



Transforming the Irrigation Area of the “Vegas del Bajo Valdavia (Palencia) Irrigation Community” into an irrigated area with PVC-O pipes

- **Application:** Irrigation
- **Year:** 2019
- **Country:** España
- **Location:** Vega-Valdavia (Palencia)
- **Projects:**

Intake, main pipeline and regulation reservoirs of the Valdavia River irrigation area

Constructor: TRAGSA

Promoter and Engineering: Government of Castilla and Leon
Irrigation network project for the Valdavia River irrigation area

Constructor: UTE Valdavia

Promoter: Las Vegas del Bajo Valdavia Irrigation Community



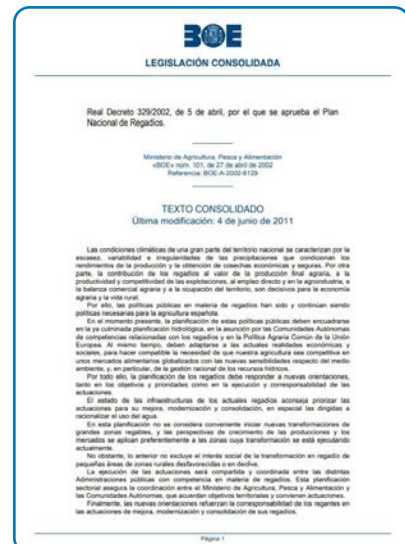
1. Background

The transformation of the **Valdavia River's** low-lying plains into irrigated land was declared to be of **Social Interest in the National Irrigation Plan** (Royal Decree 329/2002 of 5 April), based on feasibility studies for the implementation of small irrigation reservoirs carried out at the end of the 1980s.

In 2005, work began on the first of four main projects to transform the Valdavia River's irrigable area into an irrigation system. In the first of these, in 2006, six irrigation sectors were established, coinciding with municipal districts and using direct pumping to the network. A dam was to be built for each of them to divert the water from the Valdavia River, a pumping station with its corresponding pump assembly and a power line, as well as the subsequent irrigation network.

In addition, two reservoirs were planned, one at the source for supplying water in the event of breakdowns or shortages with a 2-day capacity and the other at the end of the line to collect surplus water and regulate the flow of water into the river.

In 2008, due to the deregulation of the energy sector and the consequent increase in irrigation rates, the approach to the project changed.



2. Purpose of the work

The **Irrigation network project** for the **Valdavia River** irrigation area (**Palencia**) aims to define and quantify the irrigation works required to make use of the water accumulated in the Arroyo Villafría Dam, in the **lower Valdavia River valley irrigable area**. **The objective of the project is to transform 2,700 ha** into irrigated land in the municipalities of Villaeles, Villasila de Valdavia, Villanuño de Valdavia, Bárcena de Campos, Castrillo de Villavega and Osorno (Palencia), through a demand-based irrigation system using natural pressure.

The Valdavia Valley is located in the central area of Palencia province, about 65 km north-east of the provincial capital.

To implement the transformation of the irrigable area, six work projects have been drawn up, three of which have been completed and three are under way. Two projects for the two regulation dams on two streams of the Valdavia River, the dam on the Villafría stream (completed) and the dam on the Las Cuevas stream, with a 12 hm³ capacity each. Similarly, two rural infrastructure projects were drawn up for the land consolidation road network, which was divided into two districts and has already been implemented.

Finally, the **irrigation infrastructure** has been divided into **two works projects**. The **first** contains **general interest works**, a reservoir, the construction of two regulation reservoirs and the main pipeline, to bring water stored in the Villafría dam to the irrigation area.

The **second** project with the complementary works, from the **irrigation network**, and that includes the secondary network and the required valves, the tertiary network for supplying the parcels, the system's automation and remote control to regulate it automatically, and the construction of the Irrigation Community's control centre.



Arenillas reservoir



Villanuño 2 reservoir



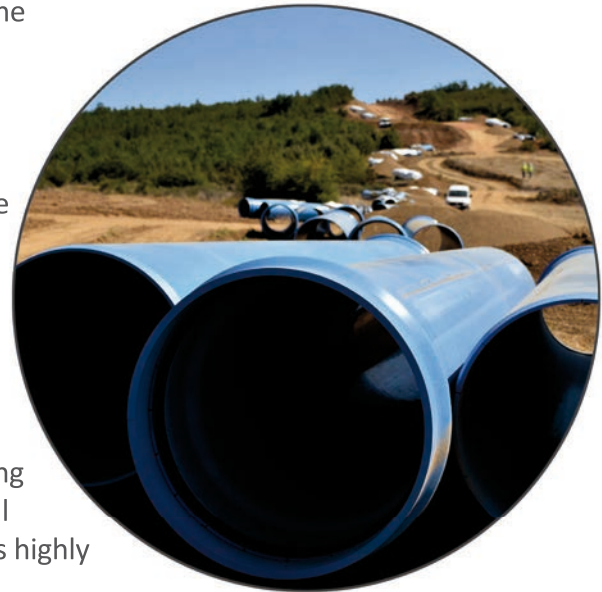
3. Purpose

Irrigation transformations are yet another tool to fight depopulation and optimise resources for a better crop diversification and production, and consequently higher profitability of the transformed areas.

Using cutting-edge technologies is essential in this type of action to reach maximum **energy efficiency** for water distribution, which will undoubtedly have an impact on the profit margins of irrigators when it comes to making the investment involved in the transformation profitable.

This is where the **TOM® Oriented PVC (PVC-O) pipes**, come in, given their maximum efficiency in water transport from their greater hydraulic capacity in some cases and their low surface roughness in others.

Since power requirements have changed, and the cost of contracting power, as well as the actual price per kW/h consumed, is very high, being able to design a system of this magnitude that does not depend on electricity is both very valuable and remarkable. Making the most of the terrain's transformation and its natural slopes to irrigate a 2,700 hectare area, as is the case, is highly worthwhile.



Therefore, the purpose of this action is to provide the area with water resources using a demand irrigation system, with natural pressure. This means that no power costs are incurred for pressure irrigation on the plots, which unquestionably makes them very competitive in terms of their operational cost-effectiveness.



4. Description of the works

The general scheme for the **irrigation infrastructure** is as follows, starting with a dam on the Valdavia River, upstream of La Puebla de Valdavia, at an elevation of 936 meters above sea level, and using a 1,000 to 1,200 mm diameter pipe that is 23,650 meters long, **the necessary flow will be transported by gravity to the irrigation network.**

The secondary network is between 160 and 1,000 mm in diameter and 62 km long. It is designed in 900 and 1,000 mm diameters. And, in 800 mm diameter it is made of **Orientated PVC (PVC-O)**. It will supply 182 irrigation units, and the **tertiary network** will come out of the hydrants, with more than 40 km of **tuberías TOM® PVC-O pipes**. Two **regulation reservoirs** will be built, one before reaching the irrigation area in Arenillas de San Pelayo and the other in Villanuño de Valdavia. These reservoirs will serve as water storage during the peak demand periods, to make up for the lack of supply from the dam, and to reduce the diameters used in the main pipeline.

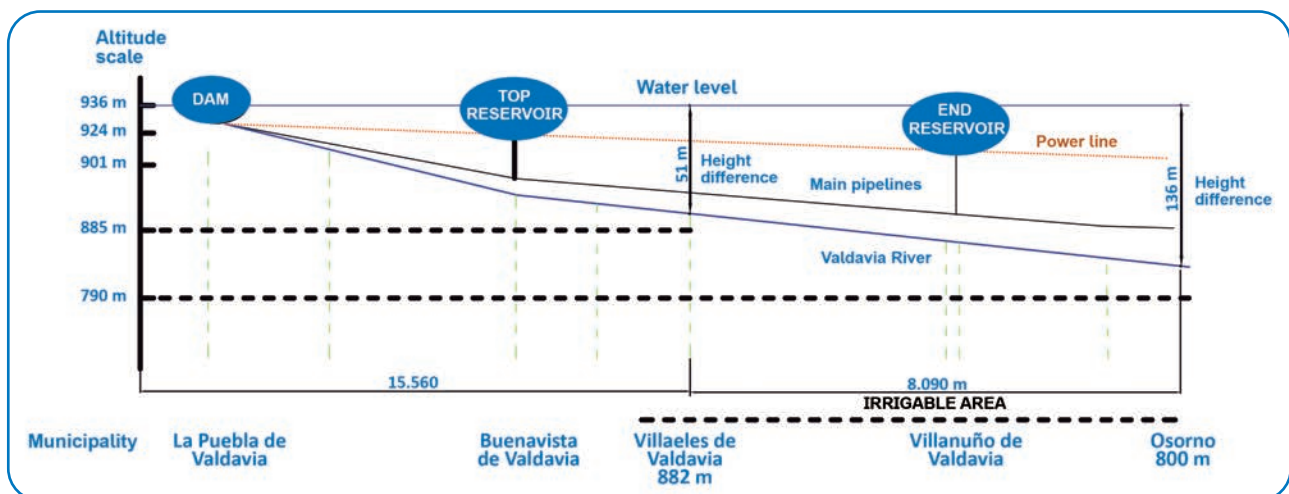


Diagram of the hydraulic operation

Diversion Dam

A 12-metre wide, 1.20-metre high dam has been built on the Valdavia river north of the town of La Puebla de Valdavia, at 936 metres above sea level. The reservoir can hold 12,449.32 m³ of water.

Based on the environmental conditions, this is a dismountable structure made of sheet metal panels that, during the irrigation season, will divert the water regulated by the top dams at a maximum of 1,400 l/s to the irrigated area's infrastructure.



An intake has been designed on the dam's left bank, which has a 21-metre-long sandbox to ensure that the water entering the pipe is filtered to 2 mm. In a lower pit, before entering the main pipeline, and complying with the immersion levels, the control and communication elements have been installed with the irrigation community's control centre.

Network design

A **continuous fictitious flow** was established for the **irrigation infrastructure design**, that is, the exact flow that would have to be supplied per hectare of land to meet the plants' water needs, if irrigation were continuous for the entire available period (24 hours a day, every day of the month). Based on July's requirements, as the highest demand month, in which the net alternative needs for irrigation of 69.56% of the area amounts to 1,034.5 m³/ha and month, which is equivalent to 0.39 l/s and ha. Applying the 0.88 application efficiency to these needs, a continuous fictitious flow rate of 0.44 l/s and ha was obtained (0.39 l/s and ha / 0.88).

The **irrigation demand flow**, understood as the flow that would need to be supplied per hectare of land being irrigated 6 days a week at 20 hours a day, amounts to 0.62 l/s and ha (0.44 l/s and ha x 168 hours a week/120 hours of irrigation a week), amounts to 1,171.8 l/s, less than the 1,400 l/s maximum flow established in the Irrigation Community's concession.

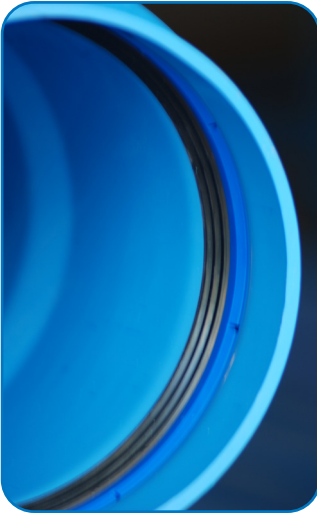
To provide the network with the established flows and pressures, hydraulic calculations have been made according to the material chosen for the irrigation network pipes, taking into account the hydraulic capacity, execution conditions, maintenance costs and operating quality, and investment cost.

The use of steel reinforced concrete pipe (SRCP) was specified for the main pipeline's largest diameters from the dam, and the beginning of the irrigation network, i.e., from 900 mm to 1,200 mm in diameter.



In the **irrigation network**, with very high static pressures of between 6 and 15 atm, we have opted to use **PVC-O**, with **160 mm to 800 mm diameters**, and **16 atm** stamping. The exception is in the irrigable area's rear branches, which has been designed with **20 atm** nominal pressure pipes.

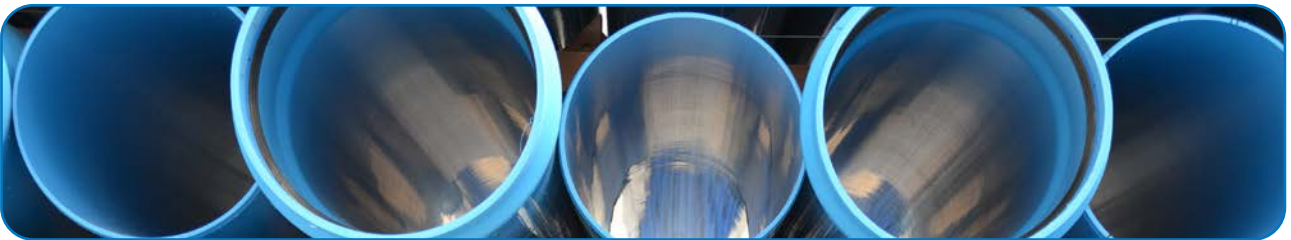
Due to their laminate structure, the **TOM® de PVC-O pipes** are extremely shock- and crack-resistant and possess excellent mechanical properties.



The reduced wall thickness that occurs in the **molecular orientation process** yields a larger internal diameter and cross-section of the pipe. In addition, the inner surface is extremely smooth, which minimises pressure losses and makes it difficult for deposits to form on the pipe walls.

Thus, between 15% and 40% more hydraulic capacity is achieved than pipes with similar external diameters made of other materials.

In addition to these advantages, there are also those related to its low speed, since the overpressure and underpressure values, as a result of transitory or water hammers caused by sudden variations in the flow supply, are much lower in **PVC-O** than in the other materials.



The Swamee Jain formula was used to calculate the dam-reservoir pipes, deducting the friction factor “f” from the White Colebrook formula.

With a 1,082 l/s flow rate, the pressure in the main pipeline, at the top of the irrigable zone is 44.47 m.c.a, increasing as it moves towards the end of the zone, due to the drop in the topographical level. The continuous fictitious flow would reach the top reservoir at a speed of 2 m/s, with a pressure of 4.74 m.c.a. Thus, it has the capacity to keep up this water flow until full.

In the second case, at a speed of 1.14 m/s, the accumulated load losses are 7.55 m. If the full flow is raised to the top basin at a velocity of 2 m/s, the normal maximum level would be reached at a pressure of 2.95 m.c.a., i.e., it has the capacity to cope with this flow until full.

The pipeline of the Top and End reservoirs will be capable of supplying the system with 1,000 l/s and 800 l/s, when the demand is higher than the flow coming from the Dam, either due to an increase in the demand during a top demand week or because it is unused.



Pipelines

Main pipeline

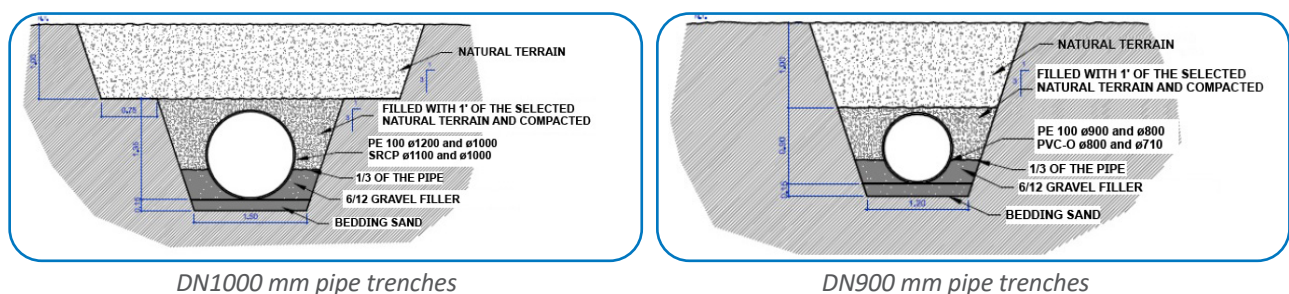
The **main pipeline** is a **23,650 m** long telescopic pipe. The first section measures 1,200 mm in diameter and has a 2 and 4.5 atm ringing system, covering a length of 10,792 m. This section **will carry the water from the dam to the bypass with the top reservoir**.

From the bypass, the connection to the top reservoir will be made with a 1,000 mm diameter concrete pipe (SRCP) and 4.5 atm nominal pressure. It is 634 m long. The top reservoir is located in the municipality of Buenavista de Valdavia, in the district of Arenillas de San Pelayo, and can hold 99,859.47 m³ of water. The reservoir's normal maximum level is 924 m, precisely the piezometric level at maximum demand with regards to the Dam.

The main pipeline will continue 2,008 m further, from the bypass to the source reservoir, until reaching the irrigable area, with a 1,100 mm diameter steel reinforced concrete pipe, with 4.5 and 6.5 ATM rings. The same pipe will be used to build 2,760 more meters in 1,100 mm diameter until reducing to a 1,000 mm diameter. The first irrigation branch line has been designed 11,937 metres from the start of the main pipeline, so that it enters at the head of the irrigable area.

Ensuring sufficient natural pressure to irrigate the parcels in this first area, the one located furthest to the north and at the highest elevation, was one of the main conditioning factors when choosing the system and pipeline characteristics.

After a diameter reduction from 1,100 to 1,000 mm, which coincides with the road intersection to the north of the Villasila de Valdavia urban zone, it will continue 6,205 metres in concrete pipe with a 1,000 mm diameter sheet metal jacket and 8.5 and 9.5 atm rings until it reaches the end reservoir bypass. The **bypass pipeline of the top reservoir** will be made of **PVC-O DN800 mm pipe and 12.5 atm** nominal pressure. It is **810 m** long. The end reservoir is located in the municipality of Villanuño de Valdavia and can hold 99,813.16 m³ of water. The normal maximum level of the reservoir is 901.5.



From the bypass to the end reservoir, the main pipeline continues until it reaches the road junction located north of the Bárcena de Campos urban zone, with a SRCP DN 1,000 pipe and 12.5 atm nominal pressure, covering 1,885 meters.

A 5 m x 5 m reinforced concrete pit will be placed in the main pipeline's two branches, with a 25 cm thick wall and a tramex to make it traversable. A prefabricated shed measuring 5.4 x 5.4 m outside and 2.50 m in height at the eaves will be installed to cover the pit and house the valve control and connection elements inside. The pit will have a drainage system.

The main pipeline from the Dam to the end point is 23,650 m long, with 1,000 to 1,200 mm pipe diameters.

The excavation volume for the main pipeline is 197,171m³, from the ascent to the top reservoir, 4,439 m³ and from the ascent to the end reservoir, 4,610 m³, which means an 8.4 m³/m.l. excavation in the first case, and 7 m³/m.l. and 4.95 m³/m.l. Excavation in the two pipelines to the reservoirs.

In all sections, manual levelling of the excavation base will be carried out to ensure that the trench bottom meets the pipe support requirements while obtaining the required lengthwise slopes in each section. The material for the bedding and pipe joint support with 6-30 gravel will be obtained from first layer sieving of the top reservoir, where the site management, based on the geo-technical study and the necessary tests, will select the collection area. The rest of the chosen material will be transported from the quarry.



Filling will be done with material taken from the excavation itself, compacting it in three layers up to 15 cm above the upper span of the pipe, to cover it with the material straight from the excavation from that point onward. It will be compacted with a compression pan to 98% of the Normal Proctor.

Pipeline tests will be performed using all special parts, valves, hydrants and vents installed, including manhole covers and anchorage rings with the required strength reached. The test is carried out on the whole installation in this manner. Whenever possible, the test sections will be separated by gate or butterfly valves, to prevent the cap anchor production that cause environmentally harmful concrete residues.

The network's set of auxiliary elements will be installed at the same time as the pipes, so that the tests can be carried out jointly. In this way, the assembly guarantees improved performance of the joints, and the parts can be laid with respect to the pipes, avoiding undue stress on them. This is particularly important for valves of more than 1,000 mm in diameter and above to be used.

Irrigation and tertiary network

The irrigation network is made up of 12.5 atm **SRCP pipe** and **PVC-O** pipe of 16 and 20 working pressure and various diameters. Lengths and diameters are shown in the table below:

Diameter (mm)	PN (atm)	Length (m)
1000	12.5	844.31
900	12.5	2,080.94
800	16	3,761.45
710	16	946.99
630	16	3,085.41
500	16	3,564.21
450	16	1,498.56
400	16	4,909.20
355	16	1,937.90
315	16	4,604.13
250	16	4,150.06
200	16	11,364.28
160	16	15,854.63
200	20	1,872.26
160	20	1,853.41
		62,327.74

The excavation volume for the **main pipeline** is 188,303.13 m³ from the main irrigation network.

The budget includes 1 valve of 800 mm, 2 valves of 700 mm, 1 valve of 600 mm, 3 valves 500 mm, 4 of 400 mm, 3 of 300 mm, 6 of 250 mm, 20 of 200 mm, and 14 of 150 mm.

Trifunctional vents will be placed at the high points of the network and vents downstream when the pipes have high points, to allow the air to escape. Seven 6" valves have been planned, as well as ten 4" valves, 25–3" valves and 106–2" valves. **Drains** will be installed at the ends of each branch, when they are low points, and at other low points of the network, located next to rivers or streams. Eighty-one drains have been planned.

Intake **hydrants** will be installed to collect water needed to irrigate the parcels. Each hydrant will comprise a **gate shut-off valve** and a **stone trap** filter will be installed, before the **hydraulic valve** equipped with a pressure and flow regulator. It ends with a quick connector fitting to the aluminium pipes used in sprinkler irrigation. Remote control will be possible.

For the 2,717 hectares that make up the Irrigation Community, it was distributed in 182 irrigation units, supplied by 182 hydrants, 96 of which measure 4" and 86 of which measure 6".

The **tertiary network**, the outlets, is **40,391 m** long, and will be made with **PVC-O pipes** of **100 to 200 in diameter** of **16 atm**. The tertiary network moves flows of **53,462.32 m³**.

A total of 233 outlets have been designed for the tertiary network, depending on the supplied area and the size of each hydrant.



Regulation reservoirs

In each of the Districts, a reservoir is planned at the beginning and end of this pipeline with a 99,859.47 m³ and 99,813.16 m³ capacity respectively.

The first reservoir will be connected to a 1,000 mm diameter **SRCP pipe** and the second with **800 mm diameter PVC-O**.

The excavation volume of the reservoirs is as follows: 58,833.22 m³ in the top reservoir, and 36,817.24 m³ in the embankment. In the end reservoir, 97,552.95 m³ of clearing and 29,028.11 m³ of embankment.



Arenillas reservoir

The reservoirs will have a bottom outlet and a drainage system that will connect to the valve station where the system can be controlled. The outlet will be made of helicoidal steel with an 813 mm external diameter and be 8 mm thick. The drainage will be made through a 508 mm external diameter and 6 mm thick helicoidal steel pipe, helically welded, shot-blasted, coated internally with epoxy paint and externally with epoxy paint or the equivalent, with a 200 micron minimum thickness, embedded in a reinforced beam with Ø 12 mm rods and HA-25 concrete, measuring 2.15 x 1.40 m.



Villanuño 2 reservoir

The beam length is 39 m in the top reservoir and 37 m in the end reservoir. It starts at the valve station and ends at a 2.15 x 2.15 m concrete cube, which houses the bends of the intake pipe, and gives access to the discharge basin, from which the drainage pipe exits. On top of the basin, a properly protected waterproofing cover will be placed. The inlets will be made with a piece of boiler work, in the form of a grate.

The tanks will be waterproofed by means of a 2 mm thick high-density polyethylene sheet, supported by a 250 gr/m² perforated geotextile.

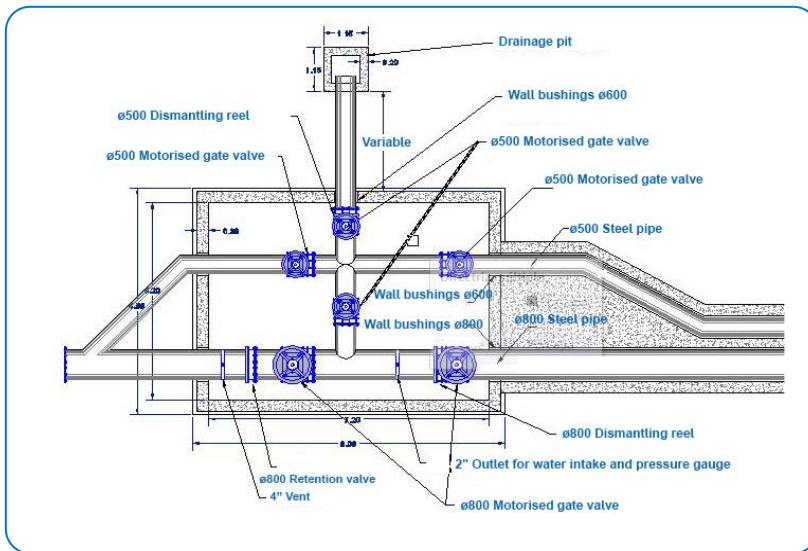


A galvanised steel collector will be installed inside each station by means of the appropriate boiler work piece, according to the reservoirs' detailed plans, in which, from the filling pipe, the parallel installed drainage pipe will be connected through a bypass. Two sets of 800 mm diameter motorised valves will be fitted for the filling collector to facilitate opening and two sets of 500 mm diameter motorised valves for the drainage collector, as well as a gate valve with a 500 mm diameter reducer for the bypass and another for the drainage.



A 4" vent will be installed on the filling collector. Two 500 mm dismantling reels will be placed at the junction with the upstream valves, which will connect with the steel pipe flange joint that carries the water through the reinforced beam and from which a 3" pipe will be drawn to act as a balance chimney at the crest of the reservoir.

Both designed reservoirs fall outside the scope of the holder's obligations established in TITLE VII, on dam, reservoir and basin safety, from the Regulations on the Public Hydraulic Domain. The first, the **Arenillas de San Pelayo reservoir**, has a **99,859.47 m³** storage capacity at its normal maximum level, with a 4.25 m foundation height, and the second, the **Villanuño de Valdavia reservoir**, has a **99,859.47 m³** storage capacity at its normal maximum level, with a 4.98 m foundation height. The Dam, on the other hand, has a 12,449.32 m³ holding capacity and a 3.20-metre foundation height.



5. Conclusions

The high hydraulic capacity and smooth surface make **Class 500 PVC-O** the ideal material for transporting water with minimum energy consumption.

This circumstance, together with the current power situation, in which the electricity contracted throughout the year is a burden for many Irrigation Communities that only use it for 6 months a year, makes the designers consider **PVC-O** as another tool for optimising the electricity costs in a modernisation or irrigation transformation project.

The **transformation of the irrigable area of the “Vegas del Bajo Valdavia (Palencia) Irrigation Community”** into an irrigation area is an example of optimal design, doing away with the need for electricity to distribute the irrigation water, taking advantage of the area's natural slopes, so that all the parcels in the area can enjoy water under suitable pressurised irrigation conditions.

These qualities would be of no use if the material's durability jeopardised the large investments that are being made. Therefore, we can talk about energy efficiency in water transport along with other qualities that are no less important, such as the material's durability, its low speed and its high impact resistance.

Until this highly complicated power situation changes, the viability of these modernisation initiatives depends on taking into account, during the design phase, as many measures as possible to reduce the operation's dependence on electricity costs, high accumulation basins, remote control systems that allow irrigation to be grouped together, frequency variators in the drives, adapting the pumping equipment to different possible demands and, of course, the use of materials in the irrigation network whose properties, as in the case of PVC-O, allow this energy optimisation goal to be achieved.

