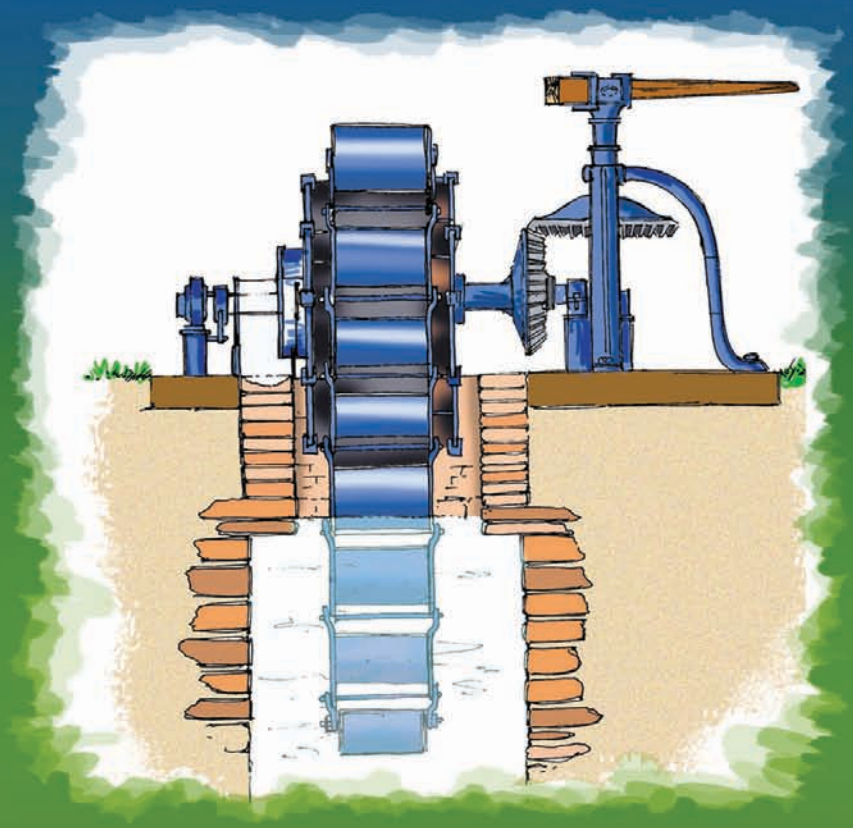
THEN, THERE WERE MINES

Volume 3

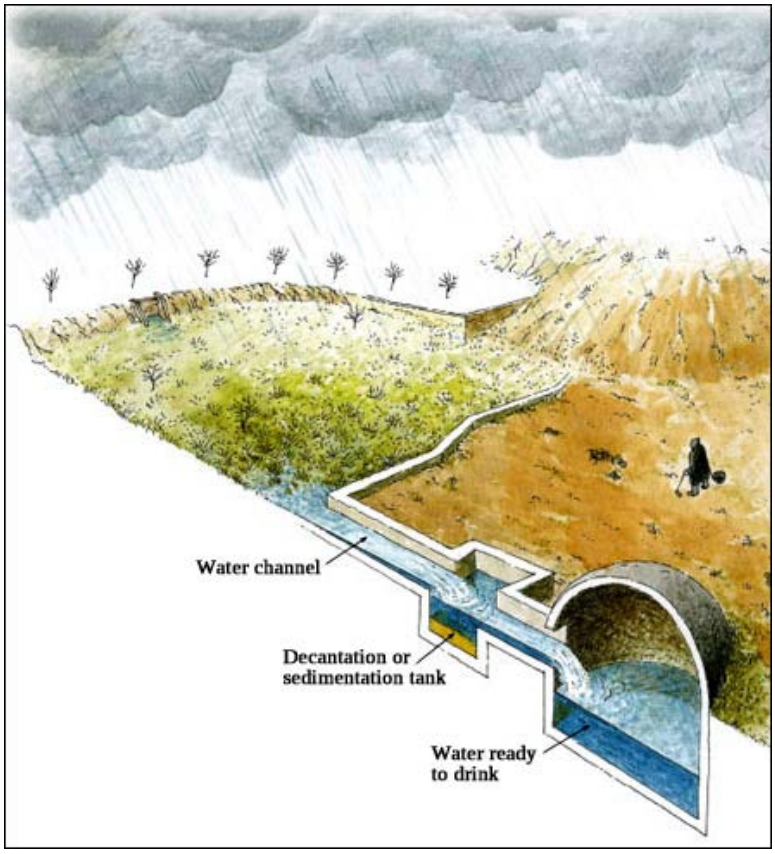


Margaret Davies

2020

THEN, THERE WERE MINES

Volume 3



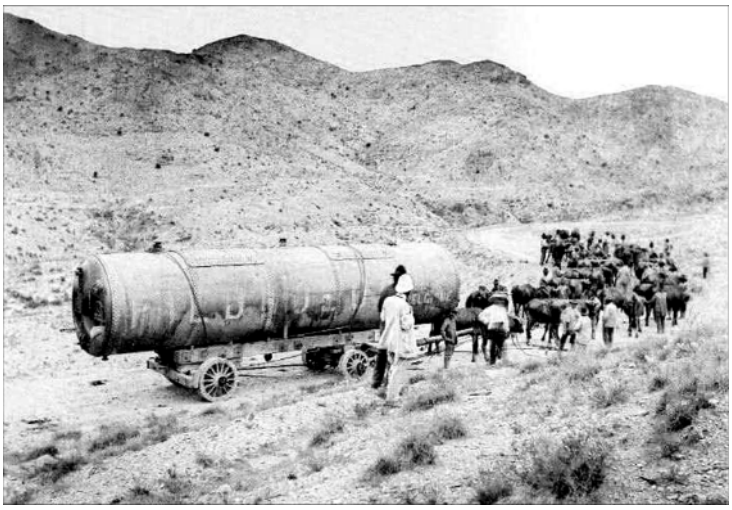
Margaret Davies
2020

Contents

Whilst I have tried to identify and attribute copyright holders to illustrations and photographs, I would be grateful for information about those where this has not been possible and would be glad to rectify any such omissions in future editions.

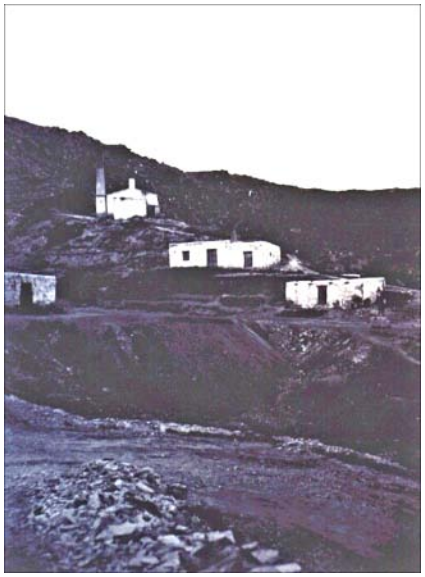
Chapter 1. Water, But Not Enough To Drink.

Low labour costs, small individual mines and good returns on extracted minerals, delayed the arrival of steam power in the Sierra Almagrera. While the desagüe had a steam driven pump as early as 1852, it was largely ineffective and unreliable.



The boiler for the desagüe arrived in Villaricos in 1851 and was transported by a team of oxen.
Sierra Almagrera y Herrerías. Bolea.

In 1864 the Purísima Concepción mine installed a steam powered winch. The benefits, in terms of achievable depths, were impressive and the use of this form of power spread. By 1883 most of the top forty mines had installed steam driven extraction machines, although Carmen, Observación and Estrella continued to use mule powered whims.



The engineer Paul Colson, responsible for 75% of the steam engines, favoured brick chimneys … …

. . . while the German firm, Humbolt, preferred a metal stack.
Both, Rodrigo.

The disadvantage of steam power was that it was a thirsty beast. A 10h.p. engine required 3,000 litres of water daily. The annual cost of transporting that amount of water was in the region of 17,000 reales. The cost of constructing a 500 cubic metre rain water cistern or balsa, was in the region of 15,000 reales

The simple balsa of the mine Ibería.

Needless to say, the owners opted for at least one balsa, or water cistern, and hoped for wet weather to fill it. In times of drought, if there was insufficient water in the balsa, the choice was to either, buy in a supply and have it brought up on the backs of mules, or, shut the engine down.

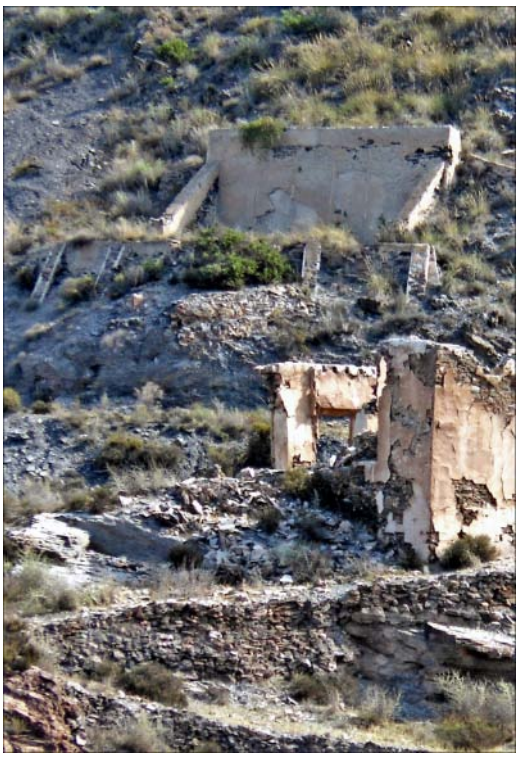
La Compañia de Águilas even pumped seawater up from the Cala del Peñón Cortado in an effort to make up the shortfall of water to feed the boilers of their pumping station in the Barranco del Francés.

There are a variety of balsas in the Sierra, each easily recognizable. Any construction that has been rendered impermeable will have been used to contain and store water. Many of them are still capable of holding some water after nearly 100 years, as demonstrated by my canine companion, in the balsa of the mine La Ibería.

The balsa at mine La Ibería.

The shallow balsa of the mine Encarnación on the way up to the "Lost Village".

As well as the type of balsa shown above there are at least two others. The first, above the lost village in the Barranco de Francés, has a high back wall, hard against the rock, and a tank at the front. A good view of this can be had from the Casa Dos Mundos promontory. Why they are constructed like this is a mystery to me. However, the design is still used in the present day. There is a massive, recently constructed example just outside Murcia.



Two views of the balsa above the "Lost Village".

What looks like another example of this type of balsa is at Ramo de Flores and is best seen when you approach the mine from the Barranco de las Palomas.

What looks like a balsa at the mine Ramo de Flores.

This structure was used for ore washing, but I'm not sure how it functioned.

The mine Venus Amante, up by the Arab Watchtower, has a raised, circular balsa as well as the more usual sunken, rectangular type.

The unusual, circular balsa of the mine Venus Amante.

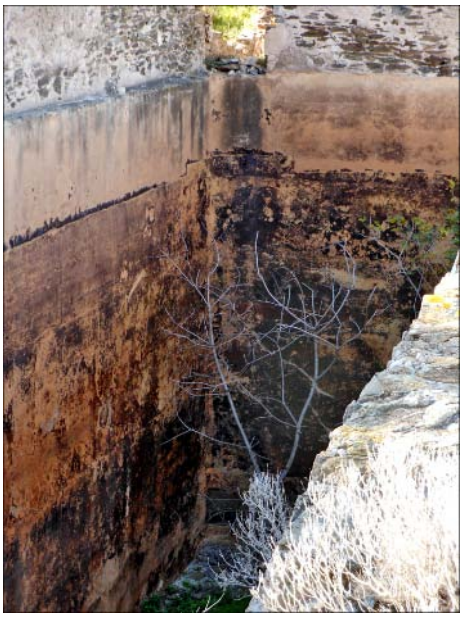
Looking inside the circular balsa.

When it came to water collection and storage, it was, again, the men from Bilbao who were the masters. At the head of the Barranco Hospital de Tierra, the mines Independiente and La Guzmana have the most striking water collection systems in the whole Sierra. Unlike the two previous types, these had roofs. The sheer size of the one that served the Independiente is quite breathtaking. The main feed channel was served by several terraces on either side.

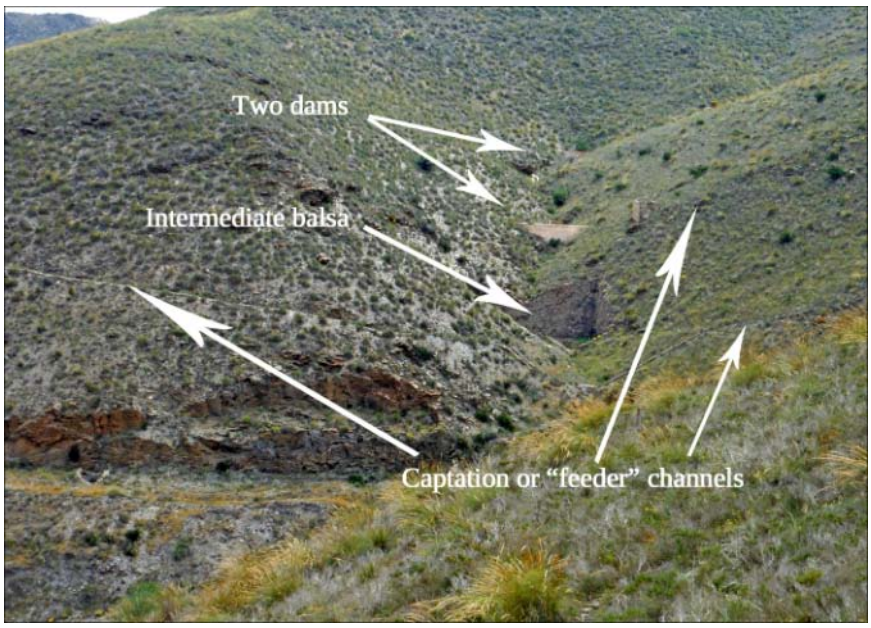
Two views of the Independiente's balsa showing the terracing and the feeder channel.

However, even the Independiente's system pales into insignificance when one looks at that of La Guzmana which was built in 1880, when the steam engine was installed.

Two views of the Guzmana balsa. To give some indication of size, I estimate its depth today to be about 7m. This is after a century of silt and rock being washed into it.



This massive 1500 cubic metre covered balsa was fed by a water collection, or captation system that extended right up the valley and comprised of a series of dams and smaller balsas. In addition, surface water from the surrounding hills was channelled into the system via a small aqueduct and a series of small canals, which extended away from the balsa for a considerable distance.



The dams and smaller balsa which formed the water collection system for the grand balsa.

The intermediate balsa had sluice gates which could be closed when necessary, allowing water to collect on either side of a low, raised wall. The wall has a depression along its length, and looks as if a pipe ran along it. I think that it carried water from the dam above it towards the main balsa. There are several small sluice gates along the way, where water could be diverted away from the balsa and onto the ore washing floor.

Above, the low wall used to conduct the water.

Right, the water could be diverted through the sluice gates.

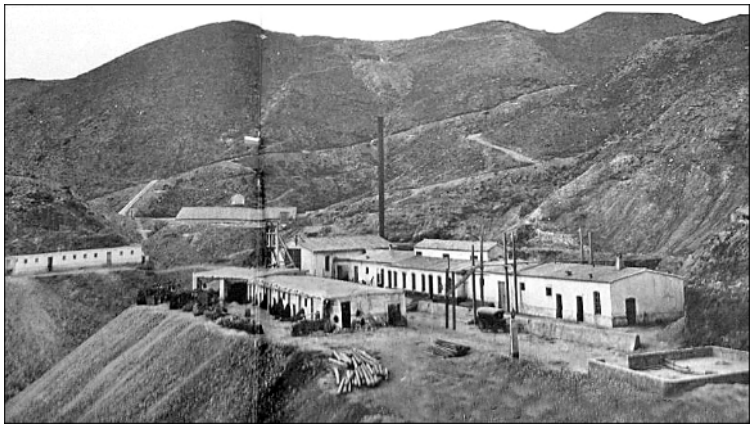
One of the channels used to collect water on the hillside. These used to be covered.

This aqueduct carried water channelled from the neighbouring hillside.

Water from one slope entered the balsa at this end via the aqueduct.

Water from the channels on the other hillsides entered at this end.

In the Spring of 1884, the local mining gazette recorded that, following heavy rain, the balsa had collected between 600,000 and 800,00 litres of water, and could have collected more. Heavy rain in the autumn of the same year saw all of the balsas in the Sierra full to capacity.



Mina Guzmana in the 1880's. The balsa can be seen centre left of the picture and the diagonal line running above it is a water channel. Humbolt installed the steam engine (note the metal stack). *Rodrigo.*

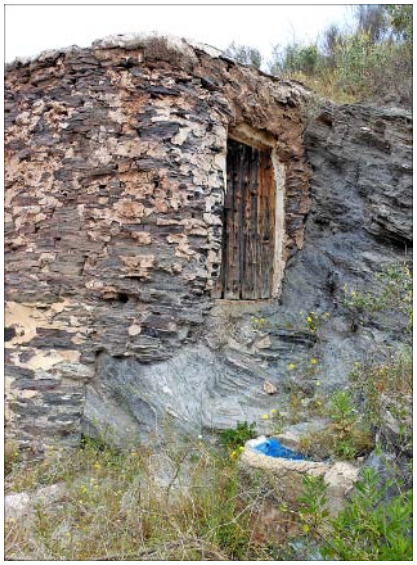
In contrast, the drought of 1905 saw every balsa in the Sierra bone dry. The wells were unable to supply sufficient water and all mining activities ceased as they waited for rain.

Although there was a higher annual rainfall in this part of Spain in the 19th and 20th Centuries, water was always in short supply. Before the mining boom, the only local supply came from ancient wells in the Barranco de los Guardos, in the section where it runs parallel to the A332, Los Lobos to Pozo del Esparto road. The remains of some of these wells can be seen from the steam-roller lay-by

The steam-roller lay-by, on the Los Lobos to Pozo del Esparto Road.

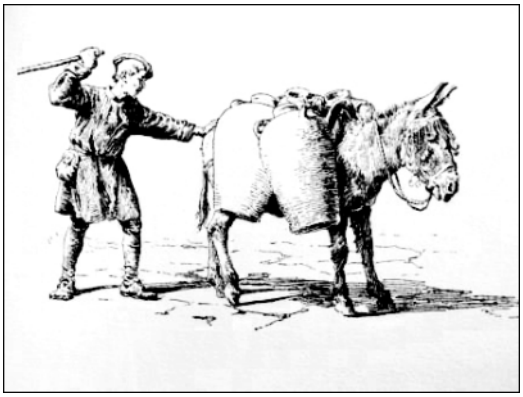
The remains of the ancient wells.

These few wells were unable to meet the demands of the growing mining industry and new sources of water were looked for. Several wells were sunk at the Boca de Mairena near to where the Barranco de Mairena and the Barranco de Granadinos converge. These provided a good source of water, as did wells sunk along the banks of the Rambla de Muleria and at El Tomillar.



Some of the newer wells at the Boca de Mairena.

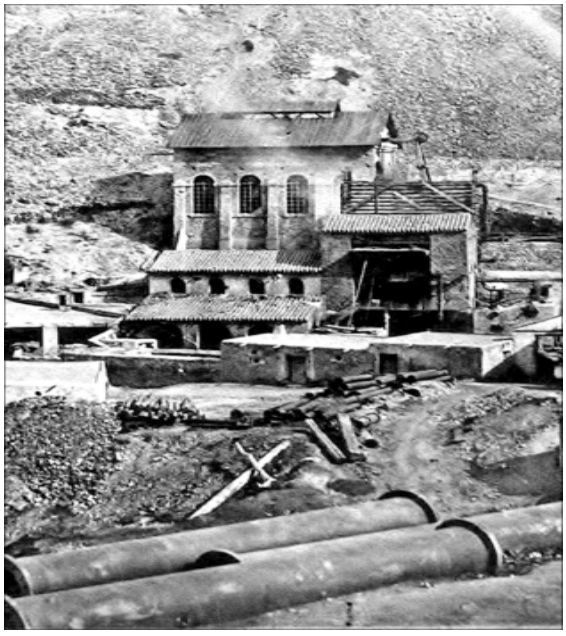
Mule trains, with each mule carrying four, 10 litre, canteens of water trekked daily up and down the dusty tracks to the various mines.



Water carrying mule.

The water was used for drinking and cooking and for the quenching of sharpened picks, mandrills and other tools. There was insufficient for any personal hygiene. As the demand increased, so did the price. It became one of the principal overheads, with a mule load of 40 litres costing between two and three reales, depending on the time of year and the position of the mine. (To put this in context, an unskilled mine worker's daily rate of pay was three and a half reales.)

The Jaroso pumping station, was hailed as the saviour of the mines. Unfortunately, the geothermal waters it discharged, contained large quantities of toxic mineral salts. This water filtered through the sandy bed of the rambla and mixed with that which fed the wells at El Tomillar. As a result, those wells were no longer able to provide water fit for human consumption. Opened in 1868, the socavón, Riqueza Positiva, drained the water from the desagüe in the other direction, to the sea. Whether the wells were ever potable again I don't know although they were still contaminated in 1890.



The desagüe in 1875. The original pumping engine was housed in the building to the front-right of the tall, later to be, engine house.

The beam and fence-like condensation pipes of the new engine can be seen above the old engine house.

Rodrigo.

All that remains of the Desagüe del Jaroso today. The stonework to the centre-left of the picture is the first window in the above 1875 photo.

The sorry story of the desagüe in the Barranco de Jaroso is chronicled in Volume 1. Its closure, in 1886, prompted La Guzmana to install a pumping engine of its own to enable it to continue deep mining. The toxic, underground water was first used in the ore washing process and then, further laden with heavy metal contaminants, discharged into the Rambla de los Granadinos. There was a general outcry when pumping started. The fear was that the wells, at the bottom of the barranco, would suffer the same fate as those at El Tomillar.

While there was a certain amount of contamination, it seems to have been resolved because some of those wells are still in use today, though probably for agricultural use only.

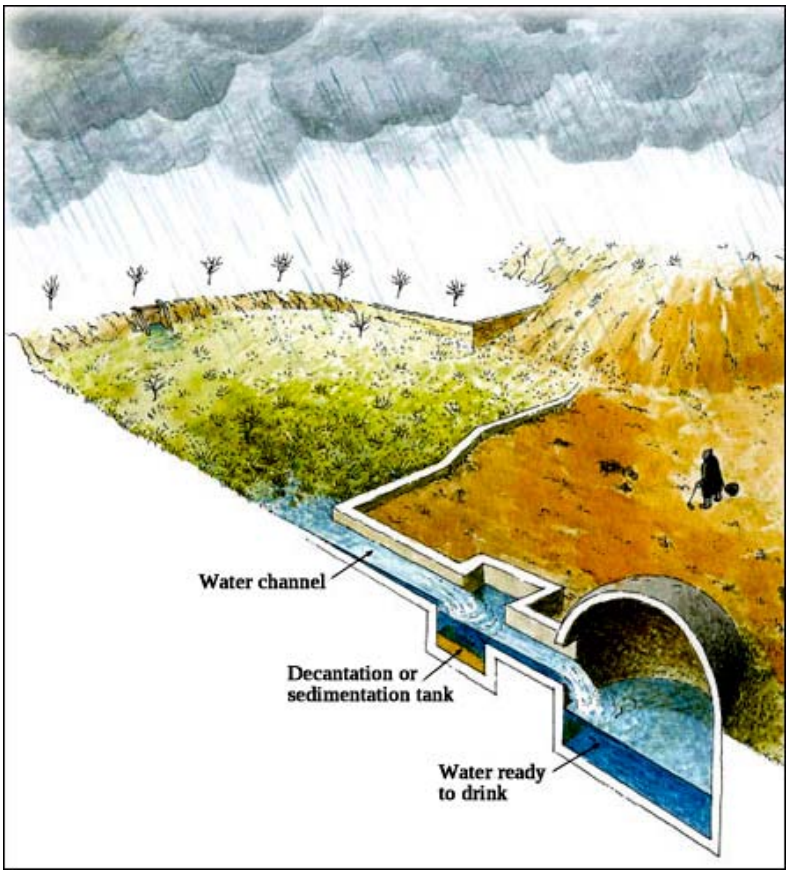
Above, a modern well-house at the Boca de Mairena.

Right, the earlier architectural styles were far more picturesque.

Chapter 2. Aljibes. A Centuries Old Solution.

With the wells under threat, the populace turned to a centuries old solution to the problem of providing drinking water. As an alternative to fresh-water wells they constructed “aljibes”, or cisterns, in order to collect and store rainwater for human consumption. The construction of aljibes was governed by laws, in particular the “Ley del Aguas, el 13 junio de 1879” of which Article 1 stated that “*the owner of the property where the rain falls is free to construct aljibes in order to collect it, provided that it does not adversely affect the public or a third party*” However, if the aljibe was to be constructed on land in the public domain, permission had to be sought from the relevant municipal authority, as stated in Article 3 of the same law. Some of the aljibes in the Sierra, whose remains can be seen today, were constructed on public land as it is a matter of record that permission was sought.

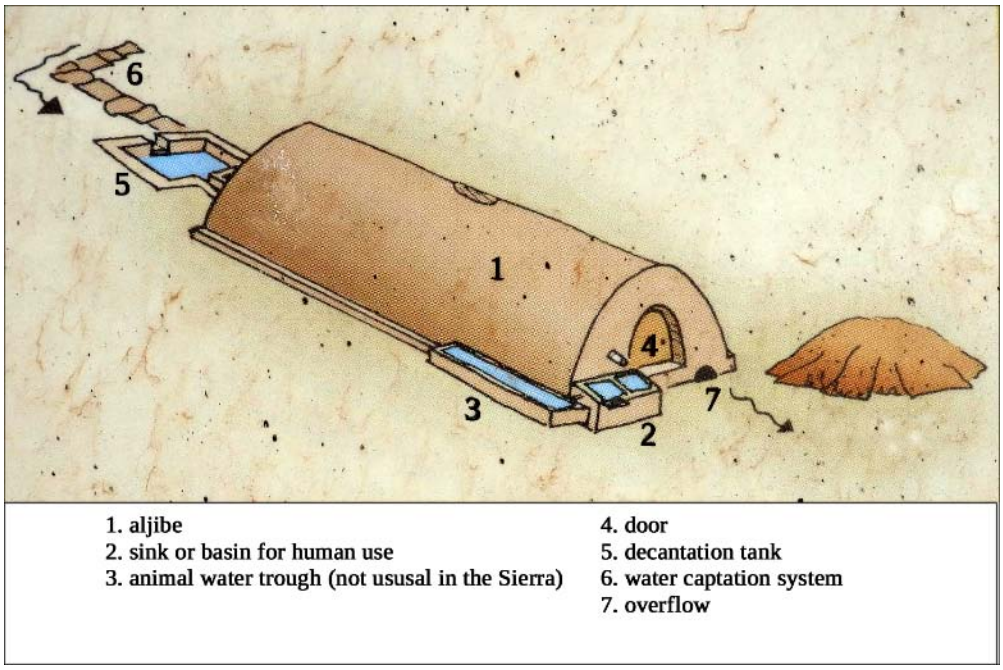
Aljibes are interesting structures, the basic design of which has remained unchanged for millennia. They are found, in one form or another, in most of the semi-arid regions bordering the Mediterranean.



An aljibe design using terracing channel the rainwater.
laverdad.es

The word aljibe itself comes from Arabic word al-yubb. Apart from the large elaborate ones found in such places as the Alhambra, the majority of aljibes in Andalucía are to be found along the routes of the annual transhumance, where livestock was moved from Summer to Winter pastures. Others are found associated with outlying farms and are their only source of water. There are also several massive ones to be seen if you travel along the coast road through the Cabo de Gata resembling white-washed, wartime, Nissan huts.

The aljibes in the mountains mostly follow the traditional Andalusian style with a barrel vaulted roof.



The classic Andalusian form for an aljibe.

Tu hobbie tu viaje

They consist of a system for collecting the rainwater, a decantation or sedimentation tank, a storage tank, or cistern, and a means of drawing water. Their size varies from 6 to10m in length, 4 to 5m in width, and with between 4 and 6m below ground level.

Constructing aljibes in the Sierra presented certain problems. The mountainsides are steeply sloping, meaning that, when it rains, the run off is very rapid. This causes an excess of debris to be brought down by the water and the sudden rush floods the sedimentation tank. In addition, they needed to be constructed where there is no danger of their being contaminated by the results of mining activities. For the most part, they had to be built at the head of a barranco above the level of any spoil tips. On the plus side, because they were set into the rock, there was no need to shore or reinforce the sides of the storage tanks and the nearly impervious terrain generated good run off.

The first aljibe that I came across was this one in the Barranco de Las Palomas. Initially, I had no idea what it was or why a large fig tree was growing there.

The remains of the aljibe in the Barranco de las Palomas, probably serving the mine Rosetón.

Like so many things in the Sierra, this one was puzzling. What had happened to its roof? By the shape of the remaining end wall, it obviously been barrel vaulted one, so where is it?

A roof of this type is an extremely strong, stable structure, which has the advantage of keeping the internal space cool and of minimizing water loss by evaporation. They were constructed using a series of arched, wooden formers. Over these, large stone slabs were arranged like segments of an arc with the slabs dovetailing into the next arc. The spaces between these large stones were filled with smaller rocks and stones and the formers removed. The whole thing was then mortared.

One possibility is that it was abandoned before it was finished. (The mortar at the top of the up-stand is very smooth.) Another possibility is that the roof was constructed of brick. If that was the case, then they could have been recycled when the aljibe fell out of use.

Another mystery of this aljibe is where the water is collected from. It appears to come directly from the rock at the end of the structure. There is nearly always water and mud in there which the dogs find. I have never ventured into it. For one thing it is very overgrown and the other is, that while it looks to be fully silted up, I am mindful that the tank in an aljibe is quite deep.

The rear of the aljibe is overgrown and silted making it impossible to work out where the water came from and how it was collected.

The second aljibe that I noticed (but still didn't know what it was) was the superb example at Casa Dos Mundos.

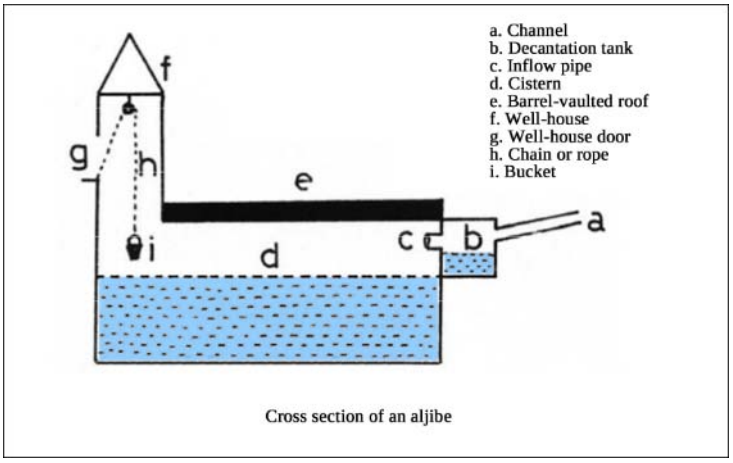
The aljibe at Casa Dos Mundos

This one is in an extremely good state of preservation. It used to have a rectangular tower at the head, where the pulley and bucket were housed and would have looked similar to the one pictured below. The small aperture next to the extraction opening is the overflow from the main tank. The construction method of the roof is very clearly visible. This roof was reinforced by the two solid buttresses at either side.

What the aljibe's tower probably looked like. *Blanco, Bermudéz and Boti.*

The bucket & pulley system inside the tower may have looked similar to this.

The Dos Mundos aljibe follows the classic "church" design as shown below.



Diagram, eicm.

At the rear of the Dos Mundos aljibe are two, dry-stone, gullies. One served to channel the rain water from the roof of the massive, adjacent building, while the other channels the water that has passed via the sedimentation tank.

The roof run-off channel enters directly into the cistern.

The run-in via the decantation tank.

In both cases the water entered the aljibe through the small opening. The roof run-off water didn't pass into the sedimentation tank, probably because there was so little debris in it. The usual practice in such cases was to use brush wood, placed in the channel, which acted like a mesh trapping any loose organic matter.

The main cistern of this aljibe is quite deep, and the various water levels have left their tide marks. Aljibes and balsas were rendered impermeable with what is known as “argamasa” which is a mix of lime, sand and water. It is evidently very effective since many of these structures still hold water. Apparently, in the absence of lime, a mixture of soot and urine was used instead.

The interior view of the cistern of the Casa Dos Mundos aljibe.

The aljibe of the Ibería mine.

Slightly different in form, the aljibe of the La Ibería mine also is in quite a good state of preservation. Here, the water was extracted via a well-like hole situated in the lean-to structure. Again, here is a mystery. The extraction hole is situated just inside the entrance of this lean-to which leaves a substantial amount of free space between it and the back wall.

The "well-hole" of the aljibe.

The bucket hooks often used in aljibes. The design allowed them to be tipped without spilling any water.

The cistern is not of sufficient depth to have required a winch and tackle, so it's unlikely that this space was used for that purpose. While it could have been used to hold water containers, it is quite a squeeze getting to the area without falling down the hole.

A different view of the aljibe showing the extent of the "lean-to".

This aljibe draws its water from the run off from the hill behind and to the side of it avoiding the contaminated hill opposite. A short channel leads to the sedimentation tank and then to the aljibe itself. The roof of this one has been brick lined, although it looks as if there is also a stone covering. The overflow was collected and stored in a small balsa at the end of the main cistern.

The roof of the aljibe is brick-lined and, possibly, constructed of stone.

The aljibe at the mine La Guzmana is situated at the bottom right of the picture below.

The water was extracted from an opening at the front where there was a small tower, similar to the one at Casa Dos Mundos. The opening in the central section of the vaulted roof of the cistern is where it has partially collapsed.

The collapse can be clearly seen from the top of the stepped structure. It looks as if it has been struck with something.

.

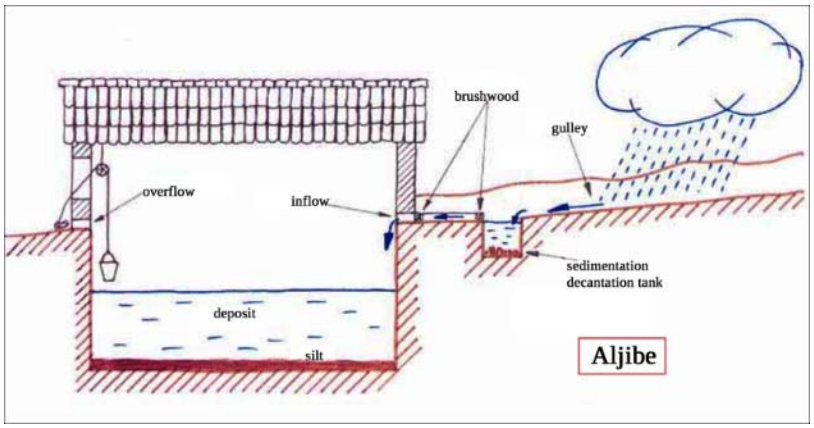
I had a theory about what looks like a flight of steps. I thought that it was to compensate for the steepness of the slope leading to the aljibe. The steps serving as both a water channel and a sedimentation system, with any mud, stones or organic material being deposited in the small troughs present on each “step”. Any build up of sediment could easily have been removed between rain storms. In the event of the “steps” being unable to cope with the amount of water, the flow could be diverted, along with any overflow from the aljibe, via a series of terraces into a large balsa situated on the level of the engine room. Antonio Jódar disagrees with me, believing that it was on ore washing system which functioned as per my theory. I shall revisit La Guzmana and look for a decantation cistern for the aljibe. If I find one then I was wrong, but I want to believe that I am correct. (Fingers Crossed!) There is, of course, the possibility that we are both correct, and there was originally a partition down the ‘steps’.

The terracing into the lower balsa, below the "steps" and the aljibe

There is one very non-traditional aljibe that I have found. It is situated between the Las Palomas and the Dos Mundos ones, at the mine Ramo de Flores.

The aljibe is to the left of the two pillars in the centre of the picture.

This one is not fully sunk into the rock, but rather was built up. It is rectangular in form and had a sloping, tiled roof.



Cross-section of this type of aljibe.
minaya.es

The water was collected from the top of the mountain behind the mine and channelled, via a small sedimentation tank into the cistern.

The water channel leading to the sedimentation tank.

A piece of slate placed at the end of the channel serves as in inlet pipe.

A shaped slate made a good inlet pipe.

The water was extracted via the small flight of steps situated at the back of the structure where the stone sink is still in place.

There is something about this small flight of worn steps, so human in scale, that evokes the spirits of a century ago.

The "tide-marks" in the cistern recording periods of wet weather remind me of the rings in a tree trunk.

The rendering inside the cistern (previous page) is in amazing condition and the “tide marks” can still be seen. Any overspill from the aljibe was channelled down to the balsa situated on the slopes below.

Venus Amante’s Polvorín

There are structures in the Sierra which look for all the world like aljibes as this picture of the structure opposite the mine Venus Amante shows. I thought that it was indeed an aljibe, but did wonder why it was positioned so close to the top of the mountain, with no apparent captation system. Once again Antonio Jódar put me right. He told me to look at the construction of it, the thickness of the walls relative to the thickness of the roof, and to consider its isolated position. When I did so, the penny dropped, these lonely ‘aljibes’ were in fact polvorínes, or magazines where the explosives used in the mines were stored. They were built with thick walls and thin roofs, so as to channel the force of any explosion upward rather than outward, and were sited well away from the mine which they served. The size of the doorway also ought to have given me more of a clue as to what they really were!

Not all polvorínes were built above ground, many of them were built into the mountainside. It really depended on the lie of the land around a concession, for example, Ánimas in the Jaroso valley, had steep slopes so was able to have an underground explosive store. The aljibe type structures tended to be right at the top of the mountain.

The polvorín of the mine Ánimas in the Jaroso valley.

Chapter 3. To Fetch a Pail of Water.

Wells.
Moving down from the Sierra and on to lower ground, other ways were found of supplying water. Looking rather like the entrance to a small aljibes, the local wells are to be seen wherever there is the possibility of finding water. There is an old well at the head of the valley which runs north before El Arteal. Frequently dry, this was the only source of water, apart from collected rain water, for those living on the East side of the Rambla de Muleria. An old man that I spoke to clearly remembers having to fetch the water from it. I'm assuming that it was easier to get to in those days. The way to it up the valley is very overgrown, and it is best accessed from above, skirting the hill opposite the rear of the new build on the way up to the Barranco del Chico de la Torre. It is a good example of the local style, built of field stone, with a domed roof. The pulley and bucket were attached to a timber set across the hole in the roof. Since there was an opening in the roof, I can only assume that rain water was allowed to freely enter the hole.

Not all holes in the ground with water at the bottom are wells. What looks like a well, round by the goat pen in El Arteal isn't a well at all (below, left). It is a pocillo, or little shaft, probably sunk as a trial in 1898 when the first drainage tunnel was driven. The water in it drains from mine workings and has percolated through the conglomerate. Although smelling sulphurous, it is not thermal water but neither is it fit for human consumption.

Definitely not a well!

There is a similar one in the field between the miners' quarters and the Rambla de Muleria, (above, right) that also has water in it. What purpose this one served I don't know, but it is unlikely to be potable.

Another strange, water associated feature is to be found in the Barranco de Sima. This is obviously relatively recent, as the pump house is made of breeze block rather than the usual county rock. Someone was prospecting for water for what ever reason, whether looking for a source of irrigation water or thermal water I have no idea. I do wonder if it was associated with Peñarrolla's investigations into the possibility of extracting lithium from the thermal water under the Sierra. However, for the time being, it remains a mystery.

Built in an attempt to find water in the Barranco de Sima.

Norias.
In 1845, Madoz, in his ‘Diccionario Geográfico Estadístico Histórico de España y sus Posesiones de Ultramar” described the Madrileña foundry which covered the area from Quitapellejos beach at Palomares to the mouth of the Almanzora. This impressive complex, consisting of 32 furnaces, of various types, together with the company’s headquarters was situated behind the pine grove on the Garrucha to Villaricos road. In addition, Madoz described the surrounding land, also owned by the company, as being cultivated and supplied with copious amounts of water from a noria.

When I read his account, I started to wonder about the rusty looking wheel, covered in wire mesh, surrounded by concrete that is at the edge of a field, opposite the pine grove. Could this be the remains of a noria?

The rusty looking wheel in the field.

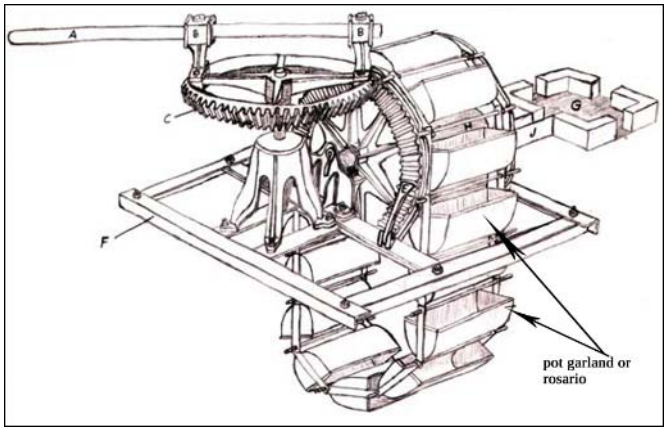
Up until then, my only understanding of a noria was of the wind powered, water lifting devices that you see in the region of Cartagena. Or rather you see the remains of them, looking like ordinary windmills, alongside the Autopista del Mediterráneo.

Remains of a wind powered noria.
Spanish Waterworks. Jill Dickin Schinas.

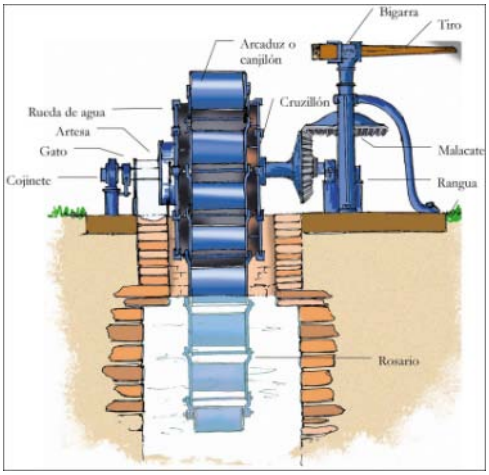
With my curiosity piqued, I started researching norias. I had, indeed discovered the remains of one, not a wind powered one but a “noria de sangre”. The use of the word “sangre” or blood, sounds rather melodramatic, but when applied to a machine, it simply means animal traction. It was a mule powered water lifting machine. Such machines are known as “aceña” in other parts of Spain.

A noria de sangre in use.

However, the term “noria” is rather romantic. It comes from the Arabic “na’ura”, meaning to shed tears or to weep. A string of small buckets or pots looped over and down from a large wheel into a water source, shed “tears” when they reach the top. The Spanish term for the pot garland is a rosario as in rosary, or prayer beads.



The mechanics of a noria. The pot garland or rosario hangs down from the wheel.



They are simple, effective machines. The animal turns a horizontal wheel, which engages with a vertical one, causing it to turn. The pots or buckets hanging from the vertical wheel scoop up a small amount of water. As the wheel rotates the pots are carried up to the top and then start their descent again, tipping the water into a trough as they do so. The containers have a hole in their base, necessary because, without one they would float, rather than sink and fill with water. As they rise, any water escaping from a pot is caught by the one underneath, and so on.

The remains of the transmission gearing and the water wheel of the Madrileña Noria.

The water was channelled into this balsa.

The size of the balsa alongside the noria gives some indication of the efficiency of the machine. I assume that the channel between the waterwheel and the balsa was covered so that the diameter of the mule's circle was not excessively large.

A noria in use. Note that the animal is blindfolded to prevent giddiness.
Spanish Waterworks. Jill Dickin Schinas.

This Madrileña's noria was probably in use until the late 1960's when most of the water sources became too saline.

I found these lines of poetry in an article in diariodesoria.es by Jose A. Martin de Marco.

"yo no se que noble,
divino poeta,
unió a la amargura de la eterna rueda,
la dulce armonía del agua que sueña,
y vendó tus ojos,
¡ pobre mula vieja"…

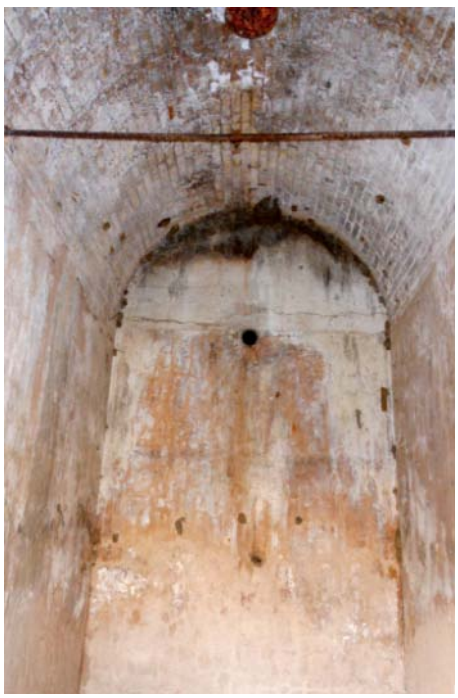
Roughly translated it reads,

"I don't know that noble,
divine poet,
yoked to the bitterness of the eternal wheel,
the sweet harmony of dreaming water,
your eyes blindfolded.
Poor old mule!"

In actual fact, what are known as noria in southern Spain are actually sakia. A true noria lifts water by using the power of undershot, running water to turn the wheel with its garland of pots.

MASA's monuments.
When El Arteal was remodelled in 1908 by the Compañia Minera é Industrial Para España, a rather sophisticated water purification plant was installed. It's purpose was not to provide potable water, but to provide water which was free of lime. The water from the Las Rozas well contained very high levels of calcium carbonate, magnesium, calcium and sodium sulphate, which together with the sodium chloride also present in it, had a serious effect on the boilers. Using the water resulted in corrosive encrustations 12 or more millimetres thick in just two weeks of operation. The encrustations had to be chipped off, an operation which took several days and damaged the internal surfaces of the boilers.

This tower supported a large water tank.



Inside the tower

Water was pumped up to a large tank situated above the tower shown. In a separate receptacle, mounted on an iron tripod above the tank, sodium carbonate was dissolved in constantly steam-heated water. Then, in carefully measured proportions, water containing the reagent was piped into large capacity tanks. Steam jets were fed into the tanks so as to speed up the chemical reaction of the sodium carbonate on the water. The treated water was then passed into six circular tanks where the various salts precipitated out. These were extracted and, after passing through a series of filters, the water was ready for use. Due to the combination of the chemical action of the reagent and the physical action of the heat, the water was free of lime salts, but did still contain small amounts of magnesium and sodium salts. Using water treated in this way, the boilers simply needed washing out with jet of water once a fortnight.

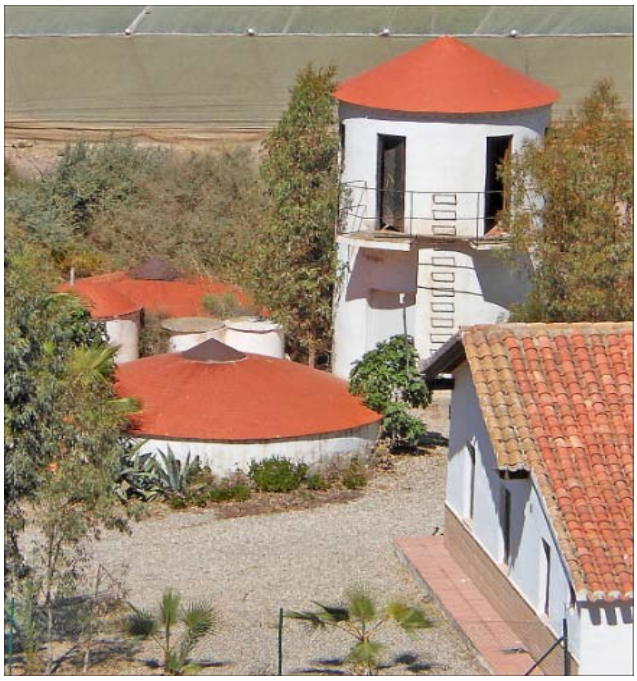
The settlement tanks are shown in the plan below as circles, situated between the water tower and the boiler house.

1908 Plan detail.

The sedimentation tanks were in this area between the tower and the boiler house.

With the move to powering the pumps at El Arteal by electricity, the water treatment plant probably become redundant and had most likely been dismantled by the time that MASA reactivated the pumping station. A well and a few small balsas were definitely not sufficient to supply water for MASA's needs. In addition to their ore processing activities, they needed water for the 200 apartments housing the married personnel and for the bath houses.

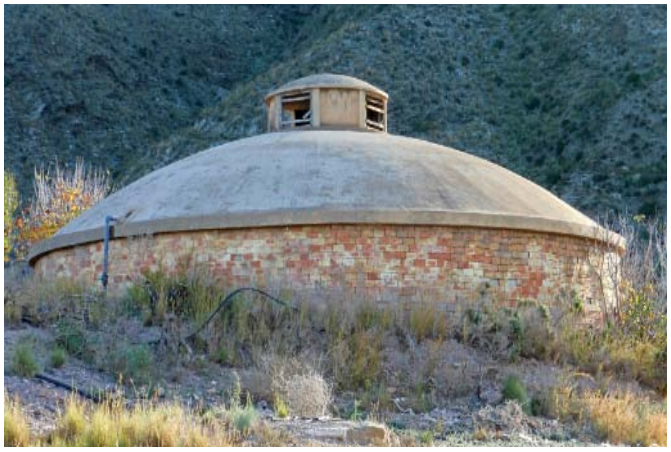
For a long time I thought that this tower, pictured below, was a type of shot-tower, and that the small domed structures next to it were old smelting furnaces. How wrong can you be? It was a water filtration and storage system. Fortunately, it wasn't demolished when the adjacent house was refurbished. In fact, rather a feature was made of it, making it look like something from a fairy story.



“Rapunzel's Tower”, the water filtration and storage system next to the doctor’s old house.

I don’t know if the water was treated in any way, but it was filtered down inside the tower and passed into the domed settlement structures. The filtered water was then pumped up to another other, larger, circular cistern which is in the area above the greenhouses. The height of this large cistern gave enough pressure to gravity feed the married quarters, which had running water, while water for the bath houses and the lavadero needed to be pump assisted.

The other domed water storage structure.



The water was definitely not potable, the warnings about this fact can still be seen by the sinks in some of the miners’ quarters. It still came from the same well in Las Rozas, which was sunk in 1898 when the El Arteal pumping station was built. Now capped, it was opposite the junction of the Las Rozas road with the Las Herrerías to Palomares road. I assume that MASA installed a new pump, but I don’t know whether or not they renewed the original steel pipeline.

The well, above, has now been capped, right.

Drinking water was brought in by bowsers from the Cabrera. I think that it may have been stored in an underground water deposit fitted with a pump at the miners' quarters. Unfortunately, nowadays, the passageway between the blocks above it is too overgrown to take a good look. Its position is marked by the spray-painted warning "POZO!" on the entrance to the courtyard.

A bowser of the type used in the 1950's.

MASA also supplied Villaricos with both potable and non-potable water. The drinking water was brought in by tanker, while surface water was collected, filtered using white netting and stored in metal deposits at Patio Borracho. I think that the ugly, squat building on at the junction of the Palomares river crossing and the Villaricos to Las Herrerías road is the aljibe where the water was collected.

The ugly aljibe by Los Conteros.

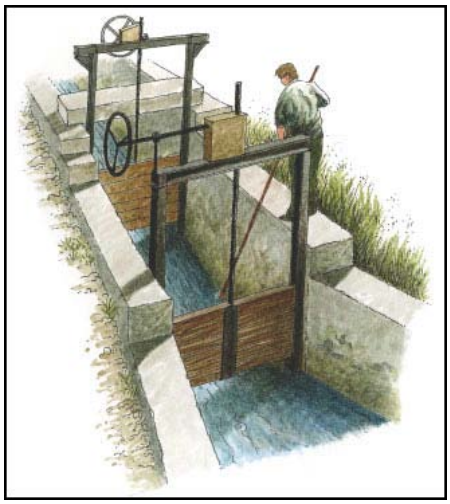
It was claimed that the run off from the lavadero at El Arteal had contaminated Villaricos's natural water supply which was from the wells by the castle. Needless to say, MASA denied any responsibility for the contamination. It is rather a grey area as mining has been going on here for well over 100 years. However, MASA's activities were of a different nature to what had gone before. What measures were taken to render the liquid waste from the froth floatation process less toxic? Either way, a government sponsored company in 1950's Spain would never have been held to account.

When MASA pulled out, Villaricos was left with no fresh water supply at all. The owner of the house with the belvedere sold surplus water from the large aljibe in its grounds and one or two people brought canteens of water in from Palomares to sell.

Surplus rain water was sold from the aljibe of this house.

More modern times.

For landowners and tenants, water, or the lack of it, has always been a problem in this area. Irrigation was by means of ditches called "acequias" the remains of which can be seen everywhere.



An Acequia or irrigation channel.

The well preserved acequia in Las Rozas.

The one that runs down through Burjulu, round Las Herrerías and through Las Rozas is one of the best preserved ones in the neighbourhood. The flow of the water could be diverted by means of sluice gates.

Right, the sluice gate mechanism by the road crossing.

Above, the old Las Rozas-Villaricos railway bridge over the acequia in las Rozas.

These acequias are clearly marked on Spanish maps, with the direction of flow indicated by blue arrows. Even though the majority are no longer used, the line of them is still clearly visible. Wherever you see a line of bushes or canes, if you look more closely, you will see the remains of a ditch and often some remains of a sluice gate.

The acequia which runs along the track by the entrance to El arteal was fed from the Rambla del Arteal. To achieve this, the Rambla del Arteal was dammed by the wall just past the goat pen. The remains of the sluice gate and the tunnel which fed the water under the hill are still there. The water then was piped under the track and into the ditch. Any excess was stored in a small deposit that used to be next to the olive grove

The wall damming the Rambla del Arteal can be seen in the centre right of the picture.

The sluice gate and the entrance to the water channel under the hill.

When the Almanzora was canalized, the feed to the many of these irrigation ditches was lost. The fields were then irrigated by means of large water deposits. In addition to collected rainwater, groundwater from wells, such as the one at Las Rozas, was pumped up into these irrigation deposits. There used to be several of these agricultural reservoirs in the area. As they were constructed on high ground there was sufficient pressure to gravity feed crops via irrigation pipes. Nowadays only one or two are maintained.

One of the few agricultural water deposits still in use.

Some have been filled in and planted over and others, like the one behind the transformer building at El Arteal, have been abandoned. The one on the way up to the lost village used to be a favourite swimming pool for the dogs, but now only has water in it after heavy rain.

The dogs cooling off in the abandoned water deposit.

The pump house next to the Portillo substation and inside the building.

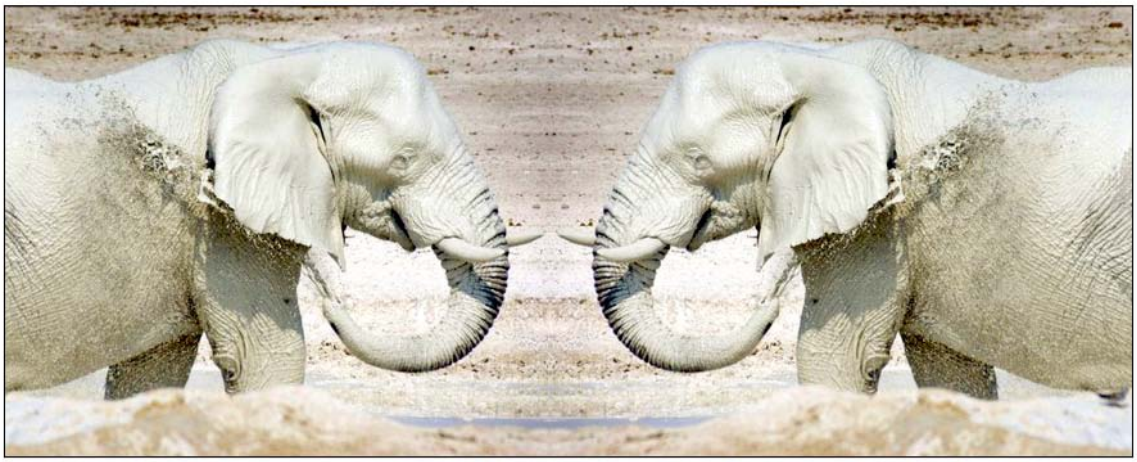
The rise of giants like Primaflor, and horticulture on an industrial scale, necessitated better irrigation infrastructure. This innocuous building by the Portillo substation in Las Rozas houses a modern pump. It is one of the main sources of agricultural water for the immediate area. Whether it pumps groundwater or

water supplied via the Negratín-Almanzora basin transfer system, I don’t know. Wherever it comes from, the pressure within the pipes is now so great that the old water deposits are largely redundant. However, it does require a cheerful man in a red bandanna, riding round all day on a moped, monitoring the system for leaks.

While horticulture is on an industrial scale, and the infrastructure is monitored, the maintenance of it is somewhat ‘laissez-faire’. The stick in this picture has been supporting the high pressure pipe for several years now.

The pipe and the stick.

Chapter 4. Two White Elephants.

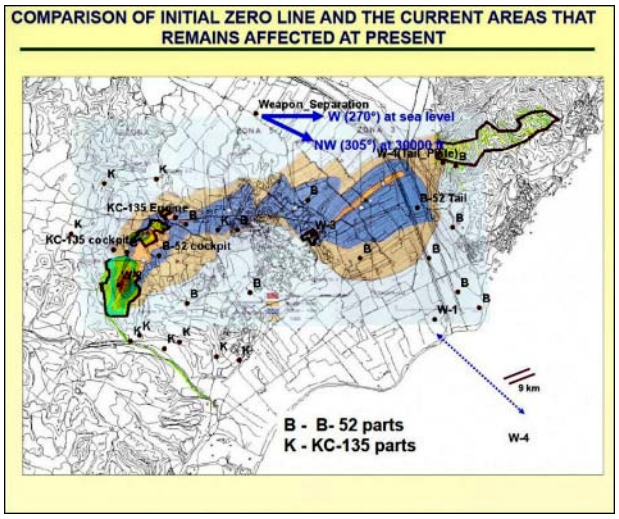


White Elephant, a definition:

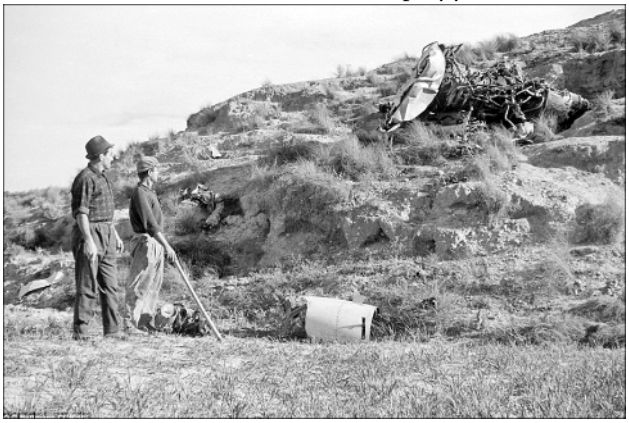
a possession which its owner cannot dispose of and whose cost, particularly that of maintenance, is out of all proportion to its usefulness.

The 'Palomares Incident' and the First White Elephant.

January 17th 1966, the day that the fuel line of an American KC-135 tanker plane struck the fuselage of a B-52 bomber which it was attempting to refuel while just off the coast of Palomares. The debris from both planes, two unarmed hydrogen bombs and several dead bodies rained down on Palomares. Due to a malfunction of the bombs' parachutes, the conventional explosives in both Palomares bombs detonated on impact, releasing a cloud of radioactive plutonium. (A third bomb landed intact in the dry bed of the Almanzora and a fourth was recovered 80 days later from the sea.)



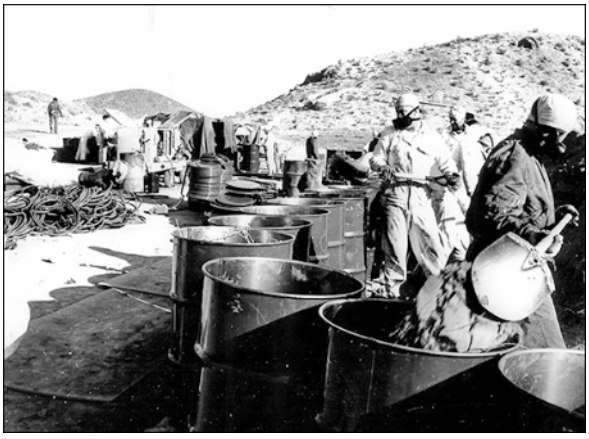
Map of fallout and aircraft wreckage. *Ciemat.*



Locals surveying the scene. *Bettman Corbis*

Wreckage at Palomares. *nytimes.com*

American servicemen clearing the ground. *nytimes.com*



Shovelling contaminated soil into barrels for shipment to the U.S . *Sandia National Laboritories*

The aftermath of the Palomares “incident” had a devastating effect on the local water supply. In order to “lay the plutonium contaminated dust” the Americans extracted 21,584 cubic metres of water between January 20th and March 10th from the aquifers. These were already at a critical level due to the increasing demands of a nascent agricultural industry, whose growth was made possible by the use of electricity rather than “sangre” to extract water from wells and norias. The inevitable result of the Americans’ actions was the salination, up to 3 grams per litre, of the supply due to the ingress of sea water.

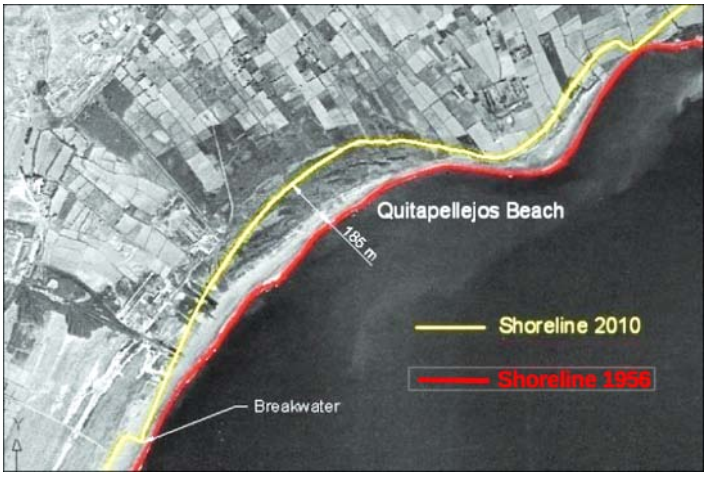
As a sweetener, the American Government offered $150,000 for the construction of a desalination plant. $105,000 was for the plant itself and $45,000 was for the distribution infrastructure to supply Palomares and Villaricos. So began the sorry tale of the First White Elephant.

The Spanish Government reasoned, that on that scale, the cost per cubic litre was high. They decided to build a much larger plant, capable of serving Vera, Garrucha and Mojácar, in order to meet the growing demand from the burgeoning tourist boom. At a cost of $427,272 the plant would be capable of producing 266 cubic metres of water daily.

As well as making up the difference in the cost of the plant, the Spanish took responsibility for both the plant maintenance and the distribution infrastructure. Work at the Vera Playa site started in 1971 and finished in 1973.

The first problem was that the salt water entering the plant from the sea was heavily contaminated with carbonates and sulphates, emanating from the geothermal springs under the Sierra Almagrera and from run off from the spoil tips, in particular, those at El Arteal. Just as the first desagüe suffered from encrustations in the pipes in 1846, so the desalination plant suffered from encrustation of the filters. No one had thought to analyse the water before building the plant!

If that wasn’t enough, the existing infrastructure in Garrucha, Mojácar and Vera was old, incomplete and suitable only for non potable water. The only solution would be to build a separate network for drinking water. With non of the councils able to undertake such a costly project the plant was deemed uneconomic. Adding insult to injury, coastal erosion was threatening the site.



Coastal erosion of Quitapellejos beach. *www. improve*

The haste, the lack of a feasibility study and the cost of the distribution network, meant that after a year and a half the Government was looking to the private sector for someone to take over the running of the plant. Unsurprisingly, nobody was found!

Quietly, as the waves came ever closer to the rusting remains, they were sold for scrap. When it was built, the Vera Playa Club Hotel made use of the access roads constructed by the Americans for the desalination plant. The last traces of the site were removed in 2008 when the breakwater was built to combat the coastal erosion.

The dual carriageway and roundabout (highlighted) were constructed by the Americans.

For further information about the incident I recommend that you Google 'Palomares Broken Arrow' for the American version. The book by José Herra Plaza. Accidente Nuclear de Palomares. Consecuencias. is a hard hitting, no holds barred, Spanish version of the event and its aftermath.

The Second White Elephant.

Basin transfers.

This region of Spain is facing a water crisis. Since the 1970's, when the first greenhouses appeared, there has been the large scale exploitation of the ground water. Without drastic change this water which took centuries, if not millennia, to accumulate, will be depleted within a generation. Furthermore, what isn't depleted will become too saline for use. The rapid rise in industrial scale agriculture was predicated by the promise of new water sources from other, wetter, regions. The Tagus-Segura and the Negratín-Almanzora inter basin transfer schemes were seen as the way forward. Even greater agricultural expansion sent demand soaring and now transferred water can only fulfil 38% of that demanded.

Desalination was seen as the way forward. Three plants were built, at Águilas, Carboneras and this one, just outside Villaricos.

The Bajo Almanzora plant is sited between the Almanzora and the Rambla de Muleria.

The Bajo Almanzora plant at Villaricos was started in 2009 and opened in 2011. It supplied 20 cubic hectometres of desalinated water. 80% of which was for irrigation, 12% for urban use, 1.20% for leisure, e.g. golf, and a mere 0.80% for industrial use. It wasn't universally welcomed by local growers, as desalinated water cost them more than transferred water.

The floods of 2012 wiped out the €77 million installation.

Hopefully, it was built able to accommodate the contaminants present in the sea water. However, the question has to be raised. Why it was built where it was? Didn't anyone remember that the same place was flooded as recently as 1973?

The now derelict desalination plant.

FYSEG. (Fulcrum and Sers Engineering Group) posted the following statement about flood protection for the desalination plant.

"Following the effects of the heavy flooding of the "Bajo Almanzora" desalination plant caused in September 2012, the purpose of this project is to perform detailed design services to improve the flood protection of this facility. Many different studies were carried out and finally the solutions chosen were: enlargement of Canalejas watercourse capacity by modifying the cross section avoiding flooding, improvement of the access road slope by using geo-textile and by rip-rap along the road slope, an overpass over "Canalejas" watercourse (4 spans precast bridge, 33m each), heightening the border of the plot of the

desalination plant, 13 drainage works (diameter 1000-1200 mm and flow 2.17-8.37 m3/s) in order to lead the storm water to Almanzora river or Canalejas watercourse, a pump station with 5 submersible pumps (2.100 l/s each) and a drainage trench."

The Canalejas watercourse referred to is the Rambla de Muleria.

While there are calls for the plant to be repaired and recommissioned, not everyone is in favour. The other two desalination plants currently only supplying 10% of their capacity to agriculture. The reason for this is the cost of the water. Growers, mindful that this is a state managed resource, complain and try to force the government to subsidise desalinated water. What the state should actually be doing is adding in the cost of over exploitation to the price of ground water. This would effectively give parity of price. For all that the growers complain, ground and transferred water accounts for between 2 and 3% of their costs, while desalinated water would account for 5%. The economics of all this are complicated, but one thing is clear. The limit has been reached on expansion, and now the emphasis needs to be on economic use, for example, drip feed irrigation, and wiser choice of crops. Lettuce, on which the locals grew rich, was actually a good choice. Grown in the winter, when there is no other European competition, makes it a water cost efficient crop.

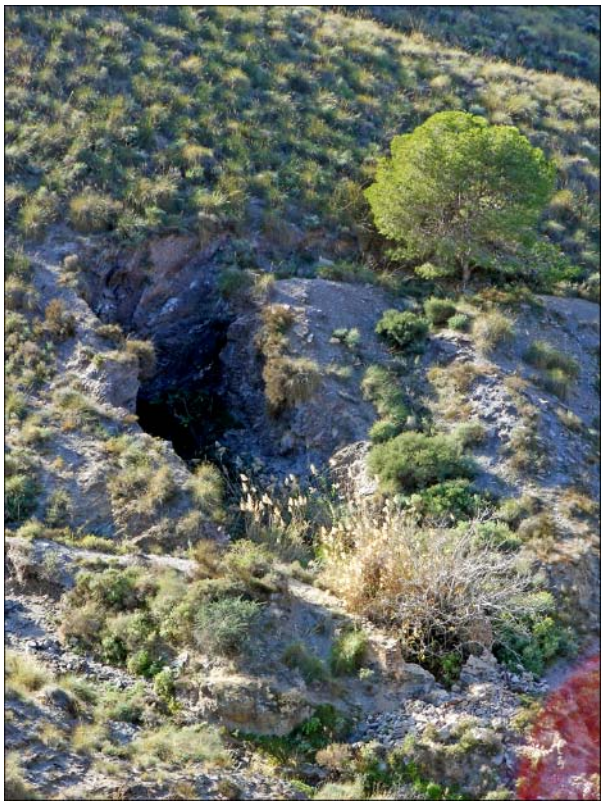
Tyvec Man.
Watering winter lettuce is actually cost efficient.
(And, no, there is nothing in Tyvec Man but wind!)

The other big question mark over the industrial scale of crop raising is the removal of the traditional terraces. The area resembles the American Dust Bowl in the month of September. The "dust devils" lift and blow away massive amounts of soil. Then comes the heavy rain which, without the terraces to contain the water and soil, washes away all in its path, including the irrigation pipes. As the year on year cost of irrigation water rises, it is noticeable that many of the growers are increasing efforts to reduce waste. Interestingly, this often takes the form of mini terracing. Who knows, balsas and aljibes may soon start reappearing. Rainwater is, after all, the sky's harvest and should be gathered.

A Fragile Environment.

The fragility of the environment was brought home to me when I walked up the Barranco de Las Palomas in January 2016. The pictures below show the dramatic change that occurred in just nine months.

The aljibe in May 2015 …



and in January 2016

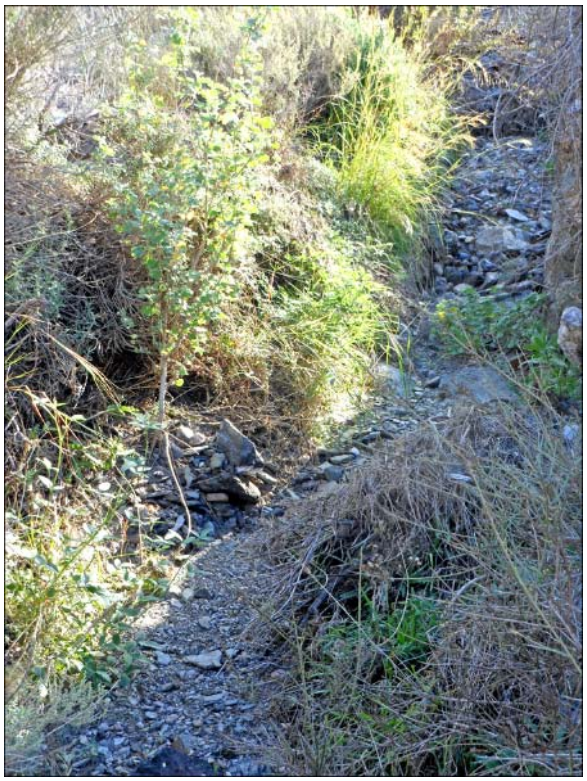
That January day, climbing out of the bed of the rambla and approaching the aljibe, a sorry sight met my eyes. The entire front had collapsed, the stones littered the path. Some traumatic event had occurred.

The front of the aljibe in May 2015 …

and all that remained by January 2016.

Scrambling up to the side of the aljibe, the reason for the collapse became apparent. It had been flooded, and the force of the water had demolished the front wall. The overflow, which would have been at the front, had long since been blocked, so there had been no escape for the excess water. But why now? Why had so much water entered the aljibe? On previous visits only rainwater had collected there and I didn't know where any other water was collected from.

The answer was clear, the rush of water had revealed the sedimentation tank and the entrance channel. It was channelled in from the side, diverting the water away from its path to the Rambla de Las Palomas.



Above, the revealed sedimentation tank.

Left, the revealed water channel at the side of the aljibe.

That answered one of my previous questions about the aljibe, I now knew where the water used to be collected from. The rush of water had cleared a lot of the sediment out and, the cistern, quite full of water, could clearly be seen.

The cistern was quite full of water.

Why had the water suddenly re-found its path into the aljibe after all these years? I found the answer. The bucket, which had “jumped” from the aero cable years ago, had blocked the feed channel and the water had cut a new channel down into the valley. Unearthing the bucket, while causing some excitement to other geeks like myself, had upset the status quo. Such a simple act has had such a far reaching consequence.

The aero cable bucket and an interested dog.

One needs to remember to tread lightly, and carefully, in this fragile environment!

Acknowledgements and Bibliography.
In addition to my “bible”, Sierra Almagrera y Herrerías; Un Siglo de Historia Minera by E F Bolea I drew heavily on the following sources.

For information about aljibes:
Los aljibes en la historia de la cultura: La realización en el campo de Cartagena. A González Blanco et al.
Minaya.es Arquetectura rural en la Mancha.
Laverdad.es.Murcia y el agua.
Cabodegata.net Cultura del agua.
Almediam.org Almería medio ambiente.

For information about norias:
yachtmollymawk.com Spanish waterworks.
Diariodesoria.es Las norias de Duero.

For information on water treatment at El Arteal in 1908:
Estadística Minera de España 1908.

And good old Wikipedia.

I was lucky enough to receive, as a birthday gift from friends, the fascinating book by José Herra Plaza. ‘Accidente Nuclear de Palomares. Consecuencias.’ As well as recounting the incident, this weighty tome details the sorry tale of the First White Elephant, the desalination plant at Vera Playa.

The 2006 doctoral thesis of John Megara entitled, ‘Dropping Nuclear Bombs on Spain, the Palomares Accident of 1966 and the U.S. Airborne Alert,’ complements Plaza’s Spanish account.

Coastal erosion information came from **researchgate.net/publication/26542383** geometric processing of GeoEye-1 satellite imagery for coastal mapping applications.

Information about water management was found at **revolve.com-Spain-water-prices**.

The recently published book, ‘Villaricos. Trienta Siglos de Historia’ by Antonio Llaguno Rojas gives some fascinating insights into life there in the 20th century and the affect of MASA’s withdrawal from the area..