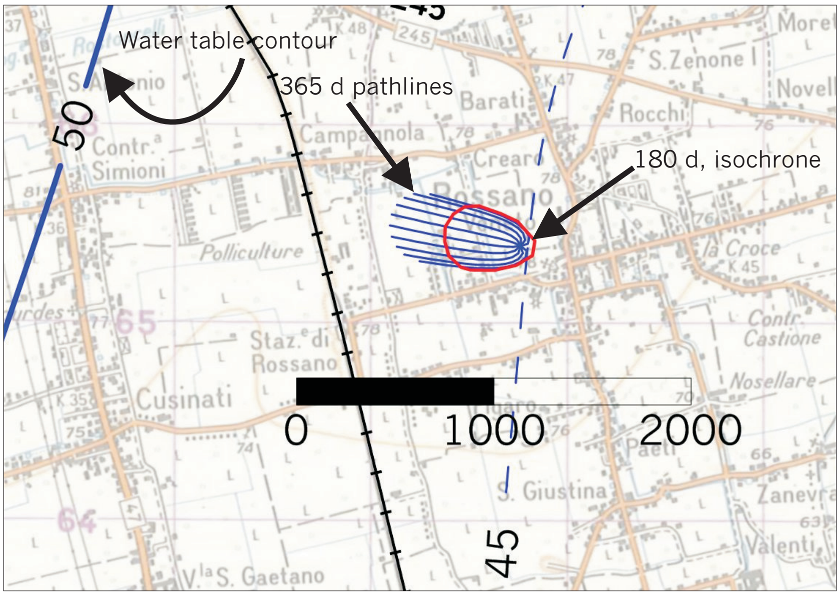
2022-23 Groundwater development plan on alluvial aquifer for potable water.

Client/References: ETRA spa, Vicenza
Ref. : geom Alessandro Scapolo
a.scapolo@etraspa.it

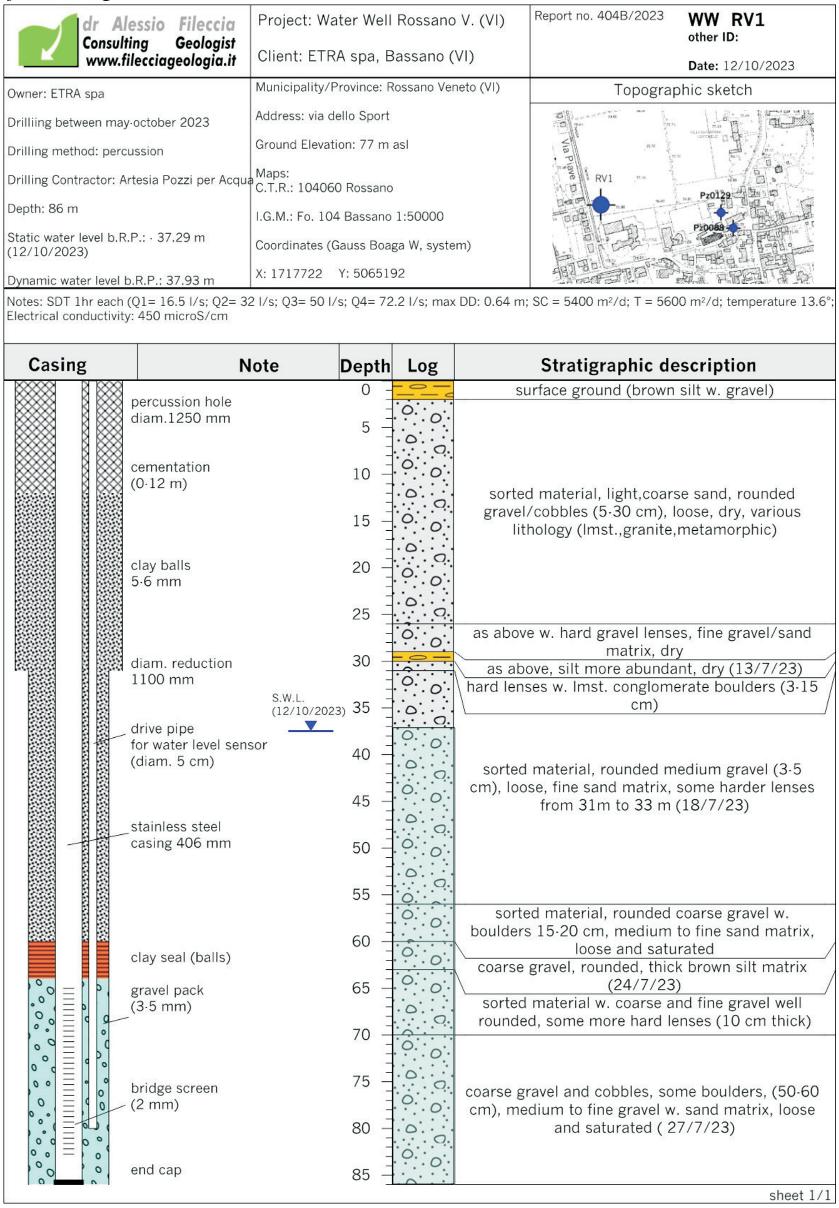
Position held: consultant, head of the project. Main tasks: drilling site selection, hydrogeological maps, drilling project and assistance, aquifer tests, grounwater protection zones delineation.

ETRA is a Water Supply Authority responsible for the civil waste treatment and the delivering of safe potable water to the citizens of Vicenza province (900000 people approx.). In order to upgrade the development of the northern plain, a new area was narrowed down after a general recon survey. The selected aquifer has considerable values of transmissivity and porosity and is capable of delivering high volumes of good and safe water. Unfortunately due to the large groundwater flow velocities of 1-2 m/d, the self-treatment power is considered low. Not least, some potential pollution activities are located far and upstream the desired borehole site. The aquifer tests made it possible to refine the local conceptual model and the application of a numerical model (WHAEM) for the delineation of the protection zones, based on the travel times of the water particles.

Below: *Insertion of the bailer for the collection of the rock samples and the drill feed.*



Above: *simplified output of the analytic element model for the delineation of the Well Head Protection Areas. The water table is positioned 36m below ground with flow direction due south east.The safe protection area was choosed as the one embracing the 365 days travel time with approx. extension of 700m upstream.*
Below: *well design of the percussion hole, and lithological description, after completion.*



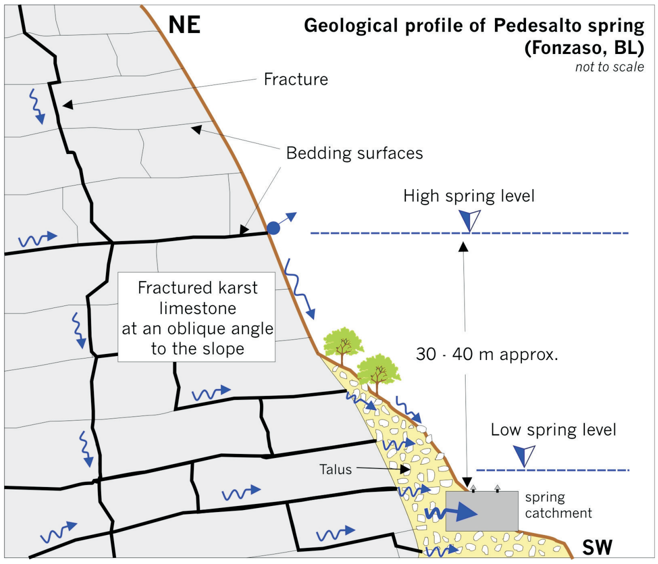
2019-20 Aquifer vunerability assesment

Client/References: BIM-GSP Belluno

Ref. : eng. Diego Iannelli diego.iannelli@gsp.bl.it

Position held: consultant hydrogeologist;

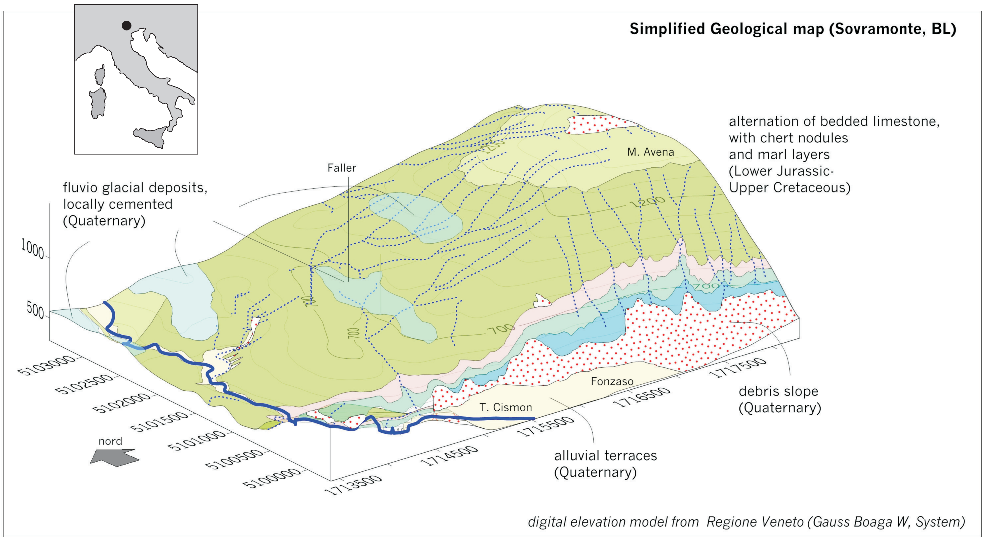
Aim of the assignment was to evaluate the vulnerability of a karst spring in view of a future sewage system planned for the municipality. The 15 km^2 area was investigated to reconstruct the detailed geology, the main underground flows and chemical aquifer quality. A continuos monitoring programm allowed to evaluate the vulnerability of the main spring, implementing the Civita half-discharge approach. As a result a more effective catchment system was engineered.



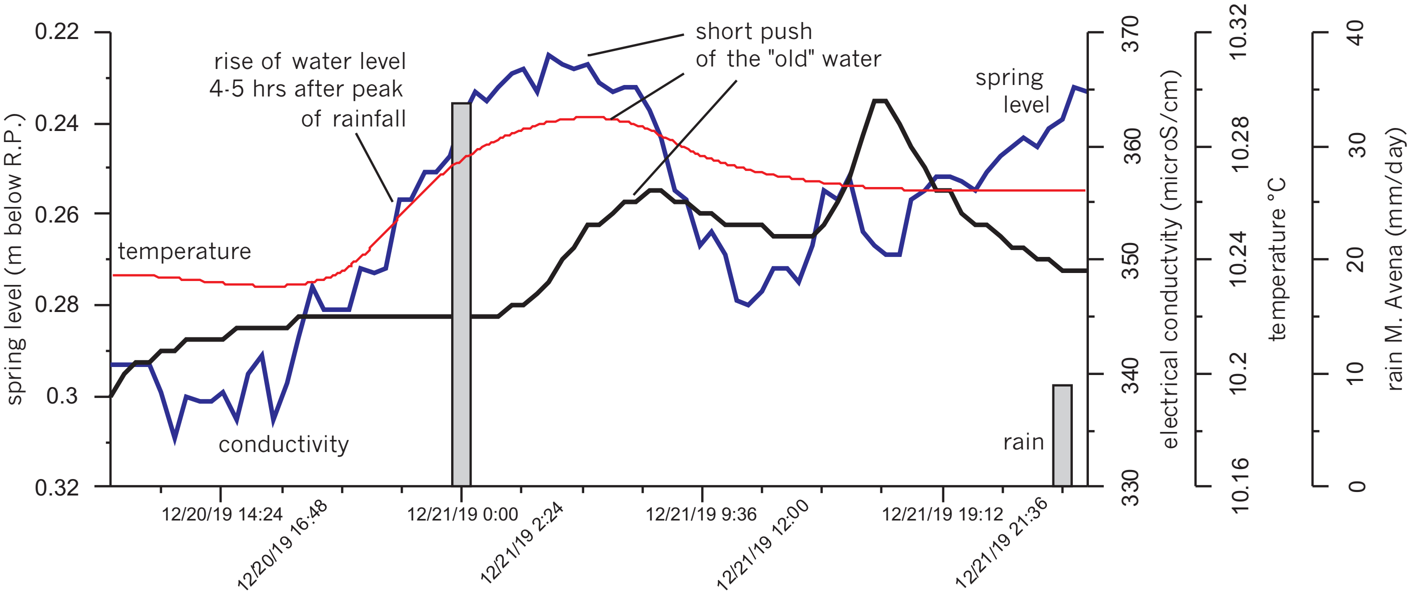
Above: *geologic profile of the Pedesalto spring. The water source is partly hidden below coarse material. leaving the limestone formation through fractures bedding planes. The level fluctuates between dry and wet season of as much of 30-40 m.*

Below right: *3D block diagram of the inferred hydrogeological basin of Pedesalto spring. Ground elevation ranges from 1440 m to 300 m. Cismon river drains most of the surface and underground flow. Rock formations are made of limestone and marl.*

Below: *recording of a few hours flood event. The graph clearly illustrates the spring behavior when new water from precipitation enters the upper part of the mountain, slowly filling up the fractures. The rapid rise of water level, electrical conductivity and temperature indicates a limited extension of the reservoir and its high vulnerability. These variations show up a few hours after the start of precipitations supporting the high velocity of the recharge water, and low self-purification properties.*



Pedesalto spring: monitoring parameters on dec. 20, 2019 (water level, electrical conductivity, temperature)

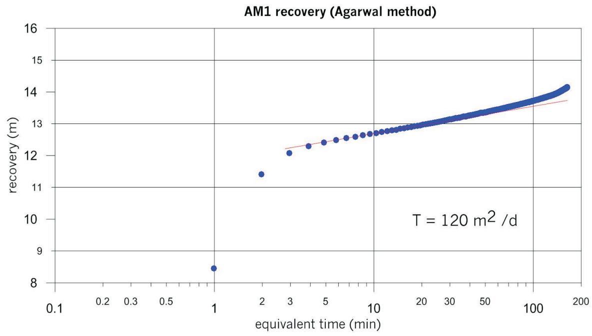


2016-17, Groundwater exploitation of a confined aquifer for irrigation purposes

Client/References: Biodinamica S. Michele, Treviso
Ref. : Anito Bonadio CEO
anito.bonadio@biodinamicasanmichele.it

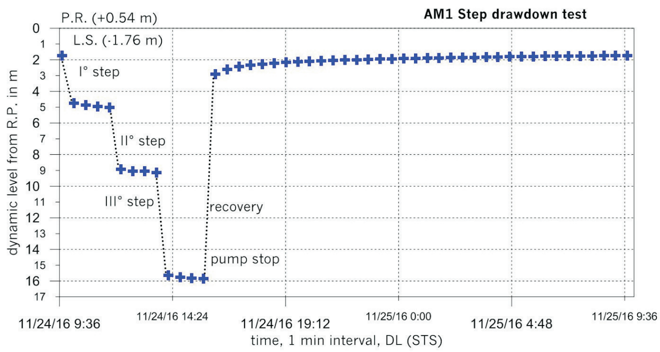
Position held: consultant hydrogeologist;
Drilling Contractor: Botti Elio, Adria (RO)

The Client is a well known farm with a large 143 ht. property. A large-scale irrigation plan requires both surface and ground water, for crop production. The area is close to the Adriatic sea and surface aquifer suffers from salt water intrusion. The initial needs were of 12 l/s from two deep wells in the confined aquifer. To prevent excessive drawdowns and well interference, an initial investigation with pilot wells and pump tests was performed, followed by production wells and long duration aquifer tests.

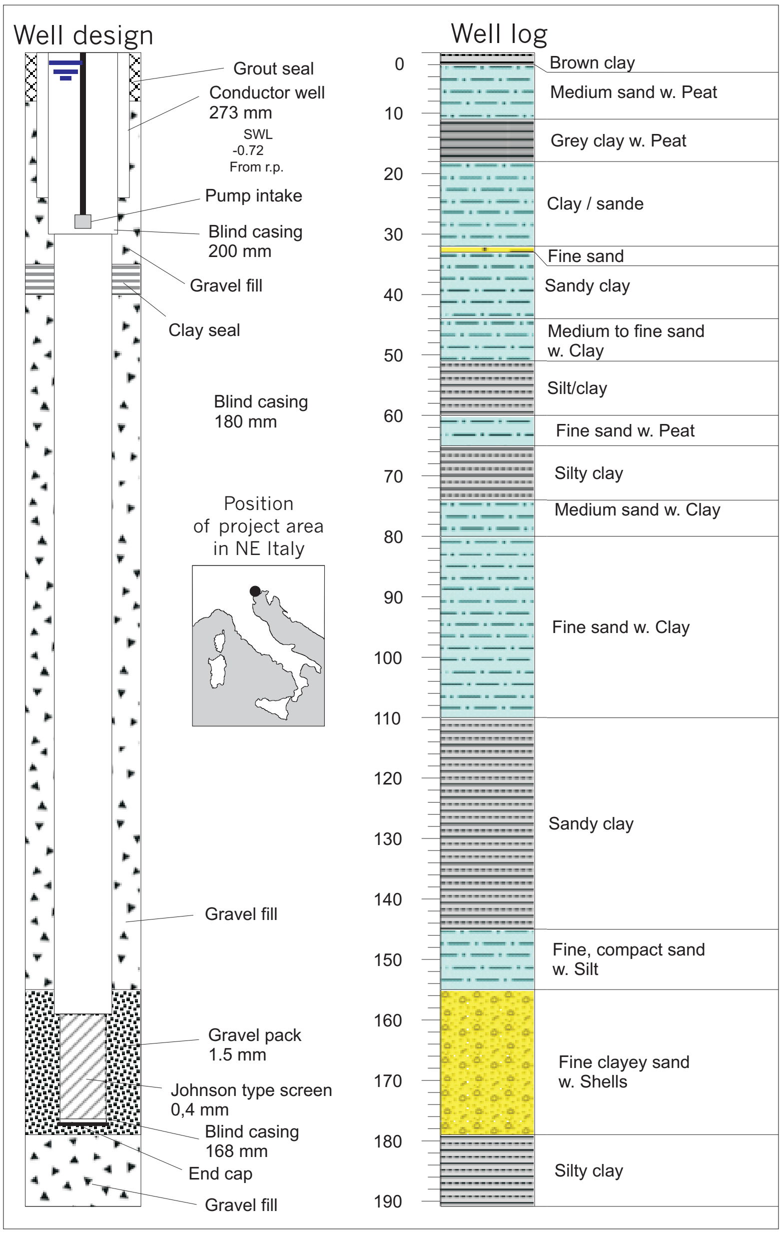


Above: field data interpretation for transmissivity, using Agarwal equivalent time method for recovery; ***Below****: well completion with 0, 4 mm Johnson screen steel type.*

Below: *Step drawdown test in one production well. Three steps of 2hrs each were performed. Discharges were 1.8 - 3.9 - 7 l/s respectively with a final well efficiency of 80%. Alla data were checked against barometric efficiency after a 30 days recording of water level and barometric pressure fluctuations.*



Below: *simplified well design and stratigraphic log for borehole Am1. The most productive aquifer is located between 156 m and 180, made of fine sand with some clay. To reduce solid tansport and increase well efficiency, continuous slot screens were installed.*



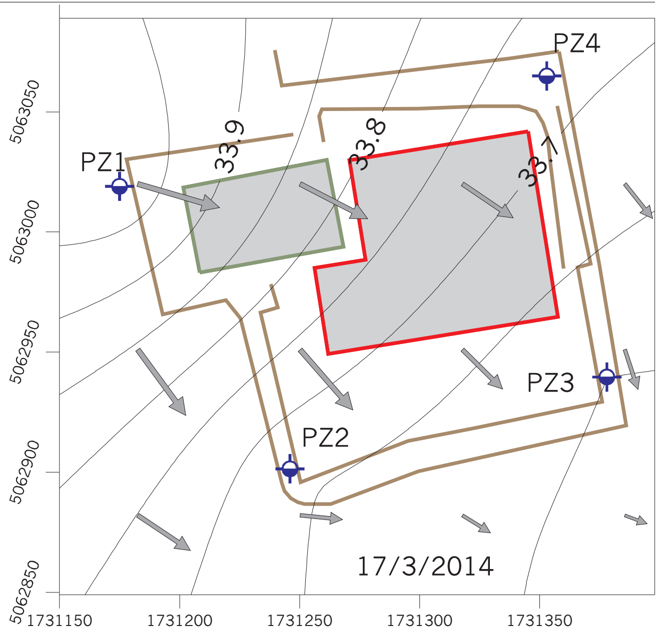
2015, dewatering project of industrial area

Client/References: Imballi spa. Treviso
Eng. Dario Gambarotto
dario.gambarotto@dfgingegneria.com

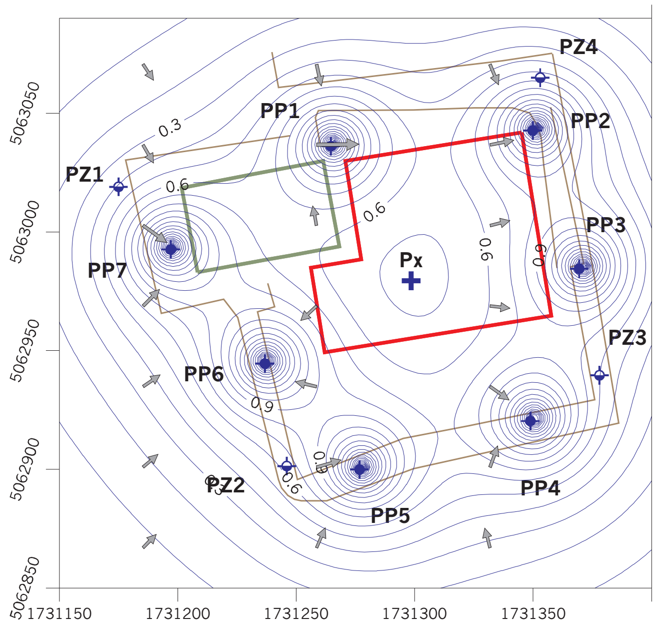
Position held: consultant

Due to the recent hydrologic changes in the last 15 years, several industrial buildings, partly underground, were involved in various detrimental water table risings. The project area has an extension of 10000 sqm, at 9 m below ground level. At the time of construction the water was within 2 m below the piles. In 2010 the whole area was submerged by 30 cm in the loading zone (see picture). The study involved a preliminary phase with drillings, aquifer tests, monitoring, hydrogeological maps, followed by a pilot well to schedule the number and design of the dewatering system, its discharge and the obtainable drawdown.
Ground conditions comprised coarse gravel mixed with sand and silt. The project was checked against a 2d numerical model. As a result we installed 7 wells abstracting 10 l/s each, that were able to lower the water level by 40-50 cm in the central area.

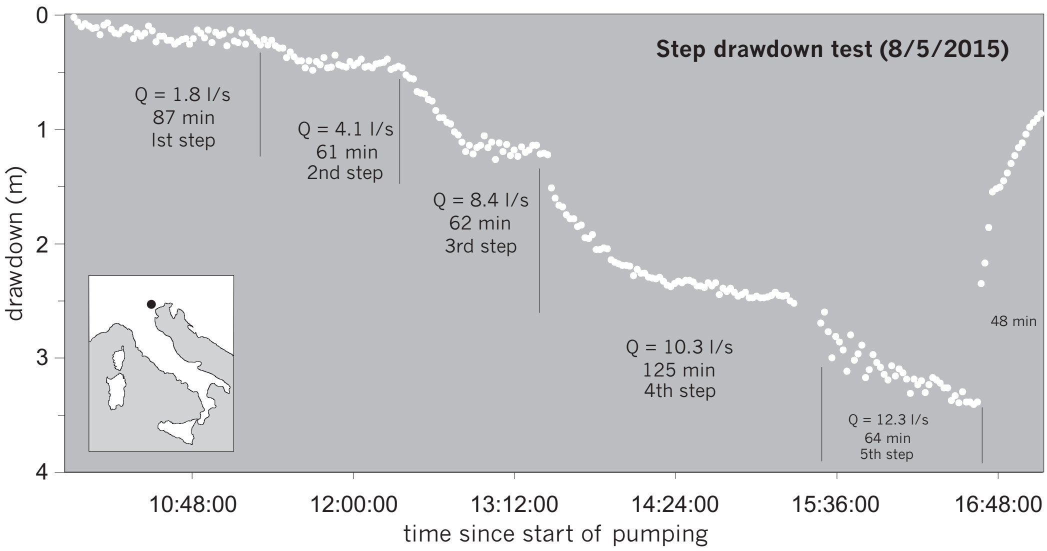
Loading area partly submerged



Above: *water table contour map during high season, natural flow is due SE*



Above: *the dewatering system in operation after one day. The calculated drawdown below the floor building is 40-50 cm at piezometer Px*



Graph showing the drawdown in the pilot well during pumping. The test is a normal procedure to correctly define the drainage well allowing also to calculate the aquifer hydrogeological parameters. For this particular case trasmissivity was in the range of 250-300 sqm/d.

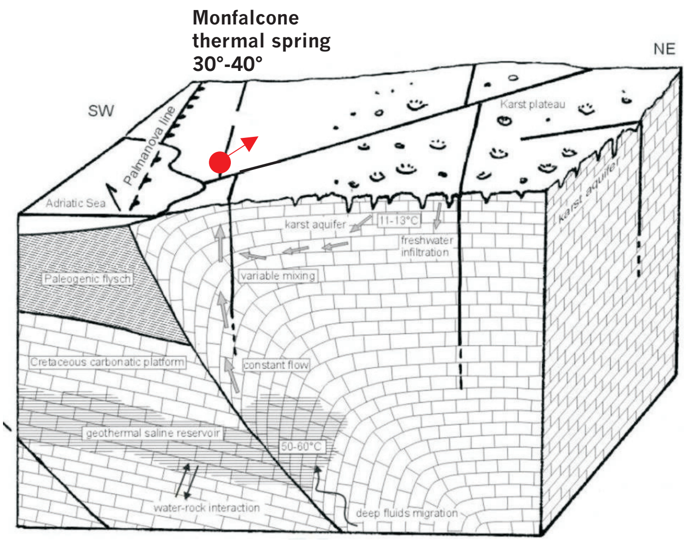
2014, hydrogeological investigations and drilling assistance for thermal water abstraction

Client/References: I.C.I. Srl, Ronchi GO
dr. Fulvio Iadarola
Iadarola@activeweb.it

Position held: consultant

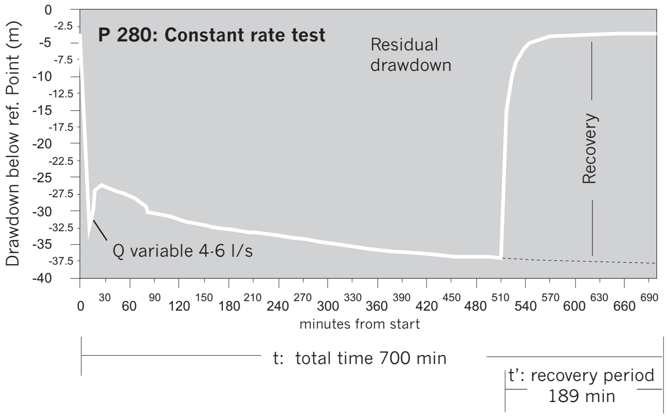
Area: Friuli region, NE Italy

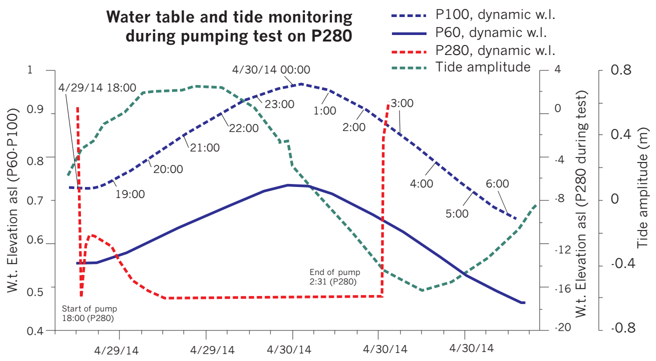
The thermal spring is known since roman time, restored during '20s it was again abandoned after the II world war. The new project aims to increase the amount of pumped water renovating the old premises. The spring is located along the northern adriatic coast and water surfaces naturally forming small ponds. A set of deep faults drives the water from below 300 m. After a monitoring campaign to separate barometric and tidal effects we planned a new deep well carrying out a long duration pumping test. The test was planned to evaluate the maximum abstraction rate to avoid salt water intrusion and an unrecoverable drawdown.



__Above:__ block diagram of the study area sketching the karst aquifer and the main fault lines (from O.G.S.)

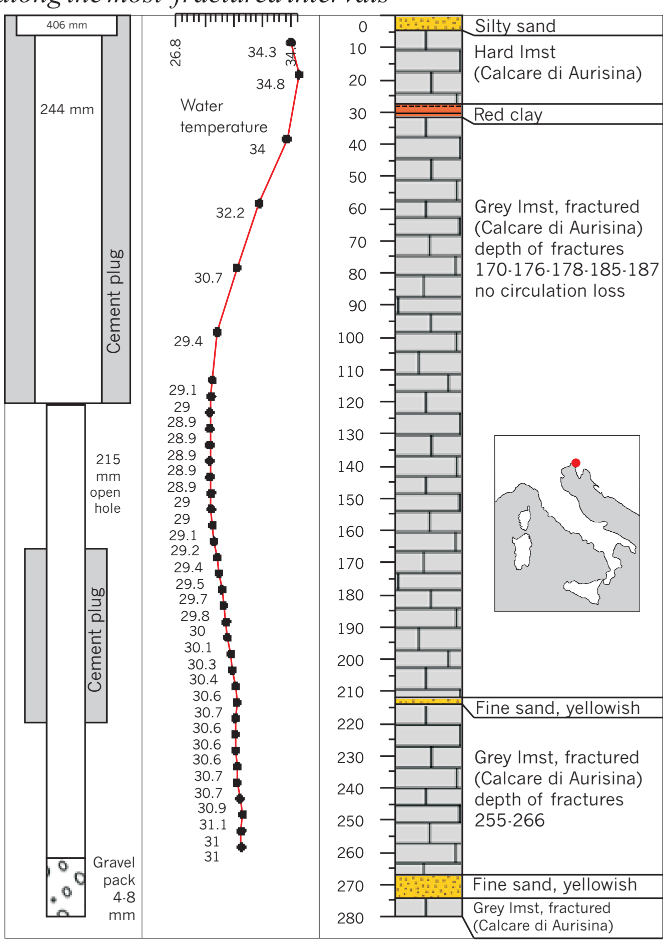
__Below:__ results of a constant rate pre test in the new deep well. The data were used for planning the long duration test to underline any influence on the upper aquifer and the surficial spring





__Above:__ recording of the water level in the upper and lower aquifer, compared to the marine tide.
__Below:__ the drilling rig can operate down to a maximum depth of 1000 m (SIME srl, Bari)

__Below:__ well design and logs. Hole was cemented only along the most fractured intervals



2013-14-15, shortcuts and analytical solutions in aquifer tests *(Web course)*

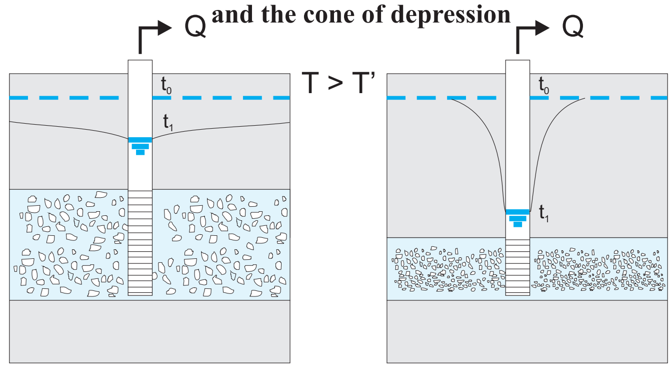
Client/References: Geocorsi srl, Chieti
dr D. Duronio
www.geocorsi.it

Position held: teacher (course language italian)

The course, attended by 150 partecipants, addresses and solves a variety of problems dealing with field tests for the calculation of hydrogeological parameters. The main goal of the lessons is to cover a gap between theory and practice giving the students a userfriendly way to solve field problems.
Main features are the following:

- Summary of hydrogeological parameters
- Importance of the hydrogeological model reconstruction as a preliminary step
- Planning an aquifer test
- Preliminary analysis of the site
- Well features
- Piezometers
- Various methods of aquifer testing, with corresponding graphs for easily determining all major hydrogeological parameters
- Various aquifer configuration (unconfined, confined)
- Various flow regimes (steady, unsteady)
- Main analytical formulas used for the interpretation of aquifer tests
- Using an hydrogeologic software package to estimate aquifer parameters: instructions and examples with screen shots from Aqtesolv software

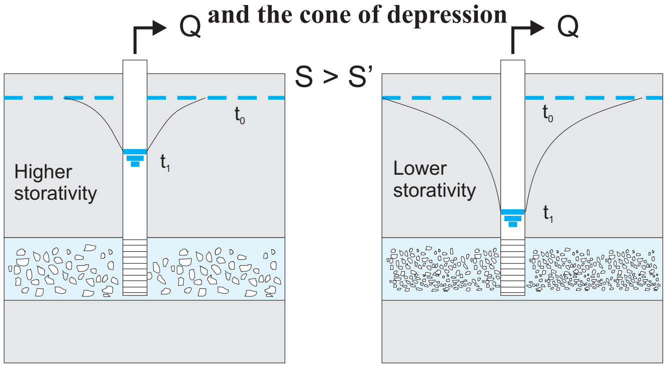
Discharge, trasmissivity, drawdown and the cone of depression



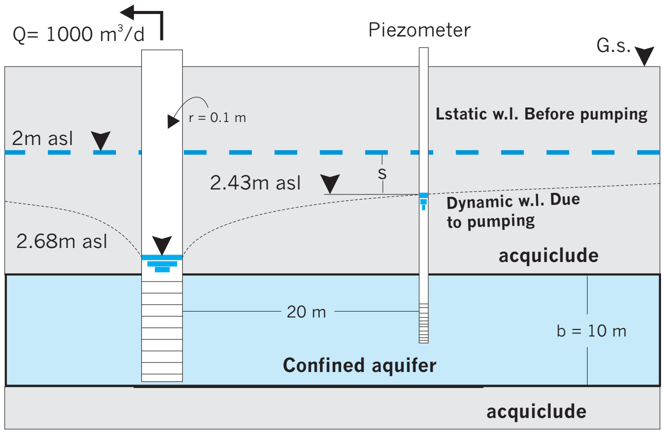
High trasmissivity aquifer
T = 1240 mq/d
s = 0,8 m
Q = 62,7 l/s

Low trasmissivity aquifer
T = 124 mq/d
s = 7,9 m
Q = 62,7 l/s m

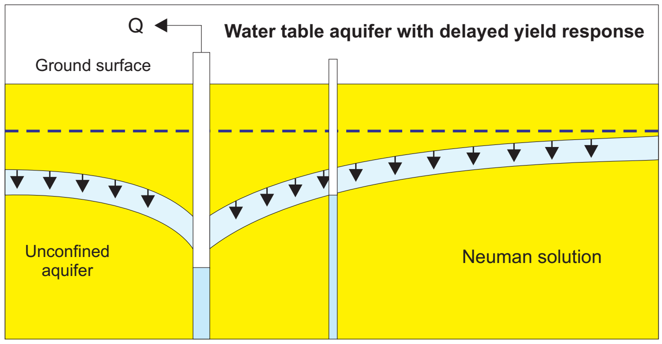
Discharge, storativity, drawdown and the cone of depression

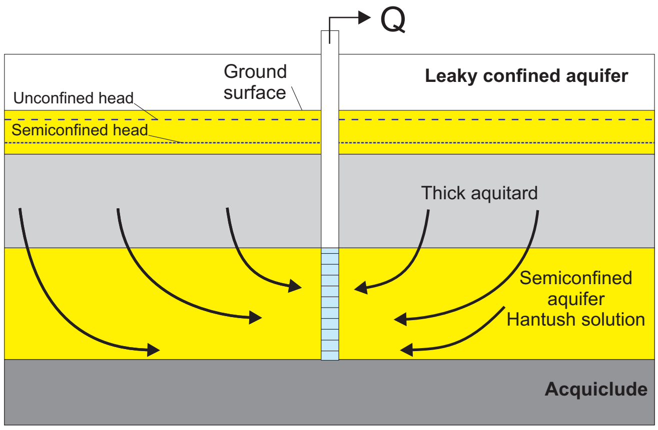


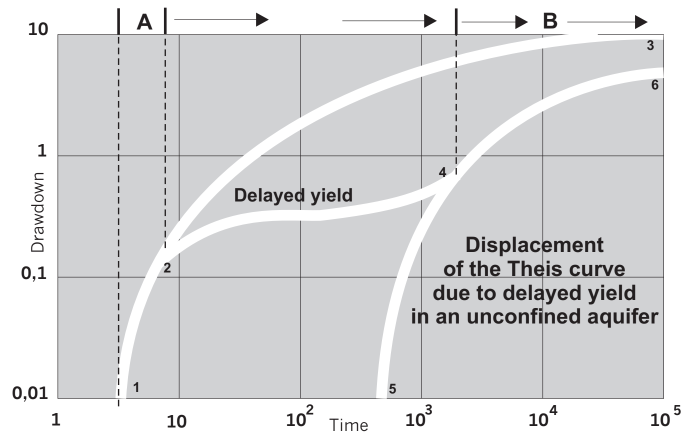
***Below:** configuration example of an aquifer test (steady state condition, confined aquifer with piezometer)*



***Below and left:** some sample figures from the lessons, describing main aquifer configurations*





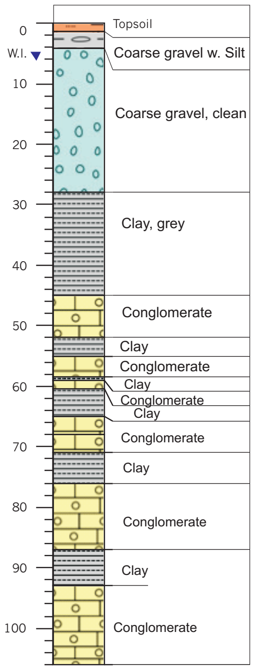


2012-2015, ground water capture zone delineation *(Methods comparison on alluvial river aquifer)*

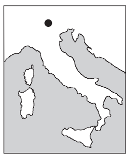
Client/References: Alto Trevigiano Servizi (ATS)
Ref. Eng. Paolo Pizzaia
www.altotrevigianoservizi.it
Position held: consultant

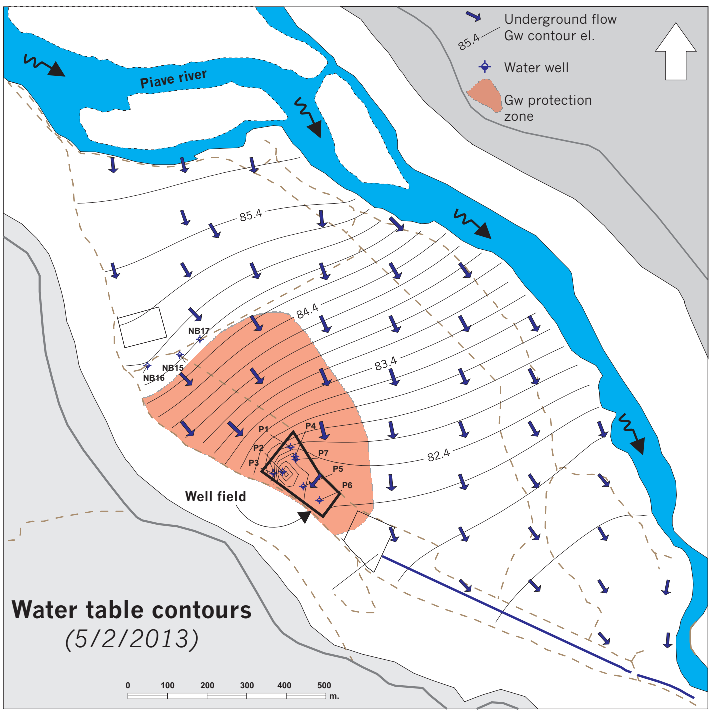
A.T.S. is in charge for potable water delivery and sewage systems to 440000 people in the region. All water comes from porous or karst aquifers.

The Nervesa well field has 7 shallow wells, with a maximum depth of 28 m and pumping rate of 150 l/s from a water table aquifer (underflow) along river Piave (below bottom).



Left: stratigraphic log of P1, production well. The upper part is made of recent loose alluvium with cobbles, and coarse gravel deposited from the river. The materials lay on a sequence of hard clay and conglomerate (puddinga); the latter being locally fractured and karstified.

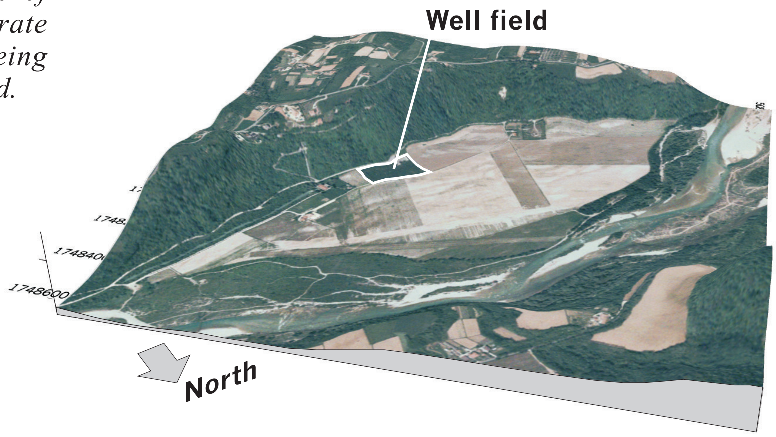




To choose the position of the new proposed large diameter well, together with the capture zone delineation, a thorough study of the site is in progress. Several field tests have been carried out to obtain main hydrogeological parameters and a reliable picture of the physical model (tracer and aquifer tests, electrical tomography, water level recordings with electronic transducers).

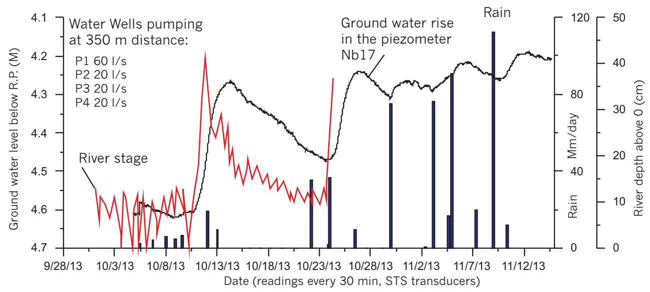
A numerical model is also to be assessed. The model will serve as a predictive tool for future abstraction but also as an interpretive one for understanding mutual relations among local parameters and as a comparison towards simpler approaches (analytical formulas and analytical models as Whaem or methodologies described in the EPA guidelines).

Below: *3D aerial photo of the investigation site. The river flows north west to south east on the northern part of a wide plain. The valleybottom is approximately 1000 m large. The river is an alpine type with floods during spring and autumn. Its discharge is variable from a few cum/s to several hundreds. The well field is located along the southern bank, at the foot of a low escarpment.*



Left: *The figure shows a piezometric map prepared during pumping. The wells do not work simultaneously and are triggered via a remote system. The water is pumped to a near 5000 cum reservoir at an higher elevation. The red area depicts a preliminary delineation of the protection zone. From its upper flow boundary a travel time of 90-120 days has been calculated.*

Below: *Surface to ground water relations were studied with the aid of continuous water level transducers. Here the movement of the w.l. in the piezometer (black line) follows few hours after the river peak (red) and the rain (blue bargraph), revealing a good hydraulic connection and general aquifer homogeneity.*



2012, geotechnical and hydrogeological investigations for a water pipe stabilisation and slope reinforcement

Client/References: Alto Trevigiano Servizi (ATS)
Eng. Paolo Pizzaia
www.altotrevigianoservizi.it

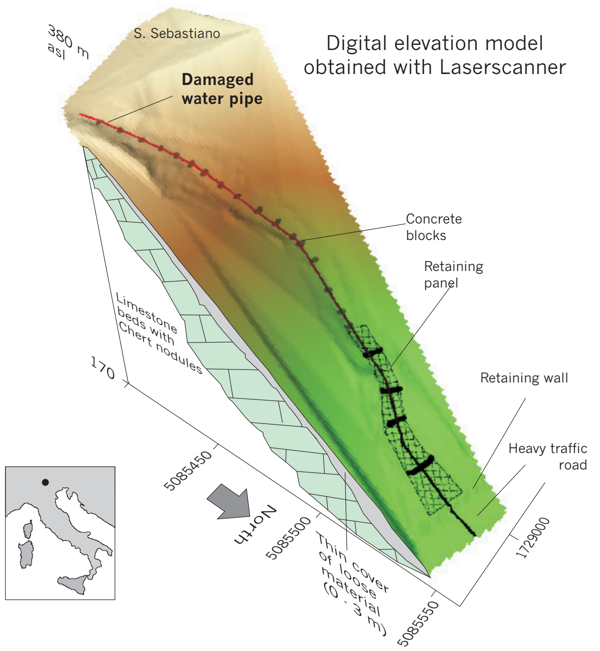
Position held: main consultant, (Land Technology System, Treviso-dr. V. Fenti as partners)

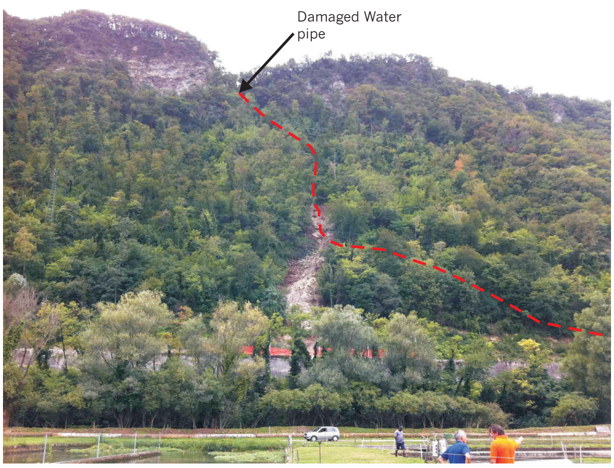
Area: Veneto region, Treviso

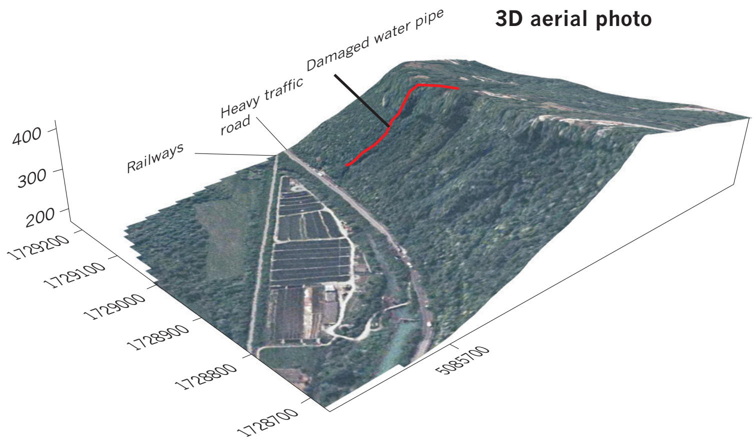
A.T.S. is in charge for the potable water delivery and sewage systems to 440000 people in the region. All water comes from porous or karst aquifers. The S. Sebastiano underground reservoir is fed by two 60 cm in diameter water pipes. The water is pumped from a well field at the valley bottom, 150 m (asl) up to 400 m (asl). The project involved a detailed geological map, surficial trenches with sampling, and a laserscanner survey. The survey resulted in a terrain model with 4/5 cm precision.

The hard rock is covered by a thin layer of loose material (cobbles, blocks) 1-2 m thick.

The pipes are simply laying on surface, dipping 45° and are held in place by concrete blocks, positioned approximately 10 m apart. During the period preceding the investigations some minor rock avalanches took place, while field reconnaisance, showed severe deterioration of the blocks with minor cracks on the pipes. The slope stabilisation was done after the site clearing and laying a 15 m large iron panel and a final net, for creating a vegetated slope and a retaining wall at the toe. The water pipes were anchored with a couple of micropile every 10-12- m. The old damaged blocks were broken in smaller pieces and taken away.





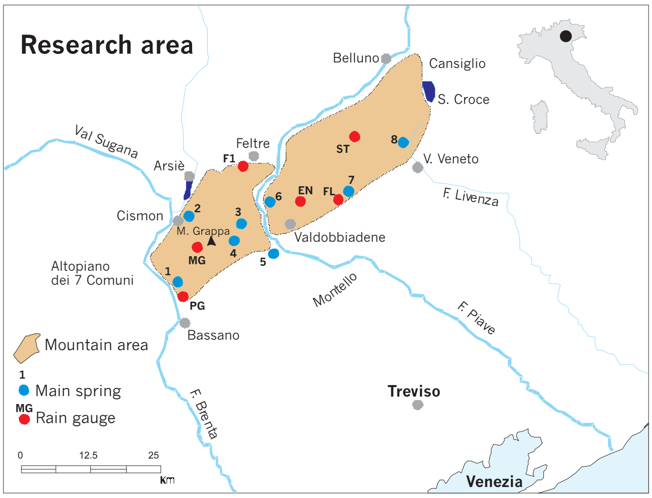


2012, hydrogeological investigations for a karst spring *(Catchment area and g.w. protection zones assesment)*

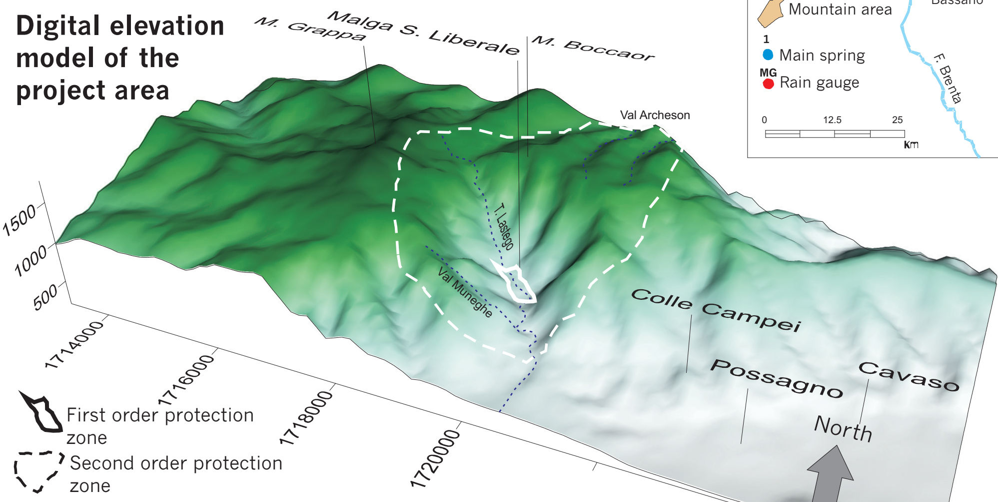
Client/References: Alto Trevigiano Servizi (ATS)
Eng. Filippo Guerra
Www.altotrevigianoservizi.it

Position held: consultant

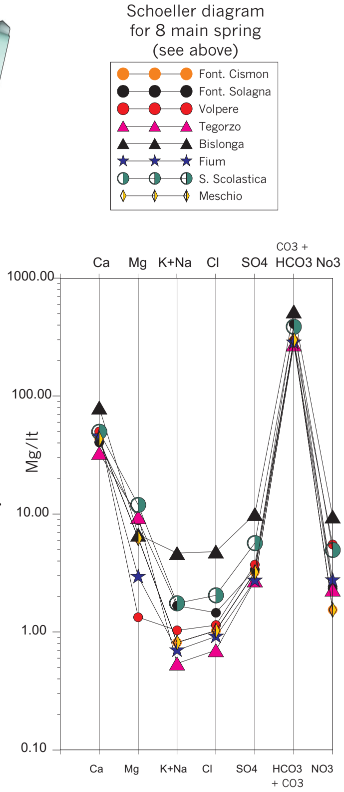
Area: Veneto region, Treviso



Digital elevation model of the project area

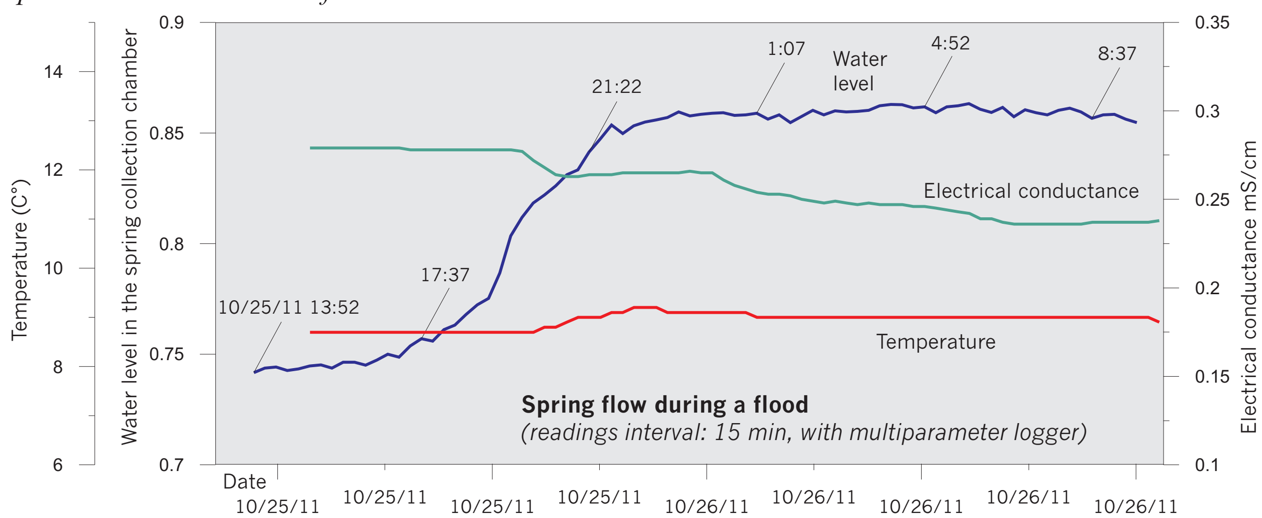


A.T.S. is in charge for the potable water delivery and sewage systems to 440000 people in the region. All water comes from porous or karst aquifers. The study aimed to reconstruct the hydrogeological basin of an important spring delivering potable water to the west system of the net. The water source is located at 600 m asl, and is fed through a karst aquifer. By means of aerial photos, field geological mapping, chemical analysis and the use of water level transducers it was possible to calculate an approx extension of 15 sqkm for the catchment area together with a range of flow velocities during and after storms (from 50 m/hr to a few cm/hr). A more general study was also performed to compare the chemical quality of main springs in the mountain range for a detailed basin classification.



Right: *the Schoeller diagram is widely used to classify water springs understand ing the composition of the rock basin. In this figure the good agreement among different curves depicts a calcareous composition for all areas.*

Below: *the three curves show the classical response of a spring to the precipitation. The rapid rising of w.l. coupled with the decrease of condutance and a slow temperature rise is an indication of the small basin extension and good fracture comunication.*



2010, hydrogeological and 3D laser survey of Castel Tesino cave

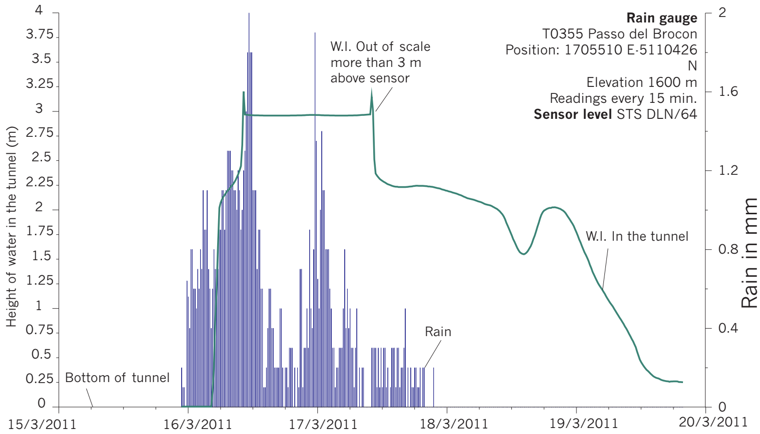
Client/References: LTS srl, Council of Trento (dr Nuccio Buccéri gen. Man.)

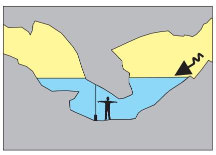
Position held: consultant

Area: Castel Tesino, Trento

The Castel Tesino cave is known for having a wide exposure of speleothems (stalactites, stalagmites, scallops, drapestones etc.) In vue of a better protection of the cave environment and use as a tourist attraction the Council charged us with a detailed 3D survey at 1 cm precision by laserscanner (see bottom photo). The hydrogeological behaviour in response to precipitation was examined by a net of rain gauges on surface and water level sensors in the cave. By measuring the lag time between peaks of rain and flooding in some tunnels we also could register the alert time in case of heavy storms and the hydraulic relations with the nearby stream.

Castel Tesino Cave
Surface precipitation and water level in the temporary sump
(16-19 march 2011 flood)

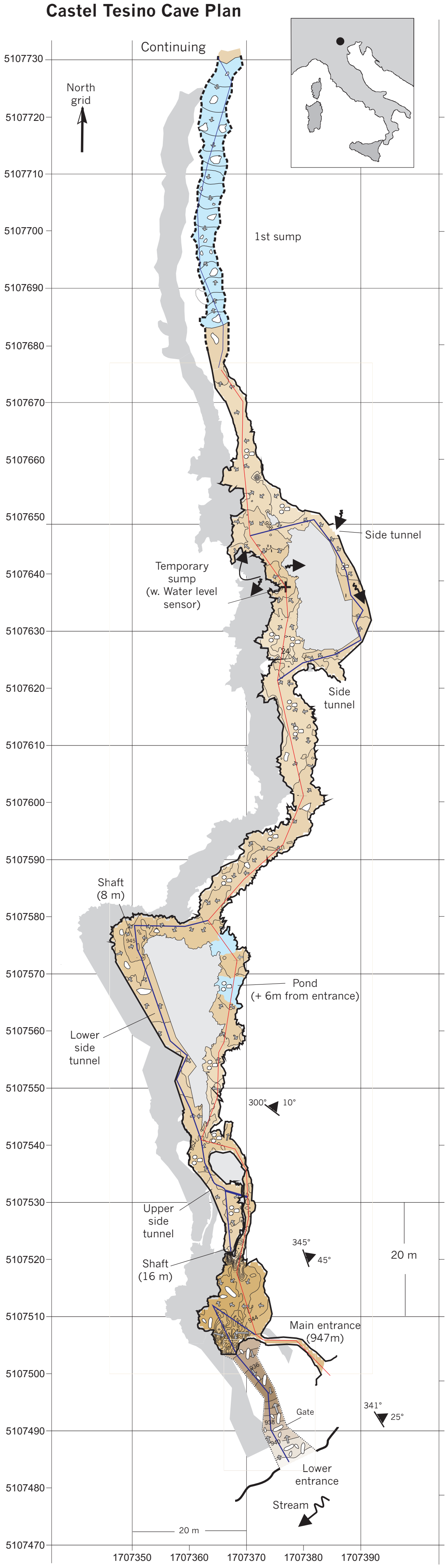




Temporary sump and w.l. Sensor position

Laserscanner at work

Castel Tesino Cave Plan



2010 in progress, aquifer rehabilitation of an abandoned industrial area *(environmental drilling, 2D modelling, aquifer monitoring, slug tests, soil volume computation, risk analysis)*

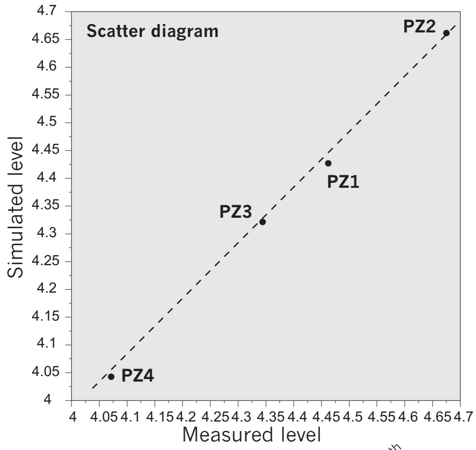
Client/References: Coveol srl
Ref. Cristina Gaion
www.coveol.it

Position held: consultant (partner: St. Gavagnin)

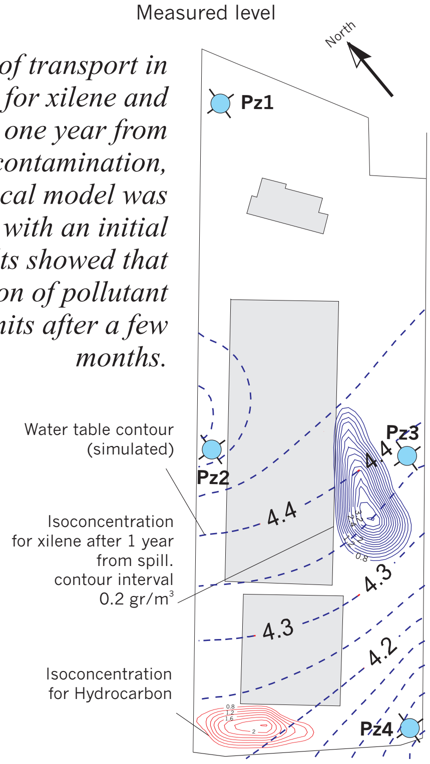
Area: Veneto Region, Treviso

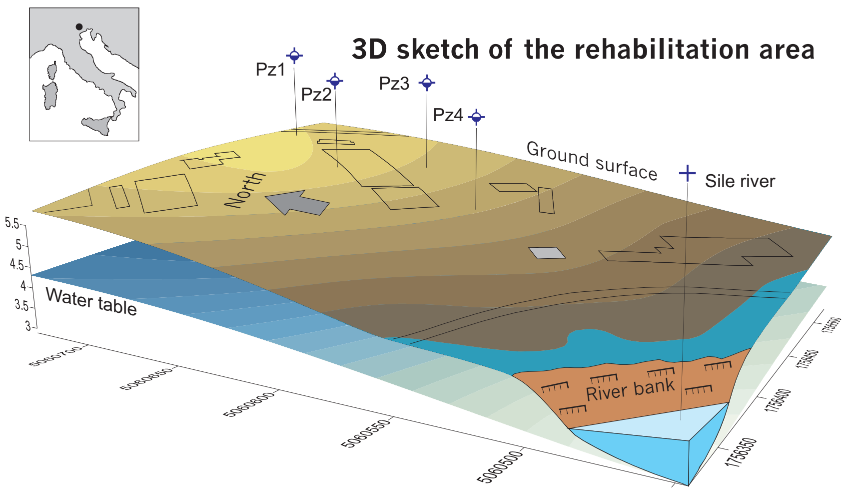
The area under investigation is aligned along a river bank and used in the past, for the manufacturing of colours and paints for the industry. Pollution involves some spots on a 14000 sqm area. Mainly xilene and hydrocarbon. Several field tests have been performed to better characterize the aquifer and transport parameters. Samples and stratigraphy were conducted following environmetal drilling guidelines. Slug tests (Bouwer/Rice procedure), continuous level monitoring, chemical analysis, single point dilution techniques and piezometric maps in different seasons, have allowed the preliminary assesment of a 2D numerical model to trace the contamination.

***Right**: plot of simulated versus measured water levels in the 4 piezometers*

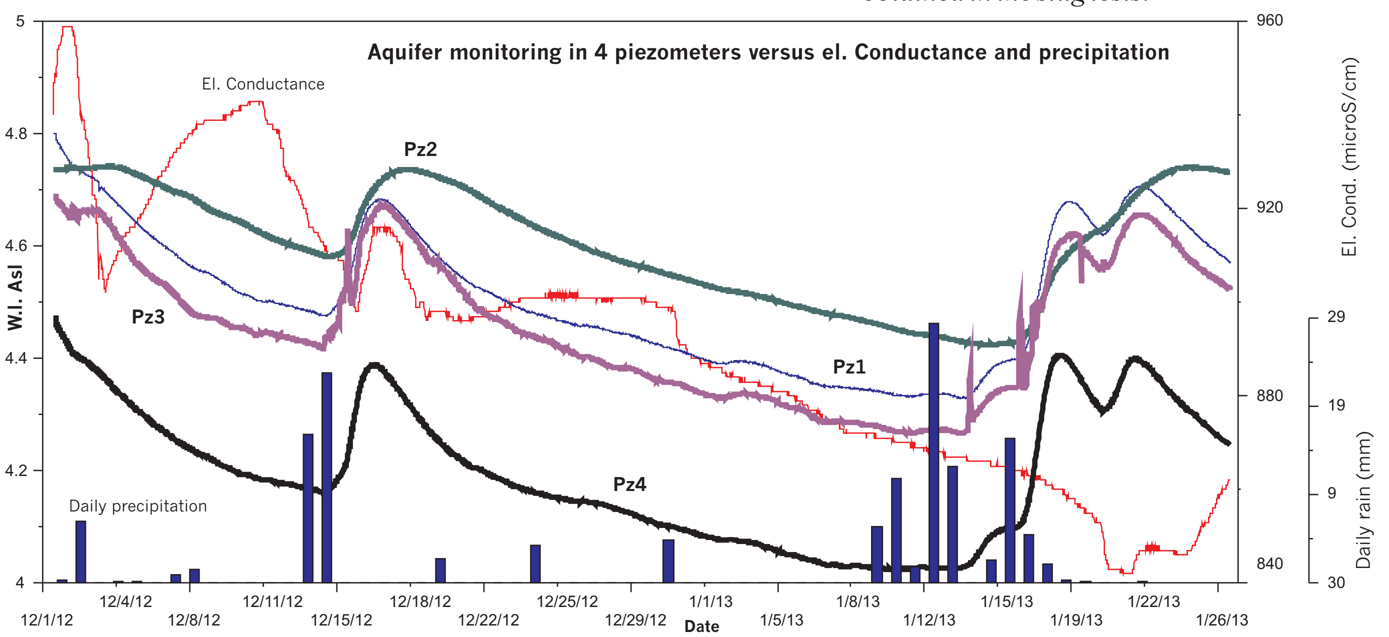


***Right**: Simulation of transport in the aquifer for xilene and hydrocarbon, after one year from spill. To study the contamination, a 2D numerical model was addressed, with an initial calibration. Results showed that the low concentration of pollutant reduced below limits after a few months.*





***Below**: The continuous monitoring of the aquifer proved its fairly good homogeneity and close dependance to precipitation. In the piezometers single well dilution tests were performed to compare K values with that obtained in the slug tests.*



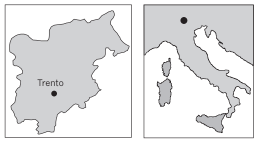
2011-2010, hydrogeological investigations and monitoring for aquifer rehabilitation

Client/References: Trento Dep. Of Justice,
dr Luigi Frassinella,
Studio@frassinellaluigi.191.it

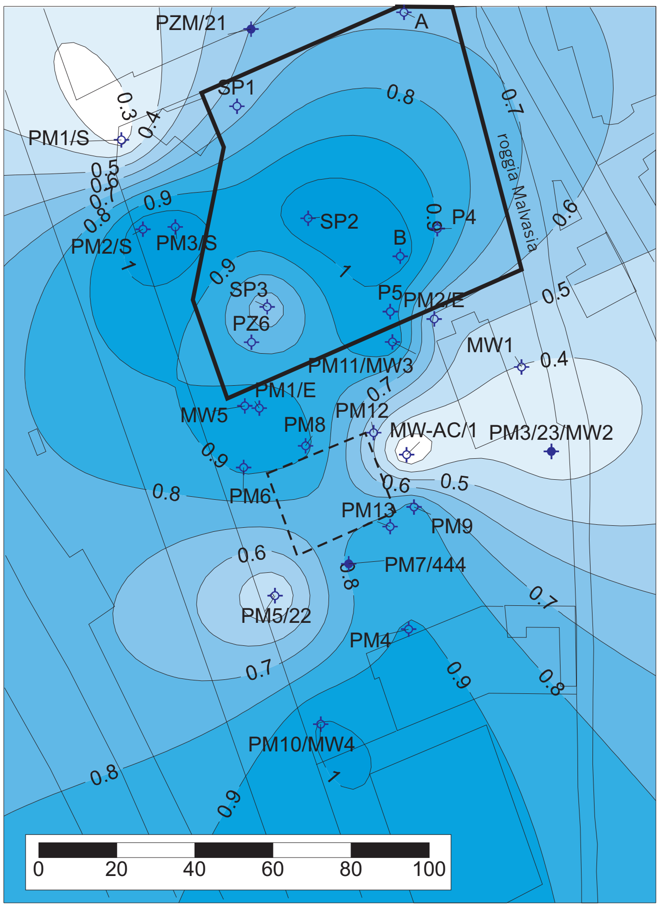
Position held: consultant

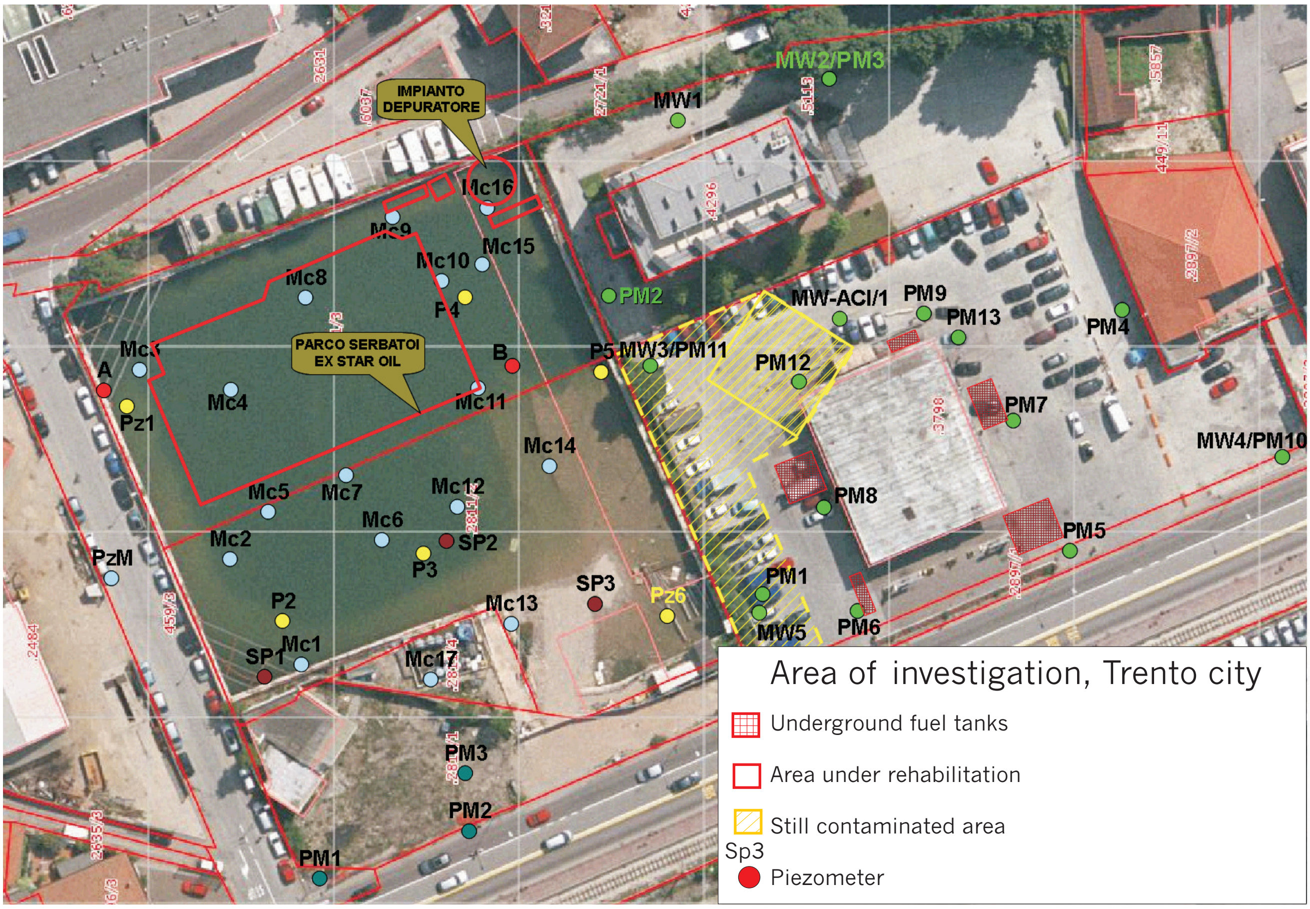
Several underground tanks have been located in the central part of Trento city since the 50'. Following the specifications in use until the turn of this last century, tanks had only one single metal wall, subject to corrosion with time.
This gave rise to various pollution plumes not always detected. The investigated area has an average extension of 12000 sqm (see aerial photo) and hydrocarbon compounds were reported since end of 90'. Aim of the study was to complete the aquifer geometry reconstruction down to 15-20 m and a quality review of the rehabilitation and dewatering technology so far applied. After 12 months of tests the best approach came out to be the continuous parameter monitoring and the setting up of piezometric maps in different hydraulic conditions.

Right: *The map shows the difference in elevation between high and low aquifer levels and can be used to evaluate recharge and discharge areas and thus the vulnerability of an aquifer (recharge is blue, discharge is white)*



Water level change map prepared for different aquifer conditions (2005 - 2010)





2002-2010, Professor of Applied Hydrogeology at the University of Trieste

Client: Department of Geological Sciences

Reference: prof. F. Cucchi, cucchi@univ.trieste.it

The course was held from january to june, covering both theory and practice and addressed to prepare the students solving most of the common tasks they will like to encounter during their professional career.

Main subjects:

Aquifer Geometry reconstruction

Hydrogeological parameters

Underground water flow and regime

Application of Darcy law

Groundwater research and exploitation

Drilling methods

Aquifer tests

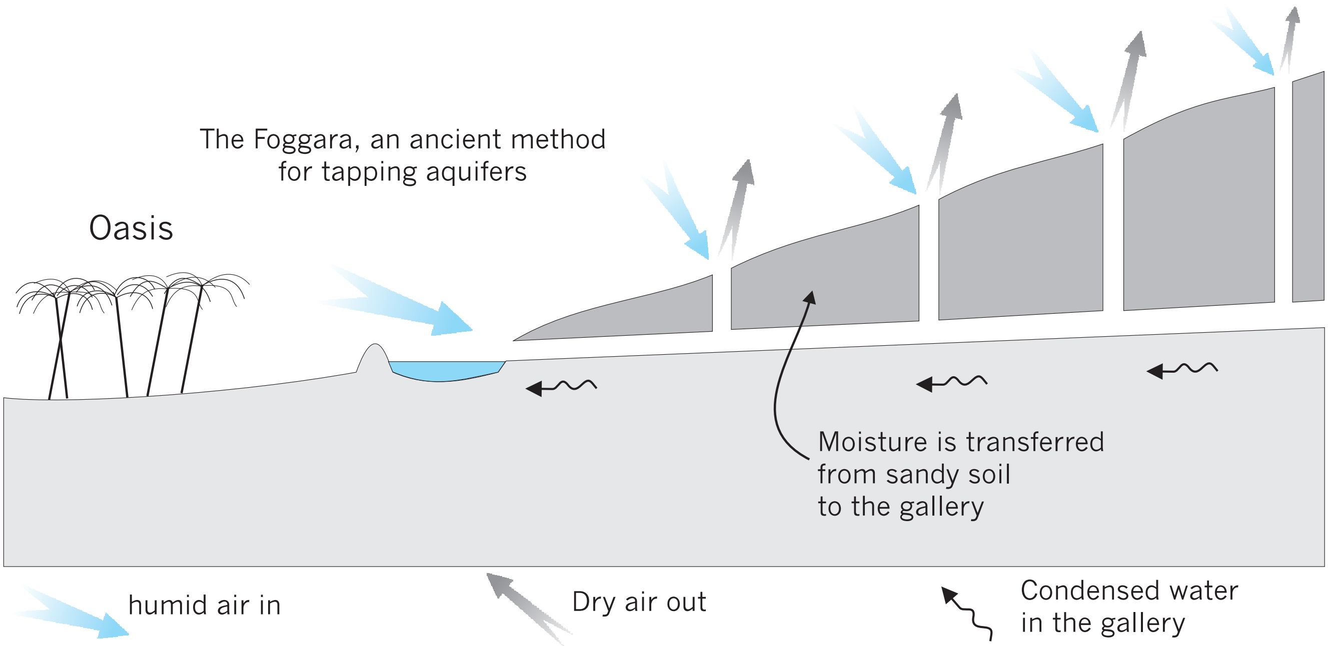
General concepts of GW modeling

Preparing technical reports

Software application for well tests

Laws and regulations for the professional career

During field trips students had to program and perform pumping tests with proper instrumentation (water level logger, conductivity meter, w.l. meter, pump)



The Foggara are spread in northern Sahara desert and well known from centuries. Gentle sloping tunnels branch off the oasis and reach the soil surface via vertical shafts spaced 10-20 m. The Foggara makes use of the strong gap in temperature between day and night together with the scarce humidity in the low air layers around the oasis.
Humid air surrounding the palm trees is sucked again through the main tunnel and the shafts towards the hot surface during the day. At night the lower temperature outside reverse the air stream, increasing the condensation in the tunnel and shafts.

2007-2008, hydrogeological study of a karst aquifer (Veneto)

Client/Partner: ATS, water work authority Montebelluna (TV); eng. R. Durigon

Position: consultant in charge of the project

Area: Follina, Cison, Miane, Mel (TV-BL)

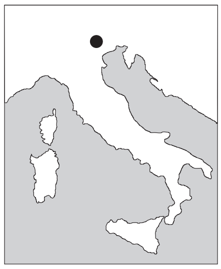
The ATS has set up many projects for the protection of ground water points (sources and wells) and optimization of the distribution pipes. The area of investigation is characterised by a rough environment and limestone formations.

The elevation ranges form 200 to 1200 m (asl). To set up future abstractions, aim of the study was to calculate the ground water potential and the aquifer vulnerability.

This was accomplished by:

- water point inventory
- geological and hydrogeological field mapping
- a preliminary hydrogeological balance
- listing of potential pollution areas

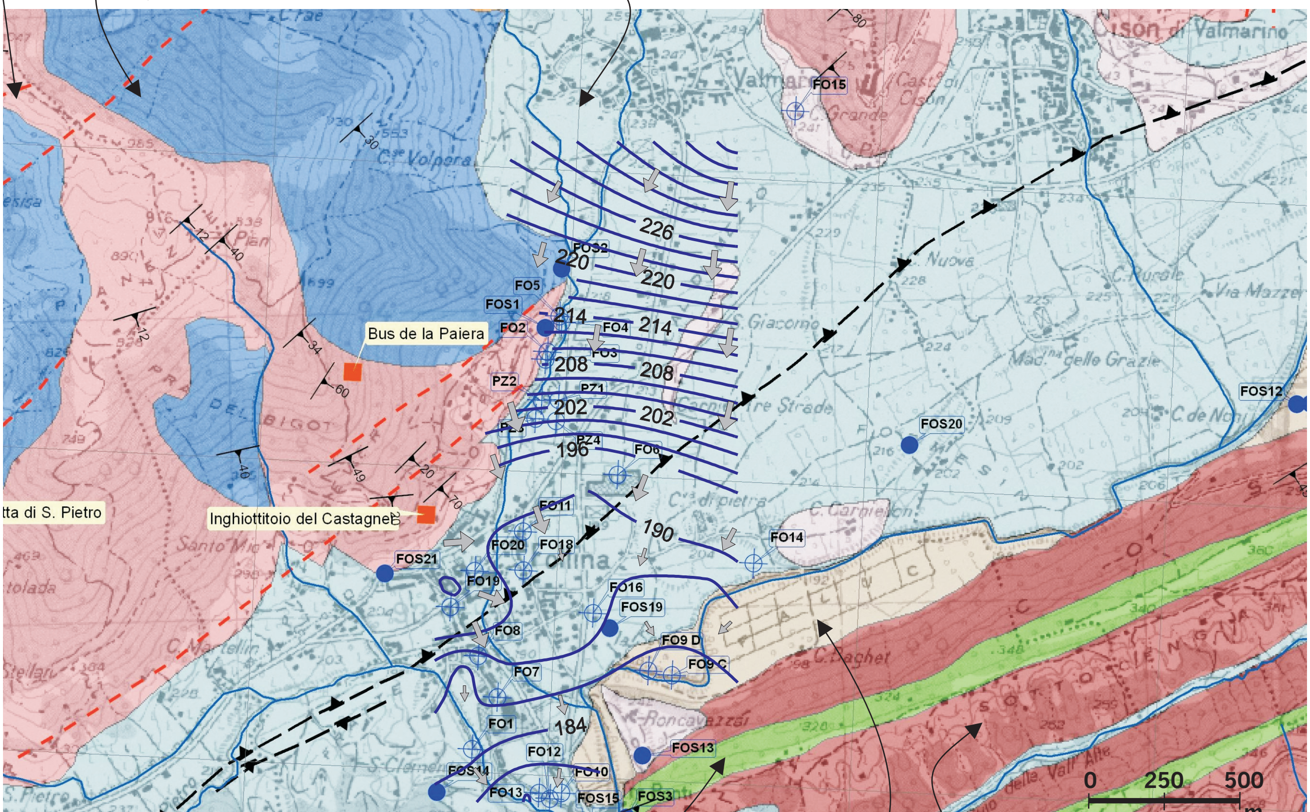
Researches have been carried out on one year period



Vertical electrical soundings (VES) for the reconstruction of bedrock morphology along valley bottom

giving informations on the most important recharge and discharge areas. Following the preliminary data, the karst aquifer can supply 300-500 lt/s , while the porous aquifer of the valley 200 lt/s, even during dry periods. To improve the results of the study we set up a 6 months monitoring program for the main springs and aquifer tests on the wells of the valley bottom.

Below: *Hydrogeological map and piezometric map (referred to the valley bottom). The whole area is 60 sqkm and has been mapped at 1:25000 scale. Rock formations range from Giurassic to Quaternary and are mainly limestones and cherty limestones. The blu contour lines show a recharge area near Fo19 and an abstraction area near FO9D.*



2004-2005, Surface to gw relations due to deep excavations

Client: Cava Verginese srl, Conegliano, TV

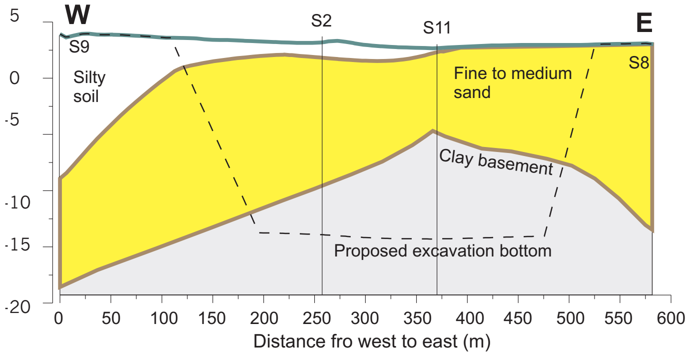
Reference: ing. R. Tonon

Role: consultant

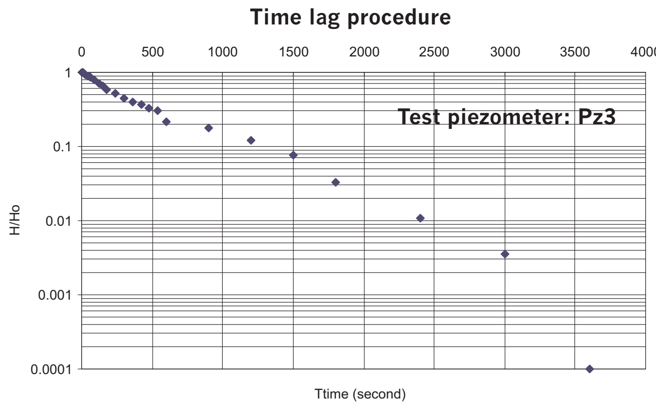
Area: Runco di Portomaggiore, FE

This is a feasability study for a sand quarry located on a low plain area, along an abandoned meandering stream. The excavations have an extension of 80000 sqm, with a total depth of 17 m. Water table is 1 m below surface. One main concern was the evaluation of lateral effects on a nearby irrigation channel and some civil buildings. To avoid any possible consequence and choose an appropriate excavation method we performed an accurate stratigraphic reconstruction down to 20 m and several field tests (slug, pumping type).
A monitoring program with water level transducers allowed to evaluate the natural variations.
Various piezometric maps were set up during one year period, giving additional clues to the hydrogeological parameters and aquifer geometry.
When all data were collected and interpreted it was possible to set up a 2D numerical model. The investigations led us to find that due to the particular strong heterogeneity of of the deposits the supposed water table lowering during works, was strongly

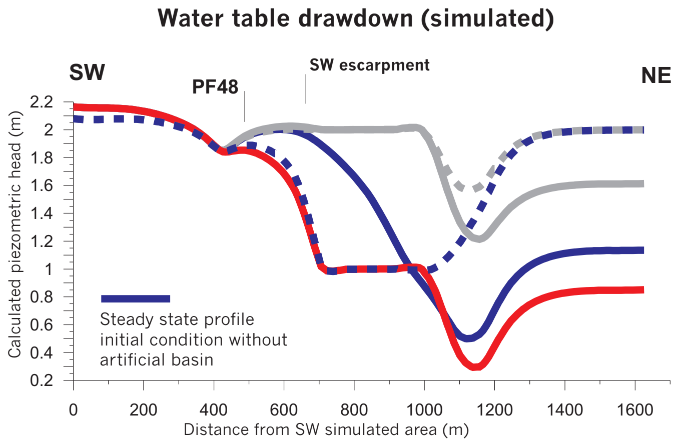
Aerial view of the proposed area (red line). To the left the Medelana channel and below the Runco village. The tree lined road follows almost exactly the ancient meandering stream (view from west to east)



***Above:** geologic profile to show the calculated ore volume (fine sand) The total amount was obtained through a detailed survey at the surface, combined with 30 stratigraphic logs*



***Above:** field curve obtained from a falling head test (time lag procedure); the test is performed into a piezometer, to calculate a reasonable value for the hydraulic conductivity*



***Above:** an example of the results of the gw modeling exercise. The different curves show the variations of the piezometric surface at steady and transient state.*
The grey line is the natural water table. The red line is the surface level with 1 m drawdown at stedy state, while the dotted blue line is at transient state.
Pf48 is a monitor well, drilled near an artificial structure to record any ground settlement.