Updated Strategies for Monitoring and Assessment of Transboundary Rivers, Lakes and Groundwaters: focus on groundwater

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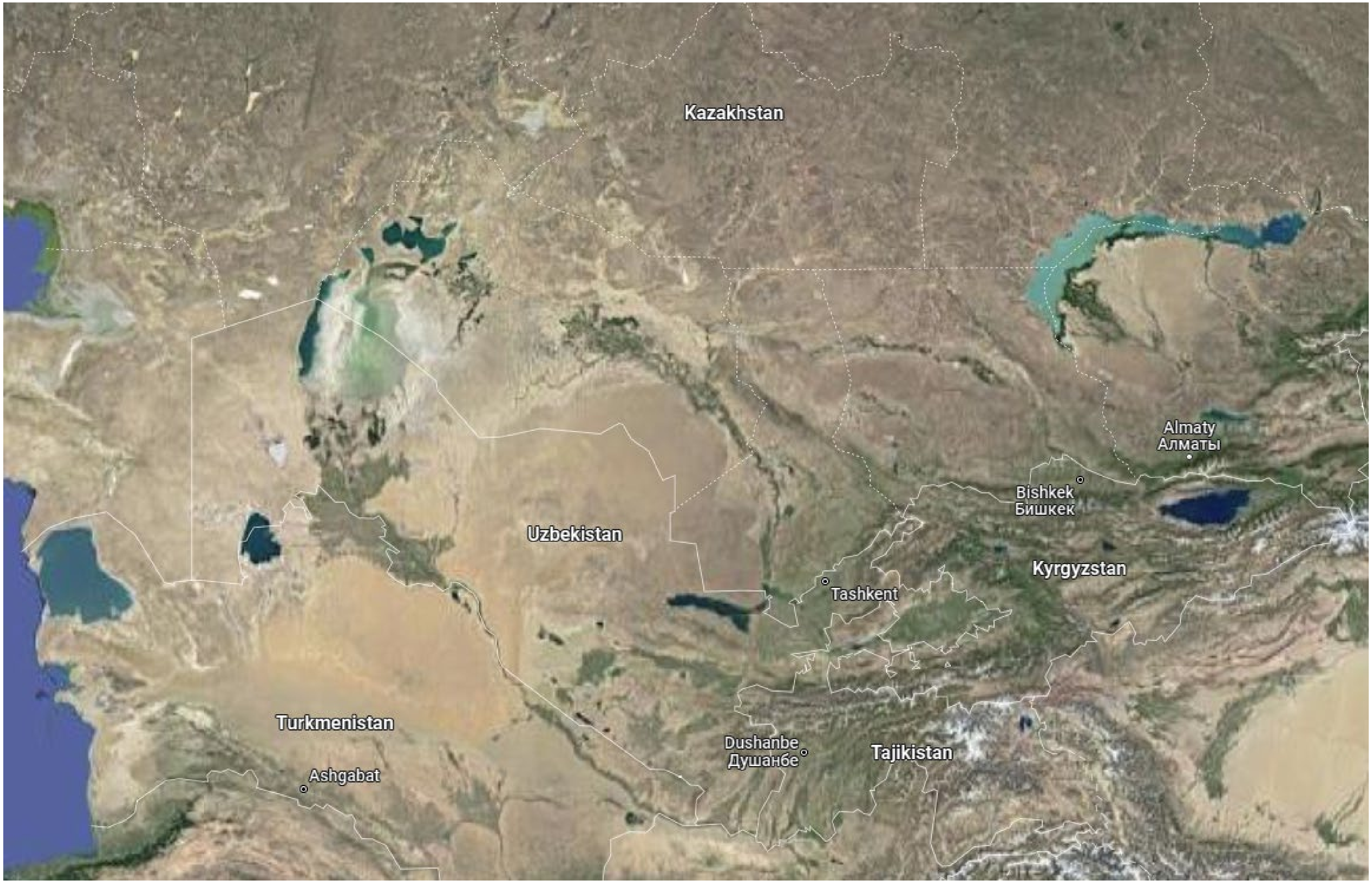


What transboundary groundwater? Where?

The very first step is to identify aquifers that are transboundary.

Preliminary assessment of transboundary aquifers

- Geological and hydrogeological maps are a good starting point to identify transboundary aquifers.

- Stratigraphic records are also needed to determine the vertical extent of hydrogeological units. Stratigraphic logs are usually recorded in borehole databases.

- Groundwater flow direction and rate can then be determined based on groundwater levels measurements, which are usually recorded in borehole databases (static water level) or in monitoring databases.

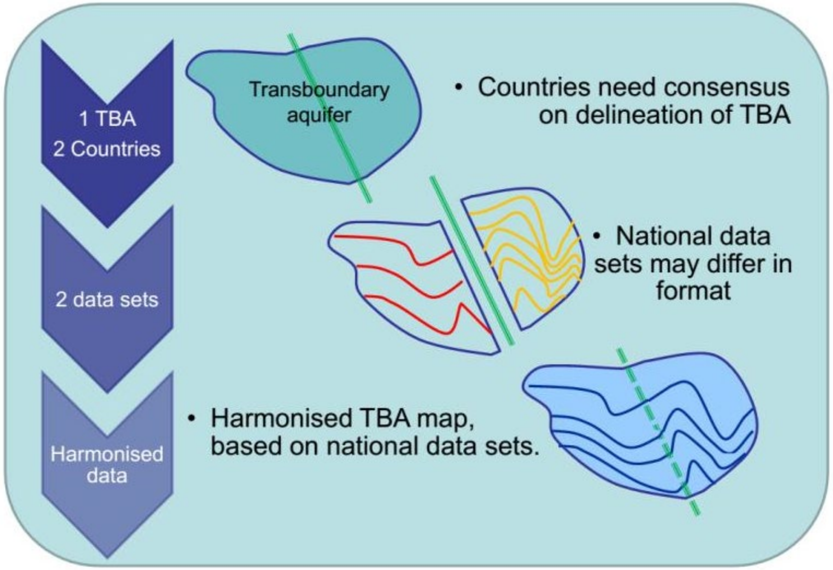
- Additional data and investigation will be needed to complement the hydrogeological assessment (e.g. geophysics, geochemical and isotopic studies, groundwater recharge estimation, numerical modeling).

- For the sake of a multidisciplinary assessment, the hydrogeological assessment needs to be complemented with data and information on the larger environmental and socio-economic context.

https://www.un-igrac.org/sites/default/files/resources/files/Guidelines%20for%20TBA%20Assessment%2020150901.pdf

- There will likely be discrepancies between the maps and datasets, requiring harmonization.

- Sharing metadata is necessary when sharing data between organizations and countries.



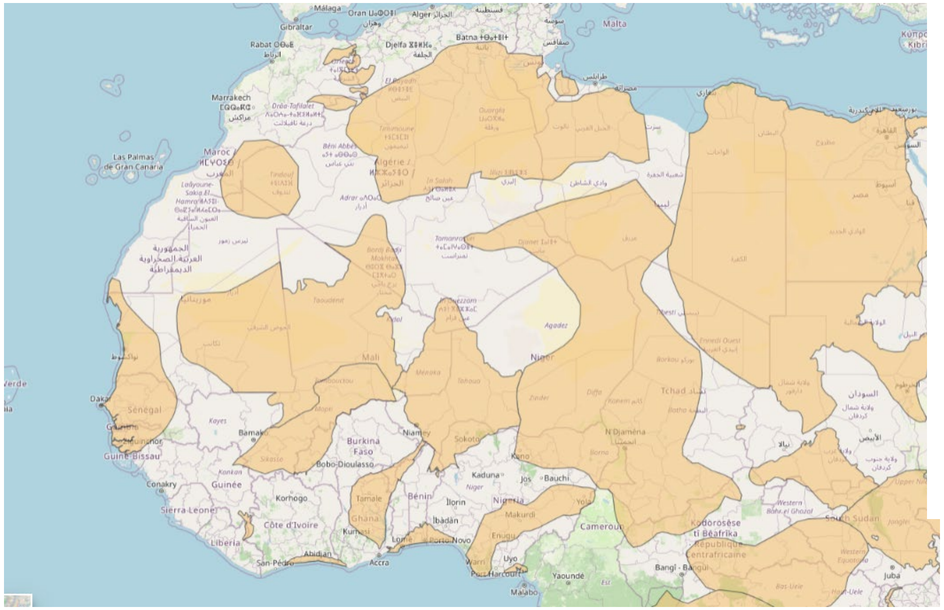
Example: Comparison of hydrogeological units in the SMAB, as reported in available hydrogeological maps (the order of the countries is from South to North).

<table>
<tr><th>Era</th><th>Period</th><th>Epoch</th><th colspan="3">Regional map
in Diene et al. 2015</th><th>Regional map
UNESCO 2006</th><th>Guinea-Bissau
Synthese hydrogeologique, 1991</th><th colspan="2">Gambia
National Water Resources Assessment and Management Strategy, 2015</th><th colspan="4">Senegal
DGPRE 2018</th><th>Mauritania
USGS 2015</th></tr>
<tr><td rowspan="6">Cenozoic</td><td>Quaternary</td><td></td><td>Coastal sands aquifer - Senegal</td><td>Alluvial aquifer – Transboundary</td><td rowspan="4"></td><td>Quaternary sand (Littoral Nord in Senegal)</td><td rowspan="2">Plio-Quaternaire</td><td rowspan="2">Shallow Sand Aquifer Unit</td><td>Phreatic aquifer</td><td rowspan="3">Quaternaire / Continental-Terminal</td><td rowspan="5"></td><td rowspan="4"></td><td></td><td rowspan="6">Coastal sedimentary deposits of Quaternary-Tertiary ages</td></tr>
<tr><td rowspan="2">Neogene</td><td>Pliocene</td><td rowspan="2">Continental-Terminal - Mauritania</td><td rowspan="3">Oligocene-Miocene / Continental-Terminal – Transboundary</td><td rowspan="2">Continental-Terminal (Trarza, Benichab and Boulenoir units in Mauritania, Unite Centrale in Senegal)</td><td>Semi-confined aquifer</td><td rowspan="6">Continental-Terminl / Oligocene Moyen / Maastrichtian</td></tr>
<tr><td>Miocene</td><td>Miocene Moyen N1(2)</td><td colspan="2" rowspan="3"></td></tr>
<tr><td rowspan="3">Paleogene</td><td>Oligocene</td><td></td><td></td><td>Oligocene-Miocene Inferieur P3/N1(1)</td><td rowspan="3"></td></tr>
<tr><td>Eocene</td><td>Amechtil aquifer - Mauritania</td><td>Brakna Aquifer - Mauritania</td><td>Lutetian limestone aquifer - Senegal</td><td rowspan="2">Paleocene-Eocene (Amechtil and Brakna units in Mauritania)</td><td rowspan="2">Paleocene/ Eocene P1/P2</td><td rowspan="3">Eocene - Maastrichtian</td></tr>
<tr><td>Paleocene</td><td>Paleocene limestone aquifer - Senegal</td><td colspan="2" rowspan="2"></td><td colspan="2">Deep sandstone aquifer</td><td rowspan="2">Paleocene/Maastrichtian</td></tr>
<tr><td>Mesozoic</td><td>Cretaceous</td><td>Upper Createaceous</td><td>Deep confined Maastrichtian aquifer – Transboundary</td><td>Maastrichtian (Unite de Bordure in Senegal)</td><td>Maastrichtian K2m</td><td colspan="2"></td><td>Maastrichtian</td><td></td></tr>
</table>

Hotspots

- In large TBAs, it is recommended to identify hotspots where activities on one side of the border will most likely impact the neighboring country: groundwater over-abstraction and contamination, but also land-use changes, surface water interventions, MAR (e.g. Genevois aquifer), etc.

- Scale is key!



https://ggis.un-igrac.org/view/tba

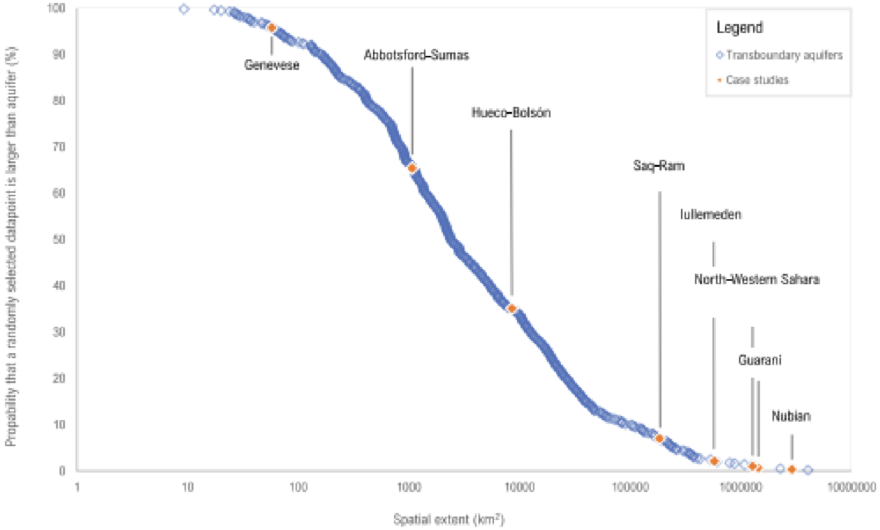
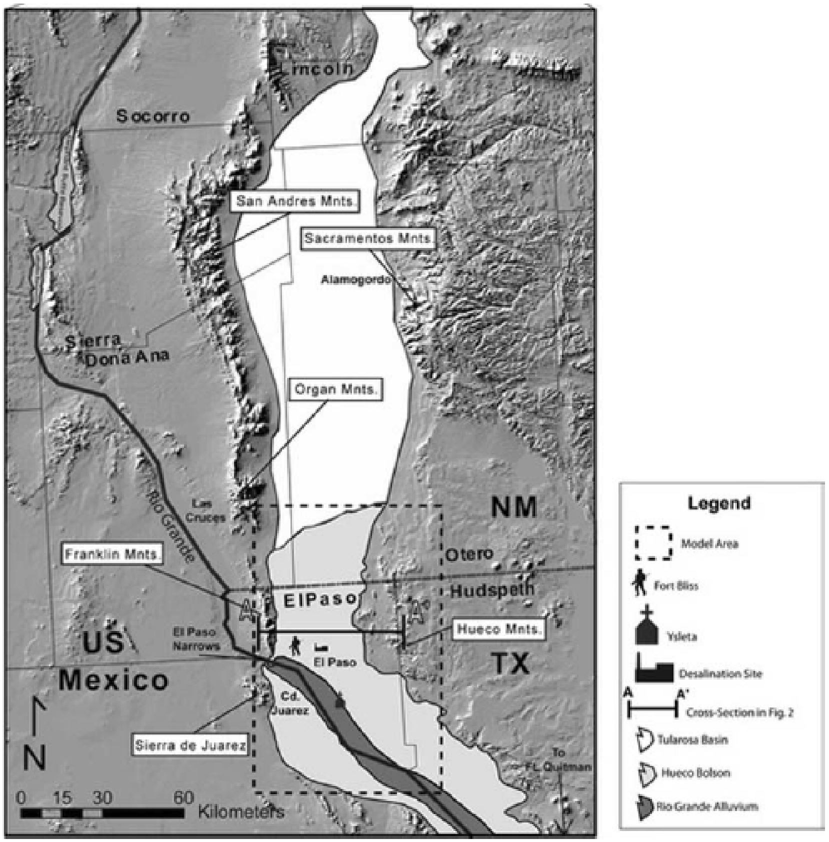
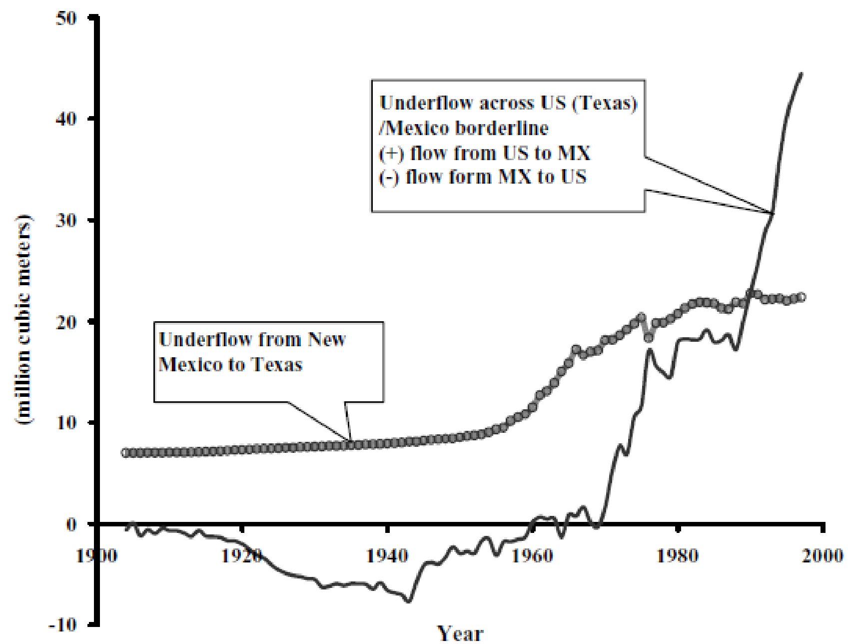


Figure 2. Distribution of transboundary aquifers by spatial extent, reflecting case study heterogeneity. Note: The Genevese belongs to the smallest 5% transboundary aquifers in the world; the Nubian Sandstone, Guaraní and the North-Western Sahara aquifer systems are among the largest 1.0%.

Maya Velis, Kirstin I. Conti & Frank Biermann (2022)
DOI: 10.1080/02508060.2022.2038925

- The natural direction and rate of groundwater flow can be modified by abstraction. Therefore, the distinction between upstream and downstream countries is not always relevant. Example of the Hueco Bolson aquifer shared between Mexico and USA.





Source: Sheng, Z., Devere, J. (2005)
https://doi.org/10.1007/s10040-005-0451-8

Transboundary groundwater monitoring

- The specific aspects of transboundary groundwater monitoring have been captured in an annex, based on the earlier *Guidelines on Monitoring and Assessment of Transboundary Groundwater*.

UN/ECE Task Force on Monitoring & Assessment
under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992)

Work Programme 1996-1999

Guidelines on Monitoring and Assessment of Transboundary Groundwaters

ISBN 9036953154

Lelystad, March 2000

- The design of a joint monitoring network will depend on the objectives of transboundary cooperation.

Table 2.3: Example of data needs from different data sources for specified objectives

	Monitoring objectives	Groundwater observation wells			Groundwater pumping wells			Springs			Surface water observation points		
		levels	discharge	quality	level	discharge	quality	level	discharge	quality	level	base flow	quality
	Groundwater development												
1	GW system characterisation	xx	n.a.		x			x			x		
2	GW potential for development (quantity and quality)	xx	n.a.	xx		xx	xx		xx	xx		xx	x
3	Best locations for well fields	xx		xx			xx			x			(x)
	Control and protection												
4	Trends of over-exploitation	xx	n.a.		x	xx			xx			xx	
5	Nature conservation	xx	n.a.			xx		x	xx			xx	
6	Saline water intrusion	x	n.a.	xx*	x	xx	xx*				x	x	(x)
7	Land subsidence	x	n.a.			xx							
8	Contamination of aquifers		n.a.	xx			xx			xx			xx

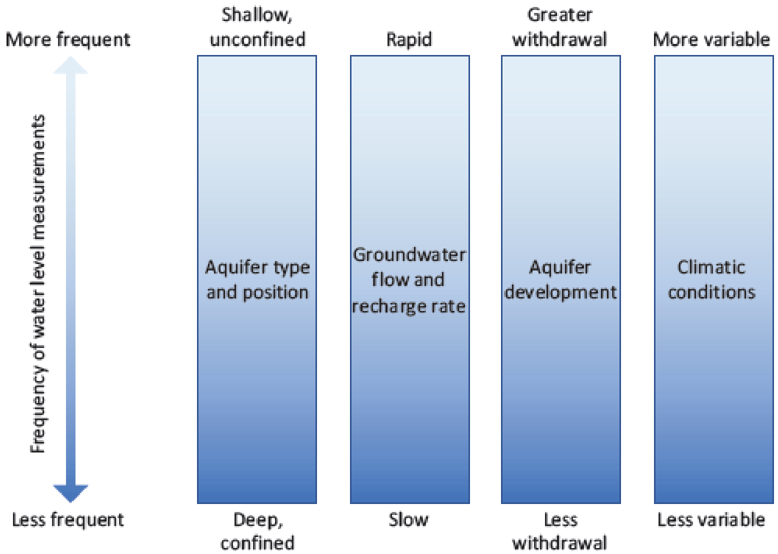
x = desirable data; xx = necessary data; xx* = mainly Chloride; n.a. = not applicable.

IGRAC (2008) https://www.un-igrac.org/sites/default/files/resources/files/WG1-7-Guideline-v12-03-08.pdf

- It will usually include groundwater level, groundwater quality and groundwater abstraction monitoring.

- The design of a joint monitoring network will also reflect the scale and the complexity of the hydrogeological system.

- Groundwater monitoring has usually a lower frequency than in rivers, because groundwater flow is slower.



Source: Taylor and Alley (2001) cited in SOGW (2013)

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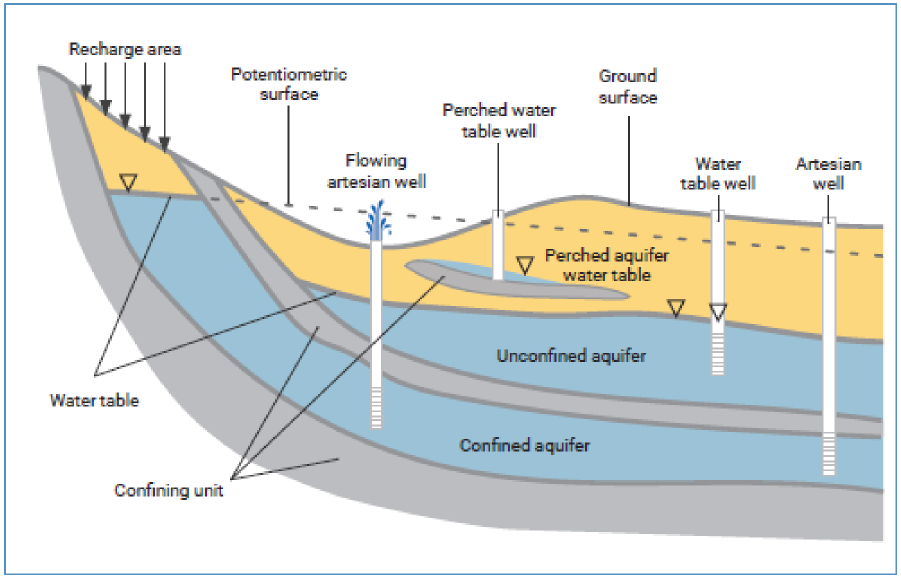
- Compared to surface water, more observation points might be necessary to capture the 3-dimensional complexity of hydrogeological systems.



WWAP 2022

- Existing observation wells would be used in the first place. However, TBA monitoring might require additional wells. This would require additional cooperation efforts from the countries.

- Monitoring of groundwater abstraction is usually restricted to wells owned by water companies or large private users. The number of boreholes and their average yield is usually used as a proxy, but it requires new boreholes to be registered. This is not always a legal obligation, and when it is, it is often not properly enforced.

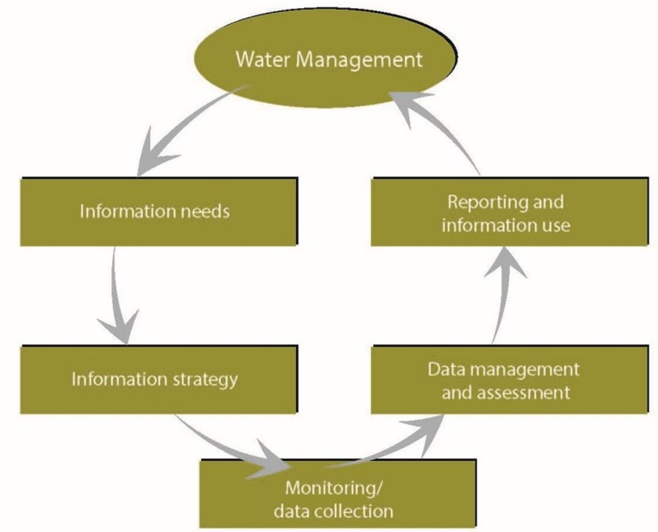
Example of the Doñana National Park, a World Heritage site threatened by illegal wells.

https://www.wwf.eu/?3877416/EU-court-rules-Spain-at-fault-over-degradation-of-Donana

- In addition to hydrogeological data (monitoring data and borehole data), other data and information might be exchanged if relevant to potential cross-border impacts.

- The monitoring program should be evaluated and updated frequently.

- New monitoring data might allow refining the assessment of TBA. It is an ongoing effort!



- The interpretation of new data requires capacity (hydrogeologists). A joint team responsible for the monitoring and the assessment of transboundary aquifers seems instrumental.

- It can be an intergovernmental institution (e.g. RBO or TBA authority), or a multi-country taskforce.

Thank you for your attention!

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