International Conference and Field Seminar

Karst Without Boundaries

DELINEATION OF A KARST CATCHMENT AREA USING SEVERAL METHODS – AN EXAMPLE OF PLITVICE LAKES CATCHMENT

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DIKTAS

PROTECTION AND SUSTAINABLE USE OF THE DINARIC KARST AQUIFER SYSTEM

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Trebinje (Bosnia & Herzegovina) - Dubrovnik (Croatia)

INTRODUCTION

- The main topic ▶ Plitvice Lakes Catchment, which is a part of the Plitvice Lakes National Park

- Karst area ▶ situated in the Dinarides, about 60 km from the Adriatic Sea
    - a wider area has been designated a NP since 1949

  … and since 1979 has been included on the UNESCO List of World Heritage

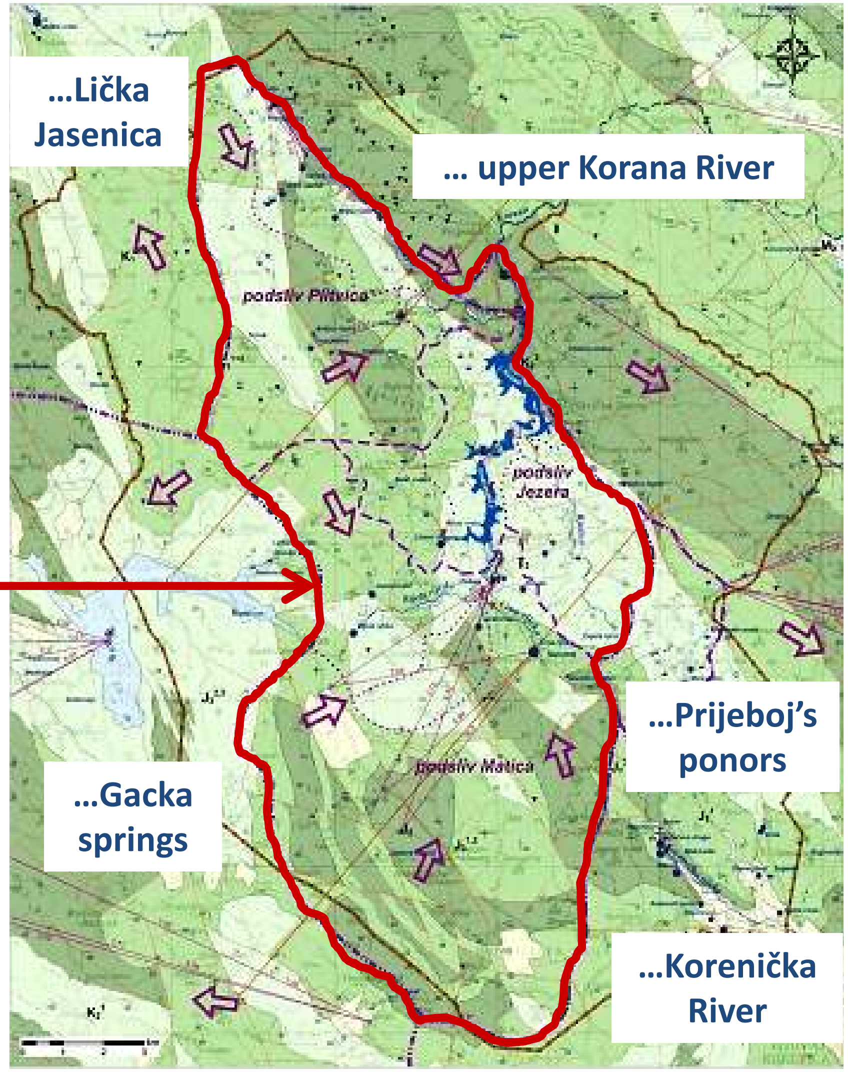
- Total surface area of the NP is about 297 km²

Plitvice Lakes Catchment (PLC)

- The determination of the catchment area provides the basis for all water balance calculations
- Basic catchment areas ▶ determined earlier, during the course of the international project (2008)

- The observed PLC area is approximately 152 km^2
- It is the largest catchment within the Plitvice Lakes National Park
- It belongs to the Danube (Black Sea) catchment

Other catchments within the NP are the catchments of the…

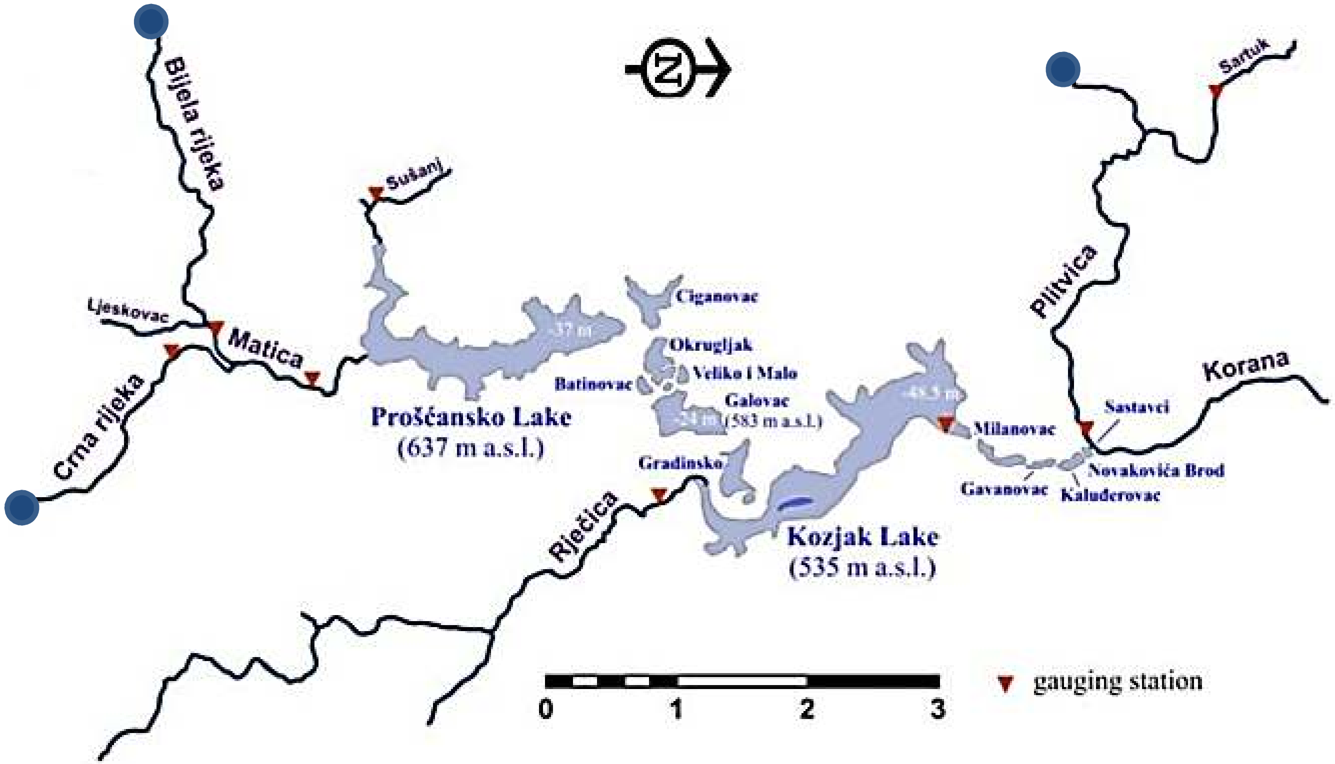


The most prominent (surface) water occurrences

- …at the first place ▶ a cascading lake system which was created by the biodynamic process of tufa barrier growth
  - There are currently about 16 lakes ▶ surfaces and forms are constantly changing over time – the largest are Kozjak and Prošćansko Lake

…besides the well-known lake system ▶ also numerous permanent karst springs

- the most important ▶ **Crna River, Bijela River** and **Plitvica**



METHODS AND RESULTS

- Delineation of the subcatchment areas was carried out using three basic sets of data:

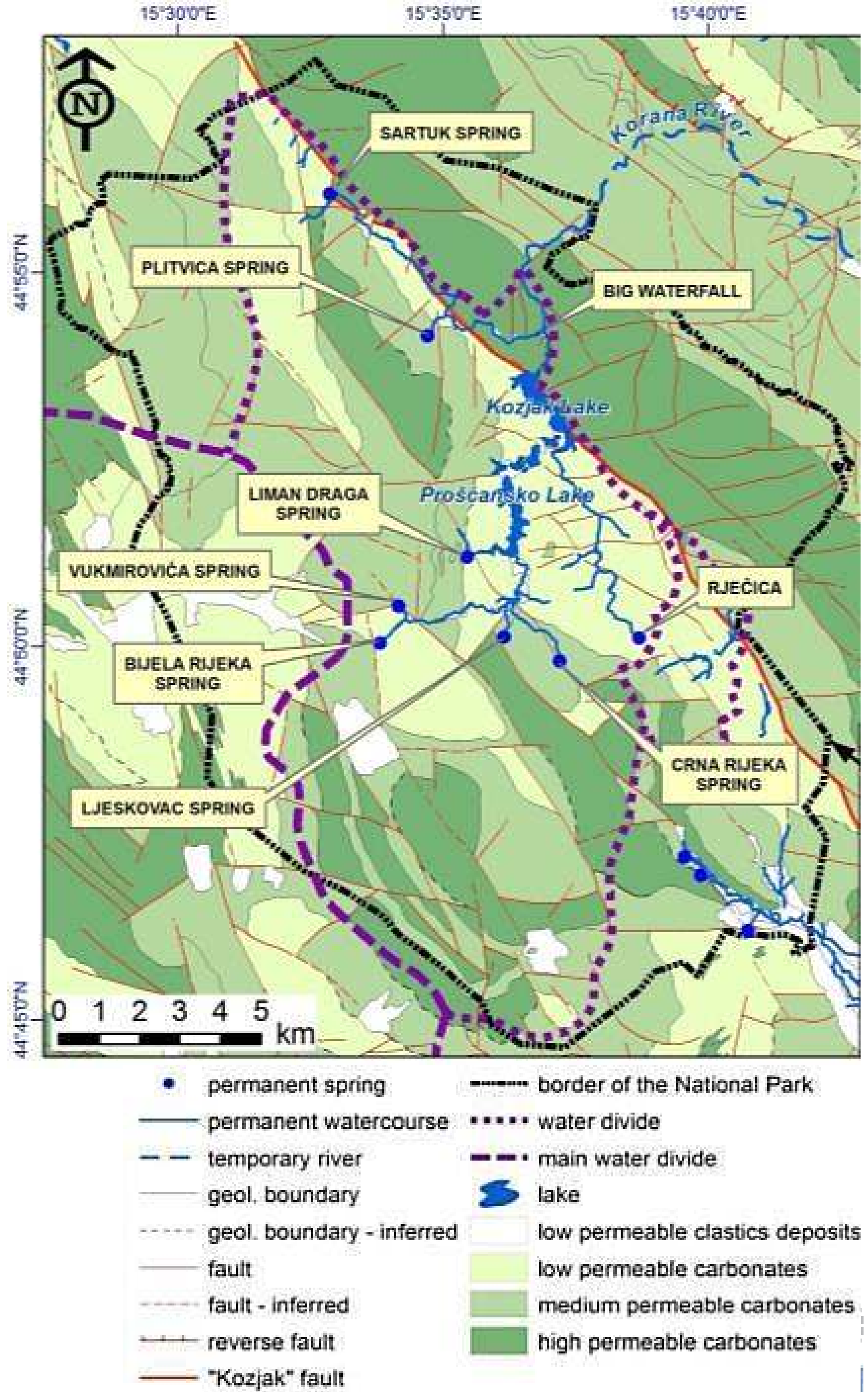
- **Hydrogeological data**
  - represents the basic data that is needed to define the conceptual position of the catchments and subcatchments
- **Hydrological and meteorological analyses**
  - were used to quantify the presumed hydrogeological catchments
  - were then confirmed by the iteration principle
- **Hydrochemical data**
  - discrete data influenced by the catchment area
  - was used for verification of obtained results

Hydrogeological research

- In the Dinaric karst area the dynamics of groundwater are related to the process of karstification of carbonate rocks of Mesozoic age
- Geotectonic and geodynamic evolution of the Dinarides has had a great impact on those processes

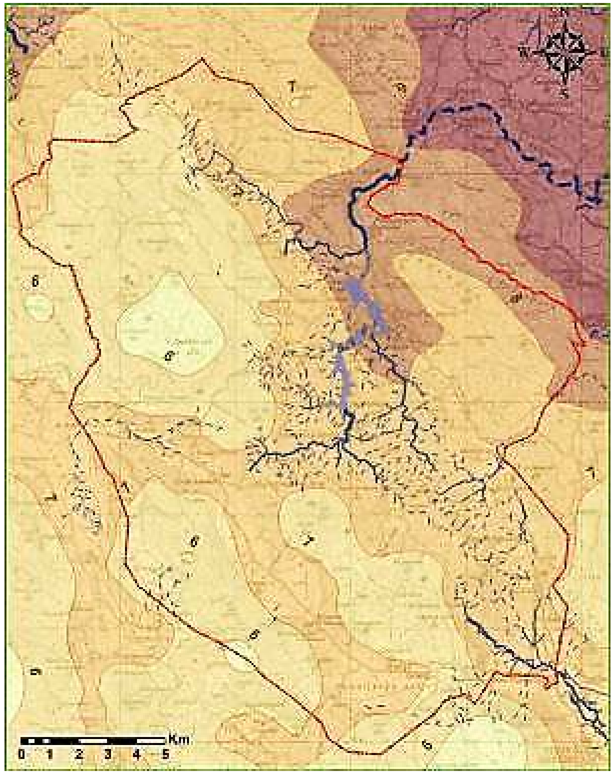
Into consideration were taken

- hydrogeological characteristics and water permeability assessments,
- position of sources and sinks
- karst geomorphological features
- results of tracing tests from the wider area, etc.

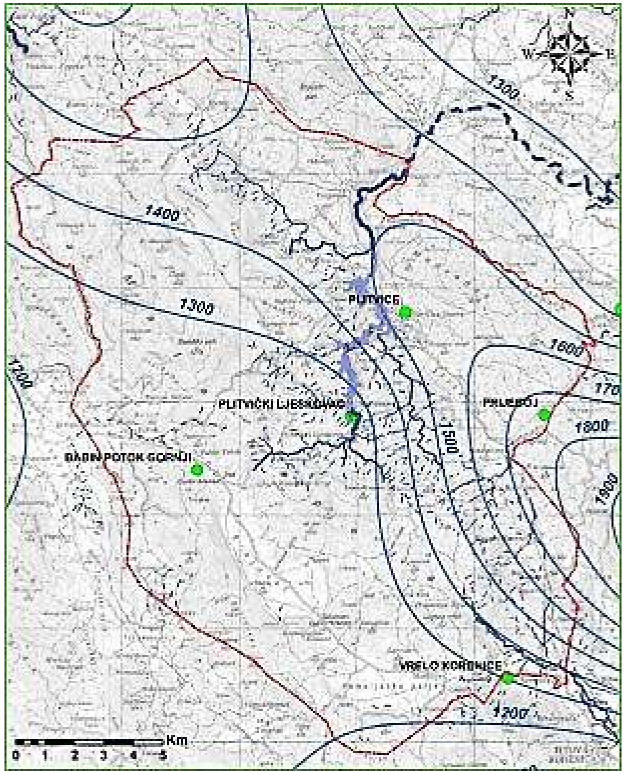


Water balance determination

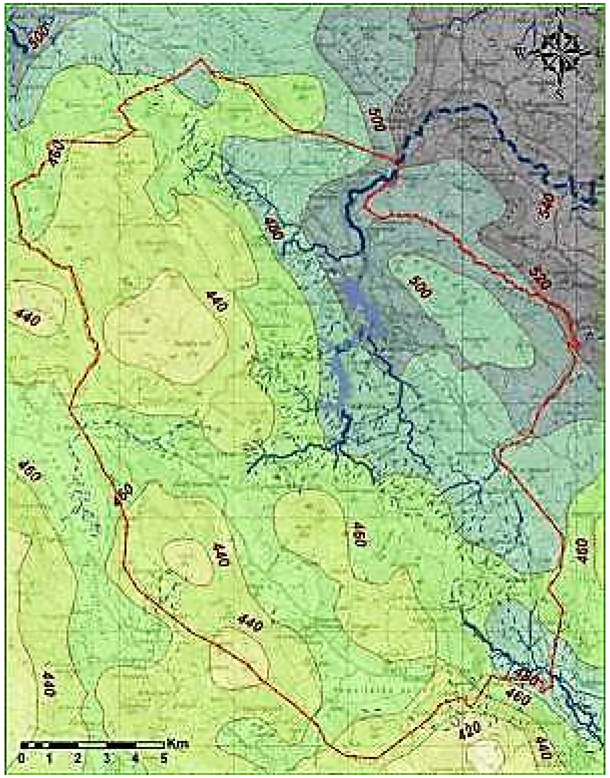
- The basic elements required to calculate the water balance, after assuming the hydrogeological catchment area - spatial and temporal distribution of rainfall, runoff and evapotranspiration amount



…temperature



…precipitation



…evapotranspiration

Flow rates analysis

Matica (no.3)

73% Crna River (no.1)

24% Bijela River (no.2)

unknown 3%

Kozjak Bridge (no.6)

68% Matica

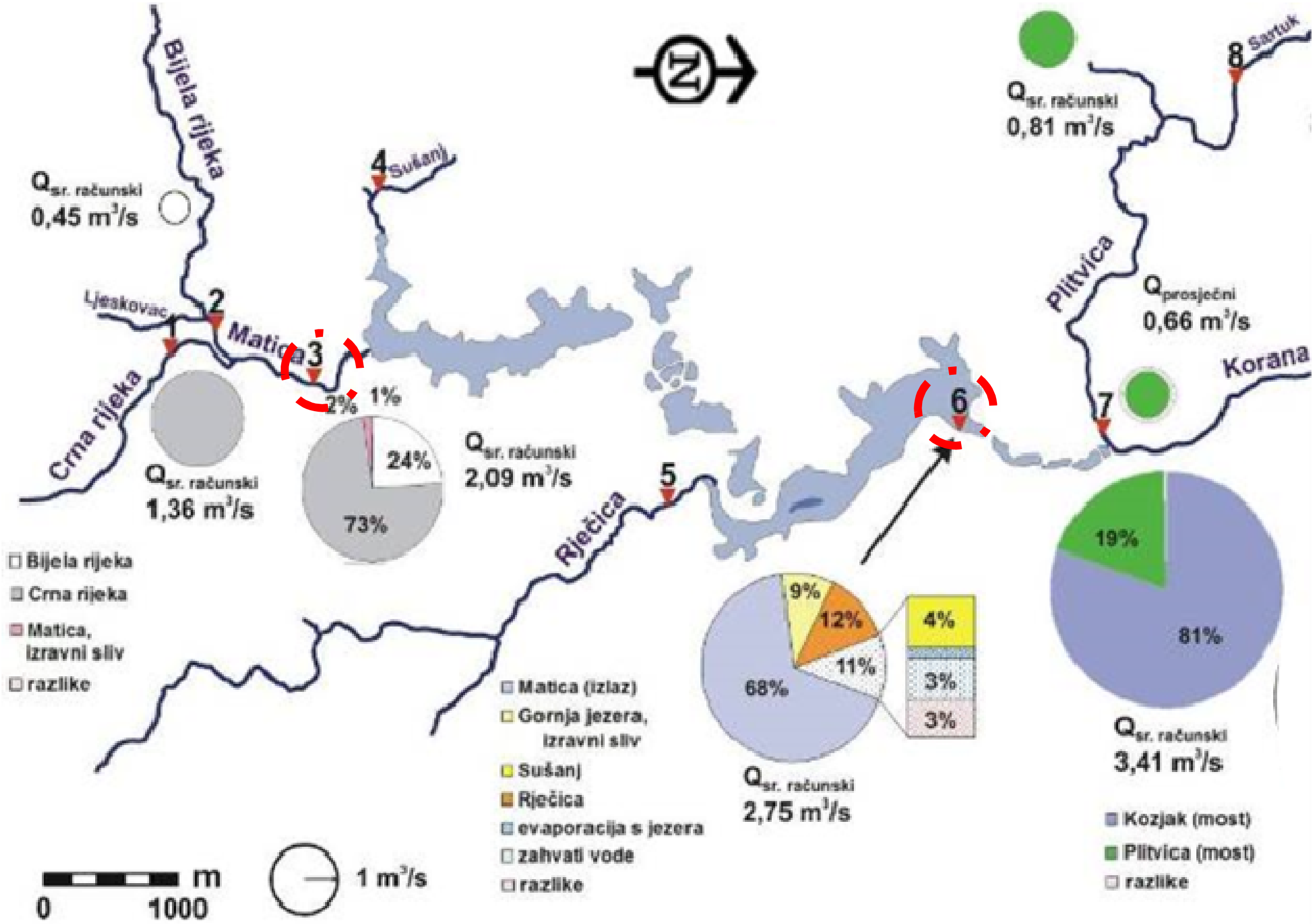
12% Rječica (no.5)

9% lakes catchment

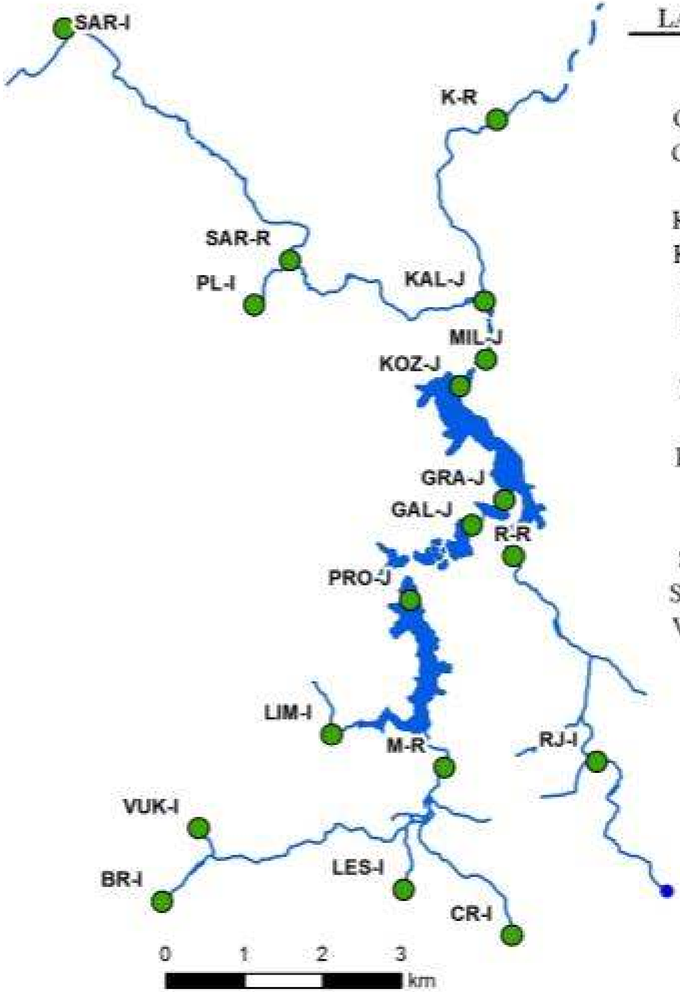
4% Sušanj (no.4)

3.5% water capture

3.5% missing



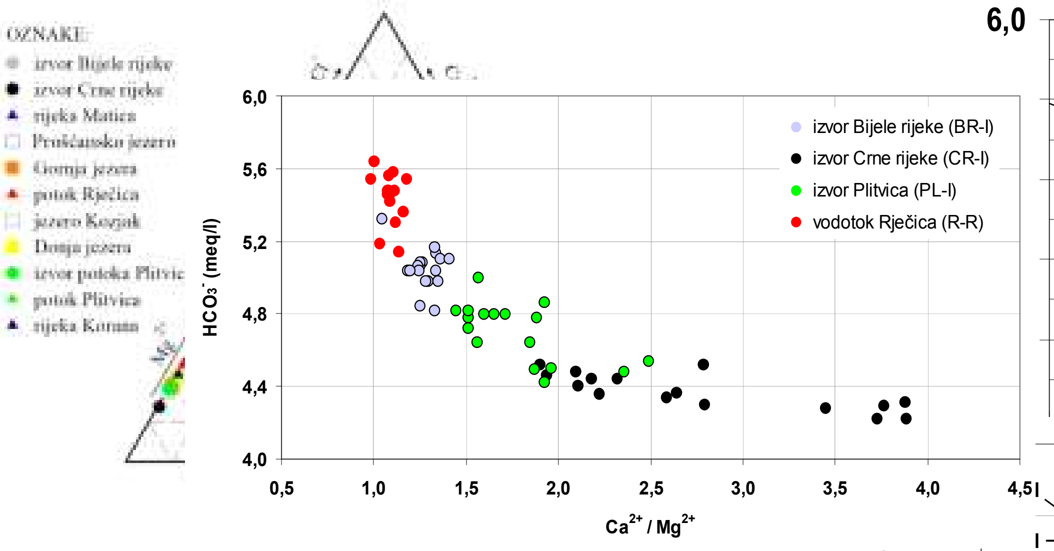
Hydrochemical analyses

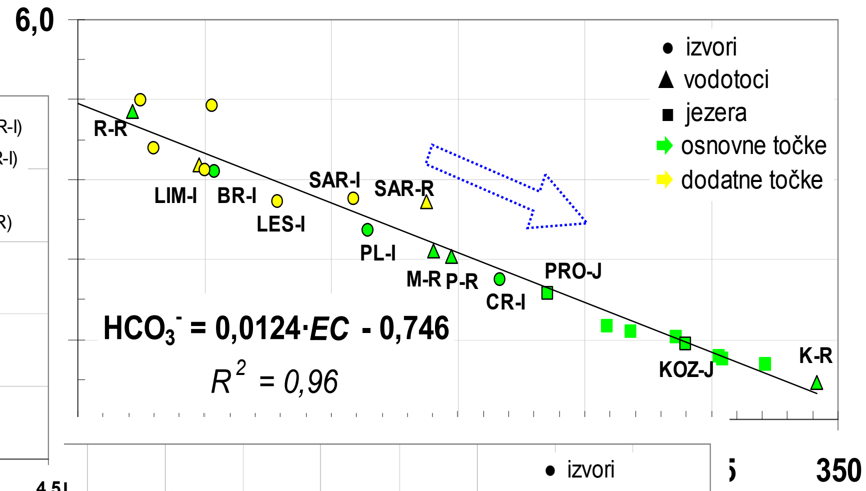


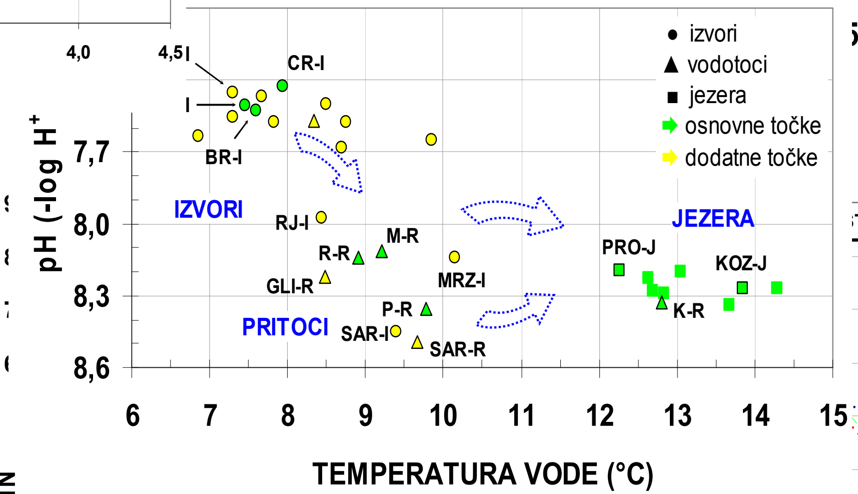
LABEL	DESCRIPTION
BR-I	Bijela Rijeka Spring
CR-I	Crna Rijeka spring
GAL-J	Lake Galovac
GRA-J	Lake Gradinsko
K-R	Korane River
KAL-J	Lake Kaluđerovac
KOZ-J	point on Lake Kozjak
LES-I	Ljeskovac Spring
LIM-I	Liman Draga Spring
M-R	Matice River
MIL-J	Lake Milanovac
PL-I	Plitvica Spring
PRO-J	point on Lake Prošćanko
R-R	Rječica River
RJ-I	Rječica River
SAR-I	Sartuk Spring
SAR-R	Sartuk River
VUK-I	Vukmirovića Spring

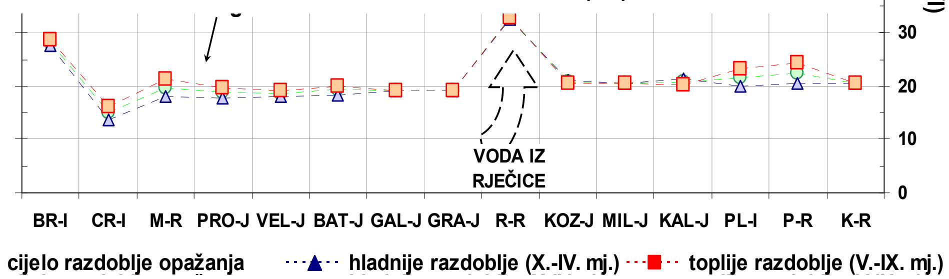
- Characterization of hydrochemical development
- Determination of chemical changes
- Spotting of potential anthropogenic impacts
- Helping with the delineation of PLC

- Measurements of physical and chemical parameters, water sampling and laboratory analysis – during two hydrological years



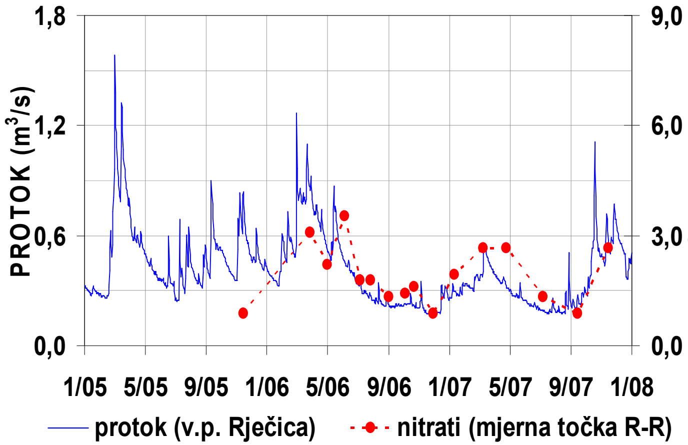






It is $Ca\text{-}HCO_3$ - $CaMg\text{-}HCO_3$ water

...and followed by a brief overview



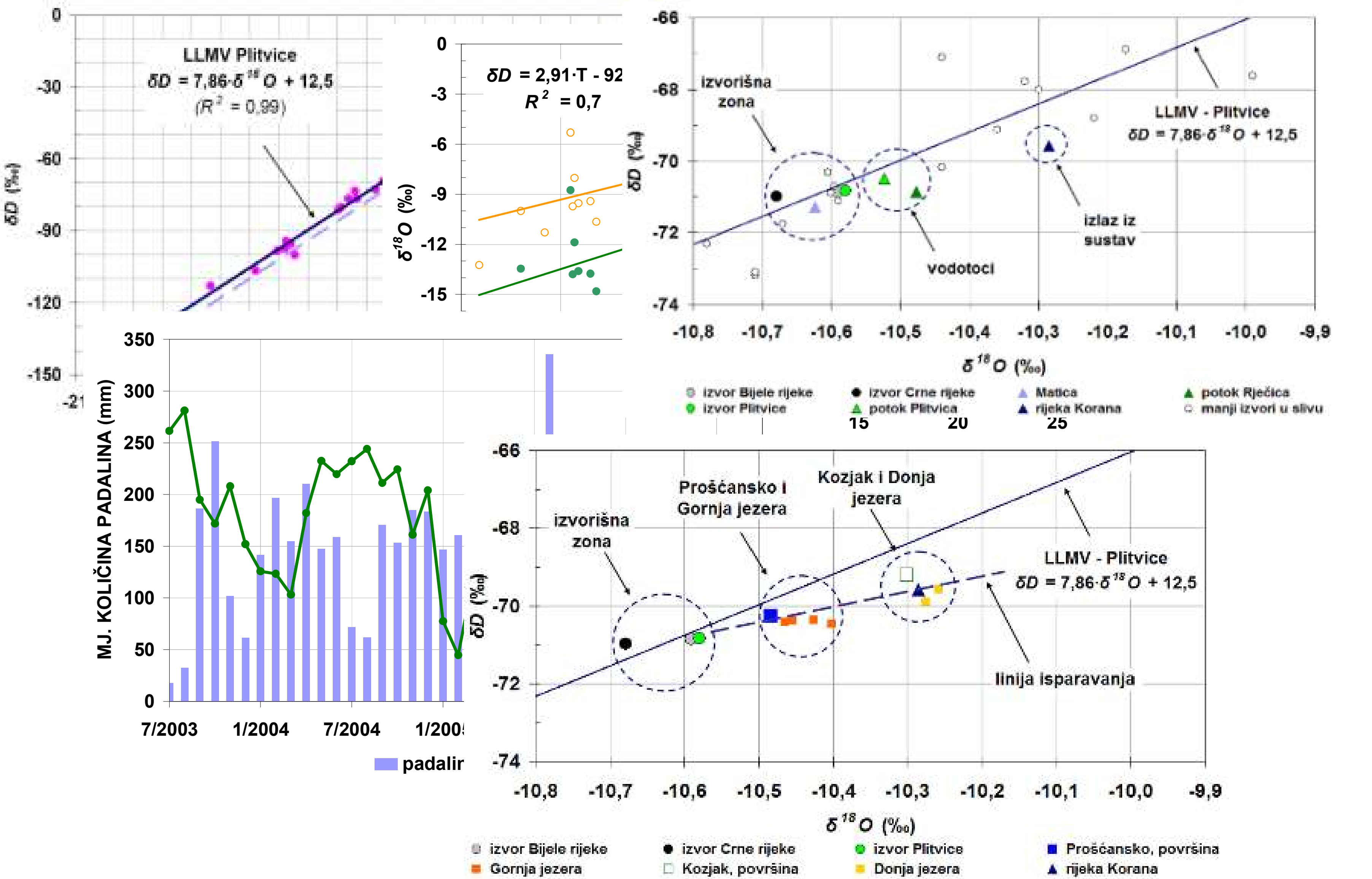
H. Meaški et al. (2014) DELINEATION OF A KARST CATCHMENT AREA USING SEVERAL METHODS – AN EXAMPLE OF PLITVICE LAKES CATCHMENT

Analysis of stable isotopes of water

- Determination of the local meteoric water line
- Correlations of the $\delta^{18}O$ and δD content in precipitation
- Determination of the $\delta^{18}O$ and δD content in surface waters
- Identification of the mean recharge altitude of springs
- Determination of the mean residence time of groundwater

…again followed by a brief overview

Analysis of stable isotopes of water



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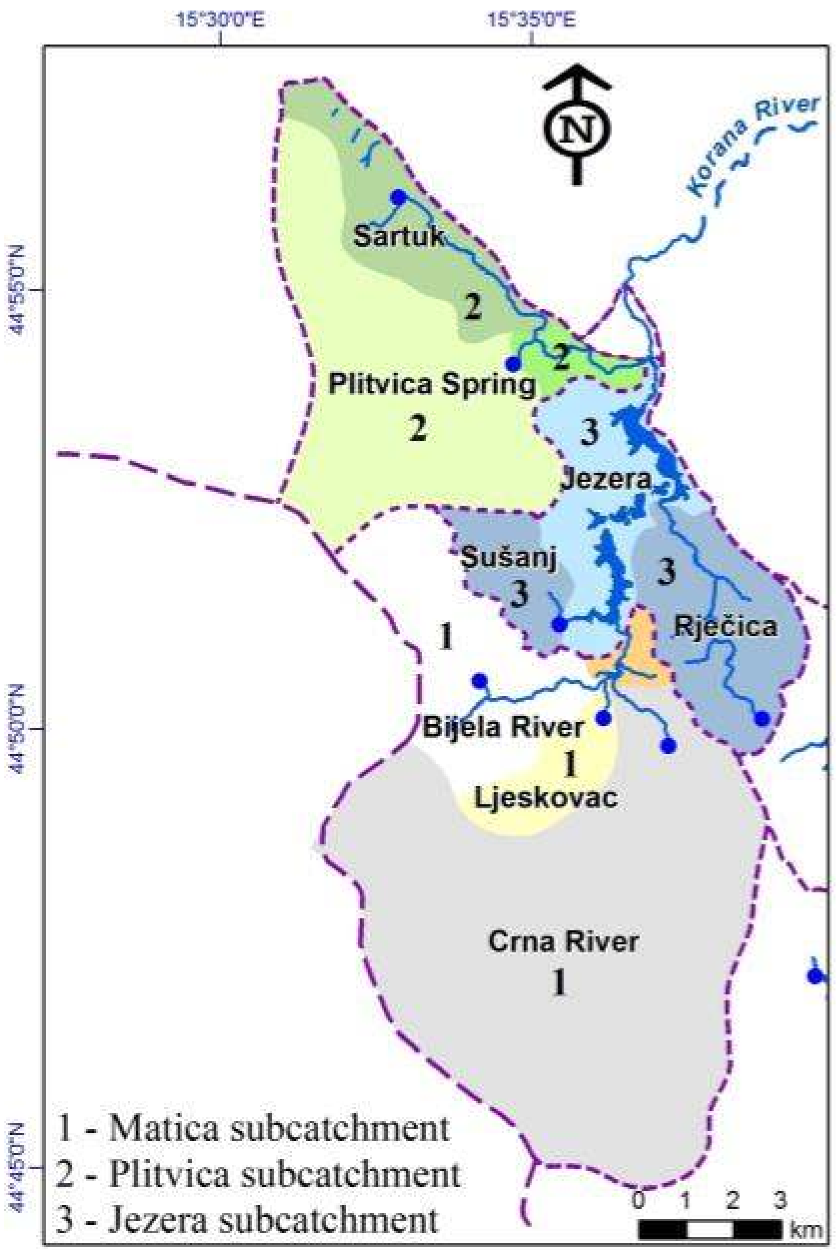


CONCLUSIONS

- The PLC is a unique hydrogeological catchment…
  - all waters are directed toward the lakes system, or the source area of the Korana River

However …

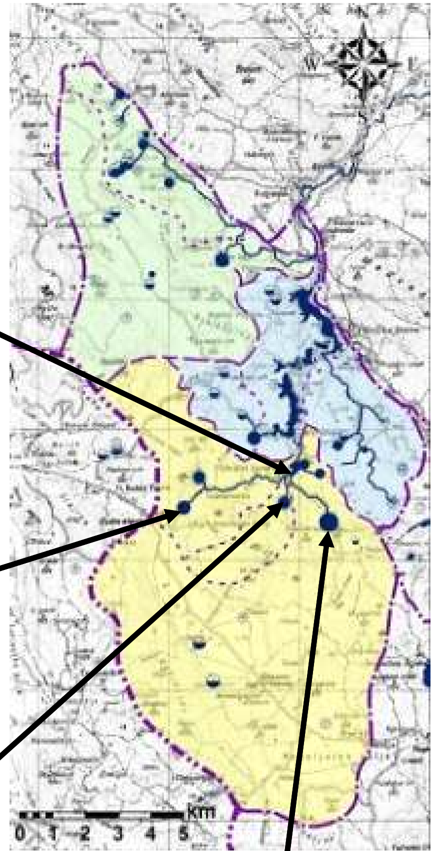
Due to its specific hydrogeological conditions it can be divided into three main subcatchments:

- **Matica**, **Plitvica** and **Jezera** (Lakes)

Matica subcatchment

- Includes all springs and streams that gravitate to the Matica River
- Covering about 55% of the PLC area
- Quantitatively about 2/3 of the total amount of water that flows into the lake system
- Could be divided into the hydrogeological part of Crna River and Bijela River

Matica River Qav. 2,09 m³/s

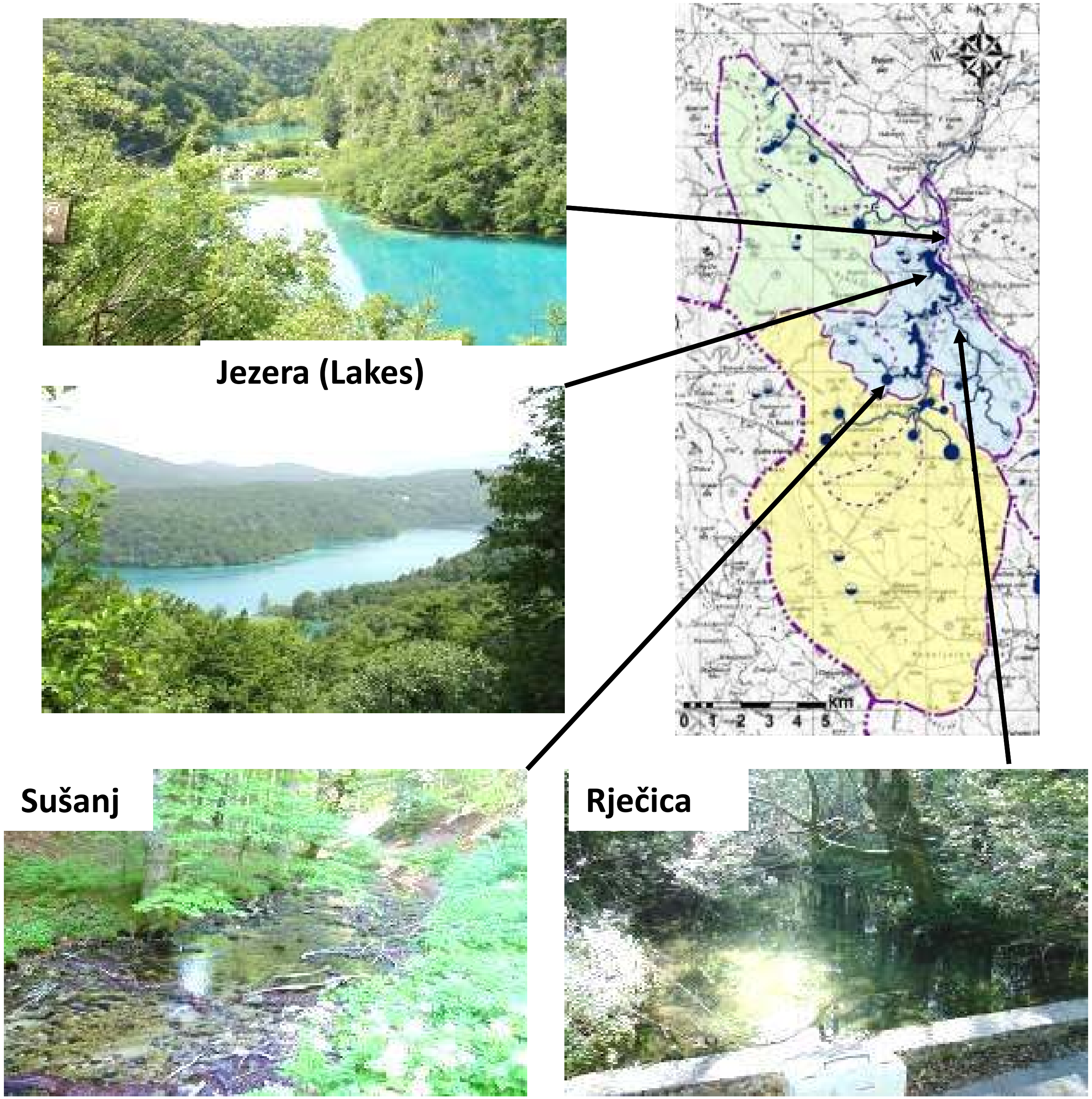


Bijela River & Ljeskovac Qav. 0,448 m³/s

Crna River Qav. 1,36 m³/s

Jezera subcatchment

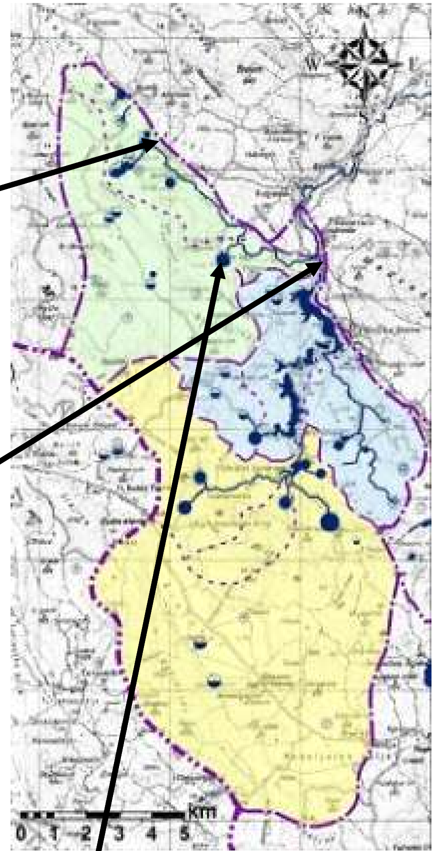
- Includes all direct inflows into the lake system
- Covering about 19% of the PLC area
- Quantitatively about 1/3 of the total amount of water that flows into the lake system
- Could be divided into the hydrogeological part of Jezera (Lakes), Sušanj, and Rječica



Plitvica subcatchment

- Includes all waters that gravitate to the Plitvica River
- Covering about 26% of the PLC area
- Flows directly across the Great Waterfall into the area called Sastavci (starting point of the Korana River)
- Could be divided into the hydrogeological part of Plitvica Spring, Sartuk and Plitvica River

Sartuk Stream Qav. 0,094 m^3/s



Plitvica River Qav. 0,655 m^3/s

Plitvica Spring Qav. ? m^3/s

- This delineation is not quite simple or unambiguous
    - reason for delineation - more effective protection of water resources
    - it is no longer advisable, nor sustainable to restrict majority of protection only to the narrow area around the lakes system but to the whole catchment system

Main data collection was carried out in the Plitvice Lakes in the period from 2005 to 2008

within the scientific project „Sustainable use and protection of water resources in the Plitvice Lakes National Park" (approved and financed by the Ministry of Science, Education and Sport of Republic of Croatia)

and

in the framework of the international project „Sustainable utilization of water in the pilot area Plitvice Lakes" through the cooperation of the Joanneum Research Institute from Graz, Austria, and Geotechnical Engineering, University of Zagreb, Croatia (co-financed by the Government of Republic of Austria and Plitvice Lakes National Park).

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Thank you for your attention!