



Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment

Monitored and Intentional Recharge (MIR).

A conceptual model to draft water quality regulations for Managed Aquifer recharge (MAR) and water reuse.

Intensive observation as a key to achieve water quality improvement.

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INTRODUCTION

Monitored and Intentional Recharge (MIR) conceptual model:

- MIR provides a basis to formulate **MAR guidelines** applied to specific **environmental conditions** that generally conform to each country's regulations.
- MIR proposes a **set of blocks** establishing a framework for MAR implementations with a high **technical guarantee** of success.
- Due to intense and planned **monitoring**, the MIR concept and its methodology are **key for water quality and security**.

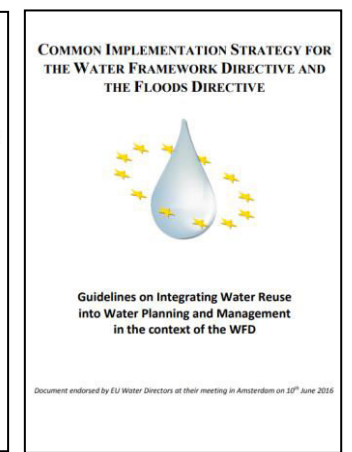
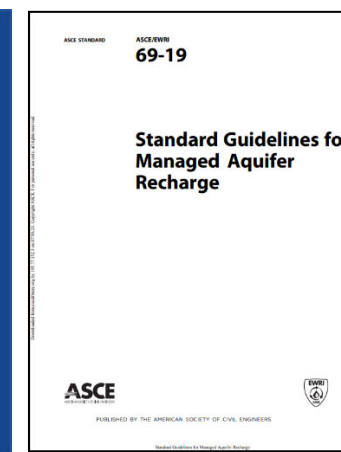
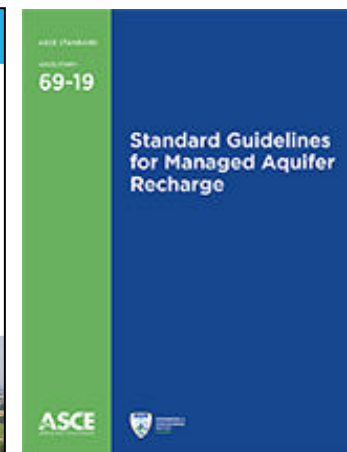
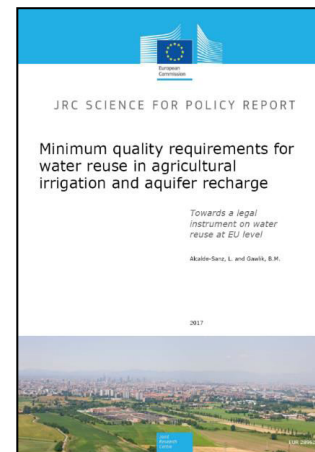
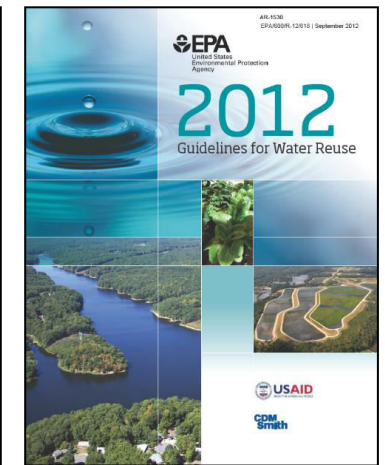
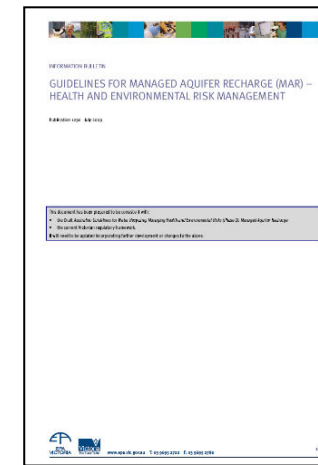
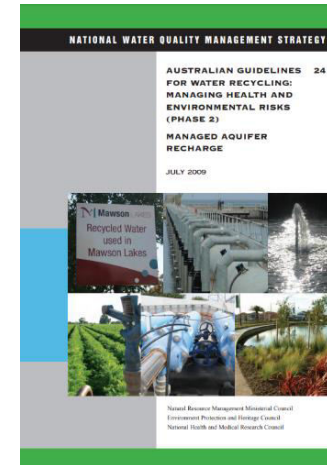
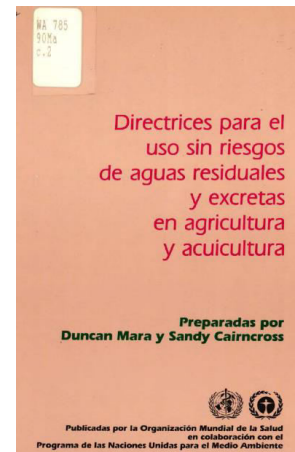
MIR is a conceptual model to draft MAR guiding documents

METHODOLOGY

Review of **22 existing regulations and guidelines** on water reuse and MAR:

- European Union
- WHO
- USA
- Chile
- Australia

...
 Special attention to **monitoring guidelines** and **risk/impact-based analyses**.



METHODOLOGY (2)

1. Selection of most important **aspects**
2. Scoring based on the **level of development** in the document
3. Final **score**

Group	Aspect	Score
General context	Wastewater reuse, including water sources and final uses	28
Risk and impact assessment	Health protection	27
MAR planning	Review of policy and legal framework	24
Operation aspects	Monitoring and pilot testing	24
Receiving medium	Groundwater source protection	22
Risk and impact assessment	Agriculture supply protection	22
Risk and impact assessment	Risk assessment	21
Risk and impact assessment	maximum allowable concentration (MACs) list	21
MAR planning	MAR system design and characteristics	20
General context	Definition of terms	19
Social aspects	Water management framework, including entities and their duties	19
Financial issues	Funding/financial issues/costs	18
Risk and impact assessment	Dependent ecosystems protection	18
Receiving medium	Recharged water—unsaturated zone interaction	17

RESULTS

1. Water **sources**
2. (Hydro)geological and environmental **conditions**
3. **MAR** technology
4. **Sensorics** for MAR
5. Final **use**
6. **Monitoring** guidelines
7. **Analytical** aspects
8. **Risk and impact** assessment
9. Others



Components of the MIR conceptual model

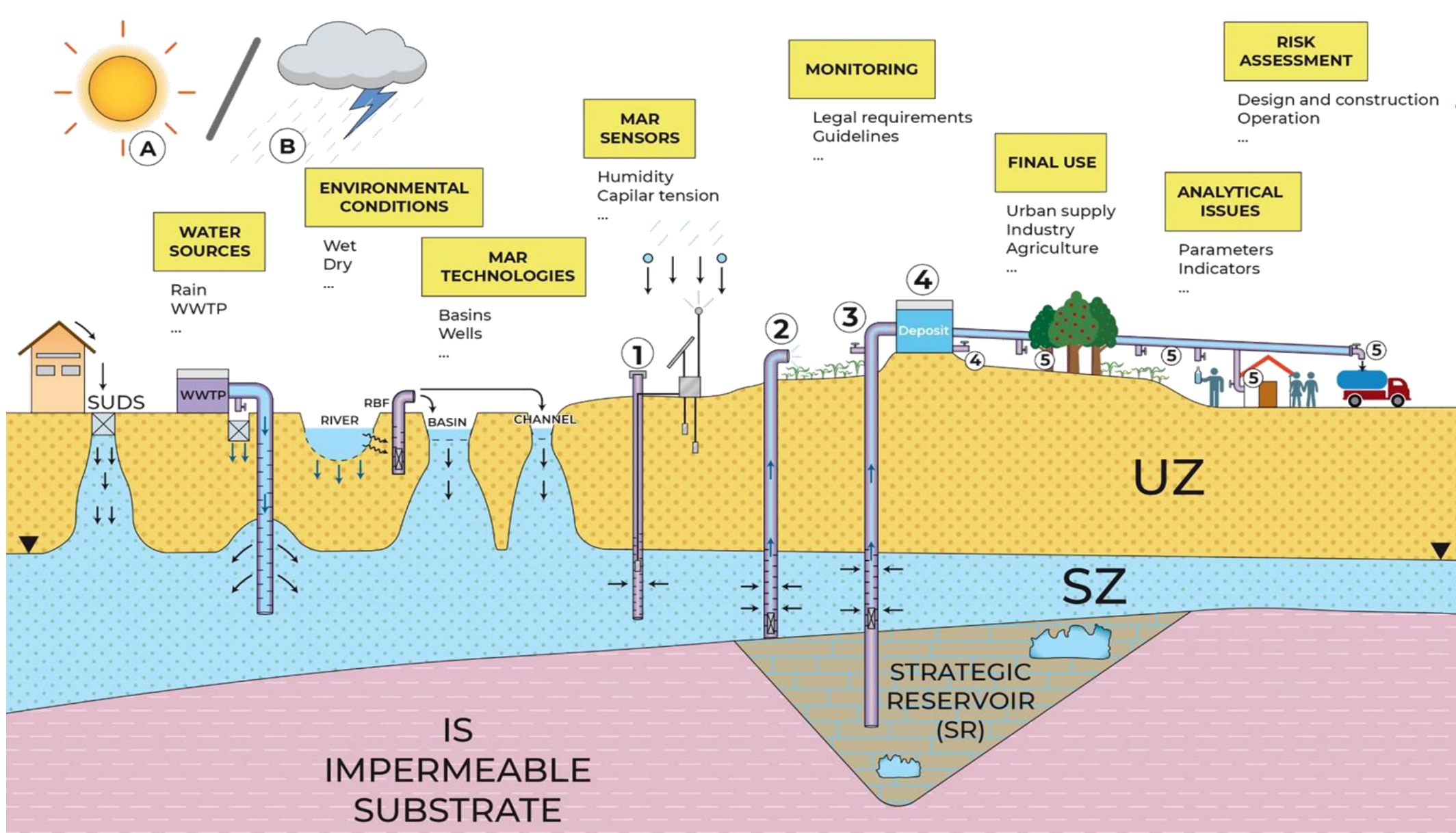
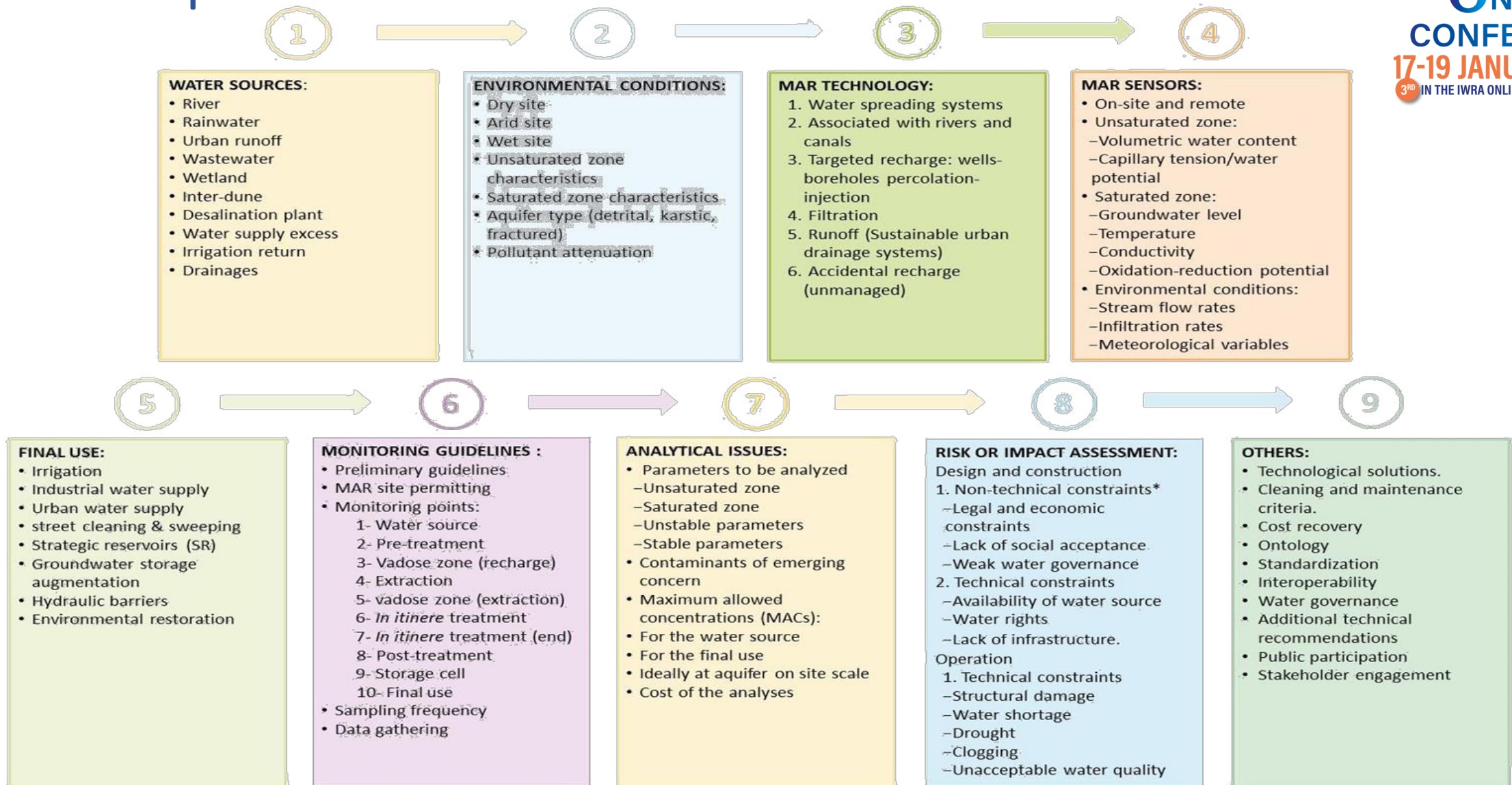


Figure summarising the Monitored & Intentional Recharge (MIR) conceptual model

MIR components



MIR conceptual model: the 9 essential blocks

M.I.R. can contribute to improve WATER SECURITY WORLDWIDE

- The MIR conceptual model proposes a complete list of **elements** to consider when **drafting guidelines and regulations on MAR**.
- It encourages a **tailored approach** based on the **specific context** of the country or region (open concept).
- MIR stresses the **importance of alternative water sources and increasing awareness of water quality** and human and ecosystem health protection
- MIR entails **water quality and security improvements** based on organized and planned monitoring activities.
- **Peru's and Niger's** water authorities are already considering the MIR conceptual model for MAR regulation. In the future, this model could be applied in **Europe and beyond**.

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Article Monitored and Intentional Recharge (MIR): A Model for Managed Aquifer Recharge (MAR) Guideline and Regulation Formulation

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Abstract: Guidelines and regulatory frameworks for conducting managed aquifer recharge (MAR) are scarce worldwide compared to the countries where MAR projects operate. At the same time, guidelines and regulations are crucial to implementing MAR activities safely, respecting human health and the environment, and guaranteeing the sustainability of the intentional recharge. The present study aims to provide a conceptual model comprising the minimum elements to consider when drafting guiding and normative MAR documents. To this end, aspects discussed in nine guidelines were evaluated through a score that allowed their significance to be assessed. The authors also reviewed 22 regulations, guidelines, or MAR site operation rules to construct the monitored and intentional recharge (MIR) conceptual model. This effort was enhanced by active participation in the real drafting of two national regulating documents for MAR. The evaluation of aspects in the documents showed the importance of water reuse and risk and impact assessment. The MIR conceptual model, which guides MAR regulations in two countries, has great potential for application in different sites under diverse contexts.

Keywords: monitored and intentional recharge (MIR); managed aquifer recharge (MAR); guidelines; regulations; monitoring; artificial recharge; formulation; maximum allowable concentrations (MACs)

1. Introduction

Managed aquifer recharge (MAR) is a term that encapsulates a series of techniques to store water underground in aquifers for diverse purposes [1,2]. Although MAR has been practiced around the world for many centuries [3,4], it has experienced accelerated growth in recent years [5], particularly to adapt first to managing water resources in normal climate variability and later to the uncertainty of a warming world with more intense and frequent extreme climatic events (e.g., droughts, floods) [6–8].

Nonetheless, negligence and lack of experience while conducting MAR can result in collateral damage that sometimes outweighs the potential benefits. Inadequate consideration of source water quality and hydrochemical interactions between recharged water and the target porous medium may cause aquifer and groundwater contamination [9–13] and consequently costly and time-consuming remediation efforts [14]. Furthermore, the increasing identification of emergent pollutants in recycling wastewater schemes (including MAR) [15–17] poses a risk to environmental integrity and human health [18,19]. In settings with shallow water tables, MAR can induce water logging and consequently crop damage [20]. An inappropriate estimate of potential clogging development in MAR systems could significantly lower their efficiency and expected lifespan [21–23].

Monitored Intentional Recharge (MIR). Methodological approach and guidelines
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INTRODUCTION
The main international guidelines on Managed Aquifer Recharge (MAR) have been studied and discussed. The advances obtained from each analysis prove to be key for the design of specific regulations or guidelines for a given country, including general rules of broad use, integrated within the Monitored Intentional Recharge (MIR) concept.

BACKGROUND
Most of the published MAR Guidelines have been prepared and studied to address the Monitored Intentional Recharge (MIR) concept and implementation methodology.

RESULTS
1- WATER SOURCES
2- HYDROGEOLOGICAL AND ENVIRONMENTAL CONDITIONS
3- MAR TECHNOLOGY
4- MONITORING GUIDELINES
5- MONITORING GUIDELINES
6- FINAL LIST

CONCLUSIONS
Eight differentiated blocks included in the methodological approach a recommendation to provide "monitored and intentional recharge" (MIR) application.

FINAL LIST
The uses of recharged water are analyzed. The figure 1 explains the most common uses.

ANALYTICAL ASPECTS & WATER SECURITY
Several lines of action related to risk and impact assessment, risk management and water safety are differentiated. The expert blocks have been prepared design and construction and operation, establishing data collection and operational boundaries.

REFERENCES
The MIR concept refers to the 27 MAR projects currently monitored by ISMAR, 2011 and MARCOM, 2018.

Managed Aquifer Recharge. A key to sustainability
www.ismar11.net

Journal Water – Special issue from ISMAR 11

https://www.mdpi.com/journal/water/special_issues/Aquifer_Recharge

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<https://dinamar.tragsa.es/file.axd?file=PDFS/P-ISMAR-11.pdf>

Thank you very much for your kind attention. Madrid, 18 January 2023