"ALLOCATING URBAN AND AGRICULTURAL WATER SUPPLY CO-OPERATIVELY IN SPAIN: SEVILLE"

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SUMMARY

In the last 25 years, Seville has suffered several periods of drought, which highlights the fact that the resources available to the system are insufficient to guarantee supply to the city and its metropolitan area. The roots of the problem are to be found in the great irregularity of the rainfall, which explains the vulnerability of the supply system, which cannot store enough water during the wet years to guarantee the supply during the cyclical periods of drought.

System resources come from four reservoirs located in the Rivera de Huelva basin. The water from these reservoirs is reserved exclusively for urban supply to Seville and its metropolitan area. In situations of scarcity, agreements have been reached both with Compañía Sevillana de Electricidad (Seville Electricity Company) for the purchase of water from its Cala reservoir, used for the generation of electricity, and with Comunidad de Regantes del Viar (Viar Irrigation Community), for the purchase of water from the Pintado reservoir, which is legally assigned to them for agricultural use.

A comparison of the regulated volume of the reservoirs in the system with the average consumption in the last ten years shows that the Seville System has a deficit both in the present situation and in the medium term. For this reason, new resources are required in order to avoid shortages affecting the population, or the need to supply low quality water, as happened during the last drought.

The Irrigation Area of the Viar spreads over six municipalities of the province of Seville, whose economy is centered on agriculture. The Pintado reservoir, built in the

1940's for irrigation, is the main water resource for this system. This area does not at present have the necessary infrastructures for a more efficient use of water.

The aim of this work is to put forward the possibility of integrating the present Irrigation Area of the Viar as one more client of EMASESA; thus, EMASESA would have to supply water for agricultural use, just as it does to cover industrial, domestic or public use. If EMASESA's current policies of demand management were extended to cover agricultural demand, the result would be a more efficient use of the resources available.

If the agricultural users became part of the Seville supply system, they would have a guaranteed supply in the same way as EMASESA's other clients, and also the possibility of obtaining water from the river, supplied by EMASESA, via the emergency pumping station and mains.

In spite of the fact that this integration would provide EMASESA with additional resources, these would still not be sufficient to guarantee an adequate supply for everyone. For which reason, it is essential to find new resources, which will be available when the Los Melonares reservoir, at present under negotiation with the European Union, is built.

"Allocating urban and agricultural water supply co-operatively in Spain: Seville"

Introduction

In the last 25 years, Seville has suffered three periods of drought, in 1975-1976, 1981-1983 and 1992-1995. It highlights the fact that the resources available to the supply system of the city and its metropolitan area have always been insufficient to guarantee supply to the population.

The last drought made it necessary to impose restrictions of up to 10 hours per day, and the population was finally supplied with water taken directly from Guadalquivir River, which quality was below the levels established by current legislation. It should be remembered that during the 1981 drought, supply cuts of up to 18 hours per day occurred.

This lack of a dependable supply has caused substantial harm and inconvenience both to the urban population and to commerce and industry, thereby producing a lack of equal opportunity situation for the development of the region, in comparison with other regions.

In spite of these dry periods, which are cyclical, the average rainfall recorded in the city is high, but the problem is that this rainfall is extremely irregular. Figure 1 shows the catchment to the reservoirs in the Seville supply system since 1942.

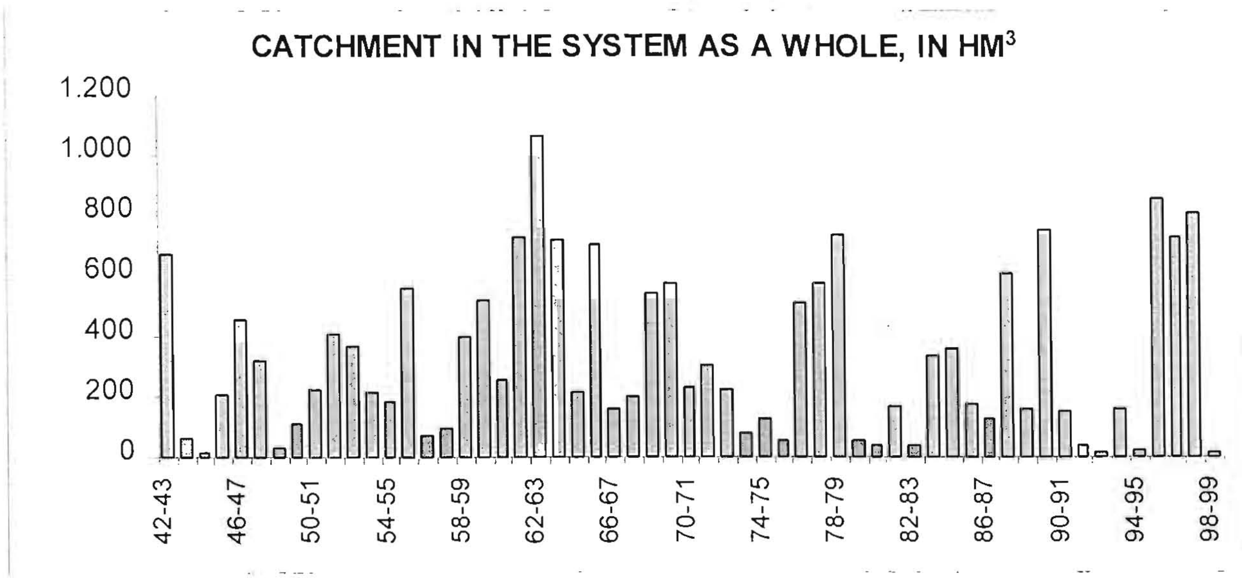


FIGURE 1

Reservoir	Location	Catchment Area (km^2)	Capacity (hm^3)	Regulation (hm^3/year)
Aracena	Rivera de Huelva	408	127	39
Zufre	Rivera de Huelva	442	168	48
Minilla	Rivera de Huelva	182	60	15
Gergal	Rivera de Huelva	188	35	15
TOTAL		1.220	390	117

TABLE 1

This irregularity of the rainfall explains the vulnerability of the system. Rain is concentrated in short periods of time, which makes it necessary to discharge large quantities of water (in the last three wet years, enough water has been discharged to fill all the reservoirs of the system almost four times, equivalent to more than ten years' demand). It is not possible to store enough water during the years of high rainfall to guarantee supply during the dry years.

General supply system

At present, the Seville supply system consists of four reservoirs in the Rivera de Huelva basin, which are reserved solely for Seville, and so no conflicts arise from the possible use of this supply by other potential competitors. Table 1, on the previous page, shows the characteristics of these reservoirs.

The resources from the Aracena-Zufre-Minilla sub-system are routed through the La Minilla canal, 42 kilometres long, which links the La Minilla reservoir to the Potable Water Treatment Plant at El Carambolo. The resources from the Gergal reservoir are brought to the same Treatment Plan through the Gergal pipeline, which is 22 Km. long. Both mains are interconnected, thereby permitting a flexible operation exploitation of the system (Figure 2).

Once the water is purified, it is distributed through more than 2,800 Km. of pipelines (Figure 3) to supply a population of 1,228,000. A 1,800 Km. long sewer network then takes used waters to one of the four wastewater treatment plants around the city.

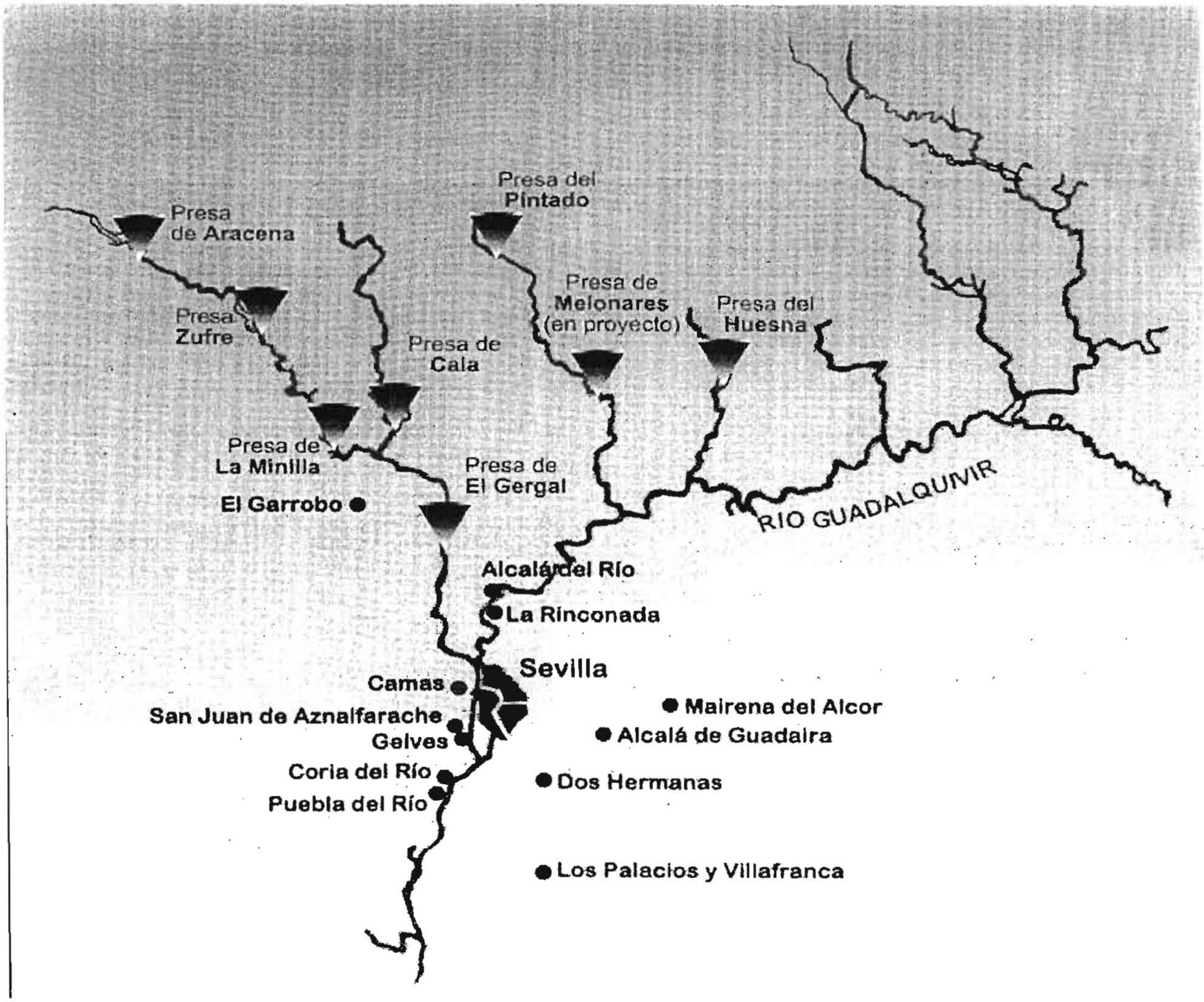

Presa
de Aracena
Presa del
Pintado
Presa
Zufre
Presa de
Cala
Presa de
Melonares
(en proyecto)
Presa del
Huesna
Presa de
La Minilla
Presa de
El Gergal
El Garrobo
RIO GUADALQUIVIR
Alcalá del Río
La Rinconada
Sevilla
Camas
San Juan de Aznalfarache
Gelves
Coria del Río
Puebla del Río
Mairena del Alcor
Alcalá de Guadaira
Dos Hermanas
Los Palacios y Villafranca

FIGURE 2

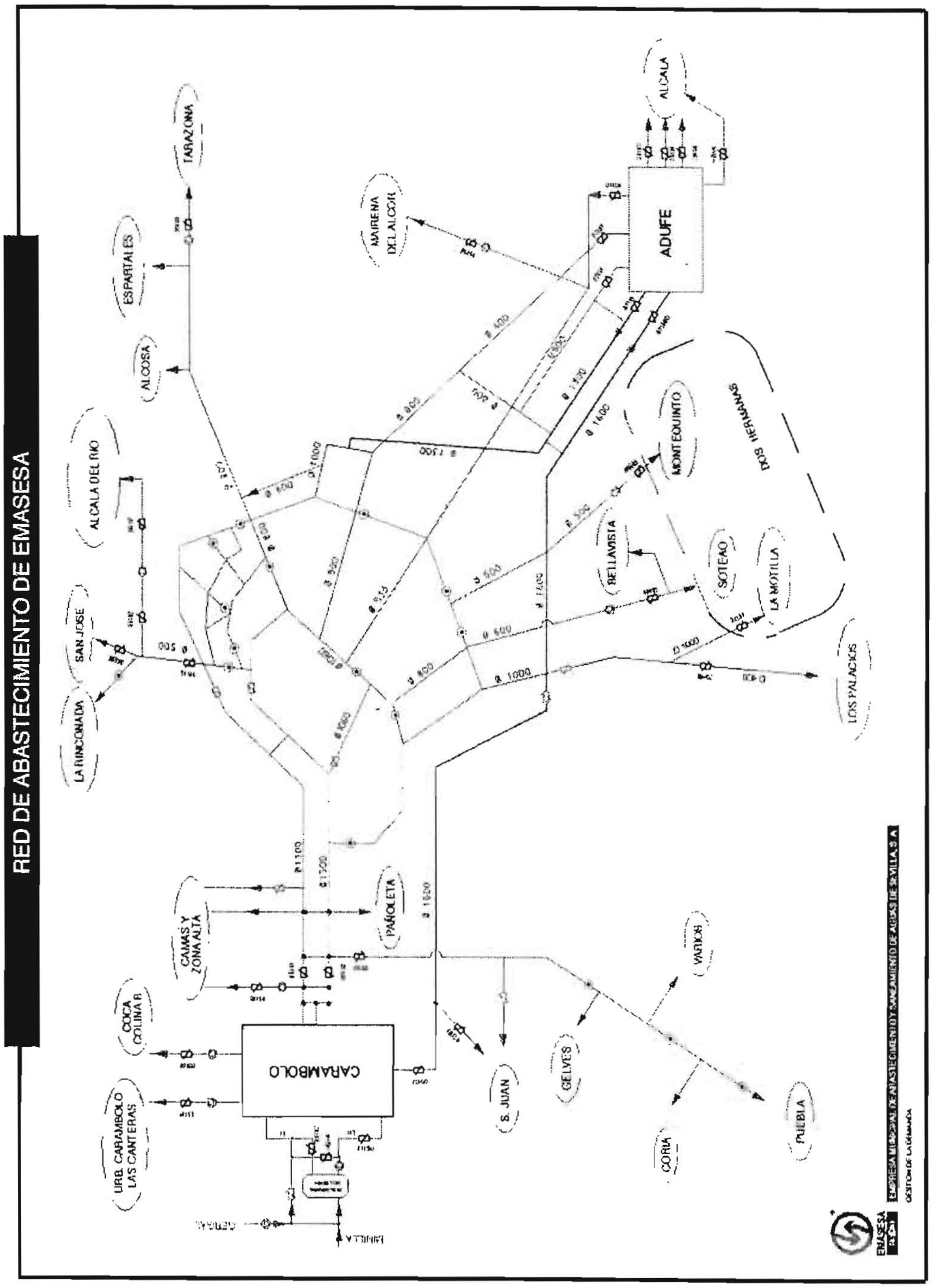

RED DE ABASTECIMIENTO DE EMASESA
CARAMBOLO
ADUFE
URB. CARAMBOLO LAS CANTERAS
COCA COLINA B
CAMAS Y ZONA ALTA
PAÑOLETA
LA RINCONADA
SAN JOSE
ALCALA DEL RIO
ALCOSA
ESPARTALES
TARAZONA
MAIRENA DEL ALCOR
ALCALA
MONTEQUINTO
DOS HERMANAS
BELLAVISTA
SOTEAO
LA MOTILLA
LOS PALACIOS
S. JUAN
GELVES
CORIA
VARIOS
PUEBLA
EMASESA

FIGURE 3

As can be seen, the main, not to say the only, sources of water for the supply system are these four reservoirs located on this tributary of Guadalquivir River, dedicated totally to the urban supply of Seville and its metropolitan area.

In situations of scarcity, agreements have been reached both with Compañía Sevillana de Electricidad (Seville Electricity Company), for the purchase of water from its Cala reservoir, used for the generation of electricity, and with Comunidad de Regantes del Viar (Viar Irrigation Community) for the purchase of water from Pintado reservoir, which is normally used for agricultural purposes.

Another source of water for the system is the pumping of water from the Guadalquivir River (Figure 4). This is made possible through three emergency connections, built to overcome the situations of scarcity arising in periods of drought. Although, due to the high salinity and the low quality of this water, below the standards set by current European legislation, the emergency connections are only used in extremely serious cases. A fourth emergency connection is currently planned upstream from the Alcalá del Río reservoir, where the water has lower salinity. In the 1980s, as a consequence of the drought, the first two emergency connections were built, on the rivers Guadalquivir and Rivera de Huelva respectively, with a maximum joint flow rate of 4.0 m^3 /s. As a consequence of the drought of 1992-1995, the competent authorities carried out a number of actions designed to increase the quality of the water taken directly from the river through the two existing connections, as well as the construction of the new Emergency Connection III in Alcalá del Rio, with a capacity of 6.0 m^3. This connection makes it possible to obtain resources from the Viar River and route them directly to Carambolo Treatment Plant or to Gergal reservoir.

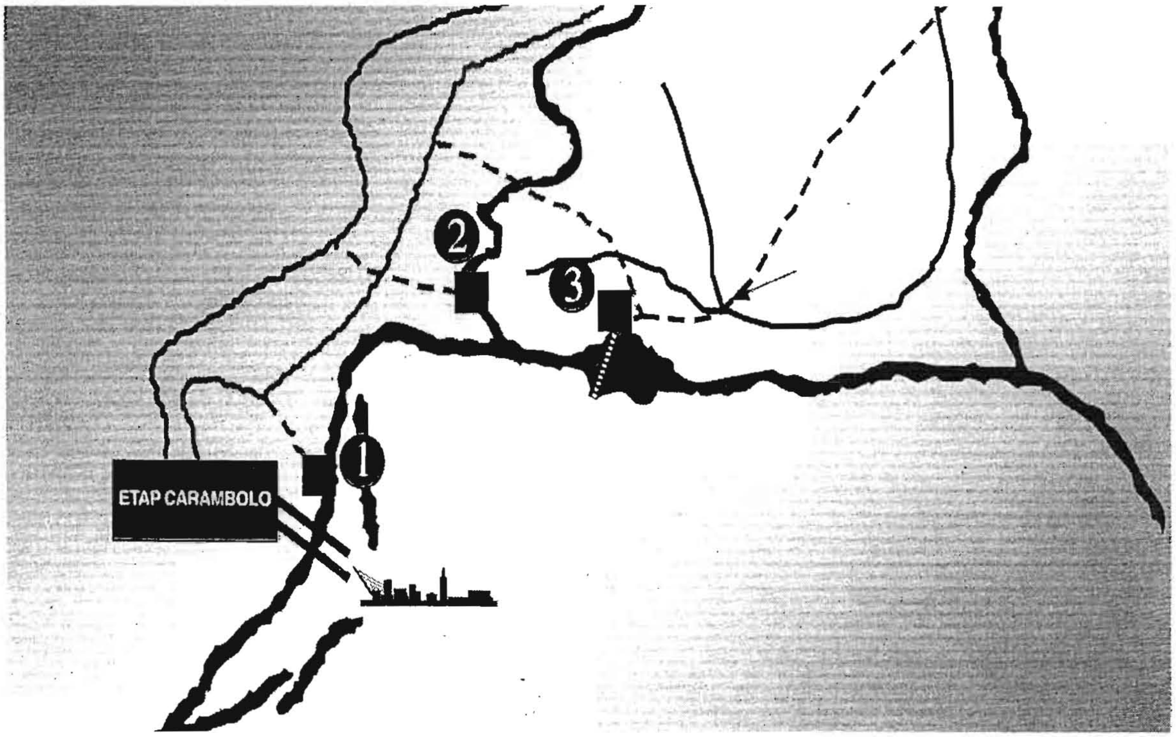


FIGURE 4

It should also be pointed out that the potential resources available from the exploitation of underground waters in the area, which have traditionally supplied the city and its area of influence throughout history, do not at present comply with current legislation on water quality standards, for the most part, and so the volume of these resources is a very small fraction of the overall demand of the system, and is not used for direct human consumption, but mainly for secondary activities such as street cleaning, some industrial processes, etc.

At first sight, a comparison of the capacity of the four reservoirs linked to the system (390 Hm^3) with the average volume taken out in the last ten years (149 Hm^3) shows that with no external contributions, the system would have enough water for approximately two and a half years. A system such as that of Seville and its surrounding area, with an average rainfall of 546 litres/m^2, could, if this were stable over the years, guarantee a sufficient supply of water over time, except in the case of a very large population increase or a change in consumer habits. The problem faced by the Seville supply system is that the rainfall collected is not only irregular on a year by year basis, but is also irregular on a month by month basis within each year.

Table 1, a comparison of the regulated volume of the system (117 Hm^3) with the average take-off in the last ten years (149 Hm^3), shows that the Sevilla system has a deficit both in the present situation and in the medium term, and for this reason new resources are required in order to avoid shortages affecting the population, or the need to supply low quality water, as happened during the last drought (Figure 5 shows the current situation of the reservoirs in the system, including Cala).

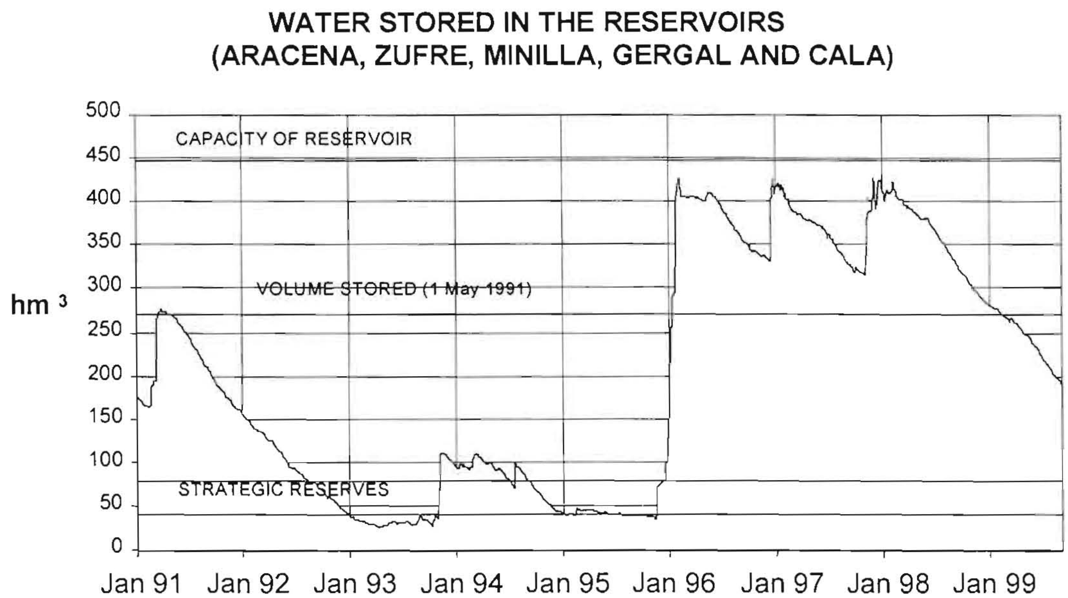

WATER STORED IN THE RESERVOIRS
(ARACENA, ZUFRE, MINILLA, GERGAL AND CALA)
hm 3
500
450
400
350
300
250
200
150
100
50
0
CAPACITY OF RESERVOIR
VOLUME STORED (1 May 1991)
STRATEGIC RESERVES
Jan 91
Jan 92
Jan 93
Jan 94
Jan 95
Jan 96
Jan 97
Jan 98
Jan 99

FIGURE 5

Viar Irrigation Community

The Irrigation Area of Viar spreads over six municipalities of the province of Seville, which have been part of this system for the last 50 years (Alcalá del Río, Villaverde, Castilblanco de los Arroyos, Burguillos, La Algaba and Guillena). The economy of these municipalities is mainly agricultural, with corn, citrus fruits, cotton, beet and sunflowers being of particular importance. This economy has for decades maintained stability in the area, avoiding massive emigration to urban, more developed areas.

The Viar Irrigation Community serves a community of 1,915 farmers, with an average lot area of 6.2 hectares, giving a total production of nearly 5,250 million pesetas (1991) and over 500,000 man/days of work per year.

The Pintado reservoir, built on Viar River in the 1940's for irrigation, is the main water resource for this system. This reservoir has a capacity of 202 Hm^3 and a regulated volume of 66 Hm^3/year. Of a total of 11,853 hectares of irrigated land, 10,513 hectares take water from the Pintado reservoir, and the remaining 1,340 hectares take water from Guadalquivir River through the Algaba Pumping Station.

In the same way as the Seville supply system, the Irrigation Area of Viar also suffers from the effects of dry periods, even more so since the Water Law stipulates that urban supply shall have priority over irrigation.

The assignment of resources from Pintado as a source of potable water for Seville would increase the resources available by 57 Hm^3/year. The regulated supply volume is lower than if the water were to be used for irrigation, since higher guarantee is required. This assignation of resources would have a direct effect on the present irrigation system, and would affect the viability of the latter, since only two alternatives would be left open:

- To irrigate the Viar region with resources from the General Regulation system.
- To convert the Viar Region into a dry farming area.

The first alternative, i.e. irrigating the Viar region with resources from the General Regulation System, would make it necessary to elevate the 66 Hm^3 regulated by the Pintado reservoir to a height of 80 metres, every year, for the irrigation of the area, which would make agriculture unviable due to the enormous cost of the energy necessary to do this. The incorporation of the Viar region into the General Regulation System would take place in conditions of quite severe deficit, and would probably make expropriation proceedings against the Viar farmers necessary, since they would not be at all happy with this solution, or else it would add that demand for irrigation water to an already deficitary system. It is sufficient here to point out that in the last three years of drought (1992, 93 and 94) the average assignation for irrigation in the General Regulation System was 1000 m^3/ha, compared with 4000 m^3/ha in the Irrigation Area of Viar.

The other alternative is to convert the Irrigable Area of Viar into a dry farming area (or maintain low volume irrigation), which would have an enormous social impact in the whole region. It is only necessary to bear in mind the number of farmers (1,915) and the average plot size (6.2 ha) to see that this would mean a drop in income of around 60% for the families affected. In other words, about 6,400 people would be condemned to poverty, in an area with 30% unemployment; 500,000 man/days would be lost, to say nothing of the indirect impact on the inhabitants of the region, whose income would be severely reduced.

Periods of scarcity: conflict of interests.

In situations of scarcity such as are experienced cyclically in this area, a conflict of interests is produced between the supply company and the farmers. In the past, specific agreements have been reached for the purchase of water or the exchange of sources. During the last drought, after the Guadalquivir Water Authority prohibited irrigation, an agreement was reached to purchase 28 Hm^3 from the farmers in exchange for economic compensation.

The Water Law stipulates that urban supply shall have priority of use. In a region with such irregular rainfall as we are describing, this very general protection seems insufficient to avoid situations of short supply. Urban supply only has priority in those years when there are not enough resources to satisfy the entire demand, and no short or medium term resource management guidelines are given for the establishment of minimum reserves. It should not be forgotten that at present 80% of the demand for water in Andalusia is for agriculture, whilst urban demand does not exceed 15%.

As can be seen from the situation described, neither the Seville supply system nor the Irrigation Area of the Viar have guaranteed supplies, which limits the economic and social growth opportunities for Seville and its metropolitan area. This area needs more water resources to allow it to consolidate and develop the two basic pillars of its economy, tourism and the agrofood industry, and irrigation farmers need a guaranteed supply to ensure the productivity of their farms.

The solution proposed, that is, to assign the Pintado reservoir to the Seville supply system, would go some way to solving the deficit suffered by the city, but it would necessarily lead, as we have said, to an intolerable reduction of income for the irrigation farmers of the Viar and the towns in that area.

Another possibility: The integration of the Irrigation Area of Viar into the supply system.

Another possibility might be to integrate the present Irrigation Area of Viar into the general supply system of Seville, as one more user of EMASESA; It would mean to undertake supply demands of water for agricultural use, just as it does to cover industrial, domestic or public use demand.

If EMASESA´s current policies of demand management were extended to cover agricultural demand, through the application of tariff policies to encourage savings, limitations on and the appropriate use of available supplies, the reduction of losses in the pipelines and investments aimend at modernising distribution and irrigation systems, the result would be a more efficient use of the resources available. Both sides would profit from this integration.

On one hand, farmers would have a guaranteed supply in the same way as the urban population has, which would be more stable than the present system, since in addition to having to cancel irrigation in periods of scarcity, it should not be forgotten that urban supply has priority over irrigation. If the agricultural users became part of the Seville supply system, they would have a guaranteed supply in the same way as EMASESA´s other clients, and in addition they would be able to obtain water from the river supplied by EMASESA through the emergency connections.

On the other hand, with this integration EMASESA would generate additional resources, as it would control water from Pintado reservoir and manage it more efficiently. These additional resources would still not be sufficient to guarantee an adequate supply, for which reason it is essential to find new resources, which will be available when the Los Melonares reservoir, at present under negotiation with the European Union, is built.

How would this integration be implemented?

In principle, there are no technical or economic obstacles impossible to overcome for the integration of the Irrigation Area of Viar in the Seville supply system.

- Technically, the Pintado reservoir could be integrated into the general supply system of Seville through the pipeline which will connect the future Los Melonares reservoir to the Potable Water Treatment Plant at El Carambolo. These two reservoirs would be part of an integrated system, since this pipeline would be connected to the others via Emergency Connection No. 3. The irrigation farmers' demand for water would be satisfied from the present Viar irrigation channel, or by elevating water from the river from the emergency connection in Alcalá del Río.

- Economically, the problem is different, involving on the one hand the price to be paid by the farmers for irrigation water, and on the other the method of financing the construction work necessary for implementing the integration. At present, the farmers pay a price which is lower than the cost of the water used; they pay a fixed sum depending on the number of hectares irrigated, and not on the number of cubic metres consumed. This fixed price is not aimed at balancing costs and income, but is based on legal precepts, which stipulate, in effect, a subsidy for this type of user. With the current system there is no incentive to reduce the farmers' demand for water, since there is no mechanism to penalise excess consumption and encourage users to save water. In addition to this, no soft loans or other financing are available from the Administration for the modernisation of irrigation infrastructures, and so there is no incentive for the farmers to reduce their consumption.

  If the farmers were integrated into the supply system, the price they pay would gradually be adjusted to reflect the real cost of water. In order to avoid this transition provoking excessive costs, and thus the unviability of farming, we propose to set up individual plans with each farmer, establishing annual consumption objectives and prices, in such a way that the product of these, i.e. the cost of water, is constant throughout the number of years necessary to implement the plan.

  To achieve this, it is necessary for real consumption to be reduced yearly, in accordance with the plan established, until it reaches the final objective agreed on. At the same time, the price paid by the farmers must gradually increase, so that when the plan ends the price reflects the real cost of raw water.

This reduction in consumption would be achieved through investment to improve water infrastructures, in order to increase efficiency in water use. The investment to be made on each farm would be financed by the purchase by the supply company of annual consumption savings. These savings arise from the difference between the initial consumption of each farmer prior to the beginning of the plan and the consumption established annually for each farmer. This surplus, which would be used to satisfy urban demand, would be paid at raw water cost, bearing in mind that the necessary funds must be raised to finance the planned volume of investment. This price would be higher than the price paid by the farmers for irrigation water during the life of the plan.

The investments would be made and managed by the supply company, both at a general level and in each of the farms, as would the financing and payment of these investments with the funds generated from the purchase of surplus water. The farmers would not intervene either in the execution or in the payment of the works, since the investments necessary to modernise the farms, and the financing of those, would be stipulated beforehand in the plan established between each farmer and the supply company.

At the end of the plan, the following would be achieved:

- The price paid by the farmers would reflect the true cost of water used, without this supposing a loss of competitiveness, since the total cost of water would remain constant from the beginning (Figure 6).

- The necessary reduction in consumption of water by the farmers, due to the improvement of infrastructures, which would partly offset the deficit suffered by the urban supply to Seville and its metropolitan area.

The total cost of water for the farmer would be constant throughout the life of the plan, since price increases are offset by reductions in consumption, in such a way that the product of both remains constant. The subsidy previously existing on the price of water (since this price does not reflect all of the items making up its cost) will gradually disappear as the price begins to reflect the real cost of water. (Figure 6)

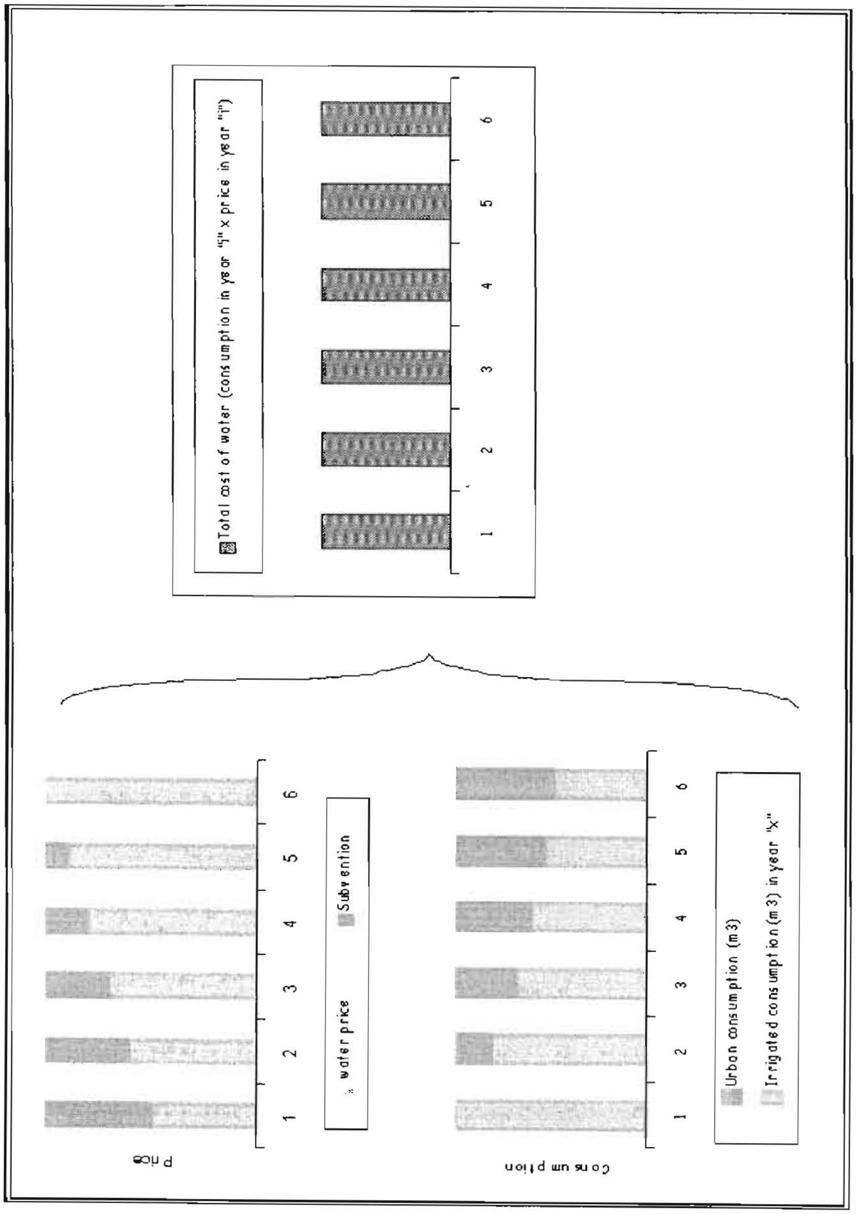
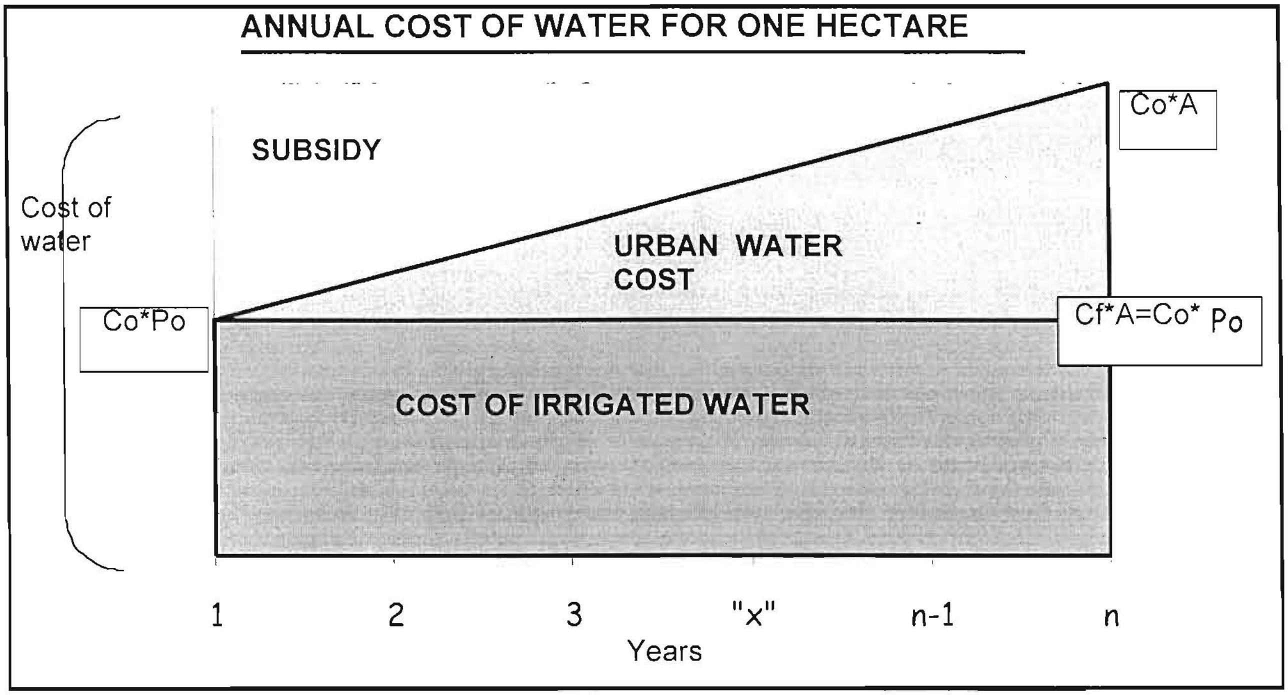

Total cost of water (consumption in year "i" x price in year "i")
1
2
3
4
5
6
Price
water price
Subvention
Consumption
Urban consumption (m3)
Irrigated consumption (m3) in year "x"

FIGURE 6

During the lifetime of the plan, the supply company would establish a mechanism to encourage farmers to achieve and even improve the objectives established. If the farmer manages to reduce consumption below the objective fixed for a particular year, the supply company would purchase this surplus at the same price as it pays for the savings fixed for each year, with the difference that this would be income for the farmer, since this money would not be used to finance the planned investments but would go directly to the farmer, to be used as he deems fit. In the same way, if the consumption were greater than that established, the farmer would be penalised, since he would have to pay for this excess consumption of water at the price paid by the supply company for the savings, which, as has been said, would be higher than the price paid by the farmer throughout the plan for the planned consumption of irrigation water. Figure 7 shows this mechanism, taking into account the following hypotheses:

▪ Initial consumption for irrigation	Co	m^3/year
▪ Initial cost of irrigation water	Po	ptas/m^3
▪ Real cost of raw water	A	ptas/m^3
▪ Final consumption for irrigation	Cf	m^3/year
▪ Planning period:	n	years

The figure shows the total cost of water for one hectare (applicable to the whole of the Irrigation Area of Viar), and as we can see the cost of irrigation water is constant throughout the lifetime of the plan at Co*Po=Cf*A, as a result of reduced consumption; otherwise the cost of irrigation water at the end of the plan would be the product of Co*A. At the end of the process, part of the cost is borne by the farmer (Cf*A) and part by the supply company (Co*A - Cf*A) through the purchase of savings in water, and over time the subsidy which existed on the price of water disappears, as it now includes all of the costs necessary.



ANNUAL COST OF WATER FOR ONE HECTARE
SUBSIDY
Cost of water
URBAN WATER COST
COST OF IRRIGATED WATER
Co*Po
Co*A
Cf*A=Co* Po
1
2
3
"x"
n-1
n
Years

Figure 7

Figure 8 shows the system of incentives and penalties. For consumption lower than that stipulated, that is, below the red line in the figure, which represents the consumption fixed for each year, the farmer receives a direct profit from the sale of this water to the supply company at the same price that the supply company pays for the savings already established. If the consumption is greater than the established consumption, i.e. above the red line, the farmer pays a penalty for this excess, since he would have to pay for this water at the price paid by the supply company for the savings established, which, as has been said, would be higher than that paid by the farmer for irrigation water.

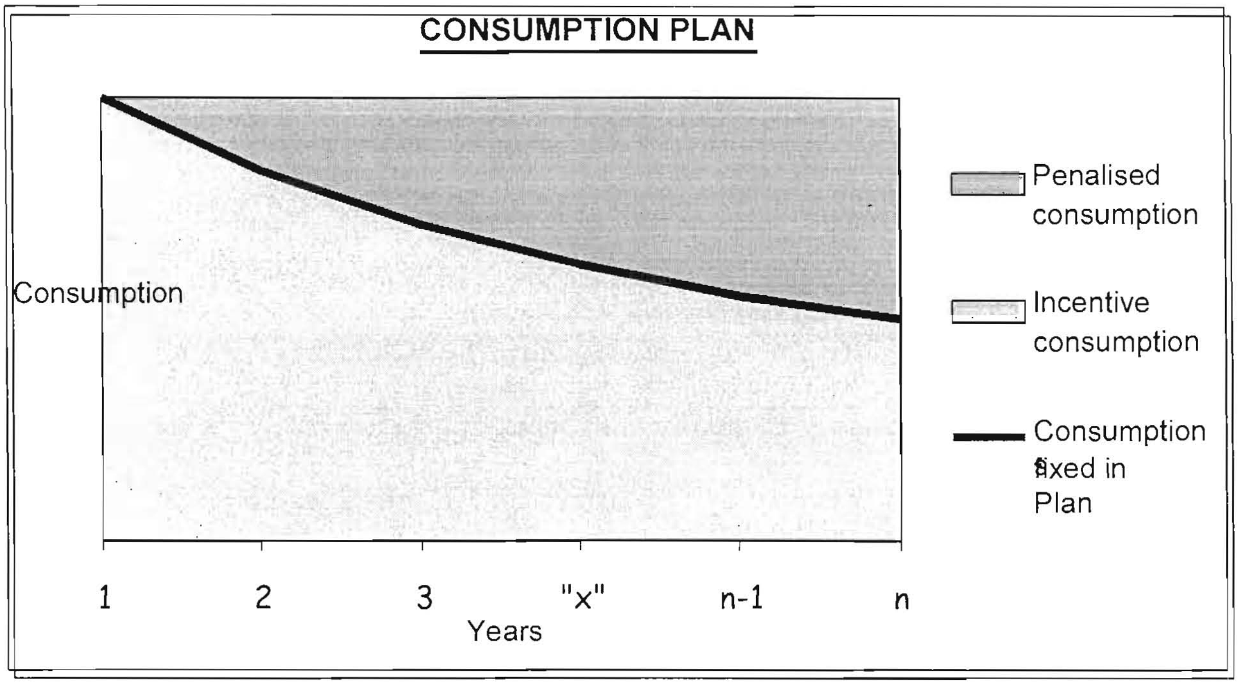

CONSUMPTION PLAN
Consumption
Penalised consumption
Incentive consumption
Consumption fixed in Plan
1
2
3
"x"
n-1
n
Years

FIGURE 8

ANNEX.

Agreements reached to date between the Irrigation Area of Viar and EMASESA

The agreements on the purchase of water or water rights between the Seville Municipal Water Supply Company and the Viar Irrigation Community have always been made during dry periods, when urban supply has been in need of additional resources.

- During the drought of 1974-76 the first agreement was reached, for the purchase of 10 hm^3 from Pintado reservoir, deducted from the summer irrigation plan. The total cost was 21,394,462 pesetas, as finally 5 hm^3 were used at a cost of 4 pesetas/m^3, which also released the farmers from the payment of canon for irrigation water normally paid to the River Authority.

- In the drought of 1981-83, no agreement was reached since there were no resources available in Pintado reservoir.

- In the last dry period, in 1992-95, due to the seriousness of the situation, the Guadalquivir Water Authority prohibited irrigation with water from El Pintado, and these resources were assigned to urban supply. During these years, 28 Hm^3 were used for this purpose, and an agreement on compensation was reached with the Viar Irrigation Community. This compensation amounted to 8.5 pesetas/m^3, of which 0.5 pesetas corresponded to canon paid to the River Authority.