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MAR SOL MANAGED AQUIFER RECHARGE SOLUTIONS

MONITORING WATER QUALITY IN INDUCED RIVERBANK FILTRATION: The case study of the Sant'Alessio plant (Italy)

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Managed Aquifer Recharge (MAR): a growing field in water resources management

- re-equilibrate unbalanced aquifers,
- increase water availability
- support sustainable approaches to water management

To assure safety of the MAR scheme:
geochemical and biological investigation
monitoring prior to plant set-up and during ongoing operations

monitoring the presence of emerging substances (i.e. pharmaceuticals) that could be a potential risks for the environment and humans

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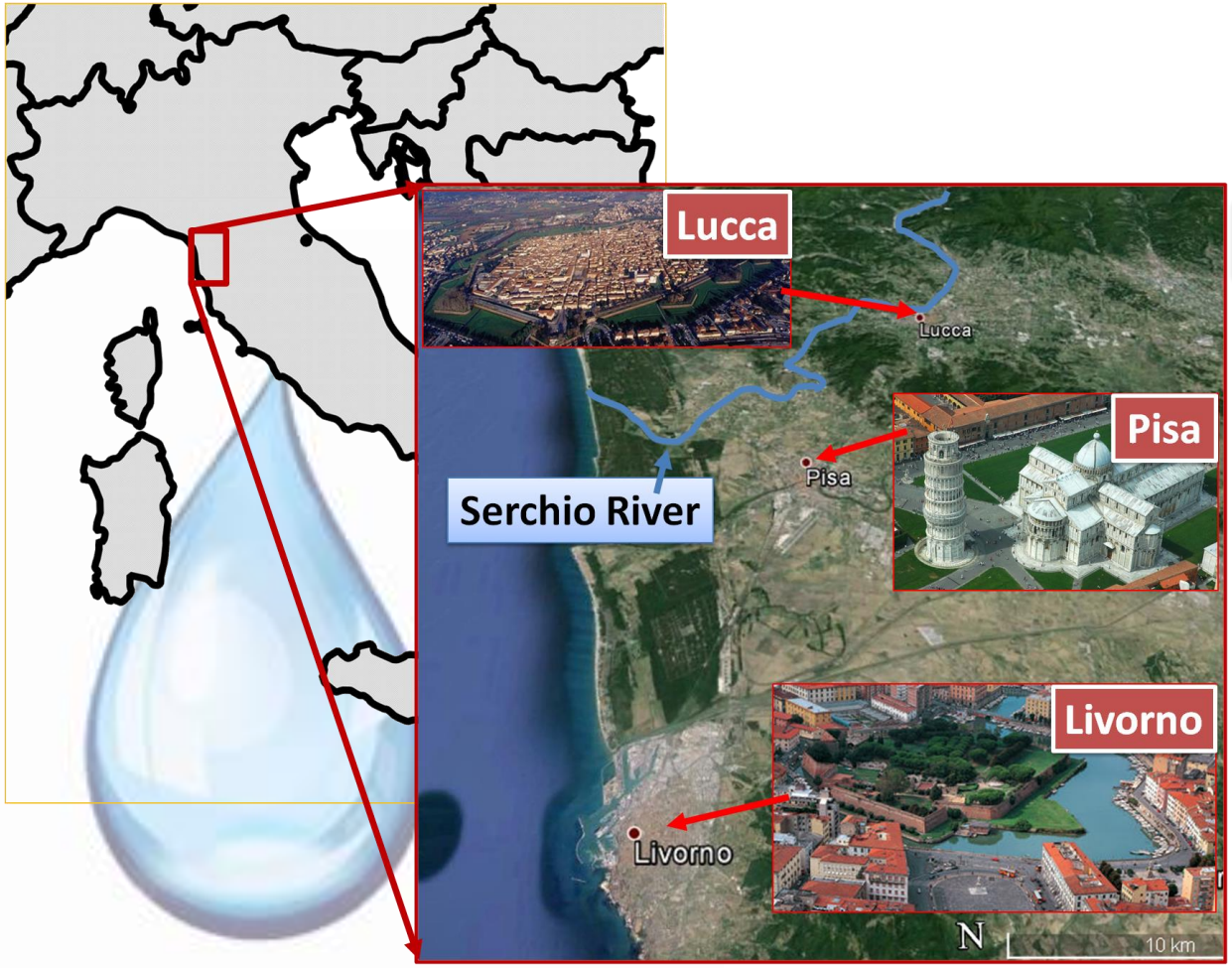
SANT'ALESSIO INDUCED RIVERBANK FILTRATION MAR SCHEME



MAR for large drinking water supply

(~ 300,000 inhabitants)

MAR worth

15 Mm³/year

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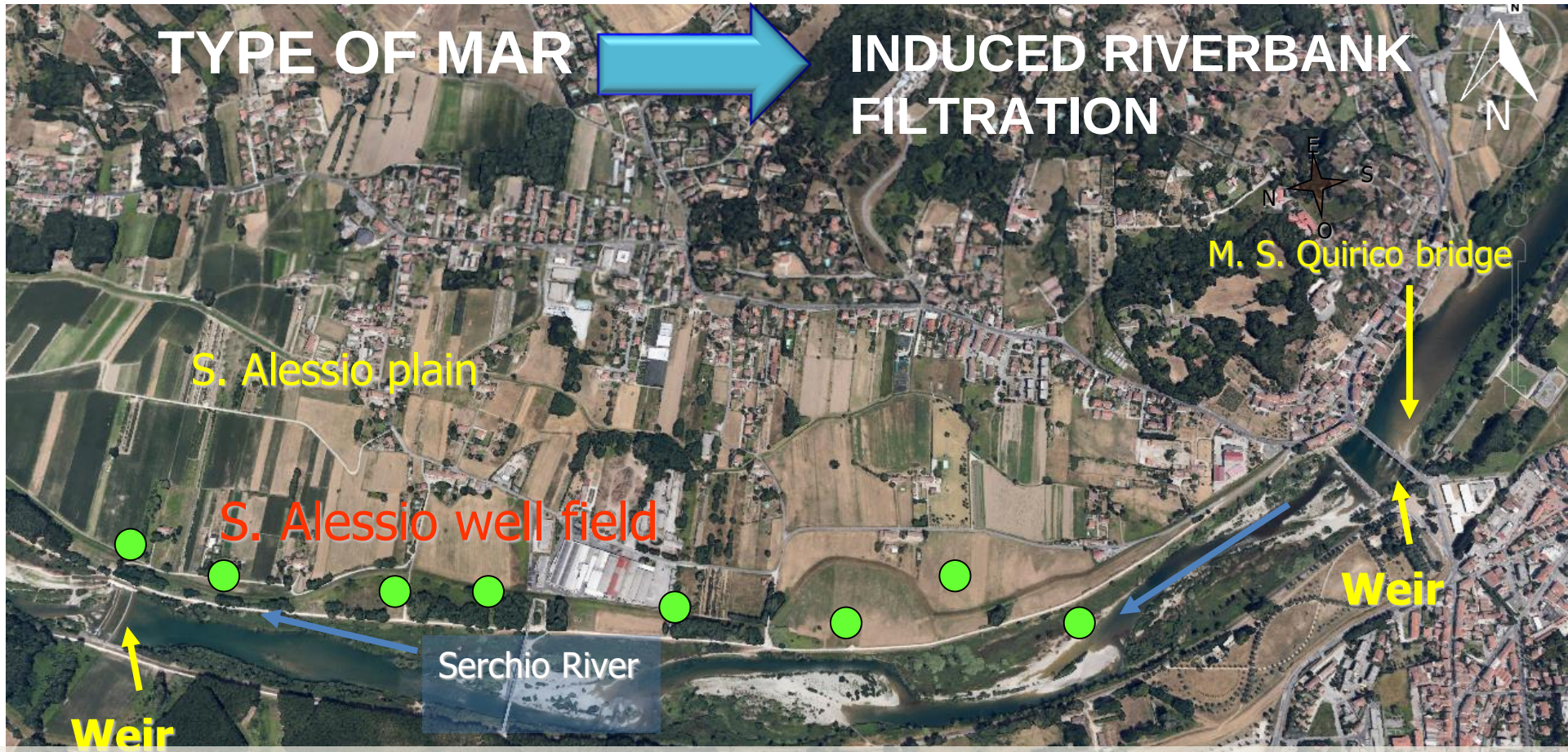
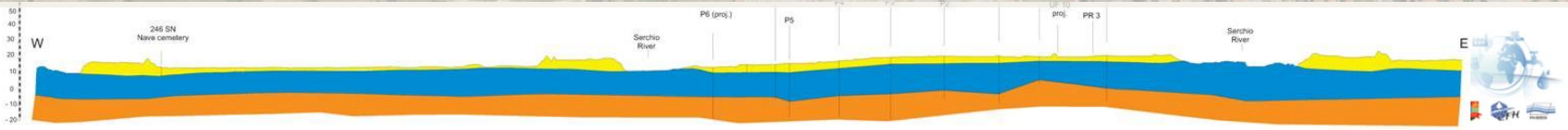
TYPE OF MAR → INDUCED RIVERBANK FILTRATION



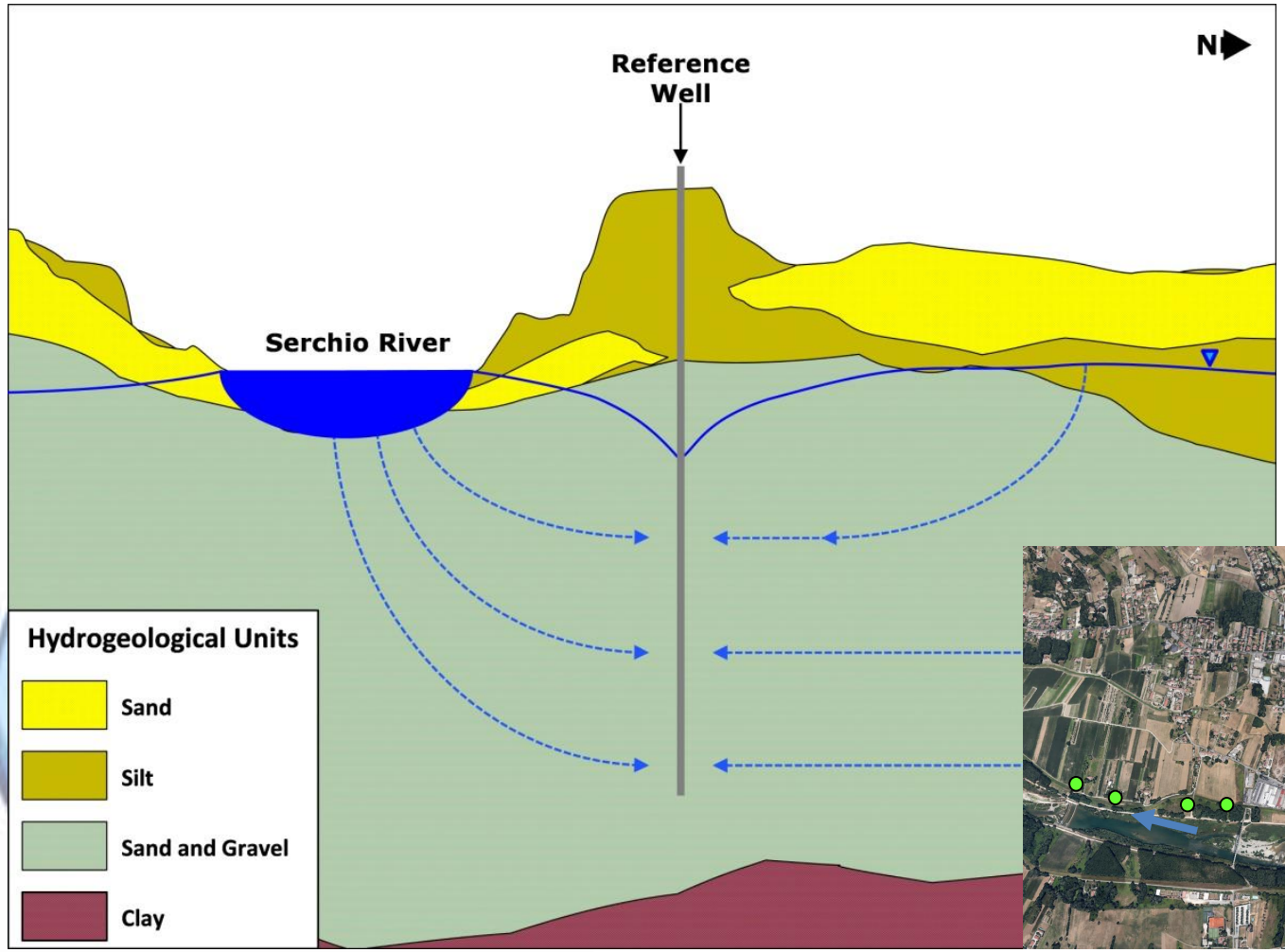
MAR plant

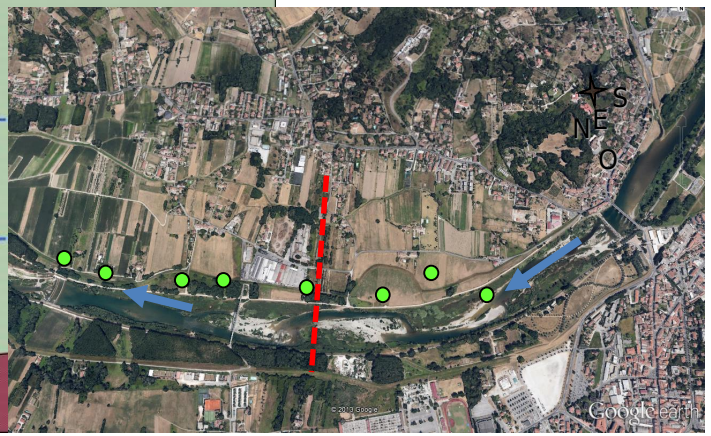
10 vertical wells

1 river weir to raise groundwater head (up to 3m) and increase aquifer storage



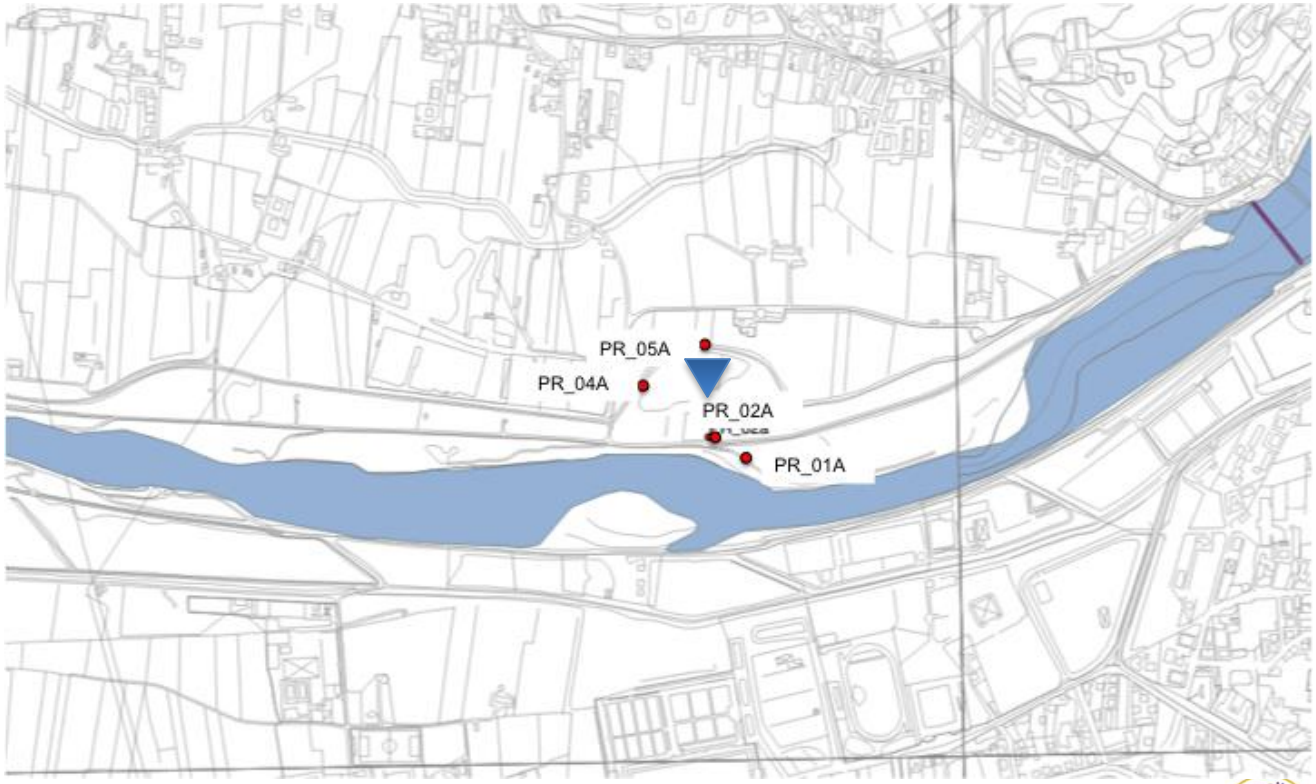
SANT'ALESSIO MAR SITE CONCEPTUAL SCHEME

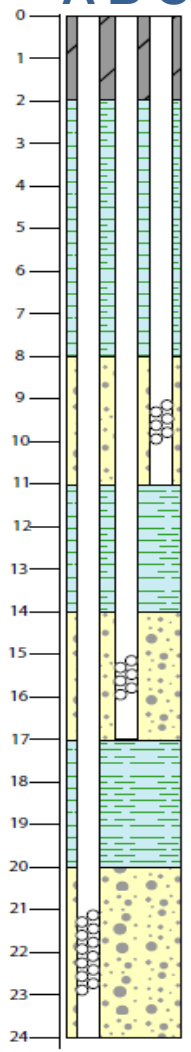




MONITORING SYSTEM: continuous acquired measurements

The designed monitoring system include **sensors** in **surface** and **ground-water**. The groundwater monitoring system consists of a set of 4 sensor in the piezometer drilled around the reference well of the Pisa-Lucca pipeline.





Acquisition and transmission of data

- Data acquired 6 times per hour (every 10 min.)
- The data aquired are then transmitted to an open geo database and can be visualized within a dedicated plug- in in Qgis
- All these is developed in an open source framework

Examples of recorded data

Data recorded at probe 1 (temperature, EC, water table level)

GW temperature (in °C)

Edit Data - MarsolPublic (93.145.196.238:5432) - dbmarsol - gw_monitor_1

File Edit View Tools Help

No limit

	idsgw_1 integer	date date	time time without	temperature real	ces real	level real
408	5440	2016-03-13	11:51:12	16.3063	414.294	11.5112
409	5441	2016-03-13	12:01:13	17.7752	423.277	11.889
410	5442	2016-03-13	12:11:13	16.8628	417.428	11.6018
411	5443	2016-03-13	12:21:13	17.2345	419.935	11.72
412	5444	2016-03-13	12:31:13	18.0625	424.949	11.9819
413	5445	2016-03-13	12:41:13	17.1331	419.099	11.6947
414	5446	2016-03-13	12:51:13	17.9611	424.113	11.9481
415	5447	2016-03-13	13:01:14	17.5758	421.625	11.7794
416	5448	2016-03-13	13:11:14	18.3949	426.65	12.0415
417	5449	2016-03-13	13:21:14	17.0298	418.276	11.6187
418	5450	2016-03-13	13:31:14	17.8659	423.3	11.8724
419	5451	2016-03-13	13:41:14	16.9445	417.857	11.5849
420	5452	2016-03-13	13:51:14	17.3199	419.951	11.7033
421	5469	2016-03-14	10:05:56	14.2352	401.93	11.1696
422	5470	2016-03-14	10:15:56	15.2432	408.472	11.5207
423	5471	2016-03-14	10:25:56	15.1516	408.064	11.4872
424	5472	2016-03-14	10:35:56	14.1893	401.521	11.1612
425	5473	2016-03-14	10:45:56	15.6862	411.335	11.6628
426	5474	2016-03-14	10:55:56	16.2818	415.423	11.8717
427	5475	2016-03-14	10:06:08	14.2199	401.521	11.1696
428	5476	2016-03-14	10:16:08	16.1902	415.015	11.8383
429	5477	2016-03-14	10:26:08	15.6251	410.926	11.646
430	5478	2016-03-14	10:36:08	14.6628	404.793	11.32
431	5479	2016-03-14	10:46:08	14.6475	404.384	11.3117
432	5480	2016-03-14	10:56:08	14.5712	403.975	11.2866
433	5481	2016-03-14	11:06:10	15.2628	408	11.4149

Edit Data - MarsolPublic (93.145.196.238:5432) - dbmarsol - temperature_gw

File Edit View Tools Help

No limit

	date date	time time without	temperature_1 real	temperature_2 real	temperature_3 real	te re	temperature_5 real	temperature_6 real
408	2016-03-13	11:51:12	16.3063	18.2817	18.2447		16.6532	18.9734
409	2016-03-13	12:01:13	17.7752	16.4909	17.9824		19.2063	17.6178
410	2016-03-13	12:11:13	16.8628	18.3847	18.3635		17.212	18.0372
411	2016-03-13	12:21:13	17.2345	19.2423	16.4406		19.1164	18.9126
412	2016-03-13	12:31:13	18.0625	18.2775	18.2769		17.1042	17.9278
413	2016-03-13	12:41:13	17.1331	19.153	16.3366		17.4995	18.3473
414	2016-03-13	12:51:13	17.9611	16.6874	18.173		18.3798	19.2227
415	2016-03-13	13:01:14	17.5758	19.1305	16.7544		17.9493	18.7879
416	2016-03-13	13:11:14	18.3949	17.1291	17.1566		18.3482	17.7942
417	2016-03-13	13:21:14	17.0298	19.0403	16.2122		17.3691	18.199
418	2016-03-13	13:31:14	17.8659	19.437	16.597		19.2909	19.1007
419	2016-03-13	13:41:14	16.9445	18.4633	17.4539		17.2603	18.107
420	2016-03-13	13:51:14	17.3199	19.3288	16.4921		17.6773	17.1133
421	2016-03-14	10:05:56	14.2352	16.8163	15.0777		17.2001	16.3133
422	2016-03-14	10:06:08	14.2199	16.7998	15.5538		17.2664	16.3808
423	2016-03-14	10:15:56	15.2432	16.2069	15.6967		17.8629	16.9712
424	2016-03-14	10:16:08	16.1902	16.2728	15.4586		16.2225	18.0172
425	2016-03-14	10:25:56	15.1516	15.1693	15.1095		17.2498	16.8869
426	2016-03-14	10:26:08	15.6251	16.9316	15.1888		17.3161	17.393
427	2016-03-14	10:35:56	14.1893	16.7669	16.2363		16.7196	15.8241
428	2016-03-14	10:36:08	14.6628	16.8328	16.5061		16.0402	17.393
429	2016-03-14	10:45:56	15.6862	15.7293	15.2364		15.6756	17.4605
430	2016-03-14	10:46:08	14.6475	15.5646	15.9982		15.5099	17.2918
431	2016-03-14	10:55:56	16.2818	16.3881	14.6492		17.283	15.959

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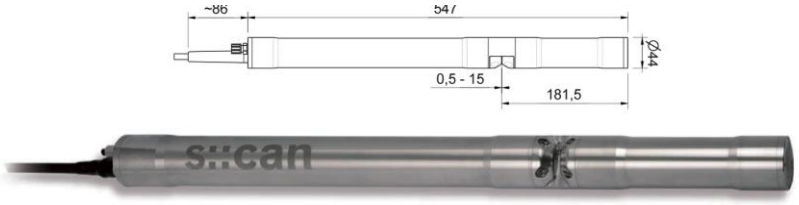
MONITORING SYSTEM: continuous acquired measurements



Spectro ::lyser™ 8 parameters

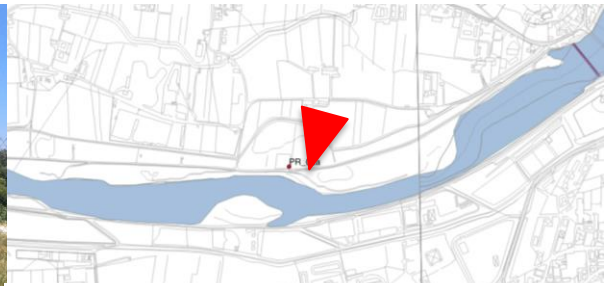
- Turbidity
- NO3-N
- TOC
- DOC
- UV254
- Color
- Temperature
- TSS

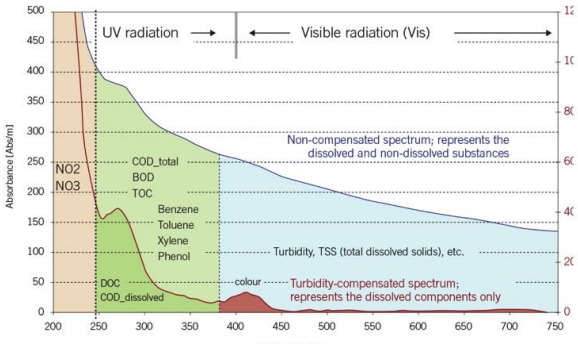
The multi-parameter probe for the detection of selected analytes was installed in the piezometer CL2A in the S.Alessio well field.
No moving parts , no reagents -> resulting in **extremely low operating costs**

long term stable and maintenance free in operation

factory precalibrated, local multi-point calibration possible

automatic cleaning with compressed air





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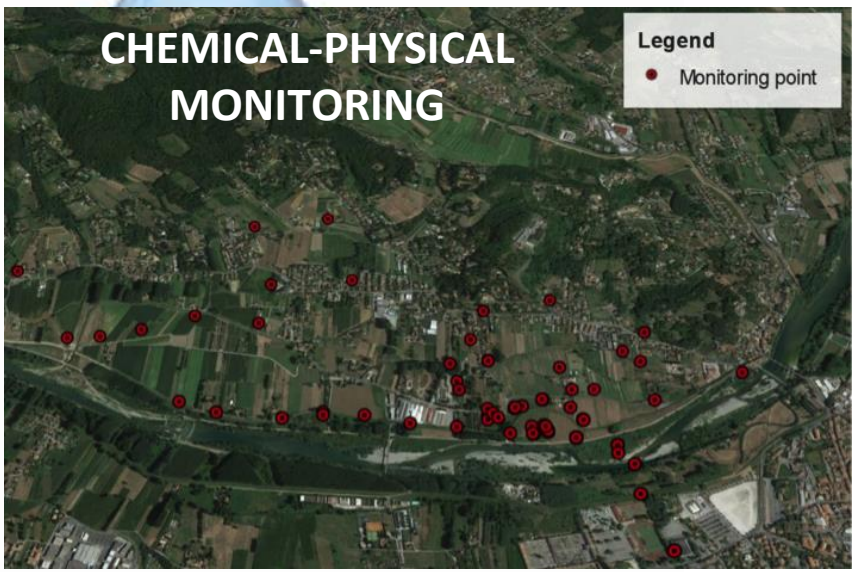
MONITORING SYSTEM: discrete sampling

- 70 points
- 12 surveys
- 6 in situ parameters
- laboratory analyses



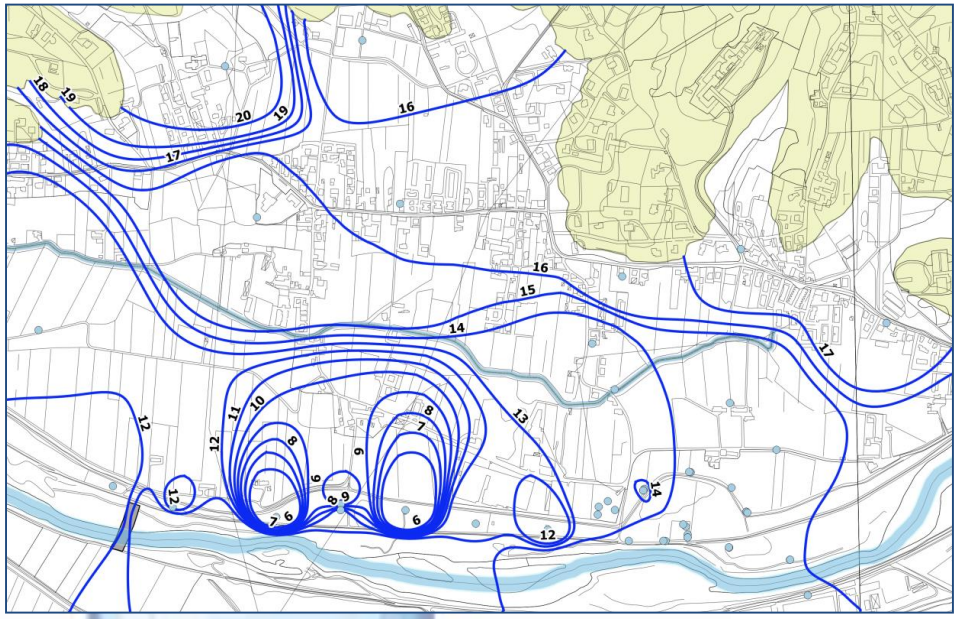
Type		n°
Surface water		4
Groundwater	Piezometer	36
	Well	15
	Pisa-Lucca pipeline	13

2014	2015	2016
November	January	January
December	February	March
	March	May
	May	July
		August
		September

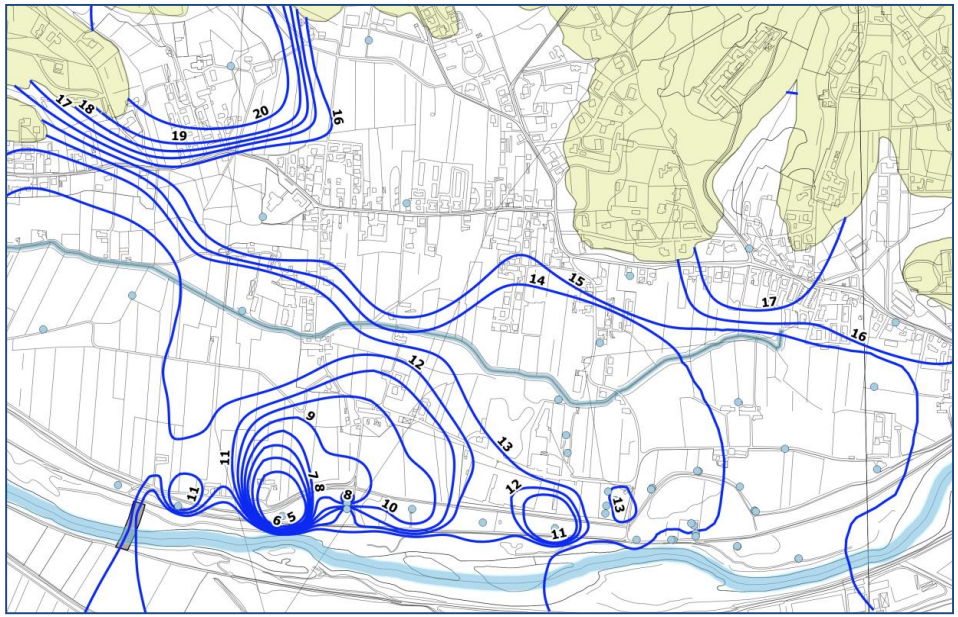
Water quality analyses
Major and trace elements
Stable isotopes ($\delta^{18}O$ and δD)
Microbiological parameters (E.Coli and Total Coliform)
Emerging contaminants

HYDRAULIC HEAD

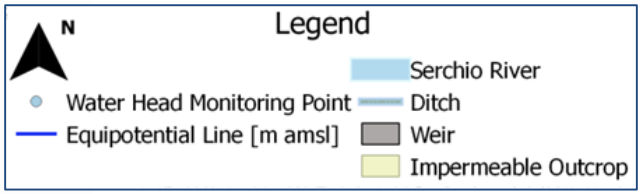
- 3 main flow directions
- no direction changes in time



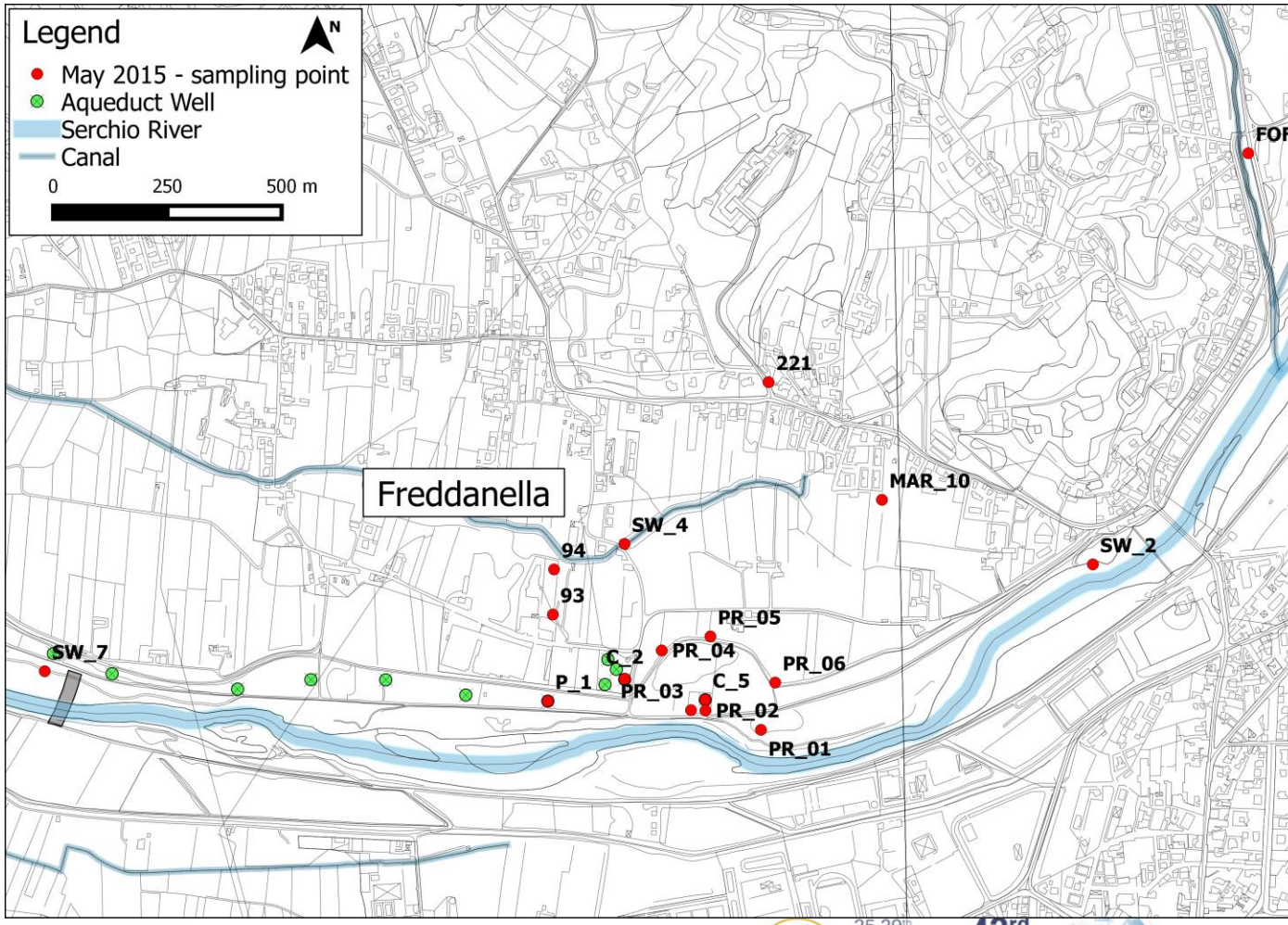
DECEMBER 2014



MAY 2015

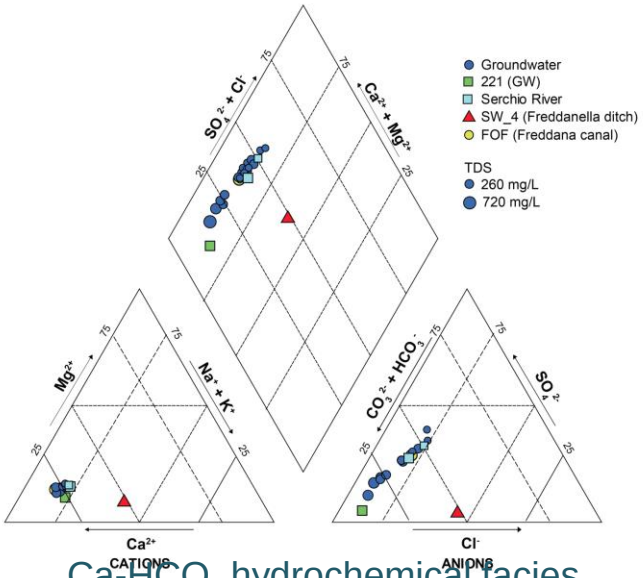


HYDROGEOCHEMICAL MONITORING

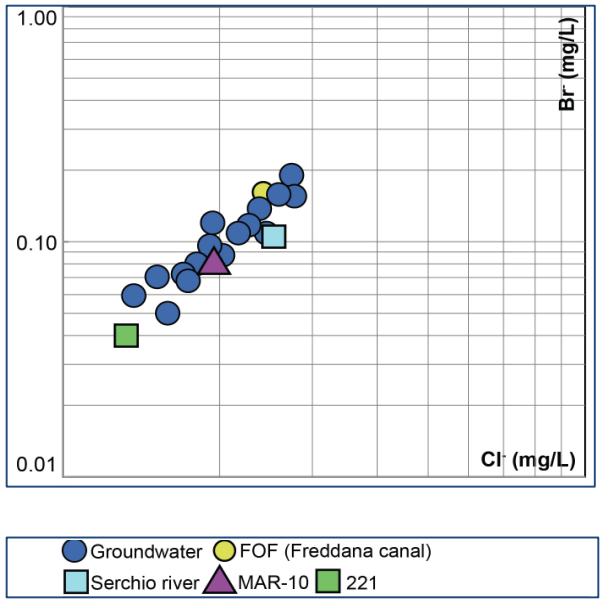


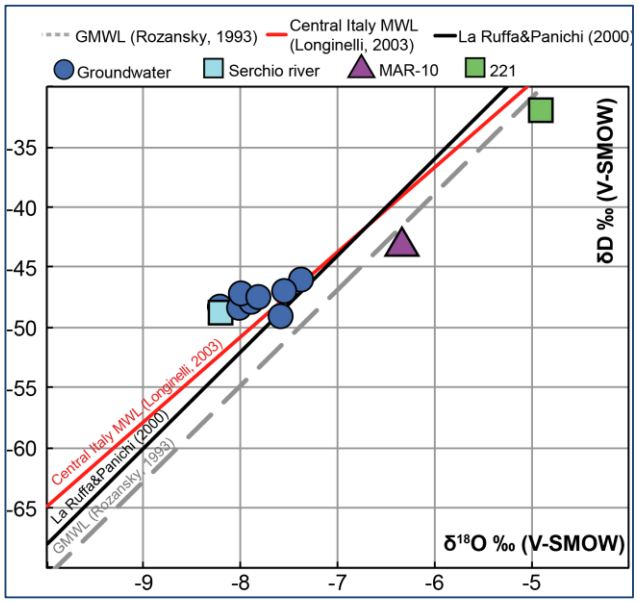
The main sources of the pumping well is the Serchio River water

The most conservative elements such as Cl^-, Br^-, and SO_4^{2-} clearly indicate mixing processes between the River Serchio water and groundwater in the pilot area.



Ca-HCO_3 hydrochemical facies





As concern the nutrient species, nitrate content ranges between 0.2 mg/L and 9 mg/L in GW samples and between 0.8 mg/L and 3.2 mg/L in the Serchio river

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EMERGING POLLUTANTS: Pharmaceuticals

- selected points in different hydrological periods
- substances included in the **EU-watch list**
- evaluation on the medicines distributed in the territory (Northern Tuscany)

	October 2014	July 2015	March 2016	August 2016	September 2016	October 2016
SW	2	4	2	1	1	*coming soon*
GW	5	2	4	6	6	*(after IAH)*

Substances (ng/L)	C5	P2	PR01_A	PR08	Serchio	SW_4
Atenololo	N.D.	N.D.	0.06	N.D.	1.23	176
Claritromicina	0.69	0.51	0.81	N.D.	6.96	222
Eritromicina	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Deidro-eritromicina	0.81	0.98	1.62	N.D.	5.91	50.7
Ibuprofene	0.70	9.02	N.D.	N.D.	2.34	35.4
Diclofenac	N.D.	N.D.	0.51	N.D.	1.59	76.9
Naproxene	N.D.	N.D.	N.D.	N.D.	1.22	342
Estrone	N.D.	N.D.	N.D.	N.D.	10.4	1.2
Estradiolo	N.D.	N.D.	N.D.	N.D.	N.D.	2.5
Etinilestradiolo	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Carbamazepina	0.12	0.33	1.44	N.D.	2.04	15.6
10,11-Diidro-10,11-Diidrossi	0.18	0.31	1.19	N.D.	2.36	27.0

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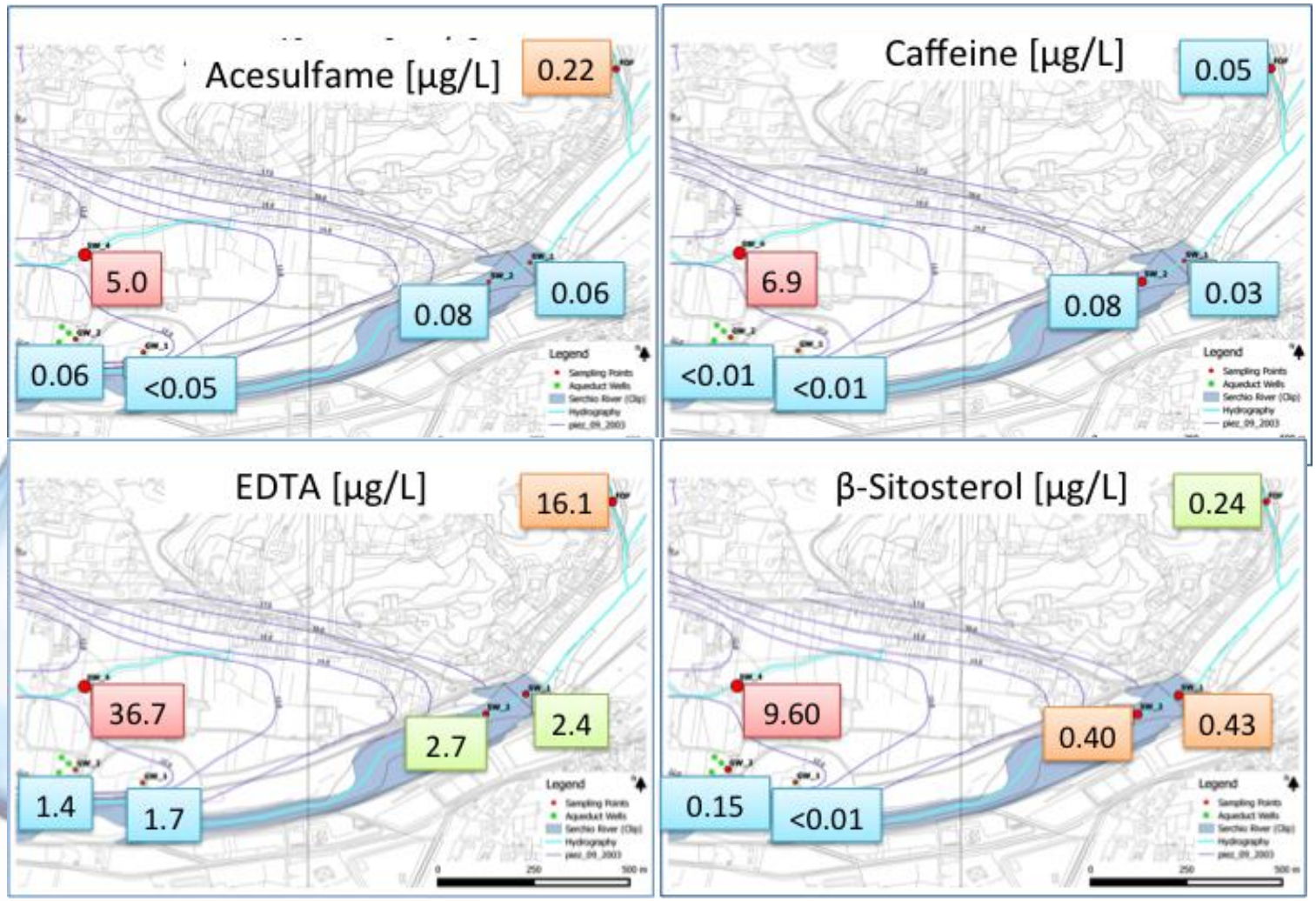
EMERGING POLLUTANTS: results of the first screening (2014)



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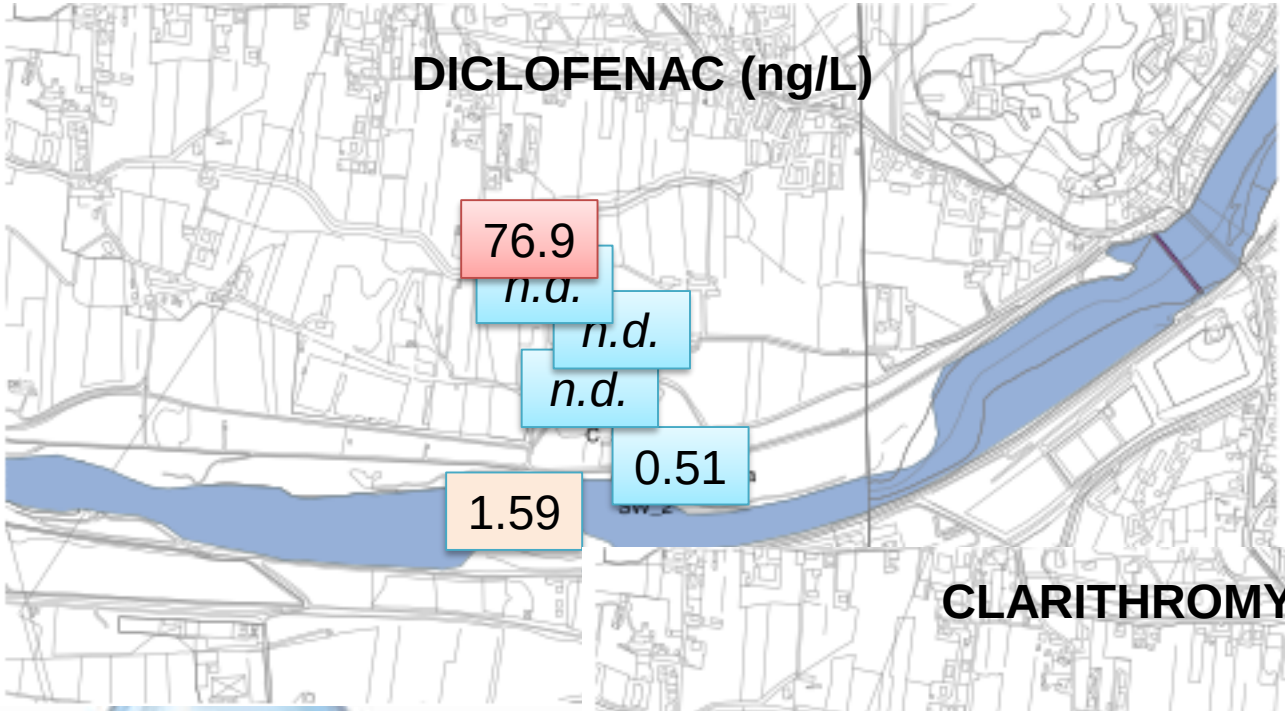
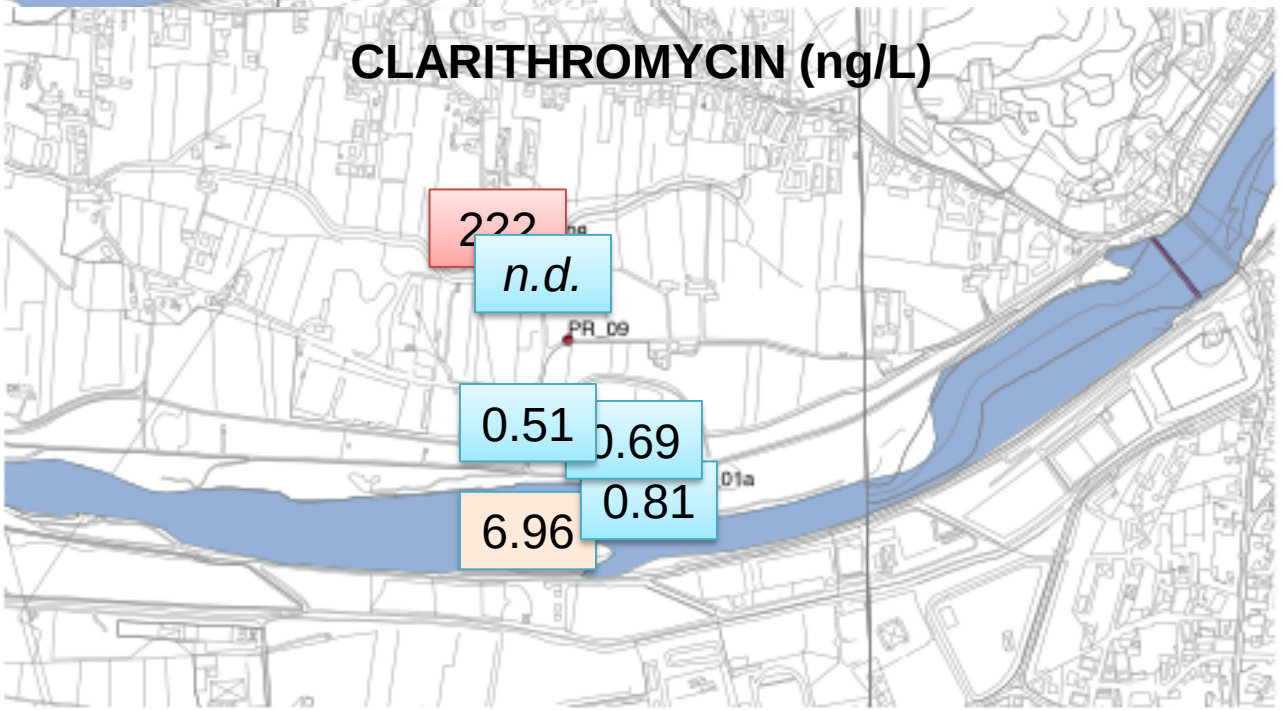


EMERGING POLLUTANTS:

results of the screening in March 2016



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CONCLUSIONS

- Within **MAR** schemes one of the most relevant point is the monitoring of the water quality. This is not often duly addressed
- In the framework of **FP7 MARSOL** we designed a monitoring scheme and protocol at the S.Alessio (Lucca) MAR test site
- The results confirm that Serchio River water constitutes the bulk of the GW abstracted at Sant'Alessio well field
- In the investigated period no contaminations events were detected also if conteminats are present in the systems
- **The results obtained so far confirm IRBF plant as reliable schemes to provide drinking water**

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THANK YOU

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Institute of Life Sciences

Scuola Superiore S.Anna – Pisa

This presentation is co-financed within the framework of the EU FP7-ENV-2013-WATER-INNO-DEMO MARSOL (Grant Agreement n. 619120)

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