

Engineering Design of Bajo Almanzora Seawater Desalination Plant

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Abstract

Sociedad Estatal Aguas de las Cuencas Mediterráneas (ACUAMED), under the instances of the Environmental Ministry of Spain, is promoting, as part of the hidrological plan called Programa AGUA, the New Seawater Desalination Plant (SWDP) of Bajo Almanzora. This plant will be located in the nearbyes of Bajo Almanzora River creek, between Palomares and Villaricos Towns, in the municipality of Cuevas de Almanzora, Almería (Spain). This project is framed within Law No.10/2005 which modifies Law 10/2001, of July the 5th, of the Spanish National Hydrological Plan, and it is considered a priority and urgent actuation in the list of proposed investments for the South Hydrographical Basin. The objective of this new plant is to provide new resources for drinking water supplies and irrigation needs in eastern Almería.

Once the Information Project was exposed to public audience and the Environmental Impact Declaration was issued and obtained on March the 24th 2006, Acuamed published the Call for Tender for the Design, Construction and Operation of the New SWDP of Bajo Amanzora Project, that was awarded August the 2nd 2006 to a Joint Venture formed by FCC-Befesa-Aqualia-SPA, with a detailed engineering design period of 3 months, a maximum construction period of 18 months and an operation and maintenance period of 15 years after the plant commissioning.

This SWDP capacity is 60.000m³/day, with a seawater intake through 14 beach wells as the raw water supply to the process, 12+2 standby. Moreover, 4 more beach wells are implemented for brine dilution.

The plant design guaranties fulfilment of Spanish Drinking Water Standards and Regulations and other additional constraints relative to the water for irrigation purposes.

On this trend, and in order to introduce measures for a sustainable development, the project includes the implementation of renewable energies to satisfy power demands on non-directly water production related energy needs.

Environmental and landscaping impact mitigation measures are also specially considered in the design. The whole plant design, taking all the above into consideration, will contribute to consolidate the role and image of Acuamed and its commitment with the creation of new water resources, characterised by stylish simple line buildings with minimal visual impact and by the generation of green and water inspired landscapes.

As a conclusion, this paper shows the design of a high efficiency SWDP that will significantly increase the water resources of the region.

I. INTRODUCTION

The great agricultural development of the province of Almería has been based, since its origins, on the use of underground water. Based on this resource, the farming of areas such as Campo de Dalías, Bajo Andarax, Campo de Níjar and Almanzora Valley have grown. This agricultural development with the increasingly consolidated tourism development has been demanding a greater supply of water in recent decades, which it has not always been possible to meet. But in the current situation, when it can be considered that the growth of the agricultural surface area has stabilized, guarantee of supply and suitable water quality are especially required, conditions which underground water or aquifers which have considerably decreased in activity, nor the very irregular surface waters this territory has, can give.

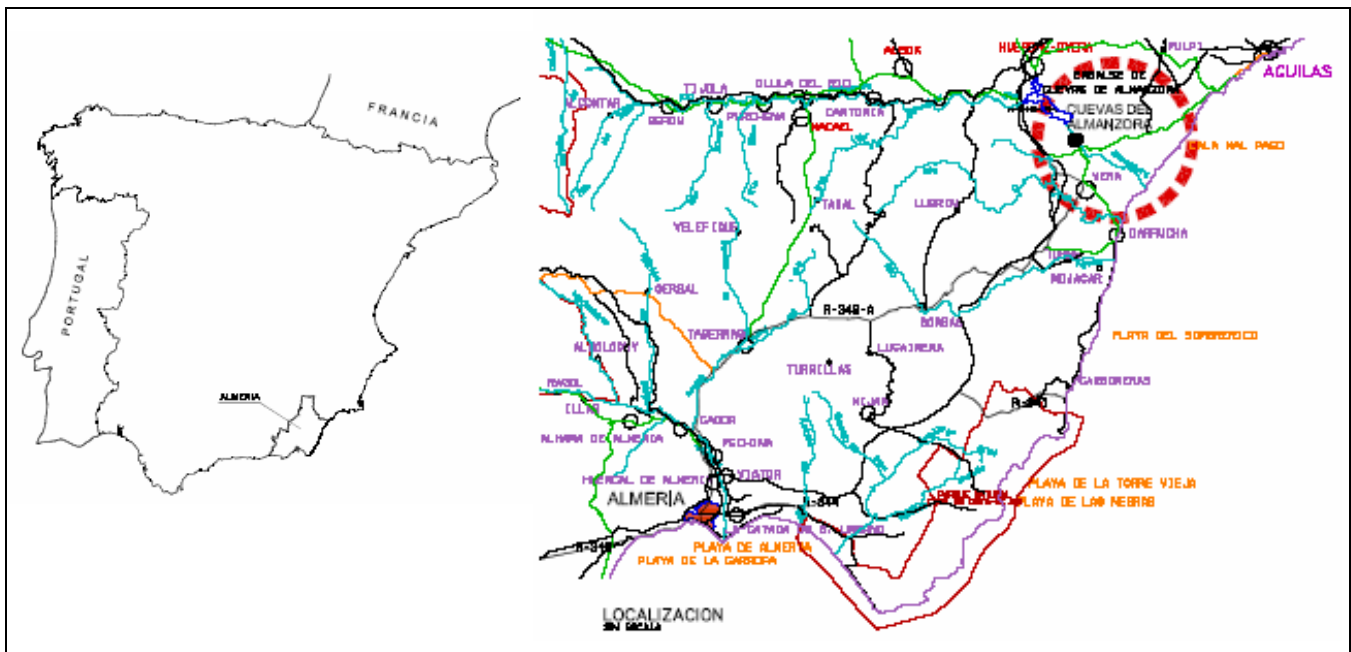


Figure 1. Almeria province and Almanzora Valley location

The Almanzora Valley, which extends from the low plains of the Antas and Almanzora rivers in the north-easternmost area of Almería, is, after Campo de Dalías, the second largest agricultural area in the province, with a surface area of around 13,000 hectares in use. In this area, open air, although very technified, vegetable cultivation and the cultivation of extra-early citrus fruits predominate. The aforementioned underground waters of the H.U. 6.06: Bajo Almanzora, H.U. 6.01: El Saltador, H.U. 6.04: Huércal-Overa and 6.05: Ballabona-Sierra Lisbona, have been initially complemented with the supply of water from the Tajo Segura Diversion; later, small private desalination plants were incorporated, mainly of salt water, even making a large-sized plant (6 Hm³/year). Finally, since 2004, it has included the supply of the water from the Negratín Reservoir, through the Negratín-Almanzora Connection.

Since this area is prolonged on the Levante Almeriense coast, from the municipality of Carboneras, to the south, also including Vera, Garrucha, Mojácar, Huércal-Overa and Cuevas de Almanzora, its strong tourist development, due to its magnificent natural conditions, also requires the water resources is guaranteed in quantity and quality.

In this context, the AGUA (Water) Program of the Ministry of the Environment includes the construction of the New Bajo Almanzora Desalination Plant, as well as the other infrastructures which, as part of this program, are being developed in the area.

An example of this is the pipeline from the Carboneras Desalination Plant to the Almanzora Valley, which is executed in parallel to the New Bajo Almanzora Desalination Plant, and which will provide all the Levante Almeriense coast with an artery of salt water which enables the consolidation of a potable water distribution system whose supply is guaranteed at all times, as it is connected to the two desalination plants that Acuamed has in this strip of the coast.

Thus, the New Bajo Almanzora Desalination Plant will be integrated in the system as another supply source which will permit, as basic resource, to guarantee a stable supply in quality and quantity for the consolidation of irrigation surfaces of the Almanzora Valley, and will also serve as guarantee of urban supply, in this case being an installation which enable the urban growth planned throughout this coastal strip to be absorbed.

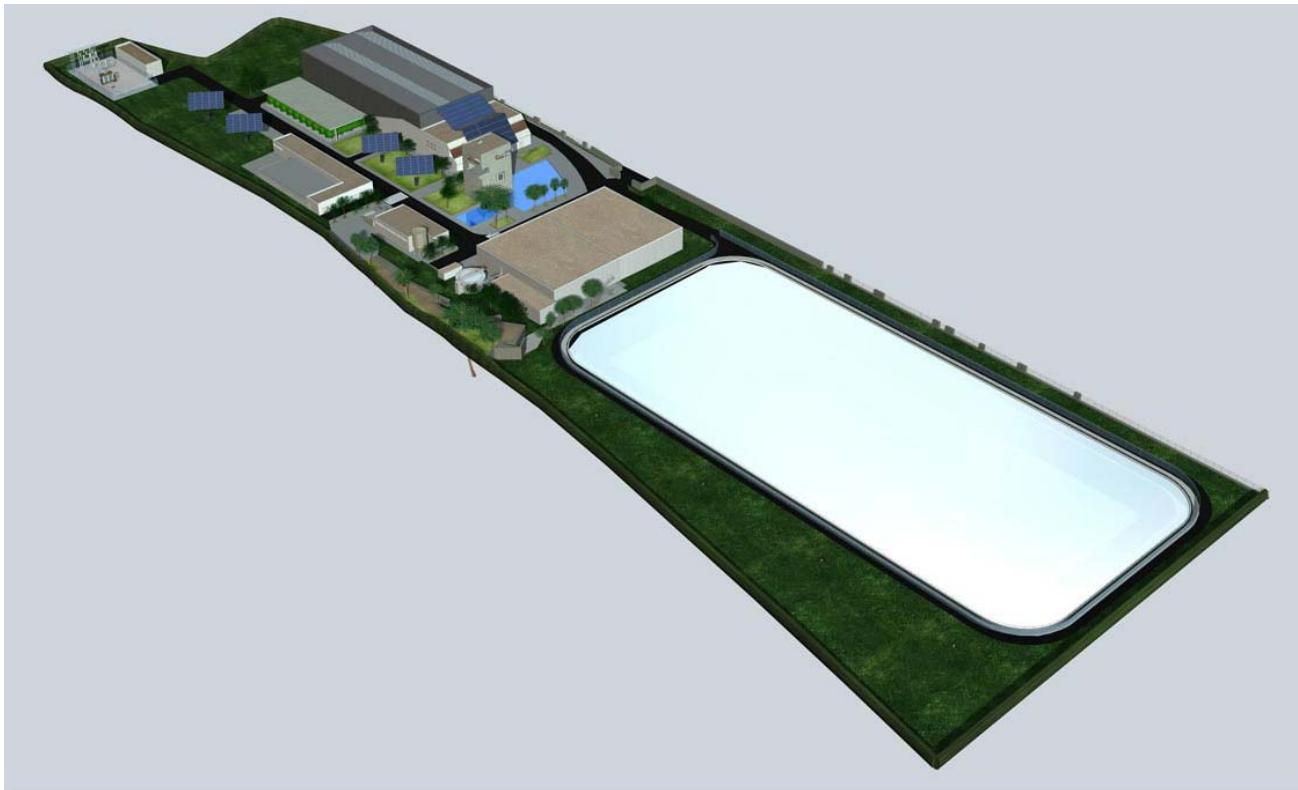


Figure 2. 3D representation of Bajo Almanzora seawater desalination plant

II. INITIAL DATA

The initial data for the process design is shown in Table 1.

Seawater desalination plant daily capacity:	60.000m ³ /day
Performance days per year:	333,33 days/year
Seawater desalination plant annual capacity:	20 Hm ³ /year
Type of raw water:	Seawater
Salinity:	39.702,6 ppm of TDS
Boron:	5,00 ppm
Temperatures of design:	. Minimum temperature: 17 °C . Maximum temperature: 23 °C

Table 1. Initial data for the process design

The evolution of the temperature of the water of sea throughout the year that has been considered in the design is shown in Figure 3.

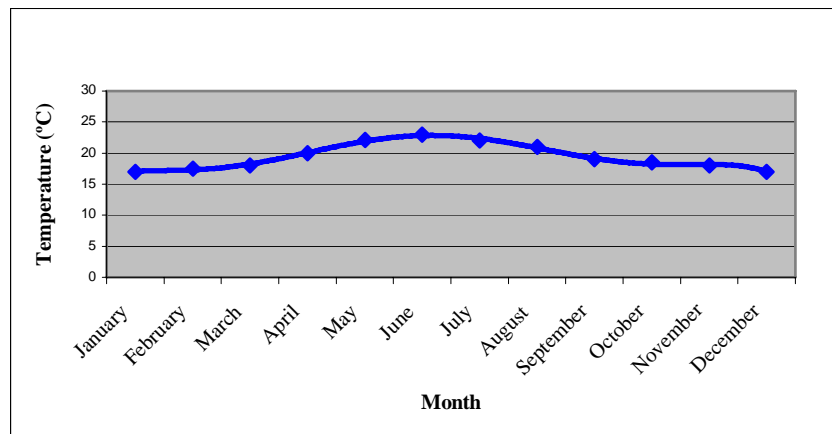


Figure 3. Evolution of the seawater temperature throughout the year

III. PRODUCT WATER

The water product will fulfill the Spanish legislation for drinking water, R.D. 140/2003, in addition to other limitations like those referring to boron or Langelier Index.

Type of product water: Drinking water

Product water salinity:

. Permeate < 200 ppm of TDS

. Product water after post-treatment < 400 ppm SDT

Chloride ions < 200 ppm

Sodium ions < 150 ppm

pH > 6,5 and < 8,5

Langelier Index > 0 and < 0,5

Boron < 0,5 ppm

IV. PROCESS DESCRIPTION

Bajo Almanzora SWDP process consists of:

- Seawater well intake.
- Pre-treatment chemical dosing.
- Regulation intake tank.
- Low pressure pumping station.
- Pressurized sand filters.
- Cartridge filters.
- High pressure pumping system - first pass-.
- Booster pumping system - first pass-.
- High pressure pumping system - second pass-.
- Reverse osmosis membrane racks – first and second pass-.
- Energy recovery system.
- Membrane cleaning and flushing system.
- Post- treatment water conditioning system.
- Product water storage tanks.
- Sub-products effluent treatments –sludge dewatering and solid handling facility-.
- Brine discharge outfall, including a brine dilution before being released to the sea.

In Figures 4 and 5 it is shown the general process diagram and general plant layout of Bajo Almanzora Seawater Desalination Plant.

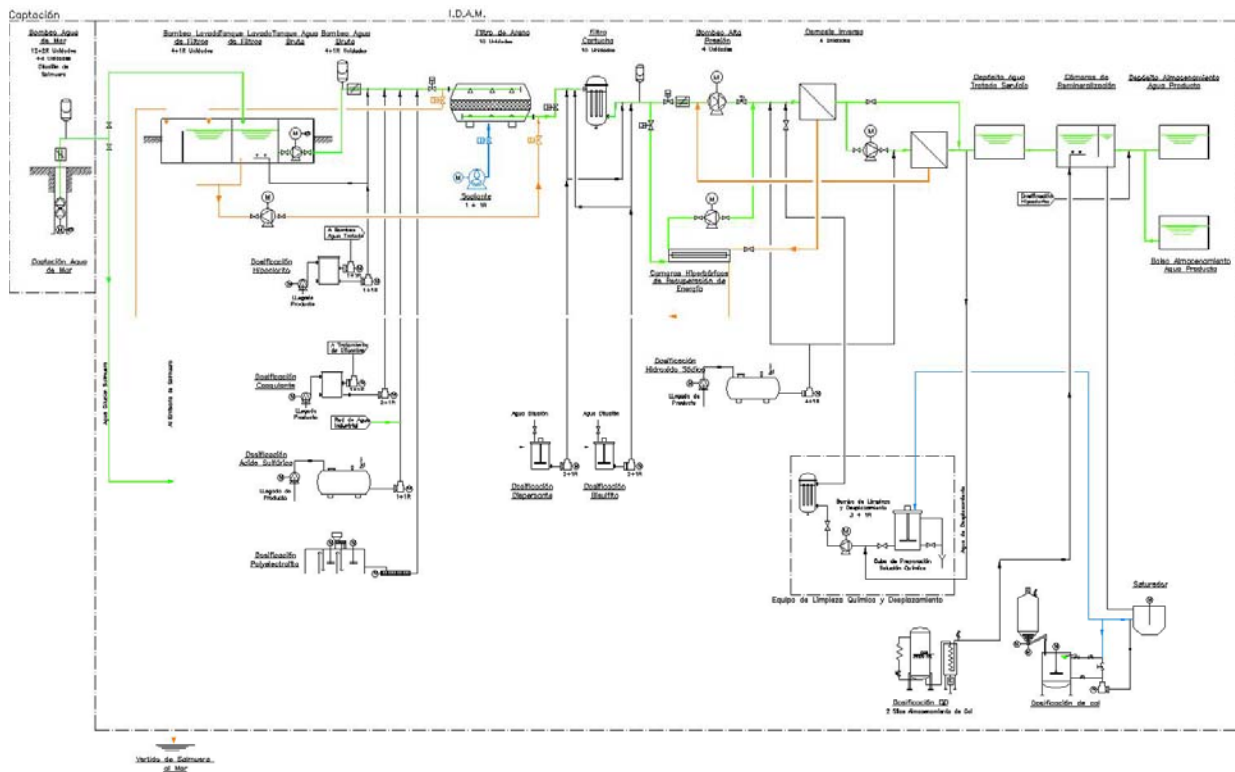


Figure 4. General process diagram

4.1. Raw water intake

Bajo Almanzora seawater intake consists of 14 beach wells for supply raw water to the process, 12+2 standby. Moreover, 4 more beach wells are implemented for brine dilution.

Each well will be a sounding covered inner by a PVC pipe that will go longitudinally perforated in its inferior part as a grid to protect it from rocks, strange elements, etc.

These wells will be equipped with submerged pumps (one for each well) that impell seawater to the plant and each one will have capacity to supply 500 m³ per hour of raw water. Total pressure at pump discharge will be maximum 2,5 bars.

A GRP pipe (nominal diameter 1.000 mm and length 2.635 meters) will be installed to transport seawater from wells to the desalination plant.

This intake type was chosen among other reasons because of the better seawater quality that provides to the process, reducing, therefore, the requirements for an optimal pre-treatment process which will be less complex than under other circumstances (for example in case of raw water open intake).

4.2. Pre-treatment

Pre-treatment design will be compounded of the following process units that are considered more than sufficient because of the high quality of the raw water.

4.2.1. Pre-treatment chemical dosing.

- Sodium hypochlorite dosing (disinfectant)

Average dose of pure product: 0,7 ppm

Maximum dose of pure product: 6 ppm (shock dosing)

Sodium hypochlorite could be added continuously or in shock dosing. 1 + 1 standby dosing pumps will be installed.

- Ferric chloride dosing (coagulating agent)

Ferric chloride (with a 40% concentration) will be used for coagulation. Ferric chloride solution will be stored in a GRP storage tank with a capacity of 20.000 litres. A mixer will be installed in the coagulation basin. Three dosing pumps (1 in stand-by) will be installed.

Average dose of pure product: 3 ppm

Maximum dose of pure product: 15 ppm

- Polyelectrolite dosing (flocculating agent)

In order to increase the aggregation capacity of the neutral colloids, an organic synthetic polyelectrolyte will be used. Dosage of Poly-electrolyte will produce bigger and heavier floccules. As flocculation reactions are slower than coagulation reactions, contact time in flocculation will be longer.

Automatic equipment will be installed for the poly-electrolyte preparation, with a capacity of 500 l/h. Also three (1 in stand-by) dosing pumps will be installed.

Average dose of pure product: 0,4 ppm

Maximum dose of pure product: 0,8 ppm

- Sulphuric acid (correction of pH)

Sulphuric acid metering equipment is designed to reduce the pH of sea water and prevent precipitation of carbonates and bicarbonates. The reduction of pH makes the bactericide action of the chlorine more effective.

In case pH adjustment is necessary a sulphuric acid solution can be prepared. Acid will be stored in a 20 m³ storage tank. Two dosing pumps (1 in stand-by) will be installed.

Average dose of pure product: 10 ppm

Maximum dose of pure product: 24 ppm

- Sodium metabisulphite dosing (reduction of the free chlorine)

This product is added in order to eliminate residual chlorine from the dosage of sodium hypochlorite. Three dosing pumps (1 in stand-by) will be installed.

The solution will be prepared in 2 GRP solution tanks each one with 2 m³ of capacity.

Average dose of pure product: 2 ppm

Maximum dose of pure product: 5 ppm

- Antiscalant dosing (incrustations inhibitor)

In order to prevent the precipitation of sparingly soluble salts, such as CaSO₄, BaSO₄, SrSO₄, CaF₂, an antiscalant will be dose. Three dosing pumps (1 in stand-by) will be installed.

The solution will be prepared in 2 GRP solution tanks each one with 2 m³ of capacity.

Average dose of pure product: 2 ppm

Maximum dose of pure product: 5 ppm

We must emphasize that, in order to design a high flexibility plant, it exist the possibility of making the chemical dosing in different points of the process.

4.2.2. Regulation intake tank and low pressure pumping station.

Seawater will be pumped from intake to a 1.308 m³ regulation tank with dimensions 21 x 14 x 4,5 m. The retention time of raw water in this tank is more than 14 minutes.

In order to pump seawater to filtration system, centrifugal pumps with the following characteristics will be installed:

. Total number of pumps installed: 5 units

. Total number of pumps in operation: 4 units

. Nominal flow: 1.480 m³/h.

. Motor power: 360 kW

Flow and pressure regulation will be made using variable frequency drivers which can fit the speed of turn of the pump motor drive.

The installation of variable frequency drivers is one of the most noteworthy aspects of the plant, as we will see throughout the development of the present article.

These variable frequency drivers will give the installation high flexibility and the processing will be optimum in terms of energy since the different pumps can work at optimum capacity and pressure at all times.

4.2.3. Pressurized sand filters.

A total of 10 pressurized filters are included in this stage, each one with a unitary surface of 71,54 m². These filters will be made of CS and epoxy or rubber lined. All filters will include pneumatic valves and necessary instrumentation for automatic functioning.

This filtration stage will provide a filtration speed of 7,77 m³/h/m² (8,64 m³/h/m² when one filter is washing).

This filtration stage also includes a bypass system.

The nozzles are designed to prevent media loss and to reduce pressure losses to the minimum. A total of 50 nozzles per square metre of filtering surface will be installed. The nozzles are made from plastic to avoid corrosion.

4.2.4. Cartridge filters.

Next, the water filtered through the sand beds will be microfiltered in cartridge filters until a filtration degree of 20 absolute microns.

To do this, ten (10) units will be installed in parallel, each one of them with capacity to house 180 cartridges.

Said cartridges will be polypropylene depth filtration with a cut-off power of 20 absolute microns, with a particle removal efficiency of 99,98% and a beta ratio of 5.000.

The processing building will be divided in three areas. It will house this equipment in the area devoted to pre-treatment.

4.3. Reverse osmosis membrane racks

4.3.1. High pressure pumping system – First pass-.

The water filtered in the cartridge filters will be sent by a common collector (1000 mm of nominal diameter PRFV pipe) towards the high-pressure delivery systems and the osmosis racks.

From this water flow, somewhat more than 47% will be delivered by the high pressure pumps. At the intake of said pumps, the pre-treated water will arrive with a minimum pressure of 2,5 bar, pressure which will be guaranteed from the intermediate or low pressure pumping.

One of the most noteworthy aspects of the Bajo Almanzora Seawater Desalination Plant is the installation in the pumps of variable frequency drivers at medium voltage which involves working with osmosis membranes at their optimum pressure at all times.

As has already been mentioned, the variable frequency drivers installed in the different pumping stations of the plant enable great flexibility throughout the process and, specifically, the variable frequency drivers in the high pressure pumping allow highly flexible racks since there is the possibility of installing a large range of membranes, both currently from different suppliers and of future generations, increasing the rack production in specific cases by the increase of the specific flow per membrane in the event of increased demand, etc.

In addition to the aforementioned energy saving, the medium voltage variable frequency drivers offer other advantages, among which we can state:

- . Limited motor start-up current (gentle start-up), a factor which is highly appreciated by the electricity company and in many cases is demandable.
- . Imperceptible voltage drops, whereby the effect on the other plant receivers is zero.
- . Low level of harmonics to the system.
- . Low reactive energy consumption.

The main characteristics of the high pressure pumps are the following:

- . Total number of pumps: 5 units
- . Number of pumps in operation: 4 units
- . Number of reserve pumps not installed (in warehouse): 1 unit
- . Nominal flow: 694 m³/h
- . Differential pressure: 649 m.w.c.
- . Electric drive:
 - Motor power: 1.600 kW
 - Voltage: 3.800 V - 50 Hz.
 - Speed: 3.000 rpm.

Both the low pressure pipes and the high pressure pipes will run in their main part through chutes in order to achieve greatest accessibility to this high pressure system, which is the main core of the plant. This concept is also applied in the case of booster pumping and second pass pumping.

4.3.2. Booster pumping system – First pass-

The % of pre-treated water flow which is not delivered by the high pressure pumps will go to the pressure exchangers from which it will exit at a pressure somewhat lower than that necessary for its entrance in the membranes. This pressure loss at the exit of the recovery devices is due to the load loss in the membranes, internal losses due to the recovery modules and load losses in valves and pipes.

This pressure lacking would be provided by the first pass booster pumping. Thus, said pumps would equal the pressure of the output current of the hyperbaric chambers with the delivery pressure of the high pressure pumps.

This pumping will also be equipped with variable frequency drivers to regulate flow and pressure.

The main characteristics of the booster pumps are the following:

- . Total number of pumps: 5 units
- . Number of pumps in operation: 4 units
- . Number of reserve pumps not installed (in warehouse): 1 unit
- . Nominal flow: 764,5 m³/h
- . Differential pressure: 51,46 m.w.c.
- . Electric drive:
- . Motor power: 160 kW

4.3.3. *High pressure pumping system – Second pass-*.

Due to the fact that with a single pass reverse osmosis system the boron quality to be guaranteed is not achieved (Boron < 0,5 ppm), it is necessary to install a second pass osmosis which will re-treat part of the flow produced from the first.

To pump the product permeate from the first pass to the second pass, it will be necessary to install a new pump with the following characteristics:

- . Total number of pumps: 5 units
- . Number of pumps in operation: 4 units
- . Number of reserve pumps not installed (in warehouse): 1 unit
- . Nominal flow: 523,36 m³/h
- . Differential pressure: 125 m.w.c.

Said pumps will also be equipped with variable frequency drivers, in line with the energy optimizing objective pursued throughout the design.

4.3.4. *Reverse osmosis membrane racks – first and second pass-*.

The execution is planned of 4 desalinated water production lines in two reverse osmosis passes, with a net nominal production of 15.000 m³/day each.

To guarantee the quality of the product water, there is the possibility of adjusting the pH by adding sodium hydroxide in both passes if necessary.

The total conversion of the system planned is 45%, with 47% in the first pass, 90% in the second pass, and a by-pass flow of 22,89 %. In other words, 77,11 % of the first pass product permeate will be treated in the second pass.

Given the high flexibility characteristics of the racks, membranes from different providers can be installed. In all cases they will be aromatic polyamides with spiral configuration.

Both the first pass and second pass will be integrated in the same structure.

Another aspect to highlight of the osmosis racks in the Bajo Almanzora plant is the installation of the multiport technology of pressurized water distribution in the pressure vessels.

This system considers groupings of two or three pressure vessels (three in the first stage and two in the second) positioned in series, a grouping which, in turn, is fed in parallel by central collectors.

This configuration is of recent application and is undergoing quick growth in its implementation due to the improvements it entails, there already being references of plants operating with it.

The main improvements of this configuration entails are the following:

- . Greater compactness of the rack.

As it reduces the necessary distance between the pressure vessels, less rack is covered by the surface, leaving greater access space around it which facilitates maintenance and conservation tasks.

- . Greater simplicity of the high pressure pipe system.

It simplifies the high pressure pipe system since it involves a lower number of distribution collectors of greater diameter, which slightly reduces the pressure loss in the delivery of the high pressure pumps.

- pH adjustment by addition of sodium hydroxide

To reduce the boron values in the permeate to below the required quality values of the product water, in addition to the fact that part of the water produced in the first pass is made to pass through the second pass osmosis, it may be necessary to adjust the pH.

For this purpose, it will have a sodium hydroxide dosage system. A dosing pump per line plus one reserve pump will be installed. The design dose included in the dimensions is 25 ppm.

- Configuration of the first pass rack.

Number of stages:	1 unit
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Membranes installed:

Number of pressure vessels per rack:	190 units
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Total number of pressure vessels:	760 units
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Number of membranes per pressure vessel:	7 units
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Number of membranes per rack:	1.330 units
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Total number of membranes:	5.320 units
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- Configuration of second pass rack.

Number of stages:	2 units
Arrangement:	
. 1 st stage	38 units
. 2 nd stage	15 units
Membranes installed:	
Number of pressure vessels per rack:	53 units
Total number of pressure vessels:	212 units
Number of membranes per pressure vessels:	7 units
Number of membrane per rack:	371 units
Total number of membranes:	1.484 units

4.3.5. *Energy recovery system.*

In order have energy optimization of the process, the installation of an energy potential recovery system from the rack brine discharge by a high efficiency hyperbaric chamber system is proposed.

The main characteristics of the proposed energy recovery modules are the following:

- . Manufacturer: ERI
- . Type / Model: PX / 220
- . Number of recovery devices installed per line: 17 units
- . Total number of recovery devices installed: 68 units
- . Small tubular chambers and concentric to a rotor that produce the rotation transmitting the high pressure energy to the low pressure side.
- . No pulsations, valves, pistons or timers are necessary.
- . Plastic and ceramic materials.
- . Can hold up to 50 m³/h per unit.
- . Fast cycles (1.500 rpm).

4.4. Membrane cleaning and flushing system.

The design of the chemical washing system has been produced with capacity to wash 50% of the first pass of a rack (first and second pass will be cleaned separately).

The equipment will have 2 cleaning tanks, recirculation pumps and cartridge filters (provided with suitable fittings and auxiliary installations).

The same pumping will be used for the flushing as for the chemical cleaning of the membranes. The seawater will be flushed with permeate water.

4.5. Post-treatment water conditioning system.

- Carbon dioxide and sodium hydroxide dosing.

Water corrosivity can be estimated by calculating the difference between actual pH and hypothetical pH at equilibrium with calcium carbonate (CaCO_3). This difference is defined as Langelier Saturation Index (LSI).

In under-saturated water, represented by a negative LSI, CaCO_3 tends to dissolve, whereas in oversaturated water, represented by a positive LSI, CaCO_3 tends to precipitate. Theoretically, in waters with LSI equal to zero, CaCO_3 neither dissolves nor precipitates.

Due to the rejection of large ions by reverse osmosis (RO) membranes, RO permeates have low pH and very little calcium and bicarbonate. As a result, RO permeates are always very corrosive.

In order to obtain the acceptable pH and LSI values, CO_2 and lime dosing will be dosed before entering the product water tank.

Average dose of carbon dioxide: 52 ppm

Average dose of calcium hydroxide: 50 ppm

- Sodium hypochlorite dosing.

Sodium hypochlorite will also be used in order to achieve a residual chlorine around 0,5 ppm. Two dosing pumps (1 in stand-by) will be installed. Same storage tanks will be used from pre and post-treatment sodium hypochlorite dosing.

Average dose of pure product: 1,5 ppm

4.6. Product water storage tanks.

The product water at its exit from the second pass will be sent to a regulation basin with 72.000 m³ capacity, when the final destination is agricultural irrigation.

The product water designed for human supply once remineralized by the addition of carbon dioxide and calcium hydroxide and thus converted in potable water, will be stored in a 12.000 m³ capacity tank.

The tank will be formed by two independent modules of the same surface and volume. The unit dimensions of each chamber are 30 x 40 x 5 m.

The water intake to both modules will be performed by 700 mm Nominal Diameter (DN) pipes, as will the outlet pipes towards the supply system.

4.7. Sub-products effluents treatments – sludge dewatering and solid handling facility-

Below, the sub-products generated in the desalination process will be described, which will basically be three types, and the treatment to be applied in each case:

- Brine discharge from the reverse osmosis process

The brine from the first pass of the reverse osmosis process will be sent to a storage tank. Part of this brine discharge will be used as washing water of the sand filters and the excess will overflow and be sent to the discharge outlet.

- Membrane washing membranes, emptied from reactive tanks and bleeds of the lime saturator. The effluents of this group should be neutralized before exiting the plant, for which purpose it will have the following installations:

The solutions from the membrane washing, the emptying of the reactives tank, and the sludge dewatering from the lime saturator, will be sent to a tank to neutralize it and then discharge it in the brine discharge outlet or the filter sludge intake tank.

There will be a 175 m³ storage tank for neutralization.

A pumping system will be installed in this tank in order to be able to remove the sub-products generated or recirculating the solutions to neutralize. This pumping system will be composed of 1+1R horizontal centrifugal pumps with 65 m³/h unitary flow.

There will also be a pump for the brine (plastic pumps) composed of 1 + 1R horizontal centrifugal pumps with 70 m³/h unitary flow.

- Brine with solids in suspension from the washing and emptying of filters

In order to concentrate the solids from the filter washing water, there will be a physicochemical treatment, which will include mixing, flocculation, lamellar decanting and dewatering due to gravity integrated with the decanting

Complying with that undertaken in accordance with the Environmental Impact Statement, the water will be sent to the brine discharge outlet.

The sludges will later be treated in a sludge dryer.

Chemical dosing in sludges treatment:

. Ferric chloride dosing

Average dose of commercial product: 25 ppm

Maximum dose of commercial product: 50 ppm

Two dosing pumps (1 in stand-by) will be installed.

. Polyelectrolite dosing

Average dose of commercial product: 0,8 ppm

Maximum dose of commercial product: 2 ppm

Two dosing pumps (1 in stand-by) will be installed.

4.8. Brine discharge outfall, including a brine dilution before being released to the sea.

The solution given in the project of the Bajo Almanzora desalination plant to the outfall of the brine discharge respects and meet the prescriptions indicated in the Environmental Impact Statement of the work issued by JUDGEMENT of 24 March 2006 of the Secretary General for the Prevention of Contamination and Climatic Change.

The outfall of the brine, produced by the discharge of the reverse osmosis membranes of the seawater desalination plant, will be performed by a brine discharge pump, whose total length is 4,287.88 m, which is composed of a terrestrial section and a submarine section.

- Terrestrial section

It starts in the seawater desalination plant, will run under the bed of the river Almanzora to the working shaft of the drive planned to save the breaker area in the submarine section, in the coastline in equinoctial low water.

Its total length is 2.384,14 metres in GFRP pipe of DN 900 mm nominal value in its first 2.313,14 metres (junction point with the delivery of seawater for the brine dilution) with a flow of 0,85 m³/s and GFRP pipe of DN 1.000 mm in the remaining 71,00 metres with the sum of the previous flow and that planned for the brine dilution, with a total of 1,36 m³/s.

- Submarine section

It starts in the aforementioned working shaft of the drive and goes to the discharge point of the brine to the marine environment. There are two clearly differentiated sections, with a total length between both of 1.903,74 metres:

. Drive section with DN 1.200 mm reinforced concrete pipe and a length of 504,47 m.

. Anchored section with DN 1.000 mm polyethylene pipe which will also have to sections of different weight: 580 metres of SDR 33 pipe and 819,27 metres of SDR26 pipe

- Diffusion section

This section has a length of 100 metres and will be placed at an approximate depth of 30 metres. It will have 21 dual exits of DN 100 pipes (paired) with a gradient of 60°, provided with different retention/diffusion valves (sleeve/duckbill) for its discharge.

These dual discharge outlets will be separated every 6 m so that it is produced by horizontal injection separated from the marine bed and below the minimum discharge depth mentioned above.

The location of the discharge point will have the following UTM and depth:

X: 609.935

Y: 4.121.186

Depth: 25 m

V. ENERGY CONSUMPTION

It must be highlighted the importance of the energy consumption warranty since Acuamed's purpose of achieving the maximum energy efficiency in its promoted plants foresees penalties or bonus to the contractor based in the degree of achievement of this committed figure.

This way, in case the energy consumption is above this limit, the operator will get a 100% electricity cost penalty for the excess and in case being below it, it will get a 50% electricity savings bonus.

This operation contractual framework is therefore an incentive to the contractor to introduce all those technical improvements that would lead to energy efficiency improvement of the plant.

As it has been described throughout the present document, the process has been designed seeking high energy efficiency and the following points should be highlighted in this regard:

- Installation of variable frequency drivers in the pump intake.
- Installation of variable frequency drivers in the low pressure or intermediate pumping.
- Installation of variable frequency drivers in first pass high pressure pumping.
- Installation of variable frequency drivers in the first pass booster pumping.
- Installation of variable frequency drivers in the second pass high pressure pumping.
- Installation of a recovery system of the energy contained in the first pass discharge brine by pressure exchangers (principle of hyperbaric chambers).

In this way, all the plant pumping can act at all times in its optimum point; The intermediate pumping will be adapted to the higher or lower load losses found in the sand filtration and cartridge filtration stages; The first pass high pressure system (first pass high pressure pump and booster pump) will provide the osmosis membranes with their optimum pressure in the design temperature range and they will be adapted to salinity changes if they occur; The second pass membranes will work in the same way as those of first pass at optimum pressure; In specific cases of increase in demand of product water the specific flow through membranes can be increased, thus obtaining a greater quantity of product water, etc.

Figure 6 shows the evolution forecast in the plant's energy consumption from its start-up to 10 years' operation, the time at which this consumption will be stabilized.

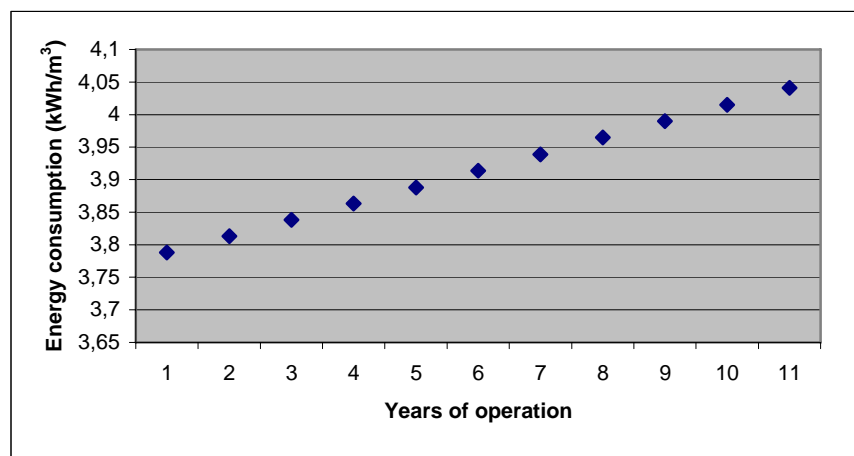


Figure 5. Evolution forecast in the plant's energy consumption

The specific water consumption guaranteed in the tender process by the awarded joint venture is 4,0426 kWh/m³.

VI. RENEWABLE ENERGIES

The plan includes the installation of photovoltaic panels to cover auxiliary energy requirements, both thermal and electrical, not destined for the production of desalinated water. The peak power of the estimated photovoltaic generation is 102 kWhp.

VII. ENVIRONMENTAL AND LANDSCAPE INTEGRATION

The ideas which have served as guidelines in the present project are highlighted below:

- Relation with the environment, not only from a close by environment, but covering a much wider vision. The insertion of an industrial complex of the dimensions of this desalination plant creates a whole network of relations within the district in which it is located.
- Recounting these relations and the benefits of this installation, with its environment. For this purpose the Desalination Interpretation Centre is created (see Figure 7). These spaces are advised to be located so that they do not affect the daily work of the premises when there is an outside visit.
- Introduction of renewable energies for the operation and internal consumption of the Plant. These installations should form part of our resources to integrate the desalination plant in the environment and not just the mere accumulation of the industrial installations regardless of its environmental impact.
- Acuumed aims that the desalination plants (both this and other project of the AGUA plan) are integrated in the environment of the area, not just with the interaction in the environment in which it is located, but showing it to be proud of them, almost having a BRAND IMAGE, so that they are appreciated as positive for people living close by and those who visit the installations.



Figure 6. 3D representation of the Desalination Interpretation Centre

VIII. CONCLUSION

In short, the Bajo Almanzora Seawater Desalination Plants, in addition to entailing a significant increase in water resources available both for human consumption and irrigation in the east Almeria, is a project that:

- Will guarantee future needs for agricultural irrigation, in quantity and quality, as well as the medium and long term development of the tourist growth of the coastal area.
- Committing to a process to obtain desalinated water from seawater with high energy efficiency, by the use of optimum technologies for it such as the variable frequency drivers in low and medium voltage and energy recovery from the brine discharge by pressure exchange systems.
- It commits to the surrounding environment, introducing a renewable energy system as producer of the energy necessary for auxiliary consumptions and typical of the plan outside the desalinated water production process and performing the necessary actions on the different plant effluents to minimize their impact on the environment.
- It also commits to the surrounding environment on a social level, creating a Desalination Interpretation Centre which, accessible to visits outside the plant operation, will recount the benefits that the installations will provide the environment with.