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Urban Hydraulics: Group project

Hydraulic network in the village of Anti-paros

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Abstract : This paper is about the design of the hydraulic network of the village of Anti-Paros island in Greece. With given data of the consumption and a map of the existing infrastructures, many calculations are made in order to find the dimensioning of the village's water network according to its needs. These calculations are detailed, the formulas used are written and all the results are attached to this paper in excel files.

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1 The Technical Report

This technical report has been prepared to address the water supply requirements of the settlement in the village of Antiparos, taking into consideration the estimated population and hydraulic considerations. Utilising the provided topographic diagrams and geological data, our task involves determining the water demands not only within the settlement but also in the surrounding areas. Subsequently, we shall identify a suitable location for the reservoir, preferably in close proximity to the settlement and at an optimal elevation, to facilitate the establishment of a water distribution network. This process entails segregating the water distribution based on pipeline-specific demand and consumption. Lastly, we shall engage in hydraulic analysis, which involves calculating the water velocities within the pipelines and the corresponding pressures at the nodes. By developing a preliminary project budget, we will be able to approximate the overall project cost.

1.1 Introduction

The data provided for this study are: a 3D plan readable on *Autocad* software presenting the topography as well as the different zones compartmentalising the village and their activities. We therefore have access to the exact dimensions of the zones as well as the lengths of the existing pipes and the difference in level.

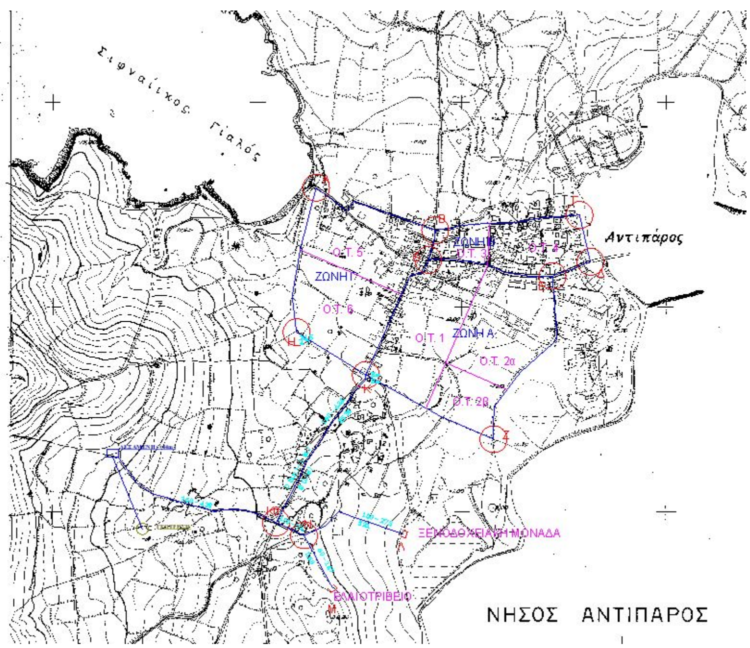


Figure 1: Photograph of the map detailing the hydraulic network of the village of Antiparos opened in Qcad software.

Firstly, as we can see on the figure 1, there is an initial conduit linking the reservoir at the top of the hill (+44m high) to the rest of the town. This conduit then splits in two at the point known as

KO. Part of the water is thus transmitted to a residential area, after the point K : the village, itself divided into three zones A, B and C. This type of network, that of the village, is known as a "**grid**", with the pipes making loops and being connected to each other. Zone A is a residential area and contains a park. Zone B is exclusively residential and zone C is a mix of residential and tourism. The other part of the pipe splits off at point KO and branches off at point N near the coast. This point N marks the separation of the pipe into two parts, one to supply an olive oil factory and the other a hotel. The rest of the network (everything except the village) is characterised as a "**dentritic**" network.

1.1.1 Topographical data

The focus of our investigation encompasses the island of Antiparos, specifically the northeastern region, which is entirely encompassed by the sea. Its geographical coordinates are 37°0000N 25°0159E / 37.00°N 25.033°E / 37.00; 25.033, and it spans an area of 35.09 square kilometers. The provided map facilitates the measurement of both horizontal distances and variations in elevation within the designated planning area. By employing linear interpolation, we can ascertain the ground slope and elevation for each point illustrated on the map. The horizontal positions of the points are indicated on the diagram, while the elevations range from 0.30 to 200.30 meters, with an increment of 0.30 meters (starting from the coastline). Notably, the majority of elevated points are situated in the central part of the island and the southeastern portion of our study area. Altitudes reach a maximum of 103.30 meters, and the highest point, at an elevation of 200.30 meters, is located prior to the settlement. Additionally, we have been informed that the isopotential curves have an equidistance of 4 meters, and the tank's height should be positioned at 44 meters above ground level. The length scale of the map is 1:5000, while the vertical scale is 1:250, providing appropriate representation of the terrain's morphology.

1.1.2 Climate

The focus of our investigation encompasses the island of Antiparos, specifically the northeastern region, which is entirely encompassed by the sea. Its geographical coordinates are 37°0000N 25°0159E / 37.00°N 25.033°E / 37.00; 25.033, and it spans an area of 35.09 square kilometers. The provided map facilitates the measurement of both horizontal distances and variations in elevation within the designated planning area. By employing linear interpolation, we can ascertain the ground slope and elevation for each point illustrated on the map. The horizontal positions of the points are indicated on the diagram, while the elevations range from 0.30 to 200.30 meters, with an increment of 0.30 meters (starting from the coastline). Notably, the majority of elevated points are situated in the central part of the island and the southeastern portion of our study area. Altitudes reach a maximum of 103.30 meters, and the highest point, at an elevation of 200.30 meters, is located prior to the settlement. Additionally, we have been informed that the isopotential curves have an equidistance of 4 meters, and the tank's height should be positioned at 44 meters above ground level. The length scale of the map is 1:5000, while the vertical scale is 1:250, providing appropriate representation of the terrain's morphology.

1.1.3 Demographic data

As per the latest population census conducted in 2021, the population of Antiparos was recorded as 1,265 individuals. This count reveals a notable increase in population since the year 1971 up until 2021. Additionally, Antiparos attracts approximately 1,000,000 visitors annually from various parts of the world. The demographic composition displays a slight predominance of both younger and older age groups, indicating that improvements in living conditions have led to an extended lifespan for the population, thereby compensating for the relatively smaller proportion of younger individuals.

Δήμος	Πληθυσμός		Άνδρες		Γυναίκες	
	2011	2021	2011	2021	2011	2021
ΠΑΡΟΥ	13.715	14.520	6.846	7.217	6.869	7.303
ΑΝΤΙΠΑΡΟΥ	1.211	1.265	619	648	592	617

Figure 2: Antiparos Census of 2021

1.2 Primary sector

1.2.1 Crop production

Crop production in Antiparos is constrained by the limited availability of agricultural land, primarily attributed to water scarcity. Consequently, the majority of crops cultivated on the island consist of arable crops, particularly cereals and legumes. The available land encompasses arable fields, pastures, and forests characterized by sparse vegetation, primarily comprising bushes and topsoil. These areas can be utilized for activities such as beekeeping and livestock farming.

1.2.2 Geological data

Antiparos, historically known as Oliaros, is situated in the Cyclades archipelago and is renowned as one of the smallest inhabited regions globally. It is located in close proximity to the southwestern coast of Paros, with the Strait of Antiparos serving as the demarcation between the two islands. The distance between Antiparos and Paros ranges from 500 to 1000 meters. Furthermore, it lies east of Sifnos, approximately 13 nautical miles away from its easternmost cape, Napu. Antiparos is encompassed by a cluster of uninhabited islets, including notable ones such as Despotiko, Strogilos, Diplo, and Kavouras. The island itself exhibits an elongated shape, featuring two distinct ends known as Cape Boreino in the north and Cape Petal in the south. The distance between these two points measures twelve and a half kilometers, with a maximum width of 5.5 kilometers. Antiparos covers an area of approximately 35 square kilometers, with a coastline stretching 57 kilometers in length.

1.2.3 Physical geography

In terms of natural geography, the island of Antiparos can be classified into two distinct parts. Situated near the middle of the northern portion is the town of Antiparos. The island's flora is characterized by modest and peculiar plant species known as alophytes, which possess the remarkable ability to thrive within the confines of limited saline soils. Moving southward, the terrain becomes hilly, dominated by two prominent hills, namely Cross (136 meters) and Prophet Elias (133 meters). Beyond lies a lowland region known as Campos, which serves as a demarcation between the northern and remaining parts of the island. The remainder of Antiparos is characterized by arid and dry conditions, featuring expansive hills. The most significant mountain range on the island is Prophet Elias, reaching an approximate height of 299 meters. Notably, the central peak of Antiparos, also named Prophet Elias, stands as the island's highest point. From this central core, several elevated ridges extend towards the coastline.

1.3 Secondary sector

1.3.1 Oil mills

The processing of olives harvested in Antiparos is conducted in five modern olive mills located in Paros. These mills employ a three-phase centrifugal method for olive milling.

1.3.2 Wineries

Significant quantities of wine grapes are supplied to wineries in Paros for the production of wines with Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) labels. Any surplus grapes, including those intended for table grapes and wine production, are made available to local producers for the creation of local wines meant for personal consumption. Additionally, they may be utilized for distillation purposes to produce traditional beverages such as souma.

1.4 Tertiary sector

1.4.1 Tourism

Tourism has emerged as a significant driver of growth in Antiparos and remains the primary economic activity for the past decade, demonstrating consistent stability. Despite notable growth in the construction sector in recent years, the importance of tourism for the island's economy has not been diminished. The tourism sector also holds regulatory importance, influencing other sectors of economic and social activities. Antiparos is a popular summer resort destination for both Greek and European visitors and has also attracted investment from American vacationers.

1.4.2 Accommodation

The total number of accommodation establishments, including hotels, camping sites, and rooms for rent in the Cyclades, is reported to be 65, along with one camping site.

1.4.3 Catering

The island of Antiparos offers a diverse catering sector, encompassing various establishments such as taverns, pizzerias, and snack bars (ouzeri). Traditional local dishes include wild rabbit, rooster patidos, carnival ravioli, and bourekakia.

1.5 Demographic data

In order to evaluate the water needs that the hydraulic network that we are building will have to answer, we have to evaluate the water needs of today but also to make assumptions of how the water needs might grow in the following years.

To evaluate this need, we are provided an *excel* file with different data and formulas that will enable us to make the study. Let's first have a look to the water needs of the village. In the previous section, we extracted the exact area values A of each block and in the excel file, we can see the density D of population (people/Ha) ; we are therefor able to evaluate the population P of each block :

$$P = A \times D \qquad \text{with the units : [people]} = [m^3] \times \frac{[people/Ha]}{10} \tag{1}$$

Once we have the population of each block, we want to evaluate how it will grow in the following years in order to size the network to meet the village's future needs A comprehensive hydraulic study is best conducted with a planning period of up to 30 years. Therefore, our calculations need to be forward-looking, and estimates should be based on a projected population for the year 2053. Utilising the formula provided below, we can estimate the expected population growth of 66.3%.

$$P_n = P_0 \cdot (1 + \alpha)^n \tag{2}$$

Where P_n is the population predicted for the year n calculated with P_0 the actual population (in 0 years) and the factor of growth α. I our case, we will anticipate the needs of the village for $n = 30$ years and we will use the factor $\alpha_A = 1.5\% = 0.015$ for the residential area of type A and $\alpha_A = 2\% = 0.02$ for the residential area B.

N. B. : This formula is used for the residential areas, for the hotel and touristic areas, the water needs are evaluated not with people but with the number of beds and the previsions are, in our case, provided by the hotel managers.

This table summarises the exact dimensions of each residential zone on the plan as well as their primary activity.

Based on the demographic data, the total population in 2023 is recorded as 1265. For Zone A, which is divided into three blocks, the first block covering an area of 57 hectares has a population of 428 individuals. The second block, consisting of block A and block B (53.6 and 20.4 hectares respectively), has a population of 268 persons. It should be noted that recreational green areas do not contribute to drinking water consumption. In Zone B, block 3 (11.6 hectares) has a population of 88, while block 4 (30.7 hectares) has a population of 231. In Zone C, specifically block 5 (48.5 hectares), the population is 243. The sixth block is dedicated to tourism and is calculated based on the number of beds available, which is 150 for hotels and 150 for the hotel unit outside the settlement.

Using the previously mentioned formula, we can estimate the population for the year 2053 as follows:

Zone	Block	Area ($\cdot 10^3 m^3$)	P_{30} (persons)
A	1	57	668
A	2α	53,5	485
A	2β	20,4	-
B	3	11,6	137
B	4	30,7	361
C	5	48,5	439
C	6	48,3	-
A+B+C	-	270	2091

Figure 3: Table summarising the dimensions of the different areas of the village

And, the estimation for the hotel unit is 250 beds.

1.6 Water needs

Once we have the number of people or the number of beds predicted for 30 years from now for each zone, we can use the data to anticipate the flow of water Q_1 consumed by each zone as a function of their activities. These data can be found in the excel file:

$$Q_1 = P_{30} \cdot q \qquad \text{with the units : [L/day]} = [people] \times [L \cdot people^{-1} \cdot day^{-1}] \tag{3}$$

With q the water need in litter per person per day depending on the activity of the area: residential, parc, tourism,... which is provided.

By a simple change of units we can find Q_2 the flow of water consumed by each zone in liter per seconds.

One final step in order to be sure that the network will correspond to the water needs of the village is by predicting the fluctuations that occur throughout the day and the year. The coefficient λ_1 predicts how many times the maximum of water consumption is bigger than the mean consumption in the day ; as well as λ_2 for the monthly consumption. In our situation, we will use the following values for theses coefficients (without units):

- λ_1=2.5
- λ_2=1.2

The design flow is calculated as follows:

$$Q_{design} = Q_2 \cdot \lambda_1 \cdot \lambda_2 \qquad \text{[L/S]} \tag{4}$$

Thus we can find the design flow in [m^3/min] that will be used in order to size the different parameters of the hydraulic network of the village of Antiparos island.

The detailed results are summarised in the following figure which is the table from the excel table, figure [4]:

BLOCK	AREA	ZONE	LAND USE	POPULATION DENSITY	POP.2023	POP.2053	Beds 2020	Beds 2050	Q1	Q2	Qdesign = (Q2*λ1*λ2)	Qd. / zone	Qd.	Qd. / zone
	x1000m^2			people/Ha (hectare)					l/day	l/s	l/s	l/s	m^3/min	m^3/min
1	57	A	Residential type A	75	428	668			147 008	1,70	5,10		0,306266	
2α	53,6	A	Residential type B	50	268	485			106 798	1,24	3,71		0,222496	
2β	20,4	A	Park - Recreational use	-	-	-			24 480	0,28	0,85	9,66	0,051	0,58
3	11,7	B	Residential type A	75	88	137			30 175	0,35	1,05		0,062865	
4	30,8	B	Residential type A	75	231	361			79 436	0,92	2,76	3,81	0,165491	0,23
5	48,5	Γ	Mixed Uses - Residential type B	50	243	439			96 636	1,12	3,36		0,201325	
6	48,3	Γ	Mixed Uses - Tourism	-	-	-	150	300	96 000	1,11	3,33	6,69	0,2	0,40
	270,3			325	1257	2091			580 533	7		20,16		
			(Outside the village)											
			Oil producing unit (manifacture)						60 000	0,69	2,08		0,13	
			Hotel				150	250	80 000	0,93	2,78	4,86	0,17	0,29

DATA (NO FIREFIGHTING NEEDS ARE INCLUDED)

		Water consumption per Land Use
220	Residential	litters per person per day
320	Tourism	litters per bed per day
2 200	manifacture - commerce	litters per 1000m2 per day
1 200	Park	litters per 1000m2 per day
60 000	Oil producing unit	litters per day

2

Residential A	75	population density today (people / hectare)
Residential B	50	population density today (people / hectare)

2,5	**λ1,** coefficient of daily peak (max/average)
1,2	**λ2,** coefficient of monthly peak (max/average)

Residential A	1,5	percentage of yearly growth (a)
Residential B	2,0	percentage of yearly growth (a)

Figure 4: Consumtion table showing the water needs of the city in 30 years - excel

2 Hydraulic calculations

In this section, we will now explain the calculations that were made in order to design the hydraulic network of Antiparos. We will separate the calculations in two networks ; the village which is a grid network and the rest which is a dendritic network. The goal of this section is to design every pipe in order to reach the water needs of every area, industry and hotel while respecting the constraints imposed by the construction materials

2.1 Grid network

First of all, we are making the calculations of the village.

2.1.1 Grid Cross calculation

According to the water needs table in figure [4], the village needs to be provided with 20.16 l/s. All this water arrives to the village from the same pipe and is injected from point K. In this same table, we can differentiate the water needs for each zone ; as visible on the following picture [5], the village water network can be model in a simple draft of to loops where each loop corresponds to one area and has it's proper water needs. On this same figure [5], we have entered the length of each pipe and the sum of these lengths for each loop.

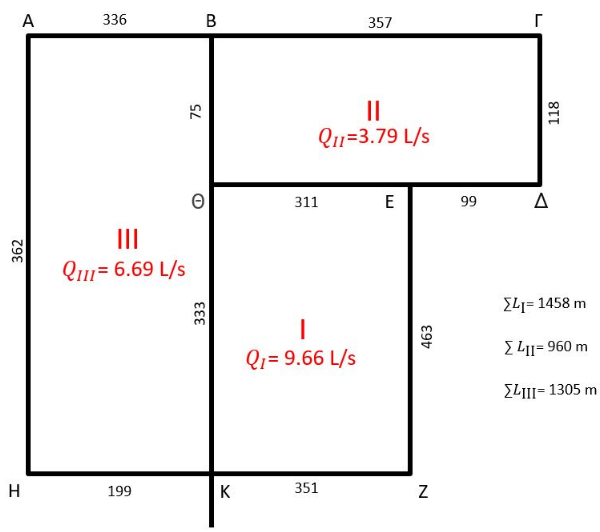


Figure 5: step 1 ; Calculation steps followed for the village network

Now that we have the draft of the village, the first step of the design of the grid network, we need to divide the water needs of each loop by it's total length in order to make a cross product and associate a flow rate with each pipe. This water flow for each pipe is then divided in two flows in opposite directions (the orange arrows). Finally, this second step, visible on figure [6], enable us to associate a value of the flow to each node of the village (the violet arrows).

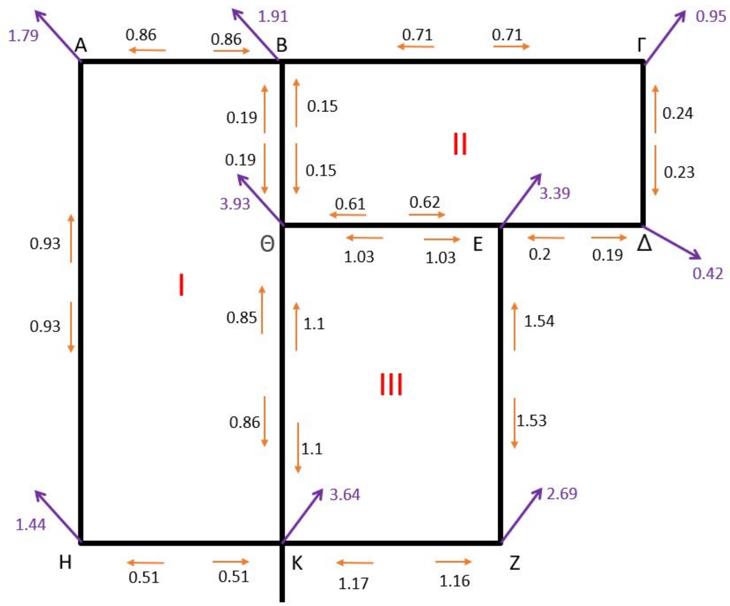


Figure 6: step 2 ; Calculation steps followed for the village network

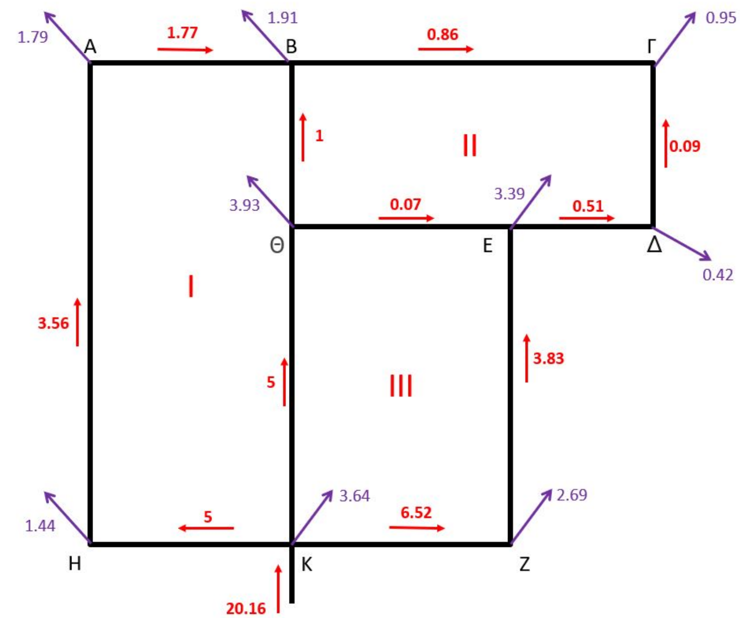


Figure 7: step 3 ; Calculation steps followed for the village network

The third and final step of this method is now to dispatch the incoming flow coming from node K into the entire village by subtracting to the flow passing trough a node the value associated to that node in the previous step. The Once this step is showed on the figure [7] where the values are represented with the red arrows designating flow values selected by the calculator, which are then entered into an Excel program detailed in the following section.

2.1.2 Pressure networks calculation

The otained values are therefore entered in the Excel program shown on figure [8], they are then converted from l/s to $m^3 \cdot min$ in order for the program to function. The length of each pipe is also specified. The calculation are first made for random values of diameter, for example, the default value is 60 mm, as this is the cheapest pipe size value. The program also needs to be informed of which pipe is used twice in two different loops, this corresponds to the ID column. The Hazen-Williams number used for the calculations is $C = 120$.

In order to model the pipes, we run the algorithm a first time and have a close look to the V_{final} column. This speed shouldn't be above 2 m/s otherwise the network couldn't hold it and may deteriorate or cease to function very quickly. If this speed is too high, we can change the diameter of the pipe, increasing the diameter of the pipe will end up in reducing the speed inside it. We must take into account diameters that are available in the market and keep in mind that the wider the pipes are, the more expensive they will be. We can run the algorithm again and again until obtaining reasonable speeds for each pipes. Once this step is done, the final table [8] can provide us with the definitive diameters, flow and speed for each pipe.

Moreover, we are provided with a ΔH value of length, in meters, that corresponds to the loss of the piezometric height after passing through the pipe in question.

Loop	Line	ID	From	To	H_{from}	H_{to}	Diam.	Length	$Q_{initial}$	Q_{final}	V_{final}	s_{final}	h_{final}	Δ_{final}	$Q_{original}$	$\Delta H_{\pi\iota\epsilon\zeta o}$	$Q_{original}$	Q_{final}
					m	m	mm	m	m^3/min	m^3/min	m/s	m	m/(m^3s)	m	m^3/min	m	L/s	L/s
1	1	2	Κ	Θ	0	0	160	333	0,662	0,66	0,55	0,00271	***0,90***		0,300	0,90	5,00	11,04
1	2	1	Θ	Ε	0	0	63	311	0,134	0,13	0,71	0,01305	***4,06***		0,004	4,06	0,07	2,23
1	3		Ε	Ζ	0	0	63	463	-0,117	-0,12	0,62	-0,01017	***-4,71***		-0,230	4,71	-3,83	-1,95
1	4		Ζ	Κ	0	0	160	351	-0,321	-0,32	0,27	-0,00071	***-0,25***		-0,391	0,25	-6,52	-5,36
														1E-16				
2	1	3	Θ	Β	0	0	90	75	0,230	0,23	0,60	0,00628	***0,47***		0,060	0,47	1,00	3,83
2	2		Β	Γ	0	0	63	357	0,113	0,11	0,61	0,00962	***3,43***		0,052	3,43	0,86	1,89
2	3		Γ	Δ	0	0	63	118	0,038	0,04	0,20	0,00129	***0,15***		-0,005	0,15	-0,09	0,64
2	4		Δ	Ε	0	0	63	99	0,003	0,00	0,02	0,00001	***0,00***		-0,031	0,00	-0,51	0,05
2	5	1	Ε	Θ	0	0	63	311	-0,134	-0,13	0,71	-0,01305	***-4,06***		-0,004	4,06	-0,07	-2,23
														3E-17				
3	1		Κ	Η	0	0	160	199	0,261	0,26	0,22	0,00049	***0,10***		0,300	0,10	5,00	4,36
3	2		Η	Α	0	0	90	362	0,153	0,15	0,40	0,00298	***1,08***		0,214	1,08	3,56	2,56
3	3		Α	Β	0	0	63	336	0,025	0,03	0,13	0,00059	***0,20***		0,106	0,20	1,77	0,42
3	4	3	Β	Θ	0	0	90	75	-0,230	-0,23	0,60	-0,00628	***-0,47***		-0,060	0,47	-1,00	-3,83
3	5	2	Θ	Κ	0	0	160	333	-0,662	-0,66	0,55	-0,00271	***-0,90***		-0,300	0,90	-5,00	-11,04
														3E-17				

Figure 8: Calculations for the energy losses in the village network

2.2 Dendritic network

We will now make the calculations for the rest of the network, this network is "tree-like" shaped, in other words, it can be qualified as dendritic. As showed in the table of water needs (figure [4]), we know the flow that requires the Oil factory (node M), the Hotel (L) and the village (K). We can trace the village network by following a simple law of nodes: incoming flows must be equal to outgoing flows. This gives us the following values, shown in the village sketch below, [9]:

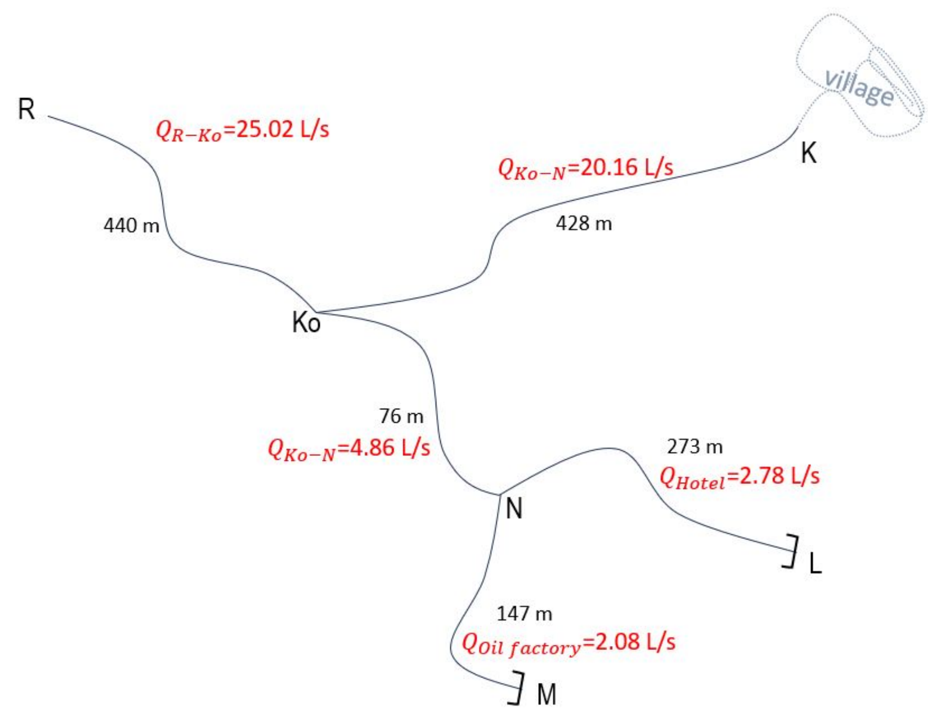


Figure 9: Draft of the Dendritic network of Antiparos

A second time, we have to design the pipes that supply the corresponding water flow. For this, we will this time use the explicit Hazen-Williams formula:

$$V = 0.849 \cdot C \cdot R_H^{0.63} \cdot S^{0.54} \tag{5}$$

Here R_H represents the hydraulic radiant which is the ratio between the wetted section and the perimeter of this section in contact with the water. In our case:

$$R_H = \frac{\pi(\frac{D}{2})^2}{\pi D} = \frac{D}{4} \tag{6}$$

The Hazen-Williams constant used here is $C = 120$. If, like for the grid network, we choose a diameter for each pipe, we can therefore find the velocity : knowing the flow that each pipe needs to provide and the diameter.

$$V = \frac{4 \cdot Q}{\pi D^2} \tag{7}$$

Again, if we find a velocity too strong, we can higher the value of the diameter in order to reduce it. Once all velocities have a decent value, we can calculate S according to the formula [5]. These results are presented in the following figure [10]

Pipeline	L (m)	Q (L/s)	D (mm)	V (m/s)	S	dH (m)
R-KO	440	25,02	160	1,2444	0,0122	5,3895
KO-K	428	20,16	160	1,0027	0,0082	3,5143
KO-N	76	4,86	110	0,5114	0,0037	0,2777
N-M	147	2,08	75	0,4708	0,0049	0,7205
N-L	273	2,78	75	0,6293	0,0084	2,2897

Figure 10: Calculations for the energy losses in the dendritic network

On this figure, we calculated the loss of height according to the length of each pipes times the S factor of losses that have been found ; we therefore find a ΔH value of length, in meters, that corresponds to the loss of the piezometric height after passing through the pipe in question.

2.3 Properties at each node

According to the previous results for each type of network, we can now calculate the piezometric height and pressure for each node according to the values of ΔH provided in the tables [8] and [10]. The first node, R, corresponds to the tank where the water is at rest and it's surface is in contact with the atmosphere ; therefore, the difference of pressure is equal to 0 Pa and the piezometric height is equal to the topographic height which is 44 m.

By only taking into account the loss of height induced by the friction between the water and the surface of the pipe and neglecting the singularity losses due to mainly due to pipe accidents, i.e. any geometric modification of the pipe. These usely include changes of direction (bends, T-joints), variations in cross-section, valves or taps that represent a smaller par of the losses than the regular losses due to friction. Theses can be neglected for a first estimate of the network but would be needed to be taken into account for a more rigorous study.

We therefore find, by following the connections between each pipe, the following information for each node represented in table [11] for the dendritic network and [12] for the grid network :

DENDRITIC			
NODE	Hpz (m)	Htopo (m)	Pressure (Pa)
R	44	44	0
KO	38,6105	20	18,6105231
K	35,0962	20	15,0962138
N	38,3328	16	22,3328221
M	37,6123	24	13,6123215
L	36,0431	4	32,0431216

Figure 11: Calculations for the piezometric hight and pressure in the dendritic network - excel

VILLAGE			
NODE	Hpz (m)	Htopo (m)	Pressure (Pa)
K	35,1	20	15,10
Θ	34,20	20	14,20
E	30,14	4	26,14
Z	25,43	4	21,43
B	33,73	20	13,73
Γ	30,29	2	28,29
Δ	30,14	2	28,14
H	35,00	26	9,00
A	33,93	26	7,93

Figure 12: Calculations for the piezometric hight and pressure in the network of the village - excel

3 Water supply network budget

In this section, we will calculate the budget according to the network we designed and all the other requirements linked to it.

3.1 Road draft

Here is the road draft model that we chose to build the network ; this model will be used in the following section to calculate the budget.

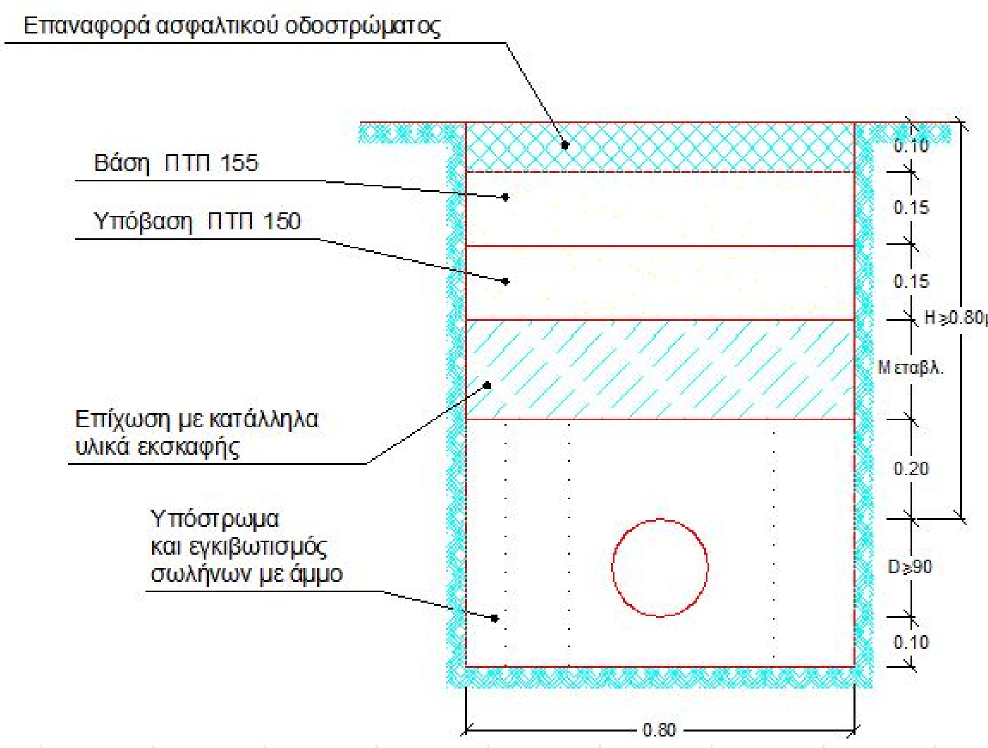


Figure 13: Draft of the water supply pipeline in an asphalted road

3.2 Calculation

- I. To begin with, we calculate the quantity of Article 1, which involves backfilling the water supply pipeline with appropriate excavation materials. The volume of backfill material required can be determined by measuring the height of the entire water supply pipeline along a paved road. The given width value is 0.8 m, and the total length of the network is L = 4368 m. Therefore, the area for the excavation materials, based on the following picture [13], can be calculated as follows:

$$A = 1 \times 0.8 \times 4368 \; [m^3] \tag{8}$$

The cost of 1 m^3 of excavation material is 0.80 € . Hence, the total cost for the backfill materials amounts to 2796 € .

- II. Moving on to Article 2, the area for laying and encapsulating the pipes with quarry sand is calculated in a similar manner as described previously. By applying the formula [9], the volume of all pipes is determined to be 1,355 m^3. The cost for 1 m^3 of quarry sand is given as 7.20 €.

$$V_{SAND} = \left((0.2 + D_{mean} + 0.1) \cdot 0.8 - \frac{D_{pipe}^2 \pi}{4} \right) \cdot L_{pipe} \tag{9}$$

where, for each type of pipe, i.e. for each diameter used :

  - D_{mean} is the mean diameter of all the pipes
  - D_{pipe} is the diameter of the pipe in question
  - L_{pipe} is the diameter of the pipe in question

Hence, the total cost for the paving and encapsulation of sand pipes can be calculated as follows:

$$[Cost] = 1,355\ [m^3] \ \times\ 7.20\ [€/m^3] \tag{10}$$
$$= 9,759€ \tag{11}$$

Therefore, the cost for Article 2, which involves the laying and encapsulation of pipes with quarry sand, amounts to 9,759 € .

- III. For the calculation of the spreading of cullet products, the volume is determined by multiplying the product of length, height, and the total length of the ducts. Specifically, the calculation is as follows: $0.30 \times 0.80 \times 4,356 = 1,134.60 m^3$.

  The cost for $1m^3$ of cullet products is given as 0.14 € . Therefore, the cost of laying the cullet products amounts to 245 € .

- IV. Moving on to the backfilling of trenches, the volume is calculated in a similar manner: $0.25 \times 0.80 \times 4,356 = 874 m^3$.

  The cost for $1m^3$ of backfilling material is given as 6.30 € . Hence, the cost for backfilling the trenches amounts to 5504 €.

In order to calculate the quantity of pipes, it is necessary to sum up the lengths of pipes with varying diameters (D):

- $L_{(D=63mm)} = 1684m$
  Therefore, considering the cost of 4.00€ per meter, the cost for 1684 meters of pipe with diameter D = 0.63m is 6,736€.

- $L_{(D=75mm)} = 420m$
  Therefore, considering the cost of 4.80€ per meter, the cost for 550 meters of pipe with diameter D = 0.075 m is 2016€.

- $L_{(D=90mm)} = 437m$
  Therefore, considering the cost of 6.50€ per meter, the cost for 550 meters of pipe with diameter D = 0.09 m is 2,840.5€.

- $L_{(D=110mm)} = 76m$
  Therefore, considering the cost of 8.70€ per meter, the cost for 76 meters of pipe with diameter D = 0.11 m is 661.2€.

- $L_{(D=160mm)} = 1751m$
  Therefore, considering the cost of 15€ per meter, the cost for 1751 meters of pipe with diameter D = 0.16 m is 26,265€.

- V. Article 13 specifies the inclusion of one DN65 valve per 100 meters of network. With a total network length of 4,356 meters, we can estimate the requirement of approximately 44 valves. Given that each valve costs 500.00€, the total cost for 44 valves would amount to 22,000€.

- VI. Article 14 calls for the inclusion of one DN50 evacuator per 500 meters of network. Considering the total network length of 4,356 meters, we can estimate the need for approximately 9 evacuators. With each evacuator priced at 700.00€, the total cost for 9 evacuators would be 6,300.00€.

- VII. Article 15 specifies the inclusion of one DN50 air vent valve per 500 meters of network. Given the total network length of 4,356 meters, we can estimate the requirement of approximately 9 valves. With each valve priced at 800.00€, the total cost for 9 valves would be 7,200.00€.

The results are detailed in the following figure [14]:

	Pipeline	L (m)	D (mm)	[1] Volume digged (m^3)	[2] Volume of sand (m^3)	[3] Excavation volume (m^3)	[4] Volume of backfilling
dendritic	R-KO	440	160	352	132,31	176,44	88
	KO-K	428	160	342,4	128,70	171,628	85,6
	KO-N	76	110	60,8	23,66	30,476	15,2
	N-M	147	75	117,6	46,51	58,947	29,4
	N-L	273	75	218,4	86,37	109,473	54,6
village	K-Θ	333	160	266,4	100,13	133,533	66,6
	Θ-E	311	63	248,8	98,80	124,711	62,2
	E-Z	463	63	370,4	147,09	185,663	92,6
	Z-K	351	160	280,8	105,54	140,751	70,2
	Θ-B	75	90	60	23,58	30,075	15
	B-Γ	357	63	285,6	113,41	143,157	71,4
	Γ-Δ	118	63	94,4	37,49	47,318	23,6
	Δ-E	99	63	79,2	31,45	39,699	19,8
	K-H	199	160	159,2	59,84	79,799	39,8
	H-A	362	90	289,6	113,83	145,162	72,4
	A-B	336	63	268,8	106,74	134,736	67,2
		SUM	MEAN	SUM	SUM	SUM	SUM
		4368	101	3494	1355	1752	874
				price (€)	price (€)	price (€)	price (€)
				2796	9759	245	5504

[5] Pipelines	Length (m)	price (€)
For D=63mm	1684	6736
For D=75mm	420	2016
For D=90mm	437	2840,5
For D=110mm	76	661,2
For D=160mm	1751	26265
		price (€)
		38519

[13] Valves	price (€)
43,68	
integer	22000
44	
[14] Evacuation valves	price (€)
8,736	
integer	6300
9	
[15] Exhaust valves	price (€)
8,736	
integer	7200
9	

price (€)	TOTAL (€)
35500	92322

Figure 14: Calculations for the budget estimation of the hydraulic network

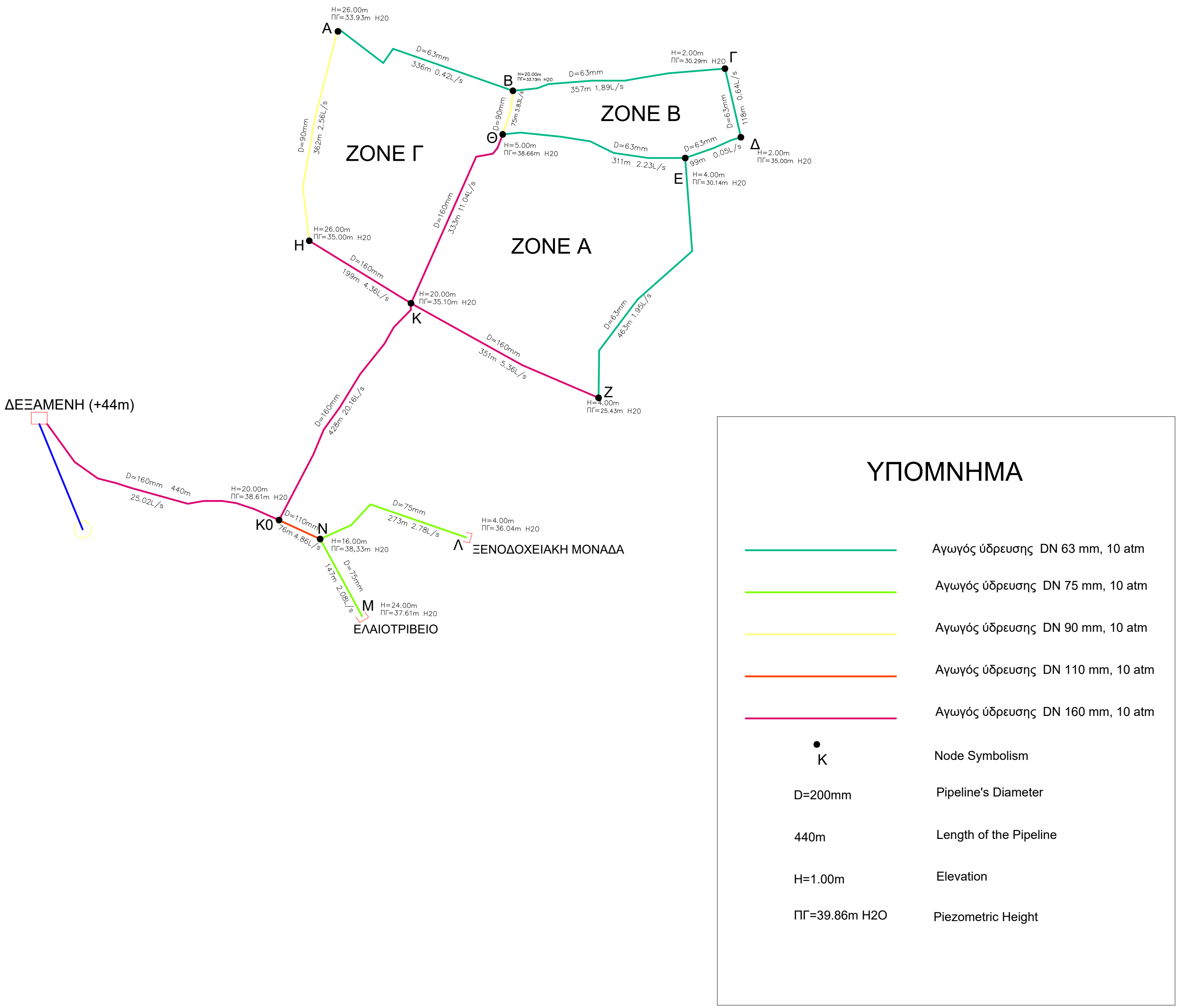
All these previous calculations are sum up in the following financial estimate of the project on figure [15].

ΠΡΟΥΠΟΛΟΓΙΣΜΟΣ ΔΙΚΤΥΟΥ ΥΔΡΕΥΣΗΣ

ΠΡΟΫΠΟΛΟΓΙΣΜΟΣ ΜΕΛΕΤΗΣ

ΕΙΔΟΣ ΕΡΓΑΣΙΑΣ	Α.Τ.	ΑΡΘΡΟ ΑΝΑΘΕΩΡ.	ΜΟΝΑΔΑ	ΠΟΣΟΤΗΤΑ	ΤΙΜΗ ΜΟΝ. (Ευρώ)	ΔΑΠΑΝΗ (Ευρώ)
Εκσαφή ορυγμάτων σε έδαφος γαιώδες ή ημιβραχώδες σε κατοικημένη περιοχή με πλάτος πυθμένα έως 3 μ. με την φόρτωση των προϊόντων εκσκαφής επί αυτοκινήτου, την σταλία του αυτοκινήτου και την μεταφορά σε οποιαδήποτε απόσταση για βάθος ορύγματος έως 4 μ.	3.01.02	ΥΔΡ 6054	m3	3 494,4	0,80	2 796
Διάστρωση και εγκιβωτισμός σωλήνων με άμμο λατομείου	Αρθρο 5.07	ΥΔΡ 6069	m3	1 355,0	7,20	9 756
Διάστρωση προϊόντων εκσκαφής	Αρθρο 3.16	ΥΔΡ 6070	m3	1 752,0	0,14	245
Επίχωση κάθε είδους ορυγμάτων εντός πόλεως με θραυστό υλικό λατομείου της Π.Τ.Π Ο-150.	Αρθρο 5.05	ΥΔΡ 6068	m3	874,0	6,30	5 506
Πλαστικοί σωλήνες από HDPE, 3ης γενιάς, 10 ατμ						
ονομ. διαμέτρου DN 63 mm / ονομ. πίεσης PN 10 atm	12.14.01.04	ΥΔΡ 6621.1	μ.μ	1 684,0	4,00	6 736
ονομ. διαμέτρου DN 75 mm / ονομ. πίεσης PN 10 atm	12.14.01.05	ΥΔΡ 6621.1	μ.μ	420,0	4,80	2 016
ονομ. διαμέτρου DN 90 mm / ονομ. πίεσης PN 10 atm	12.14.01.06	ΥΔΡ 6621.1	μ.μ	437,0	6,50	2 841
ονομ. διαμέτρου DN 110 mm / ονομ. πίεσης PN 10 atm	12.14.01.07	ΥΔΡ 6621.1	μ.μ	76,0	8,70	661
ονομ. διαμέτρου DN 125 mm / ονομ. πίεσης PN 10 atm	12.14.01.08	ΥΔΡ 6621.2	μ.μ		10,40	0
ονομ. διαμέτρου DN 140 mm / ονομ. πίεσης PN 10 atm	12.14.01.09	ΥΔΡ 6621.2	μ.μ		13,00	0
ονομ. διαμέτρου DN 160 mm / ονομ. πίεσης PN 10 atm	12.14.01.10	ΥΔΡ 6621.3	μ.μ	1 751,0	15,00	26 265
ονομ. διαμέτρου DN 200 mm / ονομ. πίεσης PN 10 atm	12.14.01.11	ΥΔΡ 6621.4	μ.μ		20,00	
Δικλείδες χυτοσιδηρές, τύπου πεταλούδας, με ωτίδες, με την προμήθεια, μεταφορά επί τόπου και πλήρη εγκατάσταση και δοκιμές - ονομαστικής πίεσης 10 atm	Αρθρο 13.04	ΥΔΡ 6652.1	τεμ	44,0	500,00	22 000
Δικλείδες Εκκένωσης	Αρθρο 13.05	ΥΔΡ-6651	τεμ	9,0	700,00	6 300
Βαλβίδες αερεξαγωγού διπλής ενέργειας	13.09.01	ΥΔΡ 6655.1	τεμ	9,0	800,00	7 200
Πυροσβεστικοί κρουνοί	Αρθρο 13.06	ΥΔΡ-6651.1	τεμ		825,00	0
ΣΥΝΟΛΟ						**92 322**
					Γ.Ε. + Ο.Ε. (18%):	16 618
Οι Συντάξαντες					ΑΘΡΟΙΣΜΑ 1:	108 940
					ΑΠΡΟΒΛΕΠΤΑ (15%):	16 341
					ΑΘΡΟΙΣΜΑ 2:	125 281
					Φ.Π.Α. (19%):	23 803
					ΤΕΛΙΚΟ ΣΥΝΟΛΟ:	149 084

Figure 15: Financial estimate of the project



ZONE Γ
ZONE B
ZONE A
ΔΕΞΑΜΕΝΗ (+44m)
ΞΕΝΟΔΟΧΕΙΑΚΗ ΜΟΝΑΔΑ
ΕΛΑΙΟΤΡΙΒΕΙΟ
A
H=26.00m
ΠΓ=33.93m H20
B
Γ
H=2.00m
ΠΓ=30.29m H20
Δ
H=2.00m
ΠΓ=35.00m H20
E
H=4.00m
ΠΓ=30.14m H20
Θ
H=5.00m
ΠΓ=38.66m H20
H
H=26.00m
ΠΓ=35.00m H20
K
H=20.00m
ΠΓ=35.10m H20
Z
H=4.00m
ΠΓ=25.43m H20
K0
H=20.00m
ΠΓ=38.61m H20
N
H=16.00m
ΠΓ=38.33m H20
Λ
H=4.00m
ΠΓ=36.04m H20
M
H=24.00m
ΠΓ=37.61m H20
D=63mm
336m 0.42L/s
D=63mm
357m 1.89L/s
D=63mm
118m 0.64L/s
D=63mm
311m 2.23L/s
D=63mm
99m 0.05L/s
D=90mm
362m 2.56L/s
D=90mm
D=160mm
333m 11.04L/s
D=160mm
199m 4.36L/s
D=160mm
351m 5.36L/s
D=63mm
463m 1.95L/s
D=160mm
428m 20.16L/s
D=160mm 440m
25.02L/s
D=110mm
76m 4.86L/s
D=75mm
273m 2.78L/s
D=75mm
147m 2.08L/s
ΥΠΟΜΝΗΜΑ
Αγωγός ύδρευσης DN 63 mm, 10 atm
Αγωγός ύδρευσης DN 75 mm, 10 atm
Αγωγός ύδρευσης DN 90 mm, 10 atm
Αγωγός ύδρευσης DN 110 mm, 10 atm
Αγωγός ύδρευσης DN 160 mm, 10 atm
K
Node Symbolism
D=200mm
Pipeline's Diameter
440m
Length of the Pipeline
H=1.00m
Elevation
ΠΓ=39.86m H2O
Piezometric Height

Conclusion

En conclusion, dimensioning the hydraulic network of a village such as Antioparos island in Greece, is a complicated task which, in order to be accurate, needs to take into account numerous factors and make hypothesis about the consumption of water. This resource needs to be taken even more seriously regarding the growing drought in such regions of the world. In this paper, we will make simplified study of the village's water needs so that, in a second phase, we can design the hydraulic network according to its needs and to the existing infrastructures.

This technical report presented various the considerations needed to be taken into account in order to estimate the water needs of the village. Then, the various hydraulic calculations enabling us to dimension the network and pipe characteristics are presented for the grid and the dendritic part. Finally, after characterising the hydraulic pressure and height at each network node, we detailed a budget study for such a project.

Bibliography

[1] *Census Result of population and housing*, **HELLENIC STATISTICAL AUTHORITIES**, ELSTAT, 2021