MAR in the Spanish Medina del Campo groundwater body as a tool to meet the objectives of European Water Framework Directive

José Antonio de la Orden Gómez
Department of Reserach in Geological Resources
Geological Survey of Spain (IGME)

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DIRECTIVE 2000/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2000

establishing a framework for Community action in the field of water policy

The purpose of this Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater

Environmental objectives for groundwater (art. 4):

- to prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of all bodies of groundwater,
- to protect, enhance and restore all bodies of groundwater, ensure a balance between abstraction and recharge of groundwater, with the aim of achieving good groundwater status at the latest 15 years after the date of entry into force of this Directive
- to reverse any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity in order progressively to reduce pollution of groundwater

ARTIFICIAL RECHARGE OF GROUNDWATER (MAR) IN THE EUROPEAN WATER FRAMEWROK DIRECTIVE.

Art. 11: Each Member State shall ensure the establishment for each river basin district, of a programme of measures, in order to achieve the environmental objectives:

f) controls, including a requirement for prior authorisation of **artificial recharge** or augmentation of groundwater bodies.

The Initial characterisation of Annex II of all groundwater bodies **shall identity the pressures to which the groundwater body or bodies are liable to be subject including artificial recharge.**

In the Review of the impact of human activity on groundwaters for those bodies of groundwater which cross the boundary between two or more Member States or are identified as being at risk of failing to meet the environmental objectives, the following information shall be collected and maintained:

d) the location of points in the groundwater body into which water is directly discharged;
e) the rates of discharge at such points;
f) the chemical composition of discharges to the groundwater body

THE WFD HAS MORE THAN 40 DEFINITIONS, BUT IT DOESN'T DEFINE WHAT IS AN ARTIFICIAL RECHARGE OF GROUNDWATER

DIRECTIVE 2006/118/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2006
on the protection of groundwater against pollution and deterioration

Article 6. Measures to prevent or limit inputs of pollutants into groundwater.
(to comply with the environmental objectives in art. 4 WFD).

3. 3. Without prejudice to any more stringent requirements in other Community legislation, Member States may exempt from the measures required by paragraph 1 inputs of pollutants that are:
d) the result of artificial recharge or augmentation of bodies of groundwater authorised in accordance with Article 11(3)(f) of WFD (measures taken in order to achieve the environmental objectives).

NEITHER IT DEFINES WHAT IS AN ARTIFICIAL RECHARGE

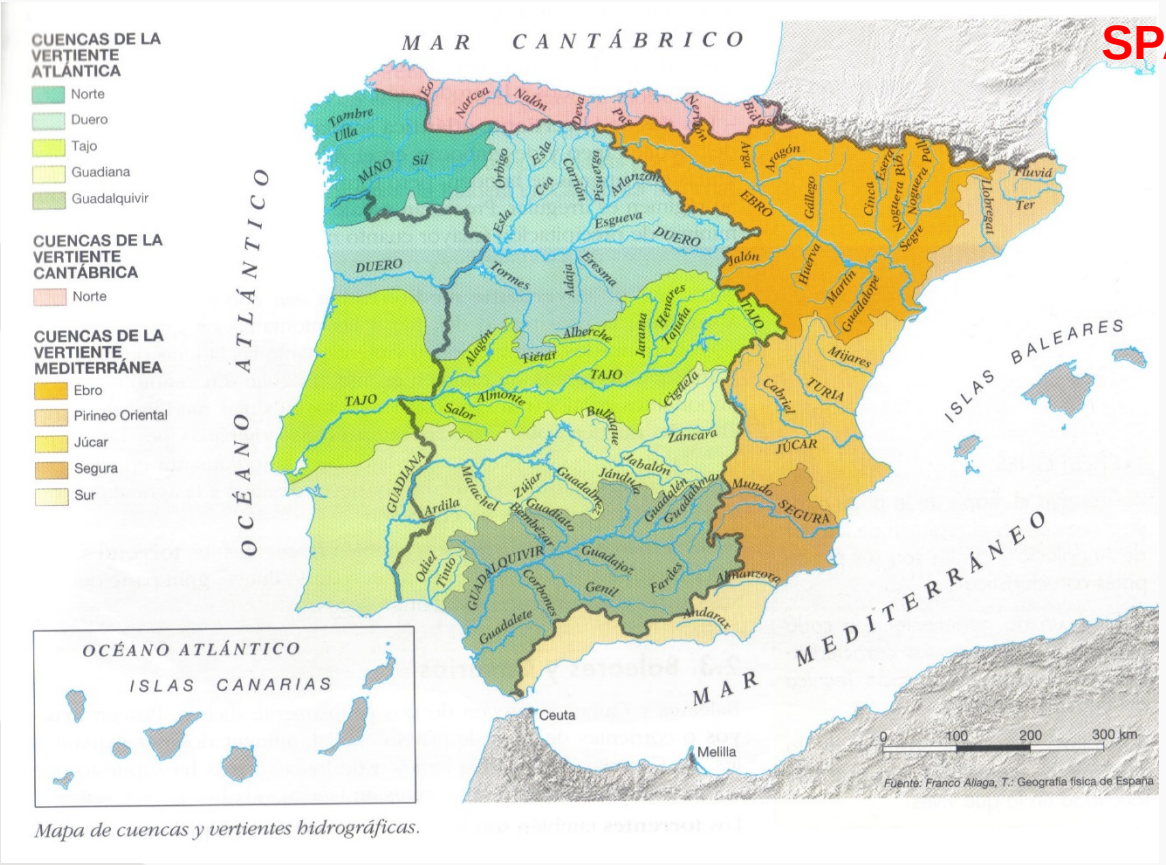
SPANISH WATER ACT.

- Unit for water resources management: RIVER BASIN
- If the river basin comprises more tan one Autonomous Region, the responsable for water management is the Central Government, by means of a public organism, called Hydrographic Confederation, which is the Water Autority.
- If the river basin is completely inside an Autonomous Region, the responsable for water management is the Regional Government.
- It is a mandatory (by WFD) that each river basin have a management plan to manage water resources.

We have:

9 river basin managed by the Central Govermnment

7 basins managed by Regional Governments



Mapa de cuencas y vertientes hidrográficas.

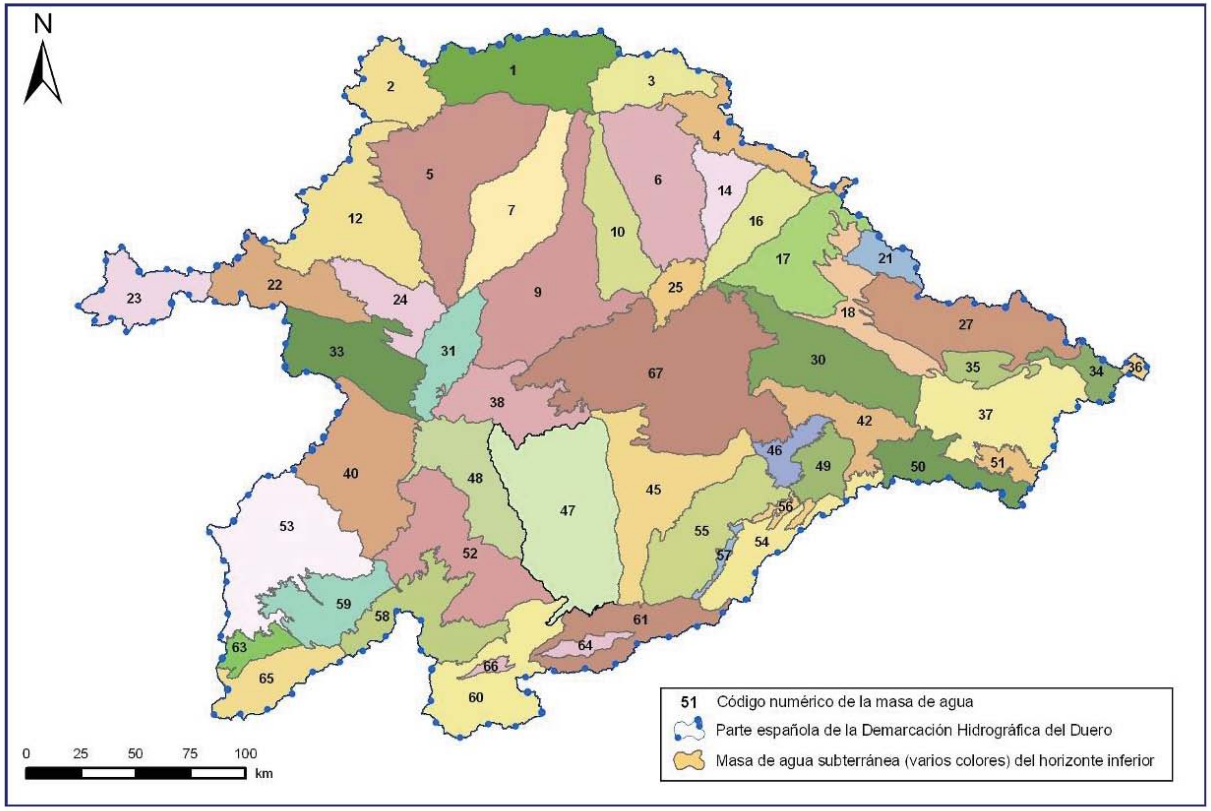
SPANISH WATER ACT.

NEITHER THE SPANISH WATER ACT DEFINES WHAT IS THE ARTIFICIAL RECHARGE OF GROUNDWATER

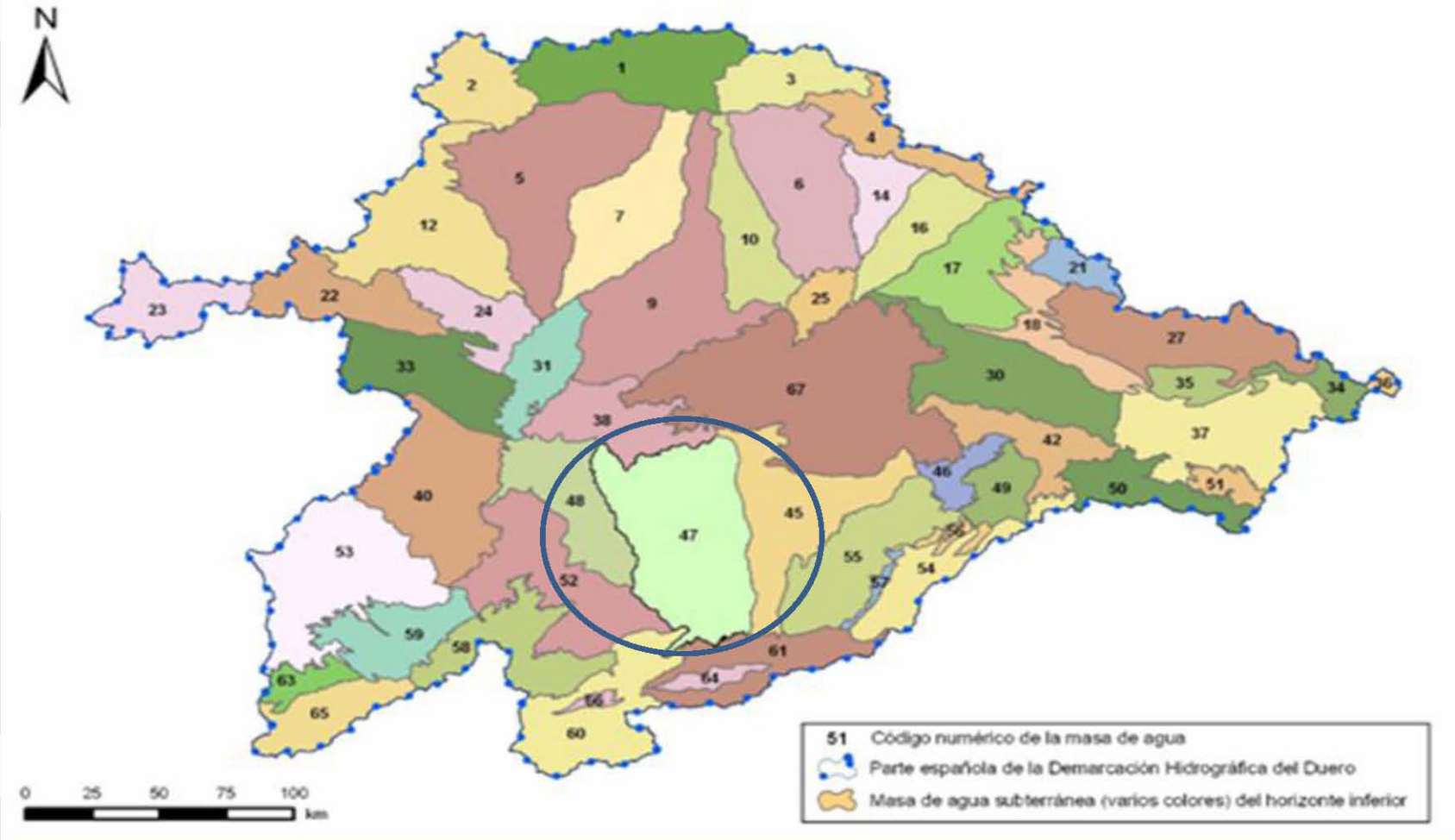
Article 42. About what must river basin management plan content.
Each river basin management plant shall include a summary of the Measures Programme to be developed to comply with the environmental objetives. They shall Include:
k') **Rules for recharge and protection of groundwater**.

SPANISH WATER ACT.

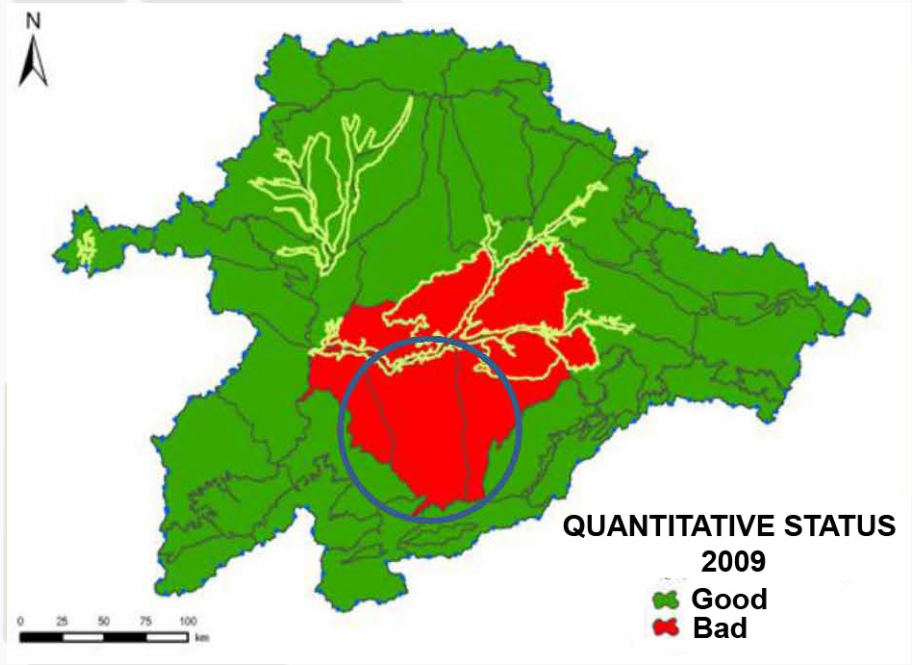
- Each River Basin Water Authority has to create, in the river basin management plant, the surface water and groundwater bodies inside its territory. The minimum water management unit is the water body (surface or underground).
- The Duero river basin plan includes the following groundwater bodies:

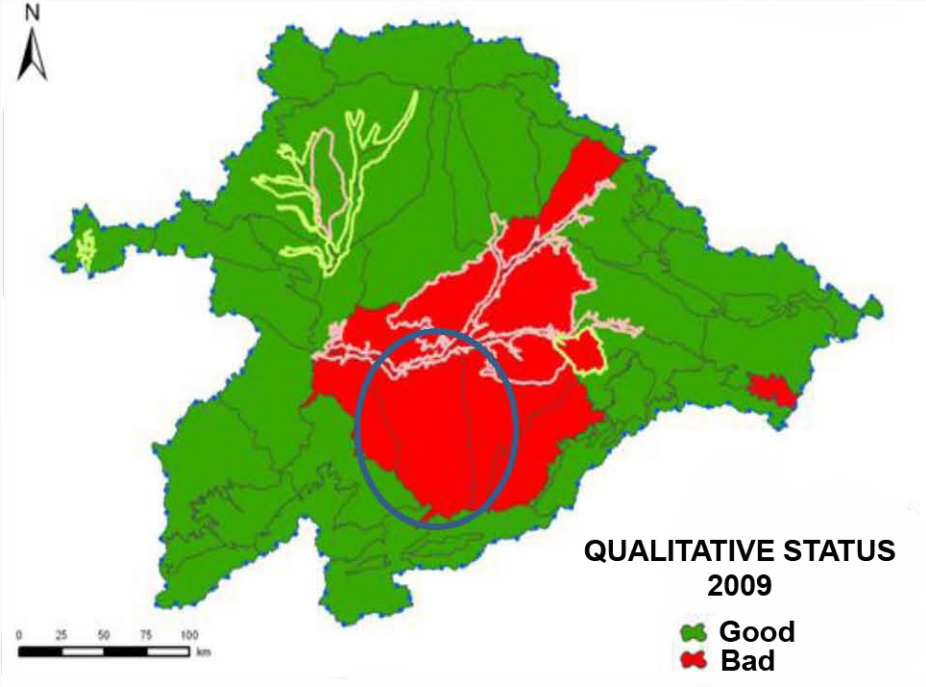


MEDINA DEL CAMPO GROUNDWATER BODY.



MEDINA DEL CAMPO GROUNDWATER BODY STATUS IN 2009.





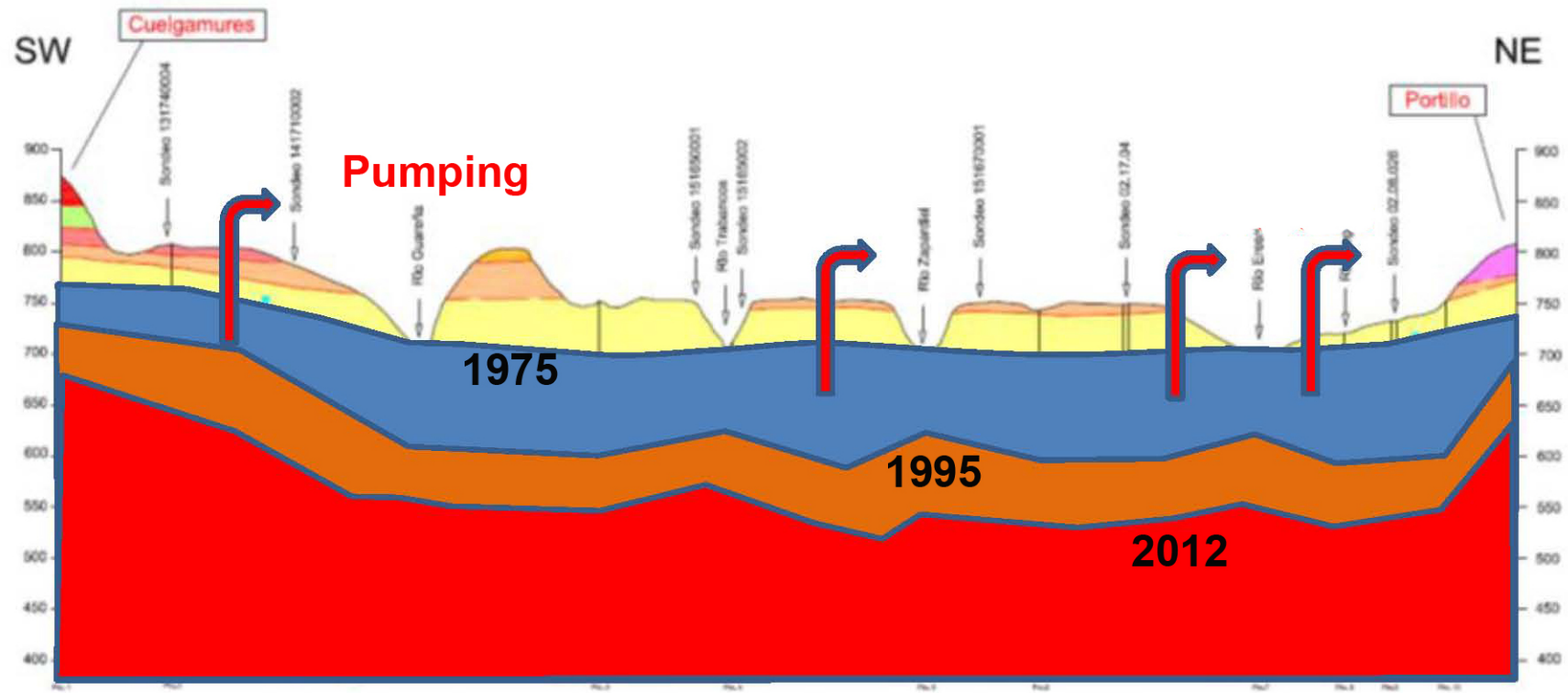
MEDINA DEL CAMPO GROUNDWATER BODY QUANTITATIVE STATUS

It is in the limit of overexploitation

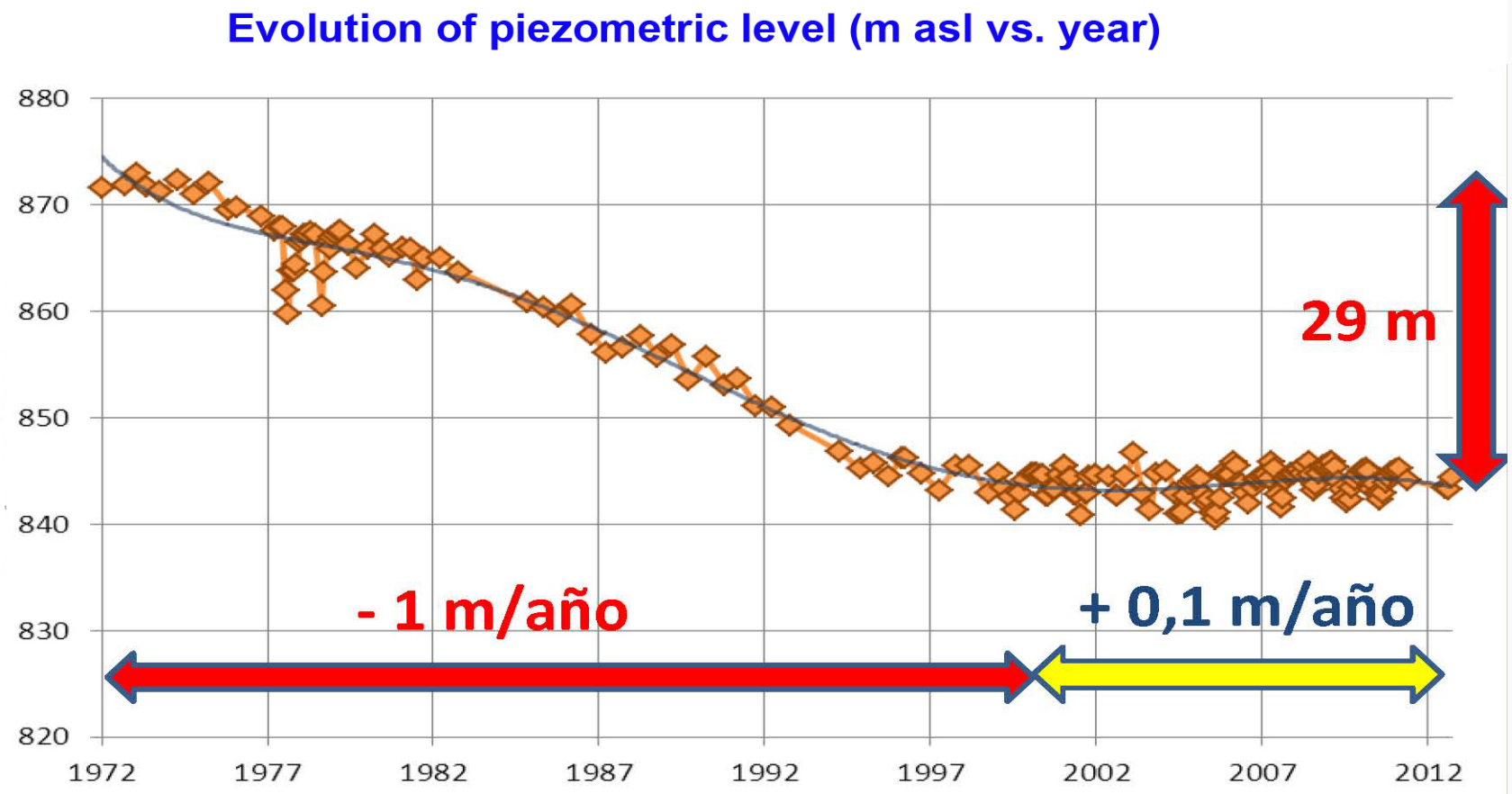
Exploitation rate = 1,3

MEDINA DEL CAMPO GROUNDWATER BODY QUANTITATIVE STATUS

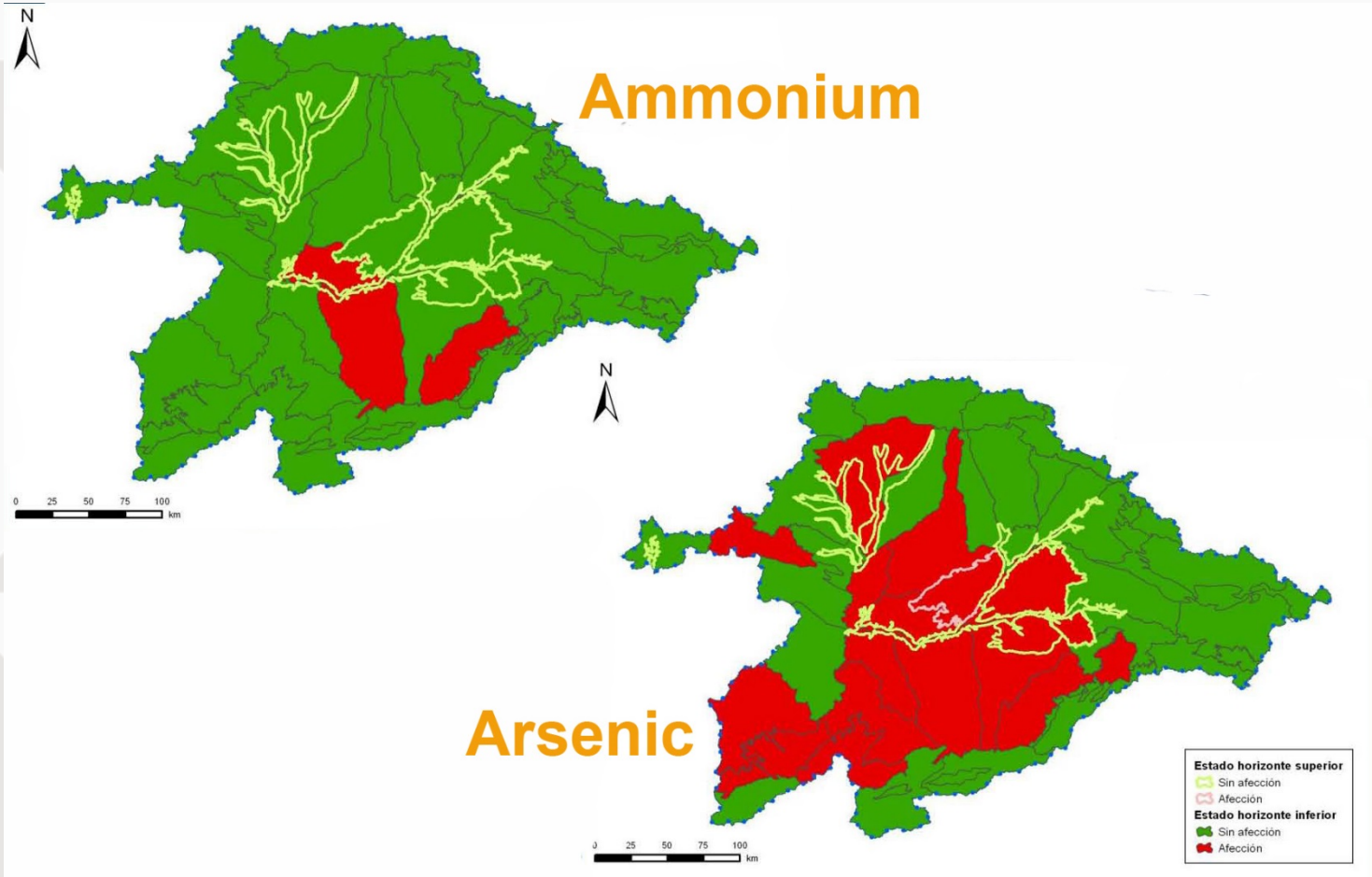
HYDROGEOLOGICAL CROSS - SECTION



MEDINA DEL CAMPO GROUNDWATER BODY
QUANTITATIVE STATUS

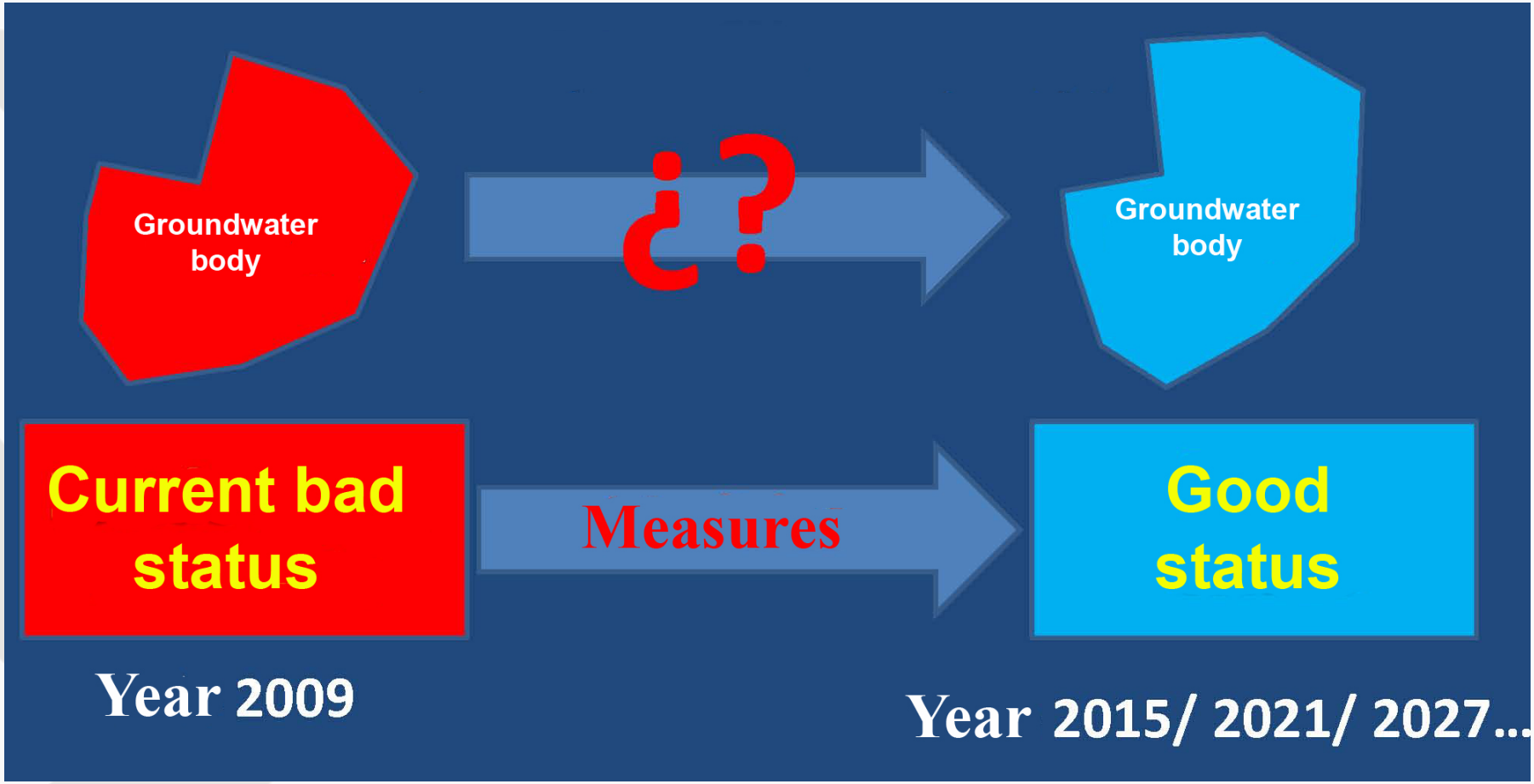


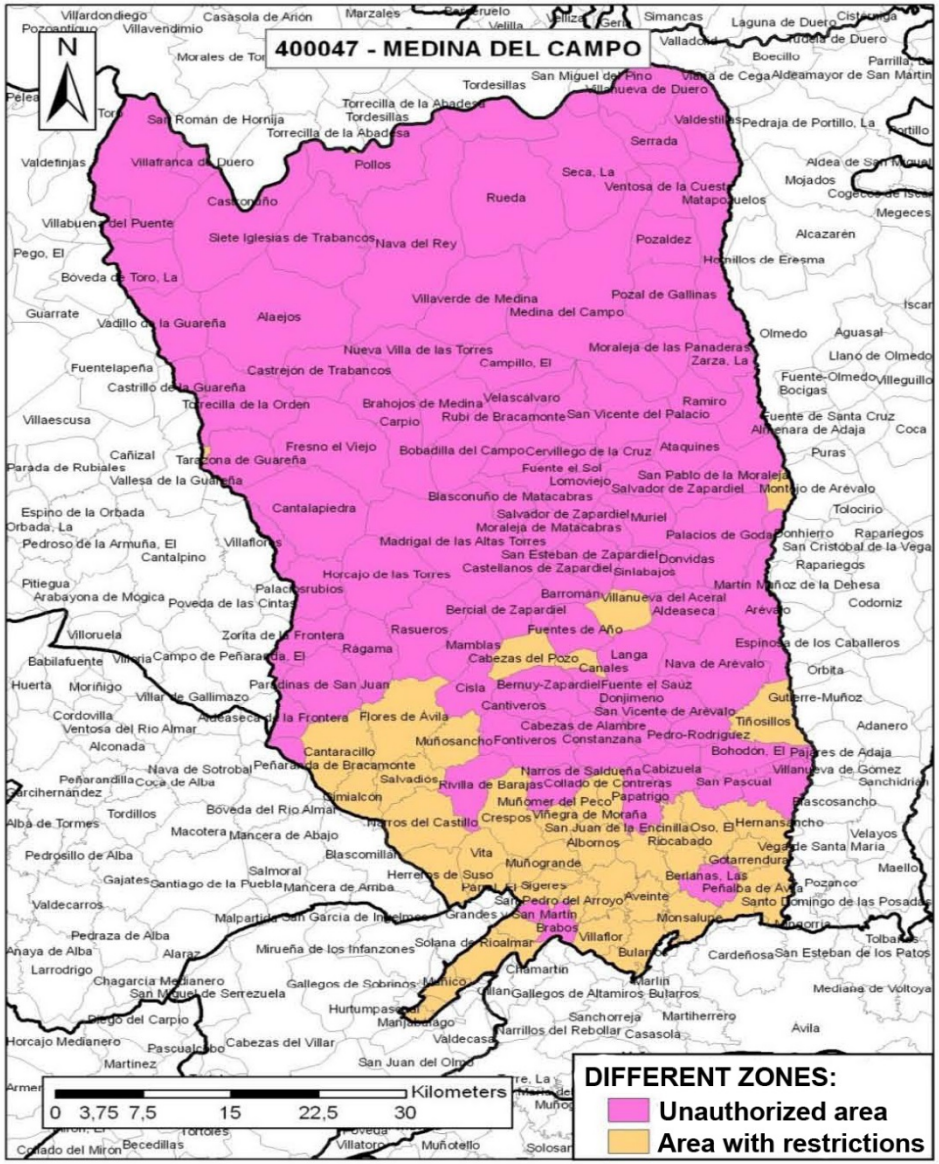
MEDINA DEL CAMPO GROUNDWATER BODY QUALITATIVE STATUS



Too nitrates are increasing due to agriculture

SO, WHAT TO DO TO COMPLY WITH THE EUROPEAN WFD?

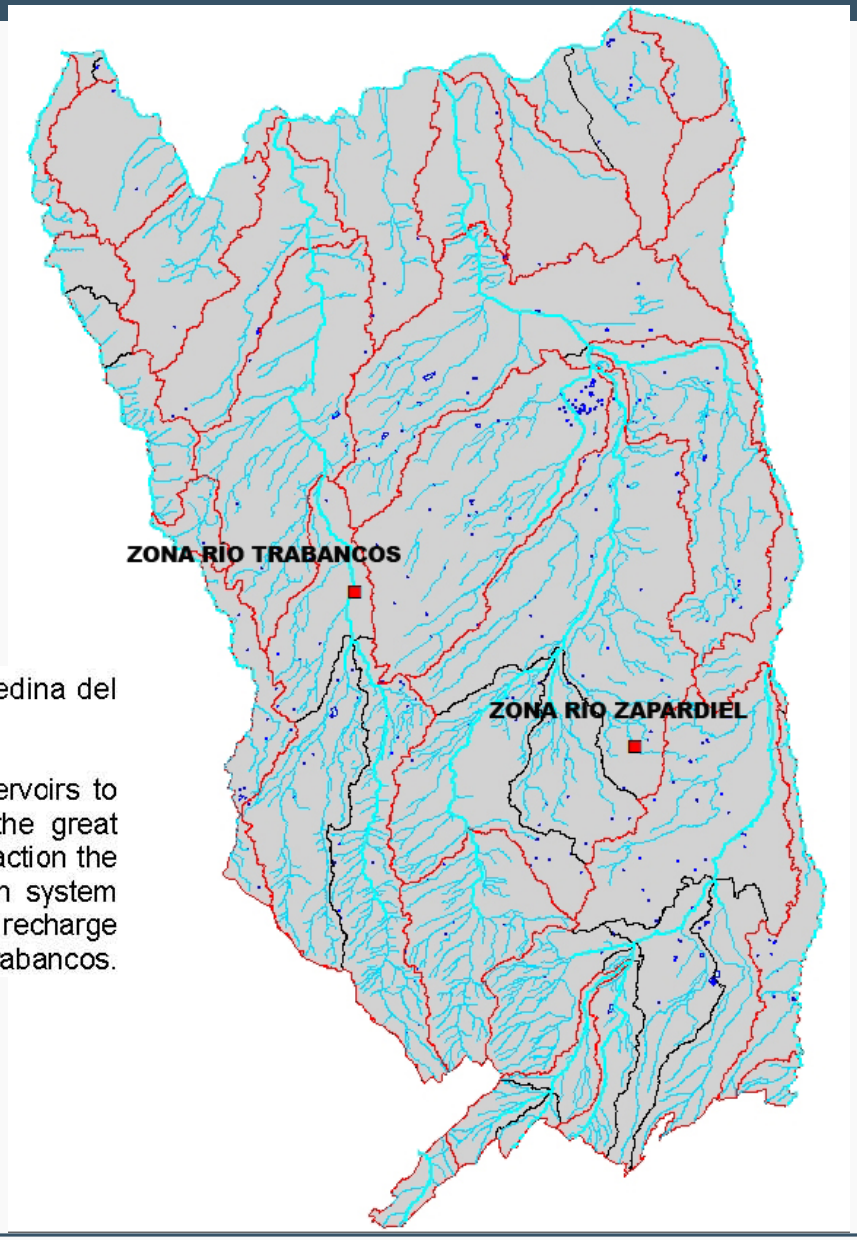




MEASURES TO TAKE:

- No new water rights will be authorized.
- Limitations to use current water rights will happen.
- Human consumption water use is a priority.
- Encourage water saving.
- Promote the participation of all stakeholders involved in water management.

THE OTHER MEASURE TO TAKE IS TO PUT INTO OPERATION AN ARTIFICIAL RECHARGE PROJECT.



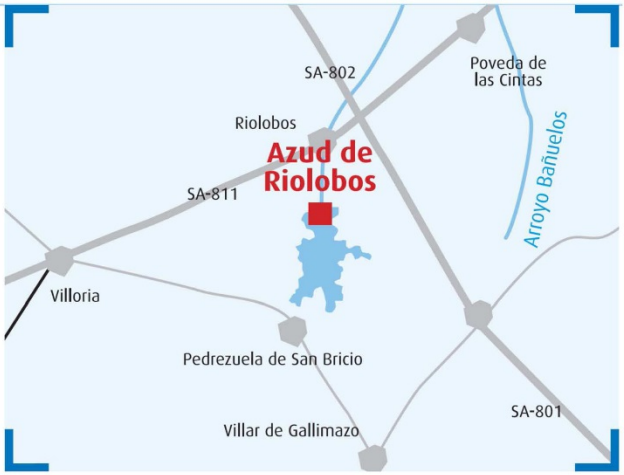
The aim of this action is to improve the general status of the aquifer of Medina del Campo by developing artificial recharge activities.

It is foreseen to canalised water from Santa Teresa and Las Cogotas reservoirs to recharge this aquifer using the existing irrigation infrastructure. Due to the great challenge that supposes the recovery of this aquifer, it is proposed as main action the recharge of the aquifer "Medina del Campo" by using the existing irrigation system called “Riolobos-La Armuña”, taking the water from the big river Tormes. The recharge is planned to be carried out through the riverbeds of the rivers Mazores and Trabancos.

1. AQUIFERS RECHARGE ACTION: RIOLOBOS WEIR

It is proposed, the recharge of the aquifer called "Medina del Campo" by using the existing irrigation system called “Riolobos-La Armuña”. The recharge is planned to be carried out through the riverbeds of the rivers Mazores and Trabancos.

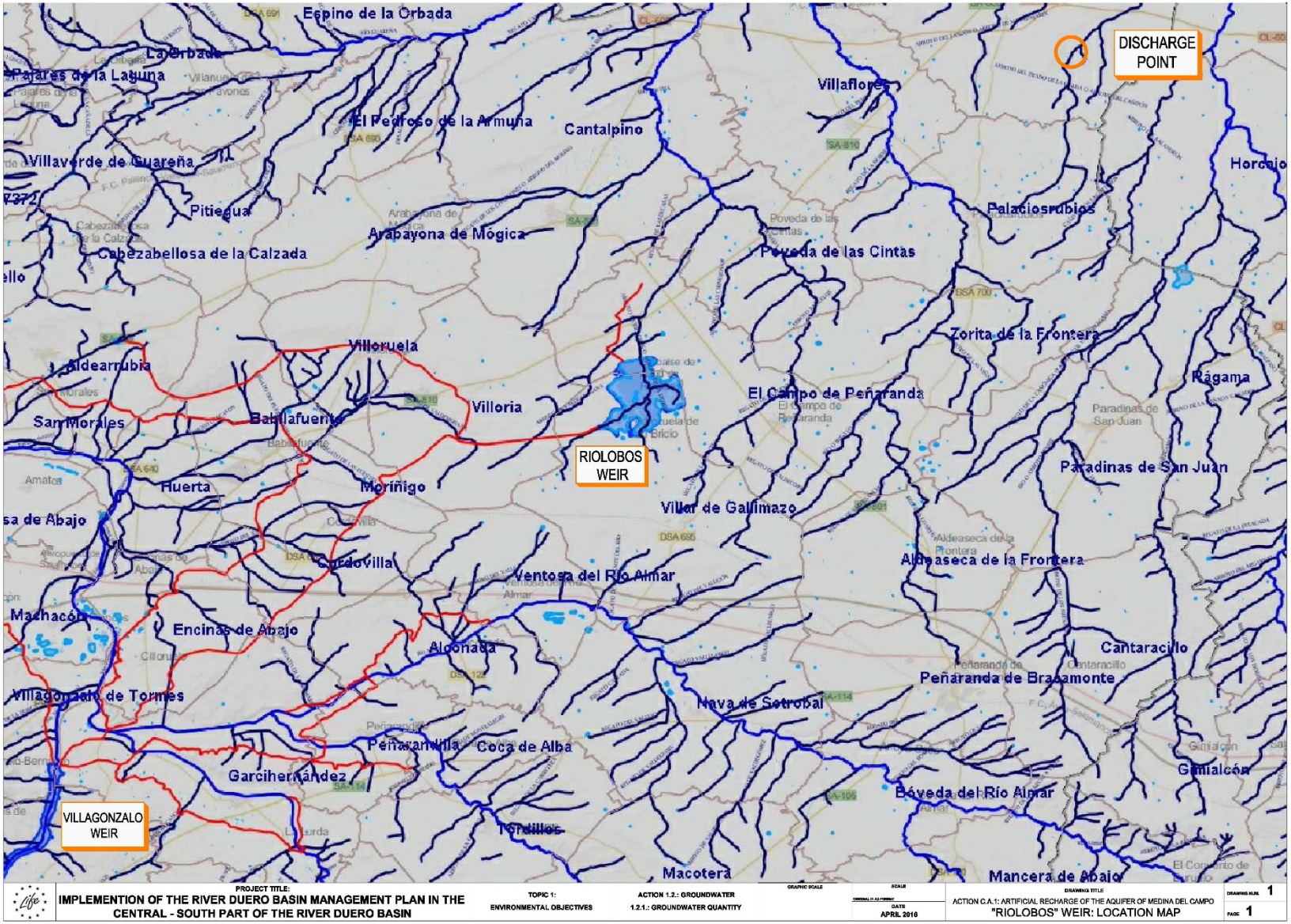
The Riolobos weir is located at the head of the Stream de la Dehesa or Riolobos, between the municipalities of Villar de Gallimazo and El Campo de Peñaranda, both belonging to the province of Salamanca.
This reservoir was built in1998 as part of the infrastructures of the Irrigation System "La Armuña". It is sourced by water from the river Tormes by the weir of Villagonzalo.



Location of the “Riolobos” weir

Water arrives to the Riolobos weir through a channel after being elevated in the pumping station of *Villoria*.

TRABANCOS RIVER RECHARGE



TRABANCOS RIVER RECHARGE

Recharge water source: Villagonzalo weir (Tormes river)

Intermediate storage: Riolobos weir

TRABANCOS RIVER RECHARGE

The Villagonzalo weir is an infrastructure, whose principal use is sourcing of water to the Irrigation Systems of “Villoria” and “La Armuña”. Water is storage upstream in the “Santa Teresa” reservoir with a maximum capacity of 496 Hm^3. It is also used as drinking water supply and for hydroelectric generation.

HIDROLOGICAL DATA	
Basin surface	790,00 km^2
Average annual contribution	714 Hm^3
Spillway peak flow	2900,00 m^3/s
RESERVOIR DATA	
Flooded surface NMN	208 ha
Capacity NMN	5,90 Hm3
Surface water elevation NMN	804,30 m.a.s.l.
DAM DATA	
Dam type	Gravity
Foundation elevation	791,30 m.a.s.l.
Height over foundation	19,00 m
Height over riverbed	13,50 m
Coronation length	146,00 m
Total volume of the dam body	25.300,00 m^3

General data of Villagonzalo weir

TRABANCOS RIVER RECHARGE

The reservoir is one of the main wetlands (in this case artificial) of the area with 387 hectares, considered an exceptional site for nesting of passage birds, as a consequence of this fact, it is a protected area included in the SPA "Campos de Alba" and is in the Regional Catalogue of Wetlands of Castilla y León.

HIDROLOGICAL DATA	
Basin surface	10,70 km^2
Average annual contribution	2,75 Hm^3
Spillway peak flow	52,00 m^3/s
RESERVOIR DATA	
Flooded surface NMN	386,83 ha
Capacity NMN	13,87 Hm3
Surface water elevation NMN	837,50 m.a.s.l.
DAM DATA	
Dam type	Loose material. Clay core
Foundation elevation	820,50 m.a.s.l.
Height over foundation	19,00 m
Height over riverbed	15,70 m
Coronation length	1.113,00 m
Total volume of the dam body	331.340,00 m^3

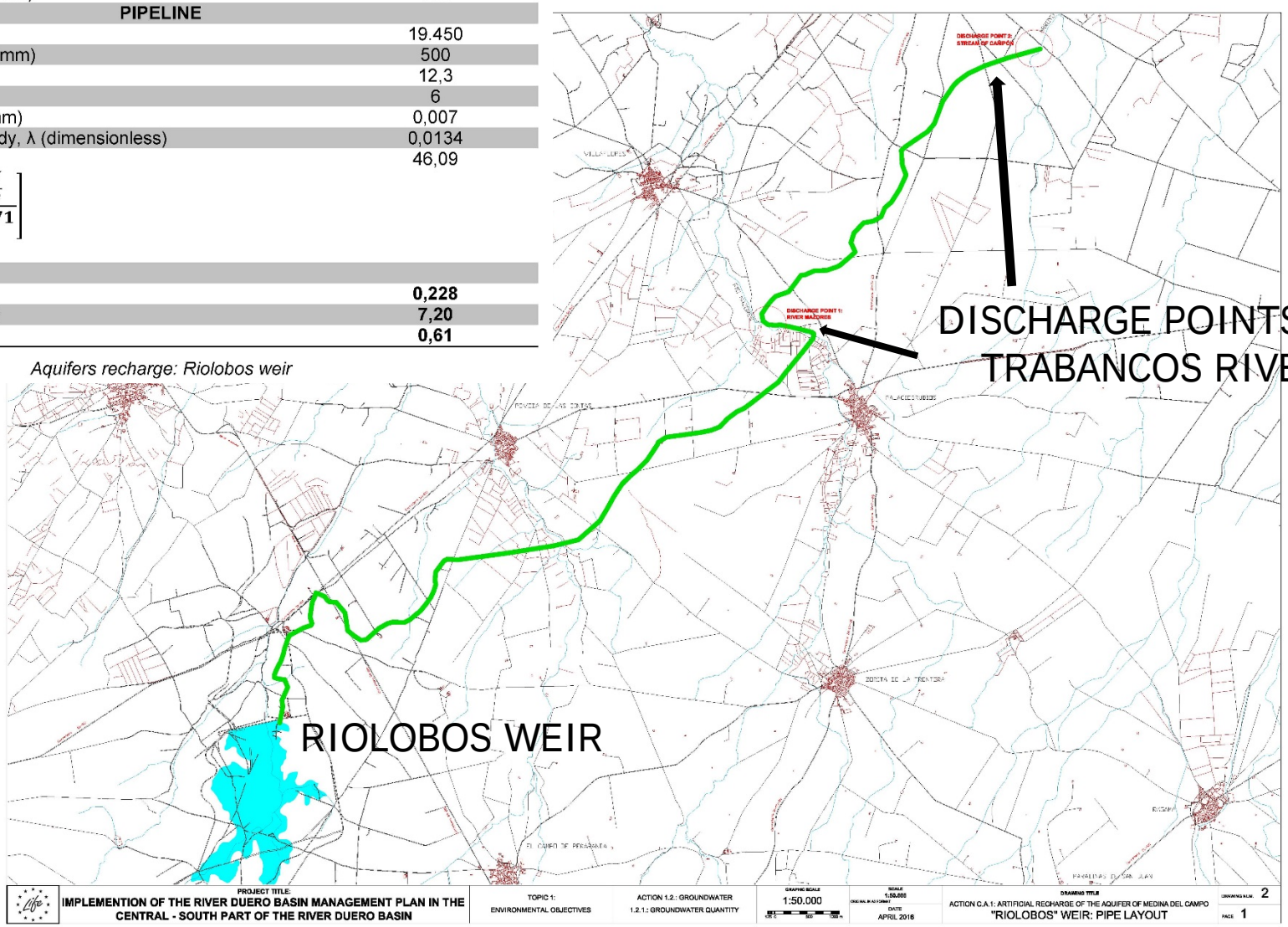
General data Riolobos weir

TRABANCOS RIVER RECHARGE

AQUIFERS RECHARGE: RIOLOBOS WEIR	
Elevation of the weir (m.a.s.l.)	834
Elevation of the river (m.a.s.l.)	788
PIPELINE	
Length (m)	19.450
Nominal diameter (D.N.) (mm)	500
Thickness (mm)	12,3
Nominal pressure	6
Absolute roughness, K (mm)	0,007
Coefficient of friction Moody, λ (dimensionless)	0,0134
Head loss (m)	46,09
Flow (m3/s)	**0,228**
Recharge volume (Hm3)	**7,20**
Speed (m/s)	**0,61**

$$\frac{1}{\sqrt{\lambda}} = -2\log\left[\frac{2,51}{Re\sqrt{\lambda}} + \frac{\frac{K}{D}}{3,71}\right]$$

Aquifers recharge: Riolobos weir



TRABANCOS RIVER RECHARGE

ZAPARDIEL RIVER RECHARGE

2. AQUIFERS RECHARGE: IRRIGATION SYSTEM "RÍO ADAJA"

It is also proposed, the recharge of the aquifer called "Medina del Campo" by using the existing irrigation system called "Río Adaja". The recharge is planned to be carried out through the riverbed of the river Arevalillo and the Stream of Las Vegas by using the existing draining pipes of the Irrigation Ponds of Nava de Arevalo and Magazos.

This Irrigation System "Rio Adaja" includes parcels belonging to the municipalities of: Gutierre Muñoz, Orbita, Espinosa de los Caballeros, Arévalo, Aldeaseca, Villanueva del Aceral, Langa and Nava de Arévalo.

The total irrigated surface is divided in five sectors and amounts to a total of 6.537 Ha. Water flow is sourced to the irrigation intakes by three pumping stations which takes water from its respective regulation ponds. The capacities of these ponds are: 475.320 m^3 Nava de Arevalo, 322.463 m^3 Portera and 167.093 m^3 Vauperal.

Water arrives to these pumping stations through a network of gravity flow pipes which begins in the derivation weir of Zorita de los Molinos. Water is upstream stored in "Las Cogotas" reservoir with a total capacity of 59 Hm^3.

The ponds located close to the urban agglomerations of Nava de Arévalo and Magazos, which belongs to the municipality of Nava de Arevalo, are the infrastructures selected to develop the recharge.

ZAPARDIEL RIVER RECHARGE

HIDROLOGICAL DATA	
Basin surface	0,50 km^2
Average annual contribution	9,29 Hm^3
Spillway peak flow	922,00 m^3/s
DAM DATA	
Dam type	Gravity Arch
Foundation elevation	895,00 m.a.s.l.
Height over foundation	22,00 m
Height over riverbed	19,00 m
Coronation length	124,00 m

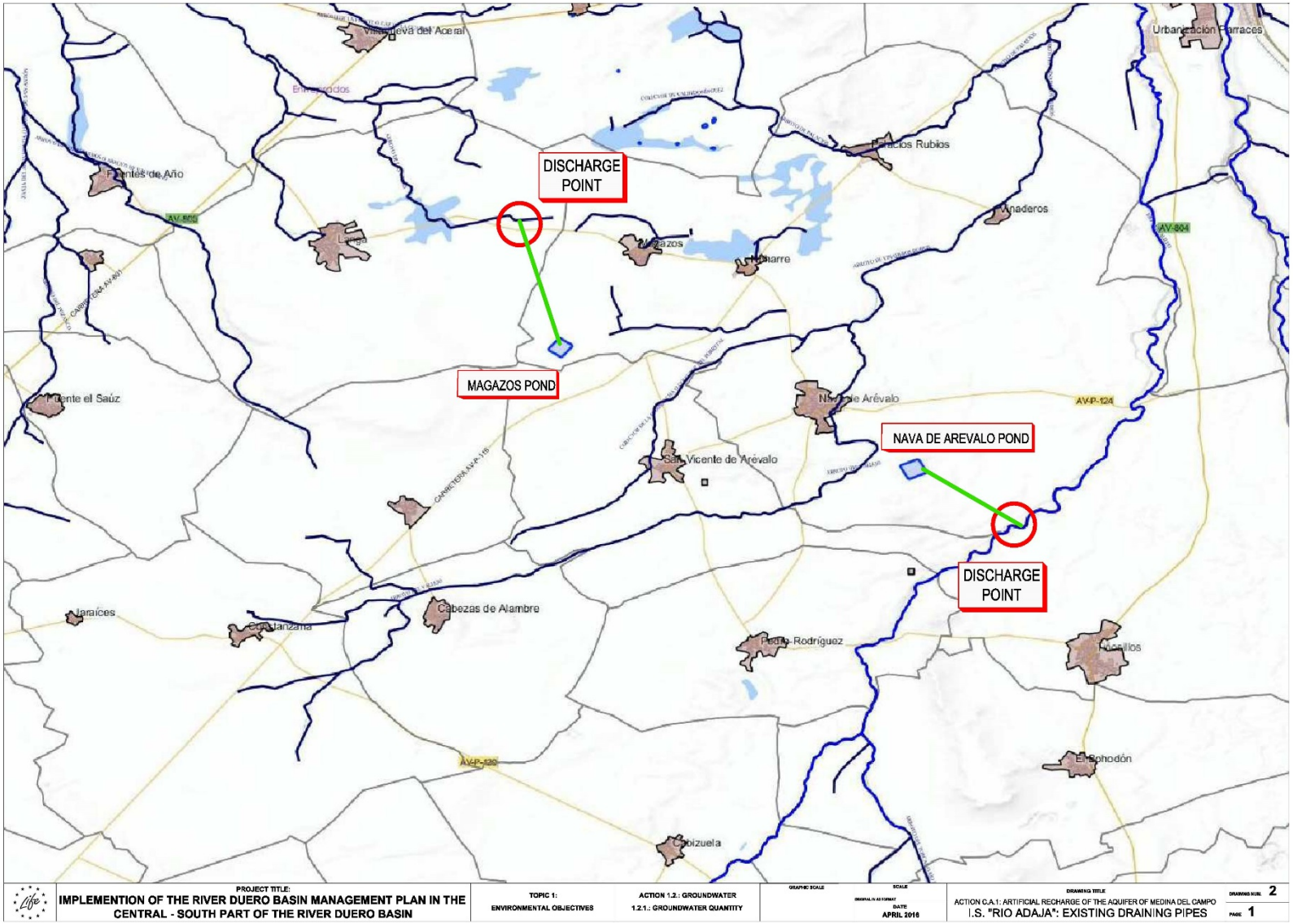
General data of Zorita de los Molinos weir

Recharge water source:
Las Cogotas reservoir (Adaja river)

Zorita de Los Molinos weir. Irrigation System "Río Adaja" (Ávila)

Peak recharge flow, when surpluses are available: 250 L/s

ZAPARDIEL RIVER RECHARGE



ZAPARDIEL RIVER RECHARGE

Due to the recharge is used taking advantage of irrigation infrastructures, it must be done when they are not being used for this aim. Therefore, the recharge time will last 180 days a year. Water surpluses from the river Adaja, stored in "Las Cogotas" reservoir, will be used to recharge the aquifer.

Receiving watercourse: River Zapardiel

TOTAL PRELIMINARY CALCULATED COST

BUDGET

CODE	CONCEPT	Nº OF UNITS	UNIT COST	PARTIAL AMOUNT
01.01	UD WATER INTAKE			
		1,000	8.932,64	8.932,64
01.02	m3 TRENCH EXCAVATION			
		44.735,000	4,18	186.992,30
01.03	m PVC PIPE ELASTIC JOINT PN6 500mm			
		19.450,000	59,63	1.159.803,50
01.04	UD PIPELINE ANCHORING			
		60,000	48,86	2.931,60
01.05	m3 TRENCH FILLING. SAND			
		11.864,500	11,10	131.695,95
01.06	m3 TRENCH FILLING. EXCAVATION MATERIAL			

PRELIMINARY VIABILITY ANALYSIS

Groundwater level rising has been calculated using the following formula:
Rise = (Recharged water flow/basin area)/effective porosity

For Zapardiel river

River basin área: 394 km^2
Recharged water flow: 7,884 Mm^3/year (1 acre-foot = 1233,5 m^3)
Effective porosity: 0,0931 course grain
Effective porosity: 0,0643 fine grain

Groundwater level rising: 0,21 m/year in course grain materials
Groundwater level rising: 0,31 m/year in finegrain materials

For Trabancos river

River basin área: 84 km^2
Recharged water flow: 7,2 Mm^3/year
Effective porosity: 0,138 course grain
Effective porosity: 0,0643 fine grain

Groundwater level rising: 0,621 m/year in course grain materials
Groundwater level rising: 1,33 m/year in fine grain materials

CURRENT WORKS

1. Mathematical flow model:

To assess the impact of artificial recharge in the aquifer

To define the most suitable areas to discharge the recharge water

2. Looking for fundings: A research project has been granted by the European Union Commission to the Duero Water Authority to construct the needed pipeline.

3. Refining the water surpluses study to know excatly how much available water there is in the Zapardiel system (Las Cogotas reservoir surpluses)

THANK YOU VERY MUCH FOR YOUR ATTENTION

Instituto Geológico
y Minero de España