NeWater

CASE STUDY DATABASE

Part B. The Caia reservoir (Guadiana basin)

Report of the NeWater project -
New Approaches to Adaptive Water Management under Uncertainty

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Policy Summary

This document is the second part of the deliverable 1.5.2 of Work package 1.5. The first part is dedicated to the Rhine basin.

As recently stated by Silberstein (2006): "modelling in the absence of adequate data is not science". The same author mentions that "improvement in the management of our environment and water resources will not come with improved models in the absence of improved data collection because we cannot manage what we do not measure".

For these reasons, WP 1.5 devotes a whole task to data collection and this report presents the dataset collected on the Guadiana case study and more precisely on Caia reservoir catchment area. This reservoir has been selected by the Portuguese stakeholder's representative (ISQ) during the NeWater general assembly 2006.

This document presents the different data collected:

- Physical data on Caia dam,
- Hydrological data on Caia reservoir catchment area,
- Data on water uses from Caia reservoir.

The data collected provide a general picture of the Caia reservoir system:

- The dam is devoted mainly to irrigation with 43% of annual uses. Energy production is the second use with 26% of consumption.
- Uses are mainly during summer months, starting in May or June.
- Upstream hydrological resources are limited and variable resulting in difficult periods (1976 and 1995) and persistence of scarcity over several years.

Policy recommendations

Financial efforts on the maintenance of measurement networks are vital for the understanding of the hydrosystem. Our study on Caia reservoir was made possible due to two factors:

- The existence of long time-series on rainfall, discharge, stored volumes and water uses,
- The availability of these data on the Web site of the Instituto National do Agua (INAG, 2006).

This dual aspect of water related data (existence of a measurement network and facilitated access) is a central issue to achieve the transition toward adaptive management. The interested reader is referred to work package 1.6 of Newater project (Transition to Advanced Monitoring Systems for Adaptive Management).

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1 Introduction

As recently stated by Silberstein (2006): "modelling in the absence of adequate data is not science". The same author mentions that "improvement in the management of our environment and water resources will not come with improved models in the absence of improved data collection because we cannot manage what we do not measure".

For these reasons, WP 1.5 devotes a whole task to data collection and this report presents the dataset collected on the Guadiana case study and more precisely on Caia reservoir catchment area. This reservoir has been selected by the Portuguese stakeholder's representative (ISQ) during the NeWater general assembly 2006.

On this basin, the WP 1.5 task was greatly simplified as the hydrological data collection work had been already done and published by the INAG (Instituto do Agua) on a Web site hosted by the SNIRH (Sistema Nacional de Informação de Recursos Hidricos, 2006). Additional data were collected from the Web site of the Portuguese National Commission on Large Dams (CNPGB, 2006).

This document presents the different data collected:

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- Data on water uses from Caia reservoir.

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2 Physical data on Caia dam

The data presented in this section have been retrieved from the Web site of the National Portuguese Commission on Large Dams dedicated to dams in Portugal (CNPGB, 2006).

2.1 General description

Caia dam is a large dam with a gross capacity of 203 million m^3. It is located in the south-eastern part of Portugal. The reservoir is filled with water flowing mainly from the Caia River, a small Portuguese tributary of Guadiana River.

Figure 1: Location of Caia dam

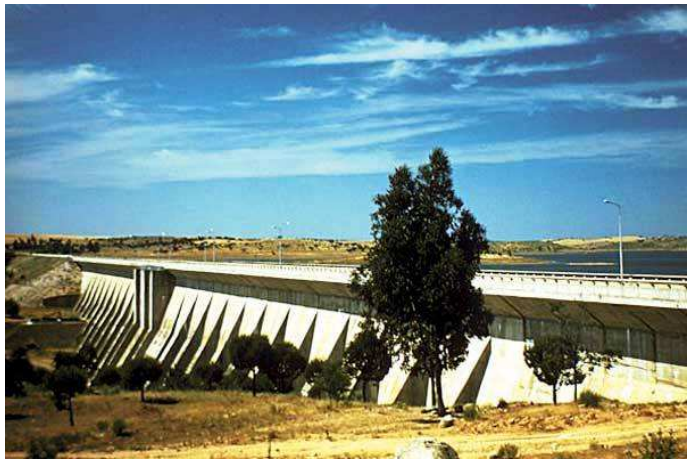

Figure 2: Pictures of Caia dam[1]

[1] Retrieved from http://cnpgb.inag.pt/gr_barragens/gbingles/CaiaIng.htm

PURPOSE - Irrigation / Water supply	
LOCATION	**GENERAL FEATURES**
District - Portalegre ***Municipality*** - Elvas ***River Basin*** - Guadiana ***River*** - Caia river	***Promoting entity*** - Associação de Beneficiários do Caia ***Owner (RSB)*** - Associação de Benef. do Caia ***Engineering by*** - DGSH ***Construction by*** - SOMEC ***Year of completion*** - 1967
HYDROLOGY	**RESERVOIR**
River basin area - 571 km^2 ***Flood runoff*** - 1080 m^3/s	***Reservoir area*** - 19700 x 1000m^2 ***Gross capacity*** - 203000 x 1000m^3 ***Effective storage*** - 192300 x 1000m^3 ***Dead storage*** - 10700 x 1000m^3 ***Normal water level (NWL)*** - 233,5 m ***Maximum flood level (MFL)*** - 233,9 m
DAM	
Earthfill - Embankment ***Concrete*** - Buttress ***Mixed dam*** - Yes ***Height above foundation*** - 52 m ***Height above streambed*** - 45,2 m ***Crest elevation*** - 235,2 m ***Crest length*** - 949 m ***Crest width*** - 11 m ***Foundation*** - Composite Rock/Earth: Schist and granite ***Volume of dam body*** - ***Earthfill*** - 171,7 x 1000 m^3; ***Concrete*** - 181,7 x 1000 m^3	
SPILLWAY	**BOTTOM OUTLET**
Location - Center ***Control type*** - Controlled ***Spillway type*** - Over the dam ***Number of gates*** - 2 ***Maximum discharge*** - 430 m^3/s ***Energy dissipation*** - Hydraulic jump	***Location*** - Thalweg ***Type*** - Through the dam ***Section*** - d 2 m ***Maximum discharge*** - 59 m^3/s ***Upstream control*** - Sluice gate ***Downstream control*** - Hollow jet valve ***Energy dissipation*** - Hollow jet and scour holes
POWER PLANT	
Power installed capacity - 0,6 MW ***Mean annual energy output*** - 1,5 GWh	

Figure 3: Description of Caia dam[2]

[2] Retreived from http://cnpgb.inag.pt/gr_barragens/gbingles/CaiaIng.htm

2.2 Water levels and stored volumes

Water levels and volumes stored in Caia reservoir are daily data from 1967 to 2005.

Figure 4 presents the relationship between observed water levels and stored volumes.

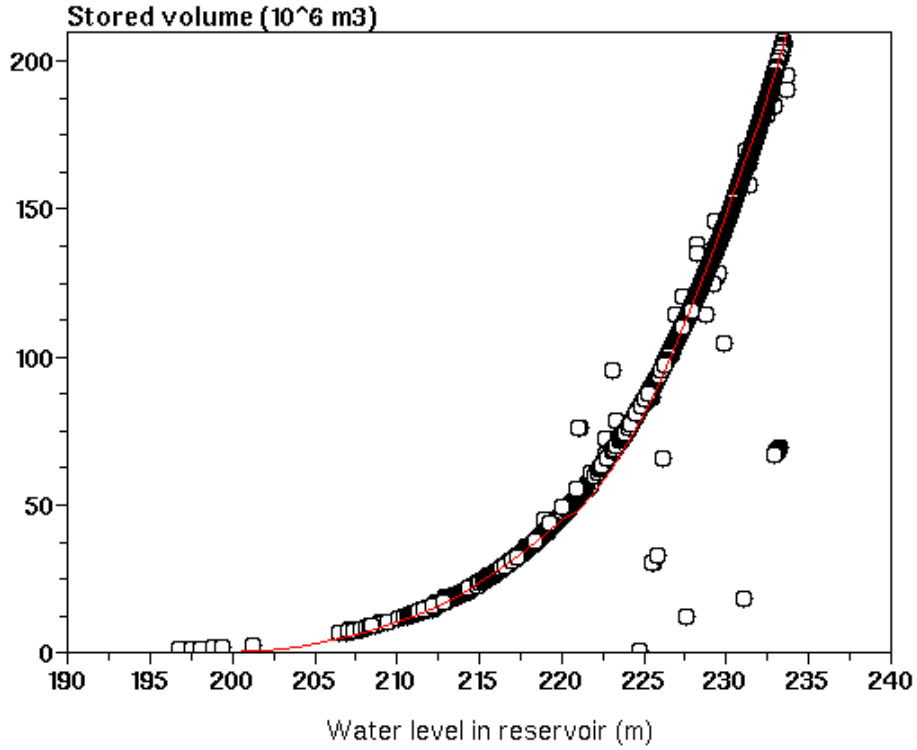

Figure 4: Water level/stored volume relationship

To facilitate hydrological modelling, a simple curve was fitted on the points shown on Figure 4. The formula are presented in Table 1.

Condition on water level	Water Level (m) – Stored volume relationship (10^6 m3)
H<220 m	V = 0.004 x (H-195) ^ 2.9
H>220 m	V = 3.246 x (H-220) ^ 1.5 + 45

Table 1: Formula to approximate the water level/stored volume relationship

The evolution of water levels and stored volumes is shown on Figure 5 and Figure 6. The latest shows statistics of stored volumes from the first of January to the 31st of December. All the available years are plotted simultaneously and quantiles are calculated on each calendar day.

These two graphs reveal the extreme versatility of inflows to Caia reservoir: considering the wide distribution of daily stored volumes (see Figure 6), there is absolutely no guarantee to fill up the reservoir from one year to another.

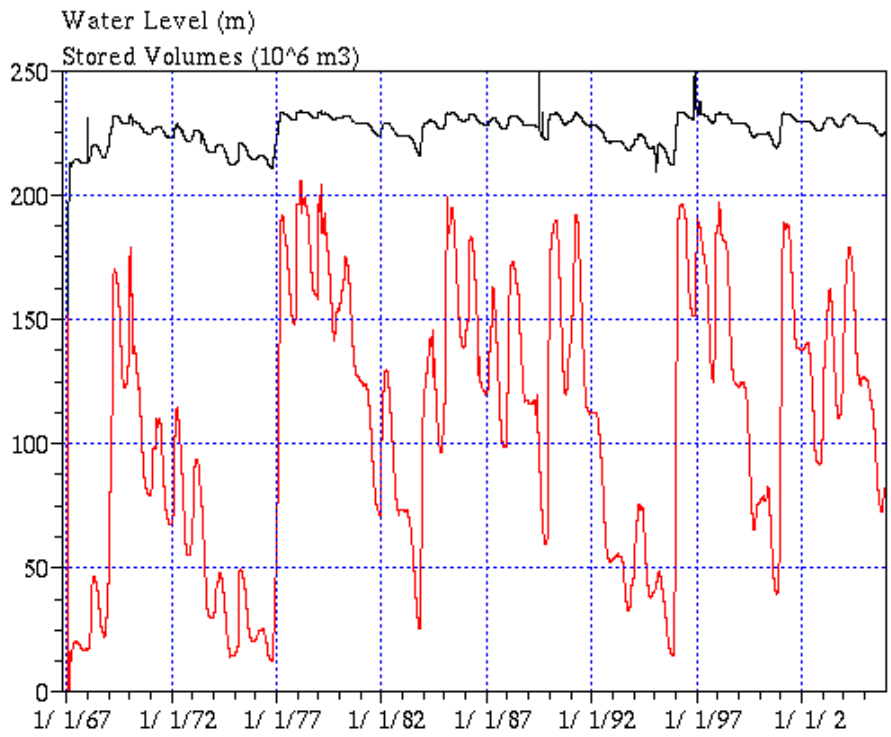

Figure 5: Water levels and stored volumes in Caia reservoir between 1967 and 2002

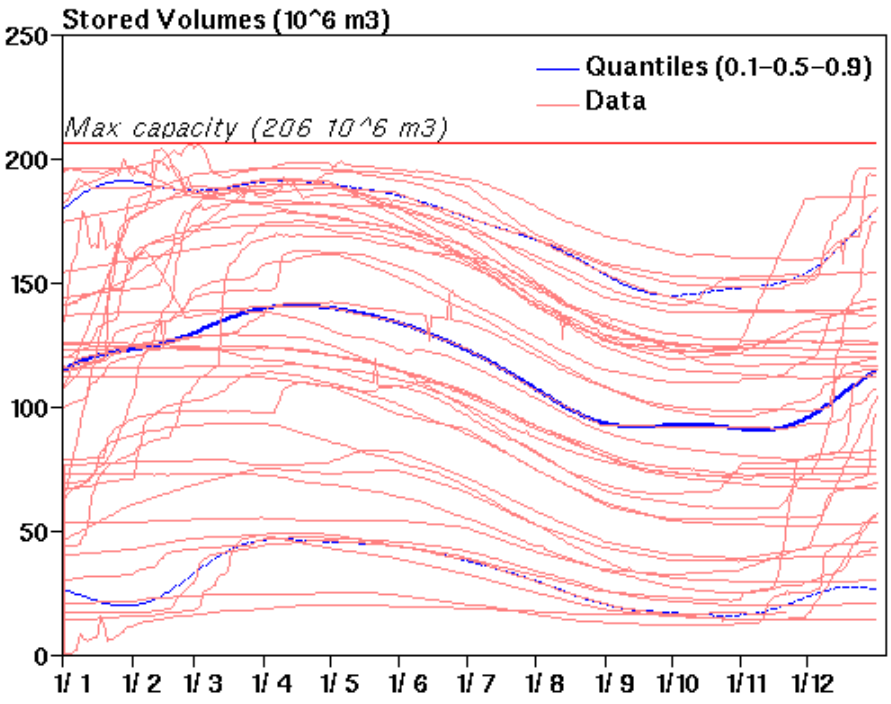

Figure 6: Statistics on stored volumes in Caia reservoir

3 Hydrological data on Caia reservoir catchment area

An important amount of data has been collected from the SNIRH Website.

3.1 Rainfall data

Rainfall data are daily values. Figure 7 presents the location of the rainfall stations used in our study.

Figure 7: Location of Rainfall stations

Table 2 presents the data availability for the 11 rainfall stations located around Caia reservoir catchment.

Station	Data Provider	Start	End	Within Caia reservoir Catch.	Mean rainfall over the 1981-1999 period (mm)	Mean rainfall over the whole period of availability (mm)
ALEGRETE (18N/02G)	SNIRH	1981	1999	Yes	865	843
ARRONCHES (19N/01UG)	SNIRH	1967	1999	Yes	572	573
CAIA (20O/02UG)	SNIRH	1980	1999	No	456	446
DEGOLADOS (19O/03UG)	SNIRH	1981	1999	Yes	548	539
ESPERANÇA (19N/03UG)	SNIRH	1980	1992	Yes	-	646
JUROMENHA (21N/01UG)	SNIRH	1967	1999	No	489	504
MONFORTE (19M/01UG)	SNIRH	1967	1999	No	506	526
SANTAEULÁLIA (19N/02UG)	SNIRH	1983	1999	Yes	-	494
SANTOALEIXO (20M/01UG)	SNIRH	1967	1982	No	-	574
SÃOJULIÃO (18N/01UG)	SNIRH	1981	1999	No	1039	1012
VILAVIÇOSA (21M/01UG)	SNIRH	1967	1999	No	721	721

Table 2: Rainfall data availability and statistics

Figure 8 presents the mean monthly rainfall on Caia catchment area from 1981 to 1999 calculated from the 5 stations on the catchment area: ALEGRETE, ARRONCHES, DEGOLADOS, ESPERANÇA and SANTAEULÁLIA.

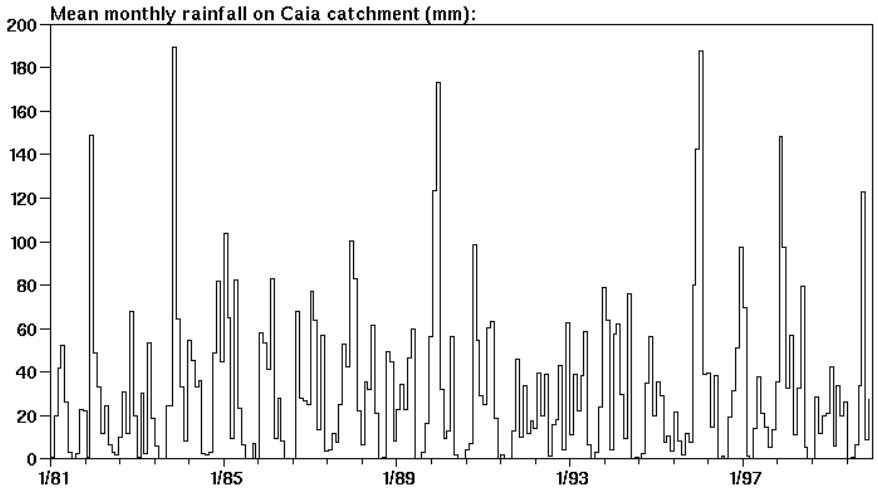

Figure 8: Monthly rainfall on Caia reservoir catchment

The remarks that can be made on rainfall over the catchment are the following:

- There is an important gradient between the upstream part of the catchment with annual rainfall greater than 800 mm and the lower part with less than 500 mm. In fact, according to the "Atlas da Agua" (INAG, 2006), the catchment of Caia reservoir benefits from a local regime of high annual rainfall (around 800 mm) on the contrary to the Guadiana river valley.
- The months of July and August appear as extremely dry: rainfall is null during these months nearly every year.

3.2 Discharge data

Discharge data are dailyvalues. Figure 9 presents the location of the gauging stations.

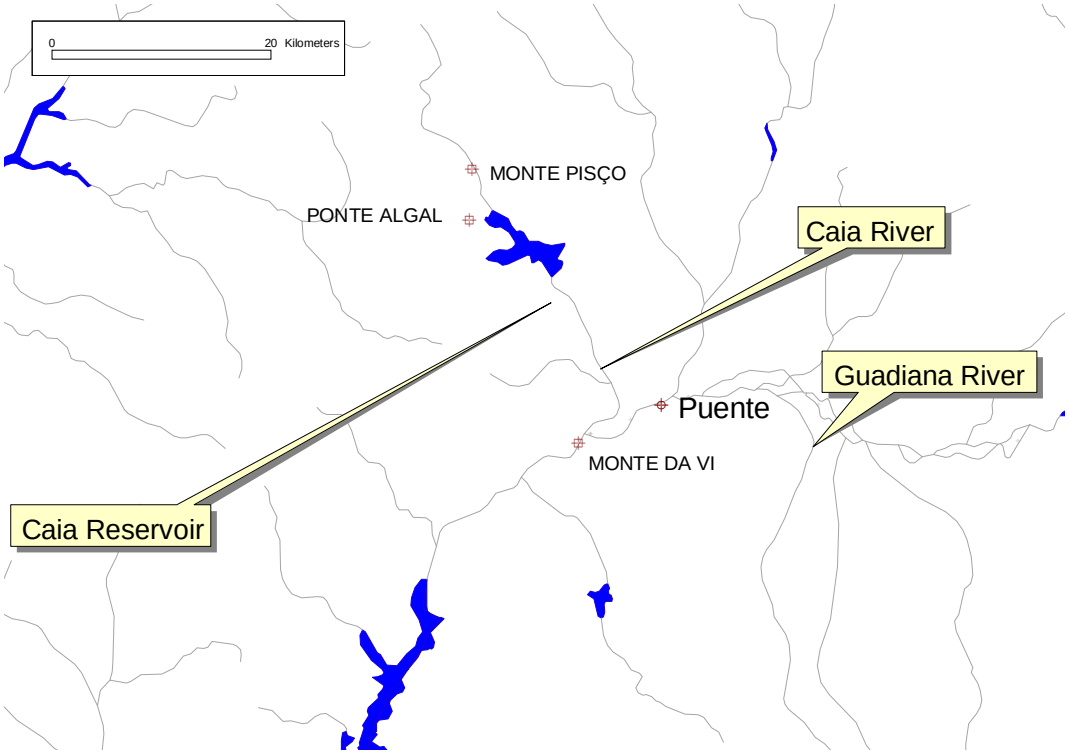

Figure 9: Location of gauging stations

Table 3 presents the data availability for the 4 gauging stations located around the Caia reservoir catchment (two stations are located on Guadiana river).

Station	Data Provider	River	Catchment size (km²)	Start	End	Mean flow over the whole period of availability (m3/s)
MONTEDAVINHA(21O/01H)	SNIRH	Guadiana	49 865	1979	2001	27.4
MONTEPISÃO(19N/01H)	SNIRH	Caia	222	1982	1990	1.3
PONTEALGALÉ(19N/02H)	SNIRH	Ribeira de Algalé	123	1982	1990	0.5
PUENTE (18)	CEDEX	Guadiana	48 515	1913	2000	

Table 3: Discharge data availability and statistics

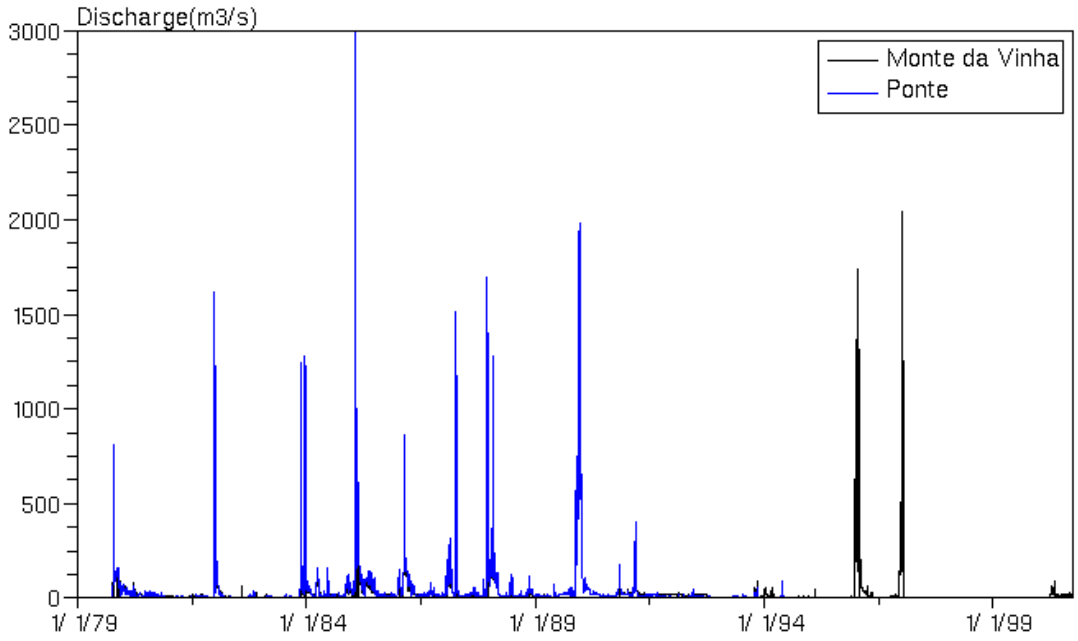

Figure 10: Discharges in Guadiana River at the Spanish/Portugal border

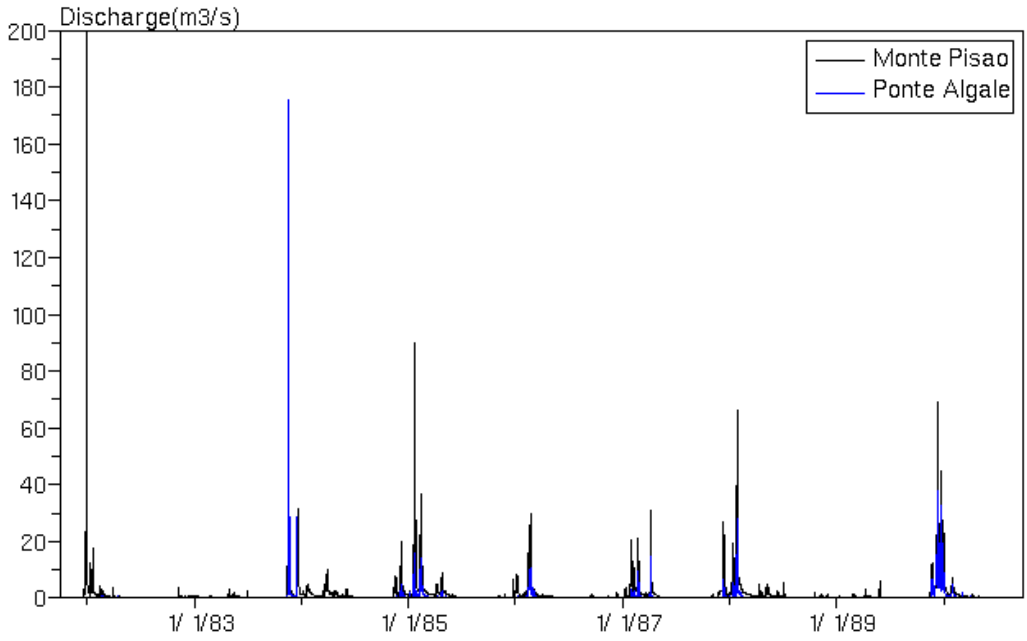

Figure 11: Discharges upstream of Caia reservoir

The observations on the discharge data are the following:

- Hydrology is highly variable with sudden floods (peak discharges exceeds 100 m3/s for catchments inferior to 200 km²) and prolonged drought periods,
- This analysis is valid for the small sub-catchment of the Caia reservoir catchment or for the whole Guadiana at the Spanish/Portuguese border.

4 Data on water uses and management from Caia reservoir system

The data on water uses are monthly values. Data were extracted from the SNIRH (INAG, 2006). The dataset starts in 1990 and ends in 2005. It covers the following water uses:

- Agriculture (one value has been corrected in october 1997 based on figures given by the Instituto de Desenvolvilmiento Rural e Hidráulica or IDRHa, 2006),
- Industry,
- Municipal water supply,
- Hydro-electricity production (started in 1992 according to the Instituto de Desenvolvimiento Rural et Hidraulica, 2006),
- Downstream releases.

No detailed explanation is provided on the nature of hydro-electricity water uses. We assumed that they are of the same type as "downstream releases".

Note that the objective of flood prevention is not mentioned in any documents collected about the Caia reservoir management.

Figure 12 and Table 4 gives a general picture on the relative importance of these uses:

- As expected the major water uses is devoted to agriculture (44% of the mean annual volume utilised) during the month of May to October. The allocation to irrigation is constant except in the year 1997.
- Two other important uses are hydro-electricity production (28%) and downstream release (23%). Energy production is centred on summer months (June to August) while downstream releases are more important in winter (January and February). Interestingly, these two uses are not mentioned in the fact sheet of the Portuguese National Commission on Large Dams (see Figure 3).

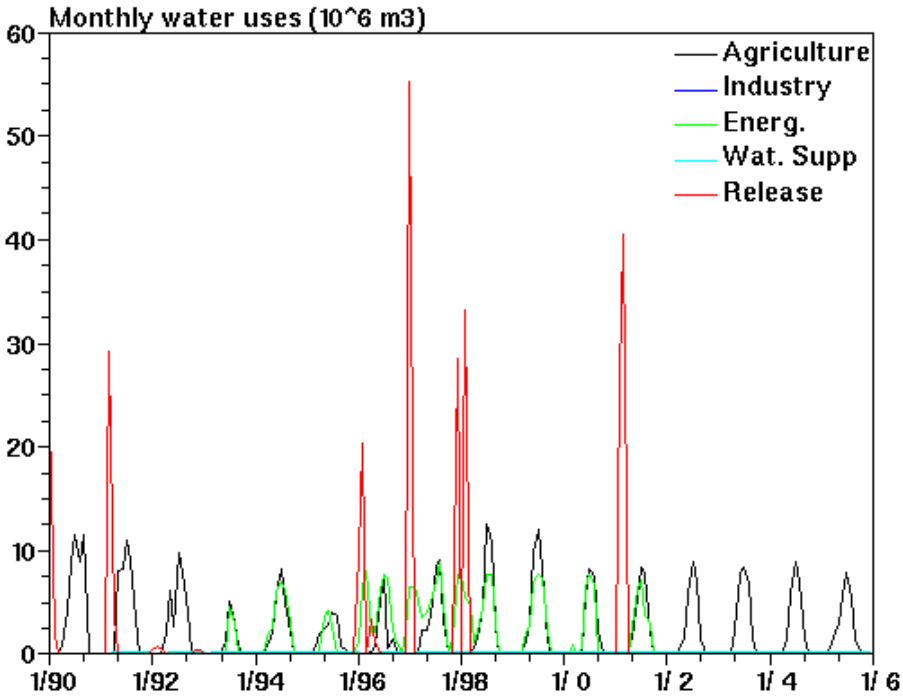

Figure 12: Caia reservoir water uses between 1990 and 2006

MONTH	Agriculture	Industry	Energ.	Wat. Supp	Release
1	0.01	0	1.17	0.17	5.21
2	0.02	0	1.42	0.14	5.17
3	0.15	0	1.44	0.16	4.39
4	0.84	0	0.91	0.18	0.44
5	2.61	0	1.57	0.2	0.07
6	5.57	0	3.52	0.22	0
7	8.82	0	4.56	0.24	0
8	6.76	0	3.9	0.24	0
9	2.56	0	1.38	0.23	0
10	0.14	0	0.09	0.21	0
11	0.01	0	0.13	0.19	0.03
12	0	0	0.76	0.2	1.8
Year	27.48 (43%)	0.01 (0%)	16.94 (26%)	2.39 (4%)	17.43 (27%)

Table 4: Mean values (period 1990-2005) of water uses from the Caia dam (10^6 m3/month)

5 Conclusion

The data collected provide a general picture of the Caia reservoir system:

- The dam is devoted mainly to irrigation with 43% of annual uses. Energy production is the second use with 26% of consumption.
- Uses are mainly during summer months, starting in May or June.
- Upstream hydrological resources are limited and variable resulting in difficult periods (1976 and 1995) and persistence of scarcity over several years.

6 References

CNPGB. (2006). "Dams in Portugal." Retrieved 27 november 2006, from http://cnpgb.inag.pt/gr_barragens/gbportugal/Caia.htm.

IDRHa. (2006). "Aproveitamento Hidroagrícola do Caia." Retrieved 20 december 2006, from http://www.idrha.min-agricultura.pt/a_hidroagricolas/exploracao/ahcaia.htm.

INAG. (2006). "SNIRH :: Sistema Nacional de Informação de Recursos Hídricos." Retrieved 7 december 2006, from http://snirh.inag.pt/.

Silberstein, R. P. (2006). "Hydrological models are so good, do we still need data?" Environmental Modelling & Software **21**(9): 1340-1352.