

Groundwaters in Hungary

by Ádám Tóth

József & Erzsébet Tóth Endowed Hydrogeology Chair
Eötvös Loránd University, Budapest, Hungary

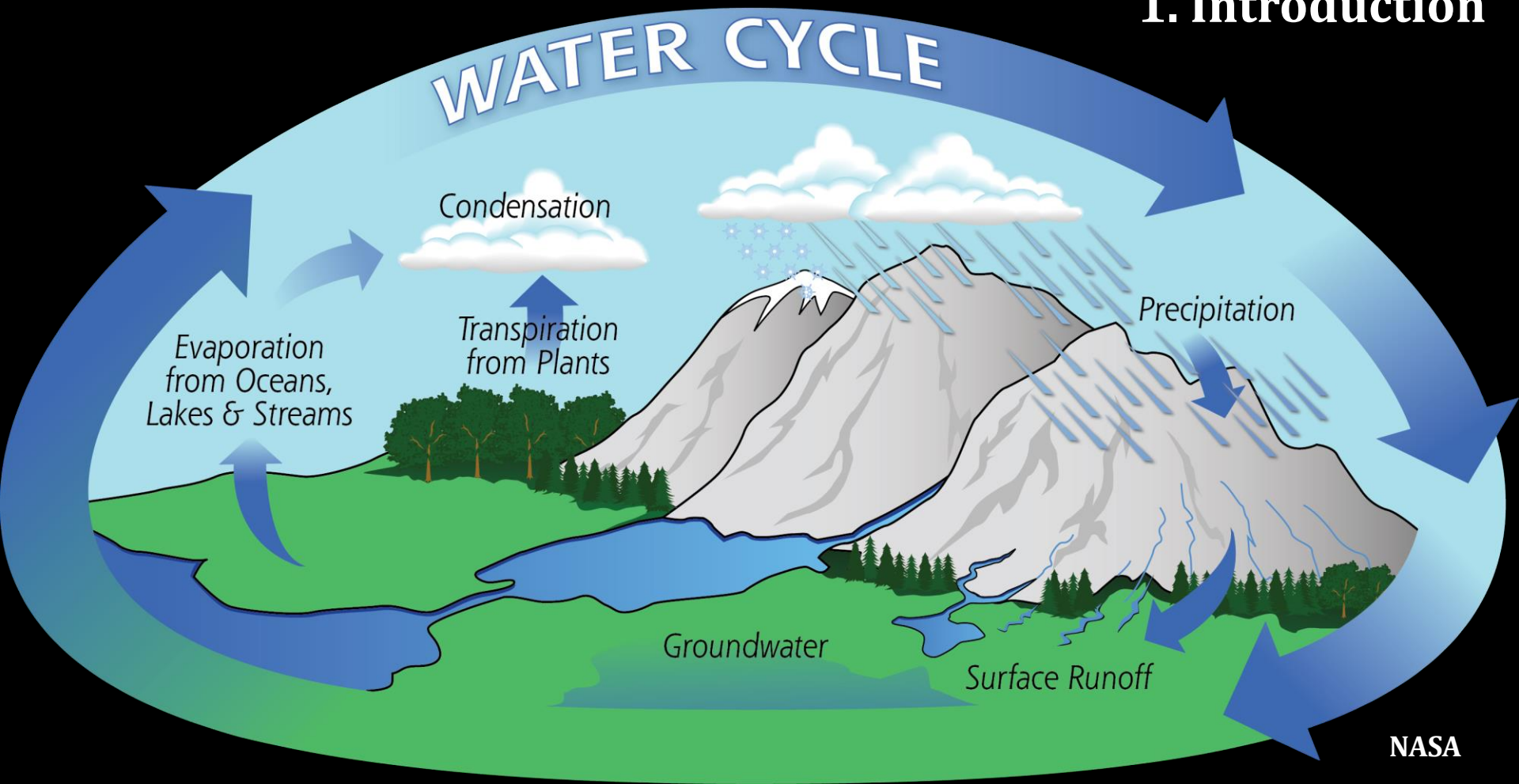
Regional Groundwater Flow Commission of International Association of Hydrogeologists



Focus on Water Summer School, 18th August 2017, Budapest, Hungary



1. Introduction



Groundwater can be a long-term reservoir of the natural water cycle. Groundwater is naturally replenished by surface water from precipitation, streams and rivers.

1. Introduction



freshwater: 35 million km³
2.8 % of the total



total water resources on Earth: 1400 million km³

total water resources on Earth: 1400 million km³

1. Introduction

surface water: 0.1 million km³

0.3 % of the freshwater

0.007 % of the total

arctic ice and glaciers:

26 million km³

75 % of the freshwater

2.14 % of the total



groundwater:

7.5 million km³

22 % of the freshwater

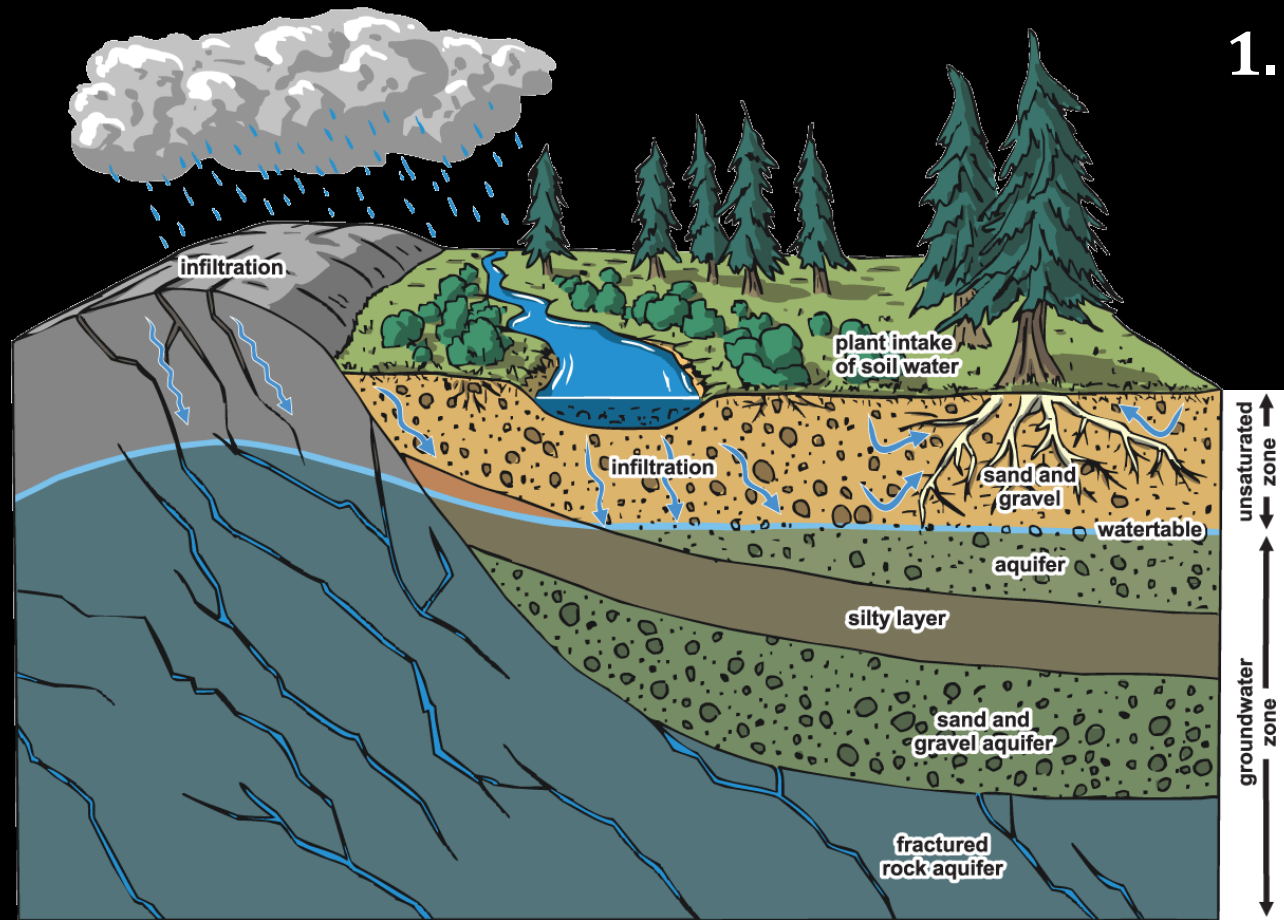
0.61 % of the total



freshwater: 35 million km³

2.8 % of the total

1. Introduction



RDN Water
Budget Project

Groundwater is the water present beneath Earth's surface in soil pore spaces and in the fractures of rock formations.

A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water.

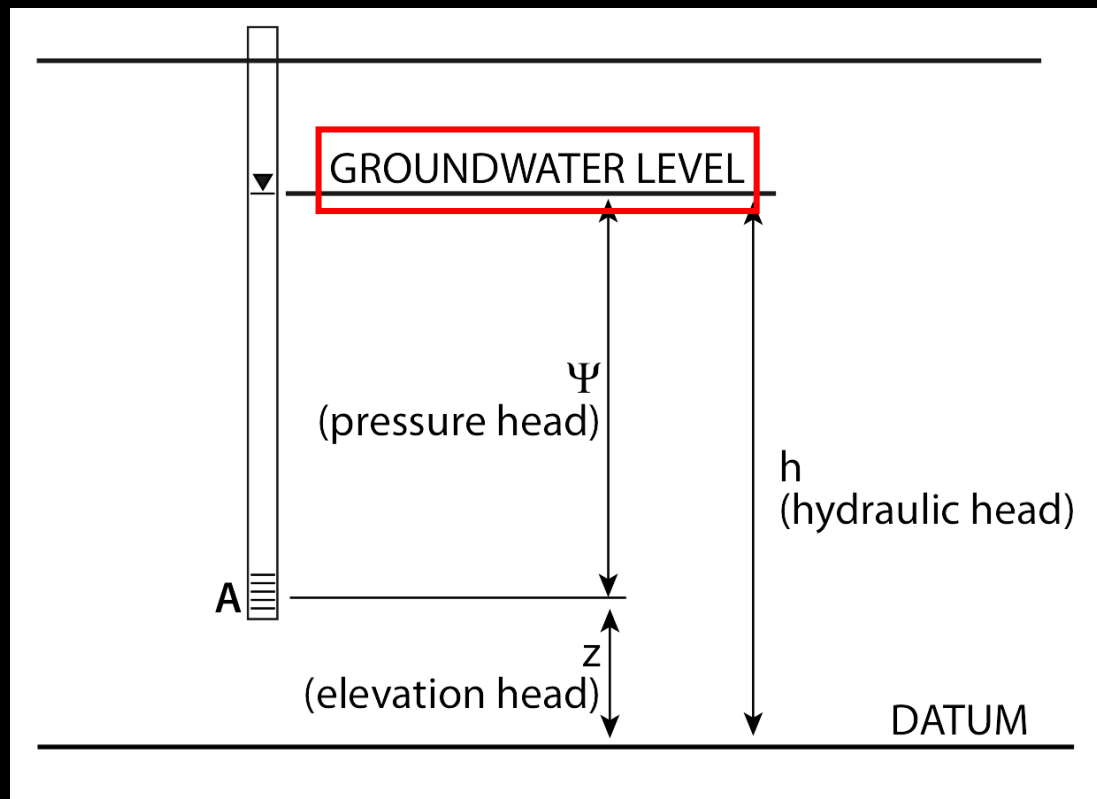
The study of the distribution and movement of groundwater is hydrogeology, also called groundwater hydrology.

2. Groundwater flow basics

Is the groundwater stagnant or flowing?

What drives the groundwater flow?

Energy differences

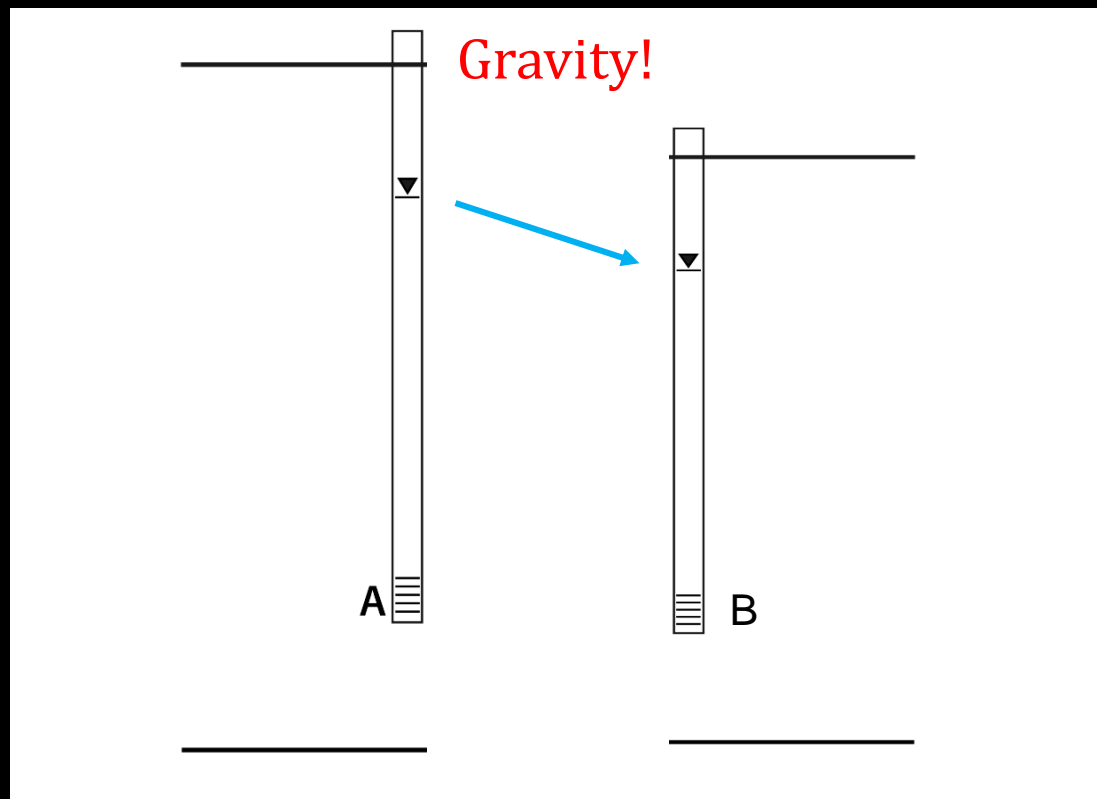


2. Groundwater flow basics

Is the groundwater stagnant or flowing?

What drives the groundwater flow?

Energy differences caused by hydraulic head differences

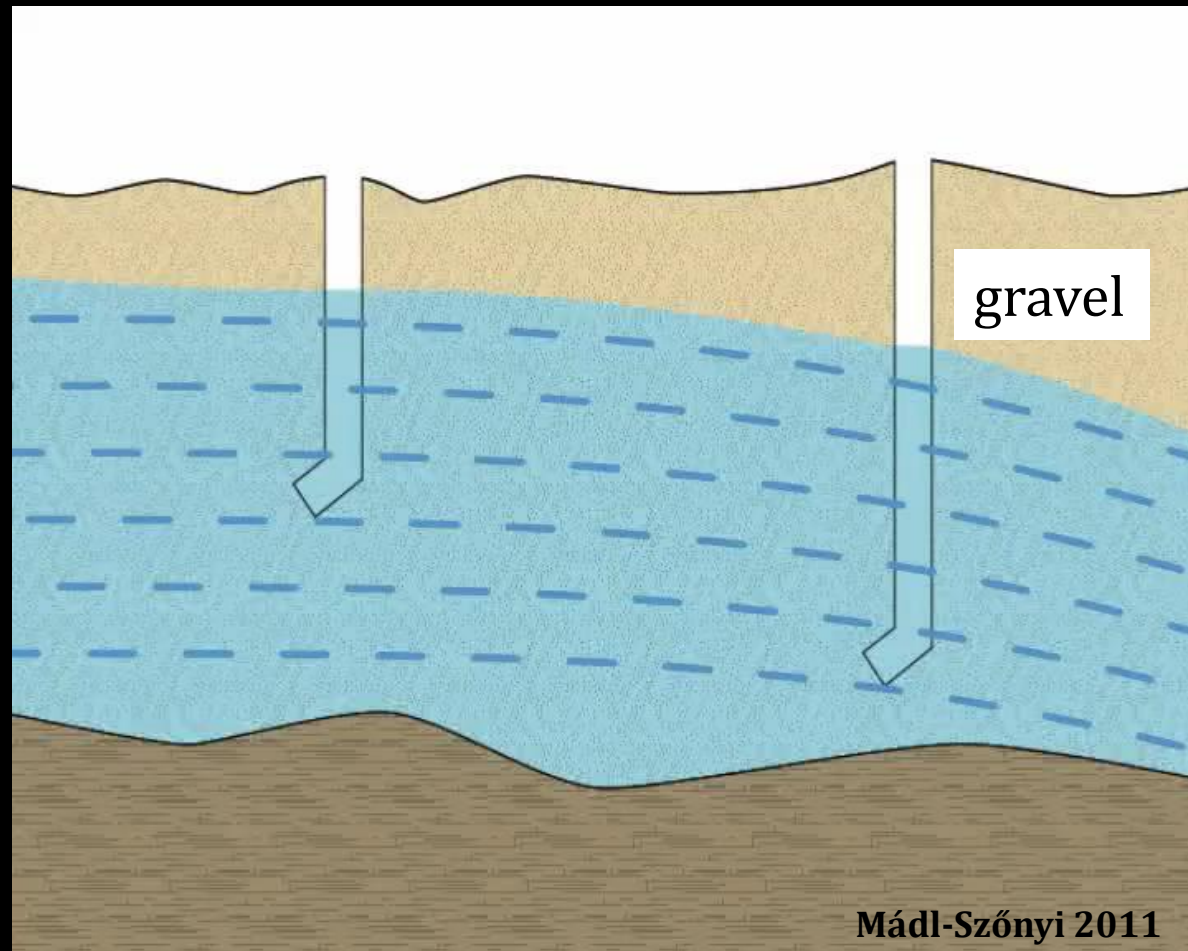


2. Groundwater flow basics

What drives the groundwater flow?

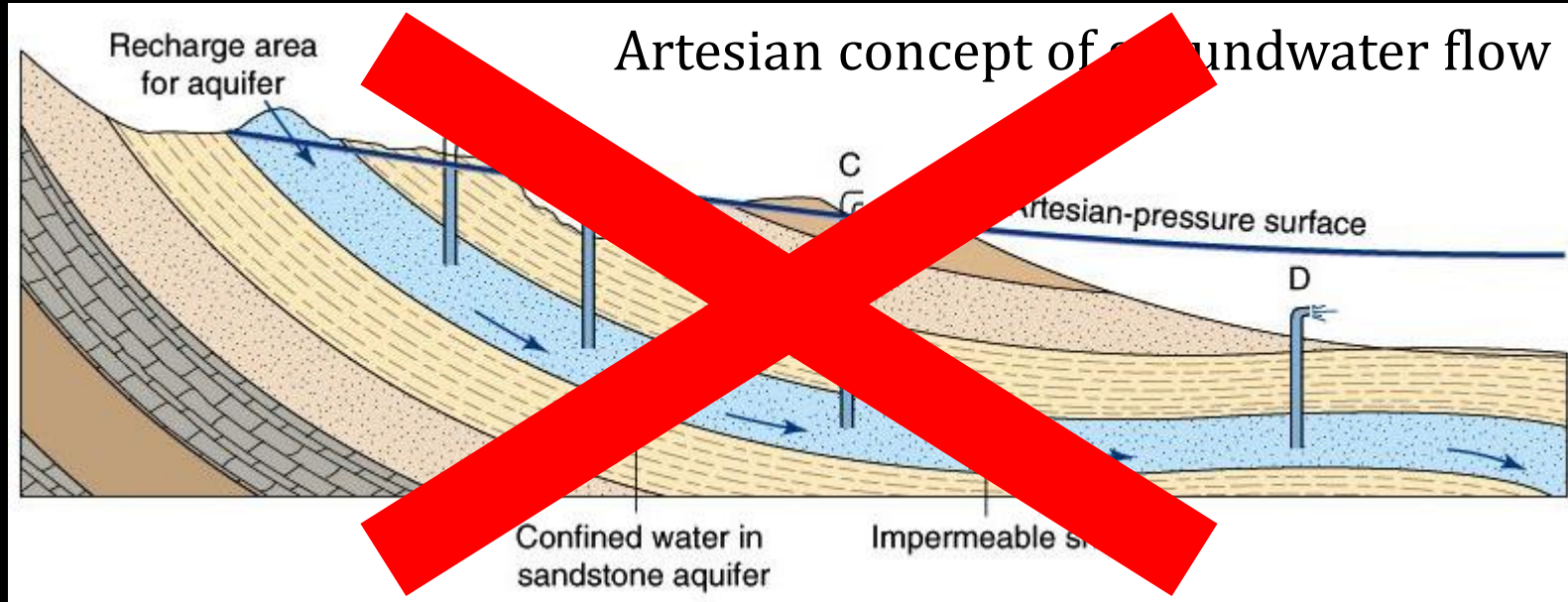
hydraulic head difference (not pressure difference!)

structure of the medium

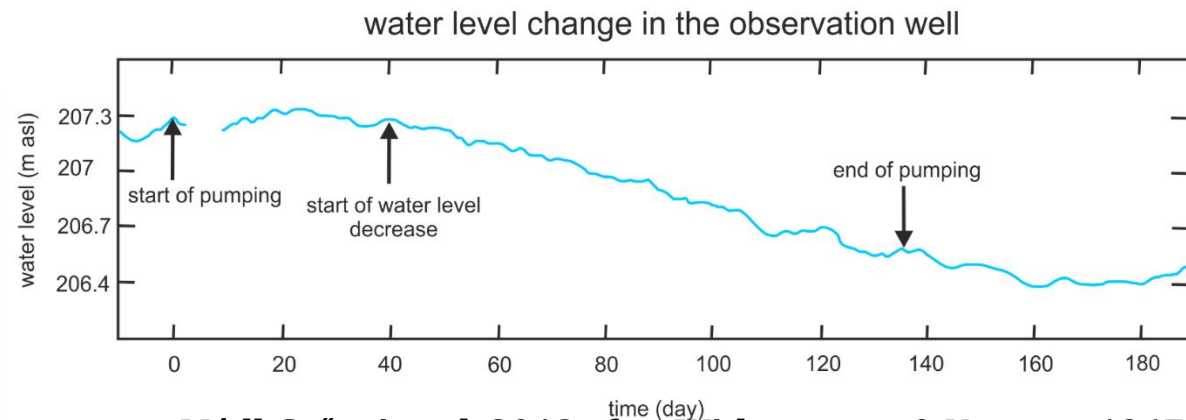
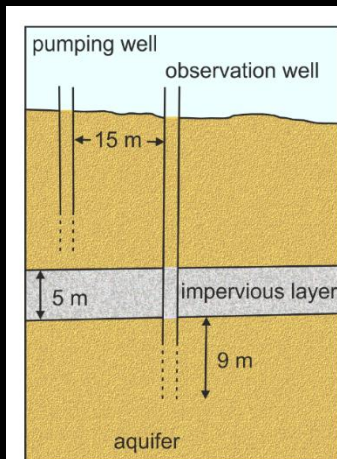


2. Groundwater flow basics

What drives the groundwater flow?



There are not any impervious layers!

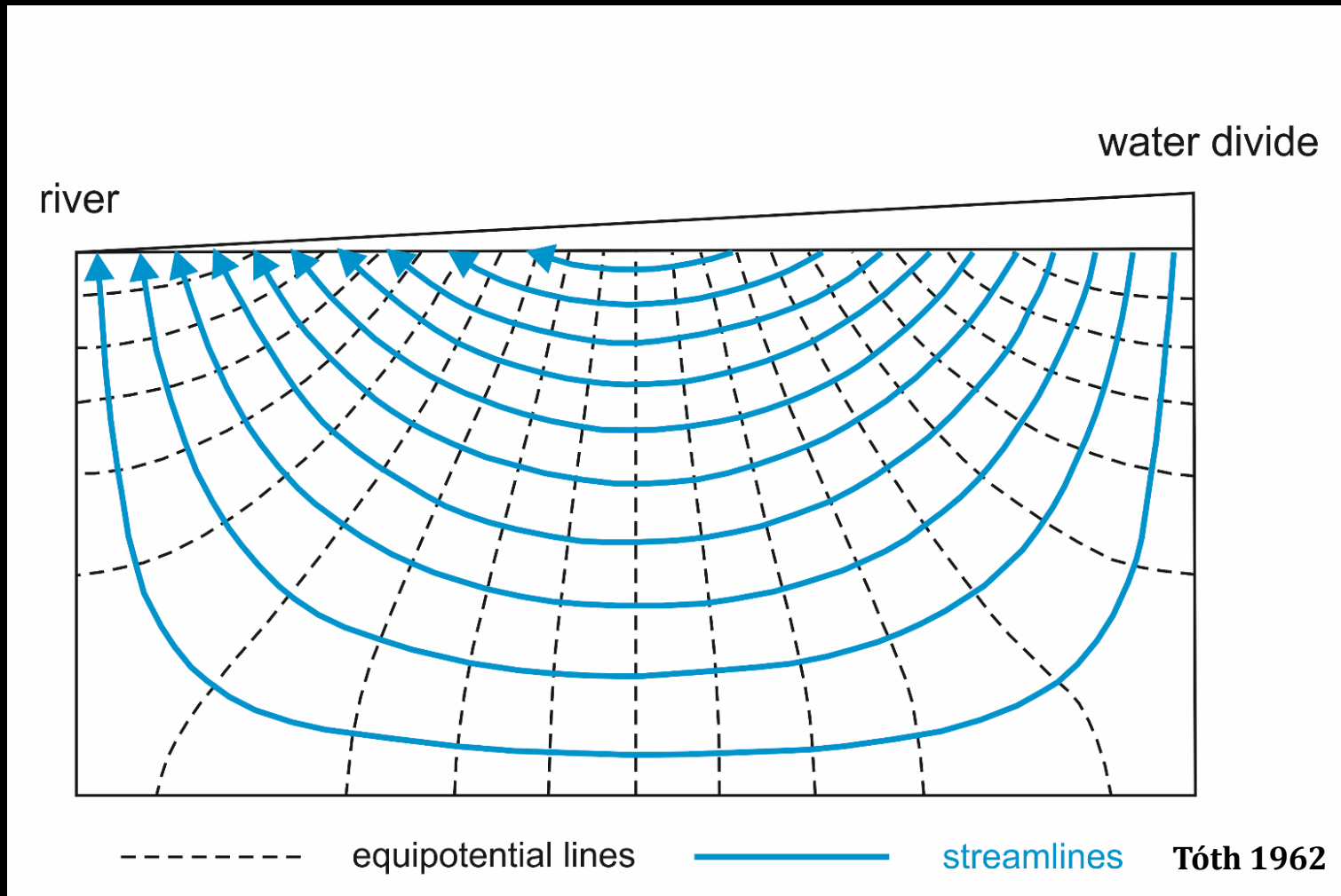


Mádl-Szőnyi et al. 2013 after Witherspoon & Neuman 1967

2. Groundwater flow basics

What drives the groundwater flow?

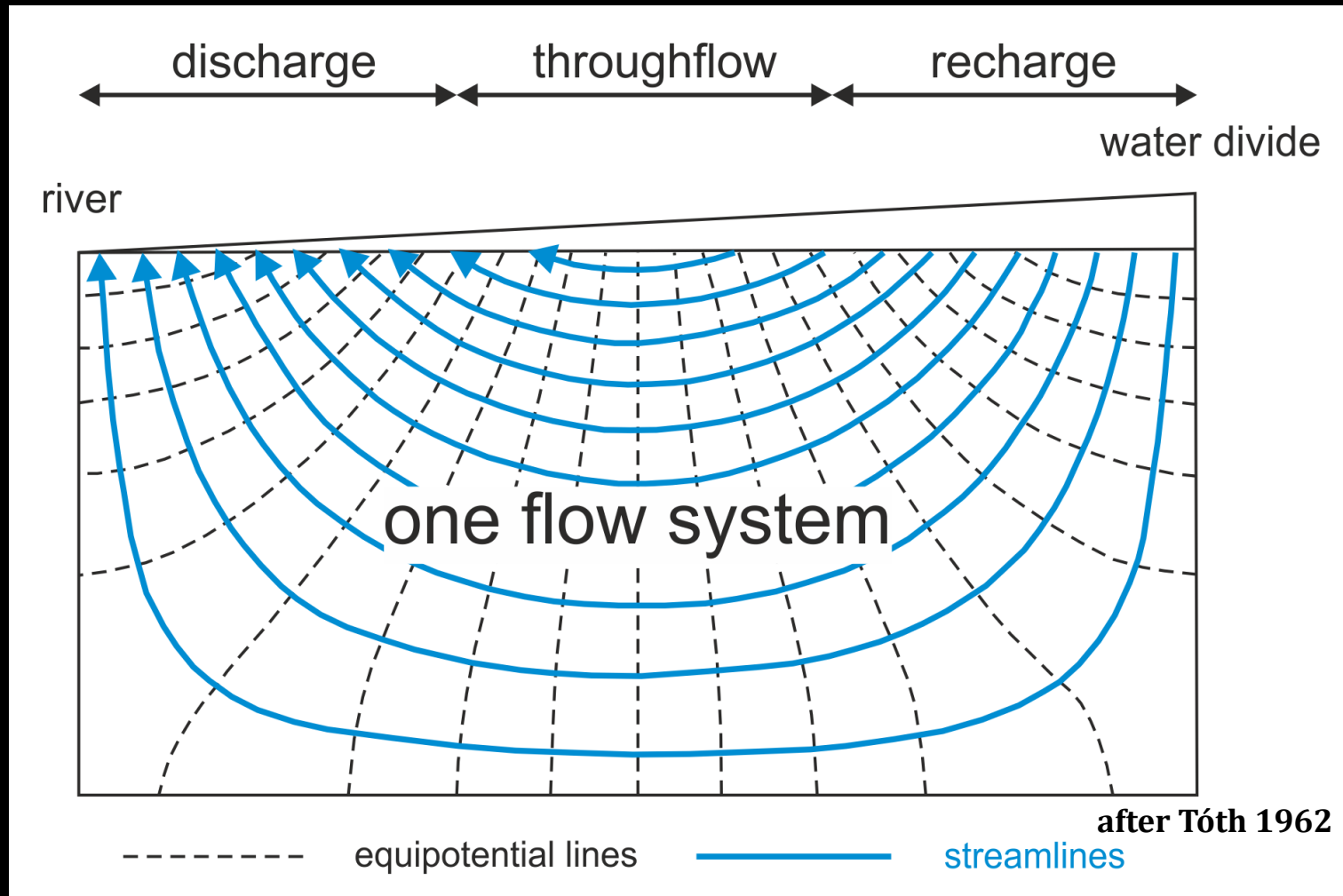
Unit basin with linear water table



2. Groundwater flow basics

What drives the groundwater flow?

Unit basin with linear water table

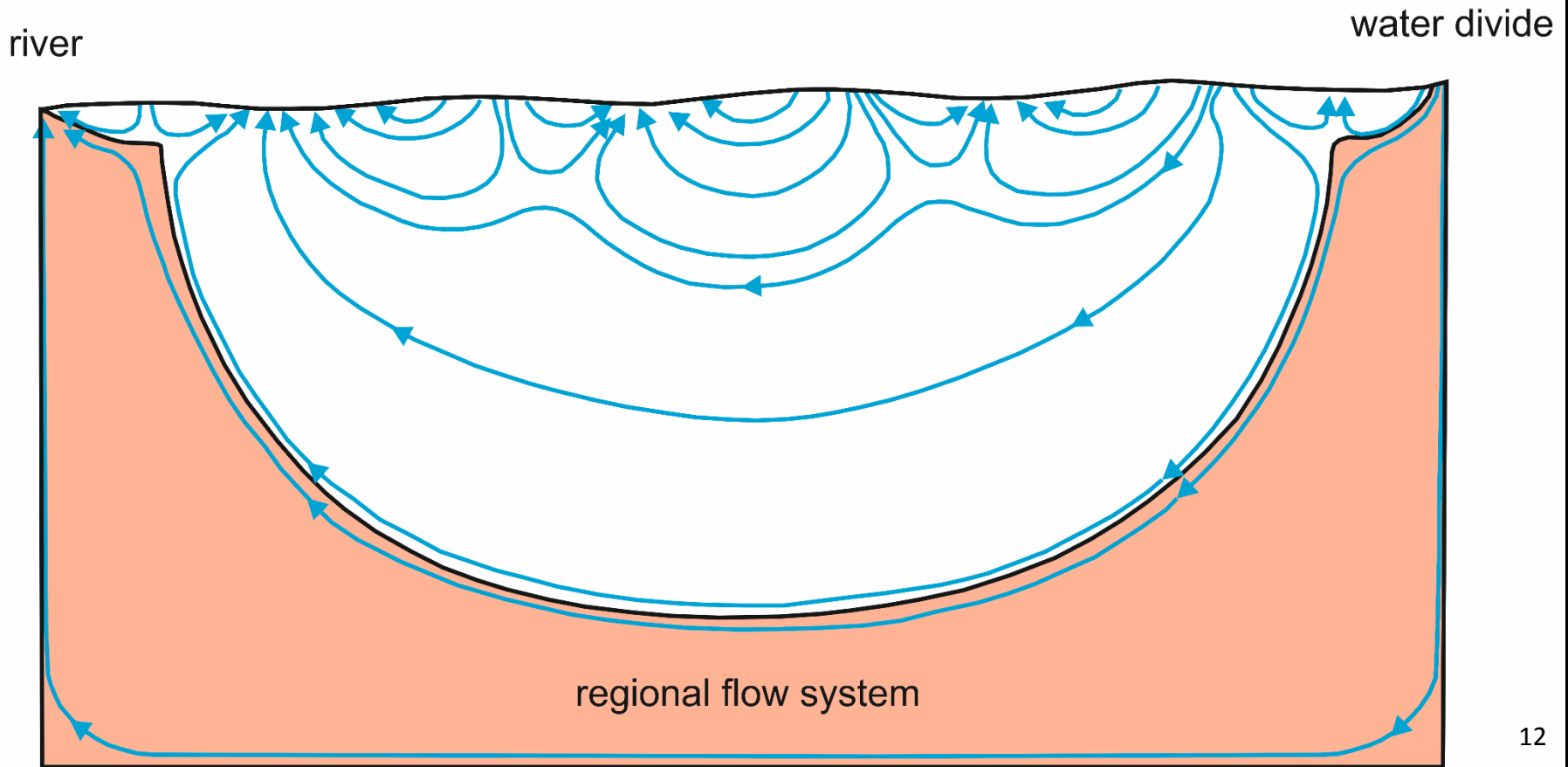


2. Groundwater flow basics

What drives the groundwater flow?

Composite basin with undulating water table

Engelen & Kloosterman 1995 after Tóth 1963, in Mádl-Szőnyi 2011

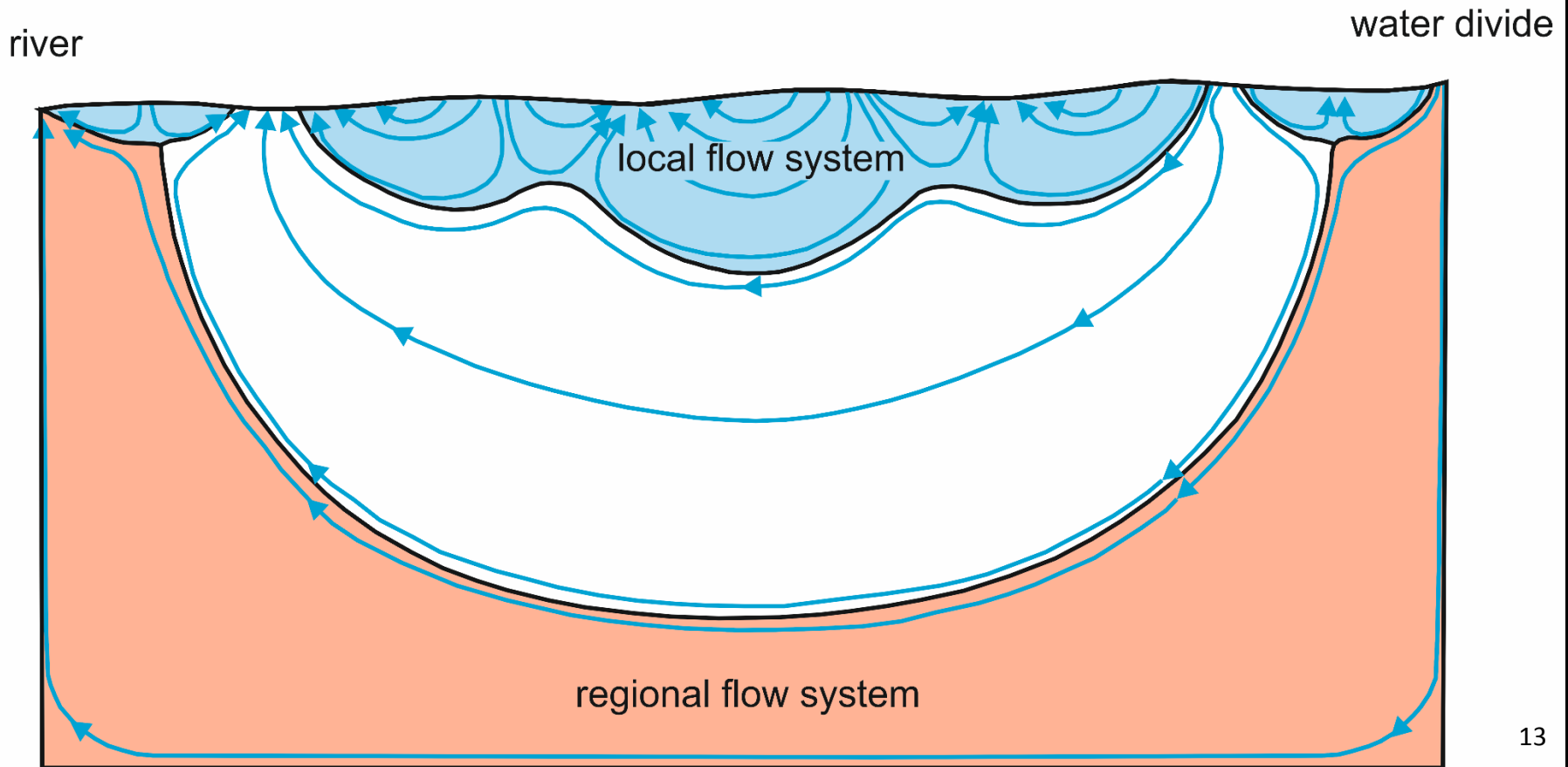


2. Groundwater flow basics

What drives the groundwater flow?

Composite basin with undulating water table

Engelen & Kloosterman 1995 after Tóth 1963, in Mádl-Szőnyi 2011

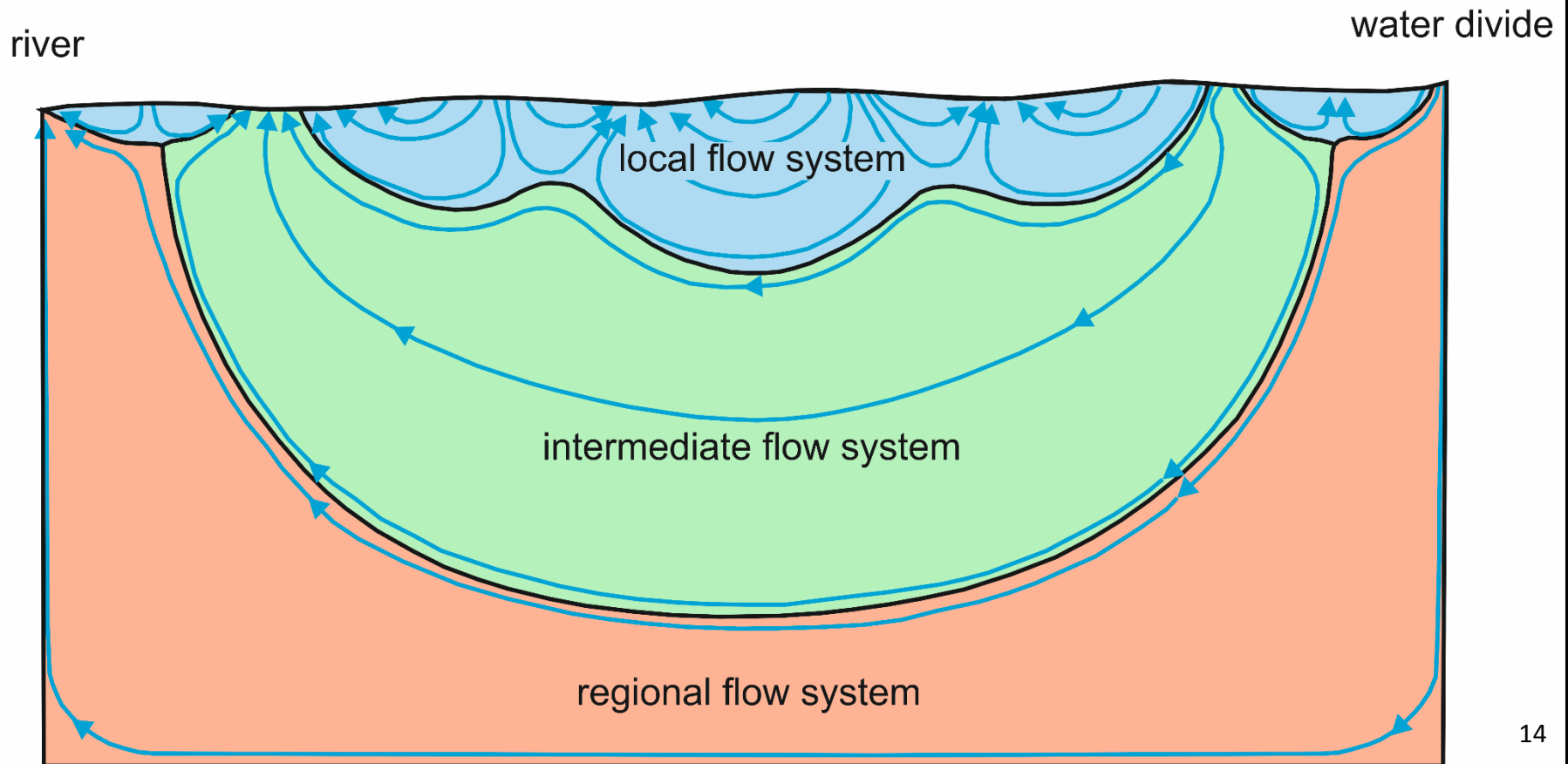


2. Groundwater flow basics

What drives the groundwater flow?

Composite basin with undulating water table

Engelen & Kloosterman 1995 after Tóth 1963, in Mádl-Szőnyi 2011

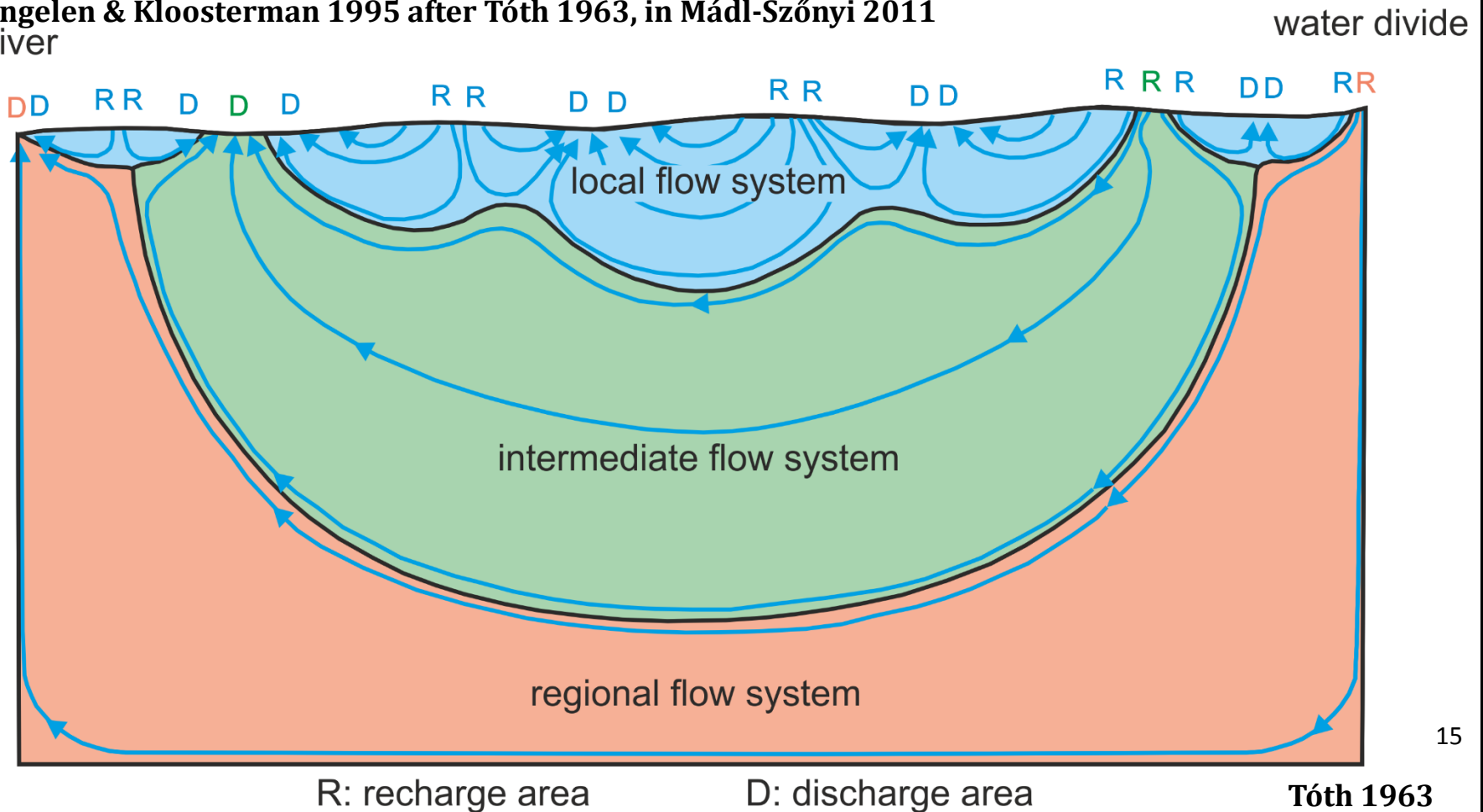


2. Groundwater flow basics

What drives the groundwater flow?

Composite basin with undulating water table

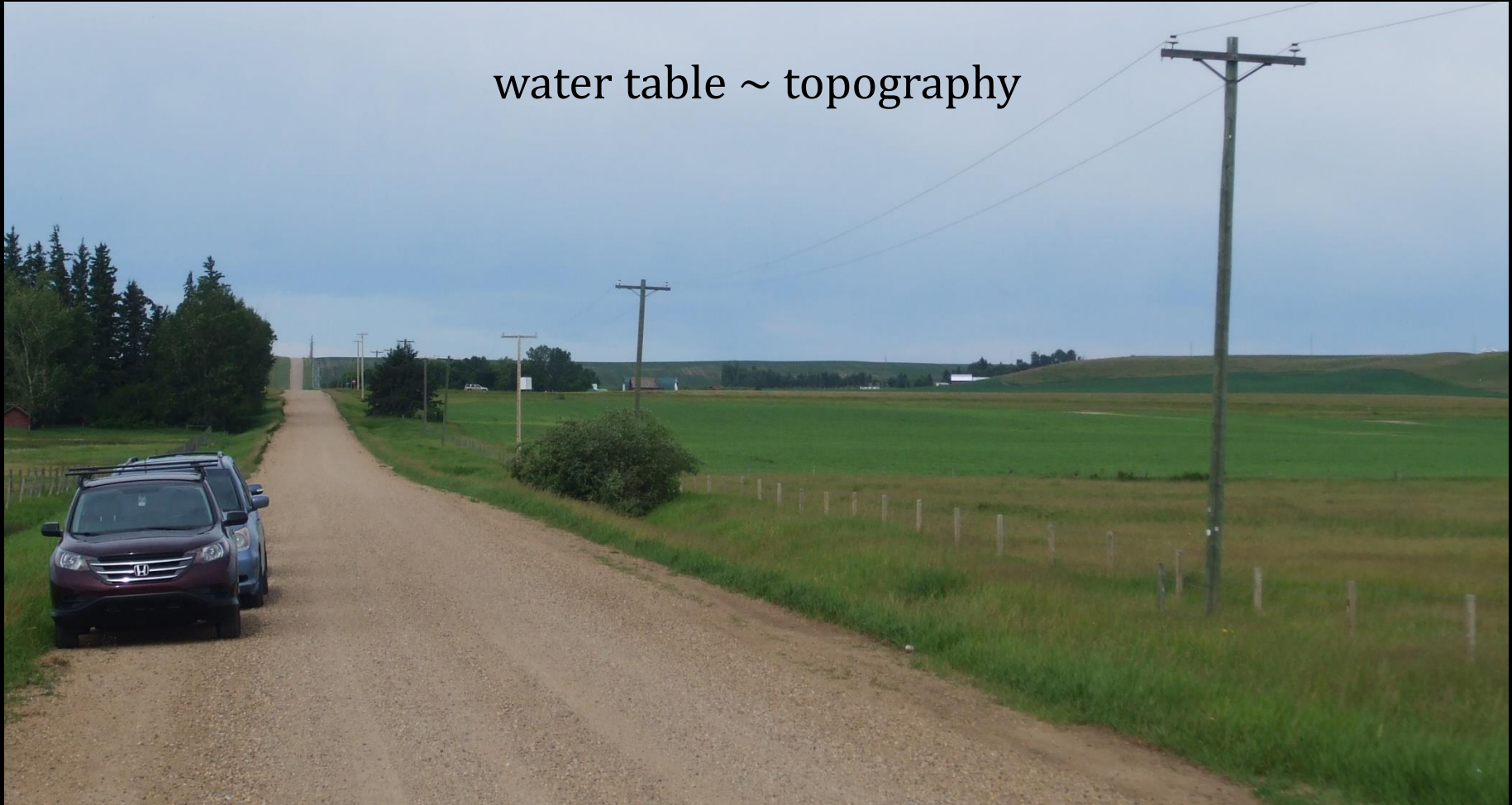
Engelen & Kloosterman 1995 after Tóth 1963, in Mádl-Szőnyi 2011



2. Groundwater flow basics

What drives the groundwater flow?

water table ~ topography



Basin of Ghost Pine Creek, Alberta, Canada

2. Groundwater flow basics

What drives the groundwater flow?

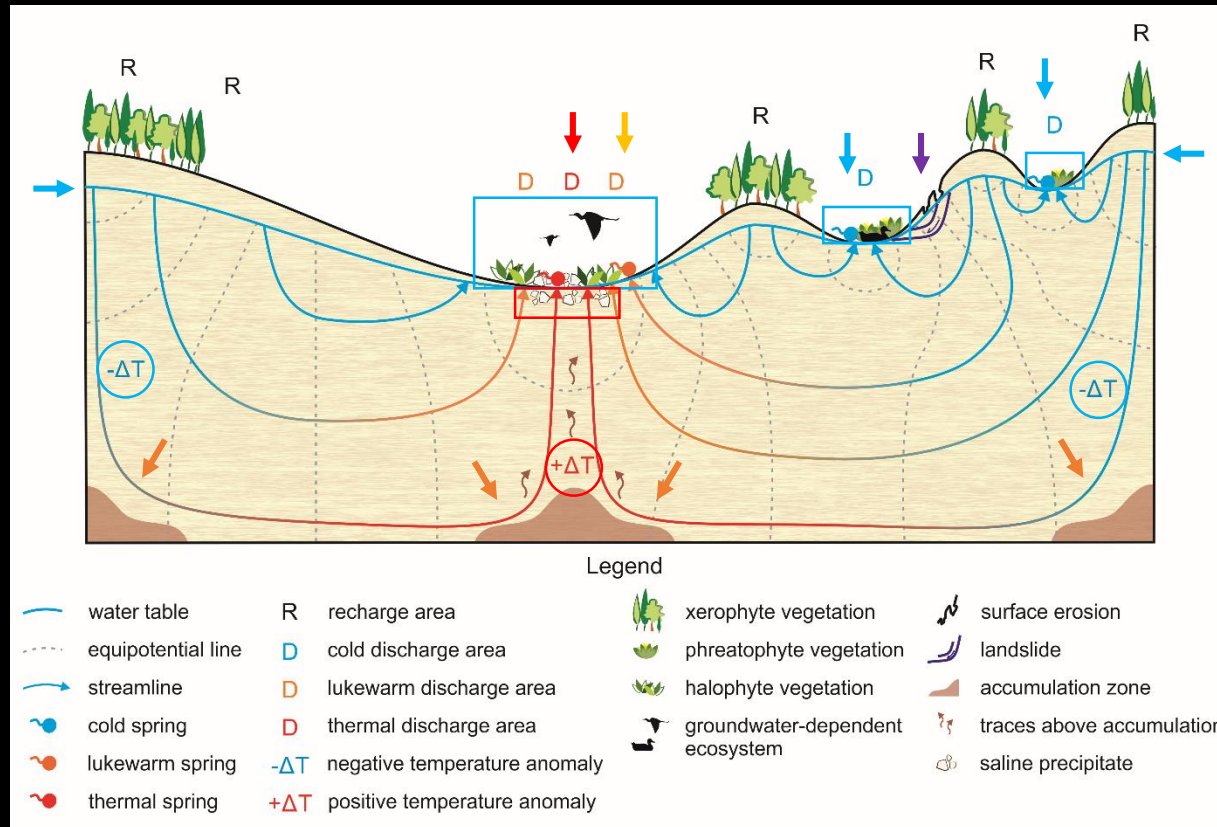
water table \sim topography



Basin of Ghost Pine Creek, Alberta, Canada

3. Consequences of groundwater flow

Flowing groundwater as environmental agent

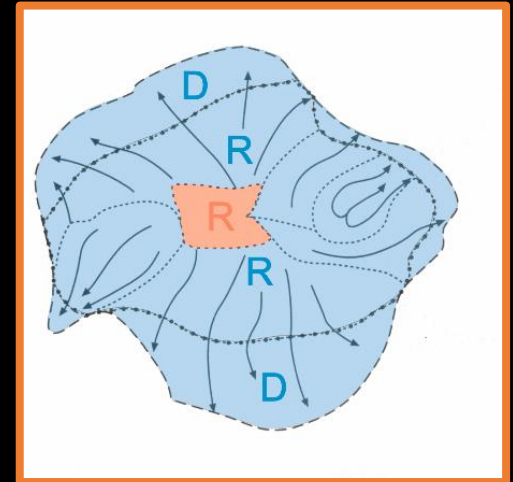
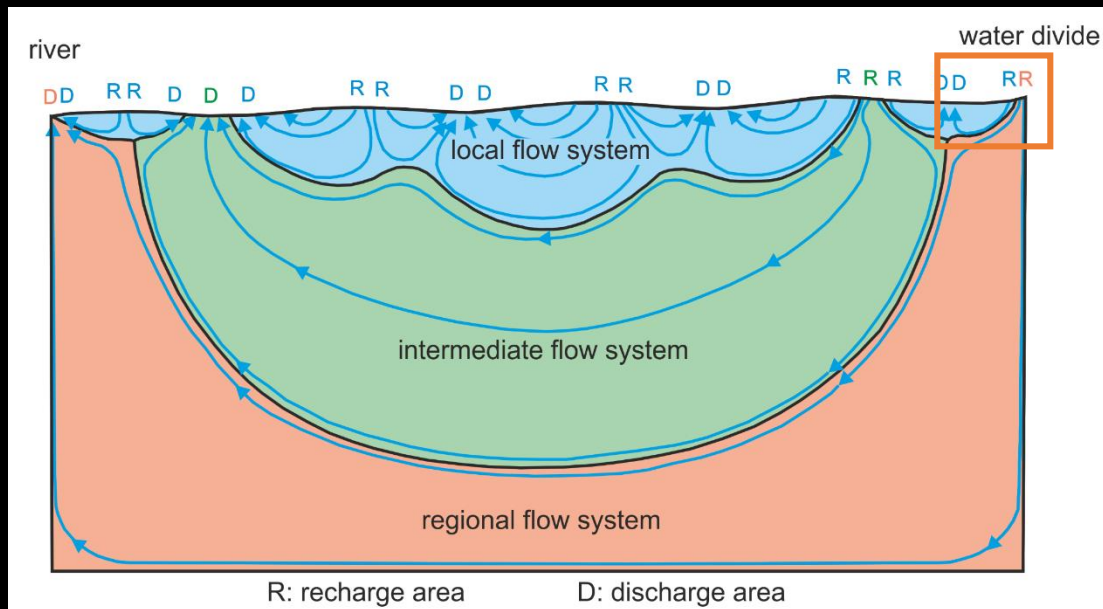


Natural conditions and phenomena due to environmental agency of flowing groundwater in drainage basin (Tóth Á. et al. 2016 modified after Tóth J. 1999)

3. Consequences of groundwater flow

Water level

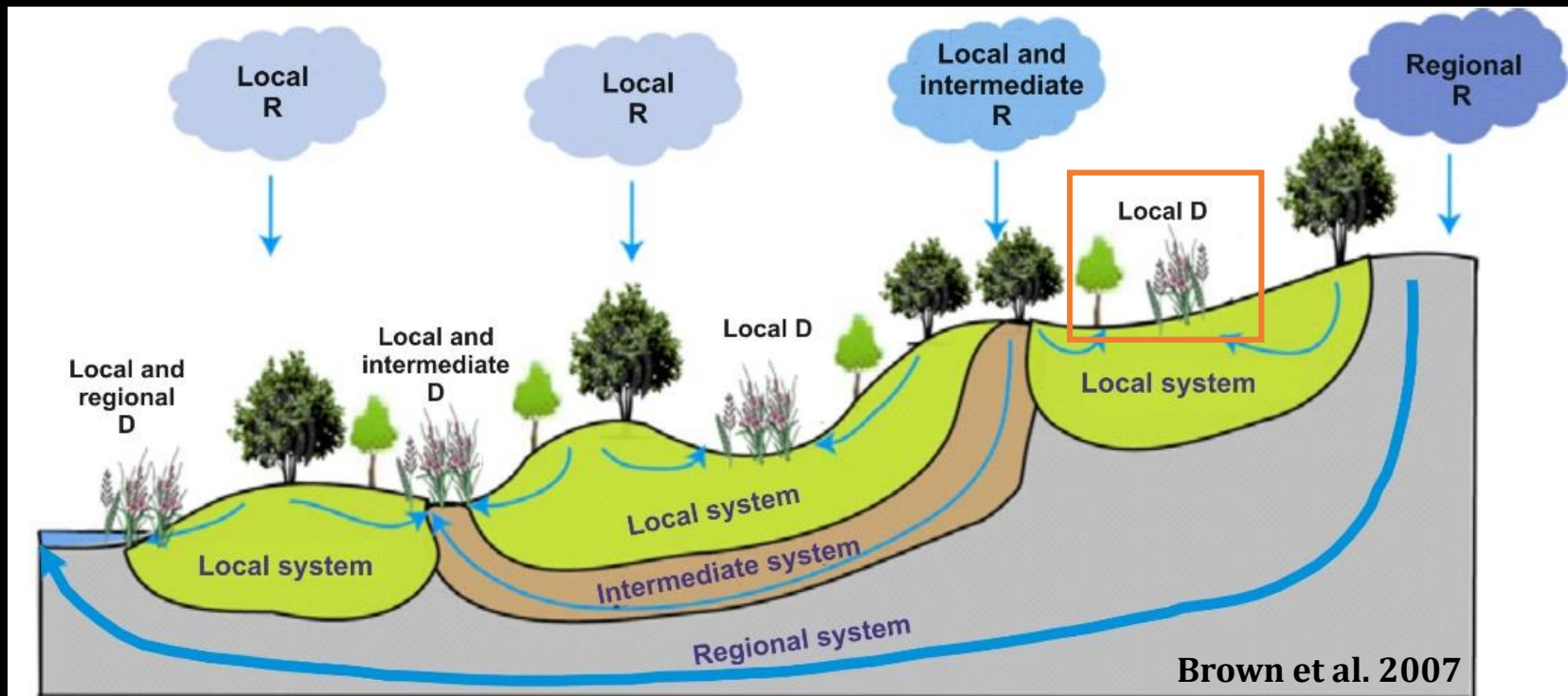
Composite basin with undulating water table



Engelen & Kloosterman 1995 after Tóth 1963, in Mádl-Szőnyi 2011

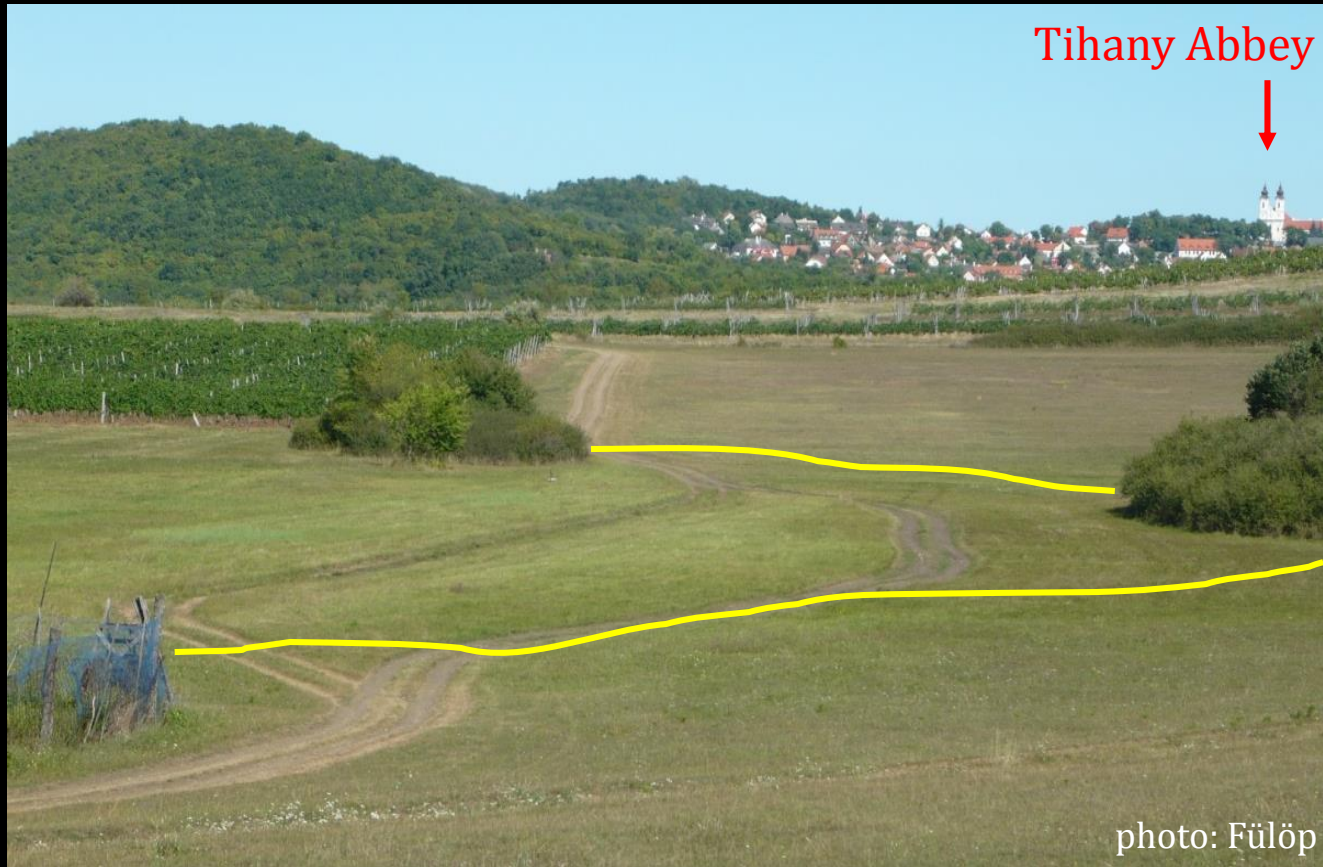
3. Consequences of groundwater flow

Vegetation – groundwater-dependent ecosystems



3. Consequences of groundwater flow

Vegetation – groundwater-dependent ecosystems



September 2011

3. Consequences of groundwater flow

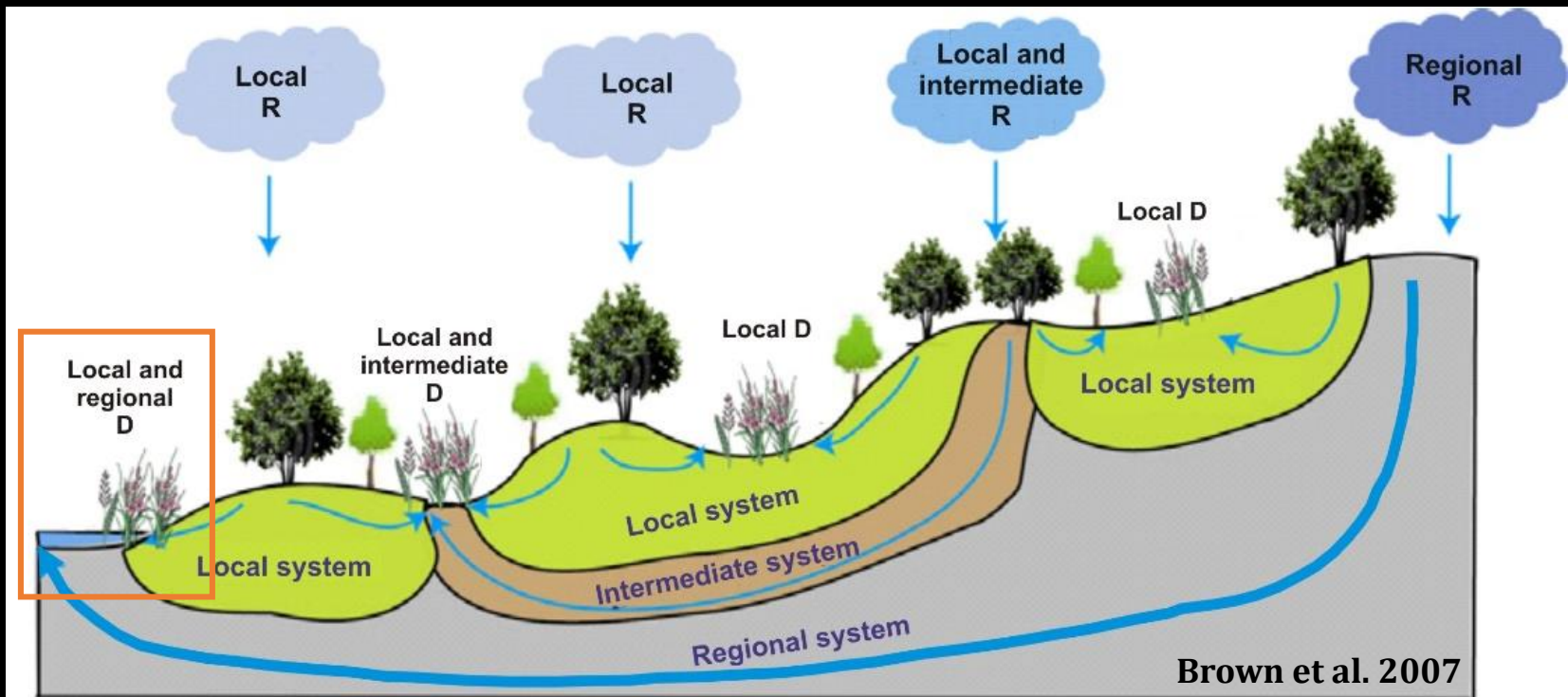
Vegetation – groundwater-dependent ecosystems



January 2011

3. Consequences of groundwater flow

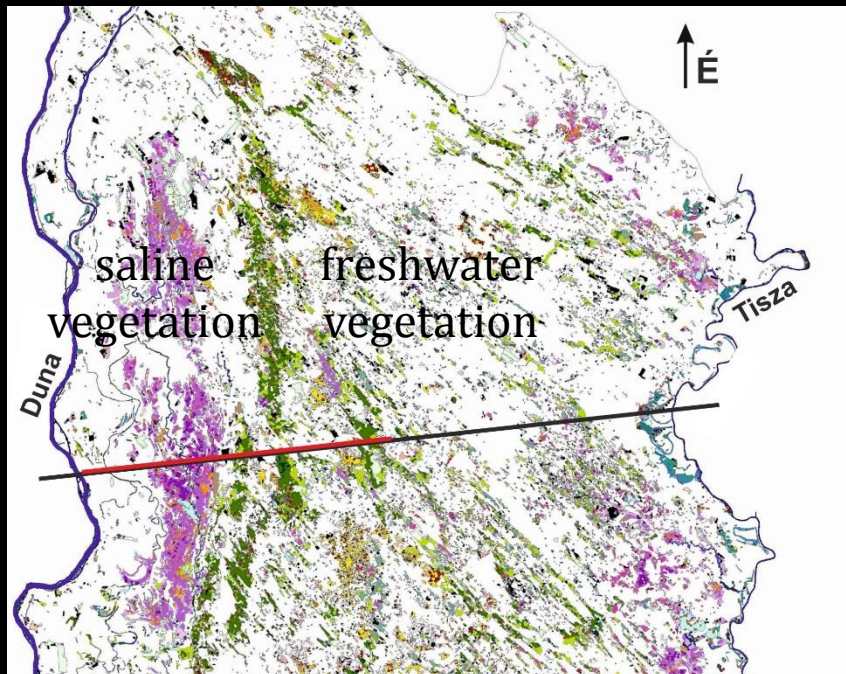
Vegetation – groundwater-dependent ecosystems



3. Consequences of groundwater flow

Vegetation – groundwater-dependent ecosystems

Soil alteration



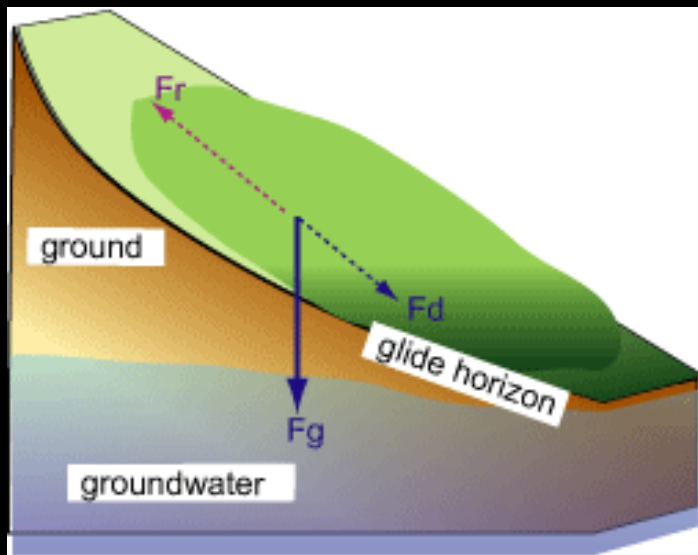
salt precipitation

Bíró et al. 2003

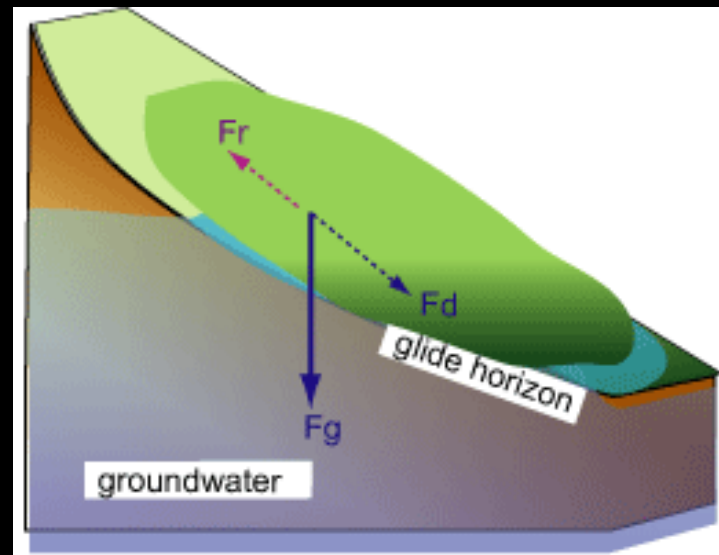
3. Consequences of groundwater flow

Landslides

dry slope



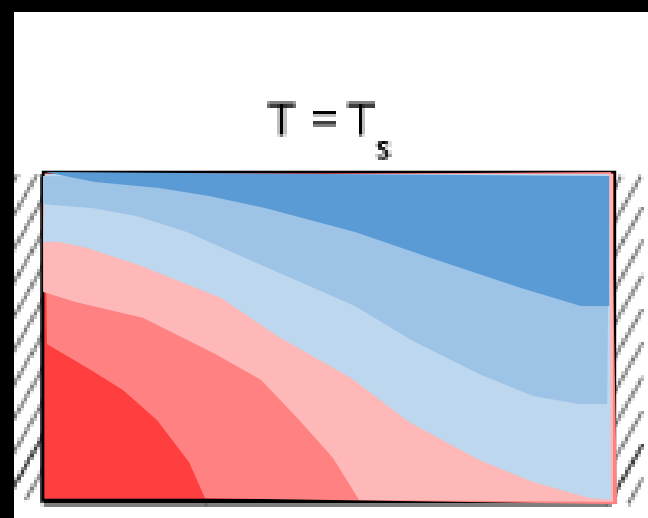
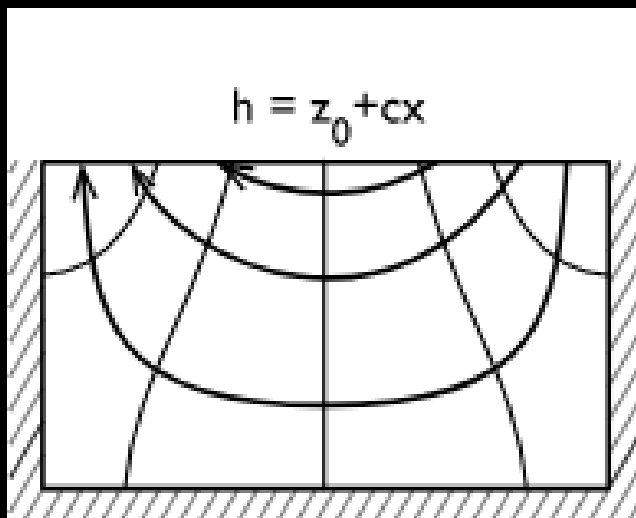
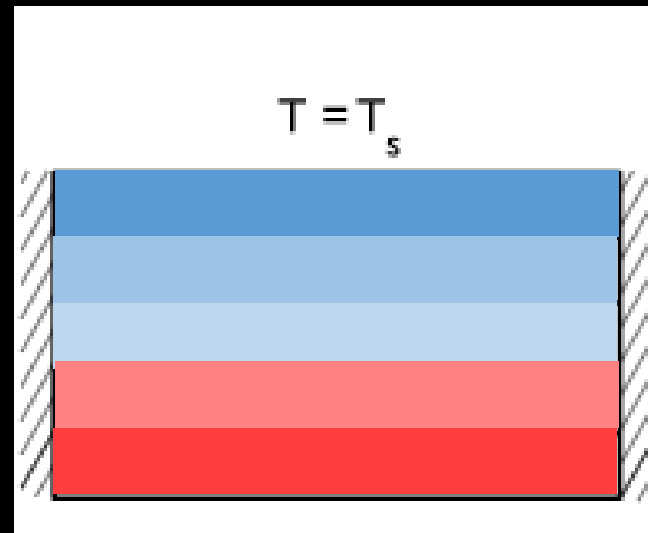
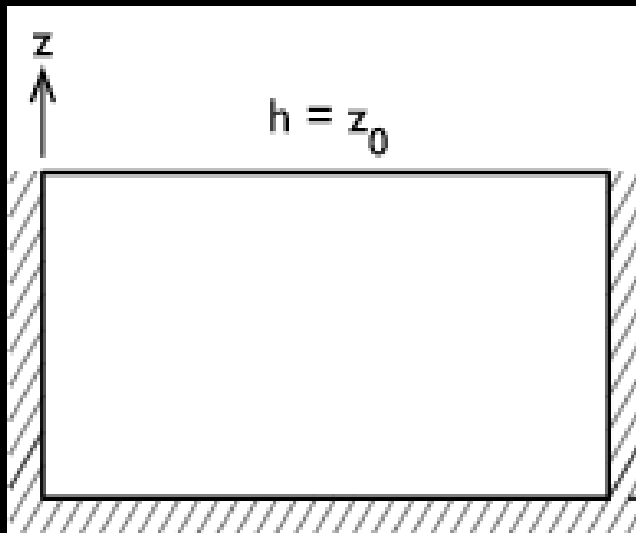
wet slope



igppweb.ucsd.edu

3. Consequences of groundwater flow

Heat transportation

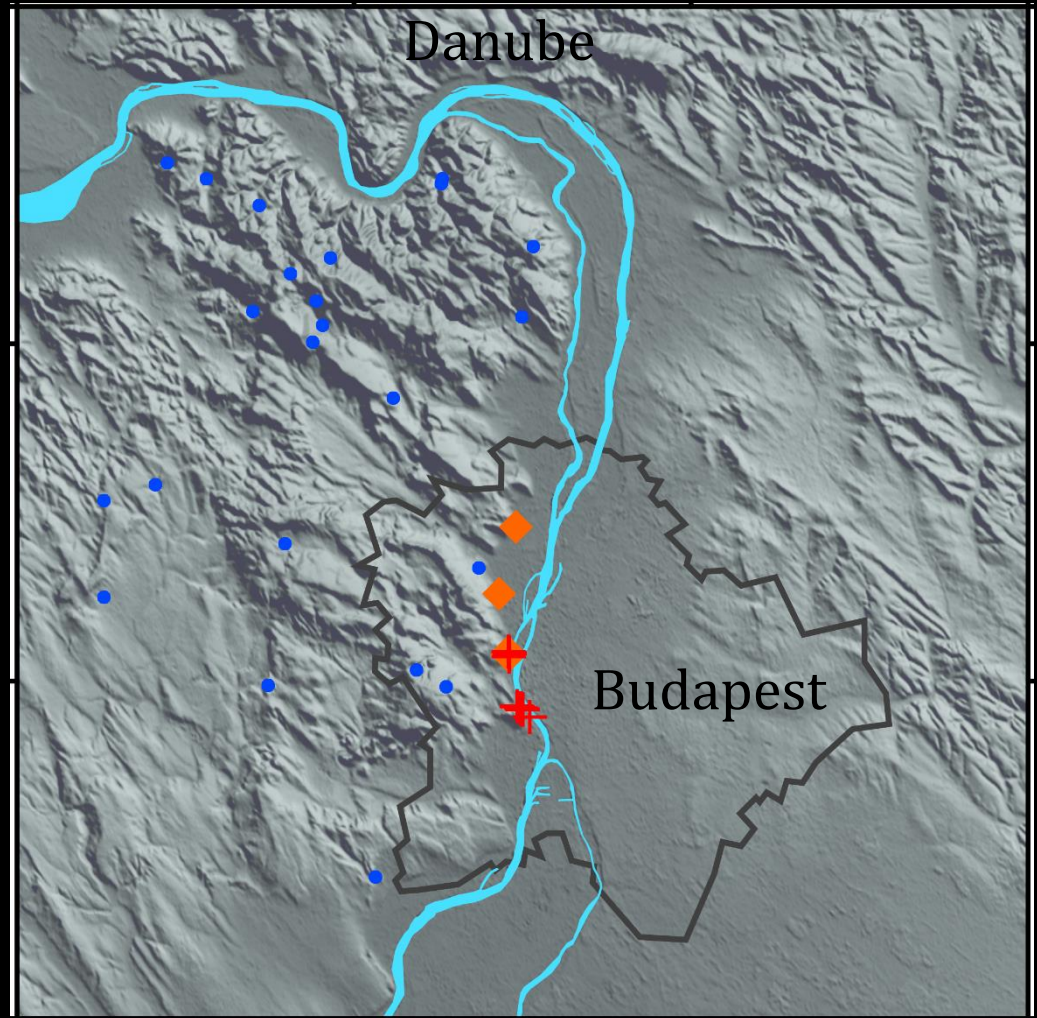


3. Consequences of groundwater flow

Heat transportation

Hot springs in Budapest

Mádl-Szőnyi & Tóth 2017



3. Consequences of groundwater flow

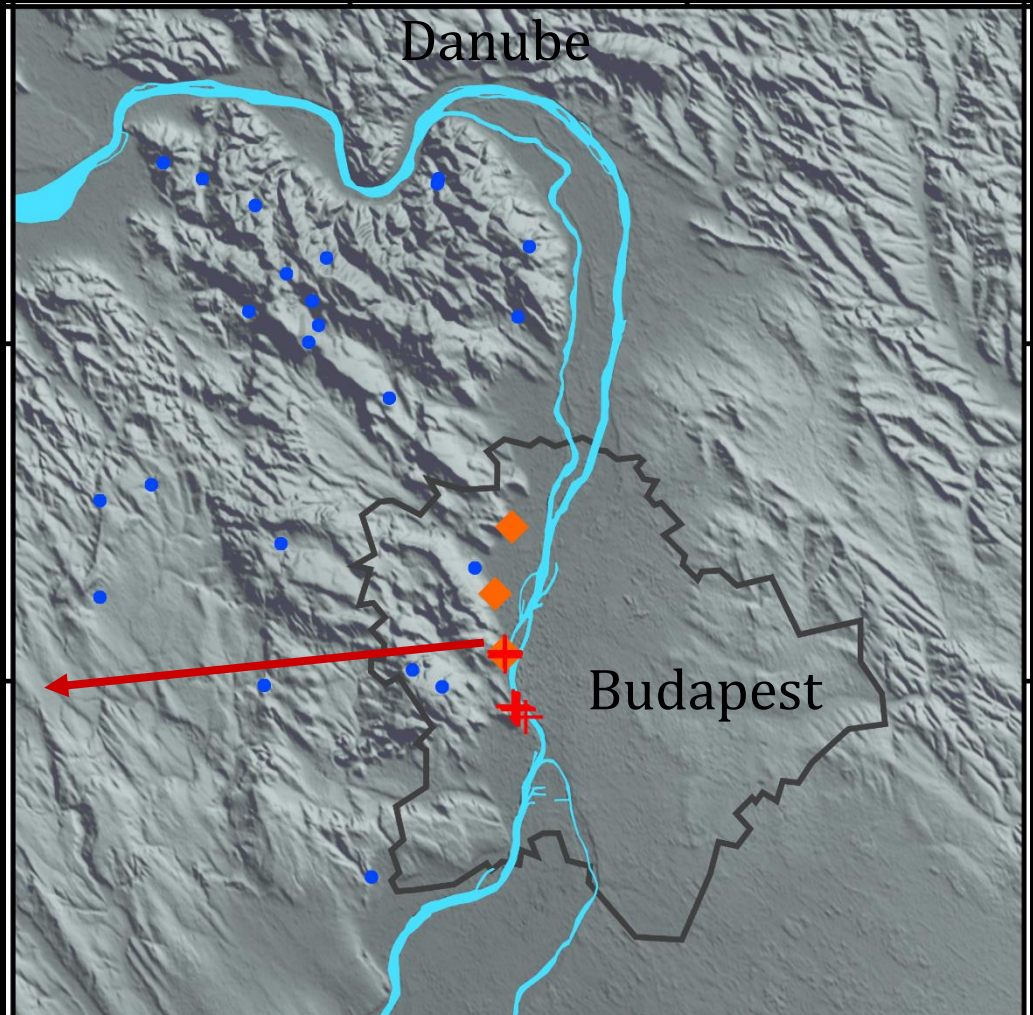
Heat transportation

Hot springs and spas
in Budapest

Lukács Spa



Mádl-Szőnyi & Tóth 2017



3. Consequences of groundwater flow

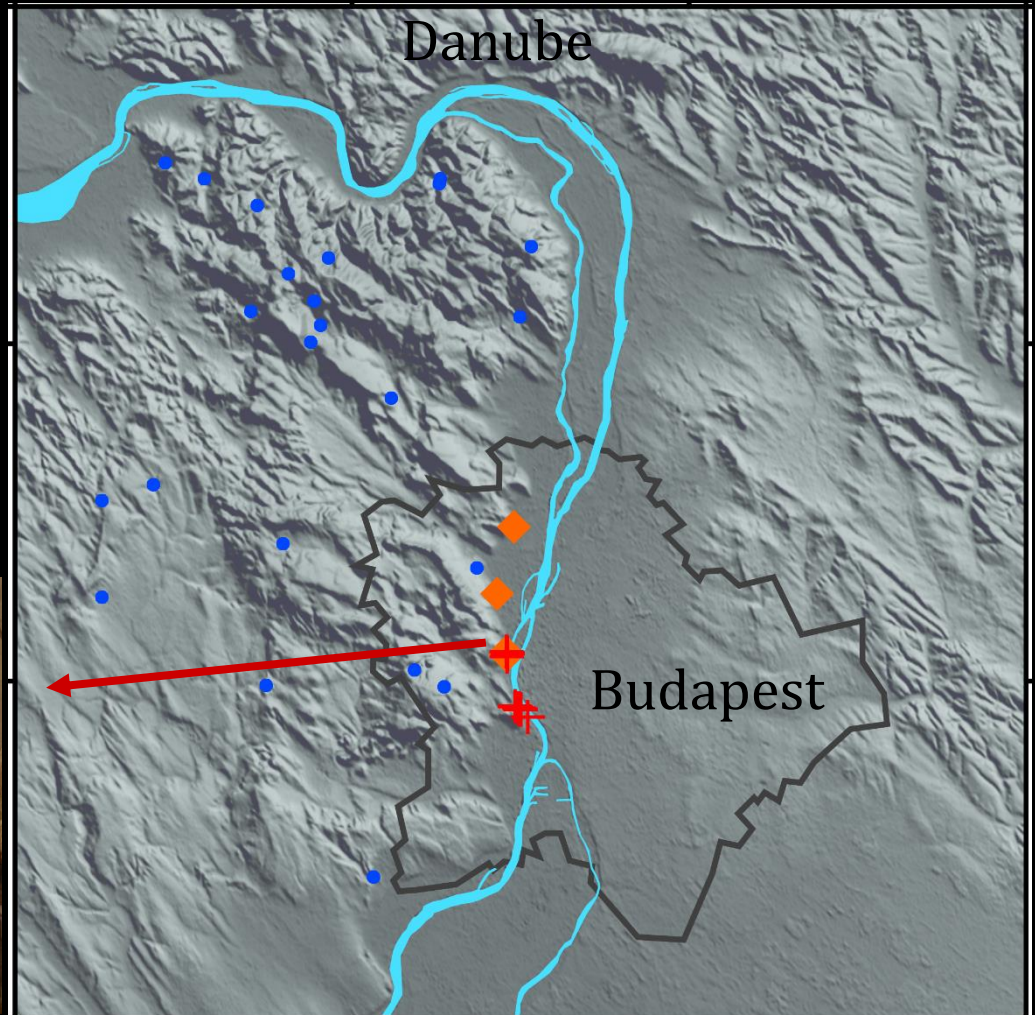
Heat transportation

Hot springs and spas
in Budapest

Király Spa



Mádl-Szőnyi & Tóth 2017



3. Consequences of groundwater flow

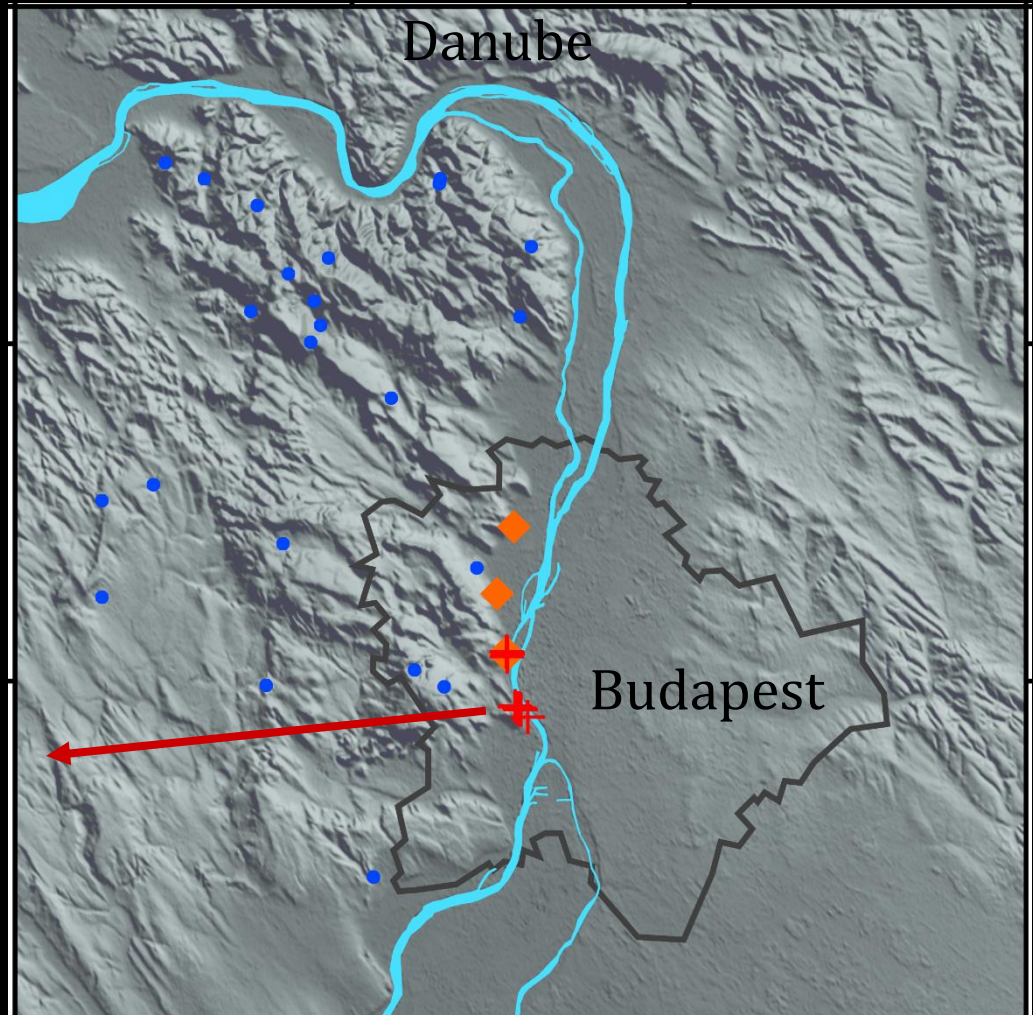
Heat transportation

Hot springs and spas
in Budapest

Rudas Spa



Mádl-Szőnyi & Tóth 2017



3. Consequences of groundwater flow

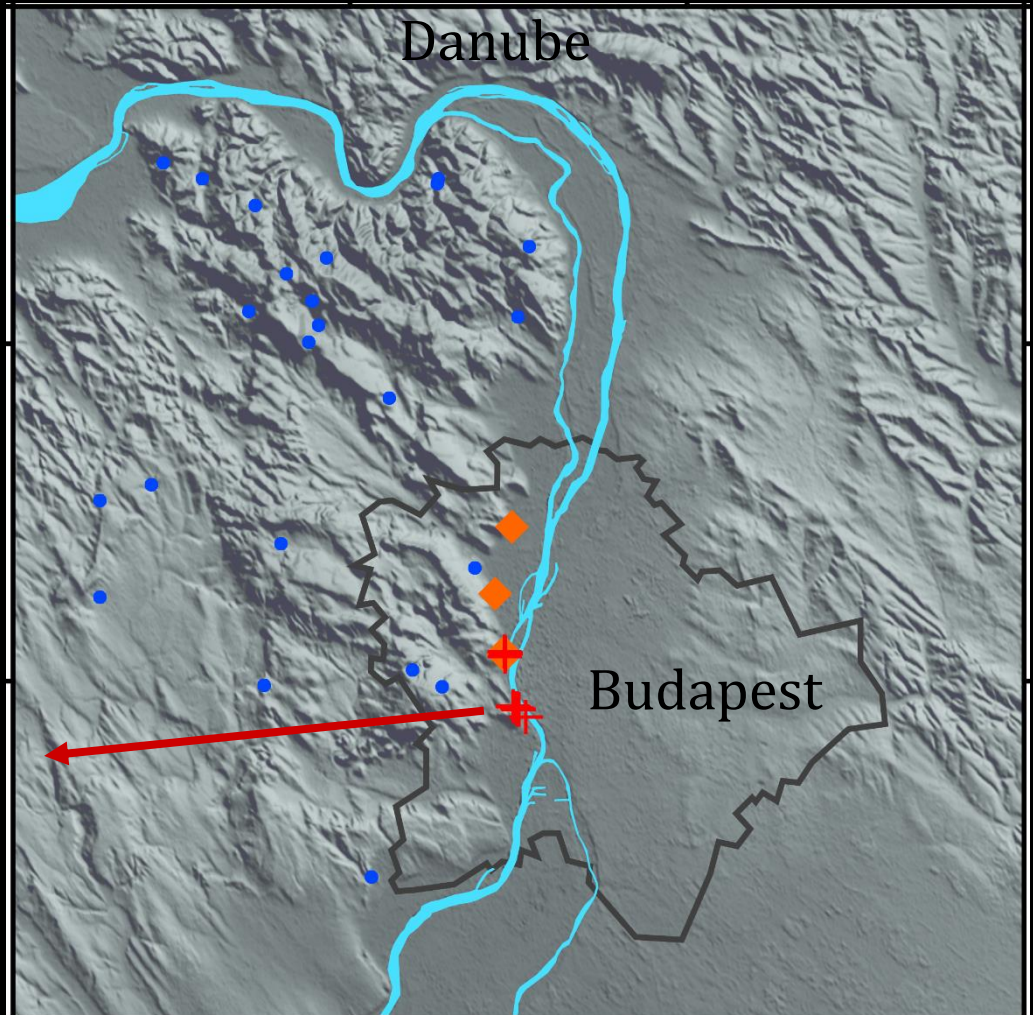
Heat transportation

Hot springs and spas
in Budapest

Gellért Spa

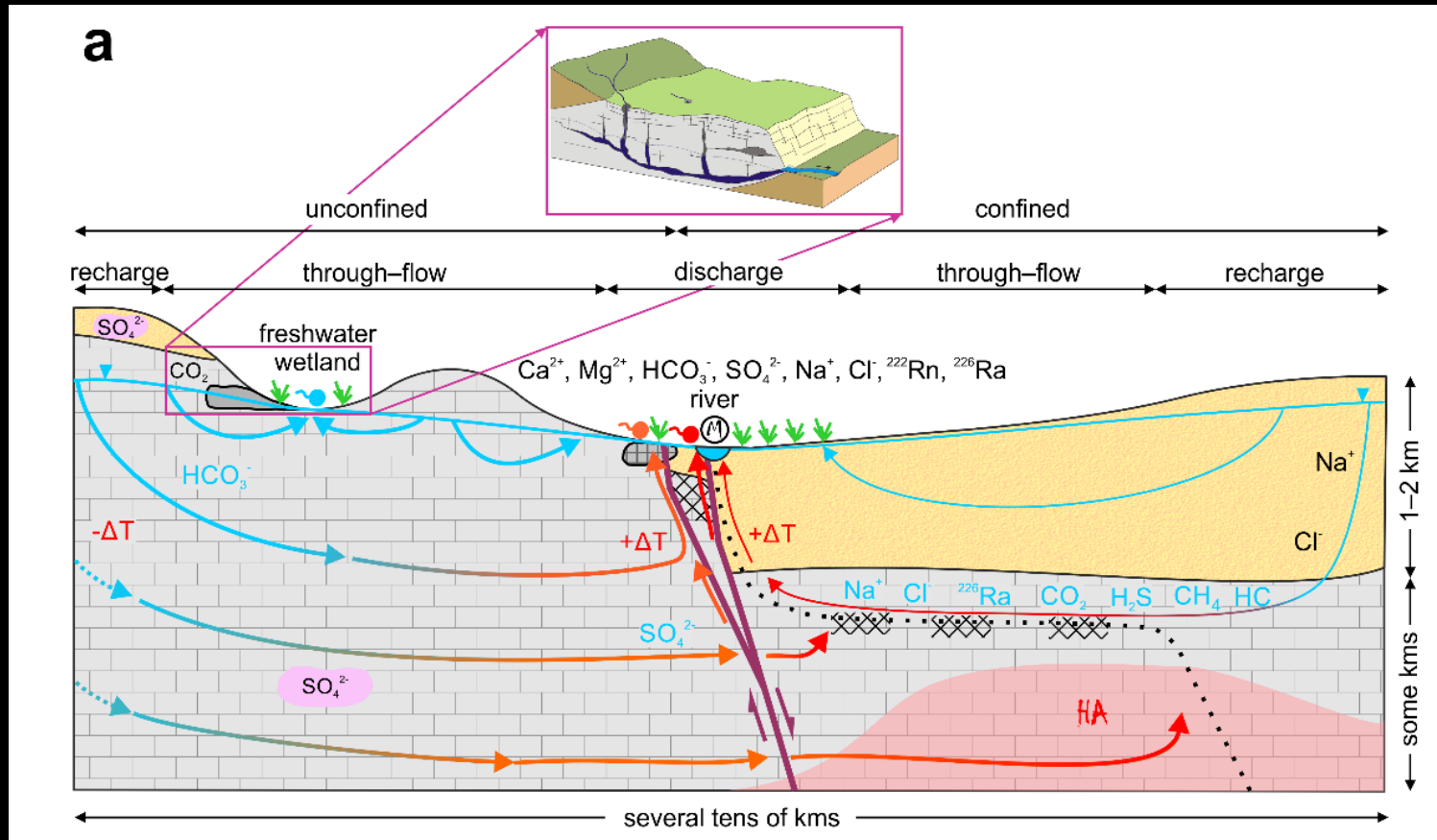


Mádl-Szőnyi & Tóth 2017



3. Consequences of groundwater flow

Cave formation – speleogenesis



Mádl-Szőnyi & Tóth 2015

3. Consequences of groundwater flow

Cave formation – speleogenesis

Budapest is the capital city of caves

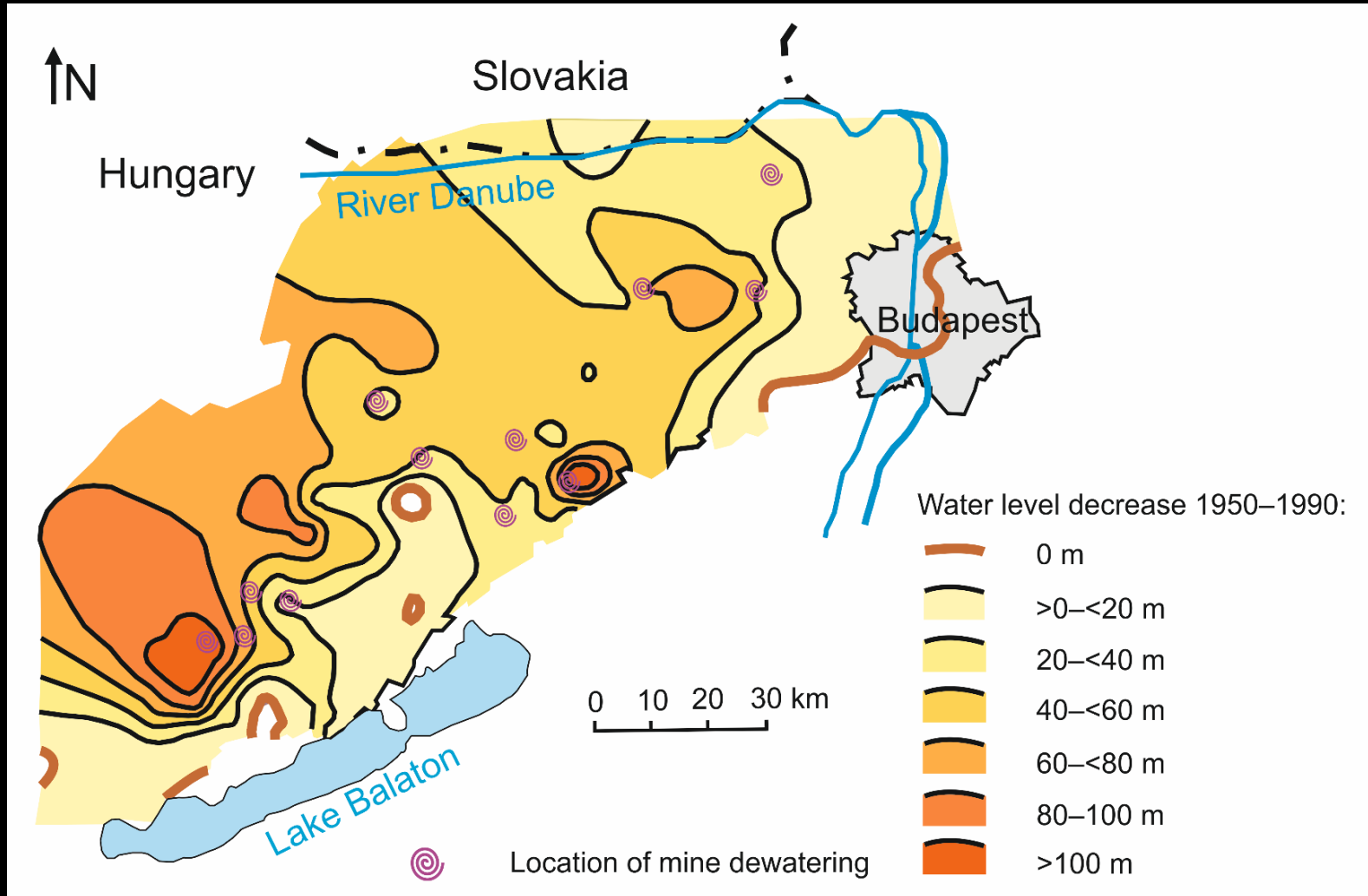
Józsefhegy Cave



Molnár János Cave

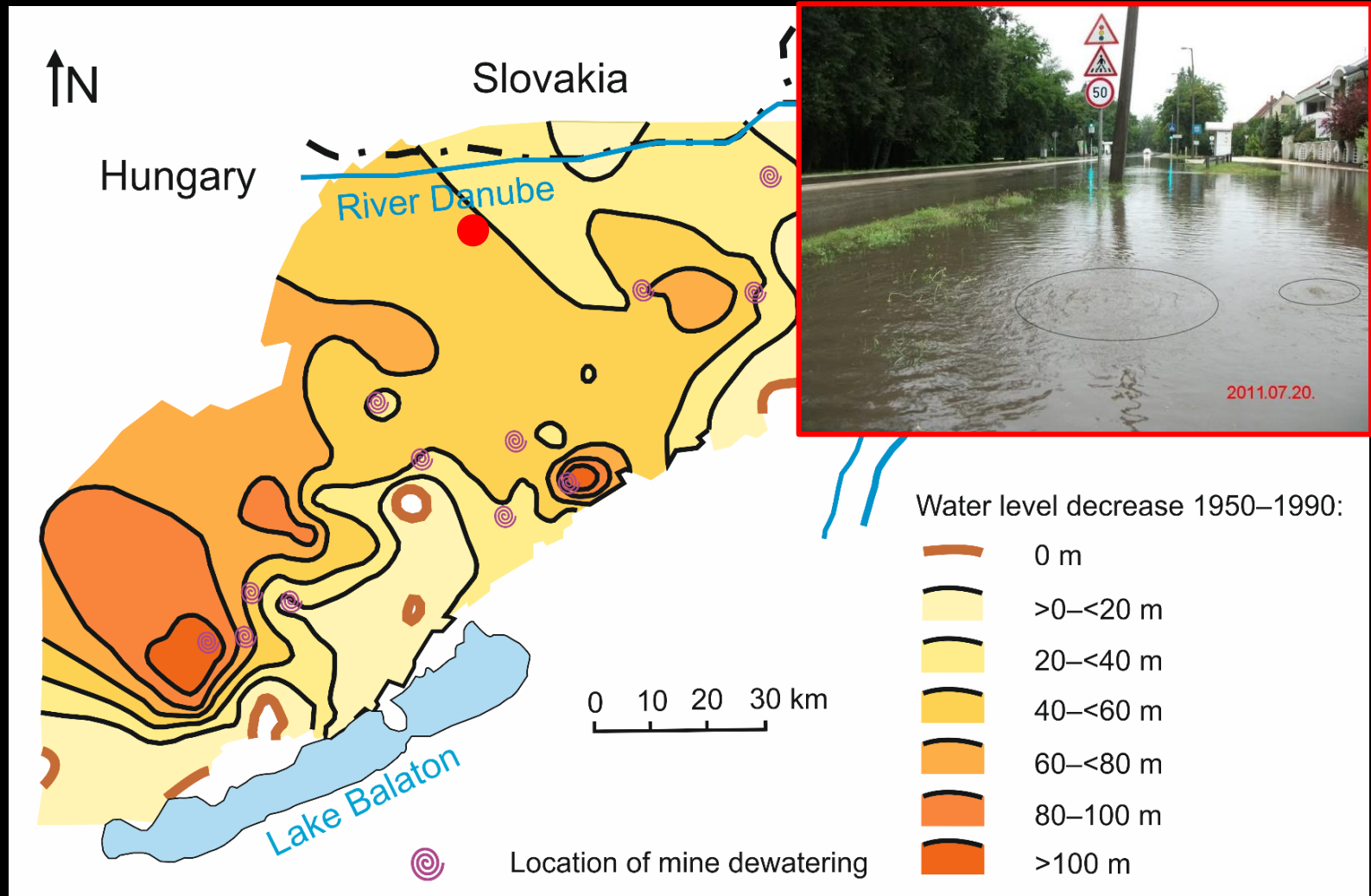
4. Human impact on groundwater

Groundwater abstraction



4. Human impact on groundwater

Groundwater abstraction



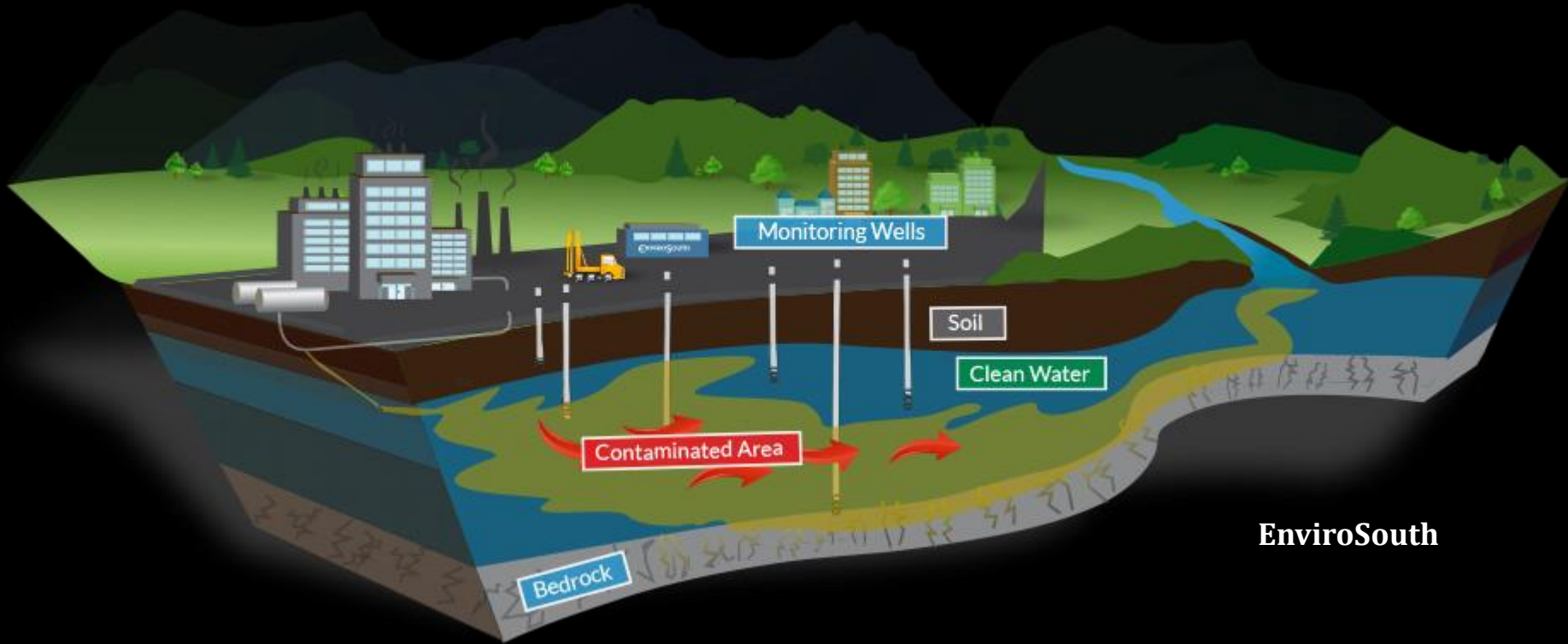
4. Human impact on groundwater

Groundwater abstraction – subsidence



4. Human impact on groundwater

Contamination



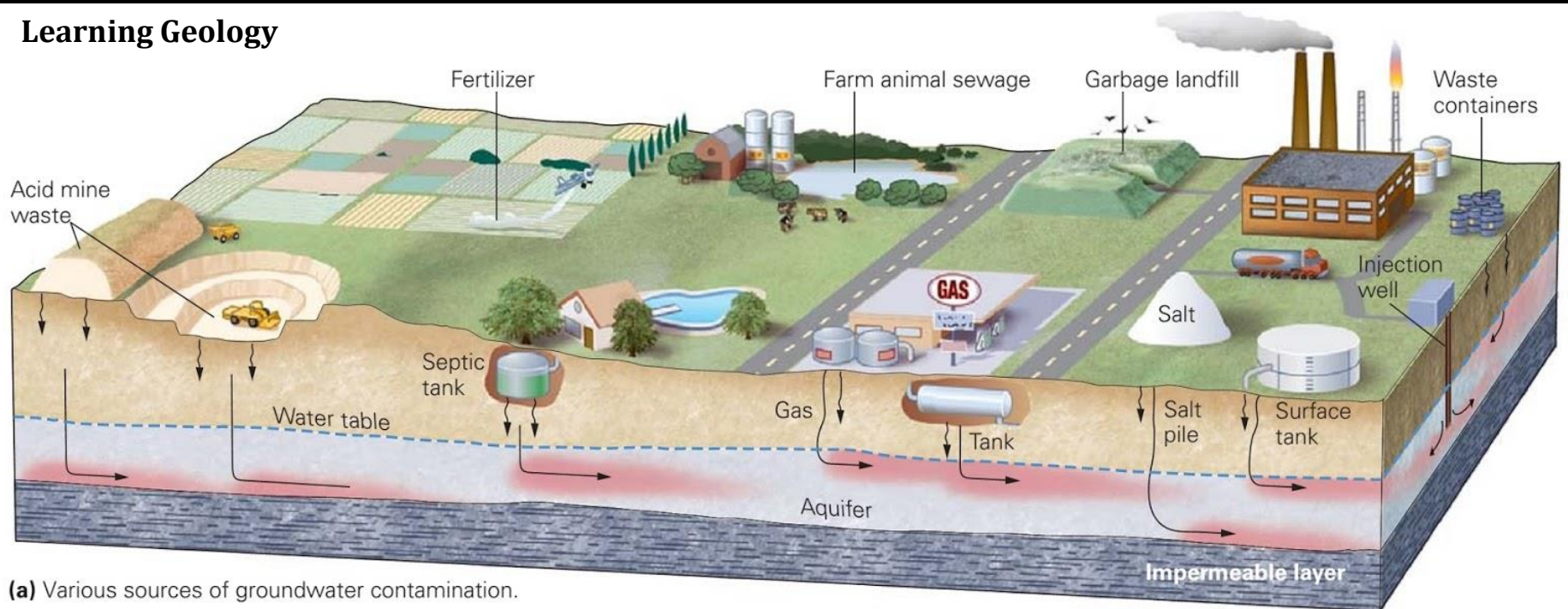
EnviroSouth

Polluted groundwater is less visible, but more difficult to clean up, than pollution in rivers and lakes.

4. Human impact on groundwater

Contamination

Learning Geology

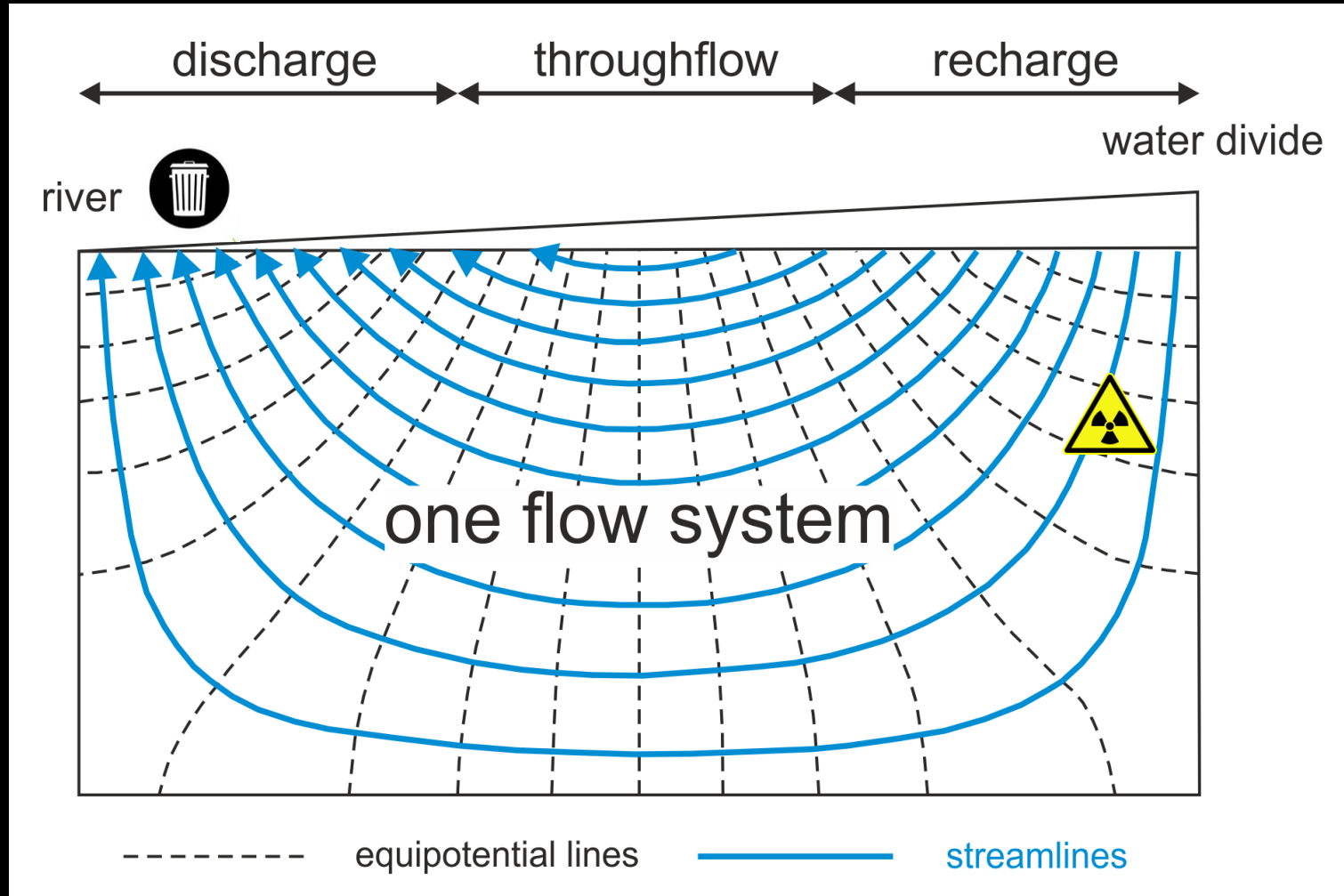


Groundwater pollution most often results from improper disposal of wastes on land. Major sources include industrial and household chemicals and garbage landfills, fertilizers and pesticides used in agriculture, industrial waste and wastewater from mines, leaking underground oil storage tanks and pipelines and sewage sludge.

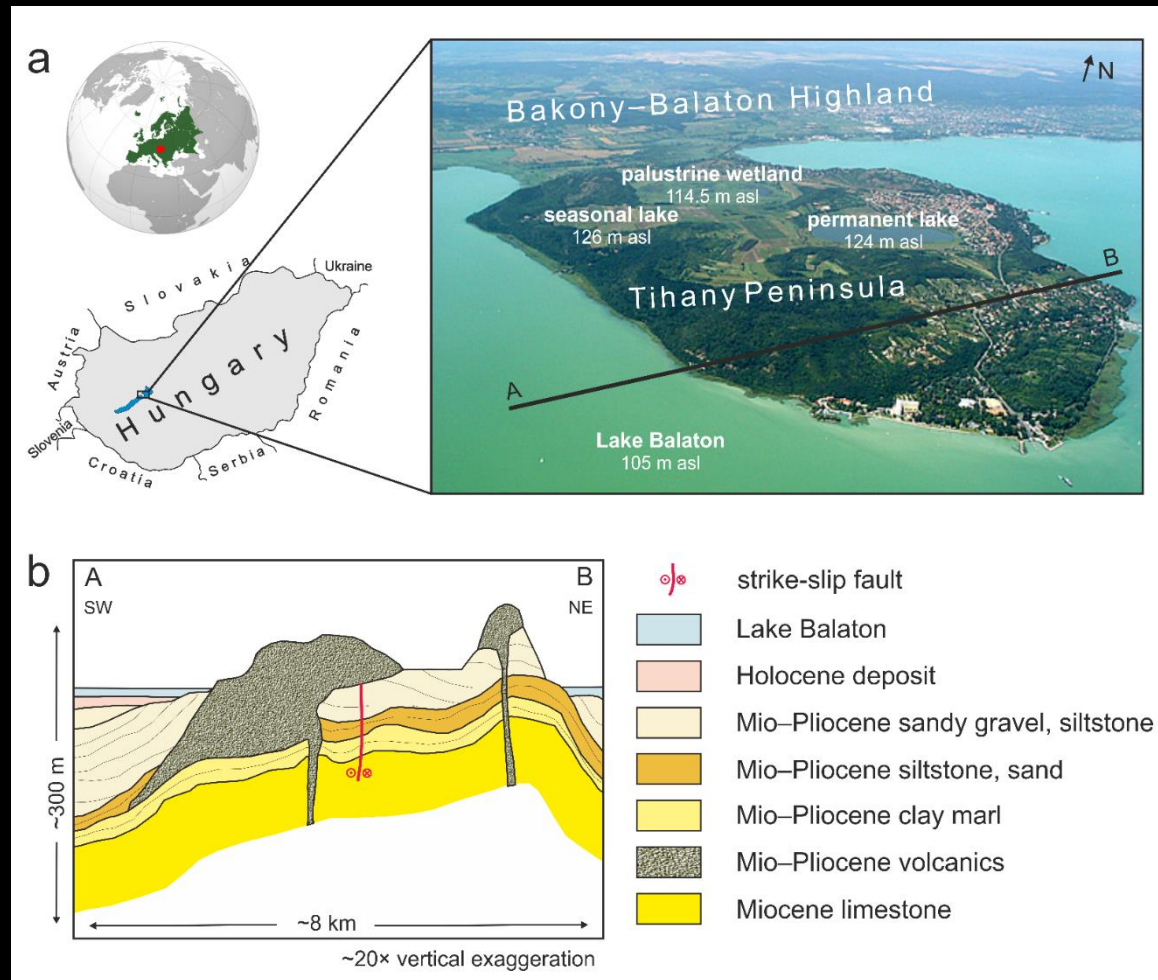
4. Human impact on groundwater

Contamination – waste disposal

What is the difference between municipal and radioactive waste?



5. Case Study – Tihany Peninsula



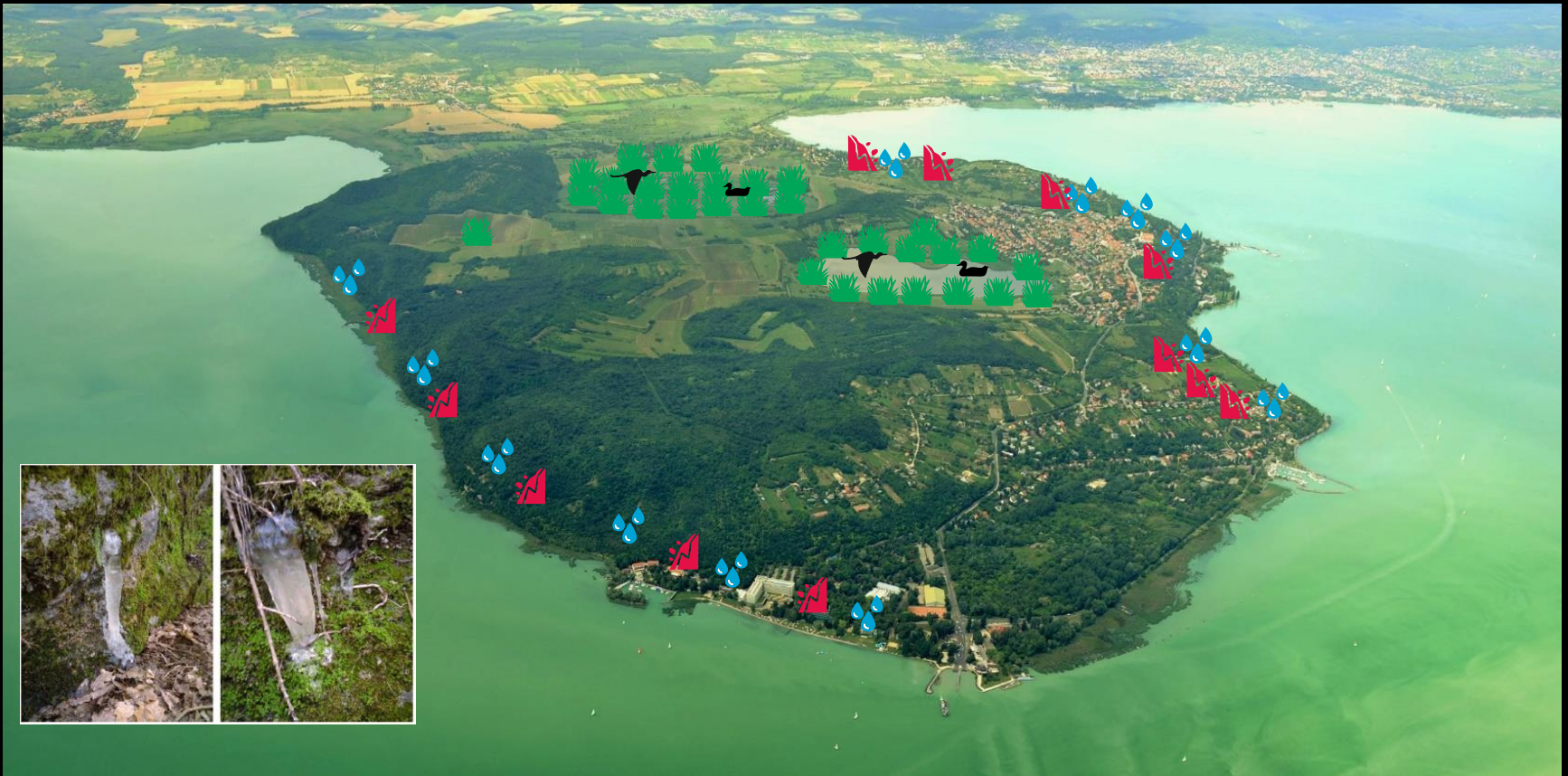
Topographic and geologic characteristics of the study area

(a) Aerial photo of the Tihany Peninsula, Hungary, Europe

(b) Geology along the cross section indicated in (a) (after Sacchi et al., 1999)

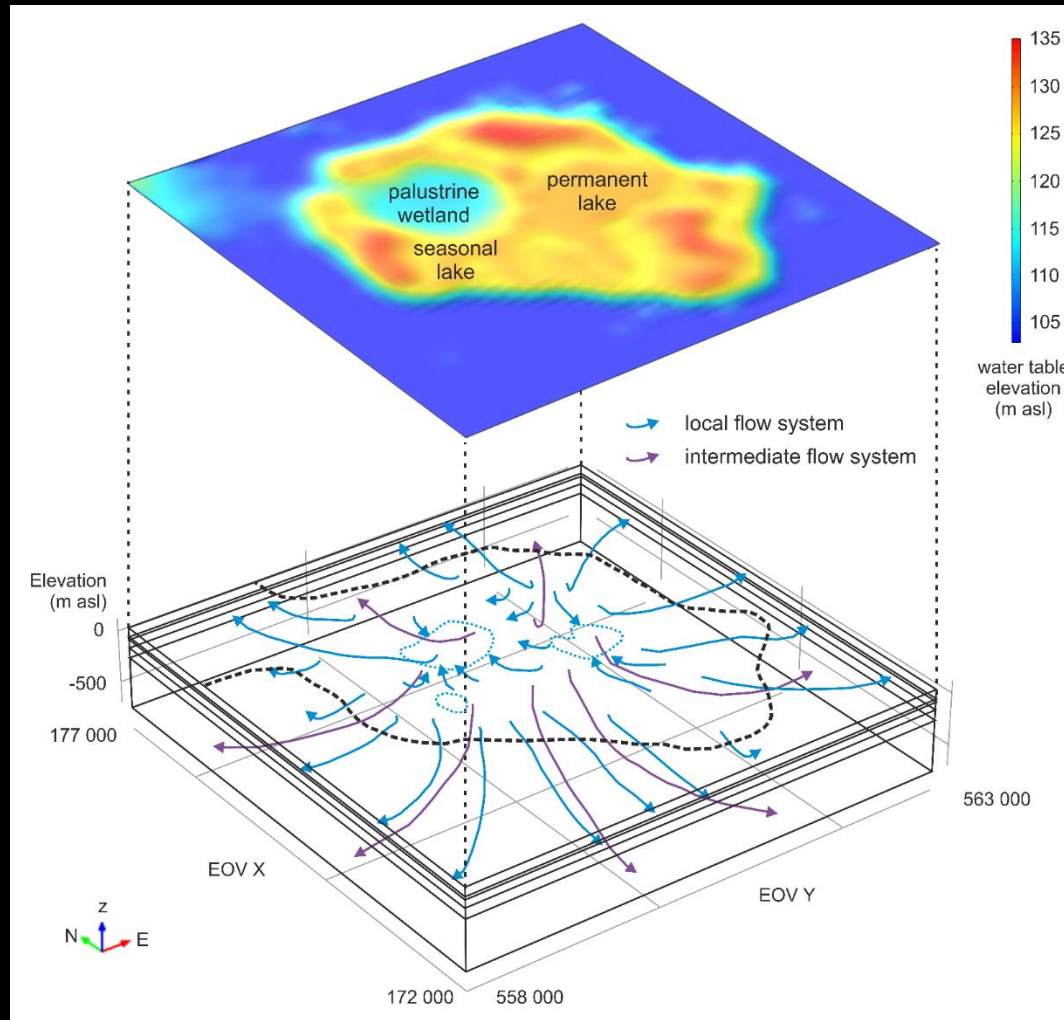
(Tóth Á. et al. 2016)

5. Case Study – Tihany Peninsula



Aerial photo of the Tihany Peninsula with the imprints of flowing groundwater (Tóth Á. et al. 2016)

5. Case Study – Tihany Peninsula



Hierarchical interpretation of simulated gravity-driven flow field displaying local and intermediate flow systems with their characteristic flow lines (Tóth Á. et al. 2016)

5. Case Study – Tihany Peninsula

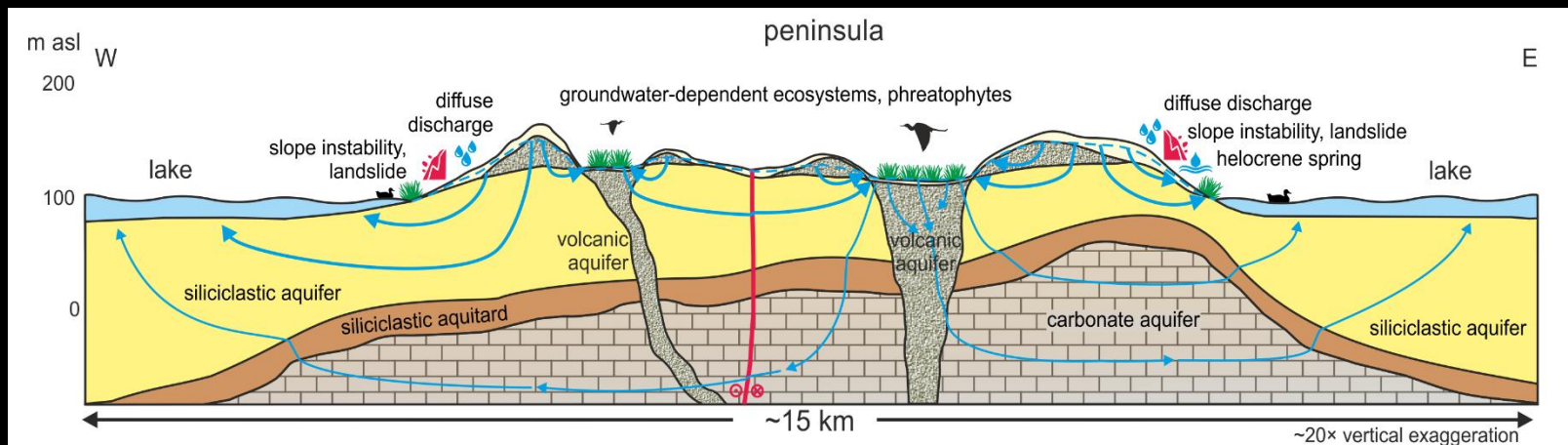
Human impact

- **water demand** cannot be supplied
- high potential of **contamination**

Climate change

- **local flow systems** mostly affected
- wetlands are **extremely vulnerable**

Water management and policy



6. Conclusion

What is groundwater?

Groundwater is the water present beneath Earth's surface in soil pore spaces and in the fractures of rock formations.

What drives the groundwater flow?

*Energy difference = hydraulic head difference = water level difference
~ topography
gravity*


What are the consequences of groundwater flow?

*Vegetation type, soil alteration, landslides, heat transportation,
cave formation, transport of contamination*

Thinking in Systems

Regional Groundwater Flow Commission

regionalgwflow.iah.org



Regional Groundwater Flow Commission



International Association of Hydrogeologists

HOME NEWS AND ANNOUNCEMENTS RGFC COMMITTEE ACTIVITIES REGIONAL GROUNDWATER FLOW VIDEOS, RESEARCH, RESOURCES


Home

Welcome from IAH's Regional Groundwater Flow Commission (RGFC). We hope you find the information useful and that it encourages you to participate. Do feel free to get in touch with questions or comments.



The RGFC Board in Calgary, Canada:
Xiao-Wei Jiang, Menggui Jin, Judit Mádi-Szőnyi, Joe Tóth, Joanne Thompson (Vice President, North America), Okke Batelaan, Ádám Tóth, Brian Smerdon

CALGARY SYMPOSIUM 2017




Characterizing regional groundwater flow systems: Insight from practical applications and theoretical development
Further information [here](#).

GET INVOLVED




József & Erzsébet Tóth Hydrogeology Chair

tothprofesszura.elte.hu



JÓZSEF AND ERZSÉBET TÓTH ENDOWED HYDROGEOLOGY CHAIR

LANGUAGE: MISSION ENDOWED CHAIR EDUCATION RESEARCH JÓZSEF TÓTH COLLECTION FUNDATION



József and Erzsébet Tóth Endowed Hydrogeology Chair was initiated by József Tóth and founded by the Eötvös Loránd University on 1 September 2016. Organizationally it is a scientific group of hydrogeologists (researchers, PhD and MSc students) and this group is part of the Department of Physical and Applied Geology, Faculty of Science, Eötvös Loránd University, Budapest, Hungary. The main aim of this Chair is to improve the state and position of the Hungarian hydrogeology, to assist the research and education of hydrogeology in Hungary and to foster the national and international relations. The key point of the education and research is the so-called modern hydrogeology which integrates the Tóthian basin hydraulics, groundwater flow systems and their related surface and subsurface manifestations and their practical application.