EU4GREEN

SURFACE WATER MONITORING DEVELOPMENT PLAN, NORTH MACEDONIA

EU 4 Green Recovery:
Support the implementation of the Green Agenda for the Western Balkans

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ABBREVIATIONS

ADA	Austrian Development Agency
BQE	Biological Quality Element
CA	Competent Authority
CIS	Common Implementation Strategy
EC	European Commission
EEA	European Environment Agency
EIONET	European Environmental Information and Observation Network
EQR	Ecological Quality Ratio
EQS	Environmental Quality Standard
EU	European Union
EU ETS MRVA	EU Emissions Trading System Monitoring, Reporting, Verification and Accreditation
GAWB	Green Agenda for the Western Balkans
GC-MS	Gas Chromatography–Mass Spectrometry
HIO	Hydrobiological Institute – Ohrid
HMS	Hydrometeorological Service
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
ISO	International Organization for Standardization
LIMS	Laboratory Information Management System
MAC	Macrophytes
MAFWE	Ministry of Agriculture, Forestry and Water Economy
MDP	Monitoring Development Plan
MoEPP	Ministry of Environment and Physical Planning
MZB	Macrozoobenthos
PAH	Polycyclic Aromatic Hydrocarbon
PFAS	Per- and Polyfluoroalkyl Substances
PHP	Phytoplankton
PHB	Phytobenthos
QA/QC	Quality Assurance / Quality Control
RBD	River Basin District
RBMC	River Basin Management Council
RBMP	River Basin Management Plan
RBSP	River Basin Specific Pollutant
SEI	State Environmental Inspectorate
SOP	Standard Operating Procedure
SWB	Surface Water Body
UBA	Umweltbundesamt (Environment Agency Austria)
WIS	Water Information System
WFD	Water Framework Directive
WISE	Water Information System for Europe

1. EXECUTIVE SUMMARY

This **Surface Water Monitoring Development Plan (MDP)** provides a structured and practical roadmap for the development, implementation, and operation of a **Water Framework Directive (WFD)-compliant surface water monitoring system in North Macedonia**. Developed within the framework of the EU4Green initiative, the plan supports North Macedonia's transition towards **sustainable water management**, improved environmental governance, and alignment with EU acquis under Chapter 27.

The primary objective of the MDP is to establish a monitoring system capable of **reliably assessing the ecological and chemical status**, detecting trends and pressures, and evaluating the effectiveness of measures under River Basin Management Plans (RBMPs). Monitoring is recognised as a **core pillar of river basin management**, providing the data necessary for evidence-based decision-making and compliance with WFD requirements.

The document outlines the **technical and methodological foundations** for WFD-compliant monitoring, including the definition of biological quality elements (BQEs), supporting hydromorphological and physico-chemical parameters, and chemical substances such as Priority Substances and River Basin Specific Pollutants (RBSPs). It describes the three monitoring types required by Annex V—**surveillance, operational, and investigative monitoring**—each fulfilling distinct roles in status assessment, pressure analysis, and problem identification.

A central component of the MDP is the **phased implementation framework**, covering:

- baseline analysis and water body characterisation (Article 5),
- monitoring programme design (Article 8 and Annex V),
- operational implementation,
- data management and quality assurance,
- status assessment and reporting, and
- adaptive review and optimisation.

This phased approach is aligned with the **six-year WFD planning cycle**, ensuring a structured transition from planning to full system operation.

North Macedonia has made **significant progress in aligning its legal framework with EU water policy**, including the transposition of the WFD into national legislation and the development of River Basin Management Plans (RBMPs) for several basins. The country has also established the fundamental spatial framework of **four River Basin Districts** and initiated monitoring and planning processes in line with WFD methodology. However, these efforts have not yet resulted in a fully operational system. The transition from **formal compliance to effective implementation** remains incomplete.

The analysis shows that the most critical bottleneck is the **limited development of the monitoring system**, which affects all subsequent stages of WFD implementation. Monitoring networks are only partially implemented, with insufficient spatial coverage, irregular sampling, and significant gaps in **biological monitoring**, which is essential for assessing

ecological status. As a result, the current system does not yet provide the reliable and comprehensive datasets required for evidence-based water management.

Closely linked to this is the **lack of an integrated data management system**. Monitoring data are fragmented across institutions and are not systematically harmonised or processed in a centralised manner. The absence of a national Water Information System (WIS) limits the ability to perform consistent status assessments, track trends, and meet EU reporting requirements, including alignment with WISE.

Institutional fragmentation further complicates implementation. Responsibilities for water management are distributed across multiple institutions, including the Ministry of Environment and Physical Planning, the Ministry of Agriculture, Forestry and Water Economy, the Hydrometeorological Service, and local authorities. While roles are formally defined, **coordination mechanisms remain weak**, leading to inefficiencies and gaps between monitoring, planning, and implementation.

Another key constraint is the **limited and unstable financial basis** for monitoring activities. The current system relies heavily on international projects and donor support, which has enabled progress but has also resulted in uneven development and limited sustainability. The absence of a **dedicated and long-term national funding mechanism** is a major barrier to establishing continuous and reliable monitoring programmes.

At the same time, the analysis identifies important opportunities. In particular, the presence of **strong scientific capacity**, such as the Hydrobiological Institute – Ohrid, offers significant potential to strengthen biological monitoring and improve the scientific basis of water status assessments. Better integration of such institutions into the national monitoring system could considerably enhance its effectiveness.

To address these challenges, the MDP proposes a **phased roadmap aligned with the WFD six-year planning cycle**, covering the period 2026–2030. The roadmap includes:

- completion of the legal and methodological framework
- strengthening of monitoring infrastructure and institutional capacity
- full implementation of WFD-compliant monitoring programmes
- development of an integrated Water Information System
- improvement of ecological status assessment and reporting
- integration of monitoring results into RBMP updates and adaptive management

The implementation of this roadmap is guided by a set of **strategic priorities**, including the expansion of monitoring networks, strengthening of data systems and laboratory capacity, improvement of institutional coordination, and securing sustainable financing.

By following the proposed approach, North Macedonia can transition from a **partially implemented and project-driven system** to a **fully operational, institutionalised monitoring framework**. This will enable the country to generate reliable data, support evidence-based river basin management planning, and meet its obligations under the EU Water Framework Directive.

In conclusion, North Macedonia stands at a **critical point in the WFD implementation process**, where the focus must shift from planning and legal alignment to **operational implementation, system integration, and long-term sustainability**. The successful implementation of this MDP will be essential for achieving a robust and effective surface water monitoring system and for supporting the country's broader EU accession objectives in the environmental sector.

2. INTRODUCTION AND SCOPE

EU4Green is an important element of the continuous support by the European Union to empower and assist the Western Balkans' transition to modern, resource-efficient and competitive economies where growth is decoupled from emissions of greenhouse gases, resource use and waste generation and where climate resilience is pursued. It is the general objective of the project to support the Western Balkans in the implementation of the Green Agenda, thus in the development and transformation towards sustainability and reaching climate neutrality by 2050. Accordingly, EU4Green is a very broad initiative building on the combined expertise and cooperation within the thematic areas EU ETS MRVA, Circular Economy, Depollution Water, Depollution Air, Depollution Soil, Biodiversity, Sustainable Agriculture, Communication, Green Education, Stakeholder participation and Green Finance.

River basin management is based on monitoring of **surface water and groundwater resources** and plays a central role in any River Basin Management Plan (RBMP).
Surface water monitoring consists of ecological and chemical monitoring in accordance with the requirements of the Water Framework Directive (WFD). Ecological monitoring includes the assessment of biological quality elements (BQEs), supported by hydromorphological and physico-chemical elements, while chemical monitoring focuses on Priority Substances and other pollutants. These monitoring components are required to supplement and validate the characterization and risk assessment, to establish the status of surface water bodies (SWBs), and to evaluate the effectiveness of the measures implemented to achieve and maintain good ecological and chemical status.

In addition, surface water monitoring is needed to detect long-term trends in water quality, identify emerging pressures, and support the design and adjustment of programmes of measures under evolving environmental and climate conditions.

Sound monitoring is a fundamental instrument for good **surface water governance**. It provides all stakeholders with up-to-date and reliable information on the status and trends of surface waters within a river basin and enables informed decision-making for water management and the implementation of programmes of measures aimed at achieving the environmental objectives laid down by the Water Framework Directive (WFD).

This **Surface Water Monitoring Development Plan (MDP)** addresses the requirements for ecological and chemical monitoring of surface waters in line with the WFD. The comparison with the current situation provides the basis for identifying gaps, drawing conclusions, and formulating options for the progressive development and successful implementation of a WFD-compliant surface water monitoring system.

3. WFD COMPLIANT MONITORING

3.1. WFD monitoring principles

Article 8 of the Water Framework Directive (WFD) establishes the requirements for monitoring the status of surface waters, groundwater, and protected areas. Monitoring programmes are designed to provide a **coherent and comprehensive overview of water status** within each river basin district.

According to Annex V of the WFD, monitoring of surface waters is required to support the following objectives:

- Classification of ecological and chemical status;
- Supplementing and validating the risk assessment carried out under Annex II;
- Supporting the efficient and effective design of future monitoring programmes;
- Assessing long-term changes in natural conditions and those resulting from widespread anthropogenic activity;
- Estimating pollutant loads transferred across international boundaries or discharged into seas;
- Assessing changes in the status of water bodies identified as being at risk, particularly in response to implemented measures;
- Identifying the causes of failure to achieve environmental objectives where these are not yet known;
- Determining the magnitude and impacts of accidental pollution events;
- Supporting intercalibration exercises (comparison with neighbouring countries);
- Assessing compliance with the objectives and standards for protected areas; and
- Quantifying reference conditions for surface water bodies where these exist.

The results of monitoring programmes are reported within River Basin Management Plans (RBMPs) through **maps of monitoring networks, status assessments, and estimates of the confidence and precision** achieved by the monitoring systems.

Under the WFD, waters to be monitored are assigned to specific geographical and administrative units, in particular **river basins, river basin districts, and individual water bodies**, which form the fundamental units of assessment. Monitoring the status of these water bodies provides the basis for evaluating progress towards achieving the environmental objectives of the Directive.

Before monitoring programmes can be implemented, several preparatory steps must be completed:

- Delineation of surface water bodies;
- Identification of water body types (rivers, lakes, transitional and coastal waters);
- Definition of type-specific reference conditions for all biological quality elements.

Where such information is not yet fully available, particularly at national scale, **pressure analysis combined with expert judgement and/or modelling approaches (risk assessment)** can be used as an interim basis.

Annex V of the WFD distinguishes three main types of surface water monitoring: **surveillance monitoring, operational monitoring, and investigative monitoring**. These are complemented by additional monitoring requirements for protected areas identified under Article 6.

3.2. Recent update

Directive (EU) 2026/805 is a **recent update of the EU water policy framework** that amends the Water Framework Directive(2000/60/EC), the Groundwater Directive (2006/118/EC), and the Environmental Quality Standards Directive (2008/105/EC). It aims to strengthen protection of surface water and groundwater by updating the list of regulated pollutants, introducing stricter environmental quality standards, and enhancing monitoring and reporting requirements. The Directive places particular emphasis on emerging contaminants such as PFAS, pharmaceuticals, and microplastics, and promotes more advanced methods, including cumulative risk assessment and effect-based monitoring, in line with the EU's Zero Pollution ambition.

3.3. Precision and confidence

According to Annex V of the Water Framework Directive (WFD), monitoring results shall achieve appropriate levels of **precision and confidence**. What is considered "acceptable", "adequate", or "sufficient" will directly influence key design aspects of the monitoring programme, including:

- the number of water bodies included in the different types of monitoring;
- the number of monitoring stations required to assess the status of each water body; and
- the frequency at which parameters representing quality elements are measured.

The Directive does not prescribe fixed quantitative thresholds for precision and confidence. Nevertheless, it is clear that the levels achieved must be sufficient to enable **robust and meaningful assessments of water status**, both spatially and temporally.

In practice, many Member States begin by evaluating their **existing monitoring networks and datasets** to determine the level of precision and confidence that can be achieved with available resources. Monitoring system design is therefore typically an **iterative process**, involving ongoing adjustment and optimisation of networks, parameters, and sampling frequencies in order to reach levels that support reliable classification and decision-making.

In addition, **expert judgement** often plays an important role, particularly in assessing the risk of misclassification. For example, in cases where a water body may be incorrectly classified as being "at risk", responsible authorities will typically seek to reduce uncertainty through

additional investigations before committing to costly measures. This approach helps ensure that management decisions are both **scientifically robust and proportionate**.

3.4. Biological quality elements for surface water

The basis of the classification of surface water bodies are the Biological Quality Elements (BQE) consisting of fish, macroinvertebrates, phytobenthos, phytoplankton, and macrophytes, while physico-chemistry and hydromorphology act as supporting elements.

- Biology
    - Macroinvertebrates (all rivers)
    - Phytobenthos (in small rivers only)
    - Phytoplankton (in very large rivers and lakes/reservoirs only)
    - Fish and macrophytes will be classified by expert judgment or by using local information (fishermen). If no information is available, these BQE will be included in a later phase. The same is true for macroinvertebrates and phytobenthos in lakes.
- Supporting elements
    - General physico-chemical parameters (all rivers and lakes)
    - Hydromorphology (based on a general classification of the river network)

“Supporting” means that the values of the physico-chemical and hydromorphological quality elements are such as to support a biological community of a certain ecological status, as this recognises the fact that biological communities are products of their physical and chemical environment. It is not intended that these supporting elements can be used as surrogates for the biological elements in surveillance and operational monitoring.

According the WFD, physico-chemical quality elements include 1) general physico-chemical parameters as listed in Annex V of the directive (temperature, O_2, nutrients, salinity, pH) and 2) specific pollutants to be expected in the respective water body. These River Basin Specific Pollutants (RBSP) have to be identified and selected beforehand.

3.5. Chemical quality elements for surface water

Chemical status assessment under the Water Framework Directive (WFD) is based on a defined set of quality elements, primarily focusing on the presence and concentration of chemical substances that may pose risks to aquatic ecosystems and human health. The core elements are the Priority Substances and Priority Hazardous Substances, which are regulated at EU level and subject to Environmental Quality Standards (EQS) in water, and in some cases also in biota and sediments. These substances include heavy metals (e.g. mercury, cadmium, lead), organic pollutants (e.g. pesticides, PAHs), and industrial chemicals. In addition, River Basin Specific Pollutants (RBSPs) are included at national or river basin level to address locally relevant pressures not fully covered by the EU list.

Assessment of chemical status requires monitoring across different matrices, primarily surface water, but increasingly also biota (e.g. fish tissue) and sediments, particularly for

substances that accumulate in the food chain. The evaluation is based on compliance with EQS thresholds, with a strict “one out – all out” principle, meaning that exceedance of any single substance leads to failure of good chemical status. A key component of chemical monitoring is also the analysis of long-term trends, especially for substances that tend to accumulate or persist, in order to identify whether pollution is increasing or decreasing over time.

Together, these quality elements ensure a comprehensive assessment of chemical pressures on surface waters, enabling authorities to detect pollution, assess compliance with environmental objectives, and design targeted measures to reduce emissions and improve water quality.

3.6. Quality elements for groundwater and transitional and coastal waters

The Water Framework Directive (WFD) applies to all inland surface waters as well as groundwater and also defines quality elements for **transitional and coastal waters**. As North Macedonia has no transitional or coastal waters they are omitted from this MDP.

For **groundwater**, EU legislation focuses on achieving **good quantitative status and good chemical status**. In addition, measures must be implemented to **prevent or limit the input of pollutants** and to **identify and reverse significant and sustained upward trends** in pollutant concentrations. For further details on groundwater, reference is made to the document “Monitoring Development Plan – Groundwater, North Macedonia”.

3.7. Surface Water Surveillance Monitoring

The Water Framework Directive (WFD) requires that a sufficient number of water bodies be included in the **surveillance monitoring programme** to provide a representative assessment of the overall surface water status within each catchment and sub-catchment of a river basin district. The design of the monitoring strategy should make use of all available information on **chemical pressures and impacts**, including knowledge of substance properties (as outlined in CIS Guidance Document No. 7), emission sources and data, identified pressures, and results from previous monitoring activities.

Surveillance monitoring must be undertaken for a **minimum period of one year within each six-year River Basin Management Plan (RBMP) cycle**. The Directive specifies that monitoring should be carried out at locations where water dynamics are most relevant at the scale of the river basin district, including:

- rivers with significant flow rates, particularly large rivers with catchment areas exceeding 2,500 km²;
- large lakes and reservoirs where water volumes are significant;
- water bodies that cross Member State boundaries; and
- additional sites required to estimate pollutant loads transferred across boundaries and into the marine environment.

Within surveillance monitoring, parameters representing **all biological quality elements (BQEs), hydromorphological elements, and general as well as specific physico-chemical quality elements** must be monitored to ensure a comprehensive assessment of status.

Proposal for monitoring frequency of surveillance sites:

With regard to monitoring frequency, a harmonised and practical approach is recommended. For rivers, it is appropriate to sample chemical parameters monthly (12 times) over the course of one year, twice per RBMP cycle. For lakes, general physico-chemical parameters, River Basin Specific Pollutants (RBSPs), and Priority Substances (PS) may be sampled four times over one year, also twice per RBMP cycle (Table 1). Biological monitoring frequencies differ depending on the quality element and water category. In rivers, biological quality elements (BQEs) are typically monitored twice per RBMP cycle (Table 2). In lakes, phytoplankton is recommended to be sampled multiple times (e.g. four times) over a year, with sampling distributed across the vegetation period to capture seasonal variability.

Table 1: Recommendations for chemical monitoring frequency at surveillance.

Monitoring	**SWB**	**Quality Elements / Group of Parameters**	**Frequency within the selected year of the RBMP cycle**	**Intervals**
Chemical Surveillance Monitoring	Rivers	General Physico-Chemical Parameters	12x	at least every 3 years
		River Basin-Specific Pollutants		
		Priority Substances		
	Lakes	General Physico-Chemical Parameters	4x	
		River Basin-Specific Pollutants		
		Priority Substances	12x	

Table 2: Recommendations for biological monitoring frequency at surveillance sites.

Monitoring	**SWB**	**Quality Elements / Group of Parameters**	**Frequency within the selected year of the RBMP cycle**	**Intervals**
Biological Surveillance Monitoring	Rivers	Benthic Invertebrates	1x	at least every 3 years
		Phytobenthos		
		Fish		
		Macrophytes		
	Lakes	Phytoplankton	4x	
		Fish	1x	
		Makrophytes		

Table 3: Recommendations for hydromorphological monitoring frequency at surveillance sites.

Monitoring	SWB	Quality Elements / Group of Parameters	Frequency / Intervals
Hydro-morphological Surveillance Monitoring	Rivers	Continuity	once in 6 years
		Hydrology	continuously
		Morphology	every 6 years
	Lakes	Continuity	-
		Hydrology	Monthly
		Morphology	once in 6 years

3.8. Surface Water Operational Monitoring

The objectives of **operational monitoring** are to:

- establish the status of water bodies identified as being at risk of failing to meet their environmental objectives; and
- assess changes in the status of these water bodies resulting from the implementation of programmes of measures.

Operational monitoring must be carried out for all water bodies identified as being at risk of failing the relevant environmental objectives. In addition, it is required for water bodies into which **priority substances** are discharged. However, it is not necessary to monitor every individual water body, as the Directive allows for **grouping of similar water bodies** and representative monitoring, provided that the approach ensures reliable status assessment.

Operational monitoring is **targeted and pressure-specific**, focusing on those parameters and quality elements that are most sensitive to the dominant pressures affecting a water body. For example, where organic pollution is a key pressure in a river, **benthic invertebrates** may serve as the most sensitive biological indicator for assessing ecological impacts.

Proposal for monitoring frequency of operational sites:

With regard to monitoring frequency, a practical and structured approach is recommended. General physico-chemical parameters should be sampled monthly (12 times per year) in rivers and four times per year in lakes, with monitoring carried out in two separate years within the six-year RBMP cycle (Table 4). For biological quality elements (BQEs), the most indicative quality elements in relation to the present pressures must be chosen to assess the water body at risk of failing the good ecological status. BQEs are typically monitored twice per RBMP cycle in rivers, while in lakes, phytoplankton is recommended to be sampled multiple times (e.g. four sampling events) within a single year, repeated twice within the RBMP cycle. These sampling events in lakes should be distributed across the vegetation period to adequately capture seasonal dynamics (Table 5). However, if the BQE results do

not allow for a clear status assessment due to the dynamics of natural systems and unpredictable events, the monitoring period should be extended by one additional year.

Where point source or diffuse pollution is identified, suspected Priority Substances and River Basin Specific Pollutants (RBSPs) should also be monitored, following comparable frequencies (e.g. 12 times per year in rivers and four times per year in lakes, repeated twice per RBMP cycle).

Table 4: Recommendations for chemical monitoring frequency at operational sites.

Monitoring	**SWB**	**Quality Elements / Group of Parameters**	**Frequency within the selected year of the RBMP cycle**	**Intervals**
Chemical Operational Monitoring	Rivers	General Physico-Chemical Parameters	12x	at least every 3 years
		River Basin-Specific Pollutants	12x*	
		Priority Substances	12x*	
	Lakes	General Physico-Chemical Parameters	4x	
		River Basin-Specific Pollutants	4x*	
		Priority Substances	12x*	

** If the risk assessment finds the SWB to be affected by point source or diffuse pollution, chemical analysis of the suspected substances should also be conducted. – Rivers: 12x; Lakes: 4x.*

Table 5: Recommendations for biological monitoring frequency at operational sites.

Monitoring	**SWB**	**Quality Elements* / Group of Parameters**	**Frequency within the selected year of the RBMP cycle**	**Intervals**
Biological Operational Monitoring	Rivers	Benthic Invertebrates	1x	at least every 3 years
		Phytobenthos		
		Fish		
		Macrophytes		
	Lakes	Phytoplankton	4x	
		Fish	1x	
		Makrophytes		

** Choose the most indicative quality element to the present pressures to assess the status of the water body at risk.*

Table 6: Recommendations for hydromorphological monitoring frequency at surveillance sites.

Monitoring	SWB	Quality Elements / Group of Parameters	Frequency / Intervals
Hydro-morphological Operational Monitoring	Rivers	Continuity	once in 6 years
		Hydrology	continuously
		Morphology	every 6 years
	Lakes	Continuity	-
		Hydrology	Monthly
		Morphology	once in 6 years

Choosing operational monitoring sites:

The following schemes A, B, and C (Figure 1, Figure 2, Figure 3) are adapted from a publication on implementing the Austrian Ordinance on the Monitoring of the Quality of Water Bodies (BMLFUW, 2008) illustrate the step-by-step approach on operational monitoring site selection:

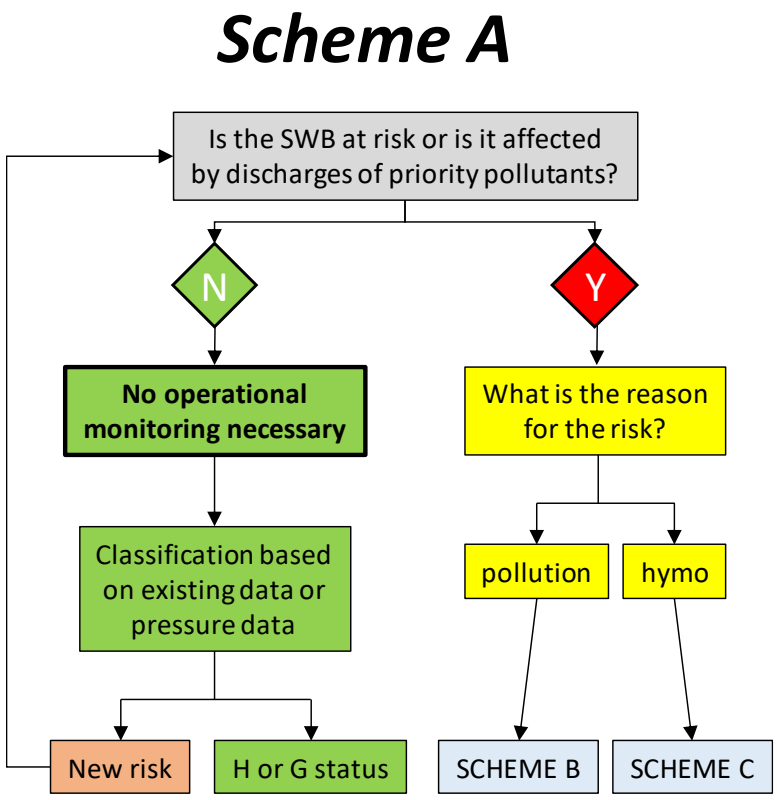

Figure 1: Scheme A of decision tree for choosing operational monitoring sites.

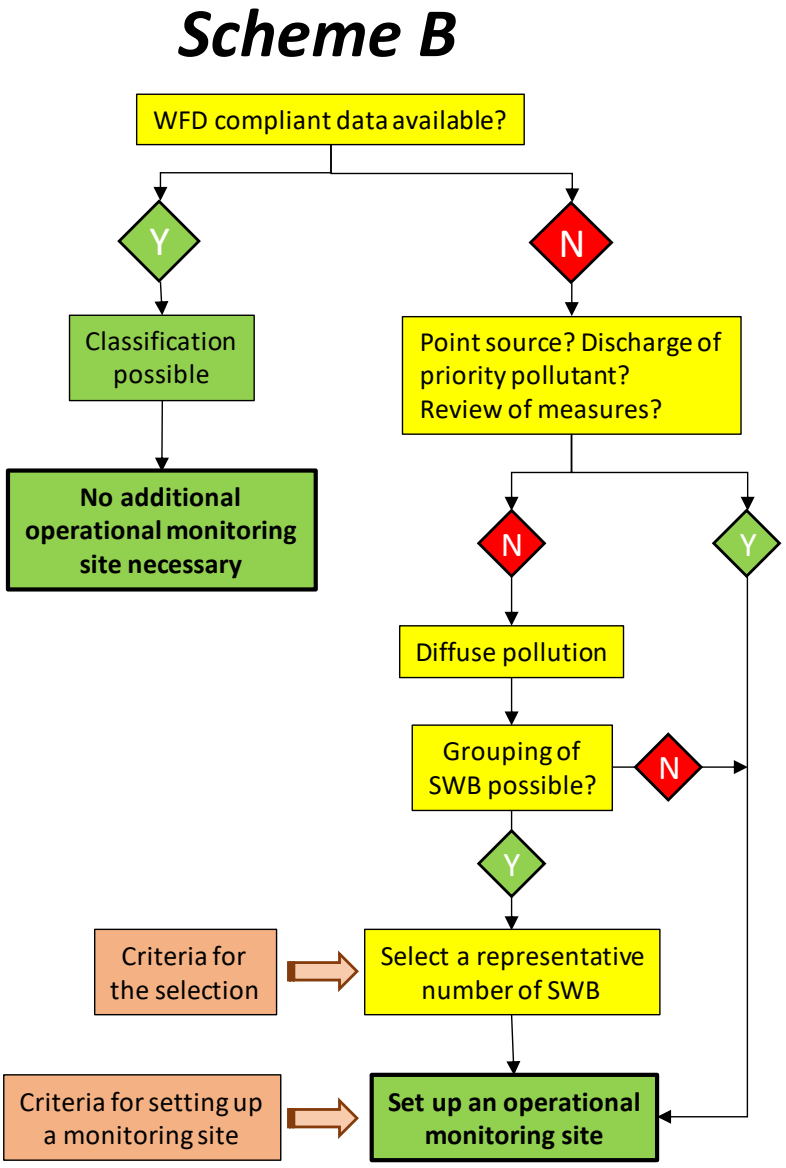

Figure 2: Scheme B of decision tree for choosing operational monitoring sites.

Criteria for the selection of representative water bodies from the group:

- Pollution from diffuse sources
- for successive SWB
    - diffuse load is uniform
    - monitoring site situated in the last SWB (most downstream)
    - Classification results can be applied to the SWB above (upstream)
- for SWB in different regions
    - diffuse load is uniform
    - SWB belong to the same type
    - SWB are comparable in terms of agricultural use

- Affected SWB of the group are affected by the same substance or combination of substances
- At least 25% of the SWB in a group are selected as representatives

Criteria for the setting up a monitoring site in rivers

- one site per SWB which is representative for the pollution
- Preferably at the lower end of the SWB
- Beware dilution effects of tributaries
- Distance to possible additional point sources should be at least 1 km or – if the river breadth is >100 m – at least the 10-fold of the river breadth

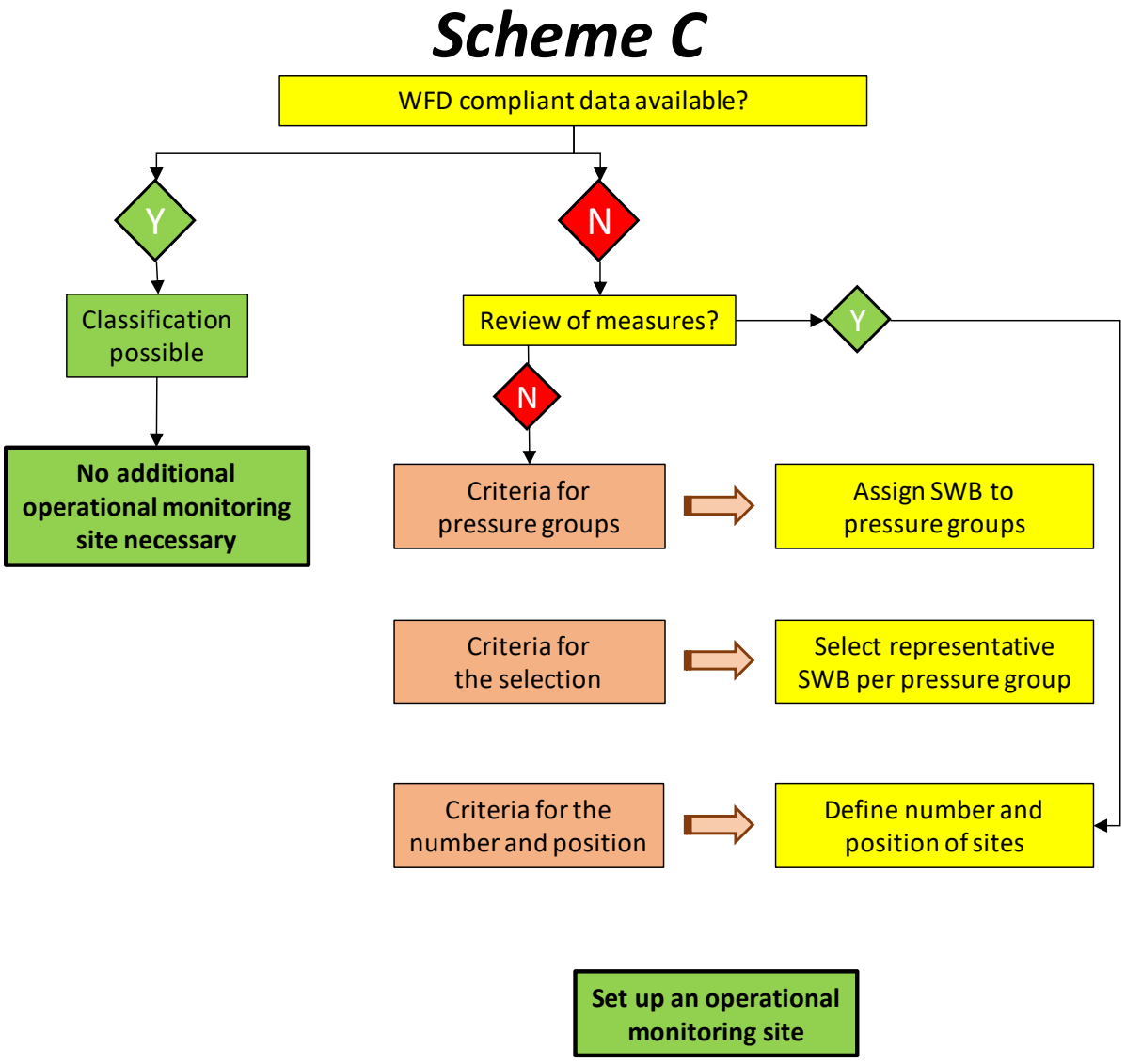

Figure 3: Scheme C of decision tree for choosing operational monitoring sites.

Criteria for pressure groups in rivers

A group of SWB

- with same river type,
- affected by the same pressure,
- which can be investigated and classified by the same indicative biological quality element

Criteria for the selection within each pressure group

- Ideally 1/3 of SWB within each pressure group
- Hydrological context: if possible, select sites within a hydrological subbasin
- No additional pressure (if possible)
- Easy to reach

Criteria for the number and position

- Morphology: one site in the longest uniform section
- Water abstraction: one site directly below the abstraction
- Continuum: one or two sites, above the weir or dam; if there is series of several weirs or dams, another one below the lowest one
- Impoundment: one site beginning (source) of the impoundment, optionally another site directly above the dam

3.9. Surface Water Investigative Monitoring

Investigative monitoring may be required in specific situations as defined in Annex V of the Water Framework Directive (WFD), including:

- where the reasons for exceedances of environmental objectives are unknown;
- where surveillance monitoring indicates that objectives are unlikely to be achieved and operational monitoring has not yet been established; or
- to determine the magnitude and impacts of accidental pollution events.

Investigative monitoring is therefore **problem-oriented and case-specific**, and its design must be tailored to the particular issue being addressed. In many cases, it involves **more intensive sampling strategies**, higher monitoring frequencies, and a focused selection of relevant water bodies, sub-areas, and quality elements.

In addition, investigative monitoring may include components of **alarm or early warning systems**, for example to protect drinking water abstractions from accidental pollution. Such systems may rely on **continuous or semi-continuous measurements** of selected parameters, including key physico-chemical indicators (e.g. dissolved oxygen) and, where appropriate, biological indicators.

Given its targeted and flexible nature, investigative monitoring is essentially an **"on-demand" approach**, triggered by specific problems or knowledge gaps. As a result, it is not possible to define standard monitoring sites, parameters, or frequencies in advance; instead, monitoring programmes must be **designed dynamically**, based on the specific objectives and pressures under investigation.

3.10. Sampling site selection in surveillance and operational monitoring

Surveillance monitoring sites should be strategically located to provide a representative and long-term overview of surface water status across the river basin district. These sites should remain **consistent across multiple RBMP cycles**, allowing for the assessment of trends and long-term changes in water quality and ecological conditions.

In contrast, **operational monitoring sites** should be applied in a more flexible manner and should not be considered part of a fixed, permanent monitoring network. Instead, their selection should directly reflect the need to assess **water bodies identified as being at risk** of failing environmental objectives.

Once the ecological status of a water body has been reliably determined through operational monitoring, it is advisable to **shift monitoring efforts to other at-risk water bodies in subsequent monitoring campaigns**. This approach allows for a more efficient use of resources and supports the progressive improvement of knowledge across the river basin district, ultimately contributing to a more comprehensive and targeted understanding of pressures and impacts.

3.11. Sampling and analysis

The representativeness of monitoring programmes begins with **careful and well-informed planning**, making full use of all available data and knowledge within the river basin. A crucial first step is to clearly define the **objectives of monitoring**—that is, the specific questions the monitoring programme is intended to answer.

An equally important aspect is the **planning and execution of sampling**. Errors introduced at the sampling stage—whether through inadequate design or improper field procedures—cannot be corrected by even the most advanced analytical methods. Therefore, it is essential to ensure the use of **appropriate equipment**, accurate selection of sampling locations, correct application of standardised methods, and the deployment of **properly trained personnel**. Effective communication with laboratories is also critical, particularly regarding sampling requirements, sample handling, preservation, and transport, in order to prevent any alteration or degradation of samples before analysis.

A number of international standards define the principles and requirements for ensuring high-quality monitoring and laboratory performance. In particular, **ISO/IEC 17025** provides a widely recognised framework for the competence of testing and calibration laboratories. This standard offers guidance on the key elements required to produce reliable and traceable results, including proper laboratory infrastructure, equipment management, and operational procedures. It

emphasises the need for **safe handling, transport, storage, and maintenance of equipment**, as well as the management of consumables to prevent contamination or deterioration.

Quality assurance (QA) is therefore a fundamental component of monitoring systems, ensuring that results are **valid, reliable, and comparable**. It must be embedded as a continuous and evolving process within laboratory operations, supporting the ongoing improvement of analytical performance and the overall quality of monitoring data.

3.12. Data management, maintenance and reporting

Purpose of monitoring is to provide sound data on the current burden of pollution of water bodies, demonstrate long term changes (as result of measures or changes of pressures) as basis for fact-based decision making. Monitoring produces a high amount of data and requires, thus, a consolidated and uniform definition of requirements and format of data. This starts with the output of raw data and their plausibility, storage and maintenance. Full power of data can only be withdrawn, when a complete and consistent set of data is available in a well-maintained database. Pre-requisite is a solid and operational network including a powerful server, which connects all involved institutions.

Collaboration between institutions and entities is key to spreading relevant information and gaining added value from data. This regards checking raw data for plausibility and interpretation of data from different users' angles.

3.13. Sustainable Budget

Any form of monitoring requires sustainable budget to guarantee a meaningful set of data. The WFD provides a concept, which needs to be adapted to the needs of every economy to best suit its demands. This encompasses resources for already existing structures in the competent authorities, Ministries and entities to coordinate and administer the concept of the WFD, but also additional expenses for sampling, analysis and data maintenance. Thus, a high degree of awareness about the tasks and obligations at high level is needed to streamline the activities related to the implementation of the WFD.

- There is need for governmental understanding of the necessity, importance and benefits of water monitoring and for strong commitment of sufficient sustainable financing of water monitoring.
- Detailed cost estimations are needed, covering all aspects of monitoring. The estimate should distinguish between
    - sufficient one-time budget to cover the investment costs like infrastructure, equipment etc.;
    - sufficient and guaranteed permanent long-term budget to cover maintenance of infrastructure and equipment; and
    - operational costs for staff, training and consumables.
- It is necessary to demonstrate the political decision makers the benefits of monitoring. The costs of monitoring should be compared with the national economic

benefits gained from e.g. water industries and water related tourism. Such a comparison could strongly convince decision makers of the importance of comprehensive water monitoring.

4. WORKPLAN FOR IMPLEMENTATION

The following chapter gives an overview of prerequisites and steps that can be used as a checklist for establishing a WFD-compliant surface water monitoring system. It covers the governance structure and roles of responsible authorities, the design of the monitoring system based on river basin characterisation, and the development of monitoring programmes including selection of parameters, sites, and frequencies. The chapter further describe the implementation of field and laboratory activities, the establishment of data management and QA/QC systems, and the processes for status assessment, classification, and reporting.

4.1. Governance, Scope, and Responsibilities

4.1.1. Institutional Setup

- Designation of the **Competent Authority** (CA)
- Definition of roles:
    - Monitoring authority / agency
    - Laboratory services
    - Data management authority
    - Reporting authority
- Establish coordination mechanisms with:
    - River basin authorities
    - Nature conservation bodies
    - Stakeholders (where applicable)

4.1.2. Scope Definition

- River basin district(s)
- Surface water categories:
    - Rivers
    - Lakes
    - Transitional waters
    - Coastal waters
- Monitoring cycle aligned with the **6-year WFD planning cycle**

4.2. Phase 1 – Baseline Analysis and System Design

4.2.1. Characterisation of Surface Waters (Article 5)

- Delineation and typology of surface water bodies
- Review of existing data and monitoring programmes
- Identification of:
    - Significant pressures and impacts
    - Waters at risk of failing good status

Deliverables:

- Typology and water body register
- Pressure and impact assessment

4.2.2. Definition of Monitoring Objectives

Biological Elements:

- Establish a compliant sampling method
- Establish a compliant lab method
- Gather data on biology in a consolidated database
- Establish a pressure-response-relationship
- Define criteria for type-specific reference (benchmark) conditions (E)
- Set class boundaries (EQR)
- Compile all methods to a binding guidance document (as a basis for the monitoring)

Chemical Elements:

- Establish a pressure-response-relationship
- Which chemical pollutants and indicators are already monitored?
- Which chemical pollutants are missing?
- Establish a compliant lab method

Define objectives for each monitoring type:

- **Surveillance monitoring**
- **Operational monitoring**
- **Investigative monitoring**

Ensure consistency with:

- Ecological quality ratios (EQRs)
- Environmental Quality Standards (EQS)

Deliverables:

- Monitoring strategy document

- Type-specific EQRs
- National sampling and assessment guidances

4.3. Phase 2 – Monitoring Programme Development (Article 8 & Annex V)

4.3.1. Selection of Monitoring Types

Monitoring type	Purpose
Surveillance	Long-term trends, baseline status
Operational	Status of water bodies at risk
Investigative	Causes of failure or incidents

4.3.2. Parameter Selection

4.3.2.1. Ecological elements:

- Biological quality elements (BQEs):
  - Phytoplankton
  - Macrophytes and phytobenthos
  - Benthic invertebrates
  - Fish fauna
- Supporting elements:
  - Hydromorphology
  - Physico-chemical parameters

4.3.2.2. Chemical elements:

- Priority substances
- River Basin Specific Pollutants (RBSPs)

Deliverables:

- Parameter list by water category & monitoring type

4.3.3. Monitoring Network Design

- Selection of monitoring sites:
  - Representative sites
  - Risk-based site selection
- Spatial and temporal coverage
- Sampling frequency according to Annex V

Deliverables:

- Monitoring network maps
- Sampling schedules

4.4. Phase 3 – Operational Implementation

4.4.1. Field Sampling and Measurements

- Development of Standard Operating Procedures (SOPs)
- Training of field personnel
- Implementation of sampling campaigns

4.4.2. Laboratory Analysis

- Use of accredited laboratories
- Compliance with QA/QC requirements
- Intercalibration where applicable

Deliverables:

- SOPs
- Sampling and analysis reports

4.5. Phase 4 – Data Management and Quality Assurance

4.5.1. Data Management System

- Establishment or adaptation of a central database
- Metadata documentation
- Data validation and plausibility checks

4.5.2. Quality Assurance & Quality Control

- Internal QA/QC procedures
- Participation in interlaboratory comparisons
- Audit and review mechanisms

Deliverables:

- Validated monitoring datasets
- QA/QC reports

4.6. Phase 5 – Assessment, Classification, and Reporting

4.6.1. Status Assessment

- Calculation of ecological quality ratios (EQRs)
- Status classification (high → bad)
- Chemical status compliance check

4.6.2. Trend and Pressure Analysis

- Temporal trend analysis
- Linkage with pressures and measures

4.6.3. Reporting

- Input to RBMPs and Programmes of Measures
- Reporting to the European Commission (WISE)

Deliverables:

- Status classification results
- Assessment reports
- WFD reporting datasets

4.7. Phase 6 – Review and Adaptive Improvement

- Evaluation of monitoring effectiveness
- Review of site selection, parameters, and frequency
- Integration of new methods (e.g. continuous sensors, eDNA)
- Update monitoring programme for next cycle

Deliverables:

- Monitoring programme review
- Updated workplan for next WFD cycle

4.8. Indicative Timeline (6-Year Cycle)

Table 7: Indicative timeline for WFD Monitoring

Year	Key activities
1	Characterisation, design, network setup
2–5	Monitoring implementation & QA
4–5	Status assessment & trend analysis
6	Reporting, review, and redesign

4.9. Key Risks and Mitigation Measures

- **Data gaps** → risk-based prioritisation

- **Resource constraints** → phased implementation
- **Method changes** → harmonisation and documentation
- **Climate impacts** → adaptive monitoring strategies

5. CURRENT WATER MONITORING SITUATION IN NORTH MACEDONIA

5.1. National Legal and Institutional Framework – North Macedonia

5.1.1. River Basin Management Structure

North Macedonia applies a **river basin–based approach to water management**, in line with the principles of the EU Water Framework Directive (WFD). According to the national Water Law and associated regulations, the country is formally divided into **four River Basin Districts (RBDs)**, which constitute the primary spatial units for water management planning:

- the **Vardar River Basin District**, covering the majority of the national territory and representing the most important hydrological unit
- the **Crn Drim River Basin District**, including the Ohrid and Prespa lake systems and draining towards the Adriatic Sea
- the **Strumica River Basin District**, located in the south-eastern part of the country
- the **South (Južna) Morava River Basin District**, covering a small area in the north draining towards the Black Sea basin

These four RBDs correspond to the country's position within three larger international drainage basins (Aegean, Adriatic and Black Sea), but are defined as **separate management units** in accordance with WFD requirements.

Among these, the **Vardar River Basin District** is by far the dominant unit, accounting for approximately 80% of the territory and serving as the central axis of water resources management and planning. The remaining districts are significantly smaller but hydrologically and environmentally important, particularly due to their **transboundary character**.

Historically, water management in North Macedonia was organised through a system of **sub-basin administrative units**, resulting in a division into multiple water management regions (e.g. 16 divisions) used for operational purposes. While elements of this structure still exist, the current policy direction is to transition toward a fully **WFD-compliant river basin district framework**, although this process is not yet fully completed.

In recent years, the country has made progress in developing **River Basin Management Plans (RBMPs)** for individual districts. These include:

- the **Bregalnica RBMP**, developed as a pilot project within the Vardar basin
- the **Strumica RBMP**, representing one of the first comprehensive basin-level plans
- the **Vardar RBMP**, currently under development as the main national RBMP

These RBMPs generally follow the WFD methodology and include:

- delineation of surface and groundwater bodies
- assessment of ecological and chemical status
- identification of pressures and impacts
- definition of environmental objectives
- development of programmes of measures

In addition to river basin–level planning, North Macedonia has developed management plans for specific sub-basins, which serve as more detailed planning instruments within individual river basin districts. A key example is the **Prespa Lake catchment management plan (2016–2021)**, which forms part of the **Crn Drim River Basin District**. This plan was prepared in accordance with the Water Law and aligned with the WFD planning cycle, representing one of the first comprehensive basin-oriented planning documents in the country. It includes detailed analysis of pressures, water status, monitoring systems and programmes of measures at the local scale.

Such sub-basin plans complement the RBMPs by providing more detailed and location-specific assessments, particularly in ecologically sensitive and transboundary areas. However, similar to the RBMPs, these plans have often been developed through **project-based initiatives supported by international donors** and are not yet fully integrated into a coordinated and systematic national river basin planning cycle.

Despite the existence of both RBMPs and sub-basin management plans, the overall river basin management system in North Macedonia remains **in a transitional stage**. The available plans differ in terms of maturity, completeness and spatial coverage, and a **fully harmonised and synchronised RBMP cycle across all four river basin districts has not yet been achieved**.

Furthermore, institutional and technical challenges—particularly in relation to **monitoring systems, data availability, and coordination between planning levels**—limit the effective implementation of basin-level management.

In conclusion, North Macedonia has established the **formal spatial framework for river basin management**, including both RBDs and supporting sub-basin plans, broadly aligned with WFD requirements. However, further efforts are needed to consolidate these elements into a fully operational and integrated system, ensuring consistent implementation across all river basin districts and strengthening the link between planning, monitoring and decision-making.

5.1.2. Institutional Responsibilities

Water management in North Macedonia is characterised by a **multi-level and multi-sectoral institutional structure**, in which responsibilities are distributed across several ministries, agencies, and public institutions. While the legal framework broadly aligns with the EU Water Framework Directive (WFD), institutional fragmentation and limited coordination remain key implementation challenges.

MINISTRY OF ENVIRONMENT AND PHYSICAL PLANNING (MOEPP)

The **Ministry of Environment and Physical Planning (MoEPP)** is the central authority responsible for the **implementation of the WFD and overall water policy development** in North Macedonia. It leads the preparation of **River Basin Management Plans (RBMPs)**, defines environmental objectives, and oversees the **classification of water bodies and ecological status assessment**. The Ministry is also responsible for establishing legal and methodological frameworks aligned with EU requirements. In addition, MoEPP coordinates monitoring of water quality and ensures reporting to national and international bodies, including within the EU accession process. Through its river basin departments, it plays a key role in linking planning, monitoring, and regulatory functions.

MINISTRY OF AGRICULTURE, FORESTRY AND WATER ECONOMY (MAFWE)

The **Ministry of Agriculture, Forestry and Water Economy (MAFWE)** is primarily responsible for the **management and allocation of water resources for economic uses**, particularly irrigation, agriculture, and water infrastructure. It oversees the operation of **dams, reservoirs, and irrigation systems**, and plays a key role in water abstraction and supply management. While not directly responsible for WFD implementation, MAFWE significantly influences the pressures on water bodies and must coordinate with MoEPP to ensure that water use complies with environmental objectives defined in RBMPs. Its role is therefore critical for translating basin-level planning into practical water management decisions.

HYDROMETEOROLOGICAL SERVICE (HMS)

The **Hydrometeorological Service (HMS)** is the main institution responsible for **hydrological and meteorological monitoring**, including data collection on surface water flows, precipitation, groundwater levels, and water quality. HMS is also responsible for water quality monitoring and data collection through its monitoring network. It provides essential datasets used in River Basin Management Plan (RBMP) preparation, water balance analysis, flood risk assessment, and water quality assessments. However, monitoring networks are often limited in spatial coverage and continuity, which affects the reliability of WFD-compliant status assessments. The HMS thus plays a crucial technical role but faces capacity and resource constraints that directly impact the effectiveness of water management planning.

ENVIRONMENTAL INSPECTORATE

The **State Environmental Inspectorate** operates under MoEPP and is responsible for **enforcement and compliance control** in the field of water protection. Its tasks include

monitoring adherence to environmental permits, regulating discharges into water bodies, and ensuring implementation of measures defined in RBMPs. The Inspectorate is therefore essential for translating legal and planning frameworks into actual environmental protection. However, its effectiveness is often limited by insufficient staffing and enforcement capacity, which weakens compliance with water quality standards.

PUBLIC WATER MANAGEMENT COMPANY / WATER ECONOMY INSTITUTIONS

Public water management entities, including the **Public Water Management Company and regional water economy organisations**, are responsible for the **operation and maintenance of hydraulic infrastructure**, such as dams, canals, and flood protection systems. These institutions ensure the practical delivery of water services and flood management, particularly in agricultural regions. While they are not directly involved in WFD planning, their activities strongly influence the hydromorphological conditions of water bodies and therefore must be aligned with RBMP objectives.

LOCAL SELF-GOVERNMENT UNITS (MUNICIPALITIES)

Municipalities play an important role in **water supply, wastewater management, and local environmental protection**. They are responsible for maintaining water utilities, sewerage systems, and wastewater treatment plants, which are key sources of pressure on water bodies. In the context of WFD implementation, municipalities contribute to the execution of **programmes of measures** defined in RBMPs, particularly in relation to pollution reduction and infrastructure development. However, limited financial and technical capacity often constrains their ability to effectively implement these measures.

RIVER BASIN MANAGEMENT COUNCILS (RBMCS)

The **River Basin Management Councils (RBMCs)** are advisory and participatory bodies established to support **stakeholder involvement in RBMP development**, as required by the WFD. They include representatives from public institutions, municipalities, water users, and civil society. Their main function is to facilitate **consultation, coordination, and public participation** in river basin planning processes. While their role is important for ensuring inclusive governance, their operational effectiveness has been limited due to institutional and organisational challenges.

5.1.3. **Legal Framework**

The legal framework for water management in North Macedonia is primarily defined by the **Law on Waters** (*Official Gazette of the Republic of North Macedonia*, as amended), which establishes the foundation for the **integrated management and protection of surface and groundwater resources**. This law reflects the country's ongoing alignment with the **European Union Water Framework Directive (Directive 2000/60/EC)** and provides the legal basis for river basin management planning, water monitoring, and environmental protection.

The **Law on Waters** defines water as a **public good under state ownership** and sets out the principles for its sustainable use, protection, and allocation. It introduces key WFD concepts, including:

- **river basin management planning** as the central planning instrument
- **classification of water bodies** based on ecological and chemical status
- establishment of **environmental objectives**
- development of **programmes of measures**

The law also requires the preparation of **River Basin Management Plans (RBMPs)** for each of the four river basin districts and defines the planning cycle in accordance with the WFD's six-year period. RBMPs are recognised as the **highest-level strategic documents** for water management at basin level and must include assessments of pressures, status, monitoring networks, and measures for improvement.

In addition to the Law on Waters, several other legislative acts contribute to the broader water governance framework, including:

- the **Law on Environment** (*Official Gazette of the Republic of North Macedonia*)
- the **Law on Nature Protection** (*Official Gazette of the Republic of North Macedonia*)
- the **Law on Urban Wastewater Collection and Treatment** (*Official Gazette of the Republic of North Macedonia*)
- the **Law on Drinking Water Supply and Wastewater Disposal** (*Official Gazette of the Republic of North Macedonia*)
- the **Law on Industrial Emissions / Integrated Pollution Prevention and Control (IPPC)** (*Official Gazette of the Republic of North Macedonia*)

These legal instruments support the implementation of the **EU environmental acquis**, particularly:

- **Water Framework Directive (2000/60/EC)**
- **Urban Waste Water Treatment Directive (91/271/EEC)**
- **Drinking Water Directive (EU) 2020/2184 (formerly 98/83/EC)**
- **Nitrates Directive (91/676/EEC)**
- **Industrial Emissions Directive (2010/75/EU)**

The legal framework also includes provisions for:

- **water permits and abstraction rights** (regulated under the Law on Waters)
- **pollution control and discharge regulation**
- **economic instruments**, including cost recovery and water pricing mechanisms
- **mandatory monitoring of water quantity and quality**

With regard to monitoring, the legislation requires the establishment of a **national water monitoring system**, including:

- **surveillance monitoring** for long-term status assessment

- **operational monitoring** for water bodies at risk
- **investigative monitoring** for identifying causes of pollution

The law further requires monitoring of:

- **physico-chemical parameters**
- **biological quality elements** (e.g. phytoplankton, macroinvertebrates, fish)
- **hydromorphological conditions**

These requirements are supported by secondary legislation (bylaws and regulations), which define:

- monitoring methodologies
- classification systems
- reporting obligations

However, despite this relatively comprehensive legal framework, a significant gap remains between **formal legal provisions and their practical implementation**.

While WFD principles have largely been transposed into national legislation, several key elements remain only partially operational:

- incomplete and fragmented **monitoring networks**
- limited implementation of **biological monitoring programmes**
- insufficient enforcement of water quality standards
- delays in the **adoption and updating of RBMPs**

Furthermore, some **secondary legislation and technical standards** required to fully operationalise the WFD are either:

- still under development, or
- not yet consistently applied across all river basin districts

As a result, the legal framework can be characterised as **largely aligned with EU requirements, but not yet fully implemented in practice**. The main challenge lies not in the absence of legislation, but in strengthening the **institutional capacity, monitoring infrastructure, and coordination mechanisms** necessary to enforce and operationalise these legal provisions.

In conclusion, North Macedonia has established a **solid legal foundation for WFD-compliant water management**, including RBMPs and monitoring obligations. However, further efforts are required to ensure **effective implementation and enforcement**, particularly in relation to monitoring systems and the practical application of river basin management planning.

5.1.4. Observations and Considerations

The analysis of the river basin management structure, institutional setup, and legal framework in North Macedonia indicates that the country is in a **transitional phase toward**

full implementation of the EU Water Framework Directive (WFD). Over the past decade, the legal and institutional foundations for integrated water management have been progressively established, including the delineation of four river basin districts and the development of river basin management plans (RBMPs). However, these efforts have not yet resulted in a fully operational and coherent system. The absence of a complete and formally adopted RBMP cycle across all river basin districts demonstrates that the transition from project-based planning towards a **systematic, cyclical WFD approach remains incomplete**.

A central observation supported by both national and EU reporting is that North Macedonia has achieved a **high degree of formal alignment with EU water legislation**, but still faces significant challenges in implementation. The legal framework provides for river basin management, monitoring systems, and environmental objectives in line with WFD requirements. Nevertheless, the **gap between legislation and practical application remains substantial**, particularly in areas such as monitoring, enforcement, and institutional coordination. The EU's 2024 progress report highlights that further efforts are needed to ensure effective implementation of environmental legislation and to strengthen administrative and institutional capacities in the water sector.

Institutional fragmentation continues to be a structural constraint. Responsibilities for water management are divided across multiple ministries and institutions, with limited coordination mechanisms. While this reflects the complexity of water governance, it also reduces efficiency and complicates the implementation of integrated river basin management. National reporting frameworks, including the Voluntary National Review, acknowledge that strengthening **inter-institutional cooperation and governance structures** is essential for achieving sustainable water management and meeting SDG 6 objectives.

The most significant operational weakness is the **underdeveloped monitoring system**, which represents a key bottleneck for WFD implementation. Although monitoring requirements are clearly defined in the legal framework, their practical implementation remains limited. Monitoring networks are insufficient in coverage and continuity, and important elements—especially **biological quality indicators required for ecological status assessment**—are not systematically monitored. The EU progress report explicitly points to the need to improve environmental monitoring systems and data quality as part of the accession process. As a result, assessments of water status are often based on incomplete datasets, which undermines the reliability of RBMPs and limits the effectiveness of planning and decision-making.

At the same time, there are underutilised opportunities within the system, namely the presence of **specialised scientific institutions** such as the Hydrobiological Institute – Ohrid. This institution possesses long-standing expertise in hydrobiological research and ecological monitoring, particularly for lake ecosystems of national and international importance. Its involvement in monitoring programmes and applied research demonstrates its capacity to contribute high-quality data and scientific analysis. However, this expertise is not yet fully integrated into the formal WFD monitoring framework. A more systematic inclusion of such institutions could significantly enhance **biological monitoring capacity**, improve ecological status assessments, and strengthen the scientific basis for water management. This represents a clear opportunity to address one of the system's most critical weaknesses.

Another defining feature of the current water management system is its **dependence on externally funded, project-based initiatives**. Many RBMPs, monitoring developments, and capacity-building activities have been initiated and supported through international cooperation programmes. While these projects have played a crucial role in advancing WFD implementation, they have also resulted in uneven development across river basin districts and limited long-term sustainability. Both national and international assessments emphasise the need to move towards more **institutionalised and nationally driven processes**, ensuring continuity beyond project cycles.

Overall, the main challenge for North Macedonia lies not in the absence of legislation or planning instruments, but in its ability to **translate formal compliance into effective implementation**. This requires strengthening institutional coordination, improving monitoring systems, and ensuring consistent application of existing legal provisions. In this context, enhancing monitoring—particularly through the integration of existing scientific expertise and the development of comprehensive data systems—will be essential for enabling evidence-based decision-making and achieving WFD objectives.

In conclusion, North Macedonia has established the core elements required for WFD-compliant water management. However, further efforts are necessary to transform these elements into a **fully functional and operational system**, where legal provisions, institutional structures, monitoring systems, and planning processes are effectively integrated and consistently applied across all river basin districts.

5.2. Human Resources and Capacity Requirements – Biological Monitoring

5.2.1. General Principles

To ensure successful implementation of WFD-compliant biological monitoring, **trained and experienced experts are essential**. Monitoring teams must be capable of covering all Biological Quality Elements (BQEs) and supporting hydromorphological assessments in accordance with **Annex V requirements**.

The staffing levels presented below represent **minimum requirements per sampling campaign**. Field teams should consist of **at least two persons** to ensure safety, quality control, and validation of results. Efforts should be made to promote **gender balance** in staffing.

5.2.2. Minimum Staffing Requirements per Biological Quality Element

Table 8: Minimum staffing requirements per BQE.

Biological Quality Element	Number of Staff	Prerequisites
MZB (macrozoobenthos)	3 (min. two hydrobiologists + one chemist)	Coverage of all macroinvertebrate groups at required taxonomic resolution; strong coordination between field and laboratory; chemist responsible for physico-chemical measurements
PHB / PHP (phytobenthos, phytoplankton)	1	Experienced algae specialist (especially diatoms); laboratory capacity required for chlorophyll-a analysis
MAC (macrophytes)	1	Specialist in aquatic vegetation; diving skills may be required depending on site conditions
FIS (fish)	4 (1 expert + 3 trained staff)	Expertise in river-type-specific sampling methods (e.g. electrofishing); high level of experience required, particularly in large rivers
HYMO (hydromorphology)	2	One expert in hydrology and one expert in morphology; understanding of river processes and habitat structure

Abbreviations: MZB = macrozoobenthos (invertebrates); PHB = phytobenthos (diatoms); PHP = phytoplankton; MAC = macrophytes; FIS = fish; HYMO = hydromorphology

5.2.3. Competence and Qualification Requirements

- Staff must have **relevant academic backgrounds** (e.g. hydrobiology, ecology, environmental sciences, chemistry)
- Taxonomic expertise is critical, particularly for:
  - macroinvertebrates
  - diatoms
  - macrophytes
  - fish fauna
- Laboratories must be equipped and staffed for **specialised analyses**, including chlorophyll-a and biological sample processing
- Competence must be aligned with **intercalibration requirements** and WFD classification systems

5.2.4. Training and Capacity Development

- Continuous **professional development and training programmes** are essential to maintain and upgrade skills
- Institutions should establish **formal internal and external training plans**, with proper documentation
- Regular participation in:
    - interlaboratory comparisons
    - intercalibration exercises
- Training should specifically address **RBMP-identified gaps**, including:
    - limited biological datasets
    - insufficient taxonomic resolution
    - inconsistent application of methods

5.2.5. Organisational and Institutional Requirements

- Monitoring activities should be **centrally coordinated** to avoid fragmentation and ensure consistency
- Clear **roles, responsibilities, and job descriptions** are required
- Regular communication and exchange between field teams, laboratories, and data managers is essential
- Monitoring responsibilities should not be treated as secondary tasks but require **dedicated staff and structures**

5.2.6. Staff Retention and Workforce Planning

- Adequate remuneration is necessary to attract and retain qualified staff
- High levels of motivation should be supported through:
    - clear task definition
    - recognition of expertise
    - career development opportunities
- Forward-looking workforce planning is required to:
    - ensure balanced staffing
    - avoid loss of expertise
    - promote recruitment of young professionals

5.3. Human Resources and Capacity Requirements – Chemical Status Assessment

5.3.1. Required Functions and Roles

Chemical status assessment under the WFD requires a combination of **field sampling staff, laboratory analysts, QA/QC specialists, and data experts**. Minimum functional roles include:

- **Sampling teams (2–3 persons per campaign)**:
    - Trained technicians for water, sediment, and biota sampling
    - Knowledge of WFD-compliant sampling protocols and preservation requirements
- **Laboratory analysts**:
    - Chemists specialised in trace analysis of Priority Substances
    - Expertise in organic and inorganic pollutant analysis (e.g. metals, pesticides, PAHs)
- **Instrumentation specialists**:
    - Operation and maintenance of advanced analytical equipment (e.g. GC-MS, LC-MS/MS, ICP-MS)
- **QA/QC officers**:
    - Oversight of quality systems, calibration, validation, and interlaboratory comparisons
- **Data management and assessment experts**:
    - Processing of analytical results
    - Compliance checking against Environmental Quality Standards (EQS)
    - Preparation of WISE-compatible datasets

5.3.2. Competence and Laboratory Requirements

- Laboratories must achieve and maintain **accreditation (e.g. ISO/IEC 17025)**
- Analytical methods must meet **WFD performance criteria**, including:
    - limits of quantification below EQS values
    - validated and standardised methods
- alternatively, collaboration with regional and beyond regional laboratories should be considered to overcome national limitations
- Staff must be trained in:
    - trace-level chemical analysis
    - sampling and preservation techniques
    - uncertainty estimation and quality control

5.3.3. Equipment and Technical Capacity

- Adequate infrastructure is required, including:
    - advanced analytical instruments (GC-MS, LC-MS/MS, ICP-MS)
    - laboratory information management systems (LIMS)
- Capacity for **biota and sediment analysis** must be ensured, not only water samples
- Regular calibration and maintenance of equipment is essential

5.3.4. Training and Quality Assurance

- Continuous **training in analytical methods and QA/QC procedures** is required
- Mandatory participation in:
    - interlaboratory comparison exercises
    - proficiency testing schemes
- Training should target RBMP-identified weaknesses, including:
    - incomplete monitoring of Priority Substances
    - insufficient detection limits
    - inconsistent QA/QC application

5.3.5. Organisational Considerations

- Chemical monitoring should be **institutionalised and not project-based** and sustainably budgeted
- Strong coordination between:
    - sampling teams
    - laboratories
    - competent authorities
- Clear workflows are required from sampling to reporting to ensure **data traceability and compliance**

6. GAP ANALYSIS VS. EU REQUIREMENTS (WFD IMPLEMENTATION ROADMAP)

6.1. Purpose of the Gap Analysis

The purpose of this gap analysis is to assess the current status of surface water monitoring in North Macedonia against the **target state defined by the Monitoring Development Plan (MDP)**, which reflects the requirements of the EU Water Framework Directive (WFD).

The analysis is structured according to the **six implementation phases defined in Chapter 4**, which represent the progressive development of a WFD-compliant monitoring system, from system design to operational integration. The comparison evaluates the extent to which North Macedonia has achieved these phases, identifying gaps between:

- the **required (target) monitoring system**, and
- the **current level of implementation**, as evidenced by RBMPs, institutional arrangements, and EU screening findings (Chapter 27).

6.2. Phase-by-Phase Gap Overview

While North Macedonia has established the fundamental legal and planning framework for WFD-compliant monitoring, substantial gaps persist across all operational phases—especially in monitoring implementation, data integration, and ecological status assessment—resulting in a system that is only partially functional and not yet fully institutionalised.

Table 9: General gap overview aligned with MDP phases.

MDP Phase	WFD Requirement	Current Status in North Macedonia	Gap Level
Phase 1 – Characterisation	Full typology, pressures, risk assessment	Largely developed through RBMPs (Bregalnica, Strumica, Vardar draft), but based on incomplete and uneven datasets; pressure and risk analysis partly reliant on assumptions due to limited monitoring data	**Moderate**
Phase 2 – Programme Design	WFD-compliant monitoring (BQEs, chemicals, network)	Monitoring design included in RBMPs and project documents, but remains partly conceptual; strong focus on physico-chemical parameters, while biological quality elements (BQEs) are insufficiently developed; incomplete methodological standardisation	**High**
Phase 3 – Implementation	Regular, systematic monitoring campaigns	Monitoring networks partially implemented; limited spatial coverage, inconsistent frequency, and strong dependence on project-based monitoring campaigns; biological monitoring largely absent or irregular	**Very High**
Phase 4 – QA/QC & Data	Accredited labs, QA/QC systems, integrated databases	Fragmented data management systems; limited QA/QC implementation; absence of a fully operational national water information system; weak interoperability between institutions and datasets	**Very High**
Phase 5 – Assessment & Reporting	Full classification (EQR, EQS) and WISE reporting	Ecological status assessments incomplete or uncertain due to insufficient data; limited application of WFD classification methods; reporting not yet fully aligned with WISE requirements; RBMPs based on partial datasets	**Very High**
Phase 6 – Adaptive Improvement	Continuous optimisation of monitoring system	Improvements ongoing, mainly driven by international projects (e.g. Vardar RBMP development, groundwater programme); system not yet institutionalised; no continuous monitoring cycle or adaptive management loop fully in place	**High**

6.3. Key Systemic Gaps Identified

The phase-based gap analysis reveals that the challenges in developing a WFD-compliant surface water monitoring system in North Macedonia are not isolated technical issues, but rather reflect a set of **systemic gaps affecting the entire water management framework**. These gaps are interconnected and mutually reinforcing, limiting the effectiveness of monitoring, planning, and implementation processes.

A primary and overarching gap is the **insufficient development and operationalisation of the monitoring system**, which represents the central bottleneck for WFD implementation. Although monitoring requirements are clearly defined in the legal framework, their practical implementation remains incomplete. Monitoring networks do not yet provide adequate spatial coverage or temporal continuity, and important quality elements—particularly biological parameters required for ecological status classification—are insufficiently addressed. As a result, the monitoring system does not yet fulfil its intended role as the foundation for evidence-based water management.

Closely linked to this is the **gap between formal legal compliance and practical implementation capacity**. North Macedonia has made substantial progress in transposing the WFD and related EU directives into national legislation, thereby establishing a solid legal basis for water management. However, the operationalisation of these legal provisions is constrained by limited technical, institutional, and financial capacities. This results in a situation where **legal requirements exist, but are only partially implemented in practice**, especially in areas such as monitoring, data processing, and enforcement.

Another systemic issue concerns the **fragmentation of institutional responsibilities**. Water management functions are distributed across multiple institutions, including ministries responsible for environment and agriculture, monitoring agencies, and local authorities. While such a division reflects the multi-dimensional nature of water management, the lack of effective coordination mechanisms leads to inefficiencies and inconsistencies. In particular, the separation between monitoring responsibilities, policy development, and implementation hinders the creation of an integrated system where data collection, analysis, and decision-making are fully aligned.

The analysis further highlights a **critical weakness in data management and information systems**. Monitoring data are collected by different institutions, often using varying methodologies and formats, and are not systematically integrated into a unified national system. The absence of a fully functional **Water Information System** limits the ability to perform reliable status assessments, track trends, and ensure consistent reporting. Consequently, the process of ecological and chemical status classification remains uncertain and incomplete, affecting the overall quality of RBMPs and decision-making processes.

A related gap is the **limited application of WFD-compliant assessment and classification methodologies**. Due to insufficient monitoring data and methodological inconsistencies, the classification of water bodies based on ecological status (including EQR and EQS standards) is often incomplete or based on approximations. This undermines one of the core objectives of

the WFD, which is to provide a scientifically robust and harmonised basis for water status assessment and management.

An additional systemic challenge is the **strong dependence on externally funded, project-based initiatives**. Many key developments in monitoring, RBMP preparation, and capacity-building have been supported by international donors and cooperation programmes. While these initiatives have significantly contributed to progress, they have also resulted in uneven development across river basin districts and limited sustainability. The lack of a stable, nationally financed and institutionalised system reduces continuity and makes long-term planning difficult.

At the same time, the analysis identifies a notable but underutilised opportunity in the form of **existing scientific capacity within the country**, (e.g. Hydrobiological Institute – Ohrid). However, the role of this national capacity within the formal WFD monitoring framework is limited and not systematically integrated. The insufficient use of such expertise represents a missed opportunity to strengthen biological monitoring and improve the scientific quality of water status assessments.

A critical cross-cutting gap in the development of the monitoring system is the **insufficient and unstable allocation of financial resources**. Although legal provisions require the establishment of comprehensive monitoring networks and data systems, the available national budget is not adequate to support their full implementation. This is reflected in:

- limited expansion and maintenance of monitoring stations
- insufficient frequency of sampling campaigns
- lack of investment in laboratory capacity and equipment
- constraints in staffing and technical expertise

As a result, many key developments in monitoring and data systems have relied heavily on **externally funded projects and international support programmes**, rather than being financed through stable national budgets. This creates a lack of continuity and sustainability, as monitoring activities are often dependent on project cycles rather than being embedded in regular institutional operations. The absence of a **dedicated, long-term financing mechanism for water monitoring** represents a major barrier to achieving full WFD compliance. Without sufficient domestic funding, it is unlikely that monitoring systems can be expanded, maintained, and operated at the level required for reliable ecological status assessment and adaptive water management.

Finally, the system is characterised by the **lack of a fully functional adaptive management cycle**, which is a core principle of the WFD. Monitoring results are not yet consistently feeding into iterative planning and management processes, and RBMP updates are not implemented in a regular, structured manner. This limits the ability of the system to respond dynamically to changes in water status, pressures, and environmental conditions.

In summary, the key systemic gaps can be understood as a combination of:

1. Monitoring system deficiency
2. Legal vs implementation gap
3. Institutional fragmentation
4. Data system weakness
5. Methodological gaps
6. Project dependency
7. Funding constraints
8. Underutilised scientific capacity
9. Lack of adaptive cycle

Addressing these systemic gaps will be essential for progressing from a partially functional framework towards a **fully operational and WFD-compliant water monitoring and management system**, and forms the basis for the priority actions outlined in the following sections.

6.4. Gap-to-Action Matrix (Priority Measures)

The gap-to-action matrix links the identified systemic gaps to targeted measures and positions them within the WFD implementation cycle. This approach ensures that recommended actions are consistent with the phased development of monitoring systems and river basin management planning.

Table 10: Gap-to-Action Matrix identifying key measures.

Gap Area	Identified Gap (North Macedonia)	Key Measures	MDP Phase(s)
Legal and Regulatory Framework	Secondary legislation incomplete or inconsistently applied; lack of detailed technical standards for monitoring and classification	- Develop and adopt missing bylaws for WFD monitoring - Harmonise national standards with EU CIS guidance - Define clear methodologies for status classification (EQR/EQS) - Ensure enforceability through regulatory updates	Phase 1, Phase 2
Institutional Coordination	Fragmented institutional responsibilities and weak coordination between MoEPP, MAFWE, HMS, and municipalities	- Establish formal inter-institutional coordination mechanism (e.g. national WFD coordination body) - Clarify roles and responsibilities for monitoring and data management - Strengthen river basin management councils - Introduce coordination protocols for data sharing and planning	Phase 1, Phase 5, Phase 6
Monitoring Network Design	Monitoring design partially developed but not fully WFD-compliant; insufficient inclusion of	- Finalise and update national monitoring programme - Ensure full inclusion of WFD parameters (BQEs, chemicals, hydromorphological)	Phase 2

	biological quality elements	- Optimise monitoring network design (location, density, frequency) - Align monitoring types (surveillance, operational, investigative) with WFD requirements	
Monitoring Implementation	Limited spatial coverage, low frequency, and strong reliance on project-based monitoring; biological monitoring largely missing	- Expand monitoring network (surface water + priority locations) - Increase sampling frequency and regularity - Establish permanent biological monitoring programmes - Integrate scientific institutions (e.g. HIO) into national monitoring operations	Phase 3
Laboratory Capacity and QA/QC	Limited QA/QC systems, lack of accredited laboratories for full parameter range, inconsistent analytical methods	- Upgrade laboratory infrastructure and equipment - Implement QA/QC systems in line with EU standards - Achieve/accredit laboratories for required WFD parameters - Standardise sampling and analytical procedures nationwide	Phase 4
Data Management and Information Systems	Fragmented datasets, no integrated national water information system, weak interoperability	- Develop a national Water Information System (WIS) - Integrate monitoring data from all institutions - Standardise data formats and reporting procedures - Enable compatibility with WISE (EU reporting system)	Phase 4, Phase 5
Status Assessment and Classification	Incomplete and uncertain ecological and chemical status classification due to insufficient data and methodologies	- Develop national classification systems (EQR, EQS) - Apply WFD-compliant assessment methodologies - Improve data quality and completeness - Train experts in ecological status assessment	Phase 5
RBMP Integration	RBMPs based on incomplete monitoring data; weak link between monitoring and planning	- Strengthen integration of monitoring results into RBMPs - Improve prioritisation of measures based on data - Ensure all RBMPs follow harmonised methodology - Finalise and adopt RBMPs for all RBDs	Phase 5
Adaptive Management	Lack of continuous monitoring cycle and feedback into planning; system not fully institutionalised	- Establish regular 6-year RBMP and monitoring cycle - Introduce adaptive management procedures - Use monitoring results for iterative	Phase 6

		planning updates - Strengthen performance evaluation mechanisms	
Scientific Integration	Underutilisation of Hydrobiological Institute – Ohrid and other scientific expertise, especially for biological monitoring	- Formally integrate HIO into monitoring system - Assign responsibilities for biological quality elements - Use scientific institutions for method development and QA/QC - Strengthen cooperation between research and authorities	Phase 3, Phase 4, Phase 5
Financing and Sustainability	Insufficient and unstable national budget; heavy reliance on donor-funded projects	- Establish dedicated national budget for monitoring - Secure long-term financing mechanisms - Reduce dependency on external projects - Prioritise monitoring investments in national strategies	All phases (1–6)
Capacity and Training	Limited technical and administrative capacity in institutions and laboratories	- Implement continuous training programmes - Strengthen institutional staffing for monitoring and data analysis - Build expertise in WFD methodologies and reporting - Develop national competence centres	Phase 2, Phase 3, Phase 4, Phase 5

6.5. Conclusions

The gap analysis presented in this chapter demonstrates that North Macedonia has made **substantial progress in establishing the legal and conceptual foundation** for WFD-compliant surface water monitoring, but remains at an **intermediate stage of implementation**, where key elements of the system are still not fully operational. The analysis across the six MDP phases clearly shows a **structural imbalance between relatively advanced planning and legislative components and significantly underdeveloped operational capacities**, particularly in monitoring implementation, data management, and system integration.

At the strategic level, North Macedonia has achieved a **high degree of alignment with EU water policy**, especially through the transposition of the Water Framework Directive into national legislation and the development of river basin management planning structures. The delineation of four river basin districts and the preparation of several RBMPs provide a solid basis for integrated water management. However, these foundations are not yet supported by fully functional technical and institutional systems, resulting in a **gap between formal compliance and effective implementation**. This gap is a central theme across all phases of the analysis.

The most critical bottleneck identified is the **incomplete development of the monitoring system**, which affects nearly all subsequent stages of the WFD implementation cycle. Monitoring networks are only partially implemented, with limited spatial coverage, inconsistent sampling frequency, and significant gaps in biological monitoring. As a result, the system does not yet provide the comprehensive and reliable datasets required for ecological and chemical status classification. This directly undermines the effectiveness of RBMPs, as planning and prioritisation of measures cannot be fully based on robust evidence.

Closely linked to this issue is the **weakness in data management and information systems**. The absence of an integrated national Water Information System results in fragmented data collection, inconsistent methodologies, and limited interoperability between institutions. Consequently, the assessment and reporting of water status remain incomplete and uncertain, and the ability to meet WFD reporting requirements, including alignment with WISE, is constrained. This highlights the need for a systematic approach to data integration, standardisation, and quality assurance.

The analysis also reveals that **institutional fragmentation and limited coordination mechanisms** significantly reduce the efficiency of water management. While responsibilities are formally defined across multiple institutions, the lack of effective coordination between policy development, monitoring, and implementation creates barriers to an integrated system. This fragmentation is further compounded by **capacity constraints**, including limited staffing, technical expertise, and laboratory capabilities, which restrict the ability to implement monitoring programmes at the required scale and quality.

Another key finding is the **strong dependence on externally funded, project-based initiatives**, particularly for RBMP development, monitoring improvements, and capacity building. While these projects have been instrumental in advancing WFD implementation, they have also resulted in uneven development across river basin districts and limited long-term sustainability. This situation is closely linked to **insufficient and unstable national funding**, which does not yet provide a reliable basis for the continuous operation and maintenance of monitoring systems. The lack of a dedicated and sustained financing mechanism emerges as a major barrier to achieving a fully operational monitoring system.

Overall, the findings indicate that North Macedonia has successfully progressed through the **initial phases of WFD implementation**, particularly in terms of legislative alignment and conceptual planning. The main challenge now lies in advancing the system through the **operational phases**, which require substantial investments in monitoring infrastructure, data systems, institutional capacity, and coordination mechanisms. Without addressing these systemic gaps, the transition to a fully functional, WFD-compliant monitoring and management system will remain incomplete.

In conclusion, North Macedonia stands at a **critical transition point**, where the focus must shift from framework development to **practical implementation and system consolidation**. The priorities identified in this chapter—strengthening monitoring networks, establishing integrated data systems, improving institutional coordination, ensuring sustainable financing, and utilising existing scientific capacity—provide the foundation for the targeted actions and timeline outlined in the following roadmap (Chapter 7).

7. ROADMAP 2026–2030 (IMPLEMENTATION PLAN)

The following roadmap translates the identified gaps into a **time-bound implementation plan (2026–2030)** aligned with the **identified gaps, MDP phases, RBMP findings, and EU Chapter 27 context.**

Table 11: Roadmap for Monitoring Development (2026–2030).

Task	Time-frame	Strategic Focus	Key Actions	Expected Outputs
Task A – System Completion	**2026–2027**	Finalisation of monitoring design and legal framework	- Complete national monitoring programme design (all WFD parameters) - Develop and adopt secondary legislation and technical guidelines - Define QA/QC framework and classification methodologies - Clarify institutional roles and coordination mechanisms	- Adopted/updated bylaws and monitoring regulations - Fully defined WFD-compliant monitoring programme - National standards and methodologies for classification (EQR/EQS) - Established institutional coordination structure
Task B – Capacity and Infrastructure Build-up	**2026–2027**	Strengthening institutional, technical, and laboratory capacity	- Upgrade monitoring infrastructure (stations, sampling equipment) - Expand laboratory capacity and accreditation - Recruit and train technical staff (incl. biological experts; e.g. integrate Hydrobiological Institute – Ohrid)	- Expanded and operational monitoring network - Accredited laboratories for WFD parameters - Operational monitoring teams across RBDs - Institutional integration of hydrobiological expertise
Task C – Full Monitoring Implementation	**2027–2028**	Establishing regular and systematic monitoring	- Implement surveillance and operational monitoring programmes - Introduce systematic biological monitoring (BQEs) - Ensure consistent sampling frequency and coverage - Reduce reliance on project-based monitoring	- Regular national monitoring campaigns - Complete datasets for physico-chemical and biological parameters - Improved spatial and temporal coverage - Operational WFD-compliant monitoring system
Task D – Data Integration and Assessment	**2028–2029**	Development of data systems, classification, and reporting	- Develop national Water Information System (WIS) - Integrate data from all institutions into central system - Apply WFD-compliant classification	- Operational national water database (WIS) - First reliable ecological and chemical status assessment - Harmonised datasets for all RBDs

			methodologies - Establish validation and QA workflows	- Improved RBMP evidence base
Task E – RBMP Update and Optimisation	**2029–2030**	Integration into planning cycle and transition to adaptive management	- Use monitoring results to update RBMPs - Improve prioritisation of measures based on data - Introduce adaptive management cycle - Secure long-term financing mechanisms	- Updated RBMPs based on robust monitoring data - Fully operational WFD planning cycle - Optimised monitoring system - Sustainable financing framework
Task F – System Consolidation and Sustainability	**Cross-cutting (2026–2030)**	Ensuring long-term sustainability and institutionalisation	- Establish stable national funding for monitoring - Strengthen institutional coordination and governance - Implement continuous training and capacity development - Align reporting with EU (WISE) requirements	- Institutionalised monitoring system - Reduced dependency on external projects - Improved governance and coordination - Full alignment with EU reporting obligations

7.1. Link to WFD Planning Cycles

The phased roadmap is designed to align North Macedonia's monitoring system with the six-year planning cycle of the Water Framework Directive (WFD), ensuring readiness for the next River Basin Management Plan (RBMP) iteration. It provides a structured pathway for transitioning from a partially operational and project-based monitoring system to a fully WFD-compliant, institutionalised, and adaptive water management framework by 2030**.**

- **2026–2027:** Transition phase from planning and fragmented implementation towards a more structured and coordinated monitoring system, including completion of monitoring design and strengthening of institutional capacities
- **2027–2029:** Progressive data generation through expanded and more systematic monitoring programmes, enabling improved ecological and chemical status assessment
- **2029–2030:** Integration of monitoring results into the next RBMP cycle and fulfilment of reporting obligations, including alignment with EU WISE requirements

By following the outlined steps, North Macedonia could, by the next RBMP update:

- establish **more comprehensive and reliable biological and chemical datasets**, including full coverage of key WFD parameters
- achieve a **fully or largely operational monitoring system**, with improved spatial and temporal coverage
- significantly improve the **quality and reliability of ecological status classification and reporting**, in line with WFD requirements

7.2. Strategic Priorities

To ensure successful implementation of the roadmap, the following priorities must be addressed:

- **Strengthen and expand the monitoring network**
  → Improve spatial coverage and ensure representative monitoring of all water bodies, including pressure and reference sites, with particular focus on under-monitored river basins and priority water bodies
- **Achieve full WFD-compliant parameter coverage**
  → Ensure comprehensive integration of biological, physico-chemical, and chemical quality elements, including priority substances, with a particular emphasis on strengthening currently underdeveloped biological monitoring
- **Ensure consistent and regular monitoring implementation**
  → Establish systematic and continuous monitoring programmes aligned with WFD requirements and move away from fragmented, project-based monitoring towards fully institutionalised operations
- **Establish an integrated Water Information System (WIS)**
  → Develop a centralised national system for harmonising monitoring data across institutions (MoEPP, HMS, laboratories, scientific institutions) and ensure compatibility with EU WISE reporting requirements
- **Strengthen data quality, QA/QC systems, and laboratory capacity**
  → Improve standardisation of monitoring and analytical methods, implement QA/QC procedures in line with EU standards, and upgrade laboratory infrastructure and accreditation
- **Enhance institutional coordination and technical capacity**
  → Strengthen cooperation between responsible institutions through formal coordination mechanisms, clarify roles and responsibilities, and increase human and technical resources for monitoring and data management
- **Improve ecological status assessment and classification systems**
  → Develop and apply robust WFD-compliant methodologies (EQR, EQS) and transition from partly provisional assessments towards reliable, data-driven ecological and chemical classification
- **Strengthen the linkage between monitoring and river basin management planning**
  → Ensure that monitoring results are systematically used to support RBMP development, prioritise measures, and improve decision-making at basin level
- **Secure sustainable financing for monitoring systems**
  → Establish stable and long-term national funding for monitoring, reducing reliance on externally funded projects and ensuring continuous operation, maintenance, and development of monitoring systems
- **Integrate scientific expertise into the monitoring system**

→ Strengthen the role of institutions in biological monitoring, ecological assessment, and methodological development to improve scientific robustness

- **Promote adaptive management and system optimisation**
  → Establish a continuous cycle of monitoring, evaluation, and planning, allowing for regular updates of RBMPs and optimisation of monitoring networks based on results and evolving pressures

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