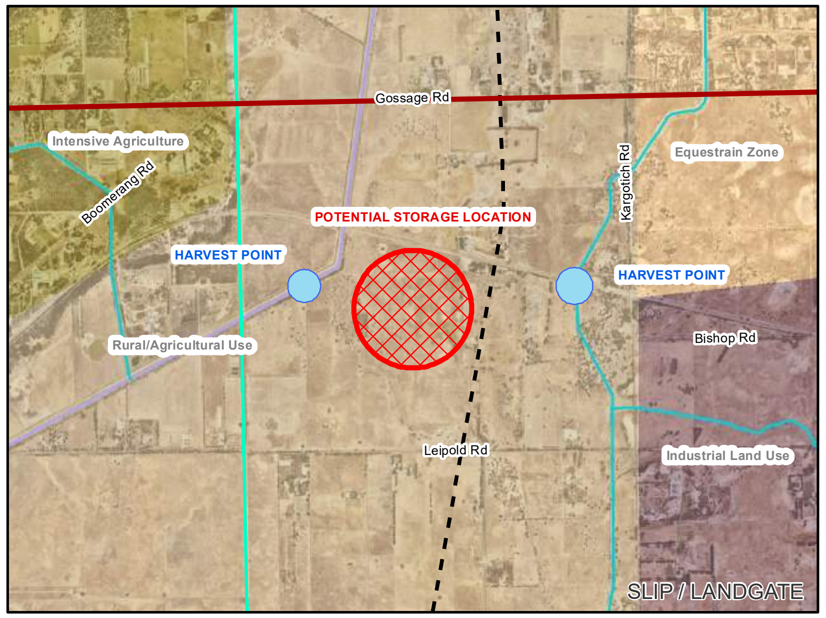

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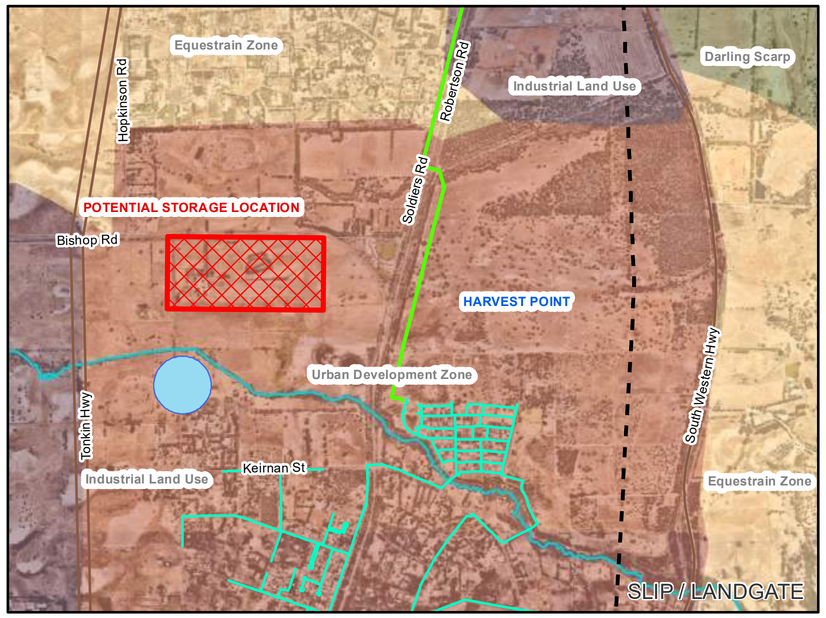

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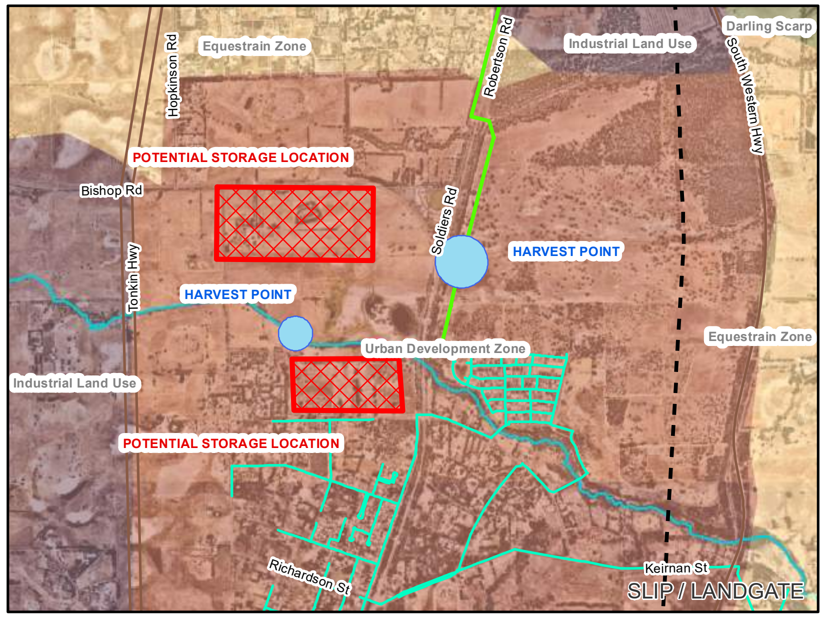

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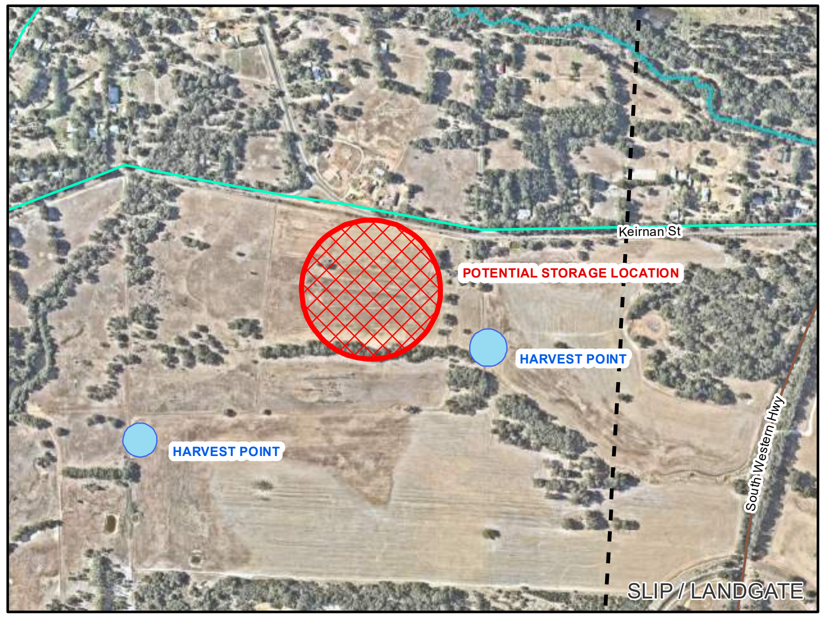
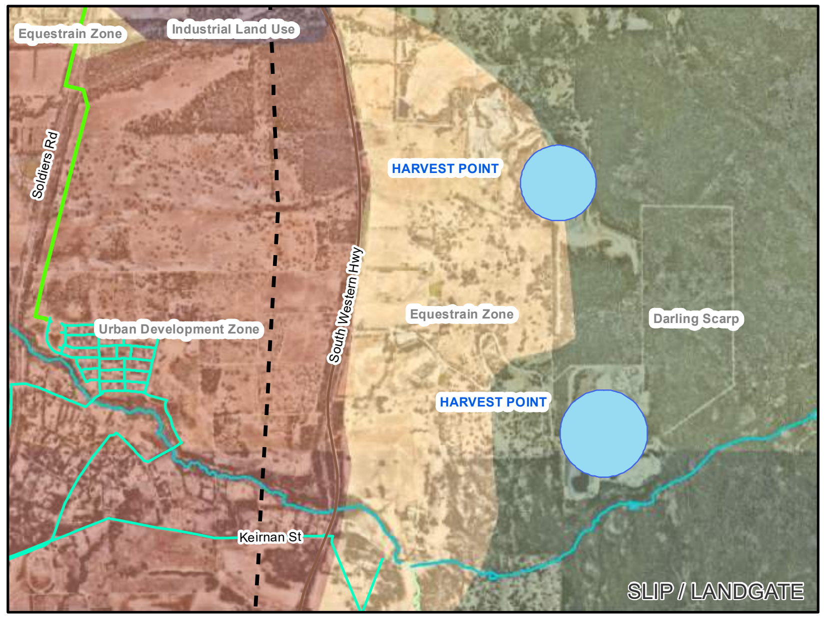
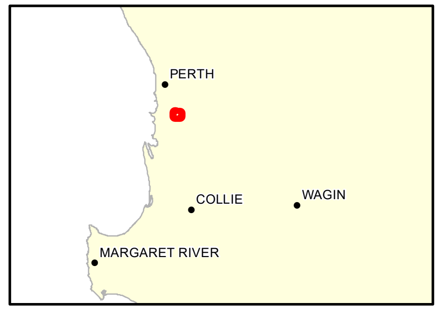


OPPORTUNITY 13

OPPORTUNITY 14



Area	Future Demand / Deficit (ML/a)	Option #	Description	Potential Supply Volumes (ML/a) ±50%
Oldbury - Mundijong	750/730	8	Harvest of surface water flows from Manjedal Brook during winter. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	3,000-5,000
		9	Harvest of surface water flows from Oakland and / or Barriga Main Drain during winter. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	5,000-10,000
		10	Sewer mining from Water Corporations sewer network or development of a decentralised wastewater treatment facility. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	1,000-2,000
		11	Integrated approach for Opportunities 8 and 9 to increase security of supply.	3,000-6,000
		12	Keirnan District Sporting Facility - harvesting of surface runoff. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	50-+50
		13	Whitby and Mundijong District Sporting Facility – Potential to harvest surface runoff from the sporting facility and surrounding school buildings. The facility is only in concept design therefore the integration of water sensitive urban design features is possible. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	20-+100
		14	Quarry Potential source of water from dewatering activities on site.	<20



- Precinct Extent
- Potential Storage Location
- Harvest Point
- Highway
- Faults
- Water Delivery Pipe
- Coastal Waterline
- Estuarine
- Mainstream
- Major River
- Minor River
- Significant Stream
- Major Trib
- MinorTrib
- Minor Trib
- Insignificant Trib
- Inundation Area
- Paleo-Drainage Line
- Infrastructure

SJ2050 Proposed Landuse

- Equestrain Zone
- Intensive Agriculture Zone
- Conservation Zone
- Darling Scarp
- Urban Development Zone
- Tourism Zone
- Rural/Agricultural Use
- Industrial Land Use

WGA
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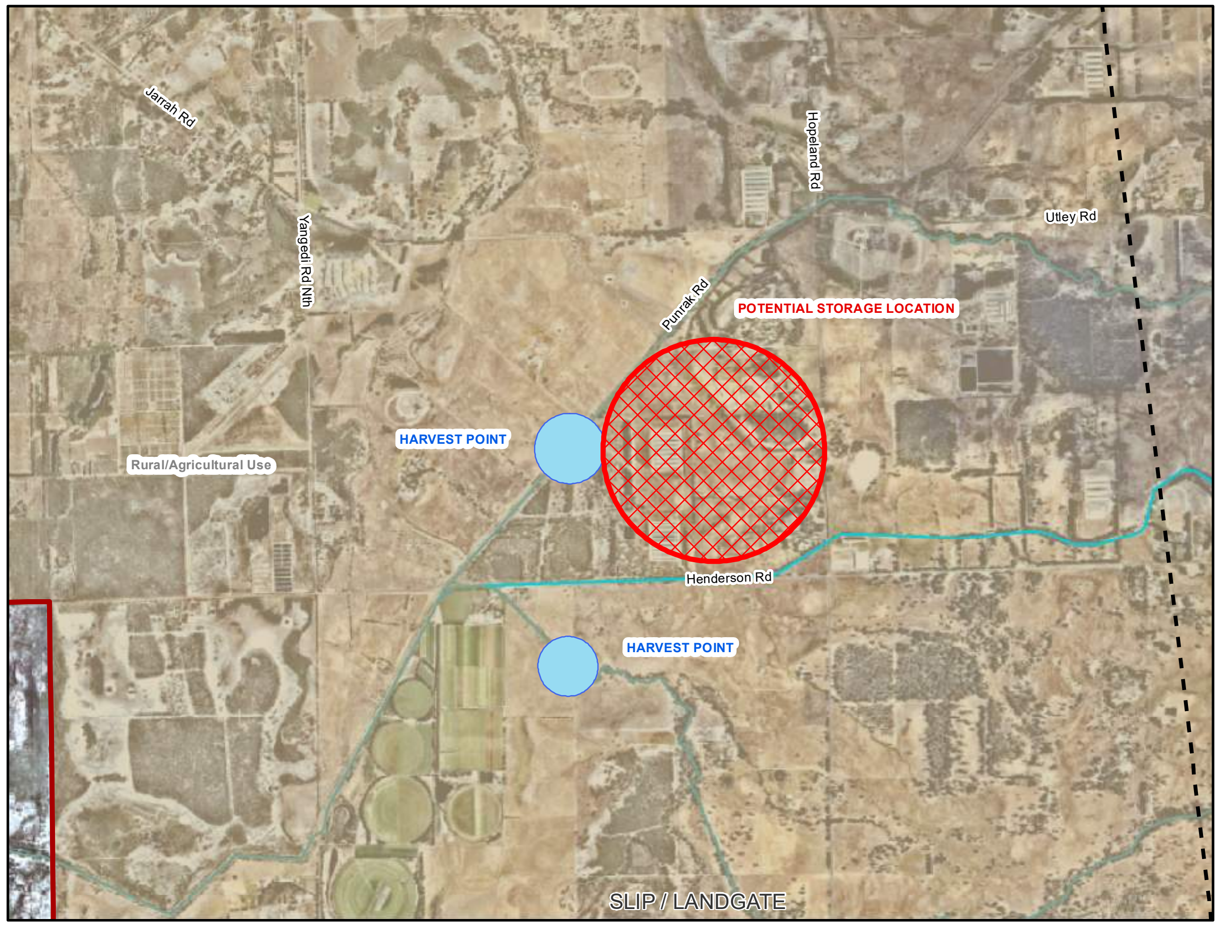
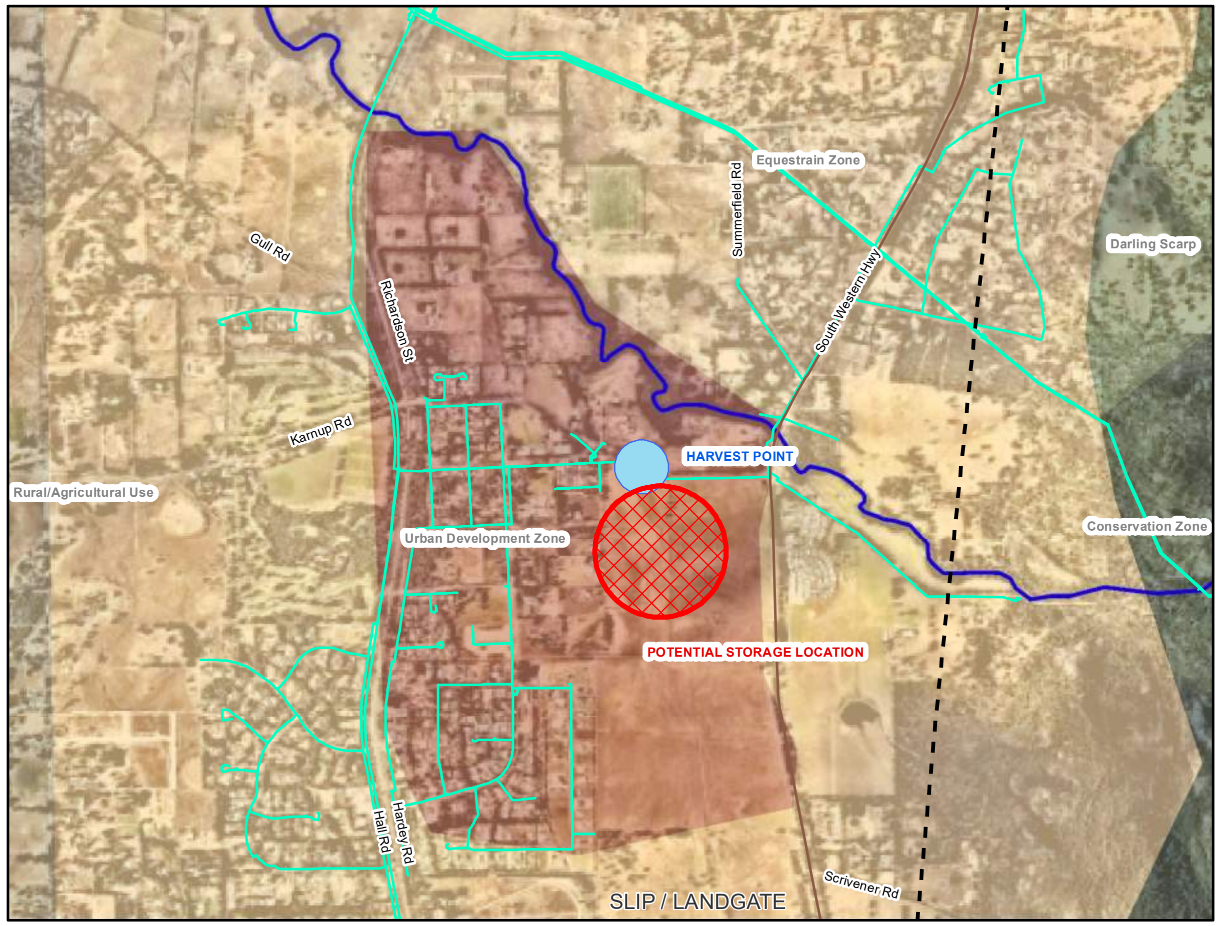
Figure **11**

Summary of Long List of Opportunities – Oldbury-Mundijong

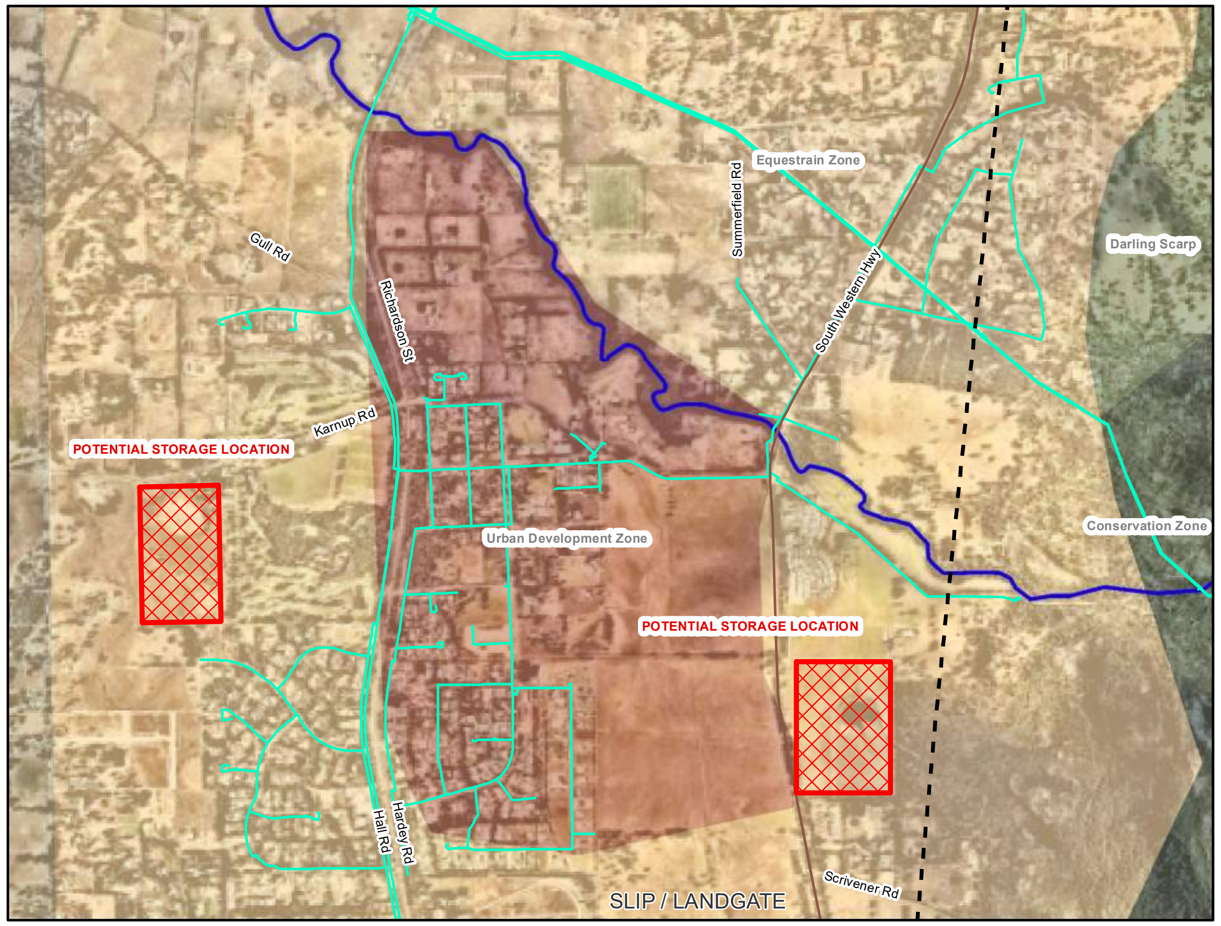
OPPORTUNITY 15



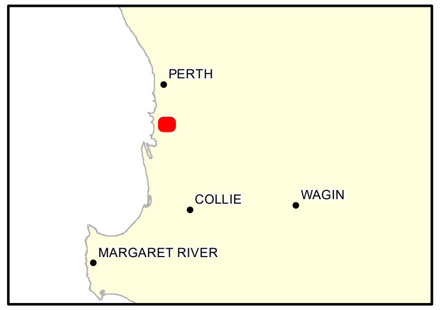
OPPORTUNITY 16



OPPORTUNITY 17



Area	Future Demand / Deficit (ML/a)	Option #	Description	Potential Supply Volumes (ML/a) ±50%
Hopeland – Serpentine - Keysbrook	340/183	15	Harvest of surface water flows from Punrack Drain during winter. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	5,000-10,000
		16	Harvesting of urban runoff through subsurface drainage network and a series of drainage basins. Water to be harvested from the drainage basins and stored in above ground infrastructure or using MAR. Supply to be via a pipes distribution network or transfer of recharge credits.	<100
		17	Development of a decentralised wastewater treatment facility. Storage using above ground structures or MAR. Distribution using pipe network of recharge credit transfer.	100-300



Precinct Extent
Potential Storage Location
Harvest Point
Highway
Faults
Water Delivery Pipe
Coastal Waterline
Estuarine
Mainstream
Major River
Minor River
Significant Stream
Major Trib
MinorTrib
Minor Trib
Insignificant Trib
Inundation Area
Paleo-Drainage Line
Infrastructure

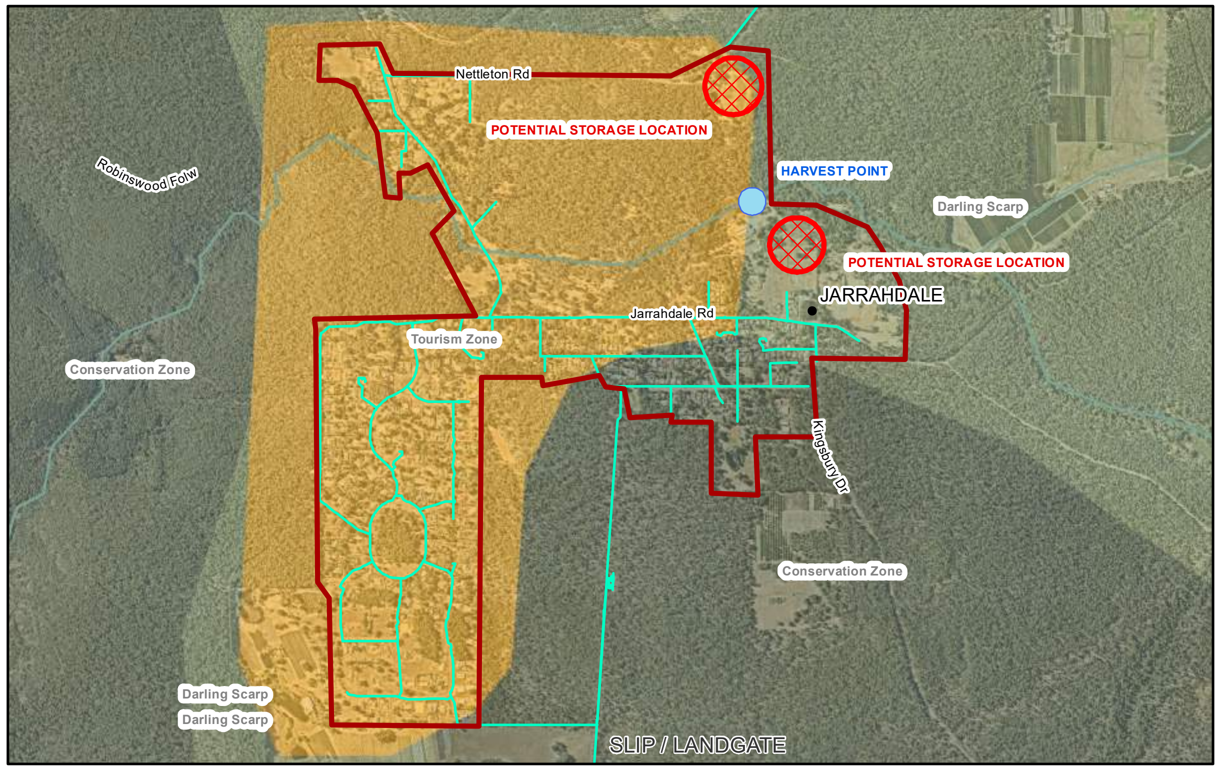
SJ2050 Proposed Landuse
Equestrain Zone
Intensive Agriculture Zone
Conservation Zone
Darling Scarp
Urban Development Zone
Tourism Zone
Rural/Agricultural Use
Industrial Land Use

WGA
WALLBRIDGE GILBERT AZTEC

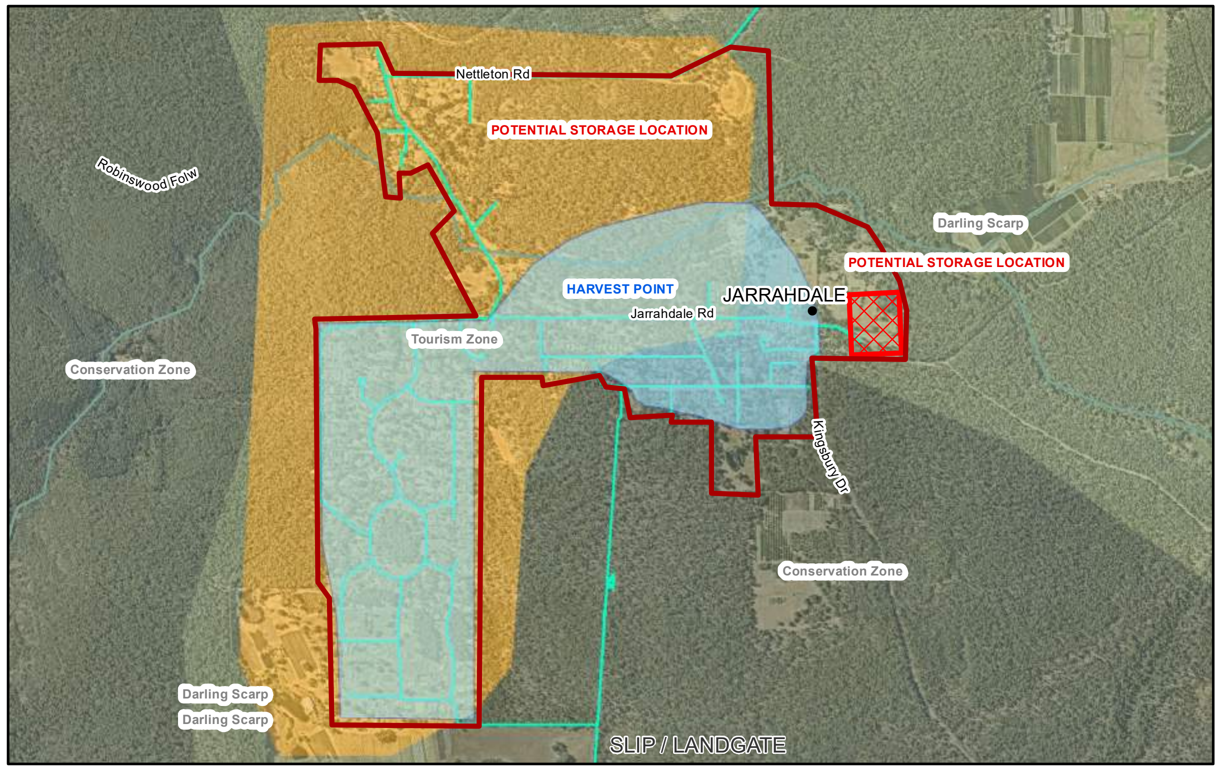
Figure 12

Summary of Long List of Opportunities – Hopeland – Serpentine – Keysbrook

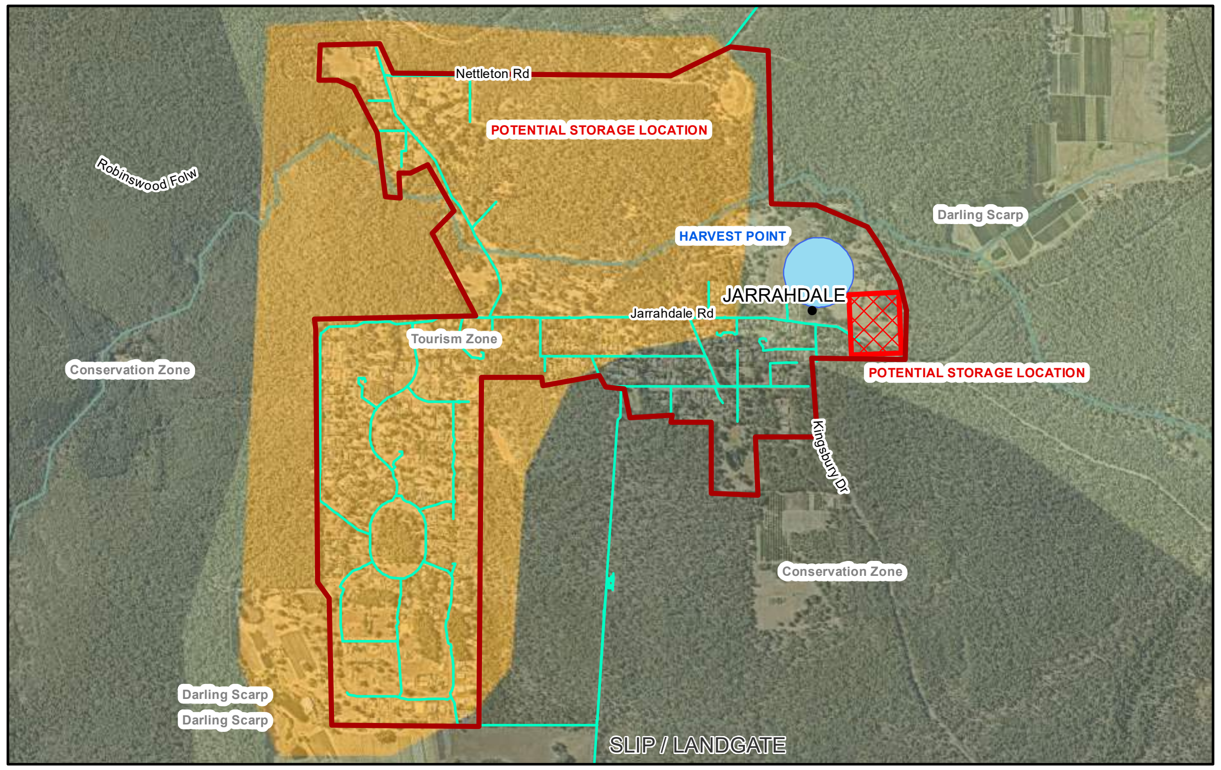
OPPORTUNITY 18



OPPORTUNITY 19



OPPORTUNITY 20



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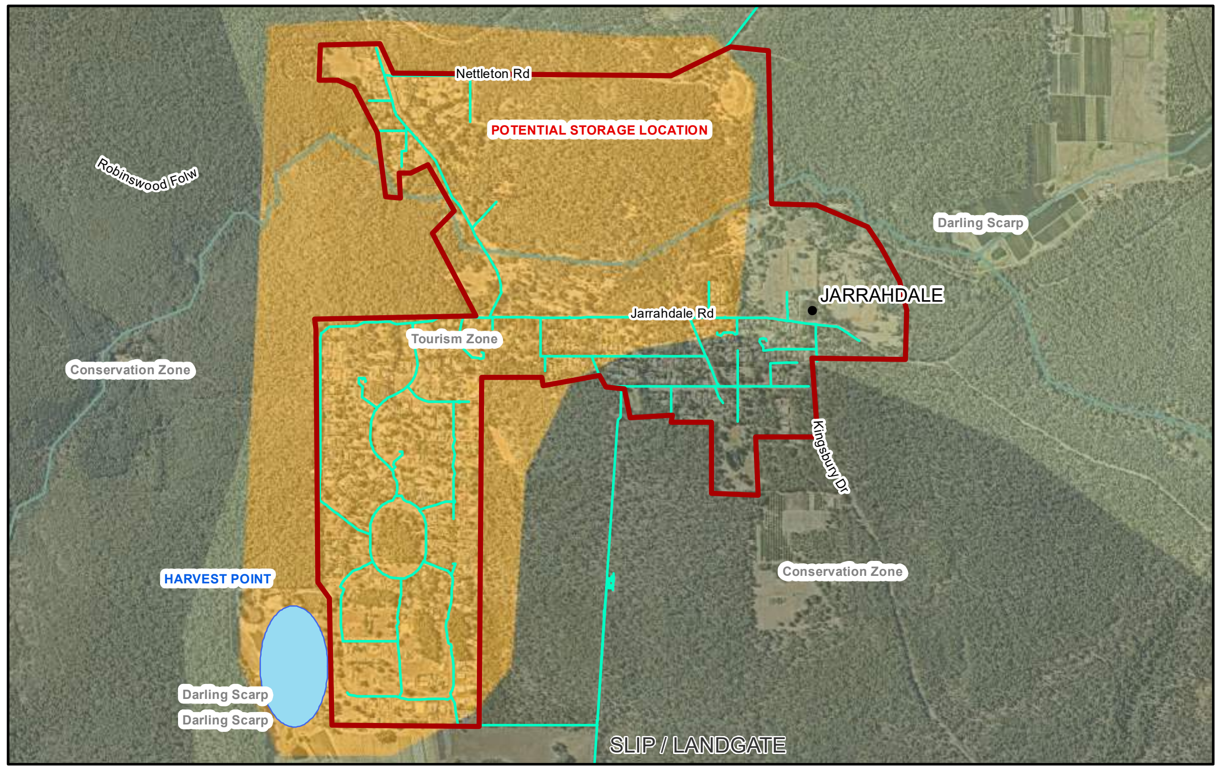
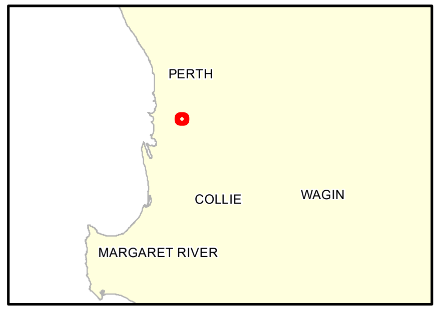


Area	Future Demand / Deficit (ML/a)	Option #	Description	Potential Supply Volumes (ML/a) ±50%
Jarrahdale	32/32	18	Harvest of surface water flows from Gooralong Brook during winter. Storage using above ground structures and distribution using a pipe network.	20-200
		19	Development of a decentralised wastewater treatment facility and retrofit the existing septic system. Storage using above ground structures and distribution using pipe network.	20-50
		20	Development of a decentralised wastewater treatment facility for the proposed Tourist Park. Storage using above ground structures and distribution using pipe network.	10
		21	Transfer of treated wastewater from Millbrook Winery via a piped network.	1



Precinct Extent
Potential Storage Location
Harvest Point
Highway
Faults
Water Delivery Pipe
Coastal Waterline
Estuarine
Mainstream
Major River
Minor River
Significant Stream
Major Trib
MinorTrib
Minor Trib
Insignificant Trib
Inundation Area
Paleo-Drainage Line
Infrastructure

SJ2050 Proposed Landuse

Equestrain Zone
Intensive Agriculture Zone
Conservation Zone
Darling Scarp
Urban Development Zone
Tourism Zone
Rural/Agricultural Use
Industrial Land Use

WGA
WALLBRIDGE GILBERT AZTEC

Figure **13**

Summary of Long List of Opportunities – Jarrahdale

5 SHORT LIST OF OPTIONS

The preliminary long options were reviewed by SSJ to determine which water supply options met their requirements and should progress to the short list assessment stage. The short-listed options are presented in this Section. The options have been re-numbered to avoid confusion later in the assessment.

The concepts have been developed based on the assumption that the end use is restricted irrigation. If unrestricted irrigation is required then additional treatment may be required in some circumstances.

During the review discussions of the long options, an additional opportunity whereby water could be recharged to a decommissioned open pit sand mine was identified. This option has been included in the short options assessment.

5.1 CONCEPT VIABILITY

SSJ are strategically considering their water supply options and security now and into the future. The primary aim is to identify a fit-for-purpose water supply for irrigation of public open space and reduce their current and future reliance on scheme water. It is currently unclear if Water Corporation's current infrastructure could manage such an increase in demand if a fit-for-purpose water supply is not developed.

For comparative purposes, the cost to supply fit-for-purpose water would traditionally be compared to the cost of scheme water. This is relevant if scheme water is available for this purpose, if Water Corporation's system cannot meet the demand then the cost comparison should be against the various alternative water supply options. As climate dependent water sources become more scarce and additional desalination and wastewater management is required, the price of water is expected to increase. The cost of water is currently in the order of $2.40/kL but is expected to increase to $4.30/kL over the next 20 years.

A significant risk to the viability of the identified concepts is the water quality treatment requirements associated with Managed Aquifer Recharge. The target aquifers are typically fresh (less than 500 mg/L), therefore, the source water may need to be treated to near potable standards prior to recharge as not to reduce the overall quality or beneficial end use of the aquifer system. Discussions have been held with DWER regarding the requirements and it has been indicated that the treatment requirement will be based on a risk management approach. As this study is high-level, the detailed assessments required to determine the risk and therefore the appropriate level of treatment have not been completed. The risk level will also likely vary in different locations.

For the purpose of this assessment, a high level of treatment, including membrane filtration, has been adopted in systems where a large volume is being recharged to the aquifer. The cost of such a system is significant and could be the difference between the concept being viable. For example, for Option 1, the cost per kL price is $2.15 to $2.60 (4-7% RDR) with the membrane but reduces to $1.50 to $1.85 (4-7% RDR) if a lower standard of treatment is acceptable.

The aquifer geometry in the region is such that recharge transfer credits may be available reducing the requirement to construct a distribution network. Recharge credits allow water to be recharged in one location and be withdrawn from the same aquifer in a different location(s). For the purpose of this study, where MAR has been adopted so has a distribution system until the viability of a credit transfer scheme can be confirmed.

Another opportunity for cost management is the use of existing infrastructure, the concepts do not consider using existing bores to recharge the target aquifer. If suitable bores are identified, then this presents a cost saving to the project.

Further investigations into the feasibility of MAR and risks is strongly recommended to further understand and develop these concepts prior to progressing to a concept design stage.

Funding to support the development of alternative water supplies may also be available from state and federal government bodies. If funding can be sought for all or a portion of the capital construction costs of a system, this could make a system financially viable for the scheme owner. For example, Option 1 (with membrane) cost per kL price is $2.15 to $2.60 (4-7% RDR), however, if 50% of the capital costs are funded through a government scheme then the cost per kL price reduces to $1.70 to $1.90 (4-7% RDR).

The larger water supply concepts, which supply gigalitres of water per annum, are scalable depending on the available capital, risk appetite and demand requirements. This will allow SSJ to manage their risk and build their knowledge of the system operation over time.

The impact of funding opportunities or treatment level requirements have not been considered in each scheme. The worst case or highest cost option has been adopted to inform SSJ, however, the scalability of each scheme (i.e. opportunities to stage the development), risks and opportunities should be considered for all concepts.

5.2 COMMUNITY AND STAKEHOLDER CONSULTATION

A consultation program was implemented during the development of this integrated water management strategy. Key stakeholders were identified at the commencement of the program, these included:

- Department of Sports and Recreation.
- Department of Planning, Lands and Heritage.
- Water Corporation.
- Department of Water and Environmental Regulation.

The information from the process has been incorporated into the plan. DWER provided additional feedback from the review of the Short Options Stage which has been presented in Appendix C. Where relevant the comments have been addressed in this plan. The main concern identified by DWER is that the estimate available flows in some drains and creeks have not been accurately monitored and will be influenced by climate change. Whilst some modelling has been undertaken the actual volume of water available is unknown. This is considered as a high risk to the project and has been reported throughout the process. Monitoring of the flows and water quality of the drains and creeks has been incorporated in the forward program of works.

The environmental flows or ecological requirements have also not been assigned to all regions; this would also need to be assessed. The determination of the environmental flows would need to be managed by DWER.

Consultation with the community across SSJ was undertaken through advertisement and a series of “drop in” sessions. **Appendix C** presented the feedback from these sessions, where relevant these have been addressed in this plan.

5.3 OTHER WATER SUPPLY CONSIDERATIONS

This plan seeks to identify alternative water supplies outside of the fully allocated groundwater and surface water supplies. An overarching water supply strategy to the concepts in this plan is to increase SSJ’s groundwater and surface water allocations, this will assist in meeting demand but also provide increases security of supply.

In addition to sourcing more water, reducing water use or the rate of use will be critical to sustainable water use in the region. Future urban development should consider the application of principles of WSUD to provide a link between urban development and urban water management. Attention is directed to the problems posed by the expected rapid increase in population, including infrastructure upgrade costs and existing system constraints, the impacts on natural waterways, urban heat and the need to secure water resources.

An important part of WSUD is applying best practice stormwater management, which will assist to maintain, protect and improve the health of the receiving environment. In the broadest scope, WSUD implementation can encompass sustainable stormwater management techniques that focusses on:

- reduction of pollutant loads to waterways.
- reduced urban connectivity to waterways.
- water saving (reduction of potable water consumption).
- alternative water use.
- Urban greening and reduction of urban heat to improve liveability, and
- groundwater quality and quantity.

The application of a strategic WSUD framework that is specifically focused on source control of stormwater could be based on achieving a balance between the three domains of WSUD practice - quantity control, pollution control and stormwater harvesting. In this regard, regional benefits will also be facilitated by this approach by:

- Attenuating the peak stormwater flow rates from urban development to waterways;
- Extending the flow hydrographs of waterways to smooth out the peaks and troughs of flows;
- Enhancing groundwater resources, and
- Using source control techniques to sustain urban greening.

At source control techniques that could be considered within future urban development strategies to contribute to regional benefits include:

- Ecological sponges – riparian zone infiltration systems incorporating ephemeral wetlands where environmental values of receiving waterways or conservation areas may warrant this approach.
- Infiltration systems (residential lot scale, local scale and regional scale).
- Wicking beds – shallow localised infiltration systems to provide passive irrigation to subsoils within informal playing fields or broad reserve areas.
- Biofiltration basin – incorporating infiltration into sub soils where feasible.
- Rain gardens and tree pits.
- Permeable pavements.
- Blue and green corridors.

The type of vegetation adopted in different areas can have an impact on the water demand. For this plan, an average of 6.5 ML/Ha/a has been adopted, however, it is acknowledged that the irrigation rate will vary depending on the vegetation. District Sporting ovals may irrigate at a higher rate of 10 ML/Ha/a whilst smaller garden areas may be irrigated at 3 ML/Ha/a. The vegetation and resultant irrigation requirements should be considered as part of the planning and development of the region to minimise water use.

The above at source controls are best adapted to urban development when urban planning is considered with water cycle management. The best outcomes can be achieved through an integrated urban planning framework that will focus on delivering the above outcomes.

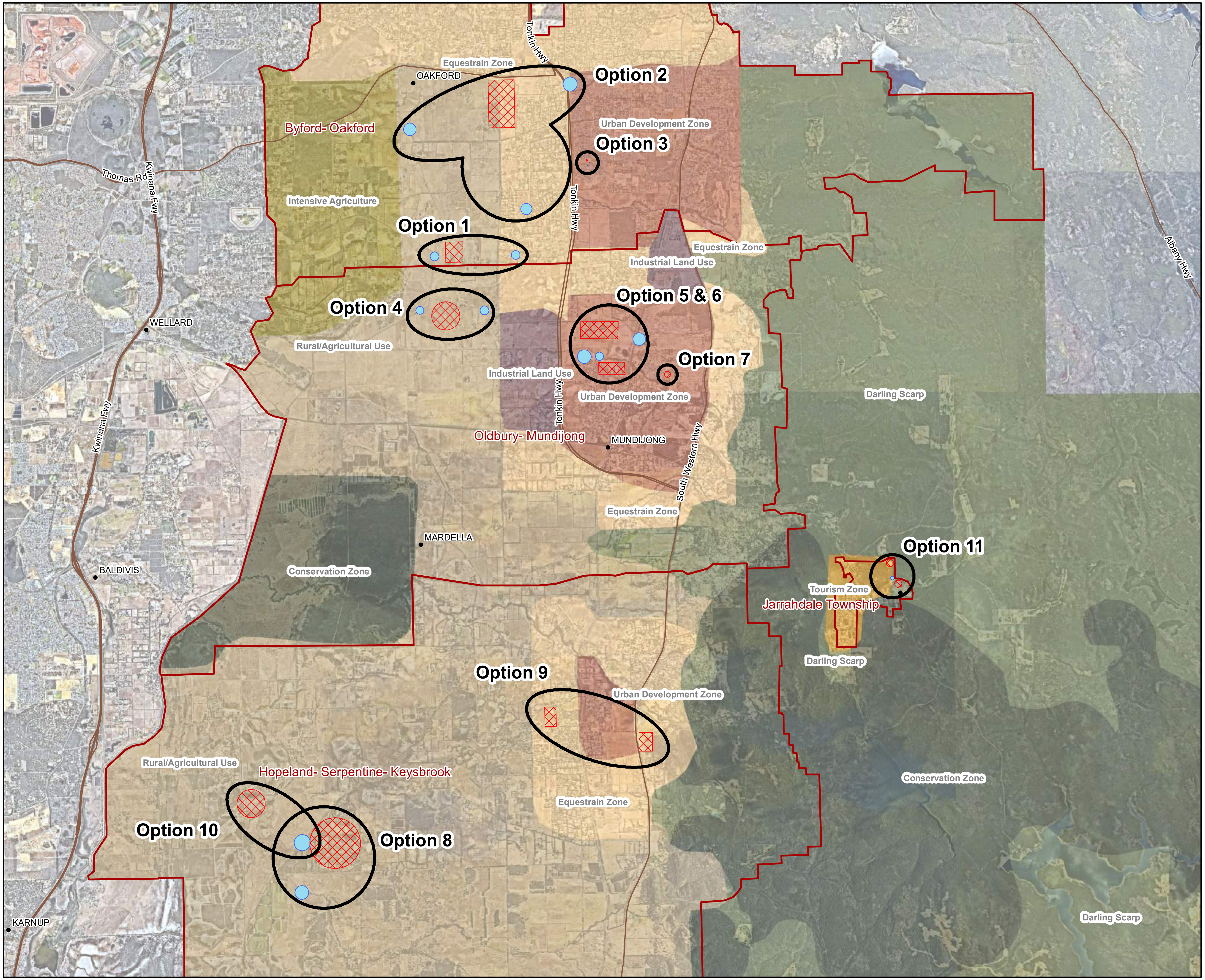
The water supply opportunities presented in the subsequent sections do not consider smaller scale WSUD opportunities as mentioned above, however, these are highly recommended to enhance the efficiency of water reuse opportunities.

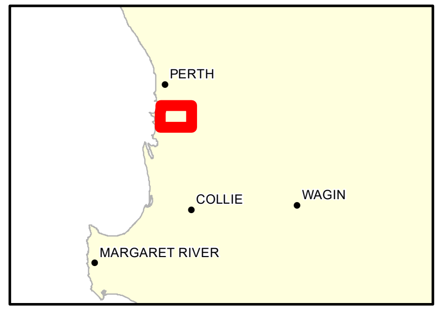
5.4 SUMMARY OF SHORT LIST OF OPTIONS

Table 6 provides a summary table of the short list of options for each precinct, the detail for each option is presented in following sections. The spatial location of the concepts is presented in **Figure 14**

Table 6: Summary of Short List of Options

Region	Demand (ML)	Option	Description	Yield (ML/a)	CAPEX	Cost per kL (4-7%RDR)
Byford – Oakford	555	1	Surface Water Harvesting from Oakland / Barriga Main Drain with MAR	4,000	$74.6 M	$2.15-$2.60
		1a	Surface Water Harvesting from Oakland / Barriga Main Drain with above ground storage	4,000	$133.7 M	$2.10-$2.92
		2	Integration of Option 1 with Sewer Mining	4,800	$99.5 M	$2.20-$2.65
		3	Woodland Grove Sporting Facility	32	$3.2 M	$17.70-$20.10
Oldbury – Mundijong	750	4	Option 1 – Alternative Location	4,000	$74.6 M	$2.15-$2.60
		5	Mundijong Decentralised Wastewater System	800	$23.9 M	$3.95-$4.70
		6	Decentralised Wastewater System with Surface Water from Manjedal Brook	3,200	$77.99 M	$3.25-$3.85
		7	Recharge Runoff from Mundijong Whitby District Sporting Facility	40	$2.5 M	$14.15-$15.70
Hopeland – Serpentine - Keysbrook	340	8	Harvest of Surface Water Flows from Punrack Drain	4,000	$74.6 M	$2.15-$2.60
		9	Construction of a Decentralised Wastewater System in Serpentine	120	$8.98 M	$2.45-$2.75
		10	Gallery Recharge into Decommissioned Open Pit Mines	40	$2 M	$10.25-$11.45
Jarrahdale	32	11	Surface Water Harvesting from Gooralong Brook	32	$3.38 M	$13.15-$15.15
		12	Construction of a Decentralised Wastewater System for the Tourist Park	8	$2.12 M	$80.30-$86.50





- Shortlisted Option
- Precinct Extent
- Potential Storage Location
- Harvest Point
- Highway

SJ2050 Proposed Landuse

- Equestrain Zone
- Intensive Agriculture Zone
- Conservation Zone
- Darling Scarp
- Urban Development Zone
- Tourism Zone
- Rural/Agricultural Use
- Industrial Land Use

N

0 1,000 2,000 3,000 m

Scale 1:100,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50

WGA
WALLBRIDGE GILBERT AZTEC

Figure 14

Short List of Options
Site Location Plan

5.5 BYFORD – OAKFORD - WATER SUPPLY OPTION 1 – SURFACE WATER FLOWS FROM OAKLAND / BARRIGA MAIN DRAIN

5.5.1 Overview

This water supply concept considers harvesting surface water flows from the Oakland and / or Barriga Main Drain, following treatment the water will be transferred to either an above ground storage or underground using MAR for storage. The water will be subsequently recovered and transferred for irrigation of SSJ land or for agriculture / industry.

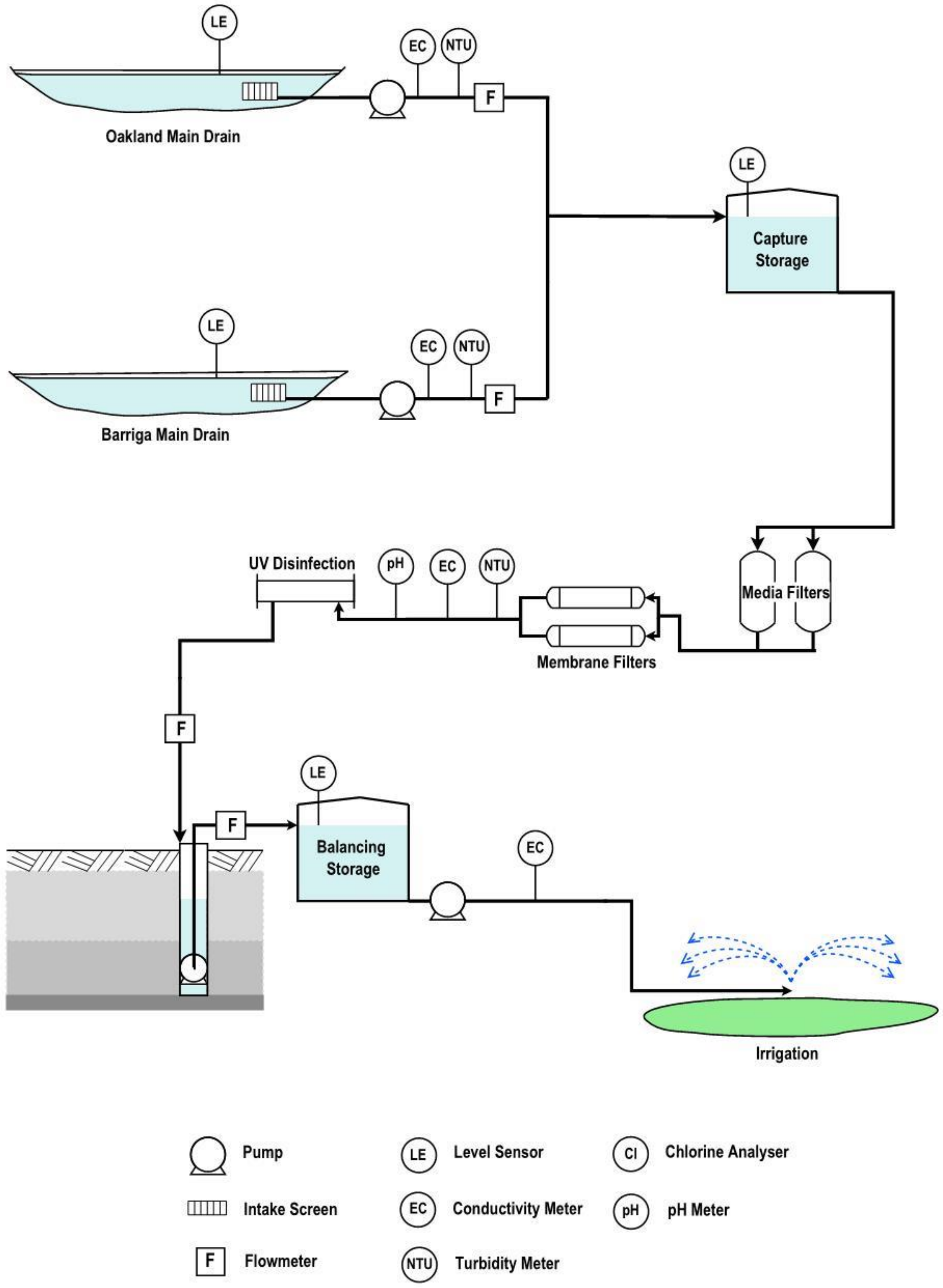


Figure 15 presents the process flow diagram for Concept 1 whilst **Figure 16** provides a spatial representation. **Table 7** presents the water balance for the system and **Table 8** presents the water supply concept components. This concept assumes a harvest volume of up to 5,000 ML/a to ultimately supply 4,000 ML/a following losses through the system.

Preliminary square modelling has been carried out by DoW (2012) which reported average annual flows of 33.8 GL/a in the Barriga Main Drain. There are no estimates of flows within the Oakland Drain. This flow is expected to increase due to an increase in runoff from the urban development. A target harvest volume of between 5 and 10 GL/a has been estimated based on the available information, however, this may be impacted by climate variability, monitoring of the flows and water quality. Further investigations are required to more accurately predict a reliable harvest volume.

Water quality variability (e.g. suspended solids or salinity) is currently unknown, water quality monitoring in the form of grab samples for a broad range of contaminants and inline monitoring of salinity, turbidity and pH is recommended to refine the treatment process required to achieve the reliable harvest volume. This concept considers a high level of treatment and hence cost allowance due to the data gaps and risk around source water quality and the receiving aquifer risk profile. Additional assessments will assist in determining the level of treatment required. The treatment level required for above ground storage is likely to be less than aquifer storage unless the necessary risks can be managed to ultimately recharge non-potable standard water.

The drains are managed by Water Corporation and approval to access the infrastructure would be required. The take of water from the drain is not currently prescribed.

The water supply concept has the opportunity to be implemented in a staged approach to meet demand requirements or budget expenditure. The timing of the development of the Byford area and the agri-precinct are unknown, therefore a staged approach assists the SSJ to manage their risk. The concept adopts an above ground balancing storage dam, this facility could be constructed in a way to provide public amenity and provide recreational facilities.

Table 7: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from Oakland / Barriga Main Drain	5,000 ML/a total assumed to be 2,500 ML/a per drain	Flow monitoring data is not available from the Oakland and Barriga Main Drains, therefore harvest volumes have been based on 50% per drain. Based on rainfall and 153 days of available harvest, an extraction rate of 285 L/s is required from each drain based on 16 hours of operation per day. Depending on the outcomes of the monitoring program this may be in the form of one or multiple pumping locations.
Balancing Storage / Capture Storage	100 ML	Capture storage provides flexibility in the operation of the system to manage injection and extraction rates, provide treatment or holding times. The flow in the drains may be such that a high extraction rate is required to capture the higher rainfall events, having a capture storage allows for continual injection (not just limited to rainfall periods) which may reduce the number of bores required. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water).
Water Treatment and Aquifer Replenishment	Injection rate of 25 L/s / bore Number of bores 23 Treatment Rate 570 L/s	Aquifer injection rates, depending on the aquifer characteristics, range between 25 and 40 L/s. To be conservative an injection rate of 25 L/s has been adopted. If higher rates are achieved the number of bores may be able to be reduced. The number of bores is based on the injection rate of 25 L/s, 16 hours a day over 153 days of operation and a target daily recharge rate of 33 ML/d.
Irrigation Supply	4,000 ML/a	Assuming losses through the system from evaporation, backwash, scour and for the environmental benefit, the losses are assumed to be 20%.

Table 8: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Surface water from Oakland and Barriga Main Drains. Pumps to harvest water from each location and transfer water to a centralised balancing storage.	No significant variation to the drain has been proposed other than the installation of the harvest offtakes. To manage the level in the drain multiple harvest locations have been proposed, based on a flow rate of 285 L/s total for each drain. Transfer infrastructure from each harvest location will be required to transfer water to the capture storage. A nominal 5 km of transfer pipework has been adopted. This will vary depending on the location of the harvest points and the balancing storage.
Balancing Storage and Transfer Lines	An above ground balancing storage dam with a storage capacity of 100 ML has been adopted	A 100 ML storage has been adopted, covering an area of approximately 260 x 260 m. Acquisition of the land has not been incorporated in to the cost analysis component. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water). Transfer infrastructure from the capture storage to the treatment facility and to the 23 production bores has been assumed to be 5 km of pipe. Scour of the production wells is required and is assumed to be transferred to a disposal location. A nominal 5 km of pipe has been assumed.
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for media filter, membrane filter, UV treatment and chlorination system. Valves, gauges and non-return valves included. If a lower level of treatment is considered acceptable membrane filtration may not be required.
Storage using ASR Typically, replenishment will be carried out in winter and recovery during summer, however this	Based on a volume of 5,000 ML/a, an injection rate of 25 L/s, 153 recharge days and 16 hours a day operation. 23 ASR bores are required. The target aquifer is either the Leederville, Yarragadee or Cattamara Coal Measures depending on	Installation of 23 production bores assuming no suitable bores exist. Installation of five monitoring bores.

Parameter	Discussion	Allowance
approach may vary depending on future rainfall patterns.	yield, location, risks and surrounding users. The depth to aquifer will vary depending on the system. A nominal bore depth of 250 m bgl has been adopted. Monitoring bores targeting the same formation and shallower systems are likely to be required. Five monitoring bores have been adopted.	Headworks infrastructure, pump infrastructure and monitoring infrastructure. SCADA system allowance and inline water quality and pressure monitoring. Pump Infrastructure has been included as the facility to scour is required.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Hydrogeological Investigations Functional Design Risk Assessment and Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site - specific irrigation infrastructure has not been considered. If transfer infrastructure is required a transfer pump and 10 km of pipe to the agricultural precinct and 10 km to the central Byford area would be required. Ultimately, the use of transfer credits in the aquifer so users can extract water from an onsite bore is the priority approach. This assumes that the groundwater at the end user location can be taken (i.e. is of suitable quality, there is no risk to the environment or human health).	Final design would need to consider onsite irrigation infrastructure. Assumes 20 km of transfer pipework. If credit transfers are viable, the cost for the installation of additional bores has not been incorporated.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

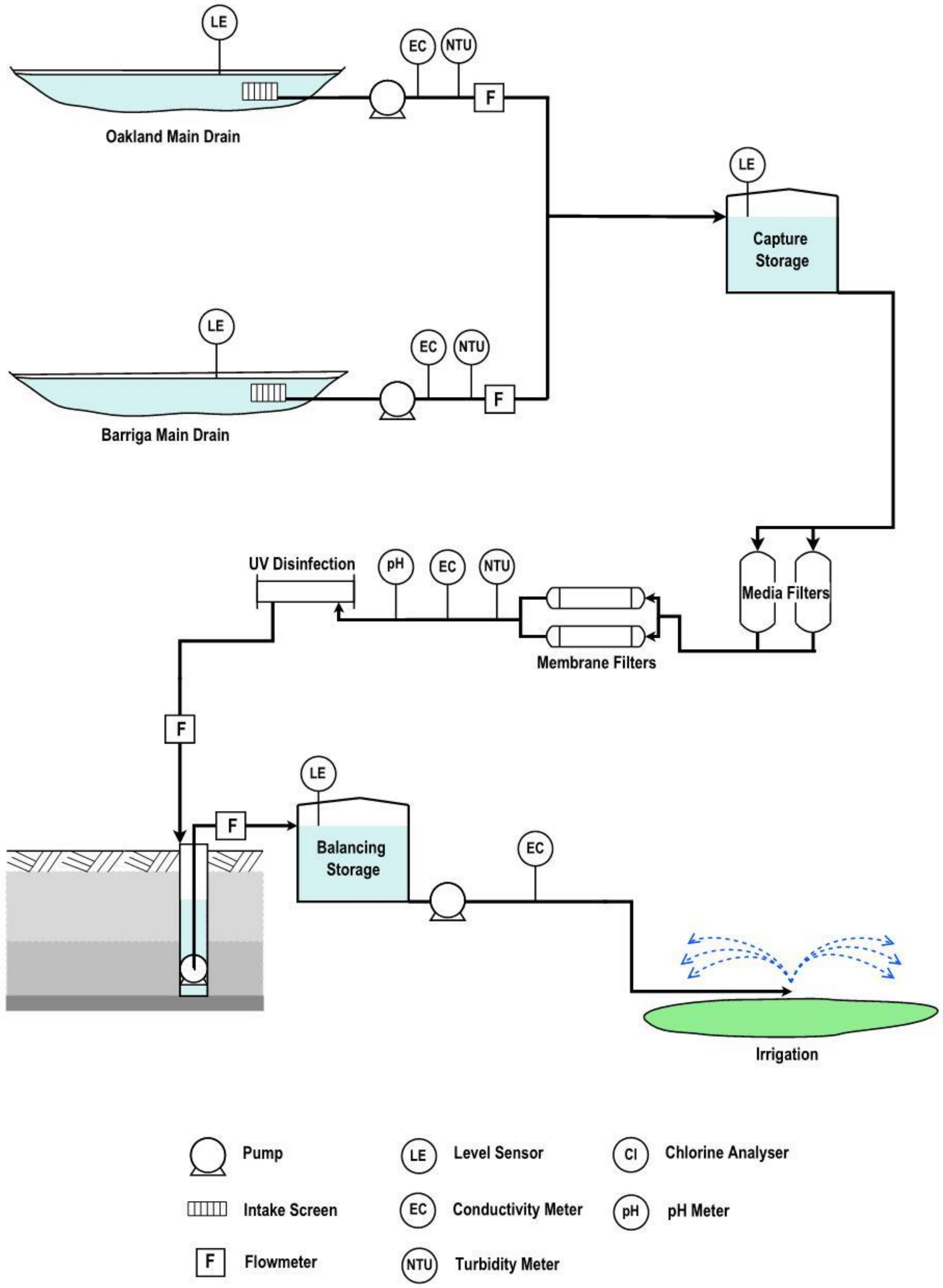


Figure 15: Operational Process Chart – Option 1

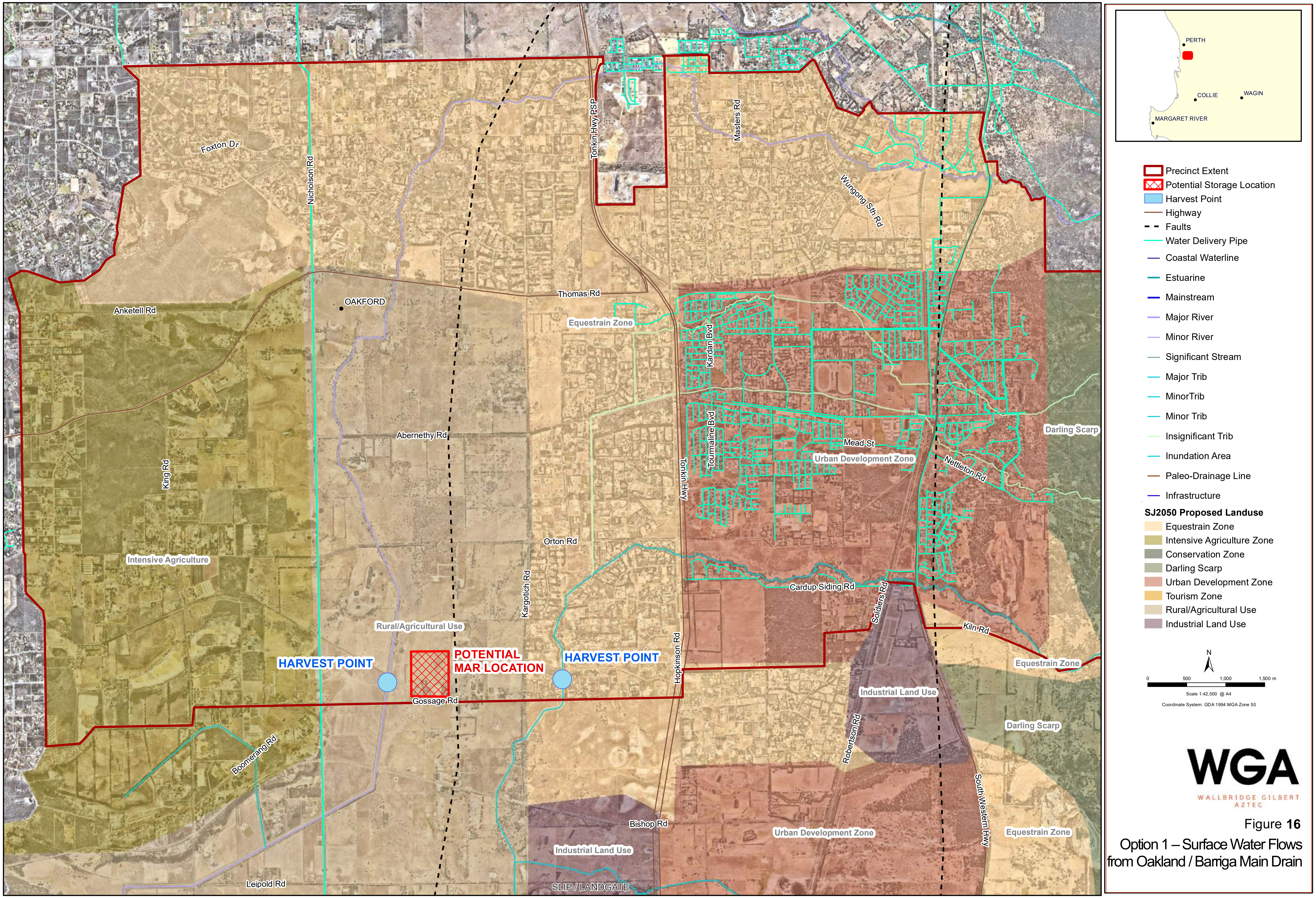


Figure 16
Option 1 – Surface Water Flows from Oakland / Barriga Main Drain

5.5.2 Above Ground Storage Opportunity

MAR is commonly adopted to reduce the requirement for above ground storage which is typically costly, or land acquisition is complicated. The land use in the proposed area is rural agriculture and land may be available for acquisition. In addition, the SSJ has expressed an interest in a water recreation facility. If the above ground storage option is adopted then this could be integrated with recreational facilities, the type of facilities, land acquisition costs and the associated cost have not been incorporated into this opportunity.

All remaining components, with the exception of the aquifer replenishment, outlined in 5.5.1 are identical. In place of the MAR storage component, a 5 GL above ground storage has been adopted. If recreation is a key driver then additional harvest volume or a reduced supply volume would be required to maintain an acceptable water level in the facility to enable use for recreation. Based on a 6 m deep facility, an area of approximately 83 Ha would be required. An example of this area is presented on Figure 8. There is also the opportunity to have a combination of both MAR and above ground storage of various magnitudes, this has not been explored here due to the number of iterations.

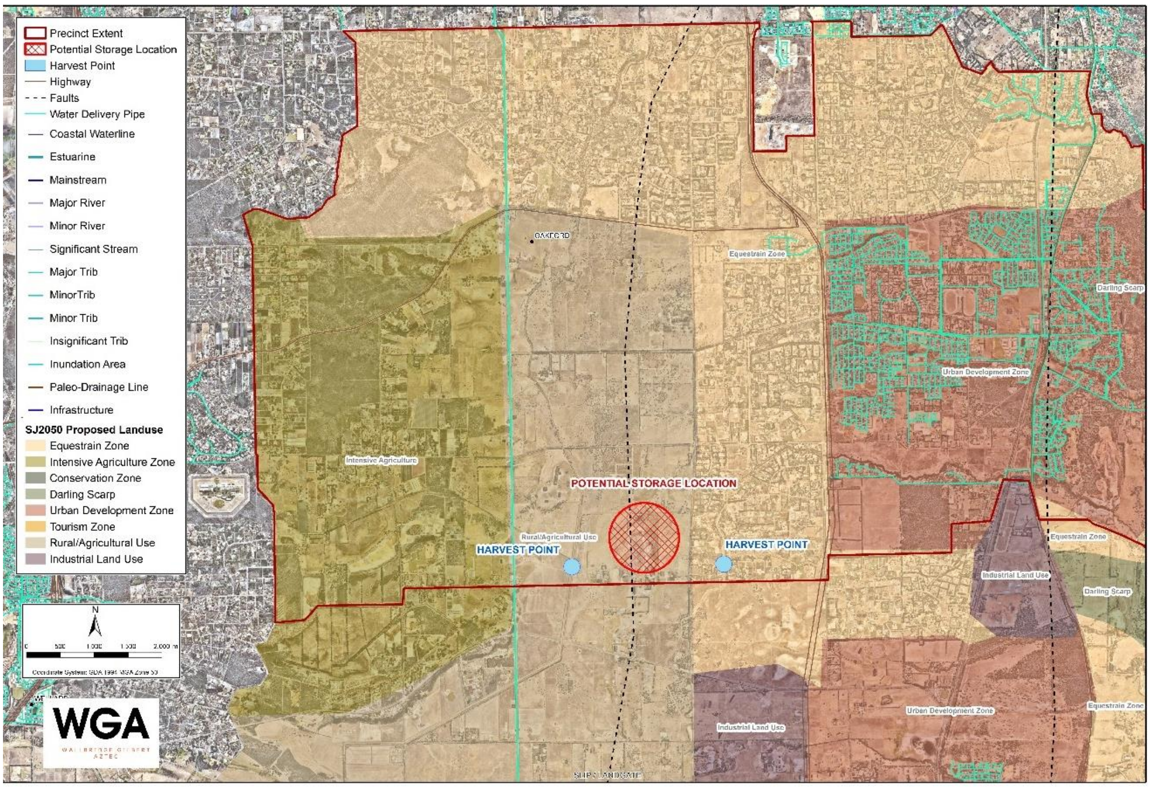


Figure 17: Option 1- Surface Water Flows from Oakland / Barriga Main Drain with Above Ground Storage

5.5.3 Cost Estimate

Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in **Table 9** with a summary breakdown and assumptions are presented in Appendix D.

Table 9: Summary of Cost Estimate – Option 1

CAPEX	$74,598,000
OPEX (annual)	$3,112,500
NPV (4-7% Real Discount Rate)	$2.15-2.60 / kL

The treatment level adopted in this scenario is near potable standards and includes membrane filtration, this is due to the water being recharged to an aquifer that is fresh. If the risk profile and DWER agree, the water quality standards could be reduced. If membrane treatment is not required, the NPV is $1.50 / kL (4% RDR) to $1.85 / kL (7% RDR).

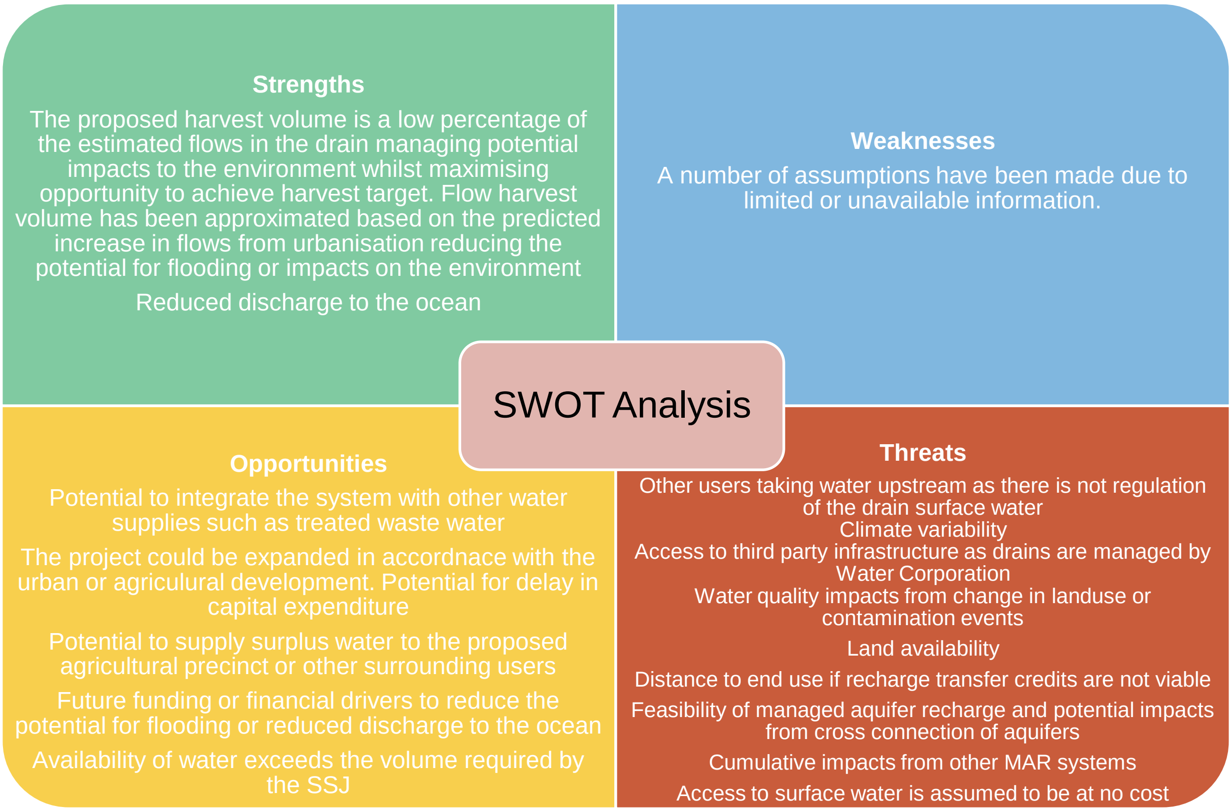
Table 10 presents the scheme costs where above ground storage is adopted instead of MAR. The costs do not include land acquisition costs, or any recreational facilities associated with the area.

Table 10: Summary of Cost Estimate – Option 1 with Above Ground Storage

CAPEX	$133,664,020
OPEX (annual)	$2,052,500
NPV (4-7% Real Discount Rate)	$2.10 – 2.95 k/L

5.5.4 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of the SSJ maintained land but also provides an opportunity for the agricultural precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.5.5 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information; additional information would be required to address these components. **Table 11** provides a recommended forward program of works for this conceptual design.

Table 11: Forward Program of Works – Option 1

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume – estimated volumes are based on high level square modelling. The water quality is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out flow (rate and timing) monitoring of both the Oakland and Barriga Drains. Carry out water quality insitu (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Survey of both drains to identify ideal harvest locations and system location.
	The drains are the responsibility of Water Corporation, therefore access to the surface water would require their approval.	Seek confirmation from Water Corporation regarding access entitlements.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. It is strongly recommended that these investigations are to be completed prior to the detailed design. The aquifer performance can have a significant impact on the borefield spacing and layout which can have significant cost implications for transfer pipework. The use of transferred recharge credits will minimise or negate the requirement of distribution transfer infrastructure.	Detailed desktop study. Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.
Demand Forecast	The demand forecast for the SSJ will be based on development and the construction of public open space in response to increased urbanisation. SSJ indicated that, if surplus water was identified, consideration could be given to supply for agriculture. The demand time for recycled water for agriculture is unknown and is based on the rate of development, end use and reduction or limitation in groundwater use allocations. This recommendation relates to the agricultural component only and is not required to meet SSJ irrigation requirements.	Participant in industry forums or engage with industry to understand the demand and willingness / capacity to pay for recycled water for agricultural purposes. The development of the system may take several years therefore timing in conjunction with the industry is critical.

5.6 BYFORD- OAKFORD - WATER SUPPLY OPTION 2 – INTEGRATION OF SURFACE WATER FLOWS FROM OAKLAND / BARRIGA MAIN DRAIN AND SEWER MINING

5.6.1 Overview

This water supply concept considers harvesting surface water flows from Oakland and / or Barriga Main Drain as described in Concept 1 and integrating the system with treated wastewater from the Water Corporation's pressure sewer main. This section described the components of the sewer mining only, a description of the process of the surface water harvesting is presented in Section 5.5.

Sewage from the existing Water Corporation pressure main would be harvested to a dedicated treatment facility. Once treated, the wastewater will be transferred to the lined above ground balancing storage and mixed with harvested surface water. The water will then be further treated and recharged into the underlying aquifer for storage using MAR and subsequently recovered and transferred for irrigation of SSJ land or for agriculture / industry.

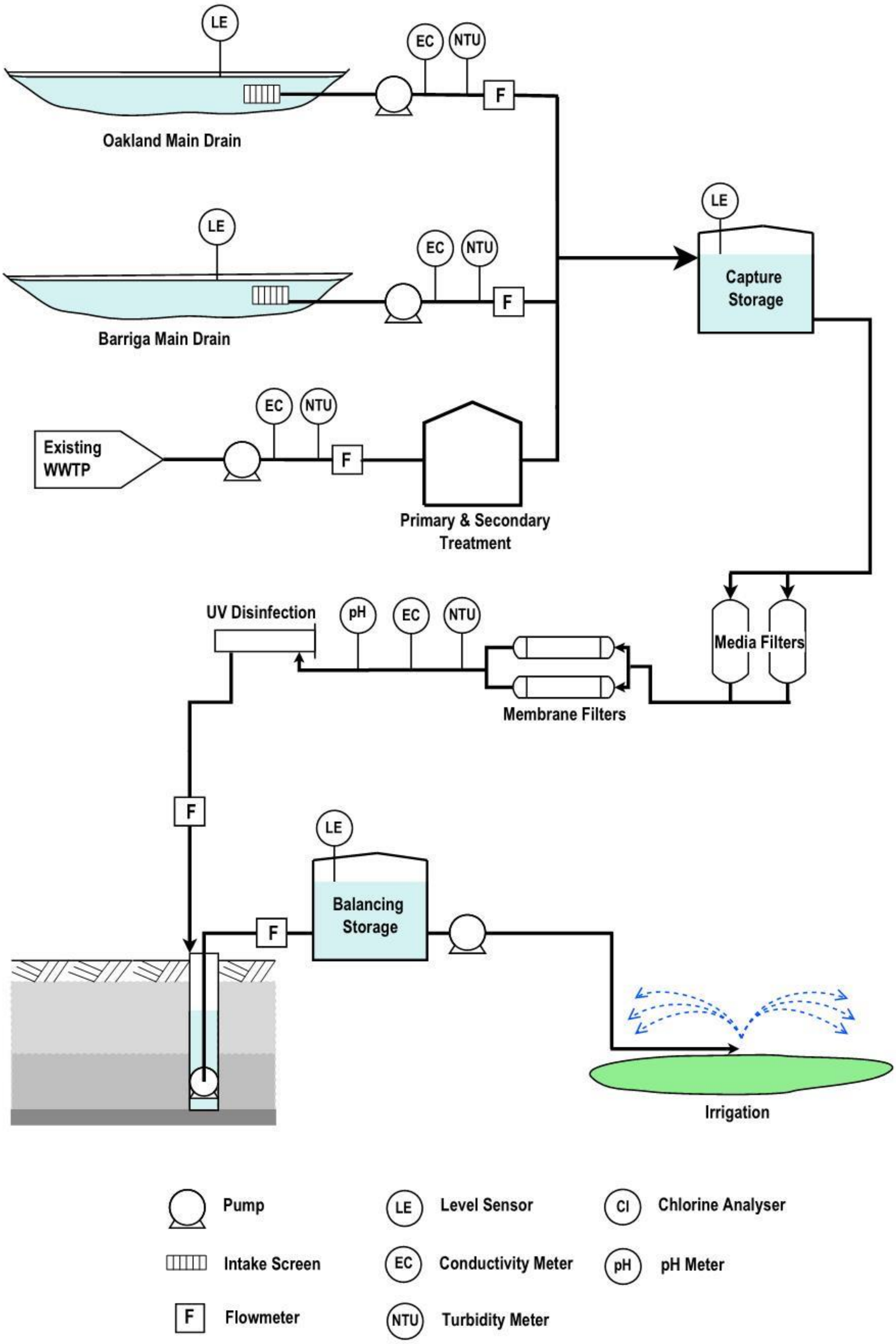


Figure 18 presents the process flow diagram for Concept 2 whilst **Figure 19** provides a spatial representation.

Table 12 presents the water balance for the system and **Table 13** presents the water supply concept components. This concept assumes a harvest volume of 6,000 ML to ultimately supply 4,800 ML following losses through the system, the wastewater component of this system aims to deliver an addition 800 ML of water for supply.

The availability of sewage from the system is unknown as this will be governed by Water Corporation and will likely be based on the flows at the time, this aspect requires clarification from Water Corporation. For the purpose of this concept, it has been assumed that take is evenly distributed over the year. The opportunity to only take water during peak demand months should be investigated with Water Corporation. The availability will be based on the urban development rate, the volume has been based on 50% of the predicted population growth for the Byford Region. There may be a supply cost of wastewater from Water Corporation, as this cost is not available a supply rate has not been adopted and would be in addition to the cost presented here.

Similar to Option 1, the wastewater component can be staged to ensure timing is appropriate to meet demand and supply and an above ground storage option could be adopted.

Depending on the treatment level at the offtake location, there is the opportunity to supply directly to irrigation sites.

Table 12: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from Oakland / Barriga Main Drain	5,000 ML/a total assumed to be 2,500 ML/a per drain	Flow monitoring data is not available from the Oakland and Barriga Main Drains, therefore harvest volumes have been based harvesting equally from both drains. Based on rainfall and 150 days of available harvest, an extraction rate of 285 L/s is required from each drain based on 16 hours of operation per day. Depending on the outcomes of the monitoring program this may be in the form of one or multiple pumping locations.
Wastewater	1,000 ML/a, assumed to be equal over 365 days a year, however, this may vary.	The availability and timing of water will need to be determined in conjunction with Water Corporation, for the purpose of this assessment a flow rate of 48 L/s assuming a 16 hour a day operational period has been adopted.
Capture / Balancing Storage	100 ML	Balancing storage provides flexibility in the operation of the system to manage injection and extraction rates, provide treatment or holding times. The flow in the drains may be such that a high extraction rate is required to capture the higher rainfall events, having a balancing storage allows for continual injection (not just limited to rainfall periods) which reduces the number of bores required. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water).
Water Treatment and Aquifer Replenishment	Injection rate of 25 L/s/ bore Number of bores 25 Treatment Rate 620 L/s	Aquifer injection rates, depending on the aquifer characteristics, range between 25 L/s and 40 L/s. To be conservative an injection rate of 25 L/s has been adopted. If higher rates are achieved the number of bores can be reduced. The number of bores is based on the injection rate of 25 L/s, 16 hours a day over 150 days of operation and a target daily recharge rate of 35 ML/d. Depending on the demand and supply profile, due to the supply of wastewater being all year-round additional injection or treatment capacity may not be required. As these components are not know at this stage an increased injection capacity has been conservatively adopted.
Irrigation Supply	4,800 ML/a	Assuming losses through the system from evaporation, backwash, scour and for environmental benefit the losses are assumed to be 20%.

Table 13: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Surface water from Oakland and Barriga Main Drains is pumped to a centralised balancing storage.	No significant variation to the drain has been proposed other than the installation of the harvest offtakes. To manage the level in the drain multiple harvest locations have been proposed, based on a flow rate of 285 L/s at each drain. Transfer infrastructure from each harvest location will be required to transfer water to the balancing storage. A nominal 5 km of transfer pipework has been adopted. This will vary depending on the location of the harvest points and the balancing storage.
Sewer Mining – Pump Station, Treatment and Transfer Line	Harvest from the Water Corporation pressure main, transfer to a treatment facility and then transferred to the balancing storage.	Pump station with the capacity to harvest 48 L/s. Allowance has been made for primary and secondary treatment. Valves, gauges and non-return valves included. 5 km of transfer pipework has been adopted.
Balancing Storage and Transfer Lines	An above ground balancing storage dam with a storage capacity of 100 ML has been adopted	A 100 ML dam has been adopted, covering an area of approximately 260 x 260 m. Acquisition of the land has not been incorporated into the cost analysis component. Transfer infrastructure from the balancing storage to the treatment facility and to the 25 production wells has been assumed to be 5 km of pipe. Scour of the production wells is required and is assumed to be transferred to a disposal location. A nominal 5 km of pipe has been assumed. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water).
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for media filter, membrane filter, UV treatment and chlorination system. Valves, gauges and non-return valves included. If a lower level of treatment is considered acceptable membrane filtration and UV treatment may not be required for restricted irrigation.
Storage using ASR Typically, replenishment will be carried out in winter and recovery during summer, however, this	Based on a volume of 6,000 ML/a, an injection rate of 25 L/s, 153 recharge days and 16 hours a day operation. 25 ASR bores are required. The target aquifer is either the Leederville, Yarragadee or Cattamara Coal Measures depending on yield, location, risks and surrounding users. The depth to	Installation of 25 production bores assuming no suitable bores exist. Installation of five monitoring bores. Headworks infrastructure, pump infrastructure and monitoring infrastructure.

Parameter	Discussion	Allowance
approach may vary depending on future rainfall patterns.	aquifer will vary depending on the system. A nominal bore depth of 250 m bgl has been adopted. Monitoring bores targeting the same formation and shallow systems are likely to be required. Five monitoring bores have been adopted.	SCADA system allowance and inline water quality and pressure monitoring. Pump Infrastructure has been included as the facility to scour is required.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Hydrogeological Investigations Functional Design Risk Assessment and Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site - specific irrigation infrastructure has not been considered. If transfer infrastructure is required a transfer pump and 10 km of pipe to the agricultural precinct and 10 km to the central Byford area would be required. Ultimately, the use of transfer credits in the aquifer so users can extract water from an onsite bore is the preferred approach. This assumes that the groundwater at the end user location can be taken (i.e. is of suitable quality, there is no risk to the environment or human health).	Final design would need to consider onsite irrigation infrastructure. Assumes 20 km of transfer pipework. If credit transfers are viable, the cost for the installation of additional bores has not been incorporated, however, the 20 km of pipework could be removed.
Operational and Maintenance Costs	An allowance for O&M costs have been included.	Operation including staff. Maintenance requirements.

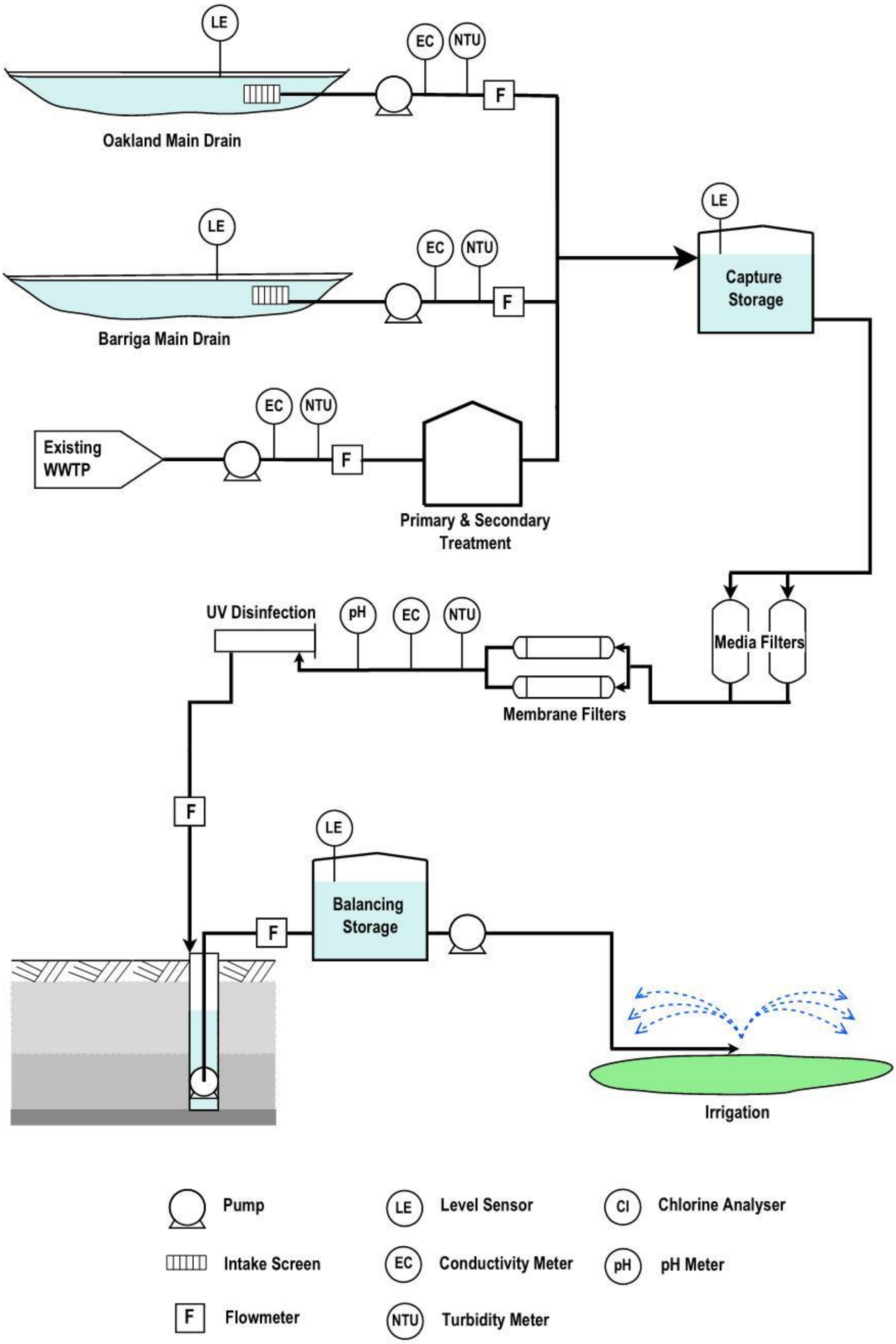


Figure 18: Operational Process Chart – Option 2

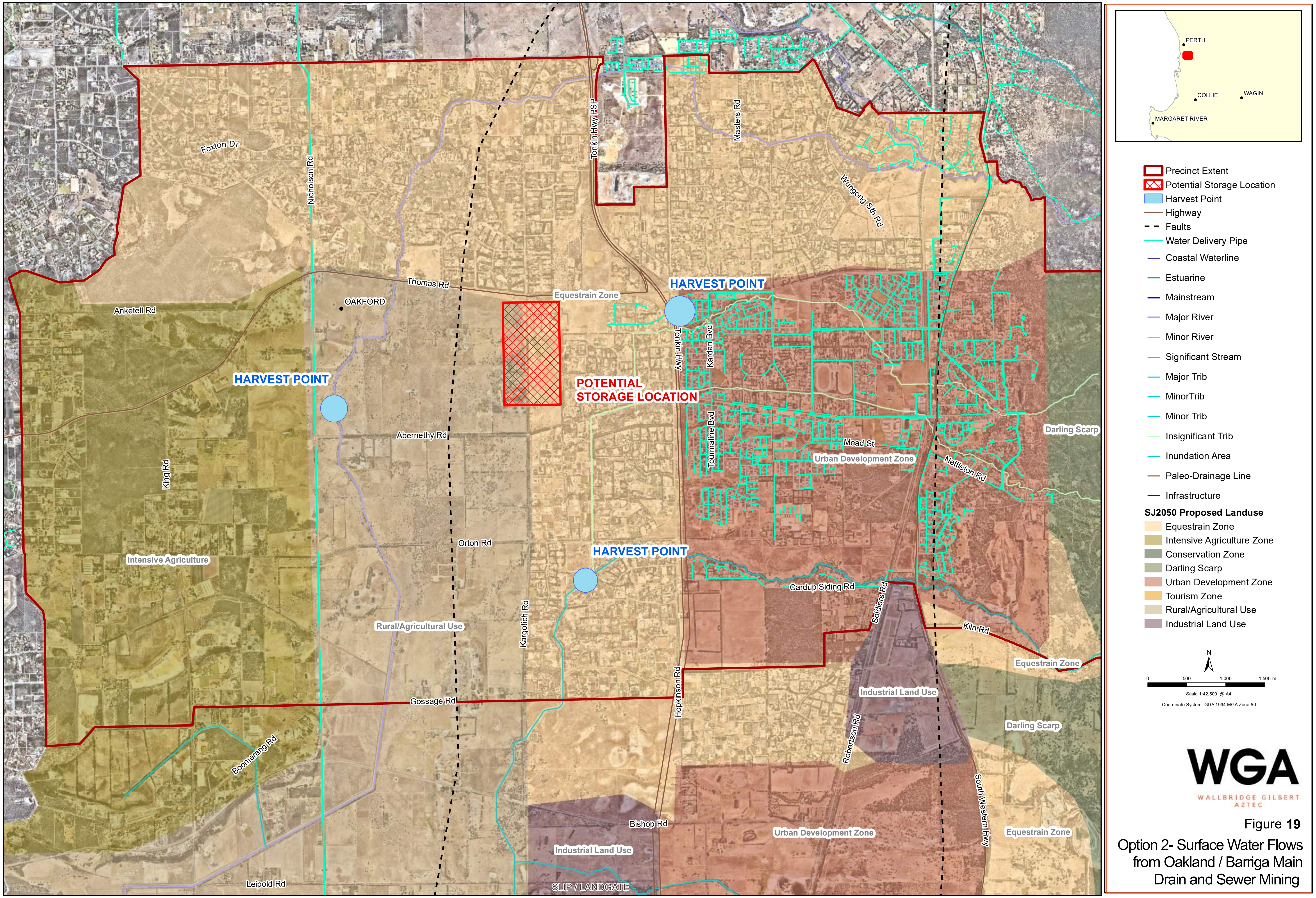


Figure 19
Option 2- Surface Water Flows from Oakland / Barriga Main Drain and Sewer Mining

5.6.2 Cost Estimate

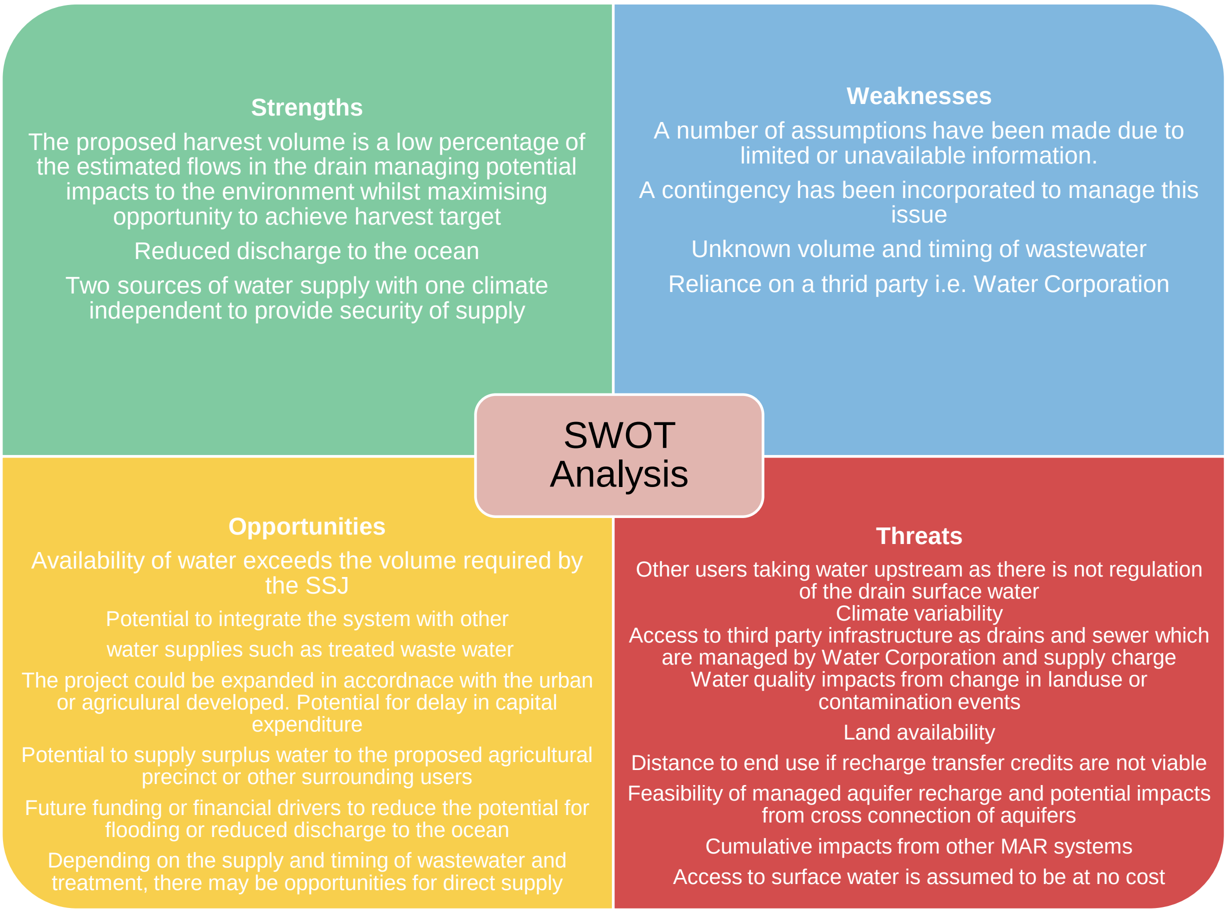
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in **Table 14** with a summary of breakdown and assumptions area presented in **Appendix A**

Table 14: Summary of Cost Estimate – Option 2

CAPEX	$99,427,000
OPEX	$3,390,500
NPV (4-7% Real Discount Rate)	$2.20- $2.65/ kL

5.6.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of the SSJ maintained land but also provides an opportunity for the agricultural precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.6.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information will be required to address these components. **Table 15** provides a recommended forward program of works for this conceptual design.

Table 15: Forward Program of Works – Option 2

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume – estimated volumes are based on high level square modelling. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out flow (rate and timing) monitoring of both the Oakland and Barriga Drains. Carry out water quality insitu (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Survey of both drains to identify ideal harvest locations and system location.
	The drains are the responsibility of Water Corporation, therefore access to the surface water would require their approval.	Seek confirmation from Water Corporation regarding access entitlements.
Wastewater	Access to Water Corporation owned and managed infrastructure and the volume and timing of supply will need to be agreed. This can be a risk or may provide an opportunity to partner.	Seek confirmation from Water Corporation regarding access entitlements and rates and timing of take.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. It is strongly recommended that these investigations are to be completed prior to the detailed design. The aquifer performance can have a significant impact on the borefield spacing and layout which can have significant cost implications for transfer pipework. The use of transferred recharge credits will minimise or negate the requirement of distribution transfer infrastructure.	Detailed desktop study Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.
Demand Forecast	The demand forecast for the SSJ will be based on development and the construction of public open space in response to increased urbanisation. SSJ indicated that, if surplus water was identified, consideration could be given to supply for agriculture. The demand time for recycled water for agriculture is unknown and is based on the rate of development, end use and reduction or limitation in groundwater use allocations. This recommendation relates to the agricultural component only and is not required to meet SSJ irrigation requirements.	Participa~~n~~te in industry forums or engage with industry to understand the demand and willingness/ capacity to pay for recycled water for agricultural purposes. The development of the system may take several years therefore timing in conjunction with the industry is critical.

5.7 BYFORD – OAKFORD WATER SUPPLY OPTION 3 – WOODLAND GROVE SPORTING FACILITY

5.7.1 Overview

Woodland Grove is a proposed sports recreational site, which includes three drainage basins and a winter creek line, which limits the design possibilities of the sporting fields. The area can accommodate two senior sized ovals and other functions such as a BMX track or skate park. There is little information pertaining to the potential harvest volumes for the sites, surface drainage from the surrounding development will be directed into the proposed onsite drainage basins, however, the catchment is currently unknown. Flow monitoring or catchment modelling has not been carried out for the creek line. Based on these data gaps, the supply volume estimates are likely to be in the order of 20 to >100 ML/a. Additional investigations are recommended to confirm the reliable harvest volume prior to the detailed design of the system.

This concept considers harvesting water from the three drainage basins and the creek via a diversion line into one of the basins. The harvested water will then be treated through passive and / or mechanical means prior to being stored for irrigation in peak demand periods. The storage mechanism should be determined by the estimated harvest volume. Smaller harvest volumes could be stored above ground while larger volumes can be recharged into an underlying aquifer. For the purpose of this conceptual design, a supply volume of 40 ML/a has been adopted and above ground storage included as MAR is likely to be a more expensive option unless existing infrastructure is present at the site and can be utilised. Irrigation infrastructure has not been incorporated.

There is the opportunity to utilise this site as a trial and educational site prior to entering into a larger scale water supply system, differing technology such as biofilters, wetlands and the adoption of MAR can be tested to inform other options. One of the drainage basins could be constructed as a wetland feature to provide not just treatment but amenity and liveability benefits for the local community.

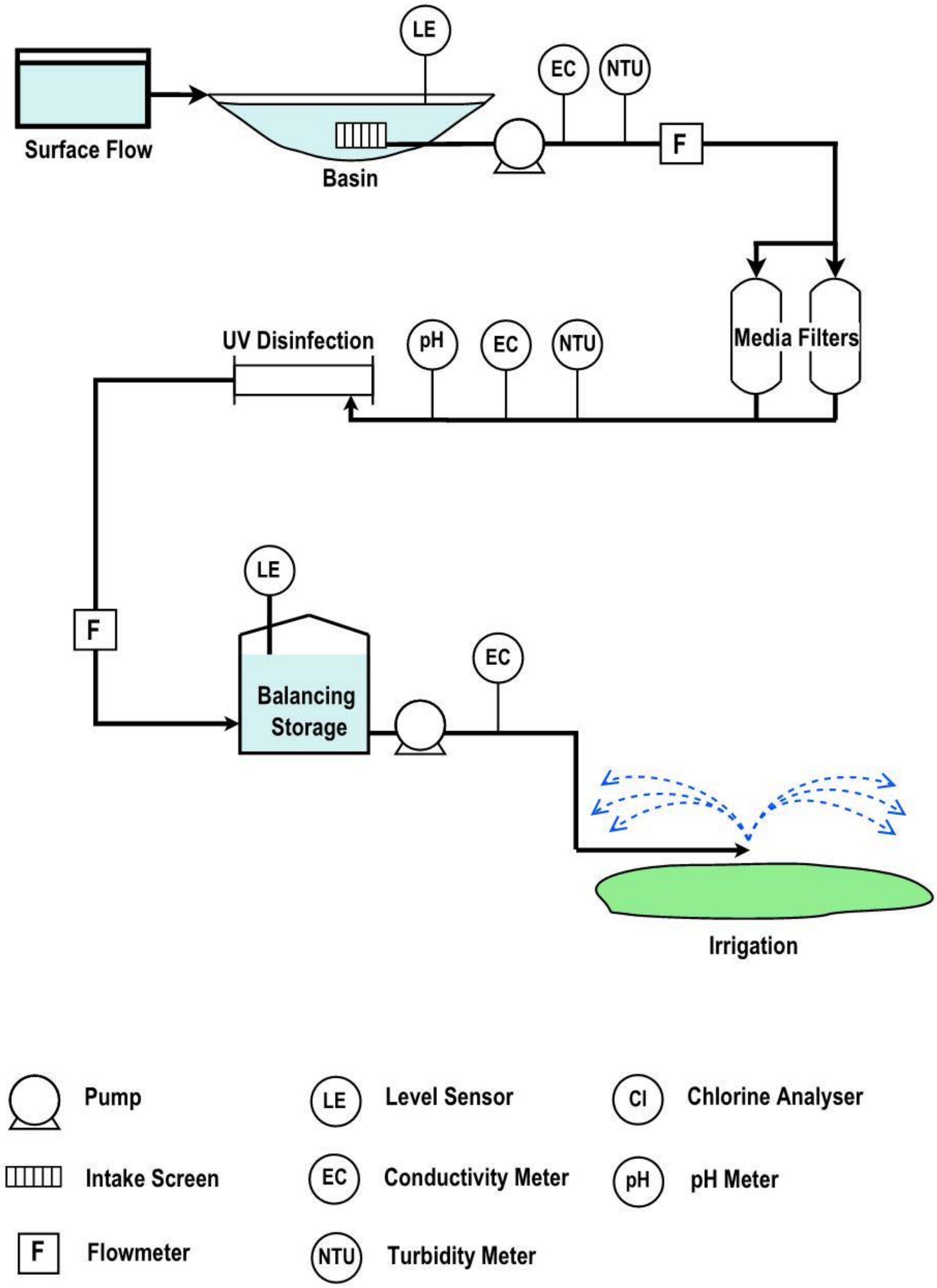


Figure 20 presents the process flow diagram for Concept 3 whilst Figure 21 provides a spatial representation. Table 16 presents the water balance for the system and Table 17 presents the water

supply concept components. This concept assumes a harvest volume of 40 ML to ultimately supply 32 ML following losses through the system.

Table 16: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from drainage basin/wetland and creek line	40 ML/a	Flow monitoring or catchment modelling data is not available for the creek line or drainage discharge basins. Based on the harvest of 40 ML over 75 days and 16 hours a day operation, a harvest rate of 10 L/s is proposed.
Above ground storage – wetland and drainage basin	Two drainage basins including existing. 0.5 Ha wetland system A 200 kL balancing tank.	There is an existing drainage basin located in the north-western corner of the site. The size is approximately 180 m^2. An additional 30 ML basin is proposed along with a 0.5 Ha wetland system. A post treatment balancing tank of 200 kL will also be included.
Water Treatment	Treatment Rate 10 L/s	Treatment rate will vary depending on the end use supply demand during peak periods
Irrigation Supply	32 ML/a	Assuming losses through the system from evaporation the losses are assumed to be 20%.

Table 17: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Water from the existing drainage basin and proposed drainage basin will be directed to the wetland. An offtake off of the creek line will divert water into the wetland.	One additional 30 ML basin and 0.5 Ha wetland. A pump to transfer water from the creek line at 10 L/s. Transfer infrastructure from each harvest location will be required to transfer water to the wetland. A nominal 500 m of transfer pipework has been adopted. This will vary depending on the location of the harvest points and the balancing storage.
Wetland and Transfer Lines	A 0.5 Ha wetland will be contrasted to provide treatment and balancing storage.	Transfer infrastructure from the balancing storage to the treatment facility has been assumed to be 200 m of pipe.
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for media filter and UV treatment system. Valves, gauges and non-return valves included. A balancing storage tank of 200 kL has been adopted.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included.	Operation including staff. Maintenance requirements.

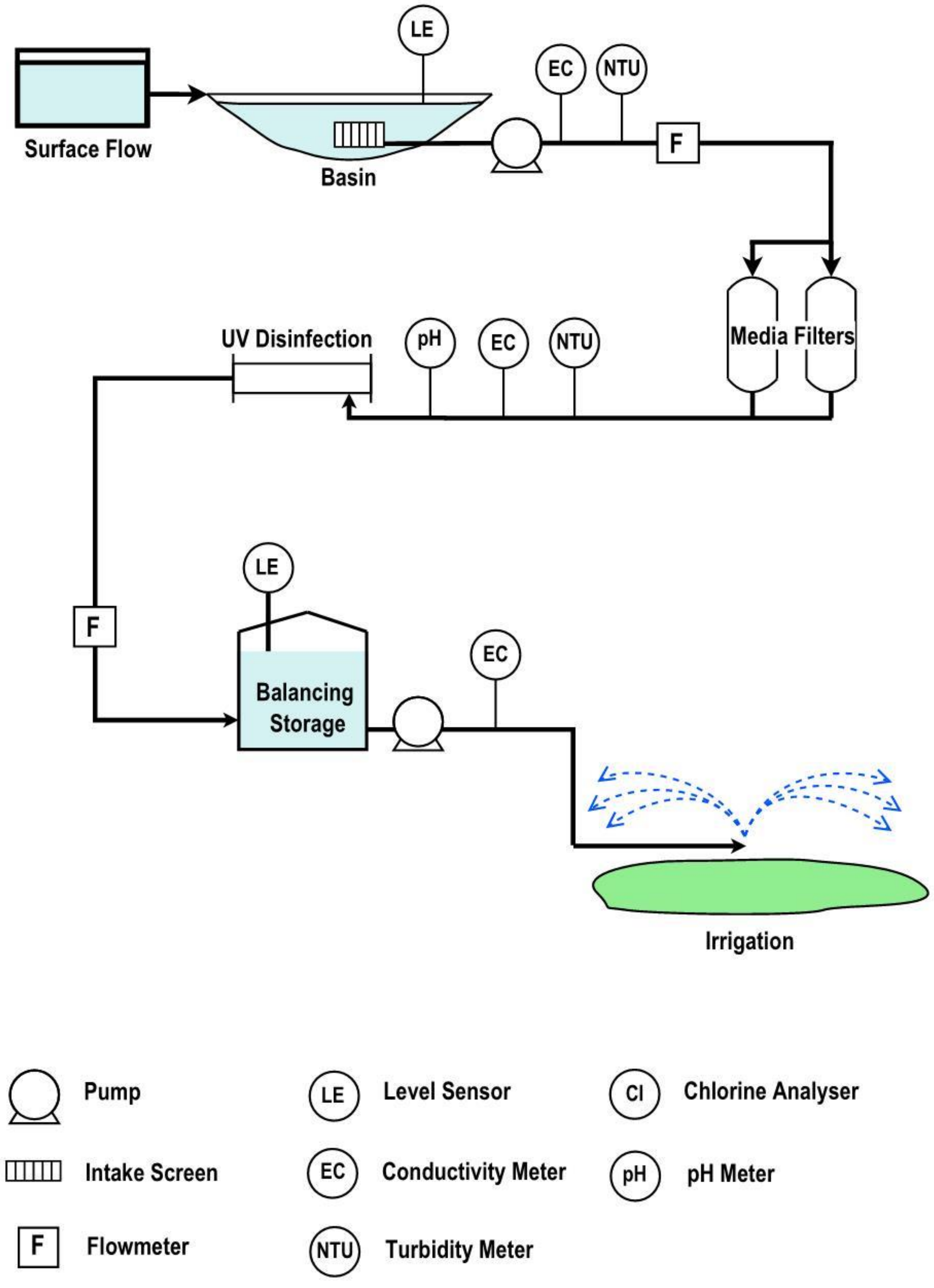
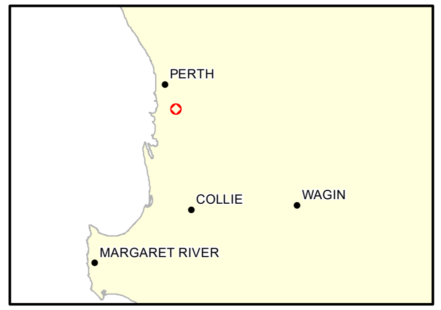


Figure 20: Operational Process Chart – Option 3



Precinct Extent
Roads_Dissolve
Potential Storage Location
Harvest Point
Highway
Faults
Water Delivery Pipe
Coastal Waterline
Estuarine
Mainstream
Major River
Minor River
Significant Stream
Major Trib
MinorTrib
Minor Trib
Insignificant Trib
Inundation Area
Paleo-Drainage Line
Infrastructure

N
0 25 50 75 m
Scale 1:2,500 @ A4
Coordinate System: GDA 1994 MGA Zone 50

WGA
WALLBRIDGE GILBERT AZTEC

Figure **21**

Option 3- Surface Water Harvesting at Woodland Grove Sporting Facility

5.7.2 Cost Estimate

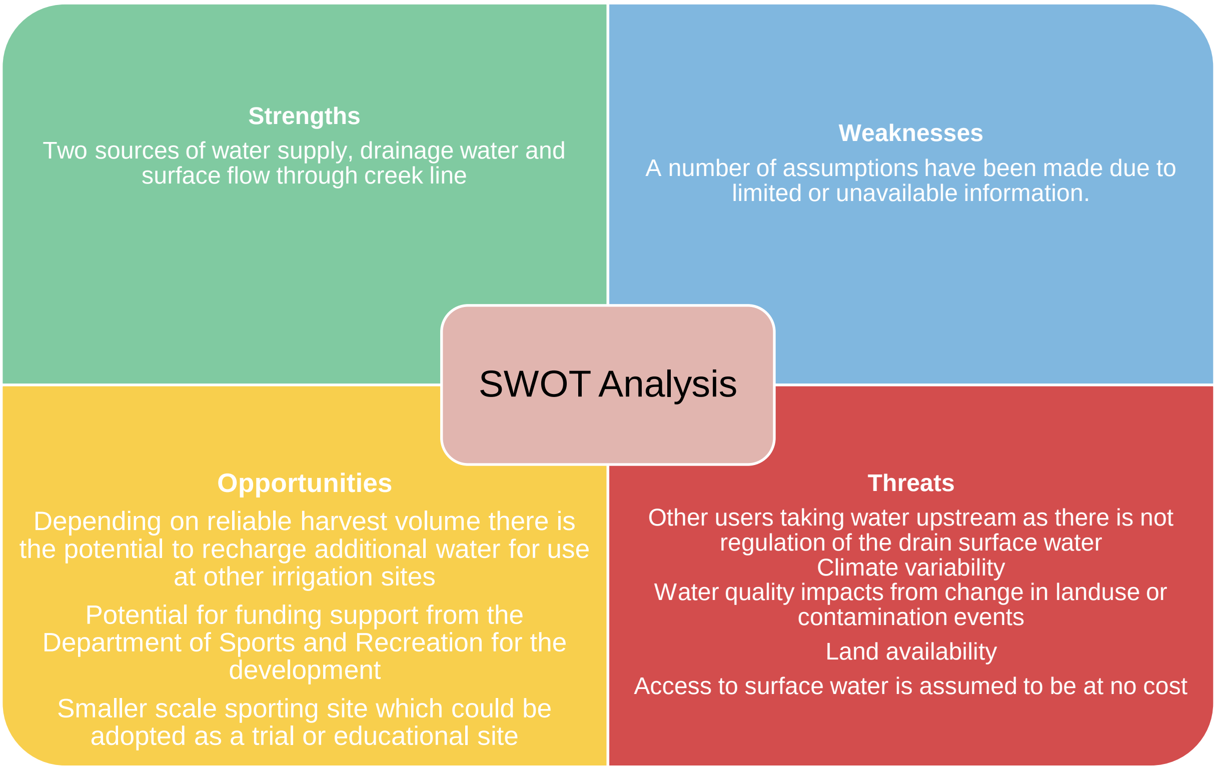
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in Table 18 with a summary of breakdown and assumptions area presented in Appendix D.

Table 18: Summary of Cost Estimate – Option 3

CAPEX	$3,217,145
OPEX	$389,500
NPV (4-7% Real Discount Rate)	$17.70-$20.10

5.7.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of this sporting facility. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.7.4 Forward Program of Works

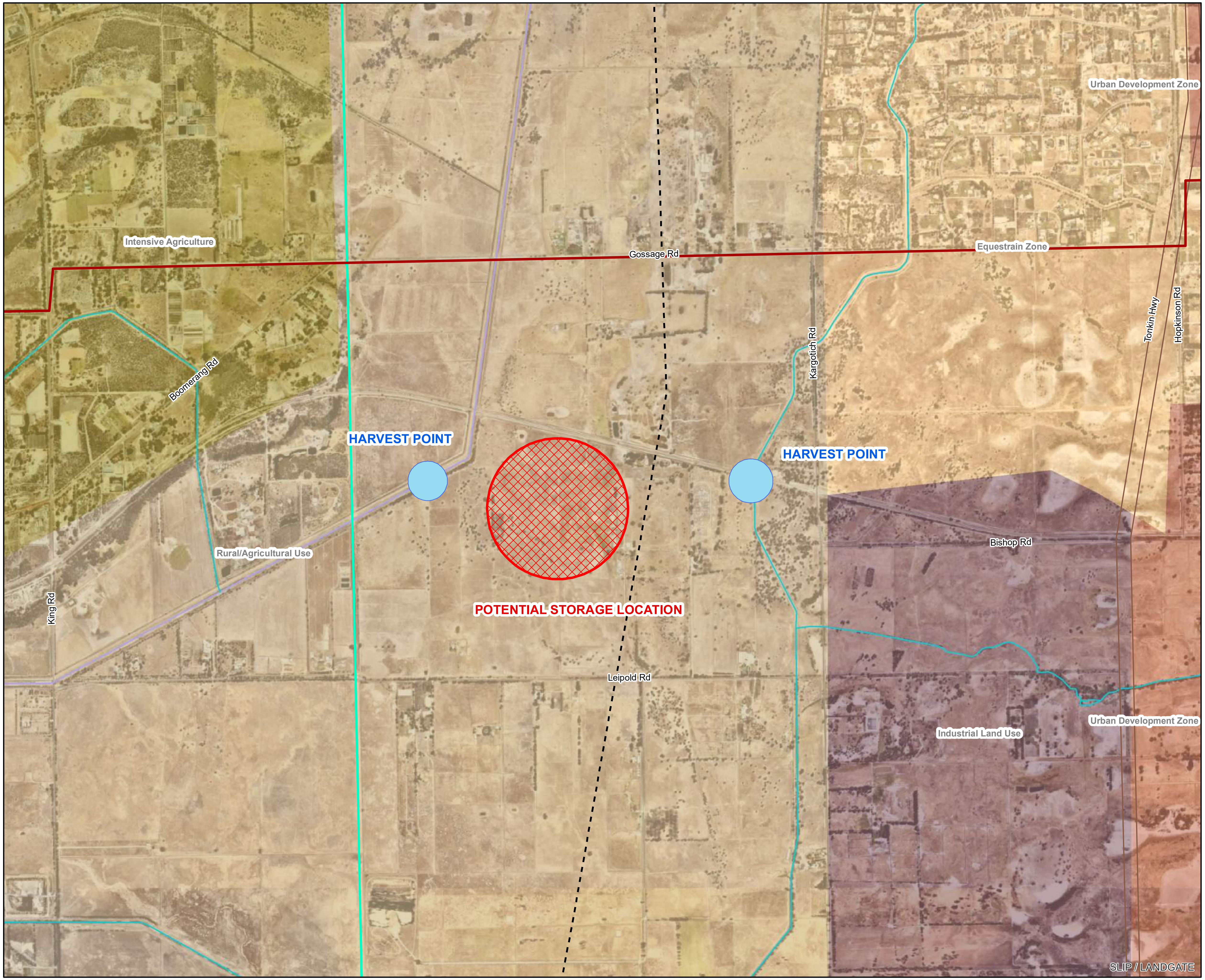
The conceptual design has been based on a number of assumptions and available information; additional information would be required to address these components. **Table 19** provides a recommended forward program of works for this conceptual design.

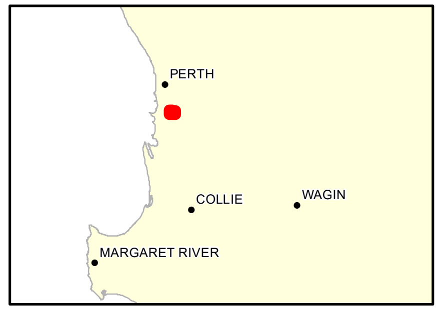
Table 19: Forward Program of Works – Option 3

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume is unknown. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out flow (rate and timing) monitoring of both the creek line. Carry out catchment modelling to estimate potential flows into the drainage basins. Carry out water quality insitu (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Discuss any permitting requirements with the relevant authorities. Confirm with DWER the requirements to harvest water from the drainage basin.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. The assessment can be completed in a staged approach to allow for sufficient hold points to identify any significant project risks. It is highly recommended that these investigations are to be completed prior to the detailed design.	Detailed desktop study Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.

5.8 OLDBURY - MUNDIJONG WATER SUPPLY OPTION 4 - SURFACE WATER FLOWS FROM OAKLAND / BARRIGA MAIN DRAIN

This option is identical to that presented in Option 1 with exception of the location. The Oakland and Barriga Main Drains intersect both the Byford and Mundijong regions indicating that the same option can be implemented at either location. There is also the opportunity to implement two schemes of varying size depending on the volume available and the demand locations. The detail pertaining to this option is outlined in Section 5.1. The proposed location is presented in **Figure 22**. This location also has the opportunity for above ground storage or the development of a recreational water park.





Precinct Extent
Potential Storage Location
Harvest Point
Highway
Faults
Water Delivery Pipe
Coastal Waterline
Estuarine
Mainstream
Major River
Minor River
Significant Stream
Major Trib
MinorTrib
Minor Trib
Insignificant Trib
Inundation Area
Paleo-Drainage Line
Infrastructure

SJ2050 Proposed Landuse

Equestrain Zone
Intensive Agriculture Zone
Conservation Zone
Darling Scarp
Urban Development Zone
Tourism Zone
Rural/Agricultural Use
Industrial Land Use

N

0 200 400 600 m

Scale 1:20,000 @ A4

Coordinate System: GDA 1994 MGA Zone 50

WGA
WALLBRIDGE GILBERT AZTEC

Figure **22**

Option 4- Surface Water Flows from Oakland / Barriga Main Drain -Alternative Location

5.9 OLDBURY – MUNDIJONG WATER SUPPLY OPTION 5 – DECENTRALISED WASTEWATER SYSTEM

5.9.1 Overview

The township of Mundijong is predicted to grow from 2,000 people to 50,000 by 2050. Wastewater in the area is managed predominantly through onsite septic systems, with the exception of a recent development where Water Corporation has extended their network into the area. Water Corporation has a sewer main from that development up to the township of Byford. There exists the opportunity to develop a decentralised wastewater system in the area or implement a sewer mining system from the Water Corporation infrastructure.

Figure 23 presents the process flow diagram for option 5 whilst **Figure 24** provides a spatial representation. **Table 20** presents the water balance for the system and **Table 21** presents the water supply concept components. This concept assumes a harvest volume of 1,000 ML to ultimately supply 800 ML/a following losses through the system. The potential volume from a decentralised system will depend on the residential area serviced by the system. The concept does not consider retrofitting of the septic tanks of the existing residents however, this could also be considered in future. As Water Corporation is starting to service the area, it is expected that development will increase and therefore the area serviced will increase prior to such time that a decentralised system could be developed.

Table 20: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – wastewater from a decentralised community system	1,000 ML/a	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 3,000 ML/a.
Sewer Network	Nil	It has been assumed that the sewer network and associated pump stations are installed by the developer and have not been incorporated into this cost analysis.
Above ground storage	A combined above ground storage capacity of untreated, treated and emergency storage. A 400 ML storage facility has been adopted	The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses serviced.
Water Treatment	Treatment Rate 50 L/s	A treatment rate of 50 L/s has been adopted based on the expected daily flow. Primary, secondary and tertiary treatment.
Irrigation Supply	800 ML/a Irrigation Distribution Network 10 km	Assuming losses through the system from evaporation and backwash the losses are assumed to be 20%. Irrigation Distribution Network of 10 km has been adopted.

Table 21: Water Supply Concept Components

Parameter	Discussion	Allowance
Water and Network	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 3,000 ML/a. It is assumed that no land acquisition is required to install the infrastructure.	1,000 ML/a source water
Treatment	The level of treatment will depend on the end use or if required disposal location.	Allowance has been made for balancing tank primary and secondary treatment. Valves, gauges and non-return valves included.
Above Ground Storage	A combined above ground storage capacity of untreated, treated and emergency storage. The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses services.	A 400 ML storage facility has been adopted.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. A nominal 10 km of distribution infrastructure has been adopted.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

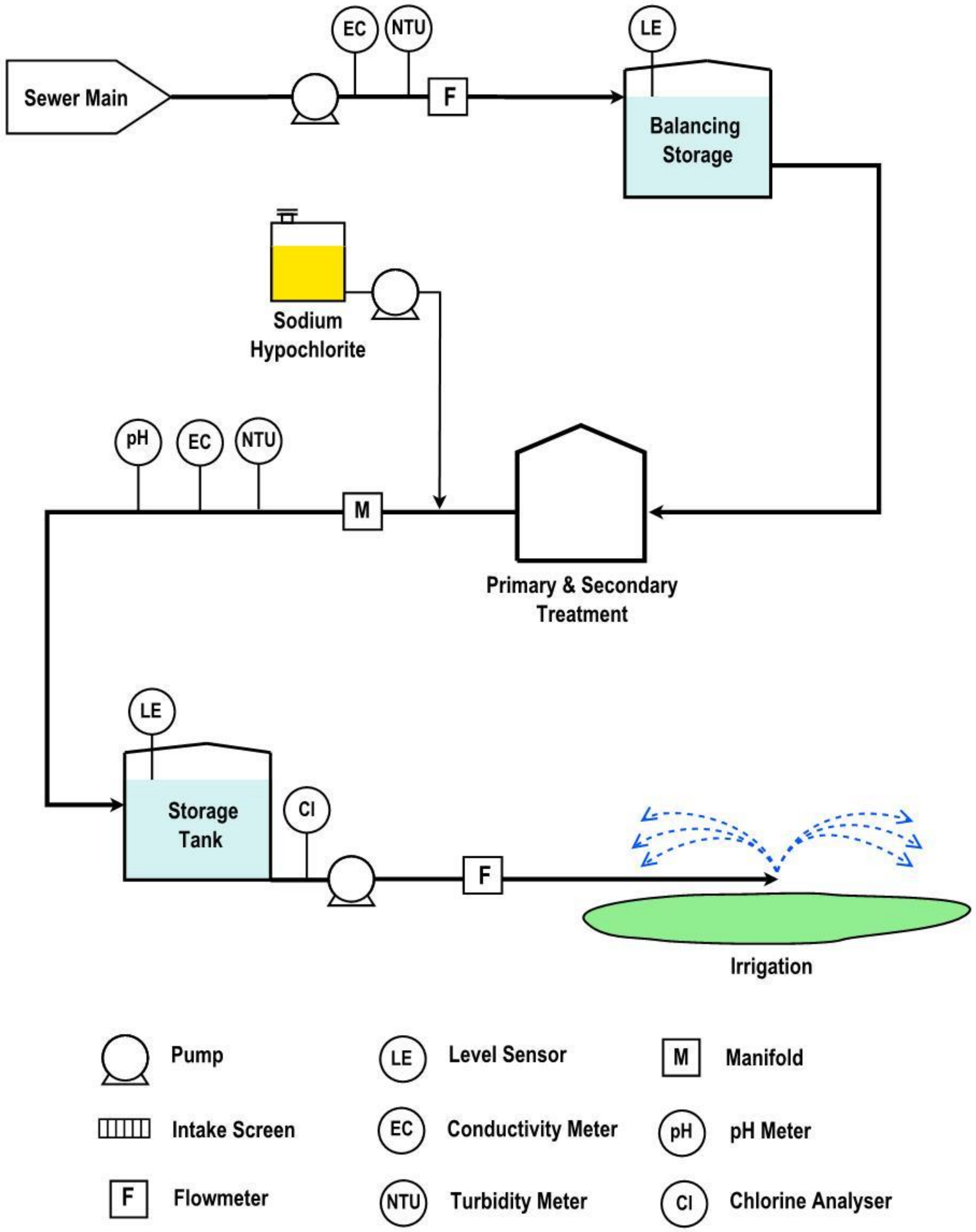


Figure 23: Operational Process Chart – Option 5

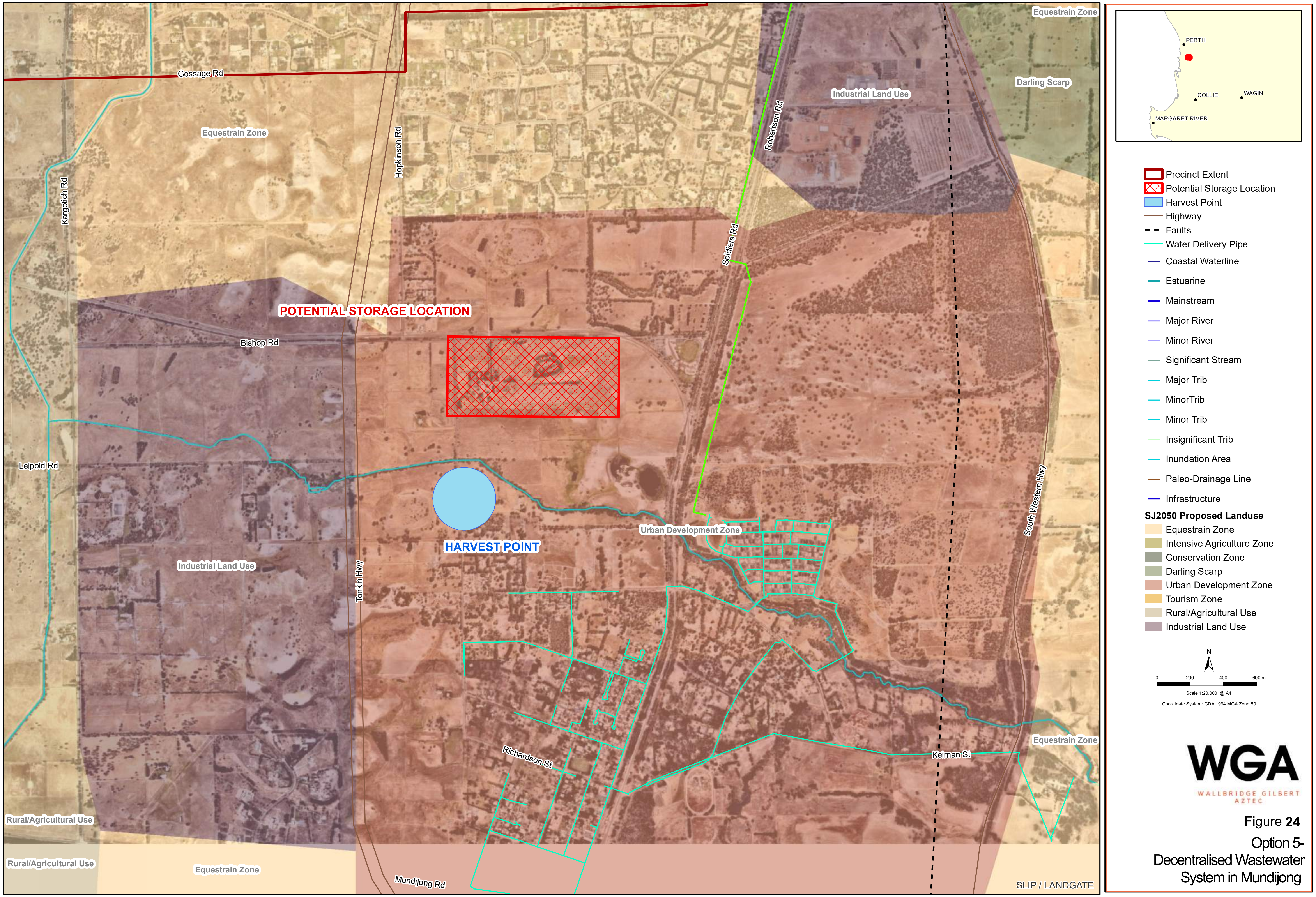


Figure 24
Option 5-
Decentralised Wastewater
System in Mundijong

5.9.2 Cost Estimate

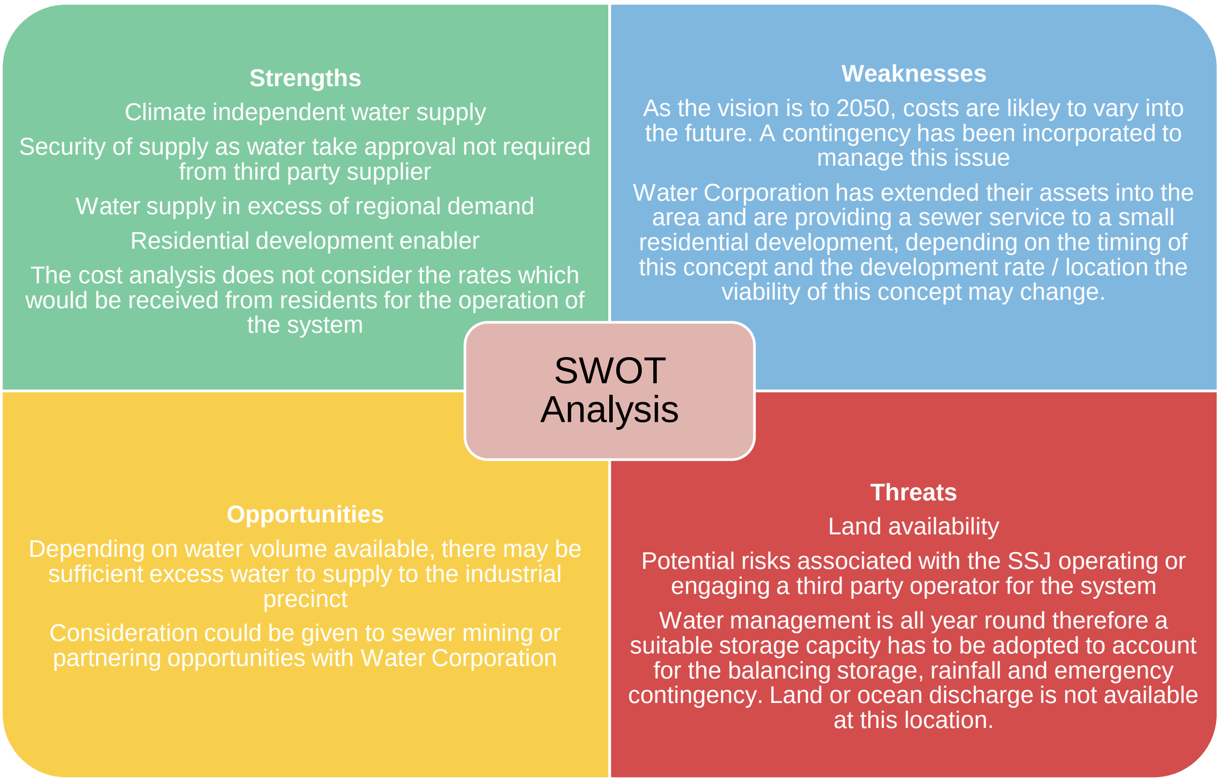
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in **Table 22** with a summary of breakdown and assumptions are presented in **Appendix D** This option does not consider the income from residential sewer rates, this will provide an income stream that can offset some of the costs.

Table 22: Summary of Cost Estimate – Option 5

CAPEX	$23,905,000
OPEX	$1,905,500
NPV (4-7% Real Discount Rate)	$3.95 – $4.70 / kL

5.9.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of the SSJ maintained land but also provides an opportunity for the industrial precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.9.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information; additional information would be required to address these components. **Table 23** provides a recommended forward program of works for this conceptual design.

Table 23: Forward Program of Works – Option 5

Data Gap	Risk	Forward Program of Work
Partnering Opportunities	Identifying a suitable operator or partner for the system is critical for either sewer mining or a decentralised system.	Identify potential partnering opportunities.

5.10 OLDBURY – MUNDIJONG WATER SUPPLY OPTION 6 – DECENTRALISED WASTEWATER SYSTEM WITH SURFACE WATER FROM MANJEDAL BROOK

5.10.1 Overview

This water supply concept considers the operation of a decentralised wastewater system as outlined in Option 5 and integrating the system with surface water from the Manjedal Brook. Flow monitoring of the Manjedal Brook has not been undertaken, however, square modelling completed by DWER (2012) indicated that 18.1 GL/a of water flows in the Manjedal Brook. This modelling is very high level and flow and water quality monitoring is recommended to determine the reliable harvest volume. This section described the components of the surface water component only, a description of the process of the decentralised wastewater system is presented in Section 5.9.

Based on the high-level flow modelling, a harvest volume of 3,000 ML/a has been adopted. Surface water is to be harvested, when available which is predominantly in winter, and transferred to the treatment / storage site adopted for the wastewater facility. Surface water does not require the same level of treatment as wastewater; therefore, a separate capture / balancing storage and treatment site will be incorporated. The use of MAR and above ground storage has been adopted for this concept.

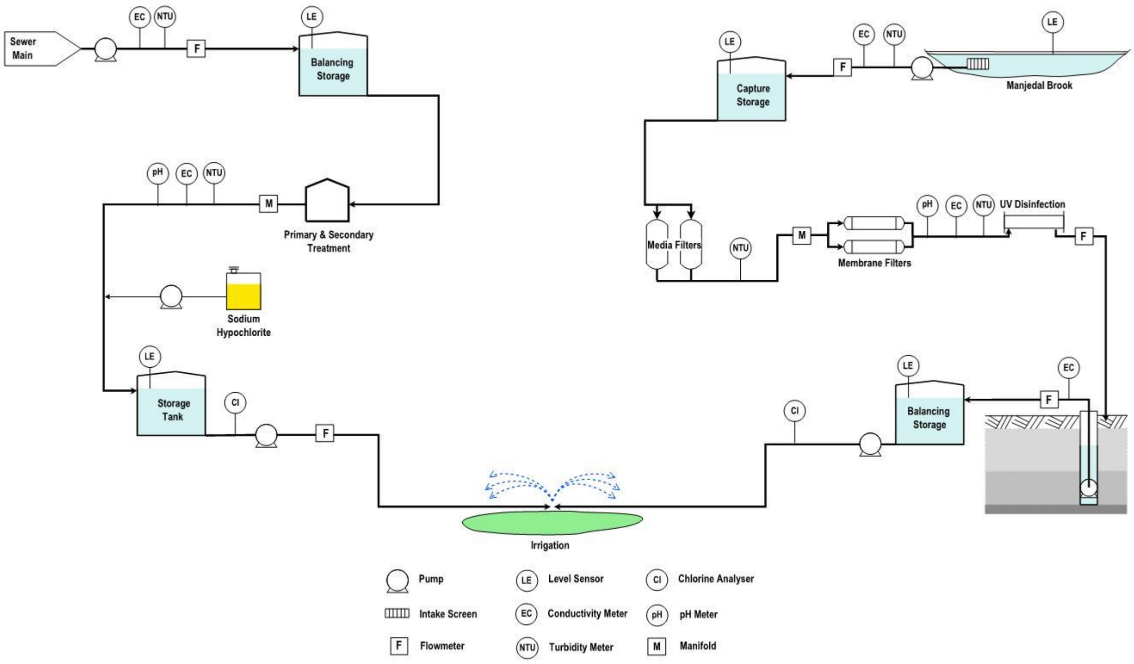


Figure 25 presents the process flow diagram for Concept 6 whilst **Figure 26** provides a spatial representation. **Table 24** presents the water balance for the system and **Table 25** presents the water supply concept components. This concept assumes a harvest volume of 3,000 ML of surface water and 1,000 ML of treated wastewater to ultimately supply 3,200 ML/a following losses through the system.

Table 24: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – wastewater from a decentralised community system	1,000 ML/a	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 3,000 ML/a.
Source water – Manjedal Brook	3,000 ML/a	3,000 ML/a based on the modelled 18.1 ML/a of flow and the increase in flow through the region as a result of urbanisation. It is assumed that the flow will be available of 100 days per annum at 30 ML/d. A harvest rate 520 L/s has been adopted.
Above ground storage	A combined above ground storage capacity of untreated, treated and emergency storage. A 500 ML storage facility has been adopted.	The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses services.
Water Treatment for Treated Wastewater	Treatment Rate 50 L/s	A treatment rate of 50 L/s has been adopted based on the expected daily flow. Primary, secondary and tertiary treatment.
Water Treatment for Surface water and Aquifer Replenishment	Injection rate of 25 L/s Number of bores 21 Treatment Rate 520 L/s	Aquifer injection rates, depending on the aquifer characteristics, range between 25 L/s and 40 L/s. To be conservative an injection rate of 25 L/s has been adopted. If higher rates are achieved the number of bores can be reduced. The number of bores is based on the injection rate of 25 L/s, a target daily recharge rate of 30 ML/d.
Irrigation Supply	3,200 ML/a Irrigation Distribution Network 10 km	Assuming losses through the system from evaporation, backwash, scour and for environmental benefit the losses are assumed to be 20%. Irrigation Distribution Network of 10 km has been adopted.

Table 25: Water Supply Concept Components

Parameter	Discussion	Allowance
Treated Water and Network	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 3,000 ML/a. It is assumed that no land acquisition is required to install the infrastructure.	1,000 ML/a source water
Treatment	The level of treatment will depend on the end use or if required disposal location.	Allowance has been made for balancing tank, primary and secondary treatment. Valves, gauges and non-return valves included.
Above Ground Storage	A combined above ground storage capacity of untreated, treated and emergency storage. The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses services.	A 500 ML storage facility has been adopted.
Source Water and Transfer Lines	Surface water from the Mandejal Brook to the storage and treatment site.	No significant variation to the drain has been proposed other than the installation of the harvest offtake. Transfer infrastructure to the storage location will be required and a nominal 5 km of transfer pipework has been adopted. This will vary depending on the location of the harvest and balancing storage.
Balancing Storage and Transfer Lines	An above ground balancing storage dam with a storage capacity of 100 ML has been adopted for the surface water component.	A 100 ML dam has been adopted, covering an area of approximately 260 x 260 m. Acquisition of the land has not been incorporated in to the cost analysis component. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water). Transfer infrastructure from the balancing storage to the treatment facility and to the 21 production wells has been assumed to be 5 km of pipe based on 200-250 m spacing. Scour of the production wells is required and is assumed to be transferred to a disposal location. A nominal 5 km of pipe has been assumed.

Parameter	Discussion	Allowance
Storage using ASR Typically, replenishment will be carried out in winter and recovery during summer, however this approach may vary depending on future rainfall patterns.	Based on a volume of 3,000 ML/a, an injection rate of 25 L/s, 100 recharge days. 21 ASR bores are required. The target aquifer is either the Leederville, Yarragadee or Cattamara Coal Measures depending on yield, location, risks and surrounding users. The depth to aquifer will vary depending on the system. A nominal bore depth of 250 m bgl has been adopted. Monitoring bores targeting the same formation and shallow systems may be required. Two monitoring bores have been adopted.	Installation of 21 production bores assuming not suitable bores exist. Installation of five monitoring bores. Headworks infrastructure, pump infrastructure and monitoring infrastructure. SCADA system allowance and inline water quality and pressure monitoring. Pump Infrastructure has been included as the facility to scour is required.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. A nominal 10 km of distribution infrastructure has been adopted.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included.	Operation including staff. Maintenance requirements.

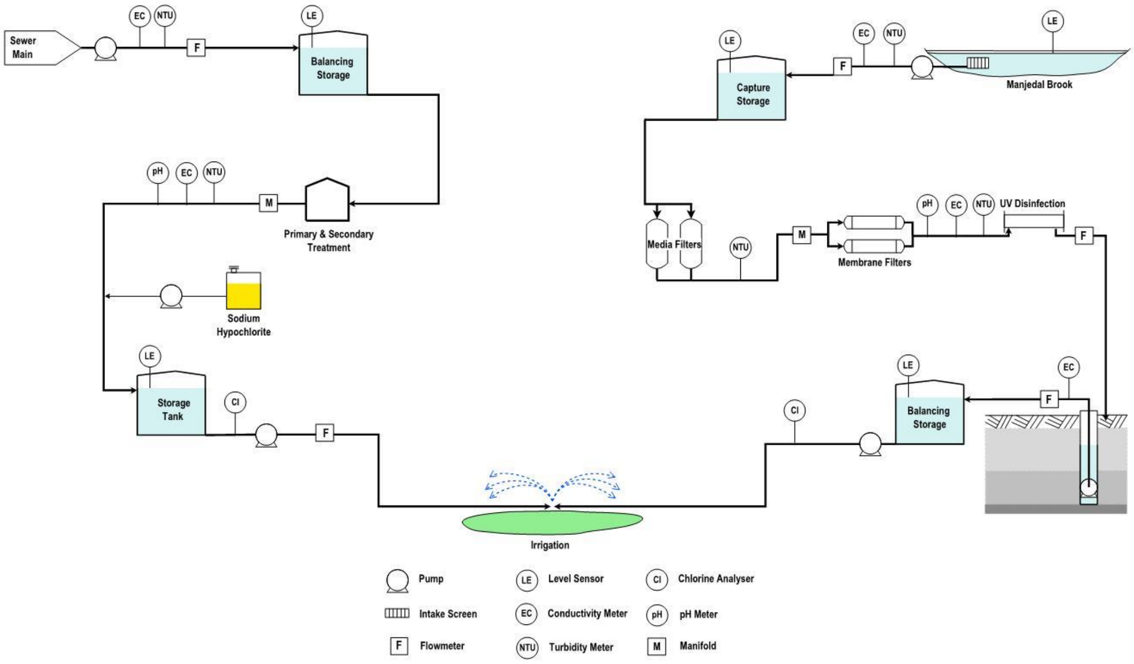
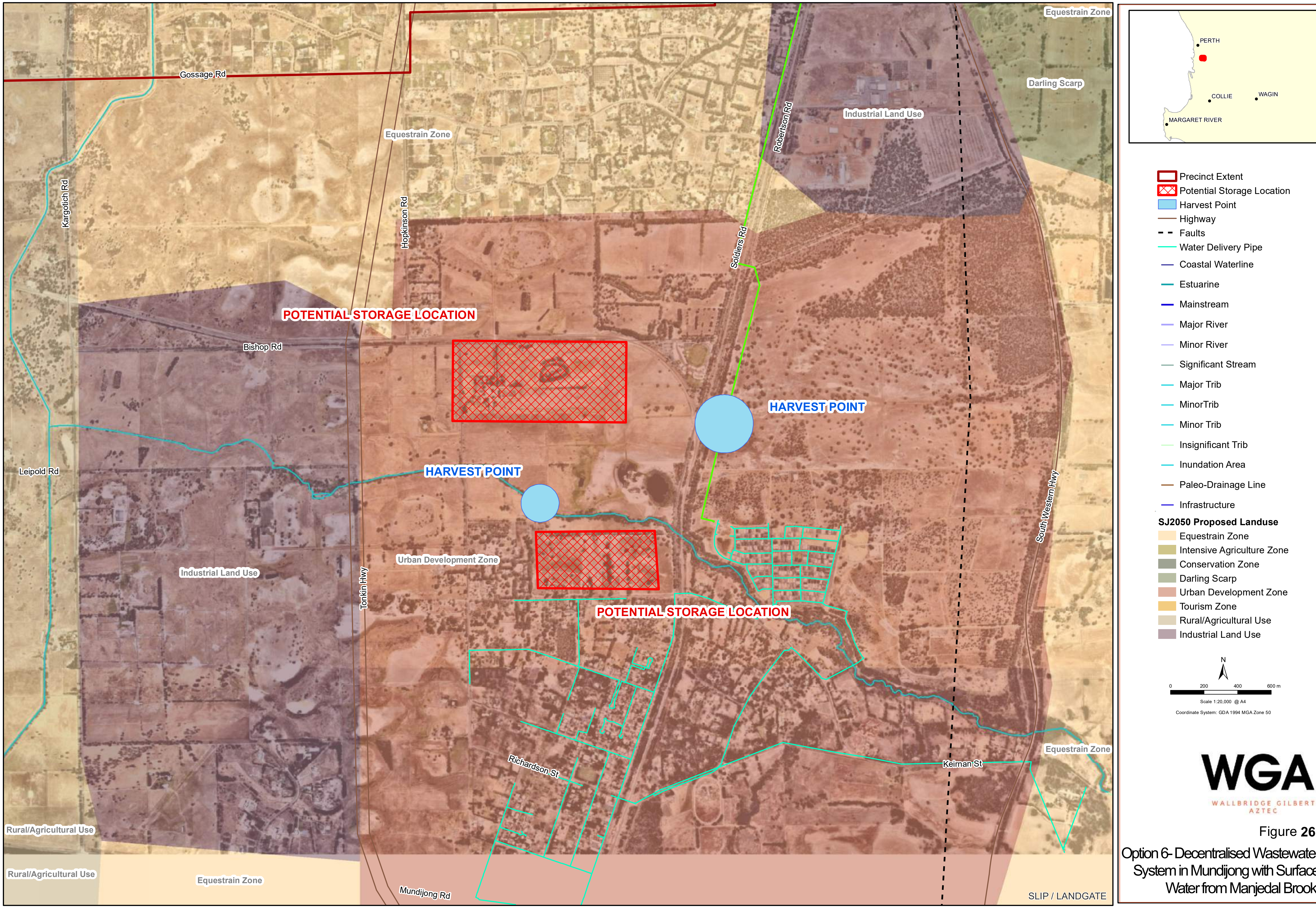


Figure 25: Operational Process Chart – Option 6



Precinct Extent
Potential Storage Location
Harvest Point
Highway
Faults
Water Delivery Pipe
Coastal Waterline
Estuarine
Mainstream
Major River
Minor River
Significant Stream
Major Trib
MinorTrib
Minor Trib
Insignificant Trib
Inundation Area
Paleo-Drainage Line
Infrastructure

SJ2050 Proposed Landuse

Equestrain Zone
Intensive Agriculture Zone
Conservation Zone
Darling Scarp
Urban Development Zone
Tourism Zone
Rural/Agricultural Use
Industrial Land Use

N

0 200 400 600 m

Scale 1:20,000 @ A4

Coordinate System: GDA 1994 MGA Zone 50

WGA
WALLBRIDGE GILBERT AZTEC

Figure **26**

Option 6- Decentralised Wastewater System in Mundijong with Surface Water from Manjedal Brook

5.10.2 Cost Estimate

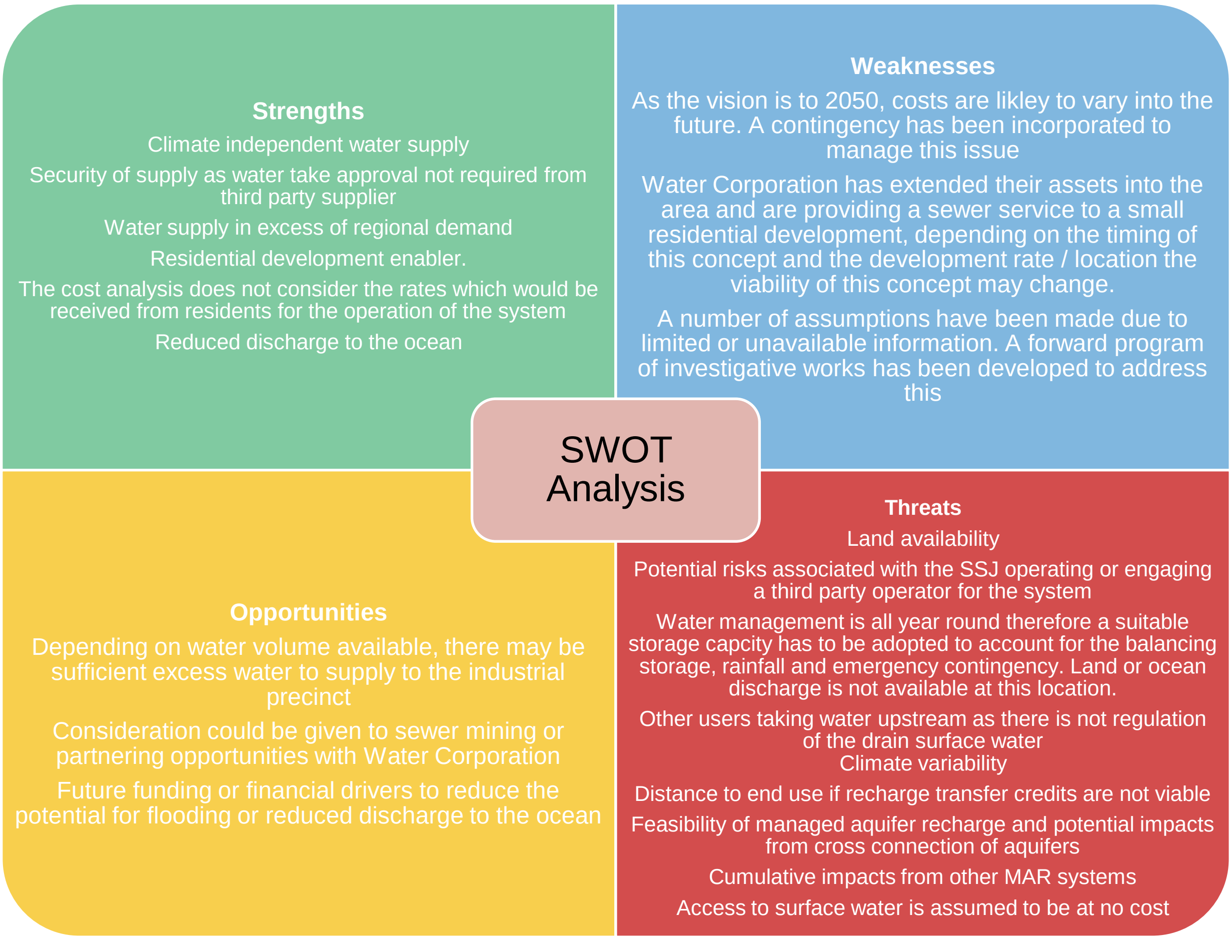
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in **Table 26** with a summary of breakdown and assumptions area presented in **Appendix D**

Table 26: Summary of Cost Estimate – Option 6

CAPEX	$77,990,000
OPEX	$4,686,000
NPV (4-7% Real Discount Rate)	$3.25-3.85

5.10.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of the SSJ maintained land but also provides an opportunity for the industrial precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.10.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information, additional information would be required to address these components. **Table 27** provides a recommended forward program of works for this conceptual design.

Table 27: Forward Program of Works – Option 6

Data Gap	Risk	Forward Program of Work
Partnering Opportunities	Identifying a suitable operator or partner for the system is critical for either sewer mining or a decentralised system.	Identify potential partnering opportunities.
Surface Water	Reliable harvest volume – estimated volumes are based on high level square modelling. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out flow (rate and timing) monitoring of Mandejal Brook. Carry out water quality insitu (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Survey of both drains to identify ideal harvest locations and system location.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. It is strongly recommended that these investigations are to be completed prior to the detailed design. The aquifer performance can have a significant impact on the borefield spacing and layout which can have significant cost implications for transfer pipework. The use of transferred recharge credits will minimise or negate the requirement of distribution transfer infrastructure.	Detailed desktop study Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.

5.11 OLDBURY – MUNDIJONG WATER SUPPLY OPTION 7 – RECHARGE RUNOFF FROM MUNDIJONG WHITBY DISTRICT SPORTING FACILITY

5.11.1 Overview

A district sporting facility is required to support the Whitby High School and proposed Mundijong High School. The 12 Ha facility is to include two senior sized ovals and supporting infrastructure and will be incorporated into the same site as the high school facilities. The proposed location has not been confirmed, however, consideration to the land on Haywire Ave is a possibility due to limited surrounding environmental features.

The concept design for the facility is high level, however, is it considered likely that roof run off from the buildings and surrounding land will be directed to a drainage basin on site. It is proposed that this water be harvested and stored in an above ground storage, then treated and supplied for irrigation. Catchment modelling for the system has not been completed, however, based on the proposed area, the supply volume estimates are likely to be in the order of 20 to 100 ML/a. Additional investigations are recommended to confirm the reliable harvest volume prior to the detailed design of the system. For the purpose of this conceptual design, a supply volume of 50 ML/a has been adopted and MAR included.

There is the opportunity to utilise this site as a trial and educational site prior to entering into larger scale water supply system, differing technology such as biofilters, wetlands and the adoption of MAR can be tested to inform other options. One of the drainage basins could be constructed as a wetland feature to provide treatment, amenity and liveability benefits for the local community. For the purpose of this assessment, a drainage basin followed by mechanical treatment has been proposed.

The source water quality is unknown therefore the level of treatment is unclear, due to the low proposed recharge volumes, a moderate level of treatment has been proposed.

Table 27 presents the process flow diagram for Concept 7 whilst **Figure 28** provides a spatial representation. **Table 28** presents the water balance for the system and **Table 29** presents the water supply concept components. This concept assumes a harvest volume of 50 ML to ultimately supply 40 ML following losses through the system.

Table 28: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from drainage basin which captures roof runoff and runoff from surrounding land	50 ML/a	Catchment modelling data is not available. Based on the harvest of 50 ML over 75 days and 16 hours a day operation, a harvest rate of 12 L/s is proposed.
Above ground storage – drainage basin	One drainage basin A 200 kL balancing tank.	A drainage basin of approximately 180 m^2 is proposed. A post treatment balancing tank of 200 kL will also be included.
Water Treatment	Treatment Rate 12 L/s	Treatment rates has been assumed based on peak irrigation rates
Irrigation Supply	40 ML/a	Assuming losses through the system from evaporation losses are assumed to be 20%.

Table 29: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Water from the basin will be directed to the treatment facility.	A 40 ML basin A pump to transfer water from the drainage basin at 12 L/s. Transfer of water from the basin to the treatment facility. Stormwater infrastructure to direct water from the building to the drainage basin has not been incorporated.
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for media filter and UV treatment system. Valves, gauges and non-return valves included. A balancing storage tank of 200 kL has been adopted.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Risk Assessment and Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. The use of transfer credits in the aquifer so users can extract water from an onsite bore has been assumed.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

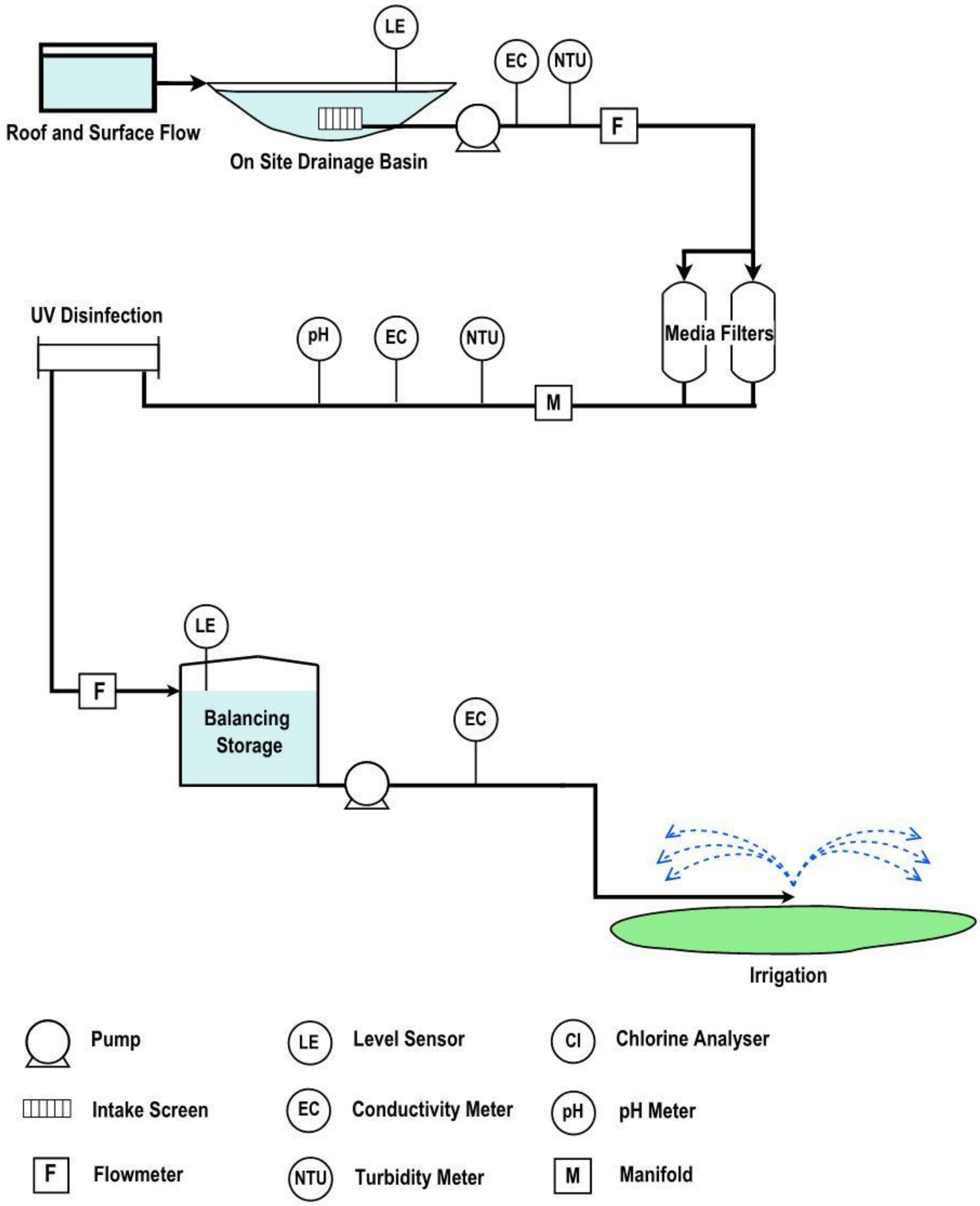
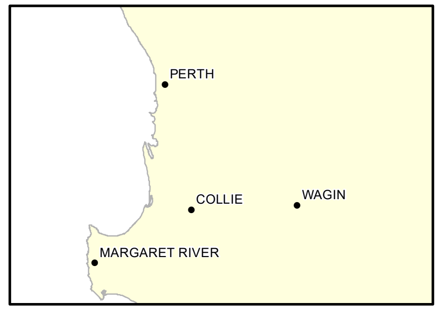


Figure 27: Operational Process Chart – Option 7



- Precinct Extent
- Potential Storage Location
- Harvest Point
- Highway
- Faults
- Water Delivery Pipe
- Coastal Waterline
- Estuarine
- Mainstream
- Major River
- Minor River
- Significant Stream
- Major Trib
- MinorTrib
- Minor Trib
- Insignificant Trib
- Inundation Area
- Paleo-Drainage Line
- Infrastructure

SJ2050 Proposed Landuse

- Equestrain Zone
- Intensive Agriculture Zone
- Conservation Zone
- Darling Scarp
- Urban Development Zone
- Tourism Zone
- Rural/Agricultural Use
- Industrial Land Use

N

Scale 1:1,646 @ A4

Coordinate System: GDA 1994 MGA Zone 50

WGA
WALLBRIDGE GILBERT AZTEC

Figure **28**

Option 7-
Whitby and Mundijong
District Sporting Facility

5.11.2 Cost Estimate

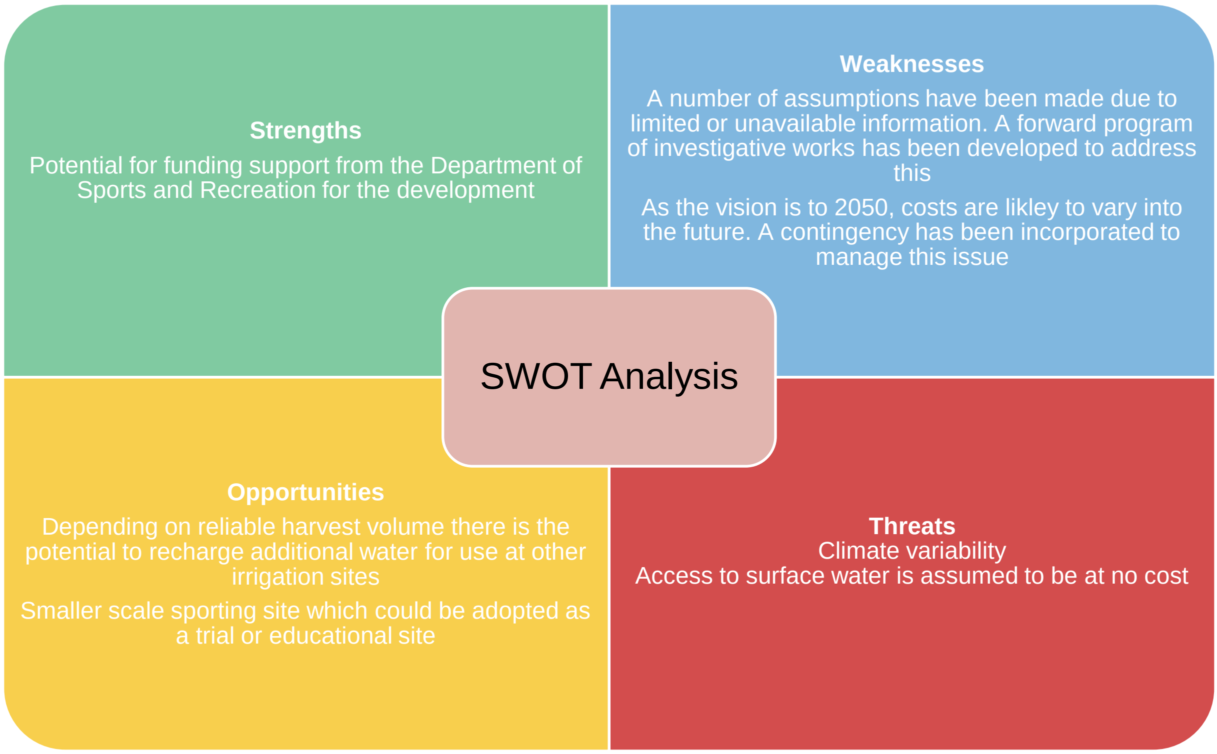
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in **Table 30** with a summary of breakdown and assumptions area presented in **Appendix D**

Table 30: Summary of Cost Estimate – Option 7

CAPEX	$2,462,000
OPEX	$420,000
NPV (4-7% Real Discount Rate)	$14.15-15.70

5.11.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation for this precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.11.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information; additional information would be required to address these components. **Table 31** provides a recommended forward program of works for this conceptual design.

Table 31: Forward Program of Works – Option 7

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume is unknown. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out catchment modelling to estimate potential flows into the drainage basins. Discuss any permitting requirements with the relevant authorities. Confirm with DWER the requirements to harvest water from the drainage basin.

5.12 HOPELAND – SERPENTINE – KEYSBROOK WATER SUPPLY OPTION 8 – HARVEST OF SURFACE WATER FLOWS FROM PUNRACK DRAIN

5.12.1 Overview

This water supply concept considers harvesting surface water flows from Karnet or Dirk Brooks or downstream in the Punrack Drain. Karnet and Dirk Brooks are located in the southern portion of the project area and feed into the Punrack Drain. Flows at Yangedi Punrack Drain are estimated to be between 35 and 42 GL/a with daily flows between 100 and 800 ML/day depending on rainfall. Salinity monitoring at this location indicates a winter and summer cycle whereby salinity in winter is in the order of 250-300 mg/L whilst in summer it increases to greater than 1,500 mg/L.

Water will be harvested, and following treatment, will be transferred to either an above ground storage or underground using MAR for storage. The water will be subsequently recovered and transferred for irrigation of SSJ land or for agriculture / industry.

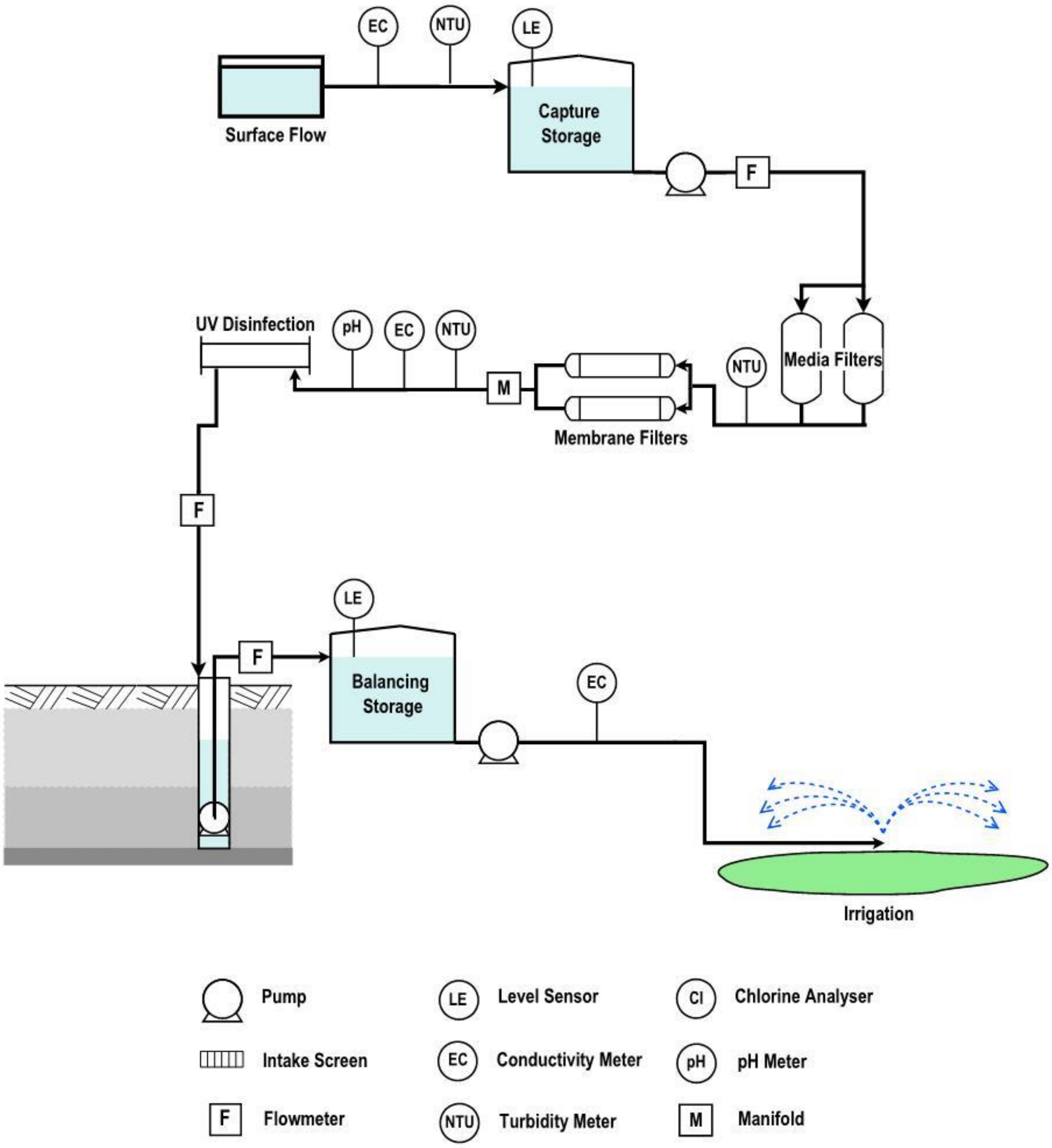


Figure 29 presents the process flow diagram for Concept 8 whilst Figure 30 provides a spatial representation. **Table 32** presents the water balance for the system and **Table 33** presents the water supply concept components. This concept assumes a harvest volume of up to 5,000 ML to ultimately supply 4,000 ML following losses through the system. This may be impacted by climate variability, monitoring of the flows and water quality is required to accurately predict a reliable harvest volume.

Water quality variability (e.g. suspended solids or salinity) is currently unknown, water quality monitoring in the form of grab samples for a broad range of contaminants and inline monitoring of salinity, turbidity and pH is recommended to refine the treatment process required to achieve the reliable harvest volume. This concept considers a high level of treatment due to the data gaps and risk around source water quality and the receiving aquifer risk profile. Additional assessments will assist in determining the level of treatment required.

The drains are managed by Water Corporation and approval to access the infrastructure would be required. The take of water from the drain is not currently prescribed.

The water supply concept has the opportunity to be implemented in a staged approach to meet demand requirements or budget expenditure. The timing of the development of the agri-precinct is unknown, therefore a staged approach assists the SSJ to manage their risk.

The concept adopts an above ground balancing storage dam, this facility could be constructed in a way to provide public amenity and provide recreational facilities (land based only), this has not been incorporated into the cost estimate at this stage.

Table 32: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from Punrack Main Drain / Karnet or Dirk Brooks	5,000 ML/a total assumed to be 2,500 ML/a per drainage feature	Flow monitoring data indicates that flows in the order of 800 ML/d occur during rainfall events. Based on rainfall and 150 days of available harvest, an extraction rate of 285 L/s is required from each drainage ling based on 16 hours of operation per day. Depending on the configuration of the drainage line, a single offtake point may be feasible.
Balancing Storage / Capture Storage	100 ML	Balancing storage provides flexibility in the operation of the system to manage injection and extraction rates, provide treatment or holding times. The flow in the drains may be such that a high extraction rate is required to capture the higher rainfall events, having a balancing storage allows for continual injection (not just limited to rainfall periods) which reduces the number of bores required. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water).
Water Treatment and Aquifer Replenishment	Injection rate of 25 L/s Number of bores 23 Treatment Rate 570 L/s	Aquifer injection rates, depending on the aquifer characteristics, range between 25 L/s and 40 L/s. To be conservative an injection rate of 25 L/s has been adopted. If higher rates are achieved the number of bores can be reduced. The number of bores is based on the injection rate of 25 L/s, 16 hours a day over 150 days of operation and a target daily recharge rate of 33 ML/d.
Irrigation Supply	4,000 ML/a	Assuming losses through the system from evaporation, backwash, scour and for environmental benefit the losses are assumed to be 20%.

Table 33: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Surface water from Karnet or Dirk Brook / Punrack Drain. Pumps to harvest water from each locations and transfer water to a centralised balancing storage.	No significant variation to the drain has been proposed other than the installation of the harvest offtakes. To manage the level in the drain multiple harvest locations have been proposed, based on a flow rate of 285 L/s at each drainage feature. Transfer infrastructure from each harvest location will be required to transfer water to the balancing storage. A nominal 5 km of transfer pipework has been adopted. This will vary depending on the location of the harvest points and the balancing storage.
Balancing Storage and Transfer Lines	An above ground balancing storage dam with a storage capacity of 100 ML has been adopted	A 100 ML dam has been adopted, covering an area of approximately 260 x 260 m. Acquisition of the land has not been incorporated into the cost analysis component. This storage may be in the form of a single basin or two smaller basins (one for raw source water and one for treated water). Transfer infrastructure from the balancing storage to the treatment facility and to the 23 production wells has been assumed to be 5 km of pipe. Scour of the production wells is required and is assumed to be transferred to a disposal location. A nominal 5 km of pipe has been assumed.
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for media filter, membrane filter, UV treatment and chlorination system. Valves, gauges and non-return valves included. If a lower level of treatment is considered acceptable membrane filtration may not be required.
Storage using ASR Typically, replenishment will be carried out in winter and recovery during summer, however this	Based on a volume of 5,000 ML/a, an injection rate of 25 L/s, 153 recharge days and 16 hours a day operation. 23 ASR bores are required. The target aquifer is either the Leederville, Yarragadee or Cattamara Coal Measures depending on	Installation of 23 production bores assuming not suitable bores exist. Installation of five monitoring bores.

Parameter	Discussion	Allowance
approach may vary depending on future rainfall patterns.	yield, location, risks and surrounding users. The depth to aquifer will vary depending on the system. A nominal bore depth of 250 m bgl has been adopted. Monitoring bores targeting the same formation and shallow systems are likely to be required. Five monitoring bores have been adopted.	Headworks infrastructure, pump infrastructure and monitoring infrastructure. SCADA system allowance and inline water quality and pressure monitoring. Pump Infrastructure has been included as the facility to scour is required.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Hydrogeological Investigations Functional Design Risk Assessment and Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site - specific irrigation infrastructure has not been considered. If transfer infrastructure is required a transfer pump and 20 km of pipe to the agricultural precinct. Ultimately, the use of transfer credits in the aquifer so users can extract water from an onsite bore is the priority approach. This assumes that the groundwater at the end user location can be taken (i.e. is of suitable quality, there is no risk to the environment or human health).	Final design would need to consider onsite irrigation infrastructure. Assumes 20 km of transfer pipework. If credit transfers are viable, the cost for the installation of additional bores has not been incorporated.
Operational and Maintenance Costs	An allowance for O&M costs have been included.	Operation including staff. Maintenance requirements.

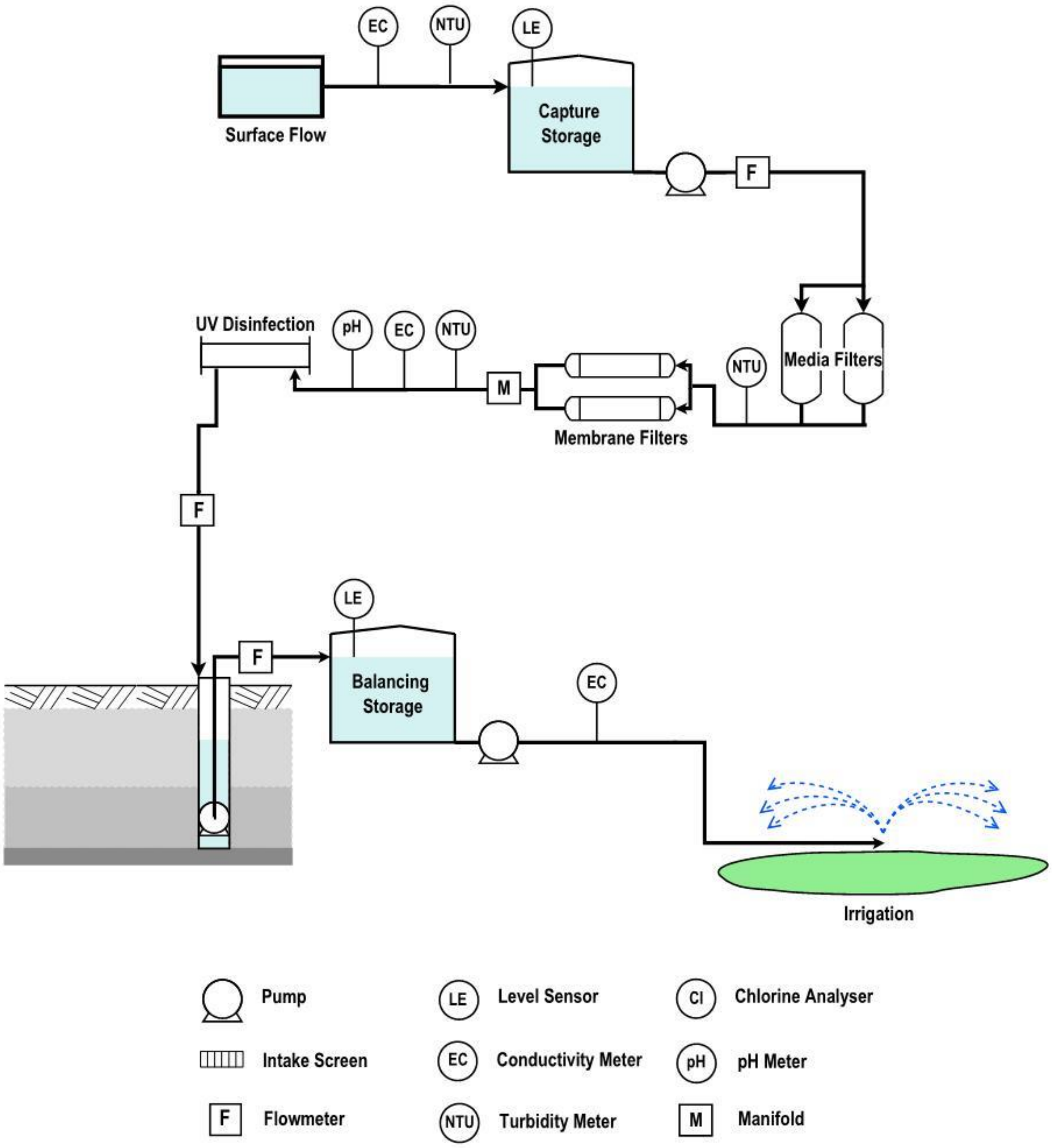


Figure 29: Operational Process Chart – Option 8

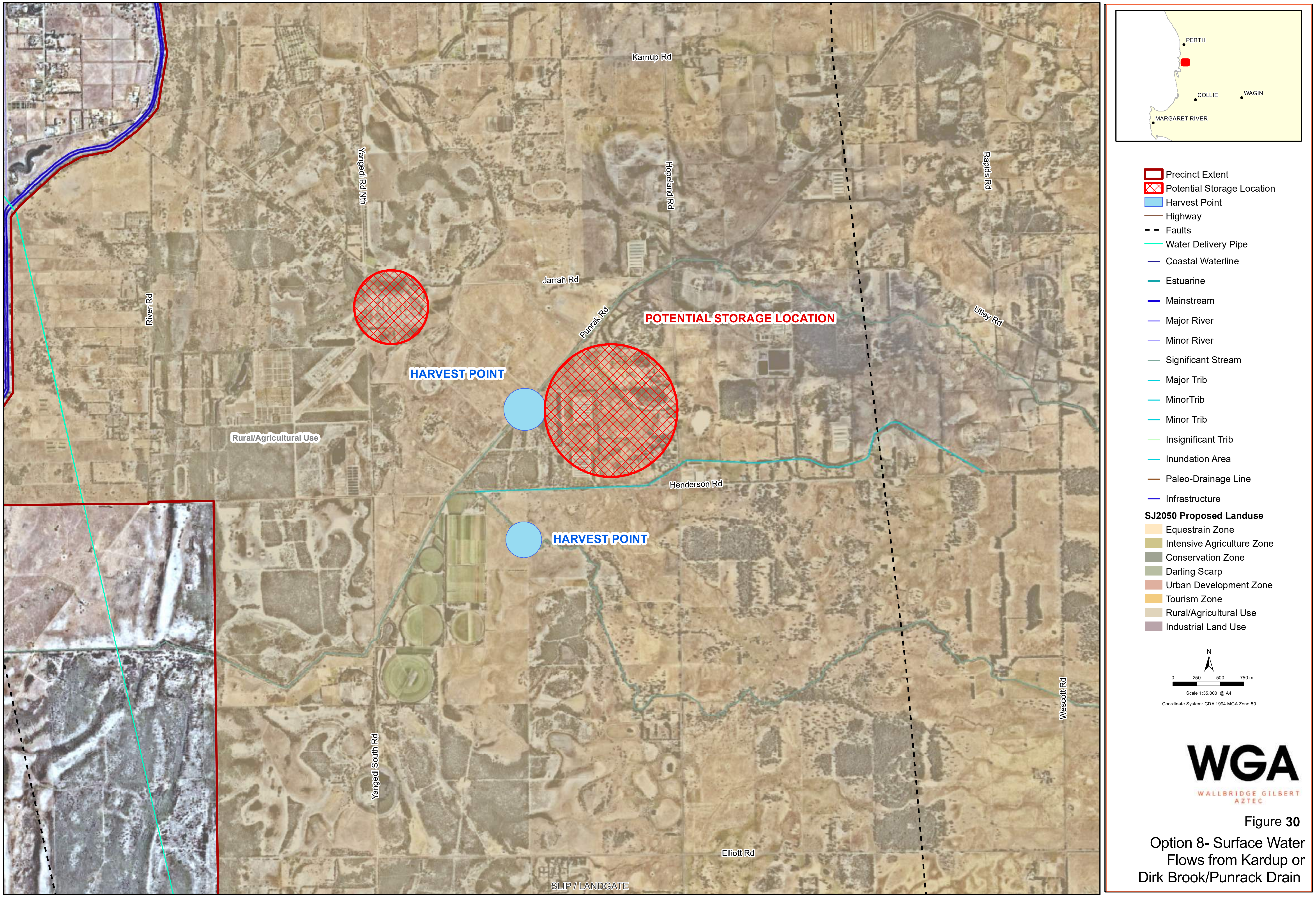


Figure **30**

Option 8- Surface Water Flows from Kardup or Dirk Brook/Punrack Drain

5.12.2 Cost Estimate

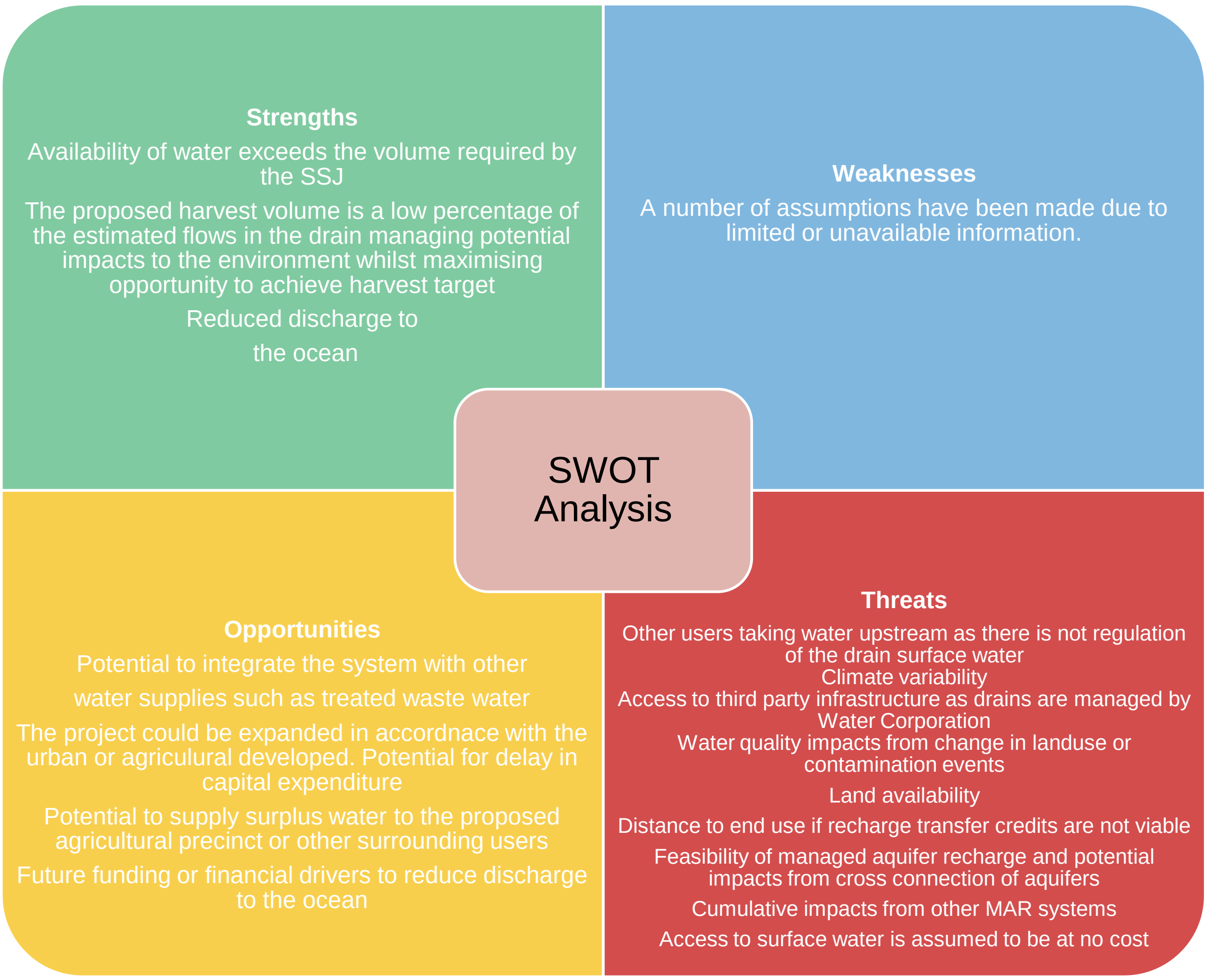
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in **Table 34** with a summary of breakdown and assumptions area presented in **Appendix D**

Table 34: Summary of Cost Estimate – Option 8

CAPEX	$74,597,000
OPEX	$3,112,500
NPV (4-7% Real Discount Rate)	$2.15-2.60 / kL

5.12.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of the SSJ maintained land but also provides an opportunity for the agricultural precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.12.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information; additional information would be required to address these components. Table 35 provides a recommended forward program of works for this conceptual design.

Table 35: Forward Program of Works – Option 8

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume – estimated volumes are based on high level square modelling. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out water quality grab samples for a broad range of analysis based on the catchment land use. Survey of both drainage lines and drain to identify ideal harvest locations and system location.
	The drains are the responsibility of Water Corporation, therefore access to the surface water would require their approval.	Seek confirmation from Water Corporation regarding access entitlements.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. It is strongly recommended that these investigations are to be completed prior to the detailed design. The aquifer performance can have a significant impact on the borefield spacing and layout which can have significant cost implications for transfer pipework. The use of transferred recharge credits will minimise or negate the requirement of distribution transfer infrastructure.	Detailed desktop study Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.
Demand Forecast	The demand forecast for the SSJ will be based on development and the construction of public open space in response to increased urbanisation. SSJ indicated that, if surplus water was identified, consideration could be given to supply for agriculture. The demand time for recycled water for agriculture is unknown and is based on the rate of development, end use and reduction or limitation in groundwater use allocations. This recommendation relates to the agricultural component only and is not required to meet SSJ irrigation requirements.	Participant in industry forums or engage with industry to understand the demand and willingness/ capacity to pay for recycled water for agricultural purposes. The development of the system may take several years therefore timing in conjunction with the industry is critical.

5.13 HOPELAND – SERPENTINE – KEYSBROOK WATER SUPPLY OPTION 9 – CONSTRUCTION OF A DECENTRALISED WASTEWATER SYSTEM IN SERPENTINE

5.13.1 Overview

The township of Serpentine is predicted to grow from 1,800 people to 10,000 by 2050. Wastewater in the area is managed through onsite septic systems. The construction of a decentralised wastewater system is required to support the predicted residential growth. The adoption of a septic based system which discharges to the shallow groundwater system is not consider environmentally viable at the predicted population. There are several different designs for community-based wastewater systems, to determine the most appropriate approach would require a detailed study of the area including survey.

Figure 31 presents the process flow diagram for option 9 whilst **Figure 32** provides a spatial representation. **Table 36** presents the water balance for the system and **Table 37** presents the water supply concept components. This concept assumes a harvest volume of 150 ML to ultimately supply 120 ML/a following losses through the system. The potential volume from a decentralised system will depend on the residential area serviced by the system. The concept does not consider retrofitting of the septic tanks of the existing residents, but this could be considered in the future with a STEDS Septic Tank Effluent Drainage scheme being one option for increasing the serviced area.

Table 36: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – wastewater from a decentralised community system	150 ML/a	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 300 ML/a.
Sewer Network	Nil	The sewer network is considered to be a component installed by the developer therefore has not been included in the cost analysis.
Above ground storage	A combined above ground storage capacity of untreated, treated and emergency storage. A 60 ML storage facility has been adopted	The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses services.
Water Treatment	Treatment Rate 10 L/s	A treatment rate of 10 L/s has been adopted based on the expected daily flow. Primary, secondary and tertiary treatment.
Irrigation Supply	120 ML/a Irrigation Distribution Network 10 km	Assuming losses through the system from evaporation and backwash the losses are assumed to be 20%. Irrigation Distribution Network of 10 km has been adopted.

Table 37: Water Supply Concept Components

Parameter	Discussion	Allowance
Treated Water and Network	Volume has been based on the predicted residential growth in the area. Depending on occupancy and timing of the implementation, a supply volume could be up to 600 ML/a. It is assumed that no land acquisition is required to install the infrastructure.	150 ML/a source water
Treatment	The level of treatment will depend on the end use or if required disposal location.	Allowance has been made for balancing tank, primary and secondary treatment. Valves, gauges and non-return valves included. If a lower level of treatment is considered acceptable membrane filtration may not be required.
Above Ground Storage	A combined above ground storage capacity of untreated, treated and emergency storage. The size of the storage volume will depend on a winter irrigation demand (i.e. industry or agriculture) and the final number of houses services.	A 60 ML storage facility has been adopted.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. A nominal 10 km of distribution infrastructure has been adopted.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

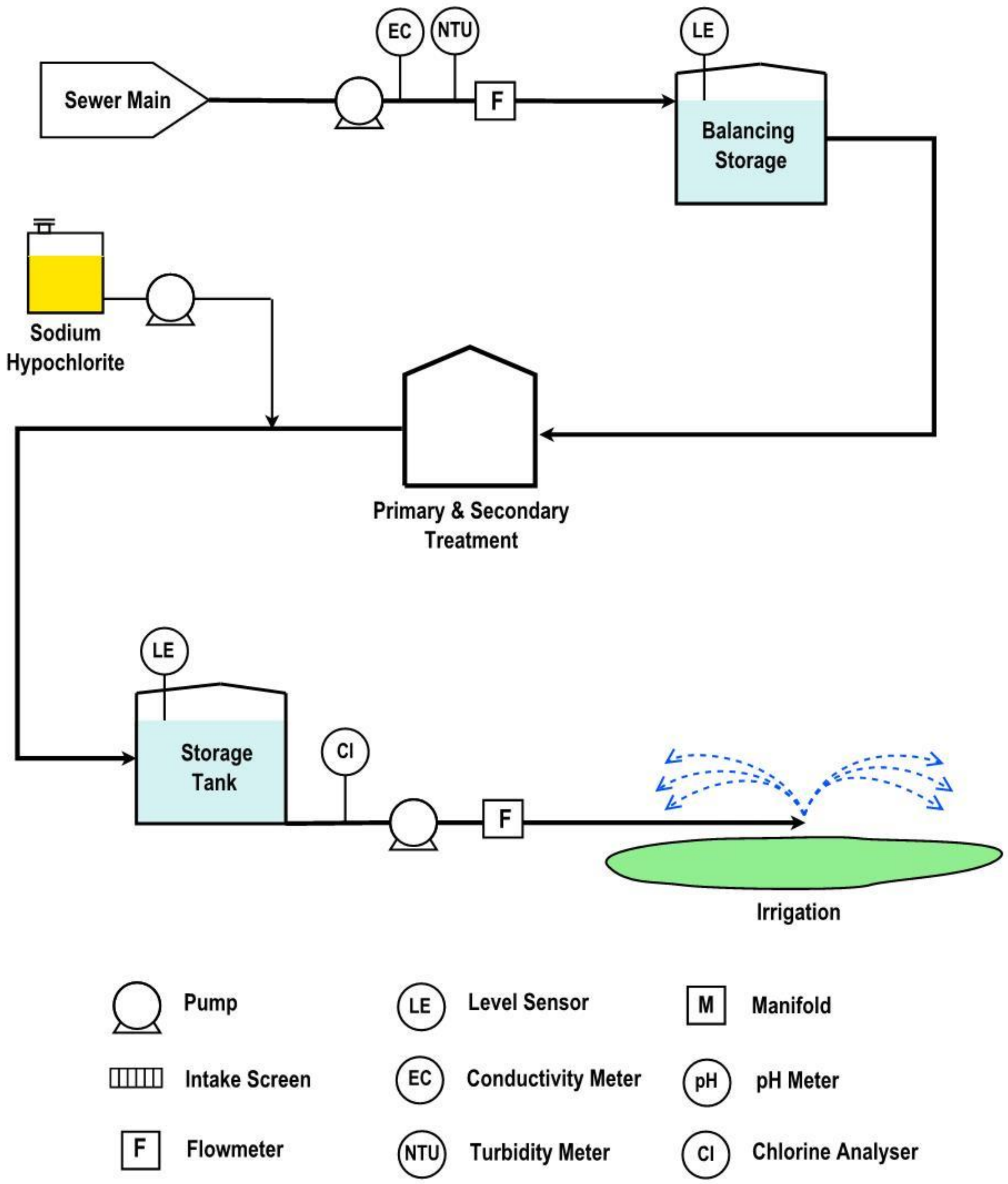


Figure 31: Operational Process Chart – Option 9

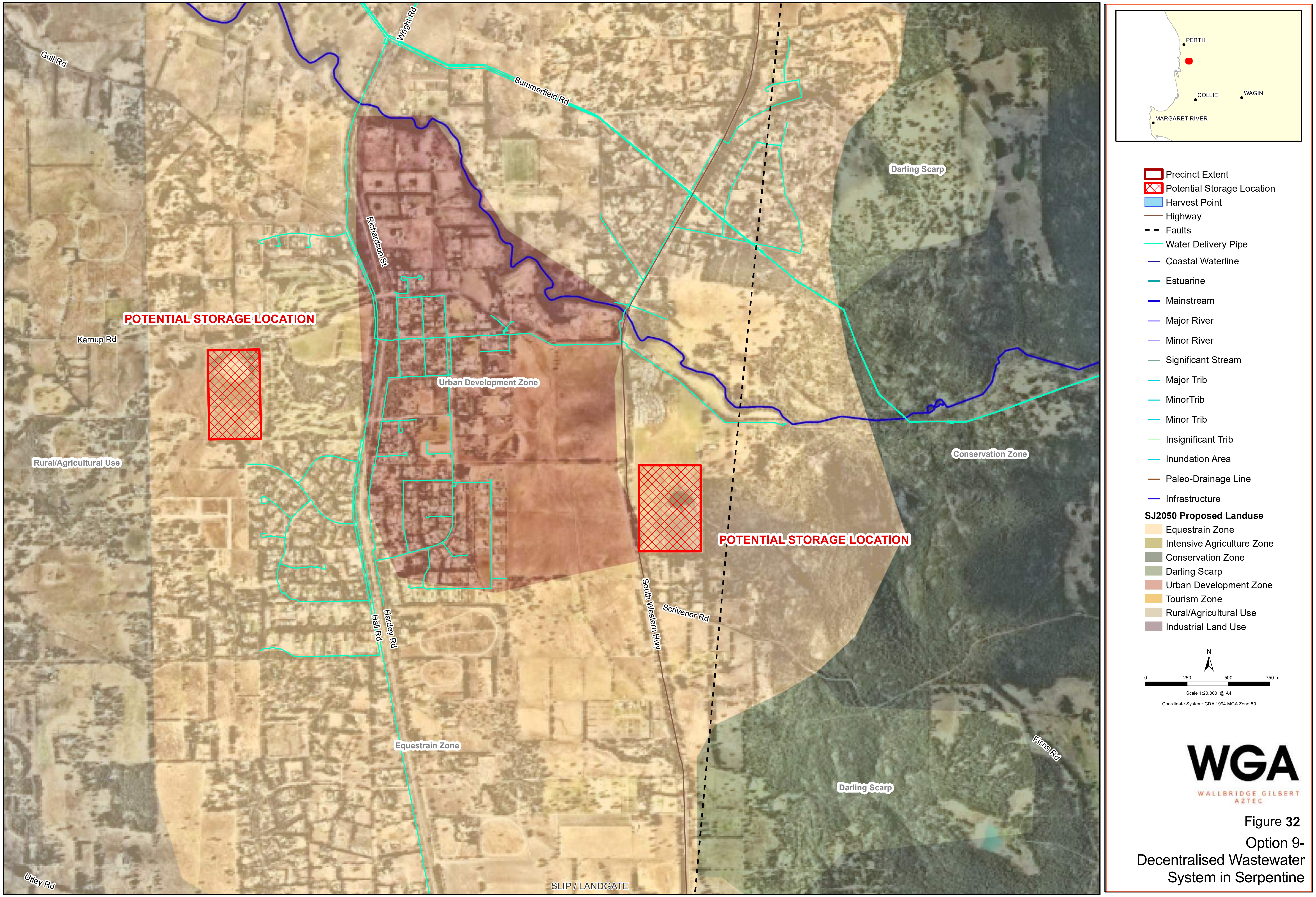


Figure 32
Option 9- Decentralised Wastewater System in Serpentine

5.13.2 Cost Estimate

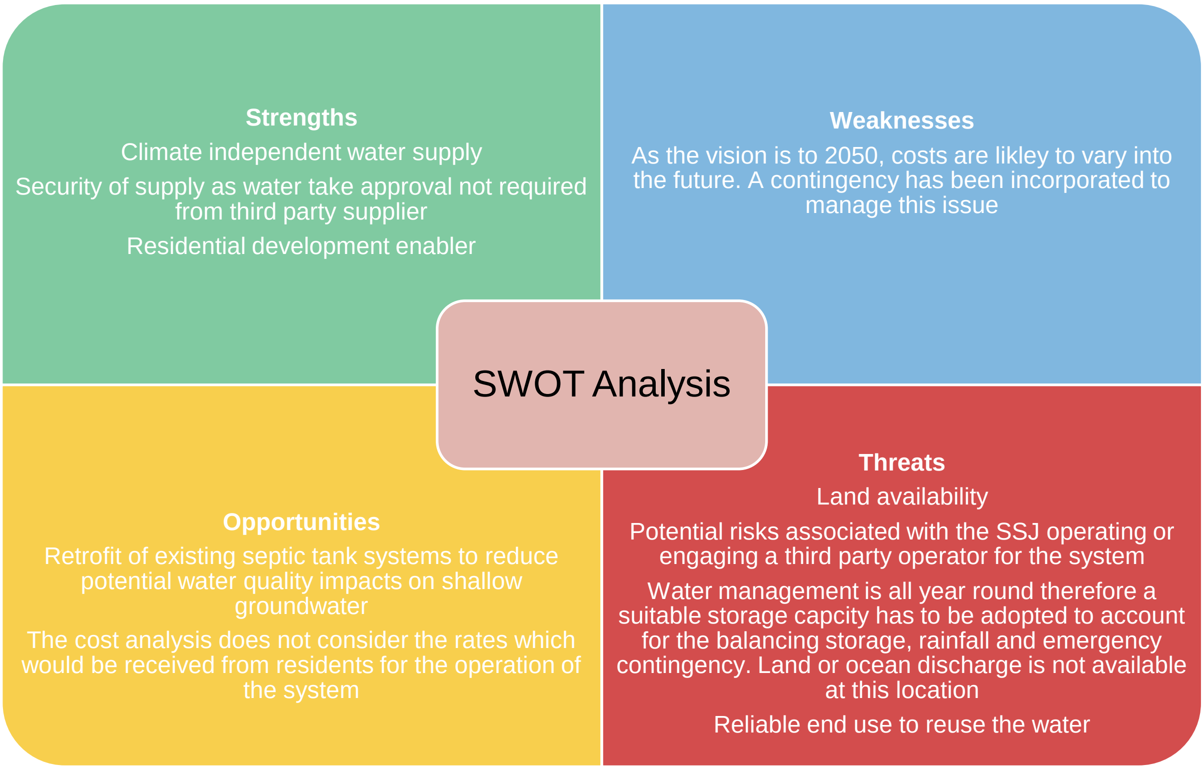
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in **Table 38** with a summary of breakdown and assumptions area presented in **Appendix D**

Table 38: Summary of Cost Estimate – Option 9

CAPEX	$8,978,000
OPEX	$1,345,500
NPV (4-7% Real Discount Rate)	$2.45-$2.75

5.13.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the majority of the requirements for irrigation in the township of Serpentine. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.13.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information; additional information would be required to address these components. Table 39 provides a recommended forward program of works for this conceptual design.

Table 39: Forward Program of Works – Option 9

Data Gap	Risk	Forward Program of Work
Partnering Opportunities	Identifying a suitable operator or partner for the system is critical for either sewer mining or a decentralised system.	Identify potential partnering opportunities.

5.14 HOPELAND – SERPENTINE – KEYSBROOK WATER SUPPLY OPTION 10 – GALLERY RECHARGE INTO DECOMMISSIONED OPEN PIT MINES

5.14.1 Overview

The region is known to have shallow groundwater and during the winter period or high rainfall events, ponding or flooding occurs. A number of drains have been constructed across the region to capture shallow water or surface drainage water and divert it to the ocean. Salinity monitoring in the Punruck Drain indicates that brackish groundwater discharges into the drain during the drier summer months. The salinity of groundwater in the vicinity of Hopeland is between 250 and 1,000 mg/L. The depth to water decreases closer to the ocean, in the western parts of the Hopeland – Serpentine – Keysbrook region the depth to groundwater is approximately 10 m below ground level.

Recharge to the shallow groundwater system was discounted in the preliminary long options due to the risk associated with exacerbating the water ponding and flooding conditions. The opportunity to recharge the shallow system using decommissioned open pit sand mines has been discussed and is being considered in this concept. This is a relatively new approach and therefore the concept has some risk and requires further investigations to determine the level of risk and treatment requirements. Further investigations will allow for modification of the concept to better understand the cost implications. The current concept design does not appear financially viable, however, if water prices increase, water scarcity increases, or technology or legislation changes then the concept may become viable.

The primary risk associated with this concept is the storage capacity of the unconfined Superficial Aquifer. Hydrogeological investigation to determine the storage capacity would be required to further assess the risk of water logging. For the purpose of this concept the open pit will be considered a recharge gallery as the base and sides would intersect the highly permeable sand layers. The intent would be to recharge at the nominated location and, using recharge credits, extract groundwater at the irrigation location in the township of Serpentine.

The SSJ has identified two registered open pit sand mines that have a limited life span, which may be suitable to adopt as recharge galleries. One is located close to Karnet Brook suggesting that the groundwater would be shallow and potentially connected to the drainage line. Recharge at this location may result in increased recharge to the drainage channel, which does not meet the intent of the concept.

The second mine is located to the west of Karnet Brook, closer to Hopeland. This location is likely to have a higher aquifer storage potential without the risk of increased groundwater recharge to surface features. For the purpose of this concept, a recharge volume of 50 ML/a has been adopted, however, the aquifer storage capacity and recharge rates require investigation.

The water would be sourced from Karnet Brook which is located approximately 2 km to the east of the site. There exists a risk that, over time, the recharge rates will reduce due to groundwater mounding to the base of the pit. This would result in limited to nil recharge through the base, however, recharge radially through the pit walls may still occur. Distribution infrastructure has not been incorporated as it has been assumed that recharge transfer credit can be adopted at this site.

The source water quality is unknown therefore the level of treatment is unclear, due to the low proposed recharge volumes, a moderate level of treatment has been proposed.

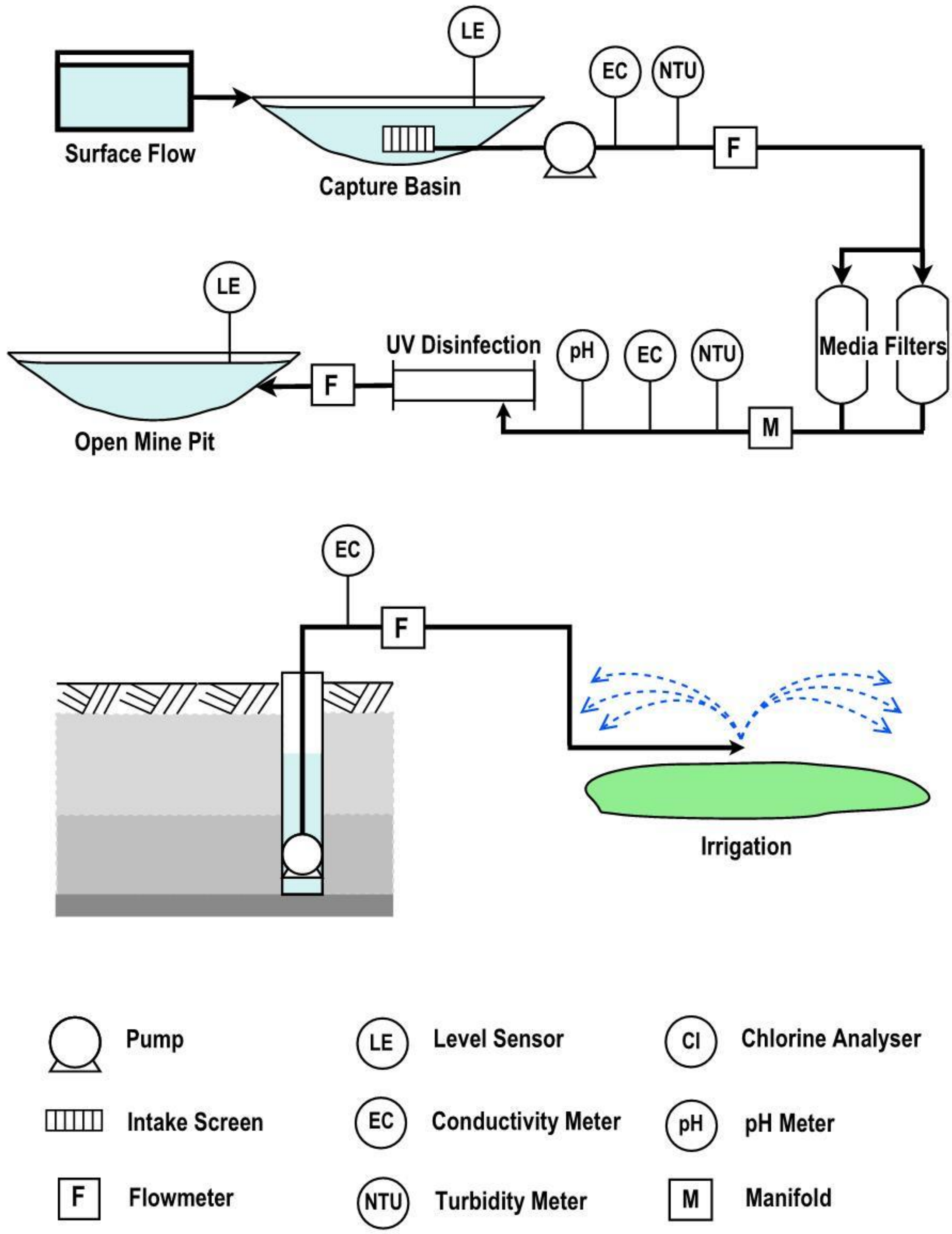


Figure 33 presents the process flow diagram for Concept 10 whilst Figure 34 provides a spatial

representation. **Table 40** presents the water balance for the system and **Table 41** presents the water supply concept components. This concept assumes a harvest volume of 50 ML to ultimately supply 40 ML following losses through the system.

Table 40: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from Karnet Brook	50 ML/a	Flow monitoring or catchment modelling data is not available for the creek line. Based on the harvest of 50 ML over 75 days and 16 hours a day operation, a harvest rate of 10 L/s is proposed.
Above ground storage and Aquifer Replenishment – existing open pit sand mine	Existing decommissioned open pit sand mine assumed recharge rate of 10 L/s	The aquifer recharge rate will be limited the extraction rate or the requirement for additional balancing storage. A recharge rate of 10 L/s across the mine pit is considered acceptable and no balancing storage has been adopted.
Irrigation Supply	40 ML/a	Assuming losses through the system from aquifer losses are assumed to be 20%.

Table 41: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water and Transfer Lines	Water from Karnet Brook and 2 km of transfer main to deliver 10 L/s.	A pump to transfer water from the creek line at 10 L/s. A nominal 2 km of transfer pipework
Treatment	Depending on the risk assessment of the environment and human health impacts, the minimum water quality requirements may be high. Additional information of the source water, aquifer and end use is required to confirm the treatment requirements.	Allowance has been made for a media filter. Valves, gauges and non-return valves included.
Storage using open pit as a recharge gallery **Typically, replenishment will be carried out in winter and recovery during summer, however, this approach may vary depending on future rainfall patterns.**	Monitoring bore targeting the same formation and shallow systems may be required. A single monitoring bore has been adopted to a depth of 20 m below ground level.	Installation of two shallow monitoring bores. SCADA system allowance and inline water quality and pressure monitoring.

Parameter	Discussion	Allowance
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Hydrogeological Investigations Functional Design Risk Assessment and Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure including groundwater wells have not been considered. The use of transfer credits in the aquifer so users can extract water from an onsite bore has been assumed.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

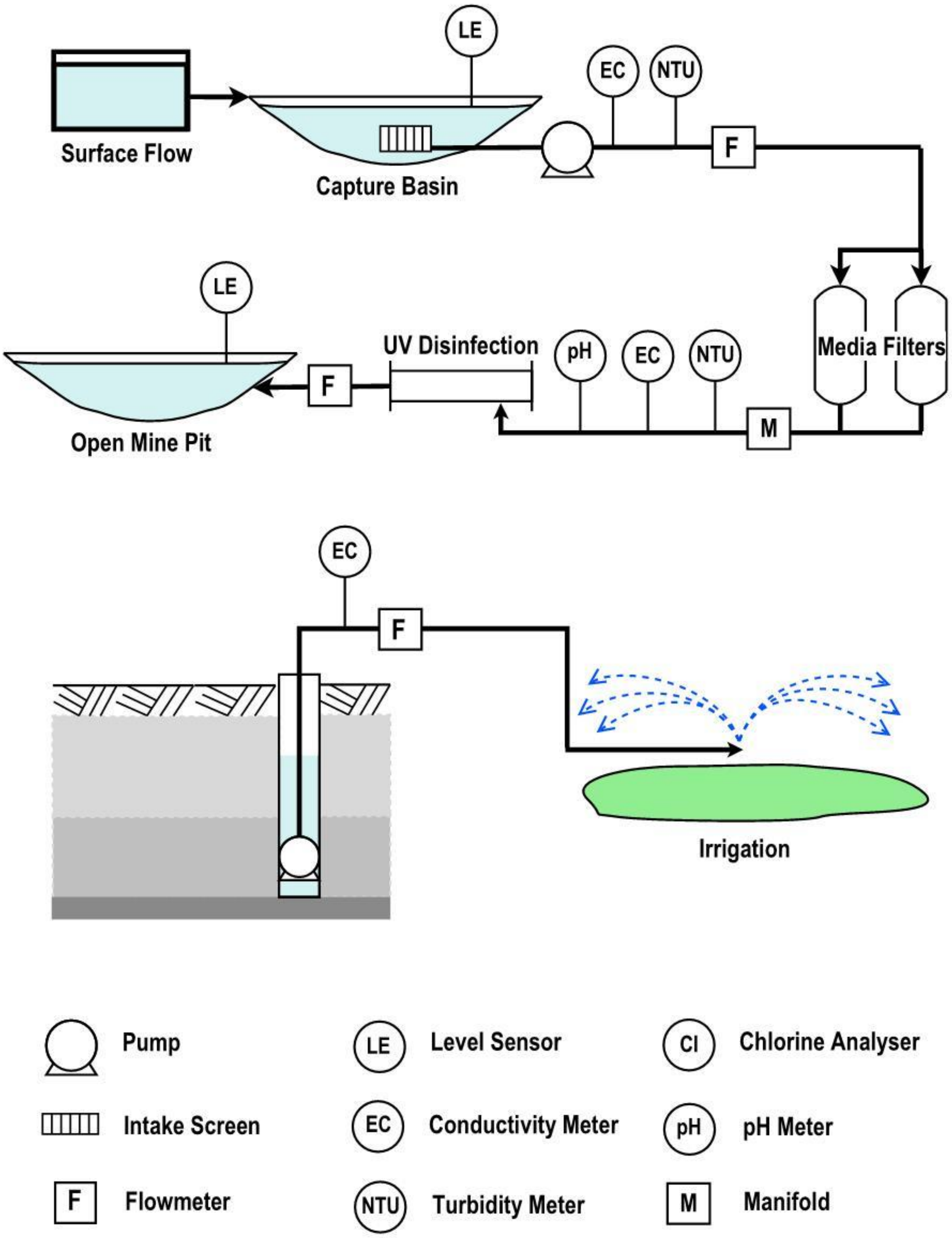


Figure 33: Operational Process Chart – Option 10

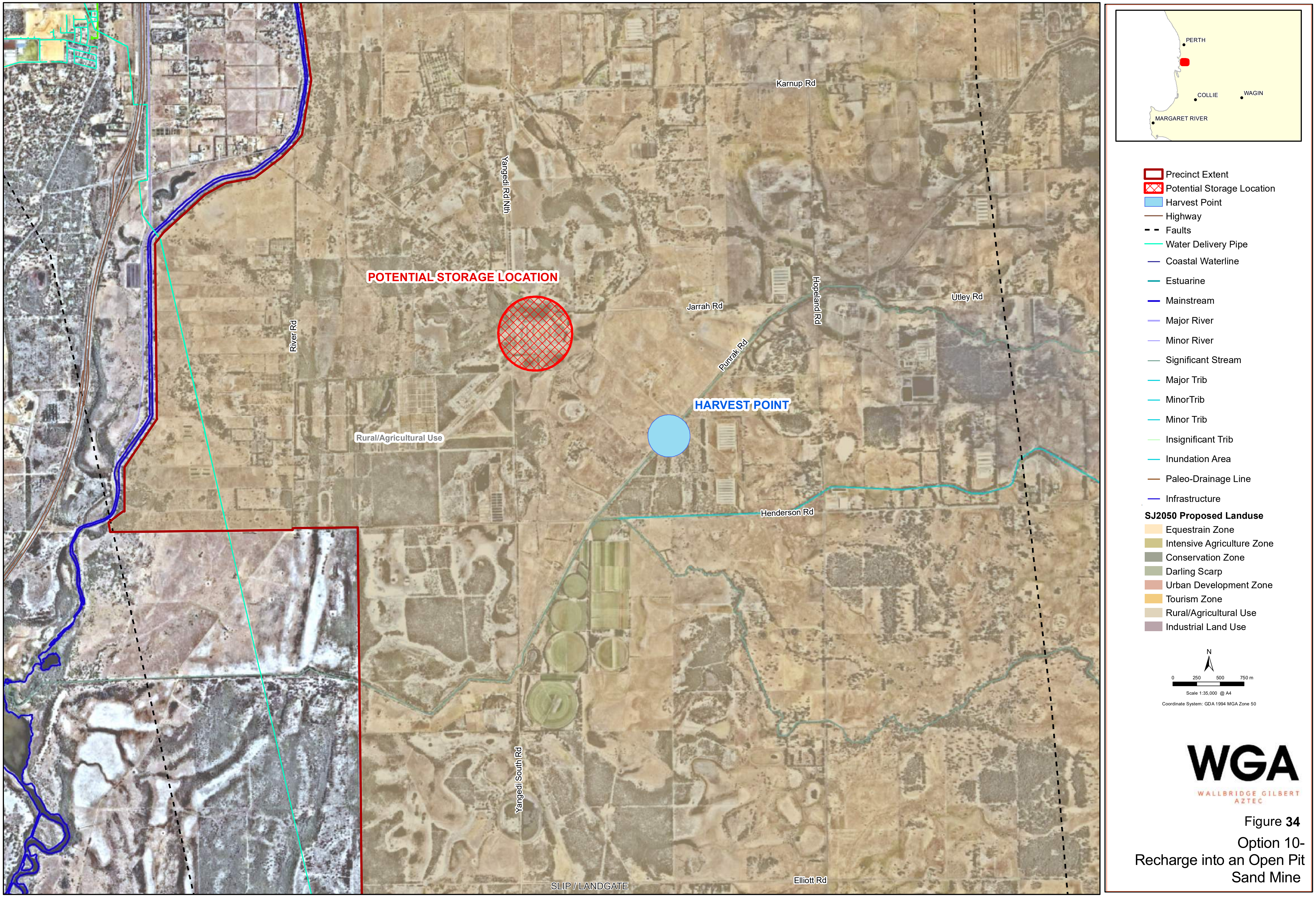


Figure **34**
Option 10-
Recharge into an Open Pit
Sand Mine

5.14.2 Cost Estimate

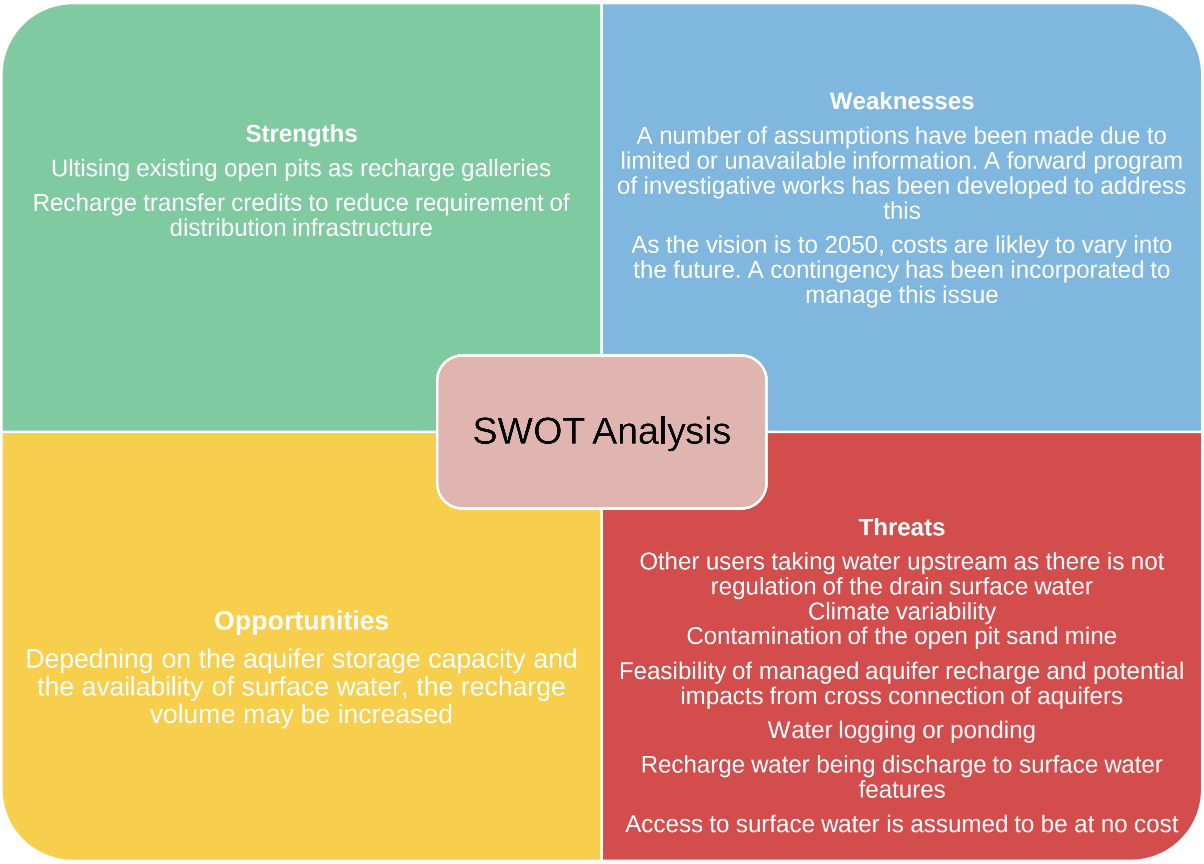
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in **Table 42** with a summary of breakdown and assumptions area presented in **Appendix D**

Table 42: Summary of Cost Estimate – Option 10

CAPEX	$2,020,000
OPEX	$295,000
NPV (4-7% Real Discount Rate)	$10.25 -11.45 / kL

5.14.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation of this precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.14.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information; additional information would be required to address these components. **Table 40** provides a recommended forward program of works for this conceptual design.

Table 43: Forward Program of Works – Option 10

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume is unknown. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Conduct flow (rate and timing) monitoring of the creek line. Carry out water quality insitu (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Discuss any permitting requirements with the relevant authorities. Confirm with DWER the requirements to harvest water from the drainage basin.
Managed Aquifer Recharge	A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to determine the risk of water logging or ponding. The assessment can be completed in a staged approach to allow for sufficient hold points to identify any significant project risks. It is highly recommended that these investigations are to be completed prior to the detailed design.	Detailed desktop study Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.

5.15 WATER SUPPLY OPTION 11 – SURFACE WATER HARVEST FROM GOORALONG BROOK

5.15.1 Overview

The township of Jarrahdale currently sources water for irrigation from Water Corporation's scheme supply. Irrigation of public open space in the area is limited with approximately 3 ML sourced annually. The SSJ has identified that redevelopment of the Jarrahdale Oval Facility as one of their key community projects, currently the oval is not irrigated and is considered to be of a suitable standard for sporting or community events. The sporting facility is expected to have one senior sized sporting oval and associated facilities.

The township's permanent residential population is not expected to grow; however, the tourism / recreational community is expected to increase due to access to the state forest and the Millbrook Winery, which is a world-class popular destination for food and wine enthusiasts. The SSJ tourism strategy (Economic Development Advisory Committee, 2018) has identified the development of a tourist park (refer to Section 2.4) to service overnight and holiday visitors. The facility is designed to accommodate the equestrian community with facilities for stables, float parking and exercise areas. The demand for water for this development will include potable supplies as well as washdown and irrigation.

This concept considers harvesting of surface water from Gooralong Brook during winter for storage in above ground tanks or a dam structure for supply during summer via a pipe distribution network. Flow monitoring of the drainage line is not available and upstream dam structures are noted as being present which may impact yield. Flow and water quality monitoring is recommended to determine the reliable harvest volume and to inform the detailed design. The supply volume estimate is likely to be in the order of 20 to 200 ML/a. For the purpose of this conceptual design, a supply volume of 50 ML/a has been adopted as this will meet the irrigation requirements and a portion of the tourist park washdown requirements. The source water quality is unknown therefore the level of treatment is unclear, due to the low proposed recharge volumes, a moderate level of treatment has been proposed.

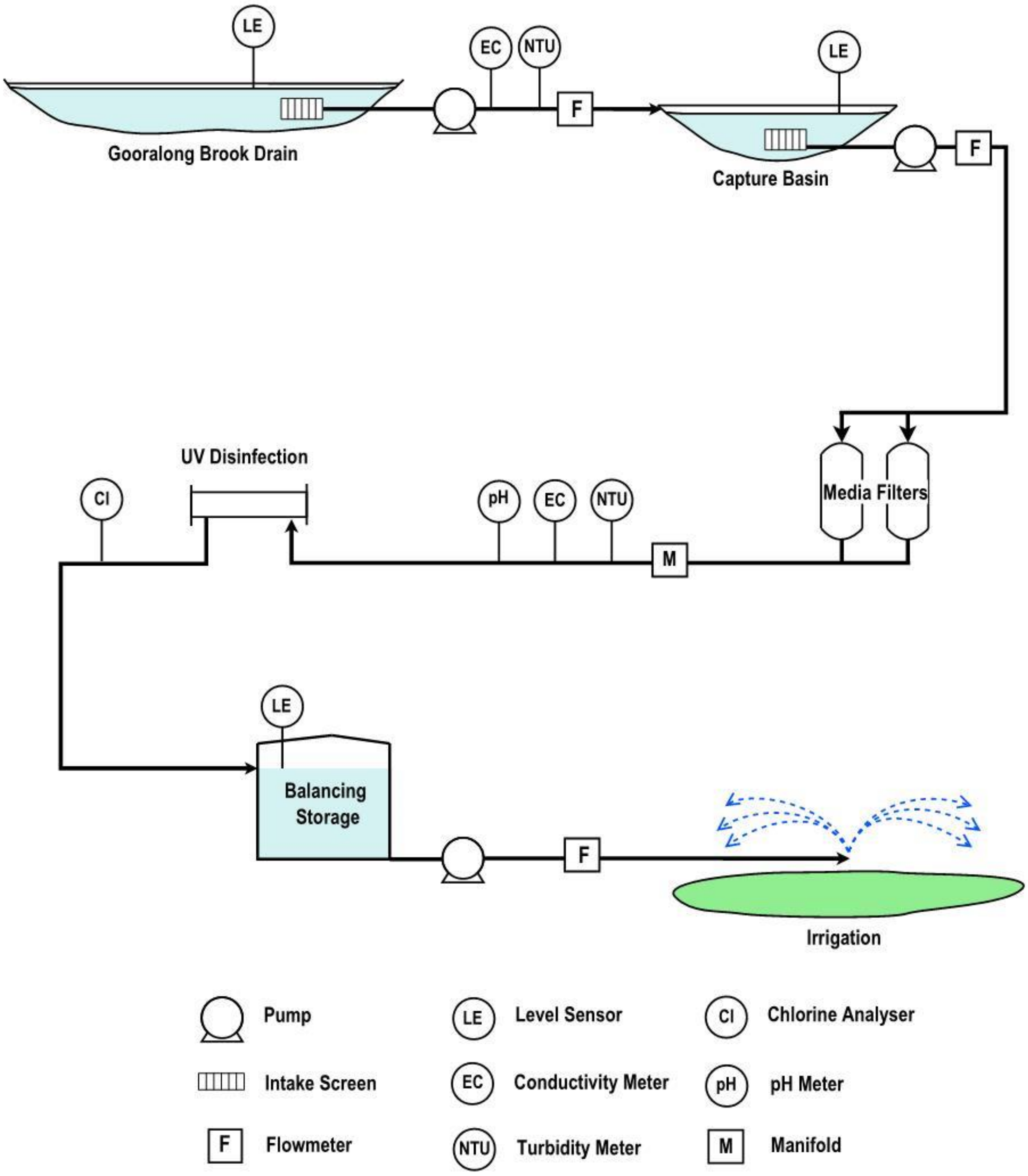


Figure 35 presents the process flow diagram for Concept 11 whilst **Figure 36** provides a spatial representation. **Table 44** presents the water balance for the system and **Table 45** presents the water supply concept components. This concept assumes a harvest volume of 50 ML to ultimately supply 40 ML following losses through the system.

Table 44: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – surface water from Gooralong Brook	50 ML/a	Flow monitoring is not available and catchment modelling has not been carried out. Based on the harvest of 50 ML over 75 days and 16 hours a day operation, a harvest rate of 12 L/s is proposed.
Above ground storage –drainage basin	One above ground structure with a 40 ML capacity A 200 kL balancing tank.	40 ML above ground storage facility A post treatment balancing tank of 200 kL will also be included.
Water Treatment	Treatment Rate 10 L/s	Peak demand will be during summer and holiday periods.
Irrigation Supply	40 ML/a	Assuming losses through the system from evaporation, backwash, the losses are assumed to be 20%.

Table 45: Water Supply Concept Components

Parameter	Discussion	Allowance
Source Water, above ground storage and Transfer Lines	Water from Gooralong Brook to the above ground storage facility.	A 40 ML above ground storage facility. A pump to transfer water from the brooke at 12 L/s. Transfer of water from the dam to the treatment facility.
Treatment	Depending on the end use and potential for environment and human health impacts, the minimum water quality requirements may be high. For the purpose of this assessment a moderate level of treatment has been adopted.	Allowance has been made for media filter and chlorination system. Valves, gauges and non-return valves included. A balancing storage tank of 200 kL has been adopted.

Parameter	Discussion	Allowance
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Hydrological Investigations Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. A nominal 1 km of distribution pipe has been allowed for.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

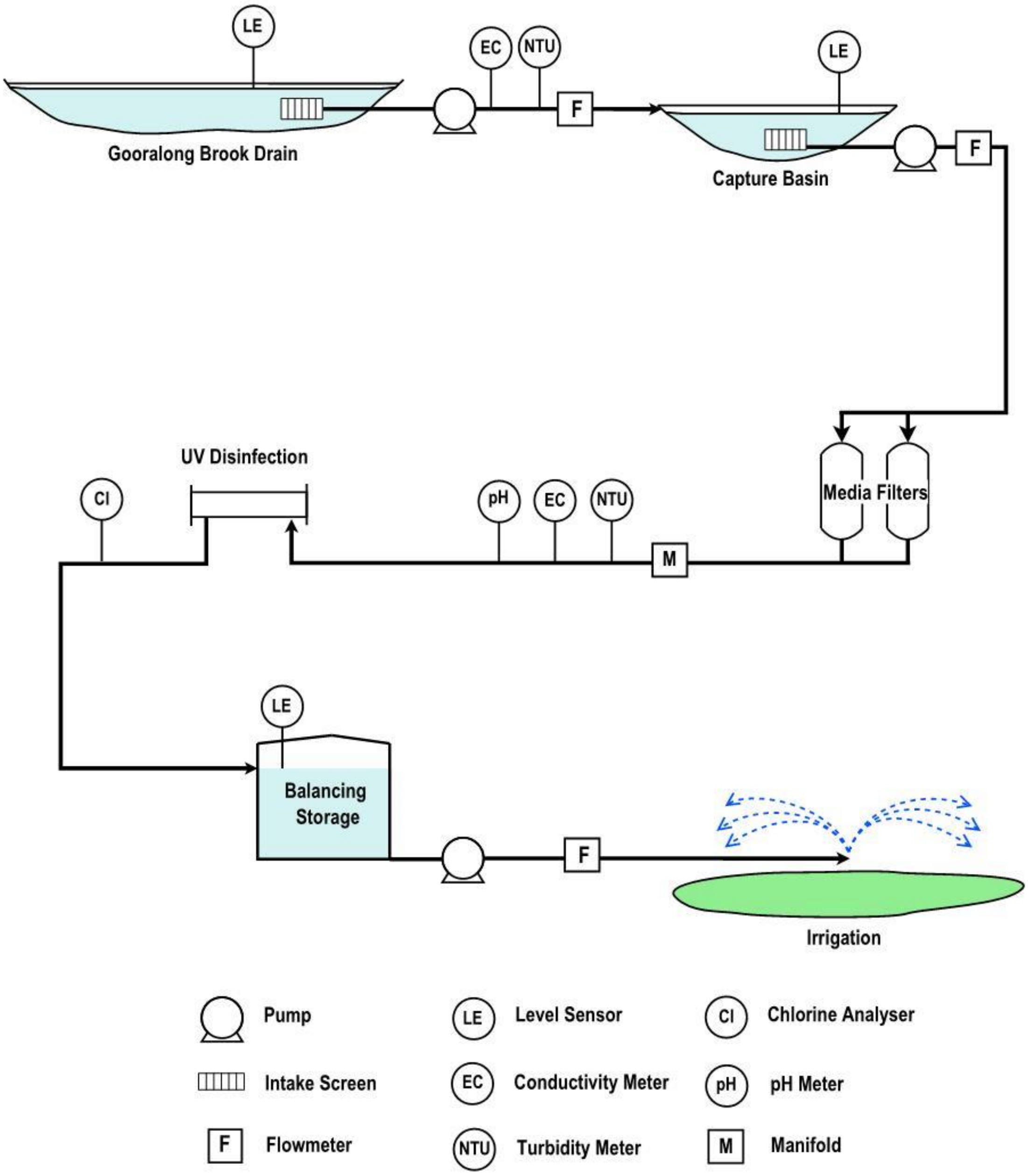


Figure 35: Operational Process Chart – Option 11

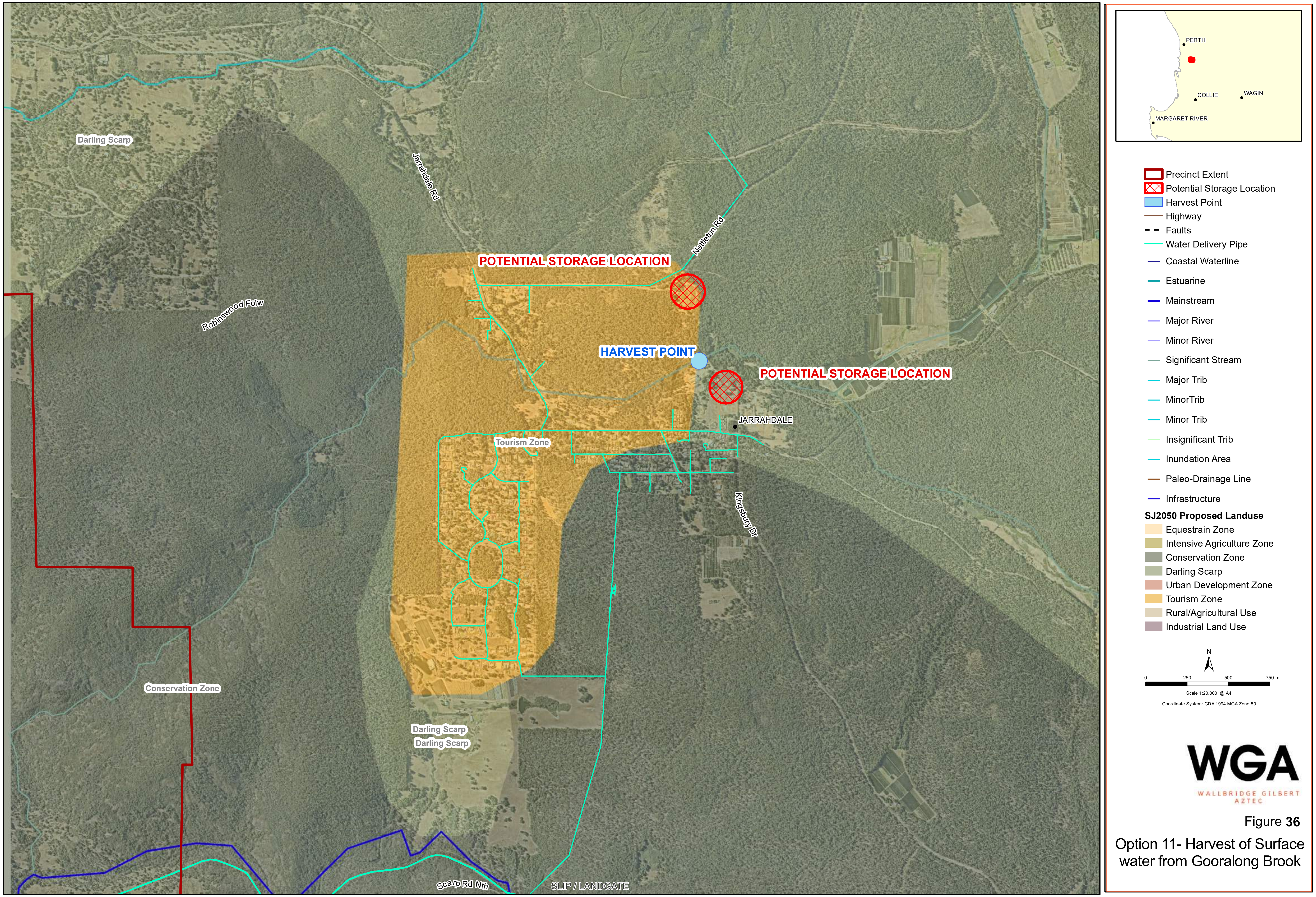


Figure 36

Option 11- Harvest of Surface water from Gooralong Brook

5.15.2 Cost Estimate

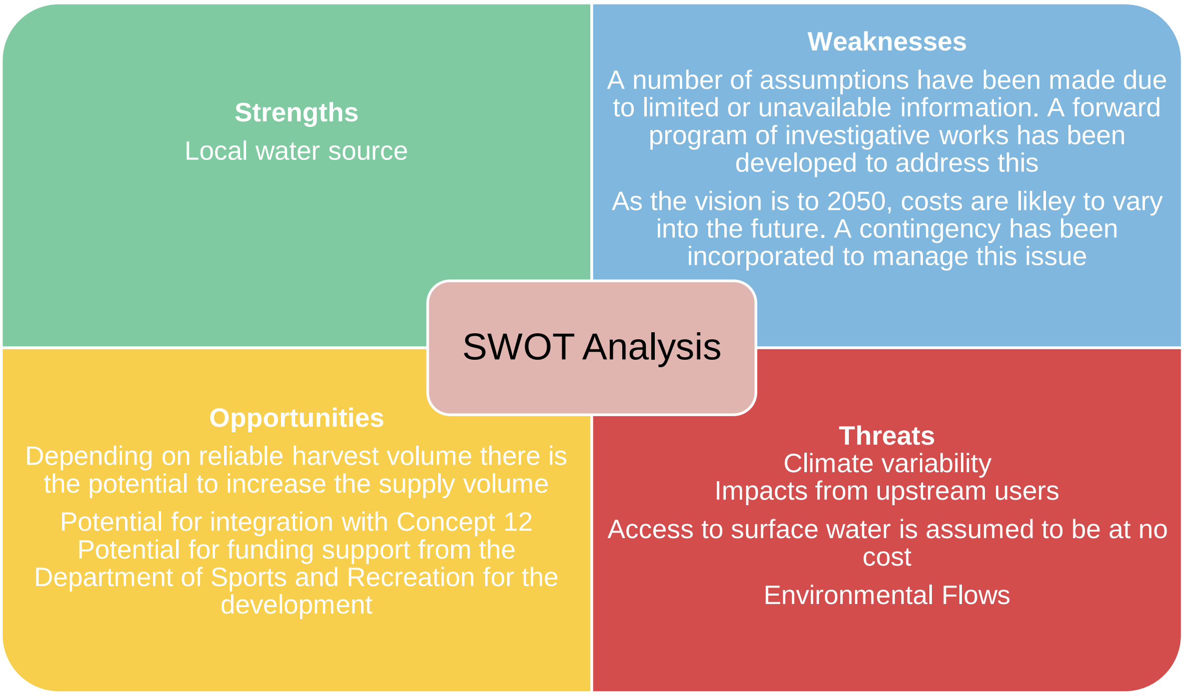
Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in **Table 46** with a summary of breakdown and assumptions area presented in **Appendix D**

Table 46: Summary of Cost Estimate – Option 11

CAPEX	$3,376,900
OPEX	$332,625
NPV (4-7% Real Discount Rate)	$13.15-15.15 / kL

5.15.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the minimum requirements for irrigation for this precinct. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.15.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information; additional information would be required to address these components. **Table 47** provides a recommended forward program of works for this conceptual design.

Table 47: Forward Program of Works – Option 11

Data Gap	Risk	Forward Program of Work
Surface water	Reliable harvest volume is unknown. The water quality of the water is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown.	Carry out flow modelling to estimate potential flows in the brook. Carry out water quality sampling to determine the level of treatment required. Review the cost- benefit analysis of treatment level versus end use – i.e. there may be a significant increase in the level of treatment required to supply the washdown area. Discuss any permitting requirements with the relevant authorities.

5.16 WATER SUPPLY OPTION 12 – CONSTRUCTION OF A DECENTRALISED WASTEWATER SYSTEM FOR THE TOURIST PARK

5.16.1 Overview

The development of a tourist park was identified as part of SSJ tourism strategy (Economic Development Advisory Committee, 2018) to service overnight and holiday visitors. The region is home to a number of accessible trails in the surrounding forest areas for equestrian, bike riding and walking purposes. **Figure 37** presents a concept design which formed part of an expression of interest in 2018. The park concept includes 166 accommodation sites including camping and caravan sites, cabins, a wellness centre with units and tree houses. A water park has also been included.

The facility is designed to accommodate the equestrian community with facilities for stables, float parking and exercise areas.

Provision of potable water to the site is assumed to be sourced from Water Corporation's Scheme Water network. In addition to drinking water supplies, water would be required for washdown facilities and irrigation. Wastewater from the site would include the plumbed facilities plus caravan disposal sites. Based on Water Corporations assumption of 180 L/d of wastewater per person and a recycling water factor, the facility may generate between 5 ML/a and 20 ML/a of wastewater for reuse depending on occupation rates. There is opportunity to capture, treat and reuse the wastewater onsite for irrigation or supply irrigation water to the Jarrahdale Oval.

Wastewater from the site would be captured, treated and stored for irrigation. Water could be used in the wash down bay, however, would require a higher level of treatment, for the purposes of this concept the end use is irrigation only.

Figure 38 presents the process flow diagram for Concept 12. **Table 48** presents the water balance for the system and **Table 49** presents the water supply concept components. This concept assumes a harvest volume of 10 ML to ultimately supply 8 ML/a following losses through the system.

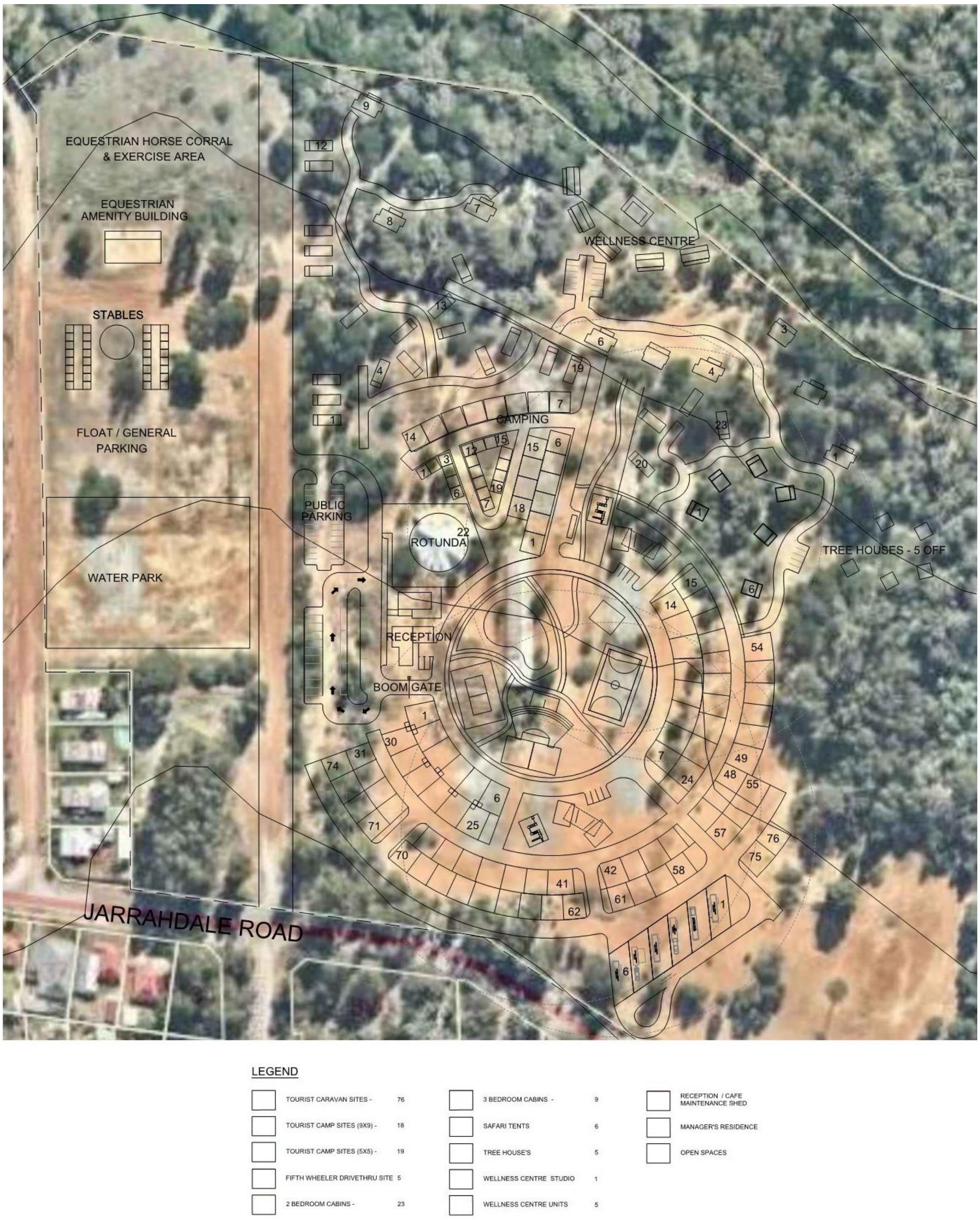


Figure 37: Tourist Park Concept Design

Table 48: Water Balance

Component	Adopted Volume or Rate	Comments
Source Water – wastewater from a decentralised tourist park system	10 ML/a	Volume has been based on the predicted occupancy rate. A supply volume could be up to 20 ML/a if the development occurs as designed with high occupancy rates.
Network to Treatment Plant	Nil	The internal pipe network has not been incorporated as this is required regardless of the wastewater system adopted. This cost forms part of the development cost.
Above ground storage	A combined above ground storage capacity of untreated, treated and emergency storage. A 5 ML storage facility has been adopted Two 100 kL storage tanks have been included	The size of the storage volume will depend on a winter irrigation demand and the final number of facilities serviced.
Irrigation Supply	8 ML/a Irrigation Distribution Network 1 km	Assuming losses through the system from evaporation and backwash the losses are assumed to be 20%. Irrigation Distribution Network of 1 km has been adopted.

Table 49: Water Supply Concept Components

Parameter	Discussion	Allowance
Treated Water and Network	Volume has been based on the concept design and average occupancy rates. If occupancy rates are higher, additional volumes may be available. The sewer capture network is difficult to determine as the development area and design. A nominal number of pump stations have been included; however, this would need to be revised as part of the detailed design.	10 ML/a source water
Treatment	The level of treatment will depend on the end use or if required disposal location.	Primary and secondary treatment has been adopted.
Above Ground Storage	A combined above ground storage capacity of untreated, treated and emergency storage. The size of the storage volume will depend on a winter wash down demand.	A 5 ML storage facility has been adopted.
Professional Fees – Design and Development	An allowance has been made for the design and investigation component of the works required to develop the system.	Functional Design Irrigation Monitoring and Management Plans Detailed Design Construction Supervision
Distribution and Irrigation Infrastructure	The expansion of the site -specific irrigation infrastructure has not been considered. A nominal 1 km of distribution infrastructure has been adopted.	Final design would need to consider onsite irrigation infrastructure.
Operational and Maintenance Costs	An allowance for O&M costs have been included over a single life cycle.	Operation including staff. Maintenance requirements.

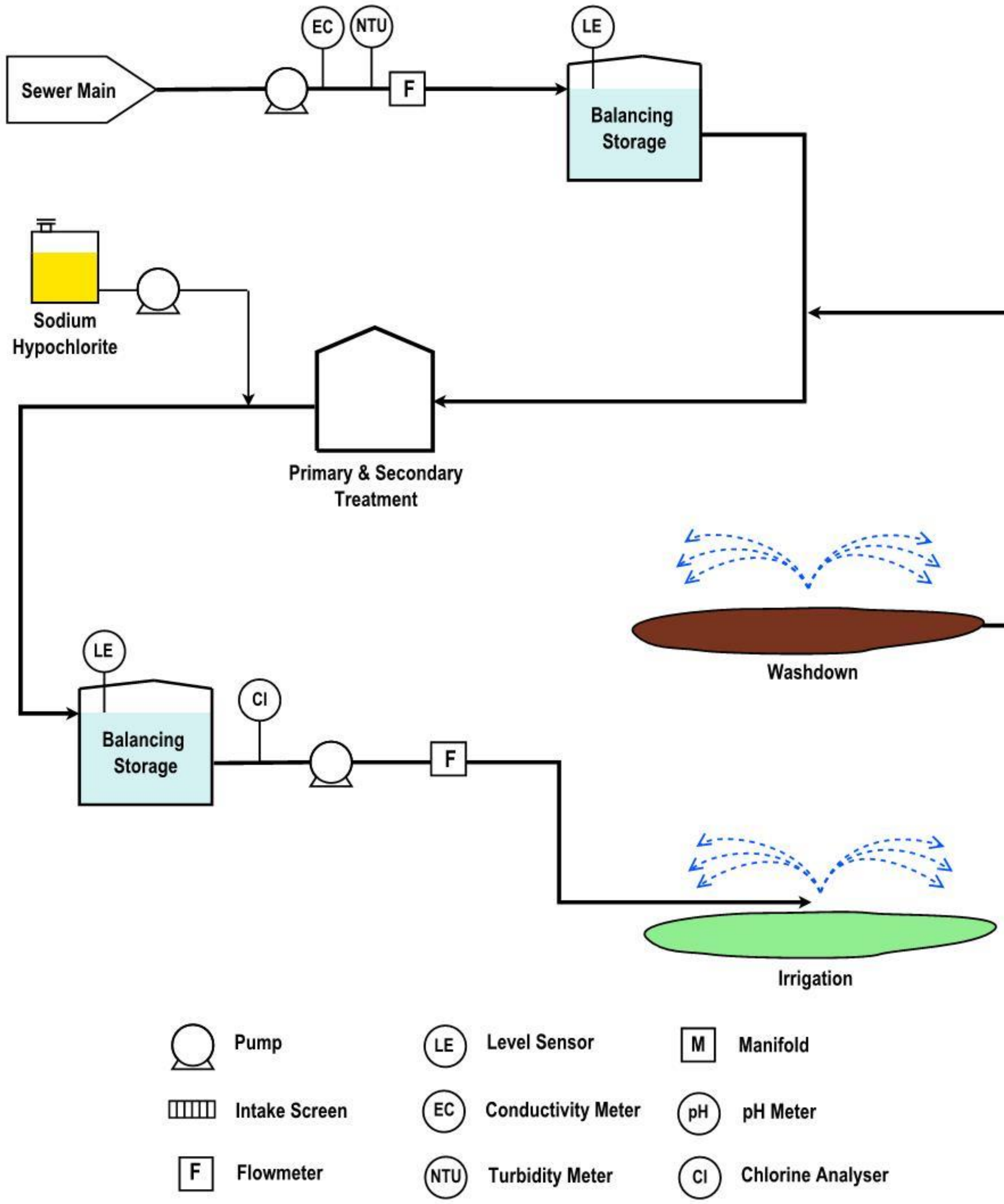


Figure 38: Operational Process Chart – Option 12

5.16.2 Cost Estimate

Preliminary cost estimates (±40%) have been undertaken to assess the scheme cost benefit. Cost outcomes for CAPEX and OPEX and NPV are outlined in **Table 50** with a summary of breakdown and assumptions area presented in **Appendix D.**

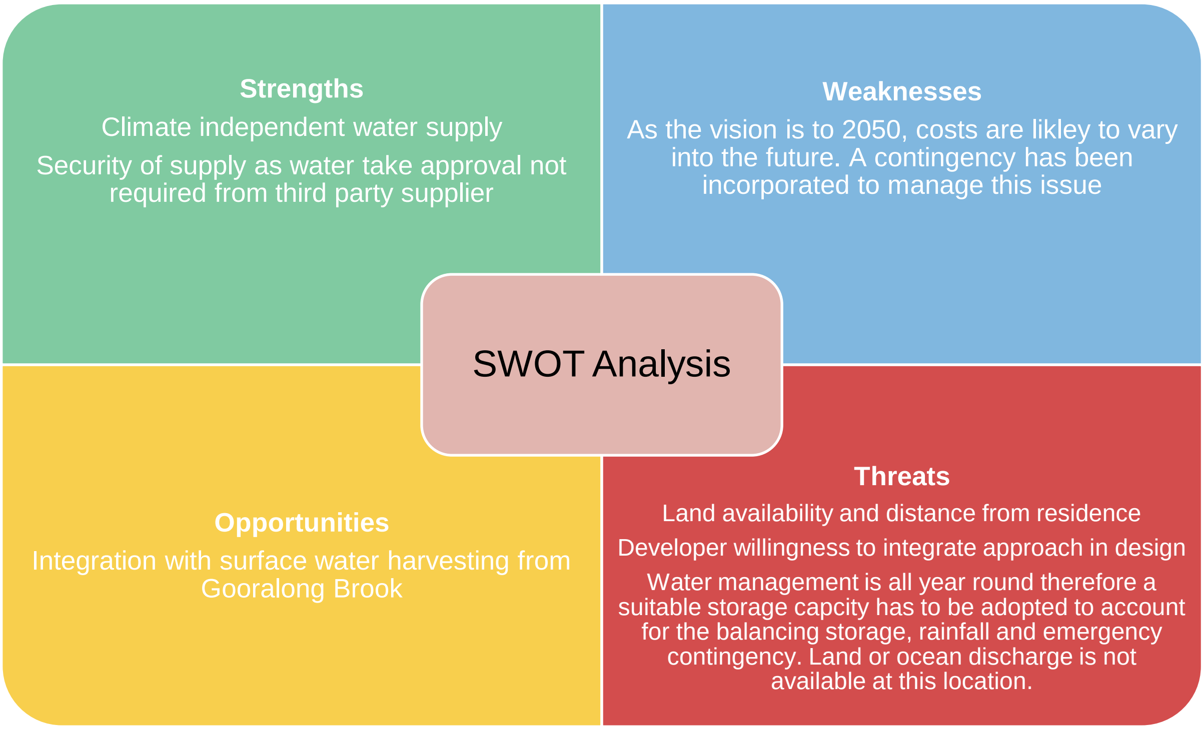
Cost offset against traditional wastewater management fees should be considered as, the capital will be required for the infrastructure, regardless.

Table 50: Summary of Cost Estimate – Option 12

CAPEX	$2,126,500
OPEX	$520,500
NPV (4-7% Real Discount Rate)	$80.30-86.50 / kL

5.16.3 SWOT Analysis

A SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis is a process used to assist in ranking the water supply concepts to determine priority of implementation. The graphic below presents the outcomes of the SWOT analysis, whilst this option has a number of unknowns or risks, it will meet the majority of the requirements for irrigation of Jarrahdale Oval. The risks or weaknesses identified have been primarily accounted for in the forward program of works.



5.16.4 Forward Program of Works

The conceptual design has been based on a number of assumptions and available information; additional information would be required to address these components**. Table 51** provides a recommended forward program of works for this conceptual design.

Table 51: Forward Program of Works – Option 12

Data Gap	Risk	Forward Program of Work
Partnering Opportunities	Identifying a suitable operator or partner for the system is critical for either sewer mining or a decentralised system.	Identify potential partnering opportunities. Willingness of developers to integrate approach

6 FORWARD PROGRAM OF WORKS

Table 52 presents a summarised Forward Program of Works for all options. The required works for each option is presented under each option in Section 5. The program of works is to address data gaps or assumptions identified in the options which may have an impact on the technical or financial viability of the proposed options.

Table 52: Summary of Forward Program of Works

Data Gap	Forward Program of Works
Managed Aquifer Recharge A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. It is strongly recommended that these investigations are to be completed prior to the detailed design. The aquifer performance can have a significant impact on the borefield spacing and layout which can have significant cost implications for transfer pipework. The use of transferred recharge credits will minimise or negate the requirement of distribution transfer infrastructure.	Detailed desktop study. Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. Modelling, numerical groundwater flow, solute or injectant migration, geochemical. Development of a risk management plan and monitoring and management plan. Seek endorsement from DWER recharge the use of transfer recharge credits to limit the requirement for distribution infrastructure.
Surface water Reliable harvest volume – estimated volumes are based on high level square modelling or there is no information available. The water quality is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown. The drains are the responsibility of Water Corporation, therefore access to the surface water would require their approval.	Carry out flow (rate and timing) monitoring of: 1. Oakland and Barriga Drains 2. Creek lines at Woodland Grove Sporting Facility 3. Manjedal Brook 4. Punrack Drain 5. Gooralong Brook Carry out water quality insitu (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Carry out catchment modelling for Whitby and Mundijong District Sporting Facility and Gooralong Brook. Survey of both drains to identify ideal harvest locations and system location.

Data Gap	Forward Program of Works
	Confirm with DWER the requirements to take water from drainage basins or non-prescribed drainage lines. Seek confirmation from Water Corporation regarding access entitlements.
Wastewater Access to Water Corporation owned and managed infrastructure and the volume and timing of supply will need to be agreed. This can be a risk or may provide an opportunity to partner.	Seek confirmation from Water Corporation regarding access entitlements and rates and timing of take.
Demand Forecasts The demand forecast for the SSJ will be based on development and the construction of public open space in response to increased urbanisation. SSJ indicated that, if surplus water was identified, consideration could be given to supply for agriculture. The demand time for recycled water for agriculture is unknown and is based on the rate of development, end use and reduction or limitation in groundwater use allocations. This recommendation relates to the agricultural component only and is not required to meet SSJ irrigation requirements.	Participant in industry forums or engage with industry to understand the demand and willingness / capacity to pay for recycled water for agricultural purposes. The development of the system may take several years therefore timing in conjunction with the industry is critical.

7 IMPLEMENTATION STRATEGY

The SSJ have prepared this plan as a tool to meet the challenges of water demand and management associated with the urban growth predicted for the region over the next 30 years. The optimal water supply solution is not known at present but the foresight to develop a plan now, that accords with other key development strategies for the region, provides sufficient time to undertake the necessary planning and investigation works to ensure SSJ are in the best position to adopt the most appropriate water strategy.

Figure 39 presents an implementation strategy for this plan. The strategy consists of three main aspects

1. Planning: establishing the land planning and urban development controls that will support the progressive implementation of the strategy without costly retrofitting or 'missed opportunities'
2. Funding: identifying partnerships and sources of funding to bring schemes to 'shovel' ready as well as funding for capital works
3. Water supply concept development and selection. The development and selection of the concepts applies an iterative approach and as more information on the concepts under consideration becomes available the iterations are refined. As there are multiple water supply concepts, a staged selection process has been developed to assist SSJ to determine the most appropriate water supply concept. Each of the components are discussed in further detail in the following sections.

The intent is that the implementation strategy is reviewed and the water supply concept assessment is applied at least annually to determine the actions the SSJ should take to progress the water strategy over time. The template to undertake the assessment is presented as **Appendix E**. An excel based spreadsheet model has been developed to enable SSJ to undertake the assessment.

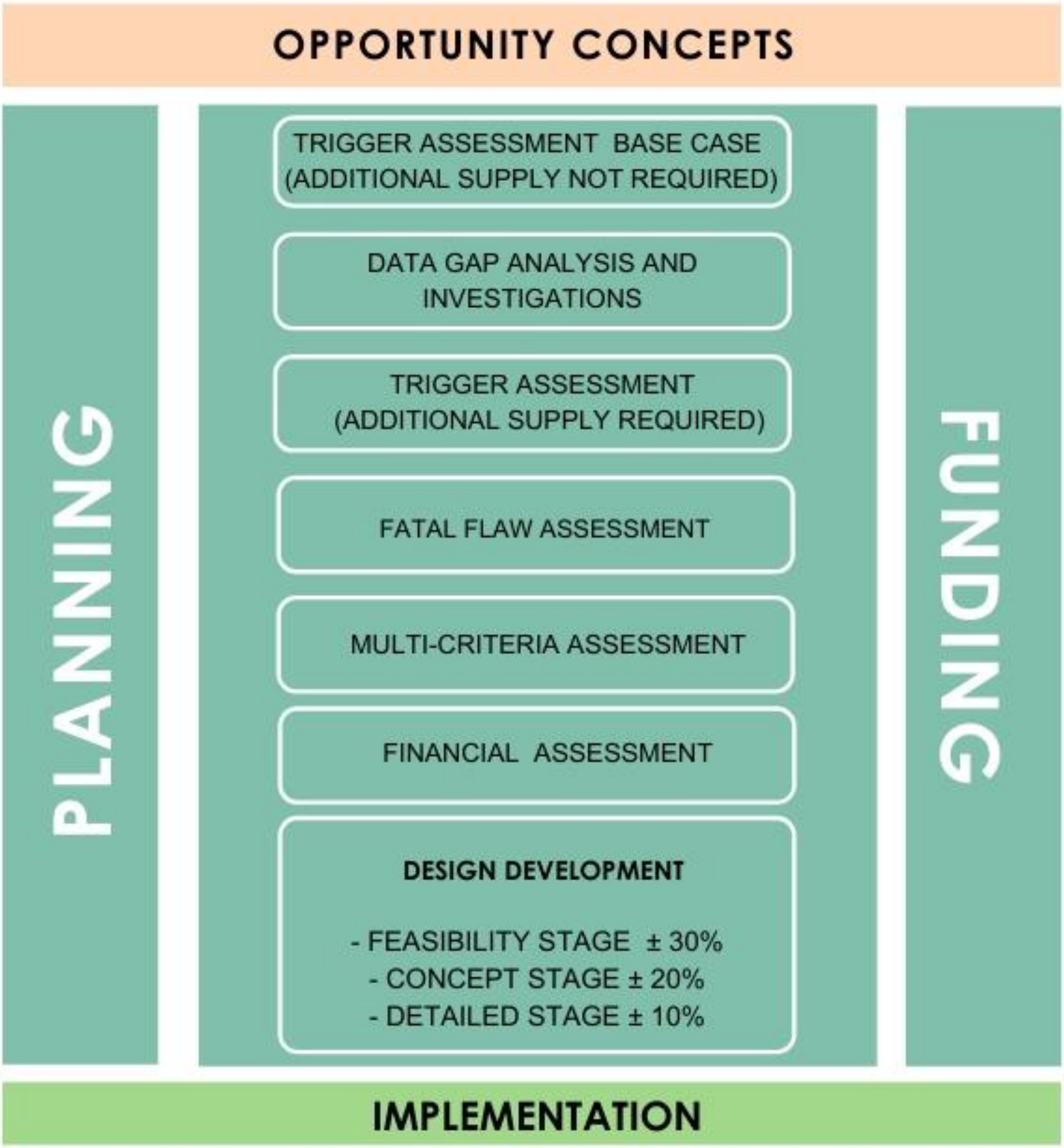


Figure 39: Implementation Strategy

7.1 PLANNING CONTROLS

Planning controls to support these concept(s) should be identified to ensure that the concepts are viable and to minimise retrofitting after development has occurred. Planning controls could relate to:

- easements or service trench allocation for pipework.
- inclusion of surface water features (e.g. wetlands).
- public open space location and allocation, vegetation time, water sources, irrigation infrastructure; and WSUD.
- stormwater or runoff management approaches e.g. WSUD, rainfall tanks, piped stormwater network.
- adoption of third pipe water systems in households or businesses.

- Land planning to support development of wastewater facilities, including treatment sites (including a buffer zone), adoption of a wastewater network in place of septic systems or retrofitting septic systems.
- location or type of industrial or agricultural development, either to support economic provision or water supply or to protect water source quality.

It will be critical that the planning division of SSJ develop relevant planning policies and work with developers to ensure that urban design allows for the potential water supply systems considered in this report. Often alternative water supply projects are not viable due to the complexity and expense of retrofitting fixed infrastructure. SSJ will need to consult with the Department of Planning, Lands and Heritage to ensure appropriate development guidelines and management of the developer contribution scheme.

Collaboration with Water Corporation to identify potential future synergies commenced throughout the development of this plan. SSJ is encouraged to continue to work with Water Corporation's Asset Investment team to identify opportunities for projects and investigations.

7.2 FUNDING OPPORTUNITIES OR PARTNERSHIPS

Opportunities for funding or partnerships are ever changing and are typically driven by a response to an event, e.g. drought conditions or flood management. The benefits of SSJ's early planning approach is that it enables further development of the conceptual design to address data gaps and firm up financial analysis, enabling SSJ to be "shovel" ready for funding as it becomes available. Additionally, having a well-developed plan that quantifies community benefits can assist at times when political support is required and during a change in government. It is recommended that SSJ actively seek funding from state and federal governments together with canvasing private investment. Funding from the different sources may be available to support feasibility or concept investigations.

Private and public partnerships can benefit SSJ through the provision of funding, operations or research expertise. For example, SSJ could partner with a local university to undertake any of the forward program of environmental monitoring or investigation works which could in part or in full be funded externally.

The Department of Sports and Recreation also have two rounds of funding per year for the development or upgrade of sporting facilities. It has been confirmed that irrigation or water facilities are included in this funding opportunity. SSJ may be able to access funding opportunities in the $100k's but it is unlikely that funding will be provided more than once for any one site.

Other private or public partnerships could include, but would be not limited to:

- Water Corporation, which maintains an active research and development program focused on testing technology and managing the environmental impacts of water services.
- Water West.
- Agricultural or industrial precincts/ businesses,
- Government departments.
- Universities or research groups such as the CRC for Water Sensitive Cities.
- Private developers e.g. tourism park at Jarrahdale.
- Private sector water infrastructure operators.

7.3 EARLY INVESTIGATION / PLANNING

Several of the water management opportunities require significant advance planning to be successful. Long-lead times investigations can mean planning across three to five-year horizons is required before a decision to adopt a system is made. For example, if a decentralised wastewater treatment facility is to be developed in Serpentine to support the future growth, early consideration will need to be given to:

- Land allocation for the treatment facility with to provide sufficient area for surface storage and buffer requirements.
- New residential developments to be fitted with appropriate sewer connections rather than retrofitting the population growth has occurred. Retrofitting of the existing septic systems may be implemented.
- Design guidelines / requirements for developers for this region.
- A disposal management plan should the water supply exceed the irrigation demand in the initial development years. Ocean disposal is not an option in this location.
- Liaison with a third party regarding the operation of the decentralised system.

The concepts that require early planning or investigations include:

- Option 1 and 4 – Surface water harvesting from Oakland / Barriga Main Drain
- Option 5 - Mundijong Decentralised Wastewater System
- Option 6 - Decentralised Wastewater System with Surface Water from Manjedal Brook
- Option 8 - Harvest of Surface Water Flows from Punrack Drain
- Option 9 - Construction of a Decentralised Wastewater System in Serpentine
- Option 11 - Surface Water Harvesting from Gooralong Brook

7.4 STAGE 1 TRIGGER ASSESSMENT

The first stage of the assessment determines the forecast need for additional water. The projected demand for water will trigger whether SSJ should review the water supply concepts to develop a forward strategy to meet the additional demand. The trigger assessment requires SSJ to review their water demand and water supply over the next 12 to 24 months. The trigger to progress the assessment is when the current supply volume is less than 80% of the predicted total demand.

7.5 STAGE 2 FATAL FLAW ASSESSMENT

Stage 2 of the assessment requires all of the proposed water supply concepts to be reviewed for fatal flaws. Fatal flaws may relate to, but are not be limited to:

4. Legislation and policy
5. Technical feasibility
6. Social
7. Environmental
8. Water Availability

If yes is answered to any of the identified "fatal flaws" the water supply concept does not proceed, and the assessment is parked. The concept is not discarded as it may prove viable in the future as conditions or triggers change. Some examples of fatal flaws are presented below:

- The minimum environmental flows are not being achieved under current conditions resulting in a decline in wetland health. Further extraction or diversion would result in increased degradation to wetland health.
- A treatment failure or overflow event has occurred so that the community is reluctant to use treated wastewater due to the perceived risk to the environment or human health. Significant consultation over time would be required to change the community perception and regain confidence.

Concepts where no fatal flaws are identified progress to Stage 3 of the assessment.

7.6 STAGE 3 MULTI-CRITERIA ASSESSMENT

Stage 3 comprises a multi-criteria assessment which includes 36 questions around the following categories:

1. Capacity to Meet Demand.
2. Security of Supply.
3. Water Quality.
4. Water Supply Timing.
5. Technical Feasibility.
6. Environmental.
7. Social.
8. Legislation and Regulatory Requirements.
9. Political.
10. Financial Assessment (excluding cost per kilolitre assessment).

Each question has designated responses which are allocated a ranking number, the higher the number the better the concept is rated. Each question is to be answered and the total sum of the points from each question provides a ranking for each concept. The ranking of this stage alone does not determine the most viable concept. It needs to be considered in conjunction with Stage 4 which incorporates the cost per kilolitre.

This approach enables the identification of areas of risk or where further work may be required through consideration of the breakdown of ratings across the MCA criteria. A low ranked concept may not necessarily be unviable but could be parked for future consideration. If conditions change over time, the concept can be revisited, and the assessment repeated. Multiple iterations can be applied to any concept in response to changing conditions across the area administered by SSJ.

7.7 STAGE 4 COST PER KILOLITRE ASSESSMENT

The financial and economic cost of a concept has significant implications for viability especially where the project is partially or fully funded through government grants. This stage considers the capital (CAPEX) and operational costs (OPEX) along with any funding or avoided costs (e.g. discharge to ocean cost) to calculate a per kilolitre water supply rate.

This cost, coupled with the Stage 3 ranking assessment, enables a concept or multiple concepts to be prioritised for implementation depending on the situation.

7.8 COUNCIL WORKING GROUP

Successful implementation of the IWMS and multicriteria analysis requires broad and on-going communication and engagement to ensure that long-lead investigations are prioritised and 'development as usual' patterns are challenged early in planning. Early engagement will enable the potential benefits of the IWMS to be maximised and avoid costly retrofitting. A dedicated Council Working Group would strengthen the adoption and implementation of the IWMS by taking ownership of developing procedures to apply the multi-criteria assessment tool outlined above regularly update the strategy.

The specific activities within the scope of the council working group should be:

- Develop terms of reference for the working group outlining the intent of the group and the roles and responsibilities of participants. The participants on the working group will be required to source the necessary information to appropriately manage this plan.

- Develop procedures to implement an annual review of the IWMS using the multi-criteria assessment tool. A high-level user manual for the operation of the tool has been developed through this report. Specific procedures relating to internal and external contacts, data sources, strategic approaches, timeframes and approval process will need to be established. It is likely that the update procedures will be a living document and will be amended as internal workings of the council change.

- Follow up to implement necessary future works to address the data gaps and continue to develop the plan. An economic and financial strategy is to be developed to ensure sufficient funding for the proposed concepts is secured in forward planning. Engagement with a suitably experienced economic consultant is recommended.

- Identify and seek funding opportunities which may include preparation of funding submissions to support feasibility studies, monitoring or capital funding for works.

  - Regular communication of the plan to internal staff, the community and other stakeholders. The council working group will need to determine the ongoing consultation / communication requirements of the document. Consultation during the development of the plan was undertaken with key stakeholders, including parts of the council, at three community events and with other interested parties such as Water Corporation, Department of Environment and Water Regulation, Department of Planning and Heritage, and Departments of Sports and Recreation. Ongoing consultation with key internal stakeholders is required to ensure that all parties maintain engagement with the plan, adopt the strategy where relevant and have the opportunity to provide ongoing feedback. The council working group is to hold information sessions internally to ensure all business units are aware of the content of the plan and implications of strategic approach, this will be more important to some sections such as strategic planning. Communication should be implemented by providing easy access to the latest version of the document, information sheets, training sessions / workshops and ongoing communication at staff meetings particularly by senior leadership. The Council working group is to implement another round of stakeholder consultation with the community, Water Corporation, Department of Environment and Water Regulation, Department of Planning and Heritage, Departments of Sports and Recreation. It is recommended that developers are included in this consultation program to determine the current approaches to water management and to educate them on the potential changes to development requirements.
  - A timeframe for the projects identified in the community infrastructure plan or any other identified projects.
  - Determine the water use requirements for projects identified in the community infrastructure plan. This can be based on a water assessment prepared externally or area x irrigation rate.

  - Area of public open space, both existing and planned, to determine the irrigation requirements. Existing area and irrigation should be monitored through existing flow meters, if use is not known additional flow meters should be installed. The proposed area can be estimates based on area being developed by council and that being handed over or established by developers. Information should be obtained from the developers, specifically relating to irrigation area, volume, source of water and timing. Residential growth rates are published, this information could be accessed to predict the development rate in the region.
  - Groundwater and surface water allocations and annual use. Trend analysis of the use should be understood to determine the variation of use in wet and dry years.
  - Commercial opportunities (e.g. agricultural or industrial) water requirements are to the estimated based on consultation with industry groups, government departments or potential businesses.
  - Water for other uses, such as fire management, are to be determined based consultation with the relevant council group or based on rate of supply and area managed.
- Against the future demand, the Council working group should maintain visibility of the available water supply including consideration of:
- The availability and cost of scheme water supply from Water Corporation
  - Changes to groundwater and surface water allocations established by Department of Water and Environmental Regulation, and
  - Existing or proposed alternative water schemes (e.g. sewer mining, decentralised water system, surface water harvesting).

7.9 LESSONS LEARNT

Integrated water management brings together consideration of the human and natural environments through the water cycle, to deliver water-related outcomes that are valued by the community, such as a safe water supply, healthy ecosystems and high-quality urban landscapes. Integrated water management needs to reflect both the aspirations and values of communities and the local characteristics of the water cycle. Experience with IWM over the last fifteen years has highlighted the importance of three key lessons:

- The desired IWM outcomes for a project need to be clear and unambiguous, developed collaboratively and reflect community values
- The project needs to account for longer term economic and financial factors in on-going operations, as well as the need to capitalise on funding availability for up-front works; and
- There is no substitute for time in the planning, investigation and consultation phase of IWM. In response to the millennium drought, many alternative water supply system projects were fast-tracked. Some of these projects have not met expectations as flow or hydrogeological systems were not well understood so that water yields were over-estimated and on-going costs were under-estimated.

Table 53 Lessons Learned - Case study review (Urban water planning framework and guidelines: Occasional Paper 29 Case Studies, 2014)

Location	Project	Transferable Learning
ACTEW Water, **Canberra**	Climate Risk Modelling: Development of climate scenario modelling for extreme dry and wet weather	• Regular forecasting allows an adaptable approach to planning in response to defined triggers • Increased stakeholder engagement and collaboration improves ownership and acceptance of outcomes
South East Waters, Melbourne Water and Southern Rural Water, **Southern Victoria**	Water Initiatives for 2050	• Integrated planning requires collaboration with stakeholders representing extensive interests • Setting clear unambiguous objectives that cascade to the assessment criteria and strategy is critical for delivery of a coordinated program of work.
Melbourne	Upper Stony Creek Transformation	• Asbestos • Although the project could not be completed to the original design, improvements in the condition of the creek were achieved
Sydney Water	**Wet Weather Overflow Strategic Framework**	• Challenging existing regulatory approaches can lead to better customer and environmental outcomes. • Involving the regulator throughout the development of the framework allowed a number of refinements to ensure expectations were understood and addressed and built confidence in the approach.

Successful projects have benefited from early planning consideration, for example with regard to land use or roadway design. These factors can have a significant impact of the feasibility and cost of water supply systems that rely on water harvesting. For example, unlike in many parts of the eastern states, the generally simple disposal of stormwater via soakage means drainage conveyance systems are not designed in a way that can be easily adapted to maximise capture for reuse. Without consideration at the time of structure planning and subdivision development, the cost of retrofitting drainage infrastructure to provide for water supply could be prohibitive.

Applying the learnings from both successful and unsuccessful projects to the IWMS for SSJ highlights the importance of:

- Considering water supply requirements and supply options in the planning framework.
- Active and on-going stakeholder consultation to understand the concerns of the community and regulators.
- Implementing the forward program of works to close data gaps and understand key project risks around cost and water availability.
- Continuing to develop the water supply options to enable SSJ to be responsive to changing regulation, climate change and technology developments.
- Promoting ownership of IWMS outcomes within the council to ensure that the plan is adopted in all departments.
- Ensuring the plan is a living document that should be continually considered and regularly revisited.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSION

SSJ has recognised that predicted urban growth and increase in population will result in increasing pressure on the water supply and wastewater management infrastructure in the region. It has also realised that a secure water supply is required to meet the minimum community expectations, both in the urban environment and agricultural precincts.

The development of this integrated water management strategy was commissioned to understand the constraints and opportunities for water supplies in the project area and provide a platform for secure water management into the future. Water demand for council management infrastructure i.e. parks and reserves, is considered the priority in the demand projections. If surplus water is available in certain regions, consideration can be given to other local demands e.g. school ovals, dual reticulation, industrial demands or agriculture.

The current and predicted water balance for irrigation of public open space across the region was calculated and is presented in **Table 54.** This water balance takes into account proposed community development projects along with the minimum public open space development for urban environments.

The water balance indicates that SSJ will be in water deficit by more than 1.3 GL/a by 2050 if no action to increase supply is taken. This poses a significant risk to provision of community amenity and health benefits. SSJ have developed this IWMS plan to help manage the risk and position the council to be proactive and prepared for opportunistic applications for investigation or capital works funding, should it come available.

Table 54: Current and Predicted Water Demand for Irrigation of Public Open Space

Precinct	Current Demand (ML/a)	Future Demand (ML/a)	Current Groundwater Allocation (ML/a)	Deficit (ML/a)
Byford – Oakford	110	555	131	424
Oldbury – Mundijong	25	750	20	730
Hopeland – Serpentine – Keysbrook	63	340	157	183
Jarrahdale	3	32	0	32
Total	**201**	**1,677**	**308**	**1,369**

A preliminary long options assessment was undertaken to identify potential water supply strategies across the three regions. These options were reviewed by SSJ to identify a preferred short list of options which were interrogated further, and a conceptual water supply system and cost analysis completed. A total of 12 options have been prepared, as presented in **Table 55.**

Over and above these options to generate additional water supplies, the purchase of groundwater or surface water allocations is recommended, together with water sensitive urban design. Note, while the volume of water used for irrigation should be minimised through water efficient design, it needs to be recognised that maintaining the health and amenity benefits of a cool, green environment in the south-wests' drying Mediterranean climate does require a substantial amount of water.

At the time of preparing this strategy, water demand does not exceed supply. This provides the opportunity for SSJ to be proactive and work towards defining an adaptable, progressively implementable water supply strategy. Investigations and engagement now will allow sufficient time to investigate identified concepts and be prepared to respond to changes and opportunities in a drying climate.

A multi-criteria assessment framework has been developed to assist SSJ in identifying the drivers and triggers to develop components of their water supply system and identify the most viable option amongst identified concepts. This MCA framework comprises multiple stages including:

1. Trigger Assessment
2. Fatal Flaw Assessment
3. Multi-Criteria Assessment
4. Cost per Kilolitre Assessment

Each stage is outlined in detail in this document and in the accompanying excel based template. It is intended that the MCA assessment be undertaken at least annually to understand SSJ water supply position, maintain currency of input data, and provide a pathway forward for investigations and implementation if required. Regular review will allow planning to adapt to the ever changing legislative, environmental and technical environment and ensure that SSJ continues to be in the best position to manage their water resources effectively.

Table 55: Short List of Options

Region	Demand (ML)	Option	Description	Yield (ML/a)	CAPEX	Cost per kL (4-7% RDR)
Byford – Oakford	555	1	Surface Water Harvesting from Oakland / Barriga Main Drain with MAR	4,000	$74.6 M	$2.15-$2.60
		1a	Surface Water Harvesting from Oakland / Barriga Main Drain with above ground storage	4,000	$133.7 M	$2.10-$2.92
		2	Integration of Option 1 with Sewer Mining	4,800	$99.5 M	$2.20-$2.65
		3	Woodland Grove Sporting Facility	32	$3.2 M	$17.70-$20.10
Oldbury – Mundijong	750	4	Option 1 – Alternative Location	4,000	$74.6 M	$2.15-$2.60
		5	Mundijong Decentralised Wastewater System	800	$23.9 M	$3.95-$4.70
		6	Decentralised Wastewater System with Surface Water from Manjedal Brook	3,200	$77.99 M	$3.25-$3.85
		7	Recharge Runoff from Mundijong Whitby District Sporting Facility	40	$2.5 M	$14.15-$15.70
Hopeland – Serpentine -	340	8	Harvest of Surface Water Flows from Punrack Drain	4,000	$74.6 M	$2.15-$2.60
		9	Construction of a Decentralised Wastewater System in Serpentine	120	$8.98 M	$2.45-$2.75
		10	Gallery Recharge into Decommissioned Open Pit Mines	40	$2 M	$10.25-$11.45
Jarrahdale	32	11	Surface Water Harvesting from Gooralong Brook	32	$3.38 M	$13.15-$15.15
		12	Construction of a Decentralised Wastewater System for the Tourist Park	8	$2.12 M	$80.30-$86.50

8.2 RECOMMENDATION

The concepts and associated costings in this report have been based on a number of assumptions and take into account significant data gaps. For example, a high level of treatment, including membrane filtration, has been adopted in the systems where a large volume is being recharged to the aquifer. The cost of such a system is significant and could be the different between the concept being viable and non-viable. For example, for Option 1, the cost per kL price is $2.15 to $2.60 (4-7% RDR) with the membrane but reduces to $1.50 to $1.86 (4-7% RDR) if the lower standard of treatment is acceptable.

A forward program of works has been developed to further refine the options and costing. It is recommended that these works be implemented, in particular the flow and quality monitoring of climate dependent resources, to better understand concept viability and costs.

In addition to the forward program of works, a Council Working Group is to be developed to continue to drive this plan into the future. This will be critical to ensure that the plan is continually developed, opportunities or risks are identified and that the recommended next stages of the project are implemented as required.

Table 56: Forward Program of Works

Data Gap	Forward Program of Works
Managed Aquifer Recharge A high-level desktop feasibility assessment of MAR has been completed. A detailed assessment should be carried out to confirm target aquifer, feasibility and identify potential risks and appropriate management measures. It is strongly recommended that these investigations are to be completed prior to the detailed design. The aquifer performance can have a significant impact on the borefield spacing and layout which can have significant cost implications for transfer pipework. The use of transferred recharge credits will minimise or negate the requirement of distribution transfer infrastructure.	Detailed desktop study to define scope of work for investigation of specific options. Investigations could include: ○ Hydrogeological investigations including drilling, aquifer hydraulic testing and groundwater quality testing. ○ Hydrogeological modelling, including numerical groundwater flow, solute or injectant migration and geochemical aquifer change. ○ Development of a recharge risk management plan and on-going groundwater monitoring and management plan. ○ Seek endorsement from DWER for use of transfer recharge credits to limit the requirement for distribution infrastructure.
Surface water Reliable harvest volume – estimated volumes are based on high level square modelling or there is no information available. The water quality is unknown therefore the level of treatment or the potential impacts on the reliable harvest volume is unknown. The drains are the responsibility of Water Corporation, therefore access to the surface water would require their approval.	Carry out flow (rate and timing) monitoring of: 1. Oakland and Barriga Drains 2. Creek lines at Woodland Grove Sporting Facility 3. Manjedal Brook 4. Punrack Drain 5. Gooralong Brook Carry out water quality insitu monitoring (salinity and turbidity) and grab samples for a broad range of analysis based on the catchment land use. Carry out catchment modelling for Whitby and Mundijong District Sporting Facility and Gooralong Brook.

Data Gap	Forward Program of Works
	Survey of both drains to identify ideal harvest locations and system location. Confirm with DWER the requirements to take water from drainage basins or non-prescribed drainage lines. Seek confirmation from Water Corporation regarding access entitlements.
Wastewater Access to Water Corporation owned and managed infrastructure and the volume and timing of supply will need to be agreed. This can be a risk or may provide an opportunity to partner.	Seek confirmation from Water Corporation regarding access entitlements and rates and timing of take.
Demand Forecasts The demand forecast for the SSJ will be based on development and the construction of public open space in response to increased urbanisation. SSJ indicated that, if surplus water was identified, consideration could be given to supply for agriculture. The demand time for recycled water for agriculture is unknown and is based on the rate of development, end use and reduction or limitation in groundwater use allocations. This recommendation relates to the agricultural component only and is not required to meet SSJ irrigation requirements.	Participate in industry forums or engage with industry to understand the demand and willingness / capacity to pay for recycled water for agricultural purposes. The development of the system may take several years therefore timing in conjunction with the industry is critical. Monitor current water use in all areas, particularly in developing regions such as Byford to understand the water demand and the growth rate.

9 REFERENCES

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APPENDIX A

SITE CHARACTERISTICS

Study Area Description

The study area is South of Perth, and includes the towns of Jarrahdale, Serpentine, Keysbrook, Hopeland, Oldbury, Mundijong, Oakford and Byford. Splitting the area from North to South is the Darling Scarp, with the Western side of the Scarp being located in the Perth Basin, where all the towns are located, except Jarrahdale which is on the Darling Range.

Topography

The topography of the project area is characteristic of the Swan Coastal Plan and the Darling Scarp to the east. Ground elevations of the uplifted Darling ranges is typically greater than 250 mAHD. To the west of the Darling Fault on the Swan Coast Plain, elevations range between 50 mAHD and decrease to sea level near the coast.

Climate

The climate is temperate with hot dry summers and cool wet winters. Episodic summer storm events can bring rainfall during the summer periods. Figure A.1 presents the annual rainfall from the Serpentine rainfall station from 1905 whilst Figure A.2 presents the mean monthly data. The mean annual rainfall at this station is 924.2 mm/a, the lowest recorded is 500.4 mm/a and highest 1389 mm/a. The Western Australian region is currently experiencing a drying climate with a significant decrease in the annual rainfall over the 30 years.

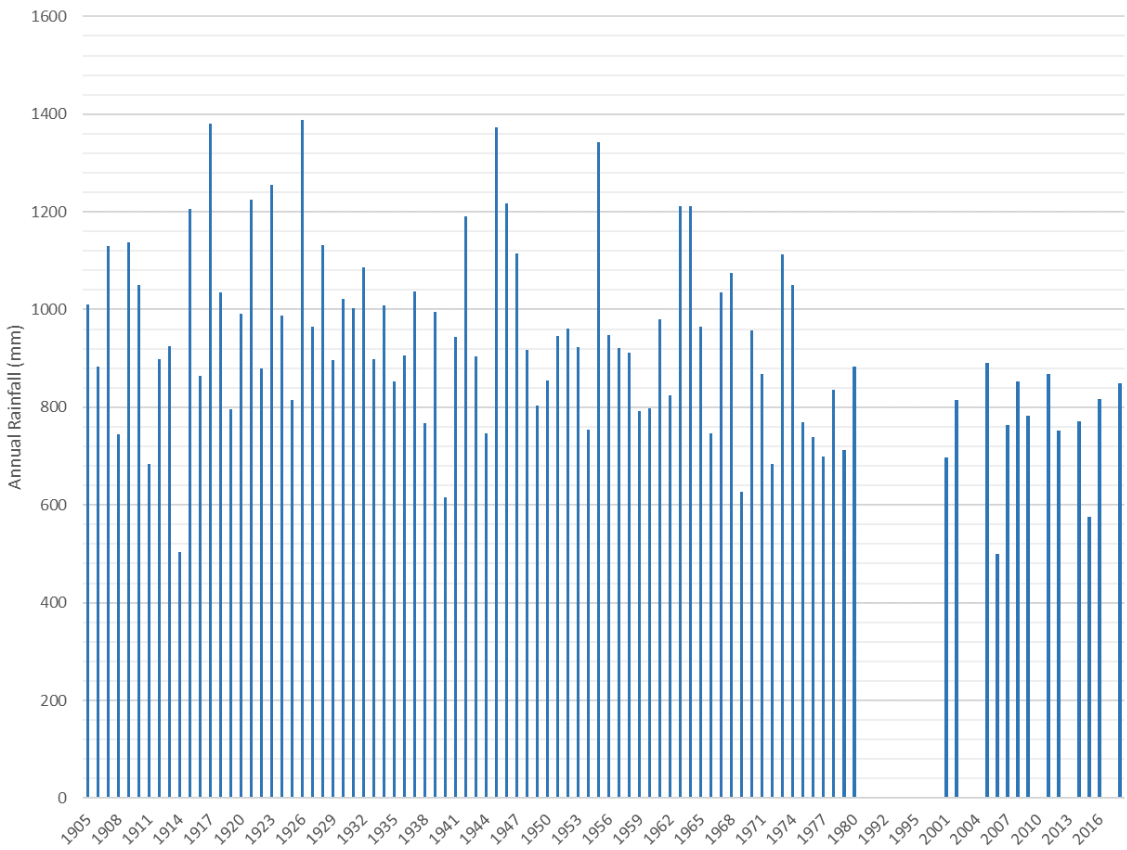

Figure A.1: Annual Rainfall – Serpentine (Source BoM: Station 9039).

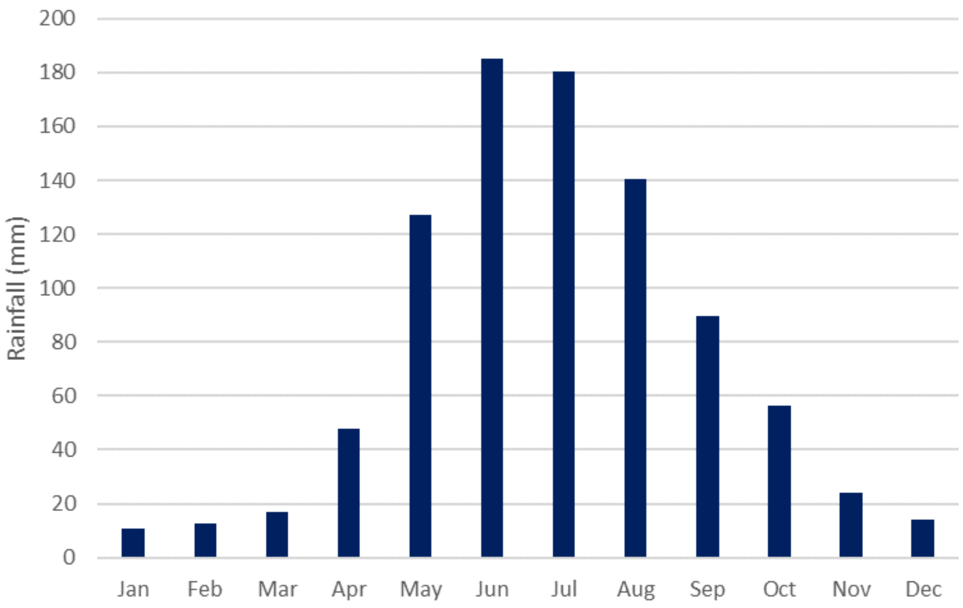

Figure A.2: Mean Monthly Rainfall – Serpentine (Source BoM: Station 9039).

Hydrogeology

A brief summary of the aquifer within the project study area is presented here to assist in determining if Managed Aquifer Recharge is a viable option in this area. External sources should be sought for a detailed description of the geological and hydrogeological system.

The project study area lies within the Perth Basin, a north-trending sediment-filled trough which runs along the south-western margin of the Australian continent. Rifting of the continental plates and deposition of sediments began in the early Permian along the Darling Fault culminating in the separating of Greater Indian continental plate from the Gondwana plate. Following this event, the Perth Basin subsided, and sediment deposition continued (DoW, 2012).

The Darling Fault is visible as the Darling Scarp and it considered to be the most significant structural feature on the Swan Coastal Plain. The Serpentine Fault passes along a north-south trending line and acts as a hydraulic barrier fault that separates the Yarragadee Formation from the Cattamara Coal Measures. The Mandurah Fault is located outside of the project area.

The formations in the region are broadly:

- Superficial Formations.
- Leederville Formation.
- Cattamarra Coal Measures.
- To the east of the Darling Fault, the Achaean basement rocks.

Table A.1 presents a summary of the geological units present in the region whilst Figure A.3 presents a geological east – west cross section.

			Lithology	Symbol	Description	Thickness	Aquifer	Hydraulic Conductivity (m/day)	Vertical Conductivity (m/day)
Cenozoic	Quaternary	Superficial Formations (TQ)	Alluvium, Estuarine and Swamp Deposits				Superficial Aquifer	0.1 to 10	0.01 to 1.0
			Safety Bay Sand	Qs	Calcareous aeolian quartz sand of fine to medium grain size, with plenty of shell debris.	Up to 50m	Superficial Aquifer	10 to 15	1.0 to 1.5
			Becher Sand	Qc		10-15m, maximum 20m near Rockingham	Superficial Aquifer		
			Tamala Limestone	Qt	Creamy white, yellow or light grey limestone, calcarenite and sand. Formation contains minor beds of clay and shell. Grains are subangular to rounded, mostly medium grained and moderately sorted. Grains are frosted and limonit stained. Aeolian sediment above +3mAHD, marine and lacustrine sediments below.	Up to 50m	Superficial Aquifer (Karst Aquifer)	100 to 1,000	10 to 100
			Bassendean Sand	Qd	White and pale grey, occasionally brown quartz sand with traces of heavy minerals. Grains are subrounded to rounded, fine to medium grains and moderately sorted. Fining upwards of grains, with a weak limonite cemented sand towards or at the water table.	Up to 30m	Superficial Aquifer	5 to 50	0.5 to 5.0
			Colluvium		Located at edge of Darling Scarp, unconformably overlaying Guildford Clay, Yoganup Formation and Precambrian rocks. Variable grain size, poorly sorted clays and silty sand up to coarse pebbly sand.	Highly variable	Superficial Aquifer	1 to 10	0.1 to 1.0
			Guildford Formation (Guildford Clay)	Qg	Mostly brown silty slightly sandy clay, occasionally pale grey or blue. Very poorly sorted conglomeratic sand lenses at the base, with grains from fine to coarse.	12m in East, reduces West	Superficial Aquifer	0.1 to 10	0.01 to 1.0

			Lithology	Symbol	Description	Thickness	Aquifer	Hydraulic Conductivity (m/day)	Vertical Conductivity (m/day)
			Quaternary Sand (Unofficial Term)		Sits with Ascot Formation. Subrounded to rounded fine to very coarse quartz and feldspar grains of pale grey to grey brown, very poorly sorted. Mostly fluvial origin.		Superficial Aquifer	5 to 20	0.5 to 2.0
	Tertiary		Ascot Formation	Ta	Grey formation of medium grained, subrounded, poorly sorted sand to fine sand, silt, clay, calcarenit, limestone and very fine gravel. Large amounts of shell debris (bivalves, gastropods, echinoid spines, brachiopod shells). Shelly, silty clay beds occasionally with thinly bedded glauconitic clay occur South of Perth.	Up to 20m	Superficial Aquifer	1 to 28	0.1 to 2.8
	Tertiary		Yoganup Formation	Ty	White, yellow-brown and orange-brown sand (due to leaching of weathered feldspar and ferruginisation) and clayey sand. The grains are fine to coarse, poorly sorted and subrounded to subangular. At the base is sometimes a gravel formed of carbonaceous traces and granite and laterite pebbles, 2cm or less.	0-15m	Superficial Aquifer	0.1 to 10	0.01 to 1.0
Mesozoic	Cretaceous	Osborne Formation (Kco)	Kardinya Shale	Kcok	Majority of Osborne Formation. Siltstone, shale and clay. Thick shale beds. Occurs along the coastal margin south of Mandurah.		Assumed to be a strongly confining aquiclude | Rockingham Aquifer	1x10^-4 to 1x10^-6	1x10^-6 to 1x10^-7
Mesozoic	Cretaceous	Osborne Formation (Kco)	Henley Sandstone	Kcoh			Aquiclude | Rockingham Aquifer		
Mesozoic	Cretaceous	Leederville Formation	Pinjar Member	Kwlp	Alternating layers of sand and clay.	Up to 100m	Upper Leederville Aquifer | Rockingham Aquifer	1 to 2	5x10^-4 to 0.2

			Lithology	Symbol	Description	Thickness	Aquifer	Hydraulic Conductivity (m/day)	Vertical Conductivity (m/day)
			Rockingham Member (proposed)	Kwlr	Yellow, brown and pale grey feldspathic quartz sand. The sand is medium to coarse grained. The feldspar likely occurred from rapid erosion and minimal chemical weathering as the grains are fresh.	Up to 150m	Upper Leederville Aquifer | Rockingham Aquifer	5 to 50	0.5 to 5.0
			Wanneroo Member	Kwlw	Sands, siltstones and shales. Sands beige to dark grey, also occasionally green (due to glauconite). Quartz sand with feldspar and occasional trace heavy minerals. Fine to medium grain size, poorly sorted and mostly uncemented. Siltstones and shales mottled olive green, brown, dark grey or black. Micaceous, with a small amount of carbonaceous material. Associated with glauconite and pyrite grains. A green clay marker bed between the Wanneroo and Mariginiup, thought to be a thin confining layer.		Upper Leederville Aquifer | Rockingham Aquifer Green clay marker bed - minor aquitard	1 to 21	5x10^-4 to 2.1
			Mariginiup Member	Kwlm	Mottled olive green, brown, dark grey or black. Siltstones and shales interbedded with sandy layers and thin beds of limestone.		Lower Leederville Aquifer	0.1 to 1	5x10^-4 to 0.1
			South Perth Shale	Kws	Interbedded silt and clay with minor sand content.		Aquiclude | Lower Leederville Aquifer		
			Gage Sandstone	Kwg	Alternative beds of silt and sand with sand beds between 3 to 30 m in thickness.		Yarragadee Aquifer		
	Jurassic		Yarragadee Formation	Jy	Interbedded sandstone, siltstone and shales.		Yarragadee Aquifer | Cattamarra Aquifer		
			Cattamarra Coal Measures	Jc	Interbedded fluvial sands, silts and clay beds with dark carbonaceous fine-grained clastic rocks and coal seams.		Cattamarra Aquifer	1 to 3	5x10^-4 to 0.3

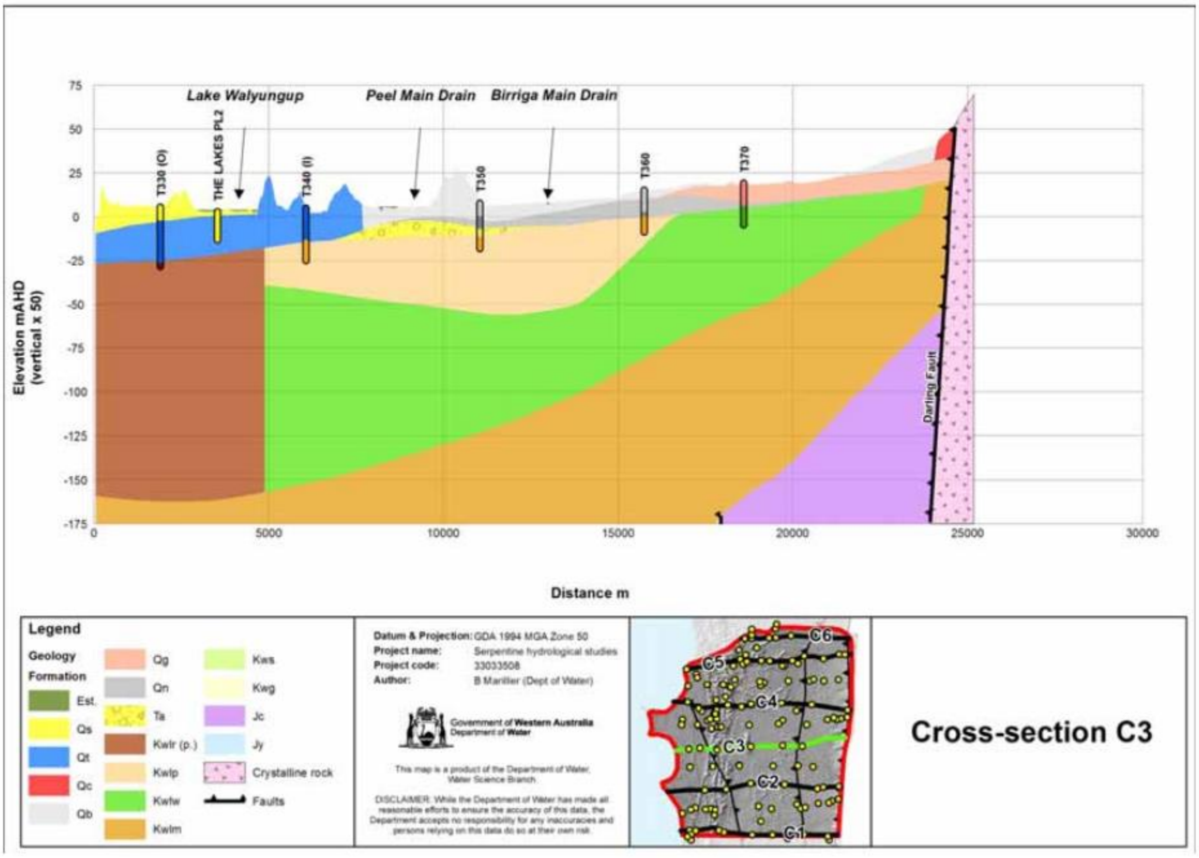

Figure A. 3: Geological Cross Section – East West (Source, DoW, 2012)

The study area has six main aquifer unit:

- Superficial Formations.
- Leederville Aquifer
- Yarragadee Formation
- Cattamarra Coal Measures.

Conceptually, the aquifer systems are hydraulically connected, especially in the daylighting areas near the Darling Fault. Hydrogeological studies have indicated that continuous pumping in the Leederville Aquifer has a pressure response in the Superficial Aquifer indicating that while aquicludes are present that the aquifers are poorly confined.

Figure A.4 presents hydrographs for the Superficial Formation, Leederville and Yarragadee Formation Aquifers. The trend shows a general decline in water levels since the 1990's. This is likely to be attributed to a decline and rainfall and therefore recharge and over abstraction. The groundwater resources across the Perth region are under pressure which has triggered a review of sustainable limits and allocation entitlements.

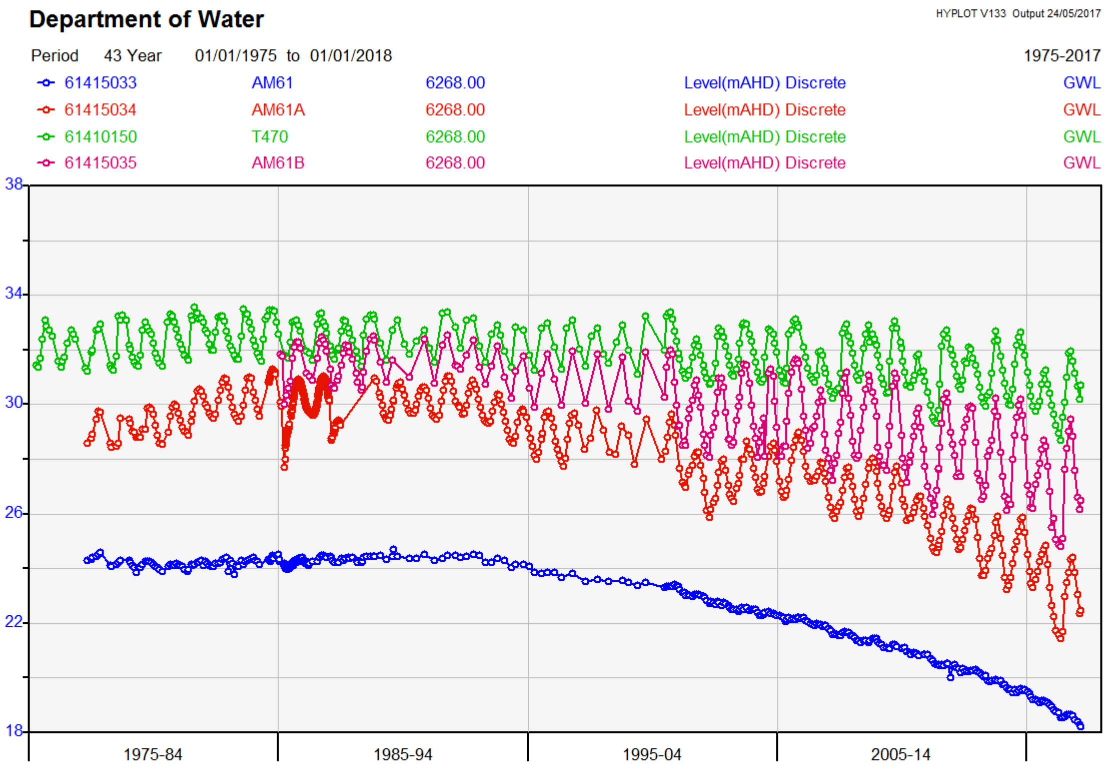

Figure A.4: Groundwater Level Monitoring – 61415033 and 61415034 (Yarragadee North), 61410150 (Superficial Swan) and 61415035 (Leederville)

Groundwater Resource Allocation

The Serpentine Groundwater Management Area is located within the project area. The allocation limit committed volume and available volumes for each aquifer in the six sub-areas are presented in Table A.2. The allocations presented do not take into account any predicted reductions as reported by DWER.

A significant volume of water is available from the Superficial Aquifer, however, due to the clayey nature the yields from the formation make it difficult to extract and harvest the water. The Superficial Aquifer is not considered to have a yield too low to be a viable water source.

Table A.2 Groundwater Allocation Serpentine Groundwater Management Area (DWER, pers.comms 24/7/19)

Management Sub Area	Resource	Allocation Limit	Allocated Volume	Committed Volume	Remaining Volume	% Allocated and Committed
Byford 2	Cattamarra Coal Measures.	0	0	0	**0**	**0.00%**
	Leederville.	1,350,000	915,897	0	**434,103**	**67.84%**
	Superficial Swan	8,077,900	497,455	0	**7,580,445**	**6.16%**
	Yarragadee North.	0	0	0	**0**	**0.00%**
Byford 3	Fractured Rock West - Fractured Rock		92,150	0	**0**	**0.00%**
	Cattamarra Coal Measures.	1,130,000	1,014,349	90,000	**25,651**	**97.73%**
	Leederville.	2,270,000	2,127,252	0	**142,748**	**93.71%**
	Superficial Swan	13,291,660	1,463,237	407,500	**11,420,923**	**14.07%**
	Yarragadee North.	0	0	0	**0**	**0.00%**
Jandakot Mound 1	Leederville.	0	0	0	**0**	**0.00%**
	Superficial Swan	3,980,000	3,629,735	189,500	**160,765**	**95.96%**
	Yarragadee North.	0	0	0	**0**	**0.00%**
Jandakot Mound 2	Leederville.	0	60,000	0	**-60,000**	**0.00%**
	Superficial Swan	1,761,500	1,469,969	214,688	**31,843**	**95.64%**
	Yarragadee North.	0	0	0	**0**	**0.00%**
Keysbrook 1	Perth - Leederville.	750,000	503,390	400,000	**-153,390**	**120.45%**
	Superficial Swan	2,000,000	2,179,906	0	**-179,906**	**109.00%**
	Yarragadee North.	0	0	0	**0**	**0.00%**
Keysbrook 2	Fractured Rock		15,000	0	**0**	**0.00%**
	Cattamarra Coal Measures.	0	436,950	0	**-436,950**	**0.00%**
	Leederville.	860,000	847,049	0	**12,951**	**98.49%**
	Superficial Swan	2,596,200	324,070	0	**2,272,130**	**12.48%**
	Yarragadee North.	0	0	0	**0**	**0.00%**
Serpentine 1	Cattamarra Coal Measures.	0	0	0	**0**	**0.00%**
	Leederville.	450,000	381,645	0	**68,355**	**84.81%**
	Superficial Swan	1,359,500	171,550	0	**1,187,950**	**12.62%**
	Yarragadee North.	0	0	0	**0**	**0.00%**
Serpentine 2	Leederville.	920,000	788,695	129,000	**2,305**	**99.75%**
	Superficial Swan	2,749,500	1,608,890	204,000	**936,610**	**65.94%**
	Yarragadee North.	100,000	0	0	**100,000**	**0.00%**
Serpentine 3	Fractured Rock		2,150	0	**0**	**0.00%**
	Cattamarra Coal Measures.	390,000	477,930	0	**-87,930**	**122.55%**
	Leederville.	790,000	798,669	0	**-8,669**	**101.10%**
	Superficial Swan	2,356,000	419,728	0	**1,936,272**	**17.82%**
	Yarragadee North.	0	0	0	**0**	**0.00%**
Totals		**47,182,260**	**20,225,666**	**1,634,688**	**25,386,206**	**46.33%**

Managed Aquifer Recharge Feasibility

Managed Aquifer Recharge (MAR) is the purposeful recharge of water to an aquifer for storage and subsequent reuse. MAR provides an alternative storage solution in place of above ground storages. This storage option also provides opportunities to harvest winter dominant water to meet peak summer water demands. With the appropriate level of investigation and design, MAR systems can be successfully established in a variety of hydrogeological settings.

The aquifer attributes are one of the key criteria that determines the viability or otherwise of an MAR system at a given location. Economics, supply and demand are other key considerations. MAR systems can be applied in almost any hydrogeological setting. However, it is typically not economically viable, nor practical to store large volumes of water in a low yielding aquifer simply because the size of a borefield and level of treatment required, and therefore cost, are much greater than in a high yielding aquifer and likely to exceed the cost of alternative supplies. Aquifer suitability is often cited as a reason for MAR not to progress when it is really that MAR is not an economically viable option for that particular hydrogeological setting.

The basement rocks of the Darling Range are not considered an aquifer due to the low yielding nature of the geological system, therefore MAR is not considered feasible in areas to the east of the Darling Fault.

Table A.3 presents a high-level review of each of potential aquifers versus the desirable aquifer characteristics to determine the likelihood of MAR being feasible targeting that aquifer unit. A detailed assessment would be required however this preliminary assessment is to be used as a guide for consideration in the preliminary long list assessment.

Table A.3: MAR Feasibility

Desirable Parameter	Superficial Formation	Leederville Aquifer	Yarragadee Formation	Cattamara Coal Measures
Groundwater Gradient Low	Moderate to High	Low to Moderate	Low to Moderate	Low to Moderate
Yield > 10 L/s	Low	High	High	High
Depth to Water >10 m bgl for unconfined aquifer	In some areas	Semi-Confined to Unconfined – Sub-artesian	Semi-Confined to Unconfined – Sub-artesian	Semi-Confined to Unconfined – Sub-artesian
Groundwater Quality Poorer or equal quality to injectant	Fresh – Higher water quality treatment requirements. High recovery efficiency.	Fresh – Higher water quality treatment requirements High recovery efficiency.	Fresh – Higher water quality treatment requirements. High recovery efficiency.	Fresh – Higher water quality treatment requirements. High recovery efficiency. Can be saline in areas to the west of the Serpentine Fault.
Transmissivity High	Low	Yes	Yes	Yes
Aquifer Characteristics High storage capacity High effective porosity Competent Rock Non-reactive Minerals Permeability Aquifer Thickness Unconfined or Confined Aquifer Closed Subsurface Faults	Potential risk of surface expression or water logging. Potential to intersect infrastructure of groundwater contamination plumes.	Additional investigations / research into aquifer connectivity, capacity and interaction with the Darling and Serpentine Faults is required to further assess this risk. DWER in conjunction with CSIRO are undertaking additional investigations in this area. A review of these additional investigation will be carried out if published during this project.		

Likelihood of Not Meeting the Desirable Criteria: Low, Medium, High

APPENDIX B

WATER BALANCE

Byford – Oakford Precinct

Current and Future Water Use

Table B1 and B2 present the current and predicted groundwater use for the public open space irrigation requirements only.

Table B1: Current Water Use (2017-18 and 2018-19) – Byford - Oakford

Site	Volume (ML/a)	Source
Kalimna Oval	23	Groundwater
Kanidimak Road Reserve	25	Groundwater
Briggs Park	31	Groundwater
Plaistowe Blvd (Reserve)	12.6	Groundwater
Sansimeon Marri Pk, Thatcher Rd	9	Groundwater
Peppies Crescent Reserve	6	Groundwater
Lot 333 Lipizzaner Road Byford	0.3	Scheme Water
Lot 1002 Castello Crescent	<0.1	Scheme Water
Lot 850 South Western Hwy (Byford Hall)	2.6	Scheme Water
Total	**109.5**	

Table B2: Future Water Use – Byford - Oakford

Site	Volume (ML/a)	Assumption
Kalimna Oval including Expansion	32.5	Increased irrigation of 1 Ha at a rate of 6.5 ML/Ha/a.
Kanidimak Road Reserve	27.5	10% increase associated with climate change.
Briggs Park and Expansion	50.5	Increased irrigation of 3 Ha at a rate of 6.5 ML/Ha/a.
Orton District Oval	40	Increased irrigation of 6 Ha at a rate of 6.5 ML/Ha/a.
Plaistowe Blvd (Reserve)	14	10% increase associated with climate change.
Sansimeon Marri Pk, Thatcher Rd	10	10% increase associated with climate change.
Peppies Crescent Reserve	7	10% increase associated with climate change.
Lot 333 Lipizzaner Road Byford	0.4	10% increase associated with climate change.
Lot 1002 Castello Crescent	<0.1	10% increase associated with climate change.
Lot 850 South Western Hwy (Byford Hall)	2.9	10% increase associated with climate change.
Woodland Grove District Oval Space	13	Increased irrigation of 2 Ha at a rate of 6.5 ML/Ha/a.
Public Open Space	325	An increase of public open space of approximately 50 Ha at a rate of 6.5 ML/Ha/a.
Total	**522**	

Water Supply Opportunities

A review of the available water sources has been carried out for each precinct, the potential water sources and anticipated volumes are summarised in Table B3 with assumptions outlined in Table B4.

Table B3: Water Source Opportunities – Byford - Oakford

Water Source	Volume ML/a	Timing	Opportunities / Constraints
Residential Wastewater	25,000 people – 985 50,000 people – 1970	All year round	Management of wastewater is required all year round therefore balancing storage required during the low demand periods as there is limited disposal options. This assumes that existing properties remain on septic systems and are not retrofitted to the sewer network.
Urban Runoff	50% developed – 600 100% developed – 1200	Winter dominant	Balancing storage required. Volume in addition to pre-development conditions only.
Cardup Brook, Beenyup Brook, Oakland Creek and Oakland Drain	Limited without flow monitoring	Winter dominant	Flow volumes are unknown, due to the upstream rural catchments of Cardup Brook, Beenyup Brook and Oaklands Creek, flow is primary attributed to runoff which is captured above. Conservatively, harvest volumes from this location have not been incorporated. Flow monitoring is recommended. Unknown existing or future extractive purposes. Water quality variability unknown, assumed to be suitable in winter only. Climate dependent.
Birriga Main Drain	8450	Winter dominant	Unknown existing or future extractive purposes. Water quality variability unknown, assumed to be suitable in winter only. Desalinisation could be considered if salinity increases during summer periods. Climate dependent.
Austral Bricks Quarry	Unknown	Unknown	Unknown planning intent Water quality or contaminant issues. Aquifer connectivity Rehabilitation program requirements
Scheme Water	Unlimited, however, the capacity for Water Corporation infrastructure to meet demands is unknown.	All year round	Use of Water Corporations Scheme Water provides a continuous supply of water fit for any purpose without treatment or balancing storage.

Table B4: Supply Calculations Byford - Oakford

Water Source	Timeframe	Potential Supply Volumes (ML/a)	Availability	Assumptions
Residential Wastewater	50% Developed	985	All year round	180 L/p/d, population of 25,000, water reuse efficiency factor of 60%
	100 % Developed	1970		180 L/p/d, population of 50,000, water reuse efficiency factor of 60%
Urban Runoff from Additional Development	50% Developed	600	Winter Dominant	Annual rainfall of 856 mm/yr, area of 1,750 Ha, runoff coefficient of 0.5, 40% reliable harvest volume. Volume over and above pre-development.
	100 % Developed	1200		
Oaklands Drain	Current	-	Winter Dominant	Flow in the Oaklands Drain is not monitored, flows from urban runoff are captured above. Conservatively, additional harvest volumes from this drain have not been adopted.
Birriga Main Drain	Current	8450	Winter Dominant	Flow estimated by DoW (2012). Due to salinity only winter period is harvestable, assumes a 25% harvest rate of total volume.

Oldbury – Mundijong Precinct

Current and Future Water Use

Table B5 and B6 present the current and predicted groundwater use for the public open space irrigation requirements only.

Table B5: Current Water Use (2017-18 and 2018-19) – Oldbury - Mundijong

Site	Volume (ML/a)	Source
Road Reserves	7.3	Scheme Water
Mundijong Reserve Oval	18	Groundwater
Total	**25.3**	

Table B6: Future Water Use – Oldbury - Mundijong

Site	Volume (ML/a)	Assumptions
Road Reserves	8	Climate change impacts are in the order of 10%.
Mundijong Reserve Oval	20	Climate change impacts are in the order of 10%.
Keirnan Park Recreational Facility	150	Based on 58 Ha sporting facility with 40% irrigated space and 6.5 ML/Ha/a irrigation rate.
District Equine Facility	40	Estimated based on other district equine facilities.
Whitby and Mundijong District Sporting Facility	50	Estimate based on 50% irrigation of the proposed 12 Ha facility
Public Open Space	390	Based on an urban development area of 1,850 Ha, 10% public open space and excluding existing or proposed developments, approximately 60 Ha of public open space is required. Assuming an irrigation rate of 6.5 ML/Ha/a.
Total	**608**	

Water Supply Opportunities

A review of the available water sources has been carried out for each precinct, the potential water sources and anticipated volumes are summarised in Table B6 with assumptions outlined in Table B8.

Table B7: Water Source Opportunities – Oldbury - Mundijong

Water Source	Volume (ML/a)	Timing	Opportunities / Constraints
Residential Wastewater	1970	All year round	Balancing storage required. Assumes that existing properties remain on septic systems.
Urban Runoff	3180	Winter dominant	Balancing storage required. Volume in addition to pre-development conditions.
Manjedal Brook	4525	Winter dominant	Unknown existing or future extractive purposes. Water quality variability unknown, assumed to be suitable in winter only. Climate dependent.
Birriga Main Drain	8450	Winter dominant	Unknown existing or future extractive purposes. Water quality variability unknown, assumed to be suitable in winter only. Climate dependent.

Table B8: Water Supply Calculations – Oldbury - Mundijong

Water Source	Timeframe	Potential Supply Volumes (ML/a)	Availability	Assumptions
Residential Wastewater	50% Developed	985	All year round	180 L/p/d, population of 25,000, water reuse efficiency factor of 60%
	100 % Developed	1970		180 L/p/d, population of 50,000, water reuse efficiency factor of 60%
Urban Runoff from Additional Development	50% Developed	635	Winter Dominant	Annual rainfall of 856 mm/yr, total area of 1,750 Ha, runoff coefficient of 0.5, 40% reliable harvest volume. Volume over and above pre-development considered.
	100 % Developed	1270		
Manjedal Brook	Current	4525	Winter Dominant	Flow estimated by DoW (2012). Due to salinity concerns in summer only winter period is harvestable, assumes a 25% harvest rate of total volume.
Birriga Main Drain	Current	8450	Winter Dominant	Flow estimated by DoW (2012). Due to salinity concerns in summer only winter period is harvestable, assumes a 25% harvest rate of total volume.

Hopeland – Serpentine – Keysbrook Precinct

Current and Future Water Use

Table B9 and B10 present the current and predicted groundwater use for the public open space irrigation requirements only.

Table B9: Current Water Use (2017-18 and 2018-19) – Hopeland – Serpentine – Keysbrook

Site	Volume (ML/a)	Source
Serpentine Courts	22.6	99% Groundwater 1% Scheme Water
Serpentine Pony Club / Sports Oval	40	Groundwater
Road Reserves	0.015	Scheme Water
Total	**62.615**	

Table B10: Future Water Use – Hopeland – Serpentine – Keysbrook

Site	Volume (ML/a)	Assumptions
Serpentine Courts	25	Climate change impacts are in the order of 10%.
Serpentine Pony Club / Sports Oval	45	
Road Reserves	0.017	
Public Open Space	270	Based on 10% public open space requirement for the development area.
Total	**340**	

Water Supply Opportunities

A review of the available water sources has been carried out for each precinct, the potential water sources and anticipated volumes are summarised in Table B11 with assumptions outlined in Table B12.

Table B11: Water Source Opportunities – Hopeland – Serpentine – Keysbrook

Water Source	Volume ML/a	Timing	Opportunities / Constraints
Residential Treated Wastewater	120 at 50% Development 315 at 100% Development	All year round	Balancing storage required Assumes that existing properties remain on septic systems.
Urban Runoff	80 ML/a based on 100% Development	Winter Dominant	Volume in addition to pre-development conditions. Urban development to remain rural residential with block sizes of 2,000 m^2.
Drainage – Punrack Drain (downstream of Karnet or Dirk Brook)	7,500	Winter Dominant	Unknown existing or future extractive purposes. Salinity increases in dry periods where recharge is groundwater dominant. Climate dependent.
Serpentine Caravan Park	Unknown	All year round	Wastewater management unknown.

Table B12: Water Supply Calculations – Hopeland – Serpentine – Keysbrook

Water Source	Timeframe	Potential Supply Volumes (ML/a)	Availability	Assumptions
Residential Wastewater	50% Developed	118	All year round	180 L/p/d, population of 3,000, water reuse efficiency factor of 60%
	100 % Developed	315		180 L/p/d, population of 8,000, water reuse efficiency factor of 60%
Urban Runoff from Additional Development	50% Developed	40	Winter Dominant	Annual rainfall of 942 mm/yr, total area of 415 Ha, runoff coefficient of 0.5, 40% reliable harvest volume. Volume over and above pre-development considered.
	100 % Developed	80		
Punrack Drain	Current	7500	Winter Dominant	Flow estimated by DoW (2012). Due to salinity concerns in summer only winter period is harvestable, assumes a 25% harvest rate of total volume.

Jarrahdale Township Precinct

Current and Future Water Use

Table B13 and B14 present the current and predicted groundwater use for the public open space irrigation requirements only.

Table B13: Current Water Use (2017-18 and 2018-19) – Jarrahdale Township

Site	Volume (ML/a)	Source
St Pauls Church	0.01	Scheme Water
Jarrahdale Hall	0.09	Scheme Water
Jarrahdale Kindy and Tennis Courts	0.016	Scheme Water
Forest Green Reserve	Estimate 3	Scheme Water
Total	**3.116**	

Table B14: Future Water Use – Jarrahdale Township

Site	Volume (ML/a)	Assumptions
St Pauls Church	0.0011	Climate change impacts are in the order of 10%.
Jarrahdale Hall	0.01	
Jarrahdale Kindy and Tennis Courts	0.017	
Forest Green Reserve	3.5	
Jarrahdale Oval	7.5	Irrigation of the oval is based on 6.5 ML/Ha/a. Climate change impacts are in the order of 10%.
Tourist Park – wash down / irrigation	18.5	Development site of 8 Ha with 5% of irrigated land and washdown requirement of 0.5 ML per week, allowing for 30% occupation of horse floats / stables.
Total	**29.5**	

Water Supply Opportunities

A review of the available water sources has been carried out for each precinct, the potential water sources and anticipated volumes are summarised in Table B15 with assumptions outlined in Table B16.

Table B15: Water Source Opportunities – Jarrahdale Township

Water Source	Volume	Timing	Opportunities / Constraints
Gooralong Brook	Estimated 285 ML/a	Winter Dominant	Storage would be required. Flow impacted by climate conditions and upstream dam structures. The development of the tourist park with equine facilities may increase the treatment requirements if runoff is not managed appropriately.
Millbrook Winery Wastewater	1 ML	February to April	Treated wastewater from this facility is currently used to irrigate an existing woodlot. The elevation difference between the winery and the end use is some 80 m therefore requiring the water to pumped.

Water Source	Volume	Timing	Opportunities / Constraints
Residential Wastewater	30-45 ML depending on reuse efficiency	All year round	Currently residential wastewater is managed through septic systems, retrofitting the houses to a sewer system would be required. Water Corporation has no plans to expand their wastewater network into this region therefore a community-based wastewater system would be required. Surplus wastewater to demand requirements would require land disposal primarily during winter and some storage capacity.
Tourist Park Wastewater	5-20 ML depending on reuse efficiency and occupancy rates.	All year round	The timing of this development, the magnitude and occupancy rates are unknown. Water Corporation has no plans to expand their wastewater network into this region therefore a locally wastewater treatment system would be required. Balancing storage would be required to manage peak supply / demand periods.

Table B16: Water Supply Calculations – Jarrahdale Township

Water Source	Timeframe	Potential Supply Volumes (ML/a)	Availability	Assumptions
Residential Wastewater	Retrofit of existing township	40	All year round	180 L/p/d, population of 1,000, water reuse efficiency factor of 60%
Millbrook Winery	Current	1.25	February - April	As outlined in site Environmental Management Plan
Gooralong Brook	Current	285	Winter Dominant	Volume calculated from runoff in the township based on 750 m2 block sizes, c=0.4 V=1270 ML/a x reliable harvest volume 25% plus a decrease in 105 ML/a from upstream dams.
Tourist Part Wastewater	Unknown	10	All year round	Based on 180 Lppd, 3 persons per site persons, variable occupancy rate and a reuse efficiency of 60%. 100% = 19 ML/a, 50% = 9 ML/a, 25% = 5 ML/a

APPENDIX C

CONSULTATION FEEDBACK

Consultation Responses	Response
Byford	
Oakford are not on scheme water	Noted
Mundijong	
Why are rural farming bores restricted?	Clarification for DWER
Slimline tanks for gardening / fire use should be mandatory	SSJ Planning consideration.
Should upload documents with the updated information on the expected population.	SSJ Noted
Consultants from Water Corp advised in 2016 that it was reported there was unlimited amounts of water.	Further clarification required.
Where will the water be stored, once harvested?	Refer to individual concept design.
Jarrahdale	
Will it be more water supply from the community?	Further clarification required.
The group are not very supportive of List #1 (gooralong brook). Supportive of List #2 (RV supportive).	Concern noted in risk analysis with further investigative works and community consultation required.
Can the facilities all have “push” taps	SSJ Planning consideration.
Last time the minister was in Jarrahdale was 9 years ago – nothing happened.	SSJ Noted.
Current water pipe going to Jarrahdale is broken asbestos, holes and filled with sticks.	Consideration for Water Corporation.
Sustainability for current situations – not just the future.	Noted
Currently very, low water pressure in Jarrahdale – concerned that this could lower the pressure more.	Consideration for Water Corporation.
Jarrahdale are on scheme in some and not in others.	Noted
Currently the tourists come and use the water from the tanks (illegally) and the fire brigade have to come and fill the tanks to ensure they are ready for fire season.	SSJ Noted.
Enforce Water tanks with all new buildings / facilities	SSJ Planning consideration.
Keysbrook	
Community were notified through the newspaper	Noted
We should not charge ratepayers for this strategy (charge them for using water).	SSJ Noted
Where is the Shire Boundary for the Fire & Emergency? It was advised that it is within the Shire of Murray.	Further consideration for SSJ.
Comments from Department of Water & Environmental Regulation	
Surface Water Supply Yields It is acknowledged this paper is a pre-feasibility high level report, for which it is intended that future qualifying studies would determine actual viability of water supply options. Notwithstanding, the Department would advise initial supply estimations for surface water harvest options may be potentially overestimated due to the following. *Climate Change* At this point it is not clear to what extent climate change has been factored into the analysis. It is understood some of the Departments modelling reports have been utilised and if so future dry climate scenarios should inform this work. There is risk in yield estimations not considering this issue. This should be also identified within future work required if not already done so.	Agree, reliable harvest volumes have a low reliability and further works are required to understand the current flow and quality and potential impacts from climate change. Forward program of works has been developed to address these data gaps, assumptions and risks. Ecological requirements are still to be determines and need to be accounted for in the reliable harvest volumes. Consultation with DWER is required to understand ecological requirements of this region.

Ecological Water Requirements The estimates at this point assume a range of harvest volumes from a number of drains and brooks around the Shire. The paper has not identified the need determine ecological water requirements of these systems to determine a sustainable yield of take. The brooks will support ecological values for which direct impact would need to be considered. Though drains mostly do not support such values, it would be important to consider impact to receiving water bodies downstream, such as the Serpentine River. Ecological water requirements have potential to significantly reduce the available take from water courses, hence this issue should either be conservatively considered within this paper or identified as future work required.	
Groundwater It is recognised the long-range bulk supply options being investigated as part of this Integrated Water Supply Strategy. However, the optimisation of existing groundwater resources may be an area for future work to identify current usage, and suitably modify abstraction and supply networks to achieve an optimised configuration which may yield a greater irrigation capacity. *Future Resource Opportunities* There is potential for broad future land use change scenarios to identify where groundwater may come available into the future. Furthermore, the IWSS (or future document) could make reference to principles of future urban form and water sensitive urban design outcomes that would balance irrigation needs.	An overarching strategy for water supply is to decrease use and purchase groundwater and surface water entitlements as a security of supply. Reduction of efficient water use is a key objection of SSJ and Water Sensitive Urban Design characteristics are presented and are to be considered in the Planning Policies.
Specific Section Comments *Water supply Option 1*: It is not clear whether adopted rates have utilised the results of the *Lower Serpentine hydrological studies: Land development, drainage and climate* scenario (DoW, 2015) report which discusses the reduction in flows which can be expected with reduced rainfall. The report indicates future medium and dry scenarios show a significant reduction in flow through all parts of the flow curve, with fewer medium and high flow events in winter. Future climate scenarios have been investigated further as part of the Department's *Peel Integrated Water Initiative* which may inform future work. Surface water flows from Oakland/Birriga Main drain with above ground storage – At the proposed location a 6 m deep facility is likely to be at least 3 m below minimum groundwater levels and therefore accessing superficial groundwater. Evaporation from an 83 ha area will need to be considered. *Intersection of groundwater* – it should be noted that any options for which infrastructure intersects the watertable, may constitute a take of groundwater that would require licencing under the *Rights in Water Irrigation Act 1914*. *Surplus water not identified a risk*: In Option 1, 1a, 2, 4, 6 and 8 future demand in the precincts is much lower than the options supply sizes. This should be considered as risk rather than opportunity. If sufficient demand would not be available from agriculture sector, the assets can't be used in their full capacity especially in the early years of the scheme and cost of water would be much higher than the estimated costs in this report. The report should identify this potential risk and propose demand forecasting as priority future work in Section 6.	Adopted harvest rates adopted represent a low percentage of the modelled volume to allow for climate change, quality and flow impacts etc. Regardless, the reliable harvest volume has a low reliability and further works are required to understand the current flow and quality and potential impacts from climate change. Forward program of works has been developed to address these data gaps, assumptions and risks. Intersection of groundwater was not considered as it was assumed to be a lined facility. Evaporation has been considered at a very high level. Further work would be required to understand the viability of this option. The larger water supply concepts which are predicted to supply more than the SSJ demand are considered to be scalable. The intent is to only develop a system that meets the demand requirements with some flexibility for security of supply. The system could be expanded to meet other demand assuming it exists. The system size is different with Mundijong having a yield of 800 ML/a and Serpentine having a yield of 120 ML/a.

Option 5 and Option 9 water cost: These options are similar, but the unit cost of water is appears much higher in Option 5. *Pumping costs*: Pumping cost has not been considered for operational cost estimations. It is recommended this is identified.	Pumping operation from a power consumption perspective has been calculated and included in the OPEX.
Figure 1 – Precinct layout and future land use: It is noted in future predictions for water needs there is an area identified as future “intensive agriculture”. It is important that estimated needs have not been based upon conventional in-ground horticulture, as such land uses contravene *Environmental Protection Peel Inlet – Harvey Estuary Policy 1992*, *State Planning Policy 2.1 – Peel Coastal Plain Catchment* and the Shire of Serpentine-Jarrahdale’s *Local Planning Policy 4.12: Horticulture*. *Wastewater treatment*: Options 2, 5, and 9 have considered conventional treatment for the wastewater treatment. If a the necessary land is not secured for the proposed wastewater treatment infrastructure, there may be a need to consider advanced wastewater treatment facilities for these options which require a lesser footprint and reduced buffers compared with conventional processes. It is recommended this is identified in forward program of work for these options. *Decentralised wastewater servicing*: The SWOT analyses for decentralised options could also identity the benefits beyond that of a non-potable water resource. Decentralised options could also supply wastewater services to the new developments, with the potential for revenue generated to offset the cost of non-potable water supply to the Shire of Serpentine-Jarrahdale. *Birrega and Oaklands catchments*: Please note MikeFlood modelling has been undertaken in 2015 on the Birrega and Oaklands catchments, which may assist this work. *Water supply Option 8*: Part of the *Peel Integrated Water Initiative hydrological modelling (DWER, in prep)* was undertaken in an area including this precinct (Punrak Drain). Available water quantities were significantly less than assumptions made in Table 29 (2,500 ML/a) at 0.25 GL at 2050 with an annual reliability of 80%. *Nomenclature*: Document uses *managed aquifer recharge* (MAR) in some water balance tables and *aquifer storage recovery* (ASR) in others however no glossary or descriptions of terms has been included. *Preliminary Water Security Study – Long List of Options*: *Appendix A*: future climate scenarios and impacts to groundwater and, in particular, surface water resources should have been discussed as it has implications for future water availability It’s noted that 10 % increase in water requirements are anticipated due to climate change impacts. This statement should also be balanced with principles of water sensitive urban design that would encourage a reduction in water requirements.	Demand for these regions have not been calculated. The purpose of this document is for public open space irrigation for SSJ only with the opportunity for additional supply if water was available. The development of decentralised wastewater treatment facilities have been identified as a “early planning” concept where consideration needs to be given in the planning division for land availability. Alternative treatment options will need to be considered if the planning framework is not updated or implemented in the necessary timeframe. Further clarification required. The provision of third pipe recycled water supply could be considered on a site by site basis but is often found to be financially unviable. Noted. This document should be reviewed once this work is available. Noted. Noted

APPENDIX D

COST ESTIMATE

Option 1 - Surface Water Flows from Oakland / Barriga Main Drain with MAR and Membrane- CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
Transfer from Oakland and Barriga Drain	Pump Stations (570 L/s) at 2 locations totally 285 L/s	$ 500,000.00	2	$ 1,000,000.00	$ 1,400,000.00	Harvest locations distributed across the two drains.
	Channel Upgrade Works	$ 50,000.00	2	$ 100,000.00	$ 140,000.00	Significant upgrades to the channel is not required. There are 2 offtake locations.
	Pipe Infrastructure	$ 500.00	5000	$ 2,500,000.00	$ 3,500,000.00	Based on 500 mm pipe diameter including valve and fittings
	Instruments, Water Quality Monitoring and Control Panel	$ 50,000.00	1	$ 50,000.00	$ 70,000.00	
Balancing Storage	100 ML above ground dam storage	$ 1,500,000.00	1	$ 1,500,000.00	$ 2,100,000.00	Land acquisition not included.
Treatment Facility	Pump Station - Balancing Storage to treatment plant (570 L/s)	$ 600,000.00	1	$ 600,000.00	$ 840,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework Balancing to Treatment Facility	$ 600.00	50	$ 30,000.00	$ 42,000.00	Based on assumptions of 600 mm diameter pipe $/mm including valves and fittings.
	Media Filtration (570 L/s)	$ 2,000,000.00	1	$ 2,000,000.00	$ 2,800,000.00	Pre Treatment, Sand filtration. Based on a treatment rate of 570 L/s.
	Membrane Filtration (570 L/s)	$ 15,000,000.00	1	$ 15,000,000.00	$ 21,000,000.00	Based on treatment of 570 L/s.
	UV Disinfection (570 L/s)	$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Based on a treatment rate of 570 L/s.
	Chlorination (570 L/s)	$ 600,000.00	1	$ 600,000.00	$ 840,000.00	Including Chlorine Dosing and Mixer, Chlorine Holding Tank (and bund), Chlorine Contact Tanks, and SCADA controls. Chlorination of recovered water prior to distribution for irrigation.
	Balancing Storage Tank	$ 160,000.00	1	$ 160,000.00	$ 224,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Treatment Plant Housing and Access	$ 250,000.00	1	$ 250,000.00	$ 350,000.00	Based on similar treatment plant developments.
ASR System	Bore Injection Pump Set (25 L/s) and Wetwall Infrastructure	$ 30,000.00	23	$ 690,000.00	$ 966,000.00	Based on pump set to supply 25 L/s. Inline water quality monitoring (wetwall) including pH, electrical conductivity and turbidity.
	Distribution Line to Production Bores	$ 200.00	5000	$ 1,000,000.00	$ 1,400,000.00	Based on assumptions of 200 mm diameter pipe $/mm including valves and fittings.
	Production Bores (x1)	$ 250,000.00	23	$ 5,750,000.00	$ 8,050,000.00	Cost based on previous projects, assuming a target depth of max 250 m bgl and PVC casing (254 mm diameter).
	Observation Bores (x1)	$ 175,000.00	5	$ 875,000.00	$ 1,225,000.00	Cost based on previous projects, assuming a target depth of max 250 m bgl and PVC casing (154 mm diameter).
	Aquifer Hydraulic Testing	$ 17,500.00	23	$ 402,500.00	$ 563,500.00	Step Discharge Test and 24 hour Constant Rate Discharge test of each production bore.
	Bore Headworks	$ 150,000.00	23	$ 3,450,000.00	$ 4,830,000.00	Based on previous project designs.
	Injection Line (x23)	$ 150.00	230	$ 34,500.00	$ 48,300.00	Based on assumptions of layflat pipe $/mm including valves and fittings.
	Rising Main (extraction x23)	$ 150.00	1725	$ 258,750.00	$ 362,250.00	Based on previous costs, pump set depth estimated to be 75 m bgl.
	Extraction Pump (x23)	$ 40,000.00	23	$ 920,000.00	$ 1,288,000.00	Based on a recovery rate up to 25 L/s.
	Distribution Line - Balancing Storage to irrigation precincts	$ 500.00	20000	$ 10,000,000.00	$ 14,000,000.00	Based on assumptions of 500 mm diameter pipe $/mm including valves and fittings.
	Scourline - (borefield)	$ 150.00	5000	$ 750,000.00	$ 1,050,000.00	Based on assumptions of 150 mm diameter pipe $/mm including valves and fittings.
Power	Control/ Housing	$ 400,000.00	1	$ 400,000.00	$ 560,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 3,453,152.50	$ 4,834,413.50	
Regulatory Approvals and Documentation		$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Hydrogeological Investigations, Numerical Groundwater Flow and Solute Transport Modelling, Geochemical Modelling, Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
			Total	**$ 53,283,902.50**	**$ 74,597,463.50**	

Option 1a -Surface Water Flows from Oakland / Barriga Main Drain with above Ground Storage CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
Transfer from Oakland and Barriga Drain	Pump Stations (570 L/s) at 2 locations totally 285 L/s	$ 500,000.00	2	$ 1,000,000.00	$ 1,400,000.00	Harvest locations distributed across the two drains.
	Channel Upgrade Works	$ 50,000.00	2	$ 100,000.00	$ 140,000.00	Significant upgrades to the channel is not required. There are 2 offtake locations.
	Pipe Infrastructure	$ 500.00	5000	$ 2,500,000.00	$ 3,500,000.00	Based on 500 mm pipe diameter including valve and fittings
	Instruments, Water Quality Monitoring and Control Panel	$ 50,000.00	1	$ 50,000.00	$ 70,000.00	
Balancing Storage	5 GL above ground dam storage	$ 75,000,000.00	1	$ 75,000,000.00	$ 105,000,000.00	Land acquisition not included.
Treatment Facility	Pump Station - Balancing Storage to treatment plant (570 L/s)	$ 600,000.00	1	$ 600,000.00	$ 840,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework Balancing to Treatment Facility	$ 600.00	50	$ 30,000.00	$ 42,000.00	Based on assumptions of 600 mm diameter pipe $/mm including valves and fittings.
	Media Filtration (570 L/s)	$ 2,000,000.00	1	$ 2,000,000.00	$ 2,800,000.00	Pre Treatment, Sand filtration. Based on a treatment rate of 570 L/s.
	UV Disinfection (570 L/s)	$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Based on a treatment rate of 570 L/s.
	Chlorination (570 L/s)	$ 600,000.00	1	$ 600,000.00	$ 840,000.00	Including Chlorine Dosing and Mixer, Chlorine Holding Tank (and bund), Chlorine Contact Tanks, and SCADA controls. Chlorination of recovered water prior to distribution for irrigation.
	Backwash Infrastructure	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Treatment Plant Housing and Access	$ 250,000.00	1	$ 250,000.00	$ 350,000.00	Based on similar treatment plant developments.
	Distribution Line - Balancing Storage to irrigation precincts	$ 500.00	20000	$ 10,000,000.00	$ 14,000,000.00	Based on assumptions of 500 mm diameter pipe $/mm including valves and fittings.
Power	Control/ Housing	$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 1,000,000.00	1	$ 1,000,000.00	$ 1,400,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 1,084,300.00	$ 1,518,020.00	
Regulatory Approvals and Documentation		$ 250,000.00	1	$ 250,000.00	$ 350,000.00	Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
			Total	**$ 95,474,300.00**	**$ 133,664,020.00**	

Option 2 - Surface Water Flows from Oakland / Barriga Main Drain with Sewer Mining CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
Transfer from Oakland and Barriga Drain	Pump Stations (570 L/s) at 2 locations totally 285 L/s	$ 500,000.00	2	$ 1,000,000.00	$ 1,400,000.00	Harvest locations distributed across the two drains.
	Channel Upgrade Works	$ 50,000.00	2	$ 100,000.00	$ 140,000.00	Significant upgrades to the channel is not required. There are 2 offtake locations.
	Pipe Infrastructure	$ 500.00	5000	$ 2,500,000.00	$ 3,500,000.00	Based on 500 mm pipe diameter including valve and fittings
	Instruments, Water Quality Monitoring and Control Panel	$ 50,000.00	1	$ 50,000.00	$ 70,000.00	
Sewer Mining from WC Pressure Main	Pump Station at 48 L/s	$ 250,000.00	1	$ 250,000.00	$ 350,000.00	
	Connection Pipework balancing to Treatment Facility	$ 150.00	50	$ 7,500.00	$ 10,500.00	Based on assumptions of 150 mm diameter pipe $/mm including valves and fittings.
	Primary and Tertiary Treatment	$ 12,500,000.00	1	$ 12,500,000.00	$ 17,500,000.00	
	Balancing Storage Tank	$ 160,000.00	1	$ 160,000.00	$ 224,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Treatment Plant Housing and Access	$ 250,000.00	1	$ 250,000.00	$ 350,000.00	Based on similar treatment plant developments. Land acquisition has not been included.
	Transfer Pipe Infrastructure	$ 150.00	5000	$ 750,000.00	$ 1,050,000.00	Based on 150 mm diameter pip $/mm
	Instruments, Water Quality Monitoring and Control Panel	$ 30,000.00	1	$ 30,000.00	$ 42,000.00	
Balancing Storage	100 ML above ground dam storage	$ 1,500,000.00	1	$ 1,500,000.00	$ 2,100,000.00	Land acquisition not included.
Treatment Facility	Pump Station - Balancing Storage to treatment plant (620 L/s)	$ 600,000.00	1	$ 600,000.00	$ 840,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework Balancing to Treatment Facility	$ 600.00	50	$ 30,000.00	$ 42,000.00	Based on assumptions of 600 mm diameter pipe $/mm including valves and fittings.
	Media Filtration (620 L/s)	$ 2,200,000.00	1	$ 2,200,000.00	$ 3,080,000.00	Pre Treatment, Sand filtration. Based on a treatment rate of 620 L/s.
	Membrane Filtration (620 L/s)	$ 16,500,000.00	1	$ 16,500,000.00	$ 23,100,000.00	Based on treatment of 620 L/s.
	UV Disinfection (620 L/s)	$ 600,000.00	1	$ 600,000.00	$ 840,000.00	Based on a treatment rate of 620 L/s.
	Chlorination (620 L/s)	$ 660,000.00	1	$ 660,000.00	$ 924,000.00	Including Chlorine Dosing and Mixer, Chlorine Holding Tank (and bund), Chlorine Contact Tanks, and SCADA controls. Chlorination of recovered water prior to distribution for irrigation.
	Balancing Storage Tank	$ 160,000.00	1	$ 160,000.00	$ 224,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Treatment Plant Housing and Access	$ 250,000.00	1	$ 250,000.00	$ 350,000.00	Based on similar treatment plant developments.
ASR System	Bore Injection Pump Set (25 L/s) and Wetwall Infrastructure	$ 30,000.00	25	$ 750,000.00	$ 1,050,000.00	Based on pump set to supply 25 L/s. Inline water quality monitoring (wetwall) including pH, electrical conductivity and turbidity.
	Distribution Line to Production Bores	$ 200.00	5000	$ 1,000,000.00	$ 1,400,000.00	Based on assumptions of 200 mm diameter pipe $/mm including valves and fittings.
	Production Bores (x1)	$ 250,000.00	25	$ 6,250,000.00	$ 8,750,000.00	Cost based on previous projects, assuming a target depth of max 250 m bgl and PVC casing (254 mm diameter).
	Observation Bores (x1)	$ 175,000.00	5	$ 875,000.00	$ 1,225,000.00	Cost based on previous projects, assuming a target depth of max 250 m bgl and PVC casing (154 mm diameter).
	Aquifer Hydraulic Testing	$ 17,500.00	25	$ 437,500.00	$ 612,500.00	Step Discharge Test and 24 hour Constant Rate Discharge test of each production bore.
	Bore Headworks	$ 150,000.00	25	$ 3,750,000.00	$ 5,250,000.00	Based on previous project designs.
	Injection Line (x25)	$ 150.00	250	$ 37,500.00	$ 52,500.00	Based on assumptions of layflat pipe $/mm including valves and fittings.
	Rising Main (extraction x25)	$ 150.00	1725	$ 258,750.00	$ 362,250.00	Based on previous costs, pump set depth estimated to be 75 m bgl.
	Extraction Pump (x25)	$ 40,000.00	25	$ 1,000,000.00	$ 1,400,000.00	Based on a recovery rate up to 25 L/s.
	Distribution Line - Balancing Storage to irrigation precincts	$ 500.00	22000	$ 11,000,000.00	$ 15,400,000.00	Based on assumptions of 500 mm diameter pipe $/mm including valves and fittings.
	Scourline - (borefield)	$ 150.00	5200	$ 780,000.00	$ 1,092,000.00	Based on assumptions of 150 mm diameter pipe $/mm including valves and fittings.
Power	Control/ Housing	$ 400,000.00	1	$ 400,000.00	$ 560,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 3,363,412.50	$ 4,708,777.50	
Regulatory Approvals and Documentation		$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Hydrogeological Investigations, Numerical Groundwater Flow and Solute Transport Modelling, Geochemical Modelling, Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
			Total	**$ 71,019,662.50**	**$ 99,427,527.50**	

Option 3 - Woodland Grove Sporting Facility CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
Transfer from drainagge basins and creekline	Pump Station from creek (10 L/s)	$ 80,000.00	1	$ 80,000.00	$ 112,000.00	Harvest locations distributed across the two drains.
	Channel Upgrade Works	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Significant upgrades to the channel is not required. There are 2 offtake locations.
	Drainage Basin and Wetland	$ 1,000,000.00	1	$ 1,000,000.00	$ 1,400,000.00	30 ML basin
	Pipe Infrastructure	$ 100.00	500	$ 50,000.00	$ 70,000.00	Based on 100 mm pipe diameterincluding valve and fittings
	Instruments, Water Quality Monitoring and Control Panel	$ 15,000.00	1	$ 15,000.00	$ 21,000.00	
Treatment Facility	Pump Station - wetland to treatment plant (10 L/s)	$ 80,000.00	1	$ 80,000.00	$ 112,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework Blancing to Treatment Facility	$ 100.00	30	$ 3,000.00	$ 4,200.00	Based on assumptions of 100 mm diameter pipe $/mm including valves and fittings.
	Media Filtration (10 L/s)	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Pre Treatment, Sand filtration. Based on a treatment rate of 10 L/s.
	UV Disinfection (10 L/s)	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Based on a treatment rate of 10 L/s.
	Balancing Storage Tank	$ 40,000.00	1	$ 40,000.00	$ 56,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 5,000.00	1	$ 5,000.00	$ 7,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Treatment Plant Housing and Access	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Based on similar treatment plant developments.
Power	Control/ Housing	$ 200,000.00	1	$ 200,000.00	$ 280,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 300,000.00	1	$ 300,000.00	$ 420,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 64,960.00	$ 90,944.00	
Regulatory Approvals and Documentation		$ 150,000.00	1	$ 150,000.00	$ 210,000.00	Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
			Total	**$ 2,297,960.00**	**$ 3,217,144.00**	

Option 5 - Decentralised Wastewater System - Mundijong CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
Balancing Storage	400 ML above ground dam storage	$ 6,000,000.00	1	$ 6,000,000.00	$ 8,400,000.00	Land acquisition not included.
Treatment Facility	Pump Station - Balancing Storage to distribution (50 L/s)	$ 250,000.00	2	$ 500,000.00	$ 700,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework Blancing to Treatment Facility	$ 600.00	50	$ 30,000.00	$ 42,000.00	Based on assumptions of 600 mm diameter pipe $/mm including valves and fittings.
	Primary and Secondary Treatment	$ 5,000,000.00	1	$ 5,000,000.00	$ 7,000,000.00	
	Chlorination (50 L/s)	$ 150,000.00	1	$ 150,000.00	$ 210,000.00	Including Chlorine Dosing and Mixer, Chlorine Holding Tank (and bund), Chlorine Contact Tanks, and SCADA controls. Chlorination of recovered water prior to distribution for irrigation.
	Balancing Storage Tank	$ 160,000.00	2	$ 320,000.00	$ 448,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Instruments, Water Quality Monitoring and Control Panel	$ 150,000.00	1	$ 150,000.00	$ 210,000.00	
	Treatment Plant Housing and Access	$ 250,000.00	1	$ 250,000.00	$ 350,000.00	Based on similar treatment plant developments.
Distribution Insfrastructure	Pipe Infrastructure	$ 300.00	10000	$ 3,000,000.00	$ 4,200,000.00	Based on 10 km of 300 mm pipe
Power	Control/ Housing	$ 300,000.00	1	$ 300,000.00	$ 420,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 714,700.00	$ 1,000,580.00	
Regulatory Approvals and Documentation		$ 150,000.00	1	$ 150,000.00	$ 210,000.00	Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
			Total	**$ 17,074,700.00**	**$ 23,904,580.00**	

Option 6 - Decentralised Wastewater System with Surface Water from Manjedal Brook CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
Transfer from Mandejal Brook	Pump Stations (520 L/s)	$ 560,000.00	1	$ 560,000.00	$ 784,000.00	Harvest locations distributed across the two drains.
	Channel Upgrade Works	$ 10,000.00	2	$ 20,000.00	$ 28,000.00	Significant upgrades to the channel is not required. There are 2 offtake locations.
	Pipe Infrastructure	$ 500.00	5000	$ 2,500,000.00	$ 3,500,000.00	Based on 500 mm pipe diameter including valve and fittings
	Instruments, Water Quality Monitoring and Control Panel	$ 50,000.00	1	$ 50,000.00	$ 70,000.00	
Balancing Storage	100 ML above ground dam storage	$ 1,500,000.00	1	$ 1,500,000.00	$ 2,100,000.00	Land acquisition not included.
Treatment Facility - SW	Pump Station - Balancing Storage to treatment plant (520 L/s)	$ 560,000.00	1	$ 560,000.00	$ 784,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework balancing to Treatment Facility	$ 600.00	50	$ 30,000.00	$ 42,000.00	Based on assumptions of 600 mm diameter pipe $/mm including valves and fittings.
	Media Filtration (520 L/s)	$ 1,800,000.00	1	$ 1,800,000.00	$ 2,520,000.00	Pre Treatment, Sand filtration. Based on a treatment rate of 570 L/s.
	UV Disinfection (520 L/s)	$ 800,000.00	1	$ 800,000.00	$ 1,120,000.00	Based on a treatment rate of 570 L/s.
	Chlorination (520 L/s)	$ 550,000.00	1	$ 550,000.00	$ 770,000.00	Including Chlorine Dosing and Mixer, Chlorine Holding Tank (and bund), Chlorine Contact Tanks, and SCADA controls. Chlorination of recovered water prior to distribution for irrigation.
	Balancing Storage Tank	$ 160,000.00	1	$ 160,000.00	$ 224,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Treatment Plant Housing and Access	$ 250,000.00	1	$ 250,000.00	$ 350,000.00	Based on similar treatment plant developments.
ASR System	Bore Injection Pump Set (25 L/s) and Wetwall Infrastructure	$ 30,000.00	21	$ 630,000.00	$ 882,000.00	Based on pump set to supply 25 L/s. Inline water quality monitoring (wetwall) including pH, electrical conductivity and turbidity.
	Distribution Line to Production Bores	$ 200.00	5000	$ 1,000,000.00	$ 1,400,000.00	Based on assumptions of 200 mm diameter pipe $/mm including valves and fittings.
	Production Bores (x1)	$ 250,000.00	21	$ 5,250,000.00	$ 7,350,000.00	Cost based on previous projects, assuming a target depth of max 250 m bgl and PVC casing (254 mm diameter).
	Observation Bores (x1)	$ 175,000.00	2	$ 350,000.00	$ 490,000.00	Cost based on previous projects, assuming a target depth of max 250 m bgl and PVC casing (154 mm diameter).
	Aquifer Hydraulic Testing	$ 17,500.00	21	$ 367,500.00	$ 514,500.00	Step Discharge Test and 24 hour Constant Rate Discharge test of each production bore.
	Bore Headworks	$ 150,000.00	21	$ 3,150,000.00	$ 4,410,000.00	Based on previous project designs.
	Injection Line (x23)	$ 150.00	210	$ 31,500.00	$ 44,100.00	Based on assumptions of layflat pipe $/mm including valves and fittings.
	Rising Main (extraction x23)	$ 150.00	1680	$ 252,000.00	$ 352,800.00	Based on previous costs, pump set depth estimated to be 75 m bgl.
	Extraction Pump (x23)	$ 40,000.00	21	$ 840,000.00	$ 1,176,000.00	Based on a recovery rate up to 25 L/s.
	Scourline - (borefield)	$ 150.00	5000	$ 750,000.00	$ 1,050,000.00	Based on assumptions of 150 mm diameter pipe $/mm including valves and fittings.
Power	Control/ Housing	$ 400,000.00	1	$ 400,000.00	$ 560,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 1,561,770.00	$ 2,186,478.00	
Regulatory Approvals and Documentation		$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Hydrogeological Investigations, Numerical Groundwater Flow and Solute Transport Modelling, Geochemical Modelling, Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
Balancing Storage	400 ML above ground dam storage	$ 6,000,000.00	1	$ 6,000,000.00	$ 8,400,000.00	Land acquisition not included.
Treatment Facility - WW	Pump Station - Balancing Storage to distribution (50 L/s)	$ 250,000.00	2	$ 500,000.00	$ 700,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework Balancing to Treatment Facility	$ 600.00	50	$ 30,000.00	$ 42,000.00	Based on assumptions of 600 mm diameter pipe $/mm including valves and fittings.
	Primary and Secondary Treatment	$ 5,000,000.00	1	$ 5,000,000.00	$ 7,000,000.00	
	Chlorination (50 L/s)	$ 150,000.00	1	$ 150,000.00	$ 210,000.00	Including Chlorine Dosing and Mixer, Chlorine Holding Tank (and bund), Chlorine Contact Tanks, and SCADA controls. Chlorination of recovered water prior to distribution for irrigation.
	Balancing Storage Tank	$ 160,000.00	2	$ 320,000.00	$ 448,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Instruments, Water Quality Monitoring and Control Panel	$ 150,000.00	1	$ 150,000.00	$ 210,000.00	
	Treatment Plant Housing and Access	$ 250,000.00	1	$ 250,000.00	$ 350,000.00	Based on similar treatment plant developments.
Distribution Infrastructure	Pipe Infrastructure	$ 300.00	10000	$ 3,000,000.00	$ 4,200,000.00	Based on 10 km of 300 mm pipe
Power	Control/ Housing	$ 300,000.00	1	$ 300,000.00	$ 420,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 714,700.00	$ 1,000,580.00	
Regulatory Approvals and Documentation		$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Hydrogeological Investigations, Numerical Groundwater Flow and Solute Transport Modelling, Geochemical Modelling, Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
			Total	**$ 41,797,470.00**	**$ 58,516,458.00**	

Option 7 - Recharge Runoff from Mundijong Whitby District Sporting Facility CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
	Drainage Basin	$ 600,000.00	1	$ 600,000.00	$ 840,000.00	40 ML Basin
	Instruments, Water Quality Monitoring and Control Panel	$ 15,000.00	1	$ 15,000.00	$ 21,000.00	
Treatment Facility	Pump Station - wetland to treatment plant (12 L/s)	$ 80,000.00	1	$ 80,000.00	$ 112,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework Blancing to Treatment Facility	$ 100.00	30	$ 3,000.00	$ 4,200.00	Based on assumptions of 100 mm diameter pipe $/mm including valves and fittings.
	Media Filtration (12 L/s)	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Pre Treatment, Sand filtration. Based on a treatment rate of 10 L/s.
	UV Disinfection (12 L/s)	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Based on a treatment rate of 10 L/s.
	Balancing Storage Tank	$ 40,000.00	1	$ 40,000.00	$ 56,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 5,000.00	1	$ 5,000.00	$ 7,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Treatment Plant Housing and Access	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Based on similar treatment plant developments.
Power	Control/ Housing	$ 200,000.00	1	$ 200,000.00	$ 280,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 300,000.00	1	$ 300,000.00	$ 420,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 64,960.00	$ 90,944.00	
Regulatory Approvals and Documentation		$ 150,000.00	1	$ 150,000.00	$ 210,000.00	Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
			Total	**$ 1,757,960.00**	**$ 2,461,144.00**	

Option 8 - Harvest of Surface Water Flows from Punrack Drain CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
Transfer from Punrack Drain	Pump Stations (570 L/s) at 2 locations totally 285 L/s	$ 500,000.00	2	$ 1,000,000.00	$ 1,400,000.00	Harvest locations distributed across the two drains.
	Channel Upgrade Works	$ 50,000.00	2	$ 100,000.00	$ 140,000.00	Significant upgrades to the channel is not required. There are 2 offtake locations.
	Pipe Infrastructure	$ 500.00	5000	$ 2,500,000.00	$ 3,500,000.00	Based on 500 mm pipe diameterincluding valve and fittings
	Instruments, Water Quality Monitoring and Control Panel	$ 50,000.00	1	$ 50,000.00	$ 70,000.00	
Balancing Storage	100 ML above ground dam storage	$ 1,500,000.00	1	$ 1,500,000.00	$ 2,100,000.00	Land acquisition not included.
Treatment Facility	Pump Station - Balancing Storage to treatment plant (570 L/s)	$ 600,000.00	1	$ 600,000.00	$ 840,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework Blancing to Treatment Facility	$ 600.00	50	$ 30,000.00	$ 42,000.00	Based on assumptions of 600 mm diameter pipe $/mm including valves and fittings.
	Media Filtration (570 L/s)	$ 2,000,000.00	1	$ 2,000,000.00	$ 2,800,000.00	Pre Treatment, Sand filtration. Based on a treatment rate of 570 L/s.
	Membrane Filtration (570 L/s)	$ 15,000,000.00	1	$ 15,000,000.00	$ 21,000,000.00	Based on treatment of 570 L/s.
	UV Disinfection (570 L/s)	$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Based on a treatment rate of 570 L/s.
	Chlorination (570 L/s)	$ 600,000.00	1	$ 600,000.00	$ 840,000.00	Including Chlorine Dosing and Mixer, Chlorine Holding Tank (and bund), Chlorine Contact Tanks, and SCADA controls. Chlorination of recovered water prior to distribution for irrigation.
	Balancing Storage Tank	$ 160,000.00	1	$ 160,000.00	$ 224,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Treatment Plant Housing and Access	$ 250,000.00	1	$ 250,000.00	$ 350,000.00	Based on similar treatment plant developments.
ASR System	Bore Injection Pump Set (25 L/s) and Wetwall Infrastructure	$ 30,000.00	23	$ 690,000.00	$ 966,000.00	Based on pump set to supply 25 L/s. Inline water quality monitoring (wetwall) including pH, electrical conductivity and turbidity.
	Distribution Line to Production Bores	$ 200.00	5000	$ 1,000,000.00	$ 1,400,000.00	Based on assumptions of 200 mm diameter pipe $/mm including valves and fittings.
	Production Bores (x1)	$ 250,000.00	23	$ 5,750,000.00	$ 8,050,000.00	Cost based on previous projects, assuming a target depth of max 250 m bgl and PVC casing (254 mm diameter).
	Observation Bores (x1)	$ 175,000.00	5	$ 875,000.00	$ 1,225,000.00	Cost based on previous projects, assuming a target depth of max 250 m bgl and PVC casing (154 mm diameter).
	Aquifer Hydraulic Testing	$ 17,500.00	23	$ 402,500.00	$ 563,500.00	Step Discharge Test and 24 hour Constant Rate Discharge test of each production bore.
	Bore Headworks	$ 150,000.00	23	$ 3,450,000.00	$ 4,830,000.00	Based on previous project designs.
	Injection Line (x23)	$ 150.00	230	$ 34,500.00	$ 48,300.00	Based on assumptions of layflat pipe $/mm including valves and fittings.
	Rising Main (extraction x23)	$ 150.00	1725	$ 258,750.00	$ 362,250.00	Based on previous costs, pump set depth estimated to be 75 m bgl.
	Extraction Pump (x23)	$ 40,000.00	23	$ 920,000.00	$ 1,288,000.00	Based on a recovery rate up to 25 L/s.
	Distribution Line - Balancing Storage to irrigation precincts	$ 500.00	20000	$ 10,000,000.00	$ 14,000,000.00	Based on assumptions of 500 mm diameter pipe $/mm including valves and fittings.
	Scourline - (borefield)	$ 150.00	5000	$ 750,000.00	$ 1,050,000.00	Based on assumptions of 150 mm diameter pipe $/mm including valves and fittings.
Power	Control/ Housing	$ 400,000.00	1	$ 400,000.00	$ 560,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 3,453,152.50	$ 4,834,413.50	
Regulatory Approvals and Documentation		$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Hydrogeological Investigations, Numerical Groundwater Flow and Solute Transport Modelling, Geochemical Modelling, Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
			Total	**$ 53,283,902.50**	**$ 74,597,463.50**	

Option 9 - Construction of a Decentralised Wastewater System in Serpentine CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
Balancing Storage	60 ML above ground dam storage	$ 900,000.00	1	$ 900,000.00	$ 1,260,000.00	Land acquisition not included.
Treatment Facility	Pump Station - Balancing Storage to distribution	$ 250,000.00	2	$ 500,000.00	$ 700,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework Blancing to Treatment Facility	$ 600.00	50	$ 30,000.00	$ 42,000.00	Based on assumptions of 600 mm diameter pipe $/mm including valves and fittings.
	Primary and Secondary Treatment	$ 1,000,000.00	1	$ 1,000,000.00	$ 1,400,000.00	
	Balancing Storage Tank	$ 160,000.00	2	$ 320,000.00	$ 448,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Instruments, Water Quality Monitoring and Control Panel	$ 75,000.00	1	$ 75,000.00	$ 105,000.00	
	Treatment Plant Housing and Access	$ 250,000.00	1	$ 250,000.00	$ 350,000.00	Based on similar treatment plant developments.
Distribution Insfrastructure	Pipe Infrastructure	$ 150.00	10000	$ 1,500,000.00	$ 2,100,000.00	Based on 10 km of 150 mm pipe
Power	Control/ Housing	$ 400,000.00	1	$ 400,000.00	$ 560,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 320,950.00	$ 449,330.00	
Regulatory Approvals and Documentation		$ 500,000.00	1	$ 500,000.00	$ 700,000.00	Hydrogeological Investigations, Numerical Groundwater Flow and Solute Transport Modelling, Geochemical Modelling, Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
			Total	**$ 6,305,950.00**	**$ 8,828,330.00**	

Option 10 - Gallery Recharge into Decomissioned Open Pit Mines CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
Transfer from Kardup Brook	Pump Station from creek (10 L/s)	$ 80,000.00	1	$ 80,000.00	$ 112,000.00	A single harvest location.
	Channel Upgrade Works	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Significant upgrades to the channel is not required. There are 2 offtake locations.
	Pipe Infrastructure	$ 150.00	2000	$ 300,000.00	$ 420,000.00	Based on 150 mm pipe diameterincluding valve and fittings
	Instruments, Water Quality Monitoring and Control Panel	$ 15,000.00	1	$ 15,000.00	$ 21,000.00	
Treatment	Media Filtration (10 L/s)	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Pre Treatment, Sand filtration. Based on a treatment rate of 10 L/s.
	UV Disinfection (10 L/s)	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Based on a treatment rate of 10 L/s.
	Treatment Plant Housing and Access	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Based on similar treatment plant developments.
	Observation Bores (x1)	$ 15,000.00	2	$ 30,000.00	$ 42,000.00	Cost based on previous projects, assuming a target depth of max 250 m bgl and PVC casing (154 mm diameter).
Power	Control/ Housing	$ 200,000.00	1	$ 200,000.00	$ 280,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 300,000.00	1	$ 300,000.00	$ 420,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 58,100.00	$ 81,340.00	
Regulatory Approvals and Documentation		$ 150,000.00	1	$ 150,000.00	$ 210,000.00	Hydrogeological Investigations, Numerical Groundwater Flow and Solute Transport Modelling, Geochemical Modelling, Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
			Total	**$ 1,443,100.00**	**$ 2,020,340.00**	

Option 11 - Surface Water Harvest From Gooralong Brook CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
Transfer from brook to above ground storage	Pump Station from creek (12 L/s)	$ 80,000.00	1	$ 80,000.00	$ 112,000.00	Harvest locations distributed across the two drains.
	Channel Upgrade Works	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Significant upgrades to the channel is not required. There are 2 offtake locations.
	Above Ground Storage	$ 600,000.00	1	$ 600,000.00	$ 840,000.00	40 ML storage
	Pipe Infrastructure	$ 200.00	20	$ 4,000.00	$ 5,600.00	Based on 200 mm pipe diameterincluding valve and fittings
	Instruments, Water Quality Monitoring and Control Panel	$ 15,000.00	1	$ 15,000.00	$ 21,000.00	
Treatment Facility	Pump Station - wetland to treatment plant (12 L/s)	$ 80,000.00	2	$ 160,000.00	$ 224,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework Blancing to Treatment Facility	$ 100.00	30	$ 3,000.00	$ 4,200.00	Based on assumptions of 100 mm diameter pipe $/mm including valves and fittings.
	Media Filtration (10 L/s)	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Pre Treatment, Sand filtration. Based on a treatment rate of 10 L/s.
	UV Disinfection (10 L/s)	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Based on a treatment rate of 10 L/s.
	Chlorination (10 L/s)	$ 160,000.00	1	$ 160,000.00	$ 224,000.00	
	Balancing Storage Tank	$ 40,000.00	2	$ 80,000.00	$ 112,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 5,000.00	1	$ 5,000.00	$ 7,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Treatment Plant Housing and Access	$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Based on similar treatment plant developments.
Distribution	Distribution Pipe	$ 150.00	1000	$ 150,000.00	$ 210,000.00	
Power	Control/ Housing	$ 200,000.00	1	$ 200,000.00	$ 280,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 300,000.00	1	$ 300,000.00	$ 420,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 95,060.00	$ 133,084.00	
Regulatory Approvals and Documentation		$ 250,000.00	1	$ 250,000.00	$ 350,000.00	Function Design, Risk Assessment, Water Quality Monitoring and Management Plans.
			Total	**$ 2,412,060.00**	**$ 3,376,884.00**	

Option 12 - Wastewater System at the Tourist Park CAPEX Costs

Item	Element	Rate	Number of Units	Estimate	Including 40% Contingency	Assumption
Balancing Storage	5 ML above ground storage	$ 75,000.00	1	$ 75,000.00	$ 105,000.00	Land acquisition not included.
Treatment Facility	Pump Station - Balancing Storage to distribution (10 L/s)	$ 40,000.00	2	$ 80,000.00	$ 112,000.00	Cost based on previous project costs, allowing shed, pump station (dual pump redundancy) and valves.
	Connection Pipework Blancing to Treatment Facility	$ 200.00	30	$ 6,000.00	$ 8,400.00	Based on assumptions of 200 mm diameter pipe $/mm including valves and fittings.
	Primary and Secondary Treatment	$ 150,000.00	1	$ 150,000.00	$ 210,000.00	
	Balancing Storage Tank	$ 160,000.00	1	$ 160,000.00	$ 224,000.00	200 kL Balancing Storage Tank has been allowed.
	Backwash Infrastructure	$ 10,000.00	1	$ 10,000.00	$ 14,000.00	Backwash infrastructure from treatment facility to be discharged to Lake, Sewer or to an appropriately Licenced facility.
	Instruments, Water Quality Monitoring and Control Panel	$ 50,000.00	1	$ 50,000.00	$ 70,000.00	
	Treatment Plant Housing and Access	$ 150,000.00	1	$ 150,000.00	$ 210,000.00	Based on similar treatment plant developments.
Distribution Insfrastructure	Pipe Infrastructure	$ 150.00	1000	$ 150,000.00	$ 210,000.00	Based on 10 km of 150 mm pipe
Power	Control/ Housing	$ 200,000.00	1	$ 200,000.00	$ 280,000.00	Based on previous project costs for a similar size, including SCADA, controls, cabling and switchboard.
	Augmentation	$ 300,000.00	1	$ 300,000.00	$ 420,000.00	Allowing for new power supply, transformer and authority costs with contingency.
Detailed Design		7% of CAPEX		$ 87,920.00	$ 123,088.00	
Regulatory Approvals and Documentation		$ 100,000.00	1	$ 100,000.00	$ 140,000.00	Irrigation Management Plans for Reuse
			Total	**$ 1,518,920.00**	**$ 2,126,488.00**	

APPENDIX E

MULTI-CRITERIA ASSESSMENT

Shire of Serpentine Jarrahdale WGA WALLBRIDGE GILBERT AZTEC

Shire of Serpentine Jarrahdale
Integrated Water Management Strategy
Multi-criteria Assessment
Instruction Sheet
18 February 2020

INSTRUCTIONS

OVERVIEW

This multi-criteria assessment tool has been developed to assist the Shire of Serpentine Jarrahdale (SSJ) in planning and assessing concepts suitable for an integrated management strategy plan. The intent is that the assessment is to be implemented at least annually to determine if the SSJ has to progress the water strategy.

Four individual stages form the basis of this assessment, a summary of each section is provided below.

GENERAL INSTRUCTIONS

Each stage will require the user to input data for the assessment. The cells requiring input from the user are highlighted in a light blue colour (see below). Please ensure macros are enabled as this tool relies on the use of macros to function.

User input required

OPTIONS

Each concept option to be assessed is to be described on the Options tab. This information will be sourced throughout the workshop with the exception of the cost per kilolitre as a driver to ensure that any funding or avoided costs have been captured.

Note that if a yield is not specified for a particular option, that option is deemed as a 'fail' throughout the assessment and does not proceed to the subsequent assessments.

STAGE 1 - TRIGGER ASSESSMENT

The first stage of the assessment is to determine if additional water is required, and therefore whether the strategy needs to be reviewed. The trigger assessment requires the user to review all the aspects which may increase an irrigation demand over the next 2 years.

The trigger assessment is split into three tabs, one each for demand (TAD), supply (TAS) and summary (SUM). The role of each tab is summarised below:

Demand - This tab requires the user to input the Demand for each Project/Development for each region. If the demand is unknown, a demand is able to be estimated by selecting the irrigated area and an appropriate irrigation rate. The irrigation rates included are predetermined and have been separated into a low, medium and high irrigation rate based on the *WA Government's Irrigation Calculator* . Note the user **cannot** input a known **and** estimated demand. There is also a space allowance to include a map and description of the demand for record purposes.

Supply - This tab requires the user to input data for the water Supply in each region. An annual volume is required and the user is able to write a short description of each option. There is also a space allowance to include a map and description of the supply for record purposes.

Summary - This tab provides a summary of the total demand and supply for each region. The demands and supply's are summarised and a trigger is included as part of the overall assessment. The trigger to progress the assessment is: *If the demand exceeds 80% of the supply volumes. This allows some lead time before SSJ requires more water.* The user must click the 'Update Trigger Assessment' box to update the worksheet.

If the trigger is not exceeded, the assessment stops at this stage. Note that the remaining tabs will remain hidden. Should the user wish to continue the assessment, this can simply be done by ticking the "Continue with Assessment" box.

STAGE 2 - FATAL FLAW ASSESSMENT

The fatal flaw assessment requires all of the proposed water supply concepts to be reviewed for fatal flaws. Each of these flaws are required to be checked individually for each option. This process is outside of this worksheet.

A tick is given to the fatal flaw if it 'passes' and there is no flaw. If a fatal flaw is identified, the box should remain unticked and the concept is deemed as a 'fail' at this time.

If any fatal flaws for the specific option are found to fail, then that option does not proceed to the next stage and is not included in subsequent assessments. This means that the option is parked but should still be considered for future assessments.

STAGE 3 - MULTI-CRITERIA ASSESSMENT

Stage 3 comprises of a multi-criteria assessment which includes 36 questions from varying categories. Each question has designated responses which are allocated a ranking number, where a higher number indicates a better concept for that question. Each question is to be answered and a total sum is given at the top of the page.

A drop down box for each question with the allowable responses is provided. If an option does not pass the Stage 2 Fatal Flaw Assessment, it will be automatically hidden. Note that this will happen once the 'Update MCA' button is clicked (located in the 'Questions' heading cell). Please ensure you update the sheet before commencing the Stage 3 Assessment.

This approach enables the identification of areas of risk or where further work may be required, if this occurs the concept may not necessarily be unviable or may need to be park. If sufficient time allows, the necessary investigations can be implemented and the assessment revisited. The assessment may require multiple iterations. An indication of unanswered questions is provided in the summary bar located along the top of the page.

Note: The ranking of this stage alone does not determine the most viable concept, but should be considered in conjunction with the Stage 4 assessment.

STAGE 4 - COST PER KILOLITRE ASSESSMENT

The cost of the concept has significant implications on the viability of the concept, especially where the project is partially or fully funded through government grants. This stage considers the capital (CAPEX) and operational (OPEX) costs along with any funding or avoided costs to a per kilolitre water supply rate.

A target cost per kilolitre supply rate can be inputted by the user, and the options are compared to this rate. Note that this assessment does not calculate CAPEX, OPEX or cost per kilolitre and it is expected these are calculated outside this worksheet and inputted manually. The implication of funding on the cost is also to be considered as it can have a significant impact on viability. Stage 4 will ask for the cost for the concept and then the cost once funding has been considered. Once again this is a manual process outside the worksheet.

The Stage 4 assessment is to be coupled with the Stage 3 ranking assessment enabling a concept or multiple concepts to be considered depending on the situation.

Note that similarly to the Stage 3 Assessment, the options that have not passed the Stage 2 Fatal Flaw Assessment will be hidden. Select the 'Update Table' button to update the sheet before commencing the Stage 4 Assessment.

SUMMARY

A summary page is provided compiling the key results from each stage of the assessment. It is the expectation that SSJ will review the results of the assessment and select the most appropriate concept(s) to progress.

The summary table can be displayed so that the results are sorted, favouring the cost per kL results from the Stage 4 assessment. This can be done by clicking the 'Update Summary' button to update and sort the table. The top 3 total scores for the Stage 3 assessment are highlighted in green.

Shire of Serpentine Jarrahdale

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Shire of Serpentine Jarrahdale

Integrated Water Management Strategy

Multi-criteria Assessment

Options Description

18 February 2020

Region	Demand (ML)	Option	Description	Abbreviation	Yield (ML/a)	CAPEX ($ Mill)	OPEX ($ Mill)	Cost per kL (4-7% RDR)
Byford – Oakford	555	1	Surface Water Harvesting from Oakland / Barriga Main Drain with MAR	Byf - SW - Oakland/Barriga MAR	4,000	$74.60	$3.11	$2.15-$2.60
		1a	Surface Water Harvesting from Oakland / Barriga Main Drain with above ground storage	Byf - SW - Oakland/Barriga AGS	4,000	$134.10	$2.05	$2.10-$2.92
		2	Integration of Option 1 with Sewer Mining	Byf - Optn 1 plus WW	4,800	$99.50	$3.39	$2.20-$2.65
		3	Woodland Grove Sporting Facility	Byf - Woodland Grove	32	$3.20	$0.39	$17.70-$20.10
Oldbury – Mundijong	750	4	Option 1 – Alternative Location	Mun - Optn 1 - Alt Location	4,000	$74.60	$3.11	$2.15-$2.60
		5	Mundijong Decentralised Wastewater System	Mun - DWS	800	$23.90	$1.91	$3.95-$4.70
		6	Decentralised Wastewater System with Surface Water from Manjedal Brook	Mun - Optn 5 plus SW	3,200	$77.99	$4.69	$3.25-$3.85
		7	Recharge Runoff from Mundijong Whitby District Sporting Facility	Mun - Whitby DSF	40	$2.50	$0.42	$14.15-$15.70
Hopeland – Serpentine - Keysbrook	340	8	Harvest of Surface Water Flows from Punrack Drain	Serp - SW Punrack Drain	4,000	$74.60	$3.11	$2.15-$2.60
		9	Construction of a Decentralised Wastewater System in Serpentine	Serp - DWS	120	$8.98	$1.35	$2.45-$2.75
		10	Gallery Recharge into Decommissioned Open Pit Mines	Serp - Open Pit Mine	40	$2.02	$0.30	$10.25-$11.45
Jarrahdale	32	11	Surface Water Harvesting from Gooralong Brook	Jarra - SW - Gooralong Brook	32	$3.38	$0.33	$13.15-$15.15
		12	Construction of a Decentralised Wastewater System for the Tourist Park	Jarra - Tourist Park DWS	8	$2.13	$0.52	$80.30-$86.50
			Additional Option 1					
			Additional Option 2					
			Additional Option 3					
			Additional Option 4					
			Additional Option 5					

Shire of Serpentine Jarrahdale
Integrated Water Management Strategy
Multi-criteria Assessment
Stage 1 - Trigger Assessment Demands
18 February 2020

Trigger Assessment Demands						
Project / Development	Known Demand (ML/a)	Estimated Demand				Notes
		Area (m^2)	Irrigation Rate (ML/Ha/a)		Estimated Demand (ML/a)	
Region: Byford - Oakford Precinct						
Kalimna Oval				N/A	N/A	Has this oval been developed / expanded or is planned in the next 24 months?
Kanidimak Road Reserve				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Briggs Park				N/A	N/A	Has this park been developed / expanded or is planned in the next 24 months?
Orton District Oval				N/A	N/A	Has this oval been developed / expanded or is planned in the next 24 months?
Plaistown Blvd (Reserve)				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Sansimeon Marri Pk, Thatcher Road				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Peppies Crescent Reserve				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Lot 333 Lipizzaner Road Byford				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Lot 1002 Castello Crescent				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Lot 850 South Western Hwy (Byford Hall)				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Woodland Grove District Oval Space				N/A	N/A	Has this oval been developed / expanded or is planned in the next 24 months?
Public Open Space, Garden Beds and Road Reserve				N/A	N/A	Are to be handed over to Council from developers to be managed or area being developed by Council.
Agricultural Demand				N/A	N/A	Is there agricultural demand that can not be met by other water supplies or presents an opportunity for SSJ?
Industrial Demand				N/A	N/A	Is there industrial demand that can not be met by other water supplies or presents an opportunity for SSJ?
Council Irrigation Demand External to SSJ				N/A	N/A	Have any councils outside of SSJ requested water?
Fire Management Initiatives		*Known demand only*				Has SSJ adopted any Fire Management Initiatives which would increase water demand?
Climate Variability Impacts		*Known demand only*				Applied as a percentage of total irrigation. This is options if demand volumes are understood with the maximum volume recorded adopted.
Total Demand for Byford - Oakford Precinct					0.00	ML/a
Region: Oldbury - Mundijong Precinct						
Road Reserves				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Mundijong Reserve Oval				N/A	N/A	
Keirnan Park Recreational Facility				N/A	N/A	Has this park been developed / expanded or is planned in the next 24 months?
District Equine Facility				N/A	N/A	Has this facility been developed / expanded or is planned in the next 24 months?
Public Open Space, Garden Beds and Road Reserve				N/A	N/A	Are to be handed over to Council from developers to be managed or area being developed by Council.
Agricular Demand				N/A	N/A	Is there agricultural demand that can not be met by other water supplies or presents an opportunity for SSJ?
Industrial Demand				N/A	N/A	Is there industrial demand that can not be met by other water supplies or presents an opportunity for SSJ?
Council Irrigation Demand External to SSJ				N/A	N/A	Have any councils outside of SSJ requested water?
Fire Management Initiatives		*Known demand only*				Has SSJ adopted any Fire Management Initiatives which would increase water demand?
Climate Variability Impacts		*Known demand only*				Applied as a percentage of total irrigation. This is options if demand volumes are understood with the maximum volume recorded adopted.
Total Demand for Oldbury - Mundijong Precinct					0.00	ML/a
Region: Hopeland - Serpentine - Keysbrook Precinct						
Serpentine Courts				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Serpentine Pony Club / Sports Oval				N/A	N/A	Has this oval been developed / expanded or is planned in the next 24 months? What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Road Reserves				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Public Open Space, Garden Beds and Road Reserve				N/A	N/A	Are to be handed over to Council from developers to be managed or area being developed by Council.
Agricultural Demand				N/A	N/A	Is there agricultural demand that can not be met by other water supplies or presents an opportunity for SSJ?
Industrial Demand				N/A	N/A	Is there industrial demand that can not be met by other water supplies or presents an opportunity for SSJ?
Council Irrigation Demand External to SSJ				N/A	N/A	Have any councils outside of SSJ requested water?
Fire Management Initiatives		*Known demand only*				Has SSJ adopted any Fire Management Initiatives which would increase water demand?
Climate Variability Impacts		*Known demand only*				Applied as a percentage of total irrigation. This is options if demand volumes are understood with the maximum volume recorded adopted.
Total Demand for Hopeland - Serpentine - Keysbrook Precinct					0.00	ML/a

Region: Jarrahdale

St Pauls Church				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Jarrahdale Hall				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Jarrahdale Kindy and Tennis Courts				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Forest Green Reserve				N/A	N/A	What is the maximum recorded irrigation volume for the site (recorded) or what standard will the area be maintained to?
Jarrahdale Oval				N/A	N/A	Has this oval been developed / expanded or is planned in the next 24 months?
Tourist Park - wash down / irrigation				N/A	N/A	Has this facility been developed / expanded or is planned in the next 24 months?
Public Open Space, Garden Beds and Road Reserve				N/A	N/A	Are to be handed over to Council from developers to be managed or area being developed by Council.
Agriculural Demand				N/A	N/A	Is there agricultural demand that can not be met by other water supplies or presents an opportunity for SSJ?
Industrial Demand				N/A	N/A	Is there industrial demand that can not be met by other water supplies or presents an opportunity for SSJ?
Council Irrigation Demand External to SSJ				N/A	N/A	Have any councils outside of SSJ requested water?
Fire Management Initiatives		*Known demand only*				Has SSJ adopted any Fire Management Initiatives which would increase water demand?
Climate Variability Impacts		*Known demand only*				Applied as a percentage of total irrigation. This is options if demand volumes are understood with the maximum volume recorded adopted.
			Total Demand for Jarrahdale		0.00	ML/a

Total Demand for the Shire (ML/a)	0.00	ML/a

Please insert map and description here

Shire of Serpentine Jarrahdale

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Shire of Serpentine Jarrahdale
Integrated Water Management Strategy
Multi-criteria Assessment
Stage 1 - Trigger Assessment Supply
18 February 2020

Trigger Assessment Supplies		
Source	**Annual Volume (ML/a)**	**Source Description**
Region: Byford - Oakford Precinct		
Groundwater Allocation - Superficial Aquifer		
Groundwater Allocation - Leederville Aquifer		
Groundwater Allocation - Cattamarra Aquifer		
Surface Water Allocation / Take		
Existing Recycled Water Supply (stormwater, drainage water, surface water)		
Existing Recycled Water Supply (wastewater)		
Planned Recycled Water Supply (stormwater, drainage water, surface water)		
Planned Recycled Water Supply (wastewater)		
Accepted Scheme Water Use (no other options)		
Total Supply for Byford - Oakford Precinct Region	**0**	**ML/a**
Region: Oldbury - Mundijong Precinct		
Groundwater Allocation - Superficial Aquifer		
Groundwater Allocation - Leederville Aquifer		
Groundwater Allocation - Cattamarra Aquifer		
Surface Water Allocation / Take		
Existing Recycled Water Supply (stormwater, drainage water, surface water)		
Existing Recycled Water Supply (wastewater)		
Planned Recycled Water Supply (stormwater, drainage water, surface water)		
Planned Recycled Water Supply (wastewater)		
Accepted Scheme Water Use (no other options)		
Total Supply for Oldbury - Mundijong Precinct	**0**	**ML/a**
Region: Hopeland - Serpentine - Keysbrook Precinct		
Groundwater Allocation - Superficial Aquifer		
Groundwater Allocation - Leederville Aquifer		
Groundwater Allocation - Cattamarra Aquifer		
Surface Water Allocation / Take		
Existing Recycled Water Supply (stormwater, drainage water, surface water)		
Existing Recycled Water Supply (wastewater)		
Planned Recycled Water Supply (stormwater, drainage water, surface water)		
Planned Recycled Water Supply (wastewater)		
Accepted Scheme Water Use (no other options)		
Total Supply for Hopeland - Serpentine - Keysbrook Precinct	**0**	**ML/a**
Region: Jarrahdale		
Groundwater Allocation - Fractured Rock Aquifer		
Surface Water Allocation / Take		
Existing Recycled Water Supply (stormwater, drainage water, surface water)		
Existing Recycled Water Supply (wastewater)		
Planned Recycled Water Supply (stormwater, drainage water, surface water)		
Planned Recycled Water Supply (wastewater)		
Accepted Scheme Water Use (no other options)		
Total Supply for Jarrahdale	**0**	**ML/a**

Total Supply Volume (ML/a)	**0**	**ML/a**

Please insert map and description here

Shire of Serpentine Jarrahdale

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Shire of Serpentine Jarrahdale
Integrated Water Management Strategy
Multi-criteria Assessment
Stage 1 - Trigger Assessment Summary
18 February 2020

Stage 1 Summary		
Region	**Demand (ML/a)**	**Supply (ML/a)**
Byford - Oakford Precinct	**0**	**0**
Oldbury - Mundijong Precinct	**0**	**0**
Hopeland - Serpentine - Keysbrook Precinct	**0**	**0**
Jarrahdale	**0**	**0**
Total	**0**	**0**

Trigger Assessment	**Supply is okay**

Continue with Assessment?	☑

Shire of Serpentine Jarrahdale

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Shire of Serpentine Jarrahdale

Integrated Water Management Strategy

Multi-criteria Assessment

Stage 2 - Fatal Flaw Assessment

18 February 2020

Options			Fatal Flaw Assessment					
No.	**Description**	**Yield (ML/a)**	**Legislation and Policy** *Does the option meet all legislation and policy requirements?*	**Technical Feasibility** *Is this option technically feasible?*	**Social** *Does the option have any social impacts?*	**Environmental** *Has the environmental impact of the option been assessed?*	**Water Availability** *Is the water readily available for this option?*	**Pass/Fail**
1	Surface Water Harvesting from Oakland / Barriga Main Drain with MAR	4000	☐	☐	☐	☐	☐	FAIL
1a	Surface Water Harvesting from Oakland / Barriga Main Drain with above ground storage	4000	☐	☐	☐	☐	☐	FAIL
2	Integration of Option 1 with Sewer Mining	4800	☐	☐	☐	☐	☐	FAIL
3	Woodland Grove Sporting Facility	32	☐	☐	☐	☐	☐	FAIL
4	Option 1 – Alternative Location	4000	☐	☐	☐	☐	☐	FAIL
5	Mundijong Decentralised Wastewater System	800	☐	☐	☐	☐	☐	FAIL
6	Decentralised Wastewater System with Surface Water from Manjedal Brook	3200	☐	☐	☐	☐	☐	FAIL
7	Recharge Runoff from Mundijong Whitby District Sporting Facility	40	☐	☐	☐	☐	☐	FAIL
8	Harvest of Surface Water Flows from Punrack Drain	4000	☐	☐	☐	☐	☐	FAIL
9	Construction of a Decentralised Wastewater System in Serpentine	120	☐	☐	☐	☐	☐	FAIL
10	Gallery Recharge into Decommissioned Open Pit Mines	40	☐	☐	☐	☐	☐	FAIL
11	Surface Water Harvesting from Gooralong Brook	32	☐	☐	☐	☐	☐	FAIL
12	Construction of a Decentralised Wastewater System for the Tourist Park	8	☐	☐	☐	☐	☐	FAIL
	Additional Option 1	*No yield specified*	☐	☐	☐	☐	☐	FAIL
	Additional Option 2	*No yield specified*	☐	☐	☐	☐	☐	FAIL
	Additional Option 3	*No yield specified*	☐	☐	☐	☐	☐	FAIL
	Additional Option 4	*No yield specified*	☐	☐	☐	☐	☐	FAIL
	Additional Option 5	*No yield specified*	☐	☐	☐	☐	☐	FAIL

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Shire of Serpentine Jarrahdale
Integrated Water Management Strategy
Multi-criteria Assessment
Stage 3 - Multi-Criteria Assessment
18 February 2020

Multi-Criteria Assessment

Option No.	1	1a	2	3	4	5	6	7	8	9	10	11	12					
Option Description	Byf - SW - Oakland/Barriga MAR	Byf - SW - Oakland/Barriga AGS	Byf - Optn 1 plus WW	Byf - Woodland Grove	Mun - Optn 1 - Alt Location	Mun - DWS	Mun - Optn 5 plus SW	Mun - Whitby DSF	Serp - SW Punrack Drain	Serp - DWS	Serp - Open Pit Mine	Jarra - SW - Gooralong Brook	Jarra - Tourist Park DWS					
Total Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yield (ML/a)	4000	4000	4800	32	4000	800	3200	40	4000	120	40	32	8	0	0	0	0	0
Trigger	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered	Warning: Some questions have not been answered

Questions

No.	Question	Score	Score Description
Capacity to Meet Demand			
1	Has the source water availability supply and reliability been confirmed?	1	Unknown, low confidence, no information
		2	Somewhat known, low to moderate confidence, modelling or water balance
		3	Somewhat known, moderate confidence, modelling with some field information
		4	Known, moderate to high confidence, modelling with seasonal field monitoring
		5	Known, high confidence, modelling with seasonal field monitoring over a more than 1 year time span
2	Does the option meet the demand requirements?	1	Demand not met, option supplies less than 40% of demand
		2	Demand not met, option supplies between 40 and 75%
		3	Demand nearly met, option supplied between 75 and 95%
		4	Demand met
		5	Demand met with staging and flexibility
3	Is the option proximity such that water can be supplied through a pipe network or MAR Recharge Transfer Credits?	1	Pipe network or MAR Recharge credits not feasible
		2	Pipe network or MAR Recharge credits feasible unknown
		3	Pipe network or MAR Recharge credits feasible, low confidence
		4	Pipe network or MAR Recharge credits feasible, moderate confidence
		5	Pipe network or MAR Recharge credits feasible, high confidence
4	Is the option scalable?	1	Option not scalable
		2	Option has limited scalability
		3	Option has some scalability
		4	Option is scalable
		5	Option can have multiple stages of development
5	Number of water sources in the system? i.e. what is the security of supply and flexibility should a single source be compromised.	1	Single water source with no flexibility in design infrastructure
		2	Single water source, with infrastructure flexibility
		3	Single water source with alternative back up water supply
		4	More than one water source with security greater than 50%
		5	More than one water source with security greater than 80%
6	Do other options needs to be considered to meet supply or for security of supply?	1	Yes, water demand not met (<80%) and low security of supply
		2	Water supply meets 80% of demand, moderate to low security of supply
		3	Water supply meets 80% of demand, moderate security of supply
		4	Water demand met, moderate to high security of supply
		5	No, water demand met with high security of supply
7	Water supply variability, is storage required?	1	Significant storage required 100% of demand
		2	Storage required >70% of demand
		3	Storage required >50% of demand
		4	Storage required >30% of demand
		5	Direct supply, no or limited (<30%) storage required
8	Timeframe between construction and supply?	1	Significant delay between construction and supply, greater than 5 years
		2	Minimal delay between timeframes – less than 5 year, alternative interim water supply required or alternative disposal mechanisms required
		3	Minimal delay between timeframes – less than 3 year, manageable with interim water supply or delay in POS development or disposal opportunity (i.e. wastewater)
		4	Minimal delay between timeframes – less than 1 year, manageable with interim water supply or disposal opportunity (i.e. wastewater)
		5	Construction and supply timeframe align
Security of Supply			
9	Is the source water supply climate dependent?	1	Highly dependent on climate variability
		2	Moderate dependent on climate variability (1 in 2 years failure to meet demand)
		3	Somewhat dependent on climate variability (1 in 5 years failure to meet demand)
		4	Limited dependency on climate variability (1 in 10 years failure to supply rate)
		5	No dependency on climate variability, e.g. residential wastewater

10	What is the percentage of harvest to source water availability?	1	Demand to availability ratio >40%
		2	Demand to availability ratio >30%
		3	Demand to availability ratio <20%
		4	Demand to availability ratio <10%
		5	Demand to availability ratio =<5%
11	Is the availability of source water impacted by third parties, existing and future?	1	Unknown
		2	High risk from third party users
		3	Moderate to high risk from third party users
		4	Minimal risk from third party users
		5	Low risk from third party users
Water Quality			
12	Is the proposed treatment train outlined in the concept suitable to meet end use or storage requirements (i.e. MAR)?	No	Review treatment train and costings prior to proceeding
		Yes	Continue with assessment
13	Potential for contamination to impact flows? i.e. likelihood of cease supply or injection.	1	High risk of contamination or land use change or unknown
		2	Moderate to high risk of contamination or land use change
		3	Moderate risk of contamination or land use change
		4	Low to moderate risk of contamination or land use change
		5	Low risk of contamination or land use change
Water Supply Timing			
14	Does the timing of supply meet the demand timing? i.e. is a decentralised waste water system is constructed, supply of the full design may not be realised for 5-10 years.	1	Unknown
		2	Significant gap in timing between supply and demand
		3	Manageable gap in timing between supply and demand by using other interim water sources or managing demand
		4	Manageable gap in timing
		5	Yes
Technical Feasibility			
15	Is the concept technically feasible? Considerations: power supply, MAR feasibility, water treatment, capture, land availability, etc	1	Developing or leading-edge technology, no proven examples, high risk, low confidence
		2	Developing or leading-edge technology, some examples, moderate to high risk, low confidence
		3	Feasible, moderate risk, moderate confidence
		4	Feasible, proven examples, low to moderate risk, moderate to high confidence
		5	Feasible, industry standard, low risk, high confidence
16	Are there any unknowns or data gaps?	1	Significant data gaps or unknown i.e. concept viability or cost has low confidence
		2	Data gaps or unknowns, manageable with standard contingency (40%)
		3	Some data gaps or unknowns, manageable with standard contingency (40%)
		4	Limited data gaps or unknowns, manageable with standard contingency (20%)
		5	No or limited data gaps or unknowns, high confidence in the option
17	Can the option be implemented at this location?	1	Unknown or not feasible
		2	Option may be feasible but at a distance from the demand location (>20 km)
		3	Option may be feasible but at a distance from the demand location (>10 km)
		4	Option feasible with an acceptable distance from the demand location (<10 km)
		5	Option feasible at the location
18	Are waste streams produced?	1	Yes, acceptable management option not identified or is unknown
		2	Waste streams are produced and are manageable, low confidence
		3	Waste streams are produced and are manageable, moderate confidence
		4	Waste streams are produced and are manageable, high confidence
		5	No waste streams are produced
19	Operability – what is the ability of council or a third party to operate the system successfully?	1	Unknown or skilled operators unavailable or cost prohibitive
		2	Some demonstrated experience in operating comparable systems and cost prohibitive
		3	Skilled operators available and cost prohibitive
		4	Demonstrated experience operating comparable system
		5	Skilled operators available with experience in operating similar and cost effective
Environmental			
20	Are the potential environmental impacts acceptably low or manageable?	1	High or unknown risk of significant environmental impacts
		2	Moderate risk of significant environmental impacts
		3	Low to moderate risk of significant environmental impacts
		4	Low to moderate risk, acceptable with management measures
		5	Low or acceptable risk to the environment
21	What is the likelihood of impact to the environment? e.g. change in hydrology, GDEs, biodiversity, native vegetation or environmentally sensitive areas.	1	High likelihood of significant impact to the environment
		2	Moderate likelihood of unacceptable impact to the environment
		3	Low likelihood of unacceptable impact to the environment
		4	Moderate likelihood of low or positive impact to the environment
		5	High likelihood of low or positive impact to the environment
22	Are there any impacts to the environment from the management of waste products?	1	Yes
		2	No

23	Does the option have benefits for fire management?	1	No
		2	Yes
Social			
24	Does the option meet the community and social expectations?	1	High level of community concern or unknown
		2	Low level of community support
		3	Moderate level of community support with manageable concerns
		4	Moderate to high level of community support with manageable concerns
		5	High level of community support
25	What is the likelihood of impact to cultural or heritage sites?	1	High level of risk or unknown
		2	Moderate to high level of risk
		3	Moderate level of risk
		4	Low to moderate level of risk
		5	Low level of risk
Legislation and Regulatory Requirements			
26	Are the legislative and regulatory requirements understood and clear?	1	Significant risk, no regulatory support, unknown
		2	Poorly understood or imminent changes in policy are unknown or pose a risk to the project
		3	Clearly understood with potential changes proposed (0-5 year timeframe)
		4	Clearly understood with no significant changes proposed
		5	Clearly understood with regulatory support
27	What is the potential for legislation to change in the next 5 years?	1	High risk of change or unknown
		2	Moderate to high risk of change
		3	Moderate risk of change
		4	Low to moderate risk of change
		5	Low risk of change
28	Does the option meet the legislative or regulatory requirements?	1	No, low chance of being accepted or unknown
		2	No, need to seek acceptance by the regulators, moderate chance of success
		3	Generally yes, aligns with water management policy initiatives but need to seek acceptance by the regulators, high chance of success
		4	Yes, with some exceptions accepted by the regulators
		5	Yes
29	Are the compliance requirements understood and manageable?	1	Poorly understood
		2	Somewhat understood
		3	Moderately understood
		4	Understood
		5	Well understood
Political			
30	Are the political risks acceptable?	1	Unacceptable or unknown
		2	High risk
		3	Moderate risk
		4	Acceptable or low risk
		5	Acceptable with political support
Financial			
32	Is the CAPEX clearly understood and represent the cost to manage any risks identified above? Note: If option can be staged, the cost presented should represent that equal to meet demand.	1	Costs not clear or unknown
		2	Costs understood with high contingency (±40%)
		3	Costs understood with moderate contingency (±30%)
		4	Costs understood with acceptable contingency (±20%)
		5	Costs clearly understood (±10%)
33	Is the OPEX clearly understood and represent the cost to manage any risks identified above? Note: If option can be staged, the cost presented should represent that equal to meet demand.	1	Costs not clear or unknown
		2	Costs understood with high contingency (±40%)
		3	Costs understood with moderate contingency (±30%)
		4	Costs understood with acceptable contingency (±20%)
		5	Costs clearly understood (±10%)
34	Has the project been funded partially or fully through grants?	1	No funding support
		2	Project <25%
		3	Project 25-50%
		4	Project 50-75% funded
		5	Project 75-100% funded
35	Are there any avoided costs (e.g. nutrient disposal costs) or additional revenue (e.g. sewer rates)?	1	No
		2	Yes, take into consideration in financial assessment
36	Does the concept offer employment benefits plus local economic sustainability?	1	No or limited benefits
		2	Moderate benefits
		3	Significant benefits

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Integrated Water Management Strategy

Multi-criteria Assessment

Stage 4 - Cost per kL Assessment

18 February 2020

Cost per kL Target	

Option	Description	CAPEX ($ Mill)	OPEX ($ Mill)	Yield (ML/a)	Original NPV ($ Mill)	Funding ($ Mill)	Final Cost per kL ($)
1	Surface Water Harvesting from Oakland / Barriga Main Drain with MAR	74.60	3.11	4,000			
1a	Surface Water Harvesting from Oakland / Barriga Main Drain with above ground storage	134.10	2.05	4,000			
2	Integration of Option 1 with Sewer Mining	99.50	3.39	4,800			
3	Woodland Grove Sporting Facility	3.20	0.39	32			
4	Option 1 – Alternative Location	74.60	3.11	4,000			
5	Mundijong Decentralised Wastewater System	23.90	1.91	800			
6	Decentralised Wastewater System with Surface Water from Manjedal Brook	77.99	4.69	3,200			
7	Recharge Runoff from Mundijong Whitby District Sporting Facility	2.50	0.42	40			
8	Harvest of Surface Water Flows from Punrack Drain	74.60	3.11	4,000			
9	Construction of a Decentralised Wastewater System in Serpentine	8.98	1.35	120			
10	Gallery Recharge into Decommissioned Open Pit Mines	2.02	0.30	40			
11	Surface Water Harvesting from Gooralong Brook	3.38	0.33	32			
12	Construction of a Decentralised Wastewater System for the Tourist Park	2.13	0.52	8			
	Additional Option 1						
	Additional Option 2						
	Additional Option 3						
	Additional Option 4						
	Additional Option 5						

Shire of Serpentine Jarrahdale

Integrated Water Management Strategy

Multi-criteria Assessment

Summary of Assessment

18 February 2020

Option	Description	**Stage 2 Results** *Fatal Flaw Assessment Pass/Fail*	**Stage 3 Results** *Multi-Assessment Total Score*	**Stage 4 Results** *Final Cost per kL*
6	Decentralised Wastewater System with Surface Water from Manjedal Brook	FAIL	0	N/A
1	Surface Water Harvesting from Oakland / Barriga Main Drain with MAR	FAIL	0	N/A
10	Gallery Recharge into Decommissioned Open Pit Mines	FAIL	0	N/A
1a	Surface Water Harvesting from Oakland / Barriga Main Drain with above ground storage	FAIL	0	N/A
5	Mundijong Decentralised Wastewater System	FAIL	0	N/A
2	Integration of Option 1 with Sewer Mining	FAIL	0	N/A
3	Woodland Grove Sporting Facility	FAIL	0	N/A
4	Option 1 – Alternative Location	FAIL	0	N/A
7	Recharge Runoff from Mundijong Whitby District Sporting Facility	FAIL	0	N/A
8	Harvest of Surface Water Flows from Punrack Drain	FAIL	0	N/A
9	Construction of a Decentralised Wastewater System in Serpentine	FAIL	0	N/A
11	Surface Water Harvesting from Gooralong Brook	FAIL	0	N/A
12	Construction of a Decentralised Wastewater System for the Tourist Park	FAIL	0	N/A
	Additional Option 1	FAIL	0	N/A
	Additional Option 2	FAIL	0	N/A
	Additional Option 3	FAIL	0	N/A
	Additional Option 4	FAIL	0	N/A
	Additional Option 5	FAIL	0	N/A

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