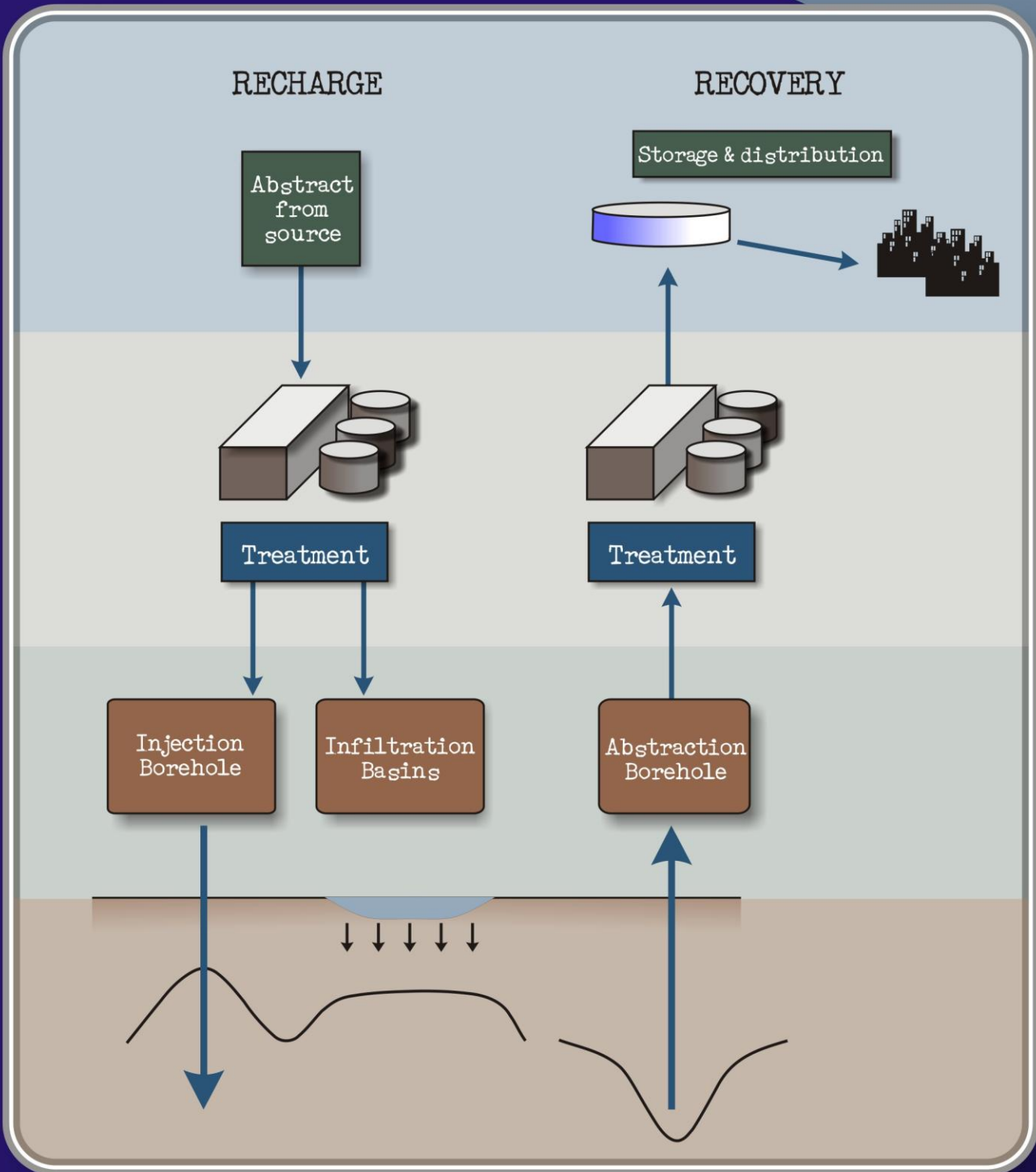


ARTIFICIAL RECHARGE STRATEGY

Version 2



November 2010



water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

Title:	Artificial Recharge Strategy Version 2
Authors:	Ricky Murray <i>Groundwater Africa</i> Phillip Ravenscroft <i>Maluti GSM</i>
Layout and design:	DTP Solutions
Project Name:	Strategy and Guideline Development for National Groundwater Planning Requirements
DWA Contract Number:	WP 9390
DWA Report Number:	P RSA 000/00/14110
Status of Report:	Final

ILISO Consulting (Pty) Ltd

Approved for ILISO Consulting (Pty) Ltd:

Director:
ILISO Consulting (Pty) Ltd
Dr Martin van Veelen

Project Manager:
Department of Water Affairs
Mr Fanus Fourie

**Department of Water Affairs
Water Resource Planning Systems**

Approved for the Department of Water Affairs:

Director:
Water Resource Planning Systems
Dr Beason Mwaka

Deputy Director:
Water Resource Planning Systems
Mr Elias Nel

Published by
Department of Water Affairs
Private Bag X313
Pretoria
0001
Republic of South Africa
Tel: (012) 336-7500

Copyright reserved

No part of the publication may be reproduced in any manner without full
acknowledgement of the source

This report should be cited as:

Department of Water Affairs, 2010. Strategy and Guideline Development for National Groundwater Planning
Requirements. Artificial Recharge Strategy Version 2, dated November 2010.

Disclaimer:

Although the information contained in this document is presented in good faith and believed to be correct, the Department
of Water Affairs makes no representations or warranties as to the completeness or accuracy of the information, which is
only based on actual information received, and makes no commitment to update or correct information.

Professional Service Provider:

203 Witch-Hazel Avenue
Highveld Technopark
0157

PO Box 68735
Highveld
0169

Tel: 0861 245 476
Fax: (012) 665 1886



Pentagon House
Cnr Clifffendale & Plettenberg Road
Faerie Glen

PO Box 40161
Faerie Glen
0043

Tel: 083 290 7253
Fax: 086 6842 611



54 Irene Avenue
Somerset West
7130

54 Irene Avenue
Somerset West
7130

Tel: (021) 852 0847
Fax: (021) 852 0847



Unit 126 Phase 4
Midrand Business Park

PO Box 218
Midrand
1685

Tel: (011) 315 6791
Fax: (011) 312 2148

CONTENTS

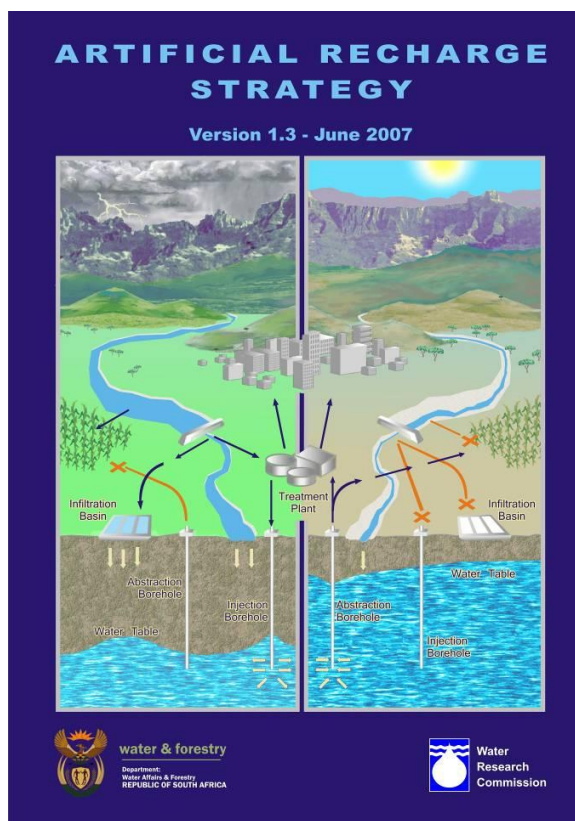
CHAPTER 1 BACKGROUND	2
CHAPTER 2 THE ARTIFICIAL RECHARGE STRATEGY	3
2.1 Introduction	3
2.2 Artificial Recharge Themes: Status and updated actions	4
2.2.1 Theme 1 Knowledge	4
2.2.2 Theme 2 Legislation and Regulation	8
2.2.3 Theme 3 Planning	11
2.2.4 Theme 4 Implementation	16
2.2.5 Theme 5 Management	19
2.2.6 Theme 6 Research	21
2.2.7 Theme 7 Strategy Implementation	23
CHAPTER 3 CONCLUSIONS AND SUMMARY OF THE WAY FORWARD	26
CHAPTER 4 REFERENCES	28

ARTIFICIAL RECHARGE STRATEGY - VERSION 2

CHAPTER 1. BACKGROUND

In 2007, the Department of Water Affairs (DWA), then the Department of Water Affairs and Forestry, published their Artificial Recharge Strategy (DWA, 2007). The document provides a substantial account of artificial recharge and includes sections on the types of artificial recharge, national and international examples, the factors that affect the viability of artificial recharge schemes, guidance on implementing and authorizing schemes, and it describes numerous support-documents. In essence, the bulk of the document is a text book on artificial recharge in a South African context. The document ends with the Artificial Recharge Strategy, which sets out the vision or overall goal, and the necessary tasks required to meet the goal.

This document describes the status of the abovementioned strategy and updates it with new tasks that have been added to provide additional substance in meeting the long-term goal. It is one of a number of new reports published by DWA during the roll-out of the Artificial Recharge Strategy under the project entitled: *Strategy and Guideline Development for National Groundwater Planning Requirements (2007 - 2010)*. During this project artificial recharge awareness resources were produced, lecture materials were handed over to universities, maps were drafted showing areas of potential artificial recharge, existing schemes were described and new projects were initiated. The final task in rolling-out the artificial recharge strategy was to provide the status on the strategy and update it where necessary – which is captured in this document.



Artificial Recharge Strategy
Version 1.3 (DWA, 2007)

CHAPTER 2. THE ARTIFICIAL RECHARGE STRATEGY

2.1 Introduction

This section presents the artificial recharge strategy as adapted from the original version (Version 1.3, DWAF, 2007). It effectively provides the recommended approach for creating an enabling environment for artificial recharge to become an integral part of the country's water resource management philosophy. Included here are the achievements emanating from the roll-out of the strategy Version 1.3 as well as new tasks that have been added to the original strategy.

The Artificial Recharge Strategy is presented in the following manner:

<i>The Vision:</i>	The long-term goal
<i>The Themes:</i>	Areas that need to be addressed in order to realise the Vision
<i>The Management Objectives:</i>	The objective of each Theme
<i>The Situation Assessments:</i>	The current status ("where we are now") in relation to the Management Objectives
<i>The Strategic Approach:</i>	Key focus areas that need to be addressed in order to reach the Management Objectives
<i>Actions:</i>	The tasks required to fulfil the Strategic Approach
<i>Responsibility:</i>	The organisation responsible for implementing the Actions
<i>Priority:</i>	The order of implementing the Actions

Table 1 presents the Vision, Themes and Management Objectives.

Table 1 Artificial Recharge Vision, Themes and Management Objectives

VISION	
<i>To use natural sub-surface storage as part of Integrated Water Resource Management wherever technologically, economically, environmentally and socially feasible.</i>	
Artificial recharge themes	Management objectives
1. Knowledge Theme	To create awareness and provide education on artificial recharge.
2. Legislation and Regulation Theme	To enable water management and water services institutions to adopt and regulate artificial recharge as part of IWRM.
3. Planning Theme	To facilitate the use of artificial recharge in achieving sustainable, efficient and cost effective water resource use and management.
4. Implementation Theme	To support water management and water services institutions in implementing artificial recharge.
5. Management Theme	To optimise the management of artificial recharge schemes.
6. Research Theme	To develop a body of knowledge that supports efficient and effective implementation and operation of artificial recharge schemes.
7. Strategy Implementation Theme	To implement and update the artificial recharge strategy.

2.2 Artificial Recharge Themes: Status and updated actions

In the tables below, the column **2007 priority** refers to the prioritization given to tasks in the 2007 artificial recharge strategy (Version 1.3). The column **2010 status** refers to items completed and outstanding after the roll-out of the Version 1.3 strategy between 2007 and 2010. Items marked with a “1” in the column 2010 status are prioritized for immediate implementation. These are summarized in **Table 2** in Chapter 3. The column **Deliverable** contains the reference to the particular actions that have been completed.

2.2.1 Theme 1 Knowledge

**Theme 1
Knowledge**

Management Objective	<i>Create awareness and provide education on artificial recharge.</i>
Situation Assessment	<p><i>The</i> concept of transferring surface water to be held in underground storage is usually more efficient than above-ground storage. Evaporation losses are negligible and the risk of contamination is a less than in surface reservoirs. However, artificial recharge is not well known and so far, has not been adopted on a wide scale.</p> <p>Since 1998 two Water Research Commission reports and one booklet have been published on case studies and the factors that affect the viability of artificial recharge schemes. This information has been presented at national water conferences, lectures in major urban centres, and it has had limited coverage in magazines, newspapers and radio. The hydrogeological sector, and to a lesser extent, the broad water sector, have been given access to the artificial recharge concept and its applicability. Once-off lectures on artificial recharge have been given at universities, but it has not been incorporated their curricula.</p>
Strategic Approach	<p>The strategic approach should aim to: 1. Make the artificial recharge strategy accessible; 2. Spread the awareness of artificial recharge to a diverse audience; and 3. Educate people on artificial recharge. A flagship project for awareness and educational purposes should be developed to assist in achieving these aims.</p> <p>More specifically:</p> <ol style="list-style-type: none"> 1) Accessible: Make the artificial recharge strategy broadly accessible by advertising it and presenting it throughout the country. 2) Awareness: Broaden awareness on artificial recharge amongst the water and planning sectors and amongst governmental departments other than DWA. 3) Educate: Educate students, government officials and practising professionals on the value, applicability, feasibility, implementation and operation of artificial recharge schemes. 4) Develop a flagship project to demonstrate the value and operation of an artificial recharge scheme and serve as an educational centre.

Management Actions, Responsibility & Priority			
Actions	Responsibility	2007 Priority	2010 Status
1. Make the artificial recharge Strategy accessible.			
1.1 Place it on DWA's website and print hard-copies. Release it to the media: 1. Professional media, including newsletters, magazines and journals from municipal, water, engineering, planning, environmental, agricultural, mining and industrial sectors. 2. Popular media, including newspapers, television and radio.	DWA HO	1	✓a ✓a
1.2 Present the strategy in 10 centres around the country: Pretoria, Cape Town, Durban, Port Elizabeth, East London, Kimberly, Bloemfontein, Upington, Polokwane and Nelspruit. The target audience should include: Municipalities, DWA Regional Offices, CMAs, DEAT Regional Offices, academic/training institutions and engineering, planning, hydrogeological and hydrological consultants. <i>2010 update: Present the strategy in Kimberly, Upington, Polokwane and Nelspruit (where it was not presented during the roll-out of the 2007 strategy).</i>	DWA HO	2	✓b 1
1.3 Present the strategy at national water, municipal and development planning conferences (eg WISA and IMIESA); and at an international artificial recharge conference (ISMAR).	DWA HO	2	✓c
2. Broaden awareness on artificial recharge.			
2.1 Produce posters for DWA, DEAT and Municipalities. These should include the types of artificial recharge, their benefits and the criteria for successful implementation.	DWA HO	2	✓a
2.2 Produce billboards at existing artificial recharge sites. These should inform people that artificial recharge is practiced in the area and of its main purposes.	DWA RO	2	2
2.3 Produce information on artificial recharge. This should include booklets, journal articles and magazine articles. The subject matter should include the types of artificial recharge, their benefits and the criteria for successful implementation. The target audiences should include Government Departments (eg DWA, DEAT), Local Government, Mines and Energy and Agriculture, Catchment Management Agencies, Water User Associations, Municipal Associations (eg Water Services Authorities and Water Services Providers), Farming Associations, Water Boards and engineering/water science professionals.	DWA HO & WRC	2	✓a

3. Promote artificial recharge education .			
3.1 Develop a training course on implementing and operating artificial recharge schemes. Include all the issues that need to be assessed in feasibility studies and the implementation stages, as well as general operation and maintenance procedures. The course should be housed at the information centre of the flagship project.	DWA HO	3	✓a, d & e
3.2 Artificial recharge should be incorporated into university curricula. The target disciplines should include development planning, engineering, hydrology and hydrogeology. Presentations and notes need to be developed and made accessible to teaching staff.	WRC	3	✓a, d & e
<p><i>2010 update:</i> <i>The course was presented and handed over to the UFS (Institute for Groundwater Studies), University of Stellenbosch (Engineering Department and the Sustainability Institute).</i></p> <p><i>Get feedback from lecturers on the course, establish how often it is presented, update the lecture to include new case studies, hand over the course to more universities and train lecturers in presenting the course.</i></p>			1
4. Promote a flagship project .			
4.1 Identify and assist a municipality in developing an artificial recharge scheme that can be used as a demonstration site.	DWA HO	3	✓f
<p><i>2010 update:</i> <i>Prince Albert (town in Southern Cape) – the feasibility study was conducted and a Project Implementation Readiness report was written (DWA, 2010).</i></p>			
4.2 Develop an information centre at the municipality and train staff as guides for the information centre and field visits. Aim to demonstrate the value of artificial recharge in one or more of the following: Capturing and storing surplus runoff, bridging the peak summer water demand period, providing security against droughts, minimising evaporation losses, improving water quality, enhancing the catchment's water Reserve, improving the ecological status of the area.	DWA HO	3	✓a, g & h
<p><i>2010 update:</i> <i>Information Centre: The website www.artificialrecharge.co.za was developed as the "Information Centre".</i></p> <p><i>Atlantis (town near Cape Town): A comprehensive description of the scheme including its history was written together with a Field Guide on how to go about visiting the site and what to see (DWA, 2010).</i></p>			
2010: New Actions			
5. Present artificial recharge at conferences such as WISA and IMIESA.			
<p><i>2010 update:</i> <i>Presentations on artificial recharge were given at various national conferences.</i></p>		DWA HO	✓a

<p><i>Present the progress achieved in rolling-out the artificial recharge strategy (especially new case studies) at national and international conferences such as WISA, IMIESA and ISMAR.</i></p>			<p>1</p>
---	--	--	----------

<p>Priority 1</p>	<p>Immediate</p>
<p>Priority 2</p>	<p>Within 2 years</p>
<p>Priority 3</p>	<p>Within 5 years</p>

References

- a. Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements Completion Report for Activity No 4: AR1 – AR Awareness. Internal DWA Report.
- b. Artificial recharge presentations were delivered Port Elizabeth (SAICE), Durban (DWA), East London (DWA), Pretoria (DWA) and Cape Town (IMESA & Groundwater Division of the Geological Society of South Africa).
- c. Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. Completion Report for Activity No 17 AR 05 Management. ROARS No: AR5.1. Internal DWA Report.
- d. Department of Water Affairs. 2009. The intentional banking and treating of water in aquifers. Presentation on artificial recharge. Available from www.artificialrecharge.co.za.
- e. Department of Water Affairs. 2009. Lecture notes on artificial recharge. Available from www.artificialrecharge.co.za.
- f. Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. Potential Artificial Recharge schemes: Planning for Implementation.
- g. Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. Completion Report for Activity 32: AR6 –AR Information Centre. Internal DWA Report.
- h. Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. The Atlantis Water Resource Management Scheme: 30 years of Artificial Groundwater Recharge. PRSA 000/00/11609/10 - Activity 17 (AR5.1), dated August 2010.

2.2.2 Theme 2 Legislation and Regulation

Theme 2 Legislation and Regulation

Management Objective	Enable water management and water services institutions to adopt and regulate artificial recharge as part of IWRM
Situation Assessment	<p>Artificial recharge with fresh water is not mentioned specifically in the National Water Act but is referred to indirectly in the regulations promulgated in terms of the Act. The regulations effectively state that the storage of any volume of water underground requires licensing. However current application forms are not suited to artificial recharge, as they are geared towards storage in dams.</p> <p>Artificial recharge with waste water is mentioned in the NWA. The discharge of wastewater into an aquifer is regulated and requires registration and licensing in all cases.</p> <p>The only other reference to artificial recharge is in a Government Gazette (No 26187a), in the context of stream flow reduction activities and altering a watercourse. It lists artificial recharge structures as one of the types of infrastructure that is covered by those regulations.</p> <p>The National Environmental Management Act (NEMA) and associated regulations describe a number of activities that would “trigger” the need for either a basic assessment or a full environmental study, comprising a scoping study and an environmental impact assessment. Many of these trigger activities may be part of an artificial recharge scheme, like building roads, a dam etc., but only listed activity 13 is groundwater specific. This stipulates that a basic assessment is required if the volume of groundwater abstracted is greater than the amount authorised under a general authorisation. In summary, artificial recharge is not listed but groundwater abstraction above the general authorisation is a listed activity for a basic assessment and most artificial recharge schemes will trigger a basic assessment on that basis. Once triggered, the environmental study would typically include the assessment of the impact of the project on natural, cultural and socio-economic environments.</p>
Strategic Approach	<p>Under the current legislation artificial recharge projects can be implemented and authorised. However, authorisation will be problematic because the terms and definitions used in current legislation are open to various interpretations when applied to artificial recharge projects. This should be addressed by undertaking the following actions:</p> <ol style="list-style-type: none"> 1. Clarify the current legal requirements for authorising artificial recharge projects. 2. Clarify the authorisation process and provide guidance and training on this. 3. Review the current legislation and establish whether amendments or new regulations are needed.

Management Actions, Responsibility & Priority			
Actions	Responsibility	2007 Priority	2010 Status
1. Clarify the current legal requirements for authorising artificial recharge projects.			
1.1 Based on the requirements of the National Water Act and the National Environmental Management Act identify the legal requirements for authorising artificial recharge schemes. <i>2010 update:</i> <i>An updated guide for planning and authorising artificial recharge schemes was developed (DWA, 2010).</i> <i>Authorise a new scheme.</i>	DWA HO	✓	✓a 1
1.2 Update Item 1.1 above after experience has been gained in authorising artificial recharge schemes (as yet no artificial recharge scheme has been authorised).	DWA, Legal Services	3	2
1.3 Draft a booklet for planners, engineers, environmentalists and hydrogeologists on how to interpret the legal requirements for implementing artificial recharge. <i>2010 update:</i> <i>The legal requirements are adequately captured in the Artificial Recharge Strategy Version 1.3.</i>	DWA HO / WRC	3	3
2. Clarify the authorisation process and provide guidance and training on this.			
2.1 Provide guidance on the artificial recharge authorisation process.	DWA HO	✓	
2.2 Produce an artificial recharge authorisation guideline.	DWA HO	3	✓a
2.3 Produce a document to assist regulators in approving / rejecting / improving artificial recharge applications. The document should include the types of conditions that should accompany artificial recharge authorisation. Required supportive documents are listed below and in Objectives 4 and 5.	DWA HO / WRC	3	3
2.3.1 Develop principles regarding the modification of natural groundwater taking into account the Resource Quality Objectives as specified by DWA.	DWA HO	3	3
2.3.2 Produce artificial recharge monitoring guideline documents. The documents needed are: 1. Guidelines on water level monitoring; 2. Guidelines on water quality monitoring (including recharge water quality objectives	DWA HO	3	3

and recovered water minimum quality requirements); 3. Environmental monitoring requirements (including ecological baseline data requirements). The guidelines must relate to the artificial recharge implementation stages and to the scale of artificial recharge schemes.			
2.3.3 Define public and environmental health risk assessment needs and management requirements. This relates strongly to the use of reclaimed wastewater and liabilities associated with water quality issues.	DWA HO	3	3
2.3.4 Develop principles regarding the right to use artificially recharged water, and how to incorporate this right in the licence agreement.	DWA HO	3	3
2.4 Train regulatory authorities in assessing and processing artificial recharge scheme applications and in reviewing the effectiveness of artificial recharge schemes. The main target audience should be DWA and CMAs.	DWA HO	3	3
2.5 Provide a preliminary framework for the institutional arrangements and reporting requirements.	DWA HO	✓	
2.6 Update the framework on institutional arrangements to include complex scenarios such as multiple user schemes (eg competing agricultural and domestic users)	DWA HO	3	3
3. Review the current legislation and establish whether amendments or new regulations are needed.	DWA, Legal Services	3	✓a
2010 update:			
4. Regulate existing schemes			
4.1 Identify reporting requirements from schemes such as Atlantis, Kharkams and Williston, and ensure that they meet these requirements.	DWA HO / DWA ROs	-	1

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

References

- a. Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. Planning and Authorising Artificial Recharge Schemes, dated November 2010.

2.2.3 Theme 3 Planning

Theme 3 Planning

Management Objective	Facilitate the use of artificial recharge in achieving sustainable, efficient and cost effective water resource use and management
Situation Assessment	<p>Artificial recharge has many uses. The two prime uses in South Africa are water storage and water conservation. Aquifers, like dams, can be used to store water, and in doing so, water that would otherwise be lost to evaporation or outflow to the oceans, can be conserved for later use.</p> <p>To date, maximising sub-surface storage through artificial recharge has not been considered by water sector planners. This Strategy document provides the first attempt to address this. During the course of developing this Strategy document, the artificial recharge potential at the Water Management Area (WMA) scale was estimated. Only areas with known high permeability were used, as these areas are favourable for rapidly recharging and abstracting groundwater. The total water volume that could be stored over and above existing natural groundwater storage is estimated to be 8 000 Mm³ (see Chapter B.4).</p> <p>The water conservation concept is prevalent amongst water resource planners and is reflected in most planning documents. Artificial recharge, however, is rarely mentioned, although it is recommended in some Internal Strategic Perspective documents (ISPs). Listed below are a number of strategic documents where water conservation and the wise use of existing water resources are encouraged.</p> <ul style="list-style-type: none"> • National Water Resource Strategy (NWRS) (DWA, 2004). The NWRS encourages all forms of water conservation. Artificial recharge, although not mentioned in the NWRS, is one way of achieving conjunctive water use and water conservation. • National Water Conservation and Water Demand Management Strategy (DWA, 2004a). A National Water Conservation and Water Demand Management Strategy (WC/WDM) was developed by DWA's Directorate: Water Use and Efficiency, and incorporated into the National Water Resource Strategy (NWRS). One of the roles of the WC/WDM Strategy is to: "promote the use of new technologies which will raise the level of water use efficiency in all sectors". Artificial recharge, although not a "new technology", is an under-utilised, innovative approach to water use efficiency. • Catchment Management Strategies (CMS), once completed, will form the next (lower) level of water resource planning. WC/WDM and groundwater use and management need to be incorporated into the CMSs, and artificial recharge should be mentioned as one form of integrating and maximising available water resources. • Internal Strategic Perspectives (ISPs) were developed as an interim measure for each Water Management Area (WMA) or sub-WMA. Recommendations pertaining to artificial recharge are given in some of the ISPs, for example "Aquifer Storage and Recovery could be used to boost recharge during infrequent periods of surplus flow, taking advantage of aquifer storage". Aquifer Storage and Recovery is an artificial recharge term used specifically for borehole injection. • At the Water Services Level, the documents that include the principles of artificial recharge are:

	<ul style="list-style-type: none"> - Integrated Development Plans (IDPs). These are the strategic plan for the development of municipalities. - Water Services Development Plans (WSDPs). WSDPs form part of the IDPs, and describe current and planned water resource use and management. South Africa's oldest and largest artificial recharge scheme, Atlantis, is not mentioned in Cape Town's WSDP even though it provides about a third of the water requirements for Atlantis town. Likewise, artificial recharge has not been considered as a potential alternative technology in Cape Town's WSDP or mentioned in its section on Integrated Water Resource Management (IWRM). This reflects the current reality in South Africa, where artificial recharge is not recognised as an effective or potentially effective form of water resource management. DWA has developed a guide for developing WSDPs, and the latest version includes artificial recharge (DWA's Guide, Framework and Checklist for the Development of WSDPs, Version 10). - Three separate documents: Water Conservation and Water Demand Management Strategy for the Water Services Sector; the Agricultural Sector; and the Industry, Mining and Power Generation Sector. Artificial recharge, while not mentioned in these documents, is a recognised water conservation measure in the water services sectors.
<p>Strategic Approach</p>	<p>Planning for artificial recharge needs to be accommodated at national, regional and local levels. The following areas should be targeted:</p> <ol style="list-style-type: none"> 1. Artificial recharge needs to be adequately addressed in strategy and planning documents. Planning tools that include artificial recharge also need to be developed for water resource management institutions and water services institutions. Artificial recharge needs to target two spheres within the water sector: <ul style="list-style-type: none"> • The Water Resource Management Sphere, and • The Water Services Sphere. 2. The artificial recharge potential per WMA and sub-areas needs to be quantified. Existing figures presented in this document need to be updated using localised data sets and the methodology needs to be verified with case studies. 3. Localised areas where artificial recharge is needed should be identified. This should include areas where water tables have dropped due to high groundwater abstraction, where a suitable source water is available, and where aquifer hydraulics and water quality characteristics are favourable for artificial recharge. 4. Identify specialised planning areas and purposes where artificial recharge could have significant impact. For example, areas where artificial recharge could assist in mitigating the effects of climate change (such as areas vulnerable to an increasing variability in rainfall); and areas where artificial recharge could augment the Reserve. 5. There is a need to better understand the economics of artificial recharge. Internationally, artificial recharge has been found to be far cheaper and more cost effective than other water resource development options.

Management Actions, Responsibility & Priority			
Actions	Responsibility	2007 Priority	2010 Status
1. Ensure that artificial recharge is incorporated in relevant IWRM documents.			
1.1 Ensure that artificial recharge is incorporated in relevant National scale IWRM documents.			
1.1.1 Incorporate artificial recharge in updated versions of the NWRS. <i>2010 update: This has been sent to the team responsible for updating the NWRS.</i>	DWA HO	3	✓a
1.1.2 Incorporate artificial recharge in updated versions of the National WC/WDM Strategy. <i>2010 update: This needs to be done when the National WC/WDM Strategy is updated.</i>	DWA HO	3	3
1.1.3 Incorporate artificial recharge in updated versions of the WC/WDM Strategies for the Water Services, Agriculture and Industry, Mining and Power Generation Sectors. <i>2010 update: This needs to be done when these strategies are updated.</i>	DWA HO	3	3
1.1.4 Incorporate artificial recharge in DWA's Guide, Framework and Checklist for the Development of WSDPs.	DWA HO	✓	
1.1.5 Incorporate artificial recharge in updated versions of Water Services Feasibility Studies: Applications Procedures, Checklist and Minimum Standards.	DWA HO	✓	
1.1.6 Incorporate artificial recharge in updated versions of Water Services Planning Framework. <i>2010 update: This needs to be done when this document is updated.</i>	DWA HO	3	3
1.1.7 Incorporate artificial recharge in updated versions of Implementation Guidelines for Water Conservation and Demand Management in Agriculture: Development of Water Management Plans. <i>2010 update: This needs to be done when these documents are updated.</i>	DWA HO	3	3
1.1.8 Incorporate artificial recharge in updated versions of Guidelines for Catchment Management Strategies. <i>2010 update: Artificial recharge was incorporated into the training material for the courses that were given on developing Catchment Management Strategies.</i>	DWA HO	3	✓a

1.1.9 Incorporate artificial recharge in updated versions of strategic documents pertaining to environmental affairs and sustainable development (eg A Strategic Framework for Sustainable Development in South Africa: Draft for Review, 2006)	DEAT	3	3
1.2 Ensure that artificial recharge is incorporated in relevant Catchment / Water Management Area scale IWRM documents.			
1.2.1 Incorporate artificial recharge in Catchment Management Strategies. <i>2010 update: This needs to be done on an on-going basis. DWA to monitor this.</i>	DWA HO / CMAs	2	2
1.3 Ensure that artificial recharge is incorporated in relevant Municipal scale IWRM documents.			
1.3.1 Ensure that artificial recharge is included in WSDPs. <i>2010 update: This needs to be done on an on-going basis. DWA to monitor this.</i>	DMs	3	2
2. Assess the artificial recharge potential at the WMA and Local scale.			
2.1 Undertake a preliminary assessment of artificial recharge storage potential at the WMA scale.	DWA HO	✓	
2.2 Undertake a detailed assessment of artificial recharge storage potential at the WMA scale (update item 2.1). <i>2010 update: A WMA-scale artificial recharge potential assessment was conducted for the Olifants/Doorn Catchment (WMA 17). This example was written up in a step-by-step manner (DWA, 2009) which can easily be repeated for the other WMAs.</i>	DWA ROs / CMAs	2	✓b 2
2.3 Identify aquifers with an artificial recharge storage potential of 250 – 500 Mm ³ , 500 – 750 Mm ³ and 750 – 1 000 Mm ³ . <i>2010 update: Potential artificial recharge areas were identified (DWA, 2009). The storage capacities were not determined.</i>	WRC / DWA HO: Options Analysis	2	✓b 3
2.4 Quantify the surplus surface water that could be used for artificial recharge	WRC / DWA HO: Options Analysis	2	2
2.5 Develop an updated yield balance per WMA and reconciliation figures that include artificial recharge.	CMAs	3	3
3. Identify localised areas where artificial recharge is needed.			
3.1 Establish areas where water tables have dropped due to high groundwater abstraction, where suitable source waters are available, and where aquifer hydraulics and water quality characteristics are favourable for artificial recharge. Identify Local Municipalities with artificial recharge potential and initiate a localised groundwater monitoring programmes. <i>2010 update: Specific areas have been identified (DWA, 2009). The list is not</i>	CMA / DWA	2	✓b

<i>exhaustive. Groundwater monitoring programmes were initiated or enhanced in Prince Albert, Plettenberg Bay and Hermanus. This activity needs to be broadened to include all areas where groundwater is the sole water source and where groundwater is heavily utilised.</i>			1
4. Identify specialised planning areas and purposes for artificial recharge.			
4.1 Identify areas where artificial recharge could be beneficial for purposes such as climate change mitigation and Reserve augmentation.	DWA HO	3	2
5. Undertake an economic assessment of artificial recharge.			
5.1 Establish artificial recharge implementation and operation costs and develop an economic model to compare artificial recharge with other water resource development options.	DWA HO	3	✓c
<i>2010 update: Implementation costs were determined for Prince Albert, Plettenberg Bay and Sedgefield. An economic still needs to be developed.</i>			2
<i>2010 update:</i>			
6. Identify areas for large-scale sub-surface storage			
6.1 Identify areas where new dam sites are planned or raising existing dam walls are planned and establish the potential for large-scale artificial recharge as an alternative or for conjunctive use.	DWA HO	-	1
6.2 Identify potential large-scale artificial recharge sites in areas with surplus water.	DWA HO	-	1

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

References

- a. Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. *Completion Report for Activity 13: AR3 – AR Planning Documents*. Internal DWA Report.
- b. Department of Water Affairs. 2009. Strategy and Guideline Development for National Groundwater Planning Requirements. Potential Artificial Recharge Areas in South Africa. PRSA 000/00/11609/1 - Activity 14 (AR04), dated September 2009.
- c. Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. Potential Artificial Recharge schemes: Planning for Implementation.



Infiltration Basin 7 at the Atlantis Water Resource Management Scheme

2.2.4 Theme 4 Implementation

Theme 4 Implementation

Management Objective	Support water management and water services institutions in implementing artificial recharge
Situation Assessment	<p>The current status of artificial recharge projects and schemes in South Africa is listed below.</p> <p>Operational schemes:</p> <ul style="list-style-type: none"> • Atlantis • Kharkams <p>Unplanned scheme:</p> <ul style="list-style-type: none"> • Polokwane <p>Emergency water supply scheme:</p> <ul style="list-style-type: none"> • Calvinia <p>Feasibility studies:</p> <ul style="list-style-type: none"> • Langebaan • Plettenberg Bay • Prince Albert <p>The biggest implementation problem is not whether the country has the skills and resources to implement artificial recharge schemes, but the lack of borehole water level and abstraction data in areas of high groundwater use. Without these it is not possible to rapidly establish whether artificial recharge is necessary or not. The challenge is to upgrade nation-wide water level monitoring for all groundwater-dependant users.</p> <p>In the cases of Plettenberg Bay and Prince Albert existing data was inadequate to establish how the aquifers have responded to large-scale abstraction. According to the pump operators, certain boreholes had “run dry”. While artificial recharge may be the most appropriate solutions for both towns, data is required to know this. Boreholes had to be properly equipped for monitoring, staff needed to be trained and borehole data loggers had to be installed.</p> <p>Artificial recharge schemes have to be well designed and appropriate for the level of management expertise in order for them to be efficient and effective. This relates to infrastructure (water supply, water treatment, and recharge and abstraction infrastructure) as well as operation and management capacity. During the feasibility stage, the appropriate level of technology must be established to match current and future operational and management expertise.</p>

<p>Strategic Approach</p>	<p>The approach to supporting the implementation of artificial recharge schemes should follow five key areas:</p> <ol style="list-style-type: none"> 1. Support groundwater monitoring. 2. Provide guidance on the technical aspects around assessing the viability of schemes, on implementing schemes and on technical aspects regarding authorising schemes. 3. Create an incentive mechanism for local government authorities to adopt artificial recharge. The aim should be to encourage the wise use of existing water resources and infrastructure before developing more costly new sources. 4. Develop support mechanisms for implementing artificial recharge schemes. 5. Develop a training course on implementing artificial recharge schemes. 		
<p>Management Actions, Responsibility & Priority</p>			
<p>Actions</p>	<p>Responsibility</p>	<p>2007 Priority</p>	<p>2010 Status</p>
<p>1. Support groundwater monitoring</p>			
<p>1.1 Ensure that groundwater monitoring at the local, groundwater user level is incorporated in the Groundwater Strategy.</p>	<p>DWA HO</p>	<p>1</p>	<p>✓a</p>
<p>2. Produce guideline documents on assessing the feasibility of artificial recharge schemes and implementing artificial recharge schemes. The documents should cover all the criteria for successful implementation and operation. Some of the key guidelines are listed below.</p>			
<p>2.1 Develop a guideline on water quality requirements for artificial recharge. This should include pre- and post-treatment in relation to both health issues and clogging prevention. The guideline should include water quality standards (with respect to turbidity, microbial quality, chemistry, etc) for the different recharge techniques and water types, to prevent, for example, clogging of the filtration surface and the aquifer.</p>	<p>DWA HO</p>	<p>3</p>	<p>3</p>
<p>2.2 Develop a guideline on environmental requirements for authorising and monitoring the impact of artificial recharge schemes.</p>	<p>DWA HO</p>	<p>3</p>	<p>3</p>
<p>2.3 Develop a procedure for undertaking artificial recharge feasibility studies.</p>	<p>DWA HO / DEAT</p>	<p>2</p>	<p>✓b</p>
<p>3. Create an incentive mechanism for local government authorities to adopt artificial recharge.</p>			
<p>3.1 Develop an incentive mechanism for water resource management and services institutions to adopt artificial recharge as a form of water conservation. Consider ways to discount water resource management costs (for example, by basing it on the premise that water conserved through artificial recharge creates the potential for additional licences for other users).</p>	<p>DWA HO</p>	<p>3</p>	<p>3</p>

4. Develop support mechanisms for implementing artificial recharge schemes.			
4.1 Establish an Advisory Committee to assist artificial recharge applications (consider funding sources like the incentive scheme mentioned in 2.1 above).	DWA HO	3	3
4.2. Identify local and international institutions/resources that could be approached to support artificial recharge initiatives.	DWA HO	3	3
5. Develop a training course on implementing artificial recharge schemes.			
5.1 Develop a training course on implementing and operating artificial recharge schemes. Include all the issues that need to be assessed in feasibility studies and the implementation stages. The course should be housed at the information centre of the flagship project (See objective 1).	DWA HO	3	✓c&d
2010 update:			
6. Support the implementation of artificial recharge projects			
6.1 Support potential artificial recharge projects in conducting pre-feasibility studies, feasibility studies and preparation for implementation readiness. These should include conducting artificial recharge tests, environmental assessments (for authorisation requirements), water use license applications, scheme design and drafting reports in a suitable manner for funding applications, such as in the Municipal Infrastructure Grant format.	DWA HO / DWA ROs	-	1
6.2 Show-case the artificial recharge schemes. This should include documenting the lessons learnt, presenting papers at conferences such as IMIESA and WISA, presenting the case studies at a number of centres around South Africa.	DWA HO	-	1

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

References

- a. Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. Groundwater Strategy.
- b. Department of Water Affairs. 2009. Strategy and Guideline Development for National Groundwater Planning Requirements. A checklist for implementing successful artificial recharge projects. PRSA 000/00/11609/2 - Activity 12 (AR02), dated September 2009.
- c. Department of Water Affairs. 2009. The intentional banking and treating of water in aquifers. Presentation on artificial recharge. Available from www.artificialrecharge.co.za.
- d. Department of Water Affairs. 2009. Lecture notes on artificial recharge. Available from www.artificialrecharge.co.za.

2.2.5 Theme 5 Management

Theme 5 Management

Management Objective	Optimise the management of artificial recharge schemes
Situation Assessment	<p>All artificial recharge schemes require management and an operation and maintenance budget. They require staff that are dedicated to optimising the efficiency and effectiveness of schemes.</p> <p>The following tasks are common to most artificial recharge schemes: transferring the source water to the artificial recharge facility, treating the source water, operating the artificial recharge infrastructure, preventing and managing clogging, monitoring the aquifer's response to artificial recharge, optimising abstraction after recharge, and monitoring and managing the recovered water quality. Depending on the size and nature of the scheme, these tasks may be very simple or fairly sophisticated, but either way, they all require management if schemes are to run optimally. In addition to these technical tasks, reporting is required to meet licence agreements.</p> <p>The Atlantis Water Resource Management Scheme has dedicated staff assigned to operating and managing the artificial recharge facilities, and the City of Windhoek appointed a full-time hydrogeologist to manage the Windhoek aquifer and artificial recharge scheme.</p> <p>In addition to support in managing artificial recharge schemes, it is evident that they need to be regulated. Associated with this is the need for regular reviewing of the operational procedures and the effects of artificial recharge. This is particularly important when water of marginal quality is used as the source water for recharge. The aim should be to ensure that water of unacceptable quality is not used for recharge. Performance monitoring is also important where the environmental consequences of mismanagement are severe, for example, in dolomitic aquifers where sink holes can form from groundwater over-abstraction.</p>
Strategic Approach	<p>The approach to enhance capacity to manage artificial recharge schemes needs to focus on three key areas:</p> <ol style="list-style-type: none"> 1. Provide guidance and support mechanisms for effectively operating artificial recharge schemes. This needs to include identifying the skills required to operate schemes, a mechanism for assessing the performance of schemes, and a system to support data capture and management. 2. Develop a training course on the operation and maintenance of artificial recharge schemes. 3. Develop standards pertaining to the operation and management of artificial recharge schemes.

Management Actions, Responsibility & Priority			
Actions	Responsibility	2007 Priority	2010 Status
1. Develop a support mechanism for water supply institutions that operate artificial recharge schemes.			
1.1 Develop a checklist of the skills required to operate and manage the various types of artificial recharge schemes. Identify key performance indicators and develop a mechanism for assessing them.	DWA HO/ WSA	1	✓a
<p><i>2010 update:</i> <i>This is site specific and should rather be done for each completed scheme.</i> <i>Identify management problems at existing schemes such as Kharkams and Williston and assist in overcoming these problems.</i></p>			
1.2 Develop a system for supporting institutions and staff involved in operating artificial recharge schemes.	DWA HO	2	2
1.3 Develop a system for supporting data management.	DWA HO	2	2
2. Develop a training course on the operation and maintenance of artificial recharge schemes.			
2.1 Develop a training course on artificial recharge scheme operation and maintenance. The course should be housed at the information centre of the flagship project (see Objective 1).	DWA HO	3	3
3. Develop standards relating to the operation and performance of artificial recharge schemes.			
3.1 Develop standards relating to the operation and performance of artificial recharge schemes, and a reporting system that accommodates an annual review of the scheme performance (including data on source- and groundwater quality, volumes recharged and abstracted, and aquifer water levels). The standards should include source water quality (quality limitations suitable for the various types of recharge and end-user use), source water quality monitoring, groundwater level monitoring and groundwater quality monitoring. The standards should be developed with licensing requirements in mind – so that licence conditions can be linked to the standards.	DWA HO	2	2

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

References

- a. Department of Water Affairs. 2009. Strategy and Guideline Development for National Groundwater Planning Requirements. A checklist for implementing successful artificial recharge projects. PRSA 000/00/11609/2 - Activity 12 (AR02), dated September 2009.

2.2.6 Theme 6 Research

Theme 6 Research

Management Objective	Develop a body of knowledge that supports efficient and effective implementation and operation of artificial recharge schemes
Situation Assessment	<p>Two Water Commission Research (WRC) reports have been published in recent years: <i>Artificial Recharge: A Technology For Sustainable Water Resource Development</i> (Murray and Tredoux, 1998) and <i>Pilot Artificial Recharge Scheme: Testing Sustainable Water Resource Development in Fractured Aquifers</i> (Murray and Tredoux, 2002). In addition to these reports, the WRC published a booklet for the layperson: <i>Artificial Groundwater Recharge: Wise Water Management for Towns and Cities</i> (Murray, 2004).</p> <p>Since 1998, numerous papers on artificial recharge have been presented at local and international conferences, and the WRC supported presentations at many cities and towns throughout South Africa.</p> <p>Southern Africa is leading the world in applying artificial recharge to fractured aquifers. New questions will arise as this technology is increasingly applied to different types of fractured aquifers, and research will need to be geared towards developing efficient scheme designs and operating procedures. International research has largely focussed on water quality issues, and in particular, the use of treated waste water for recharge, the prevention and management of clogging in boreholes and infiltration basins, and the prevention of hydrochemical risks. South Africa needs to remain well connected to international researchers and contribute towards in the international knowledge pool.</p> <p>A key challenge for South Africa at the moment is to provide the means to authorise well designed artificial recharge schemes in a timeous and cost-effective manner. The most pressing research needs relate to authorisation and regulation. Officials need guidance on topics such as: the water quality limits acceptable for recharge; the extent to which natural groundwater can be modified (which relate to DWA's Resource Quality Objectives); acceptable aquifer water level fluctuations, etc. These topics require research that is grounded in international experience and modified to suit South Africa's particular hydrogeological and management conditions.</p> <p>The key water quality research areas that are of immediate relevance are clogging in iron-rich groundwaters, clogging in fractured aquifers and the use of treated effluent as a source water for artificial recharge.</p>
Strategic Approach	<p>There are three areas where research that is particular to South Africa is required:</p> <ol style="list-style-type: none"> 1. That which is geared towards developing principles or guidelines to assist officials in authorising schemes and setting licence conditions. This theme should focus largely on water quality issues and environmental impacts. 2. Particular water quality issues such as hydrochemical risks and clogging in iron-rich, and fractured aquifers. 3. Issues pertaining to the use of using treated waste water as a source for artificial recharge.

Management Actions, Responsibility & Priority			
Actions	Responsibility	2007 Priority	2010 Status
1. Research requirements.			
1.1 Establish and prioritise the key research requirements (some of which are listed below). <i>2010 update:</i> <i>Further and regular discussions need to take place.</i>	WRC	1	✓a 1
2. Artificial recharge authorisation			
2.1 Identify the knowledge constraints that could cause lengthy delays in authorising schemes and in establishing licence conditions (eg environmental monitoring requirements).	WRC	1	2
3. Water quality issues.			
3.1 Research water quality issues pertaining to clogging in iron-rich groundwaters and clogging in fractured aquifers.	WRC	3	2
3.2 Identify social and environmental requirements for using treated effluent as source water for artificial recharge.	WRC	3	3
<i>2010 update:</i>			
<i>4. Recharge enhancement methodologies development</i>			
<i>4.1 Identify and develop methods to enhance recharge as climate change adaption methods. Focus on appropriate methods for both small- and large-scale applications that include urban and rural settlements, and farmers.</i>	WRC/HO DWA	-	1

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

References

a. Internal DWA and WRC communication, 2009.

2.2.7 Theme 7 Strategy Implementation

Theme 7 Strategy Implementation

Management Objective	Implement and update the artificial recharge strategy
Situation Assessment	<p>This is South Africa's first national artificial recharge strategy and its development has followed a process of compiling two draft versions for review and comment.</p> <p>During the course of developing the strategy, some of the key actions required to create an enabling environment for implementing artificial recharge schemes have been completed. These have been included in the listed actions in this strategy so that progress on strategy implementation can be assessed. The actions listed below are geared to ensure that the strategy is implemented and periodically updated.</p>
Strategic Approach	<p>The artificial recharge strategy will be successful if people from diverse professional backgrounds consider artificial recharge as an option to address water supply, water quality and environmental issues. That is, awareness regarding the benefits and applications of artificial recharge need to reach a wide audience. The focus of implementing the artificial recharge strategy should be to reach this diverse audience and to ensure that the necessary "tools" (technical, legal, etc) are in place for artificial recharge to be implemented efficiently and timeously. This will require artificial recharge champions from DWA who drive the implementation of the strategy and who are proactive in incorporating artificial recharge within other strategies and planning documents, such as Catchment Management Strategies, Water Conservation and Demand Management Strategies, Water Services Development Plans, etc.</p>

Management Actions, Responsibility & Priority			
Actions	Responsibility	2007 Priority	2010 Status
1. Find a driver for the artificial recharge strategy			
1.1 Find a home and a champion for the artificial recharge strategy and a funding source for implementing it.	DWA: Water Resource Planning Systems	✓	
2. Facilitate high-level inter-departmental awareness of the strategy			
2.1 Develop an information sheet on the artificial recharge strategy, and inform the Director Generals of the strategy.	DWA HO	1	✓a
3. Ensure that DWA staff are aware of the strategy and its purpose.			
3.1 Circulate an information sheet on the strategy to all DWA staff above Deputy Director level.	DWA HO	1	✓b
4. Implement the strategy			
4.1 Develop an artificial recharge implementation plan	DWA HO	1	✓c
4.2 Implement the strategy starting with the 1st Action in Objective 1.	DWA HO	1	✓d
4.3. Develop a plan to ensure that the strategy is reviewed and updated.	DWA HO	3	✓e
2010 update:			
5. Implement Version 2 of the strategy			
5.1 Implement the key (No 1) items listed in the 2010 status columns	DWA HO		1

Priority 1	Immediate
Priority 2	Within 2 years
Priority 3	Within 5 years

References

- a. Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements Completion Report for Activity No 4: AR1 – AR Awareness. Internal DWA Report.
- b. Internal DWA communication, 2009.
- c. The artificial recharge plan resulted in the roll-out of the Artificial Strategy (ie this component of the DWA project Strategy and Guideline Development for National Groundwater Planning Requirements).
- d. The strategy was implemented in the roll-out of the Artificial Strategy (ie this component of the DWA project Strategy and Guideline Development for National Groundwater Planning Requirements).
- e. This document, Artificial Recharge Strategy, Version 2, is the culmination of this task.



In-stream filter upstream of Kharkams' artificial recharge borehole

CHAPTER 3. CONCLUSIONS AND SUMMARY OF THE WAY FORWARD

The Water Research Commission started supporting research into artificial recharge in 1997. This led to a substantial drive by DWA to support artificial recharge awareness and initiatives, and as a result, numerous feasibility studies have been initiated and a host of materials have been developed and placed on South Africa's Artificial Recharge Information Centre, the website www.artificialrecharge.co.za.

Support for artificial recharge should now turn to getting projects off the ground. What is most needed in South Africa are successful demonstration sites, as these will show people in the water sector the value of storing and treating water in the subsurface. South Africa already has one successful artificial recharge scheme, the Atlantis Water Resource Management Scheme which uses the infiltration technique. The country needs more successful schemes, and in particular borehole injection schemes to demonstrate this cost-effective form of water conservation and management. The key tasks in taking artificial recharge forward are those prioritized in Chapter 2. They are summarized in **Table 2**.



Infiltration Basin 7 at Atlantis Water Resource Management Scheme

Table 2 Artificial Recharge Strategy Version 2 - Actions requiring immediate implementation

Artificial Recharge Vision: To use natural sub-surface storage as part of Integrated Water Resource Management wherever technologically, economically, environmentally and socially feasible.	
Artificial recharge themes	Prioritised Actions
1. <i>Knowledge Theme</i>	<ul style="list-style-type: none"> • Hold artificial recharge information sessions in Kimberly, Upington, Polokwane and Nelspruit. • Update the artificial recharge lecture: get feedback from lecturers on the course, establish how often it is presented, update the lecture to include new case studies, hand over the course to more universities and train lecturers in presenting the course. • Present the progress achieved in rolling-out the artificial recharge strategy (especially new case studies) at national and international conferences such as WISA, IMIESA and ISMAR.
2. <i>Legislation and Regulation Theme</i>	<ul style="list-style-type: none"> • Identify reporting requirements from existing schemes such as Atlantis, Kharkams and Williston, and ensure that they meet these requirements.
3. <i>Planning Theme</i>	<ul style="list-style-type: none"> • Initiate groundwater monitoring in heavily used groundwater areas where artificial recharge may be required. • Identify areas where new dam sites are planned or raising existing dam walls are planned and establish the potential for large-scale artificial recharge as an alternative or for conjunctive use. • Identify potential large-scale artificial recharge sites in areas with surplus water.
4. <i>Implementation Theme</i>	<ul style="list-style-type: none"> • Support potential artificial recharge projects in conducting pre-feasibility studies, feasibility studies and preparation for implementation readiness. These should include conducting artificial recharge tests, environmental assessments (for authorisation requirements), water use license applications, scheme design and drafting reports in a suitable manner for funding applications, such as in the Municipal Infrastructure Grant format. • Show-case the artificial recharge schemes. This should include documenting the lessons learnt, presenting papers at conferences such as IMIESA and WISA, presenting the case studies at a number of centres around South Africa.
5. <i>Management Theme</i>	<ul style="list-style-type: none"> • Identify management problems at existing schemes such as at Kharkams and Williston and assist in overcoming these problems.
6. <i>Research Theme</i>	<ul style="list-style-type: none"> • Identify areas for large-scale sub-surface storage
7. <i>Strategy Implementation Theme</i>	<ul style="list-style-type: none"> • Facilitate the implementation of the above actions.

CHAPTER 4. REFERENCES

Department of Water Affairs and Forestry, 2007. Artificial Recharge Strategy: Version 1.3.

Department of Water Affairs. 2009. Strategy and Guideline Development for National Groundwater Planning Requirements. Potential Artificial Recharge Areas in South Africa. PRSA 000/00/11609/1 - Activity 14 (AR04), dated September 2009.

Department of Water Affairs. 2009. Strategy and Guideline Development for National Groundwater Planning Requirements. A checklist for implementing successful artificial recharge projects. PRSA 000/00/11609/2 - Activity 12 (AR02), dated September 2009.

Department of Water Affairs. 2009. Lecture notes on artificial recharge.

Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. The Atlantis Water Resource Management Scheme: 30 years of Artificial Groundwater Recharge. PRSA 000/00/11609/10 - Activity 17 (AR5.1), dated August 2010.

Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. Water Banking – A practical guide to using Artificial Groundwater Recharge.

Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. Potential Artificial Recharge schemes: Planning for Implementation.

Department of Water Affairs. 2010. Strategy and Guideline Development for National Groundwater Planning Requirements. Planning and Authorising Artificial Recharge Schemes, dated November 2010.