Work Package 2
Peer To Peer for Experience Sharing

Appendix 1
P2P No. 7: Focus Group on Groundwater (GW) protection and GW body delineation

Groundwater Report

SWIM–Horizon 2020 Support Mechanism
August 2018

Version	Document Title	Author	Review and Clearance
V3	P2P No. 7: "Groundwater zone protection and groundwater body delineation"	Grath Johannes (Non-key expert)	Suzan TAHA (Key Water Expert)

THE SWIM AND H2020 SUPPORT MECHANISM PROJECT (2016-2019)

The SWIM-H2020 SM is a Regional Technical Support Program that is funded by the European Neighborhood Instrument (ENI) South/Environment. It ensures the continuation of EU's regional support to ENP South countries in the fields of water management, marine pollution prevention and adds value to other important EU-funded regional programs in related fields, in particular the SWITCH-Med program, and the Clima South program, as well as to projects under the EU bilateral programming, where environment and water are identified as priority sectors for the EU co-operation. It complements and provides operational partnerships and links with the projects labelled by the Union for the Mediterranean, project preparation facilities in particular MESHIP phase II and with the next phase of the ENPI-SEIS project on environmental information systems, whereas its work plan will be coherent with, and supportive of, the Barcelona Convention and its Mediterranean Action Plan.

The overall objective of the Program is to contribute to reduced marine pollution and a more sustainable use of scarce water resources. The Technical Assistance services are grouped in 6 work packages: WP1. Expert facility, WP2. Peer-to-peer experience sharing and dialogue, WP3. Training activities, WP4. Communication and visibility, WP5. Capitalizing the lessons learnt, good practices and success stories and WP6. Support activities.

Disclaimer:

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ABBREVIATIONS

DcWM	Decentralised Water Management
GD	Guidance Document
GW	Groundwater
GWD	Groundwater Directive
P2P	Peer to Peer
SWIM-H2020 SM	Sustainable Water Integrated Management & Horizon 2020 - Support Mechanism
WFD	Water Framework Directive
WP	Work Package

1. CONTEXT

As part of its overall work plan, and under its work package (WP2), the EU-funded "Sustainable Water Integrated Management & Horizon 2020 - Support Mechanism (SWIM-H2020 SM)" project is now implementing a Peer to Peer (P2P) activity on one of its Priority Themes: Decentralised Water Management (DcWM).

One of the three focus groups is dealing with **"**Groundwater zone protection and groundwater body delineation". The objectives of the Peer to Peer activity, which involves direct exchange of experience between peers from relevant institutions in the beneficiary countries, are:

- Sharing expertise and guidance among Peers on a specific issue/topic;
- Boosting south-to-south (and also north-to-south) cooperation;
- Building the cornerstones for long-lasting relations and exchanges, as opposed to one-time ad-hoc exchange.

The exchange within the P2P activity is typically focused around pressing/emerging issues in the beneficiary countries, which drove the identification of the focus groups following a match-making process between those countries requesting the expertise and those offering it. In this regard, the following focus group has been identified as part of the DCWM theme, together with the coach and the country offering the expertise as per the following table (Table 1)

Table 1: Countries and peers involved in P2P 7 Focus Group

Focus Group	Country Receiving	Country offering	Coach and contact information
	Expertise and contact persons		
P2P 7: Groundwater zone protection and groundwater body delineation	Egypt and Palestine **Egypt**: Ahmed Abdelwahab **Palestine**: Azhar Sharif		Johannes Grath Umweltbundesamt GmbH T: 0043 1 313 04 3510 Email: johannes.grath@umweltbundesamt.at

2. PREVAILING ISSUES WITHIN THE FOCUS GROUP

The peers from Palestine and Egypt requesting expertise had been asked to identify the imminent issues/questions pertaining to the focus group. The questions were discussed within

the focus group at the Regional Training (REG 5) Workshop on decentralised water management held in Vienna (April 2018).

The outcomes of the discussions on how to group and deal with the specific topics are summarised in the table below:

Table 2: Proposed themes and grouping of the issues raised by the peers

Country	Proposed specific topic	Proposed theme and grouping of specific topic
Egypt	1. What are the most polluting groundwater activities?	5.1 Delineation and Characterisation of GW-bodies and identification of pressures (reference to Art. 5 and Annex II WFD as well as to specific guidance documents)
	2. How can well drilling method cause groundwater pollution?	
	3. How can groundwater pollution be measured quantitatively and qualitatively?	5.2 Principles for developing a monitoring strategy and for monitoring network design (requirements outlined in Art. 8 WFD), e.g. distribution of sites, identification of relevant pollutants, monitoring frequency, etc.
	4. What are the procedures used to contain and treat different contaminants of groundwater?	Remark: Within the Peer to Peer breakout session at the REG 5 Workshop in Vienna (April 2018) it was concluded that this issue should not be dealt with in the peer to peer activity, since it is a technical issue specifically depending on the type of pollutant
	5. What are the procedures for protecting the single well, well fields, and groundwater aquifers?	5.3 Principles outlined in the WFD concerning GW protection – from general approaches down to the GW body level and sampling sites; Prevent or limit requirements according to Art. 6 GWD will be described; examples will be provided according to the structure of the programme of measures in Annex VII WFD **Remark on 7**: since this is not an issue in Austria, hardly any information can be provided
	6. Is it possible to protect the groundwater reservoir from pollution from any contaminant in the source of recharge (river, lake, or any water body)?	
	7. What are the procedures for protecting groundwater from deterioration of quality and increase of dissolved salts as a result of pumping?	
	8. Is it possible to protect groundwater from increased recharge due to dams and arches?	**Remark**: Within the breakout session at the REG 5 Workshop in Vienna (April 2018) it was concluded that this issue should not be dealt with in the peer to peer activity
	9. Are there any previous feasibility studies that can be used to evaluate the effect of groundwater protection on sustainable development?	**Remark**: Within the breakout session at the REG 5 Workshop in Vienna (April 2018) it was concluded that this issue should not be dealt with in the peer to peer activity
	10. How to develop formal mechanisms to ensure public participation in the management of well fields and protection	**Remark**: This issue will not be dealt with under the peer to peer activity; It will be covered under the “public participation”

	of aquifers?	section of SWIM.
Palestine	1. What is the best and simplest mean to delineate protection zone 2?	5.4 Requirements concerning water used for the abstraction of drinking water (Art. 7 WFD); More specific issues will be addressed by the Expert Facility EFS_-S-1 currently in progress under SWIM-H2020 SM in Palestine.
	2. How to detect pollutant track?	5.5 This issue will be partly covered in a rather generic way as far as possible under: 'Principles for developing a monitoring strategy and for monitoring network design' (requirements outlined in Art. 8 WFD) e.g. distribution of sites, identification of relevant pollutants, monitoring frequency, etc.

3. SCOPE AND OBJECTIVE

Based on the issues that have been identified (see above), and considering the available resources and time, it was agreed that the following themes will be addressed. **Accordingly, a document was prepared that responds to the following issues raised by the country:**

- Delineation and characterisation of GW bodies and identification of pressures (reference to Art. 5 and Annex II WFD as well as to specific guidance documents developed under the WFD Common Implementation Strategy (CIS)) (**corresponding to the proposed topics no. 1 and 2 by Egypt**)
- Principles for developing a groundwater monitoring strategy and for monitoring network design (requirements outlined in Art. 8 WFD), e.g. distribution of sites, identification of relevant pollutants, monitoring frequency, etc.(**corresponding to the proposed topic no. 3 by Egypt and topic no. 2 by Palestine**)
- Principles outlined in the WFD concerning GW protection – from general approaches down to the GW body level, production sites and sampling sites (**corresponding to the proposed topics no. 5, 6 and 7 by Egypt**)
- Measures to prevent or limit input of pollutants into Groundwater according to Art. 6 GWD will be described; examples will be provided according to the structure of the programme of measures in Annex VII WFD (**corresponding to the proposed topics no. 5, 6 and 7 by Egypt**)
- Requirements concerning water used for the abstraction of drinking water (Art. 7 WFD) (**corresponding to the proposed topic no. 1 by Palestine**)

4. METHODOLOGY

Since there are no peers from countries offering expertise, the information will be provided by the coach only, i.e. the coach acts as coach and peer at the same time.

As discussed and agreed at the regional training workshop (REG 5) held in Vienna (See section 2 above), the questions which were submitted by the peers from Palestine and Egypt will be subsumed in a concise report under the following topic:

„Principles for groundwater protection against pollution in line with the European Water Framework Directive 2000/60/EU (WFD) and the Groundwater Directive 2006/118/EU (GWD)“

The report is structured as follows and comprise the following issues – based on existing guidance documents and experiences made so far:

- Delineation and characterisation of GW bodies and identification of pressures (reference to Art. 5 and Annex II WFD as well as to specific guidance documents developed under the WFD CIS):
  - Delineation and characterisation of GW bodies and identification of pressures are the basis for developing a monitoring strategy and for monitoring network design (requirements outlined in Art. 8 WFD), e.g. distribution of sites, identification of relevant pollutants, monitoring frequency, etc.;
- Measures for GW protection– from general approaches down to the GW body level and sampling sites:
  - examples will be provided according to the structure of the programme of measures in Annex VII WFD;
  - Measures to prevent or limit input of pollutants into groundwater according to Art. 6 GWD;
  - further aspects as considered relevant;
- Requirements concerning water used for the abstraction of drinking water (Art. 7 WFD).

The report is based on guidance documents which were developed at the European level to support the implementation of the EU Water Framework Directive and the EU Groundwater Directive (under the WFD **Common Implementation Strategy** (CIS)), and on selected assessment reports.

Moreover, Austrian experience concerning groundwater management – in particular by implementing the EU Water Framework Directive and the Groundwater Directive, with an emphasis on GW body delineation and characterisation, risk assessment, monitoring and status assessment, and on groundwater protection measures is brought in. Since groundwater is the predominant source for drinking water abstraction in Austria (at around 99% of all drinking water being abstracted from groundwater), information concerning drinking water protected areas is shared, as well.

5. PRINCIPLES FOR GW PROTECTION AGAINST POLLUTION IN LINE WITH THE EUROPEAN WFD 2000/60/EU & THE GWD 2006/118/EU

5.1 DELINEATION AND CHARACTERISATION OF GW-BODIES AND IDENTIFICATION OF PRESSURES

This section addresses the **following questions raised by Egypt** through specific reference to Art. 5 and annex II of the WFD as well as to specific guidance documents:

1 What are the most polluting groundwater activities?

2 How can well drilling method cause groundwater pollution?

5.1.1 What are the most polluting groundwater activities?

Groundwater bodies are distinct geographical units used to manage groundwater in the European Union. By defining groundwater bodies, extensive aquifers are split into manageable parts so that it becomes possible to analyse the conditions in which the groundwater is (naturally and due to anthropogenic pressures such as abstraction or agricultural pollution), and to find ways to protect it and improve these conditions. The aim is to manage groundwater sustainably meaning that all groundwater bodies are in good status, while meeting the different and sometimes conflicting functions and uses of groundwater. 'Status' is the term used to describe the quantitative and chemical conditions of groundwater bodies considering human activity which might have negative influences on them. The functions and uses of groundwater include the abstraction of water for drinking water supply, irrigation and industry, but also supporting and nurturing both terrestrial and aquatic ecosystems such as rivers and wetlands.

„Specific guidance on bodies of groundwater

Definitions

The application of the term body of groundwater must be understood in the context of the hierarchy of relevant definitions provided under Article 2 of the WFD.

1. *Article 2.2: Groundwater means all water, which is below the surface of the ground in the saturated zone and in direct contact with the ground or subsoil.*
2. *Article 2.11: Aquifer means a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater.*

3. *Article 2.12: Body of groundwater means a distinct volume of groundwater within an aquifer or aquifers.*

A body of groundwater must be within an aquifer or aquifers. However, not all groundwater is necessarily within an aquifer.

The environmental objectives of preventing deterioration of, and protecting, enhancing and restoring, good groundwater status apply only to bodies of groundwater. However, all groundwater is subject to the objectives of preventing or limiting inputs of pollutants and reversing any significant and sustained upward trend in the concentration of any pollutant."

"The Directive's definition of the term body of groundwater does not provide explicit guidance on how bodies should be delineated."

"The delineation of bodies of groundwater must ensure that the relevant objectives of the Directive can be achieved. This does not mean that a body of groundwater must be delineated so that it is homogeneous in terms of its natural characteristics, or the concentrations of pollutants or level alterations within it. However, bodies should be delineated in a way that enables an appropriate description of the quantitative and chemical status of groundwater".

Source: Technical report on groundwater body characterisation issues as discussed at the workshop of 13th October 2003, 11 April 2004

The unit 'GW body (GWB)' should be regarded as a management unit. The delineation of groundwater bodies is primarily based on (hydro)-geology and hydrochemistry. Moreover, watersheds and catchments are considered for the delineation as well as anthropogenic pressures such as:

- diffuse pollution (agriculture, mining, sanitation systems etc.),
- point source pollution (contaminated sites, industry, landfills etc.) and groundwater abstraction;
- the importance and uses of groundwater and
- monitoring results for both quality and quantity,
- …..

In order to develop a system of groundwater bodies it is **first** necessary to identify those aquifers which are relevant from a WFD perspective. This is the case when an aquifer *'allow[s] either a significant flow of groundwater or the abstraction of significant quantities of groundwater'*. More precisely, it has been agreed that the criterion of '*providing more than 10 m^3 a day as an average or serving more than 50 persons*' as well as the intention for such future use as defined in Article 7 of the WFD can be used to determine whether an aquifer allows the abstraction of significant quantities of groundwater.

Secondly, within these relevant aquifers, groundwater bodies need to be delineated and characterised. Note that the WFD leaves considerable freedom in how groundwater bodies are delineated. Depending on the natural characteristics of the aquifers and considering aspects such as the biggest risks for groundwater, available knowledge, monitoring requirements and resource constraints, the responsible public authorities can delineate groundwater bodies as they see best fit. More than 80% of all groundwater bodies are

assigned to the first groundwater horizon (groundwater layer) and 15% to the second horizon. However, the majority of EU Member States also reported groundwater bodies down to the forth horizon.

The delineation and characterisation (i.e. describing them and developing conceptual models to understand how they work) are iterative processes. If it turns out after some time that the initial delineation does not, in fact, allow a clear description of groundwater body status, or that it was not possible to apply measures to protect and improve their status appropriately, then they can be re-delineated. The conceptual model of the groundwater body will also improve with more and better monitoring data, which might in turn show that a different option of delineating groundwater bodies may be preferable.

When delineating GW-Bodies, it should be kept in mind that there is also the third i.e. vertical dimension to be considered. According to the definition of „Groundwater body" the units can be delineated separately for different overlying strata (horizons) or one single GW-body may comprise different overlying strata. There is flexibility left and the procedure applied should be according to the needs within a country – considering the different issues mentioned above e.g. pressures.

The characterisation of a GW body is specified in Annex II, section 2 of the Water Framework Directive; http://ec.europa.eu/environment/water/water-framework/index_en.html

Below are citations from the said Directive:

2 GROUNDWATERS

2.1. Initial characterisation

Member States shall carry out an initial characterisation of all groundwater bodies to assess their uses and the degree to which they are at risk of failing to meet the objectives for each groundwater body under Article 4. Member States may group groundwater bodies together for the purposes of this initial characterisation. This analysis may employ existing hydrological, geological, pedological, land use, discharge, abstraction and other data but shall identify:

- *the location and boundaries of the groundwater body or bodies,*
- *the pressures to which the groundwater body or bodies are liable to be subject including:*
  - *diffuse sources of pollution*
  - *point sources of pollution*
  - *abstraction*
  - *artificial recharge,*
- *the general character of the overlying strata in the catchment area from which the groundwater body receives its recharge,*
- *those groundwater bodies for which there are directly dependent surface water ecosystems or terrestrial ecosystems.*

2.2. Further characterisation

Following this initial characterisation, Member States shall carry out further characterisation of those groundwater bodies or groups of bodies which have been identified as being at risk in

order to establish a more precise assessment of the significance of such risk and identification of any measures to be required under Article 11. Accordingly, this characterisation shall include relevant information on the impact of human activity and, where relevant, information on:

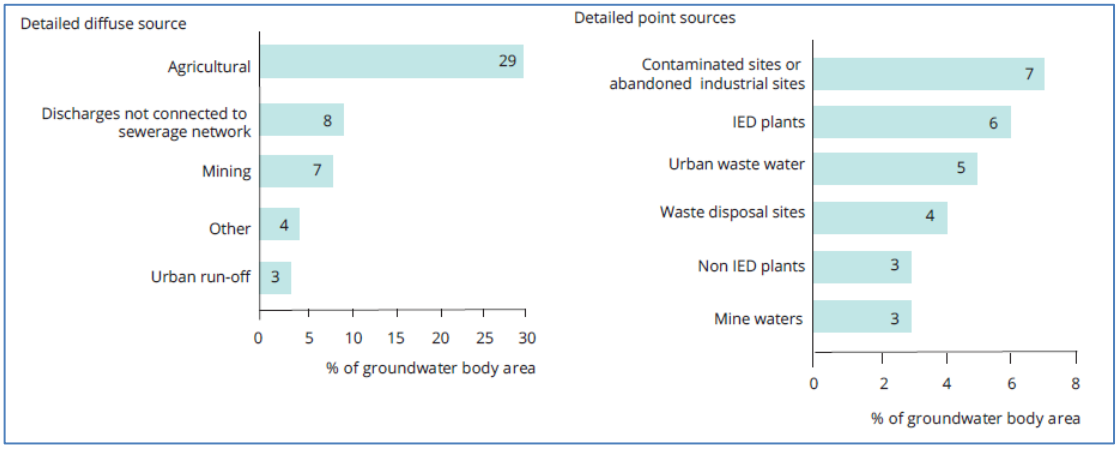
- *geological characteristics of the groundwater body including the extent and type of geological units,*
- *hydrogeological characteristics of the groundwater body including hydraulic conductivity, porosity and confinement,*
- *characteristics of the superficial deposits and soils in the catchment from which the groundwater body receives its recharge, including the thickness, porosity, hydraulic conductivity, and absorptive properties of the deposits and soils,*
- *stratification characteristics of the groundwater within the groundwater body,*
- *an inventory of associated surface systems, including terrestrial ecosystems and bodies of surface water, with which the groundwater body is dynamically linked,*
- *estimates of the directions and rates of exchange of water between the groundwater body and associated surface systems,*
- *sufficient data to calculate the long term annual average rate of overall recharge,*
- *characterisation of the chemical composition of the groundwater, including specification of the contributions from human activity. Member States may use typologies for groundwater characterisation when establishing natural background levels for these bodies of groundwater. Groundwater bodies may be grouped for characterisation and monitoring.*

Based on the above information, and in accordance with Art. 5 of the WFD, an analysis is performed aiming to identify whether there is risk of failing good chemical and quantitative status or not. In case there is such a risk, then additional attention is required to protect and if necessary restore the groundwater body.

The results based on the 2nd River Basin Management Plans, which were due in 2015 and reported by the EU Member States, are summarised across Europe in the Agency's report „European waters – assessment of status and pressures 2018" (EEA, 2018 https://www.eea.europa.eu/publications/state-of-water) :

The **main pressures identified in relation to groundwater** chemical status in the EU Member States are **diffuse sources**, **point sources**, **atmospheric deposition** and **other anthropogenic** pressures. The information concerning both diffuse sources and point sources in the EU Member States is presented in figure 1 below:

Figure 1: Proportion of groundwater bodies affected by diffuse sources and point sources pressures in relation to groundwater chemical status in the EU Member States



Note: Proportion of groundwater body area affected by the main pressure groups and by detailed pressures for diffuse sources and point source pressures. Note the differences in the scale of the X-axis. IED plants are industrial emissions covered by the Industrial Emission Directive (EC, 2018g).

Source: Results based on WISE-SoW database including data from 25 Member States (EU-28 except Greece, Ireland and Lithuania). Groundwater bodies: Significant pressures — overview and Groundwater bodies: Significant pressures.

Note: Total groundwater body area for which information was provided by 25 EU Member States is 4.3 million km²

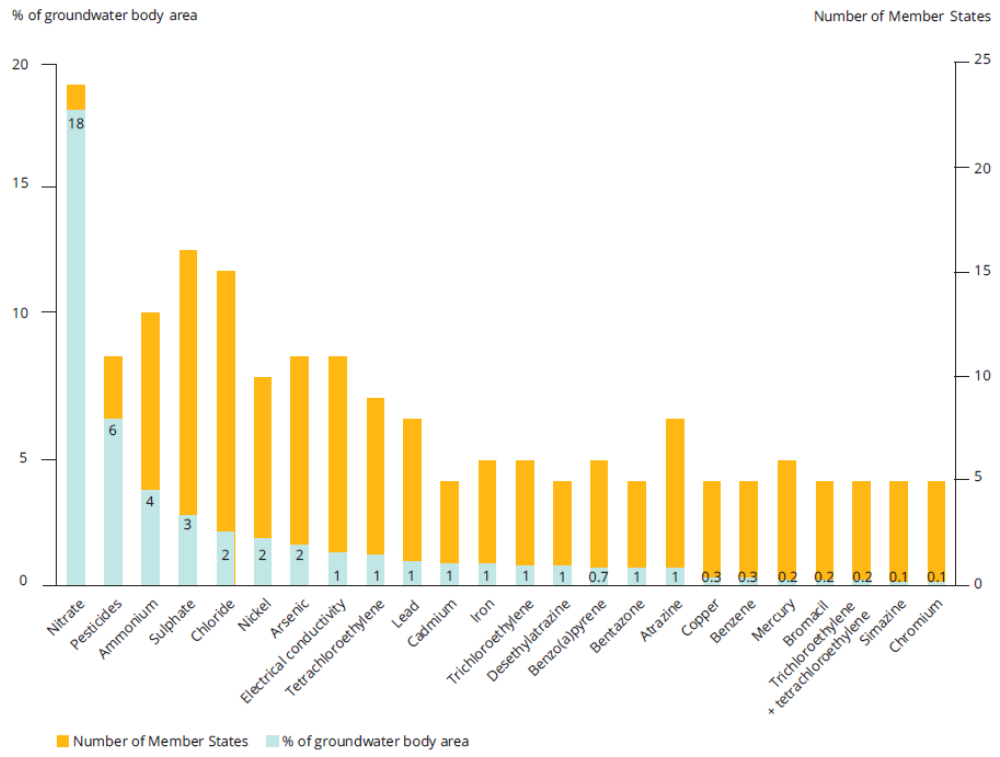
Source: EEA, 2018 https://www.eea.europa.eu/publications/state-of-water

Figure 2 below shows the **pollutants** causing **failure to achieve good chemical status** in groundwater at least in five Member States. The blue section of the bars indicates the proportion of total GW body area. The number of Member States where these pollutants cause failure is shown in orange.

These results show that across Europe the pressures from diffuse sources, and particularly those caused by agriculture, are the most relevant ones. Nitrate is the pollutant which most frequently causes failure to achieve good chemical status.

Contaminated sites or abandoned industrial sites rank highly as far as point sources of pollution are concerned, closely followed by IED plants. These are large industrial plants falling under the provisions of the Industrial Emissions Directive (2010/75/EU).

Figure 2: pollutants causing failure to achieve good chemical status in groundwater at least in five Member States



Notes: Pollutants causing failure shown by proportion of total groundwater body area. The substances shown have caused failure in groundwater in at least five Member States.

Source: Results based on the WISE-SoW database including data from 25 Member States (EU-28 except Greece, Ireland and Lithuania). Groundwater bodies: Pollutants — overview and Groundwater bodies: Pollutants.

Source: EEA, 2018 https://www.eea.europa.eu/publications/state-of-water

Globally, diffuse pollution from agriculture, which includes pollution by nutrients, is a critical problem (UN-Water World Water Development Report 2018). Simultaneously, groundwater abstraction for irrigation has increased by a factor of 10 since the 1960s (UN-Water World Water Development Report 2016). Furthermore, large parts of the world's soils are in less than good condition with an ongoing negative trend, leading to increased evaporation and surface water run-off, and decreased groundwater recharge (UN-Water World Water Development Report 2018).

5.1.2 How can well drilling method cause groundwater pollution?

Drilling wells always means an artificial intervention into the groundwater system by means of penetrating the overlying strata, which usually have protection function for the groundwater.

To avoid groundwater pollution, caution is needed when drilling wells. Different ways concerning groundwater pollution should be considered:

- Pollution transfer from overlying strata e.g. contaminated soil into the groundwater (with the drilling equipment). Prior investigation should be performed, whether there is contamination, which contaminants and properties of contaminants. Suitable drilling technique depending on the contamination should be chosen.

- Hydraulic short circuit of different groundwater horizons – this should be avoided by adequate well construction (bring in of mineral sealing in in the aquiclude zones and of filter gravel in the aquifer zones).
- Drilling fluid – as far as possible drilling methods without using fluids should be preferred. In case, fluids are needed, clean water is an option. If other fluids are needed, it should be proven that no contaminant is included in the fluid or that biodegradable fluids are used.
- Adequate sealing / plugging of the first meter(s) of the borehole (surrounding the tube/pipe) / of the well chamber to ensure that there is no infiltration of surface water into the groundwater.

As a rule, drilling of wells should be subject of prior authorization by the competent authority and carried out by experienced drill masters and drilling companies.

Literature:

Groundwater body characterisation:

1. Technical report on groundwater body characterisation issues as discussed at the workshop of 13th October 2003, 11 April 2004 https://circabc.europa.eu/sd/a/157c2240-b988-417b-9137-a14e89db41d8/Groundwater%20characterisation%20report.pdf
2. Guidance on risk assessment and the use of conceptual models for groundwater; Guidance Document No. 26
3. The results across Europe are summarised in the report „European waters – assessment of status and pressures 2018" (EEA, 2018 ***https://www.eea.europa.eu/publications/state-of-water***)

Groundwater body delineation:

1 CIS Guidance Document 35: WFD Reporting Guidance 2016. Final – Version 6.0.6. Annex 4: Groundwater bodies and horizon assignment

5.2 PRINCIPLES FOR DEVELOPING A MONITORING STRATEGY AND FOR MONITORING NETWORK DESIGN (REQUIREMENTS OUTLINED IN ART. 8 WFD), E.G. DISTRIBUTION OF SITES, IDENTIFICATION OF RELEVANT POLLUTANTS, MONITORING FREQUENCY, ETC.

This section is related to question 3 raised by Egypt: How can groundwater pollution be measured quantitatively and qualitatively?

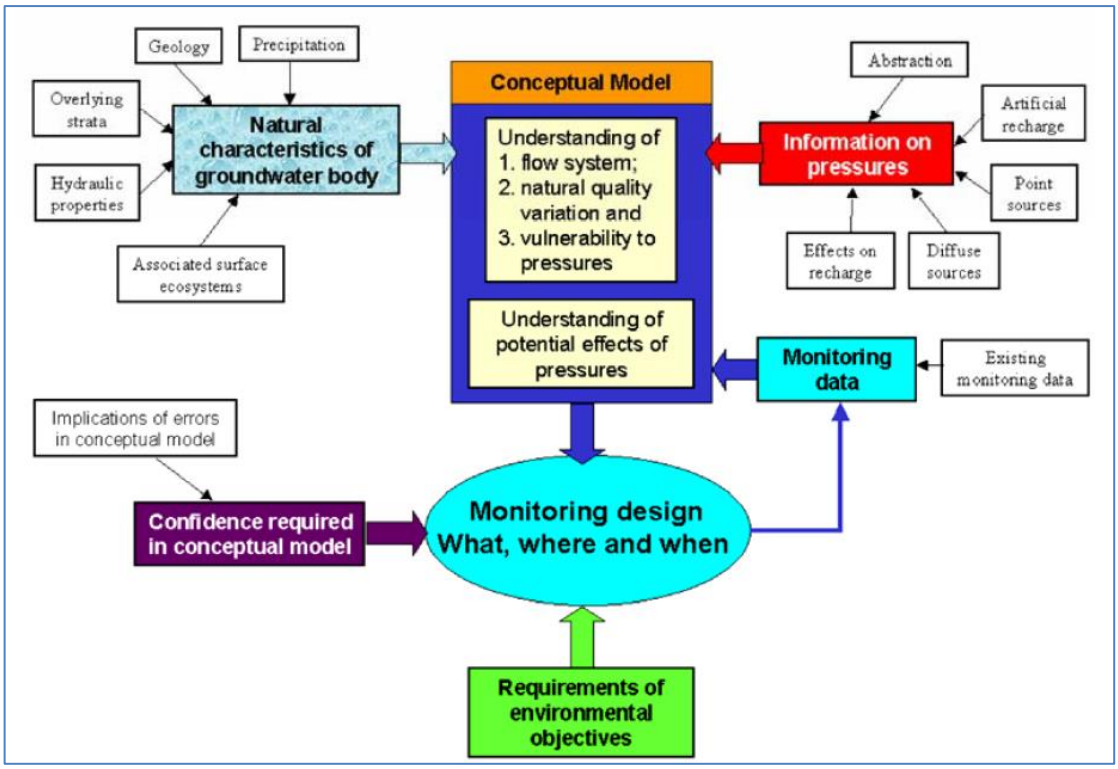
5.2.1 How can groundwater pollution be measured quantitatively and qualitatively?

The characterisation of a groundwater system as mentioned above (individual groundwater bodies or groups of groundwater bodies) and the development of a conceptual model to understand such systems are the basis for developing an adequate monitoring network. Based on an understanding of the anthropogenic pressures exerted on the groundwater bodies, the relevant pollutants can be selected for the monitoring programme of each groundwater body. This allows an assessment of whether pollutant concentrations are going up or down over time, and of how effective the applied groundwater protection measures are.

Figure 3 below illustrates the principles and elements of a conceptual model and its relationship to the monitoring design. Such a conceptual model can be developed at different scales. For example, a conceptual model on the local scale could focus on point sources of pollution, while a conceptual model on to the GW body scale could allow assessing the chemical status of GW bodies.

“The conceptual model will represent the current understanding of the groundwater system on the knowledge of its natural characteristics (e.g. the aquifer type, three dimensional structure, dynamics and boundary conditions), perceived pressures and knowledge of impacts” (European Communities, 2007).

Figure 3: Link between the conceptual model/understanding and monitoring (European Communities, 2007)



Based on the natural characteristics of the GW body and information on pollutant sources and pollutant properties, the monitoring network design can be developed. The hydrogeological setting, the groundwater flow regime, land use and anthropogenic pressures etc. are input information for the conceptual model and the monitoring network. The network design comprises the spatial distribution, number and density of sites and the technical details of the sites including well depth, screens, filter packs etc. Moreover, the frequency of sampling depends on the factors mentioned above.

As an example for monitoring frequencies, in table 3 below the proposed monitoring frequencies for surveillance monitoring (where understanding of aquifer systems is inadequate) are presented.

Table 3: Proposed monitoring frequencies for surveillance monitoring (where understanding of aquifer systems is inadequate)

		Aquifer Flow Type				
		Confined	Unconfined			
			Intergranular flow significant		Fracture flow only	Karst flow
			Significant deep flows common	Shallow flow		
Initial frequency – core & additional parameters		Twice per year	Quarterly	Quarterly	Quarterly	Quarterly
Long term frequency – core parameters	Generally high-mod transmissivity	Every 2 years	Annual	Twice per year	Twice per year	Twice per year
	Generally low transmissivity	Every 6 years	Annual	Annual	Annual	Twice per year
Additional parameters (on-going validation)		Every 6 years	Every 6 years	Every 6 years	Every 6 years	-

Note: This table proposes monitoring frequencies that can be used as a guide where the conceptual understanding is limited and existing data are not available. Where there is a good understanding of groundwater quality and the behaviour of the hydrogeological system, alternative monitoring frequencies can be adopted as necessary.

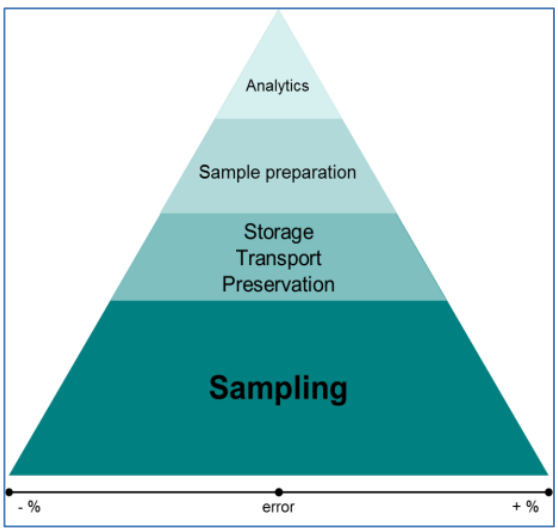
Source: Guidance on Groundwater Monitoring, Guidance Document No. 15 (European Communities, 2007)

In the respective Guidance Document further information is given for operational monitoring.

To ensure the quality of monitoring data, the field sampling and measurements, storage and transport of samples to the laboratory and finally the analyses according to the needs (e.g. adequate limit of quantification) are highly relevant.

Mistakes made during sampling, for example, make it impossible to obtain high quality data even if the laboratory analysis is carried out according to the state of the art (see figure 4 below). Therefore, the weakest element in this chain of tasks and responsibilities is decisive, and improving this element has the highest priority. Hence, it is important to elaborate standard operation procedures for sampling and give training to the staff.

Figure 4: Potential sources of error and their extent in sampling and analytics,© Umweltbundesamt



Literature:

1. Guidance on Groundwater Monitoring, Guidance Document No. 15 (European Communities, 2007)

5.3 PRINCIPLES OUTLINED IN THE WFD CONCERNING GW PROTECTION – FROM GENERAL APPROACHES DOWN TO THE GW BODY LEVEL AND SAMPLING SITES.

This section is related to question 5 and 6 raised by Egypt:

- What are the procedures for protecting the single well, well fields, and groundwater aquifers?
- Is it possible to protect the groundwater reservoir from pollution from any contaminant in the source of recharge (river, lake, or any water body)?

The European Water Framework Directive WFD (2000/60/EC) is the principal European legislation concerning the protection and management of both surface water and groundwater. Concerning groundwater chemical status and trends it is complemented by the daughter Groundwater Directive (GWD) (2006/118/EC).

Art. 4 of the WFD lays down the environmental objectives. For groundwater this includes that "Member States shall implement the measures necessary to prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of all bodies of groundwater. Complementary provisions are laid down in Article 7 WFD concerning „Waters used for the abstraction of drinking water."

The **criteria for the assessment of chemical status and trends are laid down in the GWD**. **The criteria are further put into practical means of implementation in the CIS Guidance Document No. 18.** With regard to chemical status, this **guidance document defines five tests for groundwater chemical status.** These **tests** concern:

- saline or other intrusions;
- surface waters;
- groundwater dependent terrestrial ecosystems;
- drinking water protection areas; and
- general quality assessment.

They link the chemical status of the groundwater body to its interactions with its uses and functions (ecosystems, drinking water provision, general groundwater quality). All relevant tests (i.e. all tests concerning status classification elements that are at risk of not achieving good status) must be completed successfully, and the worst result is decisive for the chemical status of the entire groundwater body. Similarly, both chemical and quantitative status must be good for the groundwater body to be in good overall status.

This means, for example, that if the ecology or chemistry of an aquatic ecosystem associated with a given groundwater body (such as a river fed by groundwater) is impaired (i.e. the

surface water test fails), then the groundwater body does not achieve good chemical status. Consequently, it is also in poor overall status.

Both the WFD and the GWD are complemented by so called sectoral Directives with relevance for the protection of groundwater:

- Nitrates Directive (91/676/EEC) – The Directive aims to **reduce** nitrate pollution from agricultural sources **and** **prevent** further pollution. https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:31991L0676
- Urban Wastewater Treatment Directive (91/271/EWG) – '*The objective of the Directive is to protect the environment from the adverse effects of waste water discharges*.' https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31991L0271
- Regulation of the European Parliament and of the Council concerning the placing of plant protection products on the market (1107/2009) – '*The purpose of the Directive is to ensure a high level of protection of both human and animal health and the environment and to improve the functioning of the internal market through the harmonization of the rules on the placing on the market of plant protection products, while improving agricultural production.'* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32009R1107
- Biocidal Products Regulation (528/2012) – '*The purpose of this Regulation is to improve the functioning of the internal market through the harmonisation of the rules on the making available on the market and the use of biocidal product, whilst ensuring a high level of protection of both human and animal health and the environment*.' https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012R0528
- Industrial Emissions Directive (2010/75/EU) – '*This Directive lays down rules on integrated prevention and control of pollution arising from industrial activities. It also lays down rules designed to prevent or, where that is not practicable, to reduce emissions into air, water and land and to prevent the generation of waste, in order to achieve a high level of protection of the environment taken as a whole*.' https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32010L0075

For the assessment of groundwater chemical status, provisions for quality standards are laid down in the GWD. These numerical criteria are differentiated into two types. First, all EU Member States shall use the same groundwater quality standards (subject of Annex I of the GWD) for nitrate and pesticides. Secondly, Member States shall establish threshold values (i.e. national quality standards) for pollutants, group of pollutants and indicators of pollution which, within their territory, have been identified as contributing to the characterization of bodies or groups of groundwater bodies as being at risk.

If, for example a Member State finds out that a certain industrial chemical has sufficiently harmful characteristics and is used in sufficient quantity, or that there are sufficiently large historical sites of pollution, to put a groundwater body at risk of not achieving good chemical status because one of its uses or functions might be impaired (which links to the status tests mentioned above), then the Member State authorities must set a threshold value for this pollutant. This threshold value can be set for different areas of geographical coverage,

ranging from individual groundwater bodies through river basin districts to the entire area of the Member State.

The GWD further specifies how to identify significant and sustained upward trends in pollutant concentrations in groundwater and how to define the starting points for trend reversals. This is complemented by the provision to assess the impact of existing plumes of pollution in bodies of groundwater that may threaten the achievement of the environmental objectives (Art. 4, WFD) and in particular those plumes resulting from point sources and contaminated land.

Article 6 of the GWD regulates “Measures to prevent and limit inputs of pollutants into groundwater”. All measures necessary to prevent inputs into groundwater of any hazardous substances shall be taken.

For pollutants which are not considered hazardous, all necessary measures shall be taken to limit inputs into groundwater so as to ensure that such inputs do not cause deterioration or significant and sustained upward trends in the concentrations of pollutants in groundwater.

GWD Article 4 provides that if the quality standards and threshold values are exceeded at one or more than one monitoring point of a groundwater body **but** appropriate investigations in the form of the chemical status tests show that this does not result in negative consequences, then the groundwater body is still of good status.

In such cases, the Member State **must take measures** that may be necessary to protect aquatic ecosystems, terrestrial ecosystems and human uses of groundwater, depending **on the part of the groundwater body represented by the monitoring point or points at which the value for a groundwater quality standard or the threshold value has been exceeded.**

This provision is regarded as relevant concerning the protection of single wells.

Literature:

1. CIS Guidance Document No. 16 on Groundwater in Drinking Water Protected Areas
2. CIS Guidance Document No. 17 on preventing or limiting direct and indirect inputs in the context of the groundwater directive 2006/118/EC
3. CIS Guidance Document No. 18 on groundwater status and trend assessment

5.4 REQUIREMENTS CONCERNING WATER USED FOR THE ABSTRACTION OF DRINKING WATER (ART. 7 WFD)

This section addresses question 1 raised by Palestine, namely:

- What is the best and simplest mean to delineate protection zone 2?

According to WFD Art. 7.1 and Guidance Document No 16 on Groundwater in Drinking Water Protected Areas (DWPAs), DWPAs are whole groundwater bodies, which are used for the abstraction of water intended for human consumption providing more than 10 m^3 a day as an average or serving more than 50 persons, and those bodies of water intended for such future use.

However, in Art. 7.3, it is further specified that Member States shall ensure the necessary protection for the bodies of water which are used for the abstraction of drinking water with the aim of avoiding deterioration in their quality in order to reduce the level of purification treatment required in the production of drinking water. Member States may establish **safeguard zones** for those bodies of water.

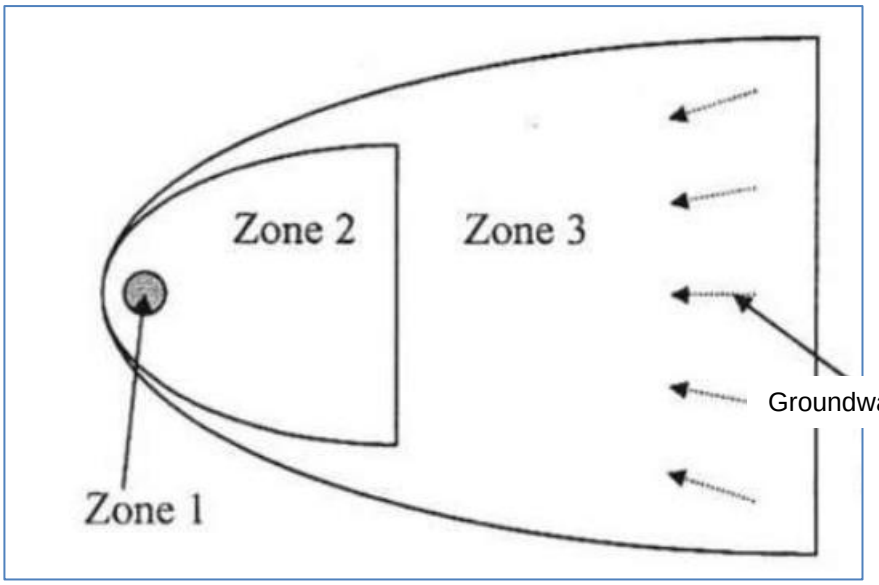
In Austria there are different types of safeguard zones – both are introduced by the Federal Water Act:

- Protection zones around drinking water abstractions ("Schutzgebiete") and
- Source protection zones ("Schongebiete") and framework orders ("Rahmenverfügung").

Protection Zones are divided into three zones:

- Zone 1 – total prohibition of anthropogenic land use types in order to account for short flow paths and short travel times, which do not allow natural purification nor timely response to pollution events. This zone comprises the immediate surrounding of the abstraction well and should be protected by a fence – if feasible.
- Zone 2 – is based on the 60 days travel time of groundwater, aiming at the protection concerning microbial pollution
- Zone 3 – considers GW renewal and properties of the covering layers

Figure 5: Scheme for protection zones



Source: http://www.ooewasser.at/de/wasserversorgung/technik/wasserschongebiet-und-wasserschutzgebiet.html, *modified*

In a guidance document by the Austrian Federation of Gas and Water (ÖVGW) further details are specified, concerning the delineation of the different zones for the protection of drinking water abstractions (Richtlinie W72, Schutz- und Schongebiete 2004).

According to this guidance, the vertical flow through the unsaturated zone is not considered for the assessment of the 60 days travel time as a rule; it is regarded as additional safety margin.

Among others, it is listed, which hydro(geo)logical information is needed to allow for the assessment of the different zones – in particular for zone 2. For example, information is needed on:

- permeability (kf value)
- groundwater gradient (I)
- porosity (n)
- groundwater thickness
- abstraction
- …

***Remark from Palestinian Experts**: In Palestine there is regulation of protection and delineation of water resources , the regulation defined the groundwater protection zones into 3 zones:*

- *The first zone : Is the area directly surrounding the well, within this area the contaminants can transfer pollutants to the well, and is determined by a distance not less than 30 meters towards the source of water feeding and not less than 15 meters in other directions*
- *The second protection zone is determined from the hydrological information related to the movement of groundwater to calculate the distance and the speed of the access of the pollutants to the water source, reports and technical studies that can calculate the distance and velocity of the water by the specialists in the Water Authority, so that the time of the arrival of pollutants to the water source is not less than 50 days and not to exceed the distance towards the source of nutrition 2 km and the distance in in other directions 50-150 meters.*
- *The third protection zone is determined based on the main areas of groundwater recharge, the geological outcrops of the aquifers and the aquatic layer sensitivity maps, which are estimated from the hydrological characteristics of the area and the aquatic layers of the recharge basin*

According to the information provided, it seems, the approach applied in Palestine for the delineation of protection zones around drinking water abstractions is similar to the approach in Austria – in both countries there is a differentiation into three zones. However, the used parameters are a little bit different. The first zone comprises the direct surrounding of the abstraction well, the second zone is delineated based on travel time which is 50 days in Palestine and 60 days in Austria. Finally the third zone goes beyond zone I and II and depends on groundwater recharge and on the consistency of overlying strata. In Austria the risk of pollution is considered as well, i.e. in case of favourable conditions it is also possible only to delineate zone I and II.

Moreover, in Austria source protection zones can be delineated as outlined above, to protect water sources for existing abstractions but also for potential future uses.

Finally, the peer from Palestine is requested to consult with the SWIM-H2020 SM focal point (Mageda Alawneh), for specific information on the on-going project activity under the Expert Facility workpackage, Activity „EFS-PS-1: Mainstreaming Drought Risk Management " . Task 3 of this activity will define groundwater protection zones based on the methodology that will be agreed upon between the project and the partners at PWA. It will assign local-scale groundwater vulnerability and protection zones, and implement the methodology in 2 pilot areas with the priority focus for the protection zones on the good quantitative status of groundwater. Within this task, the effect of Urbanization on the Aquifer vulnerability will also be evaluated.

The expected outcome of this task is hence:

- Definition of groundwater protection zones in 2 pilot areas
- Development and calculation of a groundwater vulnerability index

5.5 'COMPLEMENTARY TO 5.2: PRINCIPLES FOR DEVELOPING A MONITORING STRATEGY AND FOR MONITORING NETWORK DESIGN' (REQUIREMENTS OUTLINED IN ART. 8 WFD)

This section is related to question 2 raised by Palestine; namely:

- How to detect pollutant track?

The monitoring network design as outlined in section 5.2 above may be complemented by a more local groundwater monitoring – e.g. a "prevent and limit" monitoring – this is primarily designed to ensure compliance with site conditions and authorisations in the cases of regulated activities or for site specific investigations, i.e. compliance monitoring, or for purposes of characterising sites specific impacts and designing and assessing remedial action programmes, i.e. investigation monitoring (Guidance Document No. 17, on preventing and limiting direct and indirect inputs in the context of the Groundwater Directive 2006/118/EC).

In case of contaminated sites the following procedure can be applied:

- Identification of a contaminated site
  - area, source
  - potential pollutant (fate, behaviour, ….)
- hydrogeological investigation concerning groundwater in particular identification of flow direction, discharge, ….
- monitoring wells
  - upstream the contaminated site
  - downstream the contaminated site – starting very close to the boundary of the site; number of monitoring wells varies according to the area and extent of the site
- sampling and analyses
  - sampling depends on pollutant type – e.g. in case of mineral oil scoop water, and in in case of other pollutants pump water, …
  - sampling of different vertical levels
  - (long term) pumping tests – samples are taken and analysed during the test
  - …..
- Based on first results, the monitoring design is further developed and adapted.

Moreover, further innovative technologies (passive sampler, multi-level sampling, direct push e.g. to identify pollutant plume) ….. are applied.

It is important to stress that the procedure applied depends highly on the site specific conditions!

Concluding remark: For the identification of pollutant tracks downstream contaminated sites as a rule no models are applied but investigations and monitoring is performed as described above.

For further information concerning conceptual models and monitoring network design, see section B above "How can groundwater pollution be measured quantitatively and qualitatively?"

Literature:

1. Guidance Document No. 17, on preventing and limiting direct and indirect inputs in the context of the Groundwater Directive 2006/118/EC.

Literature - referred to in the document:

1. Technical report on groundwater body characterisation issues as discussed at the workshop of 13th October 2003, 11 April 2004 https://circabc.europa.eu/sd/a/157c2240-b988-417b-9137-a14e89db41d8/Groundwater%20characterisation%20report.pdf
2. Guidance on risk assessment and the use of conceptual models for groundwater; Guidance Document No. 26
3. The results across Europe are summarised in the report „European waters – assessment of status and pressures 2018" (EEA, 2018 *https://www.eea.europa.eu/publications/state-of-water*)
4. CIS Guidance Document 35: WFD Reporting Guidance 2016. Final – Version 6.0.6. Annex 4: Groundwater bodies and horizon assignment
5. Guidance on Groundwater Monitoring, Guidance Document No. 15 (European Communities, 2007)
6. CIS Guidance Document No. 16 on Groundwater in Drinking Water Protected Areas
7. CIS Guidance Document No. 17 on preventing or limiting direct and indirect inputs in the context of the groundwater directive 2006/118/EC
8. CIS Guidance Document No. 18 on groundwater status and trend assessment
9. Guidance Document No. 17, on preventing and limiting direct and indirect inputs in the context of the Groundwater Directive 2006/118/EC.