International Groundwater Resources Assessment Centre

# Assessment of Transboundary Aquifers (TBA)

## Transboundary Aquifers of Europe

Lena Heinrich

Berlin , 2011

# Contents:

# What is IGRAC?

- **IGRAC - International Groundwater Resource Assessment Centre is an independent foundation working under the auspices of UNESCO and WMO**

- **IGRAC facilitates and promotes global sharing of information and knowledge required for sustainable groundwater resources development and management**

- **Focused on information and knowledge management, transboundary aquifer assessment and groundwater monitoring**

- **Receives financial support from the government of The Netherlands**

- **Located in Delft, The Netherlands.**

# TBA Assessment at IGRAC

- **ISARM Regional Activities**

  **(cooperation with OAS, SADC, INWEB, UNECE, OSS, GWP-MED, GEF, UNEP, UNDP..)**

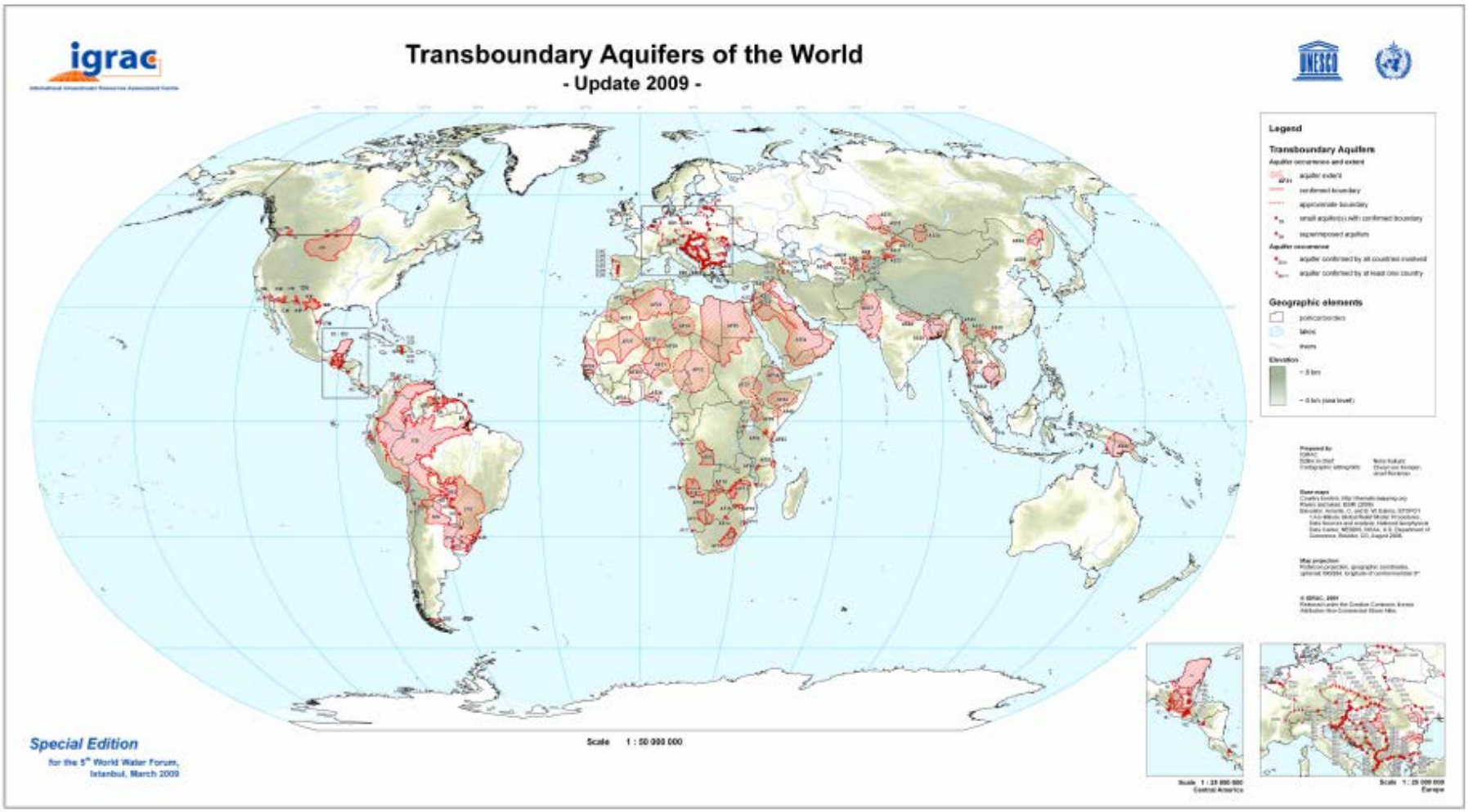
  **- www.isarm.org**

- **UNECE Assessments in Europe and Asia**

- **Participation in GEF (Global Environment Facility) projects**

- **Development of a TBA Methodology and a TBA Course, contribution to WWAP, …**

- **A map Transboundary Aquifers of the World**

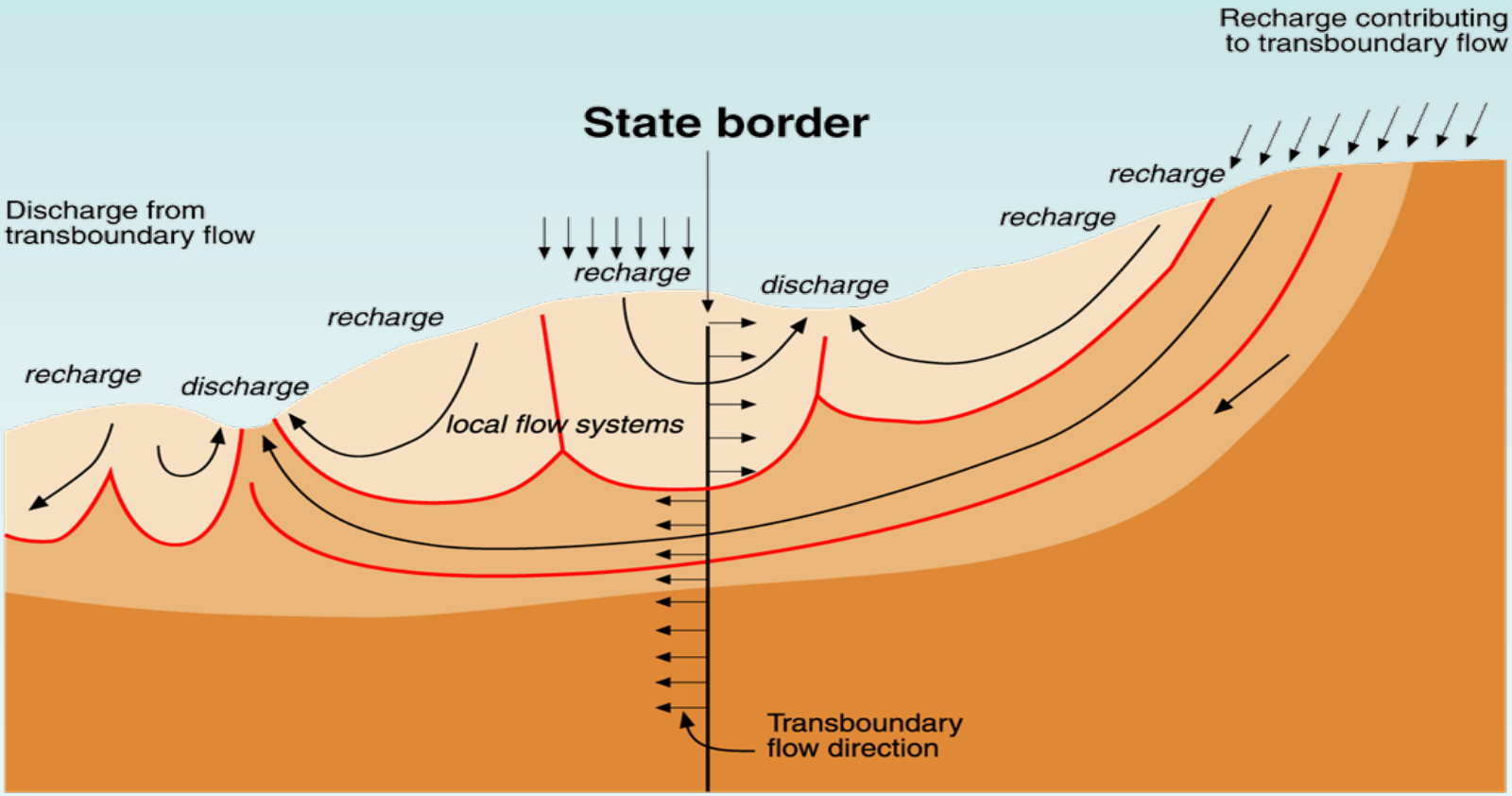

Transboundary Aquifers of the World
- Update 2009 -
Legend
Transboundary Aquifers
Geographic elements
Scale 1 : 50 000 000
Special Edition
for the 5th World Water Forum,
Istanbul, March 2009

International Groundwater Resources Assessment Centre

# Global Assessment of Transboundary Aquifers (TBA)

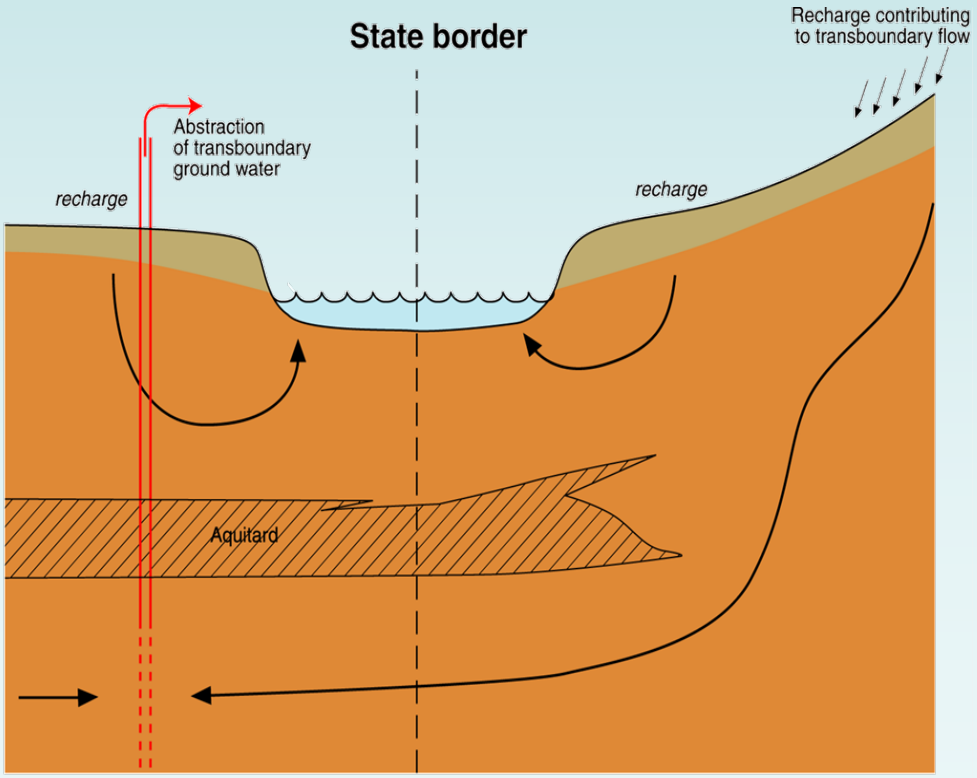
# Transboundary Aquifers Assessment

- **Transboundary aquifer or transboundary aquifer system refers to an aquifer or aquifer system, parts of which are situated in different States**



# Transboundary Aquifers Assessment

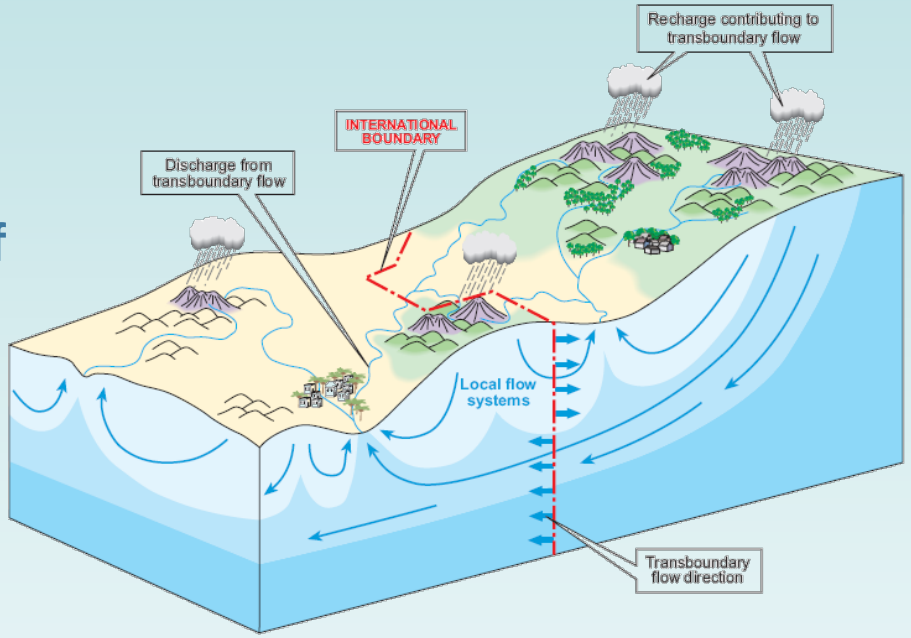
- **The fact**: many aquifers cross the political borders
- Potential cross-boundary **problems**: changes in groundwater flows, levels, volumes (quantity) and dissolved substances (quality)
- **Actions**: TBA characterisation and an appropriate management
- **Benefits**: eliminating potential sources of conflict and improving the overall benefit from groundwater.



# TBA Assessment Rationale

## What does a **TBA assessment** encompass?

- **ISARM programme: hydrogeological, legal, socio-economic, institutional and environmental aspects/facets of TBAs**




- **In practice, mostly a hydrogeological assessment but other aspects are very much present and equally relevant**

- **To date UN, GEF and EU have already accumulated valuable experience however there are still no comprehensive guidelines for TBA assessment.**

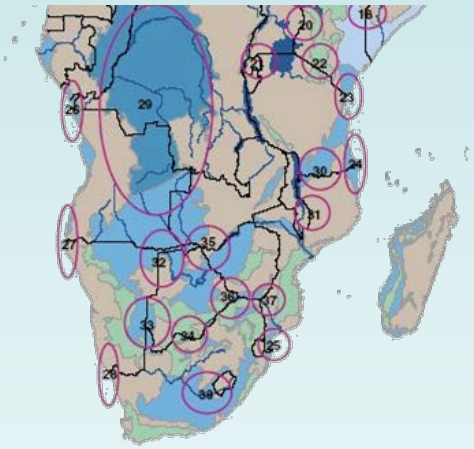
# TBA assessment (HY), the steps:

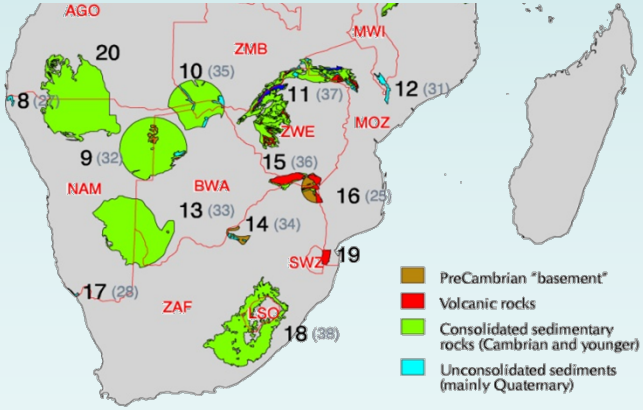
- Delineation and description
- Classification, diagnostic analysis and zoning
- Data harmonisation and information management

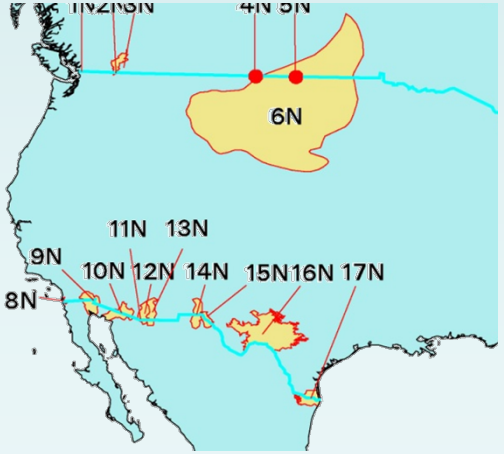
- **Delineation and description**
  - "inventory" or "characterisation" (stage and scale dependent)
  - chiefly about collecting, combining and interpreting the field information
- **Classification, diagnostic analysis and zoning**
  - information necessary for decision-making (problems, opportunities, most responsive aquifers and aquifer zones)
- **Data harmonisation and information management**
  - Extra dimension in an international context (more difficult, more elaborate and politically sensitive)

# Step 1: Delineation and Description

- chiefly about collecting, combining and interpreting the field information
- “**inventory**” or “**characterisation**” (stage and scale dependent)





# Step 1: Delineation and Description

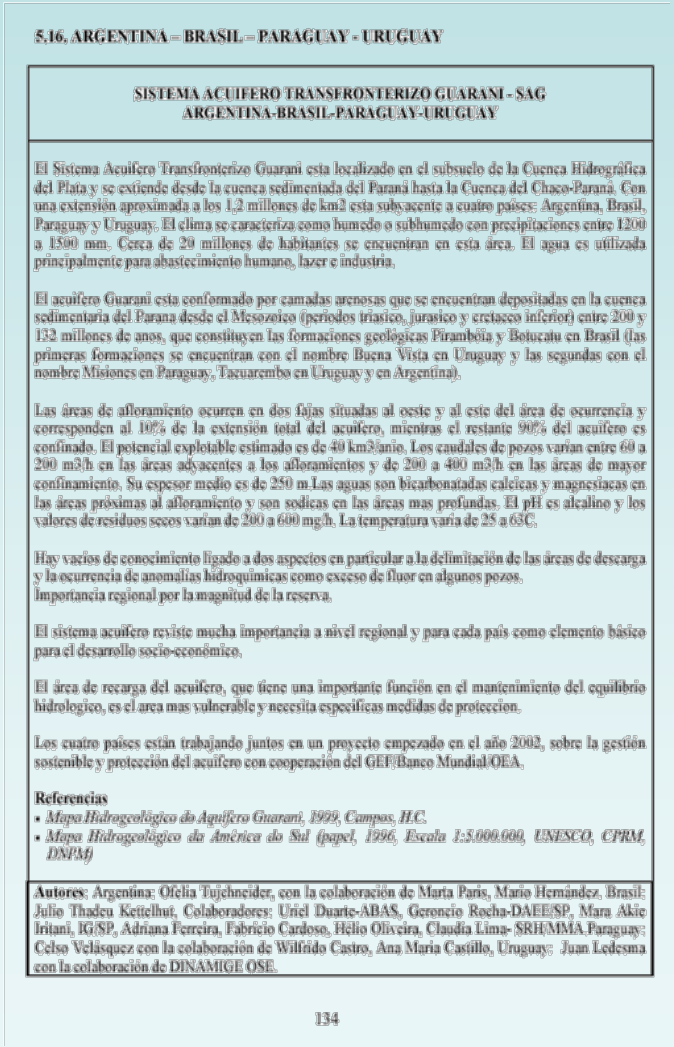
- A TBA description should a.o. include info recharge/discharge mechanism and hydraulic properties

- Superimposed on these hydrogeological characteristics are the anthropogenic influences such as abstraction and pollution from various sources.

- Input for the DPSIR: status pressure factors, GW quality and quality problems, management measure, future trends.

| Aquifer No. 1: Osh Aravoij | | Shared by: Uzbekistan and Kyrgyzstan |
|---|---|---|
| Type 5, Medium links to surface water systems, groundwater flows from Uzbekistan to Kyrgyzstan | | |
| | Uzbekistan | Kyrgyzstan |
| Area (km²) | | |
| Water uses and functions (percentage of total abstraction) | Drinking water supply (25-50%), irrigation, mining, livestock (<25%) | Drinking water supply (25-50%), irrigation |
| Pressure factors | Agriculture, industry, waste disposal | Agriculture |
| Problems related to groundwater quantity | Polluted water drawn into aquifer | Lack of relevant data to be quantified |
| Problems related to groundwater quality | Serious problems with pesticides, moderate problems with heavy metals, slight problems with hydrocarbons and radioactive elements | Lack of relevant data to be quantified |
| Transboundary impacts | Decline of groundwater level, groundwater pollution | Lack of relevant data to be quantified |
| Groundwater management measures | Need to be improved: transboundary institutions, monitoring of groundwater quantity and quality, need to be applied: abstraction management, efficiency of use, mapping, good agricultural practices, integrated river basin manage ment, treatment of industrial effluents, data exchange | Need to improved: transboundary institutions, monitoring of groundwater quantity and quality |
| Status and what is most needed | Improvement of the monitoring of groundwater quantity and quality | Improvement of the monitoring of groundwater quantity and quality |
| Future trends and prospects | Expected pressure on the water resources due to economic growth and climate change | Expected pressure on the water resources due to economic growth and climate change |

# Step 1: Standardised TBA Description



5.16. ARGENTINA – BRASIL – PARAGUAY - URUGUAY

**SISTEMA ACUIFERO TRANSFRONTERIZO GUARANI - SAG**
**ARGENTINA-BRASIL-PARAGUAY-URUGUAY**

El Sistema Acuífero Transfronterizo Guarani esta localizado en el subsuelo de la Cuenca Hidrográfica del Plata y se extiende desde la cuenca sedimentada del Paraná hasta la Cuenca del Chaco-Paraná. Con una extensión aproximada a los 1,2 millones de km2 esta subyacente a cuatro países: Argentina, Brasil, Paraguay y Uruguay. El clima se caracteriza como humedo o subhumedo con precipitaciones entre 1200 a 1500 mm. Cerca de 20 millones de habitantes se encuentran en esta área. El agua es utilizada principalmente para abastecimiento humano, lazer e industria.

El acuífero Guarani esta conformado por camadas arenosas que se encuentran depositadas en la cuenca sedimentaria del Parana desde el Mesozoico (periodos triasico, jurasico y cretaceo inferior) entre 200 y 132 millones de anos, que constituyen las formaciones geológicas Piramboia y Botucatu en Brasil (las primeras formaciones se encuentran con el nombre Buena Vista en Uruguay y las segundas con el nombre Misiones en Paraguay, Tacuarembo en Uruguay y en Argentina).

Las áreas de afloramiento ocurren en dos fajas situadas al oeste y al este del área de ocurrencia y corresponden al 10% de la extensión total del acuífero, mientras el restante 90% del acuífero es confinado. El potencial explotable estimado es de 40 km3/anio. Los caudales de pozos varian entre 60 a 200 m3/h en las áreas adyacentes a los afloramientos y de 200 a 400 m3/h en las áreas de mayor confinamiento. Su espesor medio es de 250 m.Las aguas son bicarbonatadas calcicas y magnesiacas en las áreas próximas al afloramiento y son sodicas en las áreas mas profundas. El pH es alcalino y los valores de residuos secos varian de 200 a 600 mg/h. La temperatura varia de 25 a 63C.

Hay vacios de conocimiento ligado a dos aspectos en particular a la delimitación de las áreas de descarga y la ocurrencia de anomalias hidroquimicas como exceso de fluor en algunos pozos.
Importancia regional por la magnitud de la reserva.

El sistema acuífero reviste mucha importancia a nivel regional y para cada país como elemento básico para el desarrollo socio-económico.

El área de recarga del acuífero, que tiene una importante función en el mantenimiento del equilibrio hidrologico, es el area mas vulnerable y necesita especificas medidas de proteccion.

Los cuatro países están trabajando juntos en un proyecto empezado en el año 2002, sobre la gestión sostenible y protección del acuífero con cooperación del GEF/Banco Mundial/OEA.

**Referencias**

- *Mapa Hidrogeológico do Aquífero Guarani, 1999, Campos, H.C.*
- *Mapa Hidrogeológico da América do Sul (papel, 1996, Escala 1:5.000.000, UNESCO, CPRM, DNPM)*

**Autores**: Argentina: Ofelia Tujchneider, con la colaboración de Marta Paris, Mario Hernández. Brasil: Julio Thadeu Kettelhut, Colaboradores: Uriel Duarte-ABAS, Geroncio Rocha-DAEE/SP, Mara Akie Iritani, IG/SP, Adriana Ferreira, Fabricio Cardoso, Hélio Oliveira, Claudia Lima- SRH/MMA.Paraguay: Celso Velásquez con la colaboración de Wilfrido Castro, Ana Maria Castillo, Uruguay: Juan Ledesma con la colaboración de DINAMIGE OSE.

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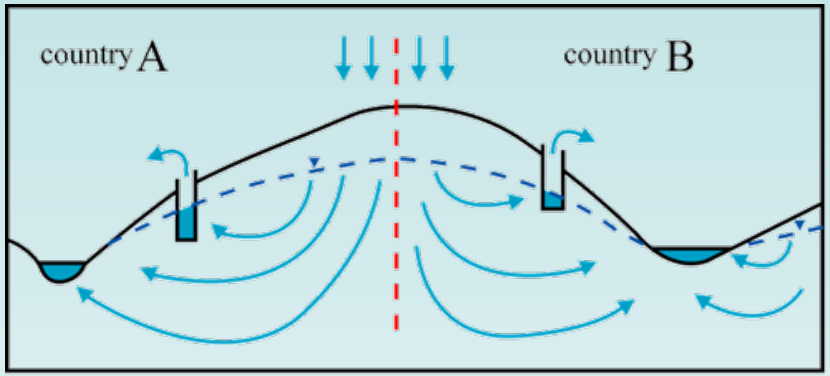
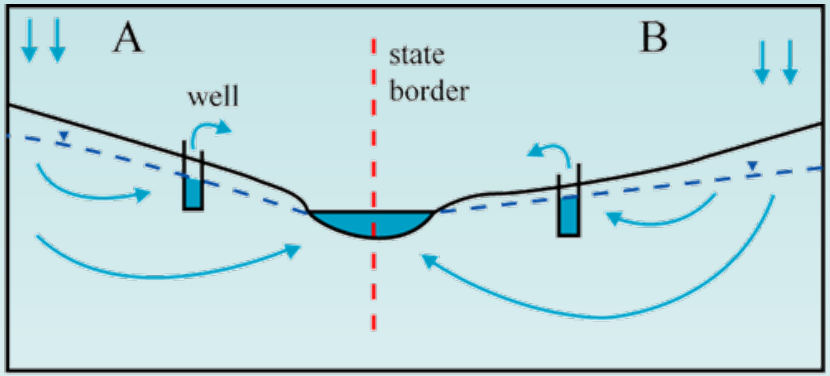
**(TBA Activities Americas)**

- Physiographic, Demographic & Water Use
- Geological Setting of Aquifer
- Water Quantity & Quality
- Importance and need for TBA
- TBA cooperation
- References
- Authors

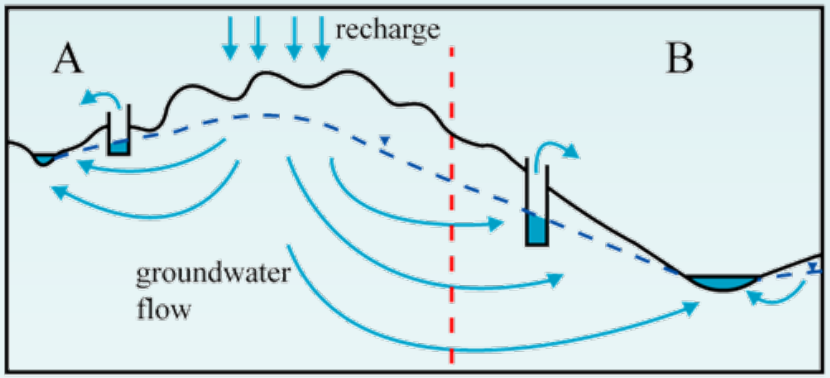
# Step 2: Classification, Diagnostics and Zoning



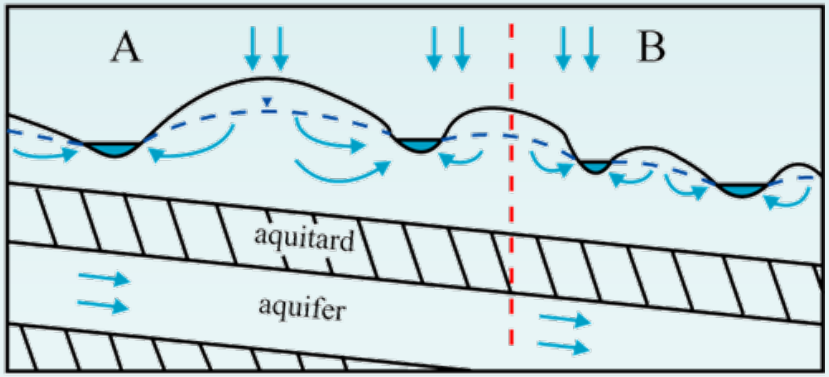

(1) state border follows surface water catchment and groundwater divide, little transboundary groundwater flow.




(3) state border follows major river or lake, alluvial aquifer connected to river, little transboundary flow.




(2) Surface water and groundwater divides separate from state border, recharge in one country, discharge in adjacent.



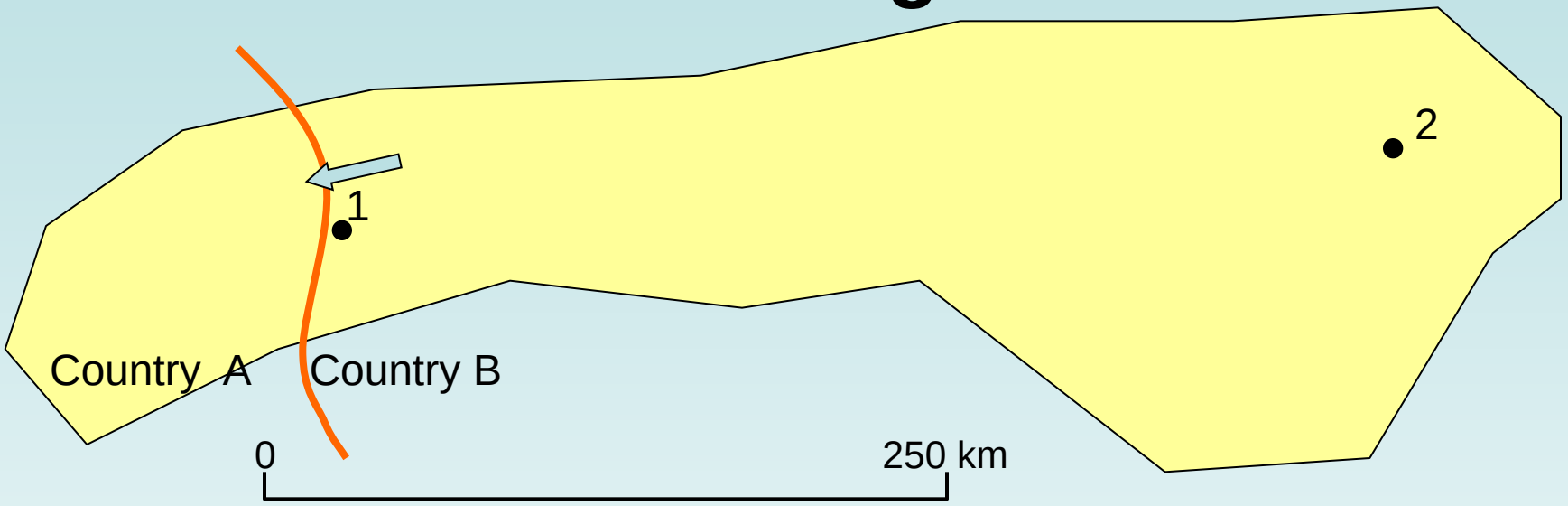

(4) Large deep aquifer, recharged far from border, not connected to local surface water and groundwater.

# Step 2: Classification, Diagnostics and Zoning

- Input for **classification**:
  - aquifer size and hydraulic properties,
  - vulnerability,
  - current functions,
  - observed or perceived stresses,
  - possible groundwater interferences, etc.

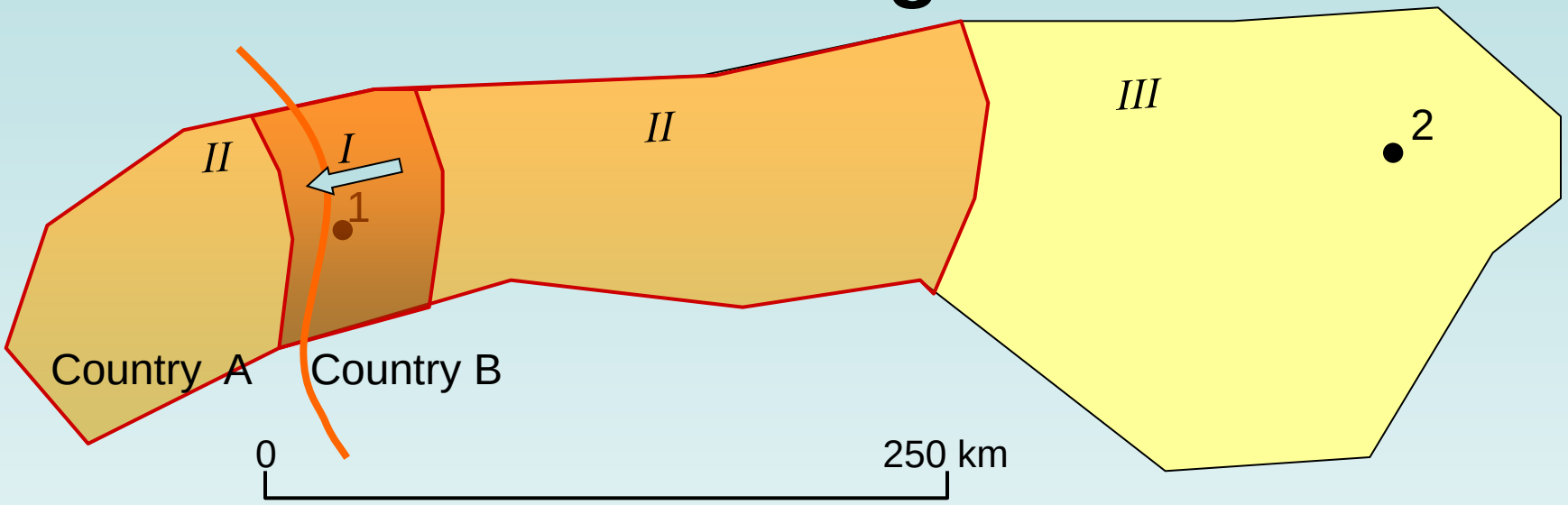
- Input for **diagnostics**:
  - inventory of major perceived issues and problems;
  - overview of possible actions
  - priority and feasibility study, stakeholders and institutional analysis.

# Step 2: Classification, Diagnostics and Zoning




- Activities at location 2 in country B will be much less risky for the aquifer in country A than activities at location 1
- Effects resulting from causes at larger distance will be smaller and come with more retardation
- General flow direction does matter

# Step 2: Classification, Diagnostics and Zoning

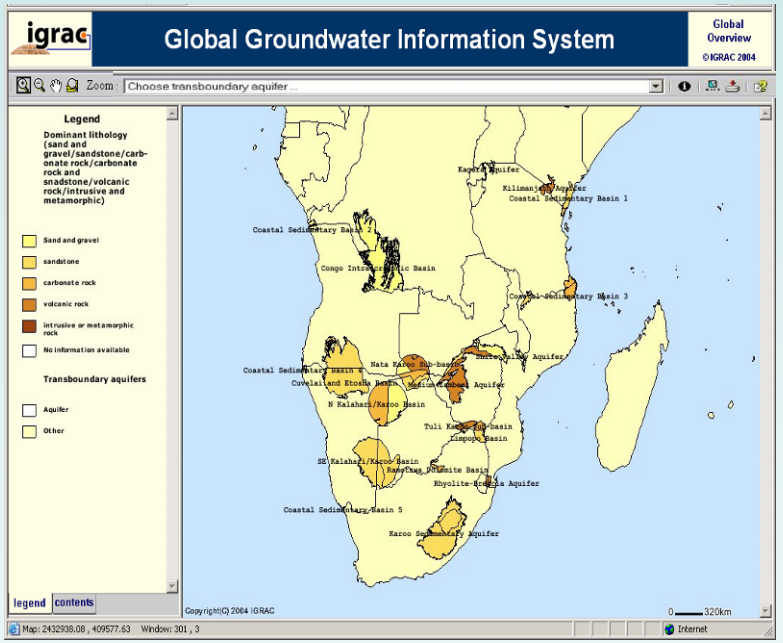



- Activities at location 2 in country B will be much less risky for the aquifer in country A than activities at location 1
- Effects resulting from causes at larger distance will be smaller and come with more retardation
- General flow direction does matter

# Step 3: Harmonisation & info management

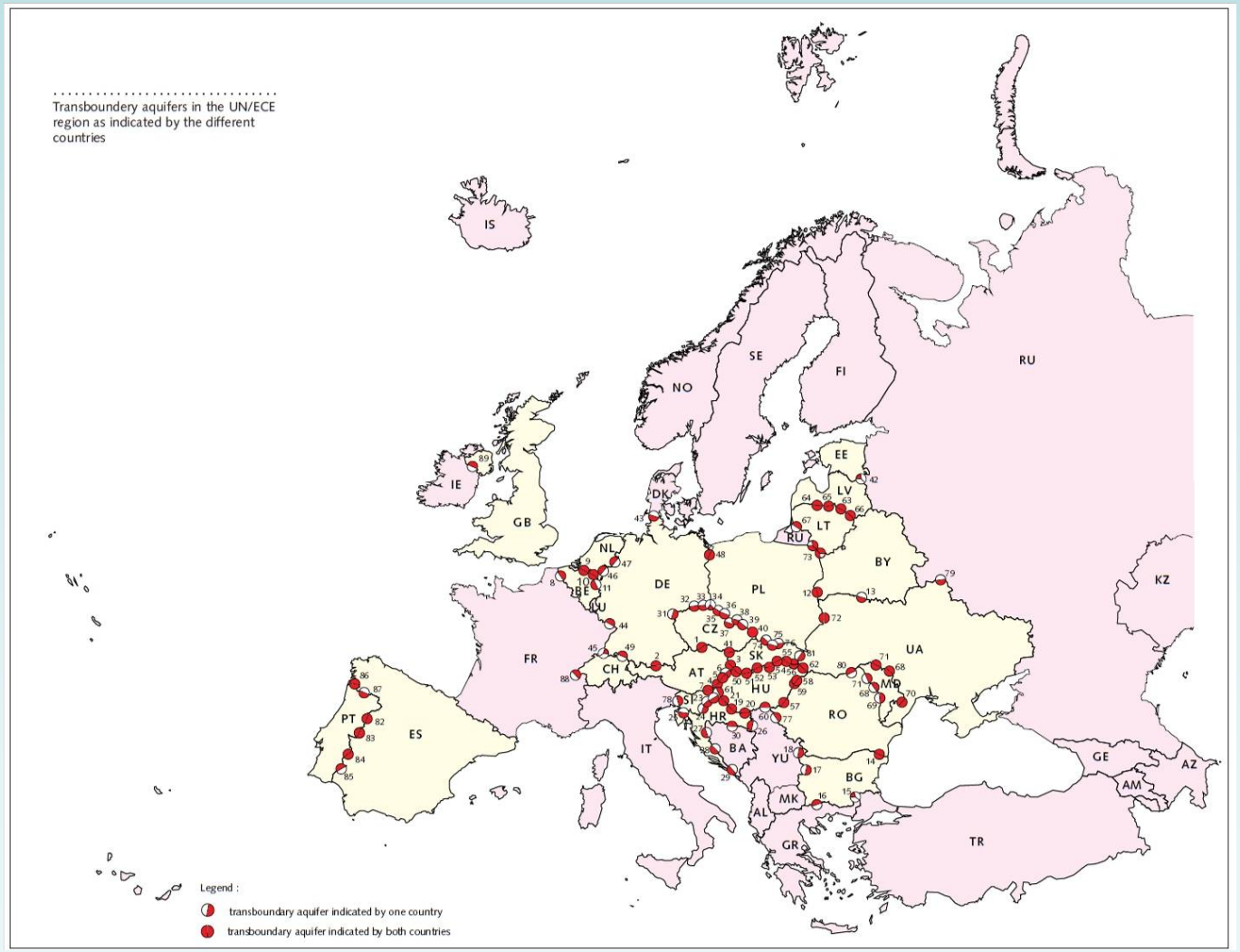
- Basically **technical activity**: harmonisation of formats, classifications, terminologies, reference systems, levels, software and hardware specific, etc.

- Ideally, **on-line** synchronised **access** to distributed information services (data and information remain at the source!)

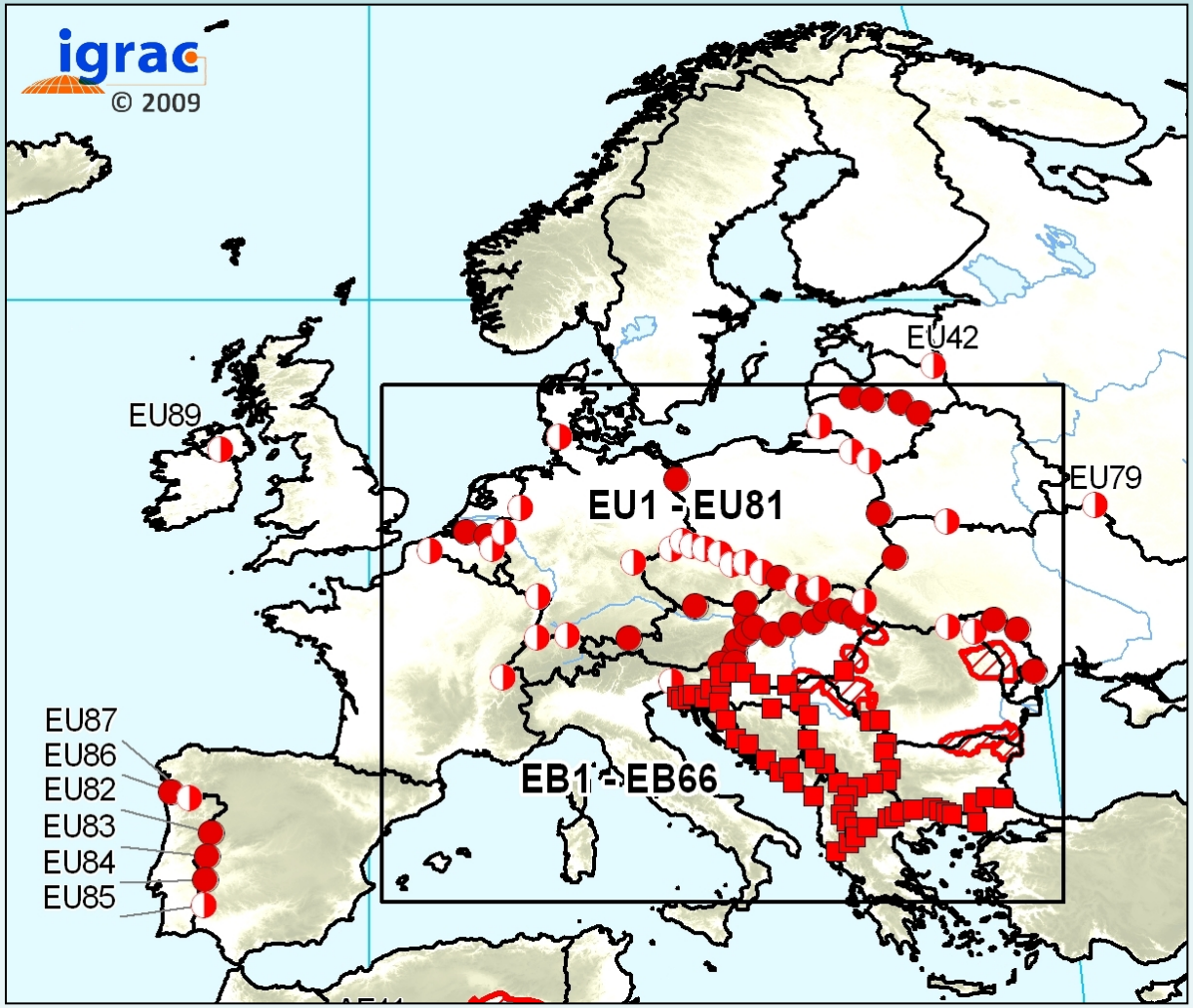


# TBA Assessment in Western and Central Europe

# UNECE TBA Inventory 1999

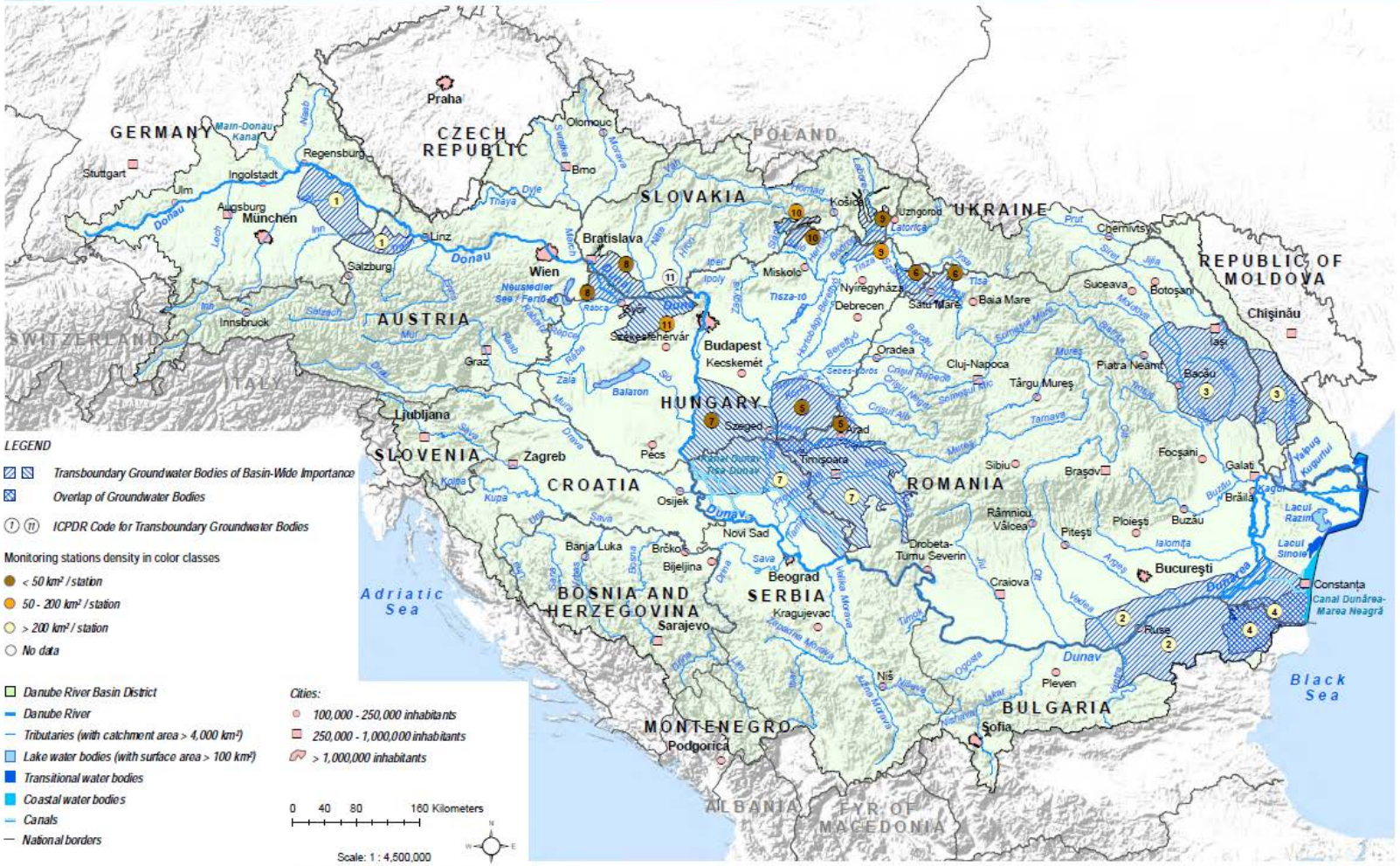


# TBAs of the World: Detail Europe



# Danube River Basin District:
# Transboundary Groundwater Bodies of Basin-Wide Importance and their Transnational Monitoring Network

MAP 4




*LEGEND*

- *Transboundary Groundwater Bodies of Basin-Wide Importance*
- *Overlap of Groundwater Bodies*
- *ICPDR Code for Transboundary Groundwater Bodies*

Monitoring stations density in color classes

- *< 50 km² / station*
- *50 - 200 km² / station*
- *> 200 km² / station*
- *No data*

- *Danube River Basin District*
- *Danube River*
- *Tributaries (with catchment area > 4,000 km²)*
- *Lake water bodies (with surface area > 100 km²)*
- *Transitional water bodies*
- *Coastal water bodies*
- *Canals*
- *National borders*

*Cities:*

- *100,000 - 250,000 inhabitants*
- *250,000 - 1,000,000 inhabitants*
- *> 1,000,000 inhabitants*

0 40 80 160 Kilometers

Scale: 1 : 4,500,000

(Scale 1: 6,000,000 in A4 landscape paper format)

www.icpdr.org

icpdr iksd

International Commission for the Protection of the Danube River

Internationale Kommission zum Schutz der Donau

*This ICPDR product is based on national information provided by the Contracting Parties to the ICPDR (AT, BA, BG, CZ, DE, HR, HU, MD, RO, RS, SI, SK, UA) and CH, except for the following: EuroGlobalMap v2.1 from EuroGeographics was used for national borders of AT, CZ, DE, HR, HU, MD, RO, SI, SK and UA; ESRI data was used for national borders of AL, ME, MK; Shuttle Radar Topography Mission (SRTM) from USGS Seamless Data Distribution System was used as topographic layer; data from the European Commission (Joint Research Center) was used for the outer border of the DRBD of AL, IT, ME and PL.*

*Vienna, December 2009*

# Transboundary Aquifers of South East Europe

## - 2nd UNECE Assessment -


### Legend

**Transboundary groundwater**

- WFD groundwater body (GWB)/ set of GWBs
- GWB (partially) overlapping with aquifer
- Aquifer
- (Partially) overlapping aquifers
- Exact location/extent of aquifer uncertain
- 143 In the Assessment
- 246 Not in the Assessment

**Geographic features**

- National capital
- River
- Surface water
- Political border

# Transboundary Aquifers of Europe

## - 2nd UNECE Assessment -


**Legend**

**Transboundary groundwater**

- WFD groundwater body (GWD)/ set of GWDs
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- Aquifer
- (Partially) overlapping aquifers
- Exact location/extent of aquifer uncertain
- 143 In the Assessment
- 246 Not in the Assessment

**Geographic features**

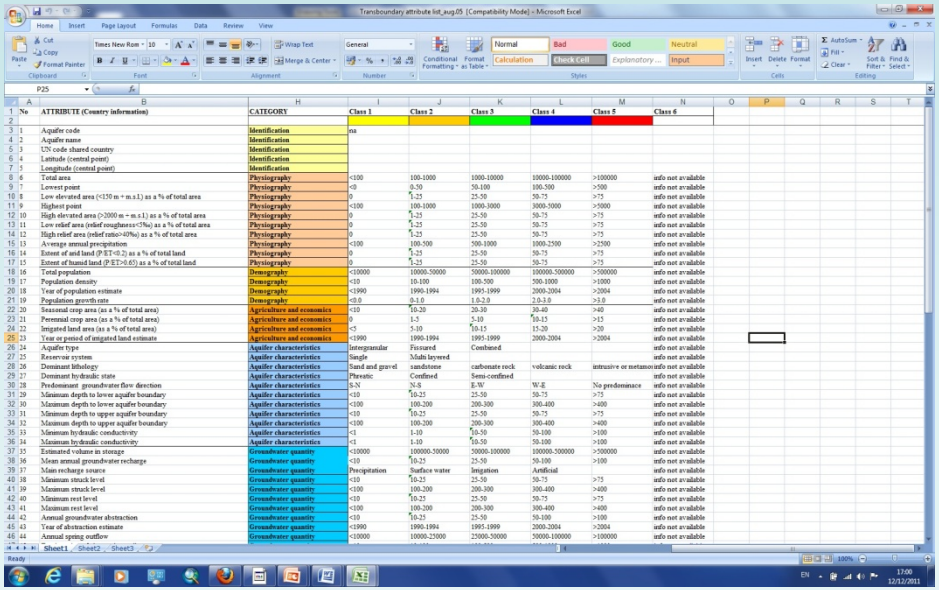
- National capital
- River
- Surface water
- Political border

0 300 600 Kilometers

**Map Projection**
Robinson Projection
Spheroid WGS84, longitude of central meridian 0°.

# Challenges ahead:

- Moving from delineation (inventory stage) to quantitative descriptions
- Cartographic challenges of aquifer systems and adding 3rd dimension to delineations
- Data Harmonisation



| No | ATTRIBUTE (Country information) | CATEGORY | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 | Class 6 |
|---|---|---|---|---|---|---|---|---|
| 1 | Aquifer code | Identification | na | | | | | |
| 2 | Aquifer name | Identification | | | | | | |
| 3 | UN code shared country | Identification | | | | | | |
| 4 | Latitude (central point) | Identification | | | | | | |
| 5 | Longitude (central point) | Identification | | | | | | |
| 6 | Total area | Physiography | <100 | 100-1000 | 1000-10000 | 10000-100000 | >100000 | info not available |
| 7 | Lowest point | Physiography | <0 | 0-50 | 50-100 | 100-500 | >500 | info not available |
| 8 | Low elevated area (<150 m + m.s.l.) as a % of total area | Physiography | 0 | 1-25 | 25-50 | 50-75 | >75 | info not available |
| 9 | Highest point | Physiography | <100 | 100-1000 | 1000-3000 | 3000-5000 | >5000 | info not available |
| 10 | High elevated area (>2000 m + m.s.l.) as a % of total area | Physiography | 0 | 1-25 | 25-50 | 50-75 | >75 | info not available |
| 11 | Low relief area (relief roughness<5%) as a % of total area | Physiography | 0 | 1-25 | 25-50 | 50-75 | >75 | info not available |
| 12 | High relief area (relief ratio>40%) as a % of total area | Physiography | 0 | 1-25 | 25-50 | 50-75 | >75 | info not available |
| 13 | Average annual precipitation | Physiography | <100 | 100-500 | 500-1000 | 1000-2500 | >2500 | info not available |
| 14 | Extent of arid land (P/ET<0.2) as a % of total land | Physiography | 0 | 1-25 | 25-50 | 50-75 | >75 | info not available |
| 15 | Extent of humid land (P/ET>0.65) as a % of total land | Physiography | 0 | 1-25 | 25-50 | 50-75 | >75 | info not available |
| 16 | Total population | Demography | <10000 | 10000-50000 | 50000-100000 | 100000-500000 | >500000 | info not available |
| 17 | Population density | Demography | <10 | 10-100 | 100-500 | 500-1000 | >1000 | info not available |
| 18 | Year of population estimate | Demography | <1990 | 1990-1994 | 1995-1999 | 2000-2004 | >2004 | info not available |
| 19 | Population growth rate | Demography | <0.0 | 0-1.0 | 1.0-2.0 | 2.0-3.0 | >3.0 | info not available |
| 20 | Seasonal crop area (as a % of total area) | Agriculture and economics | <10 | 10-20 | 20-30 | 30-40 | >40 | info not available |
| 21 | Perennial crop area (as a % of total area) | Agriculture and economics | 0 | 1-2 | 5-10 | 10-15 | >15 | info not available |
| 22 | Irrigated land area (as a % of total area) | Agriculture and economics | <5 | 5-10 | 10-15 | 15-20 | >20 | info not available |
| 23 | Year or period of irrigated land estimate | Agriculture and economics | <1990 | 1990-1994 | 1995-1999 | 2000-2004 | >2004 | info not available |
| 24 | Aquifer type | Aquifer characteristics | Intergranular | Fissured | Combined | | | info not available |
| 25 | Reservoir system | Aquifer characteristics | Single | Multi layered | | | | info not available |
| 26 | Dominant lithology | Aquifer characteristics | Sand and gravel | sandstone | carbonate rock | volcanic rock | intrusive or metamo | info not available |
| 27 | Dominant hydraulic state | Aquifer characteristics | Phreatic | Confined | Semi-confined | | | info not available |
| 28 | Predominant groundwater flow direction | Aquifer characteristics | S-N | N-S | E-W | W-E | No predominace | info not available |
| 29 | Minimum depth to lower aquifer boundary | Aquifer characteristics | <10 | 10-25 | 25-50 | 50-75 | >75 | info not available |
| 30 | Maximum depth to lower aquifer boundary | Aquifer characteristics | <100 | 100-200 | 200-300 | 300-400 | >400 | info not available |
| 31 | Minimum depth to upper aquifer boundary | Aquifer characteristics | <10 | 10-25 | 25-50 | 50-75 | >75 | info not available |
| 32 | Maximum depth to upper aquifer boundary | Aquifer characteristics | <100 | 100-200 | 200-300 | 300-400 | >400 | info not available |
| 33 | Minimum hydraulic conductivity | Aquifer characteristics | <1 | 1-10 | 10-50 | 50-100 | >100 | info not available |
| 34 | Maximum hydraulic conductivity | Aquifer characteristics | <1 | 1-10 | 10-50 | 50-100 | >100 | info not available |
| 35 | Estimated volume in storage | Groundwater quantity | <10000 | 100000-50000 | 50000-100000 | 100000-500000 | >500000 | info not available |
| 36 | Mean annual groundwater recharge | Groundwater quantity | <10 | 10-25 | 25-50 | 50-100 | >100 | info not available |
| 37 | Main recharge source | Groundwater quantity | Precipitation | Surface water | Irrigation | Artificial | | info not available |
| 38 | Minimum struck level | Groundwater quantity | <10 | 10-25 | 25-50 | 50-75 | >75 | info not available |
| 39 | Maximum struck level | Groundwater quantity | <100 | 100-200 | 200-300 | 300-400 | >400 | info not available |
| 40 | Minimum rest level | Groundwater quantity | <10 | 10-25 | 25-50 | 50-75 | >75 | info not available |
| 41 | Maximum rest level | Groundwater quantity | <100 | 100-200 | 200-300 | 300-400 | >400 | info not available |
| 42 | Annual groundwater abstraction | Groundwater quantity | <10 | 10-25 | 25-50 | 50-100 | >100 | info not available |
| 43 | Year of abstraction estimate | Groundwater quantity | <1990 | 1990-1994 | 1995-1999 | 2000-2004 | >2004 | info not available |
| 44 | Annual spring outflow | Groundwater quantity | <10000 | 10000-25000 | 25000-50000 | 50000-100000 | >100000 | info not available |

igrac

International Groundwater Resources Assessment Centre

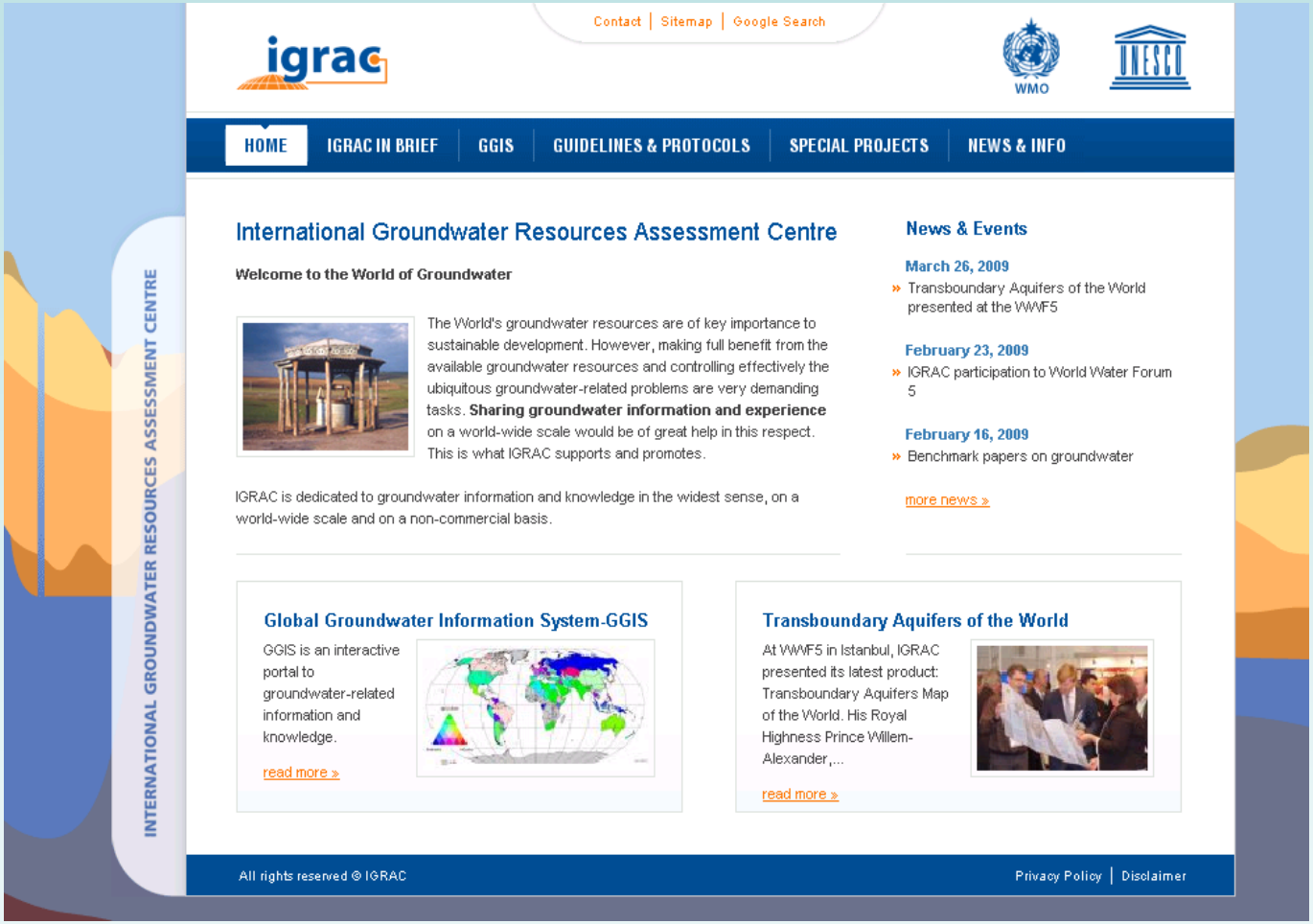
# Thanks

United Nations Educational, Scientific and Cultural Organization

World Meteorological Organization

Government of The Netherlands

# IGRAC Portal




**www.un-igrac.org**