Groundwater Planning under the RBMPs: Integrating Quantitative and Qualitative Management in Basin Context

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- Role of RBMPs under the EU Water Framework Directive (WFD)
- Aim of RBMPs
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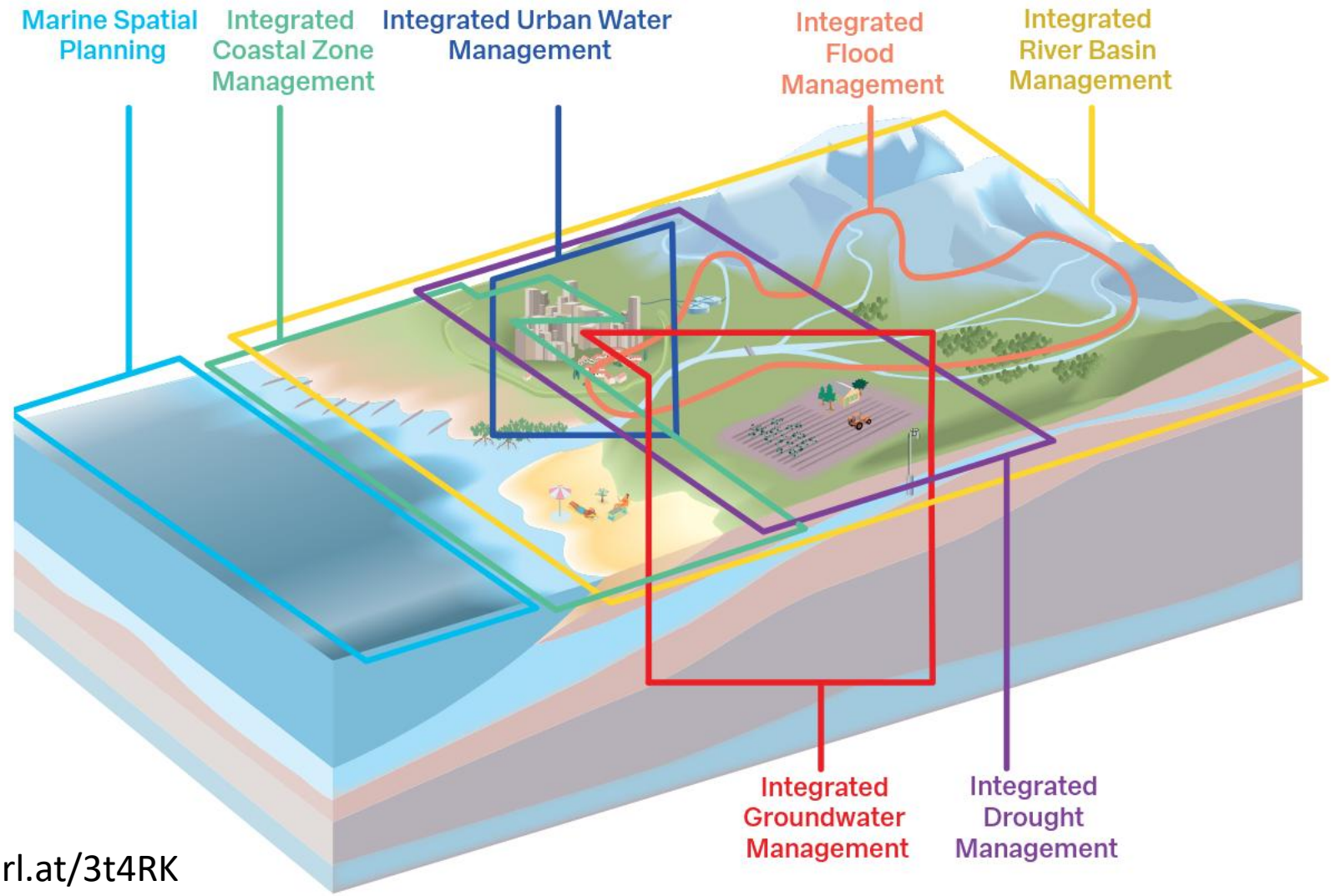
Geospatial coverage of water systems plans



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River Basin Management Plan (RBMP)

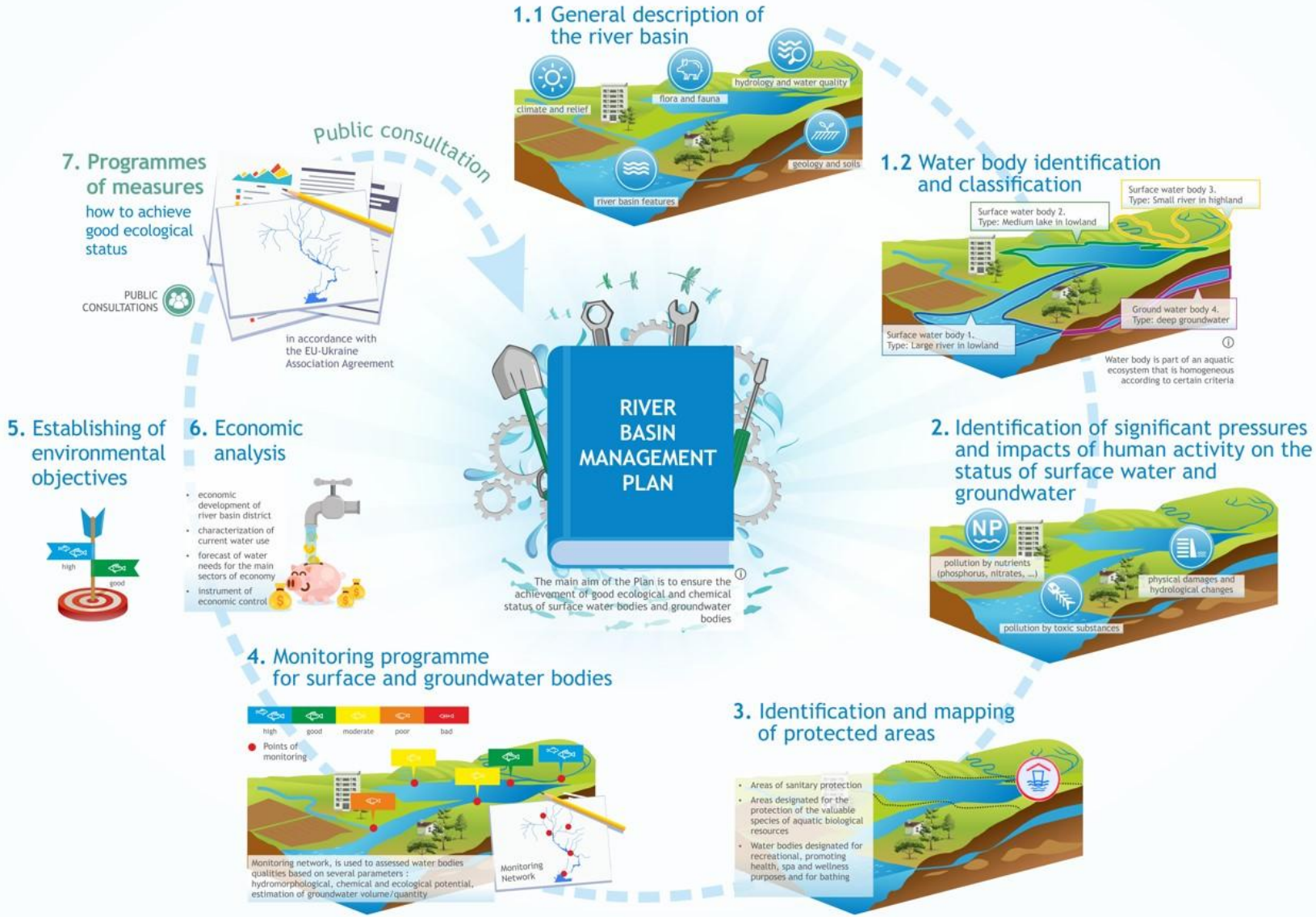
River Basin Management Plan (RBMP)

- A national plan that aims to protect and restore good water quality in our rivers, lakes, estuaries, groundwater, and coastal waters.

Aim of RBMPs when it comes to groundwater:

- Sustainable and integrated groundwater management for the benefit health, biodiversity, climate, communities, and jobs.

RIVER BASIN MANAGEMENT PLAN



EU Water policy: A Brief Overview

The Water Framework Directive (WFD) establishes a legal framework to guarantee sufficient quantities of good quality water across Europe. Its key aims are to:

- expand water protection to all waters: inland and coastal surface waters and groundwater;
- achieve "good status" for all waters by 2015;
- base water management on river basins;
- combine emission limit values with environmental quality standards;
- ensure that water prices provide adequate incentives for water users to use water resources efficiently;
- involve citizens more closely;
- streamline legislation.

Directive 2000/60/EC
Water Framework Directive (WFD)

- The WFD contemplates each Member State defining each of its river basin districts, territorial units that include one or more neighbouring river basins and the groundwater and coastal waters associated therewith.
- These are the main units for the management of water resources, which must be based on the forecasts contained in the relevant basin management plans, defined in (WFD, Article 13).
- All these Directives, the modifications thereto and the decisions of the European Court of Justice, together with WFD, constitute the corpus of EU water law, which forms the basis for the management of water resources in the territory of the Union.
- These include, but are not limited to, the following:

Directives

- Directive 75/440/EEC, concerning the quality required of surface water intended for the abstraction of drinking water in the Member States.
- Council Directive 79/869/EEC, of 9 October 1979, concerning the methods of measurement and frequencies of sampling and analysis of surface water intended for the abstraction of drinking water in the Member States.
- Directive 91/271/EEC, concerning urban waste-water treatment.
- Directive 96/61/EC, concerning integrated pollution prevention and control.
- Directive 98/83/EC of the Council on the quality of water intended for human consumption.
- Directive 2006/7/EC of the European Parliament and of the Council, concerning the management of bathing water quality.
- Directive 2006/11/EC of the European Parliament and of the Council on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community.
- Directive 2006/44/EC of the European Parliament and of the Council on the quality of fresh waters needing protection or improvement in order to support fish life.
- Directive 2006/113/EC of the European Parliament and of the Council, of 12 December 2006, on the quality required of shellfish waters.
- Directive 2007/60/EC of the European Parliament and of the Council, of 23 October 2007, on the assessment and management of flood risks.

Directives related to groundwater

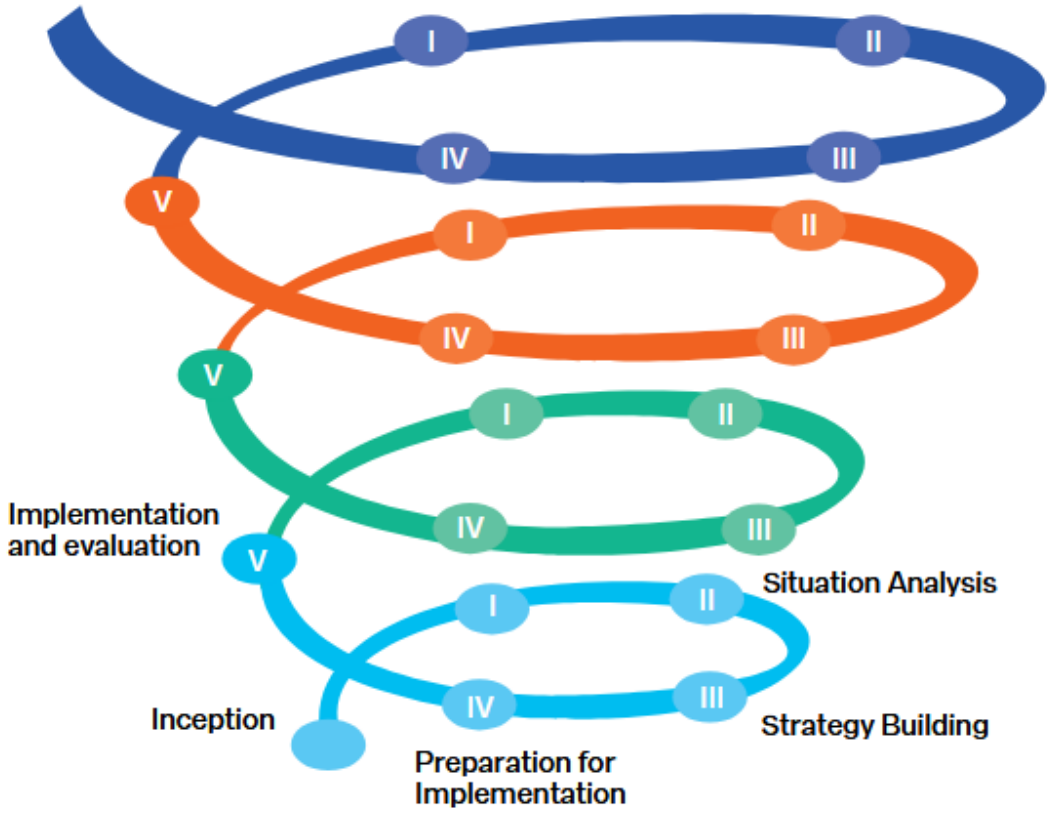
- Directive 91/676/EEC, concerning the protection of waters against pollution caused by nitrates from agricultural sources.
- Directive 2006/118/EC of the European Parliament and of the Council, of 12 December 2006, on the protection of groundwater against pollution and deterioration Developed in response to the requirements of Article 17 of the WFD with regard to the adoption of specific measures to prevent and control groundwater contamination.
- Links to Floods Directive and Habitats Directive

Groundwater

- In order to meet demand and ensure sufficient quality for its use in human activities, groundwater needs to provide a safe and long-term sustainable source of water.
- As a finite resource, groundwater needs to be protected from pollution and over-exploitation.
- The EU legislation on protecting groundwater focuses on achieving good chemical status and good quantitative status.
- Measures must also be taken to prevent and limit the input of pollutants and reverse deteriorating trends in groundwater quality.

Integrated planning is a spiral process

A cyclic approach that makes it also possible to respond to changing social, economic, and environmental needs and enables practitioners to gradually improve management as they move up the spiral, progressively developing the water resources, building a more integrated institutional framework, and improving environmental sustainability.



UNESCO-IHP et al. (2009)

Programmes of Measures (PoMs)

- WFD requires Member States, under Article 11, to set up PoMs as part of the RBMP that must be submitted every six years (WFD planning cycle).
- An interim report of the implementation of the planned PoM (Article 15.3 of the WFD) has to be submitted within 3 years of the publication of the RBMP or any update thereof.
- The PoM assessments reflect the situation as reported electronically to the Water Information System for Europe (WISE) database.

Programmes of Measures (PoMs)

Basic measures

- regulatory,
- permitting,
- abstraction control.

Supplementary measures

- recharge enhancement,
- pollution reduction.

Integration with land use and agriculture policies.

Groundwater

Objectives of Groundwater Planning

- Ensure good quantitative and chemical status
- Protect dependent ecosystems
- Balance abstraction and recharge
- Support climate resilience

Groundwater

The WFD protects groundwater across Europe and highlights the importance of its sustainable management. It defines good groundwater status in terms of **both quantitative and chemical status**.

Member States must designate groundwater bodies as management units and ensure that each one achieves the WFD's environmental objectives, same as the requirements for surface water bodies.

The WFD also recognises the importance of the links between groundwater and surface waters and specifies that good status also means protecting the surface water bodies and terrestrial ecosystems that depend on groundwater both from a flow and quality perspective.

Groundwater Directive (GWD)

Directive 2006/118/EC on the protection of groundwater against pollution and deterioration

The GWD provides the detailed procedures for meeting the WFD's environmental objectives for groundwater quality.

It sets EU-wide groundwater quality standards for a small number of pollutants in Annex I, requires Member States to set threshold values for substances of national concern, including, where relevant, those listed in Annex II, and requires measures to be taken to prevent or limit the input of pollutants into groundwater.

The GWD establishes quality criteria allowing further improvements to be made based on monitoring data and new scientific knowledge.

Definitions

Groundwater quality standard

An environmental quality standard expressed as the concentration of a particular pollutant, group of pollutants or indicator of pollution in groundwater, which should not be exceeded in order to protect human health and the environment;

Threshold value

A groundwater quality standard set by member states in accordance with article 3. Threshold values can be established at the national level, at the level of the river basin district or the part of the international river basin district falling within the territory of a member state, or at the level of a body or a group of bodies of groundwater.

Background level

The concentration of a substance or the value of an indicator in a body of groundwater corresponding to no, or only very minor, anthropogenic alterations to undisturbed conditions;

Baseline level

The average value measured at least during the reference years 2007 and 2008 on the basis of monitoring programmes implemented under article 8 of directive 2000/60/EC or, in the case of substances identified after these reference years, during the first period for which a representative period of monitoring data is available.

Inventories

- State of basin natural resources
- GW Dependent Ecosystems
- Groundwater availability and demands
- Pollution sources
- Land use
- Trends:
  - Environmental degradation (e.g. deforestation; floods and droughts)
- Monitoring
  - Any monitoring programs?

Assessment

- Groundwater Characterisation
  - Delineation of groundwater bodies
  - Hydrogeological mapping
  - Water Allocation
- Groundwater dependent ecosystem needs
- Vulnerability
  - Key pressures and drivers (abstraction, pollution, land use)
  - Groundwater recharge
  - Rain and groundwater availability

Pressure and Impact Analysis

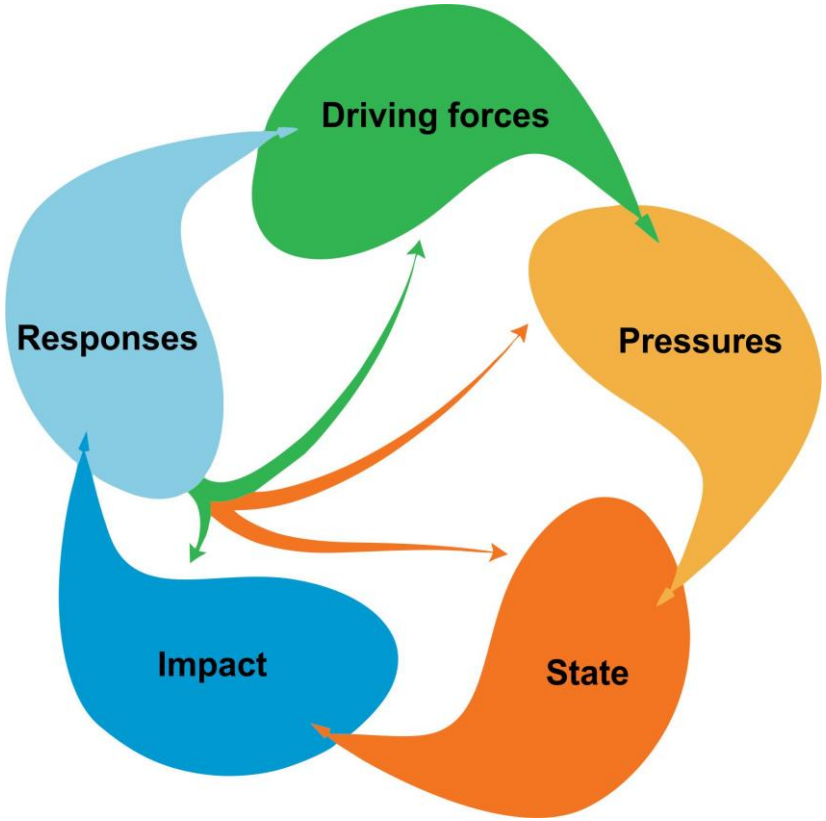
Human pressures:

- agriculture,
- industry,
- urbanisation

Natural pressures:

- climate variability,
- droughts

DPSIR framework (Drivers–Pressures–State–Impact–Response)

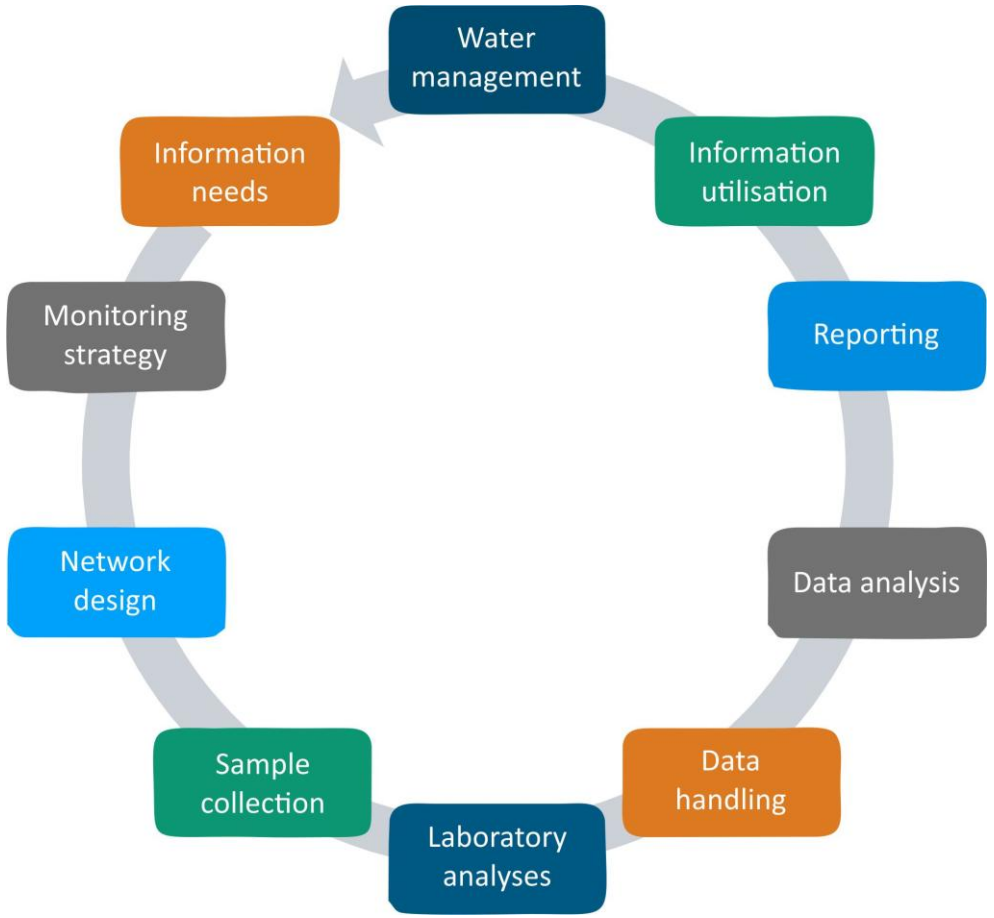


Status Assessment

Quantitative status
- water balance,
- trends, and
- thresholds

Chemical status
- pollutants,
- nitrates,
- pesticides,
- salinity

Monitoring network design



Risk Assessment and Prioritisation

- Identification of “at risk” groundwater bodies
- Criteria and indicators
- Prioritising measures and resources

Stakeholders and stakeholder's involvement

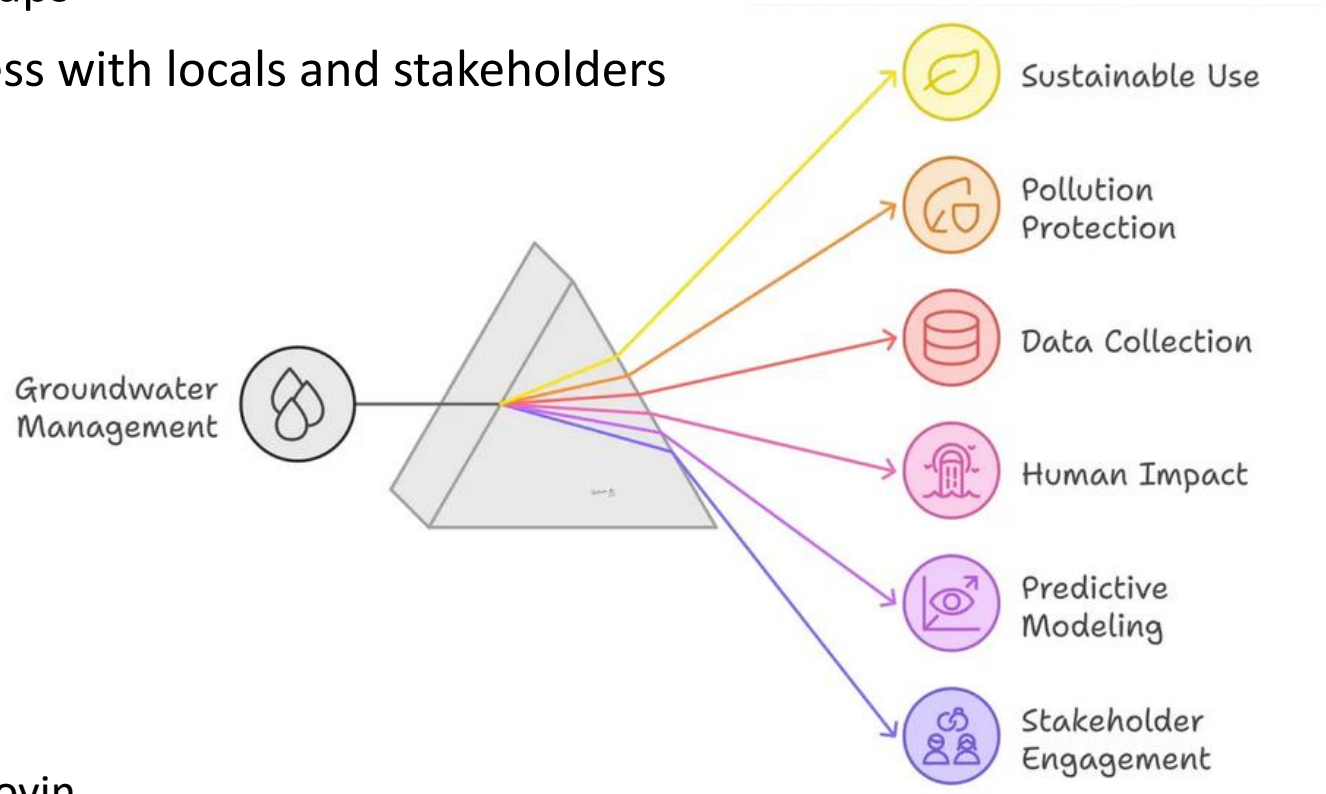
- Stakeholders
  - Inhabitants
  - Municipalities
  - NGO's
  - Who else?
- Stakeholder needs
  - Overview of needs and interests of stakeholders
- Mechanisms for participation
  - Gather information about current ways of participation;
  - Create awareness among inhabitants;
  - Communicate with the political leaders
- Public participation requirements under RBMPs
- Coordination with local authorities, users, and NGOs
- Building ownership and compliance

Priority issues

Get to know the ecological, social and economical system

- Approach stakeholders (governmental and non governmental), researchers
- Investigate data gaps

Start awareness process with locals and stakeholders



Source: https://rb.gy/a2oyin

Goals

Short-term

- e.g. Protect groundwater dependent ecosystems by enforcing of existing rules and developing new rules

Long-term

- Groundwater quality improvement
- Mitigate vulnerability to drought and flooding

Water allocation and water quality objectives

- Water quality
  - Fertilisers
    - No exceeding of the carrying capacity
  - Silt, floating matter
    - Decrease erosion processes
- Water allocation
  - Fair distribution between different uses
  - Think of and implement innovative solutions for water usage

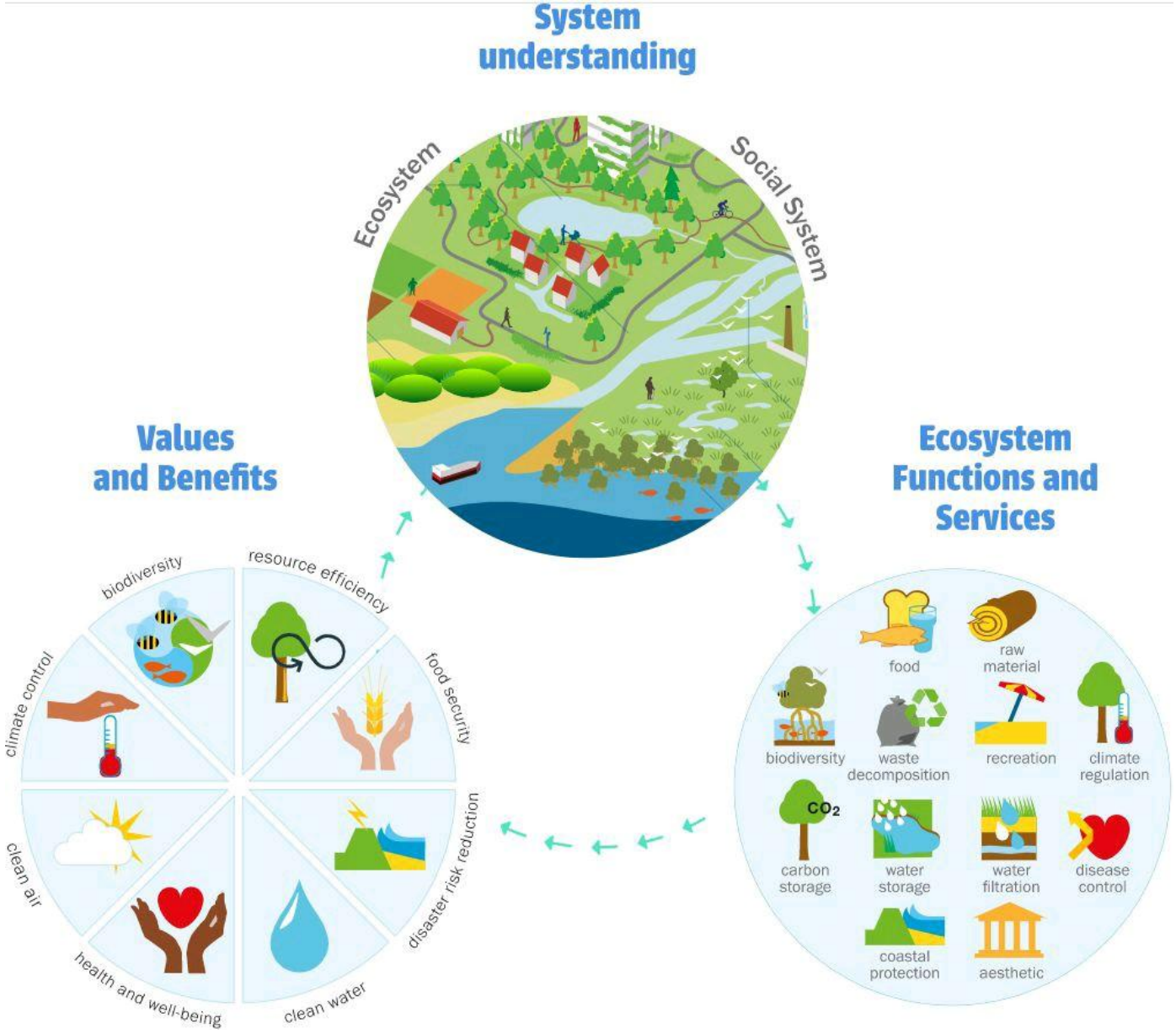
Benefit shares

Negotiations and compromises between stakeholders

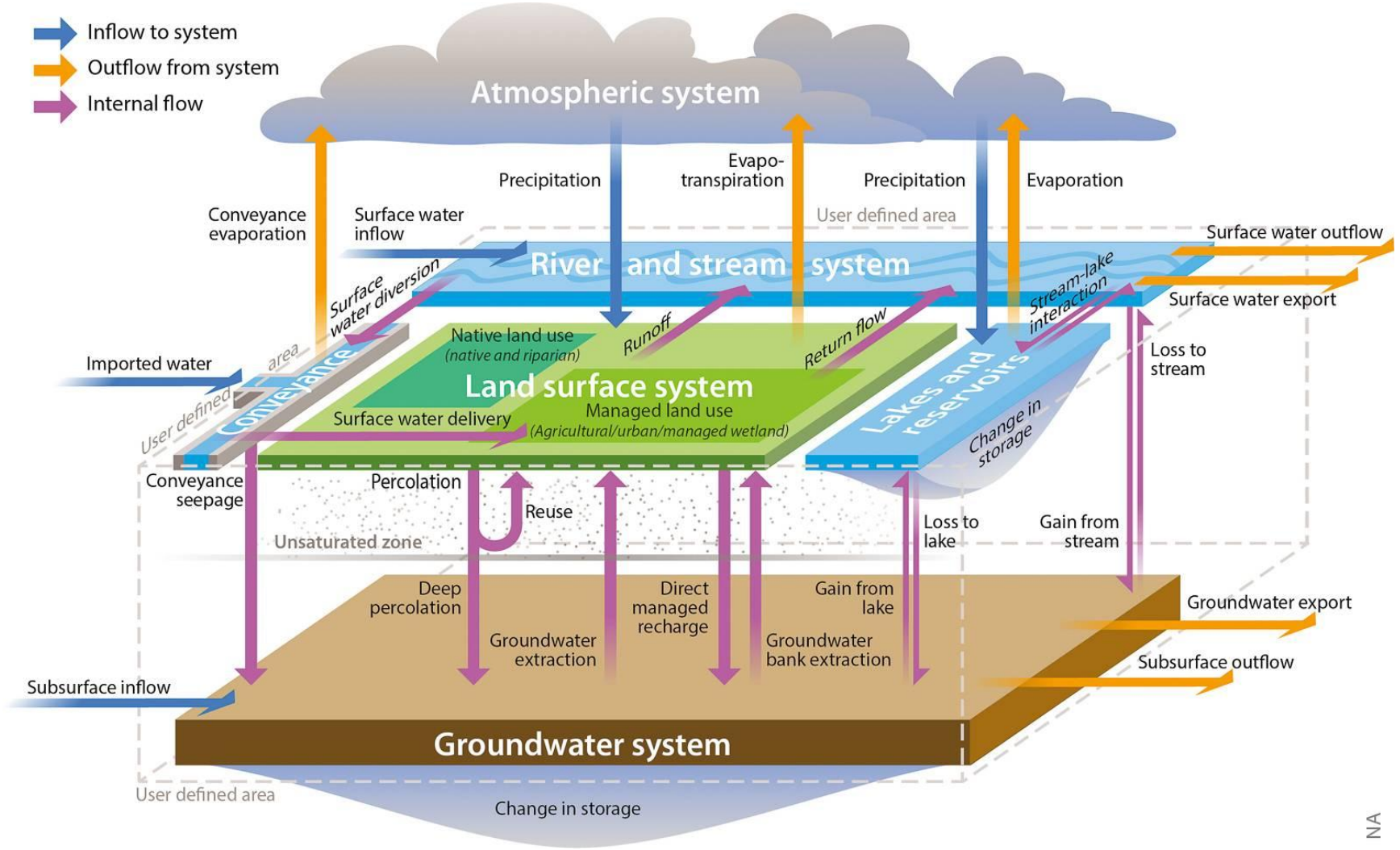
- National, regional and local

Win-win situation between nature and socio-economy

- Using natural resources in a sustainable way

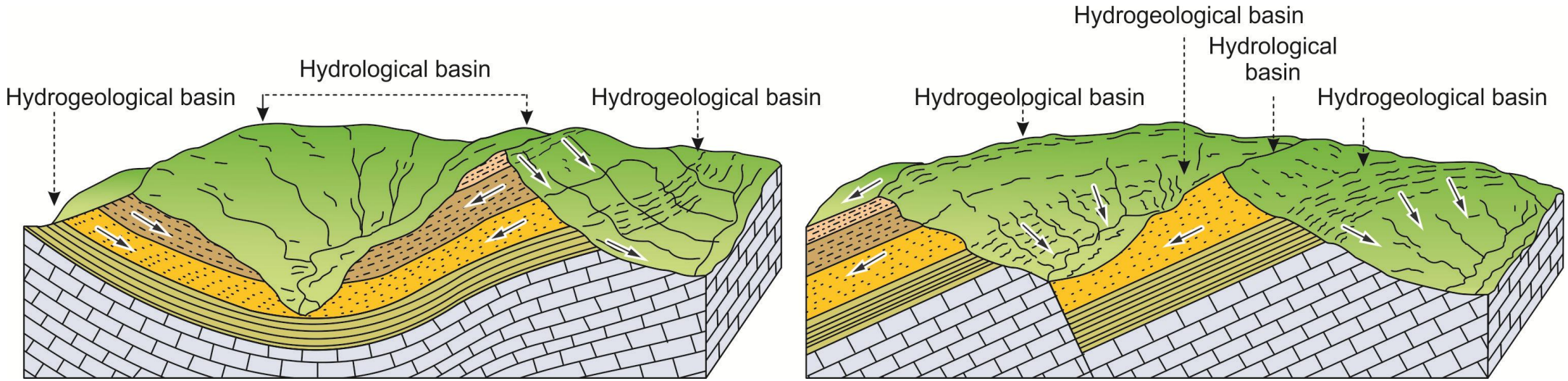


Water bodies and the catchment



Hydrogeological classification

Define hydrogeological units

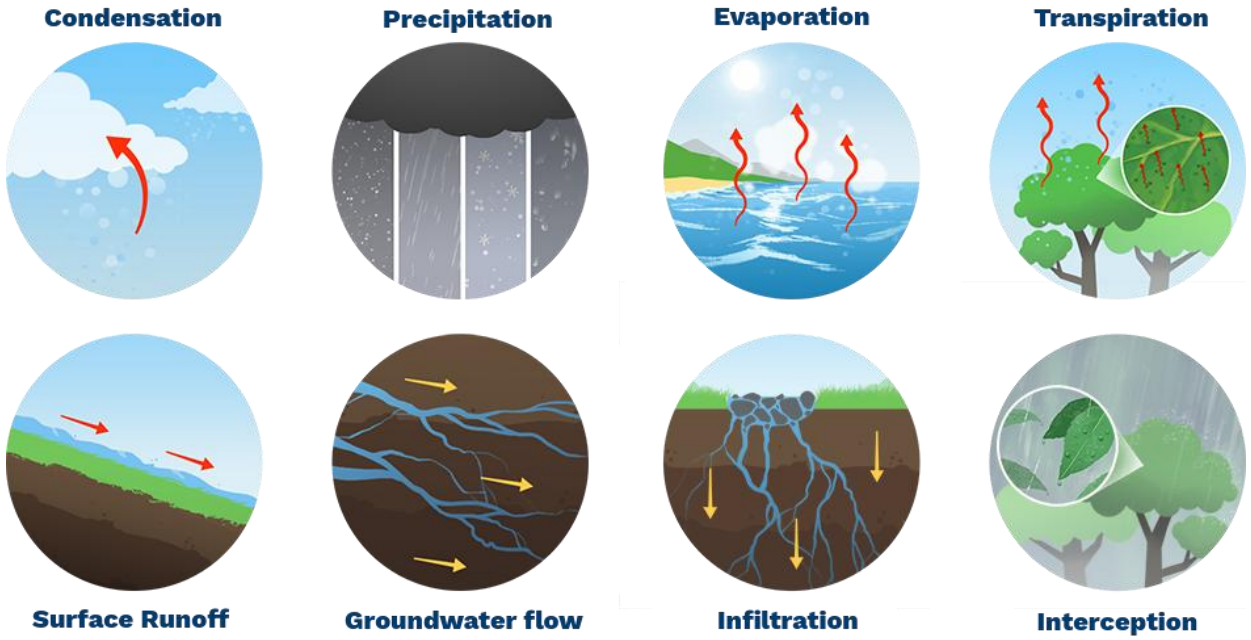


Hydrological *vs* hydrogeological basin

Groundwater Quantity Assessment

Data needs

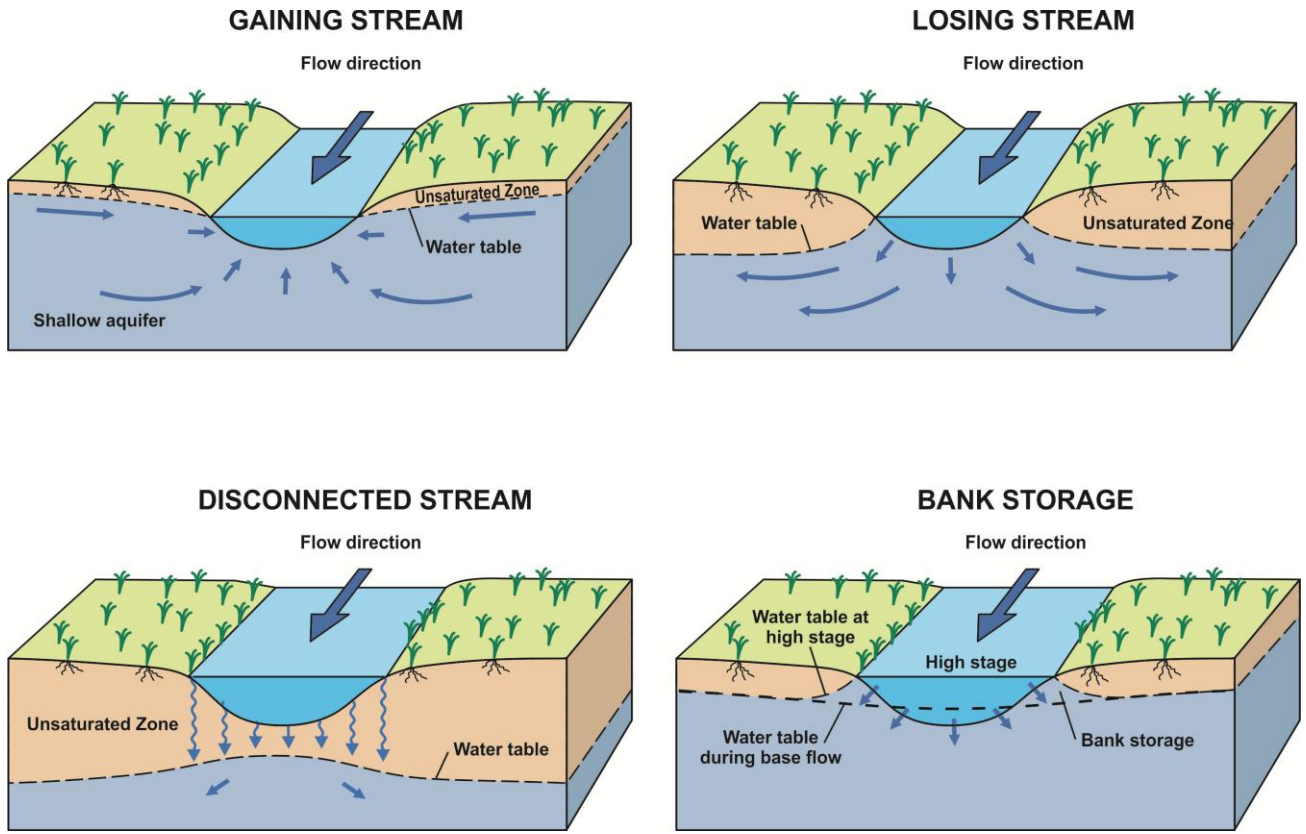
- Temperature
- Precipitation
- Evapotranspiration
- Groundwater recharge
- Hydraulic permeability
- Depth to water table
- Abstraction volumes
- Pollution sources map
- Land use map
- Topographic map
- Geological map
- Soil profiles and properties



Source: https://theory.labster.com/water-cycle-processes/

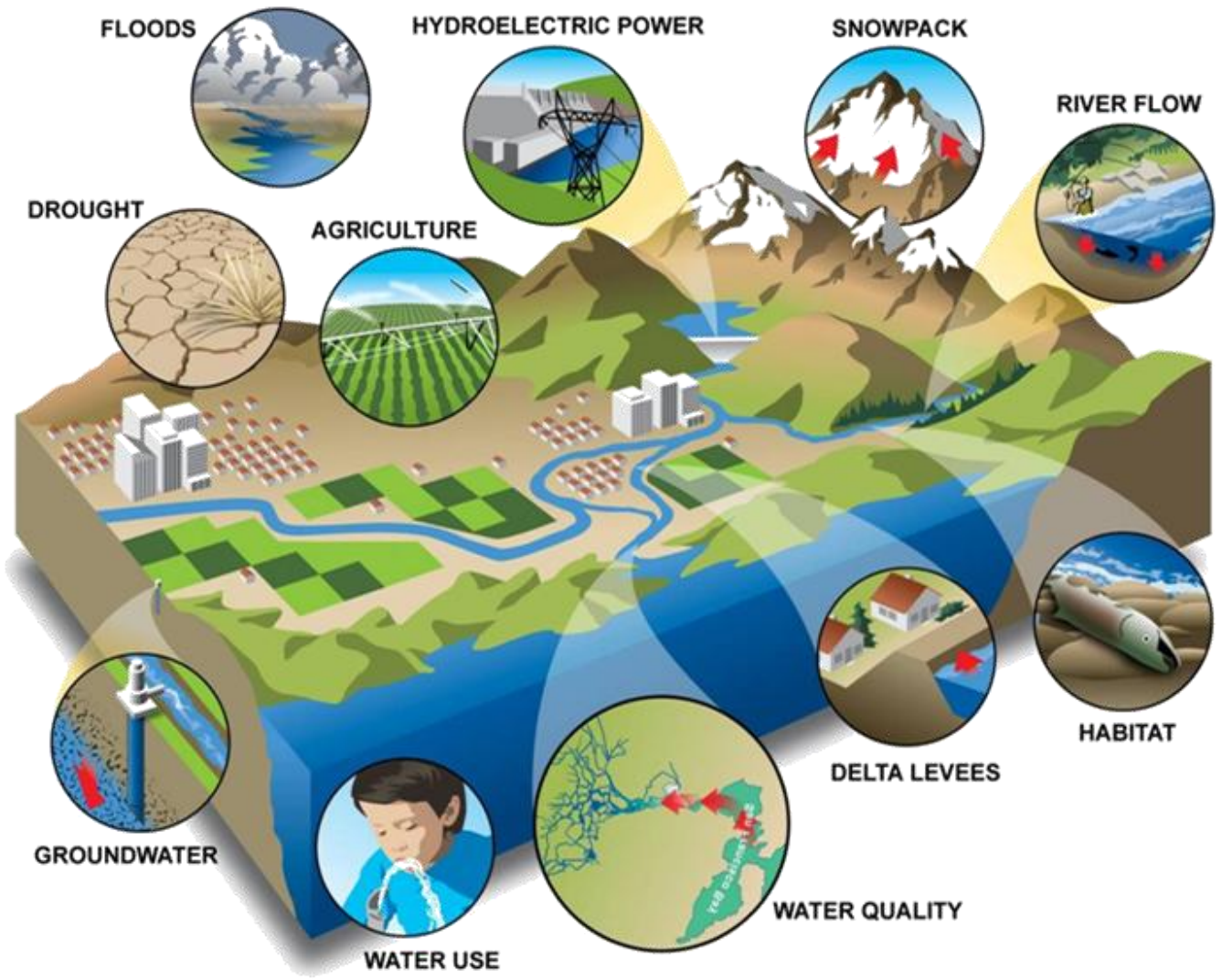
Groundwater–Surface Water Interaction

- Conceptual linkages and exchange zones
- Case examples of interaction management
- Relevance for ecological status and flow objectives

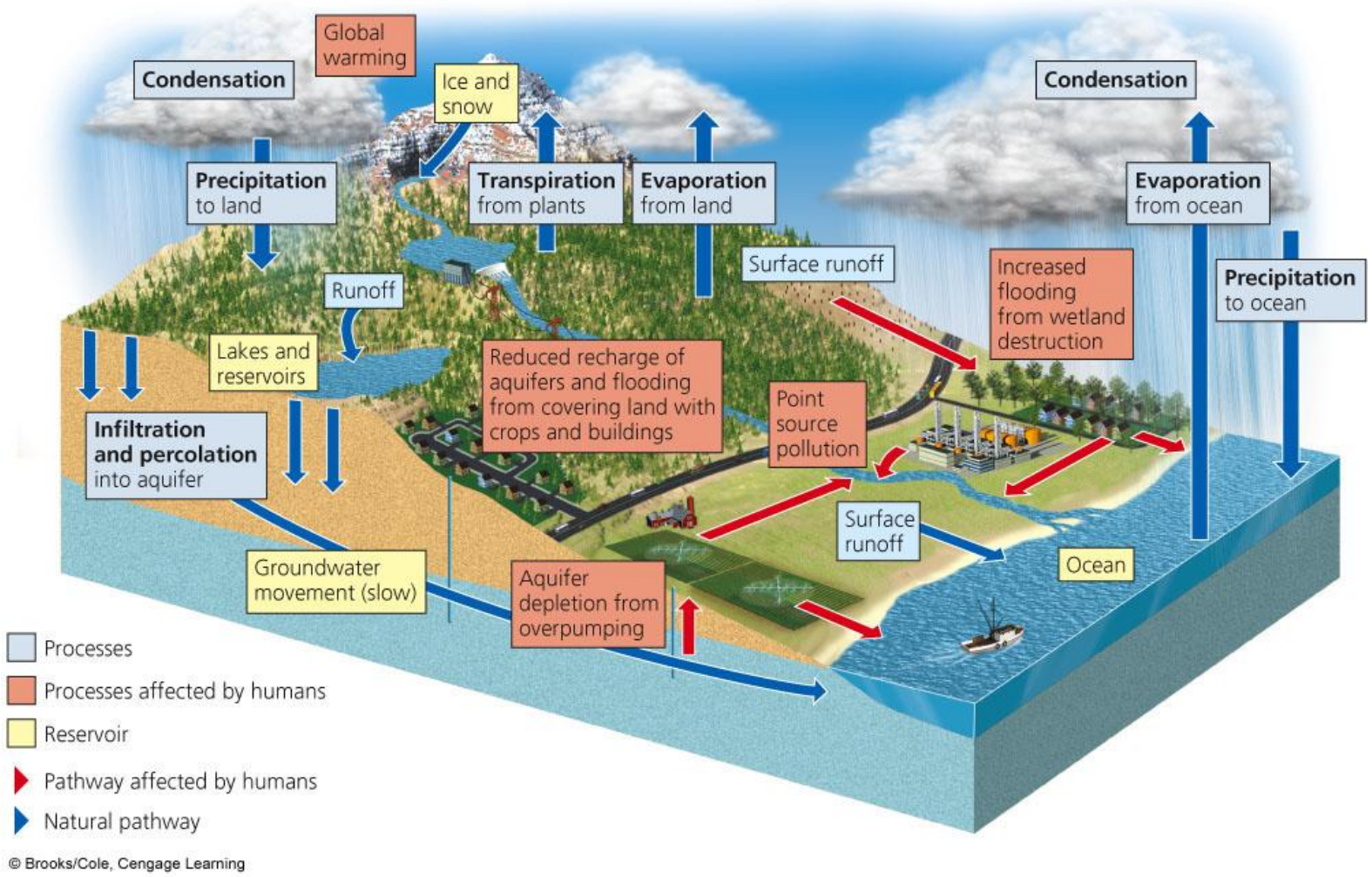


Winter et al. (1998)

River catchment and different pressures



Human influences



Characteristics of surface- and groundwater

Features	Groundwater (aquifers)	Surface water (rivers, lakes, wetlands)
Storage volume	Very large	Small to moderate
Resource areas	Extensive, widely available below surface	Restricted to water bodies
Flow velocities	Low	Moderate to high
Residence times	Decades/centuries	Weeks/months
Drought propensity	Generally low	Generally high
Evaporation losses	Low and localised	High in dry/warm climates
Resource evaluation	Higher cost and significant uncertainty	Lower cost and often less uncertainty
Abstraction impacts	Delayed and dispersed	Immediate, impact on downstream areas
Natural water quality	Generally good (but not always)	Variable
Vulnerability to pollution	Less vulnerable, natural protection varies	More vulnerable, largely unprotected
Persistence of pollution*	Pollution more long-lasting	Pollution more transitory
Recovery from pollution	Slow to restore	Quicker to restore
Remediating pollution	More costly and complex	Less costly and less complex

*Persistence of a temporary pollution load

Groundwater Quality Assessment

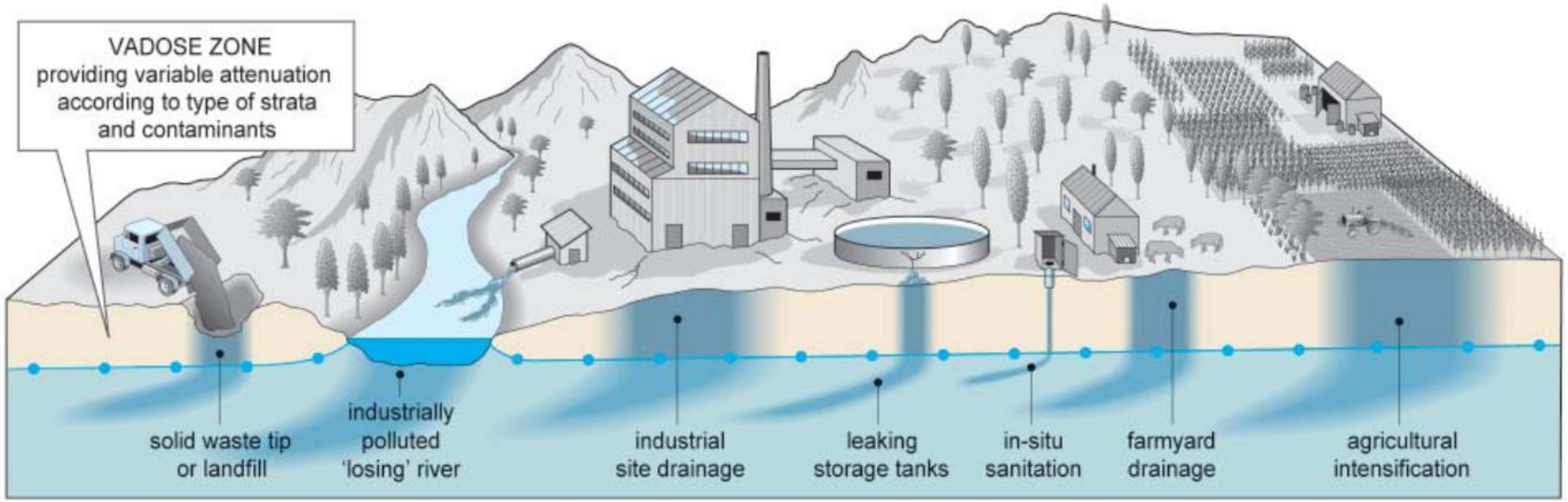
For the purposes of investigating whether the conditions for good groundwater chemical status [Article 4(2)(c)(ii) and (iii), WFD] are met, Member States will assess the:

- impact of the pollutants in the body of groundwater;
- amounts and the concentrations of the pollutants being, or likely to be, transferred from the body of groundwater to the associated surface waters or directly dependent terrestrial ecosystems;
- likely impact of the amounts and concentrations of the pollutants transferred to the associated surface waters and directly dependent terrestrial ecosystems;
- extent of any saline or other intrusions into the body of groundwater; and
- risk from pollutants in the body of groundwater to the quality of water abstracted, or intended to be abstracted, from the body of groundwater for human consumption.

Ten basic rules for successful water quality assessment (Chapman, 1996)

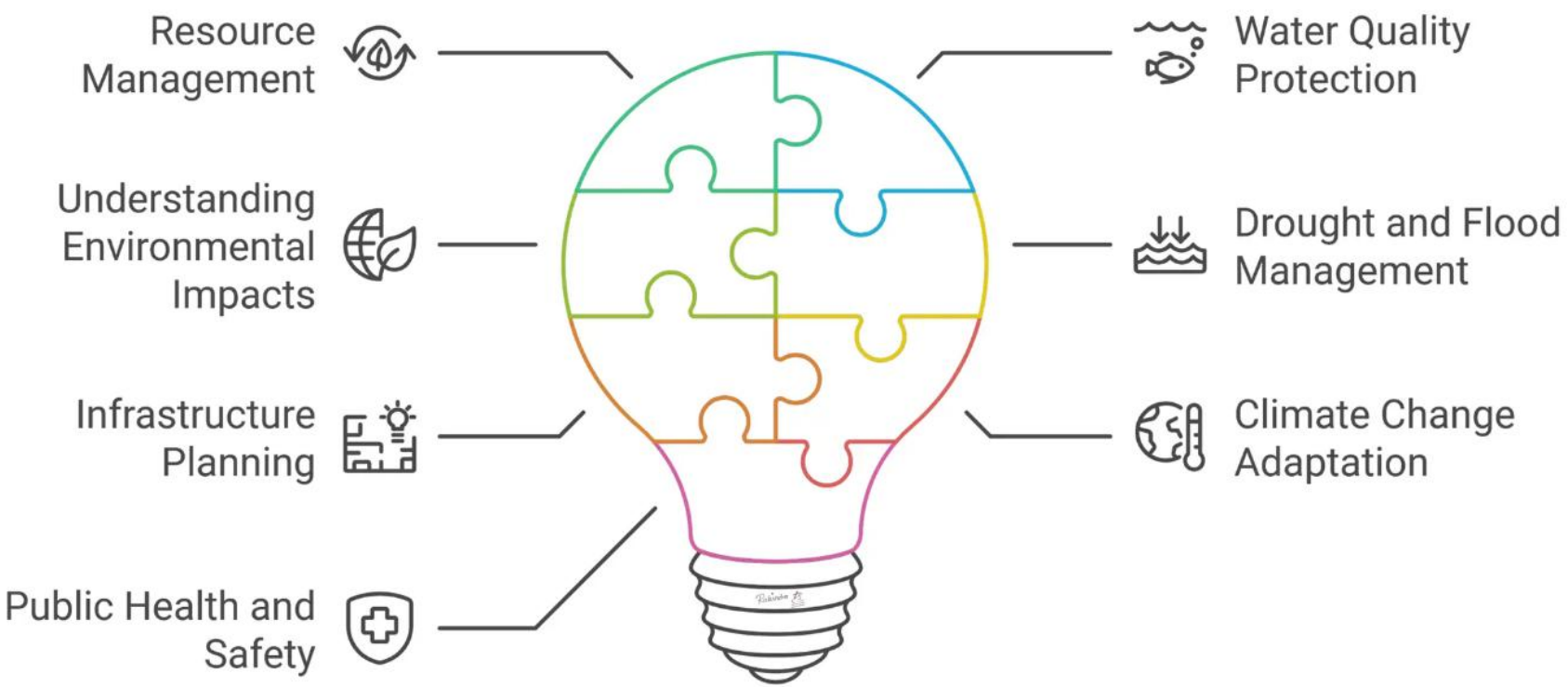
1. Define **objectives** first, then the programme. Ensure adequate financial support.
2. A clear **understanding** of the water body characteristics with preliminary survey is required.
3. Choose appropriate **media** (water, sediment, biota).
4. **Select** parameters, stations and frequency in line with the objectives and resources.
5. **Select** methods, instruments, laboratory facilities in line with the objectives and resources.
6. Establish a complete and operational **data treatment scheme.**
7. Integrate water quality with **hydrological** monitoring.
8. Good **quality** assurance and control programme.
9. Provide decision makers with interpreted data and **recommendations.**
10. Regularly **evaluate** the programme.

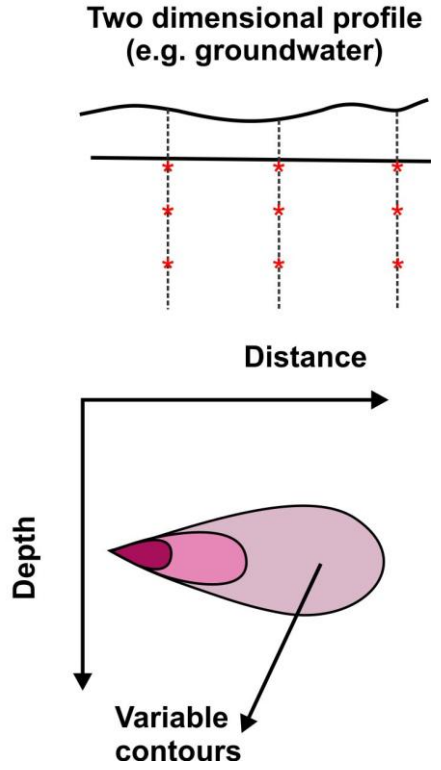
Groundwater Quality Assessment



Common activities generating a groundwater pollution hazard

Importance of groundwater monitoring

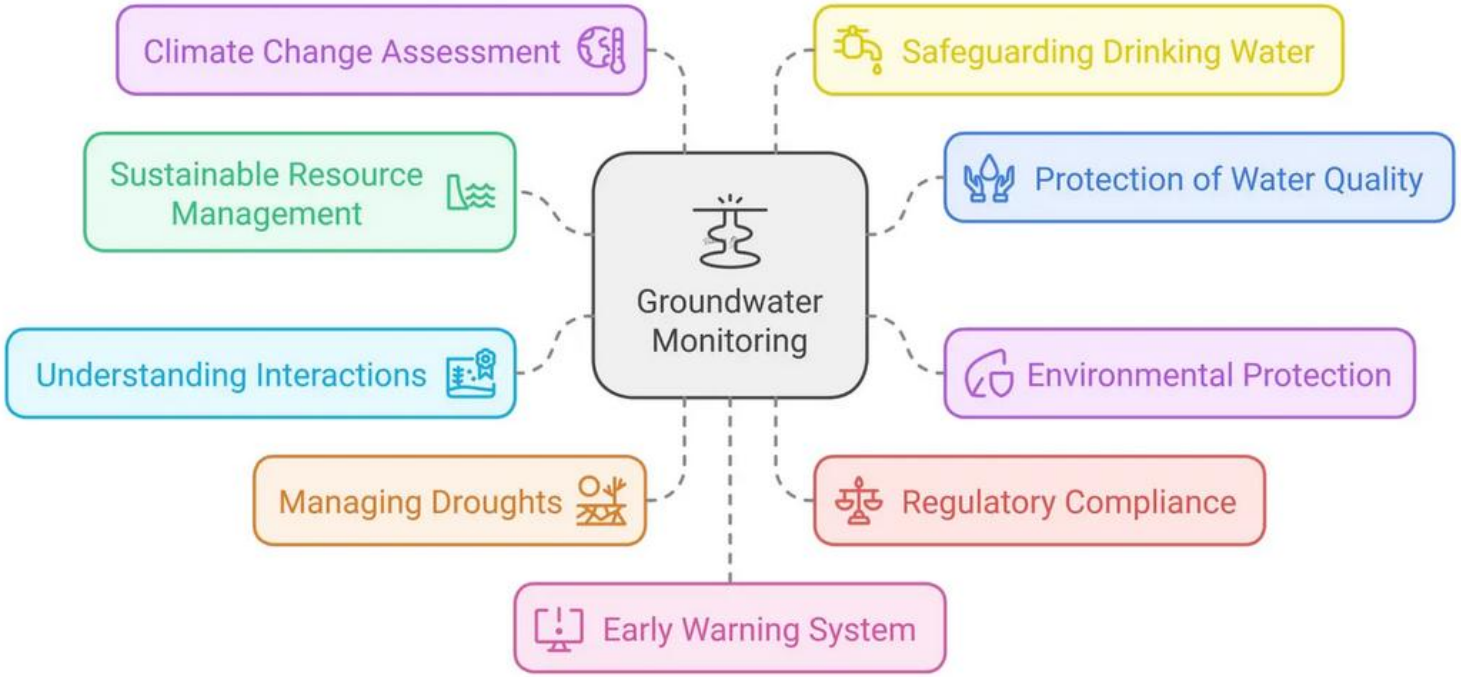




Source: https://rb.gy/a2oyin

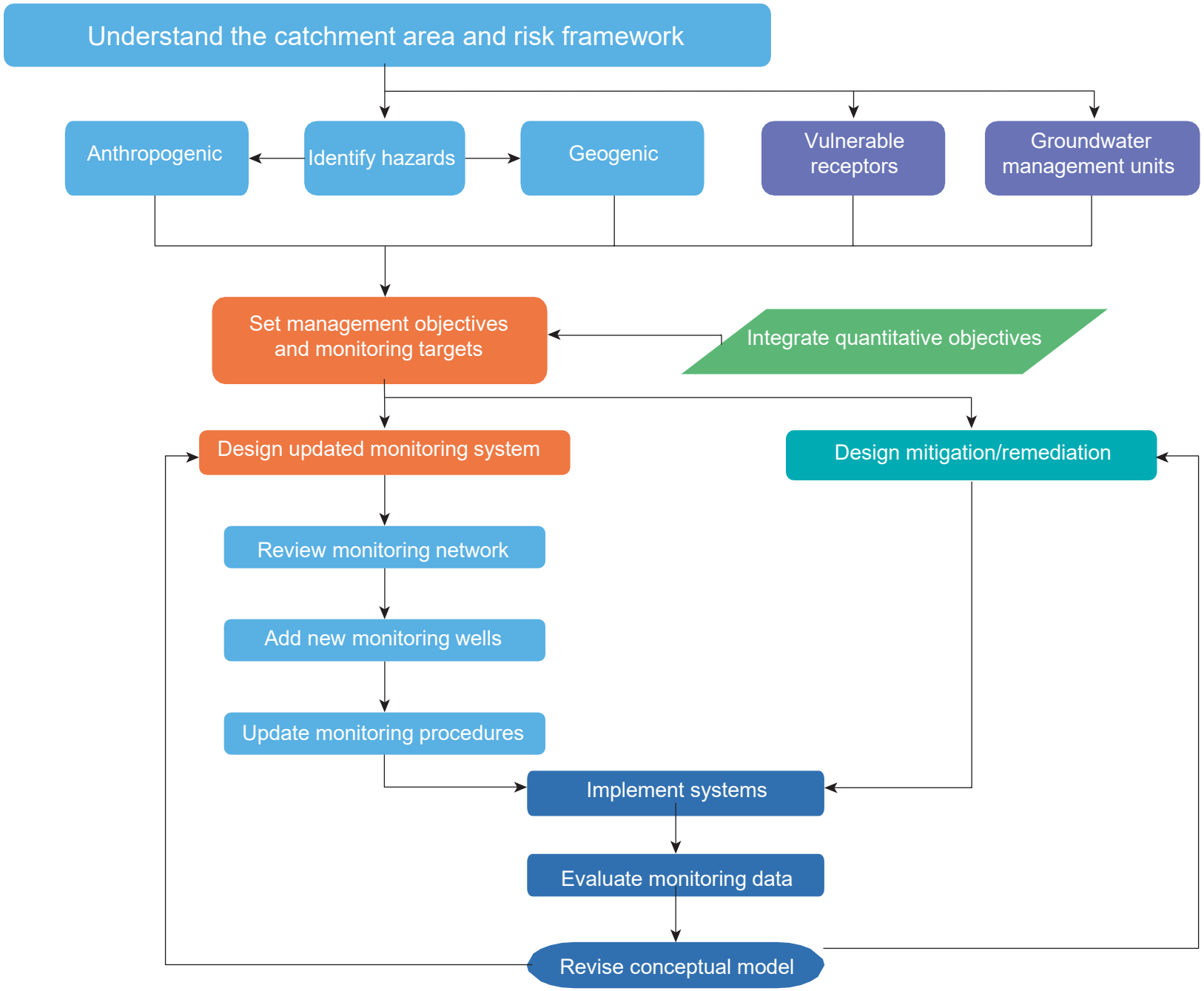
Climate Change Impacts on Groundwater

- Trends in recharge, droughts, and evapotranspiration
- Adaptive measures in RBMP context
- Resilience planning



Source: https://rb.gy/a2oyin

Monitoring of groundwater		
Monitoring of quantitative status	Monitoring of chemical status	
Level monitoring network	Surveillance monitoring	Operational monitoring
Purpose Provide data to: a) validate conceptual model of groundwater flow system b) enable classification of status calculation of available resource and estimation of flows across. Member state boundary	Purpose Provide data to: a) Supplement and validate risk assessment (e.g., test conceptual model); b) Help assess trends in pollutants and natural trends; and c) Inform the design of the operational monitoring network.	Purpose Provide data to: a) establish the status of bodies and groups of bodies at risk; b) the presence of trends in pollutant concentrations; and c) the reversal of such trends.
Where Sufficient points in bodies, or groups of bodies, to adequately validate the conceptual model	Where Sufficient points in bodies or groups of bodies, at risk and those not at risk to achieve the above purposes. Sufficient points in cross-border bodies to assess risks to all uses	Where Sufficient points in bodies, or groups of bodies. at risk to reliably classify the bodies (e.g., achieve a suitable level of confidence in the conceptual model and describe significant pollutant trends
What Data on water level, spring flow, base-flow in rivers as most appropriate for validating conceptual model	What O_2, pH, NO_3, NH_4, EC Indicators of pollutants relevant to the risks to the objective or to uses of transboundary groundwater flow	What Indicators for pollutants causing the body or group of bodies to be at risk
When Sufficient frequency distinguish short- and long-term variations in recharge from the impacts of abstractions and discharges	When For each plan period	When Period between surveillance monitoring, at sufficient frequency to detect impacts but minimum of once per annum

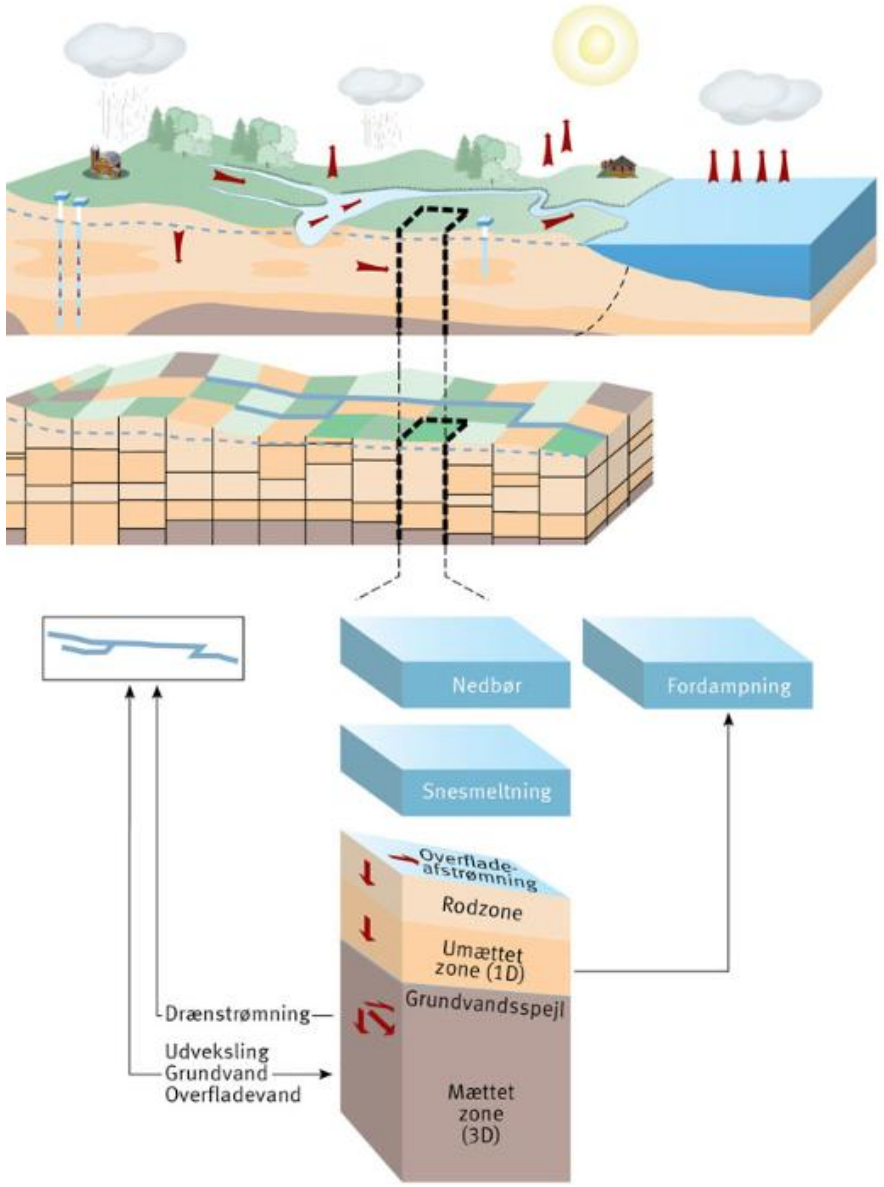

Understand the catchment area and risk framework
Anthropogenic
Identify hazards
Geogenic
Vulnerable receptors
Groundwater management units
Set management objectives and monitoring targets
Integrate quantitative objectives
Design updated monitoring system
Design mitigation/remediation
Review monitoring network
Add new monitoring wells
Update monitoring procedures
Implement systems
Evaluate monitoring data
Revise conceptual model

Quantitative Management Tools

- Groundwater modelling and budgeting
- Allocation planning and abstraction licensing
- Managed aquifer recharge and drought planning

Modelling: MIKE-SHE code

- Entire land phase of the hydrological cycle
- 3D-FD groundwater flow model
- Streamflow routing module
- Couples SW – GW
- Coupled 1D unsaturated zone/ET module

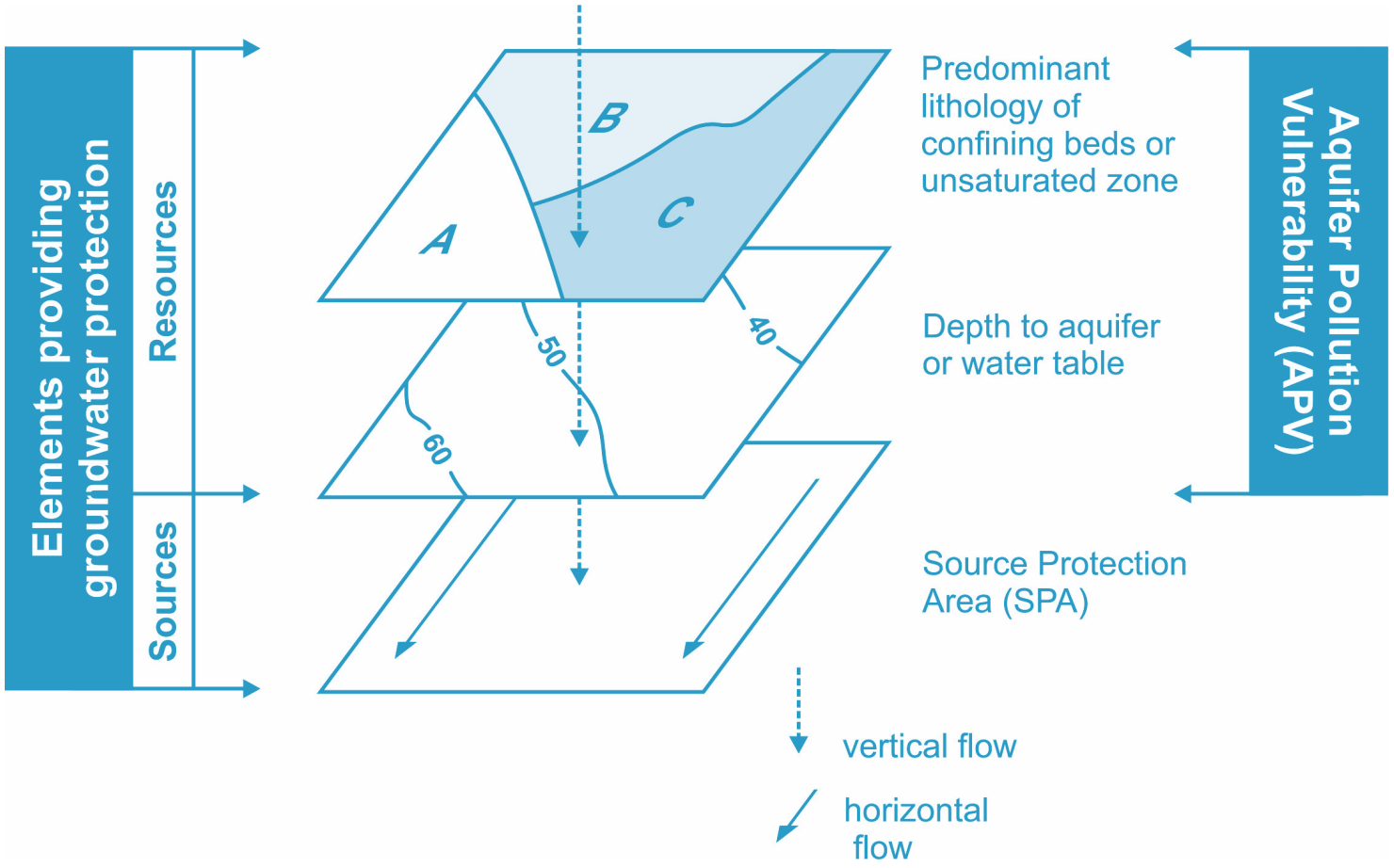


Source: https://shorturl.at/BtWJb

Qualitative Management Tools

- Source protection zones
- Pollution prevention and remediation
- Nitrate and pesticide management zones

Components of groundwater pollution vulnerability assessment



Groundwater protection

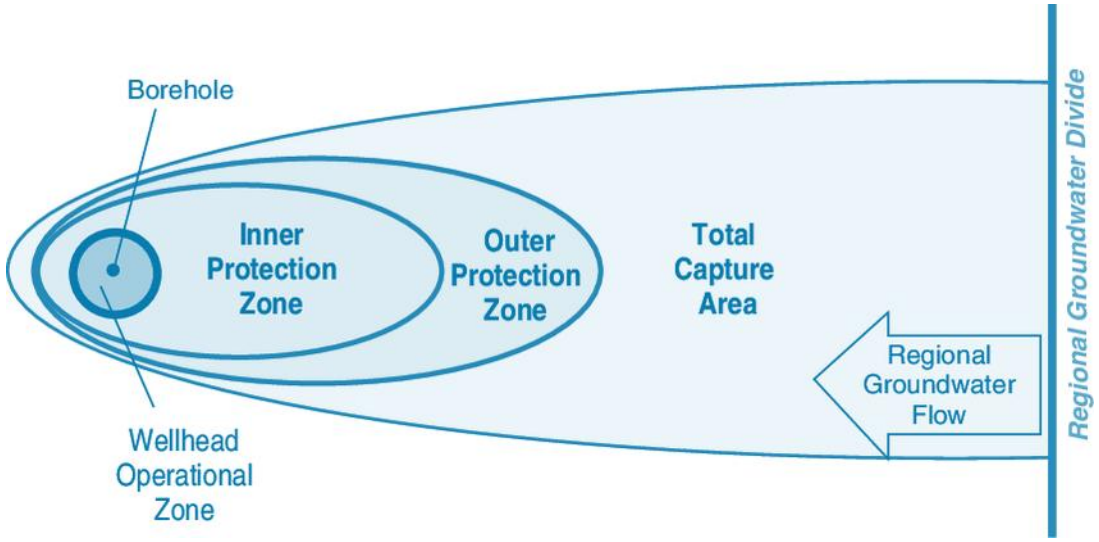
Groundwater Protection Zones (GPZ)

General aim:

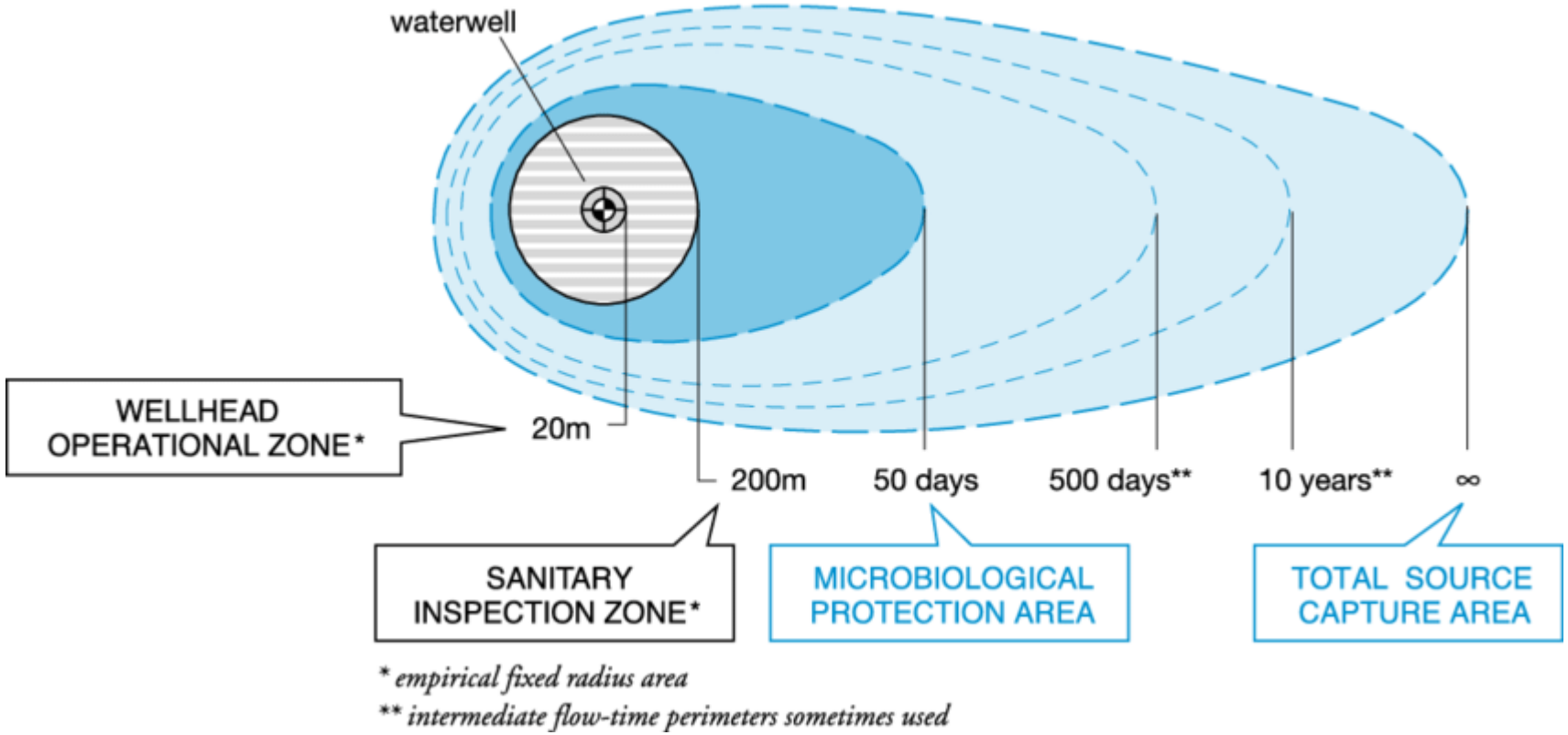
- To protect drinking water resources in the groundwater contribution zone upstream of the well/spring from pollution.

Common approach worldwide involves:

- Protection of water resources by employing Groundwater Protection Zones (GPZ)
  - Zone I Immediate Protection Zone
  - Zone II Inner Protection Zone
  - Zone III Outer Protection Zone



Groundwater Protection Zones (GPZ)



Zone I

Protects well/spring from direct contamination

Zone II

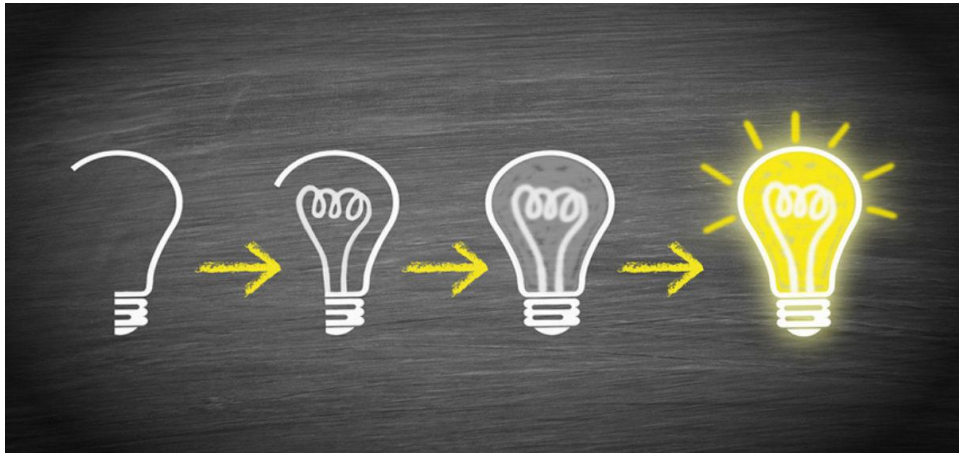
Protects drinking water source against pathogenic microbiological constituents *bacteria, viruses, parasites.*

Zone III

Protects against contamination affecting drinking water source over long distances (for chemical substances, which are non or hardly degradable)

Challenges and Lessons Learned

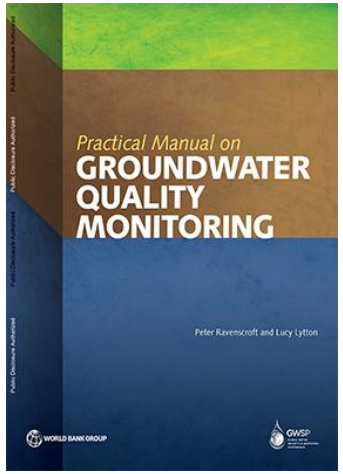
- Data gaps and uncertainties
- Climate change impacts
- Governance and enforcement issues
- Funding and capacity constraints



Relevant links

- https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32006L0118
- http://data.europa.eu/eli/dir/2006/118/oj
- https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32006L0118
- https://circabc.europa.eu/ui/group/9ab5926d-bed4-4322-9aa7-9964bbe8312d/library/f6ca9779-8dd9-43cc-addd-2566e28fdc19/details
- https://circabc.europa.eu/ui/group/9ab5926d-bed4-4322-9aa7-9964bbe8312d/library/07b22660-7a01-4094-bcb3-78c8dc3934ef/details
- https://southernscientificireland.com/2023/11/20/water-monitoring-for-different-bodies-of-water/

Further reading



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