LIFE PHOENIX:
Project updates and implementation of forecast tools to support decision-making

Roberto Lava, Giovanni Onofrio **ARPAV (Italy)**

ENSOR online, 18 May 2020
International workshop Emerging policy challenges on New Soil contaminats

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AIM OF LIFE PHOENIX

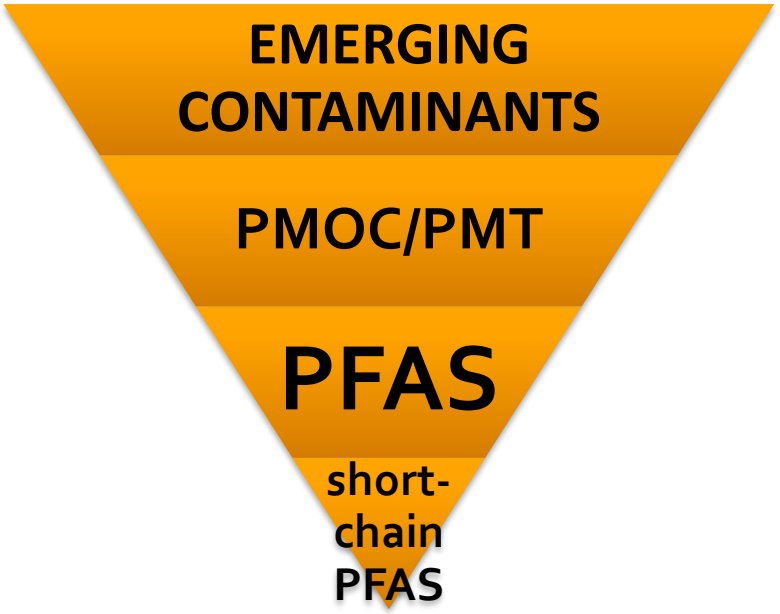
LIFE Programme
Total budget: 2.176.493 €
End Project: March 2021

Innovative interinstitutional governance system for managing risks related to the diffusion of emerging contaminants in the environment

- **PMOC → PMT**
  focus on **short-chain PFAS** (C_4 – C_6)

- supported through **INNOVATIVE FORECAST TOOLS** and **MITIGATION ACTIONS**

- this system will help **to avoid or at least reduce public expenditure** on damages caused by persistent emerging pollutants
  (environment → human health)



prompt, effective, efficient action

Perfluorinated compounds HOlistic ENvironmental Interinstitutional eXperience

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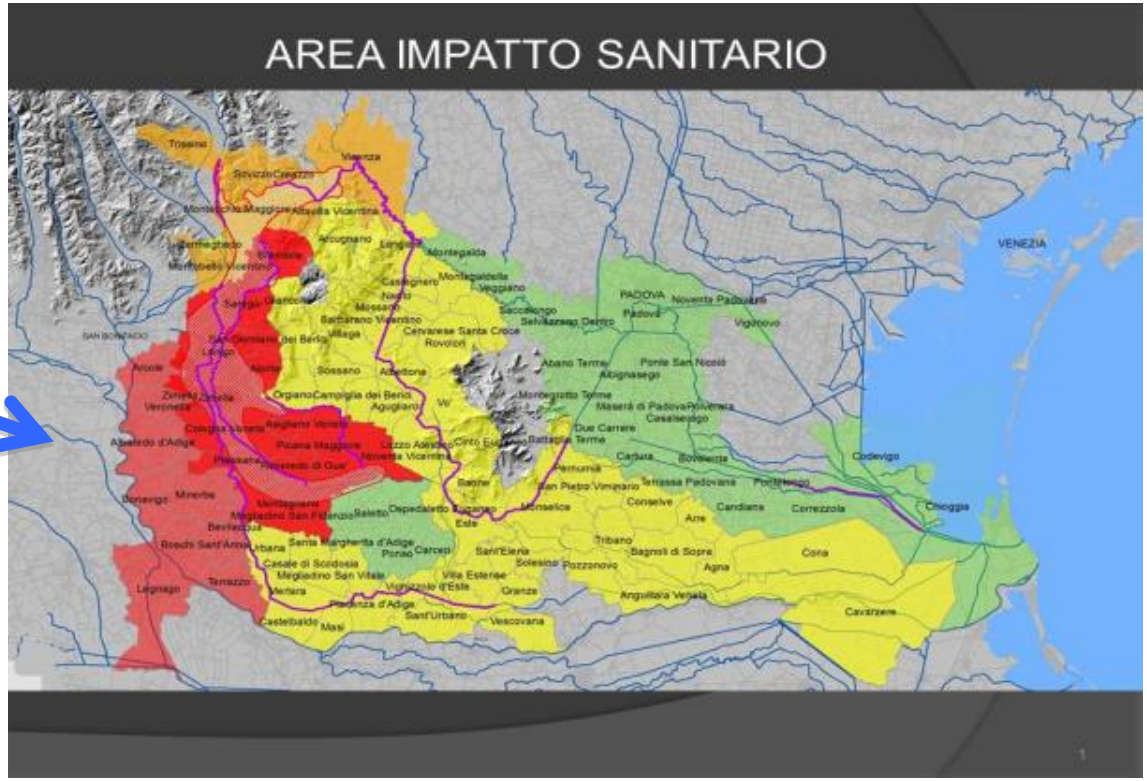

Estimation of 350000 people exposed to the contamination (930 km²)

Research

A Section 508–conformant HTML version of this article is available at https://doi.org/10.1289/EHP5337.

Serum Levels of Perfluoroalkyl Substances (PFAS) in Adolescents and Young Adults Exposed to Contaminated Drinking Water in the Veneto Region, Italy: A Cross-Sectional Study Based on a Health Surveillance Program

Gisella Pitter,[1] Filippo Da Re,[2] Cristina Canova,[3] Giulia Barbieri,[3] Maryam Zare Jeddi,[3] Francesca Daprà,[4] Flavio Manea,[4] Rinaldo Zolin,[5] Anna Maria Bettega,[5] Giampaolo Stopazzolo,[5] Silvia Vittorii,[5] Lorena Zambelli,[6] Marco Martuzzi,[7] Domenico Mantoan,[8] and Francesca Russo[2]

[1]Screening and Health Impact Assessment Unit, Azienda Zero—Veneto Region, Padua, Italy
[2]Directorate of Prevention, Food Safety, and Veterinary Public Health—Veneto Region, Venice, Italy
[3]Unit of Biostatistics, Epidemiology, and Public Health—University of Padua, Padua, Italy
[4]Laboratory Department—Regional Agency for Environmental Prevention and Protection—Veneto Region, Venice, Italy
[5]PFAS Team—Local Health Unit "Azienda ULSS 8 Berica", Vicenza, Italy
[6]Epidemiology, Prevention of Chronic Disorders, Screening and Health Promotion Unit—Local Health Unit "Azienda ULSS 9 Scaligera", Verona, Italy
[7]Regional Office for Western Pacific—World Health Organization, Seoul, Republic of Korea
[8]Health and Social Area—Veneto Region, Venice, Italy

Env. Health Perspectives, 2020

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PHOENIX STRUCTURE

Operative/Implementation actions:

- **B1** Organising a control and risk analysis system
- **B2** Implementing an informative and statistic system
- **B3** Technological innovation and development (Drinking and irrigation waters)
- **B4** **Innovative and integrated forecast tools to support decision-making**

Monitoring actions:

- **C1** Environmental monitoring
- **C2** Socio-economic impact

Public awareness and dissemination of results:

- **D1** Communication and dissemination to general audiences
- **D2** Communication and dissemination to technical audience and stakeholders

Project management

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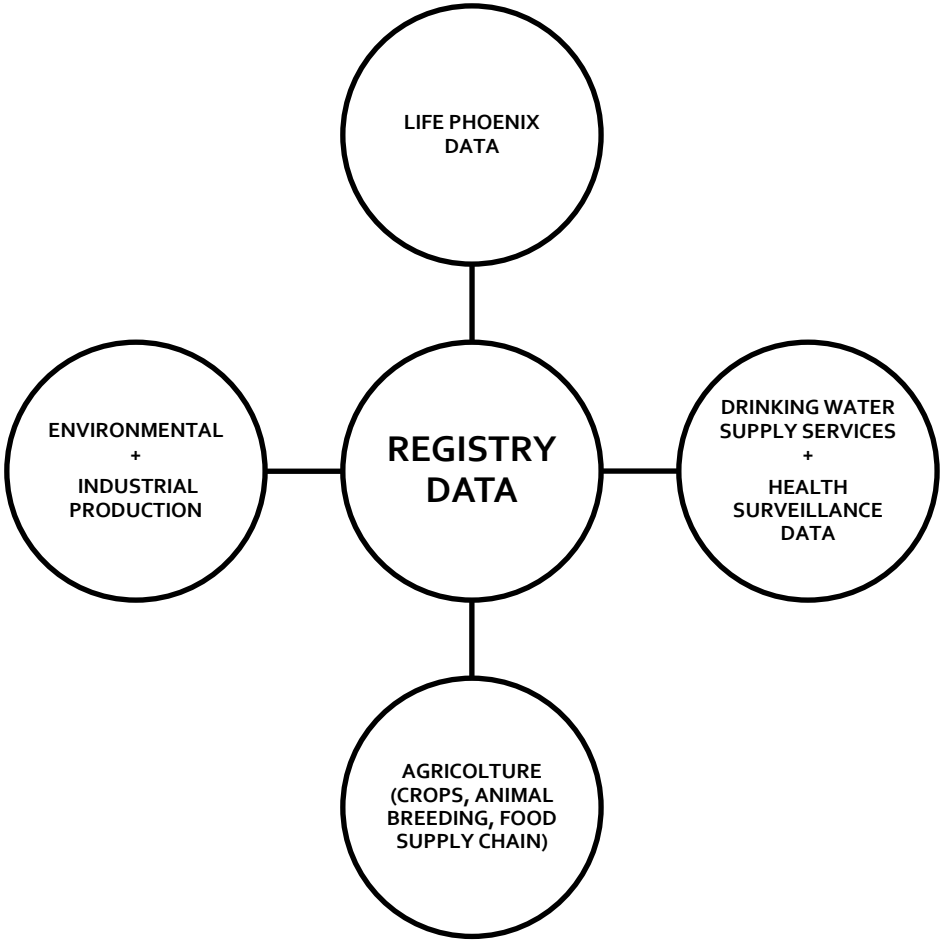
IMPLEMENTING AN INFORMATIVE AND STATISTIC SYSTEM



DATA WAREHOUSE almost implemented, SAS Iinformation Technology

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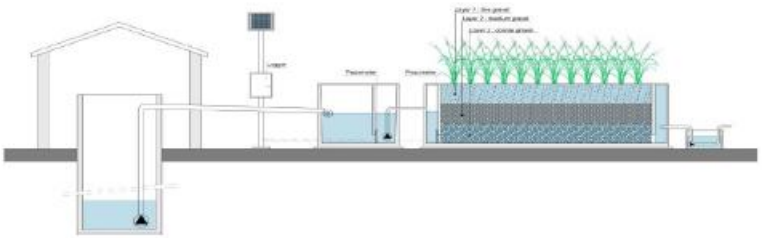
MITIGATION STRATEGIES

IRRIGATION WATER

Pilot plants based on
NATURAL SOLUTIONS

PHYTOREMEDIATION



upscale at real size → 3 different wetland systems

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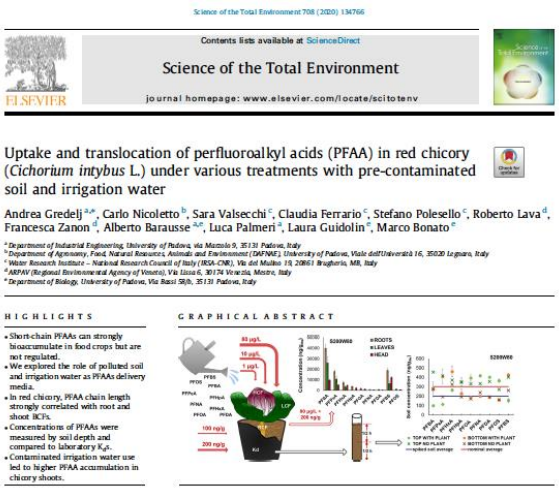
DISSEMINATION OF RESULTS

lifephoenix.eu

Uptake and translocation of PFAS in red chicory

2 peer-reviewed papers


Science of the Total Environment 708 (2020) 134766

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

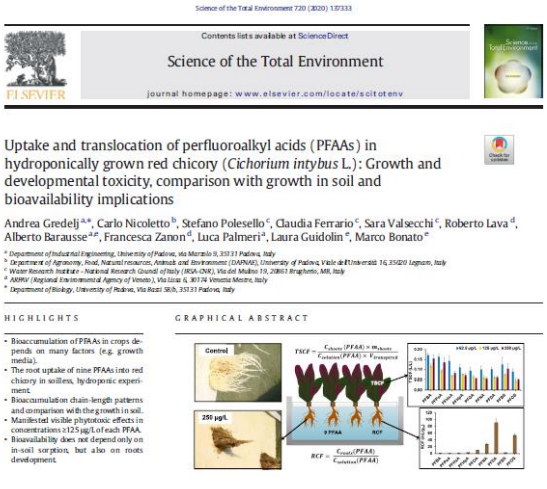
Uptake and translocation of perfluoroalkyl acids (PFAA) in red chicory (*Cichorium intybus* L.) under various treatments with pre-contaminated soil and irrigation water

Andrea Gredelj [a,e], Carlo Nicoletto [b], Sara Valsecchi [c], Claudia Ferrario [c], Stefano Polesello [c], Roberto Lava [d], Francesca Zanon [d], Alberto Barausse [a,f], Luca Palmeri [a], Laura Guidolin [a], Marco Bonato [e]

HIGHLIGHTS

- Short-chain PFAAs can strongly bioaccumulate in food crops but are not regulated.
- We explored the role of polluted soil and irrigation water as PFAAs delivery media.
- In red chicory, PFAA chain length strongly correlated with root and shoot BCFs.
- Concentrations of PFAAs were measured by soil depth and compared to laboratory K_{oc}.
- Contaminated irrigation water use led to higher PFAA accumulation in chicory shoots.

GRAPHICAL ABSTRACT


Science of the Total Environment 720 (2020) 137333

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Uptake and translocation of perfluoroalkyl acids (PFAAs) in hydroponically grown red chicory (*Cichorium intybus* L.): Growth and developmental toxicity, comparison with growth in soil and bioavailability implications

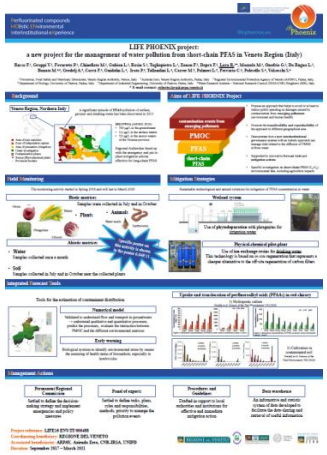
Andrea Gredelj [a,*], Carlo Nicoletto [b], Stefano Polesello [c], Claudia Ferrario [c], Sara Valsecchi [c], Roberto Lava [d], Alberto Barausse [a,e], Francesca Zanon [d], Luca Palmeri [a], Laura Guidolin [a], Marco Bonato [e]

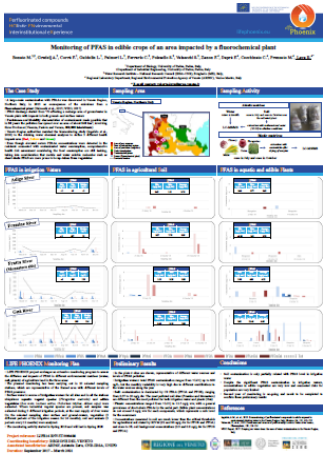
HIGHLIGHTS

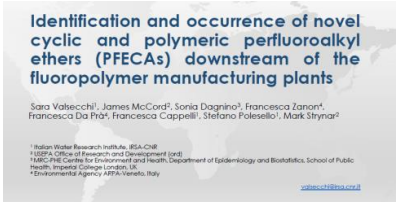
- Bioaccumulation of PFAAs in crops depends on many factors (e.g. growth media).
- The root uptake of nine PFAAs into red chicory in soilless, hydroponic experiment.
- Bioaccumulation chain-length patterns and comparison with the growth in soil.
- Manifested visible phytotoxic effects in concentrations ≥125 μg/L of each PFAA.
- Bioavailability does not depend only on in-soil sorption, but also on roots development.

GRAPHICAL ABSTRACT

environmental monitoring (edible crops impact) + study on cC6O4







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ACTION B.4:

Innovative and integrated forecast tools to support decision-making

Action B.4.1:

Production and validation of the flow and transport numerical model

Working Group ARPAV
Massimo Mazzola, Giovanni Onofrio, Matteo Cultrera

REGIONE DEL VENETO
arpav Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto
REGIONE DEL VENETO AZIENDA ZERO
IRSA CNR
UNIVERSITÀ DEGLI STUDI DI PADOVA

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Presentation Overview:

- Brief Overview about Area of Interest and the Model Domain Delineation;
- The Hydro-geological Conceptual flow Model and its implementation;
- Groundwater Recharge (Infiltration Rate);
- Groundwater Withdrawals;
- Hydrostratigraphic Units Delineations;
- The Groundwater calibration process and its outcomes;
- Transport model highlights (Work in progress)

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Area of Interest and Model Domain

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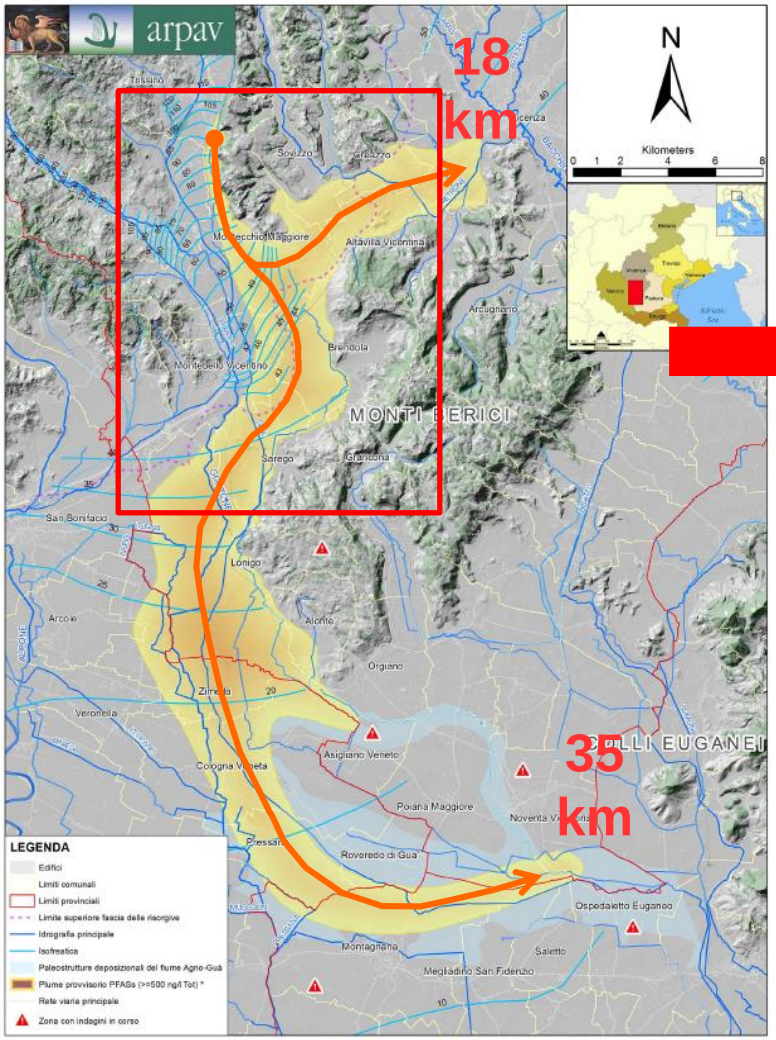

- **Pollution processes involved more than 40 years in the whole water cycle;**
- **ARPAV has been studying it since 2013;**
- **Effective emergency management, applying groundwater modelling, result in a better outcomes on a scale of 100 km2;**

fig. 1: study area

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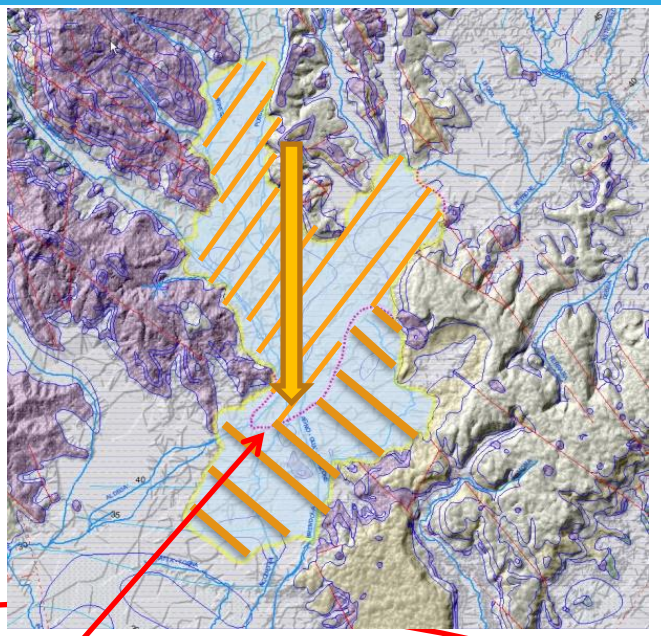
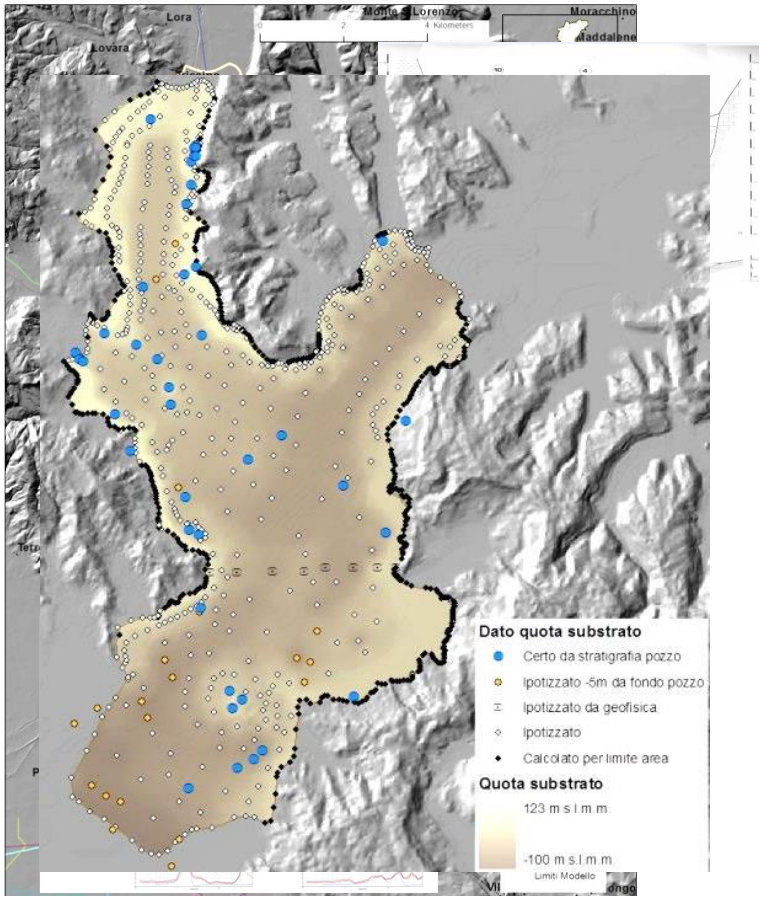
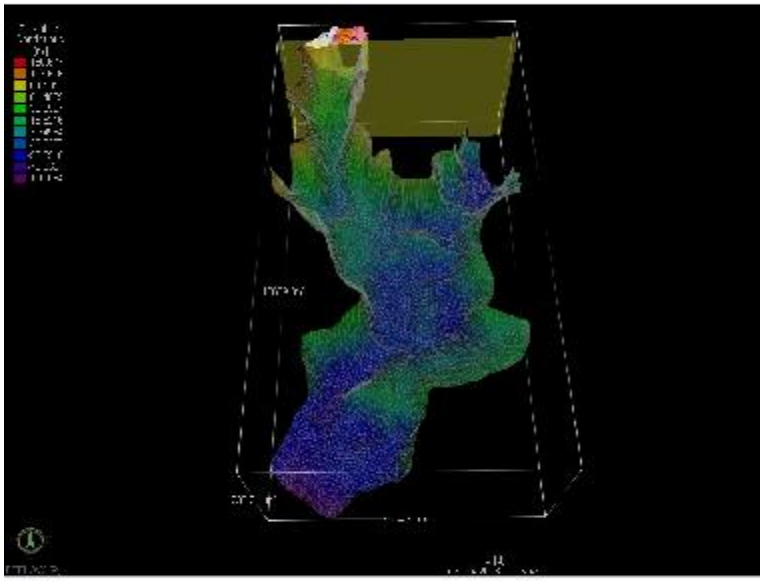
Alluvial aquifers in the high and medium plain



GEOLOGICAL DATA

A very extensive data collection from different databases and studies (Antonelli 1993; IRSEV 1979, GIADA project 2005-2010) allowed the definition of a three-dimension geological model. Moreover, data collected from public department supported the overall database (Geni civili, Distretto Alpi Orinetali). In addition, a geophysical survey has been performed. When the geological data was not available, the sequence stratigraphies were hypothesized and interpreted.





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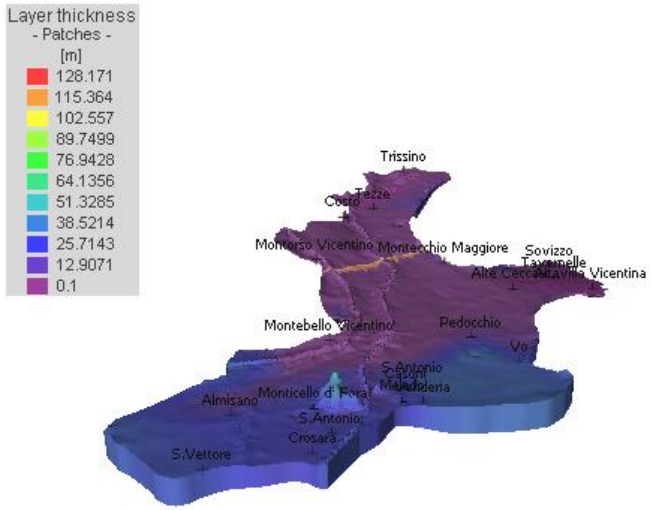
3D GEOLOGICAL CONCEPTUAL MODEL

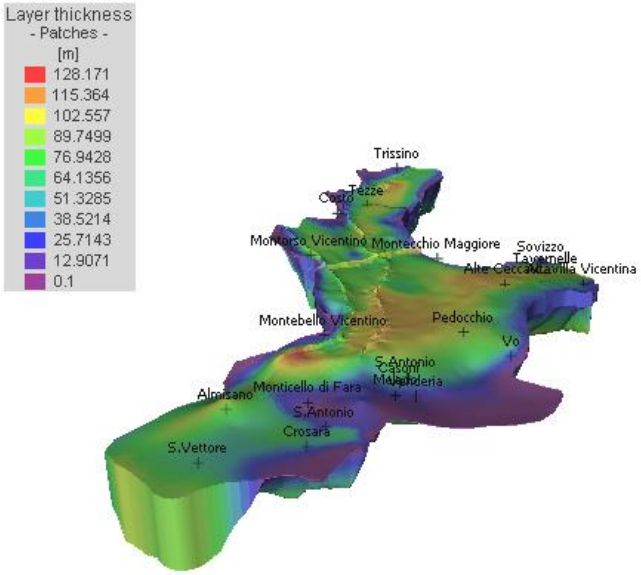
- 2 LAYERS -

The porous aquifers was simplified in two distinct layers.

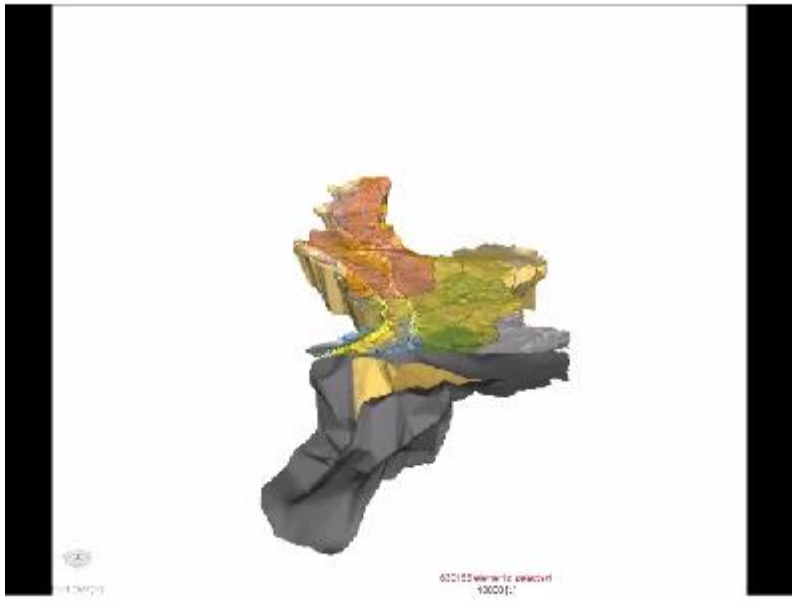
Layer 1: The first represents the total clay thickness under the spring wells which is thicker in the low plain (Top Figure);

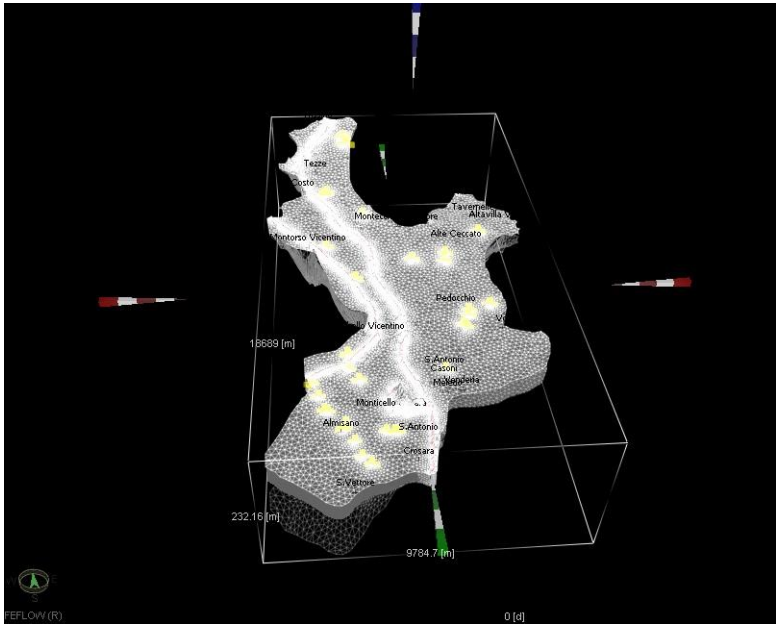
Layer 2: The second one represents the porous layers such as gravels and sands sediments, which are merged in one level across the whole domain; (Bottom Figure);





2 LAYERS – 3D MODEL





***Area* : 93.8 km²**
***Volume*: 6.8 Km³**

Undiferenziated Aquifer (North of the spring wells in gold color):

- Magnitude thickness range: average of 60 m with values that can reach 100 meters in the center of the valley and becoming thinner and thinner toward borders domain according to the original fluvial deposition ;

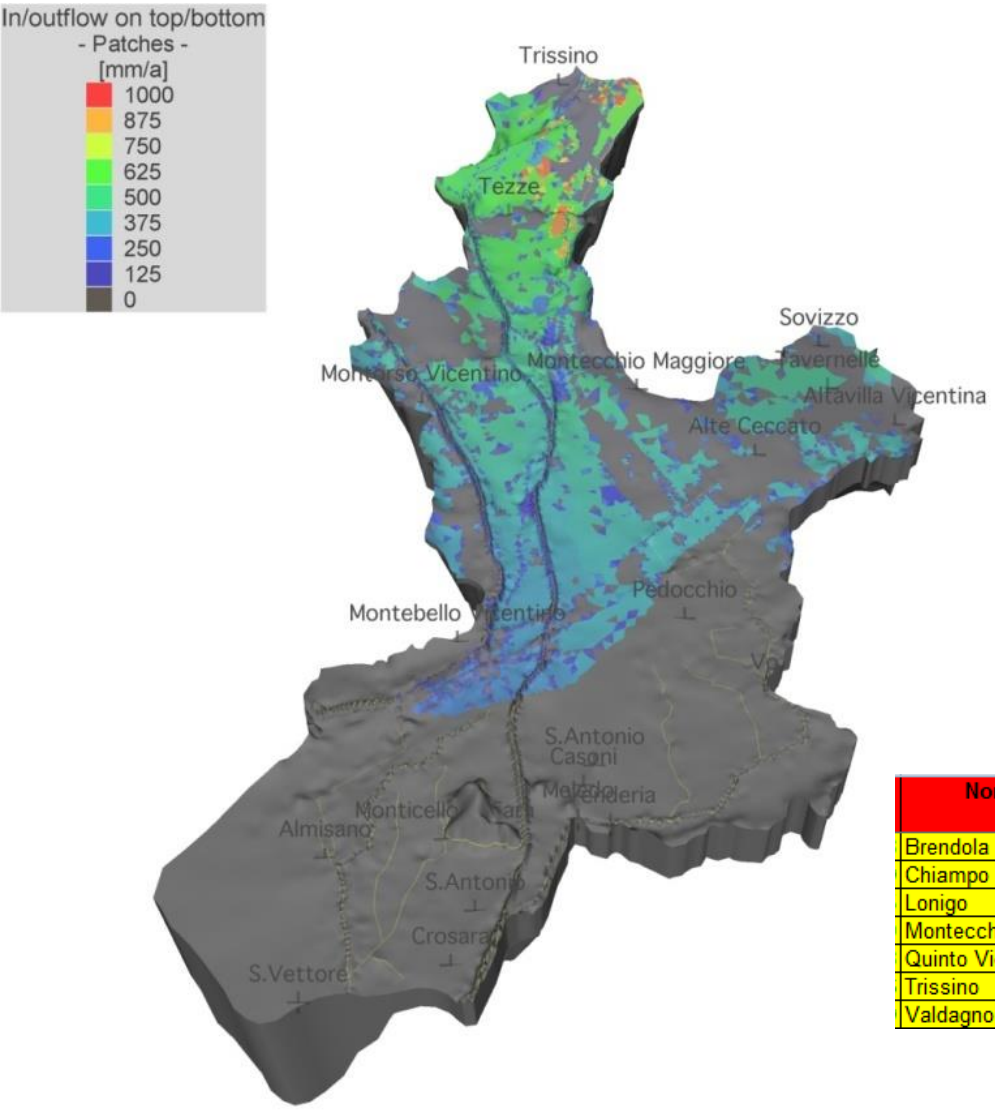
Aquifers in the south of the spring gray color:

- Total Thickness Range : in about 50 - 60 m

Mesh	
Number of Dimensions	3
Nodes per Element	6
Element Type	Triangle prism
Mesh Elements	360,540
Mesh Nodes	271,413

Mesh Quality	
Interior Holes	0
Obtuse-angled triangles	0.0% > 120°, 5.1% > 90°
Delaunay-violating triangles	0.1%

GROUNDWATER RECHARGE (Infiltration Rate)



- The infiltration rate was obtained indirectly by the run-off coefficient, **estimated by Kennesey methodology that extracts the run-off** coefficient as sum of 3 physic components: permeability, acclivity, vegetation cover;
- 7 rain-gauge stations (average of the last 10 years);
- Keep in account the kind of Irrigation over the model domain (Sprinkling or flooding);
- the infiltration rate has been estimated equal to zero in urban areas and below the spring belt system ;
- To sum up: The effective infiltration varies from 0 to 1000 mm per year (See figure);
- Under Revising by *Soil Water Balance Model*;

Indici di aridità (Ia)			<25	25<>40		>40
Nome Stazione	X	Y	mmAPrec	mmAETP	Infilmm/a	Infilmm/a
Brendola	1693037	5038382	1179,9	892,5	287,4	287,4
Chiampo	1679112	5045126	1528,3	845,9	682,4	682,4
Lonigo	1686304	5029116	835,8	884,2	-48,4	0
Montecchia di Crosara	1678503	5037502	1044,4	919,8	124,6	124,6
Quinto Vicentino	1705283	5049560	1174,6	909,5	265,1	265,1
Trissino	1683986	5050040	1497,2	822,1	675,1	675,1
Valdagno	1679980	5055700	1782,4	849,5	932,9	932,9
C_p2	Media		0.12	0.16		0.20
C_p3	Buona		0.06	0.08		0.10
C_p	Elevata		0.03	0.04		0.05

GROUNDWATER WITHDRAWALS (SINGLES OR WIDESPREADS)

Groundwater withdrawals were acquired by *Giada project database (LIFE 00 ENV/IT/00184)*. Data was split in **single or widespread ones if the water pumping is** greater or no than **10 l/s** respectively.

Comune	Tipologia utilizzo				Totale (mc/anno)
	igienico e assimilato (mc/anno)	industriale (mc/anno)	irriguo (mc/anno)	potabile (mc/anno)	
ALONTE	662,256		2,002,536	315,360	2,980,152
ALTISSIMO		31,536			31,536
ARZIGNANO	126,144	12,898,224	488,808	4,667,328	18,180,504
BRENDOLA	63,072	946,080	4,399,272	1,513,728	6,922,152
CASTELGOMBERTO	94,608	126,144	141,912	409,968	772,632
CHIAMPO	157,680	8,325,504	47,304	1,261,440	9,791,928
CORNEDO VICENTINO	189,216	368,971	1,214,136	2,712,096	4,484,419
CRESPADORO	0			1,261,440	1,261,440
GAMBELLARA	1,072,224	283,824	646,488	504,576	2,507,112
LONIGO	2,838,240	2,680,560	14,168,179	15,137,280	34,824,259
MONTEBELLO VIC.NO	1,768,854	4,020,840	6,316,661	1,324,512	13,430,867
MONTECCHIO MAGGIORE	473,040	4,572,720	3,216,672	3,090,528	11,352,960
MONTORSO VIC.NO	63,072	2,175,984	1,072,224	473,040	3,784,320
NOGAROLE VIC.NO				1,261,440	1,261,440
RECOARO TERME			47,304		47,304
S. PIETRO MUSSOLINO		2,018,304		1,261,440	3,279,744
SAREGO	1,261,440	3,118,910	5,488,525	567,648	10,436,524
TRISSINO	220,752	1,595,722	867,240	1,513,728	4,197,442
VALDAGNO	94,608	1,923,696		946,080	2,964,384
ZERMEGHEDO		2,049,840	189,216	126,144	2,365,200
Totale	9,085,206	47,136,859	40,306,477	38,347,776	134,876,318

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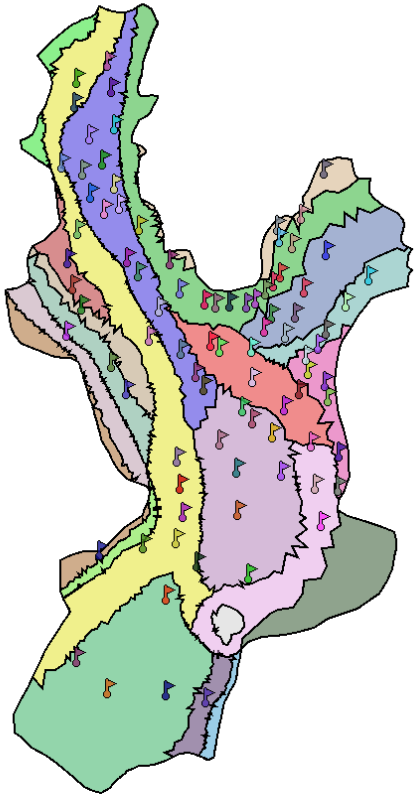
HYDRO-STRATIGRAPHIC UNITS

Hydrostratigraphic Units Delineations were chosen according to:
Old watercourses (IRSEV) - groundwater drainage axes - geological evidences (K-Pumping tests);



Hydrostratigraphic Units Delineations

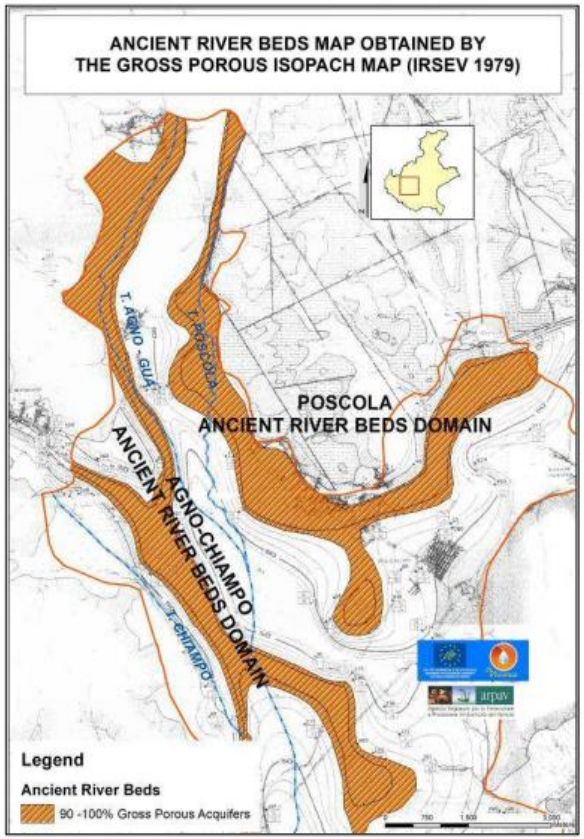


fig. 3: Map of Holocenic and Pleistocenic riverbeds obtained by the non-cohesive porous isopach maps (IRSEV, 1979).

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GROUNDWATER FLOW CALIBRATION
PRE-POST (TRIAL AND ERROR - FEPEST)

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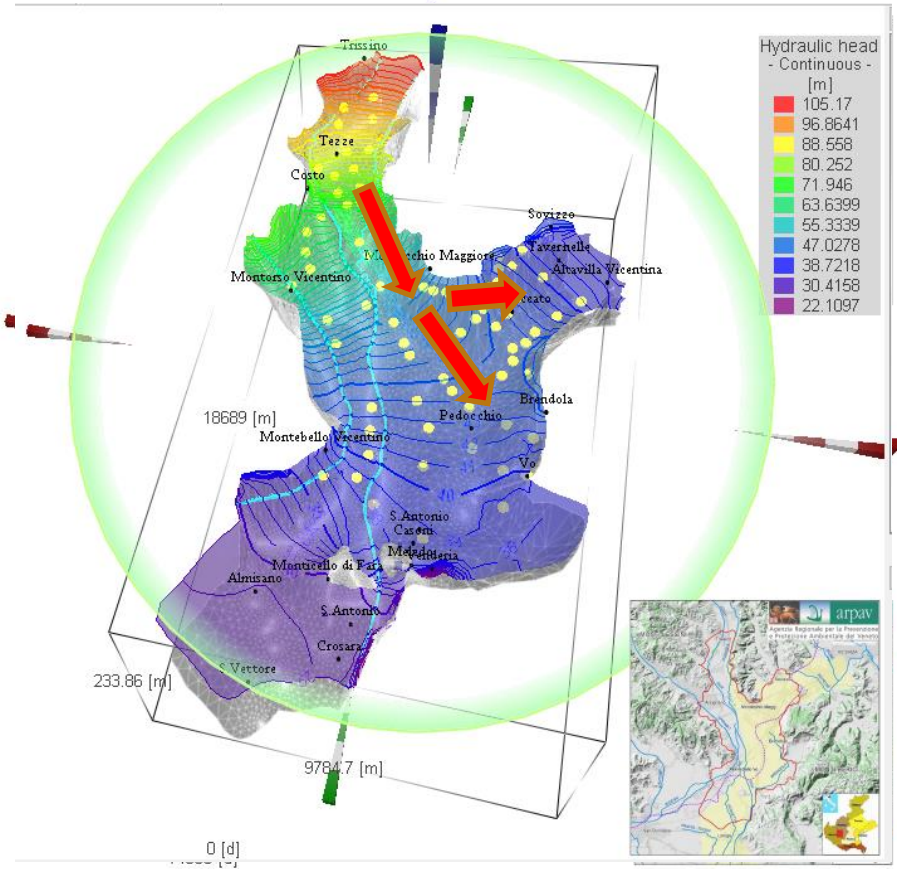

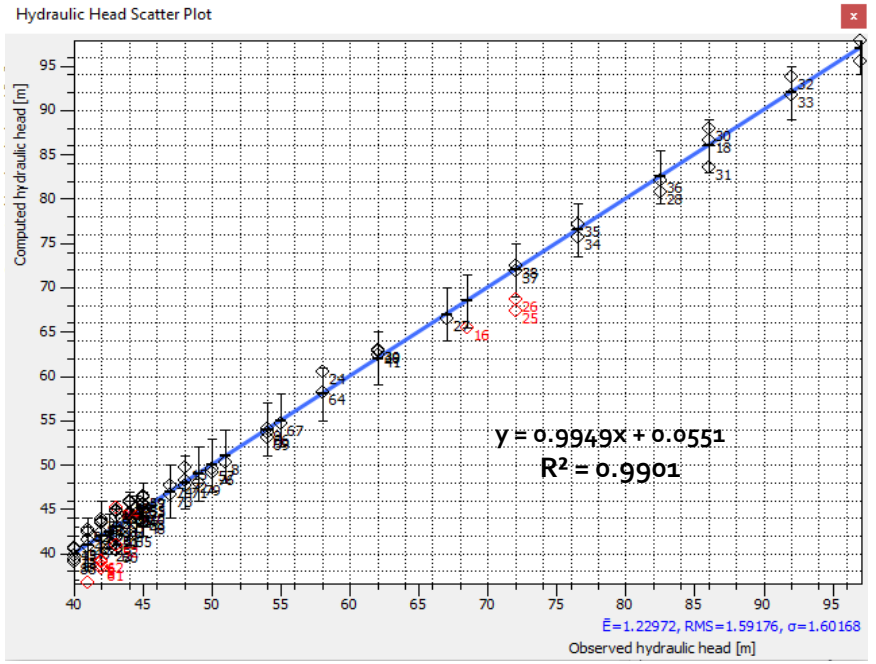

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GROUNDWATER FLOW AND ITS BALANCE

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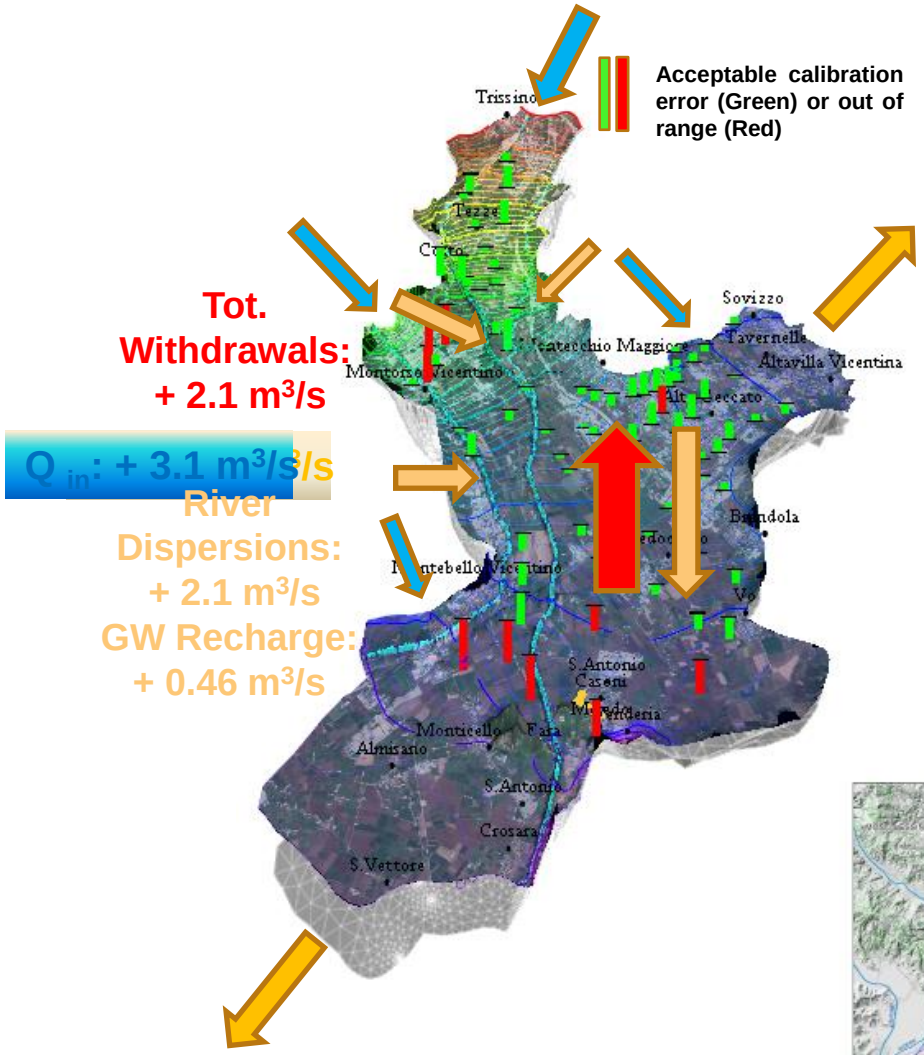

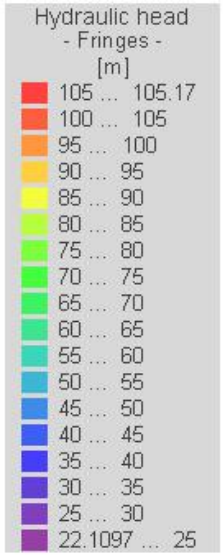

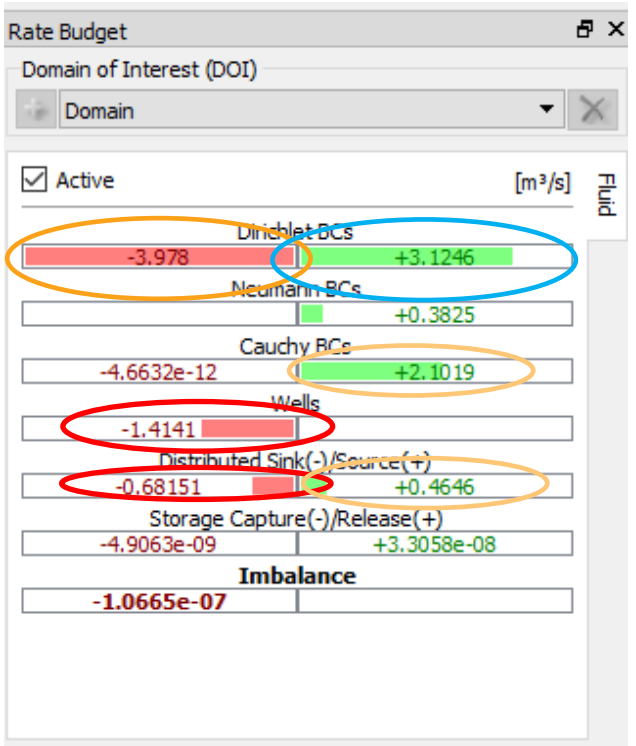

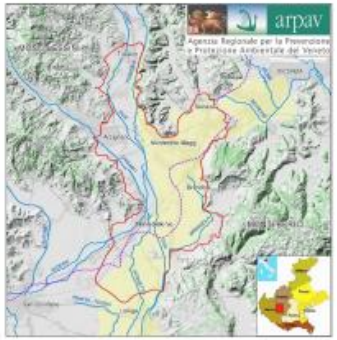

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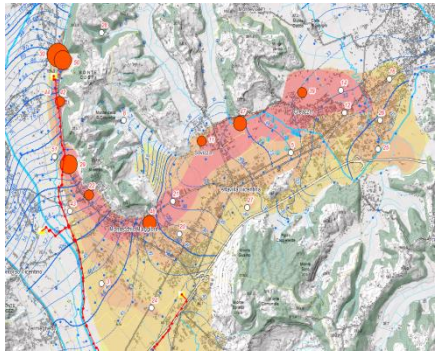
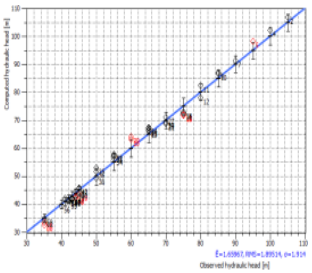
WORK IN PROGRESS…

- *Perform groundwater flow validation in extreme condition (Water scarsity…) ;*
- *Sensitivity analysis by FEPEST;*

•Develop the transport Model (Advection – Dispersion)





•Design specific predictive scenarios after a suitable calibration

- *When did the pollution start?*
- *What's the amount of contaminated mass that has been leaked in the groundwater?*
- *Why do exist different contamination plumes? (one for each PFAS species) What's kind of implication could be involved in?*
- *In which way is possible to interpret the detected concentration anomalies? (e.g. at Monticello Farra,..*
- *How long the pollution could be still present?*
- *……*

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THANKS FOR YOUR ATTENTION

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