Government of Western Australia
Department of Water and Environmental Regulation

Guideline

Water and environmental considerations for managed aquifer recharge operations in Western Australia

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Contents

1. Introduction 1
1.1 What is MAR? 1
1.2 Why is this guideline important? 2
2. What are the approvals needed for a MAR operation? 3
2.1 Approvals for site preparation and construction 4
2.2 Approvals for obtaining source water 6
2.3 Approvals needed before MAR begins 7
2.4 What else is there to consider? 10
3. What supporting information is needed for MAR applications? 14
3.1 Hydrogeological assessment 14
3.2 Risk assessment 19
3.3 Operating strategy 19
4. Ongoing monitoring and reporting for MAR operations 21
4.1 Metering 22
4.2 Water quality analysis 22
Document custodian and review 24
Appendices 25
Appendix A — Examples of MAR scenarios in WA 25
Appendix B — Key documents and approvals for MAR in Western Australia 29
B.1 Key state and national documents for MAR 29
B.2 Summary of MAR approvals that may be required in WA 33
Appendix C — Legislation and requirements for each agency 37
Appendix D — Water quality testing for MAR operations 45
Appendix E — Testing for reactions with aquifer materials 47
Appendix F — Guidance for predicting iron and arsenic mobilisation 48
Appendix G — Schematic MAR management zone 50
Glossary 51
References and further reading 54

1. Introduction

This guideline assists with the implementation of the Department of Water and Environmental Regulation's (the department's) policy, *Managed aquifer recharge in Western Australia* (2020).

The managed aquifer recharge (MAR) policy outlines water and environmental considerations in the planning and development of MAR operations and the information required to support licence and permit applications. It also provides examples of some MAR scenarios in Western Australia (Appendix A).

MAR can be part of the solution to the challenge of meeting increasing demand for water by users and the environment. Our natural groundwater and surface water resources are becoming more limited as our population grows. At the same time, rainfall to our aquifers, watercourses and dams continues to decrease in some parts of the state as result of climate change, particularly in the south-west. MAR can help to optimise the use of our valuable water resources and supplement or even replace traditional water sources.

MAR can have many social, economic and environmental benefits where hydrogeological and environmental conditions are suitable, provided it is well managed to ensure that potential impacts on the environment, water users and public health are acceptable.

1.1 What is MAR?

As defined in the department's MAR policy, MAR is the intentional recharge of an aquifer under controlled conditions for subsequent recovery, demonstrable environmental benefit[1], or mitigation of the impacts of abstraction[2]. MAR recharge must be an additional contribution to an aquifer, not a return of abstracted water.

Hydrogeological and environmental conditions need to be suitable to successfully undertake MAR. Cost effectiveness may also be a consideration for proponents.

Aquifers can be recharged by injection or infiltration. Water may be injected using one or more bores/wells, or infiltrated through works such as infiltration ponds or galleries. Abstraction or recovery of the recharge water is normally undertaken using one or more bores/wells. In some cases, recharge and recovery can be undertaken using the same bore/well. The MAR method adopted is largely governed by the hydrogeological setting and land availability.

[1] Managed aquifer recharge that directly benefits groundwater-dependent ecosystems.

[2] Managed aquifer recharge that directly counteracts the impacts of abstraction, such as creating a barrier that prevents movement of the saltwater interface.

Any source of water can be used for MAR, provided the relevant approvals are obtained. Pre-treatment of source water may be required to ensure the quality is acceptable before recharging the aquifer.

The *Australian Guidelines for Water Recycling: Managing health and environmental risks (Phase 2), Managed Aquifer Recharge* (NRMMC, EPHC, NHMRC, 2009), outline the different types of MAR and provide more guidance on determining the feasibility of a MAR project.

Key state and national documents for MAR are outlined in Appendix B.

1.2 Why is this guideline important?

This guideline provides direction on how the department interprets and applies the legislation it administers.

Department guidelines are not mandatory considerations; rather, their purpose is to assist applicants to provide information in the best possible manner to ensure efficient and effective assessment of their application.

Applications that do not align with the appropriate guidelines may result in protracted assessment timeframes and, if the information provided is not sufficient for the department to complete an assessment, the application may be declined or refused.

2. What are the approvals needed for a MAR operation?

The department issues licences and permits for water and environmental regulation in Western Australia. Applicants are encouraged to contact the department early in the planning phases of a MAR project for guidance on specific requirements for their proposal.

In some cases, regulation is required under both water and environment legislation. We aim to minimise duplication where possible and streamline assessment and licensing processes through a one-stop-shop approach to regulation (dwer.wa.gov.au/one-stop-shop). Our Application Coordination Framework allows us to coordinate multiple application assessments relating to Part IV and V of the *Environmental Protection Act 1986* (EP Act) and the *Rights in Water and Irrigation Act 1914* (RIWI Act) to ensure consistency of approach and decision making as far as the legislative requirements allow. The framework also allows us to coordinate on the timing of decisions where possible.

Applications submitted to the department must be supported by additional information to demonstrate that the operation's impacts on the environment, water users and public health will be acceptable and manageable. The potential impacts of MAR operations should be investigated by the proponent in line with the department's MAR policy, this guideline and related documents and legislation.

MAR proposals that are likely to have a significant effect on the environment should be referred to the Environmental Protection Authority (EPA) under Section 38 of the EP Act. The EPA will determine whether the proposal is likely to have a significant impact on the environment and therefore warrant formal assessment. If an assessment under Part IV of the EP Act occurs, Ministerial conditions may be applied to the proposed operation if it is approved, and the proponent must comply with these.

For proposals that are referred to the EPA, parallel assessments under Part V of the EP Act and/or under the RIWI Act may be undertaken, consistent with the one-stop-shop approach to regulation. The department will not finalise its decision on water and environmental licence and permit applications until the EPA has completed its environmental impact assessment process of the proposal. Decisions on applications under Part V of the EP Act must be consistent with any decision made under Part IV of the EP Act.

The department may receive proposals for MAR operations by way of district and local water management strategies, in support of land planning decisions, as MAR may be one of the options for fit-for-purpose water supply in areas where water sources are limited. The department's role in the land planning process is to provide expertise and advice about water resource and environmental protection and

management to planning authorities, including the Department of Planning, Lands and Heritage (refer to Appendix C).

Several other State Government agencies also have a role in the approval and ongoing management of MAR operations (refer to Appendix C). Proponents are responsible for contacting the relevant government agencies and ensuring that all regulatory requirements are met. A summary of the approvals and supporting information that may be required for all government agencies is included in Appendix B.

The approvals required for the different stages of development of a MAR operation are outlined below.

2.1 Approvals for site preparation and construction

Approvals required by the department for the site preparation and construction phase of a MAR operation are outlined below.

Approval may also be required from local government and planning agencies for the clearing, development and/or use of land (e.g. development approval for development and/or use of land, and a building permit for the construction of infrastructure such as infiltration works or wastewater treatment plants. See Appendix B).

Site preparation

MAR proposals that require clearing of native vegetation and are not approved under Part IV of the EP Act, or otherwise exempt, need a clearing permit under Part V, Division 2 of the EP Act. In such cases, proponents must submit a valid application to the department and be granted a permit before undertaking any clearing (see Appendix C).

Construction of recharge and recovery infrastructure

Construction of injection/infiltration works that intersect groundwater, and recovery bores/wells require a licence to construct or alter a well under Section 26D of the RIWI Act if constructed within:

- non-artesian aquifers and surface water resources[3] in areas proclaimed under the Act (including proclaimed rivers)
- artesian aquifers anywhere within the state
- irrigation districts proclaimed under the Act.

[3] Includes artificially modified watercourses and wetlands (e.g. those modified into constructed drains or irrigation channels).

The licence will include conditions and timeframes for drilling, investigation and provision of information to the department.

Construction activities near watercourses and wetlands

A permit is required for any activity or work that disturbs, destroys or interferes with the bed or bank of a:

- watercourse in a proclaimed surface water area (including a proclaimed river) or irrigation district, or
- wetland situated wholly or partly on crown land, or land demised by the Crown (i.e. leased or transferred for years or life).

In addition, any person who causes, conveys or discharges any sludge, mud, earth, gravel or other matter likely to obstruct the flow of current into watercourses is guilty of an offence.

Any MAR works constructed in the vicinity of wetlands and their buffers and waterways and their foreshore areas should be consistent with the following documents:

- *Environmental factor guideline: Inland waters* (Environmental Protection Authority 2018)
- Chapter B4 and B5 of *Environmental guidance for planning and development – Guidance statement 33* (Environmental Protection Authority, 2008)
- *State planning policy 2.9 water resources* (Western Australian Planning Commission, 2006)
- *Better urban water management* (Western Australian Planning Commission, 2008)
- *Operational policy: Identifying and establishing waterways foreshore areas* (Department of Water, 2012)
- Draft *Guideline for the determination of wetland buffer requirements* (Western Australian Planning Commission, 2005).

MAR applicants will need to demonstrate that they will not adversely impact high-value water resources. For example, high-value water resources are listed in the *Environmental factor guideline: Inland waters* (Environmental Protection Authority 2018) and *Environmental guidance for planning and development – guidance statement no. 33* (Environmental Protection Authority 2008). In guidance statement 33, this includes natural areas of high conservation significance (chapter B1.2.1); native vegetation and flora of high conservation significance (chapter B2.2.2); areas of high conservation significance for native fauna (chapter B3.2.2); wetlands of high conservation significance (chapter B4.2.2); waterways of high conservation significance (chapter B5.2.2); Swan and Canning Rivers Development Control Area (attachment B5.5); public drinking water source area wellhead protection zones and

reservoir protection zones (chapter B6.1); landscapes and landforms of high conservation significance (chapter B8.2.1); and karst areas of high conservation significance (chapter B9.2.2).

Site-specific assessment may identify additional high-value water resources, for example where limited mapping has been undertaken. Any potential impacts should be considered and managed on a case-by-case basis.

Construction activities relating to prescribed premises

Under Section 52 of the EP Act, the occupier of a premises who carries out any work on or in relation to the premises, which causes the premises to become, or to become capable of being, a prescribed premises, commits an offence unless the occupier does so in accordance with a works approval. Changes to existing prescribed premises will also require approval via a works approval or licence amendment under Section 53.

MAR schemes may meet the definition of a prescribed premises category (which includes wastewater treatment plants and associated infiltration/injection activities) as defined in Schedule 1 of the Environmental Protection Regulations 1987. The application form sets out the information required for a works approval or licence application under Part V Division 3.

2.2 Approvals for obtaining source water

Any source of water can be used for MAR, provided the relevant approvals are obtained. Natural groundwater or surface water resources may be used, as well as alternative sources such as wastewater, stormwater, drainage water and desalinated water. Pre-treatment of source water is usually required before infiltrating or injecting into the aquifer, to ensure the water quality and environmental values of the aquifer are protected.

A licence to take water will be required from the department under Section 5C of the RIWI Act if source water is to be taken from:

- non-artesian aquifers and surface water resources[4] in areas proclaimed under the RIWI Act (including proclaimed rivers)
- artesian aquifers anywhere within the state
- irrigation districts proclaimed under the RIWI Act.

To obtain approval to take and use the source water, proponents must demonstrate that ecological water requirements will be met, and that potential impacts on other water users will be acceptable.

[4] Includes artificially modified watercourses and wetlands (e.g. those modified into constructed drains or irrigation channels).

If stormwater is to be taken from a drain for use as the source water for MAR, approvals must be obtained from the relevant water service provider that manages the drain, and other relevant agencies. In such cases, proponents need to assess the impacts on the hydraulic viability of the drain, as well as relevant environmental values, and any ecosystems dependent on water from the drain, and demonstrate that impacts will be acceptable. Approvals must be submitted to the department with licence applications. Approval may also be required from the department if the drain is a water resource under the RIWI Act, as mentioned above.

If wastewater is to be sourced from a wastewater treatment plant or via sewer mining, approvals and/or contractual agreements must be obtained from the relevant water service provider and submitted to the department with licence applications.

2.3 Approvals needed before MAR begins

Proponents must obtain all relevant approvals required from each agency before commencing recharge or recovery operations (refer to Appendix B.2 for a summary of MAR approvals for each agency).

Approvals for recharge with recovery

For MAR operations involving recharge with subsequent recovery, relevant approvals should have been obtained for the construction of any necessary infrastructure as outlined in section 2.1.

To undertake recharge with subsequent recovery, proponents will need to apply for a licence to take water under Section 5C of the RIWI Act within:

- non-artesian aquifers and surface water resources[5] in areas proclaimed under the RIWI Act (including proclaimed rivers)
- artesian aquifers anywhere within the state
- irrigation districts proclaimed under the RIWI Act.

Proponents must hold this licence before they start recharge operations. For the licence to be granted by the department, the location of the recovery bores/wells or works (draw points) must be known, and the licensee must have legal access to the land on which they are located. If access to land has not been obtained at the time of the 5C licence application, the department may give an undertaking to grant a licence at a later time, in accordance with *Operational policy 5.05 – Giving an undertaking to grant a water licence or permit.* This undertaking is valid for a short period of time and is not transferable. It may apply to a new licence to take water or licence to construct or alter a bore, a permit to interfere with a watercourse, or the transaction

[5] Includes artificially modified watercourses and wetlands (e.g. those modified into constructed drains or irrigation channels).

of an existing entitlement (trade, transfer, agreement/lease). Approvals may be granted when the applicant acquires legal access to the land under the terms of Schedule 1, clause 3 of the RIWI Act within the stated time-frame.

The following information will be required to support the licence application, in addition to any other information requested by the department:

- a hydrogeological assessment
- a risk assessment
- an operating strategy.

The recharge phase should be addressed in these documents as well as the recovery phase. It is recommended that proponents manage their recharge operations as well as recovery operations in accordance with the operating strategy.

Section 3 outlines the information that should be included within these documents to support licence applications. Considerations for recharge and recovery are outlined in section 3.1.

As required under the department's MAR policy, it must be demonstrated that water will be available for abstraction when required, and that the impacts of recharge and recovery on the environment, water users and public health will be acceptable.

Any licence to take water issued for the MAR operation may be subject to conditions, including a requirement to monitor the impacts of the operation, and provide regular water quality data and metered data of the amount of water infiltrated or injected (refer to section 4 and Appendix D).

MAR operations that are prescribed premises under the Environmental Protection Regulations 1987 require a licence under Part V, Division 3 of the EP Act to operate a MAR scheme, or to discharge to the environment (wastewater, treatment concentrate, chemicals) (refer to Appendix C – *Environmental Protection Act*).

For MAR operations only involving recharge, see the section below on 'recharge without recovery'.

Approvals for recharge without recovery

Some MAR operations may be undertaken for environmental benefit or to mitigate the effects of abstraction, and only involve recharge, not recovery. Examples include artificial maintenance of a wetland through groundwater recharge and mitigating the inland movement of a saltwater interface.

These operations may require a licence to construct or alter a well under Section 26D of the RIWI Act, if the bores/wells or infiltration works to be used for recharge intercept groundwater (refer to section 2.1). As water will not be recovered, a licence to take water will not be required under the RIWI Act.

As there is no specific licensing instrument under the RIWI Act to regulate infiltration or injection, it is recommended that proponents prepare and follow an operating

strategy to manage recharge operations. To allow assessment of the potential impacts of recharging the aquifer, the department will request that proponent's undertake a hydrogeological assessment and risk assessment. The reports should be provided to the department upon completion of the hydrogeological investigations. Refer to section 3 for details on assessments and operating strategies.

The recharge may be regulated under Part V, Division 3 of the EP Act if it is considered as an emission or discharge from a prescribed premises. In this situation, activities will be subject to a risk-based assessment and regulatory controls (works approval or licence conditions) may be imposed to monitor or validate emissions or discharges in order to establish a steady-state operation and/or to continually verify that MAR operations are presenting an acceptable risk to the environment, public health, and public amenity.

Approval may also be required from local government and planning agencies for the clearing, development and/or use of land, as mentioned in section 2.1.

Approvals for recovery where recharge is undertaken by another party

In some circumstances, there might be cases where different parties undertake the recharge and recovery (refer to the department's MAR policy (section 5.4, Water). For example, treated wastewater may be infiltrated into an aquifer by a wastewater plant operator, and the water may be recovered by a local government authority for irrigating public open space. Another scenario could be that a water service provider recharges an aquifer to increase the groundwater supplies of a group of groundwater users (refer to Appendix A for example scenarios of MAR using treated wastewater).

A third party may apply for a licence to recover water recharged by another party, provided they have legal access to the land from which the water is being recovered, and a contractual agreement is in place with the recharge proponent (e.g. a commercial or recycled water supply agreement). The licence applicant will be required to provide a copy of the agreement with their application to take water. As outlined in the department's MAR policy, the contractual agreement must ensure that:

- recharge will occur before recovery is undertaken and continue for the duration of the recovery period
- the recovery volume will not exceed the recharge volume
- accurate metering data will be provided to the licence applicant to enable them to comply with their licence.

Relevant approvals should be obtained for the construction of any recovery bores/wells as outlined in section 2.1.

Proponents will need to apply for a licence to take water under Section 5C of the RIWI Act from:

- all artesian wells and bores

- non-artesian wells and bores in proclaimed areas.

For the licence to be granted by the department, the location of the recovery bores/wells or works (draw points) must be known, and the licensee must have legal access to the land on which they are located. If access to land has not been obtained at the time of the 5C licence application, the department may give an undertaking to grant a licence at a later time, in accordance with *Operational policy 5.05 – Giving an undertaking to grant a water licence or permit.*

The following information will be required to support the licence application, in addition to any other information requested by the department:

- a hydrogeological assessment
- a risk assessment
- an operating strategy
- a copy of agreements to access and take water.

Section 3 outlines the information that should be included in the hydrogeological assessment, risk assessment and operating strategy. Considerations for recovery are outlined in section 3.1.

As required under the department's MAR policy, it must be demonstrated that water will be available for abstraction when required, and that the impacts of abstraction upon the environment, water users and public health will be acceptable.

Any licence to take water issued for the MAR operation may be subject to conditions, including a requirement to monitor the impacts of the operation, and provide regular water quality data and metered data of the amount of water infiltrated or injected (refer to section 4 and Appendix D).

2.4 What else is there to consider?

The elements of MAR operations outlined in this section should be considered in the planning and design of MAR operations.

Proponents should also follow the *Australian Guidelines for Water Recycling: Managed Aquifer Recharge* (NRMMC, EPHC, NHMRC 2009).

Siting of MAR recharge and recovery works

The siting of recharge and recovery bores/wells and infiltration works is an important part of the design of a MAR operation, and the following factors should be taken into account:

- *Conservation of native vegetation.* Siting of MAR recharge and recovery works should avoid native vegetation clearing wherever possible. If avoidance is not possible, then siting should minimise clearing and mitigate the impacts of clearing, such as by avoiding areas of higher environmental value.

- *Potential impacts of recharge on water quality.* When siting MAR bores/wells or infiltration works, the proximity to existing production bores/wells, public drinking water source areas and environmental receptors (e.g. groundwater-dependent ecosystems or connected surface water systems) needs to be considered because of the potential for recharge water to adversely affect water quality and impact the environment and public health. There may be cases where it is beneficial to site injection bores/wells or infiltration works close to environmental receptors such as groundwater-dependent ecosystems, to positively impact water levels. But in these cases, the quality of recharge water must also be acceptable (refer to section 4 for water quality guidance). This is particularly important if the recharge water is of a different quality to the receiving groundwater, but the potential for chemical changes within the aquifer also need to be considered (refer to Appendix E and F). The location of contaminated sites also needs to be identified to ensure that MAR operations do not worsen any existing water quality issues (refer to the department's website www.dwer.wa.gov.au).
- *Potential impacts of recovery on water levels and supplies.* The distance between proposed recovery bores/wells and existing production bores/wells needs to be considered to ensure that the impacts on water levels and water supplies in existing bores/wells are minimised. Adequate distance is also required so that MAR recharge water is not accessed by the existing bores/wells. Siting MAR recovery bores/wells too close to environmental receptors such as wetlands may lower water levels and result in adverse impacts on the ecology.
- *Distance between recharge and recovery.* The distance between recharge and recovery sites must take into account factors such as the travel time and residence time within the aquifer (refer to section 3.1, determining the time between recharge and recovery). For aquifer storage and recovery operations, where recharge and recovery is undertaken using a single bore/well, travel time is not a factor but residence time may be.
- *Optimising recovery.* Recharge and recovery works should be sited to allow optimal recovery of water. For example, installing injection bores/wells near the coast and recovery bores/wells up-gradient near groundwater-dependent ecosystems, may limit the volume or recharge water that can be recovered, as it will flow offshore.

Construction of bores/wells for recharge and recovery

Bores/wells should be constructed to the accepted standards set out in the *Minimum construction requirements for water bores in Australia* (2012). This will minimise the potential for adverse impacts from recharge and recovery, and reduce the potential of contamination from surface activities, or cross-contamination between aquifers. Additional considerations should be taken into account for MAR bores/wells, particularly for injection, including:

- the effects of construction and annulus backfill materials on well efficiencies and upward flow in the well annulus (e.g. consider using natural formation material in the annulus instead of gravel pack, and if gravel pack is to be used it should be washed)
- appropriate headworks design to eliminate air entrainment and cascading in the well
- appropriate use of materials for the MAR operations' expected timeframe (i.e. they should ensure longevity of bores/wells)
- best practice cementing procedures, including use of stabilisers, pressure cementing, cement bond logs and pressure testing
- appropriate construction and use of materials to withstand anticipated injection pressures (e.g. use of thrust blocks to increase stability, if using PVC, glued and screwed, butt-jointed PVC gives higher tensile strength and minimises leakage)
- appropriate construction to allow remediation if required (e.g. upon clogging) and monitoring
- adequate development of well upon completion
- if sumps are used, they should be cleaned out before re-use between injection cycles to minimise effects on water quality
- removal and appropriate disposal of any oils or muds from within wells and well sites – this also applies to abstraction wells.

Test pumping should be carried out when bores/wells are completed to determine appropriate abstraction rates, ensure that injection is feasible, and calculate optimum injection rates. The department provides some guidance on test pumping in its *Operational policy 5.12* (Department of Water, 2009).

The performance of bores/wells should be monitored regularly to minimise potential problems such as well screen and aquifer clogging. Strategies such as filtration and back-flushing may need to be used regularly to prevent clogging, depending on the quality of the recharge water and groundwater.

The department will place conditions on licences granted to construct bores/wells to ensure that they are properly constructed by an appropriately certified driller.

Protection of stored recharge water

Protection of the quality of stored recharge water should be considered by proponents during the planning of MAR operations to ensure the recharge water is available to the intended end user at the required quality. Factors such as polluting activities or land uses over unconfined aquifers, existing contaminant plumes in groundwater, or aquifer contamination from nearby bores/wells and reactions with the aquifer matrix should be considered to minimise the potential for contamination. It is

the proponent's responsibility to ensure the water is fit-for-purpose and to factor in any possible impacts that a change in water quality may have, as well as consider contingency planning in the event that the water is not fit-for-purpose. To manage risks to water quality, the department provides advice on best management practice for a range of land use activities (www.dwer.wa.gov.au).

The department will apply its groundwater protection strategies when assessing MAR proposals within public drinking water source areas (PDWSAs), including *Water quality protection note no. 25: Land use compatibility for public drinking water source areas* (Department of Water, 2016). Although the department protects groundwater quality within PDWSAs, we cannot guarantee that the water quality will meet the proponent's requirements.

The Department of Health has a role in ensuring that the intended use of recovered water does not jeopardise public health. Within PDWSAs, they will regulate the quality of recharge water and ensure that it meets drinking water standards.

3. What supporting information is needed for MAR applications?

Key supporting information that will generally be common to all MAR applications includes:

- a hydrogeological assessment
- a risk assessment
- an operating strategy.

The requirements for each are outlined below and summarised in the table provided in Appendix B. The information is required in support of applications under the RIWI Act and will also be referred to, if required, for assessment under the EP Act.

Supporting information for applications under the EP Act is outlined on application forms (refer to Appendix B).

The investigations, monitoring and reporting required to support licence applications and compliance with licence and Ministerial conditions must be undertaken at the applicant/proponent's expense.

3.1 Hydrogeological assessment

Hydrogeological assessments should assess the viability and potential impacts of sourcing, recharging and recovering water on the environment, water users and public health.

They must be completed in accordance with this guideline and associated MAR policy. The department's hydrogeological reporting policy (*Operational policy 5.12,* Department of Water, 2009), covers general issues to consider in relation to the potential impacts of recovering or taking water, and outlines reporting requirements for hydrogeological assessments. Any additional requirements determined during consultation with the department must also be covered.

Hydrogeological assessments for MAR operations require appropriate groundwater modelling, so detailed assessments will be necessary.

Investigations such as infiltration/injection tests or test pumping will generally be required to determine feasible recharge and recovery rates and volumes. The degree of testing that is appropriate may vary depending on the scale of the proposed operation.

Water quality testing of source water and native groundwater or surface water resources will generally be required to provide baseline or background data and allow ongoing monitoring of the impacts of MAR operations (refer to section 4).

A small-scale trial may be appropriate, particularly for large MAR operations. All relevant approvals must be obtained to conduct the trial as well as the full-scale operation.

Proponents should assess impacts on the built environment for consideration in planning approvals required from other statutory decision-makers, such as local governments or development assessment panels.

Impacts on the built environment are not considered by the department when assessing applications for licences to take water under the RIWI Act. Environmental factors potentially relevant to impacts on the built environment, such as impacts to groundwater levels, may be considered by the department when assessing Part IV proposals and/or Part V applications under the EP Act, and this information may be referred to other statutory decision-makers where appropriate.

Factors to consider in hydrogeological assessments

The factors to consider in the hydrogeological assessment of MAR operations are outlined in the following sections. Where required, these should be addressed in the proponent's operating strategy for the MAR operation.

Recharge operations

Factors to consider in relation to recharge operations are outlined below.

- The capacity of the aquifer(s) to be recharged, considering the nature of the aquifer, existing groundwater levels and other relevant factors.
- Potential recharge rates and volumes based on injection capacity of infiltration works and injection bores/wells
    - appropriate infiltration rates and injection pressures must be determined to avoid water logging and potential damage to aquifers (e.g. fracturing).
- Estimates of recharge volumes should be provided, taking into account losses (e.g. through evaporation).
- Groundwater mounding or raising of the watertable to a level that causes problems such as waterlogging or flooding, with risks to other bores/wells, the environment and public health.
- Surface discharge if groundwater mounding is too close to the surface, with potential impacts on surface water bodies and vegetation, or potential health and safety implications where human contact occurs.
- Changes to the groundwater flow regime.
- Determining the area of influence of recharge (i.e. spatial extent and depth), for protection of environmental values and users, and determining boundaries of MAR management zones (refer to the department's MAR policy and the section on defining a MAR management zone, below).

- Changes to groundwater chemistry (improvements/degradation) in the aquifer being recharged or overlying/underlying aquifers because of differences in the chemistry of the recharge water and in-situ groundwater, or chemical reactions between recharge water and aquifer sediments (e.g. salinity and mixing, oxidation-reduction processes, acidification, mobilisation of arsenic, iron and heavy metals). The risks of these potential changes must be considered in the risk assessment and may be determined through monitoring, geochemical modelling, and techniques such as aquifer matrix testing (refer to Appendix E and F, and section 4).
- Significant changes in groundwater temperature, which can result in geochemical changes (e.g. changes in pH levels or the solubility of minerals) or stratification, and/or reduce the efficiency of the MAR operation.
- Changes to water chemistry in hydraulically connected surface water systems.
- Potential for clogging of infiltration works, injection bores/wells or aquifers (biological, physical, chemical or mechanical) and changes to the aquifer's recharge potential (over time, dissolution and precipitation of minerals can affect aquifer transmissivity and also stability).

Recovery operations

In MAR operations, recharge water may be abstracted or recovered after recharge (allowing for travel time and any required residence time where applicable), or after a period of storage (referred to as banking).

Factors relating to recovery of recharge water include:

- potential impacts of recovery upon ecosystems and other water users
- potential for movement of the saltwater interface as a result of abstraction (i.e. saline intrusion)
- potential for intercepting contaminated water or changing the flow direction of a contaminant plume
- connectivity across aquitards, other geological units or geological structures (e.g. faults)
- hydraulic connection between recharge and recovery points.

Determining recovery volumes

The proponent will need to consider the aquifer's hydrogeological characteristics controlling the rate and direction of movement of groundwater when determining the volume of water that can be recovered at the proposed time and location of abstraction.

It may be possible to recover all or the majority of recharge water where losses are negligible and impacts of abstraction are acceptable. Any management strategies

specific to MAR that are outlined in water allocation plans, surface water management plans or other documents will need to be taken into account.

Factors to consider in determining recovery volumes include:

- *Location of recharge and recovery bores/wells or works.* Potential impacts on groundwater users or ecosystems need to be considered when siting recharge and recovery bores/wells or works. They may need to be relocated, or recovery volumes reduced, if it is determined that they may unacceptably impact these receptors.
- *Recharge volumes.* If the volume of recharge increases or decreases, the recovery volume will change accordingly. Proponents should take the reliability of the source into account when determining potential recharge and abstraction volumes, as this may affect the continuity of supply and feasibility of the operation.
- *Losses.* Potential losses or depletion of recharge water may occur during the MAR operation, including:
  - during the recharge phase (e.g. evaporation during infiltration, discharge to surface waters/drains/ground surface)
  - during the storage/banking phase (the longer the water is banked in an aquifer, the less likely it will be recoverable, as recharge water may migrate away from recovery points or discharge to surface waters or offshore – see point below).
- *Migration of groundwater away from the recharge and recovery points.* The rate of migration or travel of groundwater will depend on factors such as the transmissivity of the aquifer and the location. For example, if recharging near the coast, water may quickly flow offshore, depending on aquifer characteristics, and the recovery volume will be limited. In a highly transmissive aquifer such as limestone, recharge water may flow away from recovery points very quickly, making storage or even recovery unfeasible.
- *Storage requirements.* The maximum volume of surface water to be stored at any one time should be calculated to determine adequate storage requirements.
- *Banking periods and volumes.* Recovery volumes will need to account for banking where this is proposed.

Determining the time between recharge and recovery

The estimated time between recharge and recovery may vary depending on a number of factors. Factors to consider in determining this time lag include:

- aquifer characteristics, hydraulic gradients and the distance between recharge and recovery bores or works (i.e. travel time)

- a requirement or allowance for residence time within the aquifer to meet water quality standards for end use, or to protect environmental values (e.g. to allow sufficient denitrification prior to reaching a wetland or watercourse). If the potential exists for human exposure (e.g. through irrigation of public open space), the Department of Health will require determination of appropriate residence time in the aquifer, and validation and verification of water quality
- a requirement to recharge water for a certain period of time before recovery; for example, to allow increases in potentiometric levels or water levels to reach the recovery bore/well
- if the recharge water is to be banked for a period of time.

Defining a MAR management zone

Proponents may be required to define MAR management zones as part of the hydrogeological assessment, to facilitate the licensing of bores/works and management of water quality and quantity.

The MAR management zone boundary should define the zone of influence around the recharge bore(s)/well(s) or infiltration work(s), considering both water quality and water quantity.

The MAR management zone may incorporate several sub-zones as outlined in the *Australian Guidelines for Water Recycling, Managed Aquifer Recharge* (NRMMC, EPHC, NHMRC 2009) (the schematic diagram from the guidelines is included in Appendix G as an example).

The area of influence of water quality changes needs to be considered when defining sub-zones, taking into account factors such as the water quality requirements for intended end uses, the protection of other water users, and the environmental values of aquifers and ecosystems. This may require a zone of attenuation to be included. Recovery bores/wells should be located within the appropriate part of the MAR management zone to ensure water quality requirements are met.

The area of hydraulic impact of the proposed recharge should also be taken into account and a hydraulic impact sub-zone may be included as part of the management zone. Recovery bores/wells should be located within the area of hydraulic impact, as there must be connection between recharge and recovery to ensure water quantity requirements are met.

Within confined aquifers, recovery should be from the area where the injection of water increases groundwater storage (i.e. within the zone of pressure head change). As this area can be large, further constraints to the management zone boundaries and recovery locations may need to be determined on a case-by-case basis.

The potential for interference effects with other users should also be minimised.

Requirements of other agencies, particularly the Department of Health, will also need to be considered in defining the boundary of the MAR management zone.

MAR management zone boundaries will be mapped in the department's spatial information system.

MAR zones may also be identified in allocation plans for significant or long-term MAR operations.

The Australian Guidelines referenced above provide further guidance on determining the zones of influence of a managed aquifer recharge operation.

3.2 Risk assessment

Proponents will be required to demonstrate that they have fully assessed the risks of proposed MAR operations when submitting applications to the department, and that residual risks to the environment, water users and public health are acceptably low. Risk assessments should be undertaken in accordance with this guideline and the department's MAR policy, and the processes outlined in the *Australian Guidelines for Water Recycling: Managing Health and Environmental risks, Phase 1* (NRMMC, EPHC, AHMC, 2006) and *Managed Aquifer Recharge, Phase 2* (NRMMC, EPHC, NHMRC 2009). The hydrogeological assessment (see section 3.1) should also inform the risk assessment.

The level of detail required for a risk assessment will depend on factors such as the scale of the operation, source of the water, method of treatment, sensitivity of the receiving environment, potential impacts of abstraction, and the proposed end-use of the abstracted water.

As part of the risk assessment process, the proponent needs to identify the relevant environmental values to be protected within the aquifers in which recharge and abstraction will take place, as well as any connected water-dependent ecosystems. Other water users, sensitive water resources such as PDWSAs, and assets (e.g. infrastructure, recreation areas and heritage sites) that may be impacted must also be identified. Proponents can contact the department for guidance.

3.3 Operating strategy

Proponents will generally be required to develop a water resource management operating strategy for MAR operations in accordance with this guideline and the department's MAR policy, in addition to requirements in the department's *Operational policy 5.08 – Use of operating strategies in the water licensing process*. The operating strategy will also be referred to if required, for assessment under the EP Act.

Operating strategies should include information relevant to the ongoing management, monitoring and reporting of MAR activities that have the potential to impact water resources, the environment, water users and public health. Proponents should consult the department to determine the specific requirements and content of their operating strategy.

What to consider for operating strategies

Operating strategies may include:

- details of source water for MAR (e.g. source, quality, quantity)
- details of injection and abstraction bores/wells, and infiltration works, including relevant metering information (e.g. meter type, size, and date of installation)
- operation and maintenance of infiltration works and recharge and recovery bores/wells in the short and long term, particularly to address risks identified in the risk assessment (e.g. the condition of infiltration works or bores/wells may deteriorate over time and result in adverse impacts such as rising groundwater levels, mixing of aquifer waters or leakage of contaminants into aquifers when casing fails)
- banking periods and volumes
- volume of water to be abstracted and injected or infiltrated per year (including banked volumes), reporting and subtracting losses
- specification of appropriate flow rates and flow pressures
- an approved monitoring and reporting program (refer to section 4)
- details of any third-party arrangements or contractual obligations
- contingency plans, including, but not limited to identification and corrective action for:
  - clogging of infiltration works or injection bores/wells
  - impacts on nearby water users or the environment
  - insufficient flows to provide enough source water for the MAR operation
  - trigger levels for action on water quality monitoring results (e.g. when potential contaminants reach unacceptable levels based on relevant water quality guideline thresholds)
  - trigger levels for action on water level monitoring results
  - trigger levels for action on Ministerial conditions
- monitoring and testing of bores/wells and works, to identify deterioration in condition and prevent risks to aquifers, ecosystems, water users and public health
- maintenance, decommissioning and replacement options when bores/wells are at risk of failure or where failure occurs, and remediation options for more extreme scenarios where bore/well failure results in aquifer contamination.

4. Ongoing monitoring and reporting for MAR operations

Monitoring and reporting requirements will be specified in the conditions on the licence to take water (under Section 5C of the RIWI Act) and may include Ministerial conditions. Approved monitoring and reporting programs will be included in related operating strategies, as mentioned in section 3.3.

Monitoring and reporting should be undertaken in accordance with this guideline and the associated MAR policy. The department's hydrogeological reporting policy (*Operational policy 5.12,* Department of Water, 2009) outlines reporting requirements. Any additional requirements determined during consultation with the department must also be covered.

The level of monitoring required will depend on the scale of a MAR operation, the end use of recovered water, and the level of risk to the receiving environment and water users.

Proponents will generally be required to monitor groundwater levels/pressures and quality to ensure that environmental values of aquifers and ecosystems are maintained and water users and public health are not adversely impacted. This includes verifying the spatial extent and depth of recharge water. Construction of monitoring bores will generally be required, unless there are appropriate existing bores/wells that can be used.

Groundwater monitoring reports will generally need to be submitted to the department on an annual basis for MAR operations.

The groundwater monitoring report will be used for compliance with the RIWI Act and may also be used for EP Act requirements.

Monitoring requirements should be determined in consultation with the department and may include:

- baseline, validation, verification and operational monitoring as per the *Australian Guidelines for Water Recycling: Managed Aquifer Recharge* (NRMMC, EPHC, NHMRC 2009)
- appropriate monitoring suites as outlined in Appendix D of this guideline
- any additional parameters to ensure that potential contaminants and geochemical changes (e.g. acidification, iron and arsenic mobilisation) from the operation are sufficiently monitored (decision trees to identify potential arsenic and iron release in MAR are included in the *Australian Guidelines for Water Recycling: Managed Aquifer Recharge* (NRMMC, EPHC, NHMRC 2009)
- any additional monitoring requirements under Part IV or Part V of the EP Act

- recharge and recovery volumes for all MAR bores/wells and works based on metering (generally monthly, but frequency will be specified in licence conditions or operating strategy)
- temperature of native groundwater and recharge water (generally monthly, but frequency will be specified in licence conditions or operating strategy)
- water levels or pressures in recharge and recovery bores/wells, infiltration works and monitoring bores (generally monthly, but frequency will be specified in licence conditions or operating strategy)
- flow rates and flow pressures in recharge and recovery bores/wells and works.

Other agencies may also have monitoring and reporting requirements.

4.1 Metering

It is the proponent's responsibility to purchase, install and maintain accurate cumulative water meters on all recharge and recovery bores/wells and works. Meters must be installed in accordance with the Rights in Water and Irrigation Regulations 2018; the department's policy, *Measuring the taking of water (2016)* and *Guidelines for water meter installation* (2009); and legislative provisions under the Rights in Water and Irrigation (Approved Meters) Order 2009.

If recharge is undertaken via infiltration, measurement must occur at or before the point of entry into the infiltration works and adjusted for estimated evaporation to determine recharge volumes.

The department will review metering data received from proponents to ensure that recovery volumes do not exceed recharge volumes.

The volume that can be recharged is also controlled under Part V licences under the EP Act where the MAR operation falls under the definition of a prescribed premise, and the metering data will be used for both water and environmental licences.

4.2 Water quality analysis

Appendix D contains a recommended minimum suite for MAR operations, which may be modified based on variables such as:

- risks determined for the operation based on environmental values identified and proposed uses of the recovered water
- factors such as the source water and hydrogeology which may require other parameters
- the purpose of analysis (e.g. baseline or operational monitoring)
- the proponent's hydrogeological assessment, risk assessment and other relevant information

Relevant guidelines should also be used to determine appropriate monitoring suites, water quality criteria for recharge, and trigger values for monitoring. These include:

- *Australian Guidelines for Water Recycling* (refer to Appendix B.1, National documents)
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2018)
- *Australian Drinking Water Guidelines* (2011, [2018 update])
- *Guidelines for the non-potable uses of recycled water in Western Australia* (Department of Health 2011)
- other relevant guidelines.

Proponents should consult with the Department of Water and Environmental Regulation, Department of Health and other relevant agencies, to ensure that requirements are covered.

Document custodian and review

This document will be continuously evaluated and reviewed no later than three years from the date of issue or sooner if required.

Document details	
Lead group (custodian)	Strategic Policy
Current version	Guideline: Water and environmental considerations for managed aquifer recharge operations in Western Australia
Previous versions	Operational Policy 1.01, Managed aquifer recharge in Western Australia (Department of Water, 2011)
Corporate file number	DWERDT388932

Appendices

Appendix A — Examples of MAR scenarios in WA

Various examples of MAR scenarios in Western Australia are outlined below to provide more specific guidance on the application of policy principles and general regulatory requirements.

Recharge and recovery scenarios

As stated in the Department of Water and Environmental Regulation's (the department's) MAR policy, recharge and recovery should ideally be undertaken within the same aquifer, but may be undertaken in different aquifers that are interconnected and part of the same groundwater system, provided connection between recharge and recovery is demonstrated. One possible scenario could be to inject water into an unconfined aquifer along the coast to prevent movement of the saltwater interface, while groundwater is recovered up-gradient within the same aquifer, or from a deeper, connected aquifer. Another scenario could be to recharge an aquifer near a valued wetland to maintain the wetland's water levels, while recovering water elsewhere within the aquifer or connected aquifers where impacts would be minimal.

Within confined aquifers, recovery should be from the area where the injection of water increases groundwater storage (i.e. within the zone of pressure head change). As this area can be large, any further constraints should be determined on a case-by-case basis. Other abstraction scenarios could also be acceptable, such as injection into the confined aquifer's recharge area, with recovery elsewhere in the aquifer.

MAR using treated wastewater

Treated wastewater is a climate-resilient water resource that can be used for drinking (see sub-section below) and non-drinking purposes.

The most common source of wastewater is municipal wastewater derived from sewerage systems in urban and rural areas and collected at wastewater treatment plants (WWTPs). This water has historically been treated and disposed of into the ocean or into shallow aquifers via infiltration works such as ponds, trenches and galleries. As pressures on groundwater resources have increased, and some management areas have become fully allocated (i.e. all available water resources have been allocated), interest in using this wastewater as an alternative water source has risen, particularly for non-drinking purposes such as irrigating public open spaces and golf courses. There is also interest in using treated wastewater to mitigate the effects of abstraction (e.g. maintaining the saltwater interface), for environmental benefits (e.g. increasing or maintaining water levels in wetlands) or for use in horticulture.

Treated wastewater may also be obtained via sewer mining, or from industrial or commercial processes.

Where such MAR operations are considered feasible, WWTP operators may apply for a licence to recover recharged wastewater where it has not been previously accounted for, and it can be demonstrated that additional water is available for abstraction as a result of the recharge. As outlined in the department's MAR policy, the WWTP operator may form an agreement with another party under the *Rights in Water and Irrigation Act 1914*, to enable the third party to abstract the recharged water for an agreed period within the term of the licence.

Alternatively, another party may apply for a licence to take the recharge water, provided they have a contractual agreement with the relevant water service provider (e.g. Recycled Water Supply Agreement) to obtain access to the treated wastewater, and the licence application meets all water and environmental requirements. The agreement must also meet the requirements outlined in the MAR policy and guideline, and be submitted to the department with the licence application. As stated in the MAR policy, historical recharge that has occurred prior to the licence application will not count towards banking volumes.

Approval may also be required from the Department of Health to ensure that water is treated to appropriate standards and potential impacts on public health are well managed (e.g. reducing the risks of human contact when irrigating public open space, sporting ovals and barbecue areas).

In all cases, approval is subject to the regulatory requirements outlined in this policy and the associated guideline, including treatment to the appropriate level prior to infiltration or injection, and an acceptable risk assessment using the *Australian Guidelines for Water Recycling* (refer to Appendix B.1, National documents).

The department's *Guideline for the approval of non-drinking water systems in Western Australia – urban developments* (2013) provides information about the general considerations and specific approval requirements for establishing a non-drinking water system.

MAR using recycled water from wastewater treatment plants for drinking purposes

Within PDWSAs, recharge of recycled wastewater is compatible if it is treated to drinking water standard prior to infiltration or injection, and may be supported with conditions.

The use of recycled wastewater for drinking purposes is a relatively new example of MAR in Perth, undertaken by the Water Corporation (a major water service provider in Western Australia), using treated wastewater from its WWTP at Beenyup. The process (referred to as groundwater replenishment) involves further treating the wastewater to drinking water quality and pumping it into suitable confined aquifers in the Gnangara groundwater system. The water is generally recovered some time later

and further treated to an appropriate level for use in Perth's drinking water supply system.

The scheme is regulated by the Department of Water and Environmental Regulation and the Department of Health. A MAR management zone has been defined and will be published in the Gnangara Water Allocation Plan.

MAR using stormwater

When land in a catchment is developed, the proportion of land covered by impervious surfaces (e.g. roads, parking areas, compacted soils, roofs, driveways and pavement) is increased. This typically results in greater runoff than would have occurred pre-development, resulting from reduced evapotranspiration and infiltration into the soil, and ultimately groundwater.

Traditionally, the runoff was drained away from the catchment to surface water bodies (ocean, rivers, lakes etc.) through open or piped drains. These may carry away up to 80 per cent of the rainfall volume in clay catchments and up to 25 per cent in sandy catchments. As a result, recharge of the shallow, unconfined aquifers reduces and the volume of water in receiving surface water bodies increases.

Current stormwater management practices aim to manage runoff from small rainfall events at or near the source to keep the water balance of the site as close as possible to its pre-development hydrology. This prevents the collection and conveyance of pollutants, maximises infiltration (where site conditions allow) and recharges the local groundwater. This design philosophy is known as water sensitive urban design. This infiltration of stormwater is not considered MAR.

The department's *Decision process for stormwater management in WA* outlines the State Government's approaches and criteria for planning and designing new and existing (retrofitting) stormwater systems throughout Western Australia. The decision process is a part of the department's *Stormwater management manual for Western Australia* (Department of Water 2004–2007).

Current stormwater practices are discussed in detail in the *Stormwater management manual* on the department's website.

Stormwater may be harvested or redirected and used as a source of recharge water as outlined in the sections below.

Harvested stormwater

In high-density developments or in areas with limited infiltration potential (e.g. areas with high groundwater levels or clay soils), stormwater runoff might be increased. There may be opportunities to collect stormwater from the roofs of buildings and other impervious surfaces (such as driveways and carparks), and use it to maintain a site's water balance.

In some circumstances, where it is demonstrated that excess stormwater is available, the 'harvested' stormwater runoff can be used directly as an alternative source of

water (e.g. roof water collected and plumbed into houses for washing machines and toilets).

Stormwater may also be collected in rural areas using streambed structures such as weirs or inflatable dams. This may be used to increase recharge of rare surface water flows, which can provide environmental flows and improve water quality.

Stormwater runoff may be contributing to the water requirements of ecosystems such as waterways or wetlands. The ecological water requirements of these ecosystems must be satisfied before stormwater is used as a source for MAR operations.

The water must also be of a demonstrably acceptable quality to ensure that the aquifer's environmental values are maintained or enhanced. Treatment may be required before recharge to achieve the desired water quality for the receiving aquifer. This decision and the proposed management of MAR operations can be informed by a risk assessment undertaken in accordance with the *Australian guidelines for water recycling: Stormwater harvesting and reuse* (NRMMC, EPHC, NHMRC, 2009) and *Managed aquifer recharge* (NRMMC, EPHC, NHMRC, 2009).

Redirected stormwater

Stormwater that is discharged to surface waters or the ocean can be redirected to infiltrate into the ground, creating additional recharge to aquifers. This form of change to a stormwater system is commonly known as 'retrofitting'.

The proponent must demonstrate that ecological water requirements of any ecosystems previously receiving the stormwater input have been accounted for. The water must also be a demonstrably acceptable quality to ensure that the aquifer's environmental values are maintained or enhanced. Treatment may be required to achieve the desired water quality. This decision and proposed management of the MAR operations can be informed by a risk assessment undertaken in accordance with the *Australian guidelines for water recycling: Managed aquifer recharge (*NRMMC, EPHC, NHMRC, 2009).

Appendix B — Key documents and approvals for MAR in Western Australia

B.1 Key state and national documents for MAR

Key state and national documents that guide the development of MAR operations are outlined below.

State

Department of Water and Environmental Regulation

Policy, Managed aquifer recharge in Western Australia (Department of Water and Environmental Regulation, 2020)

Provides a management framework for MAR operations in Western Australia under current water resource management and environmental protection legislation.

Guideline for environmental and water resource considerations in managed aquifer recharge operations (Department of Water and Environmental Regulation, 2020)

Assists with implementation of the department's MAR policy. It outlines factors to consider in the planning and development of MAR operations and the information required to support applications.

Operational policy 5.12 – Hydrogeological reporting associated with a groundwater well licence) (Department of Water, 2009)

Provides a framework for hydrogeological reports submitted to the department. It covers hydrogeological assessments and groundwater monitoring reports.

Operational policy 5.08 – Use of operating strategies in the water licensing process (Department of Water, 2010)

Outlines when operating strategies are likely to be required for licence applicants, the issues to be addressed, and provides reporting formats.

Strategic policy – Protecting public drinking water source areas in Western Australia (Department of Water, 2016)

Describes PDWSAs are managed in Western Australia, continuing government's long-standing commitment to the protection of PDWSAs. It explains the existing integrated land use planning and PDWSA protection program, the planning mechanisms used to protect PDWSAs and informs the community about the role they have in protecting PDWSAs.

Water quality protection note no. 25, Land use compatibility for public drinking water source areas (Department of Water, 2016)

Provides guidance to state and local government to protect PDWSAs by preventing, minimising or managing development in these areas, to ensure the ongoing availability of a reliable, safe drinking water supply for consumers at a lower cost. It also provides important guidance to land owners, developers and consultants when preparing development applications for submission to agencies with decision-making responsibilities for land use planning.

Guideline for the approval of non-drinking water systems in Western Australia – urban developments (Department of Water, 2013)

Supports the *Better urban water management framework* (Western Australian Planning Commission, 2008), which recognises that water efficiency, re-use and recycling are integral components of total water cycle management. It aims to give proponents of non-drinking water projects a greater understanding of the general considerations and regulatory requirements at various planning stages and have more confidence in assessing the viability of their proposal.

Environmental guidance for planning and development – Guidance statement 33 (Environmental Protection Authority, 2008)

The main purpose of this document is to provide information and advice to assist participants in land-use planning and development processes to protect, conserve and enhance the environment; and to describe the processes the Environment Protection Authority (EPA) may apply under the *Environmental Protection Act 1986* (EP Act), in particular the environmental impact assessment process.

Environmental factor guideline: Inland waters (Environment Protection Authority, 2016)

To communicate how the factor '*Inland Waters'* is considered by the EPA in the environmental impact assessment process.

Environmental Factor Guideline: Social Surroundings (Environment Protection Authority, 2016)

To communicate how the factor 'social surroundings' is considered by the EPA in the environmental impact assessment process.

Contaminated sites guideline, Use of monitored natural attenuation for groundwater clean-up (Department of Water and Environmental Regulation, in prep.)

To assist proponents and environmental practitioners when planning and implementing a monitored natural attenuation program and when preparing report(s) to be submitted to the Department of Water and Environmental Regulation and/or accredited contaminated site auditors under the *Contaminated Sites Act 2003*.

Other agencies

State planning policy 2.9, Water resources (Western Australian Planning Commission, 2006)

This policy is directly related to the overarching sector policy *SPP 2, Environment and Natural Resources* and provides clarification and additional guidance to planning decision-makers for consideration of water resources in land use planning strategy.

Better urban water management (Western Australian Planning Commission, 2008)

This document aims to facilitate better management and use of our urban water resources by ensuring an appropriate level of consideration is given to the total water cycle at each stage of the planning system.

National

National Water Quality Management Strategy (Australian Government, 2018*)*

The strategy sets out a national framework within which all stakeholders can contribute to better water quality management. It is based on policies and principles for water quality management that apply nation-wide. The policy objective of the strategy is to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development. The strategy includes a number of guidelines that underpin the department's MAR policy and guideline, as described below.

Australian Guidelines for Water Recycling

These guidelines comprise a risk management framework and specific guidance on managing the health and environmental risks associated with the use of recycled water. They include:

- *Australian Guidelines for Water Recycling: Managing health and environmental risks (Phase 1)* (NRMMC, EPHC, AHMC, 2006)
- *Australian Guidelines for Water Recycling: Managing health and environmental risks (Phase 2), Augmentation of drinking water supplies* (NRMMC, EPHC, NHMRC, 2008)
- *Australian Guidelines for Water Recycling: Managing health and environmental risks (Phase 2), Managed Aquifer Recharge* (NRMMC, EPHC, NHMRC 2009)
- *Australian Guidelines for Water Recycling: Managing health and environmental risks (Phase 2), Stormwater harvesting and reuse* (NRMMC, EPHC, NHMRC, 2009).

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC-ARMCANZ, 2018)

These guidelines include default physical and chemical guideline values which must be linked to the use of water resources and environmental values that need to be

protected in undertaking MAR operations. Local water quality information should always be considered as the first reference point where available.

Guidelines for Groundwater Quality Protection in Australia (ARMCANZ & ANZECC, 2013)

The guidelines for groundwater protection rely on a framework which requires the identification of existing and potential environmental value categories for groundwater. 'Environmental value' is the term applied to a particular category of value or use of the groundwater that is important for a healthy ecosystem or for public benefit, welfare, safety or health.

Australian Drinking Water Guidelines (NHMRC, NRMMC 2011 [2018 update])

These guidelines are the principal reference for the Australian community and the water supply industry on what defines safe, good-quality water, how it can be achieved and how it can be assured. They provide a framework for good management of drinking water supplies to ensure safety at point of use and address both the health and aesthetic quality aspects of supplying good-quality drinking water.

B.2 Summary of MAR approvals that may be required in WA

Agency	Activity	Regulatory instrument	Supporting information required	Legislation	When required
Department of Water and Environmental Regulation	Clearing of native vegetation.	Clearing permit (may also be authorised through a works approval or licence)	Information/surveys on existing vegetation, information on application form	*Environmental Protection Act 1986* (Pt V, Div.2)	Required unless exempt (under Schedule 6)
	Construction/alteration of wastewater treatment plant.	Works Approval to construct or to alter a wastewater treatment plant	Information on Pt V application form	*Environmental Protection Act 1986* (Pt V)	Prescribed Premises (or potential) (Category 54/85)
	Construction of injection bores/wells and infiltration works intercepting groundwater.	Works Approval	Information on Pt V application form	*Environmental Protection Act 1986* (Pt V)	Prescribed Premises (or potential) (Category 54/85)
		Licence to construct or alter a well	Information on application form	*Rights in Water and Irrigation Act 1914* (s.26D)	Proclaimed Groundwater Areas, artesian aquifers
	Construction of injection bores/wells and infiltration works above watertable.	Works Approval	Information on Pt V application form	*Environmental Protection Act 1986* (Pt V)	Prescribed Premises (or potential) (Category 54/85)
	Taking of source water from aquifers or surface water resources in areas proclaimed under the *Rights in Water and Irrigation Act 1914*.	Licence to take water	Hydrogeological assessment, risk assessment, operating strategy, groundwater monitoring program, information on application form	*Rights in Water and Irrigation Act 1914* (s.5C)	Proclaimed Groundwater Areas, artesian aquifers
	Licence to operate a MAR scheme/discharge to the environment (wastewater, treatment concentrate, chemicals).	Pt V licence	Information on Pt V application form, Nutrient Irrigation Management Plan if irrigating with water from a MAR operation	*Environmental Protection Act 1986* (Pt V)	Prescribed Premises (or potential) (Category 54/85)
	Any activity or work that disturbs, destroys or interferes with the bed or bank of a watercourse or drain, or a wetland situated wholly or partly on Crown land, or land demised by the Crown.	Bed and Banks Permit		*Rights in Water and Irrigation Act 1914* (s.17, 17(1) and 17(3))	Proclaimed surface water area (including proclaimed river) or irrigation district

Agency	Activity	Regulatory instrument	Supporting information required	Legislation	When required
	Provision of water recharged or recovered through MAR (e.g. to the public or a third party).	Exemptions from water services licence (water service licences are issued by the Economic Regulation Authority – see below)	Exemption applications need to provide sufficient information on the proposal to determine whether the exemption is not contrary to the public interest, as set out on web site: www.water.wa.gov.au/urban-water/water-services/water-service-licensing-and-licence-exemptions	*Water Services Act 2012* – exemption	To support applications for exemption from water services licences, which are assessed by the Department of Water and Environmental Regulation
	Disposal or discharge onto or into the ground of any polluted water, or discharge into any well of any chemical, industrial waste, treated or untreated sewage, effluent or other matter that may pollute the underground water within a public drinking water source area (PDWSA).	*Metropolitan Water Supply, Sewerage and Drainage By-Laws 1981*	Information such as site investigation report and validation/verification monitoring program	*Metropolitan Water Supply, Sewerage and Drainage Act 1909*	Proclaimed PDWSAs under the *Metropolitan Water Supply, Sewerage and Drainage Act 1909*
	Depositing offensive matter within 300 m of the high-water mark or of any well or bore; depositing water containing refuse or other noisome matter in any part of a catchment area, where it may be carried by stormwater into any reservoir or well or bore, or pumping, draining; or discharge of any water or liquid waste from any quarry, mine pit, factory or industrial process.	*Country Areas Water Supply By-Laws 1957*	Information such as site investigation report and validation/verification monitoring program	*Country Areas Water Supply Act 1947*	Proclaimed public drinking water source areas under the *Country Areas Water Supply Act 1947*
	Maintenance of infiltration works such as basins and galleries.	Controlled waste licence		Environmental Protection (Controlled Waste) Regulations 2004	A carrier must hold a licence relevant to the type of controlled waste they transport
	Statutory requirement under *Contaminated Sites Act 2003* to advise on the suitability of land for subdivision or development, where a memorial has been registered on a land title due confirmed or possible contamination.		Classification of reported sites (Form 1) and part of hydrogeological assessment Feed into Development Approval	*Contaminated Sites Act 2003*	Need to ensure injected treated wastewater does not negatively impact contaminated sites (i.e. move plumes)

Agency	Activity	Regulatory instrument	Supporting information required	Legislation	When required
Environmental Protection Authority	Environmental Impact assessment under the *Environmental Protection Act 1986*.	Pt IV environmental impact assessment, Ministerial Statement	Risk assessment, hydrogeological assessment, information/surveys on existing vegetation/ecosystems	*Environmental Protection Act 1986* (Pt IV)	When likely to have a significant effect on the environment
Department of Health	Approval to install a wastewater treatment system.	Licence to construct or install an apparatus for the treatment of sewage	Drawings, treatment train and their log removal targets	*Public Health Act 2016*	Water recycling plants that treat water to drinking water quality
	Approval to use recycled water.	MoU, Recycled Water Quality Management Plan	Validation/verification monitoring program		Where protection of public health / a drinking water source is required
Department of Planning Lands and Heritage for Western Australian Planning Commission	Development, including clearing where required.	Planning approvals (e.g. Development Approval under Metropolitan Regional Scheme if required)	Planning / Better urban water management requirements Evidence of consideration of conservation areas / wetlands / flora and fauna, etc., e.g. information/surveys on existing vegetation)	*Planning and Development Act 2005*, various local Acts	Where applicable (e.g. re-zoning of land, new development)
Economic Regulation Authority	Provision of water recharged or recovered through MAR (e.g. to the public or a third party).	Water service licence	Business case The requirements for a water services licence application are specified in the ERA's *Licence application guidelines: Electricity, gas and water licences*	*Water Services Act 2012*	There are three tests. The applicant has, and will retain: - the technical capacity to provide the water service - the financial capacity to provide the service - granting the licence would not be contrary to the public interest (which is assessed by advertising the

Agency	Activity	Regulatory instrument	Supporting information required	Legislation	When required
					application for public comment)
Local government authorities	Construction of infrastructure (e.g. infiltration works, wastewater treatment plants).	Application for development and/or use of land (e.g. Development Approval and Building Permit for construction of infrastructure such as infiltration works, wastewater treatment plants)	as per planning / better urban water management requirements	*Planning and Development Act 2005, Building Act 2011,* Building Regulations 2012, Town Planning Schemes.	All areas with local planning schemes
Water Service Provider	Approval to use/access stormwater or wastewater from water service provider's infrastructure.	Formal Agreement to use/access water (e.g. Recycled Water Supply Agreement Other approvals can be obtained on the basis of a "Letter of Intent to Supply" which confirms availability of water	Conditions of supply for Recycled Water Supply Agreement (e.g. price, duration of agreement, quality)	*Water Services Act 2012*	Where applicable
	Disposal of effluent/treatment concentrate to ocean outlets/pipelines.	Formal agreement (effluent services agreement) Trade Waste Discharge Permit Ministerial Statement conditions	Quality and volume of reject stream discharge to allow assessment of impacts (dependent on site – e.g. may impact ability of the water service provider to comply with Ministerial Statement Conditions)		Where applicable
Federal Department of Agriculture, Water and the Environment	Prohibited actions under the *Environment Protection and Biodiversity Conservation Act 1999* that are likely to or will have a significant impact on the environment.			*Environment Protection and Biodiversity Conservation Act 1999*	Where applicable

Appendix C — Legislation and requirements for each agency

Department of Water and Environmental Regulation

Water Agencies (Powers) Act 1984

Section 9 of the Act describes the general functions of the Minister for Water. Those relevant to MAR operations include protecting, managing, assessing and planning for the use of water resources. These functions enable the management and provision of advice on MAR operations that are not directly regulated by the department.

Rights in Water and Irrigation Act 1914 (WA)

This Act establishes a legislative framework for managing, protecting and allocating water resources in Western Australia. Licensing and assessment provisions under this Act enable the regulation of abstraction and construction of injection/infiltration works that intercept the watertable or artesian aquifers.

Provisions of the Act relevant to MAR include:

- Sections 26A, 26B and 26D require that the construction or alteration of all artesian wells and bores is licensed throughout the state, as well as that of non-artesian wells and bores within proclaimed Groundwater Areas. This includes investigation, injection and recovery and monitoring bores/wells. The construction of infiltration works (e.g. pits, ponds, galleries, trenches) must also be licensed if the works intersect groundwater.
- Section 5C allows for the issue of a licence authorising the taking of water from excavations, bores, wells, or surface water resources throughout the state for all artesian wells and bores, and within proclaimed Groundwater and Surface Water Areas for non-artesian wells and bores. This includes artificially modified watercourses, such as those that were excavated or straightened as part of historical management practices, including where constructed drains or irrigation channels form a section or reach of the watercourse.
- Sections 11, 17, 21A and 25 prohibit any activity or work that disturbs, destroys or interferes with the bed or bank of a watercourse (including an artificially modified watercourse), or a wetland situated wholly or partly on crown land, unless authorised by a permit or by another Act. Sections 11 and 17 apply in proclaimed surface water areas (including proclaimed rivers) and irrigation districts. Sections 21, 21A and 25 apply outside proclaimed areas. Under Section 18, any person who causes, conveys or discharges any sludge, mud, earth, gravel or other matter likely to obstruct the flow of current into watercourses is guilty of an offence.
- Clause 7(2) of Schedule 1 includes matters that must be considered when deciding whether to grant or refuse a licence. Regulation 7(2) of the Rights in Water and Irrigation Regulations 2000 includes matters that must be

considered when deciding whether to grant or refuse a permit to disturb the waters, bed or banks of a watercourse or wetland. Further information can be required by the department or Minister under Clause 4(2) or 32(2) of Schedule 1 to the *Rights in Water and Irrigation Act 1914* (for licences) or regulation 4(2) of the Rights in Water and Irrigation Regulations 2000 (for permits).

Under the *Rights in Water and Irrigation Act 1914*, the right to the use and flow and control of water that is recharged into the natural groundwater system is vested in the Crown (i.e. when the recharge water enters the groundwater system, the proponent no longer controls that water, regardless of the source of the water or the investment in improvement of water quality). Proponents of MAR operations have the same rights as other licence holders and must apply for a licence to take water in order to recover the recharge water.

The Act does not include a licensing provision for infiltrating or injecting water into an aquifer. Where an application to take water includes a proposal to inject or infiltrate water, it will be managed in accordance with the department's MAR policy (2020), this guideline and related documents. Licences may also be required under Part V of the *Environmental Protection Act 1986* (EP Act).

MAR operations that do not involve abstraction will require a licence to construct or alter a well for the construction of bores/wells or infiltration works only if they intercept groundwater. These operations may be regulated under the *Environmental Protection Act 1986* (see section below on that Act), *By-laws in public drinking water source areas* (see sections below), or by other agencies including the Department of Health (see below).

The Rights in Water and Irrigation Regulations 2000 require advertising of applications to abstract more than 100,000 kl/year from a water resource and/or those of significant public interest.

Metropolitan Water Supply, Sewerage and Drainage Act 1909

The department also manages and protects water quality within PDWSAs. These PDWSAs include underground water pollution control areas, catchment areas and water reserves, proclaimed under the *Metropolitan Water Supply, Sewerage and Drainage Act 1909* and the *Country Areas Water Supply Act 1947*. The legislation is supported by policies and plans that are implemented in partnership with health and land planning agencies and water service providers. Drinking water source protection plans identify risks, recommend best management practices and protect water quality via risk-based priority areas (i.e. Priority 1, 2 and 3 areas) and protection zones (e.g. wellhead and reservoir protection zones).

MAR recharge operations that occur within PDWSAs may be subject to by-laws under these Acts that control such potentially polluting activities. Relevant by-laws include:

- 5.4.6, which prevents the disposal or discharge onto or into the ground of any polluted water unless permission is obtained from the Chief Executive Officer (CEO) of the Department of Water and Environmental Regulation
- 5.4.7, which prevents the discharge into any well of any chemical, industrial waste, treated or untreated sewage, effluent or other matter that may pollute the underground water
- 5.4.8A, which prevents substances from being placed down a well without approval of the CEO (of the Department of Water and Environmental Regulation).

Country Areas Water Supply Act 1947

Relevant by-laws under this Act which apply to PDWSAs are:

- 10, which prevents offensive matter from being deposited or be permitted to be deposited within 300 m of the high-water mark or of any well or bore
- 26, which prevents water containing refuse or other noisome matter from being deposited or permitted to be deposited in any part of a catchment area, where it may be carried by stormwater into any reservoir or well or bore
- 29, which prevents the pumping, draining or discharge of any water or liquid waste from any quarry, mine pit, factory or industrial process without the written permission of the CEO (of the Department of Water and Environmental Regulation).

Water Services Act 2012

Under this Act, a water services licence or exemption may be required if water recharged or recovered through MAR is to be provided to other parties (e.g. the public or a third party).

Section 5 of the Act requires a water service licence to provide a water service. The Economic Regulation Authority is responsible for the licensing of water services. Details on applying for a licence can be found at www.erawa.com.au

The Minister for Water may grant an exemption from the requirement to obtain a water service licence in providing a water service under Section 7 of the Act. Exemption for a water service licence will be subject to a public interest assessment and considered on a case-by-case basis. Details on the public interest assessment can be found at www.water.wa.gov.au/urban-water/water-services/water-service-licensing-and-licence-exemptions.

Environmental Protection Act 1986

This Act is the paramount environmental legislation in the state, providing powers to prevent, control, mitigate and manage environmental pollution and harm issues, ensuring protection of the environment (including water resources) and public health.

The Department of Water and Environmental Regulation assesses applications for MAR proposals in accordance with their Regulatory Framework which is available at www.der.wa.gov.au/our-work/regulatory-framework.

For MAR proposals referred to the Environmental Protection Authority (EPA) under Section 38 of the *Environmental Protection Act 1986*, the EPA will determine whether environmental impact assessment is required. Ministerial conditions may be applied to the proposed operation if it is approved.

Regulation 5 of the Environmental Protection Regulations 1987 states that any premises specified in Schedule 1 of the regulations is a prescribed premises for the purposes of Part V of the Act.

A premises becomes prescribed under Schedule 1, Part 1 and 2 of the Regulations where the threshold of production or design capacity for an activity on that premises is met.

Prescribed premises with the potential to cause emissions and discharges to air, land or water trigger regulation. The department administers this regulation in the form of works approvals to construct facilities and licences to discharge emissions, both of which are usually subject to conditions. In some cases registration is an option, rather than a licence.

A works approval is required under Part V, Division 3 of the Act for any works or construction on a prescribed premises, or works or construction which will cause the premises to become capable of being a prescribed premises. If the department decides to approve the proposed works, it may place conditions upon the approval in accordance with Section 62A of the Act, to prevent, control, abate or mitigate pollution or environmental harm. Submission of a compliance document is required upon completion of works, to verify that works have been completed in accordance with conditions on the works approval and that upon commissioning, operation of the works meets design specifications. Section 57(2) of the Act prevents a licence application from being accepted for assessment if the works are not completed as per the conditions on the works approval.

MAR proposals that use wastewater derived from sewage treatment works as the source water will fall within the description of prescribed premises and require regulation under Part V Division 3 of the EP Act if they are defined as category 54 or 85 (sewage facility) in Schedule 1 of the Environmental Protection Regulations 1987. This includes the treatment of wastewater to make it suitable for re-use and the re-use activity itself. Note that a sewage facility is defined as premises on which sewage is treated (excluding septic tanks), or from which treated sewage is discharged onto land or into water.

Activities with a production or design capacity threshold of 100 cubic metres per day are a category 54 prescribed premises under Schedule 1 of the Regulations, and require a works approval to construct and a licence to operate under Part V Division 3 of the EP Act. Activities with a production or design capacity threshold of 20, but less than 100 cubic metres per day are a category 85 prescribed premises and

require a works approval under Part V, Division 3 of the EP Act, but can be operated under a registration instead of a licence. If an emission is caused or increased, or an occupier alters or permits to be altered the nature of the waste, noise, odour, or electromagnetic radiation emitted or discharged from the prescribed premises, the occupier commits an offence unless they are the holder of a licence or works approval and the emission is in accordance with any conditions to which the licence or works approval is subject.

Conditions may be imposed on the works approval or licence under Section 62 and 62A of the Act. These may include specifications for treatment infrastructure and equipment, recycled water quality and monitoring of the receiving groundwater.

Regulation during operation may include annual audit compliance reports, annual environmental reports, and water quality monitoring.

Under Part IV of the Act, Ministerial conditions may be imposed upon licensees to monitor water quality or water quantity.

A clearing permit is required for any activity that results in the clearing of native vegetation, unless the clearing is of an exempt kind. Exemptions for clearing that is a requirement of a written law, or authorised under certain statutory processes, are contained in Schedule 6 of the Act. Exemptions for low-impact routine land management practices outside of environmentally sensitive areas (ESAs) are contained in the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (Clearing Regulations).

Under Section 51C, any person who undertakes unauthorised clearing commits an offence.

Under the Act, ‘clearing’ is defined as ‘the killing or destruction of; the removal of; the severing or ringbarking of trunks or stems of; or the doing of any other substantial damage to, some or all of the native vegetation in an area’. This includes the draining or flooding of land, the burning of vegetation, the grazing of stock, or any other act or activity that causes the killing or destruction of; the severing of trunks or stems of; or any other substantial damage to, some or all of the native vegetation in an area.

Therefore, MAR proposals that result in the clearing of native vegetation that is not of an exempt kind, including clearing that is caused by flooding or other changes in groundwater availability, require a clearing permit.

If the department decides to grant a clearing permit, it may place conditions upon the permit in accordance with Section 51H of the Act, to prevent, control, abate or mitigate environmental harm or offset the loss of the cleared vegetation.

Contaminated Sites Act 2003

The *Contaminated Sites Act 2003* may also be relevant to the establishment of MAR operations. MAR recharge and recovery works within or near a contaminated site could impact on the MAR operations and worsen existing contamination.

Contaminated sites can be identified through the department's website www.dwer.wa.gov.au.

There is also the risk that poorly managed MAR operations could themselves become contaminated sites if potentially harmful chemical constituents are introduced into groundwater or released from aquifer sediments. Therefore, laboratory testing of the interaction between recharge water and aquifer sediments is recommended as a preventative measure (refer to section 3.2 risk assessment, Appendix E and F).

Department of Health

MAR proposals that have the potential to affect public health should be referred to the Department of Health (DoH) for approval under the *Public Health Act 2016.*

This includes proposals for use of alternative water sources to augment drinking water supplies through MAR. DoH may also be interested in proposals with other water sources (such as stormwater) when the intended end use is for an essential service (eg toilet flushing and water based cooling).

Under the *Public Health Act 2016*, all recycled water for drinking purposes is considered to be sewage until it is treated to a level considered to be drinking water quality or above. A water recycling plant that treats water to drinking water quality will require an 'application to construct or install an apparatus for the treatment of sewage' in accordance with the Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974.

The DoH may enter into a Memorandum of Understanding (MoU) to ensure protection of public health and the drinking water source, particularly for large MAR schemes such as the Water Corporation's Groundwater Replenishment Scheme in Perth. The MoU will describe requirements for water quality monitoring, review, notification, compliance and audit, with which the proponent must comply.

A Recycled Water Quality Management Plan may also be required as part of the approval process. These plans are designed to manage recycled water quality from catchment to tap by incorporating an integrated quality assurance framework. They align with the 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* (2009). The plan, together with a details of a monitoring plan, must be endorsed by DoH before the commencement of recharge for operations that may affect public health or drinking water sources.

Within PDWSAs, DoH will ensure that the water meets drinking water standards (*Australian Drinking Water Guidelines,* NHMRC & NRMMC, 2011 [2018 update]).

Department of Planning, Lands and Heritage

The Department of Planning, Lands and Heritage (DPLH) considers MAR proposals under the *Planning and Development Act 2005*.

MAR proposals should be considered early in the land planning process where appropriate. This will ensure an appropriate level of consideration is given to a MAR proposal at each stage of the planning process. Proponents should liaise with DPLH and relevant agencies and refer to the following documents for guidance:

- *Better urban water management framework* (Western Australian Planning Commission, 2008), which recognises that water efficiency, reuse and recycling are integral components of total water cycle management
- Supporting *Guideline for non-drinking water systems in WA* (Department of Water, 2013), which outlines evaluation stages for non-drinking MAR proposals
- *Guidance statement: Land use planning* (Department of Water and Environmental Regulation, 2017), sets out how planning will be considered in the assessment of applications under Part V of the EP Act
- *Australian Guidelines for Water Recycling* (2009), which include guidance on entry-level assessment that incorporates planning and related requirements.

If MAR is being considered as part of a district water management strategy, the proponent should undertake a preliminary study that covers the requirements in the above documents and outlines:

- preliminary concept design with site characteristics, possible constraints and intended use
- the area's environmental features and their values
- potential sources of recharge water
- broad characterisation of the quality of recharge water and native groundwater
- preliminary review of health and environmental risks
- proposed recharge and abstraction details (e.g. land requirements, locations, estimated quantities, MAR methodology)
- institutional arrangements including roles and responsibilities for construction, operation and maintenance of the system initially and in the long term.

After assessing the study, the department will inform the DPLH and the proponent if the proposed MAR operation is considered a viable water supply option from a water resource and environmental management perspective.

If at the district water management strategy stage the proponent requires more certainty that the department will grant a licence for MAR operations, they will need to undertake the investigations required as part of the water licensing process and submit the relevant applications for water and environment licences or permits.

DPLH requires the feasibility of MAR proposals to be proven at the local water management strategy stage. If proponents have submitted the necessary applications and the department determines that the potential impacts of the proposed MAR operation are acceptable, but the proponent is not eligible to hold a licence at this stage of the planning process (i.e. has no legal access to land), the department may give an undertaking to grant a licence or permit at a later stage in accordance with its *Operational policy 5.05* (refer to section 2.3).

For MAR proposals that relate to drinking water supply (e.g. in-house/building use in an urban/industrial development), DPLH requires feasibility to be demonstrated earlier – at the district water management strategy stage – before the land is rezoned.

Protection of PDWSAs is implemented through the Western Australian Planning Commission's state planning policies for public drinking water source areas, which are supported by the department's *Strategic policy – Protecting public drinking water source areas in Western Australia* (2016), as well as publicly consulted drinking water source protection plans developed using the *Australian Drinking Water Guidelines* management framework (NHMRC & NRMMC, 2011, [2018 update]).

Local government

A licence to construct infiltration works may be required from local government authorities or other agencies, in addition to, or in lieu of, any licences required by the department.

Australian Government

Approval is required under the *Environment Protection and Biodiversity Conservation Act 1999* for MAR proposals that are likely to, or will have, a significant impact on a matter of national environmental significance.

Appendix D – Water quality testing for MAR operations

The minimum suite of parameters that is generally recommended for MAR operations is outlined below (refer to section 4 for background information). Depending on the source of recharge water, other parameters may need to be considered. This should be informed by the risk assessment.

Field analysis

- Temperature (^oC)
- pH
- Eh (oxidation-reduction potential)
- Electrical Conductivity [compensated to 25^oC; if uncompensated – report value measured and temperature; report complete units (e.g. mS/cm, not mS)]
- Dissolved oxygen
- Bicarbonate (HCO_3)

Laboratory analysis

Physico-chemical

- pH
- Electrical Conductivity [preferably compensated to 25^oC; report value measured; compensation factor and complete units (e.g. mS/cm, not mS)]
- Total dissolved solids (calculated @ 180^oC)
- Total hardness (as $CaCO_3$)
- Total alkalinity (as $CaCO_3$)

Ions (mg/L)

- Calcium (Ca^{2+})
- Magnesium (Mg^{2+})
- Sodium (Na^{+})
- Potassium (K^{+})
- Ammonium (NH_4^{+})
- Phosphate (PO_4^{3-})
- Carbonate (CO_3^{2-})
- Bicarbonate (HCO_3^{-})
- Chloride (Cl^{-})
- Sulphate (SO_4^{2-})
- Silica (SiO_2)

- Boron (B^{3+})

Metals

Analyse both total metals (unacidified, unfiltered), and filtered and acidified in field.

- Aluminium (Al)
- Arsenic (As)
- Cadmium (Cd)
- Chromium (Cr)
- Copper (Cu)
- Iron (Fe^{2+})
- Iron (Fe^{3+})
- Lead (Pb)
- Manganese (Mn)
- Mercury (Hg)
- Nickel (Ni)
- Selenium (Se)
- Zinc (Zn)

Other metals depending on hydrogeological environment (e.g. molybdenum, vanadium, uranium).

Nutrients

- Ammonium (NH_4^+)
- Nitrate (NO_3^-)
- Nitrite (NO_2^-)
- Total Kjeldahl Nitrogen (TKN)
- Total phosphorus (TP)

Other chemical parameters

- Methane (CH_4)
- N-nitrosodimethylamine (NDMA)
- Total organic carbon (TOC)

Other analytes where appropriate (e.g. bromide, other organics, pathogens, pesticides). Refer to *Australian Guidelines for Water Recycling* (2009) and *Australian Drinking Water Guidelines* (NHMRC & NRMMC, 2011, [2018 update]) for more guidance.

Appendix E – Testing for reactions with aquifer materials

To assess aquifer vulnerability to changing Eh and pH conditions, and reduce the risk of release of metals and metalloids into groundwater, sampling of the aquifer matrix or solids and sequential chemical extraction techniques may be undertaken as part of the risk assessment. Further details are provided in the Department of Water and Environmental Regulation's guideline: *Use of monitored natural attenuation (MNA) for groundwater clean-up, Contaminated sites guidelines* (Department of Water and Environmental Regulation, in prep.).

Key parameters that should be considered for laboratory analysis include:

- Total Organic Carbon (TOC)
- Cation Exchange Capacity (CEC)
- Anion Exchange Capacity (AEC)
- Total Inorganic Carbon (TIC)
- Chromium Reducible Sulfur (SCr)
- Acid Volatile Sulfides (AVS)
- Metal and metalloid concentrations by sequential extraction techniques (mg/kg)

Appendix F – Guidance for predicting iron and arsenic mobilisation

The risks of iron and arsenic mobilisation should be assessed using the decision trees in the *Australian Guidelines for Water Recycling: Managed Aquifer Recharge Phase 2,* (NRMMC, EPHC, NHMRC 2009*)*. As stated in the guidelines, arsenic release may also indicate release of other hazards such as cobalt, chromium, copper, nickel and zinc.

A helpful pictorial guide for predicting arsenic mobilisation is also included in *Figure 1* (from Neil et.al, 2012).

If potential for iron mobilisation is identified, mitigation measures should be proposed for managing clogging. High iron levels also present a significant risk of arsenic release, although that is not always the case.

If it is determined from the decision tree that there is potential for arsenic mobilisation, geochemical modelling should be undertaken using appropriate modelling tools, to predict the conditions where arsenic release into groundwater would take place. The life cycle and pathways of arsenic mobilisation during MAR must be thoroughly addressed as shown in *Figure 2* (Neil et.al, 2012).

In addition, samples of the aquifer matrix can be tested to determine the capacity and nature of potential reaction with recharge water [refer to Appendix E for more detail, and the Department of Water and Environmental Regulation's guideline, *Use of monitored natural attenuation (MNA) for groundwater clean-up*].

Further preventative measures may be undertaken to reduce the risk as outlined in the Australian guidelines noted above.

The source water used for MAR can increase the risk of arsenic mobilisation. For example, source waters such as treated sewage contain organic matter that is highly digestible for bacteria and can trigger arsenic release from the reductive dissolution of Fe oxide minerals. Increased levels of treatment can reduce these risks.

The above information and any additional information on risk assessment should be submitted to the department to support water and environmental licence applications.

Further guidance on prediction of iron and arsenic mobilisation can be obtained from technical sources such as journal papers as more knowledge on this issue and how to manage it becomes available.

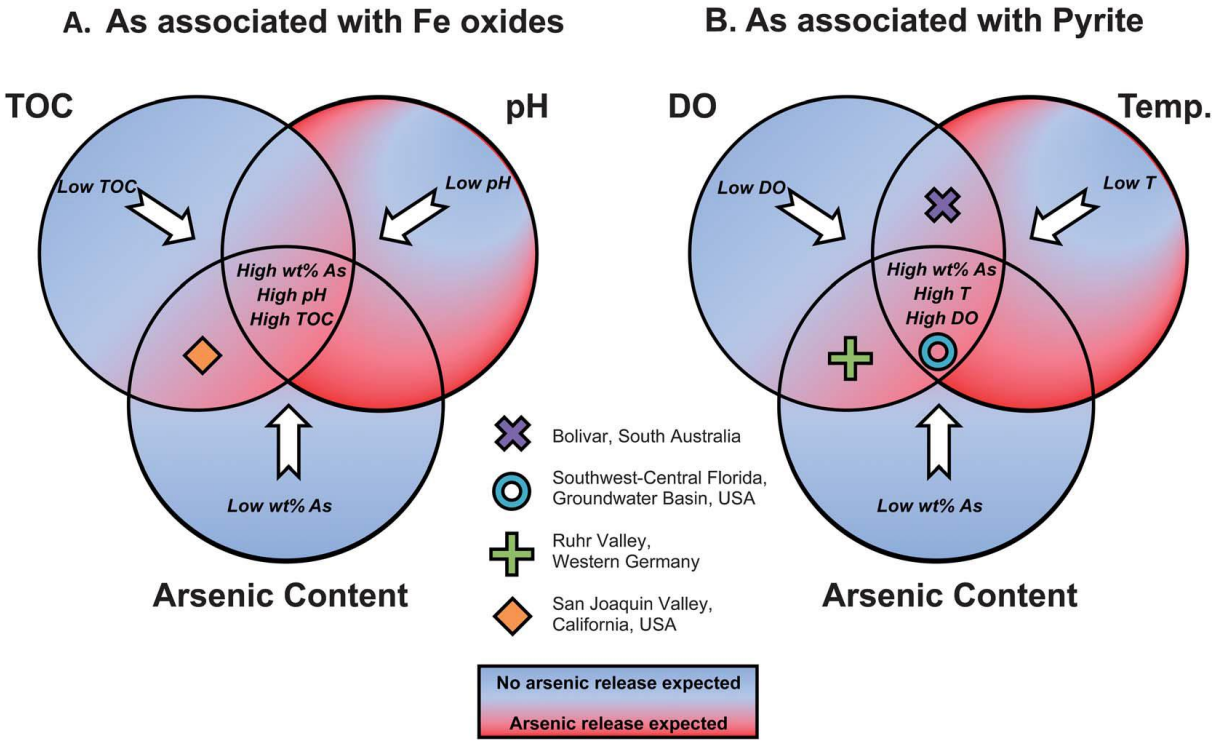

Figure 1. Pictorial guide for arsenic mobilisation prediction during MAR operation under changing redox conditions and injection water chemistry. The location of site indicators is not to scale (Neil et.al, 2012).

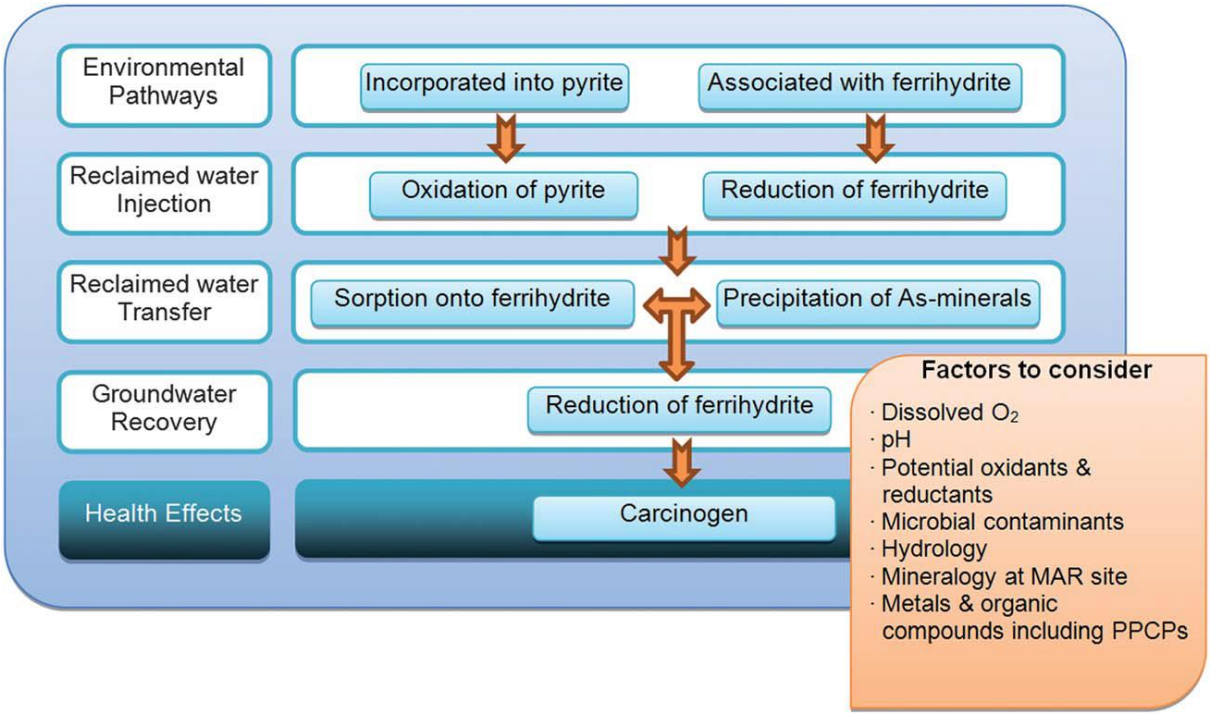

Figure 2. Life cycle analysis of arsenic remobilised during managed aquifer recharge.

Appendix G – Schematic MAR management zone

A MAR management zone may contain some or all of the zones shown in the schematic diagram below as discussed in section 3.1, Defining a MAR management zone.

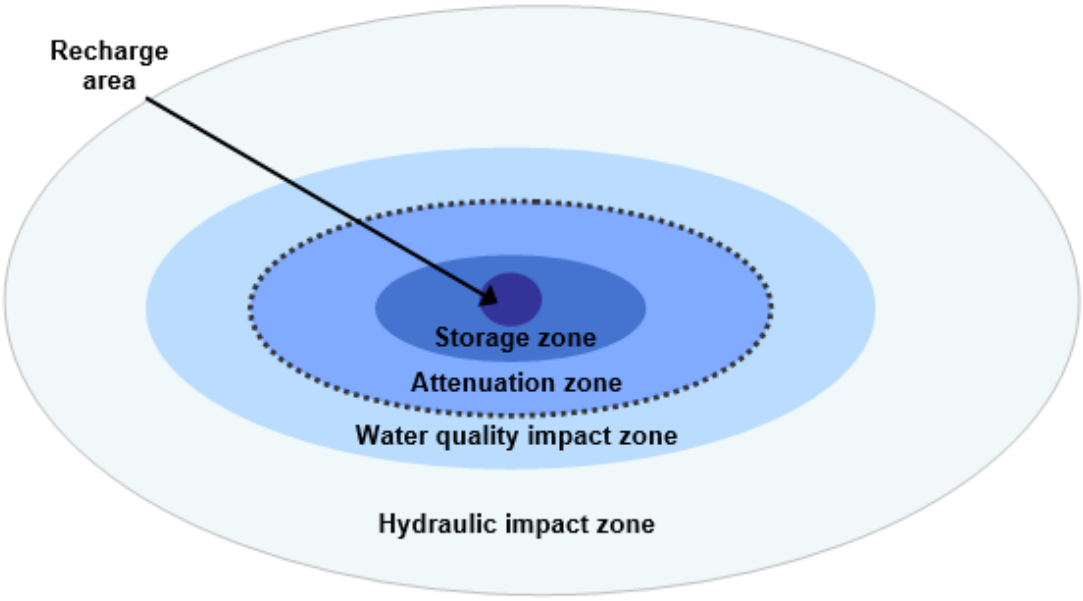

Figure 3. Schematic diagram of a MAR management zone (*Australian Guidelines for Water Recycling, Managed Aquifer Recharge,* NRMMC, EPHC, NHMRC, 2009*)*

Glossary

Abstraction	Pumping groundwater from an aquifer.
Allocation	The volume of water taken from a water source (groundwater or surface water) for use by an individual, usually in accordance with a licence granted under the *Rights in Water and Irrigation Act 1914*. Also referred to as 'water entitlement'.
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 significant quantities of water. Usually described by whether they consist of sedimentary deposits (sand, gravel, sandstone) or fractured rock. Aquifer types include unconfined, confined and artesian.
Banking	The storing of recharge water in the aquifer for a period of time, so that it can be recovered when required.
Bore	A small-diameter, normally vertical hole, usually drilled with machinery to obtain access to underground water for monitoring, injection or abstraction purposes. Referred to as a 'well' in the *Rights in Water and Irrigation Act 1914*.
Built environment	The term 'built environment' refers to the human-made environment in which people live and work, ranging in scale from buildings to cities and beyond.
Confined aquifer	An aquifer saturated with water which is under pressure because it is situated between relatively impervious layers.
Ecological values	The natural ecological processes occurring within water-dependent ecosystems and the biodiversity of these systems.
Ecological water requirements	The water regime needed to maintain the ecological values (including assets, functions and processes) of water-dependent ecosystems at a low level of risk.
Ecosystem	A term used to describe a specific environment (e.g. lake), including all of the biological, chemical and physical resources and the interrelationships and dependencies that occur between those resources.

Environment	Living things, their physical, biological and social surrounding and interactions between all of these (refer to the *Environmental Protection Act 1986*).
Environmental values	Environmental values (as defined by ARMCANZ & ANZECC, 1994) are particular values or uses of the environment that contribute to a healthy ecosystem, or public or private benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits (refer to the *Environmental Protection Act 1986*).
Groundwater	The water that occurs in pore spaces and fractures in soil and rock beneath the ground surface.
Groundwater-dependent ecosystem	An ecosystem that depends on groundwater for its existence and health.
Hydrology	The scientific study of the properties, distribution, use and circulation of the water on Earth and in the atmosphere in all of its forms.
Infiltration	Where fluids make their way under gravity to the watertable over time through purposeful activities. Only the volume of water that enters the aquifer within a suitable time period for the MAR project will be considered as infiltrate. This must be demonstrated by the proponent in their hydrogeological analyses.
Injection	Pumping of water into an aquifer under pressure via a bore/well.
Policy	A guiding principle that may not be directly supported by any legislation but has been adopted by the department as its guide to undertaking its business.
Potentiometric level	An imaginary surface representing the total head of groundwater and defined by the level (surface) to which water will rise in a well.
Recharge	All water reaching the saturated part of an aquifer (through natural or artificial means), such as rainfall recharge, managed aquifer recharge, induced recharge from other aquifers or throughflow.
Recharge water	Water that is infiltrated or injected into an aquifer to purposefully recharge the aquifer.
Recovery	Retrieval of recharge water infiltrated or injected as part of an MAR operation, via abstraction from a bore/well.

Stormwater	Water that flows over ground surfaces and in natural watercourses and drains, as a direct result of rainfall over a catchment. Stormwater consists of rainfall runoff and any material (soluble or insoluble) mobilised in its path of flow.
Unconfined or watertable aquifer	An aquifer which is nearest the surface in the geological sequence, having no overlying confining layer to limit its volume or exert pressure. The upper surface of the groundwater within the aquifer is called the watertable. The aquifer generally receives direct recharge from rainfall.
Water entitlement	The quantity of groundwater permitted to be abstracted by a licence to take water, usually specified in kilolitres/year (kL/year).
Watertable	The saturated level of the unconfined aquifer. Wetlands in low-lying areas are often seasonal or permanent surface expressions of the watertable.
Well	An opening in the ground made or used to obtain access to underground water. This includes soaks, wells, bores and excavations.

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