



MARSOL

Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought

Proposal for a regulatory scheme to guide the application of MAR projects

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Contents

1. Introduction
2. Assessment of the current regulatory framework in EU Member States
3. MAR under the Water Framework and Groundwater Directives
 - 3.1 The Water Framework Directive (2000/60/EC)
 - 3.2 The Groundwater Directive (2006/118/EC)
 - 3.3 Other relevant European Legislation
4. Regulatory Analysis
5. Proposed Regulatory Scheme
6. Conclusions
7. References

Abbreviations

MAR: Managed Aquifer Recharge

WFD: Water Framework Directive

GWD: Groundwater Directive

EU: European Union

CIS: Common Implementation Strategy

1. INTRODUCTION

The Water Framework Directive (2000/60/EC) considers artificial recharge as one of the management tools that can be used by EU Member States for the achievement of good groundwater status. In fact, whilst listing artificial recharge as one of the basic measures to be considered by Member States in their River Basin Management Plans, Article 11 of the Directive requires the establishment of “controls, including a requirement for prior authorization of artificial recharge or augmentation of groundwater bodies” [1] (p. 14). This in order to ensure that such practice does not “compromise the achievement of the environmental objectives established for the source or the recharged or augmented body of groundwater” [1] (p. 14). The provisions of the Directive in this regard are directed to ensure that the necessary controls are in place to eliminate the possibility of any degradation in the qualitative status of the receiving body of groundwater as a result of the implementation of the Managed Aquifer Recharge (MAR) scheme.

Both the Water Framework Directive and the Groundwater Directive (2006/118/EC) [2], the “daughter” Directive that has been developed in response to the requirements of Article 17 of the Water Framework Directive, are silent on the extent and the details of these controls. The two Directives pursue the harmonization of the national legal frameworks governing water management, and to this end they simply lay down certain goals that must be achieved by every Member State through the integration or modification of existing provisions established by their national, regional or local laws or other instruments [3].

The Water Framework Directive’s primary objectives are to promote the sustainable use of water, reduce water pollution in particular by “priority” and “priority hazardous” substances, and lessen the effects of floods and droughts, while introducing a co-ordinated approach to water management based on the river basin as the appropriate management unit for planning. According to Article 4 of the Directive, “surface waters” are required to meet “good ecological and chemical status” objectives and groundwater bodies [4] to meet “good chemical and quantitative status” objectives by 2015. Article 11(4) introduces the concept of supplementary measures, which Member States may consider implementing in support of the basic measures for the achievement of the Directive’s good status objectives. Artificial recharge of groundwater bodies is mentioned as a possible supplementary measure in Part B of Annex VI [1].

The Ground Water Directive seeks to establish specific measures to prevent and control groundwater pollution [5]. As far as Managed Aquifer Recharge schemes are concerned, Article 6 of the Ground Water Directive exempts their adoption and implementation by Member States from additional prevent and limit controls as long as they are authorized and/or permitted under the controls established in the respective Member State through the implementation of Article 11 of the Water Framework Directive. At the moment, this is the minimum, and rather broad, requirement in order to make the promotion and running of Managed Aquifer Recharge schemes in compliance with the Directives’ established provisions.

The MARSOL Project, from which this contribution stems, aims to demonstrate that Managed Aquifer Recharge (MAR) is a sound, safe and sustainable strategy that can be applied with great confidence [6]. As part of this project an in depth review of MAR regulatory schemes in a number of EU Member States was carried out to characterize the wide range of existing approaches, which at times were found to be even conflicting. This was followed by the development of a proposal for a common regulatory framework which incorporates the regulatory requirements of the EU’s Water Framework and Groundwater Directives to ensure their consideration in the feasibility assessments for MAR schemes. The proposed regulatory framework thus adopts the interpretation of the “prevent and limit” objectives developed under the Groundwater Directive, within the provisions of the Water Framework Directive; to lead towards the formulation of a regulatory scheme which can

guide assessments of MAR proposals to ensure their adherence with the guiding principles of these two key Directives.

The regulatory framework developed under the MARSOL project is based on the following guiding principles:

1. The undertaking of a risk assessment to assess the potential adverse impact of the proposed MAR scheme;
2. the establishment of effective control mechanisms to ensure the reliable performance of The MAR scheme; and
3. The monitoring of the performance of the MAR scheme and its impact on the augmented body of groundwater.

The application of these principles is undertaken through the development of a series of decision stages, intended to assess the compliance of the proposed MAR scheme with the regulatory requirements of both the EU's Water Framework and Groundwater Directives.

The present contribution pursues a twofold aim, namely i) to present an overview of the legal framework governing MAR schemes in EU Member States, and ii) to present a proposal for a comprehensive regulatory framework, for assessing MAR schemes, which ensures the attainment of the high level of protection of the water environment required by the Water Framework Directive.

2. ASSESSMENT OF THE CURRENT REGULATORY FRAMEWORK IN EU MEMBER STATES

It is important to highlight from the outset that with regard to the legal and regulatory framework governing MAR schemes, the present deliverable presents a rather unique contribution as very little analysis have been carried out on these specific aspects. The paper draws upon the findings outlined in two deliverables of Work Package 17 of the MARSOL Project, namely a report that encompasses relevant data concerning the national legal frameworks of 12 EU Member States that adopt MAR schemes, and the proposal for a common regulatory approach that strives to strengthen the existing and future MAR schemes' compliance with the Water Framework Directive and the Groundwater Directive.

The assessment of existing regulatory framework has been undertaken on the basis of the information collected through a questionnaire that has been submitted to a number of national experts hailing from the policy, regulation, implementation and academic sectors in the different Member States, who have relevant knowledge of the topic under consideration and its regulation. The information collected through this questionnaire has been processed using a qualitative approach [7]. Each questionnaire consisted of 20 questions aiming to: 1) identify the EU countries where the use of MAR schemes is more common and better regulated; 2) gather relevant information regarding the way the legal framework of the different countries regulates the establishment, functioning, monitoring and verification of MAR schemes.

The results of this assessment highlight the analysis of the national legal frameworks governing or applicable to MAR schemes in 12 EU Member States, namely the United Kingdom, France, Italy, Germany, Spain, Belgium, Slovakia, Romania, Cyprus, Austria, Portugal and Malta (hereinafter, the "surveyed Member States". In relation to the identification and analysis of the normative frameworks governing the functioning of Managed Aquifer Recharge in the surveyed Member States, it should be noted that there is a general lack of ad hoc and comprehensive legislation dealing with such schemes. The topic is generally covered by provisions falling within broad environmental laws and coping with artificial recharge in general.

Mechanisms for granting authorizations/permits to operators exploiting water resources and operating artificial recharge schemes, as well as for monitoring their activities are established in most of the surveyed Member States. With regard to the monitoring, both the operator/beneficiary of the permit/authorization and the relevant national, regional or local authority, in general the one who grants the permit/authorization, are equally responsible for this activity. Of course it should be noted that there are differences between the surveyed Member States because of the specific provisions that each of them has adopted. For example, in France responsibilities for monitoring are shared between different entities depending on the specific type of monitoring being undertaken: the entity carrying out a preliminary study of impact is responsible for baseline monitoring; the entity that implements the pilot system for validation monitoring; the operator/beneficiary of the permit/authorization for operational monitoring; and the competent public authority for verification monitoring. Moreover, the content and scope of the permit/authorization, granted by the relevant authority to a beneficiary operating artificial recharge schemes, are paramount for determining the latter's duties and rights concerning water management.

In general, the content and scope of the permits affect the way these schemes may be established and implemented. For example in some of the surveyed Member States, like the United Kingdom and Belgium, the permits require the beneficiary to adopt detailed pre-emptive measures to prevent the presence of hazardous substances in the recharge source water. Furthermore, they establish specific requirements concerning the quality of the recharge effluent which need to be ascertained before it is employed for recharge purposes. The permits may also require compulsory training programs to be undertaken by the management and technical staff operating artificial recharge schemes. In a few cases, the permits also require the beneficiary to define clear rules and operating procedures to be

applied in case of incidents or emergencies affecting its water installation. This is for example the case in both the United Kingdom and France where operators granted the permits must provide the relevant authority with plans for dealing with incidents that might damage the water environment. However, it should be noted that in most of the surveyed Member States the definition of specific procedures for emergency or incident management of water installations are not dealt with neither in the authorization/permit nor by the law, e.g. in Austria, Spain, Cyprus, Slovak Republic, Italy and Romania. Only in Germany, emergency management for water installations or infrastructures (those adopted for MAR schemes included) is coped with specific warning and alarm plans implemented at the regional level [8].

This brief overview shows that each EU Member States implements its own regulatory approach that departs to different degrees from the requirements of the Water Framework Directive and the Groundwater Directive. As a result it appears relevant to highlight that the regulatory structure proposed under the MARSOL project could have a significant impact on the existing laws in terms of uniformity and compliance with the requirements of both Directives.

3. MAR UNDER THE WATER FRAMEWORK AND GROUNDWATER DIRECTIVES

The Water Framework Directive aims to ensure the establishment of a regulatory and management structure for the protection of the water environment. In as much the Directive encourages the implementation of schemes for the augmentation of bodies of groundwater, in order to support the achievement of Good Groundwater Quantitative Status. Managed Aquifer Recharge schemes fall in this broad aquifer management perspective. The Directive, however, stresses that Good Quantitative Status should not be achieved at the expense of Good Qualitative Status, and in as much introduces a series of controls to *prevent and limit* the discharge of pollutants to groundwater.

3.1 The Water Framework Directive (2000/60/EC)

Article 1 of the Water Framework Directive establishes as the main objective of this Directive the protection of inland surface waters, transitional waters, coastal waters and groundwater. Article 4 of the Directive, further outlines its Environmental Objectives; where in the case of groundwater, it highlights the following requirements:

- Article 4(1)(b)(i): *Member States shall implement the measures necessary to prevent or limit the input of pollutants and to prevent the deterioration of the status of all bodies of groundwater, ...*
- Article 4(1)(b)(ii): *Member States shall protect, enhance and restore all bodies of groundwater, ensure a balance between abstraction and recharge of groundwater, with the aim of achieving good groundwater status at the latest 15 years after the entry into force of the Directive, ... and*
- Article 4(1)(b)(iii): *Member States shall implement the measures necessary to reverse any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity in order progressively to reduce pollution of groundwater [1] (p. 9).*

Most importantly the Water Framework Directive under Article 4 requires the achievement of good groundwater status, including good quantitative status, through the implementation of a set of water management measures. Moreover, measures concerning good quantitative and qualitative status are defined under Annex 6 of the Directive. However, the Directive through the same Article 4 introduces also the safeguards necessary to ensure that good quantitative status is not achieved at the expense of the qualitative status of the groundwater body.

This approach is further supported by Article 11(3)(j) which introduces a prohibition of all direct discharges of pollutants into groundwater, subject to certain exemptions. Article 2(32) of the Directive defines a 'direct discharge' as the *discharge of pollutants to groundwater without percolation throughout the soil or subsoil.*

Article 11 of the Directive, which sets out the requirement for Member States to establish a Programme of Measures within each river basin district with the aim of supporting the achievement of the Article 4 Environmental Objectives, under sub-article (3)(f) outlines artificial recharge as one of the basic measures which Member States may consider for this purpose. However Article 4(3)(f) outlines the requirement for *"controls, including a requirement for prior authorisation of artificial recharge or augmentation of groundwater bodies. The water used may be derived from any surface water or groundwater, provided that the use of the source does not compromise the achievement of the environmental objectives established for the source or the recharged or augmented body of groundwater. These controls shall be periodically reviewed and, where necessary, updated [1] (p. 14)."*

3.2 The Groundwater Directive (2006/118/EC)

The Groundwater Directive introduces criteria for assessing good groundwater qualitative status and for identifying significant and sustained upward trends and starting points for trend reversals. This Directive also introduces the necessary provisions for making the Water Framework Directive's prevent or limit objectives operational, emphasising on precautions to reduce anthropogenic alterations. In fact, by introducing the concept of preventing '*inputs*' instead of '*discharges*', this Directive widens the scope of the pollution-preventive actions to cover all pollutants that enter the groundwater.

Under the old Groundwater Directive (80/68/EEC), such preventive actions were solely restricted to deliberate disposals. This old Directive was repealed in December 2013 under the provisions of Article 22(2) of the Water Framework Directive.

The prevent or limit concept is introduced under Article 6(1) of the new Groundwater Directive which requires that "*In order to achieve the objective of preventing or limiting inputs of pollutants into groundwater, ..., Member States shall ensure that the programme of measures ... includes:*

- *all measures necessary to prevent inputs into groundwater of any hazardous substances...;*
- *for pollutants ... which are not considered hazardous, ... all measures necessary to limit inputs into groundwater so as to ensure that such inputs do not cause deterioration or significant and sustained upward trends in the concentration of pollutants in groundwater [2] (p. 23)."*

Under the same Article however, the Directive aims to facilitate the adoption of Artificial Recharge schemes by introducing a specific exemption. In fact, Art 6(3)(d) notes that "*without prejudice to any more stringent requirements in other Community legislation, Member States may exempt from the measures required by paragraph 1 inputs of pollutants that are:*

(d) The result of artificial recharge or augmentation of bodies of groundwater authorized in accordance with Article 11(3)(f) of Directive 2000/60/EC [2] (p. 24)."

Article 6 of the Directive however also clarifies that these "*exemptions ... may be used only where the Member States' competent authorities have established the efficient monitoring of the bodies of groundwater concerned, ..., or other appropriate monitoring is being carried out [2] (p. 24)"*

The Groundwater Directive thus, whilst recognizing MAR schemes as important tools for the achievement of good groundwater quantitative status, requires the enactment of all measures deemed necessary and reasonable to avoid the entry of polluting substances into groundwater through these schemes. It also requires that the impact of MAR schemes on the qualitative status of the augmented groundwater body be effectively monitored such that any management and/or regulatory decisions taken are based on a sound understanding of the real conditions of the groundwater body.

3.3 Other Relevant European Legislation

Other European Legislation indirectly provide regulatory approaches which need to be considered in the assessment of Managed Aquifer Recharge schemes. The most relevant legislation is listed below:

- Nitrates Directive (91/676/EEC) – defines waters containing more than 50 mg/l of nitrates as polluted waters and requires Member States to devise and implement an action programme in those cases where the amount of nitrate contained in groundwater is exceeding or is likely to exceed this quality standard [9];
- Urban Wastewater Treatment Directive (91/271/EEC) – aims to protect the environment from the adverse effects of discharges of urban waste water and waste water from certain industrial sectors. This directive is indirectly relevant to managed aquifer recharge schemes

due to its requirements for encouraging the re-use of treated wastewaters, thus providing a potential new water source for MAR schemes [10];

- Environment Liability Directive (2004/35/EC) – provides a driver to prevent and remediate pollution in groundwater [11]; and
- Environmental Impact Assessment Directive (2011/92/EU) – requires the undertaking of an Environmental Impact Assessment for managed aquifer recharge schemes exceeding the utilisation of 10 million m³ of recharge water per year [12].

4. REGULATORY ANALYSIS

Article 4(1)(b)(i) of the Water Framework Directive requires *Member States to implement the measures necessary to prevent or limit the input of pollutants and to prevent the deterioration of the status of all bodies of groundwater* [1] (p. 9). The Groundwater Directive then, introduces the necessary provisions for making the WFD's prevent or limit objectives operational. According to the Groundwater Directive, substances to be **PREVENTED** from entering groundwater are those substances which have been identified by Member States as being hazardous. In as much, one may consider that the substances which need to be **LIMITED** in groundwater such that pollution does not occur are all other pollutants.

In this respect it is noted that the Groundwater Directive recognizes that it is not technically feasible to stop all inputs of hazardous substances, in particular the input of some small inputs of hazardous substances which are environmentally insignificant and thus do not present a risk to groundwater. For such cases, the Groundwater Directive introduces a series of exemptions. Artificial recharge is considered under these exemptions.

Guidance Document 17 on preventing or limiting direct and indirect inputs in the context of the Groundwater Directive published by the European Commission under the Common Implementation Strategy of the Water Framework Directive, provides an interpretation of this prevent and limit concept. According to this EU Guidance Document therefore to **PREVENT** an input into groundwater means: *Taking all measures deemed necessary and reasonable to avoid the entry of hazardous substances into groundwater and to avoid any significant increase in concentration in the groundwater, even at a local scale* [13] (p. 14).

Also in this regard it is noted that the prevent and limit conditions are a requirement of the Water Framework Directive under Article 4(1)(b)(i). Therefore, although the Groundwater Directive under Article 6(3)(d) introduces an exemption for Managed Aquifer Recharge schemes permitted under Article 11 of the WFD from the prevent and limit requirements introduced under the Directive's Article 6(1); the fact that the permit was issued under the WFD implies that the permit should in itself already give due consideration to the WFD's prevent and limit objectives. The proposed regulatory scheme under MARSOL which is presented in the subsequent section of this paper, attempts to address this potential grey area in the Directives, by interpreting the WFD's prevent and limit objectives for MAR schemes in the light of the interpretation developed under the Groundwater Directive for the prevent and limit concept.

In fact, the EU's Guidance Document 17¹ on the Prevention and Limitation of Direct and Indirect Inputs to Groundwater provides an excellent example of the situation which may arise when the Groundwater Directive in the context of the regulation of MAR schemes is considered in isolation. The Guidance Document proposes a scheme for assessing whether new activities may result in inputs that are acceptable, i.e. whether they meet the requirements of the Water Framework Directive. This scheme is based on the following decision points:

- Does this activity fall under an existing exemption of GWD Article 6 or is an exemption planned, e.g. is the input so small as to obviate any present or future danger of deterioration in the quality of the receiving groundwater?
- Is the input direct or indirect?
- Is the substance hazardous or non-hazardous?

¹ The Guidance Document is issued under the Common Implementation Strategy (CIS) of the Water Framework Directive. The role of the CIS in the implementation of the Water Framework Directive is further explained in the following link: http://ec.europa.eu/environment/water/water-framework/objectives/implementation_en.htm

- Can sufficient controls be put in place to prevent or limit the substance from entering groundwater?

On the basis of this analysis, the Guidance Document proposes a decision support system to assess the eligibility of new activities with the requirements of the Water Framework Directive. A schematic representation of the decision support system is presented in Figure 1.

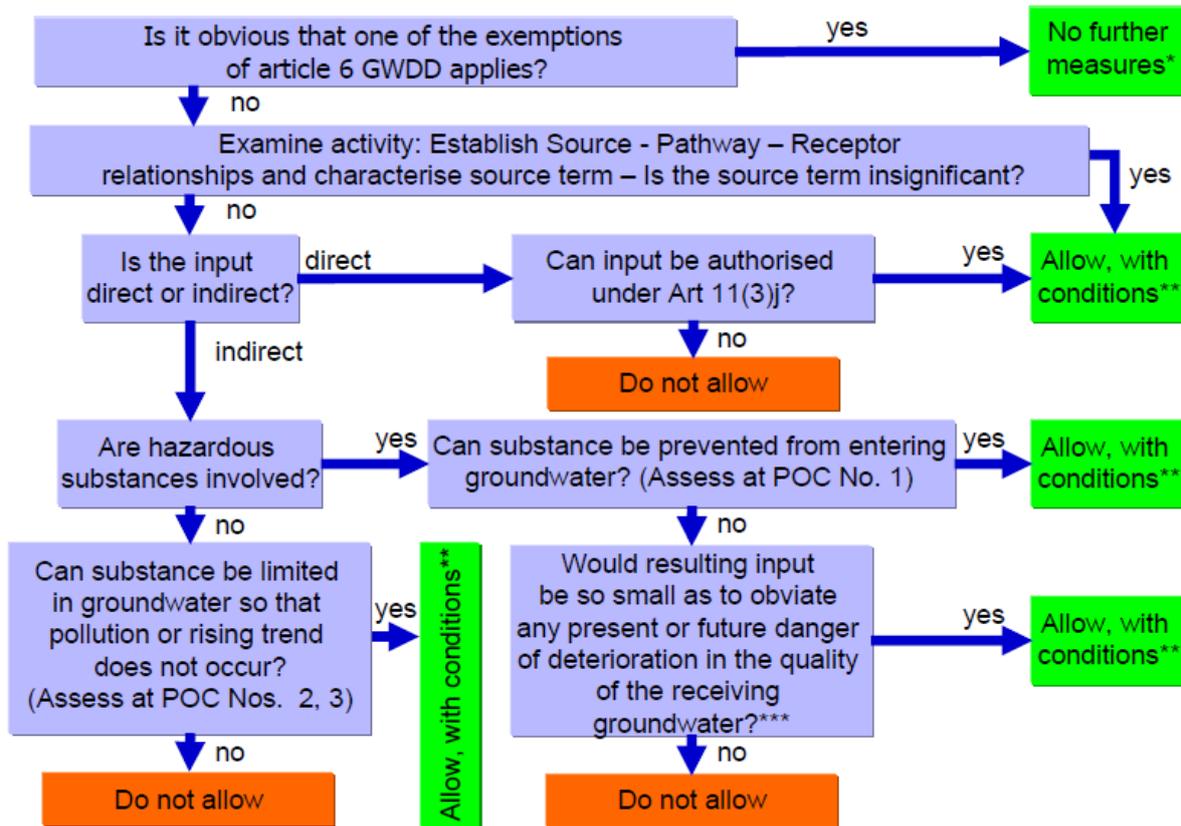


Figure 1. Scheme for assessing new activities under CIS Guidance Document 17.

However, since Article 6 of the Groundwater Directive considers artificial recharge under its exemptions, the scheme developed under the WFD CIS Guidance Document can effectively be reduced to a single decision point when applied to MAR schemes as shown in Figure 2. It is felt, that this interpretation can lead to situations which do not lead towards the establishment of the necessary level of protection to ensure that MAR schemes do not negatively impinge on the qualitative status of the receiving body of groundwater. Hence the proposed comprehensive regulatory scheme under the MARSOL project.



Figure 2. Applying the CIS ‘new activities’ scheme to Managed Aquifer Recharge Schemes.

5. PROPOSED REGULATORY SCHEME

A regulatory structure is therefore being proposed under the MARSOL project which interprets the prevent and limit requirements introduced under the Water Framework Directive in the light of the interpretation developed under the Groundwater Directive.

This proposed regulatory structure, which is schematically illustrated in Figure 3, is based on the following principles:

- (i) The undertaking of a risk assessment to determine the potential adverse impacts which could arise as a result of the MAR scheme on the status of the groundwater body.
- (ii) The establishment of control mechanisms to ensure the reliable performance of the MAR scheme
- (iii) Monitoring of the performance of the MAR scheme and its impact on the augmented body of groundwater.

This three tiered assessment structure has also been developed with the aim of harmonising and integrating the regulatory requirements of the Water Framework and the Groundwater Directive with the vision of the Environmental Impact Assessment Directive. This since the proposed regulatory assessment can effectively be considered as an Environmental Impact Assessment for MAR schemes in its own right. It is felt that this approach further supports the achievement of the Water Framework Directive's environmental objectives for groundwater bodies.

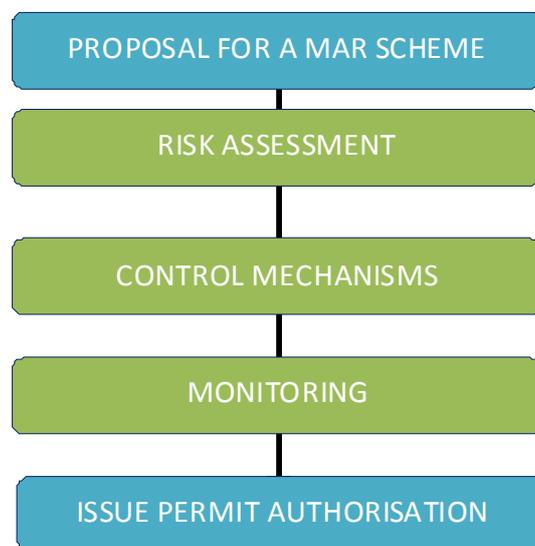


Figure 3. Proposed regulatory framework for the assessment of new MAR schemes.

In the analysis undertaken in Work Package 17 of the MARSOL Project, each of the three decision phases in the above regulatory framework has been broken down into a series of decision points, which are intended to assess the compliance of the proposed MAR scheme with the regulatory requirements of both the Water Framework and the Groundwater Directives.

The proposed decision points are:

1. Risk Assessment Phase

The Risk Assessment phase presents four decision points namely a Groundwater Status Test, a Prevent and Limit Test, an Associated Surface Water Bodies Test and a Drinking Water Quality Test. Proposed MAR schemes must meet the conditions of each test, and will not be considered as meeting the regulatory requirements of the Directives should they fail even one of the tests. In order to support regulatory authorities develop the conditions necessary to assess compliance at each decision point, a series of queries/conditions which must be met by the proposed MAR scheme have been developed and are presented below:

- (i) Groundwater Status Test: Can the MAR scheme potentially lead to deterioration in the status of the receiving body of groundwater?
- (ii) Prevent and Limit Test: Does the MAR scheme include the safeguards necessary to ensure the quality of the recharge effluent and therefore avoid the entry of hazardous substance in the groundwater?
- (iii) Associated Surface Water Bodies Test: Can the MAR scheme result in failure to achieve the environmental objectives specified under Article 4 of the Water Framework Directive for associated surface waters nor any significant diminution of the ecological or chemical quality of such bodies nor in any significant damage to terrestrial ecosystems which depend directly on the groundwater body?
- (iv) Drinking Water Quality Test: Does the MAR scheme create risks to pollution in the receiving body of groundwater to the quality of water abstracted, or intended to be abstracted from the body of groundwater for human consumption?

2. Control Phase

Similarly the Control Phase presents a decision point which MAR schemes need to complete. This decision point is defined by the following test:

- (i) Control Mechanism Test: Does the MAR scheme include the necessary technical control mechanisms and safeguards to ensure the reliability of the recharge water quality, prevent irreversible damage and prevent hazards to public health?

3. Monitoring Phase

Finally the Monitoring Phase presents three other decision points, the conditions of which must be met by the assessed MAR schemes. These decision points are defined by the following tests:

- (i) Groundwater Baseline Quality Test: Is there sufficient data (even at seasonal level) on the baseline quality of the groundwater body to which the MAR scheme will be applied?
- (ii) MAR Source Water Test: Has a monitoring network for the MAR source water been established and approved by the relevant regulatory authorities?
- (iii) Groundwater Monitoring Test: Has a monitoring network for the receiving groundwater body been designed and approved by the relevant regulatory authorities?

In addition to these regulatory tests, the proposed framework requires that the respective roles and responsibilities of the resource and environmental regulatory authorities with respect to the eventual regulation of the MAR scheme are clearly defined and established. This would entail amongst others that the necessary reporting flows to enable the technical and regulatory assessment of the impact of the MAR scheme have been clearly defined and adopted by these regulatory authorities. It is felt that this condition is a pre-requisite to ensure the effective implementation of the proposed regulatory framework.

The proposed regulatory scheme is presented in Figure 4 as a flow process establishing these decision points which the MAR schemes have to complete, grouped under the Risk Assessment, Control Mechanisms and Monitoring phases respectively. It is further noted that the scheme requires that all decision points be successfully completed for an eventual authorisation to be issued.

Furthermore, it is noted that the Water Framework Directive requires that permits/authorisations for Managed Aquifer Recharge schemes need to be time limited to ensure that these can be periodically reviewed and new operational and environmental information collected during the permit period can be considered during the permit review process.

The regulatory scheme also proposes that initially every new MAR scheme should be operated “under control” through the issuance of a temporary permit. The full operational permit being issued only when it is fully ascertained through real monitoring data that the MAR scheme is in reality functioning as planned and therefore having a positive impact on the status of the receiving body of groundwater.

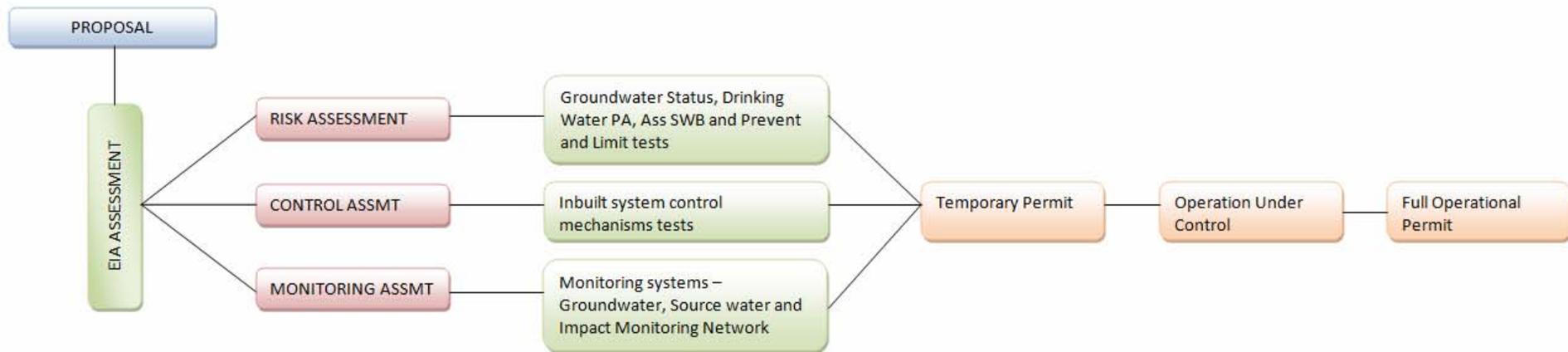


Figure 4. Proposed MAR Regulatory Scheme under the MARSOL Project.

6. CONCLUSIONS

The proposed regulatory framework for MAR schemes under the MARSOL project aims to develop a comprehensive approach in the different EU Member States. The framework aims to address the overlap which exists between the Water Framework and the Groundwater Directives, in particular with respect to the interpretation of the 'prevent and limit' objectives under the Water Framework Directive; where the proposal seeks to establish complementarity with the understanding established under the Groundwater Directive.

The proposed framework is however sufficiently flexible to allow its adoption and implementation by the existing different institutional set-ups found in the different Member States. This since the regulatory set-up required for the implementation of the proposed framework can be undertaken by different regulatory frameworks and/or different regulatory approaches.

The application of the proposed regulatory framework seeks to ensure that MAR is undertaken in a sound, safe and sustainable way, and supports the achievement of the good status objectives of the Water Framework Directive. In so doing, the application of the regulatory framework thus seeks to develop the safeguards necessary to enable regulatory authorities in the EU Member States to ensure that MAR is not used as a screen for the discharge of pollutants to groundwater.

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