Government of **Western Australia**
Department of **Water**

Securing Western Australia's water future

Western Trade Coast heavy industry

local water supply strategy

Department of Water
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November 2016

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Photos back page: Industry in the Western Trade Coast- courtesy of Kwinana Industries Council, Woodman Point Wastewater Treatment Plant- courtesy of Water Corporation

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Summary

The Western Trade Coast including the Kwinana Industrial Area is the most significant heavy industry estate in Western Australia. Heavy industry makes a major contribution to the Western Australian economy with strong links to the mining, petroleum and gas sectors.

The water supply planning objective for the Western Trade Coast is that '*feasible, cost-effective and affordable water supplies are identified that can be developed within industry's required timeframes'.*

Reliable, fit-for-purpose water supplies now and into the future are essential to support the development of heavy industry and provide economic benefits locally and across the state. The *Western Trade Coast heavy industry local water supply strategy* will help to ensure water supply investment is aligned with state development objectives and land use planning at a local scale. It will also provide the foundation for more detailed planning at the site scale.

Water demand in the Western Trade Coast is expected to increase from 28.5 gigalitres per year (GL/year) to between 36 and 52 GL/year by 2031. Water demand scenarios reflect a diverse range of economic activity based on historical trends.

Heavy industry sources most of its water from the superficial aquifer of the Cockburn Groundwater Area. Groundwater allocation limits have been reset based on a drier climate, with lower rainfall and groundwater recharge, than previously experienced in the Perth metropolitan area. The Department of Water is working with licence holders over the next five years to reduce water abstraction rates to ensure the long-term use of the resource while protecting the environment and resource.

Sustainable groundwater will remain an important water supply to support heavy industry into the future. Groundwater is the lowest cost water supply in the Western Trade Coast. Potable water from the Perth Integrated Water Supply Scheme only meets around 10 per cent of the water used by heavy industry (e.g. potable uses and industrial processes).

In addition to the existing sources, alternative water sources will be required to meet the future water needs of industry in the Western Trade Coast. Treated wastewater is the primary alternative water source. Over 50 GL/year of treated wastewater is disposed in the ocean through the Water Corporation's Sepia Depression Ocean Outfall Line, a pipeline through the centre of the Western Trade Coast. The proximity of this pipeline presents an opportunity for recycled wastewater to meet most of the future demand from heavy industry if economically and technically viable.

The strategy clarifies the responsibility of the proponent to identify any potential effects of the proposed recycled wastewater supply option. This should be completed before seeking approval from the regulating authorities. The construction and operation of a recycled wastewater supply scheme would be financed by the proponent.

While more expensive than direct groundwater abstraction, preliminary cost estimates show that recycled wastewater schemes are likely to be cheaper than water supplied from the Perth Integrated Water Supply Scheme. The level of treatment necessary to meet environmental and health approvals can account for up to 75 per cent of the total cost. Even with the high treatment costs, recycled wastewater can be a cost-effective water supply.

1 Purpose of this strategy

1.1 Background

The Western Trade Coast is the state's largest industrial estate and the only heavy industrial area within the Perth metropolitan region. Existing industry produces around $15.5 billion annually and government's long-term aim is to increase this output to $28.3 billion (Government of Western Australia 2011; WAPC 2015).

The Kwinana Industrial Area is the premier industrial area for the State. The Department of State Development is the lead agency for the identification, planning and development of Strategic Industrial Areas (including Kwinana). This role includes coordinating the provision of project-ready land for strategic industry that is zoned, buffered, with access to services (utilities and transport) as well as to other industries and a skilled workforce.

The Government of Western Australia aims to fully develop the Western Trade Coast industrial areas. An important part of achieving this objective is timely, efficient and sustainable access to water for industrial development.

New major projects or expansions of existing industry will increase industrial water demand in the Western Trade Coast area. Uncertainty around access to reliable and cost-effective water supply options compromises the project-ready status of strategic industrial land, and the ongoing viability of existing industries. This may deter new development and future expansions, to the detriment of the state. The need to develop additional and secure water supplies has been recognised for some time.

The *Kwinana Industrial Area water planning study 2006* (Burns & Roe Worley 2006) provided an assessment of potential water supply options, treated wastewater reuse and treated wastewater disposal options. Based on supply–demand and cost considerations, the study found that the most promising water supplies were; groundwater, treated wastewater, aquifer recharge, stormwater capture and recycling of industry treated wastewater from a third party.

In 2013, the Department of Water completed a preliminary review and assessment of water supply and demand for the Western Trade Coast (DoW 2013b). This found that existing groundwater supplies were not likely to be sufficient to meet future demand for heavy industry. With large volumes of treated wastewater available in close proximity to industry, treated wastewater recycling was identified as the major feasible supply source.

In 2015 CSIRO led a study of the feasibility and cost of managed aquifer recharge (MAR) schemes in the Western Trade Coast. The study was in collaboration with the Australian Water Recycling Centre of Excellence, the Kwinana Industries Council, Water Corporation, Western Trade Coast Office and departments of Water and Health.

This strategy incorporates the outcomes of these studies.

1.2 Local water supply planning

The Department of Water carries out water supply planning to identify and assess water supply–demand gaps well before they occur and identify future water supplies for priority areas. This local water supply strategy will be captured in the long-term regional water supply strategy for the Perth-Peel region.

The department works with other government agencies and organisations to advise on water supply options for developments that are of strategic significance to Western Australia.

Water supply planning encompasses at various geographic and time scales and different levels of detail, from statewide strategic planning to the design of a local water supply. The purpose of a local water supply strategy is to identify:

- local land use planning and development objectives
- water demand by water use sector
- water supply options short-list for pre-feasibility planning
- investigation priorities
- triggers set to initiate local supply planning.

The department regulates the sustainable take of water resources and encourages efficient use of existing supplies to meet new demands. A new water supply is developed when this is no longer feasible or fit-for-purpose (Figure 1).

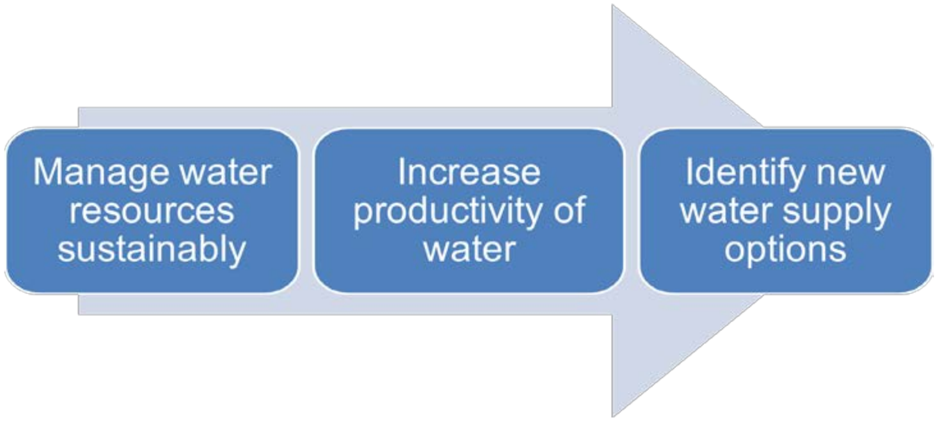


Figure 1 Process to manage a water demand increase

1.3 Strategy development

The Department of Water has worked closely with industry to develop and assess water supply options in the Western Trade Coast. This strategy was developed with input from CSIRO, the Kwinana Industries Council, Australian Water Recycling Centre of Excellence, Water Corporation, Western Trade Coast Office, the Department of Health and the Department of Environment Regulation.

Input and expertise has also been provided by the Senior Officers Group for water supply planning, chaired by the Department of Water. The Senior Officers Group includes representatives from the Water Corporation and the departments of State Development, Planning, Agriculture and Food WA, Premier and Cabinet, Treasury, Finance and Regional Development.

1.4 Strategic objectives and outcomes

During the development of this strategy industry and other state government agencies were consulted to identify whole-of-government objectives and constraints for industry on water needs in the Western Trade Coast.

The water supply planning objective for the Western Trade Coast is that '*feasible, cost-effective and affordable water supplies are identified that can be developed within industry's required timeframes'*[1].

The strategy is based on projections of water demand for heavy industry for the next 15 years. The strategy supports the following outcomes:

- an outlook of water demand and supply for heavy industry in the Western Trade Coast, focusing on the Kwinana Industrial Area and Rockingham Industrial Zone
- information on water supply options for water users and suppliers to help inform their commercial decision-making
- information and advice to government and industry on recycled wastewater approval arrangements and service provisions options
- guidance on the steps to establish a new water supply solution.

Service providers and self-supply users will undertake detailed design and cost estimations before they decide to progress a water supply option. The inclusion of an option in this strategy does not imply development or funding by the government.

1.5 Strategy area

The Western Trade Coast encompasses industrial land between Munster and Rockingham (see Figure 2) and includes the:

- Kwinana Industrial Area: an existing industrial estate containing the state's largest concentration of heavy processing industries. This includes nickel, petroleum, titanium and alumina refining; power generation; and cement, chemical and fertiliser manufacturing
- Australian Marine Complex: an existing industrial estate servicing the marine, defence and resource sectors
- Latitude 32: a new industrial area for light, general and transport uses

[1] The required timeframe has been identified as the typical approval timeframe for an industrial project from conception to operation (likely to be two to three years).

- Rockingham Industrial Zone: a largely undeveloped industrial estate, proposed to be developed for a mix of general industry and environmentally acceptable heavy industry

This strategy focuses on water demand and supply for existing and proposed heavy industry within the Kwinana Industrial Area and Rockingham Industrial Zone. Water demand is expected to be highest in these areas.

Water supplies for the light industrial areas are not covered by this strategy. Low demand volumes from light industry are likely to be primarily supplied from the Perth Integrated Water Supply Scheme (IWSS).

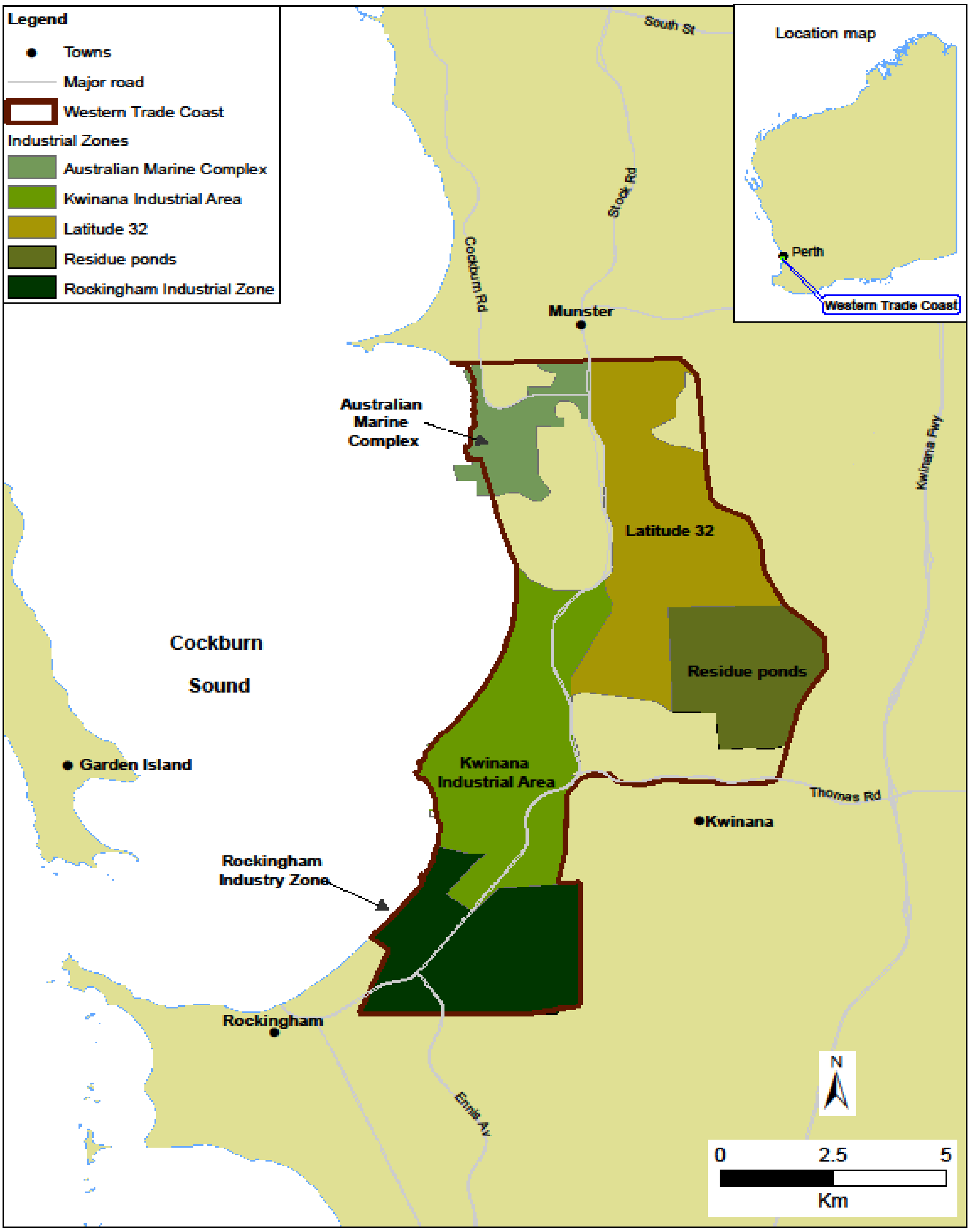


Figure 2 Western Trade Coast locality map

2 Water demand and supply situation

2.1 Current water demand

Water uses for industry in the Western Trade Coast include:

- industrial processing
- cooling towers
- wash down
- cogeneration heat and power
- dust suppression
- slurry transport
- potable use i.e. kitchen.

Heavy industry water demand during 2014 was estimated at 28.5 GL/year[2]. Figure 3 shows the distribution of this demand between industry sectors.

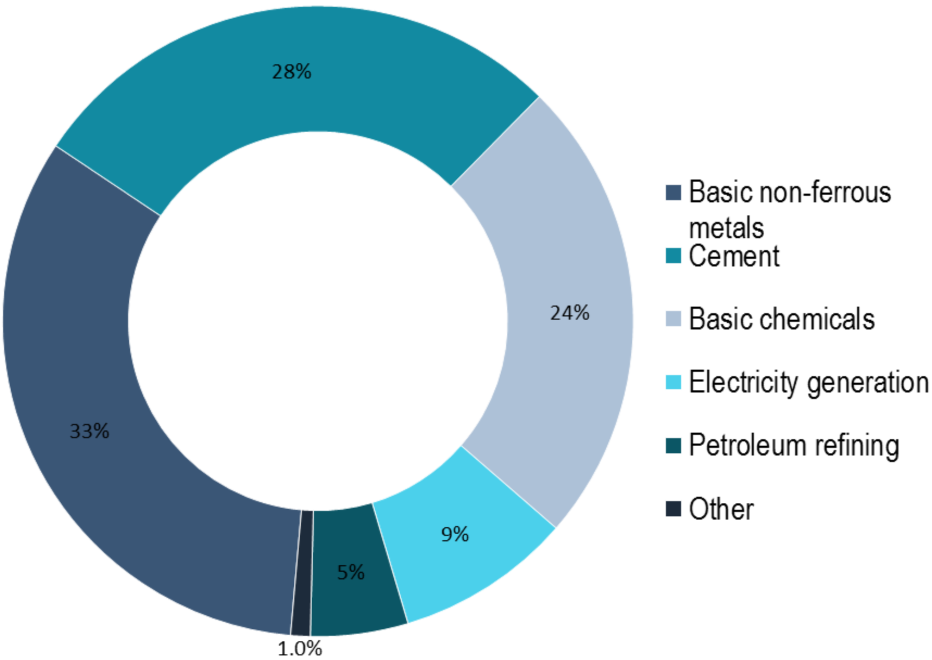


Figure 3 Water demand per heavy industry sector in 2014[3]

[2] Excludes the use of seawater. Estimate based on groundwater abstraction reporting to the Department of Water and information provided by the Water Corporation and industry for other sources.

[3] Other includes transport, storage, gas supply and other chemicals

2.2 Current water supplies

Heavy industry's water supply in the Western Trade Coast is sourced from a range of potable and non-potable supplies (Figure 4).

Different water supplies are needed to meet varying water quality requirements for numerous industrial processes (Table 1).

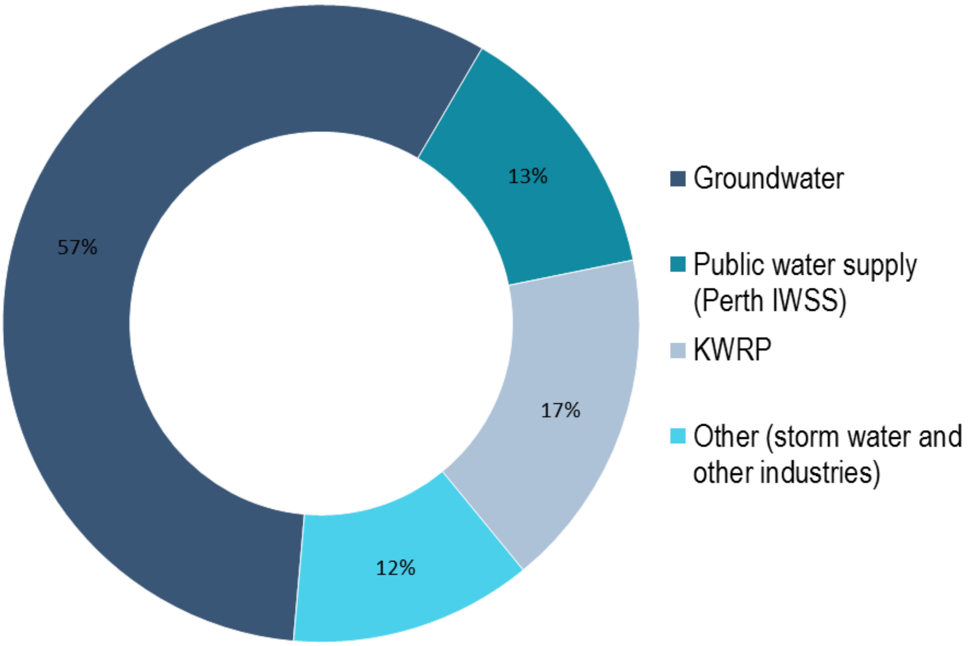


Figure 4 Current water supplies to meet demand

Table 1 Summary of typical water uses and sources in the Western Trade Coast

Water use	Water Source
Cooling tower	Kwinana Water Recycling Plant (KWRP), Perth IWSS, groundwater
Staff kitchens/showers	Perth IWSS
Wash down water	Perth IWSS, groundwater
Process water	KWRP, Perth IWSS, groundwater, onsite treatment plants
Dust suppression/slurry transport	Groundwater

Groundwater

Groundwater is a low cost water source for existing industries. It provides 58 per cent of current demand for the Western Trade Coast.

The Western Trade Coast is within the Cockburn Groundwater Area and a small portion of the Rockingham Groundwater Area (Figure 5). Water licensing in each of these areas is managed by the Department of Water under the *Rights in Water and Irrigation Act 1914*. Both areas have allocation plans, which set out how much groundwater can be abstracted from each resource per year (the water allocation limits). The plans also outline how the department manages abstraction through licensing for now and into the future.

Groundwater from the Cockburn Groundwater Area is used by industry, irrigated agriculture, parks and gardens and stock and domestic water sectors.

Public water supply

Public water supply from the Perth IWSS is also supplied to industry for potable and process requirements.

Treated wastewater

The Kwinana Water Recycling Plant (KWRP) was built in 2004 in response to industry demands for a high quality water supply and was funded by the participating industries. The plant can provide up to 6 GL/year of tertiary treated wastewater (Water Corporation 2014c).

Other supplies

Some companies harness stormwater, using basins and wetlands for treatment and storage before use. The volume available for capture varies each year depending on rainfall. Some companies also recover water from industrial processes for internal reuse or for use by a third party.

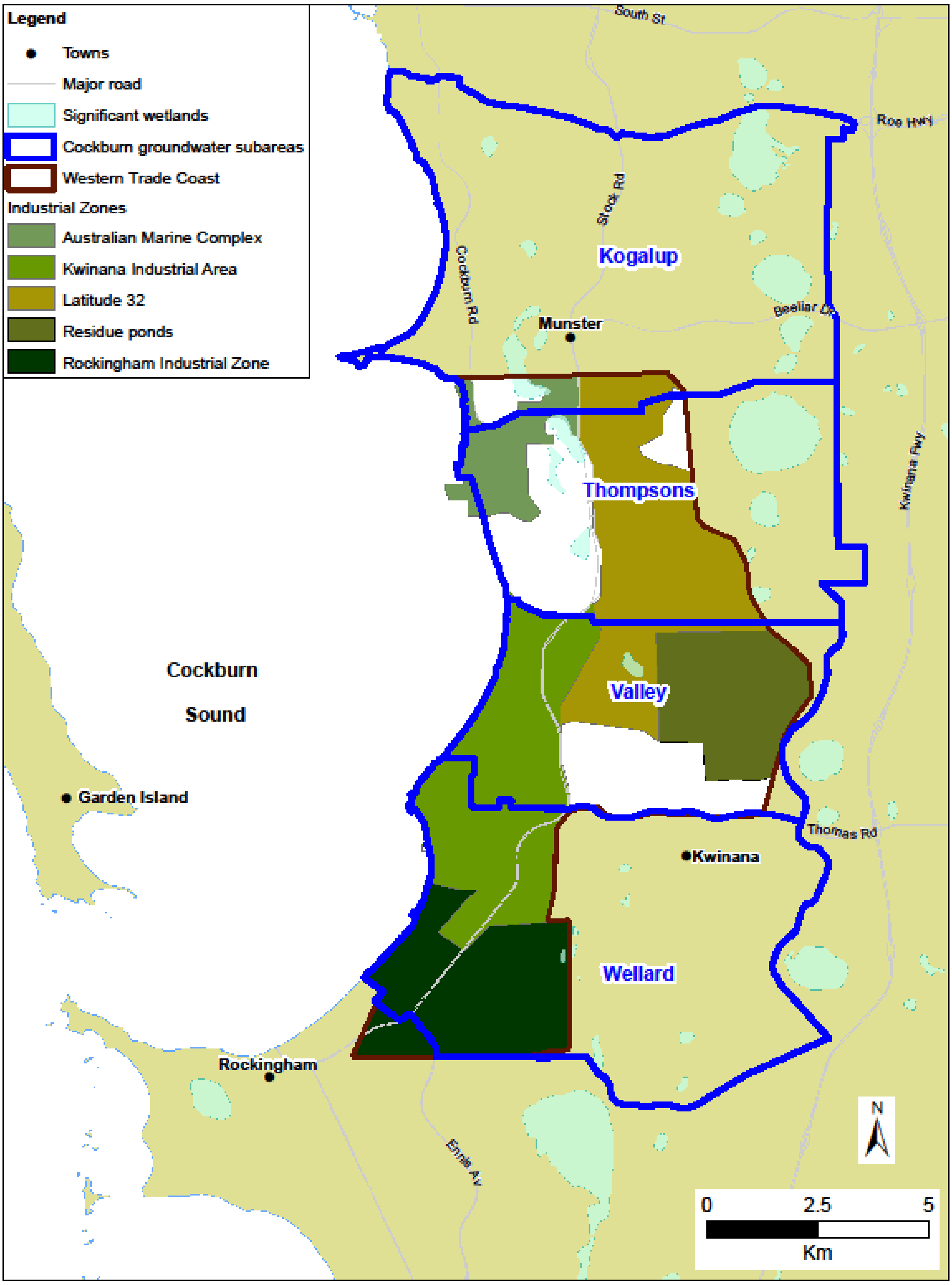


Figure 5 Cockburn Groundwater Subareas, with Western Trade Coast zones

2.3 Drivers for additional water supplies

Existing low cost groundwater supplies are at capacity. In 2014 existing industry was consulted to identify key drivers for additional or new water supplies. These were found to be:

- expansion of existing industries
- establishment of new industries
- reduction in availability of current water supplies including reduced groundwater or stormwater, or loss of water supplied from third parties
- concern about water quality, including possible impacts to groundwater quality from salt water intrusion or contamination plumes
- interest in replacing high quality water with cost effective, fit-for-purpose supplies
- development of a climate independent water supply to reliably meet demand quantity and quality in a drying climate.

2.4 Future water demand

Economic growth for heavy industry in the Western Trade Coast was projected to 2031. Heavy industries expected to grow include; petroleum, alumina and nickel refining, pigments, industrial chemicals, fertilisers, pesticides, herbicides, cement and electricity generation plants (REU 2015).

Projected water demands incorporate the latest information on macro-economic variables and an analysis of international trends for export products (REU 2015). The Monash input-output model was used to project growth in water demand based on employment, value added and total output scenarios (see Appendix A for more detail).

Water demand is projected to increase to 44 GL/year by 2031 under a medium growth scenario, but could be as high as 52 GL/year under a high growth scenario (Figure 6). Growth is based on the domestic and international market demand for commodities produced by heavy industry. Some companies have indicated plans to expand production within the next five years.

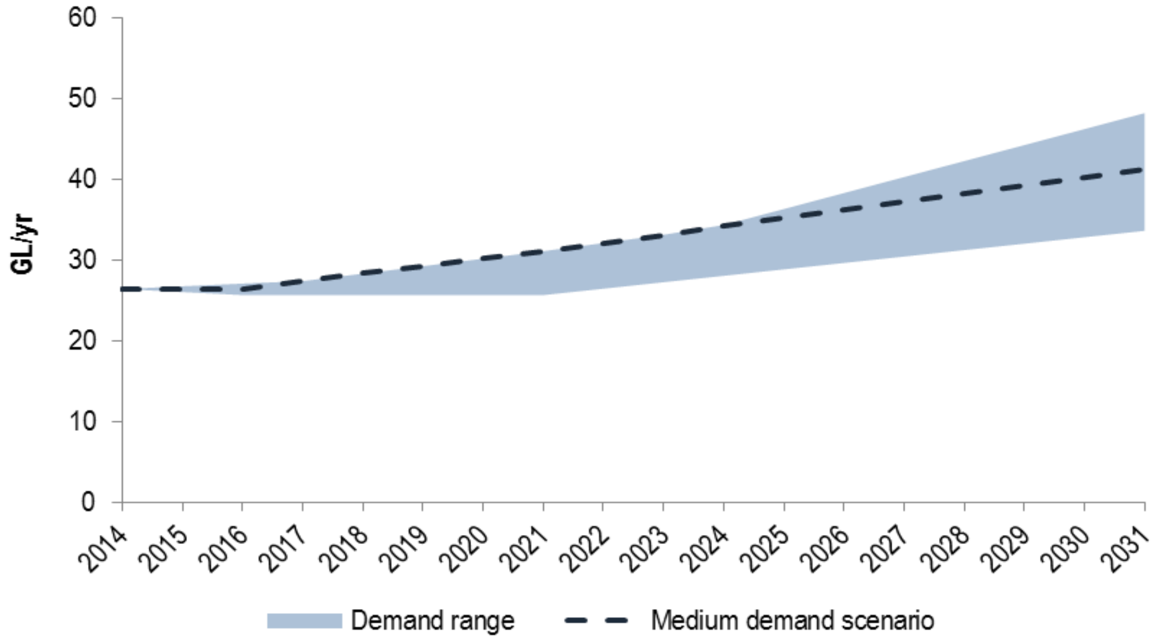


Figure 6 Projected growth in water demand for heavy industry to 2031

It is important to note that while medium growth is shown as a linear trend, demand is likely to increase in step changes as a result of existing industries expanding or as new industries develop in the area.

The purpose of the projections is to indicate the potential magnitude of demand increase for all heavy industry in the Western Trade Coast over the medium-term (15 year timeframe).

Typical water requirements for existing operations in the Western Trade Coast are considered representative of future increases in demand (Table 2).

Table 2 Projected future increase in demand based on typical water requirements for existing operations in the Western Trade Coast

Water requirements	Water quantity (GL/year)
Existing company with future expansion plans (additional water requirements per industry)	0.2 to 0.7
Total water demand for a new large company (based on current water demand for existing smaller industries and previous development proposals)	1 to 3
Total water demand for a new small company (based on current water demand for existing smaller industries and previous development proposals)	< 0.1
If existing supplies from another company no longer available an additional supply could be required	0.4 to 0.7
Public water supply use by existing industries	0.1 to 0.5

2.5 Future water supplies

This strategy recognises the importance of developing fit-for-purpose water supplies, increasing water recycling and improving water efficiencies. Alternative water supplies are needed to reduce demand on the Perth IWSS and local groundwater resources.

CSIRO's study found that based on supply–demand considerations, cost and/or environmental considerations, it was unlikely that public water supply, seawater desalination and stormwater would be feasible supplies for meeting new large industry demands in the Western Trade Coast (GHD 2015a).

Groundwater

Using groundwater more efficiently potentially delays the need for additional water sources. Many industries have already invested in high cost water efficiency improvements, such as recovery of process water for internal reuse. However, volume savings are capped and plateau over time.

Groundwater quality can vary with location and depth and may require treatment to meet a desired quality at the proponent's cost.

Water trading can occur under the *Rights in Water and Irrigation Act 1914.* Potential proponents can consult the department's online water register[4] to discover the location of existing water licences and the volumes associated with them. Applications for water trading (temporary trade, agreement or transfer) need to be consistent with the department's *Operational policy 5.13 Water entitlement transactions for Western Australia* (DoW 2010b).

The Department of Water adaptively manages and evaluates the triggers within allocation plans to identify the status of groundwater use and any changes required to meet planning objectives.

Allocation limits for the Cockburn Groundwater Area (Figure 5) were reviewed in 2012–2015 to account for the effects of the drying climate.

The objectives of the 2012–2015 evaluation review were to:

- provide for sustainable abstraction under a future drier climate and provide certainty for existing use
- reduce risk to significant wetlands such as the Ramsar-listed Thomsons Lake
- reduce the risk of inland movement of the sea water interface.

One of the outcomes of the review has been a reduction in the annual water allocation limits to less than current licensed entitlements. The department has a targeted recovery strategy, which will be implemented over a five year period, to manage the transition of licensees to the new sustainable allocation limits. A key component of the recovery strategy is to recoup long term unused portions of

[4] http://www.water.wa.gov.au/maps-and-data/maps/water-register

licensed entitlements, as per the Department of Water (2009b) *Statewide policy no 11: Management of unused licensed water entitlements*.

Public water supply

The Water Corporation's planning for the Perth IWSS does not take into account additional large water demands for industry (Water Corporation 2008) and will be assessed on application.

Industries using more than 20 ML/year of public water supply are required to prepare a water efficiency management plan detailing opportunities and actions for water savings.

Treated Wastewater

Treated wastewater is a climate independent source linked to urban growth and provides a potential water source for industry. The Sepia Depression Ocean Outfall Line (SDOOL) pipeline runs through the centre of the Western Trade Coast and provides ample capacity to meet the projected 16 GL/year increase in industrial demand by 2031. Proponents will need to negotiate a recycled water supply agreement with the Water Corporation for the supply of treated wastewater and any further treatment required to achieve a desired water quality will be at the proponent's cost.

Other supplies

Some existing companies in the Kwinana Industrial Area, capture, treat and store stormwater runoff from their sites. While localised stormwater capture and recycling will continue to supplement other water sources, the volumes are relatively small. There are water quality issues with some of the stormwater sources due to legacy contaminants from previous land uses and costly water treatment may be required (GHD 2015a).

Ongoing improvements in water efficiency, onsite recycling of process water and capturing and using onsite stormwater are all important ways to help reduce demand or delay the need for new water sources. However, on their own these supplies are unlikely to meet new, large water demands.

3 Wastewater availability and assessment

3.1 Treated wastewater in the Western Trade Coast

The Water Corporation operates more than 100 wastewater treatment plants across the state, with many already supplying recycled wastewater for community and commercial purposes.

The SDOOL receives inflows from the following:

- treated wastewater from Woodman Point, Kwinana, East Rockingham and Point Peron wastewater treatment plants (WWTP)
- treatment brine from Kwinana Water Recycling Plant (KWRP) and
- wastewater from some industries in Kwinana (Figure 7).

The SDOOL is a critical asset for the Water Corporation and conveys treated wastewater for ocean disposal from four wastewater treatment plants. It presents a significant opportunity as a water source for industry. Treated wastewater could be accessed directly from the SDOOL (at a point agreed with the Water Corporation) or from the Kwinana or East Rockingham WWTP prior to their connection with the SDOOL. The water quantity, quality and pipe pressure can vary throughout each day and along the length of the SDOOL. Proponents will need to consider these factors when evaluating SDOOL as a water source.

Treated wastewater quantity

Over 50 GL/year of secondary treated wastewater is disposed in the ocean off Point Peron via the SDOOL which is owned and operated by the Water Corporation.

The Woodman Point WWTP contributes the largest volume of wastewater to the SDOOL (141 ML/day during 2013–14). The Kwinana WWTP infiltrates most of its treated wastewater onsite with excess water discharged to the SDOOL (Water Corporation 2014c). The East Rockingham WWTP has a treatment capacity of 20 ML/day and discharges the treated wastewater to the SDOOL (Water Corporation 2016a). The Point Peron WWTP is at the outfall end of SDOOL and does not present a potential source of water for industry due to its location.

Flows into the SDOOL are projected to increase by an additional 30 GL/year by 2030 and 80 GL/year by 2060 (Figure 8). Projections of wastewater flows into the SDOOL exceed industry’s projected water demand of an additional 16 GL/yr by 2031.

Treated wastewater is also an important source of future public water supply. Water Corporation planning identifies wastewater from Woodman Point WWTP as a source of water after receiving further treatment using advanced water treatment processes. The highly treated water will be injected into confined aquifers for future abstraction for public water supply (as underway at the Beenyup Groundwater Replenishment Scheme). Given the timing and volumes needed, with aligned planning, both outcomes can be achieved.

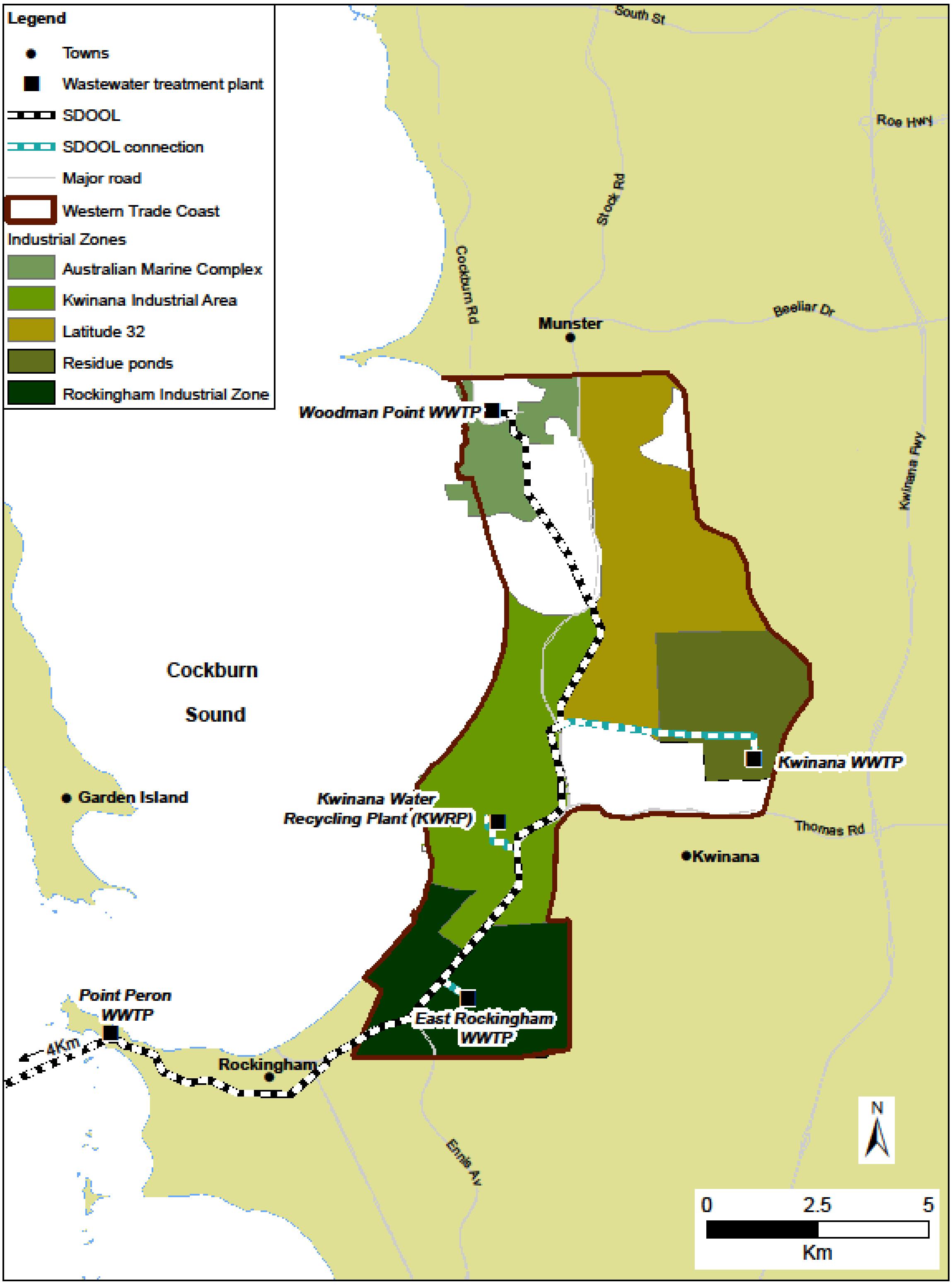


Figure 7 Wastewater infrastructure in the Western Trade Coast

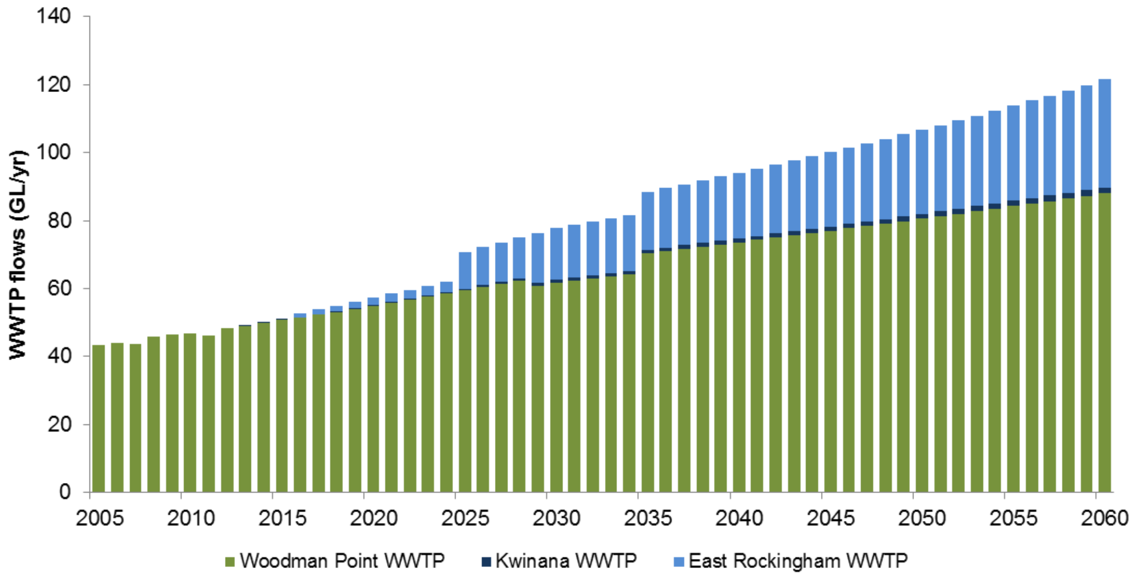


Figure 8 Historic and forecast flows to the SDOOL from Woodman Point, Kwinana and East Rockingham wastewater treatment plants (McFarlane 2015 p. 53)

Treated wastewater quality

Water quality varies along the length of the SDOOL. The Kwinana WWTP discharges a higher quality wastewater than Woodman Point WWTP, due to a more advanced treatment process and discharge from East Rockingham WWTP may be different again. In addition, industrial discharges and treatment brine from KWRP can also alter the wastewater quality along the length of the SDOOL. The offtake location along the SDOOL may influence the level of treatment required for a particular wastewater supply option. Water quality parameters measured in 2013, 2014 and 2015 at the SDOOL discharge point to the ocean are summarised in Table 3. This is the combined value from wastewater treatment plants, KWRP and industry wastewaters. The Water Corporation has set water quality criteria ranges to meet in accordance with Ministerial Statement 665 (Water Corporation 2014c).

Table 3 Snapshot of water quality parameters of treated wastewater from the SDOOL (Water Corporation 2013; 2014b; 2014c, 2015)

Water quality parameter	Value (mg/L)			Criteria range (mg/L)
	18/02/2013	18/02/2014	17/02/2015	
Ammonia (NH3)	14	11	21	0.5[5]
Biochemical oxygen demand (BOD)	29	23	46	24-32
pH	7.3	7.3	6.6	8-8.4[6]
Total suspended solids (TSS)	31	21	81	39-42
Total nitrogen (TN)	23	24	26	22-32
Total phosphorus (TP)	6.3	4.5	5.7	11-12

[5] ANZECC/ARMCANZ 2000, 99%level of protection

[6] ANZECC/ARMCANZ 2000, inshore marine ecosystems in southwest Australia

3.2 Recycled wastewater options for heavy industry

Three feasible recycled wastewater supply options to meet projected demand in the Western Trade Coast include:

1. recycled wastewater with centralised treatment
2. recycled wastewater with decentralised treatment
3. recycled wastewater with managed aquifer recharge.

The configuration of the three options is illustrated in Figure 9. Industry surveyed by the Department of Water indicated an interest in sourcing treated wastewater. The preferred supply option/s for each company will depend on their specific circumstances e.g. what infrastructure they already have in place, location, the presence of groundwater contamination, and water quality requirements.

Recycled wastewater with centralised treatment

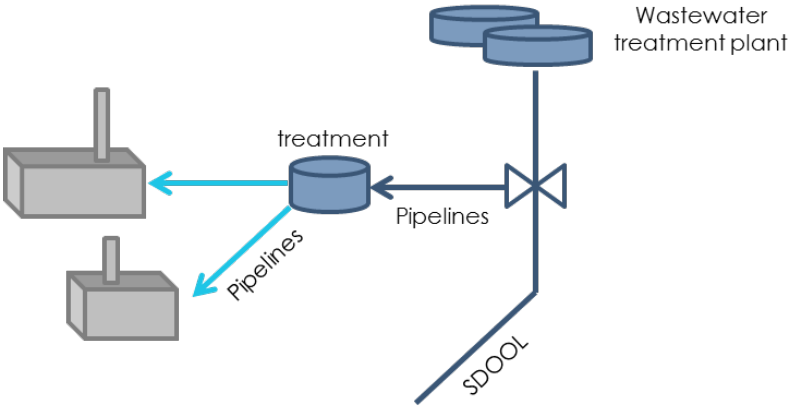
A centralised approach involves one treatment plant having direct access to treated wastewater which then supplies recycled wastewater to multiple users (Figure 9, supply option 1).

A local example of centralised treatment is the Water Corporation's Kwinana Water Recycling Plant (KWRP). KWRP is a centralised treatment plant, providing high quality tertiary treated wastewater to multiple companies. The treatment process involves microfiltration, reverse osmosis and UV disinfection. The plant capacity is 6 GL/year, and in 2013–14 almost 5 GL was supplied to industry (Water Corporation 2014b). The plant, constructed in 2004 at a cost of $28 million, has the ability to expand capacity by 3.6 GL/year if demand increases.

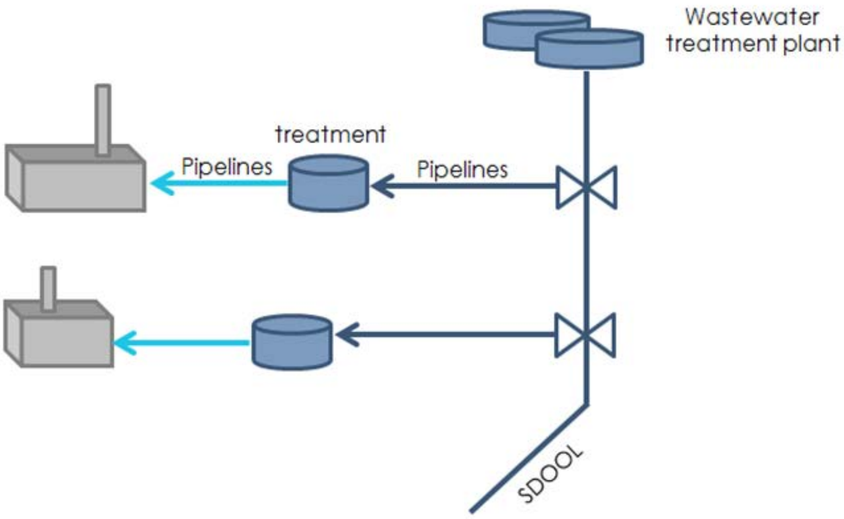
Centralised treatment plants are limited in their capacity to meet the specific needs of all customers, and generally only produce water to a single-quality. The water from KWRP is treated to a very high quality with low dissolved salts (<50 mg/L TDS) and minerals. This water quality is suitable for industrial processes (such as boiler feed) that require low TDS, but can exceed the water quality necessary for other processes such as cooling towers. Industry has adapted by blending KWRP water with other sources of water to achieve an economically viable water quality mix.

KWRP could be expanded beyond current capacity subject to a commercial and technical assessment with the proponent, or a new multi-user facility could be developed in a location central to future demand.

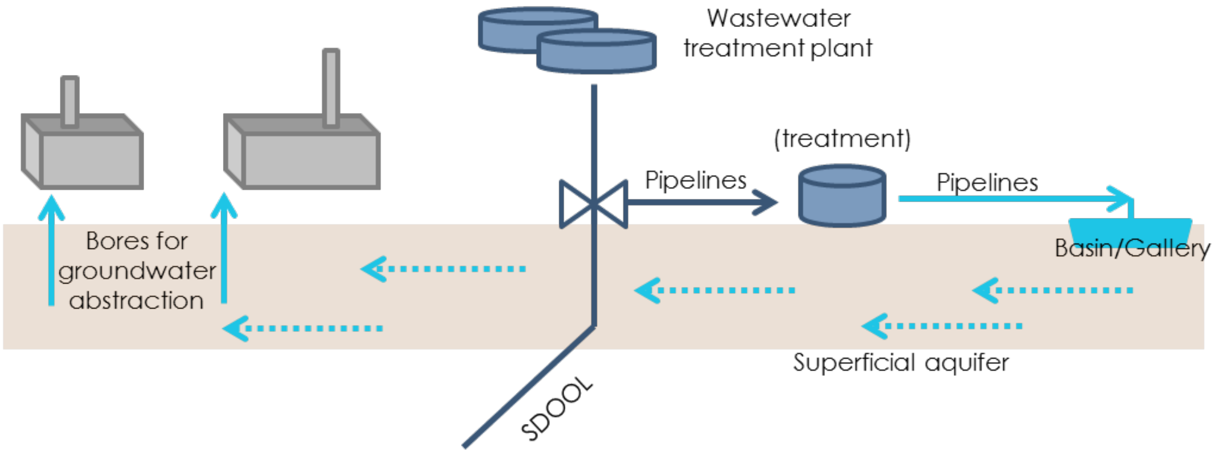
A new multi-user plant could be designed to treat the wastewater to the level appropriate to the required end use. Securing commercial agreements with multiple users that require water at the same time can be a challenge when establishing these types of facilities. Certain users purchasing the water may still need to adjust the water quality for specific use, resulting in unnecessary costs. In addition to the treatment costs, a network of expensive piping is required to distribute the water to where it is needed.



1. *Recycled wastewater with centralised treatment*



2. *Recycled wastewater with decentralised treatment*



3. *Recycled wastewater with managed aquifer recharge*

Figure 9 Schematics of recycled wastewater supply options

Recycled wastewater with decentralised treatment

Decentralised treatment involves piping wastewater from a SDOOL offtake typically to a single user for a site specific, fit-for-purpose treatment process (Figure 9, supply option 2).

This arrangement has the advantage that each user can custom design a treatment plant to create the desired water quality; and commercial arrangements only require agreement with a single proponent. There are water treatment companies capable of designing, building, owning and operating such stand-alone water treatment plants. Alternatively the proponent company could do some or all of this themselves.

Capital costs (see Section 3.4) were estimated based on a supply pipeline from the treated wastewater source and construction and operation of a decentralised basic treatment plant. The plant process includes filtration, chemical dosing and chlorination to reduce suspended solids and phosphorus and disinfect the water. Additional costs would be likely if alternative treatments were required to meet a specific water quality requirement.

Recycled wastewater with managed aquifer recharge

Managed aquifer recharge (MAR) is the process of infiltrating water into an aquifer (Figure 9, supply option 3). The water can move through the superficial aquifer and be stored until needed and then abstracted through existing or specially located groundwater bores. Recovered water may be abstracted through existing or new groundwater bores by individual or multiple users.

A non-potable MAR approach in the Western Trade Coast would consist of infiltrating treated wastewater into the superficial aquifer, as seen in Figure 10. The unconfined superficial aquifer would be recharged with treated wastewater taken from the SDOOL, with possible further treatment before infiltration. The feasibility of recharge to the deeper, confined aquifers (i.e. Leederville), can be limited by the recharge and receiving water qualities and associated higher costs.

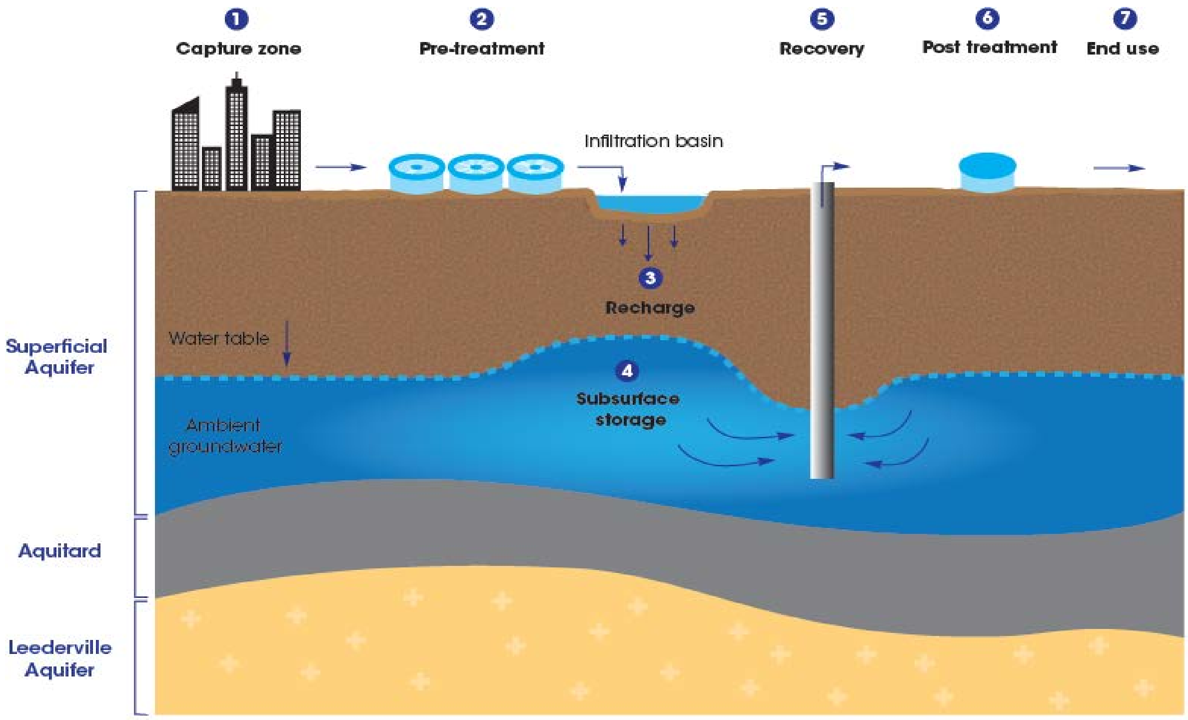


Figure 10 Example of MAR infiltration, storage, transfer and recovery

CSIRO has investigated the feasibility of using MAR as a water supply option for heavy industry in the Western Trade Coast (GHD 2015a). The study showed:

- MAR to be a cost-effective future non-potable water source
- Historical discharge of treated wastewater from Kwinana WWTP into the superficial aquifer has shown no evidence of contaminating the wetlands or of adverse down gradient groundwater discharging into Cockburn Sound. The infiltration of treated wastewater has helped to supplement the water levels in adjacent wetlands.

Environmental and health risks associated with a MAR scheme in the area would need to be addressed to ensure adequate treatment and monitoring. One study recently completed by CSIRO (Keesing et al. 2016) has analysed water quality data collected from the Cockburn Sound and Warnbro Sound between 1982–83 and 2013–14 focusing on total nitrogen, total phosphorus and chlorophyll a.

Water quality requirements for MAR will generally focus on the total suspended solids, total nitrogen and total phosphorus concentrations. Target values for these parameters is approximately < 10 mg/L (NRMMC, EPHC & NHMRC 2009) to reduce the risk of clogging during recharge. MAR involves injecting or infiltrating water into groundwater not a marine environment, so water quality criteria ranges may differ from those in Table 3.

Further site specific work would need to occur to improve knowledge on the level of pre-treatment required to address environmental and health risks. A MAR scheme could also benefit local through-flow wetlands, help manage or reverse the salt water interface and potentially assist industry to better manage known groundwater plumes in the area.

3.3 Cost and benefit analysis

This section identifies the various costs associated with the recycled wastewater supply options. This provides generalised information on the comparative cost of the recycled wastewater options to assist consideration of options by a proponent.

The costs are indicative only and proponents are advised to undertake their own investigation. The site specific cost estimate would better define the variables costs such as those associated with distance to the SDOOL or the level of treatment required.

Costs analysis

The cost of treating and supplying recycled wastewater is important for deciding which of the three recycled wastewater supplies would be most appropriate to develop in the Western Trade Coast. GHD (2015a; 2015b) have estimated general costs for recycled wastewater infrastructure and MAR schemes as a guide to industry.

The cost to the user of a recycled wastewater supply has been compared to groundwater and public water supply. Groundwater forms the lower limit with pumping costs estimated to be $0.25/kL. The cost of groundwater would likely be higher if a water licence is traded or transferred at a commercial price. In 2015–16 the commercial cost of water supplied from the Perth Integrated Water Supply Scheme (IWSS) was $2.09/kL, forming the upper limit.

Preliminary costing indicates that recycled wastewater either through direct piping decentralised treatment or MAR is significantly less than public water supplied from the Perth IWSS.

Estimated levelised[7] unit costs for decentralised treatment plant or MAR options are shown in Table 4. Note that these are a guide only with costing based on supply volumes of 1.8 GL/year and 3.6 GL/year (5 ML/day and 10 ML/day respectively).

The unit costs in Table 4 indicate the main component of the infrastructure included for each option. This is to enable existing or new industries to review a particular option that might be suited to a future demand (see Appendix C for more detail).

The treatment considered for MAR assumes filtration to reduce total suspended solids and a moving bed biofilm reactor to reduce total nitrogen. Water treatment costs can account for up to 75 per cent of total costs, and will vary depending on the source water quality, regulatory requirements and end use.

Cost estimates were based on typical infrastructure required (defined in Table 5) to develop each option. Further detail on the assumptions used in net present value (NPV) calculations are summarised in Appendix D, and can be used as a guide for typical costs for supply infrastructure.

[7] A levelised unit cost is calculated by dividing the NPV cost of the project (capital and operating) by the NPV of the units of water supplied over the project period.

Economic life of civil infrastructure (pipes and pump station) is assumed at 50 years, and 20 years for mechanical and electrical infrastructure (e.g. pumps, wastewater treatment plant).

Installing a pipe network in the Western Trade Coast is likely to result in significant challenges in negotiating roads, railway lines and decommissioned of existing private pipelines. Four kilometres of piping has been included in the MAR and decentralised treatment scenarios. This allows for half of the network to transfer the water to the point of treatment and/or infiltration, and an allowance for returning any treatment brine back to the SDOOL (providing this agreement with Water Corporation and appropriate regulatory approvals).

Table 4 Levelised unit cost of water supplies

Water supply	Unit water cost ($/kL)	Includes	Excludes[8]	
			Source cost of water taken from SDOOL ($/kL)	Service provision ($/kL)
Groundwater	<0.50	Bore construction, pumping costs	N/A	N/A
Decentralised treatment	0.40 - 0.53	Allowance for filtration and chlorination water treatment, 4000m pipe + SDOOL connection	Negotiated	Additional cost
MAR infiltration basin	0.66 - 0.89	TSS and TN reduction, 4000m pipe + SDOOL connection, MAR basin infrastructure	Negotiated	Additional cost
MAR infiltration gallery	0.78 - 1.03	TSS and TN reduction, 4000m pipe + SDOOL connection, MAR gallery infrastructure	Negotiated	Additional cost
Centralised treatment	1.89 - 2.09	Tertiary treatment based on KWRP processes	Negotiated	Additional cost
Public water supply	2.09	All costs (infrastructure, services, delivering)		Service connection fees

Table 5 Infrastructure for a recycling treated wastewater scheme

Infrastructure	Explanation
SDOOL connection	Offtake pipework, break tank and pumps
Distribution pipes	PVC pipelines (including nominal installation costs), and nominal allowances for civil works for crossing roads or railway lines
Pump stations	Pumping from SDOOL connection and pumping from treatment plant backwash back to SDOOL. Electrical costs included in operating costs
MAR infrastructure	Civil works for installing ponds or galleries. Galleries include Atlantis mini-tank modules or equivalent
Treatment plant	Depending on source and end use water quality required, further treatment of water from the SDOOL has been estimated using a moving bed biofilm reactor for reduction of total nitrogen and a disk filter for reduction in total suspended solids

[8] Refer to additional excluded costs Page 22 and 23

The capital and operating costs for recycled wastewater supply options are summarised in Table 6. These apply to new or existing companies looking to establish a new water supply (using the assumptions in Appendix E).

Table 6 Net present value capital and operating costs of recycled wastewater supply options

Scenario	Water supply option	NPV Capital ($M)	NPV Operating ($M)	Total ($M)	Unit ($/kL)
1	MAR infiltration basin, 1.8 GL/year	13.9	11.3	25.2	0.89
2	MAR infiltration basin, 3.6 GL/year	19.8	17.8	37.6	0.66
3	MAR infiltration gallery, 1.8 GL/year	15.8	13.5	29.3	1.03
4	MAR infiltration gallery, 3.6 GL/year	23.0	20.9	43.9	0.78
5	Decentralised treatment, 1.8 GL/year	9.7	5.3	15.0	0.53
6	Decentralised treatment, 3.6 GL/year	14.1	8.5	22.6	0.40

The costs analysis suggests a minimum 1 GL/year volume would be likely to achieve a levelised unit cost lower than the Perth IWSS providing a financial incentive to establish a recycled wastewater scheme.

A company with water needs of less than 1 GL/year may be able to meet their needs with one of the following supplies; groundwater (traded), potable water from the Perth IWSS or recycled wastewater from KWRP.

Options comparison

Decentralised treatment is a favourable supply option based on the preliminary cost analysis. The challenges to establish this option are linked with the minimum feasible size of a plant, and the inability for multiple, small volume connections to the wastewater source (SDOOL). The pipe network potentially required to move water to where it is needed can limit the suitability of this supply.

MAR is also an economically feasible option, and removes the costs associated with distribution networks and onsite storage. The level of pre-treatment required before infiltration accounts for a high portion of the costs. The total cost of a MAR scheme could be reduced by up to $0.30/kL if little or no pre-treatment is required. For more than twenty years treated wastewater has been infiltrated at Kwinana WWTP site, without any additional pre-treatment. This demonstrates MAR (with no additional treatment of source water) is possible in the Western Trade Coast. The proponent is to consider the level of treatment required after recovery of the infiltrated water to meet the requirements for end uses.

Excluded costs

The Department of Water notes that the costs presented are high level estimates and exclude source water, water service provider and site specific costs. It is recommended that proponents undertake their own detailed investigation for their specific proposal.

Source water

The Water Corporation will seek a joint wastewater scheme contribution from commercial users for water taken from the SDOOL. The contribution goes toward the capital and operating costs of the wastewater scheme that collects, treats and delivers the treated wastewater to the user. This negotiable charge would not be set at a level to prevent well-conceived wastewater recycling schemes establishing in the Western Trade Coast.

Water service provider costs

The commercial fee (profit and overheads) for the supply provided by a water service provider has not been included in any of the water supply options. This is subject to negotiation between the service provider and end user, and may vary with the water quality or quantity supplied.

Site specific costs

For the three recycled wastewater supply options, the following additional costs may need to be considered:

- land acquisition
- groundwater bores to abstract infiltrated MAR water
- onsite storage and pipelines to receive centralised recycled wastewater
- site specific detailed engineering design
- investigation, testing and reports for approvals
- annual monitoring and reporting
- disposal of treatment concentrate from a recycled wastewater option.

Benefits

Quantifying the value of all benefits is more uncertain given the varying ‘value’ or cost that can be associated with an intangible measure, such as the environment.

A measurable benefit is the cost of avoided potable bulk water supply. If industry were to meet the future demand using public water supply alone (no supply of recycled water), under a long run marginal cost of $2.00/kL, over a 50 year assessment period, the supply cost alone would be $56.5 million to $113 million for 1.8 GL/year and 3.6 GL/year. The average net financial benefit after deducting the capital and operating costs for a recycled wastewater scheme is $1.30/kL, based on stated assumptions. It is likely the actual saving would be less than this amount after site specific costs are included, however there is still some benefit from using recycled wastewater over public water supply.

Other benefits that have not been quantified for this strategy include:

- support from stakeholders and community members for companies using recycled water over public water supply or groundwater
- benefit of maintaining or reducing saltwater intrusion, and improving the groundwater quality with MAR
- expansion of current and establishment of new industries to deliver economic benefit to the state with associated benefits of employment, local growth and provision of support services.

4 Developing a recycled wastewater supply

4.1 Approval process

This section guides industry on the nature of issues they may encounter through the recycled wastewater approval process, as well as how to negotiate the regulatory framework. Figure 11 shows the steps a proponent would likely need to take to develop a recycled wastewater supply (DoW 2013a).

The Department of Water's *Guideline for the approval of non-drinking water systems in Western Australia* (2013a) defines the approvals process for establishing a non-drinking water system, the regulatory requirements for implementation and the recommended order of approvals. Although the guideline focuses on urban developments, the principles and requirements are also applicable to industrial recycled wastewater schemes. The following four stages have been developed to assess non-potable (non-drinking) water supplies (as seen in Figure 11):

1. Option evaluation and concept design: identify source options
2. Preliminary design: secure source and identify system
3. Detailed design and approvals: provide for infrastructure requirements and apply for approvals to use (and supply) a non-drinking water source
4. Implementation: obtain approvals to construct (and operate).

The Department of Water has aligned the guideline with the requirements and approval processes of other government agencies. The typical approval timeframe for an industrial project from conception to operation can be two to three years.

Early in the process, the proponent should contact the Department of Water to work together to define the key issues and determine what information is required for the approvals process. The Department of Water can help proponents by coordinating preliminary advice on proposals across regulatory agencies.

Approvals, conditions and monitoring requirements are linked to the level of risk to the environment and human health from a recycled wastewater scheme. Proponents of a prospective recycled wastewater scheme are responsible for identifying and quantifying the impacts of their proposed operations before seeking approval.

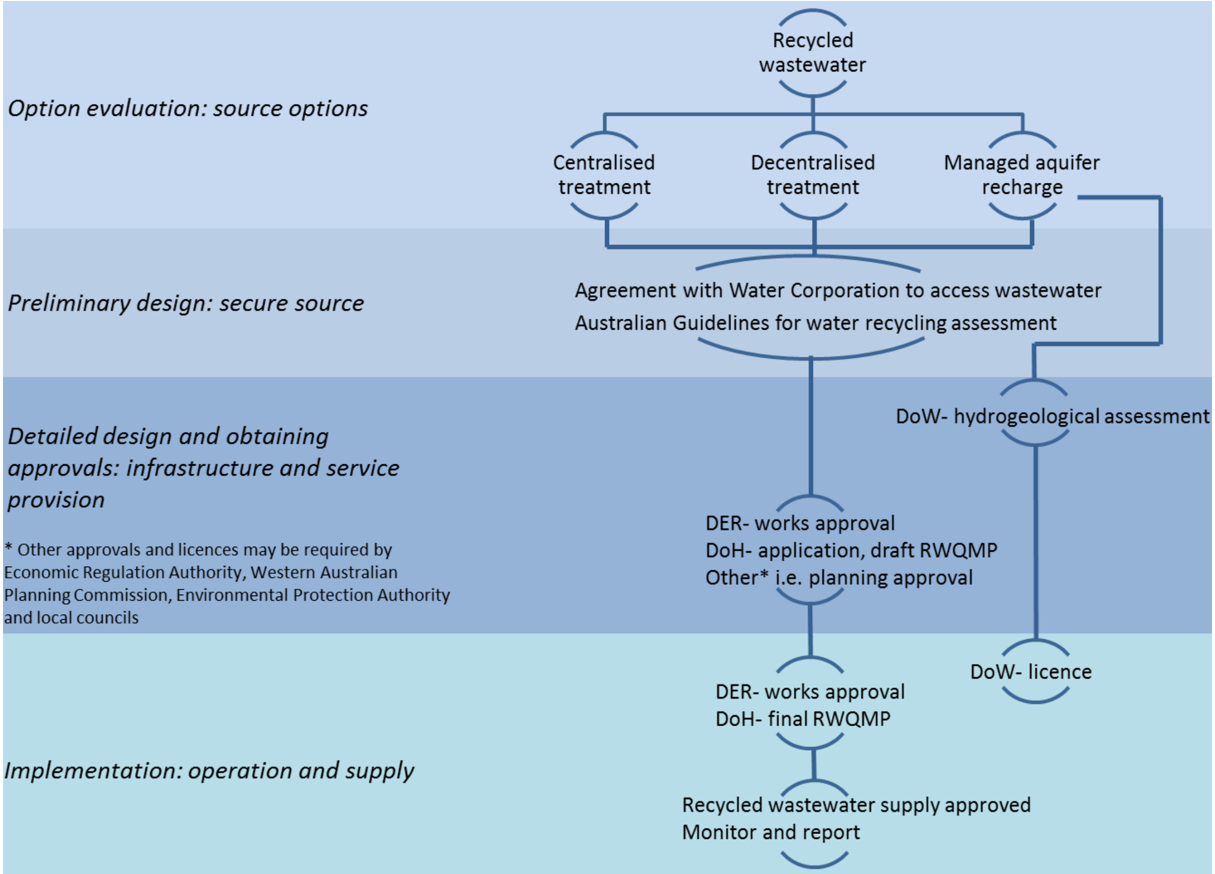


Figure 11 Summary of approval process and ongoing monitoring for a recycled wastewater supply

It is important for industry/proponents to plan their pathway through the approvals process. In the early stages of the approvals process proponents should discuss their intention to access treated wastewater with the Water Corporation. Several state government agencies have a role in the approval and ongoing management of recycled wastewater projects, including the Department of Environment Regulation (DER) and Department of Health (DoH). Additional approvals may need to be required for planning developments, if high environmental risk is present or a water service provider is required.

The DER and DoH's regulatory roles are to ensure that activities do not pose unacceptable risks to the environment and public health.

The DER have a target to determine applications for works approvals and licences within 60 working days, and clearing permit applications within 60 calendar days. DER assesses applications in accordance with their *Guidance Statement: Land Use Planning* (October 2015) under Division 3, Part V of the *Environmental Protection Act 1986*.

Proponents need to develop a Recycled Water Quality Management Plan (RWQMP) as part of the approval process with DoH. The RWQMP aligns with DoH's *Guidelines for the non-potable uses of recycled water in Western Australia* (2011) which brings the state's recycled wastewater practices and schemes in line with the Australian Guidelines for Water Recycling.

The approval process for both the DER and DoH are stepped out in the guidelines mentioned above.

Table 7 summarises the likely approvals required for each recycled wastewater option. The approvals listed are generic to recycled wastewater schemes, and the exact requirements can vary from project to project.

Table 7 Overview of likely Western Australian regulatory approvals for a recycled wastewater scheme

Agency	Approval	Centralised treatment	Decentralised treatment	MAR
Local government authorities	Infrastructure approval	Required	Required	Required
Department of Environment Regulation	Clearing permit to clear native vegetation (may be authorised under works approvals or licence)	Potentially	Potentially	Potentially
	Licence to discharge effluent into an aquifer	Potentially	Potentially	Required
	Licence/registration to operate a prescribed premises and discharge effluent to the environment	Required	Required	Required
	Licence amendment to make changes to an operational wastewater treatment plant	Required	Required	Required
	Licence to discharge treatment concentrate and any chemicals to the receiving environment	Potentially	Potentially	Potentially
Department of Health	Approval to install a wastewater treatment system	Required	Required	Potentially[9]
	Approval to use recycled water	Required	Required	Required
Western Australian Planning Commission	Land use planning process/development approval	Potentially[10]	Potentially[7]	Potentially[7]
Department of Water	26D licence to construct a bore	Not required	Not required	Required
	5C licence to take groundwater	Not required	Not required	Required
Economic Regulation Authority	Water service provider licence	Likely	Unlikely[11]	Likely
Office of Environmental Protection Authority	Assessment under the *Environmental Protection Act 1986* e.g Ministerial Statement 665	Potentially	Potentially	Potentially
Water Corporation	Formal agreement to access secondary treated wastewater	Required	Required	Required

[9] If further treatment of the wastewater is required before infiltration

[10] Could be required with changes to land zoning or new development

[11] Could be required if operated as a scheme and sold to multiple industries

	Formal agreement (effluent services agreement) to dispose of treatment concentrate to the SDOOL[12]	Potentially	Potentially	Potentially

The Commonwealth Government has developed the *Australian Guidelines for Water Recycling: Managing health and environmental risks (Phase 1)* (NRMMC, EPHC & NHMRC 2009). The Australian Guidelines for Water Recycling were developed under the National Water Quality Management Strategy and are the most current guidelines for best practice in managing risk associated with water recycling and reuse (in 2015).

Proponents are encouraged to assess their water supply option against the Australian Guidelines for Water Recycling to determine the feasibility and level of risk of the proposal. The assessment would also assist proponents in the approval process for state government approvals.

4.2 Roles and responsibilities for a recycled wastewater scheme

The three major roles in delivering a recycled wastewater scheme include:

- wastewater provider – owns, manages and provides access to the source treated wastewater (currently Water Corporation)
- scheme manager – operates the scheme, including ongoing maintenance and monitoring
- end user – uses the recycled water.

See Table 10 for further description of these roles. The roles may be undertaken by three separate parties, or one party may undertake more than one role. For example, the end user may also manage the scheme.

In some cases other parties may benefit from a recycled wastewater scheme. For example, a number of end users may wish to abstract groundwater from a MAR scheme. In this case a recycled wastewater scheme is likely to need a water service provider licence. This ensures the scheme manager has the appropriate level of water knowledge and systems in place to manage a reliable and efficient scheme for multiple end users.

Wastewater provider

The Water Corporation owns and operates the wastewater treatment plants and the SDOOL. The SDOOL is an important wastewater disposal pipeline, and the Water Corporation would require a recycled water supply agreement with proponents proposing to access the infrastructure. Considerations for assessing a proposal are listed in Table 8.

[12] Discharge to a sewer upstream of a WWTP would be subject to the Water Corporation's trade waste requirements and charges (Water Corporation, 2016b)

The Water Corporation has indicated in principle support for a third party to access secondary treated wastewater from either their wastewater treatment plants in the area or the SDOOL. Offtake would need to be limited to the location of existing SDOOL section valves or specific to a MAR location(s).

Table 8 Water Corporation's considerations for assessing a recycled water supply agreement

Consideration	Detail
First come – first served or 70% committed trigger	As per Water Corporation's Commercial Considerations paper (Water Corporation 2014a)
Volumetric	How much wastewater is required and will it affect the Corporation's potable reuse plans at Woodman Point and KWRP feed requirements?
Technical	Where the wastewater is required (i.e. access point to SDOOL)? Direct access (i.e. hot tapping) SDOOL would be reviewed on a case-by-case basis and access would be preferred at section valve bypass pipework.
Technical	Is there a waste stream to be returned to the SDOOL?
Supply conditions	As-is where-is with no commitments to pressure or continuity of supply or quality, depending on supply location.
Commercial	Joint wastewater scheme costs plus any direct costs incurred by the Corporation in the supply of the wastewater less any avoided wastewater disposal costs.
Legal	Negotiation of recycled water supply agreement.
Regulatory approvals	External regulatory approvals are granted i.e. recycled wastewater scheme approval from necessary state government agencies

In supplying treated wastewater the Water Corporation would seek to recover from the user:

- a share of the joint wastewater scheme costs as discussed in Section 3.3 Source water
- any costs directly or indirectly incurred to provide an additional service or to modify a treated wastewater process.

The conditions of access and pricing of wastewater would be negotiated between the Water Corporation and the scheme manager or end user through a formal agreement.

Scheme manager

The scheme manager is responsible for operating the recycled wastewater scheme. In many cases, particularly where the scheme will service multiple customers, the scheme manager will be responsible for completing any investigations and obtaining the necessary regulatory approvals. The scheme manager will also need to undertake ongoing maintenance, monitoring and reporting on the scheme, and ensure compliance with the terms and conditions of the required licences.

The Department of Water is legally unable to be a scheme manager. Potential scheme manager roles for a recycled wastewater scheme in the Western Trade Coast could include:

- an individual company

- a joint partnership between companies
- a water service provider
- a cooperative between users, where each user holds an equal share (similar to Harvey Water).

Considerations for each type of scheme manager role are summarised in Table 9.

Table 9 Factors to consider in establishing a scheme manager

Scheme manager	Factors
Individual company	• Feasible for new, large demand from a single industry proponent • Most companies indicated a willingness to pursue the relevant approvals and negotiations • Some companies indicated that treating water is not part of their core business – a third party could be appointed to manage the water supply on their behalf • Some companies indicated a willingness to sell water that is surplus to their needs to other companies
Joint partnership between companies	• Potential for a scenario of two or more companies in close proximity requiring additional water supply within a similar timeframe • Similar considerations as per an individual company • Requires negotiation of an agreement between the companies, including roles and responsibilities • More likely that a third party would be appointed to manage the water supply scheme
Water service provider	• Potential for a scenario of one or more companies requiring additional water supply within a similar timeframe • Scheme would need to be commercially viable, and run as a take or pay contract or with a contracted water charge to enable recoup of capital • There is a small but growing number of private sector operators that have expressed an interest in owning and/or operating a recycled wastewater scheme in Western Australia • Further detail about managing a recycled wastewater scheme can be found in *Recycled water: commercial considerations* (Water Corporation 2014a)
Cooperative between users	• Potential for a scenario of two or more companies in close proximity requiring additional water supply within a similar timeframe

End user

The end user(s) is the party using the water.

The end user would have a commercial agreement in place with the scheme manager to provide certainty of a reliable supply and monitoring requirements.

Timing of the development of a new recycled wastewater scheme would need to be considered by an end user. There is a cost involved in the water being provided and usually a commercial agreement would be in place.

Table 10 Overview of roles and responsibilities for a recycled wastewater scheme

Roles/tasks	Wastewater provider (provides access to the source)	Scheme manager (operates the scheme)	End user (uses the recycled wastewater – a scheme manager and end user may or may not be the same party)
Parties	Water Corporation	• Range of potential options – see Table 9	• Individual companies
Physical infrastructure	WWTP or SDOOL and offtake infrastructure	• MAR scheme- treatment plant and infiltration infrastructure • Centralised or decentralised scheme- treatment plant	• Abstraction and monitoring bores (need to be located within the MAR management zone)
Commercial/ contractual arrangements	Agreement between the treated wastewater provider and scheme manager to access treated wastewater including details on water quality, quantity, pricing, level of service, roles and responsibilities, contract duration, contingency measures.		Agreement between the scheme manager and each user including details on: • water quality • quantity • pricing • level of service • roles and responsibilities • contract duration • contingency measures.
Supporting documentation for approvals	Complete relevant sections of the draft recycled water quality management plan e.g. source water details (DoH)	• Risk assessment and management measures to mitigate impacts (DER, DoH, DoW) • Operating strategy, hydrogeological assessment and report, including identification of MAR management zone (DoW – only if the scheme manager is applying for, or issued with a 5C licence) • Draft recycled water quality management plan (DoH)	• Operating strategy (DoW) • Hydrogeological assessment and report, including identification of MAR management zone (DoW)
Approvals		• MAR scheme	• 26D licence to construct bore (DoW)

Roles/tasks	Wastewater provider (provides access to the source)	Scheme manager (operates the scheme)	End user (uses the recycled wastewater – a scheme manager and end user may or may not be the same party)
		• 5C licence to take groundwater (DoW) • Works approval for construction of treatment plant and approval to discharge effluent into an aquifer (DER) • Licence/registration to operate a prescribed premises and discharge effluent (DER) • Approval to install a treated wastewater treatment system (DoH) • Approval to use recycled water (DoH)(DER – if exceeds threshold may be a prescribed premise) • Water service provider licence (ERA) • State government and local government infrastructure approval (DoP, LGA) • EPA approval, if required	• 5C licence to take groundwater (agreement if different parties) • ERA licence if the end user provides water to a third party • Approval to use recycled water (DoH) • Local government infrastructure approval if assets on LGA land
Reporting, monitoring and maintenance	Existing reporting and monitoring in place e.g. SDOOL Monitoring and Management Plan	• Reporting and monitoring under the 5C licence related to water resource implications e.g. water abstraction volumes, infiltration volumes, water levels, water quality (DoW) • Reporting and monitoring under DER licence for environmental protection e.g. infiltration volumes, quality of water infiltrated and groundwater quality monitoring	• Reporting and monitoring obligations to the 5C licence holder (e.g. water abstraction volumes) • Reporting and monitoring under DoH approval for protection of public health e.g. monitoring of the treatment process and recycled water quality, volumes of recycled water produced and reused

Roles/tasks	Wastewater provider (provides access to the source)	Scheme manager (operates the scheme)	End user (uses the recycled wastewater – a scheme manager and end user may or may not be the same party)
		• Reporting and monitoring under DoH approval for protection of public health e.g. monitoring of the treatment process and recycled water quality, volumes of recycled water produced and reused • Treatment plant and pond maintenance • Reporting and monitoring under the water services licence (ERA)	

4.3 Regulation of managed aquifer recharge

Centralised and decentralised recycled wastewater plants are established practices and technology. Infiltration of treated wastewater through MAR has been developed successfully in other parts of Australia and is emerging as a secure water supply in Western Australia. This section goes into further detail on the regulatory approvals for MAR compared to the other recycled wastewater options.

The Government of Western Australia supports MAR that has environmental, social or economic benefits and maximises the use of the state's water resources. The regulatory processes in place are to protect the natural environment, existing groundwater users and public health, while enabling economic activity. To ensure a MAR scheme does not cause adverse impact, a proponent (i.e. scheme manager) needs to identify, qualify and manage risk. The scale of a MAR scheme and end use plays a significant role in determining the level of assessment and monitoring required.

The regulatory approvals for a local non-potable MAR scheme in the superficial aquifer are straightforward compared with the Water Corporation's larger potable reuse plans using the deeper confined aquifers. The recovery and reuse of the infiltrated water for industry includes additional regulatory steps beyond what has previously been demonstrated. Additional information on the regulatory requirements specific to a non-potable MAR scheme in the Western Trade Coast are outlined below.

Australian Guidelines for Water Recycling and Environmental Risks (Phase 2)

The *Australian Guidelines for Water Recycling: Managing health and environmental risks (Phase 2), Managed aquifer recharge* provides valuable information to state governments and proponents assessing the feasibility of a MAR scheme (NRMMC, EPHC & NHMRC 2009). Figure 12 shows the three different stages a proponent needs to go through to assess their MAR scheme proposal.

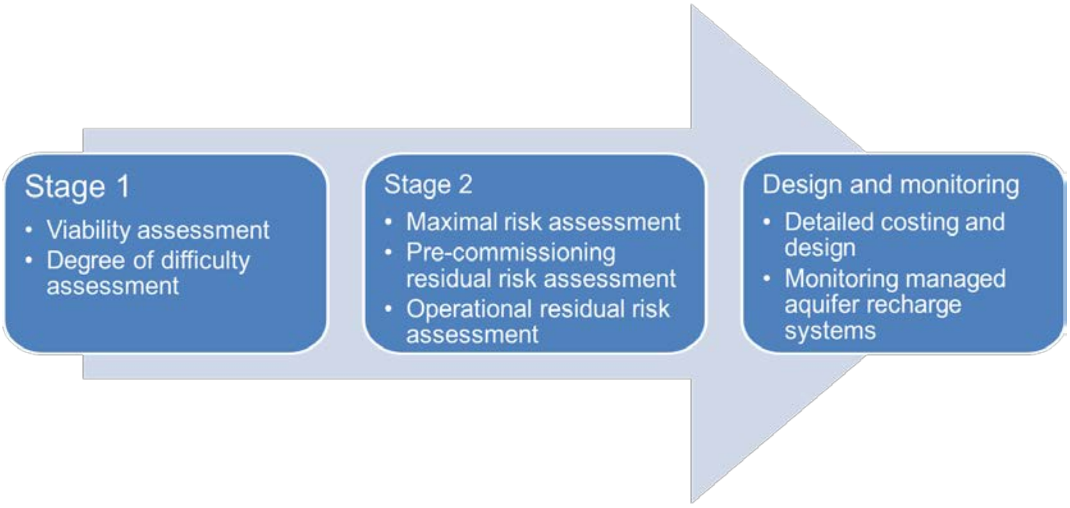


Figure 12 Stages of the Australian Guidelines for Water Recycling: Managing health and environmental risks (Phase 2), Managed aquifer recharge (NRMMC, EPHC & NHMRC 2009)

Stage 1

Stage 1 of the *Australian Guidelines for Water Recycling: Managing health and environmental risks (Phase 2), Managed aquifer recharge* (NRMMC, EPHC & NHMRC 2009) is an entry-level assessment, designed to inform a proponent on the feasibility of a potential MAR project.

As part of assessing the recycled wastewater supply options for industrial use in the Western Trade Coast, the Department of Water completed an example of the Stage 1 entry-level assessment (see Appendix B). The entry-level assessment is divided into two parts:

1 viability assessment

2 degree-of-difficulty assessment.

The example viability assessment shows why a MAR scheme is a suitable option to be considered in the Western Trade Coast. The assessment has identified:

- a local demand in the Western Trade Coast with a readily available source of treated wastewater from the SDOOL
- suitable aquifers to receive, store and transport treated wastewater (with abstraction to be guided by the Cockburn Groundwater Area allocation plan)
- suitable infiltration sites, with conceptual designs assessed and costed.

The identified areas that were rated a moderate to high level of difficulty and require additional information and assessment were:

- site-specific information relating to the chemical and physical properties of the source water and groundwater for MAR
- groundwater modelling and assessment of how infiltrated water affects groundwater-dependent ecosystems, in particular Cockburn Sound

- management of appropriate buffer zones around infiltration points
- how experienced a proponent is to design, construct and operate a recycled wastewater MAR scheme.

Stage 2

If a proposal satisfies the 14 questions of the Stage 1 assessment, a proponent would proceed with a Stage 2 assessment, which may involve testing and site investigations to assess the risk in more detail.

A specific site and water demand is required to accurately assess the risks outlined in Stage 2. The information required to complete the Stage 2 assessment closely aligns with information required for various government approvals.

Water resource regulation

The Department of Water administers MAR projects under the *Operational policy 1.01 – Managed aquifer recharge in Western Australia* (DoW 2011). The policy provides proponents guidance and examples of the approval process for a MAR scheme. Approval is required for the recharge and recovery of treated wastewater into superficial or confined aquifers in the Western Trade Coast.

Licenses for managed aquifer recharge

As part of regulating MAR, the Department of Water licenses the abstraction of groundwater under the *Rights in Water and Irrigation Act 1914.*

Proponents of a MAR scheme proposal are required to undertake a hydrogeological investigation to quantify the viability and identify potential impacts of recharge and recovery. The Department of Water's *Operational policy no. 5.11 – Timely submission of required further information* provides guidelines for expected timeframes for proponents to provide information (DoW 2009a). A detailed hydrogeological assessment usually takes 6-12 months to complete.

During the licensing application process the department carries out a risk based approach to determine the level of assessment required. This allows the department to identify and/or mitigate potential impacts to the aquifer, environment and other users.

All bores constructed for MAR recharge or recovery require a 26D licence. Infiltration works (e.g. pits, trenches, galleries) that intercept the watertable also require a 26D licence. All bores/works constructed for abstraction of groundwater in a MAR scheme require a 5C licence, regardless of the net loss to the aquifer.

As MAR introduces water into an aquifer in addition to the natural recharge, MAR recharge and recovery volumes will be managed separately to the allocation limit for natural groundwater.

The percentage of recharge water that can be recovered will be assessed on a case-by-case basis. The recovery volume will be less than or equal to the recharge volume. The department will assign appropriate recovery figures based on estimates from the proponent's hydrogeological assessments.

The identification of a MAR management zone by a proponent also forms part of the Department of Water's hydrogeological assessment to support a 5C licence application.

The Department of Environment Regulation and/or Department of Health may establish a MAR management zone around the infiltration sites or the particle flow lines to manage potential risk to the environment and public health.

Infiltrated water can be 'banked' (stored) in the aquifer for recovery at a later date, provided that appropriate monitoring has been undertaken and it can be demonstrated that the water will be available for use when required, and the impacts of abstraction are acceptable.

The approach adopted is that the 5C licence(s) will be issued to the scheme manager, who is partly responsible for the abstraction of the recharged water. The *Rights in Water and Irrigation Act 1914* contains provisions that allow the holder of a 5C water licence (scheme manager) to enter into an agreement with another party to take water under the licence for a limited period of time. This is to ensure that the volume to be abstracted is linked to the volume recharged (see Table 10 for further detail). The tenure of the licence is limited to the term of the contractual agreement.

4.4 Government role

The Government of Western Australia provides environmental, health and water resource regulation of recycled wastewater in Western Australia.

Western Australia has endorsed the National Water Initiative (NWI) pricing principles. The NWI's overall objective is to achieve a nationally compatible system for managing water resources and use – a planning, regulatory and market-based approach that aims to optimise economic, social and environmental outcomes.

These principles include that *when allocating costs, a 'beneficiary pays' approach – typically including direct user pay contributions (direct payment by those who use the scheme) should be the starting point, with specific costs shared across beneficiaries of the scheme, based on the scheme's drivers*. This principle reflects the concept that a project is most likely to succeed when the parties driving the project and receiving the benefits provide the funding.

Detailed source and supply infrastructure planning, design and construction is normally the role of the commercial operator and/or the beneficiary of the water supply. Industry or a scheme manager are generally responsible for the financial cost of developing and operating a water supply which is primarily for private benefit.

5 Planning for future supplies

New water sources are required to support the projected increase in water demand by heavy industry by 2031. In a drying climate and reducing groundwater availability, recycled wastewater is a cost-effective supply option for industry.

Developing a new water supply from conception to implementation typically takes two to three years. Early planning and ongoing exchange of information across government and industry is therefore important to ensure cost-effective, fit-for-purpose and timely provision of water supplies.

When considering a recycled wastewater supply option a proponent is encouraged to determine the feasibility and level of risk of their proposal against the *Australian Guidelines for Water Recycling*. Evaluating potential environmental and public health risks as well as costs (capital and operational) and end use water requirements.

A decentralised recycled wastewater scheme may be (subject to treatment costs) the most cost-effective recycled wastewater supply option to provide non-potable supplies to industry. Despite higher costs than decentralised treatment a MAR scheme has the advantage of providing subsurface storage and transfer using the superficial aquifer.

Validation of the level of treatment required will help a company to select a preferred water supply option. An acceptable level of total nitrogen (and other contaminants) in the infiltrated water may be refined through a field sampling, monitoring, and solute modelling study in liaison with the Department of Environment Regulation. It is important this is well understood to inform the selection of MAR infiltration sites, particularly up gradient of the sensitive ecosystem of Cockburn Sound. The ability of existing or new bores designed to intercept the recharged water could also be assessed.

To improve cost estimations, detailed engineering design will be required for the preferred recycled wastewater supply option, in particular relating to SDOOL connection, water treatment, disposal options for treatment concentrate, pipe networks and MAR infrastructure.

The Department of Water will continue to assess and monitor water demand and supply balances, particularly in areas of high demand. During the planning phase of the Perth-Peel regional water supply strategy, the department will develop a policy on the use of recycled wastewater for potable and non-potable purposes.

National and state government guidelines on using non-potable water will continue to be reviewed and updated to support the increase in innovative use of this source. The approval processes are becoming more efficient and transparent to better inform proponents of their regulatory requirements. Proponents will need to refer to the latest guidelines and any policy updates at the time of developing a new water supply.

Appendices

Appendix A — Water demand projection method

Sinclair Knight Merz and Resource Economics Unit (2013) projected water demand for the Western Trade Coast in *Western Trade Coast integrated assessment: environmental, social and economic impact*. Further to this, Resource Economics Unit (2015) has updated demand to extend projections to 2031 and incorporate the latest information on macro-economic variables and an analysis of international trends for export products.

Input-output techniques are used in economics to assess the effects of changes in the output of a specified industry on the output, value added or employment of other industries. The model provides an estimate of potential demand for increased output from existing and new industries in the Western Trade Coast, resulting from future growth in the Western Australian economy. This has been coupled with an assessment of international trends for international and interstate exports to produce projected annual growth in total output, value added and employment for 14 industry types within the Western Trade Coast from 2014 to 2031. Future water demand for heavy industry is projected by multiplying the 2014 base water demand by the projected growth rates for each industry type.

The choice of economic indicator as a predictor of water use is necessarily a matter of judgment. It will be influenced not only by the expected degree of correlation between the selected indicator and water use, but also by the adopted decision rules about hydrological uncertainties and the scale and timing of investment in new infrastructure. Possible decision rules could encompass:

- only install new capacity for highly probable water demands (i.e. assume that gains in water use efficiency mirror gains in labour productivity and thus use the employment indicator)
- guarantee water availability for the maximum possible future demand (i.e. assume no gains in water use efficiency and select the total output indicator); or
- guarantee adequate water availability for the most plausible demand projection (i.e. assume that gains in water use efficiency mirror gains in the efficient use of all intermediate inputs and hence select the value added indicator).

For the purposes of water supply planning for heavy industry requirements in the Western Trade Coast, we recommend the use of the value added indicator.

Appendix B — Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2): Managed aquifer recharge, Stage 1 entry-level assessment

Viability assessment

Attribute	Answer
Is there an ongoing local demand or clearly defined environmental benefit for recovered water that is compatible with local water management plans?	Yes. Groundwater availability in the Western Trade Coast is limited and is not expected to be sufficient to meet future demand. A range of drivers has been identified which could result in alternative supplies being required in the future (additional demand, reduced availability of current supplies, water quality concerns and replacement of high-quality supplies with fit-for-purpose supplies). The purpose of this assessment is to provide an indication of the viability and difficulty of a MAR scheme. Development of the scheme would not be triggered until actual demand arises and a proponent is identified.
Is adequate source water available, and is harvesting this volume compatible with catchment water management plans?	Yes. Approximately 50 GL/year of secondary treated wastewater is currently available and this is projected to more than double by 2060. The Water Corporation has confirmed that it is willing to provide third-party access to the wastewater subject to the commercial and technical review of the proposal and the negotiation of a recycled water supply agreement with the proponent.
Is there at least one aquifer at the proposed MAR site capable of storing additional water?	Yes. Groundwater modelling indicates that the superficial aquifer is suitable for MAR (McFarlane 2015). There may also be potential for MAR into the Leederville or Yarragadee aquifers. However, the costs are likely to be higher and most existing industry abstraction bores are located within the superficial aquifer.
Is the project compatible with groundwater management plans?	Yes. The abstraction of groundwater is guided by the Cockburn Groundwater Area water allocation plan. The DoW supports MAR activities that have environmental, social or economic benefits and maximise the use of water resources. Abstraction of water infiltrated via MAR will be managed under a separate MAR allocation component.
Is there sufficient land available for capture and treatment of the water?	Yes. Potential MAR sites were identified in McFarlane (2015). Specific location for MAR infiltration will be dependent on the location of demand.
Is there a capability to design, construct and operate a MAR project?	Yes, capacity does exist in Western Australia. The capability would need to be secured by the proponent of a MAR scheme.

Degree-of-difficulty assessment

No.	Question	Level of difficulty Identified	Comment on Level of difficulty	Level of difficulty
1	Does source water meet the water quality requirements for the environmental values of ambient groundwater?	Source water is of varying quality and does not meet all the water quality requirements for the environmental values of ambient groundwater.	Each site will need to be assessed on a case-by-case basis, taking into account the source water and environmental values of the receiving groundwater system.	Moderate–High
2	Does source water meet the water quality requirements for the environmental values of the intended end uses of the water on recovery?	Source water generally meets the water quality of the end user.	Water will be used in a fit-for-purpose environment, and in some cases may require further treatment to meet the intended use quality.	Low–High
3	Does source water have low quality?	Source water has typical low-medium values for suspended solids and total nitrogen. The sandy soil can reduce the risk of clogging.	Source water varies between treatment plants, and risks other than clogging may require further treatment of source water prior to infiltration.	Low–Moderate
4	Does ambient groundwater meet the water quality requirements for the environmental values of end uses of water on recovery?	Ambient groundwater meets the water quality requirements for the environmental values of intended end use in most cases.	Specific to each end user and water quality requirements. Groundwater is currently widely used for many industrial purposes.	Low–Moderate
5	Is either drinking water supply, or protection of aquatic ecosystems with high conservation or ecological values, an environmental value of the target aquifer?	The target aquifer to receive the infiltrated water does not supply drinking water The aquifer does, however, support high value aquatic ecosystems.	The risk to groundwater-dependent ecosystems varies across the Western Trade Coast, some sites may require further investigation to clarify this risk.	Moderate–High
6	Does the salinity of native groundwater exceed either of the following: a) 10 000 mg/L b) the salinity criterion for uses of recovered water?	The salinity of native groundwater is generally less than 10 000 mg/L.	Aquifer recharge also has potential to manage the saltwater interface.	Low–Moderate

No.	Question	Level of difficulty Identified	Comment on Level of difficulty	Level of difficulty
7	Is redox status, pH, temperature, nutrient status and ionic strength of groundwater similar to that of source water?	Typical chemical properties of wastewater and groundwater are: 1) wastewater pH ranges from 7.3–7.5, total nitrogen 7.5–14.6mg/L and total phosphorus 0.95–4.4 mg/L (50th percentile) for Kwinana and Woodman Point WWTPs respectively (average for 2010–13 period). 2) Local groundwater parameters indicate pH of the superficial aquifer ranges from 5.1–8, becoming more acidic away from the coast. Nitrate (NO3-) is 0–50 mg/L and phosphate (PO43-) 0–3 mg/L (DoW 2010a)	Details unknown. The specific water quality parameters have not been compared in detail and will require site-specific analysis.	Moderate–High
8	Are there other groundwater users, groundwater-connected ecosystems or a property boundary within 100–1000 m of the MAR site?	It is likely that other groundwater users, and groundwater-connected ecosystems will be within 100–1000 m of a MAR site.	The majority of groundwater users within a MAR zone would abstract water for industrial purposes. Modelling can be used to inform the regulatory and licensing processes to manage the risk.	Moderate–High
9	Is the aquifer: a) confined and not artesian b) unconfined, with watertable deeper than 4 m in rural areas or 8 m in urban areas?	The target aquifer for MAR is the Swan Superficial, which is unconfined, with a watertable ranging from 0 to +12 m below the surface.	Site-specific investigations required to determine the risk at the time of infiltration.	Low–Moderate
10	Is the aquifer unconfined, with an intended use of recovered water that includes drinking water supplies?	The aquifer is unconfined, and is not used or intended to be used for drinking water purposes.	While not intended for drinking water purposes, infiltrated and abstracted water must still meet the relevant requirements of the DoH.	Low–Moderate
11	Is the aquifer composed of fractured rock or karstic media, or known to contain reactive minerals?	Tamala limestone is potentially karstic. The Safety Bay Sand is calcareous fine to medium grained quartz sand and shell fragments with traces of fine grained, black, heavy minerals.	Each infiltration site would be assessed for karstic media and reactive minerals.	Low–High

No.	Question	Level of difficulty Identified	Comment on Level of difficulty	Level of difficulty
12	Has another project in the same aquifer with similar source water been operating successfully for at least 12 months?	Water has been successfully infiltrated into the Swan Superficial Aquifer for more than 12 months.	The Kwinana WWTP has been infiltrating secondary treated wastewater into the superficial aquifer since the mid-1980s. While this is a wastewater disposal solution, it does provide a case study and monitoring data to assess the risks of MAR in this area.	Low–Moderat e

Appendix C — Levelised unit cost of infrastructure – capital and operating costs

Costs are summarised into capital and operating costs for each recycled wastewater supply scenario. See Appendix D for the assumptions used in the calculation of the estimated NPV levelised unit costs.

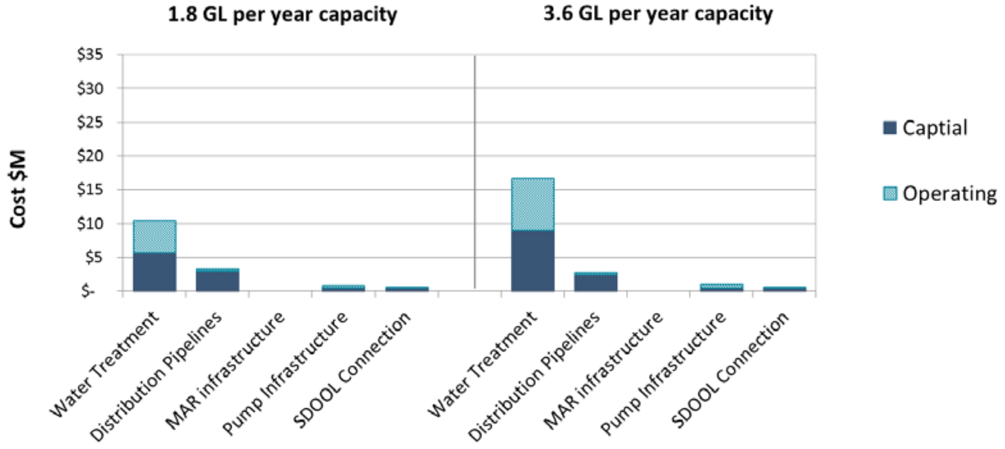
CAPITAL COSTS	Scenario	Option	Volume GL/yr	Distribution Pipelines $/kL	Pump Infrastructure $/kL	SDOOL Connection $/kL	Water Treatment $/kL	MAR Infrastructure $/kL	TOTAL CAPEX $/kL
	1	MAR, basins, site s2, 4000 m pipe, N and TSS treatment	1.8	0.092	0.035	0.017	0.304	0.042	$ 0.49
	2	MAR, basins, site s2, 4000 m pipe, N and TSS treatment	3.6	0.053	0.022	0.008	0.229	0.037	$ 0.35
	3	MAR, galleries, site s2, 4000 m pipe, N and TSS treatment	1.8	0.092	0.035	0.017	0.344	0.070	$ 0.56
	4	MAR, galleries, site s2, 4000 m pipe, N and TSS treatment	3.6	0.053	0.022	0.008	0.262	0.062	$ 0.41
	5	Decentralised treatment, 4000m pipe	1.8	0.108	0.018	0.017	0.199	0.000	$ 0.34
	6	Decentralised treatment, 4000m pipe	3.6	0.068	0.013	0.008	0.159	0.000	$ 0.25

OPERATING COSTS	Scenario	Option	Volume GL/yr	Distribution Pipelines $/kL	Pump Infrastructure $/kL	SDOOL Connection $/kL	Water Treatment $/kL	MAR Infrastructure $/kL	TOTAL CAPEX $/kL
	1	MAR, basins, site s2, 4000 m pipe, N and TSS treatment	1.8	0.007	0.005	0.001	0.329	0.056	$ 0.40
	2	MAR, basins, site s2, 4000 m pipe, N and TSS treatment	3.6	0.004	0.003	0.001	0.275	0.032	$ 0.31
	3	MAR, galleries, site s2, 4000 m pipe, N and TSS treatment	1.8	0.007	0.005	0.001	0.380	0.083	$ 0.48
	4	MAR, galleries, site s2, 4000 m pipe, N and TSS treatment	3.6	0.004	0.003	0.001	0.304	0.057	$ 0.37
	5	Decentralised treatment, 4000m pipe	1.8	0.008	0.011	0.001	0.169	0.000	$ 0.19
	6	Decentralised treatment, 4000m pipe	3.6	0.005	0.008	0.001	0.135	0.000	$ 0.15

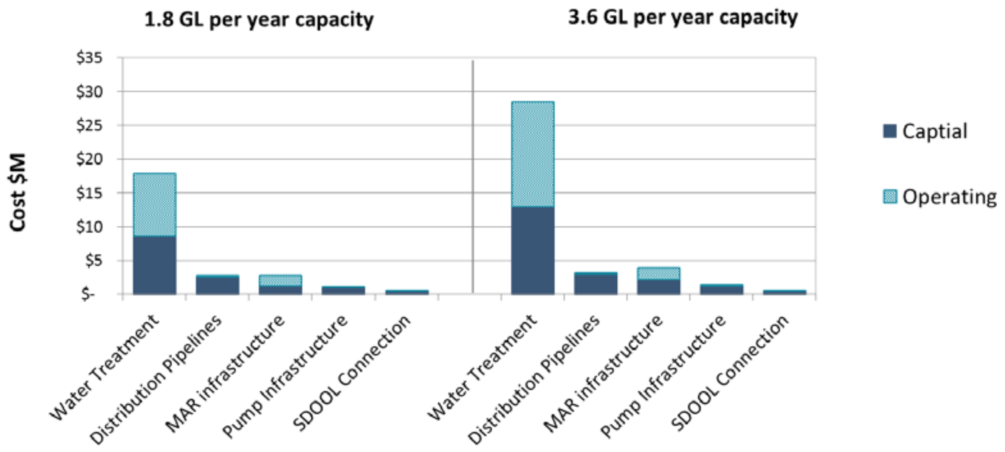
Appendix D — Assumptions used for NPV calculations

Cost Type	Item	Cost assumption (1.8 GL/year – 3.6 GL/year)	Units
Capital costs	Recharge gallery	1 400 000 – 2 500 000	$/gallery
	Recharge basin	850 000 – 1 500 000	$/basin
	Treatment for N and TSS	6 100 000 – 10 500 000	$/plant
	Treatment for TSS only	2 600 000 – 5 700 000	$/plant
	SDOOL connection	995 000 – 1 165 000	$/connection
	Decentralised treatment plant	4 000 000 – 6 400 000	$/plant
	Civil works for pipe installation	800 000	$/connection
	Pipes	400 – 600	$/m
Operating costs	Recharge gallery	150 000 – 205 000	$/gallery/year
	Recharge basin	100 000 – 115 000	$/basin/year
	Treatment for N and TSS	590 000 – 1 095 000	$/plant/year
	Treatment for TSS only	206 000 – 343 000	$/plant/year
	SDOOL connection	0.5 – 1.5	% of capital cost
	Decentralised treatment plant	0.10 – 0.13	$/kL
	Civil works for pipe installation	0.5	% of capital cost
	Pipes	1.5	% of capital cost
	Power supply	0.35	$/kW hr
	Operator attendance	100	$/hr
NPV calculations	Discount rate	6	%
	Project life	50	year
	Civil infrastructure economic life	Replace every 50 years	year
	Electrical and mechanical economic life	Replaced every 20 years	year
	Public water supply commercial volumetric charge	2.09	$/kL
	MAR recovery efficiency	100	%

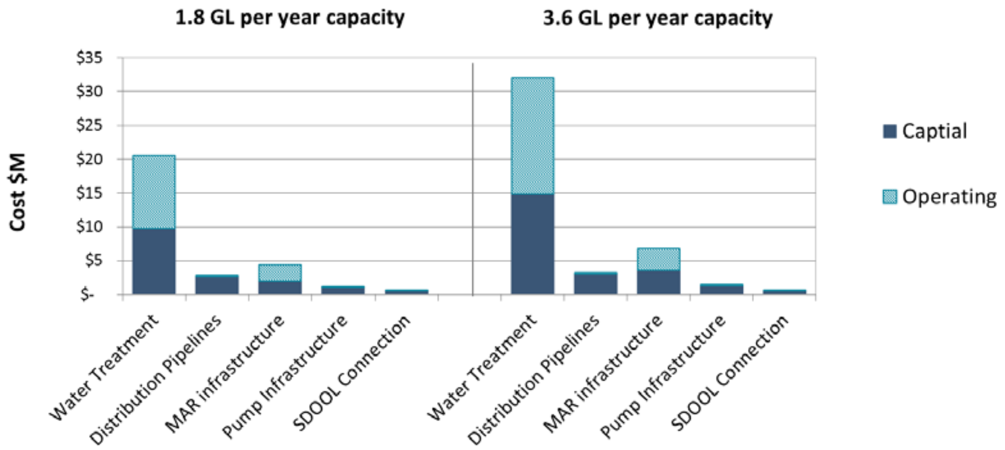
Appendix E — Summary of infrastructure capital and operating costs



a) Decentralised treatment, 4000 m pipeline, with filtration and chlorination treatment



b) MAR infiltration basins, 4000 m pipeline, with TSS and TN treatment



c) MAR infiltration galleries, 4000 m pipeline, with TSS and TN treatment

Figure E1 Summary of infrastructure capital and operating costs

Glossary

Abstraction	Withdrawal of water from a surface water or groundwater source of supply.
Allocation limit	Annual volume of water set aside for consumptive use from a water resource.
Aquifer	A geological formation or group of formations capable of receiving, storing and transmitting water.
Fit-for-purpose	Water that is of suitable quality for the intended end purpose; implies that the quality is not higher than needed.
Groundwater	The water that occurs in pore spaces and fractures in rocks beneath the ground surface. Also see Aquifer.
Groundwater area	The boundaries proclaimed under the *Rights in Water and Irrigation Act 1914* and used for water allocation planning and management.
Licence (or licensed entitlement)	A formal permit that entitles the licence holder to take water from a watercourse, wetland or underground source under the *Rights in Water and Irrigation Act 1914.*
Manage aquifer recharge (MAR) management zone	MAR management zones may be defined to facilitate the management of groundwater quality and abstraction in the vicinity of MAR schemes, where it is considered necessary. The radius of influence around abstraction and recharge bores will be determined as part of the hydrogeological assessment.
Potable	Fresh and marginal water generally considered suitable for human consumption.
Proponent	The person who is responsible for the proposal.
Public water supply	A scheme which sources water from groundwater, surface water and/or desalination. A water service provider suppling potable water (usually to a town) via a distribution network to customers.
Salinity	The measure of total soluble salt or mineral constituents in water. Water resources are classified based on salinity in terms of total dissolved solids (TDS) or total soluble salts. Measurements are usually in milligrams per litre (mg/L) or parts per thousand (ppt).

Scheme	Water diverted for a source (or sources) by a water services authority or private company and supplied via a distribution network to customers for urban, industrial or irrigation use.
Water entitlement	The quantity of water that a person is entitled to take on an annual basis in accordance with the *Rights in Water and Irrigation Act 1914* and a licence.
Water use efficiency	Increasing water supply efficiency (e.g. reduction of leaks) and water demand efficiency (e.g. doing more with less water) to minimise the taking and use of water.

Shortened forms

BOD	Biochemical oxygen demand (over 5 days)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DER	Department of Environment Regulation
DoH	Department of Health
DoP	Department of Planning
DoW	Department of Water
EPA	Environmental Protection Authority
ERA	Economic Regulation Authority
IWSS	Integrated Water Supply Scheme
KIC	Kwinana Industries Council
KWRP	Kwinana Water Recycling Plant
LGA	Local government authority
MAR	Managed aquifer recharge
NWI	National Water Initiative
NPV	Net present value
RWQMP	Recycled Water Quality Management Plan
REU	Resource Economics Unit
SDOOL	Sepia Depression Ocean Outfall Line
PLOOM	Perth Long Term Ocean Outlet Monitoring Program
TN	Total nitrogen
TSS	Total suspended solids
WAPC	Western Australian Planning Commission
WWTP	Wastewater Treatment Plant

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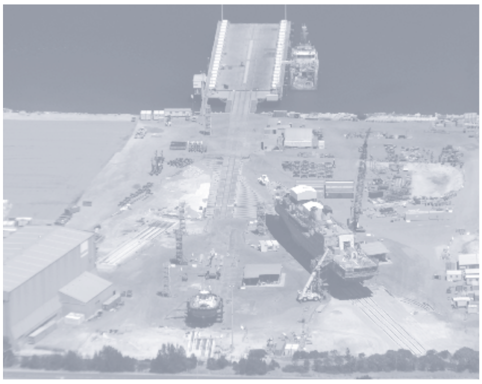

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