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**WATER INNOVATION: BRIDGING GAPS,
CREATING OPPORTUNITIES**

27 AND 28 SEPTEMBER 2017

ALFÂNDEGA PORTO CONGRESS CENTRE

**WATER AND THE CIRCULAR ECONOMY, PART 2 –
AGRICULTURE**

***NOVEL WATER SUPPLY SOLUTIONS FOR AGRICULTURE:
MANAGED AQUIFER RECHARGE AND SUBSURFACE
STORAGE***

**JOÃO PAULO LOBO FERREIRA
LNEC / EIP WATER “MARTOMARKET”
ACTION GROUP**

Managed Aquifer Recharge

Challenge and Opportunity

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J. P. Monteiro (UniAlg) and Tiago Carvalho (TARH), Portugal

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Managed Aquifer Recharge refers to different recharge techniques that allows reclaimed water to penetrate into the ground:

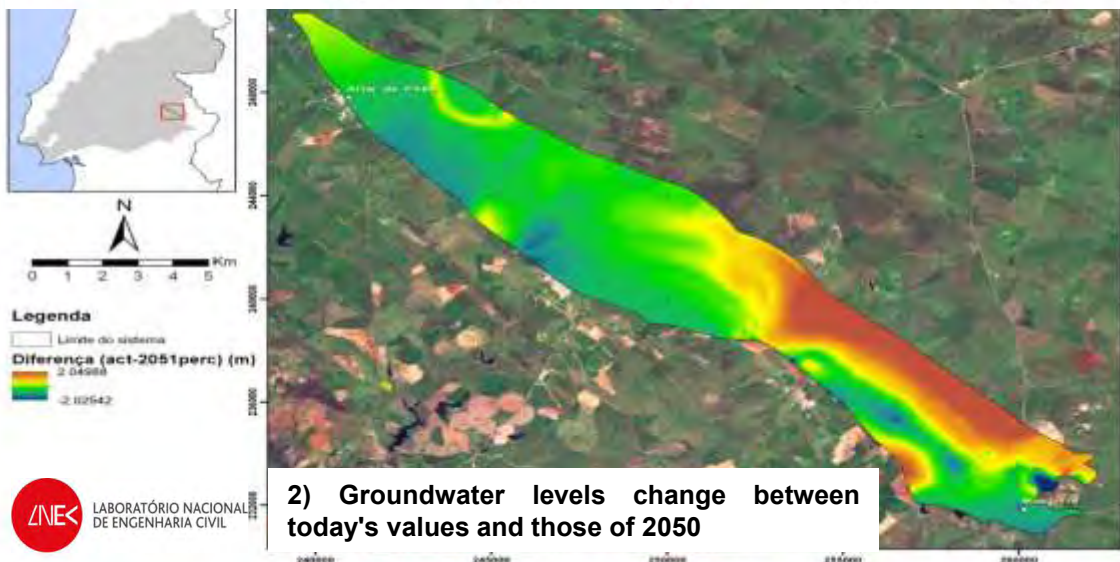
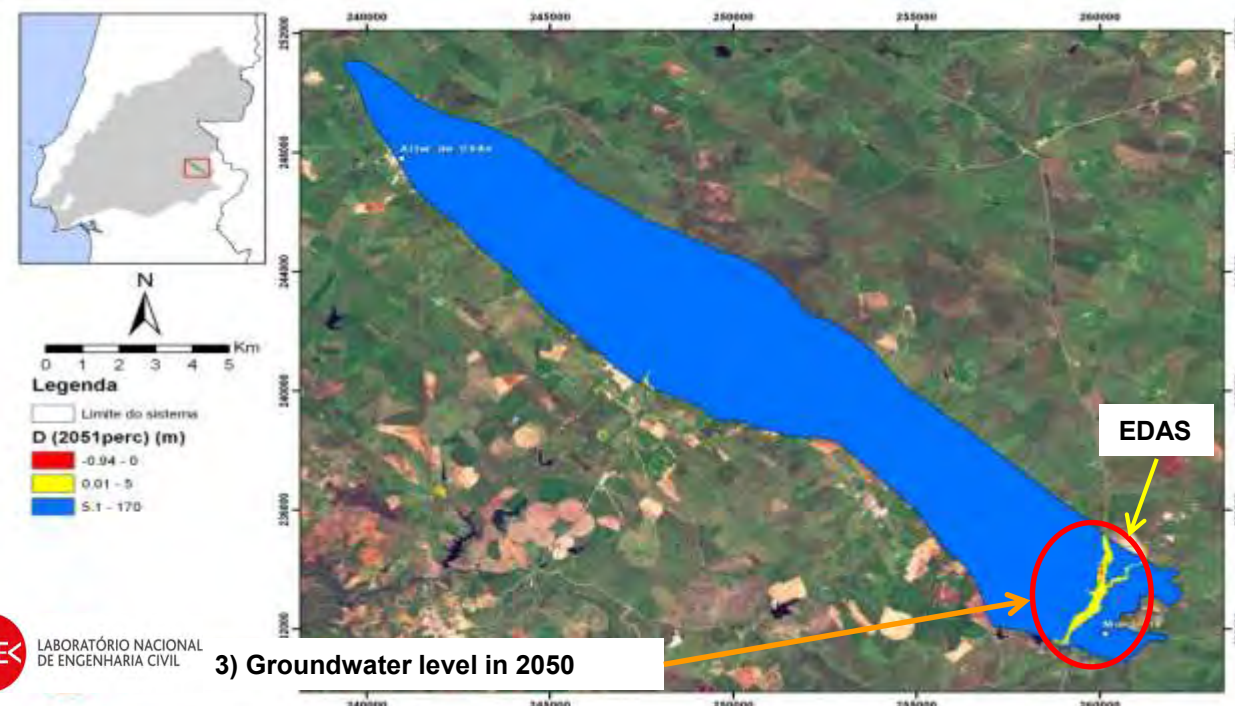
- percolating through unsaturated soil (surface groundwater recharge),
- or from below the ground, by injection or recharge wells (subsurface groundwater recharge).

The advantage is that reclaimed water such as treated blackwater, graywater or stormwater is not just discharged into surface waters, but reused as water for irrigation in agriculture or to intentionally recharge groundwater aquifers via MAR.



Climate change impacts on the behaviour of aquifers and consequently on Groundwater Dependent Ecosystems

> Groundwater levels change due to groundwater recharge decrease



> Consequences of aquifer behaviour change:

- Modifications in groundwater recharges amounts and periods
- Modification in groundwater flow directions
- Modification in the amount of groundwater reaching GW dependent ecosystems
- Modification on the behaviour of GW dependant ecosystems (eventually at risk)



MARSOL

Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought (FP7-Env-2013-Water-Inno-Demo)

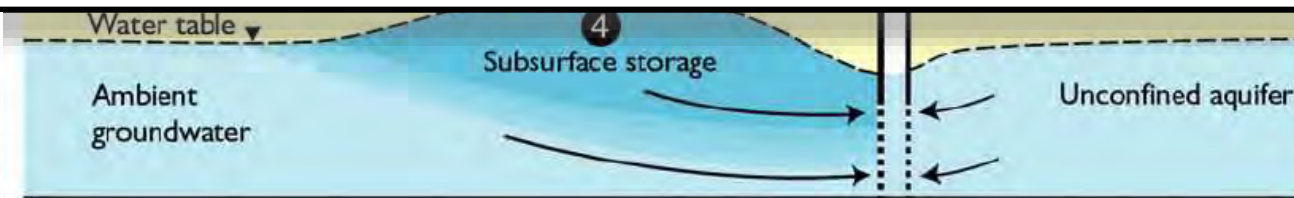
Start: 12.2013

Duration: 2 years EU Contribution: 5.2 Mio €

The main objective is to develop a **strategy that can be implemented** to store reclaimed water and use of excess water to

...sound, safe and sustainable strategy...

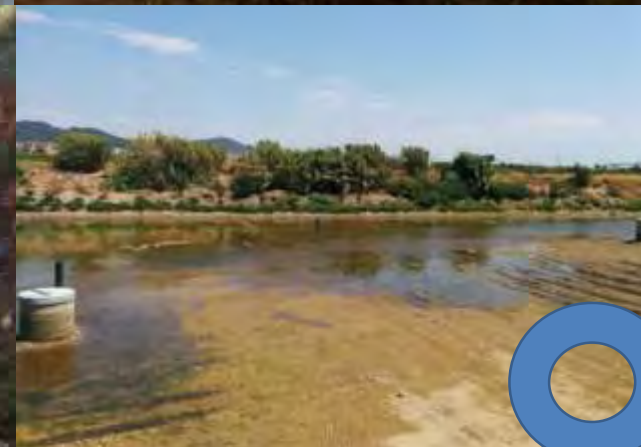
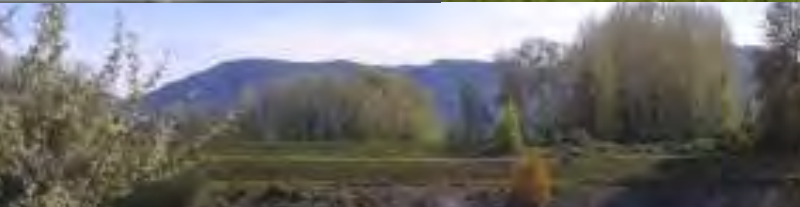
safe and sustainable to stimulate the use of M through storage



MARSOL

Demonstration sites activities...

...treated waste water, river water, desalinated water,
rainwater harvesting ...



1

“**Technical Solutions**” (T.S) are not related to Managed Aquifer Recharge (MAR) technique as if it was the problem to solve. They are, to a large extent, the **group of activities to increase MAR effectiveness**, being MAR the solution to many related water management dysfunctions.

DEL 13.1 MAR TECHNICAL SOLUTIONS

Q:

How to increase the **effectiveness of the devices and the infiltration rate?**

A:

Adoption of Soil and Aquifer Treatments (**SATs**) and other **complementary techniques**, such as design and management improvements applicable to existing devices



MARSOL demo sites: Experiences in 8 Mediterranean demo sites:

- 1- Lavrion
- 2- Algarve & Alentejo
- 3- Arenales
- 4- Llobregat
- 5- Brenta
- 6- Serchio
- 7- Menashe
- 8- Malta South



WP12 “Modelling”

https://www.researchgate.net/publication/314957907_White_book_on_MAR_modelling_Selected_results_from_MARSOL_PROJECT



MARSOL

**Demonstrating Managed Aquifer
Recharge as a Solution to Water Scarcity
and Drought**

**White book on MAR modelling: Selected
results from MARSOL PROJECT**

Deliverable D12.7

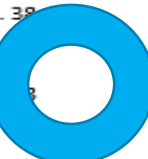
Deliverable No.	D12.7
Version	1.0
Version Date	31.01.2017
Author(s)	J.P. LOBO FERREIRA, TERESA LEITÃO, TIAGO MARTINS and ANA MARIA GARMEN IJUE (LNEC), JOSÉ PAULO MONTEIRO, LUÍS COSTA and RUI HUGMAN (UALG), TIAGO CARVALHO, RUI AGOSTINHO and RAQUEL SOUSA (TARH), LAURA FOGLIA, ANJA TOEGL AND CHRISTOS POLIARIS (TU DARMSTADT), RUDY ROSSETTO (SSSA), IACOPO BORSI (TEA), XAVIER SANCHEZ-VILA AND PAULA RODRIGUEZ-ESCALES (UPC), ENRIQUE F. ESCALANTE (TRAGSA), MANUEL M. OLIVEIRA (LNEC), ANDREAS KALLIORAS (NTUA), YORAM KATZ (MEKOROT)
Dissemination Level	PU
Status	Final



The MARSOL project has received funding from the European Union's Seventh Framework Programme for Research, Technological Development and Demonstration Under grant agreement no 619170.

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DEL 13.1 MAR T

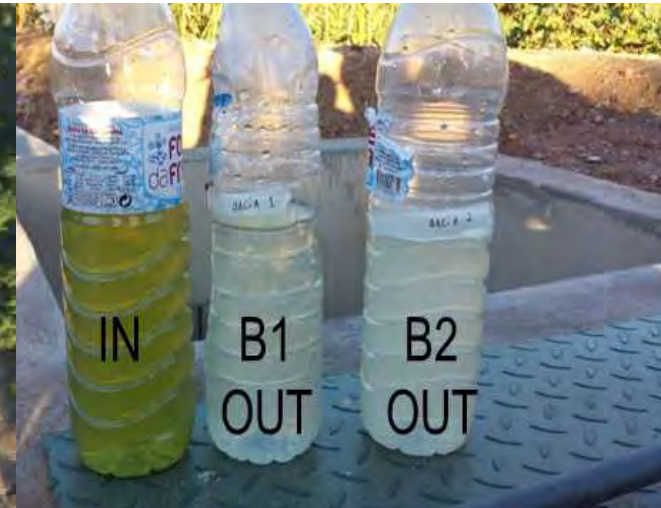
25 devices

N	SYSTEM	MAR DEVICE	LOGO	FIGURE	PHOTO	LEGEND
1	DISPERSION	INFILTRATION PONDS/WETLANDS				Artificial wetland to recharge in Sanchón, Coca, Segovia (Spain). Photo: DNA MAR.
2		CHANNELS AND INFILTRATION DITCHES				Artificial recharge channel of the Basin of Santibáñez, Segovia, Spain, operative since 2002. Photo: DNA MAR.
3		RIDGES/ SOIL AND AQUIFER TREATMENT TECHNIQUES				Ridges in the bottom of a infiltration pond. California. Photo: D. Peyton.
4		INFILTRATION FIELDS (FLOOD AND CONTROLLED SPREADING)				Infiltration field in Omdel (Namibia). Photo: G. Tredoux.
5		ACCIDENTAL RECHARGE BY IRRIGATION RETURN				Artificial recharge by irrigation return. Extremadura, Spain. Photo: Tragsa.
6		BOFEDALES WETLANDS				Bofedales (Colombia)
7	CHANNELS	RESERVOIR DAMS AND DAMS				Artificial recharge dam in basin head. Alicante, Spain.
8		PERMEABLE DAMS				Permeable dam in Huesca, Spain. Photo: Tragsatec.
9		LEVEES				Levees in Santa Ana river, Orange County, California, USA. Photo: A. Hitchinsan.
10		RIVERBED SCARIFICATION				Scarification at Besós riverbed, Barcelona, Spain. Photo: J. Armenter.
11		SUB-SURFACE/ UNDERGROUND DAMS				Sub-surface dam in Kintu, Kenya. Photo: Sanford de Haas.
12		DRILLED DAMS				Drilled dam. Lanjarón, Granada, Spain. Photo: Tragsatec.

WP4: DEMO SITE 2 - PORTUGAL



PT2_6 Algarve, São Bartolomeu de Messines



Sources for the artificial recharge : Quantity

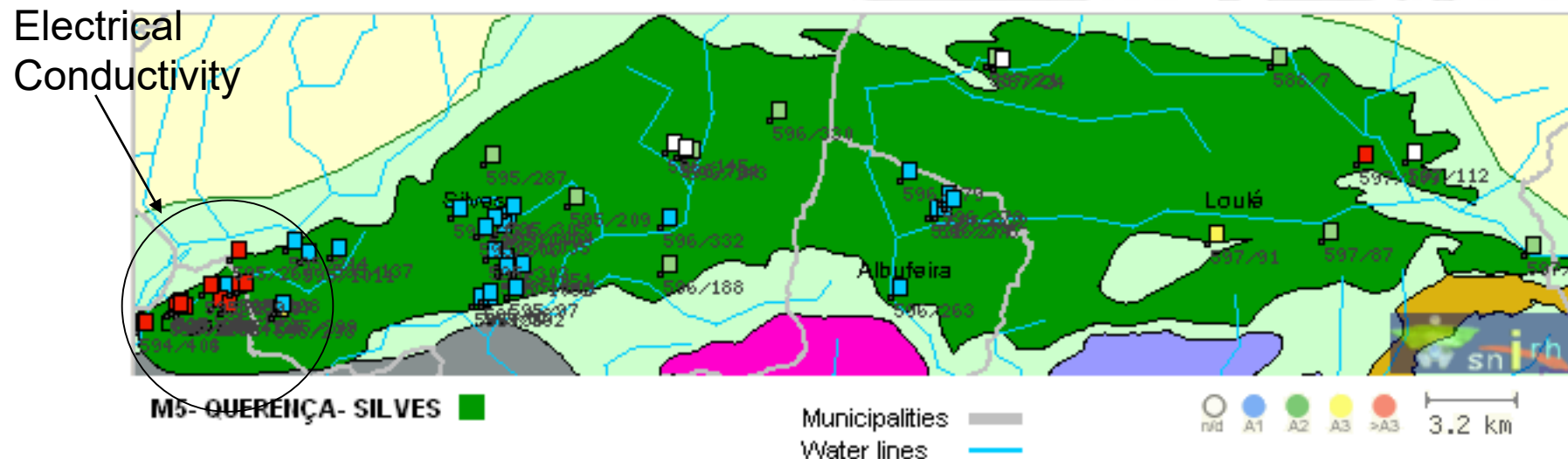
Dam	Hydrological year	Depth discharge (*10 ³ m ³)	Surface discharge (*10 ³ m ³)	Total discharge (*10 ³ m ³)
ARADE	2000/2001	37 499.20	19 256.70	56 755.90

Dam	Hydrological year	Depth discharge (*10 ³ m ³)	Surface discharge (*10 ³ m ³)	Total discharge (*10 ³ m ³)
ARADE	1995/96	0	81 255.39	81 255.39
	1996/97	0	42 599.62	42 599.62
	1997/98	8 556.65	113 762.30	122 318.97
TOTAL (*10³ m³)				246 173.98



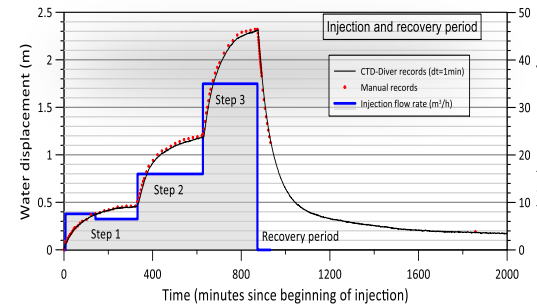
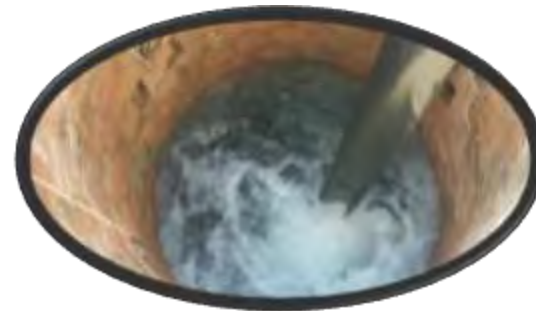
During the extreme drought of 2004/2005

	Volume of withdrawal water (*10 ⁶ m ³)	Percentage
Agriculture	23.79	47.31%
Urban supply of the <i>Águas do Algarve</i> regional system of Algarve	14.25	28.34%
Urban supply of the local municipalities	12.25	24.36%
Private users	Not Available	-
Total	50.29	100%





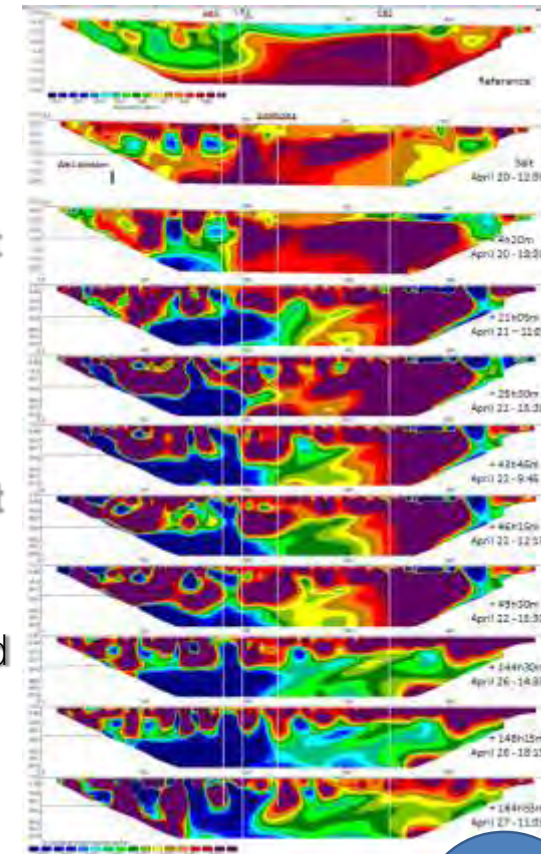
- Experiment goal: assess Cerro do Bardo MAR site infiltration capacity and groundwater flow path
- Recharge experiment: infiltration of 47 L/s (~170 m³/h) of water in Cerro do Bardo dug well and natural sinkholes during 90 hours (coming from a AdA well located ~1,4 km distance)
- Tracer: 1000 kg NaCl



This MAR infiltration and tracer test allowed confirming that the DEMO Site:

- Is an adequate area to infiltrate water coming from the three dams, with the surplus from wet years
- The area has a minimum infiltration capacity of 4060 m³/d (170 m³/h, compared with 35 m³/h in Campina well..., but it depends on headwater...)

April 2016



Finite element regional flow model of the Querença Silves **Aquifer System**

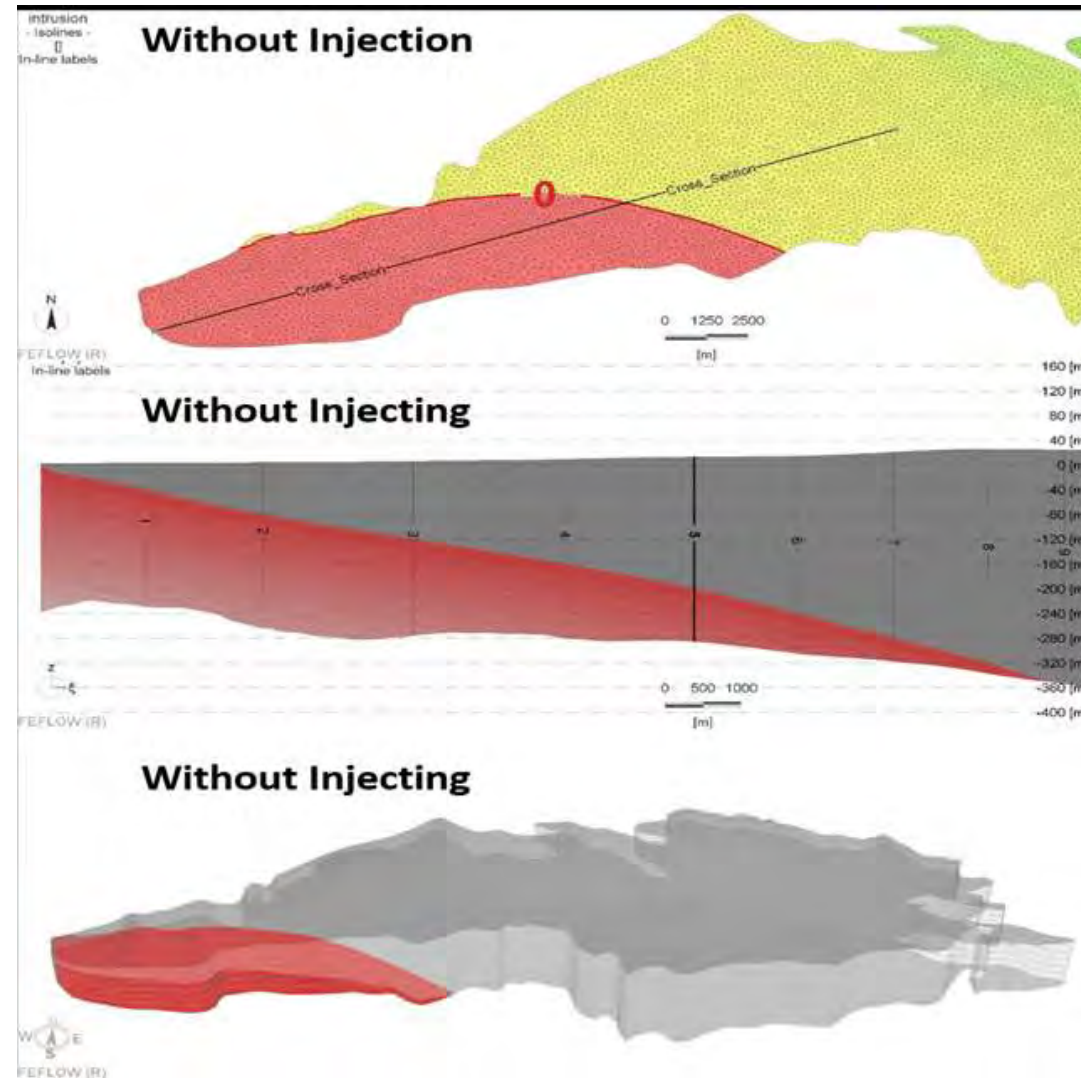
- SW-FW interface Scenario drought 2004-2005 simulation with different injection scenarios



Evolution of Seawater intrusion estimated at Bottom slice

Evolution of Seawater intrusion at cross-section view

Evolution of Seawater intrusion plume at 3D view



Results from continuous monitoring (groundwater and surface water) in Rio Seco artificial recharge basins during winter time (Out.2007/Mar.2008) Carreiros test site

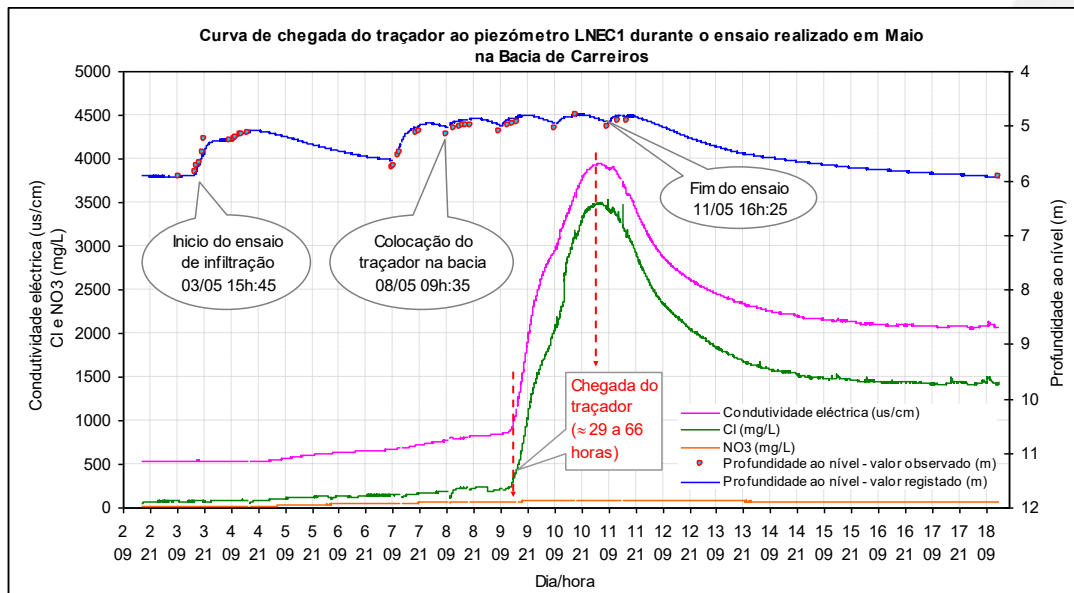
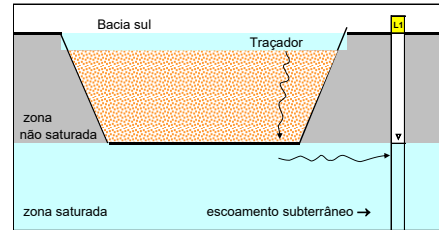


LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL



Natural recharge monitoring

✓ Continuous monitoring in three piezometers



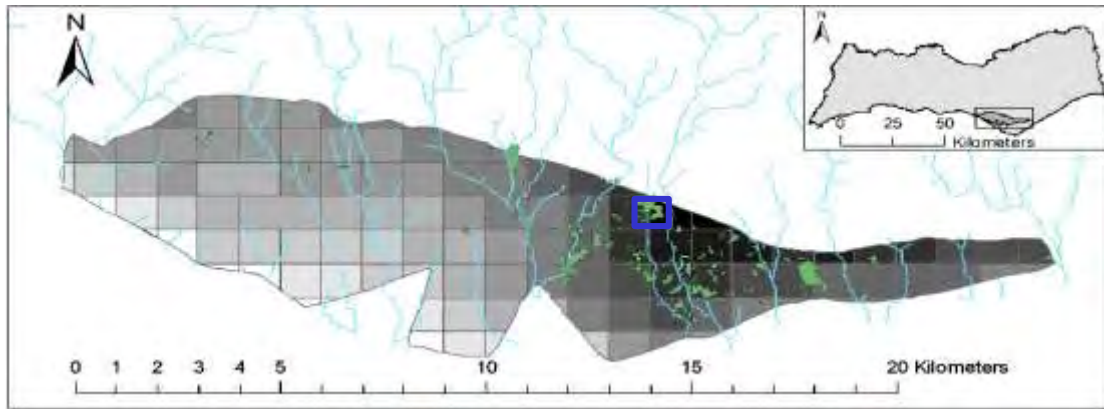
Artificial recharge experiments

✓ Electrical resistivity assessment

May 2007



Rainwater harvesting (interception of precipitation in greenhouses) in Campina de Faro, Algarve

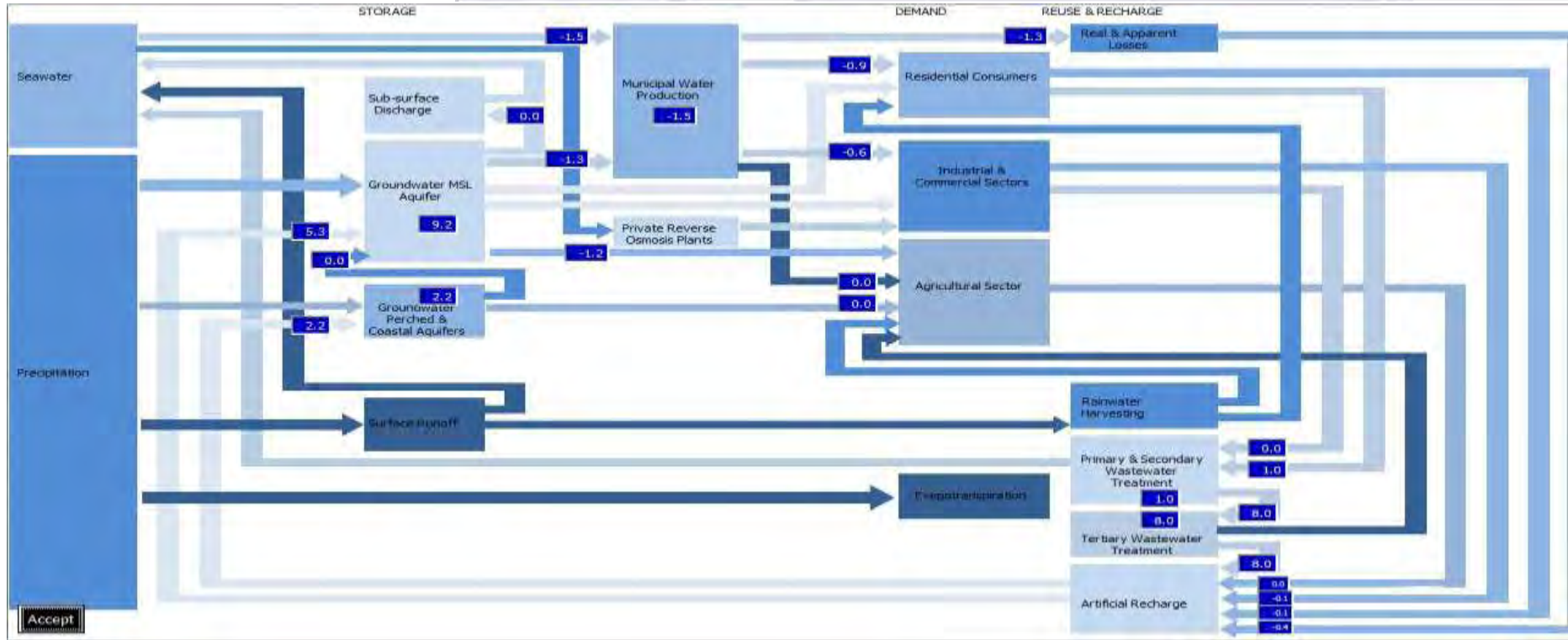
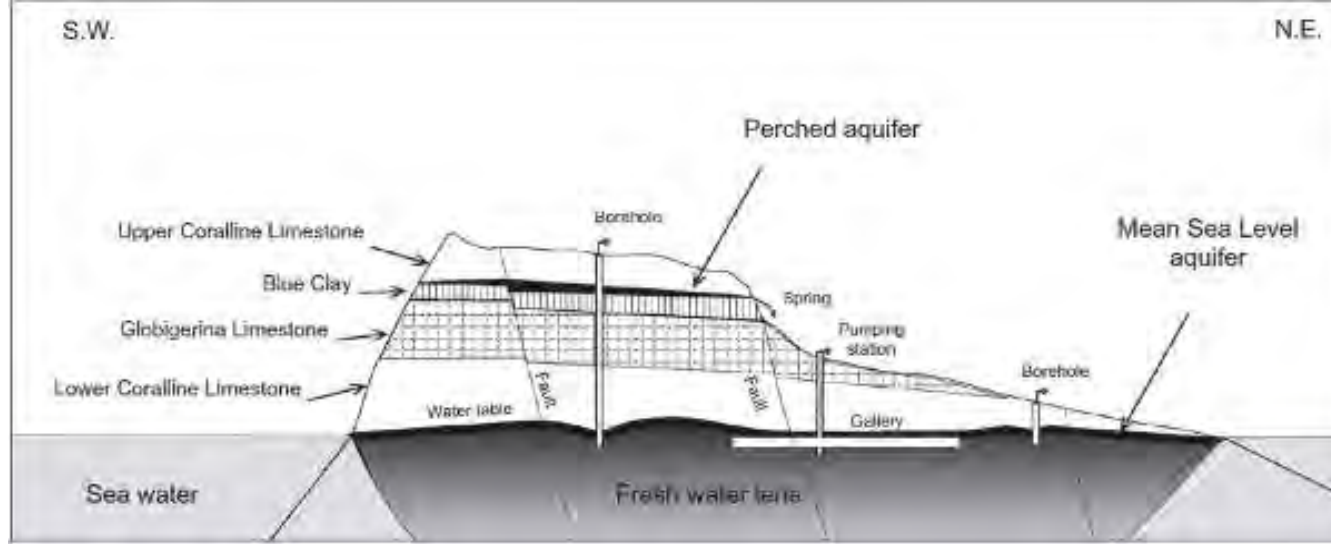


Aerial view of a greenhouse complex and **picture showing it's actual drainage system.**

The area is flat and is characterised by low recharge rates. In this conditions drainage is a serious problems in this area.



Malta MAR: reusing WWTP to prevent saltwater intrusion



LA RECARGA GESTIONADA DEL ACUÍFERO DE LA CUBETA DE SANTIESTE
JORNADA TÉCNICA INFORMATIVA "MAR4FARM"

Expos. Apto. de Santiago de San Juan Bautista (España)
 Miércoles, 20 de octubre de 2014, 17 h.
 Jornada técnica de la cubeta de Santiago

PROGRAMA PRELIMINAR

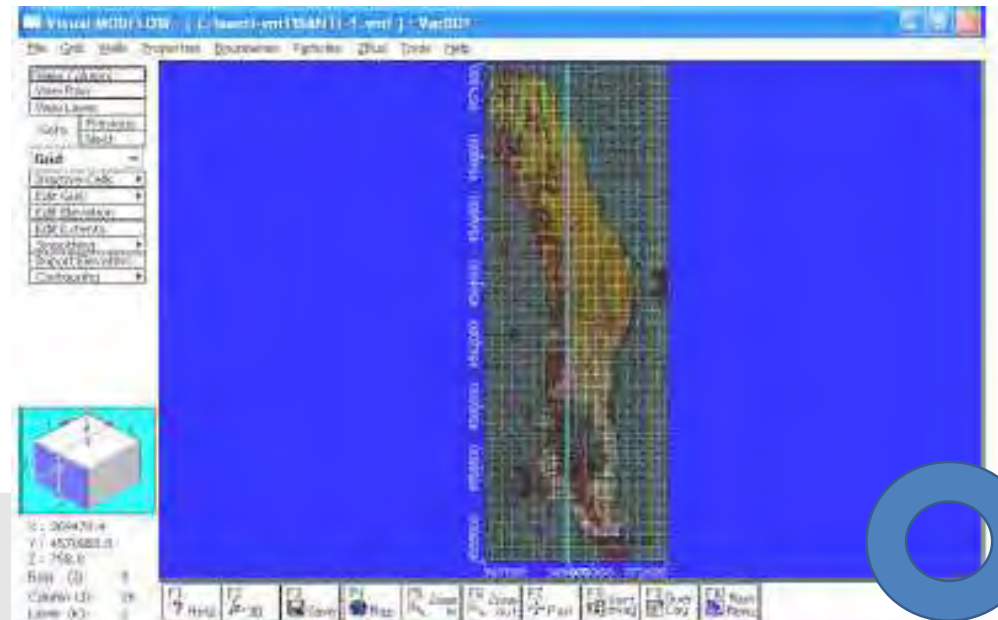
07:00 - 07:30	Bienvenida. D. Carlos Sánchez (Presidente del CSUR) y D. Carlos de Santiago
07:30 - 07:45	Aspectos generales sobre la técnica gestionada (sistema de recarga artificial)
07:45 - 07:55	Dr. Ing. Juan Pablo León Fariña (Ingeniero del CSUR), Ponente
07:55 - 08:15	La artificialidad está desde la caracterización hidrogeológica del Duero: Estudio y balance general
08:15 - 08:30	Dr. Carlos Sánchez (Presidente del CSUR), Ponente
08:30 - 08:45	Regulación con aguas regeneradas: La experiencia de Portugal
08:45 - 09:00	Dr. Juan Carlos Sánchez (Ingeniero del CSUR), Ponente
09:00 - 09:15	Plan de agua
09:15 - 09:30	Planificación del acuífero
09:30 - 09:45	Dr. Enrique Fernández Domercq (Ingeniero de TRAGSA)
09:45 - 10:00	Descripción de las obras
10:00 - 10:15	Dr. Carlos Sánchez (Presidente del CSUR), Ponente
10:15 - 10:30	Estado ambiental y recarga gestionada: Impacto ambiental de la actuación
10:30 - 10:45	Dr. Carlos Sánchez (Presidente del CSUR), Ponente
10:45 - 11:00	Elaboración de gestión técnica y control de calidad: Mecanismo de control
11:00 - 11:15	Dr. Carlos Sánchez (Presidente del CSUR), Ponente
11:15 - 11:30	Experiencia para la gestión estratégica y uso de modelos matemáticos para el régimen en las Arenales (Castilla y León)
11:30 - 11:45	Dr. Juan Manuel Sánchez Domercq (Ingeniero de TRAGSA), Ponente
11:45 - 12:00	Debate abierto
12:00 - 12:15	Reserva D. Luis Reygadas (Ingeniero de TRAGSA)
12:15 - 12:30	Clausura. D. Carlos Sánchez (Presidente del CSUR)

BALANCE HÍDRICO

ENTRADAS	DESCRIPCIÓN	VALOR (mm/año)
ENTRADAS	Infiltración directa del agua de lluvia	De 2.825 a 3.287
	Infiltración a través de la escorrentía superficial	0,18
	Retornos de riegos	0,26 a 0,30 (0,28)
RECARGAS	Recarga artificial del acuífero	0.933 a 1.344
	Flejo subsuperficial y manantiales	0,081
SALIDAS	Salidas por bombeo:	
	Destino del agua de las captaciones:	
	Riego	2.849 a 2.966
	Abastecimiento urbano	(Imposiciones)
	Abastecimiento industrial	0,165
	Abastecimiento ganadero	0,154
	Salidas por cauces superficiales:	
	Percolación hacia el acuífero profundo	0,762 a 1,107 (1,0)
DESCARGAS	Descargas Manantiales y retornos	De 0,241 (0,3) a 0,677
	Drainaje subsuperficial y subterráneo hacia el resto de la Cubeta	0,039
TOTAL	E (de 3.882 a 3.817) + (AR) = S (de 4.010 a 5.108) (AV)	De - 0,628 a - 1,291 (promedio = - 0,959)
	IAF = volumen de entradas por recarga artificial	3.422 - 4.307 = 0,885

LA RECARGA GESTIONADA DEL ACUÍFERO DE LA CUBETA DE SANTIESTE: Medio ambiente y recarga gestionada de aguas subterráneas de la península

GEOLOGÍA



DEMO SITE BRENTA, ITALY (WP 7, SGI) & DEMO SITE SERCHIO, ITALY



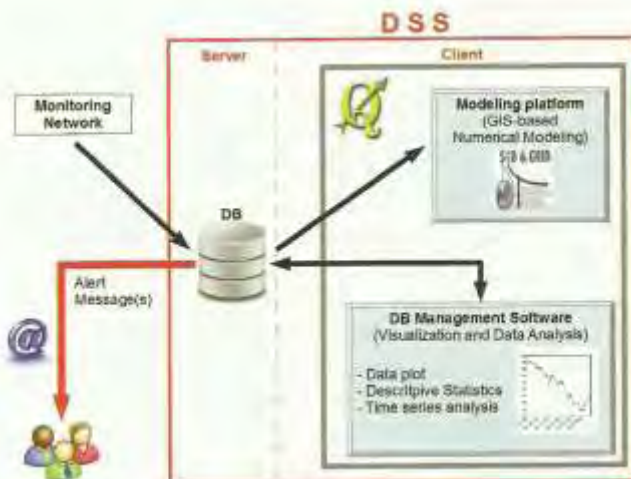
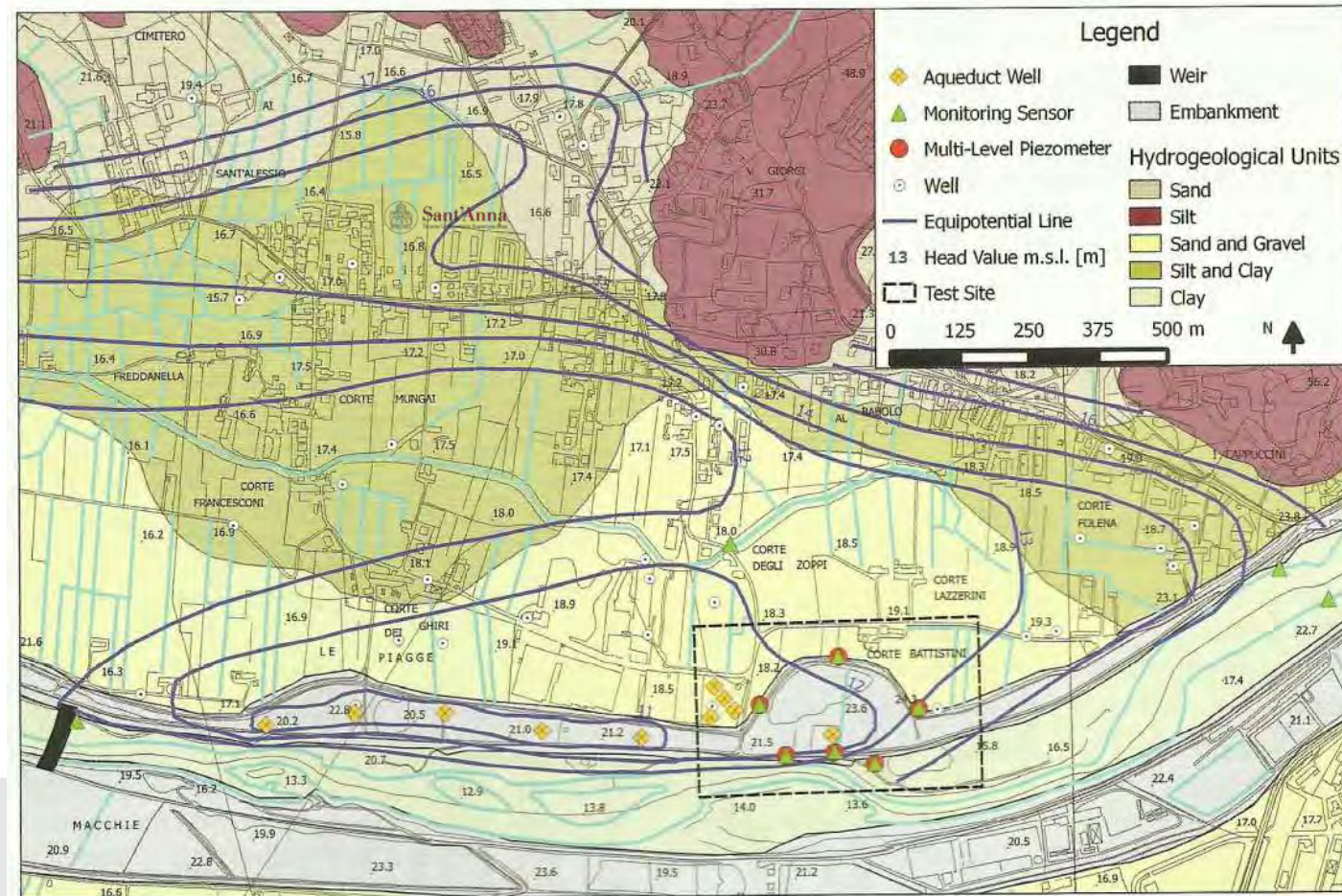
DOI:10.13131/AS-085-14-0112

Perspective research *Ricerca*

L'impianto di ricarica riverbank filtration di S. Alessio (Lucca): attività di monitoraggio e modellistica nel progetto EU FP7 MARSOL

The riverbank filtration plant in S. Alessio (Lucca): monitoring and modeling activity within EU the FP7 MARSOL project

Iacopo Borsi, Giorgio Mazzanti, Alessio Barbagli, Rudy Rossetto



SCHIAVON Forested Infiltration Area



- Approx. 2 hectares
- **Water infiltration rate: 20-50 l/sec/hectare**
- Fast growing tree species
- GW level: around -3 m b.g.l.
- Undifferentiated aquifer with high/medium permeability



The watering of the pilot F.I.A. area takes place generally during non-irrigation periods, using the existing irrigation water conveyance system (**ditches, underground pipelines**).

<http://www.marsol.eu/>

https://www.youtube.com/results?search_query=MARSOL+Demo+sites



MARSOL
MANAGED AQUIFER RECHARGE SOLUTIONS

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Imprint

Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought

MARSOL

An Environment 2013 Cooperation Project funded by the European Commission

How can the increasingly scarce resource called water be exploited and used intelligently? The joint project MARSOL is aiming to demonstrate that Managed Aquifer Recharge techniques are able to secure 'excess' water and store it in the soil. The EU is funding the MARSOL project with 5.2 million Euros over 3 years under the WATER-INNO-DEMO scheme.

It is estimated that due to climatic changes only about 50 percent of today's amount of water will be available in the Mediterranean region by 2100 – while the population continues to grow. The lack of water will result in drought and crop losses.

MARSOL
Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought
An EU FP7 Project

Coordination & Contact:
Prof. Dr. Christoph Schill
Darmstadt Technical University
Institute of Applied Geosciences
Schloßgartenstr. 9
64287 Darmstadt
Germany

Twitter Facebook LinkedIn YouTube

EU FP7 Project

MARSOL Demo sites

Cerca de 26 000 resultados

FILTRAR

- MARSOL - Demo Site PT2 SBMessines SAT basins 2016 17
166 000 visualizaciones 1:46 11:37
- MARSOL - Demo Site PT3 Melides Sandbox Model May2016
166 000 visualizaciones 1:46 11:37
- MARSOL - Demo Site PT1 Campina de Faro Clogging test July 2014
166 000 visualizaciones 1:46 11:37
- MARSOL - Demo Site PT2 Cerro do Bardo MAR test April 2016
166 000 visualizaciones 1:46 11:37
- MARSOL MAREnales Film v7 6
166 000 visualizaciones 1:46 11:37

<https://vimeo.com/channels/marsol>

Final MARSOL statements Video
from Christoph Schill

MARSOL
MANAGED AQUIFER RECHARGE SOLUTIONS

Demonstrating Managed Aquifer Recharge as a solution to water scarcity and drought

Final MARSOL statements Video / Video final del Proyecto MARSOL
Final conclusions are underlined and some pendant issues for future are mentioned.
Conclusiones finales del proyecto MARSOL narradas por siete miembros de primera línea del proyecto.

2 months ago | 11:37 | 0 Comments

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MARSOL Managed Aquifer Recharge Solutions

Created by Karl Ernst Roehl 5 months ago

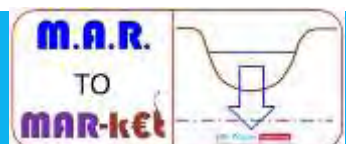
How can the increasingly scarce resource called water be exploited and used intelligently? The aim of the MARSOL project is to demonstrate that Managed Aquifer Recharge techniques are able to secure 'excess' water and store it in the subsoil. The European...

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1 Moderator

Do visit us in EIP Water Exhibition Booth 108 !



**Thank you !
Obrigado !**