



ARTIFICIAL RECHARGE OF AQUIFER'S POTENTIAL IN SPAIN

RESULTS OF DINA-MAR i+R&D PROJECT

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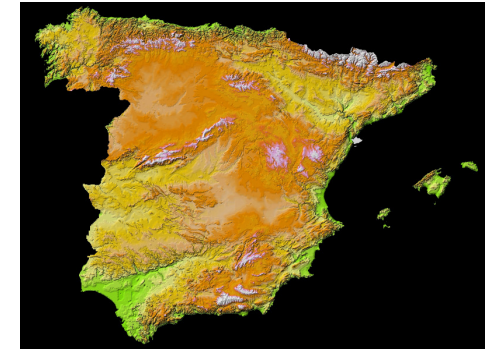


Introduction

- Spain can be considered as the country with the **greatest water shortage** in the European Union.
- There is an **ever increasing need for water**, which is a **scarce and finite resource**.
- Nowadays water **management** and aquifers' potentiality are **priority** topics to **spanish authorities**.



State of the art



- **Managed Aquifer Recharge technique (MAR)** has scarcely been applied in **Spain**.
- “*Alternative*” water management techniques, in special, **MAR**, emerge as **measures** that can **help** to alleviate **resource scarcity** and water conflicts.
- In order to increase **MAR’s potential**, all **sectors** involved in **water management (all the population)**, should have to **share the responsibility**.

Summary

- To expose an **overview** of **water management in Spain**, specially “**special techniques**” and to show some **examples** and **figures**.
- To **disseminate** some results in the frame of **i+R&D DINA-MAR** project, applicable to other countries.
- To propose an **integrated strategy** in order to **bring MAR technique to the notice of general public**.

TECHNIQUES:

Conventional

- DAMMING
- GROUNDWATER EXPLOITATION
- INTERBASIN WATER TRANSFER



Non conventional

- REUSE AND RECYCLING
- DESALINATION



Special or alternative

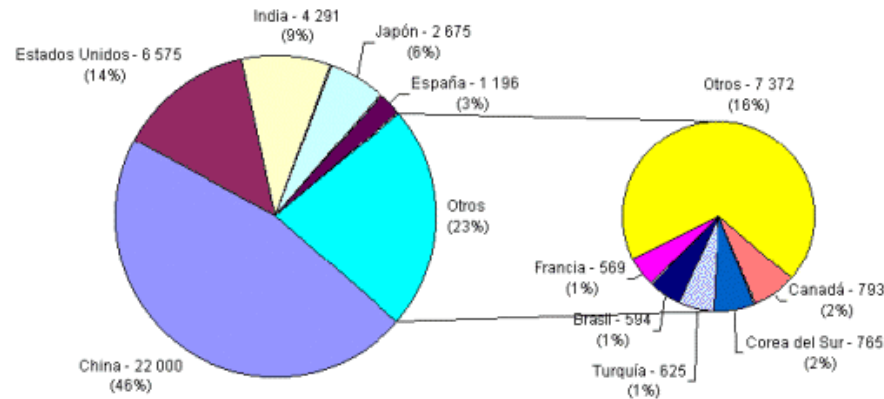
- MANAGED AQUIFER RECHARGE (MAR)
- PALLIATIVE TECHNIQUES
 - Runoff decrease in forest and urban areas
 - Runoff traps
 - Saving
 - Pipe network efficiency
 - Evaporation decrease in dams
 - Underwater freshwater springs
 - Etc.



CONVENTIONAL TECHNIQUES

DAMMING

- Spain is the 5th country all over the World in damming (IUCN, 2000).
- Dammed volume over **53.000 hm³** (2005).



GROUNDWATER EXPLOITATION

- Groundwater consumption is about **6.000 hm³/year**.
- 80 %** for **irrigation**.



NON CONVENTIONAL TECHNIQUES

**Water consumption in Spain:
>28.000 hm³/year.**

REUSE AND RECYCLING

- Volume of **waste water treated:**
400 hm³/year (2008).



DESALINATION

- 4th country in desalinated water production: **1,5 hm³/day.**
- **900** desalination plants.

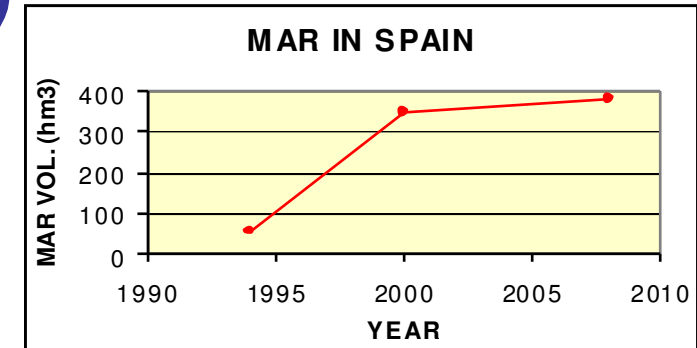


SPECIAL TECHNIQUES

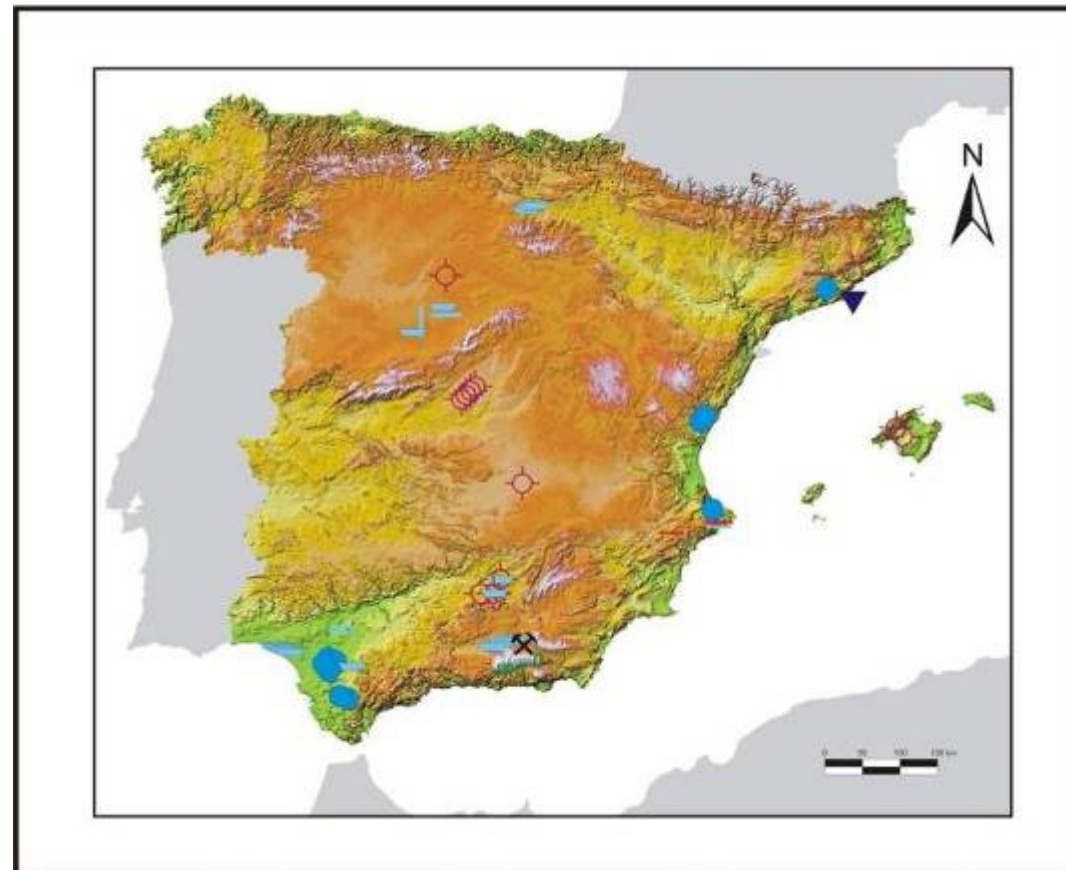
Managed Aquifer Recharge (MAR)

Figures (hm³ /year):

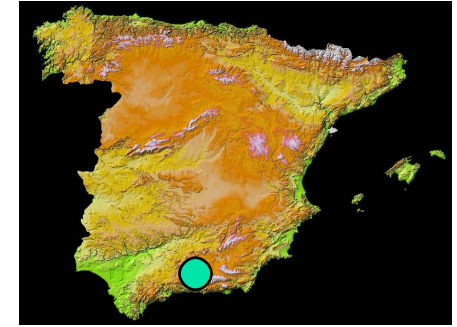
- 50-60 (1994, LBAS)
- 350 (2000, LBAE)
- 380 (2008, DINA-MAR)



At least 28
MAR experiences:



Hystoric background The "careos" ditches

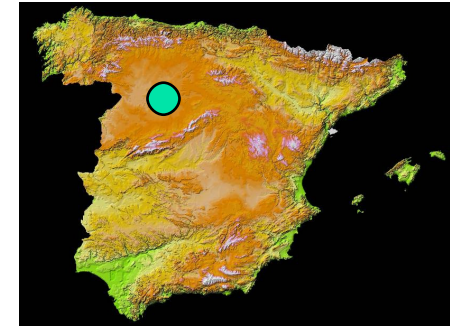


Alpujarras, Sierra Nevada National Park

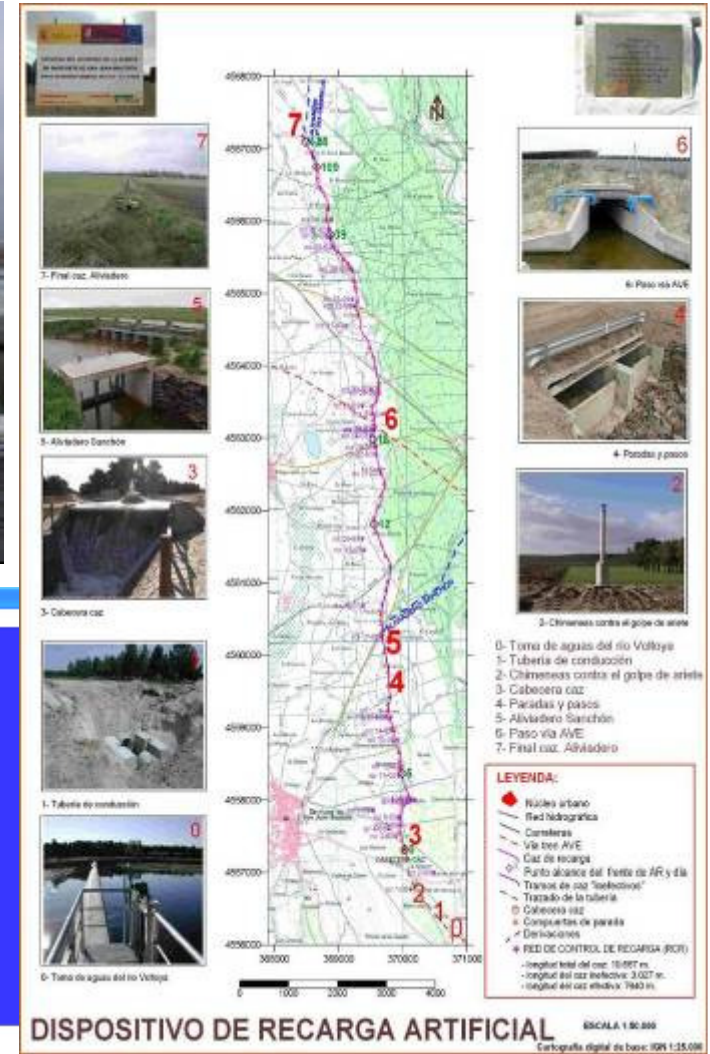
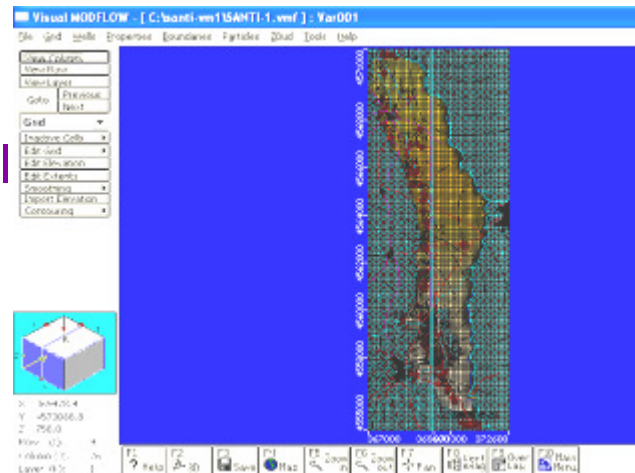


- MAR from 12 th century
- 14 MAR careos well preserved (125 km)

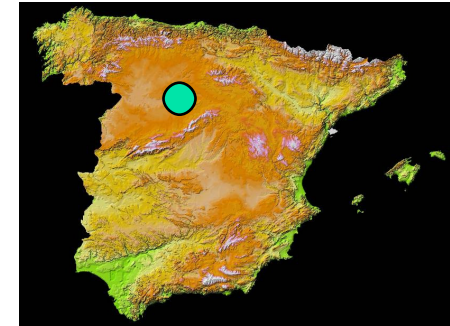
MAR at Santiuste



- 7 years operative
- 27 km of MAR channel
- 5 infiltration ponds
- 3 wetlands
- 3 AR wells

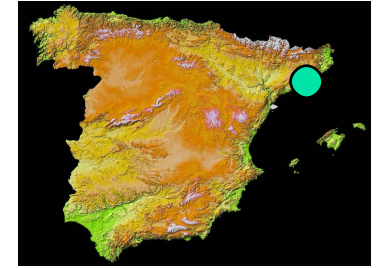


MAR at Carracillo

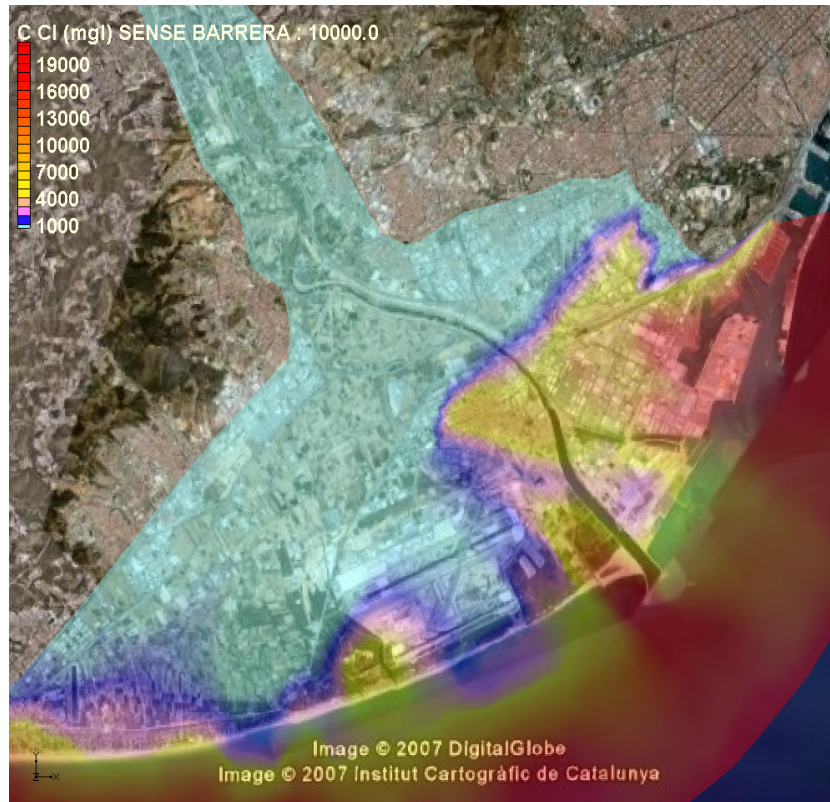


- 40,7 km of infiltration channel
- 3 infiltration ponds
- 1 RBF
- 1 artificial wetland

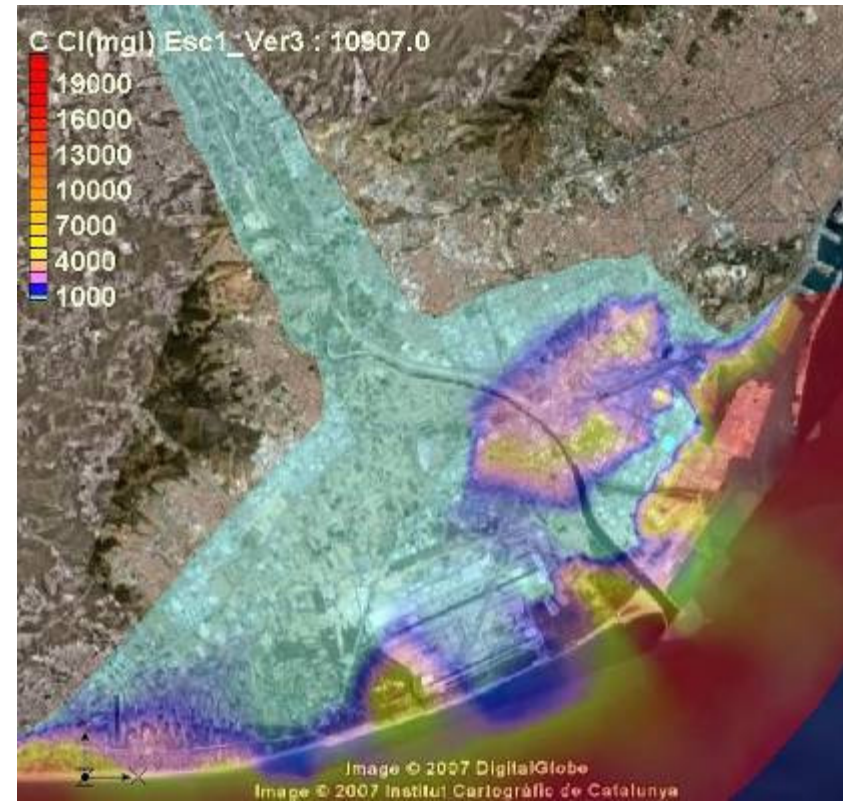
Hydraulic barrier at the Llobregat aquifer



Positive **hydraulic barrier** to prevent the **seawater progression**, by means of direct injection of treated reclaimed water.



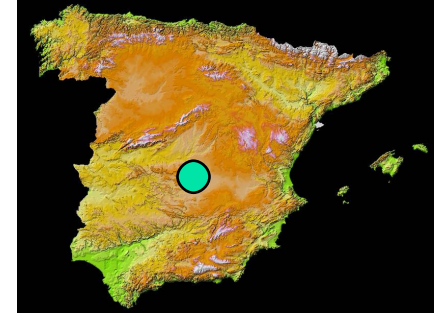
WITHOUT hydraulic barrier



WITH hydraulic barrier

Model simulation of the evolution of chlorides in the aquifer
Horizon 2036

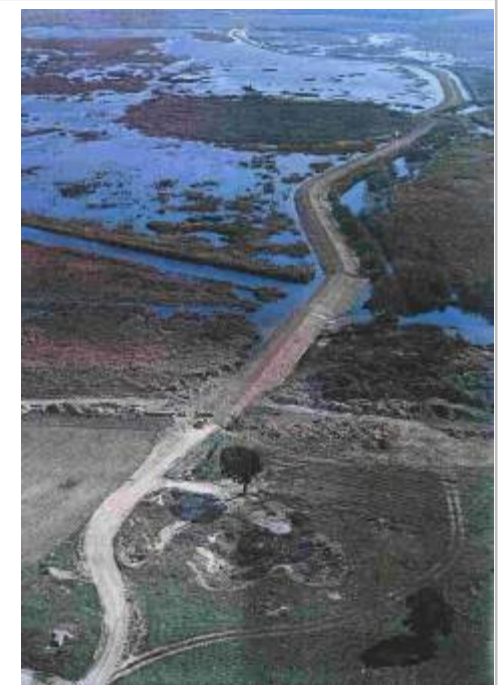
Wetlands hydric regeneration. Tablas de Daimiel National Park



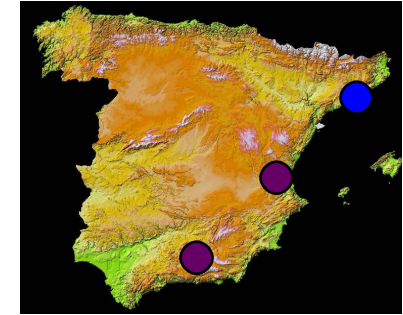
8 MAR boreholes:



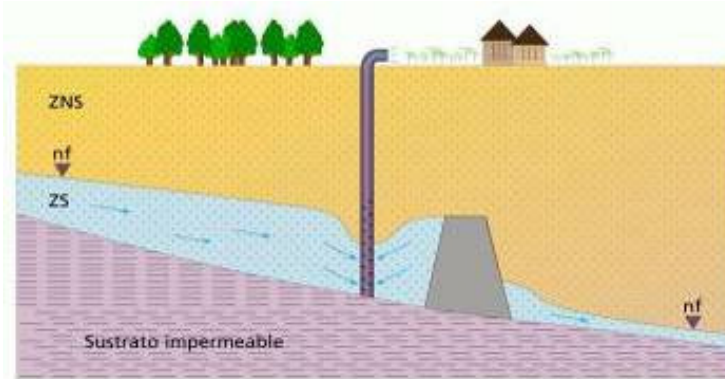
2 hydraulic devices:



Palliative techniques



RUNOFF DECREASE AND MAR IN FORESTS



RUNOFF DECREASE AND MAR IN URBAN AREAS



**Barcelona
2005/2008**

Control systems by means of SUDS

Some examples of *Sustainable Urban Drainage Systems*, (SUDS):

RUNOFF TRAPS



GREEN ROOFS



PERMEABLE SURFACES



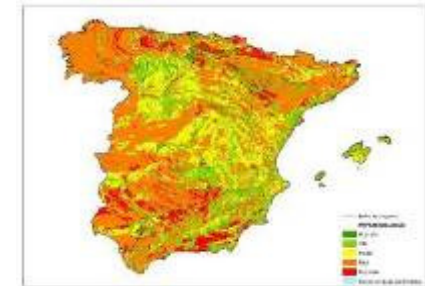
WELLS, DITCHES AND INFILTRATION DEPOSITS

TARGETS:

- AVOIDING SURFACE RUNOFF
- RECOVERING ORIGINAL INFILTRATION RATE

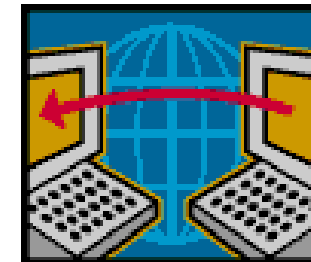
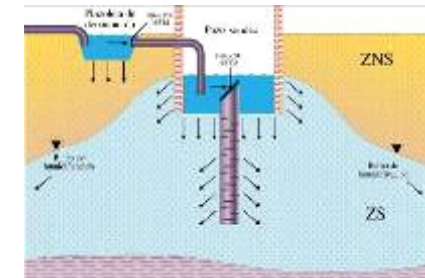
2ND OBJECTIVE

Managed Aquifer Recharge (MAR). DINA-MAR i+R&D project

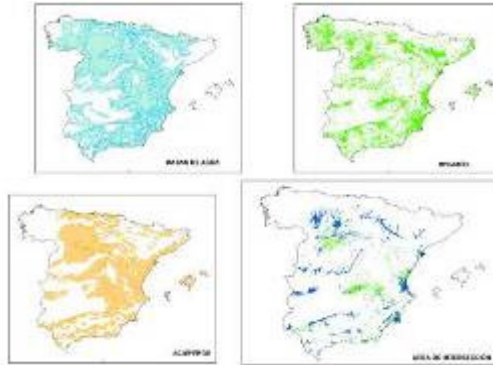


PHASES:

- 1- TARGET GEOLOGICAL FORMATIONS (**MAR ZONES**) IN SPAIN
- 2- TO FIND OUT THE MOST SUITABLE **DEVICES**
- 3- MAR AND **ENVIRONMENT**
- 4- **SOIL AND AQUIFER TREATMENT TECHNIQUES (SATs)**
- 5- **GEOSITE**



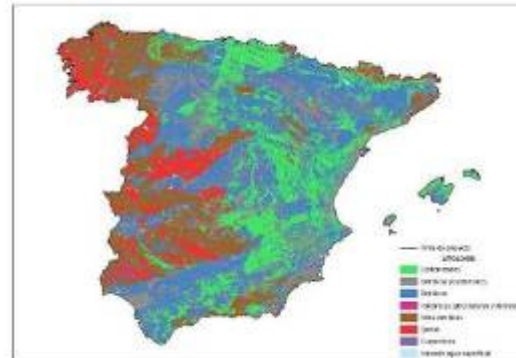
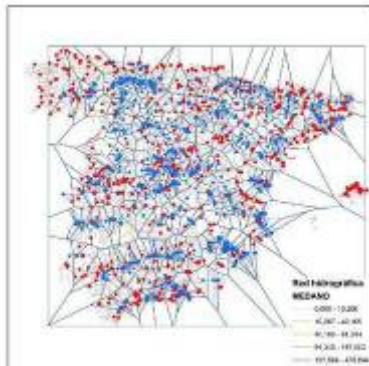
1- Target geological formations for artificial recharge



| INDICADOR | DESCRIPCIÓN | UNIDAD DE MEDIDA | VALOR | INDICADOR DE RIESGO | INDICADOR DE CALIDAD | INDICADOR DE EFICIENCIA | INDICADOR DE SOSTENIBILIDAD |
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Methodology:

- GIS: Employ of up to **82 themes**
- Study of the **decrease sequence**
- Selection of the **most relevant themes (15)**
- **Results** and figures+ **Mapping**



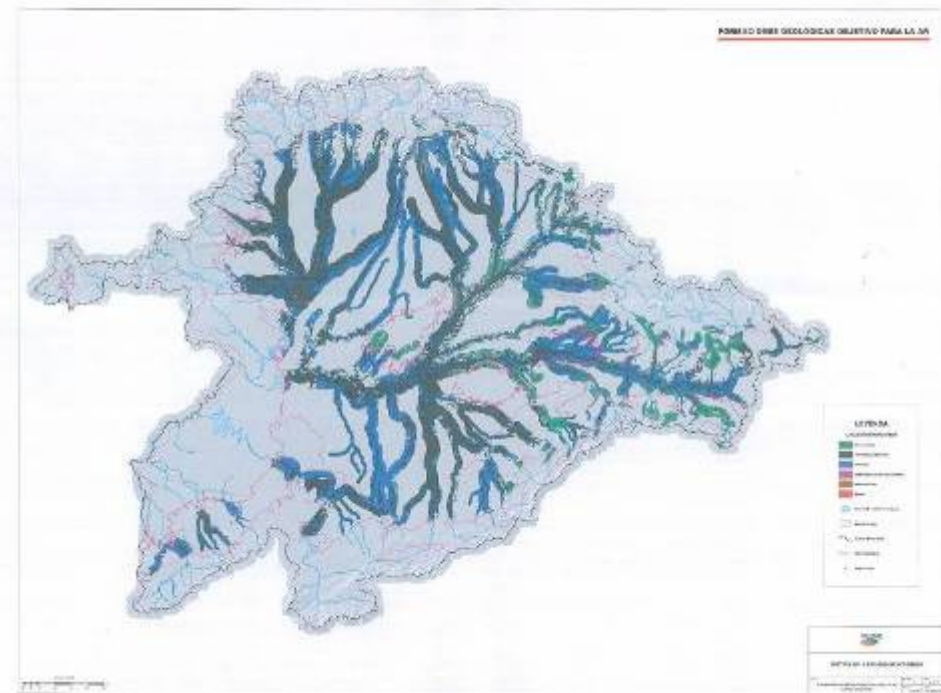
Results

About 15 % of spanish surface (excluding Canary Islands), are **MAR ZONES**

By hydrographic basins:

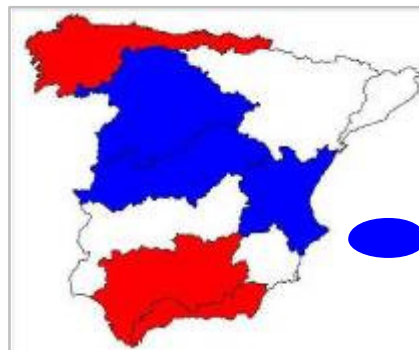
| BASIN | Total basin (km2) | % Sup. |
|--------------|-------------------|--------------|
| DUERO | 21565 | 32.3 |
| TAJO | 10186 | 15.2 |
| EBRO | 8686 | 13.0 |
| JUCAR | 7892 | 11.8 |
| GUADIANA | 5184 | 7.8 |
| GUADALQUIVIR | 4878 | 7.3 |
| SEGURA | 2283 | 3.4 |
| NORTE | 1953 | 2.9 |
| PIRINEO | 1746 | 2.6 |
| SUR | 1458 | 2.2 |
| BALEARES | 1023 | 1.5 |
| TOTAL | 66854 | 100.0 |

MAR mapping of big basins: e.g. Duero basin



Most suitable basins:

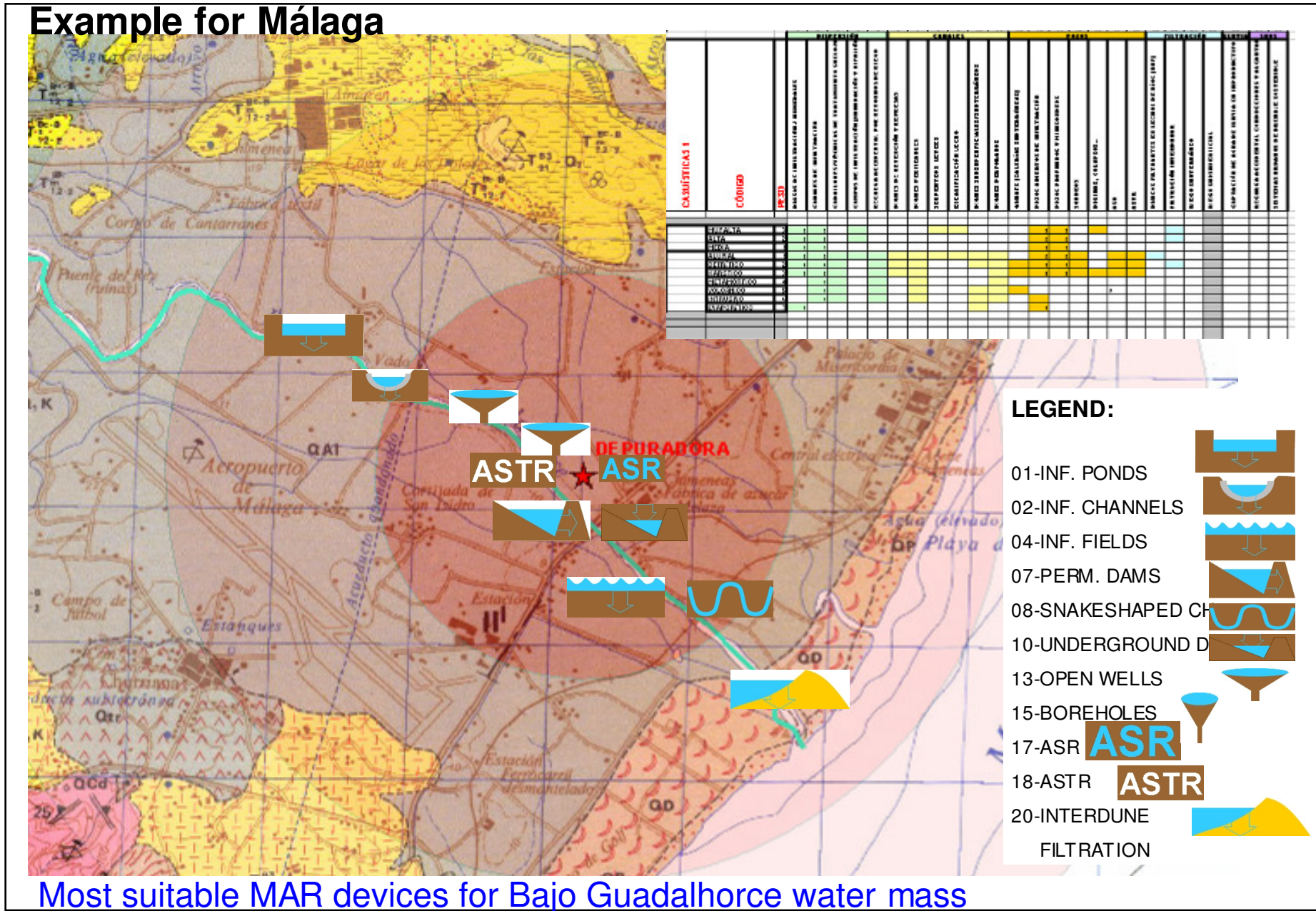
↓
Duero
Baleares
Júcar
Tajo



Maps available at:
www.dina-mar.es

2- MAR zones – AR devices links

Example for Málaga



MAR Potential

Water volume dammed up in Spain:

53.198 hm³ in 2.745 km² (2005 January)
19,37 hm³ / km²

15 % of territory is suitable for MAR (67.000 km²)

¿How much water could be stored in MAR zones?

- Feasible estimated storage capacity: 134.000 hm³ (2 hm³/km²)

**ALMOST A TRIPLE OF FEASIBLE VOLUME IN COMPARISON TO DAMMING.
POSSIBILITY OF OCCUPYING SURFACE LAND**



M.A.R. diffusion' strategy

A new “darcynian” formula:

lf:

$$T = K \cdot e$$

Where:

- T= Transmissivity; K= Permeability; e= Saturated thickness

New proposed formula:

$$K = e^2 \cdot T^3$$

Where:

- K = **K**ey element
- e²= **E**nvironmental **E**ducation
- T³= **T**echnology **T**ransference **T**echniques

**Key = COMBINATION OF ENVIRONMENTAL EDUCATION
AND TECHNOLOGY TRANSFER TECHNIQUES**

Strategy... Spin out process:

DEVELOPMENT GROUPS

Plans

**DISSEMINATION
CIRCLES**

**ACTIVITIES AND
MATERIALS**

Matrix

Matrix available at: www.dina-mar.es

| ACTIVITIES/ MATERIALS | PRODUCT | 1. POLITICIANS & MANAGERS (TECHNOLOGIANS...) | | | | |
|--|--|---|---|------------------|-------------------|--|
| | | 2. GROUPS OF SPECIALISTS (TECHNOLOGIANS...) | 3. PERSONS INVOLVED IN AND AFFECTED BY PROUGHT | 4. SCHOOL GROUPS | 5. GENERAL PUBLIC | |
| DIVULGATIVE & INSTITUTIONAL | INSTITUTIONAL TECHNICAL SESSIONS PUBLICATIONS | | | | | |
| INTERNAL DISSEMINATION DEVELOPMENT GROUP | INTRANET | | | | | |
| | INTERNAL TECHNICAL SESSIONS | | | | | |
| | INTERNAL PUBLICATION SEMINARS | | | | | |
| | DIGITAL & PRINTED | | | | | |
| | TECHNOLOGIC LOGBOOKS | | | | | |
| | GUIDES | | | | | |
| DIVULGATIVE & SPECIALIZED | TECHNICAL REPORTS | | | | | |
| | MEETINGS | | | | | |
| | INTERNATIONAL CONGRESSES | | | | | |
| | NATIONAL CONGRESSES | | | | | |
| | EXPERTS MEETINGS | | | | | |
| | CONFERENCES | | | | | |
| | SIMPOSIUMS | | | | | |
| | WORKSHOPS | | | | | |
| | TECHNICAL PAPERS SCI | | | | | |
| | INTERNET | | | | | |
| | GEO SITES | | | | | |
| | WMS SERVERS | | | | | |
| | SPECIALIZED DATA BASES | | | | | |
| | COMMERCIAL TRADE STANDS | | | | | |
| MATERIALS | DIVULGATIVE LEAFLETS | | | | | |
| | POSTERS | | | | | |
| | MONOGRAPHIES | | | | | |
| BROCHURES* & E-BROCHURES | ADVERTISEMENT BROCHURES | | | | | |
| | LISTS | | | | | |
| | DIPTYCH LEAFLET | | | | | |
| | TRIPTYCH LEAFLET | | | | | |
| | SHEETS | | | | | |
| | EXHIBITION PANEL | | | | | |
| | POSTER | | | | | |
| | LIBRETTOS | | | | | |
| | POSTCARDS | | | | | |
| | CALENDARS | | | | | |
| | CHRISTMAS | | | | | |
| RESULTS PROTECTION TECHNOLOGIC PARTNERS | PATENTS, UTILITY MODELS... | | | | | |
| | COLLABORATION AGREEMENTS | | | | | |
| OTHERS | ALLIANCES | | | | | |
| | THE MEDIA | | | | | |
| | TECHNICAL PAPERS SS | | | | | |
| INFO ACCESS IMPROVEMENT | MAGAZINES | | | | | |
| | SPECIALIZATION COURSES | | | | | |
| | SPECIFIC CAMPAIGNS | | | | | |
| CAMPAIGNS s.i. DIVERSE CHANNELS | INTERNET | | | | | |
| | FORUMS | | | | | |
| | SURVEYS | | | | | |
| | COMMUNICATION MEDIA | | | | | |
| | RADIO | | | | | |
| | TV | | | | | |
| | SPECIFIC PROGRAMS | | | | | |
| | REPORTS | | | | | |
| | DOCUMENTARIES | | | | | |
| | INTERVIEWS | | | | | |
| | SPREADING PUBLICATIONS | | | | | |
| MONOGRAPHIES NON TECHNICAL LANGUAGE | | | | | | |
| TECHNICAL BROCHURES | | | | | | |
| WEB SITES - LINKS - | | | | | | |
| PRESS ARTICLES | | | | | | |
| ADVERTISING SLOTS | | | | | | |
| SPECIFIC CAMPAIGNS | | | | | | |
| SPECIFIC REPORTS NON TECHNICAL LANGUAGE | | | | | | |
| SYLLABUS | | | | | | |
| PLANIFICATION | CURRICULUM PROGRAM | | | | | |
| GREEN PATH SIGNS | MASTERS | | | | | |
| | ADAPTATION NATURAL SPACES | | | | | |
| | GREEN PATHS WITH PANELS | | | | | |
| ETC. | ECOLOGIC PATHS | | | | | |
| | SEVERAL | | | | | |

Examples for dissemination. Materials and activities:



Conclusions

1. **Integral water management in Spain** introduces more non conventional systems such as **M.A.R. and palliative techniques than previous alternatives**. However, **M.A.R. is still underutilized in Spain** (there are only three big examples when 15% of its surface is suitable for MAR alternatives).
2. For the last years **Spanish Authorities** have carried out relevant **experiences** on the field of water management, and the results have been successful.
3. Under an **economic analysis**, MAR technique shows a **low cost** and high effectiveness for the integral water management in Spain at the 21th Century.
4. MAR could be considered as a **driving force** and an outstanding technique for **environmental proposes**.
5. **Environmental education and technology transfer** are very effective spreading techniques:

$$K = e^2 \cdot T^3$$

6. **Dissemination** should take place to the **entire population**, in such a way that citizens have a critical awareness of environmental problems and mechanisms within their reach for solving these problems.



Thank you very much...

efernan6@tragsa.es

www.dina-mar.es

Special thanks to:



Questions???

