Institute of Water Resources Management
Hydrogeology and Geophysics

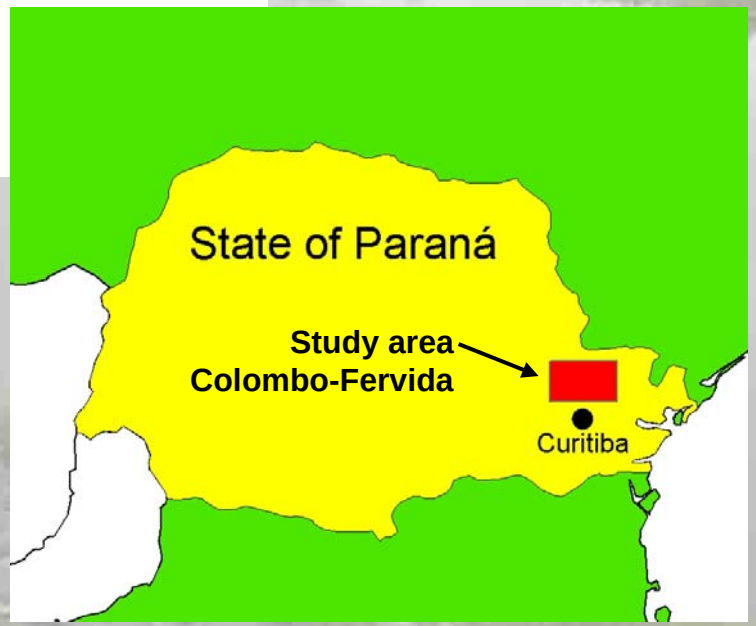
Application of remote sensing techniques for a water management concept of the compartment karst aquifer of Colombo-Fervida (Paraná, Brazil)

Autors: P. SACCON, T. HARUM, A.A. LISBOA†; J.L. VAINE & A. RIBAS

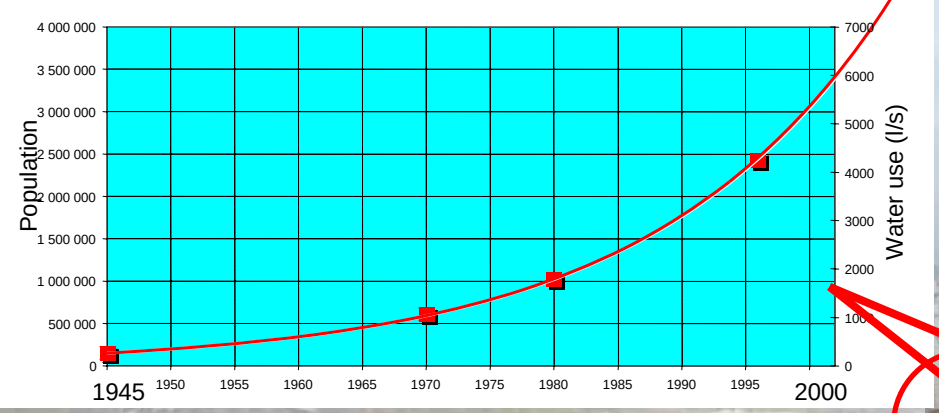
Dr. Pierpaolo Saccon
pierpaolo.saccon@joanneum.at

Institute of Water Resources Management
Hydrogeology and Geophysics

Study area



WHY the Project??



- Population growth
- Increasing water demand
- Overexploitation
- Missing groundwater protection
- Environmental damages
- Pollution risks

- Projeto Karst
- Water balance
  Groundwater recharge
- Concepts for
  - Water management
  - Karst water protection
  - Demographic and environmental planning
  - EIA/RIMA Environmental impact assessment

a TRADITION of INNOVATION

ISO 9001 certified

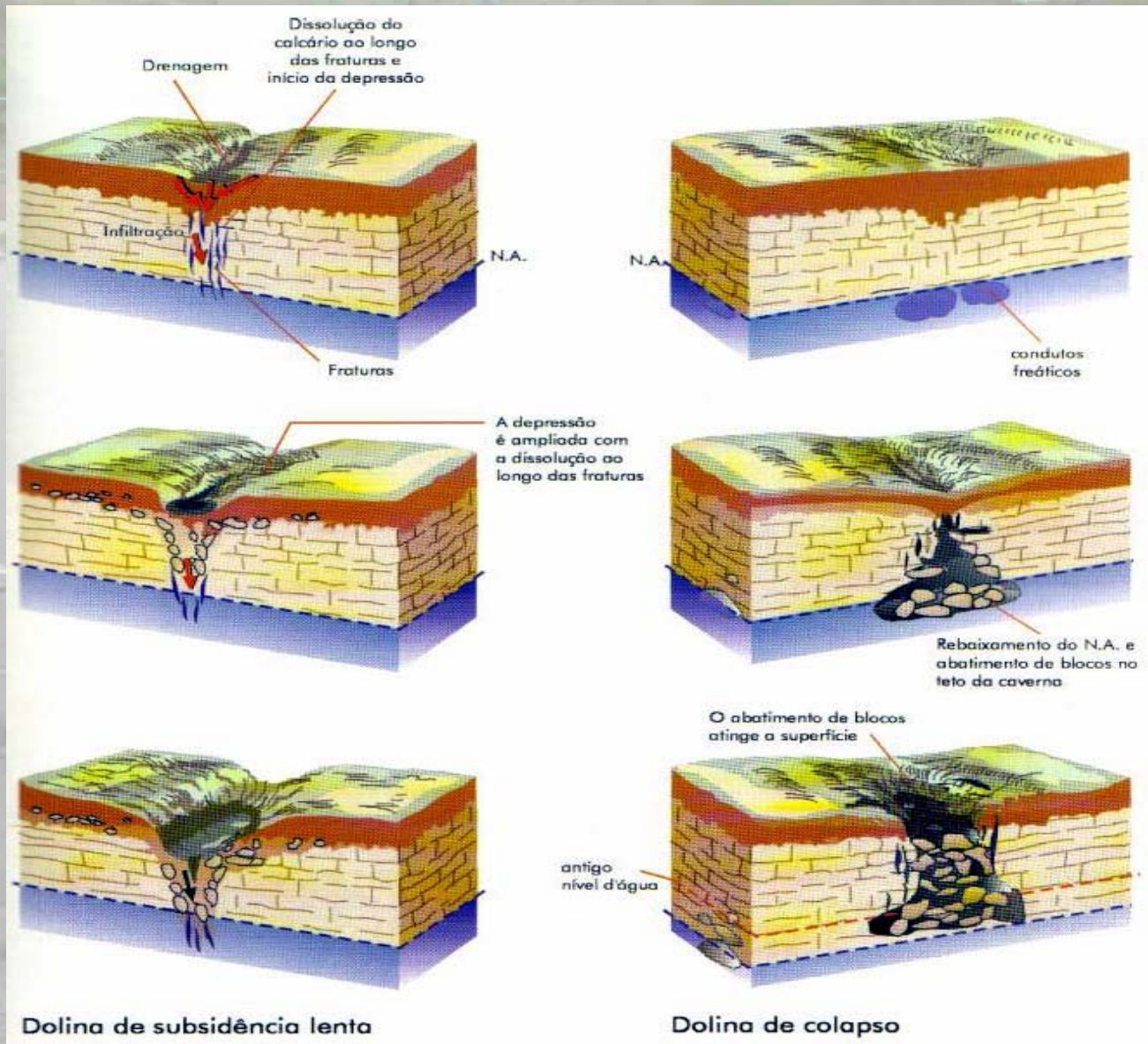
Objectives of Projeto Karst
(financed by SANEPAR and SUDERHSA, cooperation with UFPR)

- Available and usable Karst water resources
- Recharge and flow conditions in the karst aquifer
- Concept of karst water management and protection
- Suggestion of protection zones
- Avoiding future geotechnical problems
- Suggestion of areas for future water extraction
- Design of a monitoring network program

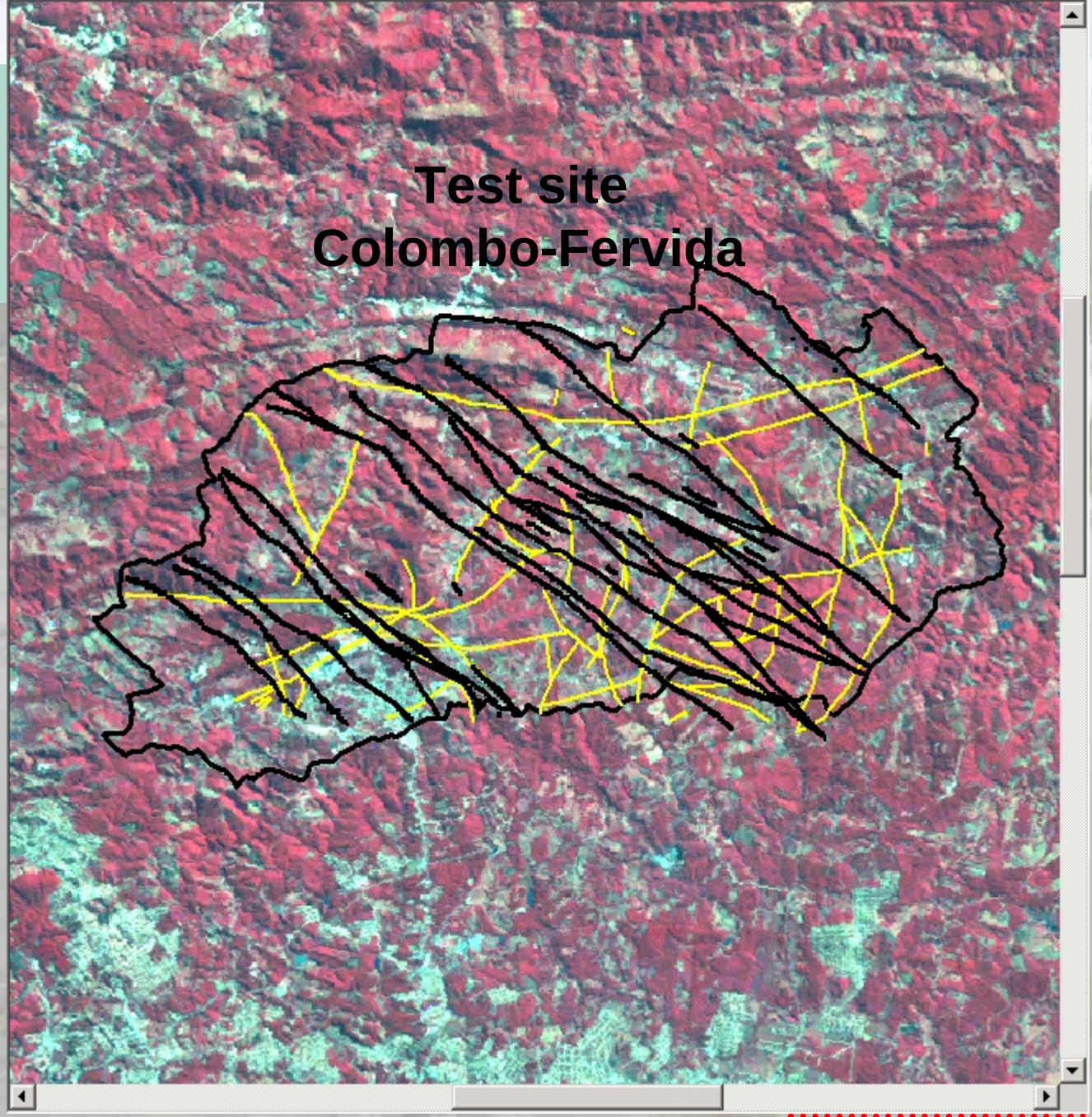
Interdisciplinary approach - applying methods from:

- Remote sensing
- Hydrology
- Hydrogeology
- Geology and tectonics
- Isotope hydrology
- GIS

Geotechnical problems

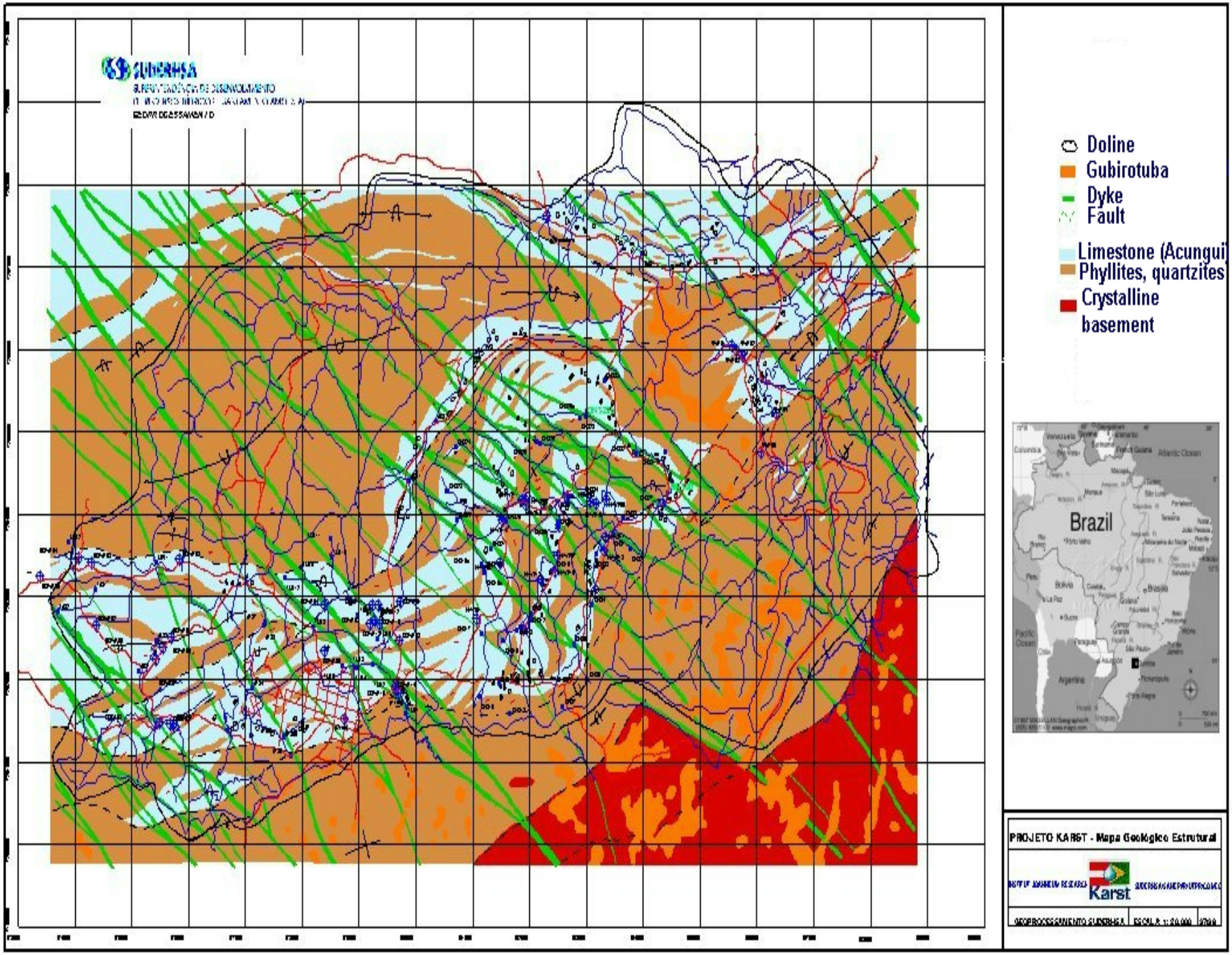


JOANNEUM RESEARCH



a TRADITION of INNOVATION

ISO 9001 certified


SUDERHSA
Doline
Gubirotuba
Dyke
Fault
Limestone (Acungui)
Phyllites, quartzites
Crystalline basement
Brazil
PROJETO KARST - Mapa Geológico Estrutural
Karst

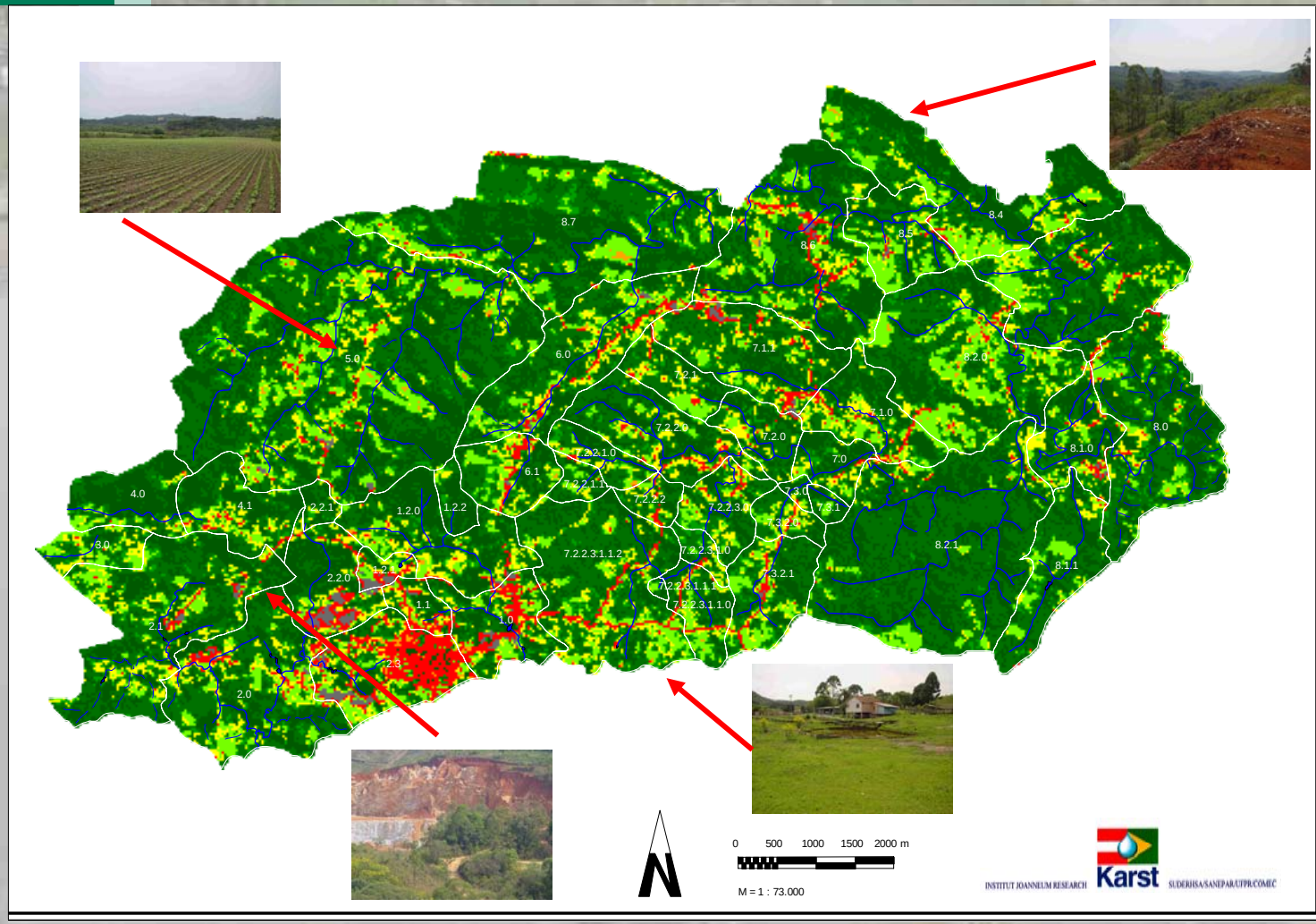
Hydrogeological boundary conditions can be deduced:

- The NW-SE volcanic dikes represent a clear hydrogeological boundary.
- Faults system dislocate dikes and the geological formation
- Therefore the karst aquifer can be divided into separated compartments.
- Springs are usually located at the contact of dolomites with dikes or with phyllites.

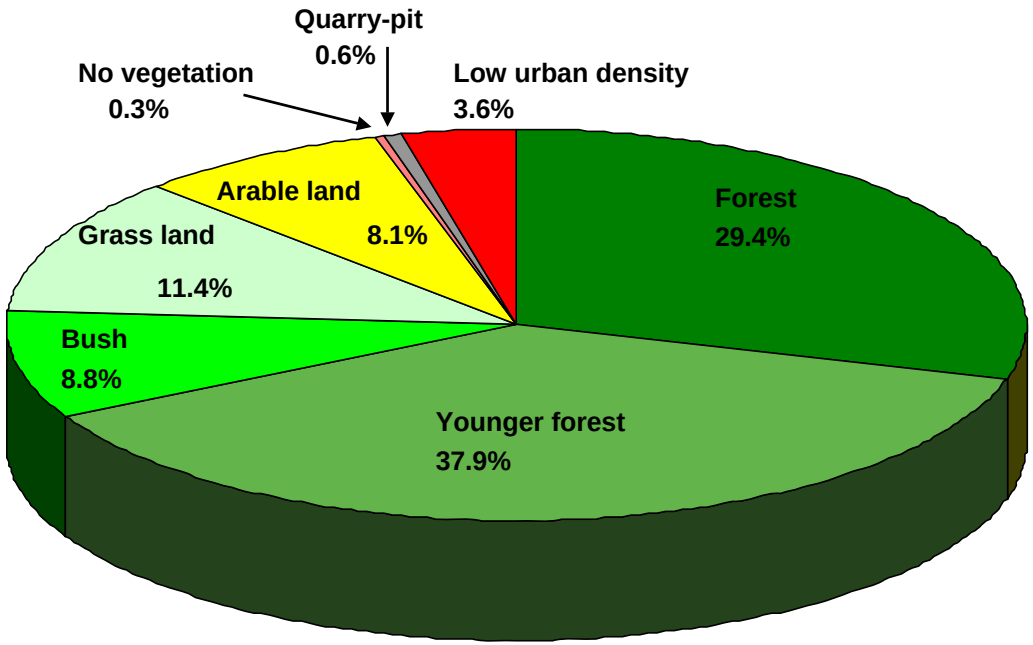
JOANNEUM RESEARCH

Institute of Water Resources Management
Hydrogeology and Geophysics

Land use from Landsat 5 TM

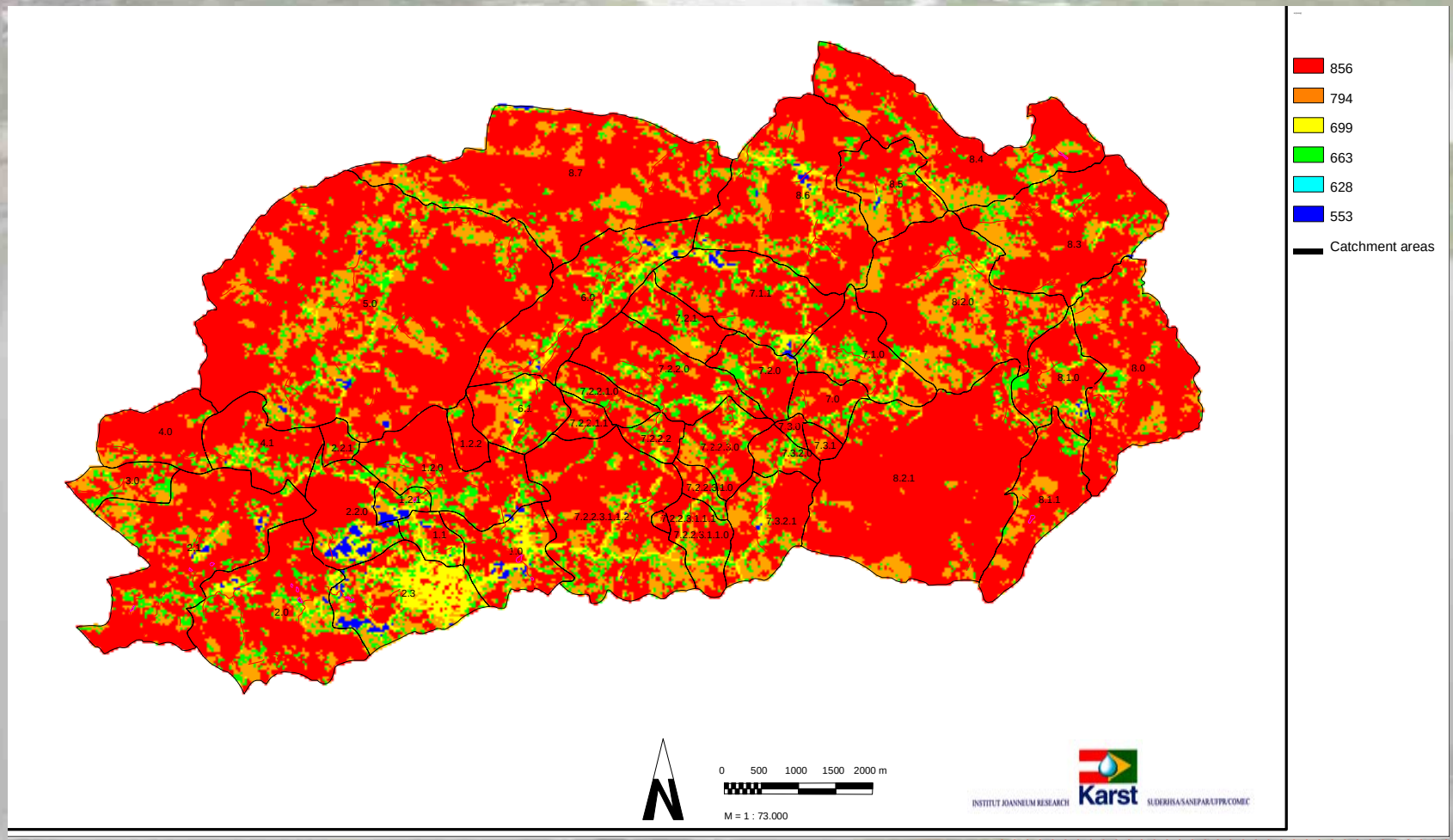


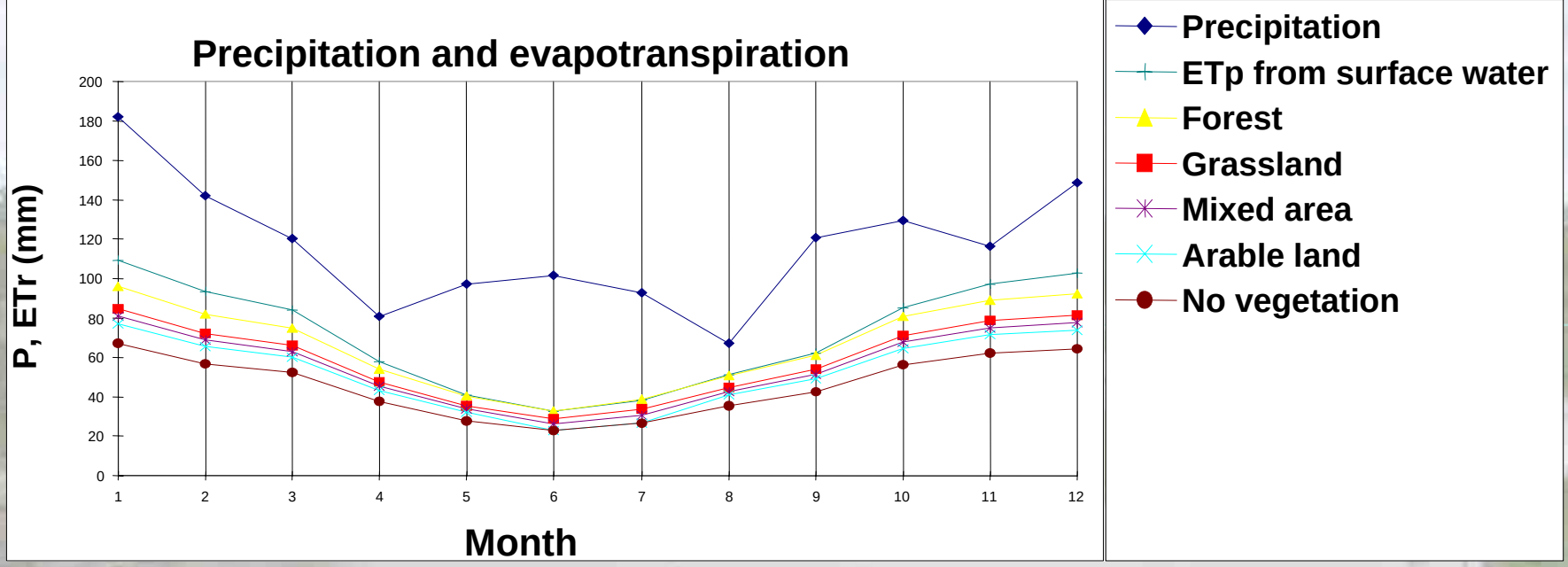
Land use from Landsat 5 TM



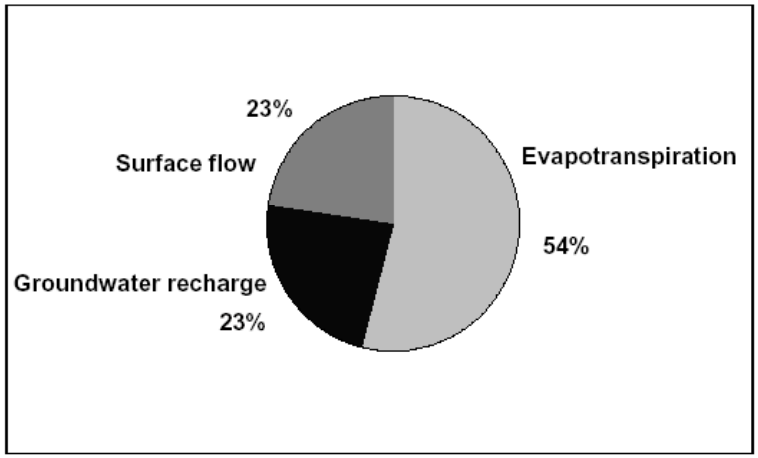
JOANNEUM RESEARCH
Institute of Water Resources Management
Hydrogeology and Geophysics

Mean annual actual evapotranspiration (mm/y)





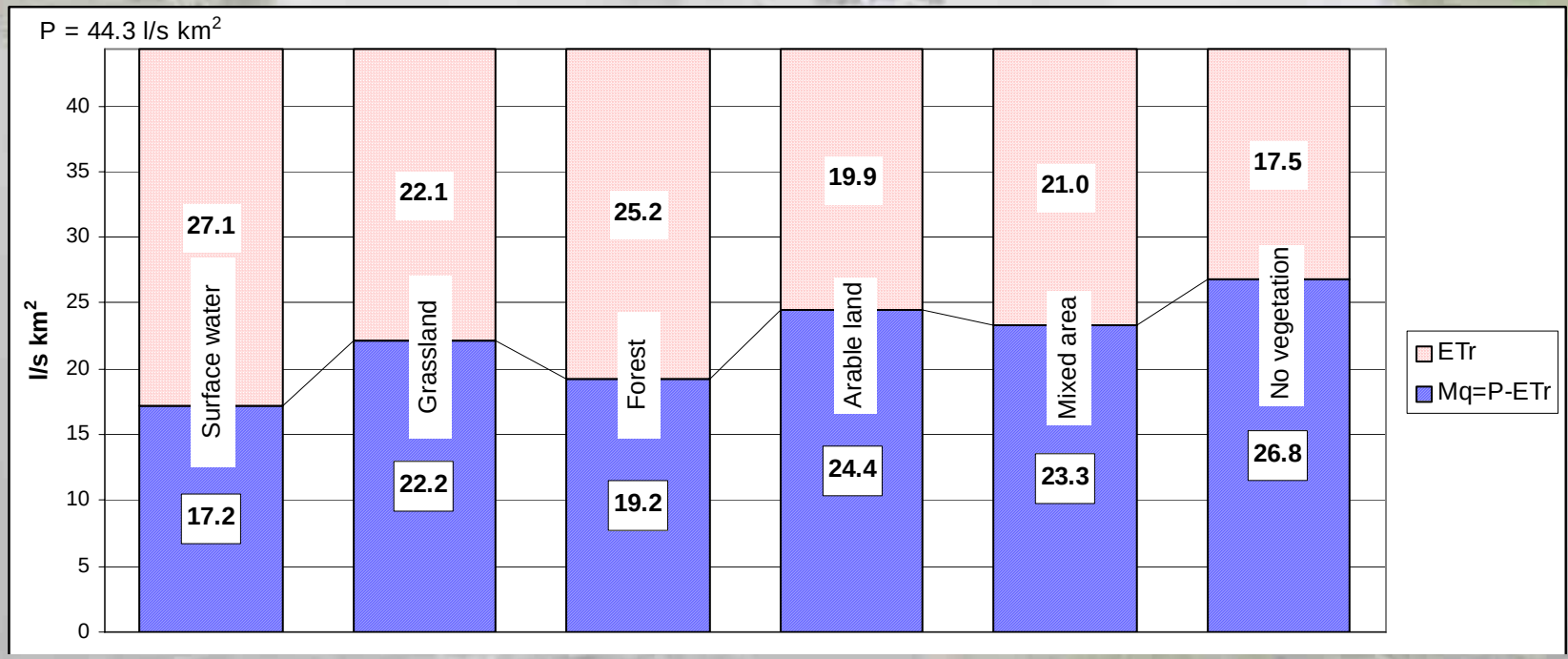
Mean monthly precipitation P and actual evapotranspiration Et_r for different land use classes in the area of Colombo-Fervida



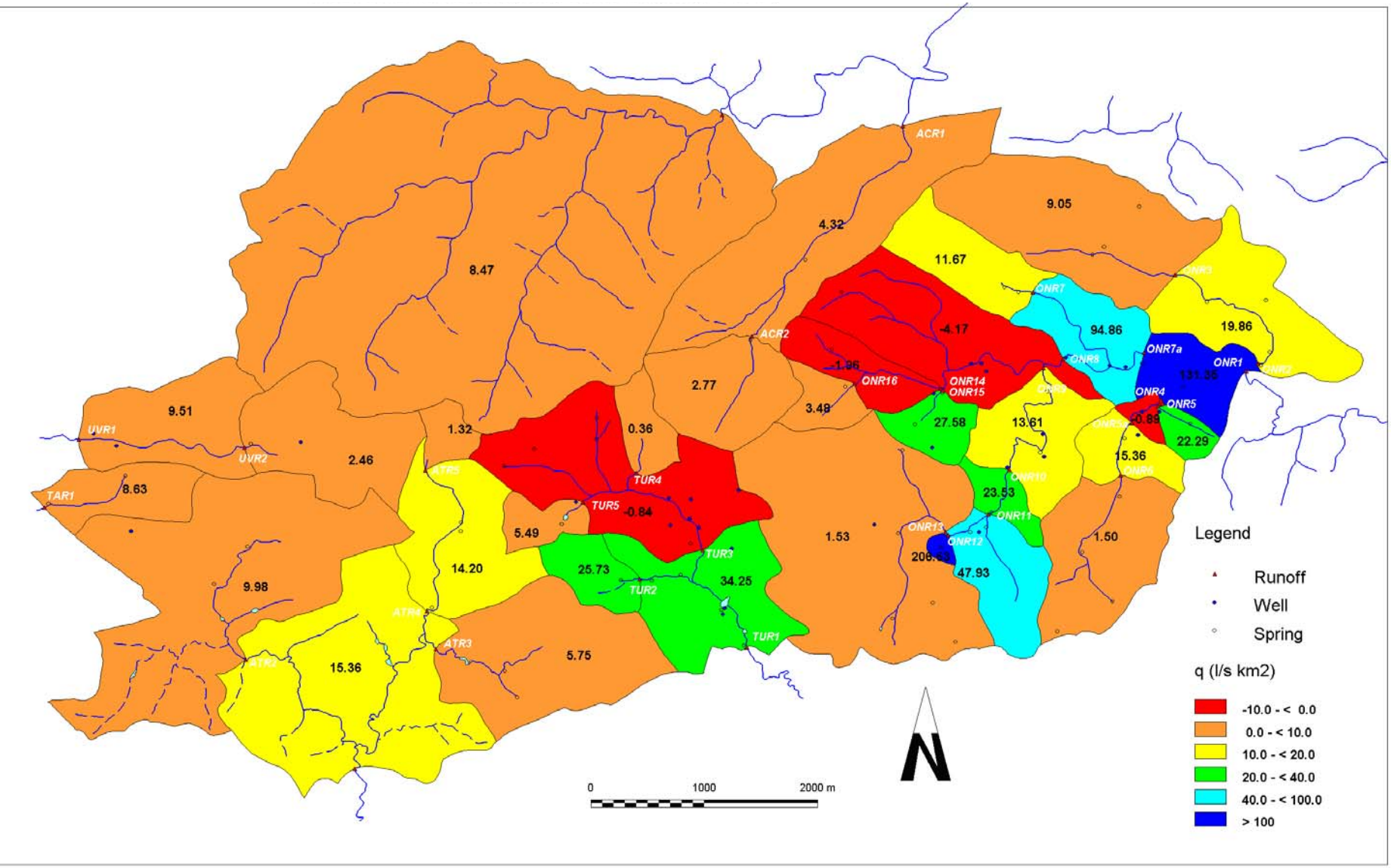
	mm	l/s km^2	l/s
P	1399	44.3	3721
ET_r	754	23.9	2006
Groundwater recharge	325	10.3	864
Surface flow	320	10.1	851

Water balance of the whole area of investigation

Mean annual precipitation P (in l/s km²) and theoretical mean total runoff yield (Mq=P-Et$_r$) for different land use classes and in the area of Colombo-Fervida



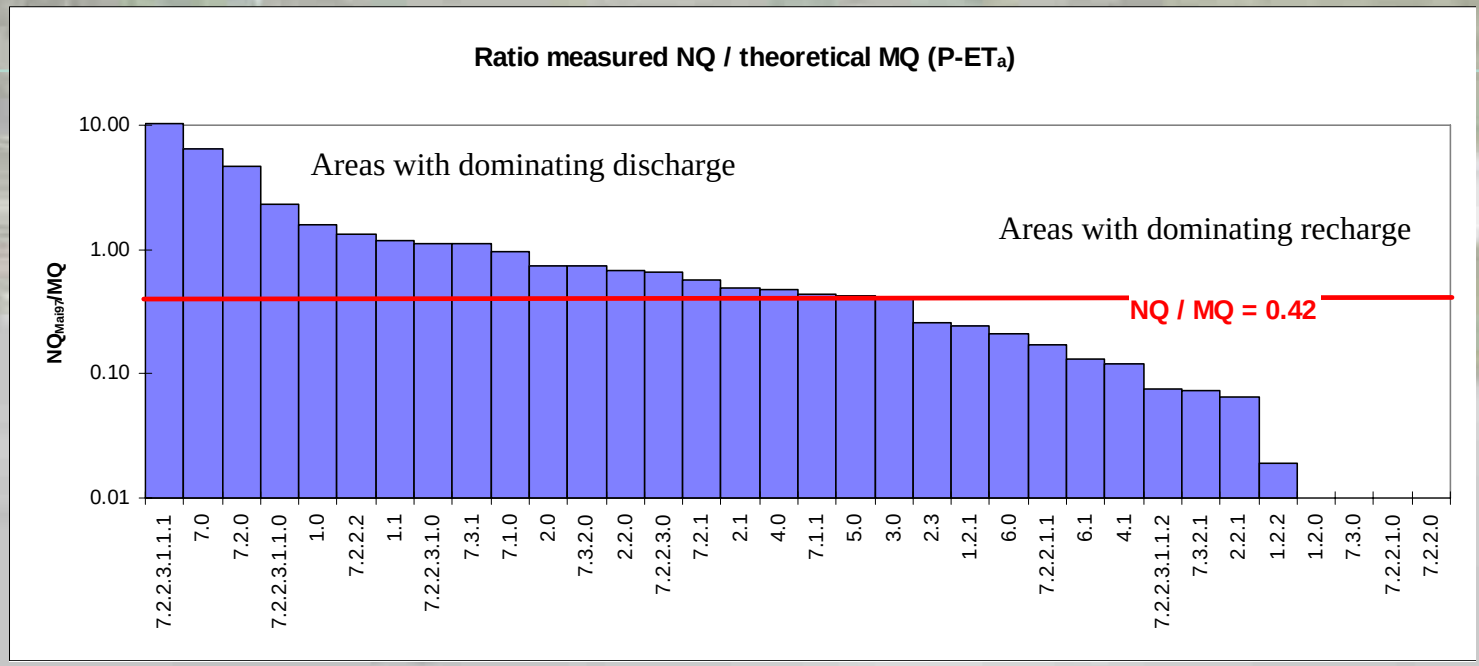
Specific yield in l/s km² of the sub-basins
The surplus in the SE part indicates the general flow direction NW-SE.



JOANNEUM RESEARCH

Institute of Water Resources Management
Hydrogeology and Geophysics

Ratio measured NQ / theoretical MQ (P-Et_r) of the sub-basins during dry season



- The recharge areas in the NW part and discharge areas in the SE part.
- Therefore the main direction of karst water flow is from NW to SE along the dikes
- The dikes that seem to be mainly a hydrogeological barrier.
- Connections under the phyllites are indicated due to the high surplus in S and SE

Residence time of karst water

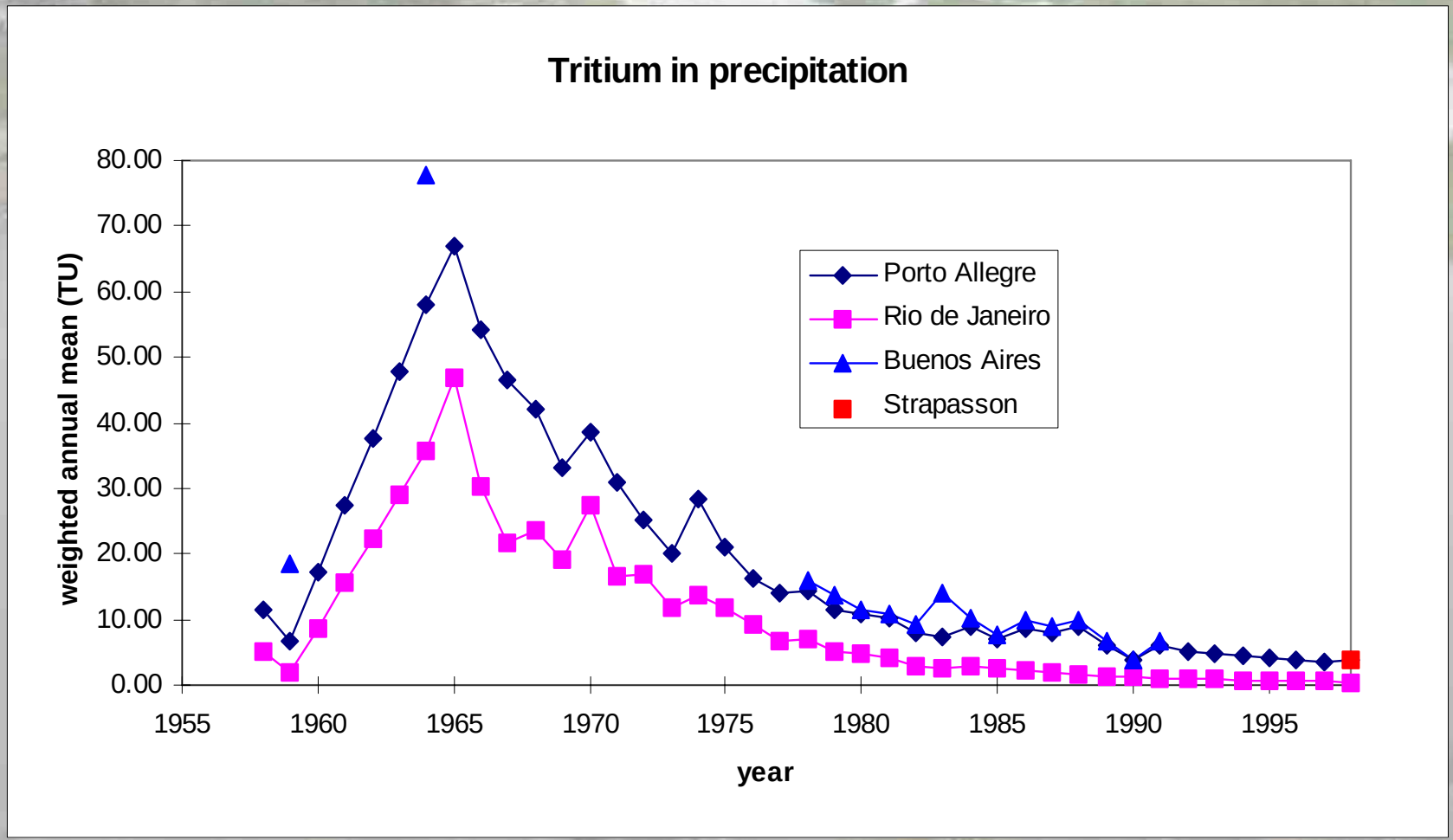
The knowledge of the residence time of karst water is an important factor for the protection of the aquifer.

It has been determined combining the monitoring of stable isotope ^{18}O and the radioactive isotope Tritium ^{3}H.

When the mean residence time is longer than approx. 5 years the stable isotope shows no seasonal variations which was the case for most of the springs in the investigation area

JOANNEUM RESEARCH
Institute of Water Resources Management
Hydrogeology and Geophysics

Tritium contents, estimated input functions in precipitation at the stations of Porto Allegre, Rio de Janeiro and Buenos Aires and actual contents at Strapasson.

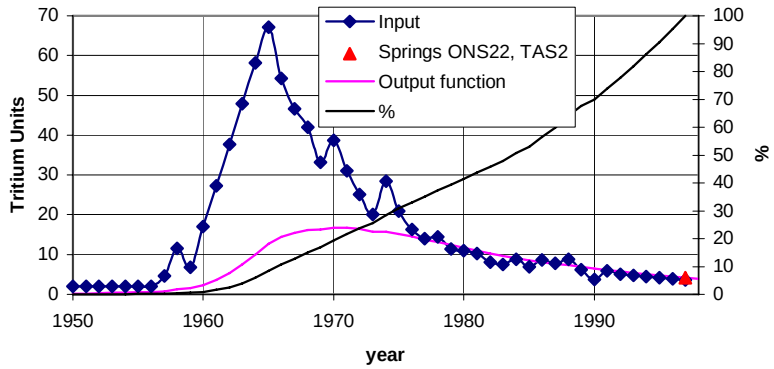


JOANNEUM RESEARCH

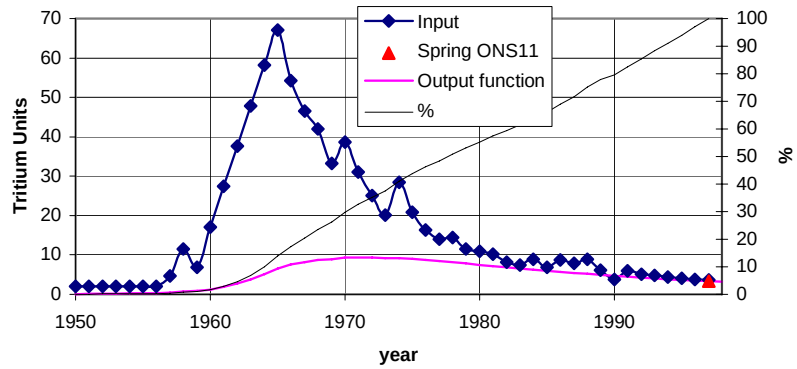
Institute of Water Resources Management
Hydrogeology and Geophysics

Input in precipitation (station Porto Allegre), simulated output function (exponential model after YURTSEVER) and measured tritium content at selected springs calculated mean transit times and portions (%) of components with different age.

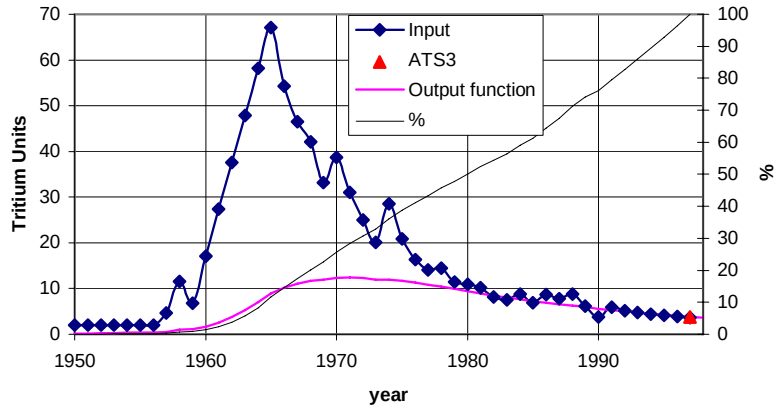
Mean transit time: 18 y



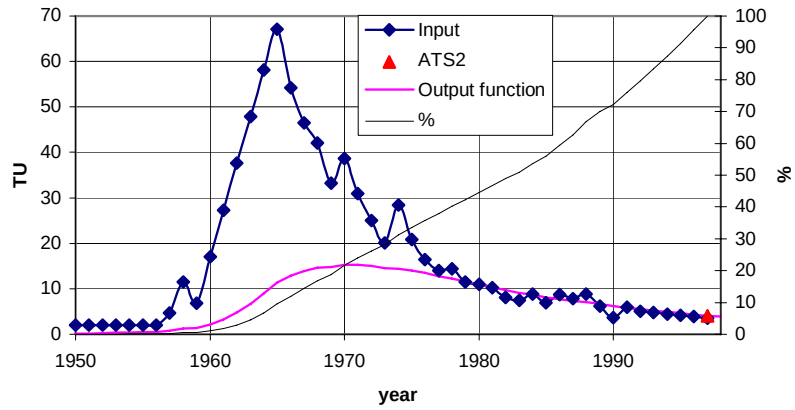
Mean transit time: 36 y



Mean transit time: 26 y



Mean transit time: 20 y



Concept of water management

Hydraulic parameters and capacity of the wells

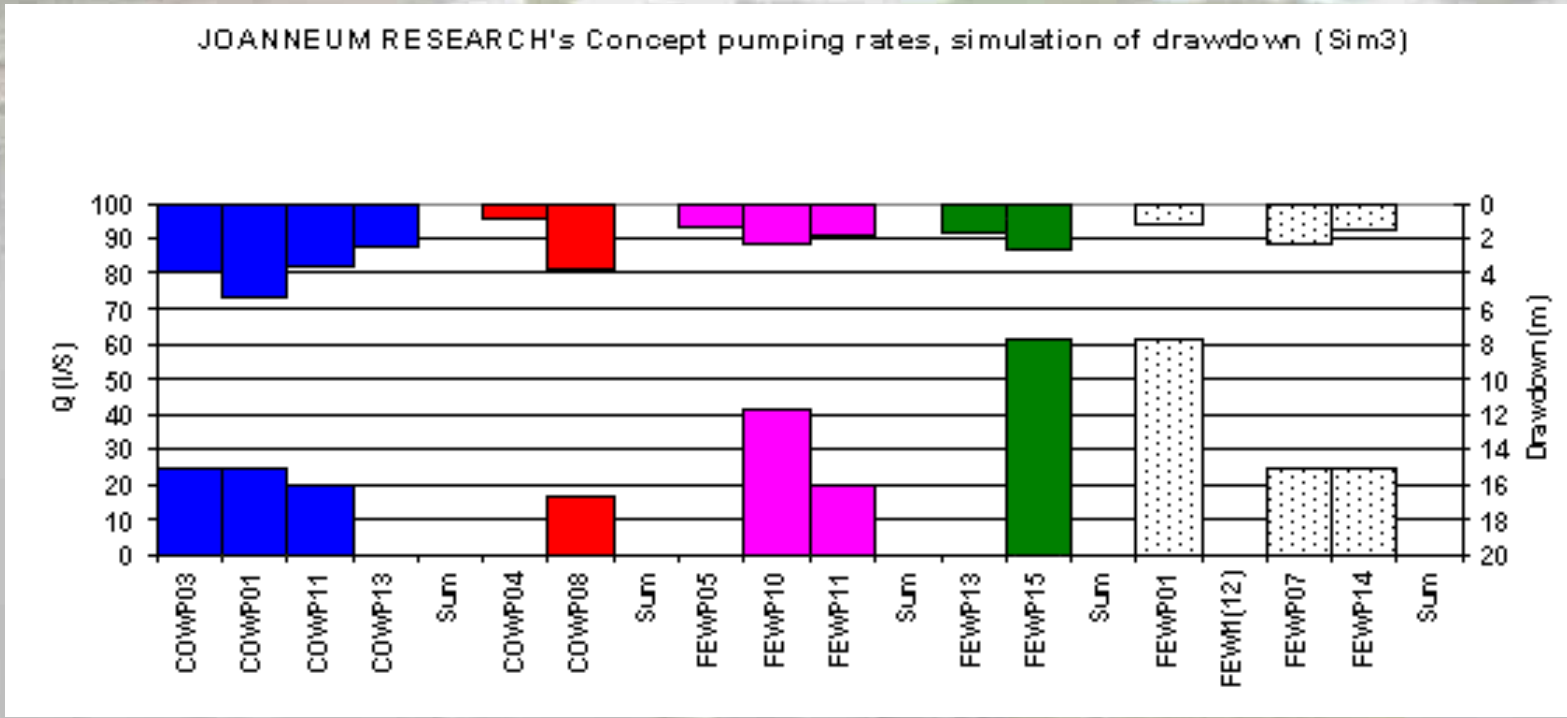
Well Nr.	H m	T m^2/s	k_f m/s	n_{eff} %	Q_{max} l/s	Q_{max} m^3/h	s_{max} m	Q/s l/s*m
COWP03	33.0	1.14E-02	3.46E-04	10.3	45.1	162.28	4.55	9.92
COWP01	28.5	1.85E-02	6.48E-04	13.2	41.2	148.24	9.50	4.34
COWP11	9.5	1.12E-02	1.18E-03	15.8	20.4	73.29	2.52	8.07
COWP13	47.2	5.90E-03	1.25E-04	5.8	32.6	117.37	12.93	2.52
COWP04	6.0	4.19E-02	6.98E-03	23.9	33.7	121.24	1.26	26.64
COWP08	10.8	7.77E-03	7.20E-04	13.6	16.2	58.46	3.69	4.40
FEWP05	12.5	2.31E-02	1.85E-03	17.9	41.2	148.49	1.22	33.75
FEWP10	9.5	2.09E-02	2.20E-03	18.7	32.4	116.67	1.39	23.33
FEWP11	15.5	2.59E-02	1.67E-03	17.4	47.3	170.25	1.92	24.63
FEWP13	3.7	2.37E-02	6.39E-03	23.5	17.9	64.43	1.07	16.72
FEWP15	38.5	4.20E-02	1.09E-03	15.5	67.8	244.16	3.47	19.55
FEWP01	12.5	6.77E-02	5.42E-03	22.7	66.8	240.65	1.83	36.49
FEWI1(12)	99.5	3.57E-03	3.59E-05	~5	32.4	116.47	36.04	0.90
FEWP07	5.3	2.46E-02	4.64E-03	22.0	25.3	90.91	2.18	11.60
FEWP14	7.5	1.83E-02	2.45E-03	19.1	25.6	92.23	1.41	18.12

Main hydraulic parameters transmissivity T, permeability k_f, effective fissure porosity n_{eff}, well capacity Q_{max} and corresponding maximum drawdown s_{max}

Institute of Water Resources Management
Hydrogeology and Geophysics

Concept of water management

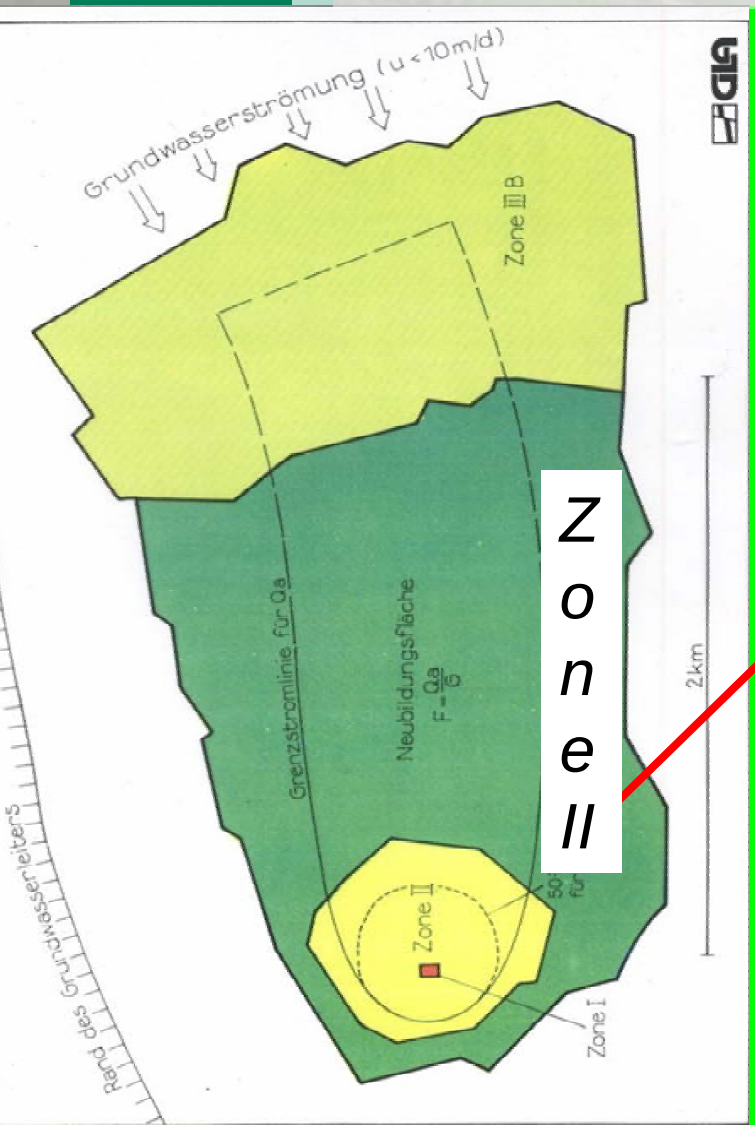
Simulation of drawdown in the wells



Simulation of drawdown of the wells of Colombo-Sede and Colombo-Fervida

JOANNEUM RESEARCH
Institute of Water Resources Management
Hydrogeology and Geophysics

PROTECTION ZONE II (GEOTECHNICAL RISK AND ATTENUATION ZONE) Measures and prohibitions



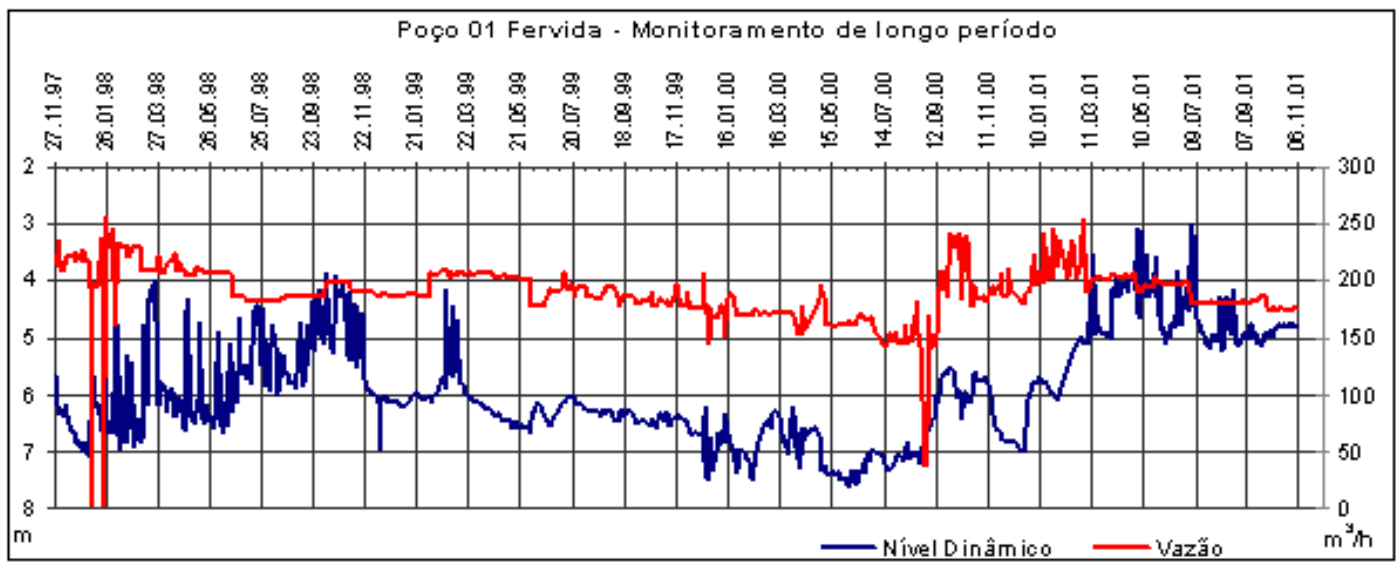
- **.Any land use by forestry, farming, agriculture and pasture forbidden, except necessary cultivation measures**
- **.Any fertilisation (chemical, mineral dunging substances, manure) forbidden**
- **.Storage and use of endangering substances forbidden, especially substances for plant protection and plant growth, insecticides, pesticides, plant growth regulation**
- **.Any damage of the natural soil, especially excavations and drillings forbidden***
- **.Any traffic (pedestrian or driving) forbidden***
- **.Construction of buildings forbidden***
  - *** except for the operation of the water supply**
- **.Complete deforestation and woodland clearing forbidden**
- **.Planting of deep-rooting plants forbidden**
- **.Use of lubricants forbidden**

JOANNEUM RESEARCH
Institute of Water Resources Management
Hydrogeology and Geophysics

Consequences of the concept of water management

After 4 years of monitoring:

- Adaptation of the discharge rate to the aquifer recharge for every karst compartment (lower pumping rates in dry season and higher one in wet season
- Avoiding of overexploitation at the wells
- Significant reduction of geotechnical problems
- Protection for the karst aquifer
- Study of environmental impact assessment




Potential areas for water uses


Urban pressure


Captured spring for water supply


Sub-urban pollution
sources near a well