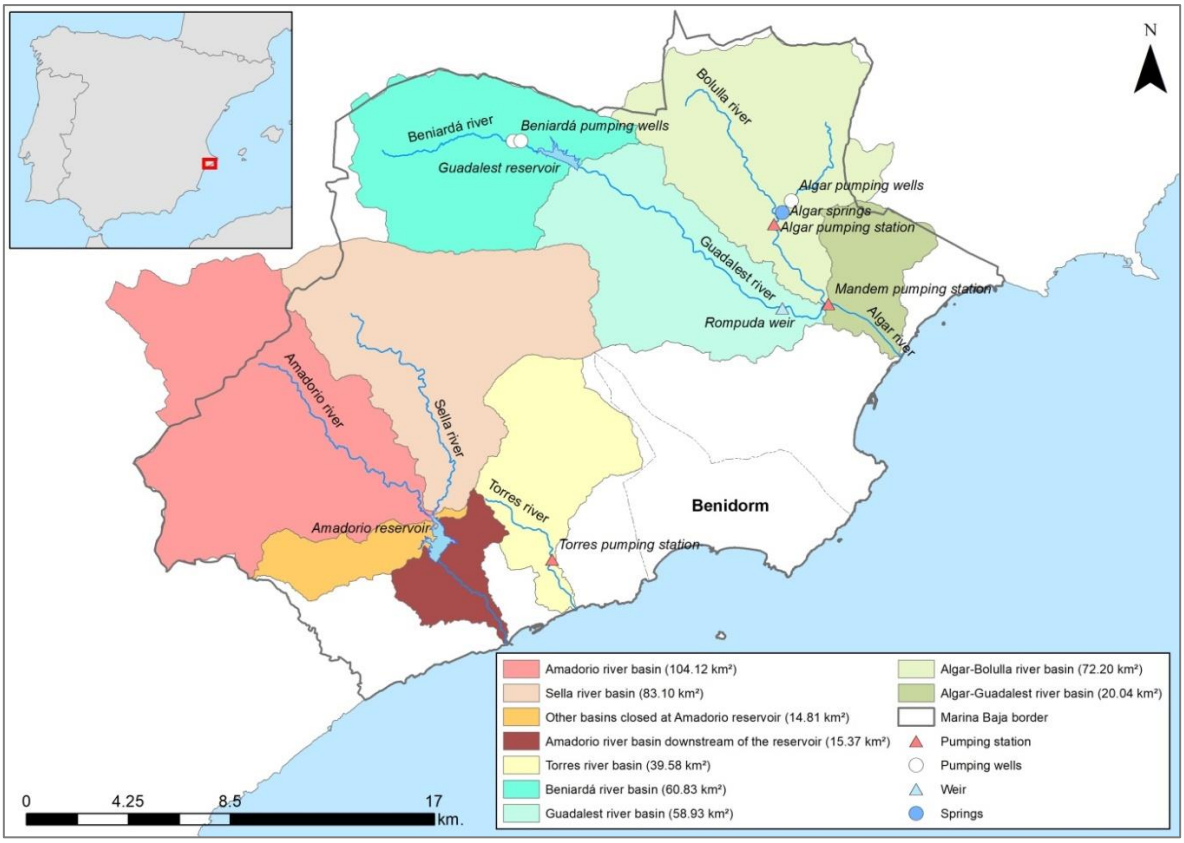
SIMTWIST PROJECT

Water supply sources and hydraulic infrastructures description of the consortium of water of the marina baja

1. STUDY AREA

The Marina Baja region is framed in the hydrographic basins of the rivers Amadorio (217 km²) and Algar-Guadalest (212 km²) (Figure 1), separated by the Sierra de Aitana and other small coastal mountain ranges (Figure 2).

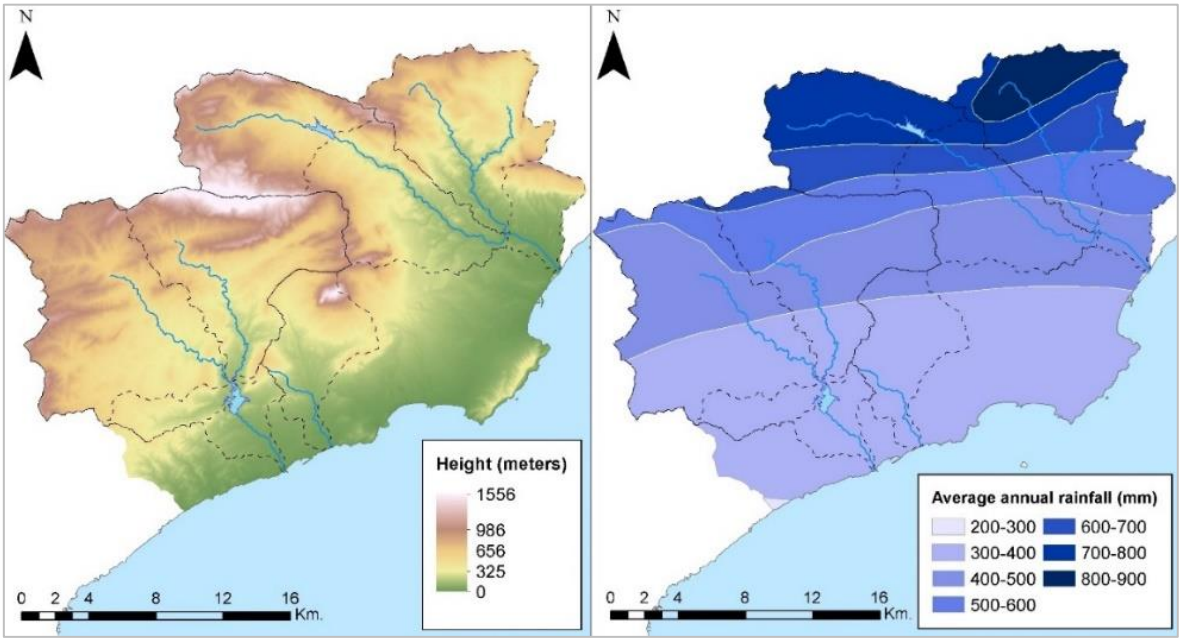
Figure 1. Main river basins of the Marina Baja region



The climatologic conditions of both basins are conditioned from their geographical position with regard to the winds that produce a higher rainfall (Northeast and East) (Figure 2). In the Algar-Guadalest basin the average annual precipitation (690

mm/year), is much higher than in the Amadorio basin with around 300 mm/year (Figure 2). For this reason, most of the water resources available in the Marina Baja come from the Algar-Guadalest basin, as evidenced in the streamflow of the main rivers and in the location of the pumping wells.

Figure 2. Relief and average annual rainfall of the Marina Baja region



The Algar and Guadalest rivers are pluvial-Mediterranean rivers (with an average streamflow of 0.787 m³/s for the Guadalest river, before Rompuda Weir, in the municipality of Callosa d'en Sarrià, and 0.909 m³/s for the Algar river, before Algar pumping station) fed mainly by natural springs. The Amadorio is instead a rambla-river, i.e. a river course with temporary or occasional flow produced during rain episodes (0.108 m³/s in the municipality of Orcheta, just upstream Amadorio reservoir). In all these rivers there are periods of absence of runoff, either during the summer or during prolonged drought situations. This fact has repercussions on the Consortium's water management, and in turn on the creation of different infrastructures and agreements between irrigators and urban users, for a joint use of water resources.

2. WATER SUPPLY SOURCES

2.1 ALGAR-GUADALEST RIVER BASIN

GUADALEST RESERVOIR: Built in 1964, has a capacity of 13 million cubic meters and is located at 350 m.a.s.l. It receives water from (Figure 3):

- Impulsion of water of the Algar river (through Algar pumping station).
- Natural contributions of the river Guadalest.
- Extractions of the Beniardá aquifer from existing wells at the side of the reservoir.

Figure 3. Algar-Guadalest system

GROUNDWATER SUPPLY SOURCES FEEDING THE ALGAR-GUADALEST BASIN:
Abundant springs of excellent quality and karstic functioning.

- Aquifer of Beniardá: It has an extension of 165 km². It produces an annual recharge of 15 million cubic meters and has an extraction of 13 million cubic meters, which mainly comes from the Beniardá well field, located at the headwater of the Guadalest reservoir (with 6 operational boreholes and a total peak capacity of 600 l/s). The extracted water is discharge to the Beniardá river and then goes to the reservoir.

- Algar Aquifer (or Carrascal-Ferrer): It has an area of 90 km². It produces an annual recharge of 13 hm³ (they have a great capacity of recovery in periods of rains) and has an extraction of 11 hm³ only during drought situations since natural aquifer discharge is produced through the Algar springs. The three Algar pumping wells, known as the Estret-Sacos wells (owned by the town council and the Callosa d'en Sarrià Irrigation Community) provide 700 liters/second. Also, below this well field are the springs of the Fuentes del Algar, which are also fed from this aquifer, but are usually dried during periods of drought. The water from this aquifer is used by the Water Consortium of the Marina Baja thanks to the agreements established with the Community of Irrigators and Users of Callosa d'en Sarrià, by which the Consortium assumes the energy costs of pumping, finances works and agricultural infrastructure and contributes between 420,000 and 600,000 €/year to this irrigation community (Appendix I and II). The wells are only put into operation during drought situations or during the summer. Water from the wells is discharged into the river Algar. Las Fuentes del Algar is a place of tourist interest that receives about 200,000 visits a year having an entrance fee of 5€. When the fountains do not provide water, the wells are put into operation.

2.2 AMADORIO RIVER BASIN

AMADORIO RESERVOIR: Built in 1957, has a capacity of 15.8 million cubic meters and is located at 95 m.a.s.l. It is owned by the Júcar Hydrographic Confederation and the main user is the Villajoyosa Irrigation Community, which collaborates with the Water Consortium for the joint use of water from the reservoir (Appendix I). The reservoir receives water from a wide variety of sources (Figure 4):

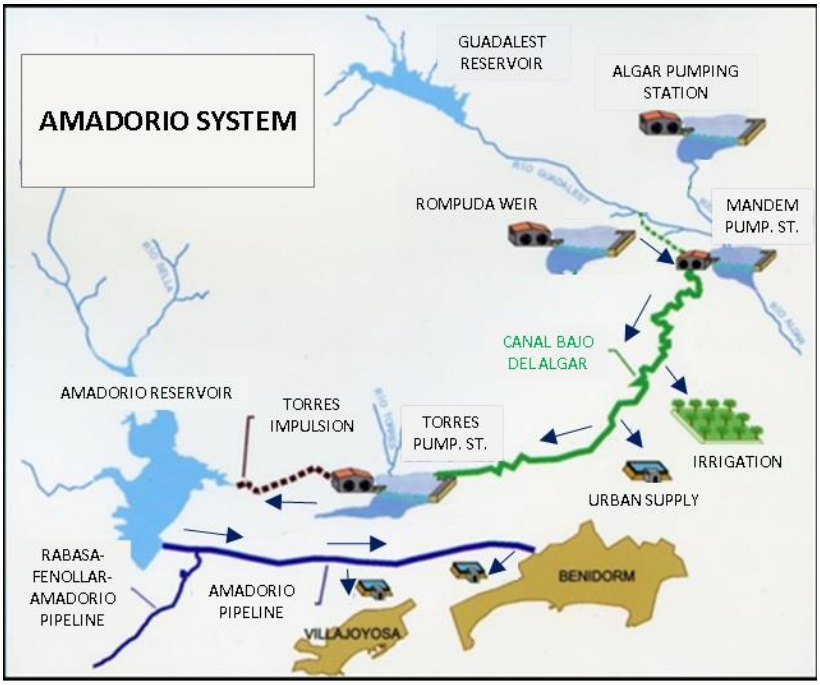
- Amadorio-Sella fluvial network.

- Excess water from the Algar-Guadalest basin through either i) the Mandem-Canal Bajo del Algar-Torres system and ii) the "900 mm diameter" pipeline (the largest contribution), not shown in the figure.

- In emergency situations, flows from the Rabasa-Fenollar-Amadorio pipeline are distributed from a different water system which is independent from the Amadorio and Guadalest rivers and aquifers (the Mancomunidad de Canales del Taibilla water system). This pipeline is directly linked to the reservoir downpipe but is connected to the dam also; though never raise water to there.

Water from the Amadorio River downstream of the reservoir is not used by the Water Consortium.

Figure 4. Amadorio system

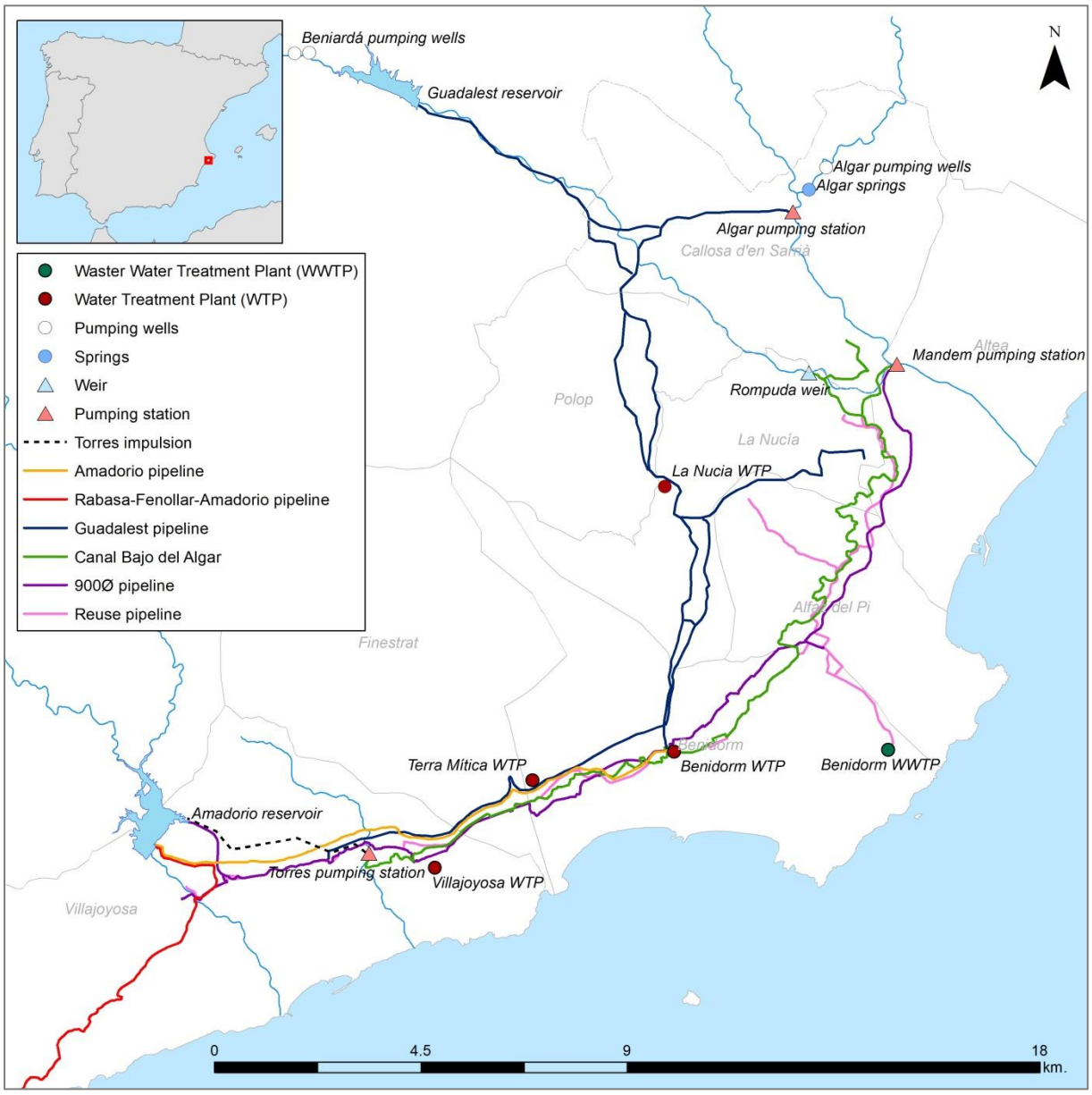


3. HYDRAULIC SYSTEM

The urban water supply system of the Water Consortium of the Marina Baja is shaped by the Algar-Guadalest system and the Amadorio system which produces that there are two independent pipelines bringing water to the water treatment plants (WTPs) of Villajoyosa

and Benidorm (Figure 5). One of these pipelines comes from the Guadalest reservoir and the other one from the Amadorio reservoir, which may store water coming from the Algar-Guadalest system. Their path is close, but they do not intersect each other. The water treatment plants of Villajoyosa and Benidorm are connected with both pipelines, but not with each other. Each water treatment plant supply water to its municipality, but the Terra Mítica WTP of Benidorm may also supply water to the coastal areas of Finestrat, which allows reducing high levels of turbidity in water during episodes of heavy. However, this connection has not been used yet and, apart from that, the water supply network of each municipality is completely isolated from the others. Furthermore, there is another WTP in La Nucía that opened in 2018, which receives water only from the Algar-Guadalest system. In summary, all the municipalities of the Water Consortium are supplied by the Guadalest pipeline but only Villajoyosa and Benidorm are supplied by both pipelines.

Figure 5. Map of the water supply system of the Water Consortium of the Marina Baja



3.1 MAIN PIPELINES

- **GUADALEST PIPELINE**: It has two starting points: the Algar Pumping Station and the Guadalest Reservoir. This is the main conduit conveying drinking water to all the municipalities of the Consortium.

- **AMADORIO PIPELINE**: Starts at the Amadorio reservoir until the Water Treatment Plant (WTP) of Benidorm. On its way it crosses Villajoyosa, feeding the Water Treatment Plants of Villajoyosa,Terra Mítica and Benidorm.

- **CANAL BAJO DEL ALGAR**: This channel is owned by the Community of Irrigators of the Canal Bajo del Algar, but thanks to agreements with the Water Consortium, there is a joint use of this infrastructure. The Consortium assumes the costs of maintenance and operation of reclaimed water from the Benidorm Wastewater Treatment Plant (WWTP). Likewise, this Irrigation Community receives between 450,000 and 600,000 euros per year from the Consortium. The Canal Bajo del Algar is fed by the water collected in:

a) The Rompuda weir on the Guadalest river and
b) The Mandem Pumping Station at the confluence of the Algar and Guadalest rivers.

The Canal Bajo del Algar supply water to the irrigators and to the water treatment plant of Benidorm and ends at the Torres River Pumping Station, from where it is possible to deliver water to the Amadorio reservoir for storage and subsequent consumption in the summer. It has a transport capacity of 750 l/s. The Canal Bajo del Algar only transports "white water", i.e. water suitable for drinking and irrigation.

- **REUSE PIPELINE**: This pipeline is owned by the Community of Irrigators of the Canal Bajo del Algar. It has been distributing purified and regenerated water from the Benidorm WWTP since 1982. This plant incorporated tertiary treatment and desalination since 2006. 75% of the volume treated by this WWTP comes from Benidorm, with the remaining 25% coming from Finestrat (coast), La Nucía and Alfaz del Pi. It has a production capacity of 25,000 m³/day (it has a regulating reservoir with a capacity of 5,000 m³) and is incorporated into the water distribution system through the Reuse Pipeline, which runs parallel to the Canal Bajo del Algar pipeline. This pipeline is sized to carry 600 l/s. This water is used by golf courses and some hotels to watering, and also for municipal uses in some municipalities, such as Benidorm. Furthermore, this water source is starting to be used to irrigate domestic gardens, as is the case of Alfaz del Pi, although it is not mandatory, but a possibility for particular users of some urbanizations . Likewise, this water is used by the communities of irrigators of the Canal Bajo del Algar and Villajoyosa. In order to avoid tensions with the irrigators of La Nucía and Altea, who have the right to use the Algar-Guadalest rivers, the Consortium has favored the connection of their irrigation networks with this purified and reclaimed water pipeline. The irrigators of Callosa d'en Sarrià do not want to use reclaimed water.

- **900Ø PIPELINE**: This infrastructure is owned by the Community of Irrigators of the Canal Bajo del Algar. Completed in 2012, this pipeline runs parallel to Canal Bajo del Algar, and involves a renewal of the old infrastructure of the Canal Bajo del Algar, increasing the transport flow to 1,500 liters/second and reducing losses. It is a 25-kilometre pipeline whose main role is to deliver freshwater from the Mandem Pumping

Station to the Amadorio reservoir, although is also connected with the Water Treatment Plant of Benidorm and the Torres Pumping Station. A big difference with the Canal Bajo del Algar is that this pipeline is linked directly to the Amadorio reservoir without the need for pumping from the Torres Pumping Station. This new pipe transports white water for irrigation and urban uses and has increased the transport and equilibrium capacity between the Algar-Guadalest and Amadorio basins to 2,250 l/s taking into account the water mobilized by the Canal Bajo del Algar (750 l/s) and the 900Ø pipeline (1,500 l/s).

- **EMERGENCY CONNECTION (RABASA-FENOLLAR-AMADORIO)**: It was built between 1996 and 1997 and is 47 kilometers long. It connects the supply system of the Mancomunidad de Canales del Taibilla (MCT), which supplies water from various sources, including desalinated water and water from the Tagus-Segura transfer, with the Marina Baja Consortium's water supply system. Begins in Rabasa (Alicante), which has a 7.8 km drive before reach the Cañada del Fenollar (Alicante), where there is a 7,500 m³ water tank and from there a second 4.8 km drive before reach to another 6,000 m³ water tank in the municipality of San Vicente del Raspeig. From there, a pipeline conveys water through 34.6 km to the Amadorio Pipeline (it also has a separate connection to the Amadorio reservoir). In 2015 the Muchamiel desalination plant (known as the Marina Baja desalination plant) was inaugurated, which is also connected to the Rabasa-Fenollar-Amadorio pipeline, but at a shorter distance from Benidorm (35 kilometers). This connection has only come into operation in two occasions: during the years of intense drought in 1999 and 2000 (with resources from the MCT), and in 2015 (with resources from the Muchamiel desalination plant).

3.2 PUMPING STATIONS

The surface and groundwater supply network of the two basins (Amadorio and Algar-Guadalest) is interconnected through three pumping stations: Torres, Mandem and Algar. The Table 1 summarizes the annual volumes pumped by station.

- **ALGAR PUMPING STATION**: Located about one kilometer downstream from the Algar River Springs, it consists of 5 pumps capable of lifting 1,500 l/s up to 300 meters manometric height. The water pumped by the station is taken from the Algar River (both from the Algar river and from the Algar aquifer) by means of a diversion dam with a capacity of 10,000 m³. This station sends water to the Guadalest reservoir or directly to Benidorm through the pipe that comes down from the Guadalest reservoir. The water that is pumped comes from the springs of the Fuentes del Algar and from the wells of Estret-Sacos, when they are operating.

- **MANDEM PUMPING STATION**: Located downstream of the previous one at the confluence of the Algar and Guadalest rivers. Specifically, at a diversion dam from which water is pumped to the Canal Bajo del Algar pipeline. It has a capacity to lift 750 l/s up to 53 meters manometric height. The use of this infrastructure takes place thanks to the agreements established with the Community of Irrigators of the Canal Bajo del Algar. The water pumped comes from the Fuentes del Algar, Algar river and Guadalest river.

- **TORRES PUMPING STATION**: This station pumps the surplus water from the Algar-Guadalest basin that arrives through the Canal Bajo del Algar and the water from the

Torres river, towards the Amadorio reservoir. It consists of 5 pumps with a lifting capacity of 1,500 l/s up to 90 meters manometric height.

Table 1. Volumes of water pumped by station (m³)

	Pumping station		
Year	**Algar**	**Mandem**	**Torres**
2006	9,918,557	9,016,166	5,316,943
2007	13,361,562	8,837,246	5,429,202
2008	7,742,913	11,561,014	7,996,590
2009	4,559,559	11,128,400	5,025,120
2010	1,029,810	6,323,740	4,408,820
2011	8,840,230	10,224,470	7,584,740
2012	7,366,710	11,168,221	6,094,418
2013	5,686,560	9,999,180	6,064,520
2014	5,576,740	5,403,490	2,534,059
2015	5,606,010	3,762,229	2,287,365
2016	5,652,110	3,336,578	2,444,459
2017	5,489,350	6,110,376	3,363,860

4. SUMMARY OF THE OPERATIONAL PERFORMANCE OF THE WATER CONSORTIUM SUPPLY SYSTEM

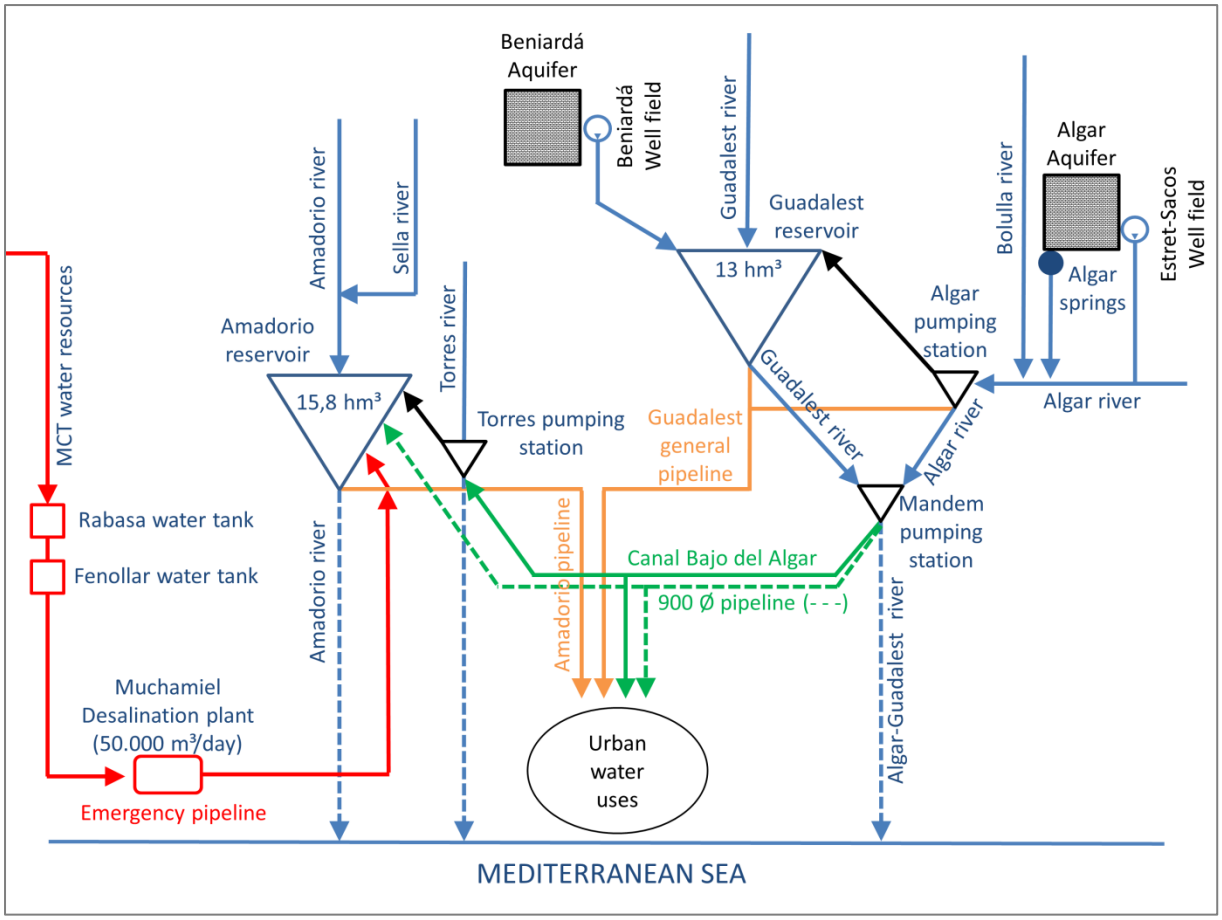
The water system managed by the Water Consortium is simplified in the Figure 6. The available water resources are interrelated in the following way:

A) On the one hand, there is the Algar-Guadalest Basin infrastructure system. This system is made up of two basins: the Guadalest, which regulates the reservoir of the same name, and the Algar, which has more resources but no regulatory dams. For this reason, its contributions may be channelled to the Guadalest reservoir through a pipeline that starts at the Algar Pumping Station, though Algar's water resources can be deliver directly to the Water Consortium municipalities. The Guadalest reservoir also regulates and stores the contributions of the Beniardá aquifer, located at the tail of the reservoir. In years of drought, such as 2014, the Guadalest reservoir did not receive natural inputs. That year it received 5.5 million cubic meters from the Algar pumping system and 9.8 million cubic meters from the Beniardá wells.

B) On the other hand, the Amadorio System, whose resources come from the surface runoffs of the Amadorio basin and its tributary, the river Sella (see Fig. 1), which is fed by the natural outflow of the Aitana Sur aquifer, which pumping wells are not being exploited by the Water Consortium. However, its greatest contribution comes from the surpluses and runoff from the Algar-Guadalest river that are collected at the Mandem Pumping Station, where both rivers meet. From this pumping station, the water is led through the Canal Bajo del Algar and the 900Ø pipeline to the Water Treatment Plant of Benidorm if necessary, and later to the dam of the river Torres along with the scarce flows of this rambla-river whereby only water runs during episodes of heavy rain. From there water is driven to the Amadorio reservoir by the Torres Pumping Station. In dry years such as 2014, the Amadorio reservoir does not receive natural contributions. In

2014 it received 2.5 million cubic meters from the Torres pumping transported by the Canal Bajo del Algar, whereas during wet years such as 2011 were pumped 7.5 hm³.

Figure 6. Simplified scheme of the Water Consortium's water supply system



5. OPERATIONAL SCENARIOS

The volume of water supplied by the Water Consortium of the Marina Baja for the period 1998-2016 is on average, and depending on the source, 24.08 million cubic meters/year of surface resources and springs regulated by the Amadorio and Guadalest reservoirs; 14.6 hm³/year of groundwater resources; and 5.7 million cubic meters/year of reclaimed water (Table 2).

Table 2. Water supplied by the Water Consortium according to water source

Year	Groundwater (m³)	Surface water (m³)	Reclaimed water (m³)	Rabasa-Fenollar-Amadorio (m³)	Total (m³)
1998	18,844,011	7,922,866	9,288,506	0	36,055,383
1999	23,776,670	0	9,715,421	6,325,362	39,817,453
2000	20,602,624	13,138,743	9,544,788	7,924,304	51,210,459
2001	17,579,855	20,187,059	10,318,919	10,891,437	58,977,270
2002	13,298,841	23,559,152	7,256,318	181,130	44,295,441

2003	13,827,442	26,720,555	5,595,694	0	46,143,691
2004	9,396,589	33,091,703	3,789,340	0	46,277,632
2005	16,813,257	28,408,060	6,038,307	0	51,259,624
2006	16,794,652	27,379,217	7,104,417	0	51,278,286
2007	8,655,586	39,161,478	5,877,934	0	53,694,998
2008	10,682,845	29,829,449	4,350,715	0	44,863,009
2009	5,558,028	34,914,785	2,713,287	0	43,186,100
2010	7,037,455	31,071,923	1,948,500	0	40,057,878
2011	8,059,027	27,031,750	2,942,982	0	38,033,759
2012	10,687,988	29,690,470	1,541,738	0	41,920,196
2013	6,435,396	26,333,988	2,306,217	0	35,075,601
2014	24,633,599	27,075,084	3,519,348	0	55,228,031
2015	23,926,000	14,375,925	6,690,156	5,003,442	49,995,523
2016	21,157,261	18,543,268	8,973,897	5,143,253	53,817,679
2017	6,170,045	31,199,680	3,211,577	0	40,581,302

The Rabasa-Fenollar-Amadorio emergency connection provided a total of 25.3 million cubic meters between 1999 and 2002 and 10.1 million cubic meters between 2015 and 2016. However, this situation may vary depending on the hydrological situation of the different years for three representative years (Figure 7), which depends to a large extent on the precipitation levels at the Guadalest and Algar river basins. Another determining factor is the water-energy nexus, as well as the production and transport costs of each source of supply.

Figure 7. Portion of water distributed by source of supply according to hydrological scenario

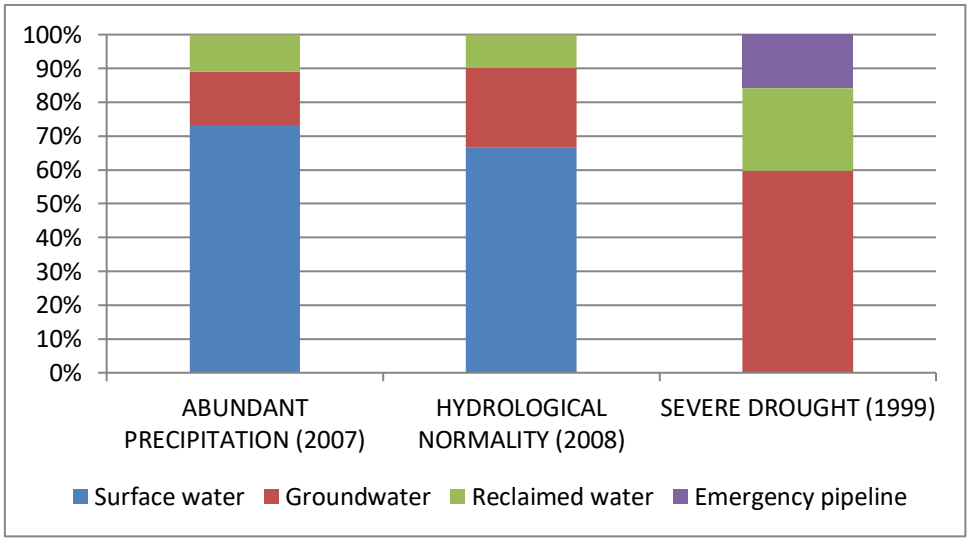


Table 3 presents the partition of the groundwater supply among the aquifers, although the Polop aquifer is used only to supply the homonymous municipality.

Table 3. Extractions from the aquifers managed by the Water Consortium (m³)

Year	Beniardá	Algar (*)	Polop	Total	Total (without Polop)
1998	5.392.011	11.807.000	1.645.000	18.844.011	17.199.011
1999	8.447.230	13.848.940	1.480.500	23.776.670	22.296.170
2000	6.993.499	12.252.260	1.356.865	20.602.624	19.245.759
2001	6.218.823	10.249.063	1.111.969	17.579.855	16.467.886
2002	5.301.070	6.809.480	1.188.291	13.298.841	12.110.550
2003	4.817.512	7.903.670	1.106.260	13.827.442	12.721.182
2004	3.933.367	4.562.030	901.192	9.396.589	8.495.397
2005	5.872.543	10.076.067	864.647	16.813.257	15.948.610
2006	7.796.163	8.359.452	639.037	16.794.652	16.155.615
2007	2.970.573	4.927.965	757.048	8.655.586	7.898.538
2008	5.334.516	4.627.519	720.810	10.682.845	9.962.035
2009	1.268.341	3.546.963	742.724	5.558.028	4.815.304
2010	2.956.656	3.391.567	689.232	7.037.455	6.348.223
2011	6.540.954	820.950	697.123	8.059.027	7.361.904
2012	4.024.649	5.966.216	697.123	10.687.988	9.990.865
2013	0	5.684.830	750.566	6.435.396	5.684.830
2014	9.878.416	13.928.292	865.835	24.672.542	23.806.707
2015	10.177.015	12.608.539	1.140.447	23.926.001	22.785.554
2016	8.370.907	11.347.004	1.439.350	21.157.261	19.717.911
2017	2.121.696	2.945.047	1.103.302	6.170.045	5.066.743

* There are no reliable data available

Table 4 shows the volumes supplied by the Consortium divided by different types of users where it is shown that approximately half of the water supplied is for urban uses and the other half for agricultural uses. Although it is listed as use for irrigation, part of the reclaimed water is used for irrigation of golf courses and irrigation of municipal and residential green areas, although no data is available in this regard.

Table 4. Total volume of water supplied by the Water Consortium by type of user

Year	Total (m³)	Urban uses		Irrigation					
		m³	%	Total		Freshwater		Reclaimed water	
				m³	%	m³	%	m³	%
2000	33.411.956	19.924.404	59,63	13.487.552	40,37	3.942.764	11,80	9.544.788	28,57
2001	41.319.248	21.131.729	51,14	20.187.519	48,86	9.868.600	23,88	10.318.919	24,97
2002	49.076.005	20.896.062	42,58	28.179.943	57,42	20.923.625	42,64	7.256.318	14,79
2003	43.338.304	21.963.500	50,68	21.374.804	49,32	15.779.110	36,41	5.595.694	12,91
2004	47.281.241	22.089.150	46,72	25.192.091	53,28	21.402.751	45,27	3.789.340	8,01
2005	47.477.247	22.467.513	47,32	25.009.734	52,68	18.971.427	39,96	6.038.307	12,72
2006	50.775.553	24.847.210	48,94	25.928.343	51,06	18.823.926	37,07	7.104.417	13,99
2007	40.946.629	21.675.955	52,94	19.270.674	47,06	13.392.740	32,71	5.877.934	14,36
2008	38.405.617	21.545.122	56,10	16.860.495	43,90	12.645.120	32,93	4.215.375	10,98
2009	41.631.100	20.326.385	48,83	21.304.715	51,17	18.591.428	44,66	2.713.287	6,52
2010	37.670.423	19.113.276	50,74	18.557.147	49,26	16.608.647	44,09	1.948.500	5,17
2011	35.647.439	19.201.691	53,87	16.445.748	46,13	13.945.088	39,12	2.500.660	7,01

2012	36.092.076	19.274.275	53,40	16.817.800	46,60	15.497.948	42,94	1.319.852	3,66
2013	36.578.625	18.809.991	51,42	17.768.634	48,58	15.854.021	43,34	1.914.613	5,23
2014	38.244.703	19.339.346	50,57	18.905.357	49,43	15.386.009	40,23	3.519.348	9,20
2015	41.681.796	19.303.015	46,31	22.378.781	53,69	15.688.625	37,64	6.690.156	16,05
2016	40.219.198	19.970.283	49,65	20.248.916	50,35	12.497.265	31,07	7.751.651	19,27
2017	36.304.575	19.104.087	52,62	17.200.488	47,38	13.168.683	36,27	4.031.805	11,11
2018	37.492.330	19.729.908	52,62	17.762.422	47,38	11.620.860	31,00	6.141.562	16,38

Finally, Table 5 provides the annual volume of urban water supplied for each municipality along the period 1990-2017. This information allows verifying that Benidorm concentrates half of the water supply for urban uses. This data represent the volume of raw water delivered by the Water Consortium. In some cases this water is subsequently conveyed to the respective Water Treatment Plant (WTP) or directly to the municipal water tanks in case of not having WTP.

Table 5. Water supplied by the Consortium for urban uses by municipality (m³)

Year	Benidorm	Villajoyosa	Alfaz del Pi	Altea	La Nucía	Finestrat	Polop	Total
1990	12.667.674	2.421.420	2.522.582	1.372.162	1.839.638	697.174	506.258	22.026.908
1991	12.214.109	2.334.721	2.432.261	1.323.032	1.773.770	672.212	538.541	21.288.646
1992	12.409.860	2.372.139	2.471.242	1.344.236	1.802.194	682.985	544.874	21.627.531
1993	12.167.930	2.810.695	1.904.288	1.294.852	1.400.676	415.590	676.215	20.670.246
1994	12.417.800	2.752.427	2.200.635	1.324.390	1.510.154	415.675	697.422	21.318.503
1995	12.104.979	2.073.478	2.180.469	1.318.506	1.334.988	469.534	658.896	20.140.850
1996	11.702.501	1.962.600	2.194.405	1.732.899	1.191.433	469.560	651.166	19.904.564
1997	11.843.150	1.353.957	1.984.176	1.191.526	1.246.079	636.019	248.667	18.503.574
1998	11.684.674	1.421.374	2.003.611	1.219.703	1.515.883	517.983	279.248	18.642.476
1999	11.380.780	1.798.948	2.144.889	1.263.056	1.615.153	518.135	320.231	19.041.192
2000	12.102.692	1.763.878	2.224.506	1.193.221	1.741.129	510.050	388.928	19.924.404
2001	12.372.659	2.260.940	2.310.398	1.265.292	1.939.347	585.630	397.463	21.131.729
2002	12.244.119	2.283.765	2.350.559	1.230.131	1.823.497	552.504	411.487	20.896.062
2003	12.833.423	2.491.011	2.466.429	1.235.106	1.871.681	566.745	499.105	21.963.500
2004	12.751.712	2.548.076	2.437.046	1.342.856	1.938.143	594.609	476.708	22.089.150
2005	12.752.331	2.382.835	2.695.867	1.400.238	2.070.541	644.537	521.164	22.467.513
2006	14.643.727	2.526.684	2.611.300	1.444.548	2.146.423	875.754	598.774	24.847.210
2007	12.358.626	2.523.523	2.513.086	1.178.766	1.797.128	774.813	530.013	21.675.955
2008	12.482.050	2.529.730	2.532.326	1.140.411	1.595.146	719.445	546.014	21.545.122
2009	11.221.616	2.608.889	2.397.391	1.164.708	1.622.696	758.069	553.016	20.326.385
2010	10.381.032	2.471.311	2.294.003	1.361.203	1.364.028	761.142	480.557	19.113.276
2011	10.330.636	2.462.747	2.318.248	1.515.775	1.433.802	771.723	368.760	19.201.691
2012	10.006.829	2.311.296	2.620.446	1.585.713	1.540.637	738.905	470.449	19.274.275
2013	9.988.102	2.154.223	2.422.680	1.694.480	1.429.854	629.129	491.523	18.809.991
2014	10.111.705	2.285.000	2.392.755	1.819.165	1.538.041	668.070	524.610	19.339.346
2015	10.057.171	2.322.944	2.185.618	2.078.165	1.444.626	718.186	525.722	19.332.432
2016	10.457.516	2.383.940	2.207.399	2.078.784	1.443.853	844.845	553.946	19.970.283
2017	10.321.581	2.335.345	2.220.984	1.618.093	1.318.153	707.424	582.573	19.104.153

5.1 SCENARIO OF ABUNDANT PRECIPITATION (1,267 mm of precipitation in Guadalest, year 2007)

- Fluvial inputs, regulated by reservoirs and sources, are sufficient. Consequently, groundwater inputs from pumping wells can be reduced. In the year 2007, of the 53.6 million cubic meters mobilized by the Water Consortium, 39.1 million cubic meters were surface resources from surface resources and springs (72.9%); 8.6 million cubic meters were underground resources (16.1%); and 5.8 million cubic meters were reclaimed water (11%). In 2007, the Guadalest reservoir received 4.6 million cubic meters of natural contributions; another 13.3 million cubic meters from the Algar Pumping and 2.9 million cubic meters from the Beniardá wells (Table 3).

- The Torres pumping station directs water to the Amadorio reservoir of the surpluses of Algar-Guadalest, transported by the Canal Bajo del Algar. In 2007, the Amadorio reservoir received 6.9 hm^3 of natural input (surface water and water from the springs of the Aitana aquifer) and 5.4 hm^3 from the pumping of the Torres.

- The water pumped at the Torres station and Algar station is used to store as much as possible in the Guadalest and Amadorio reservoirs, in order to have water stored when rainfall decreases. In addition, pumping from the Algar aquifer (Estret-Sacos wells) requires less energy due to a higher water level.

- Even in situations of hydrological bonanza, irrigators use reclaimed water. Approximately 25% of the total water used by irrigators is reclaimed water, around 4.5-5 hm^3, although this figure shows great interannual oscillations.

5.2 SCENARIO OF HYDROLOGICAL NORMALITY (686 mm of precipitation in Guadalest, year 2008)

- The need to pump water from aquifers increases since the availability of surface water is reduced.

- In 2008, of the 44.8 hm^3 mobilized by the Water Consortium, 29.8 hm^3 came from surface sources and springs (66.5%); 10.6 hm^3 were underground resources (23.8%); and 4.3 hm^3 were reclaimed water (9.7%).

- In 2008, the Guadalest reservoir received 3.6 hm^3 of natural inputs; 7.7 hm^3 from the Algar Pumping Station; and 5.3 hm^3 from the Beniardá wells.

- In 2008, the Amadorio reservoir received 4.2 hm^3 of natural inputs; and 7.9 hm^3 from the Torres River Pumping Station, with water transported by the Canal Bajo del Algar.

5.3 SCENARIO OF SEVERE DROUGHT (327 mm of precipitation in Guadalest, year 1999)

- During severe droughts situations surface water is often depleted, so groundwater pumping is increased.

- The agreements between the Consortium and the Canal Bajo del Algar Irrigation Community are activated to increase the proportion of reclaimed water from the

Benidorm WWTP to irrigation, which has a capacity of 60,000 m³/day and an average flow rate of 36,490 m³/day.

- In years of drought the proportion of reclaimed water used by irrigators may increase to 50%. In this scenario, the reclaimed water used by irrigators amounts to approximately 9-10 million cubic meters (Table 4).

- In emergency cases, the Rabasa-Fenollar-Amadorio emergency pipeline is activated. The maximum volume supplied by this pipeline was 10.8 hm³ in 2001, representing approximately 25% of the total water distributed by the Water Consortium.

- In 1999, from a total water supply volume of 39.8 hm³, 23.7 hm³ were underground resources (59.7%); 9.7 hm³ reclaimed water (24.4%); and 6.3 hm³ water distributed by the emergency pipeline (15.9%). There was no surface contribution from Amadorio and Algar-Guadalest rivers and springs.

- Another dry year was 2014. In this year the Guadalest reservoir did not receive any natural contribution from the Guadalest river. However, this year the reservoir received 5.5 million cubic meters from the Algar Pumping Station and 9.8 million cubic meters from the Beniardá wells (Table 1 and Table 3).

- In 2014, the Amadorio reservoir did not receive any natural water input. On the other hand, it received 2.5 million cubic meters of the Torres Pumping Stations (Table 1).

5.4 SUMMARY OF OPERATIONAL SCENARIOS

In summary, under conditions of normality and hydrological abundance, two thirds of the water used by the Water Consortium comes from surface resources and springs stored in the Amadorio and Guadalest reservoirs, with a greater or lesser need for groundwater extraction, respectively. The surface flow of the Algar river, together with the groundwater resources extracted from that aquifer, are pumped through the Algar pumping station to the Guadalest reservoir. Surplus water from this basin is distributed through the Canal Bajo del Algar (and the 900 mm diameter pipeline) after being pumped at the Mandem pumping station at the confluence of the Algar and Guadalest rivers. The Canal Bajo del Algar supply water to the irrigators and the Water Treatment Plant of Benidorm, since this city represents approximately half of the urban demand of the Water Consortium, and around the 25% of the whole water consumption (Table 5). The surpluses of this water are pumped, in turn, to the Amadorio reservoir, thanks to the Torres River pumping station. The Amadorio reservoir receives few natural contributions from the Amadorio and Sella rivers. Likewise, in normal situations and hydrological abundance, the reclaimed water, supplied through the reuse pipe, provides between 10 and 12% of the total water distributed by the Water Consortium.

In drought situations the extraction of groundwater is intensified, especially in the Beniardá aquifer, and the agreements carried out with the irrigators for the exchange of groundwater from the Algar aquifer (white water) for reclaimed water, which can reach 50% of the water used for irrigation, are activated. Likewise, in emergency situations, the Rabasa-Fenollar-Amadorio pipeline is triggered, which can supply water from the

supply system of the Mancomunidad de Canales de Taibilla or from the Muchamiel desalination plant.

APPENDIX I: BASIC FEATURES OF THE COLLABORATION AGREEMENTS BETWEEN THE CONSORTIUM OF LOW SEAS WATERS AND THE IRRIGATION ENTITIES

Community of Irrigators (irrigable hectares)	Collaborative stages	Scope of collaboration
Canal Bajo del Algar (2.500 ha)	I)Verbal agreements (1964–1990) II)Written agreements (1990, 1991, 1993 y 2010)	I) Joint use of the Canal Bajo del Algar for conveyance of white water from the Algar-Guadalest river to the Amadorio reservoir. II) The costs of maintenance and operation of treated water are assumed by the Consortium up to 600,000 €/year, equivalent to a volume of 3 million cubic meters/year of reclaimed water. III) Exchange of white water from the Algar-Guadalest system for treated and desalinated water at zero cost. IV) Approximate amount of the collaboration (600,000 €/year, plus works financed by the Consortium).
Villajoyosa (840 ha)	I)Verbal agreements (1981–1992) II)Written agreements (1992, 1993, 1994 y 2005)	I) Joint use of the Amadorio reservoir to store up to 1,500 l/s of surplus from the Algar-Guadalest basin. The Canal Bajo del Algar and the Torres River pumping station are used to connect with the Amadorio River. II) The Consortium has helped financially in the construction of the reservoir to regulate purified water and the distribution network of purified water. III) Exchange of white water from the Amadorio reservoir for treated water at zero cost. IV) Approximate amount of the collaboration (81,500 €/year plus works financed by the Consortium).
Callosa d´En Sarrià (1.271 ha)	I)Verbal agreements (1979–2010) II)Written agreements (2010)	I) The Consortium assumes the energy costs of the Sacos-Algar wells and other pumping to irrigators and to the Town Council of Callosa d´En Sarrià. II) The Consortium has also financed hydraulic works and agricultural infrastructure. III) The Sacos-Algar wells (700 l/s) guarantee the flows circulating in the Algar river during periods of drought, which are shared by the irrigators and the Consortium. IV) Callosa d´En Sarrià irrigators do not want to make use of treated wastewater. V) Approximate amount of the collaboration (420,000-600,000 €/year, plus works financed by the Consortium).
La Nucía y **Altea** (600 ha)	I) Specific and verbal agreements (1990–2012)	I) There has been occasional collaboration with entities of irrigators of La Nucía and Altea that have rights of use of the Algar-Guadalest rivers. II) The Consortium has favored the connection of the irrigation networks of irrigators of La Nucía and Altea with the purified water piping of the Canal Bajo del Algar and with the purification plant of Altea. III) During periods of drought the irrigators use treated water and tensions are avoided due to the use of white water from the Algar-Guadalest. IV) Works financed by the Consortium.

APPENDIX II: SUMMARY OF AGREEMENTS BETWEEN THE WATER CONSORTIUM OF THE MARINA BAJA AND THE IRRIGATION COMMUNITIES

The total amounts of these agreements add up to 1.5 million euros each year paid by the Water Consortium. This amount is mainly dedicated to the costs of electric fluid in pumping and lifting, maintenance of large conduits, irrigation installations, regeneration of wastewater and the execution of hydraulic works. The amount of aid to irrigators does not exceed 19% of the ordinary annual budget of the Water Consortium.

A) Agreements with the Community of Irrigators of the Canal Bajo del Algar

- The agreement establishes the possibility of using the Canal Bajo del Algar pipeline and the 900 pipeline by the Water Consortium to transport water from the Algar-Guadalest River to the Amadorio reservoir (aqueduct easement).

- It also regulates the exchange of white water for regenerated water at zero cost.

- The agreement also contemplates that the costs of maintenance, operation and improvement of the hydraulic infrastructures of the Canal Bajo del Algar are financed by the Water Consortium, which also pays between 450,000 and 600,000 €/year to the Irrigation Community.

B) Agreements with the Villajoyosa Irrigation Community

- The agreement establishes the joint use of water from the Amadorio reservoir and the possibility of using the distribution infrastructures of the Irrigation Community (aqueduct easement).

- Thanks to the agreement, the Water Consortium can store up to 1500 l/s of surplus from the Algar-Guadalest basin in the reservoir through the Canal Bajo del Algar and the Torres pumping station, or 900 mm pipeline.

- It also establishes the exchange of white water for reclaimed water at zero cost.

- The Water Consortium pays the Community of Irrigators 81,500 €/year in addition to some works of hydraulic infrastructures for the irrigators.

C) Agreements with the General Community of Irrigators and Users of Callosa d'En Sarrià

- The agreement allows the Water Consortium to exploit water from the Algar Springs and the Estret-Sacos well field (Algar Aquifer), which allows the exploitation of three boreholes with a combined flow of 700 l/s flowing into the riverbed and supplies the reduction of springs during the summer and drought situations. Once the needs of irrigators and the municipality of Callosa d'en Sarrià, who do not want to use regenerated treated water, are covered, the excess resources are used by the Consortium.

- The energy cost of extracting the water from the wells of Estret-Sacos (Algar Aquifer) used by this General Community of Irrigators and Users, is paid for by the Consortium of Waters of the Marina Baja.

- The Water Consortium finances the hydraulic works and agricultural infrastructure of the General Community of Irrigators and Users.

- The Water Consortium pays between 420,000-600,000 €/year for the agreement, in addition to the financing of the hydraulic works.

D) Agreements with the Municipality of La Nucía and the irrigators of Altea

- The agreement with the Town Council of La Nucía and the irrigators of Altea is established for the supply of reclaimed water to the irrigators of both municipalities through the residual piping of the Canal Bajo del Algar and the WWTP of Altea for the irrigators of that municipality.

- The agreement with the irrigators of Altea and La Nucía is made for a coordinated use of white and reclaimed waters during drought situations, as these irrigators have rights of use over the waters of the Algar and Guadalest rivers.

- The Water Consortium is also responsible for financing hydraulic works in these municipalities.