

Module 9: Legislative requirements and risk management for wastewater reuse

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SYMSITES

Module Overview

Water reuse is an essential component of I-US, however implementing wastewater reuse projects requires compliance with regulatory frameworks and the adoption of robust risk management practices to ensure the protection of human health and the environment. In this module, industry representatives can gain an overview of the legislative requirements governing wastewater reuse, particularly within the European regulatory context, and explore the risk management principles needed to design, operate, and monitor safe reuse systems.

- [Chapter 9.1: Legislative requirements and risk management for wastewater reuse](#)





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Chapter 9.1: Legislative requirements and risk management for wastewater reuse

This chapter addresses laws and regulations related to the use of treated wastewater for industry, ensuring companies understand compliance requirements, safety standards, and sector-specific legal frameworks for using reclaimed water in production processes. Since wastewater reuse plays a crucial role in industrial symbiosis, this section also explores risk management for the supply of reclaimed water, covering contamination risks, supply consistency, and quality assurance strategies.

- Target audience: Industry and SMEs
- Estimated time: 15 minutes
- Includes: Explanations





Wastewater reuse

Wastewater reuse is a key pillar of Industrial Urban Symbiosis (I-US) because it allows industries and urban systems to exchange water resources, reduce freshwater abstraction, and create circular water systems. However, implementing wastewater reuse requires strict compliance with European, national and local regulatory frameworks, alongside robust risk management systems to ensure that reuse activities protect human health, ecosystems, and economic activities.

In the European Union, wastewater reuse is governed primarily by the EU Water Reuse Regulation (EU) 2020/741, which establishes minimum requirements for water quality, monitoring, and risk management when reclaimed water is used. This regulation requires the development of a Risk Management Plan (RMP) for any water reuse scheme.





Wastewater reuse

For industries and SMEs, this means that wastewater reuse is not simply a technical issue but a governance, compliance, and risk management challenge that requires:

- Understanding applicable legislation and permitting procedures
- Implementing a risk-based management framework
- Establishing monitoring and operational control systems
- Managing environmental, health and operational risks
- Coordinating with authorities, utilities and other industrial partners

Within the I-US framework, wastewater reuse projects often involve multiple stakeholders, such as municipal wastewater treatment plants, industrial facilities, utilities, farmers, and local authorities. A structured approach to compliance and risk management is therefore essential.





Legislative framework for wastewater reuse

Key EU regulatory instruments include:

Water and environmental protection

- **Water Framework Directive (2000/60/EC)**
Ensures good ecological and chemical status of European water bodies.
- **Urban Wastewater Treatment Directive (91/271/EEC)**
Governs wastewater collection and treatment requirements.
- **Groundwater Directive (2006/118/EC)**
Protects groundwater against pollution and deterioration.
- **Environmental Impact Assessment Directive (2011/92/EU)**
Requires environmental impact assessments for certain projects.
Scenario analysis

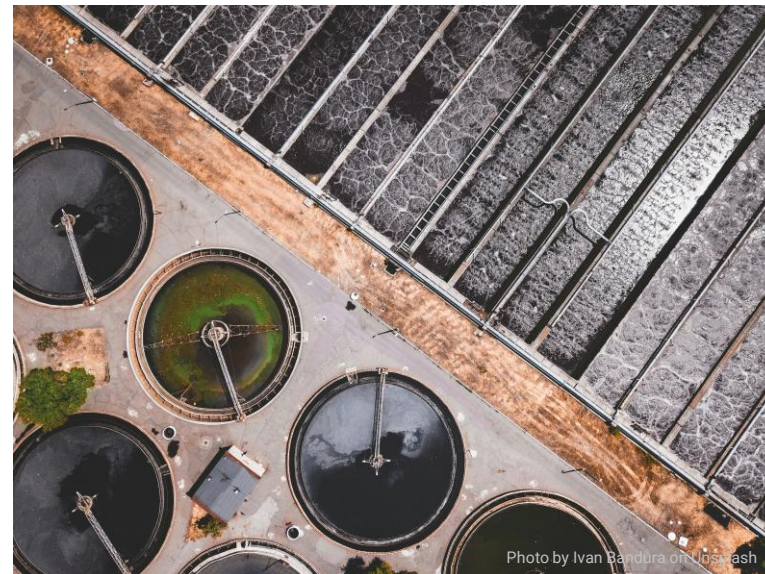




Legislative framework for wastewater reuse

Agriculture and food safety

- **General Food Law Regulation (EC 178/2002)**
Establishes safety principles for food production chains.
- **Hygiene Regulations (EC 852/2004 and 853/2004)**
Regulate hygiene requirements in food production.
- **Chemical and environmental safety**
- **REACH Regulation (EC 1907/2006)**
Addresses chemical substances used or discharged by industry.
- **Industrial Emissions Directive (2010/75/EU)**
Regulates emissions from industrial installations.





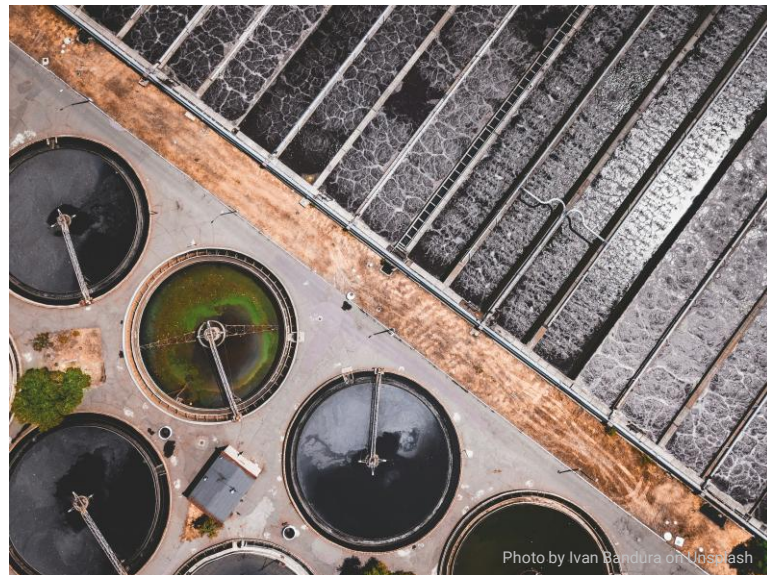
Legislative framework for wastewater reuse

Circular economy and resource efficiency

- EU Circular Economy Action Plan
- Zero Pollution Action Plan
- Water reuse strategy initiatives

For industries implementing I-US systems, it is essential to understand that **water reuse compliance is multi-layered**, involving both **water quality regulations and industrial environmental regulations**.

The European Union's primary framework for reclaimed-water use is Regulation (EU) 2020/741, which establishes minimum water-quality, monitoring, and risk-management requirements for the safe reuse of treated urban wastewater in agricultural irrigation. The regulation defines four reclaimed-water classes (A–D) with corresponding microbiological criteria and pathogen-reduction targets, detailed in tables 1 and 2 below.





Legislative framework for wastewater reuse

It also mandates a **Water Reuse Risk Management Plan**, a permit system, and clear allocation of responsibilities for operators and competent authorities. However, the regulation **applies exclusively to agriculture** and does not cover industrial reuse. Industrial wastewater streams are mentioned only as sources entering a municipal wastewater treatment plant, not as industrial or energy-sector reuse classes.

Industrial applications instead fall under the Urban Wastewater Treatment Directive (91/271/EEC) adopted in 1991, which requires Member States to collect and biologically treat urban wastewater, regulate industrial discharges into sewer systems, and ensure that treated effluent meets defined performance standards before release to the environment. Implementation of reclaimed-water use varies significantly across Member States due to differences in water scarcity, infrastructure capacity, and public acceptance.





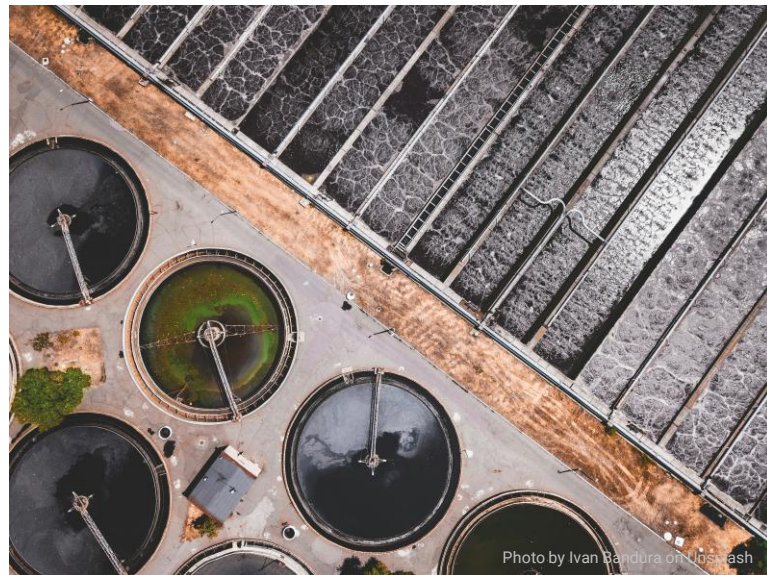
Legislative framework for wastewater reuse

National and local regulatory requirements

In addition to EU legislation, **Member States establish their own regulatory frameworks** to implement and enforce water reuse. These may include:

- Permits for water reuse operations
- Environmental discharge permits
- Industrial wastewater pre-treatment requirements
- Water abstraction and reuse licenses
- Water quality monitoring obligations
- Land use and irrigation restrictions

Countries such as Spain have advanced reuse systems supported by comprehensive national legislation. Royal Decree 1085/2024, Spain's updated EU-aligned framework, defines detailed quality classes and treatment requirements across agricultural, urban, and industrial applications.





Legislative framework for wastewater reuse

For agriculture, the four classes A.A–A. establish microbiological and physico-chemical thresholds tailored to crop-risk levels. Urban uses follow a parallel tiered structure, U.A+–U.C which set limits for turbidity, suspended solids, and E. coli, together with mandatory Legionella bacteria control for aerosol-generating activities. Industrial and process-related uses include requirements for cooling systems, general industrial washing, and other non-food applications, with minimum quality criteria based on secondary-effluent standards and disinfection performance.

Together, these classifications create a clear enforceable framework that enables safe, large-scale water reuse across Spain's agricultural, industrial, and urban sectors.





Legislative framework for wastewater reuse

Industries should work closely with:

- Environmental protection agencies
- Water authorities
- Local municipalities
- Agricultural regulators

SMEs often underestimate the **time required for permitting processes**, which may involve:

- Environmental impact assessments
- Public consultations
- Risk management plan approval
- Compliance inspections

Early engagement with authorities can significantly **reduce regulatory barriers and project delays**.





Risk management framework for wastewater reuse

The risk-based approach

Traditional water management relied mainly on **end-of-pipe monitoring**, meaning water quality was tested after treatment. However, wastewater reuse systems require a **preventive, risk-based approach** that considers the entire water reuse system

Risk management aims to:

- Identify **hazards and hazardous events**
- Assess **human health and environmental risks**
- Implement **preventive measures and barriers**
- Monitor system performance
- Ensure continuous improvement

A **Risk Management Plan (RMP)** is therefore a mandatory element of water reuse schemes in the EU.





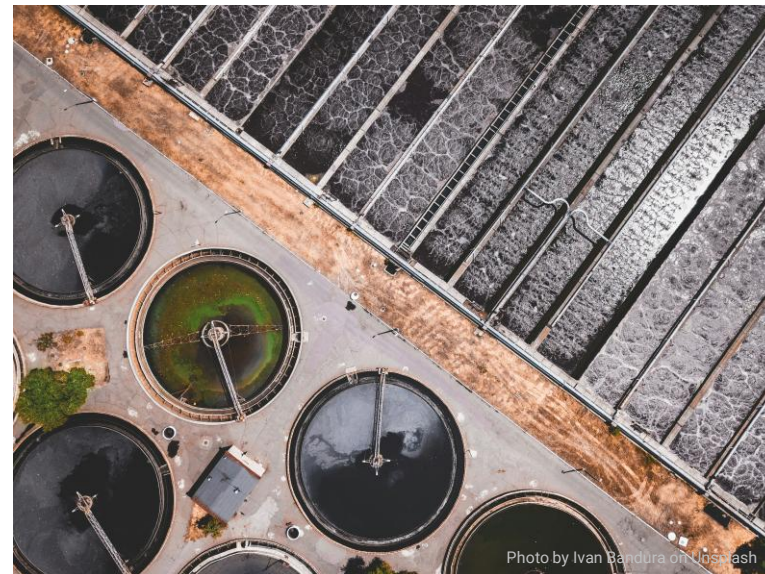
Risk management framework for wastewater reuse

Key objectives of the RMP include:

- Protecting **human health**
- Protecting **environmental resources**
- Ensuring **reliable water reuse operations**
- Maintaining **regulatory compliance**

Risk management modules

The EU guidance framework organizes risk management into **four modules**, which provide a structured methodology for industries and SMEs implementing reuse systems.





Risk management framework for wastewater reuse

Module I – System description

The first step involves understanding the **entire water reuse system**, including:

- Wastewater sources
- Treatment processes
- Storage infrastructure
- Distribution networks
- Reuse applications
- Environmental context

Industries should develop **detailed system maps** showing:

- Water flows
- Treatment stages
- Reuse locations
- Environmental receptors





Risk management framework for wastewater reuse

Tools that can support system analysis include:

- **Process flow diagrams**
- **GIS mapping**
- **Water balance assessments**
- **Digital water management platforms**

Module II – Risk assessment

Risk assessment is the core analytical phase of the risk management framework. It identifies hazards, evaluates exposure pathways, and assesses potential impacts.





Risk management framework for wastewater reuse

The process typically involves:

1. Hazard identification

Biological hazards: Pathogenic bacteria, Viruses, Protozoa, Helminths

Chemical hazards: Heavy metals, Pesticides, Industrial chemicals, Pharmaceutical residues, Microplastics, Disinfection by-products

Environmental hazards: Nutrient loading, Salinity accumulation, Soil degradation, Groundwater contamination

2. Exposure assessment

Risk assessment identifies who or what may be exposed to hazards.

Potential receptors include:

Industrial workers, Agricultural workers, Local communities, Consumers, Aquatic ecosystems, Soil organisms, Groundwater resources





Risk management framework for wastewater reuse

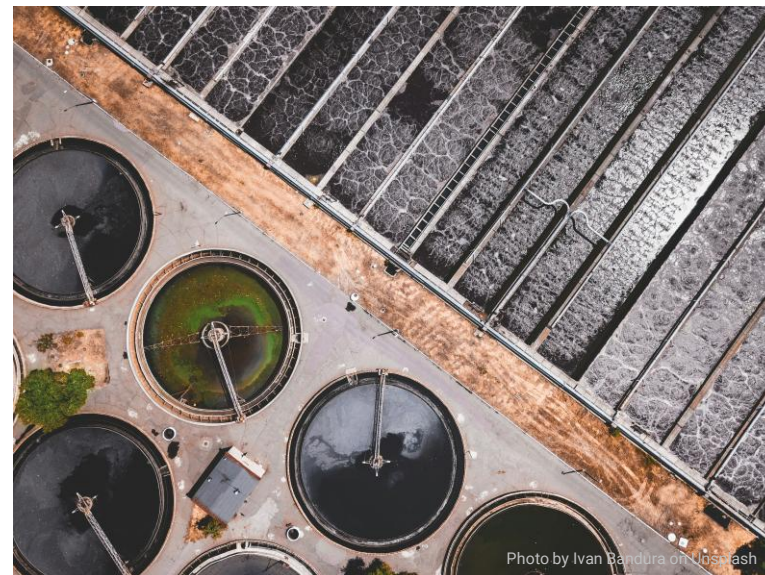
3. Risk evaluation

Risk evaluation determines whether risks are acceptable or require mitigation. Methods may include:

- **Qualitative risk assessment**
- **Semi-quantitative scoring methods**
- **Quantitative microbial risk assessment (QMRA)**

Industries often use **risk matrices** that evaluate:

- Likelihood of hazard occurrence
- Severity of consequences





Risk management framework for wastewater reuse

Module III – Monitoring and quality control

Monitoring ensures that wastewater reuse systems **perform as designed** and comply with regulatory requirements.

Monitoring activities include:

Operational monitoring

- Treatment performance
- Filtration efficiency
- Disinfection effectiveness
- Flow and pressure control

Water quality monitoring

Parameters may include: Microbial indicators (E. coli), Suspended solids, Nutrients, Salinity, Chemical contaminants





Risk management framework for wastewater reuse

Environmental monitoring

Monitoring should also include surrounding environments: Soil quality, Groundwater quality, Surface water bodies, Ecosystem health

Digital monitoring technologies increasingly support these activities:

- **Smart sensors**
- **Online water quality monitoring**
- **IoT-based monitoring networks**
- **AI-based predictive analytics**





Risk management framework for wastewater reuse

Module IV – Management and coordination

Effective wastewater reuse systems require strong **organizational governance and coordination mechanisms**.

Key elements include:

- **Incident management** - Industries should prepare **emergency response protocols** for: Treatment system failures, Contamination events, Infrastructure breakdown, Extreme weather events
- **Communication systems**: Clear communication channels are necessary between: Utilities, Industries, Farmers, Authorities, Local communities
- **Training programs**: Personnel must be trained in: Water reuse operations, Risk management procedures, Emergency response, Monitoring protocols





Risk management tools

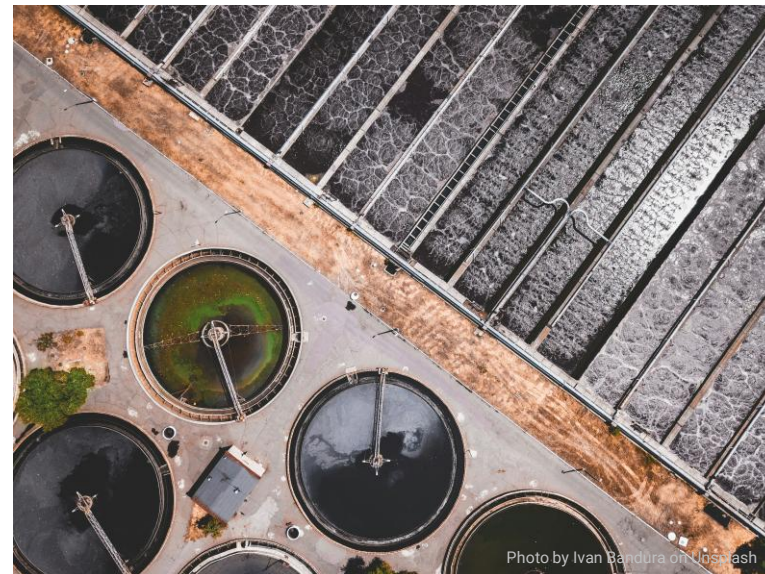
Industries implementing wastewater reuse within I-US systems can use a variety of **practical tools** to manage risks effectively.

Risk identification tools

- Hazard identification workshops
- Process safety analysis
- Failure mode and effects analysis (FMEA)
- HACCP-based approaches

Risk assessment tools

- Risk matrices
- Scenario analysis
- Quantitative microbial risk assessment (QMRA)
- Environmental risk assessment models





Risk management tools

Operational management tools

- Digital monitoring dashboards
- Predictive maintenance systems
- Water reuse safety plans
- Environmental management systems (ISO 14001)

Decision-support tools

- Water reuse feasibility studies
- Cost-benefit analysis
- Life cycle assessment (LCA)
- Multi-criteria decision analysis





Managing key risks in wastewater reuse

Industries implementing reuse systems should consider several critical risk categories.

Public health risks

Potential exposure pathways include:

- Direct contact with reclaimed water
- Aerosols generated during irrigation
- Consumption of contaminated products

Mitigation measures include:

- Advanced treatment technologies
- Worker safety protocols
- Controlled irrigation methods





Managing key risks in wastewater reuse

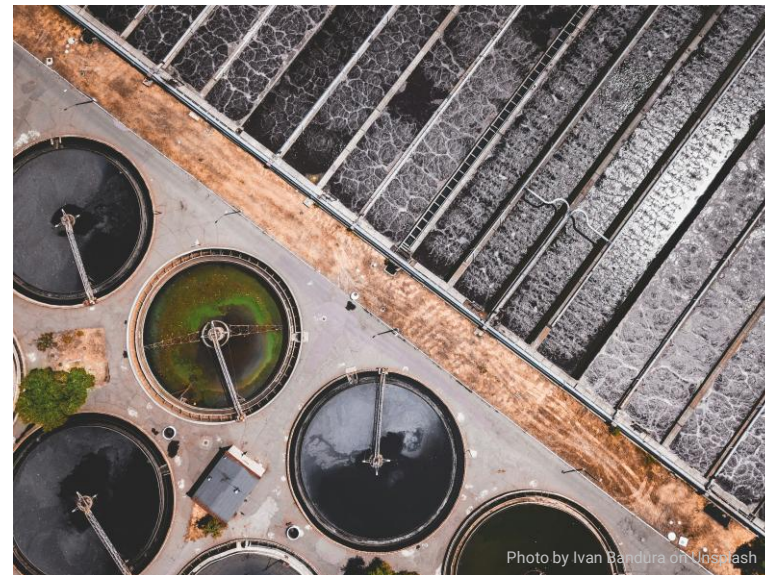
Environmental risks

Environmental risks may involve:

- Soil salinization
- Nutrient accumulation
- Groundwater contamination
- Ecosystem impacts

Mitigation strategies include:

- Soil monitoring programs
- Nutrient management plans
- Controlled irrigation schedules
- Buffer zones near sensitive ecosystems





Managing key risks in wastewater reuse

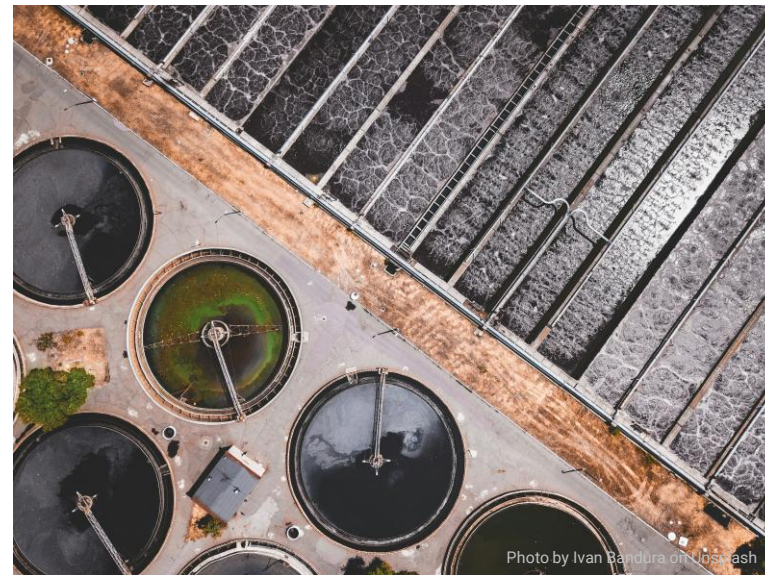
Operational risks

Operational risks may arise from:

- Equipment failure
- Poor treatment performance
- Infrastructure leaks
- Storage system contamination

Key management strategies include:

- Preventive maintenance
- Backup treatment systems
- Operational monitoring
- Early warning systems





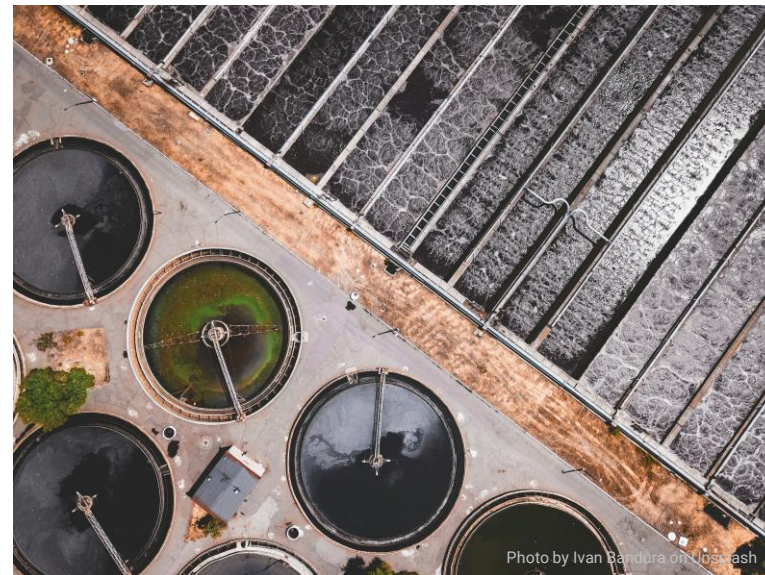
Managing key risks in wastewater reuse

Economic and reputational risks

Industries must also consider:

- Financial viability
- Public acceptance
- Regulatory compliance risks
- Market perception

Transparent governance and stakeholder engagement are critical to ensure **long-term acceptance of reuse systems.**





Best practices for industries implementing wastewater reuse

To ensure successful wastewater reuse projects, industries and SMEs should adopt the following best practices:

Integrate risk management early

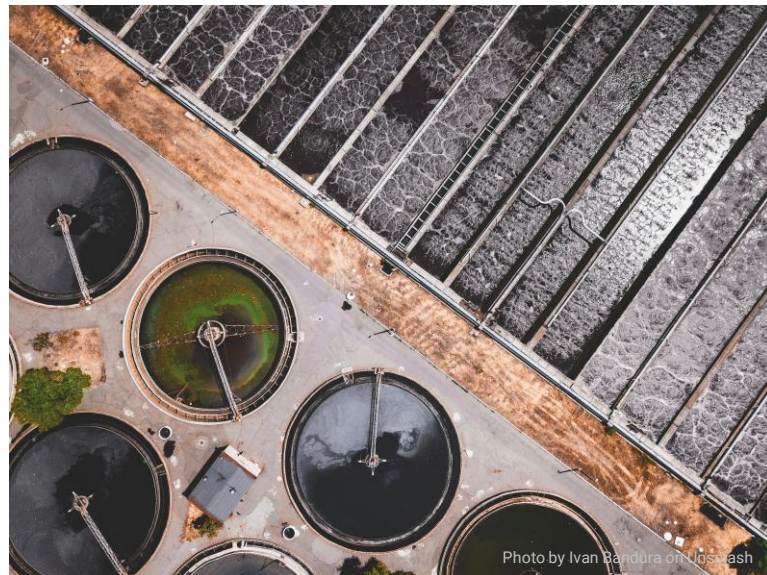
- Conduct risk assessments during project design
- Integrate regulatory requirements from the start

Engage stakeholders

- Work with local authorities and utilities
- Involve communities and end-users

Adopt a multi-barrier approach

- Use multiple protection layers:
- Treatment technologies
- Infrastructure controls
- Operational procedures
- Monitoring systems





Best practices for industries implementing wastewater reuse

Use digital tools

- Smart monitoring systems
- Predictive analytics
- Integrated water management platforms

Continuously improve systems

- Conduct regular audits
- Update risk management plans
- Implement adaptive management strategies





Monitoring, verification and quality control systems

Monitoring and verification are fundamental components of safe wastewater reuse systems. While treatment technologies can significantly reduce contaminants, continuous monitoring ensures that the treatment processes, operational controls, and preventive barriers perform as intended. Monitoring is therefore not only a compliance requirement but also a **core operational management tool** that allows industries and SMEs to detect deviations, prevent failures and ensure long-term safety of reclaimed water reuse.

Within the EU Water Reuse Regulation (2020/741) framework and its risk management plan (RMP), monitoring corresponds mainly to Key Risk Management elements KRM8 and KRM9, which address quality control systems and environmental monitoring systems. These elements ensure that the entire reuse chain (from wastewater treatment to final application) operates safely and consistently.





Monitoring, verification and quality control systems

The main objective of monitoring systems is to confirm that preventive measures and treatment barriers effectively control risks associated with reclaimed water. Monitoring must therefore address both water quality outcomes and operational process performance.

Types of monitoring in wastewater reuse systems

A comprehensive monitoring system for wastewater reuse normally includes three complementary types of monitoring:

1. Operational monitoring

Operational monitoring focuses on **process performance and control measures** within the treatment and distribution system.





Monitoring, verification and quality control systems

The purpose is to verify that technical barriers and operational practices remain effective. In wastewater reuse systems, this often involves monitoring treatment stages and system integrity.

Examples of operational monitoring parameters include:

- **Treatment performance indicators:** Turbidity, Suspended solids (SS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD)
- **Disinfection indicators:** Residual chlorine, UV intensity or dose, Contact time
- **Process integrity indicators:** Membrane pressure and integrity testing, Pumping performance, Flow rates

Operational monitoring often uses **online sensors and automated control systems** to detect abnormal changes quickly. These systems can be integrated into digital plant control platforms such as SCADA (Supervisory Control and Data Acquisition).





Monitoring, verification and quality control systems

2. Compliance monitoring

Compliance monitoring verifies that **reclaimed water meets regulatory quality standards** before being supplied for reuse.

Monitoring parameters typically depend on:

- The **final use of reclaimed water**
- The **risk classification of reuse**
- The **type of treatment technology used**

Common compliance monitoring parameters include:

Microbiological indicators: *E. coli*, Faecal coliforms, Enterococci, Pathogens (in higher-risk applications)

Physicochemical parameters: pH, Electrical conductivity, Nutrients (nitrogen, phosphorus), Salinity indicators





Monitoring, verification and quality control systems

Chemical contaminants: Heavy metals (Pb, Cd, Hg, Ni, Zn, Cu), Pesticides, Industrial chemicals, Pharmaceuticals and emerging contaminants
Compliance monitoring normally occurs at **defined control points**, particularly at:

- The exit of the wastewater reclamation facility
- The point of compliance before distribution
- Selected points within the reuse network

3. Environmental monitoring

Environmental monitoring evaluates whether the use of reclaimed water **affects surrounding ecosystems or environmental compartments.**

Key monitoring targets include:

- Surface water bodies
- Groundwater resources





Monitoring, verification and quality control systems

- Soils and sediments
- Crops and vegetation

Environmental monitoring is especially important when wastewater reuse involves:

- Agricultural irrigation
- Aquifer recharge
- Landscape irrigation
- Industrial cooling or discharge systems

Monitoring programs typically include: Nutrient accumulation in soils, Heavy metal concentrations, Salinity changes, Ecotoxicological indicators, Microbial contamination in nearby water bodies

Environmental monitoring results are essential for detecting long-term impacts and adjusting operational practices if necessary.





Monitoring, verification and quality control systems

Designing a Monitoring Plan

Designing a robust monitoring plan is a central step in the implementation of any wastewater reuse system. The plan serves as a roadmap for systematically collecting, analysing, and interpreting data to ensure that reclaimed water meets quality standards and that operational processes are functioning effectively. A properly designed monitoring plan begins with defining the **specific objectives**, which are derived from the hazards identified in the risk assessment phase. These objectives should clarify which contaminants, parameters, or process indicators need to be tracked, at what frequency, and with what level of accuracy.

The selection of **monitoring parameters** should directly reflect the identified risks, including microbial pathogens, chemical pollutants, nutrients, and other emerging contaminants that could compromise human health, industrial processes, or environmental integrity.





Monitoring, verification and quality control systems

Importantly, the plan must balance comprehensive monitoring with operational feasibility, ensuring that the selected parameters are sufficient to detect deviations without overburdening resources, particularly for SMEs with limited technical capacity.

Sampling locations are another crucial consideration in the design of a monitoring plan. Industries must carefully identify points within the wastewater reuse system where monitoring will provide the most meaningful information. These typically include the wastewater treatment plant effluent, storage reservoirs, distribution networks, and the points of water application in industrial processes or agricultural fields. Sampling at these strategic locations allows operators to verify both the efficacy of treatment and the integrity of the distribution network.

The **monitoring frequency** should be aligned with the risk profile of the system and the variability of the water source.





Monitoring, verification and quality control systems

High-risk parameters, such as microbial indicators or chemical concentrations prone to fluctuation, may require continuous or daily monitoring, while other parameters can be monitored weekly or monthly. Incorporating **event-based monitoring**, triggered by unusual rainfall, industrial discharges, or operational changes, ensures that the system remains responsive to dynamic conditions.

Finally, a modern wastewater reuse monitoring plan benefits from the integration of **advanced monitoring technologies**. Online sensors, automated sampling, and remote telemetry can provide near real-time data, enabling rapid identification of anomalies. Digital dashboards and centralized data management platforms allow operators to visualize trends, compare results against thresholds, and make informed operational decisions. By designing a monitoring plan that is both systematic and flexible, industries can maintain compliance, enhance operational reliability, and proactively manage risks associated with reclaimed water reuse.





Monitoring, verification and quality control systems

Verification and Auditing

Verification and auditing represent the next critical layer in a wastewater reuse risk management framework, ensuring that monitoring data are reliable, procedures are followed, and the overall system functions as intended. Verification is more than simply reviewing monitoring results; it is an **active process of confirming that the monitoring program accurately reflects water quality, system performance, and environmental outcomes.**

The verification process typically includes independent analyses of water samples to validate the results generated by in-house laboratories or automated sensors. Such independent testing helps ensure data integrity and provides regulators and other stakeholders with confidence that the monitoring system is accurate. Verification may also include periodic review of operational records, calibration logs, and maintenance reports, as these documents reveal whether processes and preventive measures are being applied consistently and according to plan.





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Monitoring, verification and quality control systems

Auditing extends verification by evaluating the overall compliance and effectiveness of the risk management system. Audits can be conducted internally by the organization or externally by regulatory authorities or third-party experts. They assess not only whether water quality meets regulatory standards but also whether operational procedures, staff training, and infrastructure management align with the RMP. Auditing provides an opportunity to identify gaps, inefficiencies, or systemic weaknesses that could compromise safety or compliance.

A comprehensive verification and auditing process should also include **cross-checks between monitoring results and actual system performance**, for instance, by comparing treated water quality with environmental outcomes such as soil salinity levels or groundwater contamination indicators.





Monitoring, verification and quality control systems

By systematically documenting verification and audit results, industries create a historical record that supports continuous improvement, informs risk reassessment, and demonstrates accountability to regulators and stakeholders.

In practice, a well-structured verification and auditing system ensures that **monitoring is not only a regulatory formality but also a meaningful tool for proactive management**, guiding operational adjustments, corrective actions, and long-term planning. For SMEs, integrating verification and auditing within existing operational workflows and environmental management systems enhances both efficiency and compliance, ultimately safeguarding human health, industrial processes, and the environment.





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CONSORTIUM MAP

