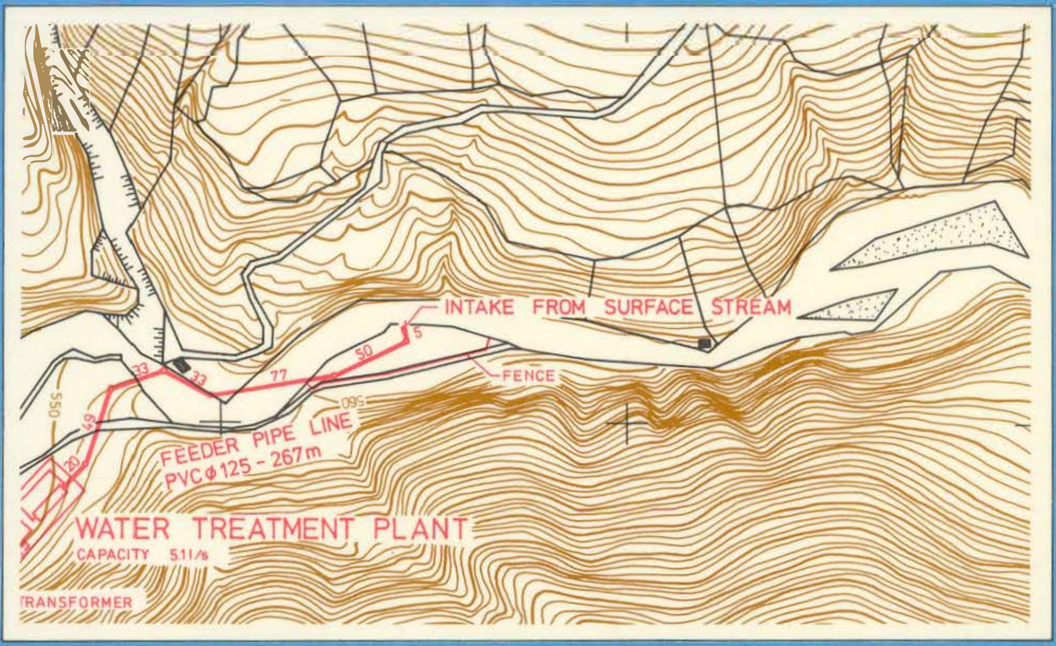
STANDARD MODEL DESIGNS FOR RURAL WATER SUPPLIES



1961–1990

WORLD HEALTH ORGANIZATION
REGIONAL OFFICE FOR EUROPE
COPENHAGEN

Standard model designs for rural water supplies

Prepared in cooperation with
Hydroprojekt Consulting Engineers
Czechoslovakia

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Introduction

Reasons for Standard Model Designs

When the need for a new water supply system is identified *(1)* and the decision is taken to proceed with construction, the first requirement is to design the system *(2,3)*. The design must be hydraulically and structurally sound as well as financially feasible. WHO has previously provided guidance on a range of designs for engineering components useful in rural water supplies *(4)*.

In the case of larger schemes, a firm of consulting engineers is usually employed to do the field investigations, topographic surveys and design work. For smaller schemes, the cost of employing such a firm is too high, and people in the local authority, municipality or water project have to prepare designs and construct the water systems themselves.

Under such conditions, it is too difficult to begin a design from basic principles, and in many cases people qualified to take on such work may not be available. Also, the design details for smaller schemes are often determined by the minimum size of pipe or tank that can practicably be constructed, rather than by criteria such as water consumption, the size of the community and other factors that determine the size of units for larger schemes *(5,6)*. Under such conditions, a standard minimum size reservoir or pumping station can be used in a system that fits the needs of a wide range of populations.

The standard model design approach therefore presents, in easily interpreted forms, a series of designs for the different units in a water supply system; these can be applied and combined in different arrangements, in order to cover as wide a range of situations as possible.

The designs are intended to be used by smaller water enterprises or municipalities to prepare their own schemes with the maximum use of their own engineering and technical capabilities.

This approach also has the advantage of standardizing the equipment used within an area, region or district. This facilitates its operation, and maintains a certain design standard that would be impossible if each community prepared designs to satisfy its own requirements.

As stated earlier, specialized design bureaus are employed to prepare proposals and details of large water supply systems. Also, much work has been done on the design of individual facilities, particularly in the developing world. The World Bank's current studies on individual well technology and handpumps are examples of this.

Little attention, however, has been paid to the needs of medium sized rural communities under conditions that fall between these two categories. This publication is an effort to tackle a part of this problem, or to offer one solution to it. If this question is not addressed, there is a danger that the problems of the least and most developed communities will be resolved during the International Drinking Water Supply and Sanitation Decade (IDWSSD), while the needs of communities at a middle level of development are ignored or overlooked.

Background to Standard Model Designs

The standard model designs presented in this publication were developed within the United Nations Development Programme/WHO-assisted project for community water supply, waste disposal and pollution control in the Socialist Autonomous Province of Kosovo in Yugoslavia (YUG/78/002, YUG/EHP 001). This project was implemented by Hydroprojekt Consulting Engineers, Czechoslovakia, during the period 1974–1977 under subcontract to the WHO Regional Office for Europe, and included a number of elements of water supply and sanitation. Within the water supply master plan for the whole of the Socialist Autonomous Province of Kosovo the standard model design approach was seen as a means of covering as many of the small rural communities in the province as possible and of providing a relatively uncomplicated tool for the provincial authorities to use after the project.

These standard model designs, using one set of criteria, cannot cover every situation, since unit sizes and construction standards must comply with local water regulations, fire-fighting requirements and building codes. The standard model designs described in this publication were developed for certain circumstances and local engineers may have to change the sizes of units to meet specific conditions. The designs of the individual units have possibilities for wider application and the examples of water supply schemes are intended to facilitate their use. In this way the standard model design approach is in accordance with the IDWSSD goal of achievement of full coverage through replicable, self-reliant and self-sustaining programmes.

Socialist Autonomous Province of Kosovo

Although this publication is intended to present one approach to the development of standard model designs for water supply, some basic information on the Socialist Autonomous Province of Kosovo (see Fig. 1) is included to show the general context within which the work was undertaken.

The Socialist Autonomous Province of Kosovo lies in the southern part of the Socialist Republic of Serbia and borders on Albania to the west, the Socialist Republic of Macedonia to the south, and the Socialist Republic of Montenegro to the north-west.

The whole territory covers an area of 10 877 km^2, of which more than 50% lies between 300 m and 700 m above sea level, 27% between 700 m and 1000 m above sea level and the remainder is mountainous with a maximum altitude of 2584 m above sea level.

The climate of the province is mostly continental. The coldest month is January, with an average temperature of – 1.3 °C at Pristina, and the warmest ones are July and August, with an average temperature of 22.8 °C at Prizren.

The average annual precipitation from 1947 to 1971 ranged from 582 mm at Pristina up to 1419 mm at Junik, but the distribution of rainfall throughout the year differed from the west to the east, indicating the increasing influence of the continental climate.

The seismic activity of the territory is relatively high with the possibility of strong tremors.

From the standpoint of water regime, Kosovo lies on a watershed with 51% of its resources flowing to the Black Sea through the Danube, 43% flowing to the Adriatic through Albania via the Beli Drim and 6% flowing through Greece to the Aegean via the Vardar/Axios (see Fig. 2). Because of its location at the very top of three catchment areas, water resources are relatively limited, but in general they are more plentiful in the western Adriatic catchment area, while industrial pollution reduces the source availability of drinking-water in the eastern Danube catchment area. However, the only major river flowing into the province, the Ibar from Montenegro, does contribute a considerable supply of good quality water before pollution at Kosovska Mitrovica.[a]

When the basic studies were made in the mid-1970s, it was estimated that 45% of the people of the province got water from surface water sources and 55% from groundwater. Of the latter group, 65% were supplied from natural springs and 35% from shallow wells.

The population of Kosovo in 1980 was 1.525 million, of which only 26% were urban and 74% were rural or semi-urban. In this context, semi-urban means rural communities that serve as centres for smaller neighbouring communities and provide such services as education and health care. However, from the standpoint of water supply and municipal services they can be treated as rural, particularly since their economies are based on agriculture.

By the end of the IDWSSD in 1990, the population of the province is expected to increase to 1.818 million, with the proportion of rural and semi-urban inhabitants having dropped to 64%. By the year 2000 the population is expected to be 2.1 million, of which 52% will be rural or semi-urban.

Out of the total of more than 1400 rural communities in Kosovo, 12 were finally selected. Standard model designs were prepared for them, using standardized structures. These examples could then be used to apply the approach to the remaining communities.

The selected communities were chosen to cover as wide a range of hydrogeological, topographic and source conditions as possible and the population ranges chosen, from 500 to 4000 people, were intended to cover most of the villages in the province.

From a list of 73 rural communities, 34 were chosen and these were visited in order to gather detailed information for the final selection (see Fig. 3).

A data sheet on each community was prepared for easy comparison of the villages and to compile data for water supply designs. Among the criteria used in selection of the villages to be treated in the study, along with questions of hydrogeology, topography and size, practical aspects such as availability of maps, possible future development and prevalence of enteric diseases were also taken into consideration. The data sheets for each of the 12 selected villages are shown in Tables 1–12 and the distribution of villages in the province is presented in Fig. 4.

Basic Design Criteria

This section does not propose the universal adoption of these basic water supply design criteria for villages or small communities but describes the criteria chosen for the designs made under the particular conditions of the study.

Water demand

A range of criteria used in various European countries for assessing small community requirements were considered in choosing the criteria of the study. If the values selected are considered

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[a] The name Kosovska Mitrovica was changed to Titova Mitrovica in 1980.

inappropriate for any conditions, the scheme designs will still be valid, although the population size can be increased or decreased according to the choice for specific water consumption in individual cases.

After considering various design criteria in current use and allowing for increased demand with time and the anticipated improvement of social conditions, the following specific water consumption figures were used for design purposes.

Population size	Specific daily water demand (Q) in litres per capita per day								
	1980			1990			2000		
	Average	Maximum	k_d^a	Average	Maximum	k_d^a	Average	Maximum	k_d^a
<1000	80	160	2.0	120	220	1.83	160	290	1.8
1 000–10 000	120	200	1.67	170	260	1.53	220	330	1.5

[a] coefficient of daily flow unevenness $k_d = \frac{Q_{maximum}}{Q_{average}}$

After field visits to the villages and rural communities of different sizes, the designers felt that water demand would not rise in all cases to the level anticipated in the basic design criteria. It was therefore decided to introduce a water demand reduction coefficient of between 70% and 90% in such cases. These reduction coefficients were based on individual observations in the communities and also took account of restricted use where the source capacity was a limiting factor.

Water pressure

It was recommended that the maximum operating pressure of between 40 m and 50 m be maintained in the distribution network and that the minimum operating pressure should be above 10 m. These pressure conditions will ensure that water losses from leakage will not be excessive, while pressures do not drop so low as to create a danger of infiltration of groundwater and contamination of the system. However, in some cases slightly higher values were admitted to avoid division of networks into pressure zones.

Water flows

The Colebrook-White formula was used to calculate hydraulic losses and flows in different types and diameters of pipeline. The absolute surface roughness (k) of inside faces of pipe walls was taken as follows:

asbestos-cement pipes	k = 0.4 mm
new cast-iron and steel pipes	k = 1.0 mm
old, slightly encrusted cast-iron and steel pipes	k = 3.0 mm
pipes of plastic materials	k = 0.01 mm

Storage capacity
Water tank storage capacity should balance the unevenness of the daily flow in the network and, moreover, certain volumes should be reserved for fire-fighting. For rural communities a volume of about 50 m^3 seems to be sufficient. It should also cover a temporary breakdown in the water source without substantial restriction of water consumption. Thus, a water tank capacity of 50% of the total maximum daily water demand was considered as a minimum.

Water quality
The valid Yugoslavian water quality standards were compared with the European and International Standards for Drinking-Water issued by WHO in 1970 and 1971, respectively, to set up design criteria for water quality.

References

1. **Cairncross, S. et al., ed.** *Evaluation for village water supply planning.* New York, John Wiley and Sons, 1980.
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3. *Technology of small water supply systems in developing countries.* The Hague, WHO International Reference Centre for Water Supply, 1981 (Technical Paper Series, No. 18).
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6. **Berthovex, P.M. & Stevens, D.K.** Reliability engineering for appropriate environment technology. *In: Environment technology for developing countries.* Istanbul, Bogazici University, 1982.

Fig. 1. The Socialist Autonomous Province of Kosovo

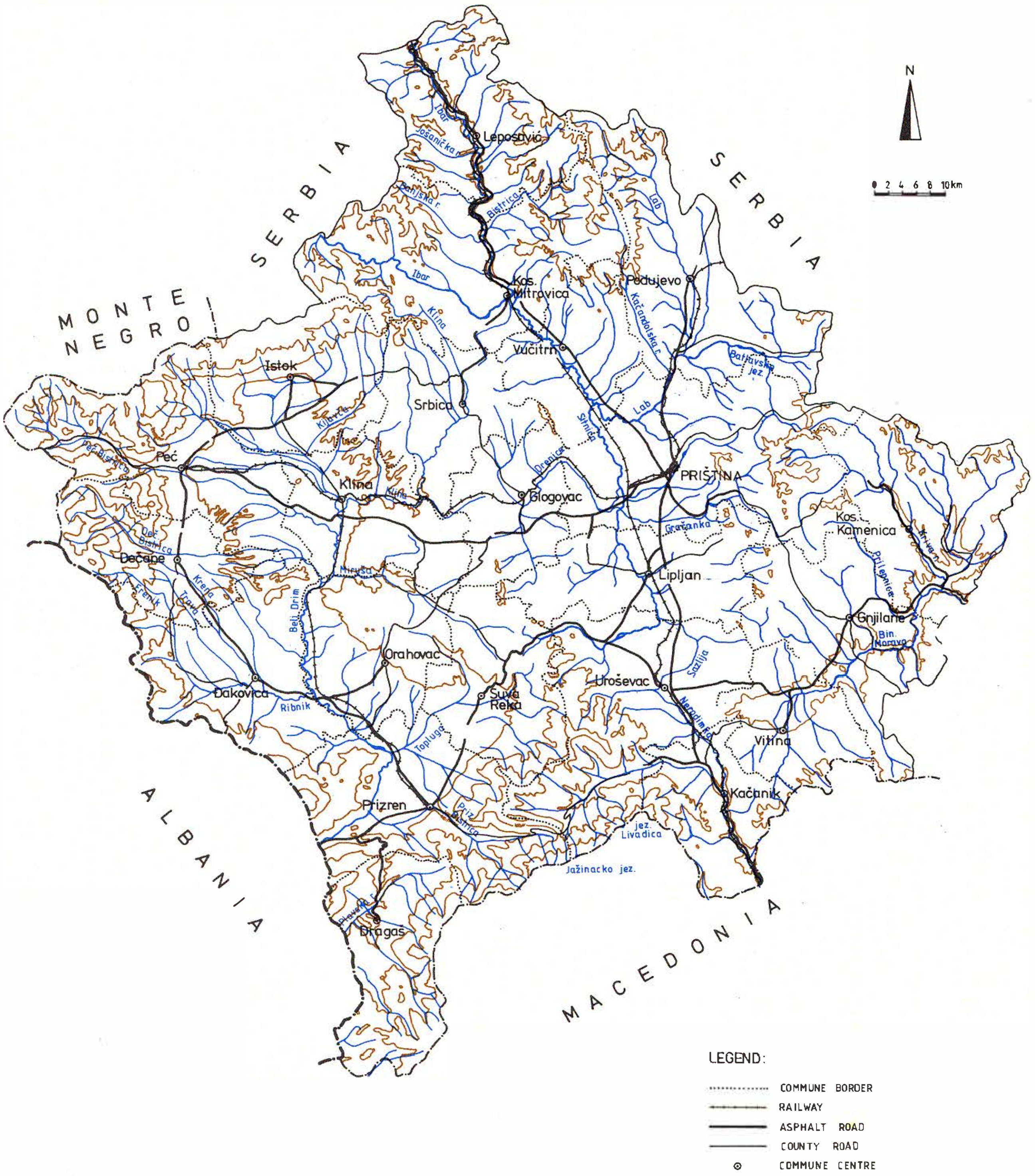


Fig. 2. Kosovo: a natural watershed of river catchment areas

Fig. 3. The selection of communities for standard model designs

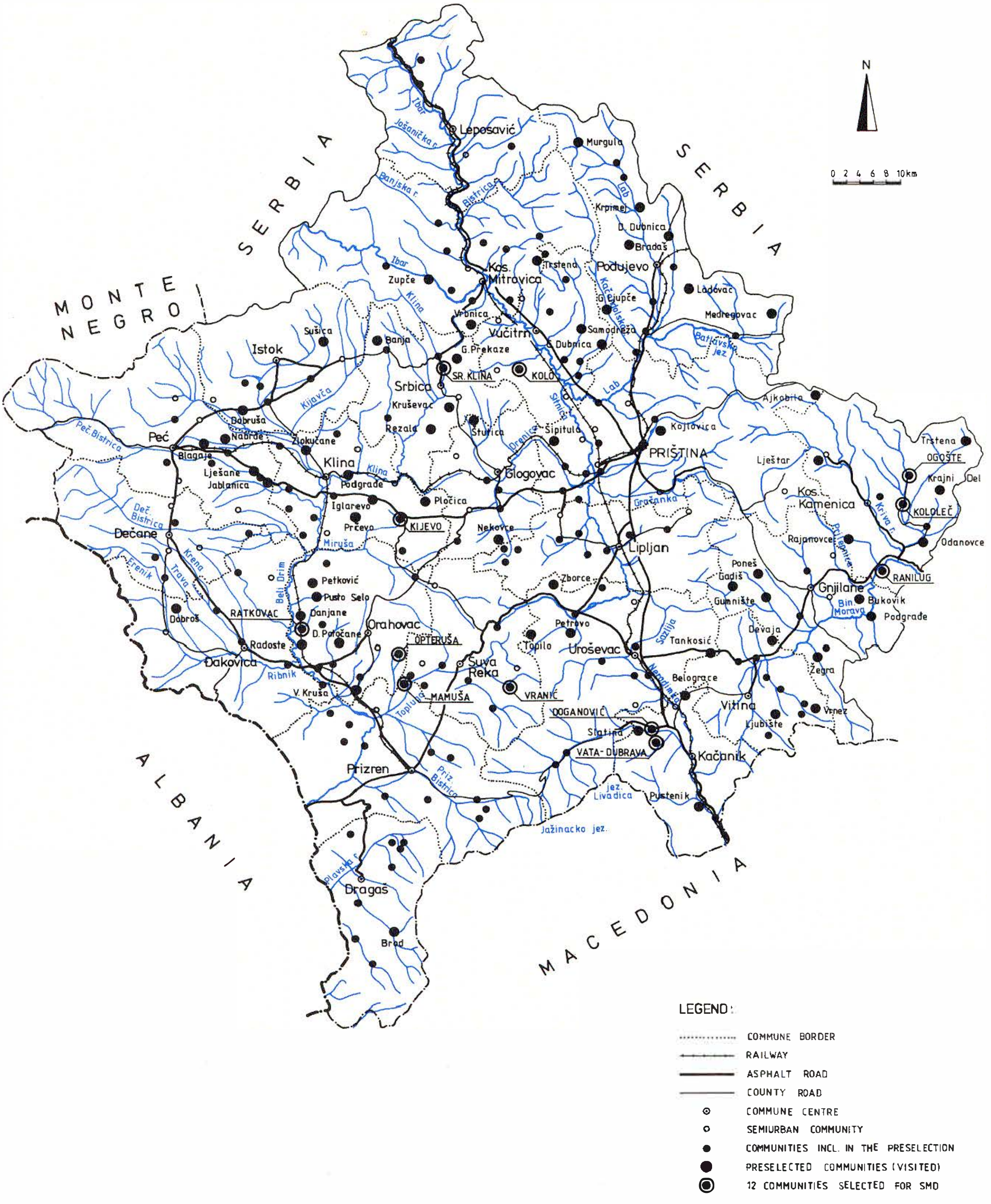


Fig. 4. Communities selected for standard model design application

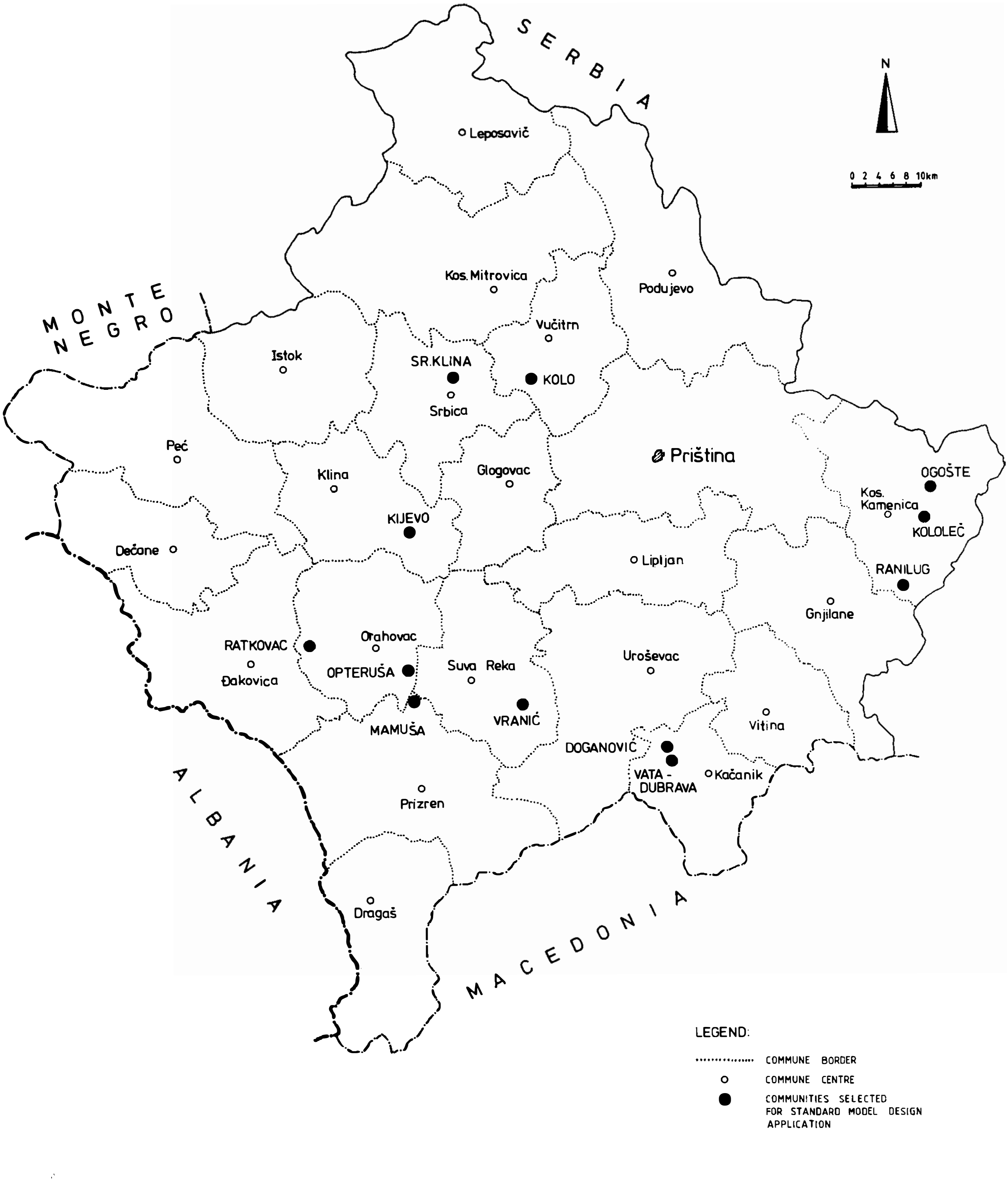


Table 1. Data sheet for Mamuša

1. General data

1.1 Commune	1.2 Community	1.3 Size
PRIZREN	MAMUŠA	4 000 INH.

2. Characteristic data about existing state:

2.1 System of housing:

Concentrated	☒	Partly concentrated	☐	Dispersed	☐

2.2 Data for water pressure zones: (m)

Present houses	max ground level	~ 355. 00	m a.s.l.
	min ground level	~ 325. 00	m a.s.l.
Future houses	max ground level	~ 360. 00	m a.s.l.
	min ground level	~ 325. 00	m a.s.l.

2.3 Facilities with high water consumption description and water demand	~~Yes~~	No
At present:		
In future :		

2.4 Power supply: Yes | Voltage: 10 000 380/220 | ~~No~~

The nearest source of power supply
(short description, voltage)

2.5 Access road to the community:

Turn off point on the main road : PIRANE (PEČ - PRIZREN)

Total distance from the turn off point to the centre of community: ~ 7.0 (km)

Surface of the road from turn off and accesibility during year: MACADAM,
ALL VEHICLES, PERMANENT

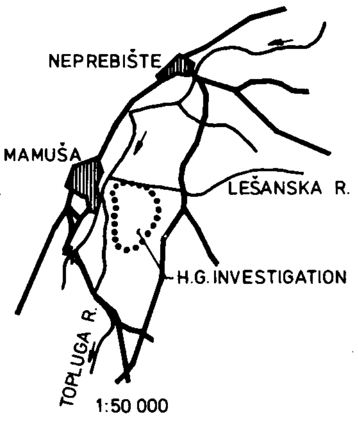
Notes: BASIC SCHOOL ~600 PUPILS - BAD SITUATION IN WATER SUPPLY
SHOP
FARM. COOPERATIVE
SERIOUS DESEASES ARE FREQUENT IN SOME PART OF THE COMMUNITY

Date of visit: 19.6.1974	Experts: CÁBEL, ČULJKOVIČ

3. Potential water sources:

3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimate
Spring			
Deep well	X		
Surface water			
Irrigation canal			
Other source	X		UTILIZATION OF THE SPRING OF STUDENČANE

3.4 Description or sketch of location of the w. source



GROUND WATER AVAILABLE ON THE LEFT BANK OF TOPLUGA RIVER (ALLUVIUM).

PROPOSAL: 1 HYDROGEOLOGICAL BORE HOLE INCLUDING PUMPING TEST (MIN. 7 DAYS) AND 2 CHEMICAL ANALYSES.

Data on existing w. supply: DEEP WELLS IN ALLUVIUM OF TOPLUGA; INVESTIGATION ON W. QUALITY NOT REGULAR (AT PRIZREN RESULTS) W. QUALITY BAD,
DEPTH 8-15 m NO WATER SHORTAGE REPORTED

Notes: ALLUVIUM OF TOPLUGA RIVER, W. SAMPLE AND PUMP TEST IS POSSIBLE, INFORMATION FROM DIRECTOR OF SCHOOL

! 26.10.1974 - SAMPLE TAKEN FROM EXISTING DEEP WELL

Date of visit: 19.6.1974	Experts: CÁBEL, ČULJKOVIČ
17. 7. 1974	KOUŘIL, PLANA
16.10.1974	RIES, CÁBEL, DAVIDOVIČ

Table 2. Data sheet for Ogošte

1. General data		
1.1 Commune KOS. KAMENICA	1.2 Community OGOŠTE	1.3 Size 4 000 INH.

2. Characteristic data about existing state:

2.1 System of housing:

Concentrated	X	Partly concentrated	☐	Dispersed	☐

2.2 Data for water pressure zones:		(m)	
Present houses	max ground level	540.00	m a.s.l.
	min ground level	520.00	m a.s.l.
Future houses	max ground level	540.00	m a.s.l.
	min ground level	510.00	m a.s.l.

2.3 Facilities with high water consumption description and water demand		~~Yes~~	No
At present:			
In future :			

2.4 Power supply:	Yes	Voltage: 10 000 380/220	~~No~~

The nearest source of power supply (short description, voltage)

2.5 Access road to the community:

Turn off point on the main road : D. KORMINJANE (GNJILANE - BUJANOVAC)

Total distance from the turn off point to the centre of community: 17.0 (km)

Surface of the road from turn off and accesibility during year: MACADAM, LORRIES, PERMANENT

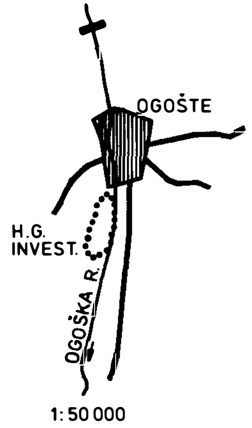
Notes: SECONDARY SCHOOL
HEALTH CENTRE
LOCAL AUTHORITIES OF GOVERMENT

Date of visit: 18.6.1974	Experts: RIES

3. Potential water sources:

3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimate
Spring	X		INSUFFICIENT
Deep well			
Surface water	X	555.00	12.10.1974 - SAMPLING Q = 50 - 60 l/s
Irrigation canal			
Other source			

3.4 Description or sketch of location of the w. source



SOURCE ON THE SLOPE OF THE KITKA HILL UNSUITABLE AND INSUFFICIENT.
POSSIBLE GROUND WATER ON THE RIGHT BANK OF OGOŠKA RIVER (ALLUVIUM) DOWNSTREAM OF THE VILLAGE.

PROPOSAL: 1 HYDROGEOLOGICAL BORE HOLE INCLUDING PUMPING TEST (MIN. 7 DAYS) AND 2 CHEMICAL ANALYSES.

POSSIBILITY OF UTILIZATION OF SURFACE WATER OF OGOŠKA RIVER UPSTREAM OGOŠTE COMMUNITY.

Data on existing w. supply: ABOUT 70% FROM DEEP WELLS, NO INVESTIGATION ON W. QUALITY

Notes: APPROX 4.0 km IN THE NORTH FROM OGOŠTE NEAR KITKA MOUNTAIN SPRING SEEMS TO BE SUFFICIENT FOR W. SUPPLY
OR DIRECTLY FROM THE OGOŠTE RIVER UPSTREAM THE COMMUNITY

Date of visit: 18.6.1974	Experts: RIES
23.7.1974 12.10.1974	KOUŘIL, PLANA RIES, CABEL, DAVIDOVIČ

Table 3. Data sheet for Ratkovac

1 General data

1.1 Commune ORAHOVAC	1.2 Community RATKOVAC	1.3 Size 4 000 INH.

2. Characteristic data about existing state:

2.1 System of housing:

Concentrated	☒	Partly concentrated	☐	Dispersed	☐

2.2 Data for water pressure zones: (m)

Present houses	max ground level	~355.00	m a.s.l.
	min ground level	~335.00	m a.s.l.
Future houses	max ground level	~360.00	m a.s.l.
	min ground level	~335.00	m a.s.l.

2.3 Facilities with high water consumption description and water demand	~~Yes~~	No
At present:		
In future :		

2.4 Power supply: Yes Voltage: 10 000 380/220 ~~No~~

The nearest source of power supply (short description, voltage)

2.5 Access road to the community:

Turn off point on the main road : RAILWAY TUNNEL (ZRZE) AT THE ROAD DJAKOVICA-PRIZREN

Total distance from the turn off point to the centre of community: ~ 6.0 (km)

Surface of the road from turn off and accesibility during year: MACADAM, LORRIES, PERMANENT

Notes: SCHOOL
HEALTH CENTRE
GREAT WATER SHORTAGE REPORTED

Date of visit: 10. 6. 1974 | Experts: RIES, CÁBEL, DAVIDOVIČ

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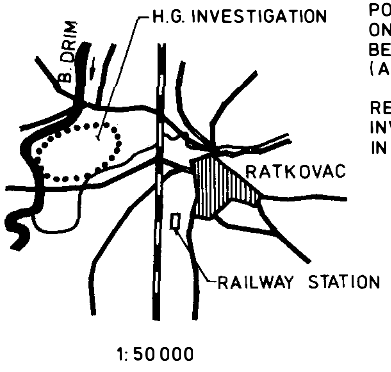
3. Potential water sources:

3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimate
Spring	☐		
Deep well	☒		
Surface water	☐		
Irrigation canal	☐		
Other source	☒		SEE NOTES BELOW

3.4 Description or sketch of location of the w. source



POSSIBLE GROUND WATER ON THE LEFT BANK OF BELI DRIM RIVER (ALLUVIUM).

RESULTS ON HYDROGEOLOGICAL INVESTIGATION PERFORMED IN 1974 UTILIZED.

Data on existing w. supply: PRIVATE DEEP WELLS; ONE PART OF COMMUNITY SUPPLIED FROM COMMON WELL; WATER DISTRIBUTED BY PEOPLE, SHORTAGE OF WATER REPORTED

Notes: CONNECTION TO RADONJIČ SYSTEM RECOMMENDED IN FUTURE

! WATER SAMPLE FROM EXISTING WELL TAKEN ON 26.10.1974

Date of visit: 10.6.1974	Experts: RIES, CÁBEL, DAVIDOVIČ
10.3.1974 26.10.1974	KOURIL, PLANA RIES, CABEL

Table 4. Data sheet for Doganovič

1. General data

1.1 Commune KAČANIK	1.2 Community DOGANOVIČ	1.3 Size 1 500 INH.

2. Characteristic data about existing state:

2.1 System of housing:

Concentrated	☐	Partly concentrated	☒	Dispersed	☐

2.2 Data for water pressure zones: (m)

Present houses	max ground level	~ 570.00	m a.s.l.
	min ground level	~ 560.00	m a.s.l.
Future houses	max ground level	~ 570.00	m a.s.l.
	min ground level	~ 560.00	m a.s.l.

2.3 Facilities with high water consumption description and water demand		~~Yes~~	No
At present:			
In future :			

2.4 Power supply:	Yes	Voltage: 10 000 380/220	~~No~~

The nearest source of power supply (short description, voltage)

2.5 Access road to the community:

Turn off point on the main road : UROŠEVAC - TETOVO

Total distance from the turn off point to the centre of community: 0.1 (km)

Surface of the road from turn off and accesibility during year: MACADAM, PERMANENT

Notes: ADM.CENTRE
SCHOOL
SHOP
HEALTH CENTRE

Date of visit: 25.6.1975	Experts: CÁBEL, DAVIDOVIČ

3. Potential water sources:

3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimate
Spring CRNI KAMEN	☒	912.00	30.7.1974 8 - 10 l/s 6.10.1974 - SAMPLING
Deep well			
Surface water	☒		LENEPAC RIVER
Irrigation canal			
Other source			

3.4 Description or sketch of location of the w. source

UTILIZATION OF CRNI KAMEN SPRING TOGETHER WITH DUBRAVA WATER SUPPLY (FOR SKETCH SEE TABLE 9)

Data on existing w. supply:

Notes:

Date of visit: 25.6.1974	Experts: CÁBEL, DAVIDOVIČ

Table 5. Data sheet for Kijevo

1 General data

1.1 Commune KLINA	1.2 Community KIJEVO	1.3 Size 1 500 INH.

2 Characteristic data about existing state:

2.1 System of housing:

Concentrated	☒	Partly concentrated	☐	Dispersed	☐

2.2 Data for water pressure zones: (m)

Present houses	max ground level	575.00	m a.s.l.
	min ground level	550.00	m a.s.l.
Future houses	max ground level	585.00	m a.s.l.
	min ground level	550.00	m a.s.l.

2.3 Facilities with high water consumption description and water demand	~~Yes~~	No
At present:		
In future :		

2.4 Power supply: Yes Voltage: 10 000 380/220 ~~No~~

The nearest source of power supply (short description, voltage)

2.5 Access road to the community:

Turn off point on the main road : KIJEVO (PRIŠTINA - PEČ)

Total distance from the turn off point to the centre of community: 0.5 (km)

Surface of the road from turn off and accesibility during year: PERMANENT

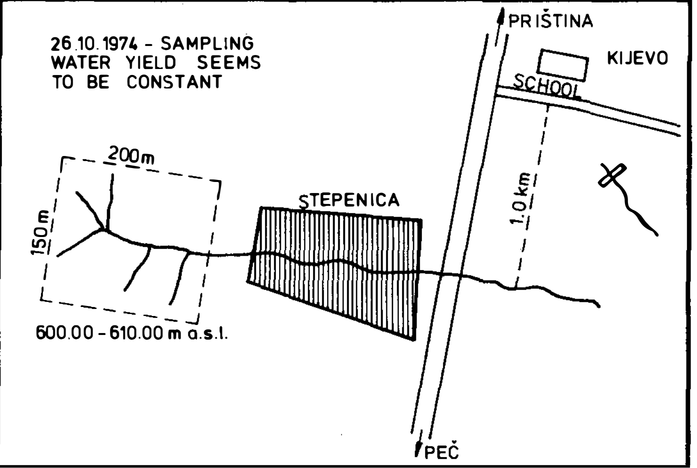
Notes: ADM. CENTRE
BASIC SCHOOL
SECONDARY SCHOOL

Date of visit: 26.10.1974	Experts: RIES . DAVIDOVIČ

3 Potential water sources:

3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimate
Spring	☒	600.00- 610.00	26.10.1974, 4-5 l/s 21 . 1.1975, 2-3 l/s
Deep well	☒		
Surface water			
Irrigation canal			
Other source			

3.4 Description or sketch of location of the w. source


26.10.1974 - SAMPLING
WATER YIELD SEEMS
TO BE CONSTANT

Data on existing w. supply:
SPRING INSIDE THE COMMUNITY.
WATER SHORTAGE REPORTED.

Notes:

Date of visit: 26.10.1974	Experts: WATTERS, RIES, CABEL, DAVIDOVIĆ
21. 1. 1975	KOUŘIL, PLANA

Table 6. Data sheet for Ranilug

1. General data

1.1 Commune KOS.KAMENICA	1.2 Community RANILUG	1.3 Size 1500 INH.

2. Characteristic data about existing state:

2.1 System of housing:

Concentrated	☒	Partly concentrated	☐	Dispersed	☐

2.2 Data for water pressure zones: (m)

Present houses	max ground level	470.00	m a.s.l.
	min ground level	430.00	m a.s.l.
Future houses	max ground level	470.00	m a.s.l.
	min ground level	425.00	m a.s.l.

2.3 Facilities with high water consumption description and water demand		~~Yes~~	No
At present:			
In future :			

2.4 Power supply: Yes | Voltage: 10 000 380/220 | ~~No~~

The nearest source of power supply
(short description, voltage)
INSUFFICIENT FEEDING LINE;
VARIABLE TENSION IN NETWORK REPORTED

2.5 Access road to the community:

Turn off point on the main road : GNJILANE - KOS. KAMENICA

Total distance from the turn off point to the centre of community: 0.5 (km)

Surface of the road from turn off and accesibility during year:
ASPH. ROAD INTO THE CENTRE OF THE COMMUNITY;
ACCESS PERMANENT

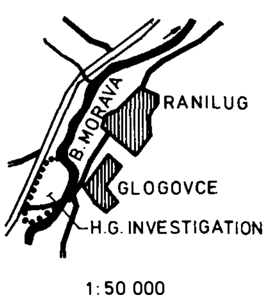
Notes: BASIC SCHOOL
HEALTH CENTRE
RANILUG AND GLOGOVCE ARE SUPPOSED TO BE ONE COMMUNITY IN FUTURE

Date of visit: 18.6.1974	Experts: RIES

3. Potential water sources:

3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimate
Spring			
Deep well	☒		
Surface water .			
Irrigation canal			
Other source			

3.4 Description or sketch of location of the w. source



POSSIBLE GROUND WATER ON THE LEFT BANK OF BINAČKA MORAVA RIVER (ALLUVIUM).

PROPOSAL: 1 HYDROGEOLOGICAL BORE HOLE INCLUDING PUMPING TEST (MIN. 7 DAYS) AND 2 CHEMICAL ANALYSES.

Data on existing w. supply:
WATER SHORTAGE DURING DRY CLIMATIC CONDITIONS;
ONLY 70% OF HOUSES SUPPLIED FROM DEEP WELLS

Notes:

Date of visit: 18.6.1974	Experts: RIES
18.7.1974 12.10.1974	KOUŘIL, PLANA RIES, CABEL, DAVIDOVIČ

Table 7. Data sheet for Opteruša

1 General data		
1.1 Commune ORAHOVAC	1.2 Community OPTERUŠA	1. 3 Size 1 500 INH.

2. Characteristic data about existing state:

2.1 System of housing:

Concentroted	☐	Portly concentrated	☒	Dispersed	☐

2.2 Data for water pressure zones: (m)

Present houses	max ground level	~ 430.00	m a.s.l.
	min ground level	~ 370.00	m a.s.l.
Future houses	max ground level	~ 450.00	m a.s.l.
	min ground level	~ 370.00	m a.s.l.

2.3 Facilities with high water consumption description and water demand		~~Yes~~	No
At present:			
In future :			

2.4 Power supply:	Yes	Voltage: 10 000 380/220	~~No~~

The nearest source of power supply
(short description, voltage)

2.5 Access road to the community:

Turn off point on the main rood : AT ORAHOVAC

Total distance from the turn off point to the centre of community: ~10.0 (km)

Surface of the rood from turn off and accesibility during year: MACADAM, PERMANENT

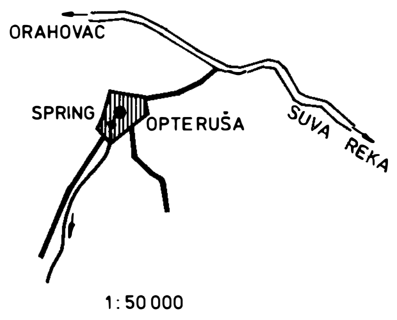
Notes: NO LOCAL GOVERN, OFFICE
BASIC SCHOOL

Date of visit: 19.6.1974	Experts: CÁBEL, ČULJKOVIČ

3. Potential water sources:

3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimate
Spring	☒		40 - 50l/s - 17. 7.1974
Deep well	☐		
Surface water	☐		
Irrigation canal	☐		
Other source	☐		

3.4 Description or sketch of location of the w. source



WATER YIELD OF THE SOURCE IN THE CENTER OF THE VILLAGE SEEMS TO BE SUFFICIENT.
IF USED, SANITARY MEASURES OF THE AREA NECESSARY.

PROPOSAL: MEASUREMENT OF YIELD AND QUALITY

Data on existing w. supply:
DEEP WELLS AND SPRING IN THE MIDDLE OF THE COMMUNITY. WATER QUANTITY AND QUALITY INVEST. RESULTS ARE AT PRIZREN. THE SHORT PERIOD OF TURBID WATER FROM THE SPRING IS FREQUENTLY REPORTED

Notes:

Date of visit: 19. 6. 1974	Experts: CÁBEL, ČULJKOVIČ
17. 7. 1974	KOUŘIL, PLANA

Table 8. Data sheet for Vranič

1. General data		
1.1 Commune SUVA REKA	1.2 Community VRANIČ	1.3 Size 1 500 INH.

2. Characteristic data about existing state:

2.1 System of housing:

Concentrated	☐	Partly concentrated	☒	Dispersed	☐

2.2 Data for water pressure zones: (m)

Present houses	max ground level	~ 680.00	m a.s.l.
	min ground level	~ 600.00	m a.s.l.
Future houses	max ground level	~ 680.00	m a.s.l.
	min ground level	~ 600.00	m a.s.l.

2.3 Facilities with high water consumption description and water demand		[✓ Yes]	No
At present:			
In future :			

2.4 Power supply:	Yes	Voltage: 10 000 380/220	[✓ No]

The nearest source of power supply
(short description, voltage)

2.5 Access road to the community: VERY BAD

Turn off point on the main road : 1km SOUTH. SUVA REKA (SUVA REKA - PRIZREN)

Total distance from the turn off point to the centre of community: ~ 10.0 (km)

Surface of the road from turn off and accesibility during year: ~3km MACADAM, ALL VEHICLES PERMANENT (TO SOPINA)
~7km COUNTY ROAD, TRACTOR, LANDROWER ONLY IN DRY CLIM. PERIOD

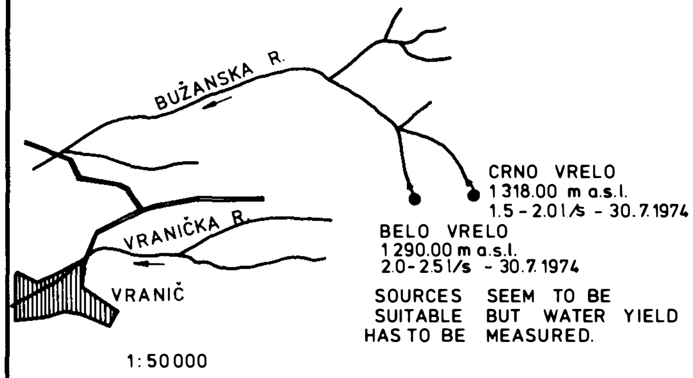
Notes: LOCAL AUTH. AT BUKOŠ (OFF. NEAR SCHOOL);
DETAILED DATA ON FINANCIAL CONDITIONS FOR PROPOSED DRINK. WATER SUPPLY PROJECT AT SUVA REKA GOVERMENT ADMINISTRATION

Date of visit: 28. 6. 1974	Experts: CÁBEL, DAVIDOVIČ

3. Potential water sources:

3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimate
Spring	☒	1 318. 00 1 290. 00	18.10.1974 - SAMPLING
Deep well	☐		
Surface water	☒		
Irrigation canal	☐		
Other source	☐		

3.4 Description or sketch of location of the w. source



SOURCES SEEM TO BE SUITABLE BUT WATER YIELD HAS TO BE MEASURED.

Data on existing w. supply: DEEP WELLS, VRANIČKA RIVER
NO DETAILED DATA AVAILABLE

Notes: SPRINGS BELO I CRNO VRELO, APPROX. 11.0 l/s;
DATA ON SPRINGS AT PRIZREN (VODNA ZAJEDNICA)

Date of visit: 28. 6. 1974	Experts: CÁBEL, DAVIDOVIČ
30. 7. 1974 18. 10. 1974	KQUŘIL, PLANA CÁBEL, RIES

Table 9. Data sheet for Dubrava

1 General data

1.1 Commune	1.2 Community	1.3 Size
KAČANIK	DUBRAVA	500 INH.

2. Characteristic data about existing state:

2.1 System of housing:

Concentrated	☐	Partly concentrated	☒	Dispersed	☐

2.2 Data for water pressure zones: (m)

Present houses	max ground level	~ 700.00	m a.s.l.
	min ground level	~ 600.00	m a.s.l.
Future houses	max ground level	~ 700.00	m a.s.l.
	min ground level	~ 600.00	m a.s.l.

2.3 Facilities with high water consumption description and water demand	~~Yes~~	No
At present:		
In future :		

2.4 Power supply:	Yes	Voltage: 10 000 380/220	~~No~~

The nearest source of power supply (short description, voltage)

2.5 Access road to the community:

Turn off point on the main road : 6km FROM DOGANOVIĆ ON THE ROAD DOGANOVIĆ - TETOVO

Total distance from the turn off point to the centre of community: ~ 2.0 (km)

Surface of the road from turn off and accesibility during year : MACADAM, ALL VEHICLES, PERMANENT

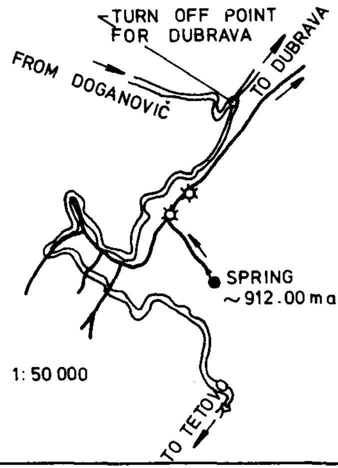
Notes: BASIC SCHOOL
SHOP
ADMIN. AND HEALTH CENTRE AT DOGANOVIĆ;
NO WATERBORNE DESEASES REPORTED

Date of visit: 21.6.1974	Experts: CÁBEL, ČULJKOVIČ

3. Potential water sources:

3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimcte
Spring CRNI KAMEN	☒	912.00	30.7.1974 8-10l/s 6.10.1974 - SAMPLING
Deep well			
Surface water			
Irrigation canal			
Other source			

3.4 Description or sketch of location af the w. source



SOURCE SEEMS TO BE SUFFICIENT.

PROPOSAL:
MEASUREMENT OF YIELD AND QUALITY.

Data on existing w. supply: DEEP WELLS;
W. SHORTAGE REPORTED

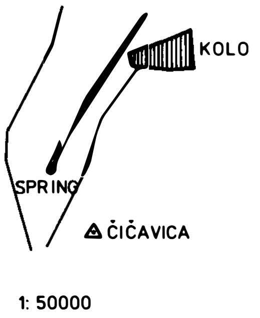
Notes:

Date of visit: 21.6.1974	Experts: CÁBEL, ČULJKOVIĆ
30.7.1974 6.10.1974	KOURIL, PLANA, CÁBEL, KREJCI

Table 10. Data sheet for Kolo

1. General data				
1.1 Commune VUČITRN	1.2 Community KOLO		1.3 Size 500 INH.	
2. Characteristic data about existing state:				
2.1 System of housing:				
Concentrated ☐	Partly concentrated ☒		Dispersed ☐	
2.2 Data for water pressure zones:			(m)	
Present houses	max ground level		645.00	m a.s.l.
	min ground level		590.00	m a.s.l.
Future houses	max ground level		645.00	m a.s.l.
	min ground level		590.00	m a.s.l.
2.3 Facilities with high water consumption description and water demand			~~Yes~~	No
At present:				
In future :				
2.4 Power supply:	Yes	Voltage: 10 000 380/220		~~No~~
The nearest source of power supply (short description, voltage)				
2.5 Access road to the community:				
Turn off point on the main road : VUČITRN				
Total distance from the turn off point to the centre of community:			7.5	(km)
Surface of the road from turn off and accesibility during year:		COUNTY ROAD, ACCESS ONLY IN DRY SEASON		
Notes:				
Date of visit: 26.6.1974		Experts: RIES, DAVIDOVIČ		

3. Potential water sources:			
3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimate
Spring	☒	953.00	SAMPLING 4.10.1974 1.0 - 1.5 l/s 29. 7.1974
Deep well	☐		
Surface water	☐		
Irrigation canal	☐		
Other source	☐		
3.4 Description or sketch of location of the w. source			



SOURCE SEEMS TO BE SUFFICIENT.

PROPOSAL: MEASUREMENT OF YIELD AND QUALITY.

Data on existing w. supply: DEEP WELLS; WATER SHORTAGE REPORTED	
Notes:	
Date of visit: 26.6.1974 29.7.1974 4.10.1974	Experts: RIES, DAVIDOVIČ KOUŘIL, PLANA, RIES, DAVIDOVIČ

Table 11. Data sheet for Kololeč

1. General data		
1.1 Commune KOS.KAMENICA	1.2 Community KOLOLEČ	1.3 Size 500 INH.

2. Characteristic data about existing state:

2.1 System of housing:

Concentrated	☒	Partly concentrated	☐	Dispersed	☐

2.2 Data for water pressure zones: (m)

Present houses	max ground level	500.00	m a.s.l.
	min ground level	470.00	m a.s.l.
Future houses	max ground level	500.00	m a.s.l.
	min ground level	470.00	m a.s.l.

2.3 Facilities with high water consumption description and water demand		~~Yes~~	No
At present:			
In future :			

2.4 Power supply:	Yes	Voltage: 10000 380/220	~~No~~

The nearest source of power supply (short description, voltage)

2.5 Access road to the community:

Turn off point on the main road : D.KORMINJARE (GNJILANE - BUJANOVAC)

Total distance from the turn off point to the centre of community: 12.5 (km)

Surface of the road from turn off and accesibility during year: MACADAM, LORRIES, PERMANENT

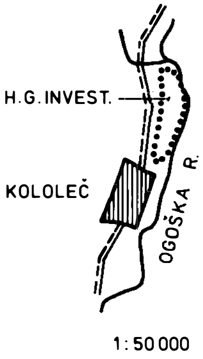
Notes: BASIC SCHOOL
SHOP

Date of visit: 24.6.1974	Experts: RIES, DAVIDOVIČ

3. Potential water sources:

3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimcte
Spring			
Deep well	X		
Surface water			
Irrigation canal			
Other source			

3.4 Description or sketch of location of the w. source



POSSIBLE GROUND WATER ON THE RIGHT BANK OF OGOŠKA RIVER UPSTREAM THE VILLAGE (ALLUVIUM).

PROPOSAL: 1 HYDROGEOLOGICAL BORE HOLE INCLUDING PUMPING TEST (MIN. 7 DAYS) AND 2 CHEMICAL ANALYSES.

Data on existing w. supply: DEEP WELLS; NO INVESTIGATION ON W. QUALITY PERFORMED BEFORE

Notes: ! W.SAMPLE TAKEN ON 12.10.1974 FROM EXISTING DEEP WELL

Date of visit: 24.6.1974	Experts: RIES, DAVIDOVIČ
23.7.1974 12.10.1974	KOURIL, PLANA RIES, CABEL, DAVIDOVIČ

Table 12. Data sheet for Srednja Klina

1 General data		
1.1 Commune SRBICA	1.2 Community SREDNJA KLINA	1.3 Size 500 INH.

2. Characteristic data about existing state:

2.1 System of housing:

Concentrated	☐	Partly concentrated	☒	Dispersed	☐

2.2 Data for water pressure zones: (m)

Present houses	max ground level	700.00	m a.s.l.
	min ground level	625.00	m a.s.l.
Future houses	max ground level	700.00	m a.s.l.
	min ground level	625.00	m a.s.l.

2.3 Facilities with high water consumption description and water demand		~~Yes~~	No
At present:			
In future :			

2.4 Power supply:	Yes	Voltage: 10 000 380/220	~~No~~

The nearest source of power supply
(short description, voltage)

2.5 Access road to the community:

Turn off point on the main road : GORNJA KLINA - SRBICA

Total distance from the turn off point to the centre of community: 0.5 (km)

Surface of the road from turn off and accesibility during year : COUNTY ROAD, PERMANENT

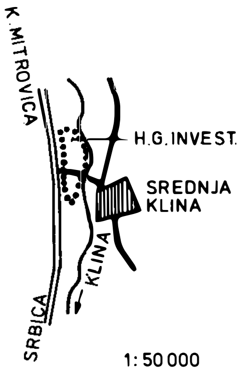
Notes:

Date of visit: 20.6.1974	Experts: RIES, VASIČ

3. Potential water sources:

3.1 Type of source		3.2 Height m a.s.l.	3.3 Capacity estimate
Spring	☐		
Deep well	☒		
Surface water	☐		
Irrigation canal	☐		
Other source	☒		

3.4 Description or sketch of location of the w. source



POSSIBLE GROUND WATER ON THE RIGHT BANK OF KLINA RIVER (ALLUVIUM).

PROPOSAL: 1 HYDROGEOLOGICAL BORE HOLE INCLUDING PUMPING TEST (MIN. 7 DAYS) AND 2 CHEMICAL ANALYSES.

Data on existing w. supply: PRIVATE DEEP WELLS; NO DATA ON QUALITY AVAILABLE

Notes: WATER SAMPLE TAKEN ON 4.10.1974 FROM THE DEEP WELL AT SCHOOL IN G.KLINA; CONNECTION TO SRBICA SYSTEM IS POSSIBLE

Date of visit: 20.6.1974	Experts: RIES, VASIČ
25.7.1974 4.10.1974	KOUŘIL, PLANA RIES, DAVIDOVIČ

PART I

STANDARD MODEL DESIGNS

Standard model designs

Spring Intake Structures

A spring intake structure is an underground structure, usually made of concrete, that collects the water issuing from a natural spring and feeds it into a delivery pipeline. In performing this function, the intake structure must also protect the spring source from contamination and ensure the hygienic quality of the raw water.

Two types of such a structure are presented. Type I is suitable for a spring that emerges in one localized spot, while Type II is designed to cope with one that flows underground over a considerable lateral distance.

Both types concentrate the flow into delivery pipes identically, as seen by comparing sectional plan C-C in Fig. 5 with sectional plan D-D in Fig. 6. However, for Type II a collection trench with permeable filter media must be provided.

The intake structure is also designed to remove sand and other suspended material, and an overflow and drain are included to avoid difficulties when the spring yield exceeds the water demand, as it normally should.

Design consideration

It is particularly important for hygienic reasons that the intake structure be located at an elevation that precludes the possibility of any backflow into the spring. The maximum water level in the collecting compartment of the structure should therefore be about 0.5 m below the level of the natural spring discharge.

The sedimentation compartment of the structure has been designed so that a flow of 10 litres per second will result in a vertical flow velocity of 1.4 cm/s. This will encourage sand and larger particles to settle.

The maximum capacity of the intake structure is 15 litres per second. For higher flows the structure should be adapted by increasing the capacity of the sedimentation compartment, overflow, measuring weir and piping.

Operation and maintenance

As the structure operates, the water issuing from the spring deposits sand in the sedimentation compartment. This should be removed when necessary. The frequency of cleaning will depend on the amount of suspended material contained in the raw water, but monthly checking and cleaning is advisable.

Every six months the outlet valve should be checked by fully closing, opening and then returning it to the desired operating position. Once a year the whole structure should be cleaned and the inside wall carefully disinfected to avoid biological growth.

Data on water quality and yield should be periodically collected and recorded in order to gain long-term information on the spring.

Bored Deep Well

Bored deep wells are designed for the technically effective, safe and economical collection of groundwater for supply purposes. Under normal conditions, these wells can be used for tapping groundwater resources in non-cohesive soil down to a depth of about 20 m. The complete well, including casing, filtration fill and locking lid, is usually constructed during the hydrogeological investigation of a potential source of water. Attention should therefore be paid to its location, distance from buildings, waste disposal structures and land use during the initial hydrological investigations of the site.

Design consideration

The yield of a well or series of wells depends mainly on the hydrogeological conditions, but is also affected by the diameter of the well itself. For example, with an unlowered groundwater depth of 6–7 m and a distance of 30–40 m between wells, a yield of about 2.5 litres per second could be expected from a well with a bored diameter of 600 mm.

The selection of the size of both the borehole and the steel well screen, and the consequent filtration fill thickness, will depend on hydraulic conditions and on the equipment to be installed. The number of layers and the grain size of the filtration fill, and the number and diameter of inlet holes in the well screen depend on the grain size and composition of the aquifer. These dimensions and parameters cannot be set down in the typical designs contained in this publication and will have to be determined on the basis of local hydrological investigation and expert engineering advice. When the machinery is installed it is very important to follow the hydrogeologist's recommendations on the pipe, strainer or submersible pump positions, while taking into account the maximum allowable water level depression and gradual well capacity degradation. The difference between the water level inside and outside the well screen usually increases during the pumping owing to filter clogging.

The bored deep well presented in Fig. 7 consists of the bore itself and the chamber for the installation of the casing head. The well consists of a perforated steel screen, filtration fill and gravel bottom fill.

The well casing head is a flanged steel pipe with an arrangement that allows the pipe to be easily fixed and passed through the blank lid flange and that allows for easy measuring of the water level inside the well. The well chamber is encased in a layer of compacted clay to prevent direct infiltration of surface water to the borehole.

The well chamber over the borehole is constructed either of reinforced concrete with moisture insulation or of water-retaining reinforced concrete, depending on soil conditions. In the roof there are two 60 × 60 cm openings: an access manhole and another directly above the borehole for assembly and maintenance. These are particularly important for the installation of a submersible pump.

The roof slab has a backfill covering, watertight insulation and protective concrete screed or cover.

The access openings have cast-iron or steel covers that can be locked, and a steel ladder is provided for access to the lower floor level.

Concrete slats should be laid flush with the tops of the covers to make a platform on top of the chamber.

Construction sequence

The borehole should be sunk from ground level or from the bottom of the excavation dug to the base level of the well chamber. The vertical bore should be sunk to the required depth, the gravel base should be placed in the borehole, the perforated steel casing installed and the filter gravel surround placed. The casing head of the well should be installed and a layer of clay placed on the bottom of the excavation. The well chamber can then be built.

Operation and maintenance

Bored wells require systematic checking. Particular attention must be paid to the packing of the valves in the well chamber. If it is not done properly, air could be drawn into the main. The water level in the well should be measured periodically and the drop in level checked and recorded in conjunction with the quantity of water pumped from the well. Every two or three years, and certainly at established regular intervals, the well should be completely cleaned. This includes dismantling and cleaning the valves, renewing protective paintwork and removing sand and sludge from the well itself.

Dug Well

The standard dug or shaft well presented in this publication is a vertical concrete structure of circular plan section. It is constructed by digging a pit whose sides are held in place by a casing that is lowered as the work progresses.

Design consideration and construction sequence

This type of well is suitable for extracting water from relatively shallow aquifers with a practical depth limit of about 10 m and a normal range of depths from 4 m to 10 m. Dug wells can also be used as collection wells in the case of wellfields where relatively large quantities of water must be stored at the wellfield.

These wells can normally only be dug in cohesive soils with an angle of internal friction of 25° or more.

The selection of the well diameter depends on the number of suction pipes that must be fitted into the shaft, although a minimum diameter is set by practical excavating limitations. For this reason the well presented in Fig. 8 has a dug diameter of 354 cm, making possible a final internal diameter of 194 cm and allowing two or three suction pipes to be fitted.

The number and size of inlet holes, as well as the grain size of the gravel/sand filter, is determined by the soil characteristics of the aquifer and the yield of water required.

The water table draw-down during pumping must also be determined in order to take measures to avoid filter clogging and to prevent air being drawn into the suction pipes.

These factors can only be determined for each case by a detailed hydrogeological calculation, carried out by a hydrogeologist. For this reason no general recommendations are provided in this publication.

The well casing intended to tap the aquifer is made of plain concrete, standing on a reinforced concrete ring. Inlet holes are provided in the casing.

People gain access to the well by a steel ladder, reached by an access opening of 60 × 60 cm and fitted with a watertight cover.

The roof over the well is of reinforced concrete with a suspension hook set in its centre for attaching lifting tackle for installation and maintenance.

The well lining should be raised above the natural ground level to exclude the possibility of surface water infiltration and consequent groundwater contamination. The height of the well casing above natural ground level may have to be increased if the wellfield is located on a flood plain. This can only be determined by detailed hydrological investigation, although for safety reasons there should be a minimum elevation of about 1 m.

The filter media around the outside of the well casing should consist of graded silica gravel, whose size and grading will depend on the aquifer soil characteristics. Specific guidance on this is essential for each case.

Clay tanking is placed on top of the filter media to seal the well and prevent contamination by surface water. Care should be taken during the digging of the well to avoid interfering with the characteristic permeability and flow of the aquifer, and there should be adequate pumping capacity to maintain a dry working area with stand-by capacity on hand.

The construction of a collection well is considerably more straightforward than that of a captation well. Although their construction is almost identical, the casing of the captation well has no inlet opening and is founded on a reinforced concrete base slab, and the casing is surrounded underneath by ordinary backfill rather than filter media, to make the structure watertight. Both types of well are shown in Fig. 8.

There are suction pipes in the captation well only. They are fitted with flap valve type strainers to prevent backflow. The upper flange of the strainer must be submerged at least 60 cm below the minimum water level to avoid the possibility of air suction. The inner diameter of the suction pipe should be designed so that the flow velocity does not exceed 1 m/s during pumping or siphoning.

In the collection well, the end of the siphon pipe should also be located 60 cm below the minimum water level. The pipework in a captation well has no valves, although in a collection well the siphon pipelines have valves to allow flow adjustment. These valves should be of a type suitable for vacuum flow conditions.

Operation and maintenance

Like bored wells, dug wells require systematic checking, with special attention to the packing of pipe joints, valves and fittings in order to prevent air from entering the system and interfering with operations.

In captation wells periodic measurements of water level are necessary, and logs should be kept so that changes in well performance can be identified and monitored.

Every two or three years both types of well should be thoroughly cleaned. The fittings should be dismantled, cleaned and reassembled or replaced as necessary and all paintwork renewed.

Pumping Stations

Pumping stations in water supply systems are designed to deliver water to a water tank or to distribution systems either where no natural gravity head is available or where it is insufficient to provide the necessary flow under minimum head conditions.

Apart from the fundamental piping equipment, a pumping station includes, in many cases, water hammer protection equipment, air release devices, valves and electrical equipment. It is commonly the most suitable location for disinfection equipment, when solution of sodium or calcium hypochlorite is to be used.

Design consideration

The pumping stations presented in this publication are designed for automatic pumping from bored wells, captation dug wells or collection dug wells, and for pumping from a wet sump that is part of the pumping station itself.

Three basic types of pumping station are included with two variations of each: Types 1.1, 1.2, 2.1, 2.2, 3.1 and 3.2. The first number of the type refers to the mechanical equipment installed in the pumping station, while the second number indicates whether the pumping station has a wet sump. The detailed characteristics are as follows.

Type 1. Pumping, chlorination, air release and water hammer protection

Type 1.1 is a pumping station without a wet sump, containing pumping machinery, water hammer protection equipment, an air release device and chlorination equipment.

Type 1.2 is a pumping station with a wet sump and the same auxiliary equipment as contained in Type 1.1.

Type 2. Pumping, chlorination and air release equipment

Type 2.1 is a pumping station without a wet sump and with the same auxiliary equipment as in Type 1.1, with the exception of water hammer protection.

Type 2.2 is a pumping station with a wet sump and the same auxiliary equipment as Type 2.1.

Type 3. Pumping and chlorination

Type 3.1 is a pumping station without a wet sump containing pumping machinery and chlorination equipment only.

Type 3.2 is a pumping station with a wet sump and the same auxiliary equipment as Type 3.1.

All these types of pumping station, with and without wet sumps, are presented in Fig. 9 and 10, while the different machinery arrangements are shown in Fig. 11, and the basic data on the electric system in a single line diagram in Fig. 12.

The pumping stations have been designed to cover a capacity range of 0.5–5 litres per second, with a possibility of increasing capacity to 10 litres per second at a later date without expanding the structure; only the pumps and motors would have to be upgraded. A total delivery head of 85 m is allowed in pumping mains, since this was considered to be the normal and practical upper head limit for smaller supply systems. If a greater lift is required for specific schemes, two pumping stations could be used.

The machinery is designed on the basis of the total output required and the calculated delivery head, while the need for water hammer protection is determined on the basis of the hydraulic analyses of the system. An air release device is included and connected to the system when the pumps are not self-priming.

The chlorine dosing equipment design depends on the flow of water and doses of chlorine needed to provide the requested residual chlorine level in the whole system.

Where pumping stations are intended for future expansion, the auxiliary equipment should be designed for the stations' ultimate capacities, to avoid too many modifications when upgrading the pump sets. This would require very little increase in the initial investment.

Calculations dealing with pumping and water hammer damping are presented in Fig. 13. This also gives some basic instructions on calculation progress that have been simplified and modified appropriately for the standard designs for rural communities.

Construction details

For pumping stations without wet sumps, Types 1.1, 2.1 and 3.1, the walls and the base of the valve space are constructed of plain concrete. The base is laid on a blinding layer, while the outer walls are provided with a waterproof bitumastic coating. Care should be taken during backfilling to avoid damaging this insulation. The inner walls of the valve space are made with cement plaster and the floor set in slope towards the drainage outlet in one corner. The roof slab of the valve space is constructed of reinforced concrete provided with a 60 × 60 cm access opening with a cover. The foundations and footing under the peripheral wall of the building, protection wall and pump foundations consist of plain concrete, while the floor of the machine room is made of concrete strengthened with a reinforcing mesh to avoid cracking. All floors should be laid on a blinding layer and insulated against damp with a bitumastic coating.

In the case of pumping stations with wet sumps, Types 1.2, 2.2 and 3.2, the floors and walls of the wet sump and valve space should be constructed of water-resistant reinforced concrete. The floor should be cast onto a damp-course layer on a blind layer of concrete. The outside of the walls below ground level should also be covered with a bitumastic coating.

The floor slabs of both the valve chamber and wet sump are benched; in the case of the valve chamber the slope is set towards the drainage outlet while in the case of the wet sump the slope is towards the pump suction.

The floors of the pumping station should be covered with fire-clay tiles, except in the auxiliary supplies store-room where a cement screed should be laid. The inside walls should be of cement-lime plaster.

The walls of both the valve space and wet sump should be plastered for a good appearance and, in the case of the wet sump, to keep suspended matter from adhering to the wall as the water level drops. The walls above ground level are built of cavity brick (38 cm thick), with the outer skin of facing brick or plain brick, and plastering depending on availability of material and the appearance desired. Partition walls are 12 cm thick and made of plain brick, and the window lintels are formed by the ring beam supporting the roof.

On three sides of the roof a peripheral brick wall is proposed, 45 cm high, with the roof screeded and sloped towards the open side to facilitate roof drainage to the rear of the building. A 60 × 60 cm access opening with a cover and an access ladder is provided for both the wet sump and the valve chamber.

Thermal and watertight insulation should be laid on the cement roof screed, and the windows can have steel, wood or aluminium frames depending on the availability and cost of materials.

The door can be of steel or timber, according to preference and security considerations.

The roof gutter and down conductor, flashings and the cover to the brickwork roof surround should be of zinc sheeting, and all steel and woodwork should have a protective paint coating.

If an aeration station is incorporated into the system, an additional door between the pumping station and the aerator should be included in the building.

During construction the foundations can be dug with excāvation machinery, although the diggers must avoid disturbing the finished bottom. Also, after construction and before backfilling, the valve space and wet sump should be hydraulically tested and leaks repaired.

Mechanical equipment

The pumping sets are designed according to the required flow and delivery head. For flows of 0.5–2.5 litres per second, self-priming pumps are recommended wherever possible although, because of reduced efficiency, non-self-priming pumps should be used for higher flows.

If the supplier can offer self-priming pumps with over 40% efficiency to cater for higher flows, these should be used, as they are particularly advantageous in a pumping station with a wet sump below the pump axis. These pumps also eliminate the need for automatic air release equipment.

For flows in the range of 0.5–5 litres per second, water hammer protection equipment is recommended only in exceptional cases with very high delivery heads. With flows of 5–10 litres per second, each set of conditions has to be analysed separately, and if the hydraulic analysis indicates the need, the equipment should be included in the design.

The building layout proposed for the pumping station allows for the installation of a pressure vessel of a maximum capacity of 1 m^3 and a space for a compressor with a capacity of 15 m^3/h of air and pressure of 1 MPa. This size equipment is small enough to be standard for all cases that require water hammer protection to be included in the design and yet is large enough for most small water supply systems.

In cases where an automatic air release is required, such as in pump impeller flooding and automatic operation of a pipe siphon system, a vacuum pump and air vessel of about 150 litres, with an electrode of the float type for automatic priming control, should be installed. The minimum water level in the air vessel must be fixed above the pump impeller in any case.

Where the actual pumping conditions do not call for complete automation and pumping is supposed to be continuous, the automatic air release equipment can be deleted and reliable flap valve type strainers should be fitted on the pump suction pipes.

The actual model to be installed depends on the flow of water, and the dissolving tank should be large enough to hold enough chemical for 10 days. This allows the tank to be filled once a week, with a few days' reserve for emergencies.

The dosing pipes can be connected to the pump suction pipes with a special type of non-return valve that automatically closes when suction is lost and the pump is out of operation. This system is used in conjunction with self-priming pumps.

When the pumps are not of this type and an automatic air release device is used to keep the pump impeller flooded, the dosing pipes should be fitted with a solenoid valve that automatically closes when the pump stops, thus preventing chlorine overdosing.

Résumé of machinery specifications

Pumps

Two horizontal centrifugal pumps are required, one operating and one as stand-by, of a capacity of 0.5–5.0 litres per second each and a maximum total delivery head of 85 m. The pump and electromotor should be mounted on a common base plate.

Sodium hypochlorite dosing equipment

One doser of required flow range is needed with a dissolving tank of 10-day capacity or 100 litres, whichever is larger.[a]

Automatic air release device (when necessary)

One air pump is required, with an air vessel having a volume of about 150 litres, fitted with a float or electrode type automatic control system and water circulating tank, if necessary, of about 30 litres capacity.

Water hammer damping device (when necessary)

One air compressor is required, with a capacity of 15 m^3/h of air to be compressed to the pressure of 1 MPa and an air vessel with a capacity of about 1 m^3 designed for the same pressure.

Drainage pump (where drainage by gravity is not possible)

A membrane or piston hand-operated pump or portable electric-driven submersible sludge pump, with a capacity of 2 litres per second and a delivery head of up to 10 m to be connected to the socket box in the station switchboard, is required.

Pipes and fittings

The following are required: steel suction and delivery pipes of 50–150 mm diameter, with flanged connection for the pressure of 1 MPa and a total length of about 30 m; air release pipework and fittings of $^3/_4$ inches (19 mm) diameter, made of galvanized steel with screwed joints, of about 30 m of total length; and chlorine dosing pipework of 15 mm diameter, made of PVC or similar material, with shut-off, non-return and/or solenoid valves and a total length of about 10 m.

Electrical equipment

The machinery of the pumping station is supplied by a 3-phase, 380/220 V, 4-wire, 50 Hz system with a solidly earthed neutral. For lighting and power sockets a single-phase, 220 V, 50 Hz supply system and for the portable light fitting a 24 V, 50 Hz system are proposed.

Its capacity, when installed, should be 45 kW without aeration equipment, and about 72 kW when aeration is included; the calculated maximum loads are 20 kW and 38 kW, respectively. The annual power consumption will depend on the size of the pumps and water delivery capacity. The electrical installation is proposed for the maximum current intensity of 10 kA. The system is protected against short circuits by neutral earthing to ensure the safety of personnel.

The pumping station should be supplied by a single feed cable from the nearest low voltage distribution line or, preferably, through a transformer station from a high voltage supply, especially when aeration is included.

The power socket box in the pumping station switchboard should contain a 3-phase, 380 V/25 A socket for a portable sludge pump connection, a single-phase 220 V/10 A socket and 24 V supply from a 100 VA, 220/24 V transformer for a portable lamp connection.

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[a] A complete spare sodium hypochlorite doser should be kept in reserve for easy and quick replacement of a faulty doser.

The building will be protected from lightning by an earthing mat to which all outer metal parts of the building are connected, although in less cohesive soil, earthing rods may have to be used to obtain the necessary resistance.

The pumping room should be well lit and should be heated where climatic conditions dictate with infrared heaters located so as to warm equipment susceptible to gathering condensation, such as pressure vessels and water tanks. A cable and lighting installation is shown in Fig. 12.

The power cables should comply with prevailing building and safety standards and be insulated with PVC. Copper conductors should be used for cross-sections of up to 6 mm^2 and aluminium conductors used for larger cross-sections. Power cables and conductors on walls and ceiling should be installed by clips or on cable trays, while cables on the floor should be passed through steel cable ducts.

For power-factor compensation, no provisions are made for motors of an output less than 4 kW, while for motors with outputs of 4–7 kW condensers of 2 kVAr will be used, and for motors of 8 kW and 9 kW the condensers should have 4 kVAr capacity. If pumping stations are to be expanded in the future to 20 kW, capacity condensers of 5–9 kVAr will be required. The condensers should be fire-proof and located in the main switchboard.

The station will have a main switchboard and a secondary switchboard should be provided in the aeration station when aeration is required. The switchboard will have provision for two pump control switches of 1–9 kW capacity each, an air compressor control of 3 kW capacity, a socket control box, a lighting circuit control and the control for two infrared heaters. This will give a total installed capacity of 45 kW with an estimated load of around 20 kW. If an aeration station is included in the system, its secondary switchboard will be connected through the main switchboard. This will add a further 27 kW to the installed capacity and 18 kW to the calculated load. Thus, the total installed capacity in that case would be 72 kW with a calculated load of 38 kW.

If the load on the switchboard is increased by 20 kW owing to increase in flow and corresponding enlargement of the machinery, the switchboard must be replaced or upgraded.

The main switchboard, consisting of two box units with overall dimensions of 1.6 × 0.7 × 2.2 m, should contain the following main equipment (see Fig. 12):

- 1 three-phase/100 A circuit breaker for the switchboard feeding line;
- 2 three-phase/25 A contactors for the pumps;
- 2 three-phase/16 A contactors for the compressor and vacuum pump;
- 1 single-phase solenoid valve outlet for automatic chlorine dosing;
- 2 three-phase/25 A fused outlets for the socket box and spare outlet;
- 1 single-phase/6 A circuit breaker for the lighting;
- 3 single-phase/10 A circuit breakers and 2 spare outlets for the infrared heaters; and
- 1 three-phase/50 A fused outlet for the aeration station connection.

Auxiliary material for the equipment installation includes cables, steel supports and clamps, iron-zinc earthing strips, wires and material for lighting.

Operation and maintenance

The operation and maintenance instructions provided by the manufacturers for each item of equipment must be followed, and the pumping station must be kept orderly and clean. The pump sets must operate alternately, according to a predetermined schedule, to ensure uniformity of operation and opportunities for servicing and maintenance.

When a self-priming pump is installed, someone should check, before starting it, that there is sufficient water in the first stage of the pump to ensure operation of the self-priming system.

When air release equipment is included, the circulating water tank should be regularly checked and topped up as necessary, and air lines should be tested for leaks.

The water hammer protection equipment should maintain the required pressure in the air vessel. However, if a non-automatic system is chosen, the air pressure must be regularly checked and brought up to the correct value if found to be low. The compressor lubricating oil level should also be regularly checked.

Apart from carefully following the manufacturers' instructions about disinfection equipment, the tightness of the non-return valve on the sodium hypochlorite solution inlet to the pump suction, or the solenoid valve function, must be checked to avoid the possibility of the solution being lost to the suction when the pumps are not running.

Aeration Station

An aeration station is necessary for systems where the raw water, mainly from underground sources, has a very low dissolved oxygen level or contains substances such as manganese and iron or a high concentration of carbon dioxide. When iron and manganese are to be removed, the aeration is followed by rapid sand filtration to remove the iron flocs. Moreover, for manganese removal it is advisable to dose the water with potassium permanganate ($KMnO_4$) before filtration. In each case, the treatment process for iron and manganese removal should be set up with the close cooperation of a chemist in order to prepare an economical and sound design.

Design consideration

The standard aeration station is a mechanical aerating device that works by pumping raw water into a mechanically ventilated spraying chamber.

The proposed station can handle flows of up to 10 litres per second and is designed to be used in combination with the standard pumping station described earlier. The designed maximum surface loading of the aeration is 30 m^3 of water per hour per m^2 of aerator cross-sectional area, while the ventilation system should provide 60 m^3 of air per hour for each 1 m^3 of aerated water.

The total hardness of the water to be treated should not be less than 90 mg/l calcium carbonate ($CaCO_3$), and the content of iron should be below 6 mg/l.

The structural arrangement of the aeration station is presented in Fig. 14 and the arrangement of the mechanical equipment is shown in Fig. 15.

Construction details

The foundation structure, including the pumping set blocks, is constructed of plain concrete with an underlying damp-course protection. The floor of the pumping room should be covered with fire-clay tiles, while that of the aerator compartment should be of screeded cement mortar.

The masonry walls above ground level are of 38 cm thick brickwork with either facing brick or a plaster finish on the outside, while the partition wall is 12 cm thick and of common brick. The window lintels are formed by the roof ring beam of reinforced concrete that is continuous with the roof slab. The internal walls of the building are of plastered cement. The roof has a felt/bituminous waterproof covering while the doors, windows, roof parapet and flashing are made to match those in the pumping station.

Mechanical equipment

The mechanical equipment in the aeration station (see Fig. 15) consists of two centrifugal pumps and a spraying chamber, or aerator, with a pump of the same capacity as that in the pumping station. Aeration pumps can be omitted from a bored or dug well. Then, the delivery heads of the pumps in the well will have to be upgraded to cover the required spraying pressure of about 0.25 MPa, the equivalent of 25 m of water column, and the water will be pumped directly to the spraying chamber. The pipework in the aeration station should be adapted accordingly.

The capacity of the spraying chamber may be increased as water demand grows by upgrading the delivery pumps. All main piping should be steel-flanged, and the air lines should be of galvanized threaded steel piping.

All machinery and pipework in the aeration station should be of galvanized steel or painted with an anti-corrosive coating.

There is a 500 × 500 mm opening in the wall of the aeration room, fitted with an air filter and fine-netting insect screen to clean the air being drawn into the station.

Résumé of machinery specifications

Pumps

Two horizontal centrifugal pumps are required of 0.5–5.0 litres per second capacity each, one as a stand-by, for a total delivery head of 25 m.

Spraying chamber

One steel chamber with spraying equipment is required, with a maximum capacity of 10 litres per second, fitted at the top with an axial screw type electric-powered ventilator of 0.26 kW.

Pipes and fittings

The main suction pipe is 80–125 mm in diameter, depending on the capacity of the station, and made of steel, as are all the adaptors, fittings, flanges and valves, while the pump delivery pipe measures 80–200 mm in diameter. The steel pipes and fittings from the spraying chamber to the pumping station wet sump are 150 mm in diameter.

Electrical equipment

The main power supply to the aeration station should be a 3-phase, 4-wire, 380/220 V, 50 Hz system with a solidly earthed neutral, light installation and the following power sockets: one 3-phase 380/25 A socket, one single-phase 220 V/10 A socket and a 24 V supply fed from a 100 VA, 220/24 V transformer.

The total capacity of the installed aeration station is 27 kW with a calculated load of 18 kW.

The aeration station is controlled from the main pumping station switchboard. It is protected from lightning by the system serving the pumping station.

The machine room is provided with one infrared heater to protect the pumps. Two such heaters should be installed to heat the spraying chamber. For the location of all equipment, lighting and cables see Fig. 16.

The switchboard, consisting of one metal box with overall dimensions of 1.0 × 0.7 × 2.2 m, should contain the following main equipment (see Fig. 16):

- — 1 three-phase/50 A circuit breaker for the switchboard inlet;
- — 2 three-phase/16 A contactors for the aeration pumps;
- — 1 three-phase/10 A contactor for the ventilator;
- — 2 three-phase/25 A fused outlets for the socket box and spare outlet;
- — 1 single-phase/6 A circuit breaker for the lighting;
- — 3 single-phase/10 A circuit breakers (1 for the infrared radiator and 2 spare breakers).

Auxiliary material for equipment installation includes cables, steel clamps and other cable supports, iron-zinc earthing strips, wires and material for lighting.

Operation and maintenance

For operation and maintenance, the instructions of the manufacturers should be followed for each item of equipment installed. The aeration station should be kept orderly and clean. The aerator itself does not require any specific maintenance, only periodic cleaning of the walls and regular recoating with protective paint. The spray jets should be regularly checked; they should be cleaned, adjusted or replaced as necessary.

Once a month the air filter in the wall ventilator should be checked and cleaned, while snow may have to be removed and anti-freeze fluid applied in winter to avoid freezing.

Once a year, all equipment, including the pipework, should be dismantled, checked, cleaned and repainted; any worn parts should be replaced and a new air filter should be installed in the wall ventilator.

Water Main Ancillary Chambers

Some ancillary structures are required on the water pipelines. These standardized structures include: a pressure head breaking chamber, air and drain valve chambers and a measuring chamber.

Pressure head breaking chamber

The pressure head breaking chamber is normally intended for use on mains between the source and the main water tank. It dissipates kinetic energy, and creates a free surface condition so that there are no excessive pressures in the downstream main. The chamber also releases air and therefore, where flow conditions allow, it should be located at peak points on the main.

Design consideration

The structure as presented in Fig. 17 is intended for flow rates of up to 15 litres per second. If higher flow rates are to be handled, the capacity of the inlet chamber has to be increased but otherwise the design remains unaltered. Of course, the pipe diameters in each system will depend on hydraulic calculation.

Operation and maintenance

The water enters the chamber through an inlet pipe that terminates in a T-piece. This is submerged about 50 cm below the top water level to help dissipate the excessive kinetic energy of the incoming flow.

From the inlet chamber the water passes over a weir to the outlet chamber. From there it flows through an outlet pipe to the next stretch of the main. The water flow is not controlled and excess water overflows into a drain.

The design allows both the inlet and outlet chambers to be drained with hand-operated valves.

For air release, an air pipe is installed downstream of the control valve on the outlet pipe.

The maintenance checks for the pressure head breaking chamber are the same as for the spring intake structure: a monthly inspection to check for structural damage and to remove any sediments from the inlet chamber, cleaning and checking the valves every six months and emptying and disinfecting the chamber each year.

Air valve chamber

The suggested air valve chamber is a simple manhole type of structure where an automatic air valve and hand-operated sluice shut-off valve are located.

Design consideration

This chamber, presented in Fig. 18, should be located at high points on the water main where no other special structures are required or located. Pressure head breaking chambers or fire hydrants can also satisfy the air release function, in which case the special air valve arrangement is not required. The relation between the air valve diameter and the diameter of the water main is shown in the table in Fig. 18.

Although a land drain is provided for the chamber, the cover should be located approximately 60 cm above the surrounding ground level so that surface water does not collect in the manhole.

Operation and maintenance

The air valve chamber and its valves and fittings should always be kept dry and clean. They should be checked every three months to avoid water leakage and to prevent flooding of the chamber. If the latter happens, the supply system may be contaminated, especially if the main is emptied. It is therefore important to keep the land drain functional.

The cover of the chamber should be locked to avoid unauthorized access.

Drain valve chamber

The drain valve chamber is a structure designed to contain a hand-operated valve that empties sections of the water main. It is therefore located at the lowest points on the water main.

Design consideration

The drain valve chamber as proposed in Fig. 19 can be used for mains up to 200 mm in diameter, with a maximum drain-pipe diameter of 80 mm. These are large enough for most small water supply systems. Where special conditions exist, such as a certain time limit for emptying the pipeline, the drain-pipe diameter can be set by a detailed hydraulic calculation.

The pipe arrangements are presented in two types. Type I, with one valve, is suitable for a system in which both the main pipeline and the drain valve chamber can be drained by gravity into a watercourse. Type II, with two valves, is suitable for a system in which the main can be emptied partly by gravity but the rest of the water must be drained through a branch valve into the chamber and pumped by a portable pump into the nearest watercourse.

The valves can be operated by extended valve spindles from the top of the chamber.

Operation and maintenance

The operation and maintenance of this structure are similar to those of the air release chamber. The watertightness of Type II pipes is important and should be checked periodically.

Measuring chamber

The measuring chamber is designed to house a water-meter.

Design consideration

The measuring chamber presented in Fig. 20 contains a water-meter up to 100 mm in diameter. With a screw water-meter 50–100 mm in diameter, a measuring range of about 1–60 m^3/h can be covered, with a measuring accuracy of about 2%.

The inside chamber size of 1.8 × 4.0 m is also sufficient for a bypass installation. The valve arrangement meets the requirements for the minimum straight pipe length. This should equal 10 times the nominal instrument diameter upstream of the water-meter and 6 times the nominal diameter downstream of the meter.

The chamber should be easily accessible and provided with a land drain and a steel cover that can be locked.

Operation and maintenance

The chamber should be kept dry and clean and the valves and meter should be checked periodically. The meter should be read every month, or more frequently if necessary. After the guarantee period of the water-meter (usually four years) expires, a new meter should be installed and the old one sent away for cleaning, repair and testing.

Sedimentation Tank

The sedimentation tank is designed for the removal of suspended particles from the raw water and can treat the water in small treatment plants before slow or rapid sand filtration. When it is the only mechanical treatment unit, its capacity is 3–5 litres per second. This can be doubled by the application of a coagulant, but the actual capacity in this case will depend on the raw water quality and the characteristics of the suspended material.

Design consideration

The structure is designed to ensure the required settling effect for flows of up to 10 litres per second, but a hydraulic overload of more than 50% is still acceptable. The raw water feeding pipeline should be designed for the ultimate flow at a minimum flow velocity of 0.7 m/s to keep the suspended material from settling. The capacity of the raw water feeding pipeline should not be more than 20 litres per second.

The sedimentation tank as presented in Fig. 21 and 22 consists of inlet, sedimentation and outlet chambers.

The inlet chamber has three compartments. The inlet compartment is for turbulence dissipation and water level stabilization and has an overflow and a drain whose capacity should guarantee the discharge of the maximum inlet flow. Coagulants are mixed and dosed in the mixing compartment, and the valve compartment provides dry space for the flow control valves and the sludge draw-off control equipment.

The sedimentation chamber is the largest part of the structure, where the mechanical cleaning of the raw water is performed, while the outlet chamber is a simple valve chamber that contains the outlet pipe and hand-operated shut-off valve, the drain and the access arrangement. The sedimentation chamber itself has been designed for a horizontal flow rate of 1–2 mm/s and for a settling velocity of 0.1–0.2 mm/s. The settling velocity can be doubled if coagulants are used. Its width to length ratio should be between 1 : 6 and 1 : 8 while the depth to length ratio should be between 1 : 10 and 1 : 15. The length of the chamber should be determined for each case according to the flow.

The water depth in the tank can be considered constant, provided that the inlet raw water flow is excessive and the water surplus overflows into the drain. The capacity of the overflow pipe should be at least double the inlet capacity of the tank. For a rate of flow of 5–10 litres per second the water depth will be between 170 cm and 160 cm, respectively, owing to hydraulic losses, the water level being controlled by a valve in the outlet chamber.

Construction details

The sedimentation tank should be built of water-retaining and frost-resistant concrete. The roof of the inlet and mixing compartments is made of timber battens for easy access during operation and cleaning. The roof slabs of the valve spaces of both the inlet and outlet chambers are made of reinforced concrete and they have steel covers and ladders.

The bottom of the settling chamber is constructed of screeded plain concrete, sloped towards the inlet compartment.

Construction sequence

Machine excavation is appropriate since the amount of earth to be removed is considerable. There must be no damage to the finished excavation, so that the structure can be founded on an undisturbed base. This is important because this structure is particularly susceptible to cracking owing to its relative length. Adequate drainage of the foundation should be laid during construction to protect it. A small building crane is recommended for lifting shutters, reinforcing steel and other materials into position to avoid unnecessary traffic across the completed profile.

Pipework

All pipework can be made of cast-iron except the perforated distribution inlet and collection pipes. These should be of steel, and the chemical dosing pipework is of PVC, polyethylene or a similar substance.

The raw water inlet pipe has a hand-operated control valve. On the pipe connecting the inlet and mixing compartments, a bypass branch with a hand-operated shut-off valve enables the settling tank to be taken out of service for cleaning, repair or maintenance.

A pipe passes from the mixing chamber through a partition and into the sedimentation chamber, where the flow of water is distributed through a perforated transverse pipe. A similar pipe at the outlet side of the tank distributes the water already treated. The total area of the perforation should be 60–70% of the cross-sectional area of the pipes. The diameter of the holes should be 20 mm or more. They should be drilled into the pipe walls at regular intervals, from the bottom in the case of inlet pipes and from the top in the case of outlet pipes.

The overflow pipe, 150 mm in diameter, in the inlet compartment empties into a drainage sump in the valve chamber, as do the valve-controlled drains from the inlet, mixing and sedimentation compartments.

The outlet pipe, provided with a hand-operated valve, is connected to the bypass pipe. When the bypass is in operation, the relevant valves in the inlet and outlet chambers should be closed.

The dosing equipment is located in the filter plant and the coagulant dosing pipe will feed coagulant to the mixing compartment at the point of inlet pipe entry.

Operation and maintenance

The sludge that collects at the bottom of the sedimentation chamber has to be removed periodically to maintain the efficiency of the unit and avoid the possibility of flocs being carried into the outlet chamber. The frequency of cleaning will depend on the quality of the raw water and the amount of coagulant added to the flow. This, in turn, will depend on the flow. The tank should, however, be inspected once a week at least, and cleaned if necessary.

All valves should be opened and closed regularly and lubricated as necessary, and all pipework should be painted at the same intervals as that in all other water supply units.

When the sludge is removed from the sedimentation chamber, the water flow must be stopped or, if the quality of the raw water permits, it can be rerouted to the filter plant.

Sand Filtration

The proposed filter plant is of the slow sand type and should be incorporated in systems where surface water sources are used, and groundwaters if their quality requires it. Normally, with a spring or artesian source such treatment would not be necessary. This type of filter is most suitable for small rural water treatment plants because of its flexibility and ease of operation.

Design consideration

The general arrangement of the filter plant is shown in Fig. 23 and an architect's view is presented in Fig. 24.

The plant can handle flows of up to 10 litres per second, equivalent to the supply for a population of about 4000. The water to be treated after sedimentation, in some cases preceded by coagulation, should normally be almost free of natural colour and have only limited turbidity, with the maximum concentration of suspended solids being 50 mg/l and an upper limit for colour being 40 True Colour Units.

The filtration plant as designed has the following parts.

For filtration

A slow sand filter is required, with a flow velocity of 0.125–0.250 m/h. The filter medium consists of a filtration layer and a distributing layer. The former should be 100 cm thick and should consist of thoroughly washed river sand with an effective grain size of 0.3–0.4 mm. The distributing layer, a total of 50 cm thick, should consist of an upper layer 5 cm thick, made of a material with an effective grain size of 1–2 mm, then three 10 cm layers of 2–4 mm, 4–8 mm and 8–16 mm effective grain sizes, and finally a 15 cm lower support layer of material with a 16–32 mm effective grain size. The actual filter area depends on the water flow, although this does not alter the design and only the length of the filter beds is adapted accordingly.

For chemical dosing
The following chemicals will be stored and mixed with the water: aluminium sulfate ($Al_2(SO_4)_3$) for coagulation, sodium carbonate (Na_2CO_3) for neutralization and sodium hypochlorite ($NaClO$) for the disinfection of filtered water. Aluminium sulfate is used to assist sedimentation in the treatment process. The actual chemical doses will have to be determined on the basis of the raw water analysis in each case.

For treated water storage
Below the machine room a tank or wet sump is provided to create a balance between the treated and pumped water.

For pumping
Pumps to deliver the treated water to the distribution systems are necessary in most cases. Two pumping sets are proposed, with one in operation and one in reserve. The pumping machinery provides water hammer protection and includes automatic air release equipment.

Construction details
The filter station presented in Fig. 23 is designed to be a rectangular structure, with the smaller area containing a machine room, a corridor, an operators' room, a chemical store and sanitary and dosing facilities. A larger area is taken up by the three filters. Roofing the filter beds is necessary only in regions with long and severe winters.

Under the machine room a wet sump, or treated water tank, is located. It is constructed of water-retaining reinforced concrete and must be tested for leaks after construction but before backfilling. It must also be thoroughly disinfected before the plant begins operation. The outer walls should be covered with a bitumastic waterproof membrane to prevent the possible penetration of groundwater when the sump is empty. The floor is benched towards a drainage pit in one corner and access to the sump is provided via a 60 × 60 cm access opening with a cover in the machine room floor and a ladder.

The floors of the corridor, chemical storage and dosing rooms and toilets are constructed of plain concrete, while the machine room floor over the wet sump is of reinforced concrete supported on integral beams.

The base and walls of the filters themselves are made of water-retaining reinforced concrete and the outer walls are painted with a bitumastic watertight coating. They should be tested before backfilling, as the wet sump should be.

The roof of the filter area is similar to that of the machine and ancillary rooms, except that it is supported on reinforced concrete columns extending from the filter dividing walls at 450 cm intervals.

A reinforced concrete stair gives access from the machine room floor level to the lower filter gallery that traverses the three filters, between the machine room and wet sump and the filters. Reinforced concrete walkways lie across the ends and along the lengths of the filters.

All doors and window frames are of steel, aluminium or wood, depending on availability and preference, and should match those on other structures in the system.

The inside surfaces of all buildings will be plastered and steel handrails erected around the filters and the stairs. The inside walls should be painted white to reflect maximum light, while the outside brick walls should be finished in the same way as those of the other structures.

Machinery can be used for excavation if geological conditions permit and precautions are taken to secure good drainage and to avoid damage or disturbance of the finished base.

The tank and filter leakage tests should be performed carefully. Particular attention should be paid to points where pipes pass through the walls between the filters and wet sump to ensure that the pipes are watertight. For these pipes special puddle-flanged sections must be used and keyed box-outs used during construction.

Mechanical equipment

The general arrangement of the mechanical equipment is shown in Fig. 25.

A steel tank is installed in the filter gallery to ensure even distribution of the inlet flow to the three filters.

Two water-meters will ensure that proper records are kept and that management of the plant is effective. One is to be located on the filter feed line in the filter gallery and the other in the machine room on the pump delivery main to the distribution system. The water level in the wet sump below the machine room is measured by a float device.

The filter station is supplied with water from a small booster station that draws water from the wet sump. This consists of a centrifugal pump and a pressure vessel with automatic pump operation and it is designed for a daily water demand of 6000 litres and a maximum flow rate of 75 litres per minute at a pressure of 0.4–0.6 MPa, the equivalent of 40–60 m of water column.

The sodium hypochlorite dosing equipment includes a 200 litre dissolving tank, and the aluminium sulfate and sodium carbonate dosers, if required, are equipped with solution-holding tanks of the same capacity. An injector system fed by the booster station is used to convey aluminium sulfate to the dosing spot while the other chemicals are dosed by gravity.

Two pumps are needed, one operating and one as a stand-by, to pump the treated water under the required head. They are installed on the machine room floor above the wet sump from which the water is drawn for delivery to the distribution system. The details of the pumps and of the application of self-priming sets, as well as of the auxiliary equipment for the water hammer protection and standard air release device, correspond to those described for the pumping station.

The suction and delivery pipes for the pumping station are of flanged steel, as are the filter feed and water collection pipework. The domestic supply piping is of galvanized threaded steel pipe and the piping for the chemical dosing is of PVC.

Résumé of machinery specifications

Pumps

Two horizontal centrifugal pumps, one operating, one as a stand-by, of a capacity of 0.5–5.0 litres per second are required, with a maximum total delivery head of 85 m. The pump and the electromotor should be mounted on a common base plate.

Automatic air release device (when necessary)
One air pump with an air vessel with a volume of about 150 litres, fitted with a float or electrode type automatic control system, is required, along with a circulating tank of about 30 litres capacity if necessary.

Water hammer damping device (when necessary)
One air compressor with a capacity of 15 m^3/h of air, to be compressed to the pressure of 1 MPa, is required, along with an air vessel of about 1 m^3 capacity, designed for the same pressure.

Domestic water supply
One self-priming centrifugal horizontal pump, with a capacity of 1.25 litres per second and delivery head of 50 m, is required. Both pump and motor should be installed on a common bed plate. There must also be one pressure tank with a capacity of 200 litres, including a level indicator and pressure gauge for automatic pump control.

Chemical dosing equipment (where required)
The following equipment is required:

- 1 doser of required flow range, including a dissolving tank of 200 litres capacity and accessories for aluminium sulfate solution;
- 1 solenoid valve of $\frac{3}{4}$ inches (19 mm) diameter for the pressure water pipe;
- 1 injector for aluminium sulfate solution transport;
- 1 doser of required flow range with a dissolving tank of 200 litres capacity and accessories for sodium carbonate dosing; and
- 1 doser as above for sodium hypochlorite dosing.

A complete spare dosing set for each chemical should be kept in the store-room for easy replacement.

Drainage pump (where drainage by gravity is not possible)
A membrane or piston hand-operated pump or portable electric-driven submersible sludge pump with a capacity of 2 litres per second is required, with a delivery head of up to 10 m. It will be connected to the socket box in the station switchboard.

Pipes and fittings
The following equipment is required:

- steel suction and delivery pipes of 50–100 mm diameter with flanged connection for nominal pressure of 1 MPa and a total length of 15 m;
- air release and domestic water supply pipework and fittings of $\frac{3}{4}$ inches (19 mm) diameter, with screwed joints, 30 m long and made of galvanized steel;
- pipework for aluminium sulfate, sodium hypochlorite and sodium carbonate, of 15 mm and 25 mm inside diameter, made of PVC or similar corrosive-resistant material, including shut-off and non-return valves, with total length of about 30 m;

- a set of flanged steel pipes with diameters of 150 mm, 125 mm and 100 mm for distributing and collecting water in the filter gallery and inside the filter beds, with total length depending on the length of the filter bed;
- hand-operated shut-off valves: 1 of 125 mm diameter, 11 of 100 mm diameter and 2 of 80 mm diameter;
- 2 non-return valves of 80 mm diameter with normal pressure of 1 MPa on the pump delivery branch;
- 1 steel distribution tank for even distribution of settled raw water to the individual filters;
- 2 horizontal screw water flow meters for average flow rate of 36 m^3/h; and
- electric-controlled shut-off valves, one of 150 mm diameter on the filter outlet, and one of 125 mm diameter on the treatment plant inlet, to be used when complete automation of the plant operation is required.

Auxiliary equipment
The following equipment is necessary:

- 1 electric-driven conveyor belt, 6 m long, for filter sand transport;
- 1 portable sludge pump for pumping sand, with a capacity of 200 litres per minute and a delivery head of 10 m, including an 80 mm-diameter easy lock-in pipe, 30 m long; and
- 1 electric-driven mixer of 250 litres capacity for washing the filter sand.

Electrical equipment
The filter station can be supplied by one low voltage cable, either from a local low voltage supply distribution network or independently from a transformer connected to the nearest transmission line.

The supply terminates in a fuse box installed on the outer wall. The power required is about 28 kW with an annual consumption, depending on equipment, of up to about 150 000 kWh. The general arrangement of the electrical equipment is presented in Fig. 26 in a single-line diagram.

The building has lighting and power sockets and the filter gallery at the lower level is illuminated by fluorescent lights installed on the ceiling. In the other rooms and on the outside walls near the entrances, appropriate fittings for filament lamps are proposed (see Fig. 27). The machine room will be heated with infrared radiation. A lightning arrester and earthing system should also be provided.

A main switchboard is installed in the machine room and controls all supplies. The main pumps can be controlled manually from the switchboard, but under normal operating conditions they will be controlled by the water levels in the main water tank near the consumption area. The shut-off electrode at the minimum water level in the wet sump under the pump room floor can stop pumping if necessary.

The water hammer air compressor operates automatically, controlled by the pressure and water level in the pressure vessel, although it can also be operated manually from the switchboard.

The standard automatic air release device is controlled by parts of its own mechanism, the electrodes in the vessel, and therefore no control other than a power outlet is required in the switchboard.

The inlet valve in the filter plant is electrically operated, as is the main outlet for the filters. These valves can be operated either from the switchboard or from the adjacent control boxes. Under normal operating conditions, however, they will be operated automatically, controlled by the water level in the wet sump below the machine room floor. The solenoid-operated valves used to control the water inlet to the chemical dosing equipment will be opened or closed simultaneously with the electric valve on the inlet to the treatment plant.

The switchboard makes auditory signals, using a bell, siren or hooter, and has pilot lamps that make continuous visual signals. Lights on the switchboard will show whether the motors are running, whether the electric valves are open, and the maximum and minimum levels in the wet sump.

The thermoplastic insulated cables should have a copper core of 6 mm^2 minimum cross-section, although for economic reasons aluminium cables of larger cross-sections will probably be used.

Compensating devices are included in the switchboard for motors with an output of 4 kW or more.

The switchboard (as shown in Fig. 26) comprises three box units with dimensions of 2.4 × 0.7 × 2.2 m. It contains the following main equipment:

- 1 three-phase/100 A circuit breaker for switchboard feeding;
- 2 three-phase/25 A contactors for the pumps;
- 1 three-phase/16 A contactor for the compressor;
- 1 15 A fused switch outlet for the air release device;
- 1 three-phase socket outlet for the domestic booster station;
- 2 16 A reversible contactors for the control valves;
- 3 single-phase solenoid valve outlets for pressure, water and chemical dosing;
- 3 single-phase/6 A contactor outlets for the lighting;
- 6 single-phase/10 A contactor outlets including 2 sockets, 2 infrared heaters and 2 spares;
- 2 three-phase/25 A fused outlets, 1 for the socket box and 1 spare outlet; and
- 1 water level indicator and recorder.

Auxiliary electrical equipment

Auxiliary electrical equipment (as shown in Fig. 27) includes:

- 1 380/220/24 V socket box;
- 4 infrared heaters;
- a set of cables including auxiliary steel supports, clamps and iron-zinc earthing strips and wires;
- lighting for the machine room (28.8 m^2) to a level of 160 lux;
- lighting for the filter gallery (185 m^2) with fluorescent lamp to a level of 60 lux;
- lighting for the corridor, store-room, operators' room and toilet (45.0 m^2) to a level of 100 lux;

— lighting for the dosing room (14.4 m^2) to a level of 200 lux; and

— lighting for the filter area (maximum 302 m^2) to a level of 100 lux.

Operation and maintenance

The operation of the filtration station will be fully automatic except for the adjustment of the chemical dosers. However, the level of automation should always correspond with the expected level of operation services.

The most important condition for the reliable operation of the filters is to avoid admitting highly turbid water. The filters must be checked for sand clogging, as it increases the hydraulic resistance of the filter bed. When the maximum level of sand is reached, the filter unit should be shut down, the water level lowered and a layer of sand about 5 cm thick scraped off.

Depending on the local climatic conditions it takes a few days, or weeks in winter, to put the filter into effective operation again. Since the water must be discharged into a drain during this period, climatic conditions could be decisive in choosing whether to roof the filter area.

When the thickness of the filter bed has decreased to about 60 cm, sand must be filled in to the original level.

The operation and maintenance of the equipment, except the dosing equipment, is similar to that of the standard pumping station.

Disinfection

Dosing with a solution of sodium hypochlorite, with a minimum contact time of 30 minutes, will disinfect rural water supplies.

The actual location of the dosing point will depend on the general layout of the system, and some systems may need more than one point of chlorination. For this reason, the designs allow a choice of several locations where chlorination may take place: the source, the pumping station, the water tank, the sedimentation tank or the filter.

Design consideration

Sodium hypochlorite was the chemical selected for dosing because it is relatively simple to handle and does not require the precautions necessary for the use of gaseous chlorine. Sodium hypochlorite is prepared in solution with 10–12% active chlorine and is transported in easily handled 50-litre plastic tanks.

Hypochlorite solutions are not stable. They lose 1–2% of the active chlorine each month and so supplies of the chemical should not be stored for more than three months. Metal compounds should not be used in conjunction with sodium hypochlorite or located near it because of its highly corrosive vapour.

Calcium hypochlorite can also be used and has the advantage of being available as a powder. Also, the solution for dosing can be made up easily on the site; 100 g of calcium hypochlorite contain about 34 g of active chlorine. It should be stored in paper bags. These should be kept in a dry room, out of direct sunlight and without large temperature fluctuations, to avoid unnecessary degeneration.

The dosing solution is usually diluted with treated water in a ratio in which 1 volume unit of sodium hypochlorite is to be diluted with a water volume of 5–50 units. The water to be used should be soft, with a hardness of less than 180 mg/l calcium carbonate ($CaCO_3$). If harder water is used, the solution must be prepared in a separate tank and, after mixing, it should be left to stand for at least 2 hours, and preferably for 24 hours, to allow the carbonates formed to precipitate.

The following table shows the approximate amounts of chemicals necessary for a three-month period on the basis of 0.3–0.5 mg/l of active chlorine dosage and a daily water consumption of 200 litres per capita.

Number of inhabitants	Daily demand for		Sodium hypochlorite per day for 90 days		Calcium hypochlorite per day for 90 days	
	water (m^3)	chlorine (kg)	kg	No. of 50-litre containers	kg	No. of 20-kg paper bags
4000	800	0.40	4	7	1.18	6
1500	300	0.15	1.5	3	0.44	2
500	100	0.05	0.5	1	0.12	1

A higher dilution ratio can be used to provide sufficient solution volume.

Water is usually dosed either by gravity, using a flow rate device, or with pumps, using a volume or flow rate device. Dosing by gravity was chosen for the rural water supply systems because it is easy and reliable. Plastic tanks of 25–200 litres for the disinfectant are sufficient to cover the demands of communities of up to 4000 inhabitants. Plastic dosing pipes of 15 mm inside diameter are connected to the dosing points located in the water tank inlet, the spring intake structure outlet or the pressure head breaking chamber outlet. The dose is adjusted manually according to the inlet flow. The inlet flow control should be omitted and the excess water allowed to overflow into the drain to avoid overdosing the water with chlorine.

In standard model pumping stations a plastic pipe of 15 mm diameter is connected to the pump suction pipes. Overdosing is precluded by a shut-off and a special non-return valve. The latter closes automatically and stops the flow of the disinfectant when suction in the pipe is lost. When the pumps are not self-priming and automatic air release equipment for pump impeller flooding is used, the solenoid valve should be fitted up on the dosing pipe to start or stop dosing as necessary.

Operation and maintenance

The disinfection equipment is an important element of any water supply scheme, so it must be carefully checked whenever the solution tank is refilled. The proper function and tightness of the non-return or solenoid valves are essential. The doser should be cleaned, washed and tested for correct function according to instructions. For this reason a complete spare doser, ready for use, should always be available.

Water Tanks

The water tanks are used to balance the supply of water from the source with the hourly fluctuation in demand throughout the day, and to provide water to the distribution system at a variable pressure.

The tanks also store sufficient water to handle emergencies and to allow the system to be disconnected from the source for limited periods for maintenance without interrupting the supply to the community.

Design consideration

The tanks presented in Fig. 28–31, of 100 m^3, 150 m^3, 200 m^3 and 250 m^3 capacities, respectively, are sufficient to satisfy the requirements of communities ranging in size from 500 to 4000 people, as calculated from the table below.

Number of inhabitants	Specific water demand (litres per capita per day)	Total water demand maximum Q_d (m^3/day)	Recommended number and capacity of tanks (m^3)	Capacity as a percentage of total daily demand
500	160	80	1 × 100	125
	220	110	1 × 100	91
1500	200	300	2 × 100 or 1 × 200	67
	260	390	2 × 100 or 1 × 200	51
4000	200	800	2 × 250	63
	260	1040	2 × 250	48

The smallest tank, with a 100 m^3 capacity, is recommended although it has a 30-hour reserve at the maximum daily demand at 1980 water consumption level only for a community with a population of 500. Although this is usually an excessive capacity, there could be considerable construction problems in building a smaller tank. On the other hand, the only advantage of additional capacity is that it ensures a supply of water in case of emergencies, such as fire or source failure.

The normal capacity allowed for in design is 45–50% of the maximum daily consumption (Q_d) and this condition is met and exceeded by all the other tank designs, with the storage capacity ranging from 48% to 91% of maximum daily demand.

Water systems that serve 500–4000 people need 47.5 m^3 of water for fire-fighting. This corresponds to two hydrants operating at 3.3 litres per second each for two hours. This amount of water should be stored in the tank at all times.

Water tanks normally lie between the water source and the community, although they can also be located on the far side of the community from the source. In the latter case, the water from the source flows through the distribution system to reach the tank.

Construction details

Water tanks are cylindrical water-storing structures whose base slabs are structured in two ways according to the type and compressibility of subsoil layers. Type I is for non-compressible subsoils such as rock and sandstone. Type II is for compressible subsoils such as clay.

The inside load depends on water depth, while the outside load depends on earth backfill. A minimum live load of 200 kg/m^2 on the top of the tank allows for snow and permits access for maintenance purposes, especially during construction. The groundwater table should be below the base slab.

The reservoirs should be tested for watertightness before backfilling and properly disinfected before they are used for water supply.

Detailed structural calculation and reinforcement drawings will be made for each system on the basis of detailed geological investigations that also consider requirements for the watertightness of the structures.

Construction details are presented in Fig. 28–31.

Construction sequence

The most important recommendations for this type of water-retaining structure are the following. A gravel sand layer about 40 cm thick, well compacted and drained, should be laid on clay subsoil to avoid soil slushing. Suitable keys should be formed between the peripheral wall and the base slab because this construction joint could become a source of leakage problems. The peripheral wall should be made of continuous concrete; the concrete should be well compacted and, after the shuttering is removed, the walls should be properly wetted to minimize concrete cracking. The central column and roof slab can be constructed of precast elements if they are properly tied and anchored. Careful attention to structural calculation and construction recommendations is essential.

Operation and maintenance

The following recommendations can assist communities to operate their own systems. Access to the tank during operation of the system should be forbidden. This reduces the possibility of contamination to a minimum. The tank and pipework should be arranged so as to ensure water circulation (see examples of pipe arrangements in the section on water-tank valve structures, below). The sediment that may accumulate in the tank should be removed at least twice a year and the tank should be thoroughly cleaned and disinfected before it is used again. All metal elements inside the tank should be protected with water-resistant paint that does not contain phenols. The paintwork should be regularly checked twice a year during the cleaning and renewed as necessary.

Water-tank Valve Structures

The valve chambers and houses control and regulate the flow of water to and from the storage and balancing tanks. The designs include types for single tanks and for pairs of tanks. The arrangements also facilitate pressure control, overflow control, flow measuring, disinfection, and access for maintenance. They range in size from a relatively simple underground valve chamber, used generally in smaller tanks where control of the inflow by a float valve is not required, to large two-storeyed valve house structures with relatively complicated pipework for pairs of larger tanks, or for smaller tanks where automatic control is necessary.

Valve chambers

The valve chamber as shown in Fig. 32 has been designed so that two systems of pipe fittings can be included using the same construction arrangement. The Type I pipe arrangement is suitable for use with a tank located between the water source and the distribution system. Type II is designed to be used with a tank at the opposite side of the distribution network from the source of supply. Neither valve chamber arrangement includes provision for disinfection.

Construction of the chamber, a rectangular underground structure of plain concrete, is simple and similar to the measuring chamber described on p. 36. The chamber should always be drained to the level of the manhole constructed on the water-tank drain and overflow pipes. Care should be taken when designing the drain-pipe to avoid flooding the chamber when the tank is drained or overflows.

Valve houses

Valve houses are essential parts of a water-tank system when the valve chamber does not have enough space for the valves and fittings. The two-storeyed valve houses in this publication are rectangular, with the upper floor standing approximately on ground level while the lower storey corresponds to that of the lower tank drainage point.

Besides housing the pipework, valves and fittings necessary for operation of the water tank, the valve house provides access to the water tank or tanks and can also serve to a limited extent as a tool store.

Design consideration

The structure has been designed in two ways, one for a single water tank and the other for a pair of tanks, while three arrangments of pipework, Type I, Type II and Type III, have been provided. The criteria for civil construction, design and type of pipework depend on the number of tanks to be connected to the valve house and the relative positions of the water source, the water tank and the distribution area, as well as the means of transporting water to the tank.

Type I pipework is suitable when the water tank or tanks are fed by gravity and situated between the source of supply and the area of distribution.

Type II pipework is used when the water tank or tanks are also located between the source of supply and the area of consumption but are supplied by pumping.

Type III pipework is useful when the water tank or tanks are located at the opposite side of the distribution system to the source of supply and where the inflow will be pumped. However, during peak hours the distribution system will be supplied by gravity via the same inlet/outlet pipe.

Construction details

The civil construction of both kinds of valve house, as shown in Fig. 33 and 34, is very similar; the valve house for one water tank can be easily adapted for the connection of another tank.

The underground compartment and the peripheral wall are of plain or reinforced concrete, depending on the structural calculation. The valve house floor, tank access platform and ceiling are made of reinforced concrete cast on the site. Underground access holes and other holes will be left for equipment installation. An I-type gantry beam 160 mm high should be fixed to the walls to facilitate assembly and maintenance of the pipework. The lower floor of the valve house is ventilated by vent-holes in the peripheral masonry and is accessible by a steel ladder. The pipes' wall passage should be sealed by flexible mastic packing applied after the settling of the water tank and valve house. For this reason the holes should be made larger, leaving a space of about 2.5 cm around the pipe perimeter. The drain-pipe should be able to discharge water during tank operation and maintenance.

Type I pipework

The inlet piping consists of steel flanged pipes with two hand-operated valves, a flow meter and a float valve to close off the inlet automatically when the maximum water level in the tank has been reached. A shaft that is fitted on the inlet pipework of the float valve installation can also function as a safety overflow. A branch pipe of 25 mm diameter and a valve are installed to take water samples. See Fig. 35 and 36.

The inlet pipe is cross-connected through a hand-operated valve to the outlet pipe for the one-tank pipe arrangement to enable a limited water supply to be maintained during inspection, repair or maintenance of the water tank (see Fig. 35).

The outlet piping consists of steel flanged pipes or cast- or wrought-iron flanged pipes and is provided with a screen/strainer and an air release valve that discharges water back to the water tank through a connection pipe.

The three valves on the inlet and outlet pipelines are operated by headstocks located on the upper floor of the valve house.

The drainage piping that passes from the tank through the valve chamber is of steel or cast- or wrought-iron flanged pipes. It has a hand-operated valve and a 25 mm diameter connection to the float shaft that has an inside diameter of 600 mm to allow for water level indication.

A waste pipe drains the valve house itself at the lowest possible point to permit gravity flow.

Type II pipework

The Type II pipework is made of the same materials as Type I pipes. The valve-operated handstocks are located on the upper floor. The inlet discharges through a bellmouth located 10 cm above the top water level in the tank to provide aeration and water circulation. See Fig. 35 and 37.

Type II pipework has the same provisions for level measuring, backflow prevention, sampling, drainage and air release as Type I. Since the Type II system is designed for a pumped supply, the float control valve on the inlet is omitted and a pressure head breaking chamber is included on the inlet pipework when a single tank is built (see Fig. 35).

Type III pipework

Again, Type III pipework is made of the same materials as Type I, but has necessary modifications in structure. See Fig. 37 and 38.

One pipe, in this instance, serves as inlet and outlet. This pipe is divided into two in the valve house, so there is a pipe for each function. The inlet pipe has a valve that is operated by a handstock located on the upper floor. The pressure head breaking chamber is located on the interconnection between the inlet and outlet pipes. This arrangement maintains the water supply when the tank is cleaned and repaired.

The inlet and the outlet pipes each have a non-return valve to prevent backflow when the tank is losing or gaining water.

Double tank arrangement

The arrangement of pipework in all three valve house types is not altered when there are two tanks instead of one, except that double connections have to be provided for inlet, outlet, drain, overflow and air pipes. This can be seen by comparing Fig. 35 and 38 with Fig. 36 and 37.

Special considerations
When selecting the type of valve chamber or house for a given project, it should first be decided whether a one- or two-tank system is to be used or if there is a likelihood that a second tank will be added to a one-tank system later.

When a one-tank system is built as a first stage, the inlet and outlet pipelines will be interconnected, or a pressure head breaking chamber installed, in the same manner as for a normal one-tank system. This temporary interconnection will be removed when the second tank is constructed.

In this case also the block-offs in the concrete for pipes and access to the second tank should be left in concrete walls, filled with brickwork and plastered over. People will be able to break into them easily at a later date.

Operation and maintenance
The equipment installed in the valve chambers and houses is intended for continuous operation, even during cleaning and maintenance work in the tank. Because of its strength and simplicity, no major difficulties should be encountered. However, every item should be operated and maintained according to the manufacturers' instructions.

Also, to prevent corrosion, the pipes and fittings should be kept painted with a rust- or corrosion-protective coating and the structure should be ventilated to avoid unnecessary dampness and condensation.

The water-meter should be checked and read each week and the float control valve should be checked for proper function.

Once every six months, all valves should be checked by fully closing and opening them, and lubricant should be applied to the glands and valve shaft if needed.

The valves, pipes and fittings should have a new protective coating applied at least once every two years.

Distribution Network Structures

Other important components of a water distribution system include fire hydrants, standpipes and house connections. Some typical designs for these are shown in Fig. 39.

Fire hydrants

The above-ground fire hydrants can be installed at any point on the distribution system, provided that a minimum water flow of 6.6 litres per second through two hydrants can be guaranteed with a minimum hydrodynamic pressure of 10 m in the system.

The hydrants should be set at a maximum distance of 100 m apart and on pipelines with a minimum diameter of 100 mm.

The above-ground fire hydrant system consists of a valve operated through a valve spindle from ground level, a 90° duck-foot bend with special fitting and a vertical stand to which the hydrant is attached.

The hydrant has an automatic drainage system that operates when the hydrant is closed.

The main components are made of cast-iron, the spindle of non-corrosive steel, and the extension pipes can be of steel, wrought-iron or cast-iron.

Standpipes

Standpipes can be located anywhere on the distribution system, although it is recommended that they be installed on pipelines with diameters of 80 mm or more.

In general, standpipes should be located where they will not be damaged by traffic, where people have easy access to them and where there is efficient drainage.

The standpipe is connected by a sleeve connection, 25 mm in diameter, to the main distribution pipe, and is installed on and supported by a 90° cast-iron duck-foot bend.

A valve 25 mm in diameter is included in the pipe connection from the water main and is operated from the ground surface via a valve spindle.

The standpipe has a spring-loaded handle or lever to avoid water loss through leaving it open.

The main parts of the standpipe are made of cast-iron. The valve seatings are made of brass, while the inner pipes and springs are of steel.

House connection

Normally, house connections have to be constructed according to the specifications of the water supply agency or according to local bye-laws. Therefore, the schematic arrangement shown in Fig. 39 is intended only for guidance or for use where no such regulations or bye-laws exist, although it was prepared in the light of existing specifications. There is also a design for a connection to a public building such as a school or health centre.

The house connection is a simple pipe connected to the delivery main. Adjacent to the main is a valve that isolates the connection for maintenance. This valve should be controlled from ground level by a valve spindle of appropriate length. A valve chamber with a manhole lies between this isolating valve and the building to be connected to the water supply. The chamber contains a water-meter and a valve. If the building has a basement, this chamber can be omitted and the valve and meter can be located inside the building.

The pipework for house connection is usually made of galvanized steel or polyethylene and should be laid in a straight line. This makes it easy to find for repairs and improves the accuracy of metering.

Operation and maintenance

The fire hydrant, standpipe and house connection require periodic checking under operating conditions to ensure that they are functioning properly and that there are no water losses. The fire hydrants should be opened once every six months or at intervals determined by the authorities. This can be done when the streets are washed. Checking a house connection is normally done when the meter is read.

Broken meters should be replaced; careful records of meters should be kept and a routine replacement and servicing programme established.

General Service Building and Construction Details

A general service building may be required at water tank, spring intake or wellfield locations where other structures are not available. It provides a room for attendants, toilet facilities, a location for disinfection equipment and storage for tools.

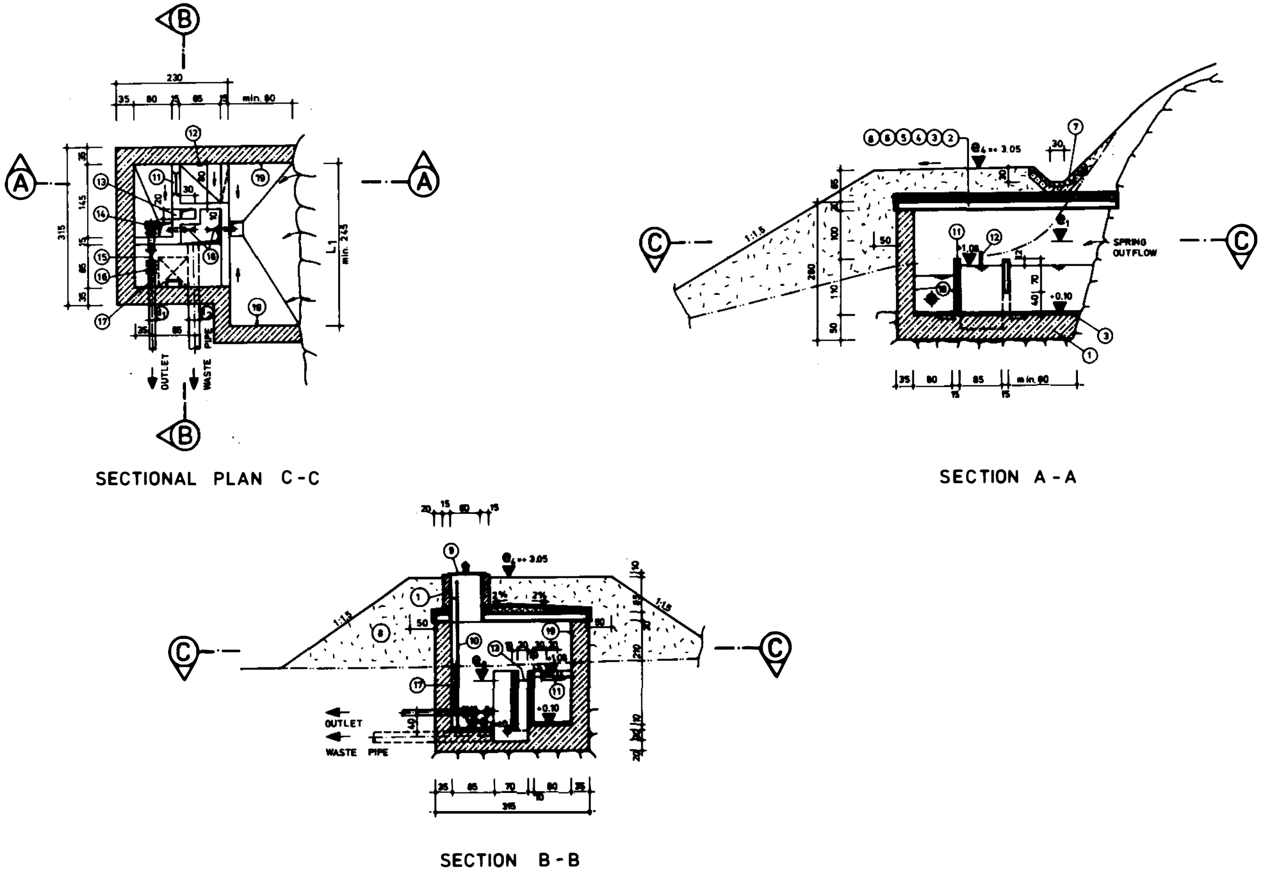
The proposed standard general service building, with foundations and floor slab of plain concrete, walls of brick or concrete blocks and a roof slab of reinforced concrete is shown in Fig. 40. The walls are separated from the floor slab by damp-course insulation, the roof has thermal and waterproof insulation, and the doors and windows are of steel, although wood can be used.

Some details of windows, doors and fittings are shown in Fig. 41. Other details of steelwork, windows and doors depend on local conditions.

The wastewater from the toilet and wash-basin will go to a septic tank of appropriate design, located so as not to threaten the water supply system. The building should be kept clean, paintwork renewed when necessary and the septic tank periodically emptied and disinfected.

The most typical construction details have been selected for standardization and presented in Fig. 42. These include fencing, pipeline crossing of watercourses and pipe laying, including pipe anchoring, drain outlet structure and precast indicator post.

Fig. 5. A spring intake structure, Type I


SECTIONAL PLAN C-C

SECTION A-A

SECTION B-B

ELEVATION RELATIONS

ELEVATION OF SPRING: e_1

BOTTOM OF CHAMBER: $e_2 = \pm 0.00$

OVERFLOW: e_3 ACC. TO MAX. YIELD OF SPRING

REFORMED GROUND: e_4

DIAMETER OF OUTLET PIPE: d_1

DIAMETER OF WASTE PIPE: d_2

LENGTH L_1 - ACCORDING TO THE WIDTH OF SPRING

LEGEND:

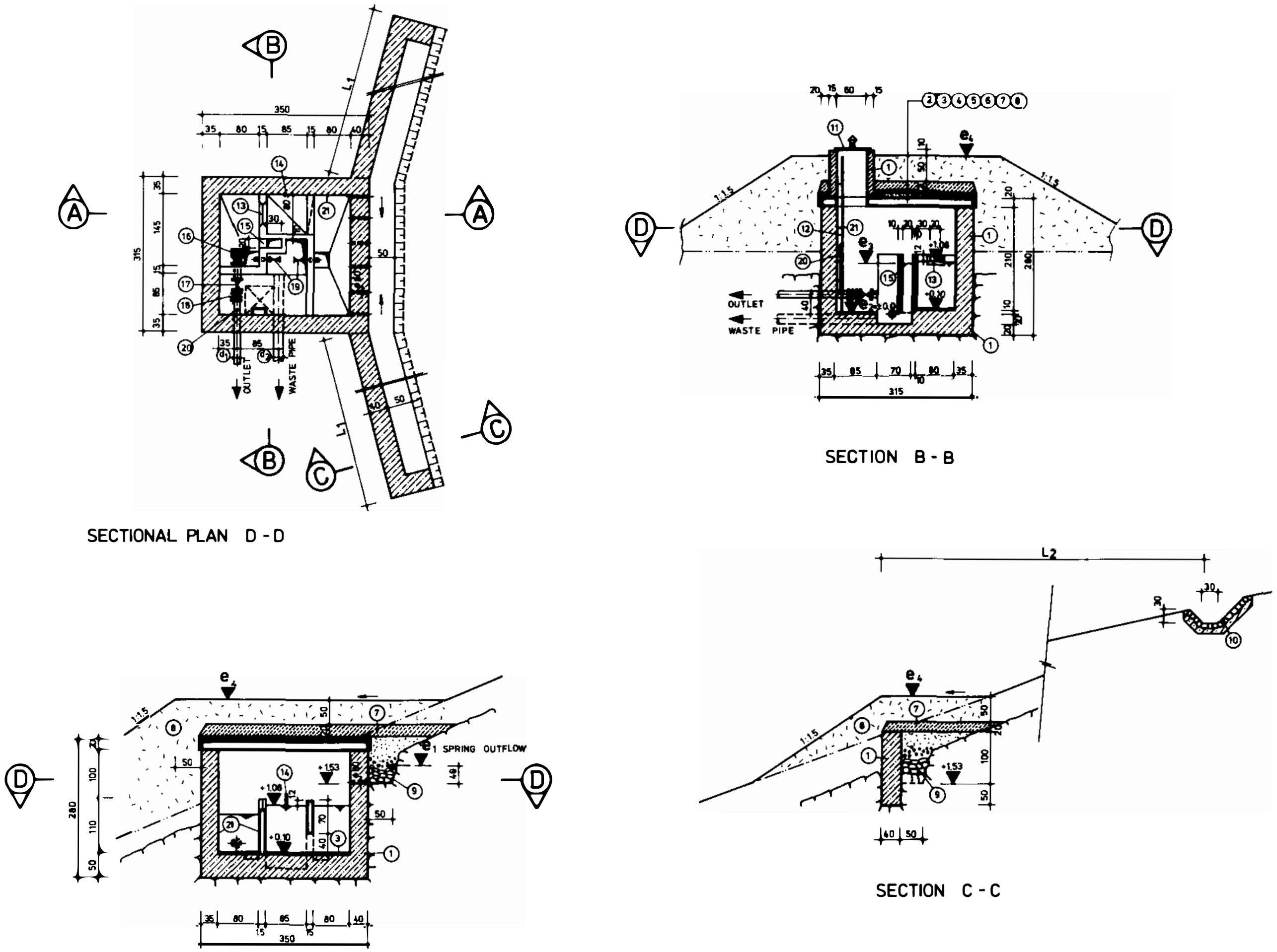
1. PLAIN CONCRETE
2. REINFORCED CONCRETE
3. BENCHING TO GRADIENT
4. CEMENT PLASTER
5. WATERPROOF INSULATION
6. PROTECTING CEMENT SCREED
7. PROTECTIVE WATER - CATCHMENT TRENCH - STONE PITCHING
8. COMPACT FILL AND HUMUS
9. LOCKED VENTILATION COVER
10. STEEL LADDER
11. MEASURING WEIR
12. MEASURING SCALE
13. OVERFLOW
14. INLET STRAINER
15. VALVE
16. MAKE - UP PIECE
17. AIR PIPE
18. DRAIN PIPE ϕ 80 mm WITH VALVE
19. WATERTIGHT CEMENT PLASTER

MEASURING WEIR CAPACITY DATA

h in cm ON SCALE	FLOW IN l/s
1.0	0.58
2.0	1.56
3.0	2.76
4.0	4.05
5.0	5.39
6.0	6.74
7.0	8.05
8.0	9.29
9.0	10.45
10.0	11.47
12.0	14.90

NOTE:
SCALE ZERO ON THE ELEVATION +1.08

0 1 2 3 m
SCALE



SECTIONAL PLAN D - D

SECTION B - B

SECTION A - A

SECTION C - C

Fig. 6. A spring intake structure, Type II

ELEVATION RELATIONS

ELEVATION OF SPRING : e_1
BOTTOM OF CHAMBER : e_2 =± 0.00
OVERFLOW : e_3 ACC TO MAX YIELD OF SPRING
REFORMED GROUND : e_4

DIAMETER OF OUTLET PIPE : d_1
DIAMETER OF WASTE PIPE : d_2

LENGTH L_1 - ACCORDING TO THE WIDTH OF THE SPRING AREA
LENGTH L_2 - ACCORDING TO THE HYDROGEOLOGIST'S RECOMMENDATION

LEGEND:

1. PLAIN CONCRETE
2. REINFORCED CONCRETE
3. BENCHING TO GRADIENT
4. CEMENT PLASTER
5. WATERPROOF INSULATION
6. PROTECTING CEMENT SCREED
7. CLAY FILL
8. COMPACT FILL AND HUMUS
9. RUBBLE DRAIN WITH FILTERING FILL
10. PROTECTIVE WATER - CATCHMENT TRENCH - STONE PITCHING
11. CAST IRON VENTILATION COVER
12. STEEL LADDER
13. MEASURING WEIR
14. MEASURING SCALE
15. OVERFLOW
16. INLET STRAINER
17. VALVE
18. MAKE - UP PIECE
19. DRAIN PIPE ø 80mm WITH VALVE
20. AIR PIPE
21. WATERTIGHT CEMENT PLASTER

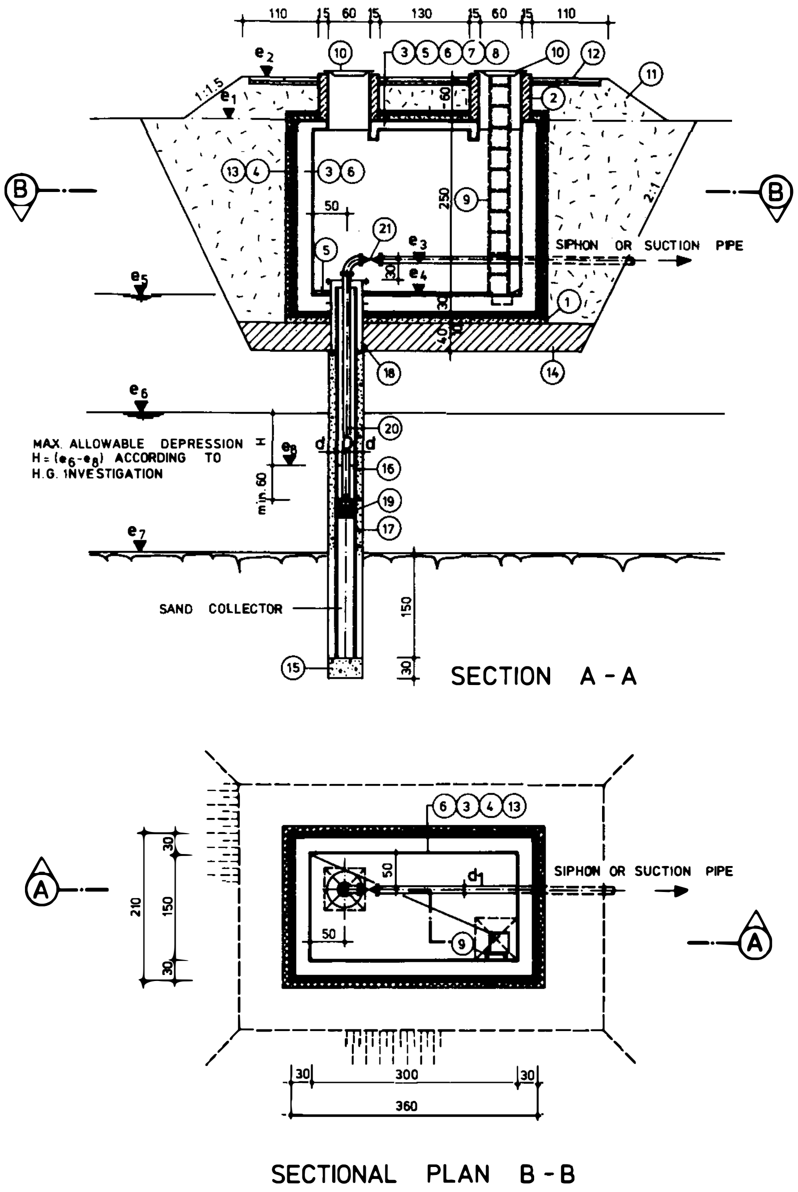
MEASURING WEIR CAPACITY DATA.

h IN cm ON SCALE	FLOW IN l/s
1.0	0.58
2.0	1.56
3.0	2.76
4.0	4.05
5.0	5.39
6.0	6.74
7.0	8.05
8.0	9.29
9.0	10.45
10.0	11.47
12.0	14.90

NOTE:
SCALE ZERO ON THE ELEVATION +1.08

0 1 2 3m
SCALE

Fig. 7. A bored deep well



ELEVATION RELATIONS

EXISTING GROUND : $e_1 = \pm 0.00$
REFORMED GROUND : $e_2 = + 0.60$
INVERT LEVEL OF PIPE : $e_3 =$
BOTTOM OF THE CHAMBER : $e_4 =$
UNLOWERED GROUND WATER LEVEL : e_5
MINIMAL GROUND WATER LEVEL : e_6
LEVEL OF IMPERMEABLE LAYER : e_7
MINIMAL WATER LEVEL IN THE WELL : e_8

DIAMETER OF SIPHON PIPE : d_1
DIAMETER OF SCREEN : D
THICKNESS OF FILTRATION FILL : d

NOTE :

D min = 300 mm, EXACT DIAMETER D AS WELL AS THICKNESS OF FILTRATION FILL d HAS TO BE DESIGNED ACCORDING TO HYDROGEOLOGICAL INVESTIGATION

LEGEND :

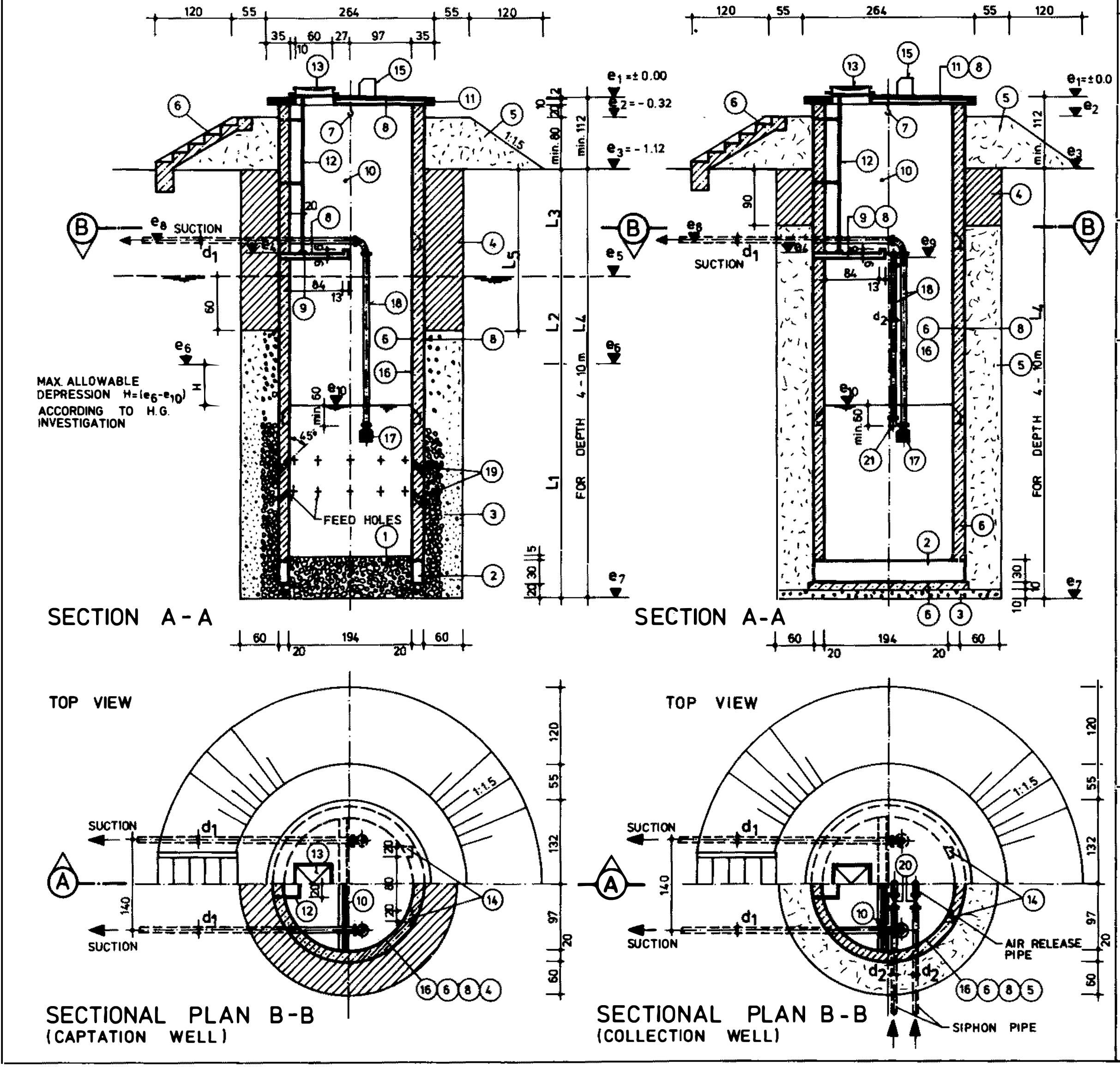
1. BLINDING CONCRETE
2. PLAIN CONCRETE
3. REINFORCED CONCRETE
4. MOISTURE INSULATION
5. BENCHING TO GRADIENT
6. CEMENT PLASTER
7. WATERPROOF INSULATION
8. PROTECTING CEMENT SCREED
9. STEEL LADDER
10. CAST IRON COVER
11. COMPACT FILL AND HUMUS
12. CONCRETE TILES LAID ON SAND BED
13. RECEPTION WALL
14. CLAY FILL
15. GRAVEL FILL
16. FILTRATION GRAVEL FILL
17. SCREEN
18. STEEL CASING HEAD ASSEMBLY
19. INLET STRAINER
20. STEEL OR CAST IRON PIPE
21. VALVE

NOTE :

WHEN $e_5 > e_4$ (CHECKED IN m a.s.l.) IN ITEM Nº 4 PRESSURE RESISTANT WATERPROOF INSULATION SHOULD BE APPLIED.

DIAMETER AND NUMBER OF FEED HOLES IN THE SCREEN HAVE TO BE DESIGNED ACCORDING TO HYDROGEOLOGICAL INVESTIGATION.

Fig. 8. Two types of dug well



TYPE OF DUG WELL

CAPTATION WELL	COLLECTION WELL
ELEVATION RELATIONS	
CEILING LEVEL : $e_1 = \pm 0.00$	
REFORMED GROUND : e_2	
EXISTING GROUND : e_3	
LEVEL OF LANDING : e_4	
UNLOWEREO GROUND WATER LEVEL: e_5	—
MINIMAL GROUND WATER LEVEL : e_6	—
BOTTOM LEVEL OF THE PIT : e_7	
INVERT LEVEL OF SUCTION PIPES : e_8	
—	INVERT LEVEL OF SIPHON PIPE : e_9
MINIMAL WATER LEVEL IN THE WELL: e_{10}	
DIAMETER OF SUCTION PIPE : d_1	
—	DIAMETER OF SIPHON PIPE : d_2
FIGURES : L_1, L_2, L_3, L_4 L_5 - DEPENDS ON THICKNESS OF COVERLAYER	FIGURES : L_4

LEGEND :

1. GRAVEL FILL	
2. REINFORCED CONCRETE	
3. GRAVEL SANO FILL	
4. CLAY TANKING	
5. FILL	
6. PLAIN CONCRETE	
7. STEEL HOOK	
8. CEMENT SCREED	
9. LANDING - REINFORCED CONCRETE	
10. STEEL HANDRAIL	
11. COVER SLAB - REINFORCED CONCRETE	
12. STEEL LADDER	
13. WATERTIGHT LOCKED COVER	
14. WALL POCKET	
15. SUPPORTING BLOCK	
16. CEMENT PLASTER	
17. SUCTION STRAINER	
18. STEEL OR CAST IRON PIPE	
19. FEED HOLES	—
—	20. VALVE
—	21. BELL MOUTH

NOTE :

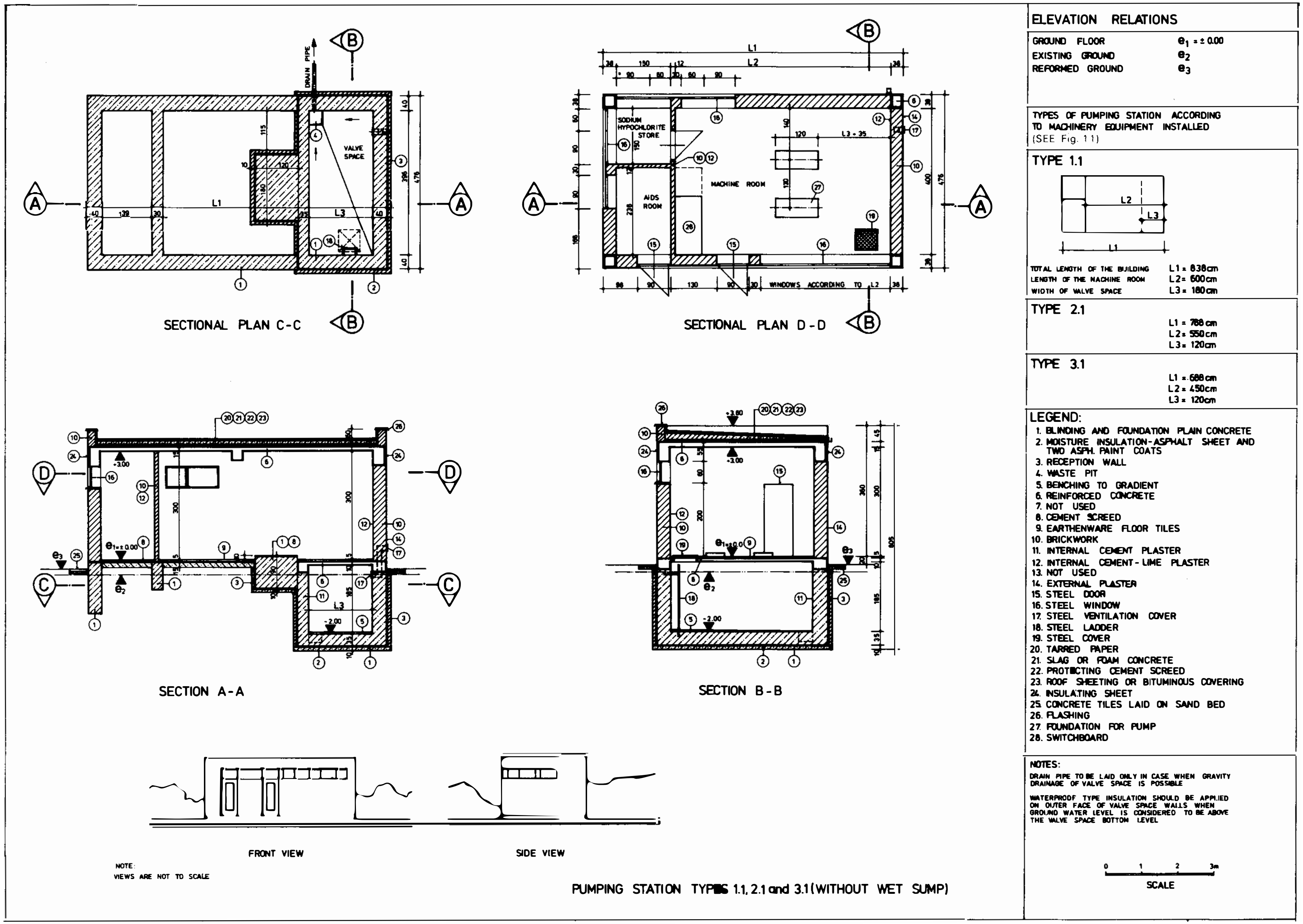
NUMBER, DIAMETER AND POSITION OF FEED HOLES WILL BE DESIGNED ACCORDING TO DETAIL HYOROGEOLOGICAL INVESTIGATION.	—

DIAMETER AND MATERIAL OF SUCTION OR SIPHON PIPE WILL BE INDIVIDUAL FOR EACH CASE AS WELL AS FIGURES L1.L2.L3. L4

0 1 2 3m

SCALE

Fig. 9. A pumping station without wet sump



ELEVATION RELATIONS

GROUND FLOOR	$e_1 = \pm 0.00$
EXISTING GROUND	e_2
REFORMED GROUND	e_3

TYPES OF PUMPING STATION ACCORDING TO MACHINERY EQUIPMENT INSTALLED (SEE Fig. 11)

TYPE 1.1

TOTAL LENGTH OF THE BUILDING	L1 = 838cm
LENGTH OF THE MACHINE ROOM	L2 = 600cm
WIDTH OF VALVE SPACE	L3 = 180cm

TYPE 2.1

L1 = 788 cm
L2 = 550cm
L3 = 120cm

TYPE 3.1

L1 = 688 cm
L2 = 450cm
L3 = 120cm

LEGEND:

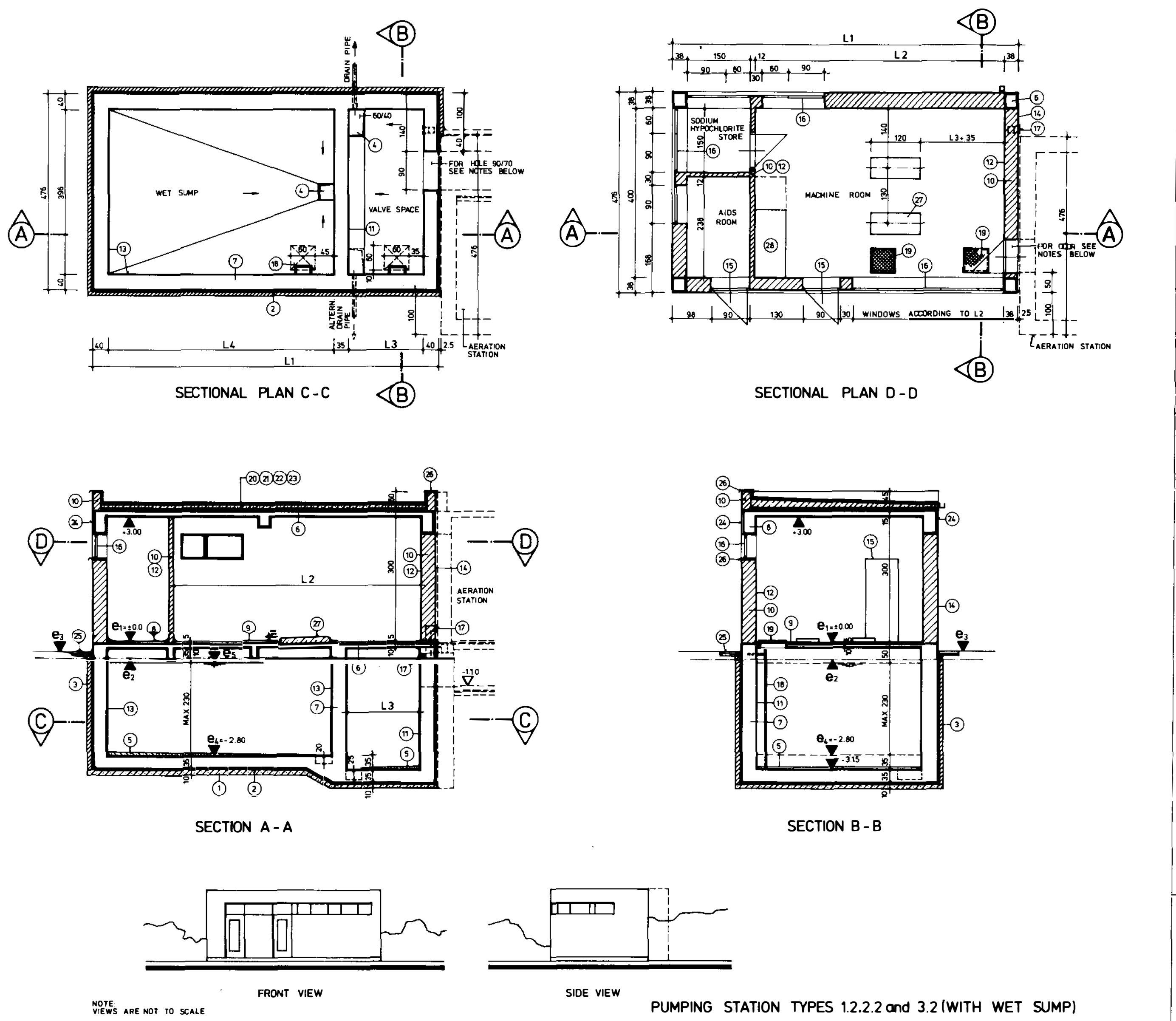
1. BLINDING AND FOUNDATION PLAIN CONCRETE
2. MOISTURE INSULATION-ASPHALT SHEET AND TWO ASPH. PAINT COATS
3. RECEPTION WALL
4. WASTE PIT
5. BENCHING TO GRADIENT
6. REINFORCED CONCRETE
7. NOT USED
8. CEMENT SCREED
9. EARTHENWARE FLOOR TILES
10. BRICKWORK
11. INTERNAL CEMENT PLASTER
12. INTERNAL CEMENT-LIME PLASTER
13. NOT USED
14. EXTERNAL PLASTER
15. STEEL DOOR
16. STEEL WINDOW
17. STEEL VENTILATION COVER
18. STEEL LADDER
19. STEEL COVER
20. TARRED PAPER
21. SLAG OR FOAM CONCRETE
22. PROTECTING CEMENT SCREED
23. ROOF SHEETING OR BITUMINOUS COVERING
24. INSULATING SHEET
25. CONCRETE TILES LAID ON SAND BED
26. FLASHING
27. FOUNDATION FOR PUMP
28. SWITCHBOARD

NOTES:

DRAIN PIPE TO BE LAID ONLY IN CASE WHEN GRAVITY DRAINAGE OF VALVE SPACE IS POSSIBLE

WATERPROOF TYPE INSULATION SHOULD BE APPLIED ON OUTER FACE OF VALVE SPACE WALLS WHEN GROUND WATER LEVEL IS CONSIDERED TO BE ABOVE THE VALVE SPACE BOTTOM LEVEL

Fig. 10. A pumping station with wet sump

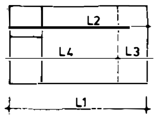


ELEVATION RELATIONS

GROUND FLOOR $e_1 = \pm 0.00$
EXISTING GROUND e_2
REFORMED GROUND e_3
BOTTOM OF WET SUMP $e_4 = -2.80$
MAX. W. LEVEL $e_5 = -0.50$

TYPES OF PUMPING STATION ACCORDING TO MACHINERY EQUIPMENT INSTALLED (SEE Fig. 11)

TYPE 1.2



TOTAL LENGTH OF THE BUILDING	L1 = 838cm
LENGTH OF THE MACHINE ROOM	L2 = 600cm
WIDTH OF THE VALVE SPACE	L3 = 180cm
LENGTH OF THE WET SUMP	L4 = 543cm

TYPE 2.2

L1 = 788cm
L2 = 550cm
L3 = 120cm
L4 = 553cm

TYPE 3.2

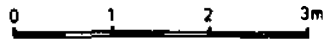
L1 = 688cm
L2 = 450cm
L3 = 120cm
L4 = 453cm

LEGEND:

1. BLINDING AND FOUNDATION PLAIN CONCRETE
2. MOISTURE INSULATION-ASPHALT SHEET AND TWO ASPH. PAINT COATS
3. RECEPTION WALL
4. WASTE PIT
5. BENCHING TO GRADIENT
6. REINFORCED CONCRETE
7. WATERTIGHT REINFORCED CONCRETE
8. CEMENT SCREED
9. EARTHENWARE FLOOR TILES
10. BRICKWORK
11. INTERNAL CEMENT PLASTER
12. INTERNAL CEMENT-LIME PLASTER
13. STERILIZATION PAINT
14. EXTERNAL PLASTER
15. STEEL DOOR
16. STEEL WINDOW
17. STEEL VENTILATION COVER
18. STEEL LADDER
19. STEEL COVER
20. TARRED PAPER
21. SLAG OR FOAM CONCRETE
22. PROTECTING CEMENT SCREED
23. ROOF SHEETING OR BITUMINOUS COVERING
24. INSULATING SHEET
25. CONCRETE TILES LAID ON SAND BED
26. FLASHING
27. FOUNDATION FOR PUMP
28. SWITCHBOARD

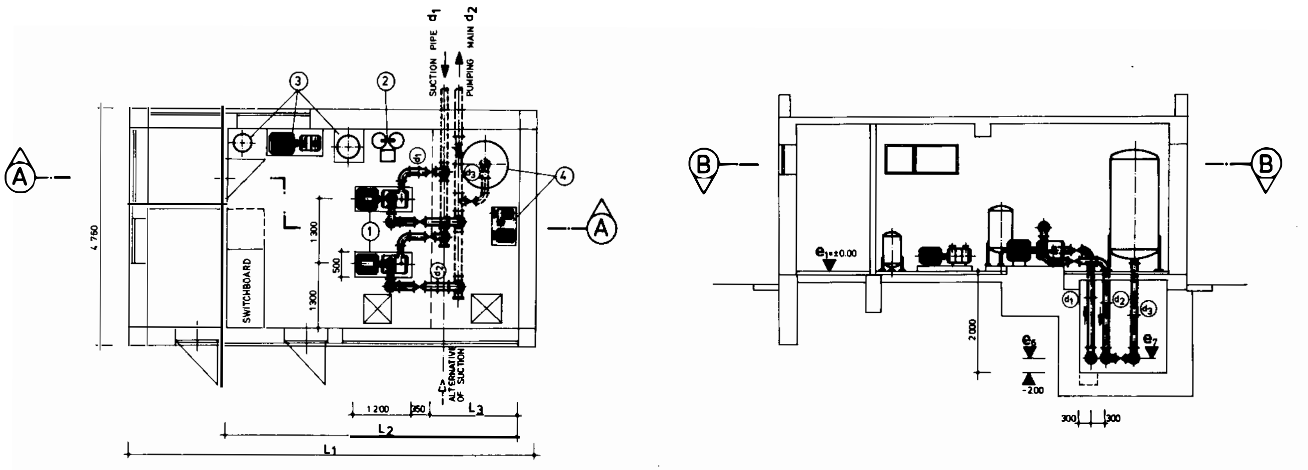
NOTES:
THE HOLE AND DOOR ARE USED IN CONJUCTION WITH AERATION STATION ONLY

DRAIN PIPE TO BE LAID ONLY IN CASE WHEN GRAVITY DRAINAGE OF VALVE SPACE IS POSSIBLE



SCALE

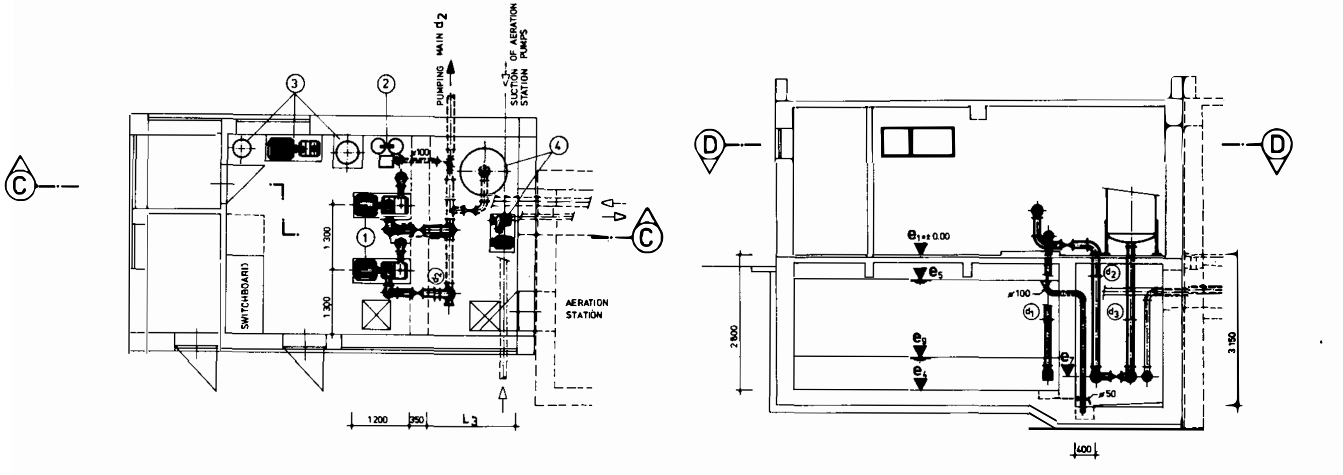
Fig. 11. Machinery for pumping stations with and without wet sump



SECTIONAL PLAN B-B

SECTION A-A

PUMPING STATION - TYPES 1.1, 2.1 and 3.1 (WITHOUT WET SUMP)



SECTIONAL PLAN D-D

SECTION C-C

PUMPING STATION - TYPES 1.2, 2.2 and 3.2 (WITH WET SUMP)

SYMBOLS:
VALVE
NON RETURN VALVE
FLOW MEASURING

ELEVATION RELATIONS

GROUND FLOOR	$e_1=\pm0.00$
BOTTOM OF WET SUMP	$e_4=-2.80$
MAX. WATER LEVEL	$e_5=-0.50$
COMMON SUCTION PIPE, 1.50m UNDER REFORMED GROUND AS A MINIMUM	e_6
PUMPING MAIN, 1.50m UNDER REFORMED GROUND AS A MINIMUM	e_7
MINIMUM WATER LEVEL IN THE WET SUMP	e_9

DIAMETERS OF PIPES

SUCTION PIPE	$\varnothing d_1$
PUMPING MAIN	$\varnothing d_2$
CONNECTION OF PRESSURE VESSEL TO PUMPING MAIN	$\varnothing d_3$

LEGEND:

1. PUMPSET OUTPUT Q=0.5 upto 5.0 l/s
   TOTAL DELIVERY HEAD H upto 85m
2. CHLORINE DOSING APPARATUS FOR DOSING OF SODIUM HYPOCHLORITE
3. AUTOMATIC AIR RELEASE DEVICE
4. WATER HAMMER DAMPING CONSISTING OF PRESSURE VESSEL AND AIR COMPRESSOR

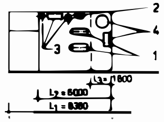
MATERIAL OF PIPES:

SUCTION, PUMPING MAIN AND CONNECTION OF PRESSURE VESSEL TO PUMPING MAIN ARE FLANGED STEEL PIPES

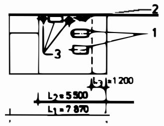
AUXILIARY PIPING OF AUTOMATIC AIR RELEASE DEVICE - GALVANIZED STEEL, THREADED CONNECTION

DOSING OF SODIUM HYPOCHLORITE - PVC OR SIMILAR CORROSIVE RESISTANT MATERIAL

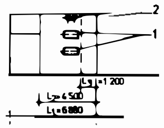
ALTERNATIVES OF PUMPING STATION ACCORDING TO THE EQUIPMENT INSTALLED



TYPE 1.1
TYPE 1.2



TYPE 2.1
TYPE 2.2

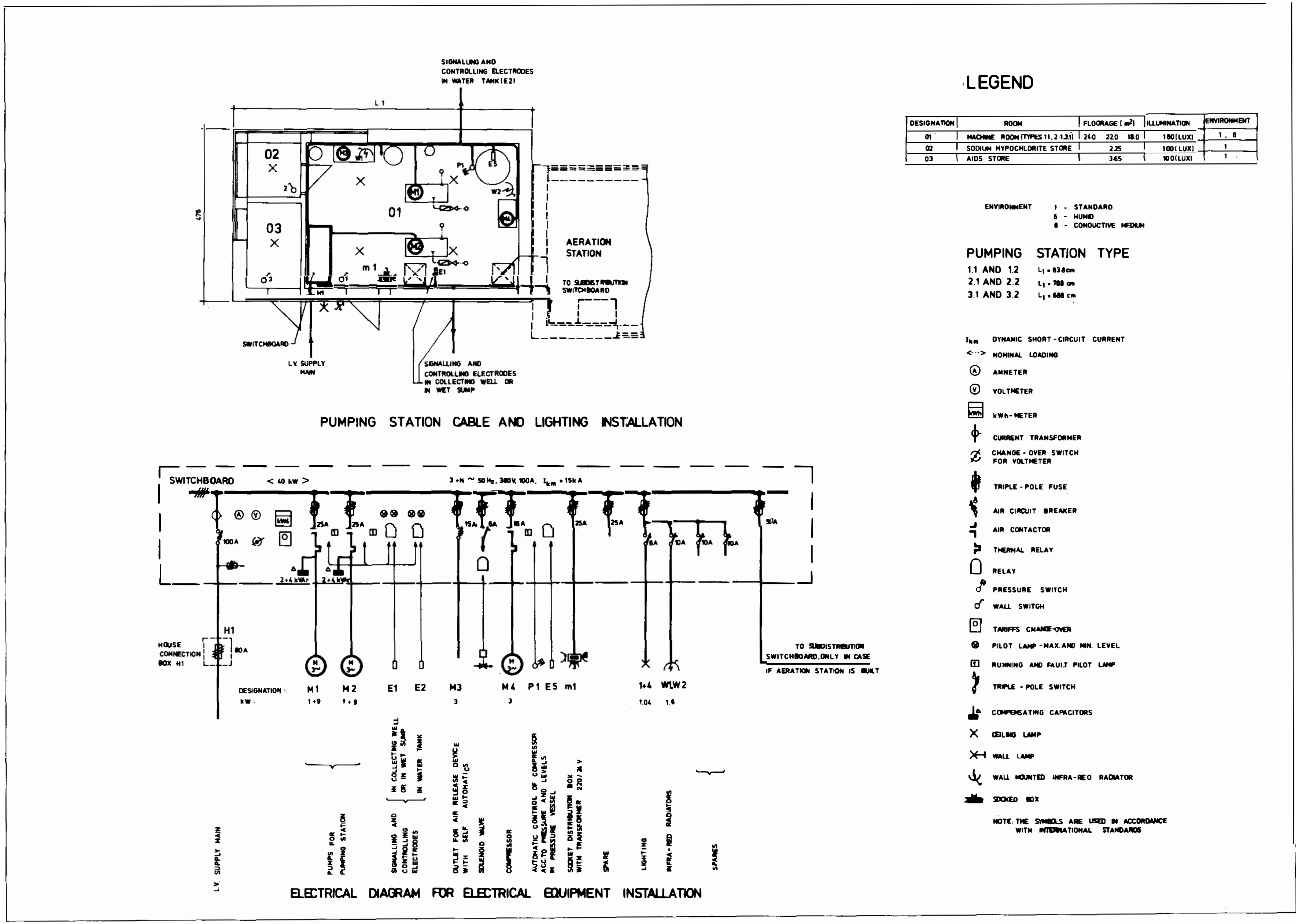


TYPE 3.1
TYPE 3.2

DIMENSIONS IN mm

0 1 2 3m
SCALE

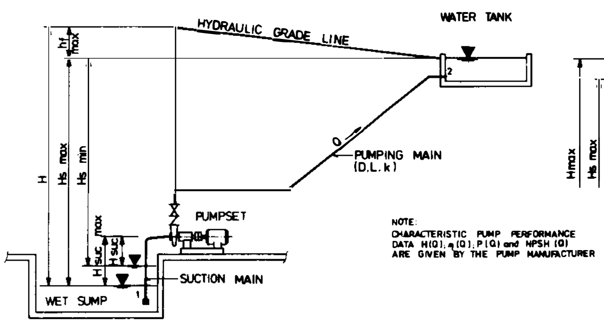
Fig. 12. Electrical equipment for a pumping station



DESIGNATION	ROOM	FLOORAGE [m²]	ILLUMINATION	ENVIRONMENT
01	MACHINE ROOM (TYPES 1.1, 2.1, 3.1)	24.0 22.0 18.0	180 (LUX)	1 , 6
02	SODIUM HYPOCHLORITE STORE	2.25	100 (LUX)	1
03	AIDS STORE	3.65	100 (LUX)	1

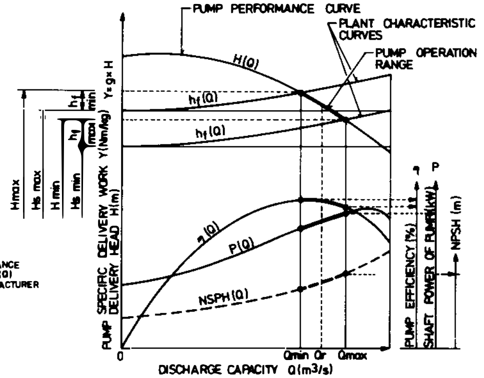
Fig. 13. Basic pump installation calculations

CALCULATION SKETCH



NOTE: CHARACTERISTIC PUMP PERFORMANCE DATA H(Q), η(Q), P(Q) and NPSH (Q) ARE GIVEN BY THE PUMP MANUFACTURER

TYPICAL PUMP PERFORMANCE AND PLANT CHARACTERISTIC CURVES



EXAMPLE OF CALCULATION

PUMP INSTALLATION CHARACTERISTIC DATA:

Qr	= 8.0 l/s	RATED DISCHARGE CAPACITY
D	= 0.100 m	INSIDE DIAMETER OF PUMPING MAIN
L	= 1,250 m	LENGTH OF PUMPING MAIN
Hs min	= 24.5 m	MINIMUM STATIC HEAD
Hs max	= 29.0 m	MAXIMUM STATIC HEAD
v	= 1.02 m/s	VELOCITY OF FLOW IN THE MAIN
h_f	m	FRICTION AND LOCAL PRESSURE LOSSES IN SUCTION AND PUMPING MAIN FROM (1) TO (2) - SEE CALCULATION SKETCH
k	= 0.10 mm	ABSOLUTE PIPE WALL INSIDE ROUGHNESS(WHITE-COLEBROOK FORMULA)
H	$= H_s + h_f$	TOTAL DELIVERY HEAD
H_{suc}		PUMP SUCTION HEAD. MAXIMUM OPERATION VALUE (HYDRAULIC LOSSES INCLUDED) SHALL BE COMPARED AND CHECKED TO THE SUCTION ABILITY OF THE PUMP TO AVOID RUNNING IN CAVITATION CONDITIONS (NPSH - NET POSITIVE SUCTION HEAD SHALL BE TAKEN IN ACCOUNT)

CALCULATED VALUES:

Qmin = 7.80 l/s	$h_f$min = 15.1 m	Hmax = 44.1 m	η = 0.62	Qmax > Qr > Qmin
Qmax = 8.50 l/s	$h_f$max = 17.7 m	Hmin = 42.2 m	η = 0.61	

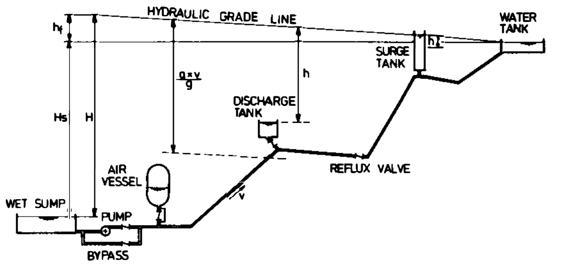
$P = \frac{Y \times Q}{\eta} = \frac{g \times Q \times H}{\eta}$ SHAFT POWER OF PUMP Pmax = 5.8 kW = P(Q) IN THE GRAPH

P_M MINIMUM OUTPUT OF ASYNCHRONOUS MOTOR. FOR P < 15kW $P_M = (1.2 \div 1.3) \times P_{max}$

$\boxed{P_M = 7.5\ \text{kW}}$

PUMP OPERATION RANGE AND ELECTRIC MOTOR OUTPUT DETERMINATION

PIPELINE PROFILE ILLUSTRATING SUITABLE LOCATIONS OF VARIOUS WATERHAMMER PROTECTION DEVICES



METHODS OF WATERHAMMER PROTECTION

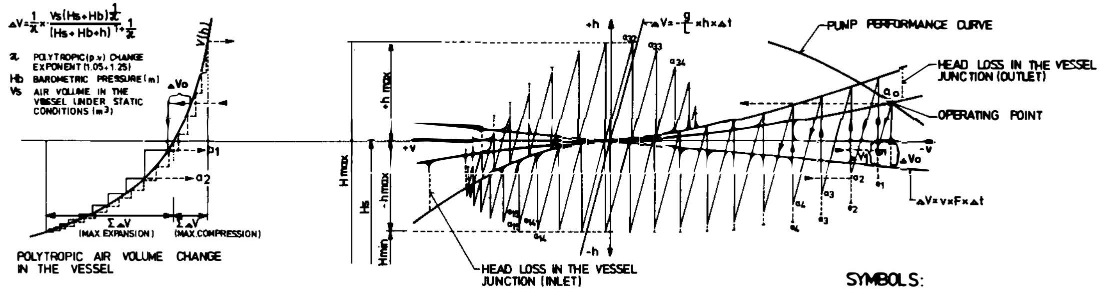
METHOD OF PROTECTION	REQUIRED RANGE OF VARIABLES	REMARKS
NO PROTECTION NEEDED	$H_{WH} = H_s + \frac{a \times v}{g} - h_f$ $H_{WH} \leq$ NP OF PIPELINE INSTALLATION	NP SHOULD BE EXPRESSED IN (m) OF WATER COLUMN h_f VALUE IS NOT DECISIVE ($H_s \gg h_f$)
PUMP BYPASS REFLUX VALVE	$\frac{a \times v}{g \times H} \gg 1$	SOME WATER MAY ALSO BE DRAWN THROUGH PUMP
IN LINE REFLUX VALVE	$\frac{a \times v}{g \times h} > 1$	USED IN CONJUCTION WITH SOME OTHER METHOD OF PROTECTION. WATER COLUMN SEPARATION POSSIBLE
SURGE TANK	h SMALL	PIPELINE SHOULD BE NEAR HYDRAULIC GRADE LINE SO HEIGHT OF TANK IS PRACTICAL
AUTOMATIC RELEASE VALVE	$\frac{a \times v}{g \times H} \ll 1$ $\frac{2L}{a} > 5\,\text{sec}$	PIPELINE PROFILE SHOULD BE CONVEX DOWNWARDS WATER COLUMN SEPARATION LIKELY
DISCHARGE TANK	$\frac{a \times v}{g \times h} > 1$	h = PRESSURE HEAD AT TANK. PIPELINE PROFILE SHOULD BE CONVEX UPWARDS
AIR VESSEL	$\frac{a \times v}{g \times H} < 1$	PIPELINE PROFILE PREFERABLY CONVEX DOWNWARDS. SIMPLE, RELIABLE METHOD

H_{WH} MAXIMUM PRESSURE HEAD DUE TO WATERHAMMER PHENOMENON IN THE PIPELINE (m)
Hs STATIC HEAD (m)
h_f HYDRAULIC LOSSES IN THE PUMPING MAIN (m)
NP NOMINAL PRESSURE
a WATERHAMMER WAVE VELOCITY (m/s) MAY BE AS HIGH AS 1100 m/s FOR RIGID WALL STEEL PIPES OR AS LOW AS 350 m/s FOR VERY FLEXIBLE PLASTIC PIPES
g ACCELERATION OF GRAVITY (m/s2)

GRAPHICAL CALCULATION (EQUIVALENT SURGE TANK METHOD)

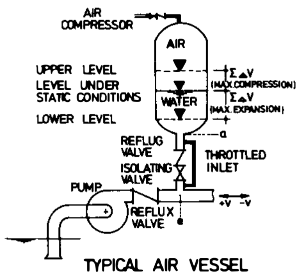
$\Delta V = \frac{1}{\varkappa} \times \frac{V_s (H_s + H_b)^{\frac{1}{\varkappa}}}{(H_s + H_b + h)^{1+\frac{1}{\varkappa}}}$

ϰ POLYTROPIC (p.v) CHANGE EXPONENT (1.05 ÷ 1.25)
Hb BAROMETRIC PRESSURE (m)
Vs AIR VOLUME IN THE VESSEL UNDER STATIC CONDITIONS (m3)

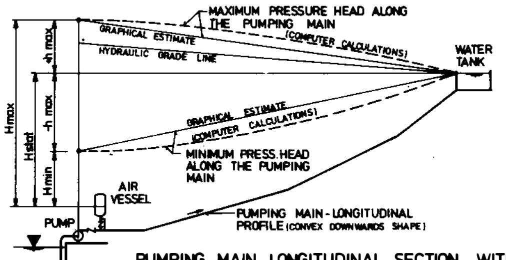


SYMBOLS:

ΔV AIR VOLUME CHANGE IN THE VESSEL (m^3)
v FLOW VELOCITY IN THE PUMPING MAIN (m/s)
+h max MAXIMUM PRESSURE INCREASE ABOVE STATIC HEAD (m)
-h max MAXIMUM PRESSURE DECREASE UNDER STATIC HEAD (m)
Δt INTERVAL OF TIME (sec)
F PUMPING MAIN CROSS SECTION AREA (m^2)
H PRESSURE HEAD IN THE AIR VESSEL (m)



TYPICAL AIR VESSEL INSTALLATION

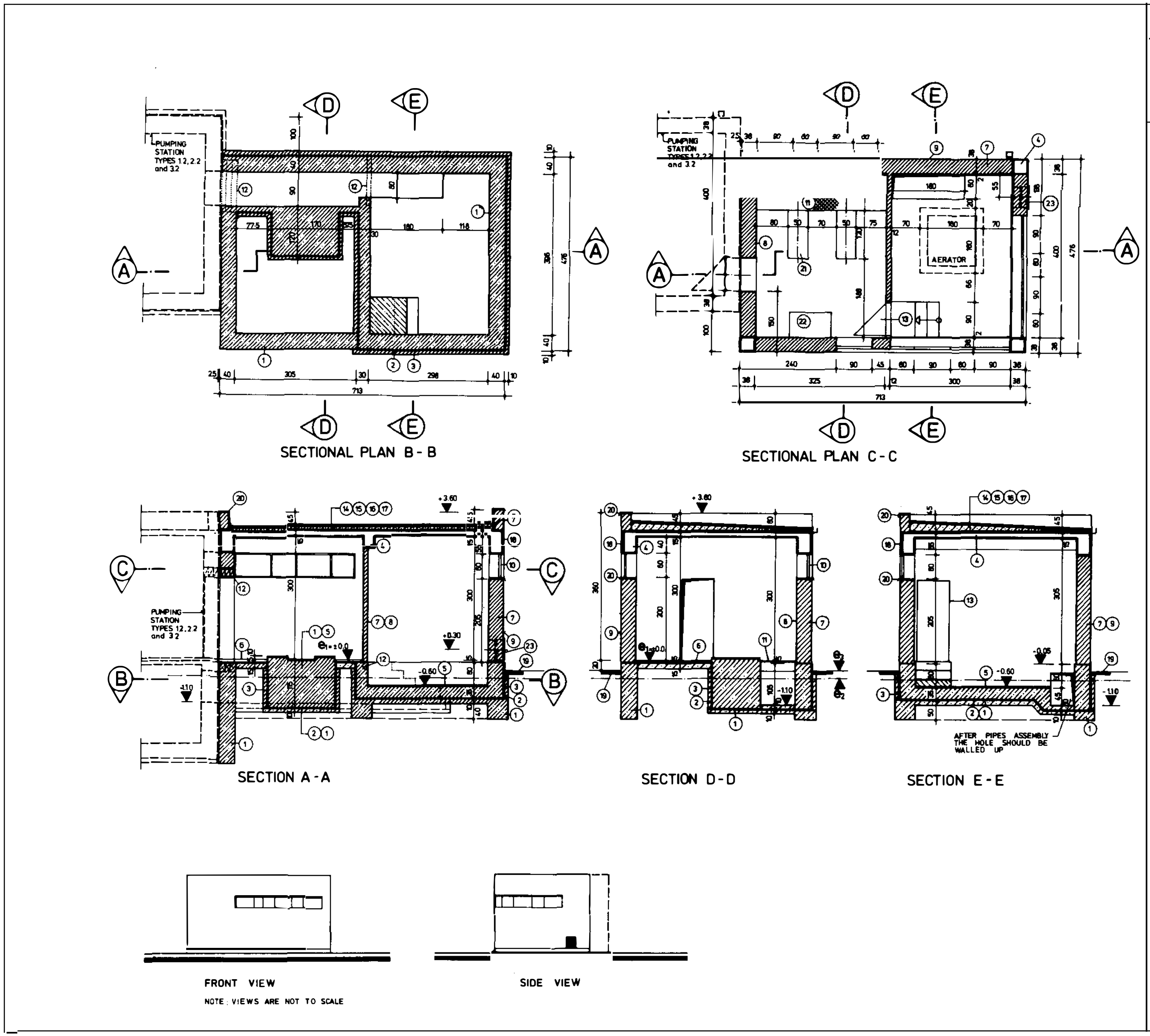


PUMPING MAIN LONGITUDINAL SECTION WITH TYPICAL PRESSURE HEAD LINES UNDER WATERHAMMER DAMPING

NOTE: WHEN DETAILED PRESSURE HEAD LINE DATA ARE REQUIRED (COMPLICATE SHAPE OF PIPE LONGITUDINAL SECTION) THE COMPUTER CALCULATION IS NECESSARY.

WATERHAMMER DAMPING

Fig. 14. The structure of an aeration station



ELEVATION RELATIONS

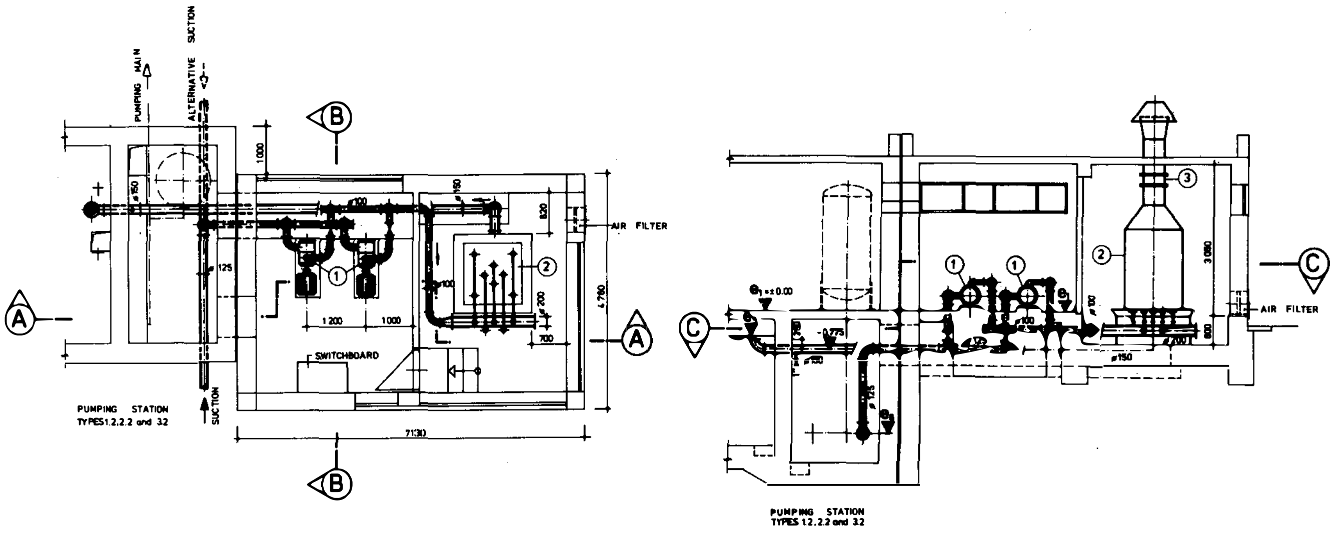
GROUND FLOOR	$e_1 = \pm 0.0$
EXISTING GROUND	e_2
REFORMED GROUND	e_3

LEGEND:

1. BLINDING AND FOUNDATION PLAIN CONCRETE
2. MOISTURE INSULATION-ASPHALT SHEET AND TWO ASPH. PAINT COATS
3. RECEPTION WALL
4. REINFORCED CONCRETE
5. CEMENT SCREED
6. EARTHENWARE FLOOR TILES
7. BRICKWORK
8. INTERNAL CEMENT-LIME PLASTER
9. EXTERNAL PLASTER
10. STEEL WINDOW
11. DUCKED COVER
12. PRECAST LINTEL
13. STEEL DOOR
14. TARRED PAPER
15. SLAG OR FOAM CONCRETE
16. PROTECTING CEMENT SCREED
17. ROOF SHEETING OR BITUMINOUS COVER
18. INSULATING SHEET
19. CONCRETE TILES LAID ON SAND BED
20. FLASHING
21. FOUNDATION FOR MACHINERY UNIT
22. SWITCHBOARD
23. VENTILATION HOLE WITH AIR FILTER

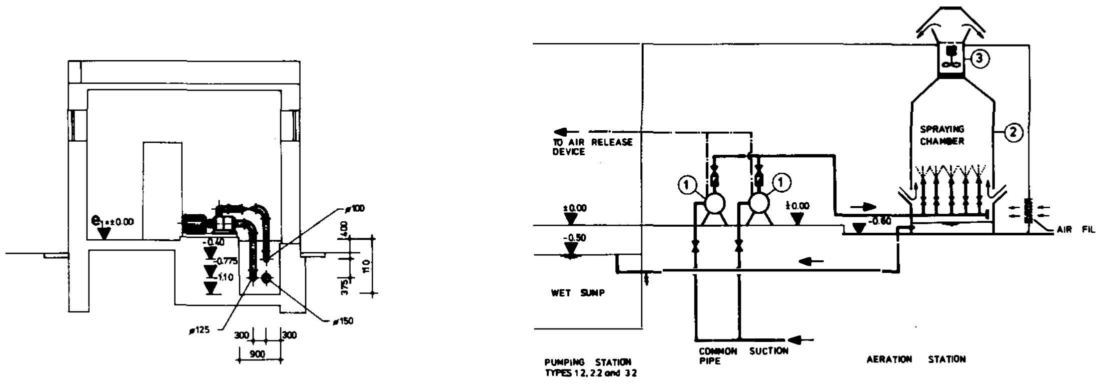
0 1 2 3m
SCALE

Fig. 15. Mechanical equipment for an aeration station



SECTIONAL PLAN C-C

SECTION A-A



SECTION B-B

FUNCTIONAL CHART OF THE AERATION

ELEVATION RELATIONS

IDENTICAL TO THE INCORPORATED PUMP STATION	$e_1 = \pm 0.00$
SEE INCORPORATED PUMP STATION	$e_5 = -0.50$
COMMON SUCTION PIPE, 1.50m UNDER REFORMED GROUND AS A MINIMUM	e_8

LEGEND:

MACHINES AND EQUIPMENT:

1. PUMPSET FOR THE AERATOR
   OUTPUT Q = 0.5 upto 5.0 l/s
   TOTAL DELIVERY HEAD H = 25m
2. AERATOR
   SPRAYING TYPE AERATOR MADE OF STEEL
   MAX. OUTPUT UPTO 10 l/s
3. SCREW TYPE VENTILATOR
   (CORROSIVE RESISTANT MATERIAL)
   BUILT IN THE AERATOR WITH FILTER AND WATER DROPS SEPARATOR
   POWER OUTPUT APPROX 0.26 kW

PIPES:

PIPES IN THE AERATION STATION ARE MADE OF STEEL, PROTECTIVE ANTICORROSIVE PAINT FROM OUTSIDE AND INSIDE APPLIED

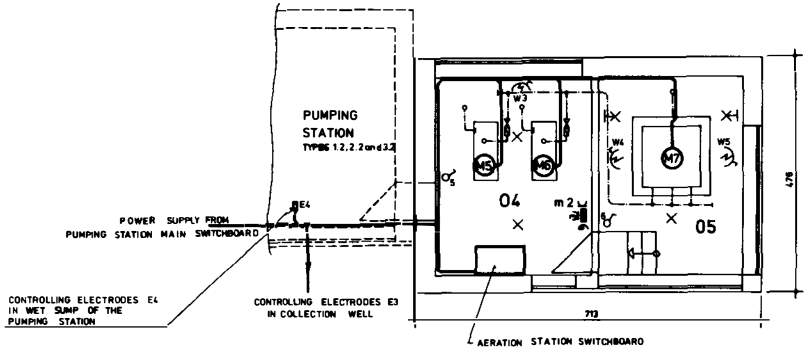
SYMBOLS:

⧓	VALVE
▬	NON RETURN VALVE

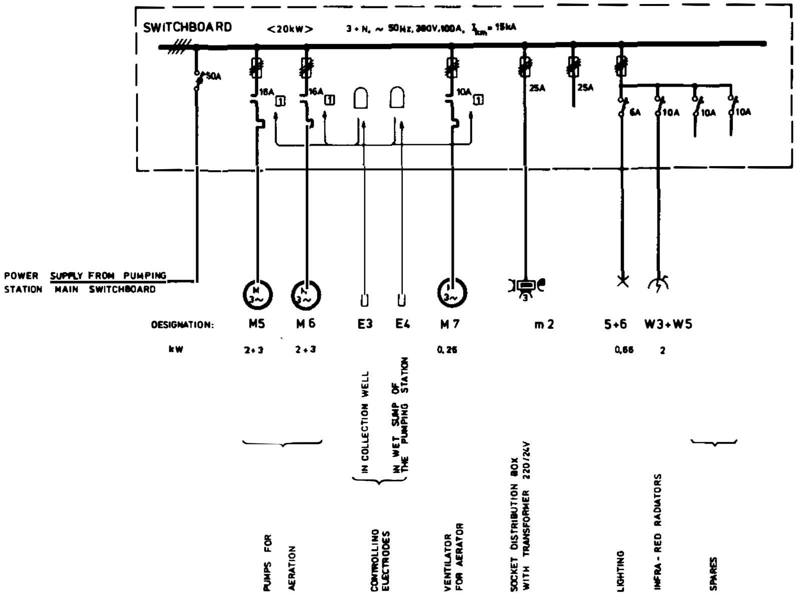
DIMENSIONS IN mm

0 1 2 3m
SCALE

Fig. 16. Electrical equipment for an aeration station



AERATION STATION CABLE AND LIGHTING INSTALLATION



ELECTRICAL DIAGRAM FOR ELECTRICAL EQUIPMENT INSTALLATION

LEGEND

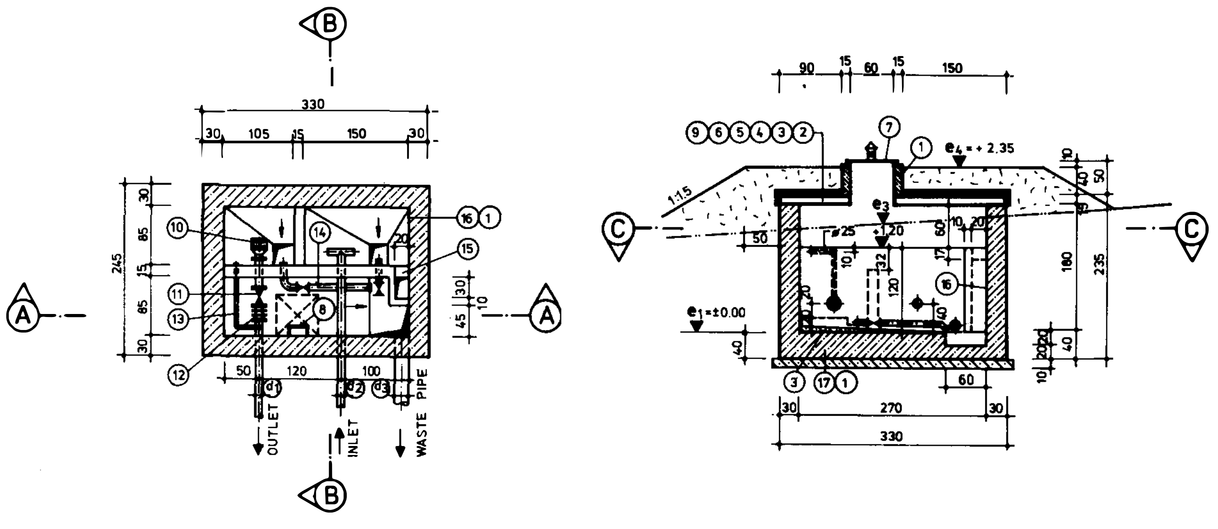
DESIGNATION	ROOM	FLOORAGE (m²)	ILLUMINATION	ENVIRONMENT
04	MACHINE ROOM	13.0	160(LUX)	1; 8
05	AERATION	12.0	100(LUX)	6; 8

ENVIRONMENT 1 - STANDARD
6 - HUMID
8 - CONDUCTIVE MEDIUM

I_{km} = DYNAMIC SHORT - CIRCUIT CURRENT
<----> = NOMINAL LOADING
Ⓐ AMMETER
Ⓥ VOLTMETER
kWh - METER
CURRENT TRANSFORMER
CHANGE OVER SWITCH FOR VOLTMETER
TRIPLE - POLE FUSE
AIR CIRCUIT BREAKER
AIR CONTACTOR
THERMAL RELAY
RELAY
WALL SWITCH
RUNNING AND FAULT PILOT LAMP
× CEILING LAMP
WALL LAMP
WALL MOUNTED INFRA - RED RADIATOR
SOCKED BOX

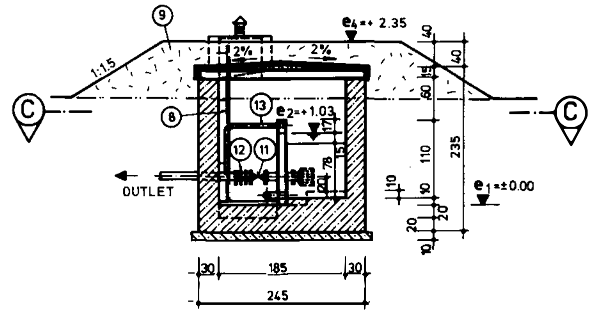
NOTE:
THE SYMBOLS ARE USED IN ACCORDANCE WITH INTERNATIONAL STANDAROS.

Fig. 17. A pressure head breaking chamber



SECTIONAL PLAN C-C

SECTION A-A



SECTION B-B

ELEVATION RELATIONS

BOTTOM OF CHAMBER :	$e_1 = \pm 0.00$
OVERFLOW LEVEL :	$e_2 = + 1.03$
EXISTING GROUND :	e_3
REFORMED GROUND :	e_4

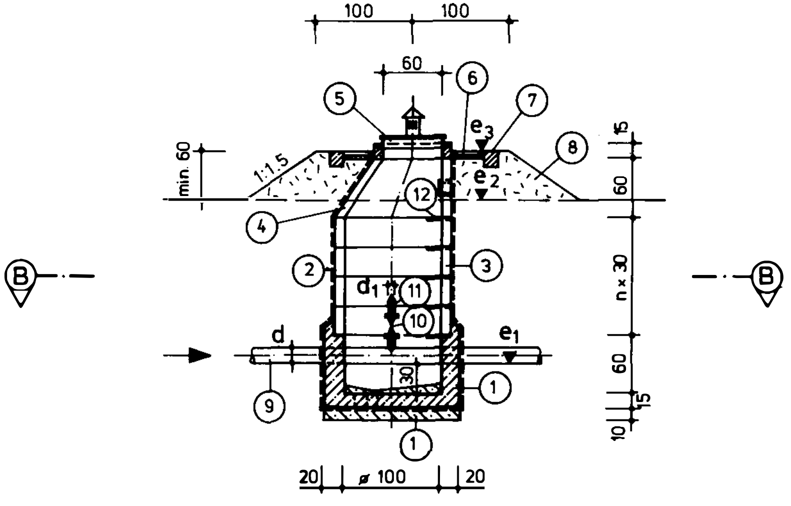
DIAMETERS OF PIPES

OUTLET :	d_1
INLET :	d_2
WASTE PIPE :	d_3

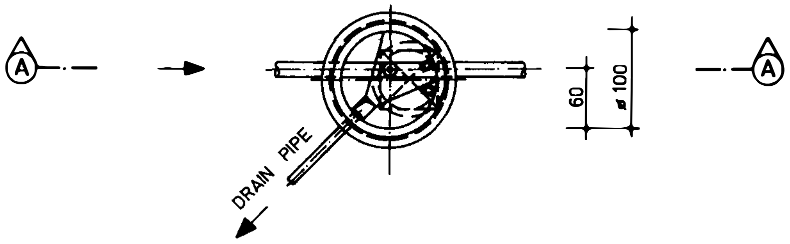
LEGEND :

1. PLAIN CONCRETE
2. REINFORCED CONCRETE
3. BENCHING TO GRADIENT
4. CEMENT PLASTER
5. WATERPROOF INSULATION
6. PROTECTING CEMENT SCREED
7. CAST IRON VENTILATION COVER
8. STEEL LADDER
9. COMPACT FILL AND HUMUS
10. INLET STRAINER
11. VALVE
12. MAKE - UP PIECE
13. AIR PIPE ø 25mm
14. DRAIN PIPE ø 80mm
15. OVERFLOW
16. WATERTIGHT CEMENT PLASTER
17. FOUNDATION CONCRETE

Fig. 18. An air valve chamber



SECTION A - A



SECTIONAL PLAN B - B

ELEVATION RELATIONS

LEVEL OF DELIVERY OR PUMPING MAIN : e_1
EXISTING GROUND : e_2
REFORMED GROUND : e_3

d - MAIN PIPELINE DIAMETER, d_1 - AIR VALVE DIAMETER

NUMBER OF PRECASTED CONCRETE CENTERINGS : n

LEGEND :

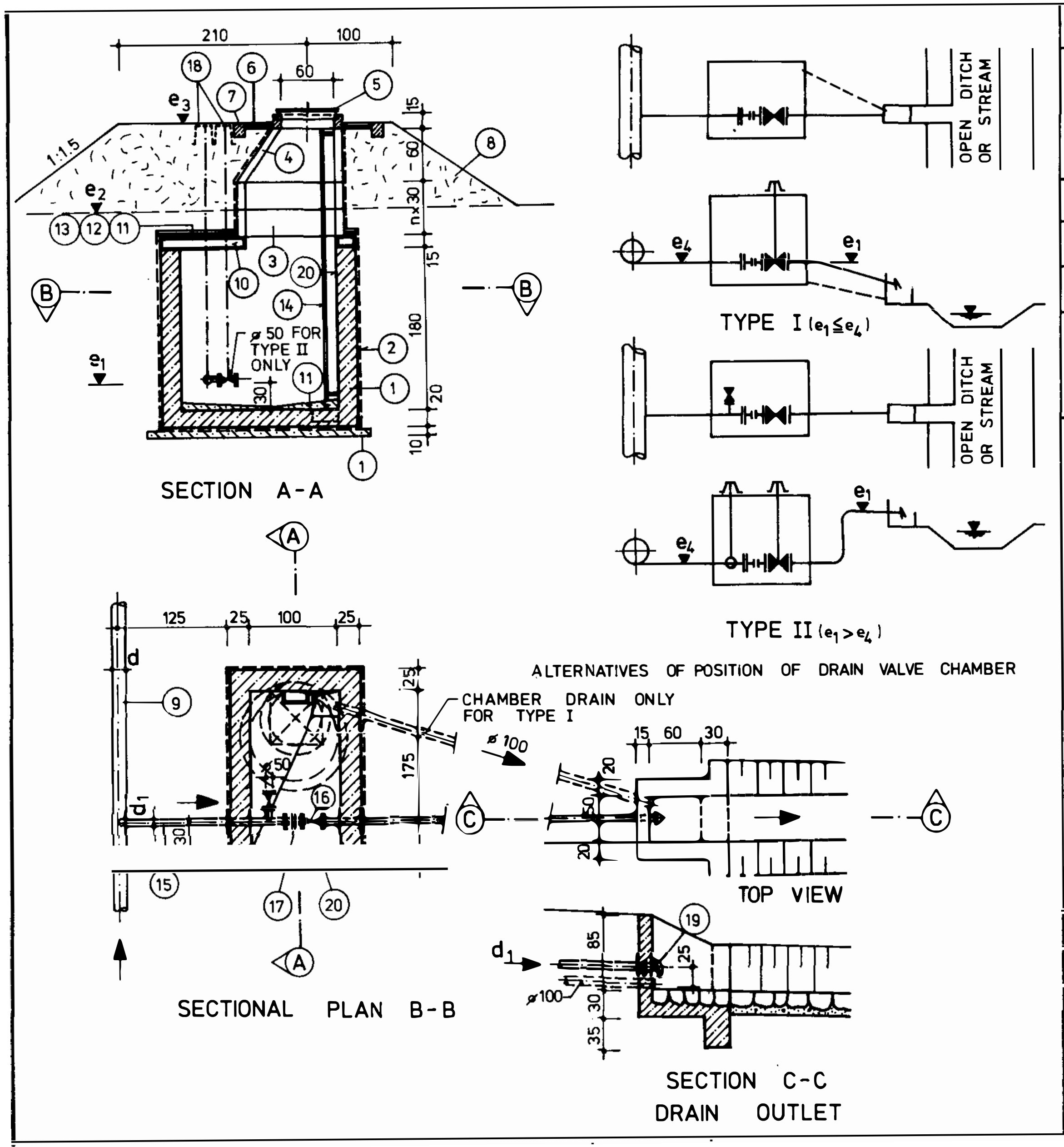
1. BLINDING AND FOUNDATION PLAIN CONCRETE
2. MOISTURE INSULATION
3. PRECASTED CONCRETE CENTERING ⌀ 100 cm
4. CONICAL PRECASTED CONCRETE CENTERING ⌀ 60 / 100 cm
5. CAST IRON VENTILATION COVER
6. CONCRETE TILES 30/30cm LAID ON SAND BED
7. KERB - STONE
8. FILL
9. DELIVERY OR PUMPING MAIN
10. VALVE
11. AIR VALVE
12. STEP IRON

⌀ d (mm)	80	100	125	150	200	250
⌀ d_1 (mm)	50	50	50	50	80	80

NOTE :

1. DRAIN PIPE IS DESIGNED ONLY IF GRAVITATIONAL DRAINAGE IS POSSIBLE

Fig. 19. A drain valve chamber



ELEVATION RELATIONS

LEVEL OF DRAIN PIPE : e_1
EXISTING GROUND : e_2
REFORMED GROUND : e_3
LEVEL OF DELIVERY OR PUMPING MAIN : e_4

DRAIN PIPE - DIAMETER : d_1

NUMBER OF PRECASTED CONCRETE CENTERINGS : n

ALTERNATIVES OF POSITION OF DRAIN VALVE CHAMBER

TYPE I - DELIVERY OR PUMPING MAIN AND DRAIN PIPE ARE ON THE SAME ELEVATION
TYPE II - DELIVERY OR PUMPING MAIN AND DRAIN PIPE ARE ON DIFFERENT ELEVATIONS

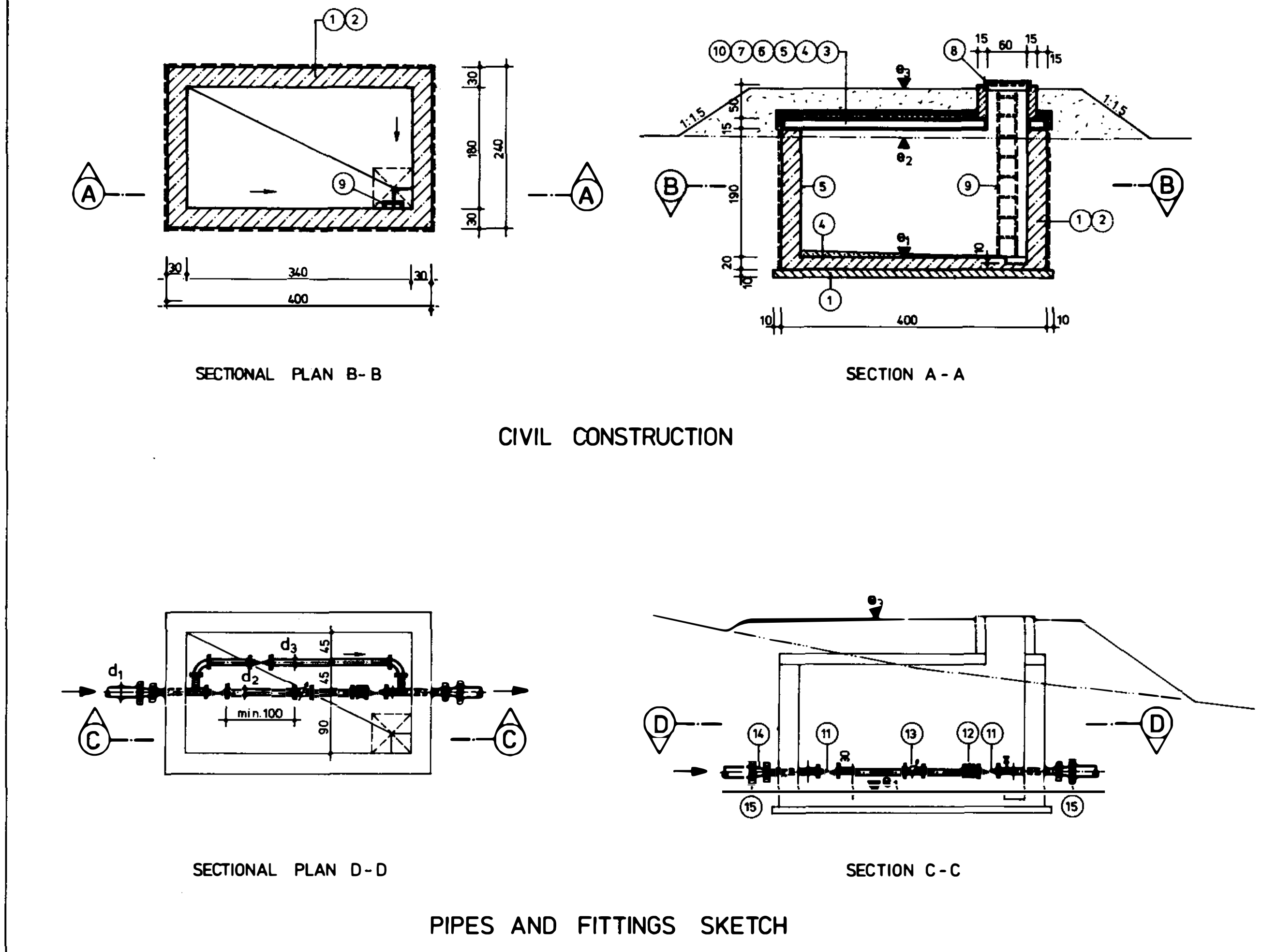
LEGEND :

1. BLINDING AND FOUNDATION PLAIN CONCRETE
2. MOISTURE INSULATION
3. PRECASTED CONCRETE CENTERING ø 100 cm
4. CONICAL PRECASTED CONCRETE CENTERING ø60/100cm
5. CAST IRON COVER (HEAVY DUTY)
6. CONCRETE TILES 30/30 cm LAID ON SAND BED
7. KERB - STONE
8. FILL
9. DELIVERY OR PUMPING MAIN
10. COVER SLAB - REINFORCED CONCRETE
11. CEMENT SCREED
12. WATERPROOF INSULATION
13. PROTECTING CEMENT SCREED
14. STEEL LADDER
15. DRAIN PIPE
16. VALVE
17. MAKE - UP PIECE
18. SURFACE LOCKED BOX
19. FLAP VALVE
20. WATERTIGHT PLASTER

ød OF MAIN PIPELINE	80	100	125	150	200
ød_1 OF DRAIN PIPE	50	50	50	80	80

0 1 2 3m
SCALE

Fig. 20. A measuring chamber



ELEVATION RELATIONS	
BOTTOM OF CHAMBER:	$e_1=\pm0.00$
EXISTING GROUND:	e_2
REFORMED GROUND:	e_3

DIAMETERS OF PIPES	
MAIN PIPELINE DIAMETER	d_1
WATER METER NOMINAL DIAMETER	d_2
BYPASS PIPE DIAMETER	d_3

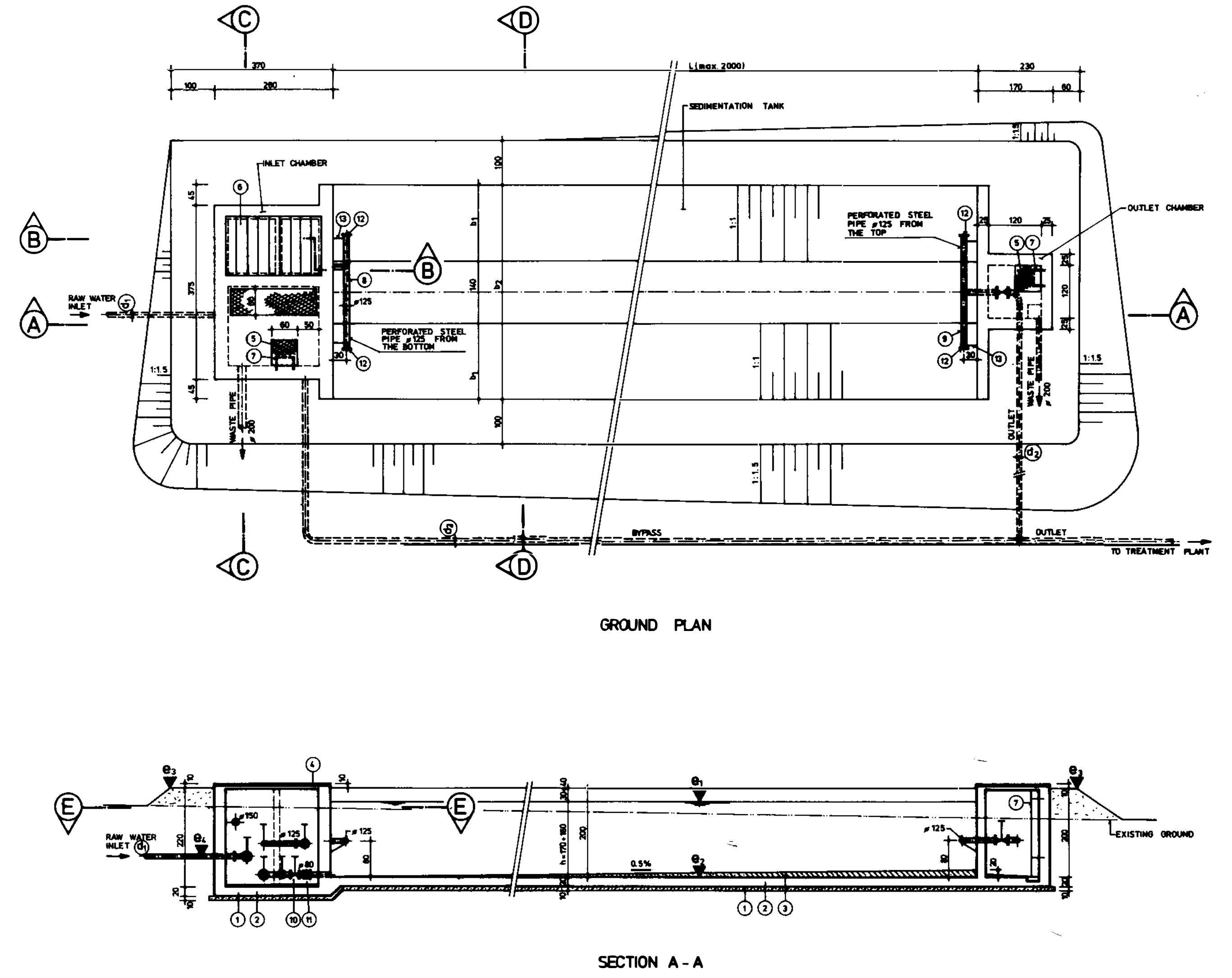
LEGEND:

1. BLINDING AND FOUNDATION PLAIN CONCRETE
2. MOISTURE INSULATION
3. REINFORCED CONCRETE
4. BENCHING TO GRADIENT
5. CEMENT PLASTER
6. WATERPROOF INSULATION
7. PROTECTING CEMENT SCREED
8. CAST IRON COVER
9. STEEL LADDER
10. COMPACT FILL AND HUMUS
11. HAND OPERATED VALVE
12. MAKE-UP PIECE
13. FLOW MEASURING
14. PIPE REDUCER (IF REQUIRED)
15. MASTIC AND WRAPPED TAPE JOINT PROTECTION

0 1 2 3m

SCALE

Fig. 21. A sedimentation tank
(for sections B, C, D and E, see Fig. 22)



ELEVATION RELATIONS

MAX. W. LEVEL	e_1
BOTTOM OF SEDIMENTATION TANK	e_2
REFORMED GROUND	e_3
CENTRE LINE LEVEL OF INLET PIPE	e_4

BASIC DIMENSIONS

GROUND WIDTHS	b_1. b_2
LENGTH	L (max. 2000cm)
DEPTH OF WATER	h (160 ÷ 170 cm)

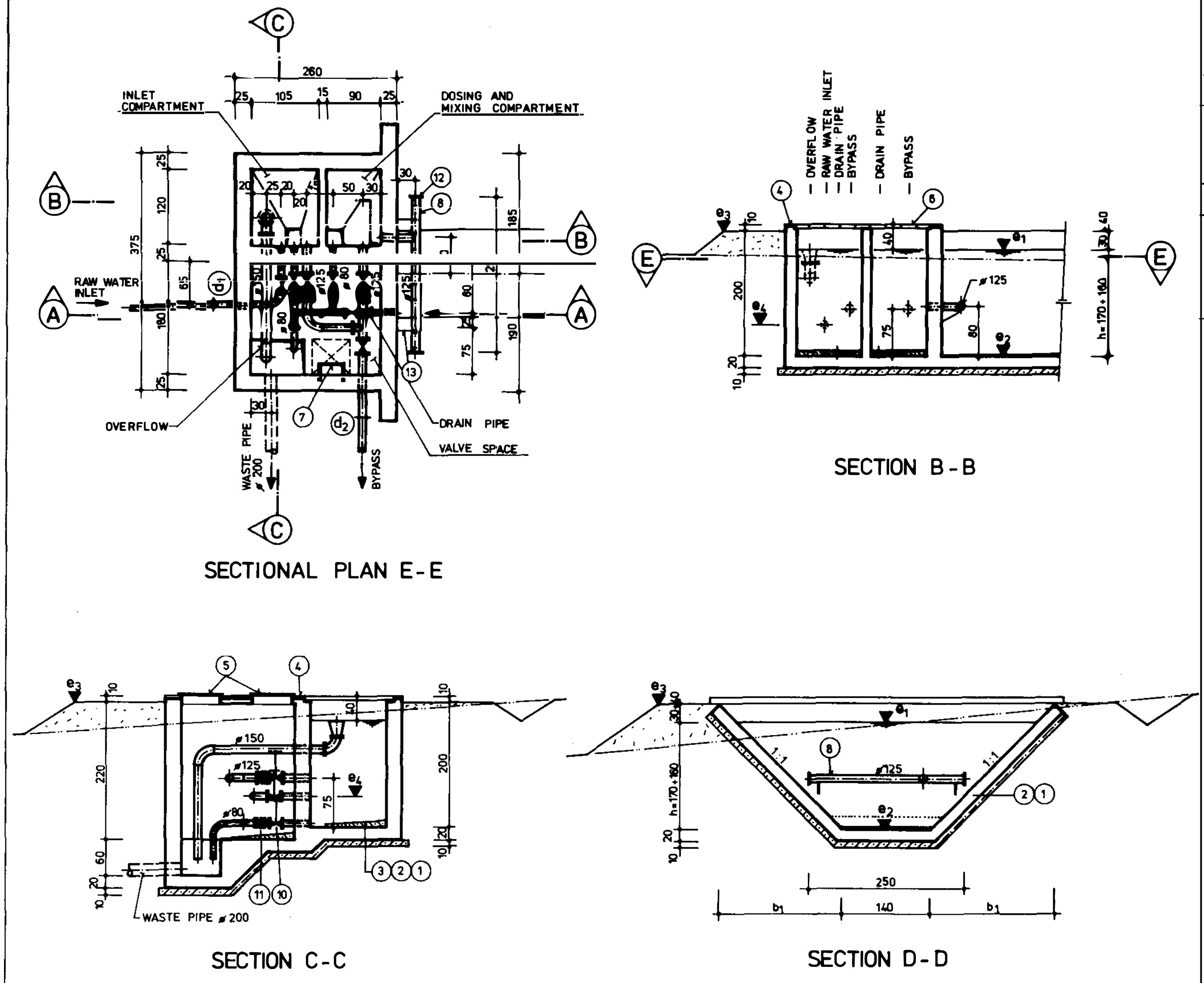
DIAMETERS

INLET	d_1
OUTLET (BYPASS)	d_2
OVERFLOW	ø 150mm
DRAIN PIPE	ø 80 mm

LEGEND:

1. BLINDING CONCRETE
2. WATERTIGHT REINFORCED CONCRETE
3. BENCHING TO ORADIENT
4. CEMENT SCREED
5. STEEL COVER
6. WOOD COVER
7. STEEL LADDER
8. PERFORED DISTRIBUTION PIPE
9. PERFORED COLLECTION PIPE
10. HAND OPERATED VALVE
11. MAKE-UP PIECE
12. BLIND FLANGE
13. ANCHORING

Fig. 22. Sections of a sedimentation tank
(for ground plan and section A, see Fig. 21)



ELEVATION RELATIONS

MAX.W. LEVEL	e_1
BOTTOM OF SEDIMENTATION TANK	e_2
REFORMEO GROUND	e_3
CENTRE LINE LEVEL OF INLET PIPE	e_4

BASIC DIMENSIONS

GROUND WIDTHS	b_1, b_2
LENGTH	L (max. 2000cm)
DEPTH OF WATER	h (160÷170cm)

DIAMETERS

INLET	d_1
OUTLET (BYPASS)	d_2
OVERFLOW	ø150mm
DRAIN PIPE	ø 80 mm

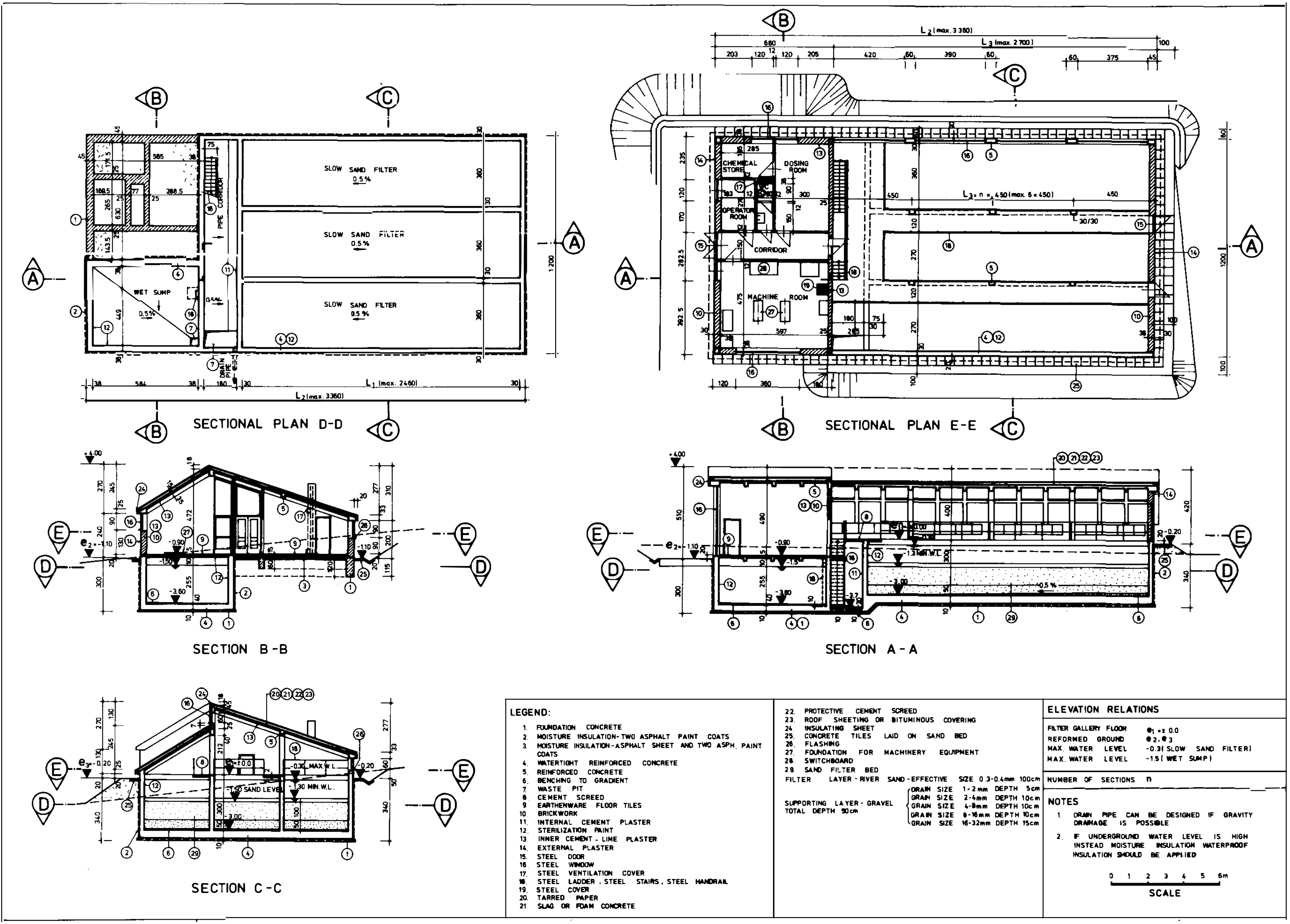
LEGEND:

1. BLINDING CONCRETE
2. WATERTIGHT REINFORCED CONCRETE
3. BENCHING TO GRADIENT
4. CEMENT SCREED
5. STEEL COVER
6. WOOD COVER
7. STEEL LADDER
8. PERFORATED DISTRIBUTION PIPE
10. HAND OPERATED VALVE
11. MAKE-UP PIECE
12. BLIND FLANGE
13. ANCHORING

0 1 2 3m

SCALE

Fig. 23. A filter plant of the slow sand type



LEGEND:

1. FOUNDATION CONCRETE
2. MOISTURE INSULATION - TWO ASPHALT PAINT COATS
3. MOISTURE INSULATION - ASPHALT SHEET AND TWO ASPH. PAINT COATS
4. WATERTIGHT REINFORCED CONCRETE
5. REINFORCED CONCRETE
6. BENCHING TO GRADIENT
7. WASTE PIT
8. CEMENT SCREED
9. EARTHENWARE FLOOR TILES
10. BRICKWORK
11. INTERNAL CEMENT PLASTER
12. STERILIZATION PAINT
13. INNER CEMENT - LIME PLASTER
14. EXTERNAL PLASTER
15. STEEL DOOR
16. STEEL WINDOW
17. STEEL VENTILATION COVER
18. STEEL LADDER, STEEL STAIRS, STEEL HANDRAIL
19. STEEL COVER
20. TARRED PAPER
21. SLAG OR FOAM CONCRETE
22. PROTECTIVE CEMENT SCREED
23. ROOF SHEETING OR BITUMINOUS COVERING
24. INSULATING SHEET
25. CONCRETE TILES LAID ON SAND BED
26. FLASHING
27. FOUNDATION FOR MACHINERY EQUIPMENT
28. SWITCHBOARD
29. SAND FILTER BED

FILTER LAYER - RIVER SAND - EFFECTIVE SIZE 0.3-0.4mm 100cm

SUPPORTING LAYER - GRAVEL
TOTAL DEPTH 50cm

GRAIN SIZE 1-2mm DEPTH 5cm
GRAIN SIZE 2-4mm DEPTH 10cm
GRAIN SIZE 4-8mm DEPTH 10cm
GRAIN SIZE 8-16mm DEPTH 10cm
GRAIN SIZE 16-32mm DEPTH 15cm

ELEVATION RELATIONS

FILTER GALLERY FLOOR	$e_1 = \pm 0.0$
REFORMED GROUND	e_2, e_3
MAX. WATER LEVEL	-0.3 (SLOW SAND FILTER)
MAX. WATER LEVEL	-1.5 (WET SUMP)

NUMBER OF SECTIONS n

NOTES

1. DRAIN PIPE CAN BE DESIGNED IF GRAVITY DRAINAGE IS POSSIBLE
2. IF UNDERGROUND WATER LEVEL IS HIGH INSTEAD MOISTURE INSULATION WATERPROOF INSULATION SHOULD BE APPLIED

0 1 2 3 4 5 6m
SCALE

Fig. 24. An architect's view of a filter plant

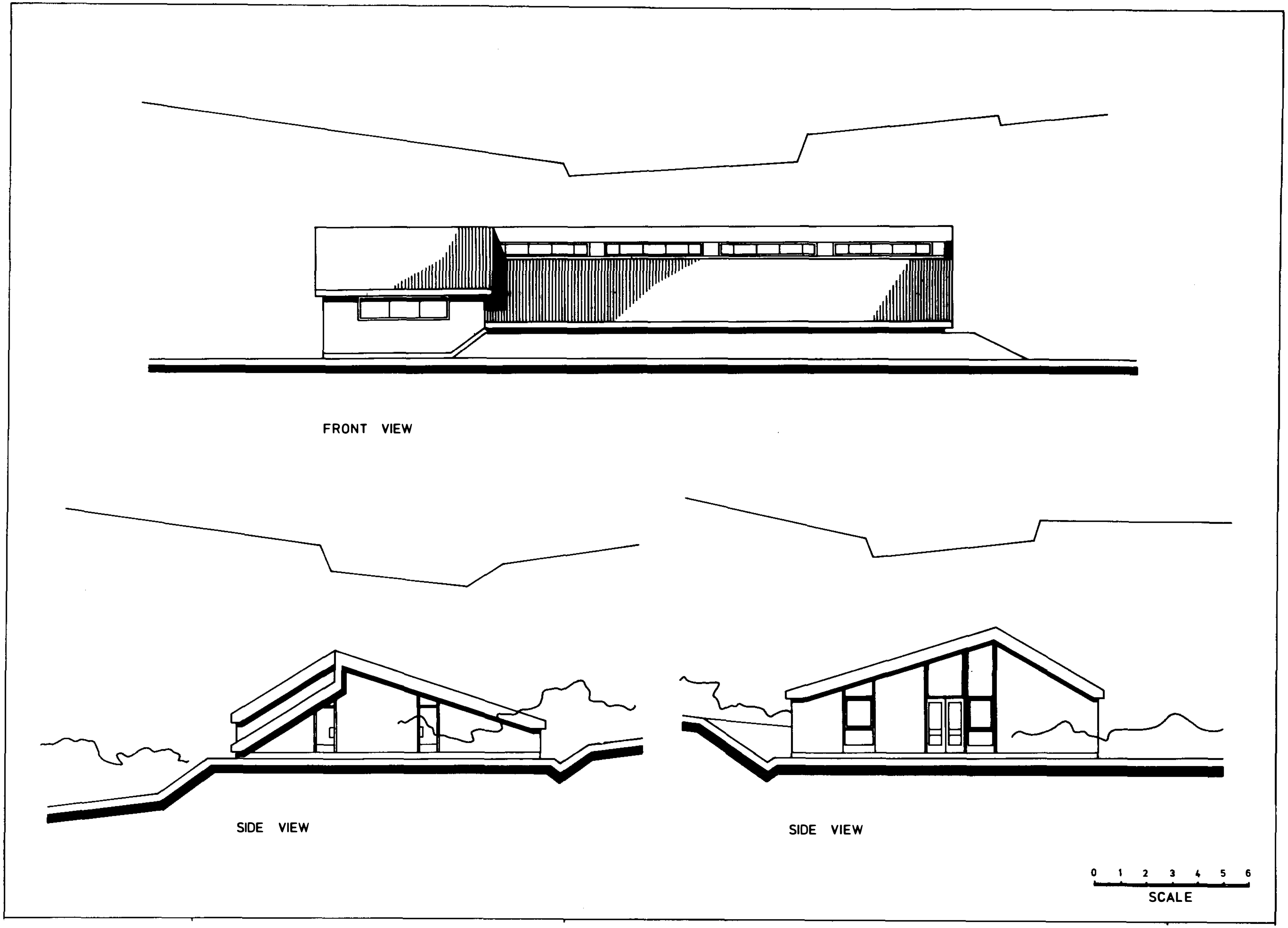


Fig. 25. Mechanical equipment for a filter plant

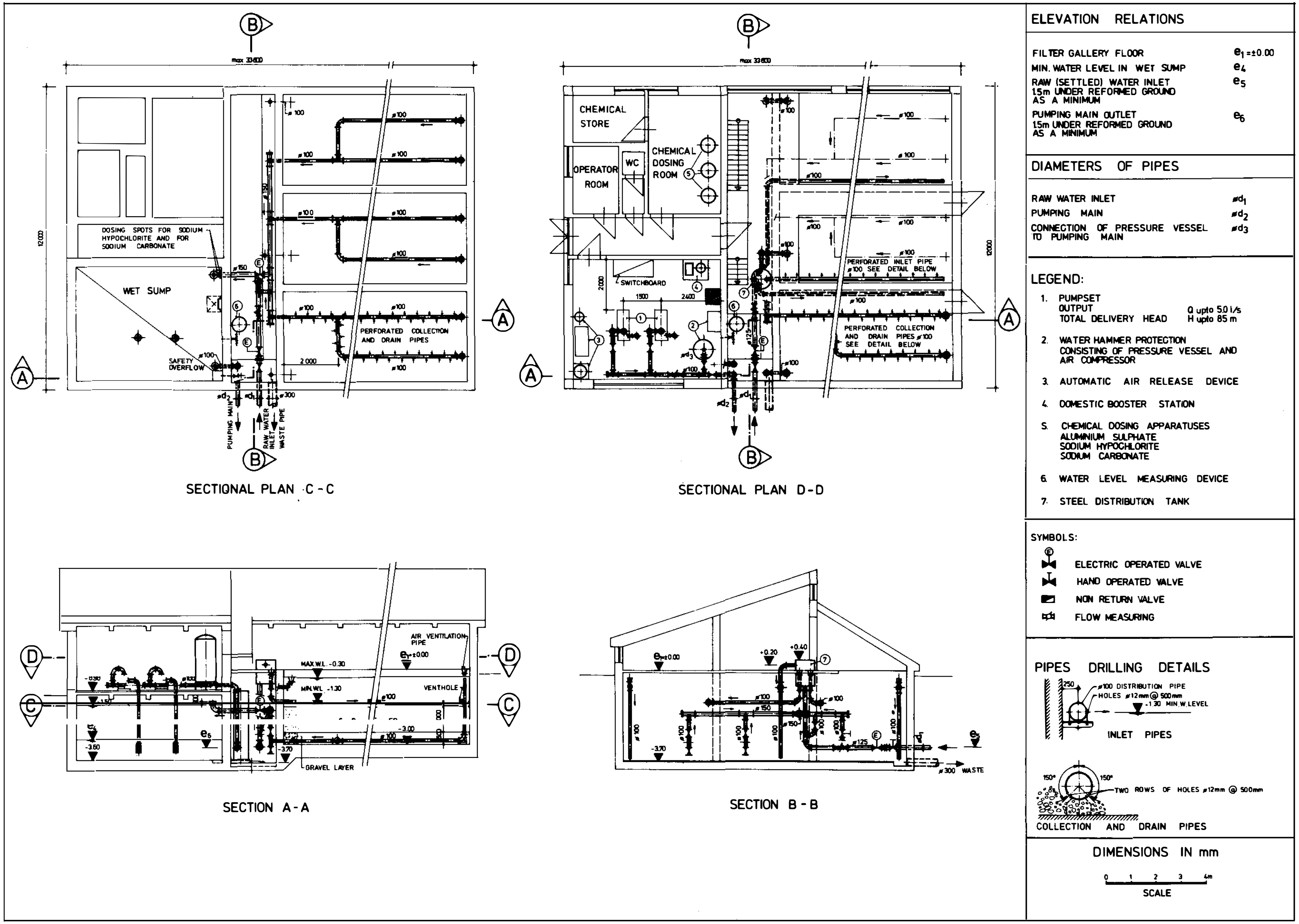
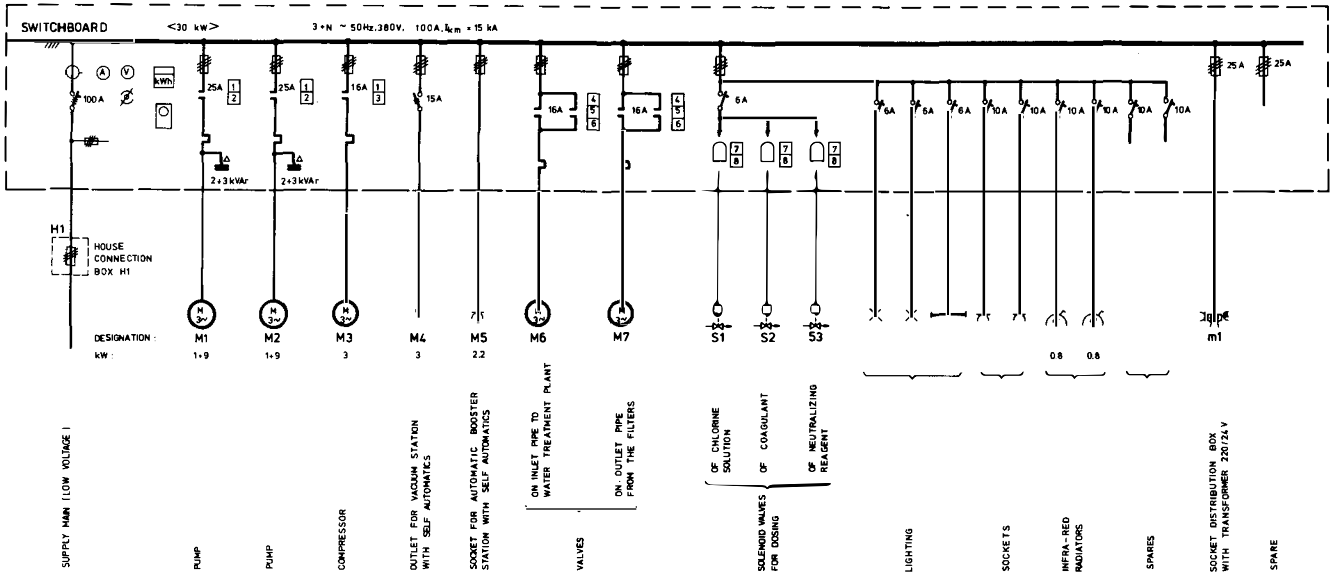


Fig. 26. Electrical equipment for a filter plant



LEGEND

1 RUNNING AND FAULT PILOT LAMP

2 AUTOMATIC CONTROL ACCORDING TO THE WATER LEVELS IN WET SUMP AND IN WATER TANK

3 AUTOMATIC CONTROL OF COMPRESSOR ACCORDING TO PRESSURE AND LEVELS IN PRESSURE VESSEL

4 PILOT LAMP OPEN-SHUT,RUNNING AND FAULT

5 AUTOMATIC CONTROL OF VALVES ACCORDING TO THE LEVELS IN WET SUMP

6 LOCAL MANUAL SWITCH NEAR THE MOTOR

7 PILOT LAMP OPEN-SHUT

8 AUTOMATIC CONTROL OF SOLENOID VALVES
SHUT-ON MAXIMUM LEVEL IN WET SUMP (INLET VALVE CLOSED)
OPEN-SIMULTANEOUSLY WITH START OF THE PUMPS (INLET VALVE OPEN POSITION)

Ⓐ AMMETER

Ⓥ VOLTMETER

CURRENT TRANSFORMER

CHANGE-OVER SWITCH FOR VOLTMETER

RELAY

AIR CONTACTOR

THERMAL RELAY

TRIPLE - POLE FUSE

I_{km} DYNAMIC SHORT-CIRCUIT CURRENT

<--> NOMINAL LOADING

kWh kWh - METER

TARIFFS CHANGE-OVER

REVERSING AIR CONTACTOR

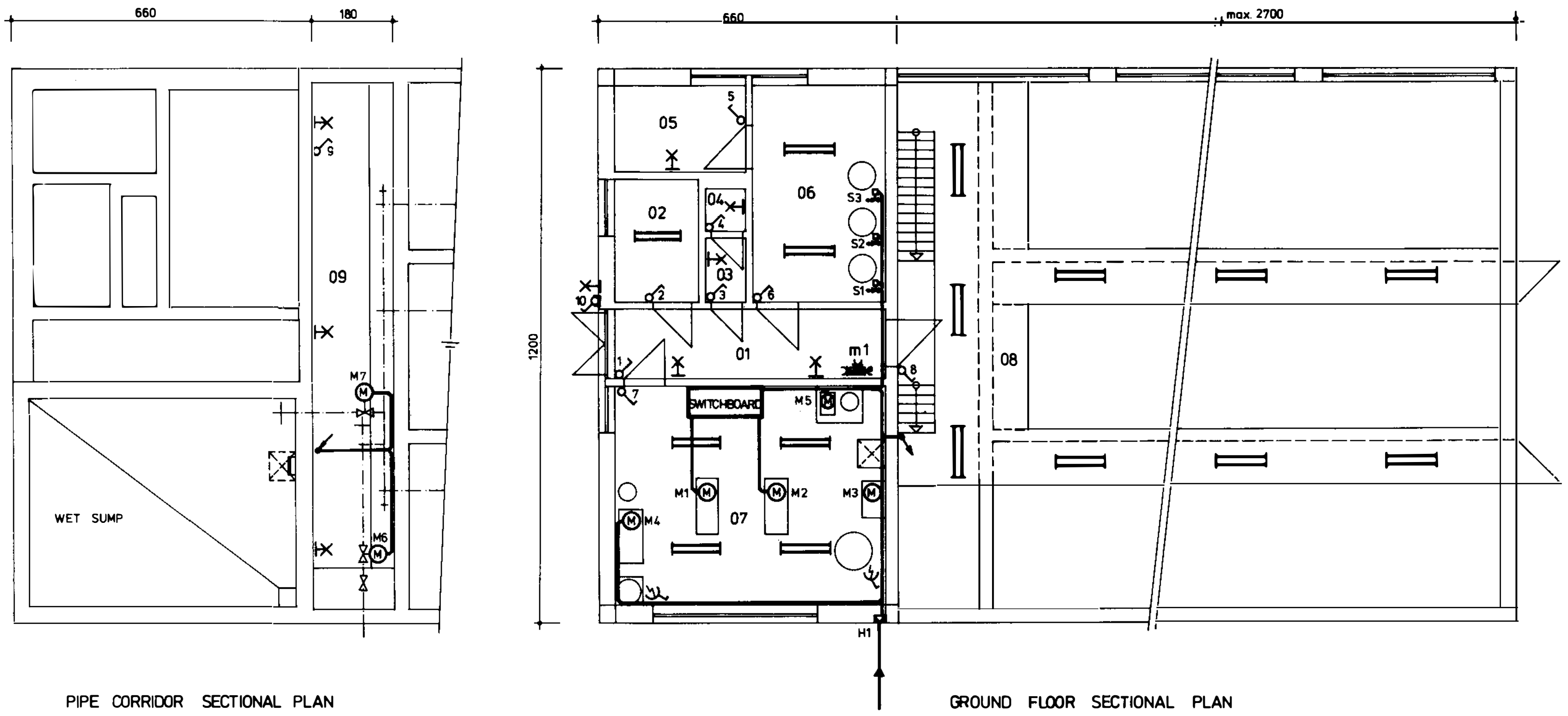
AIR CIRCUIT BREAKER

TRIPLE POLE SWITCH

COMPENSATING CAPACITORS

NOTE:
THE SYMBOLS ARE USED IN ACCORDANCE WITH INTERNATIONAL STANDARDS

Fig. 27. Lighting and cable installation for a filter plant



PIPE CORRIDOR SECTIONAL PLAN

GROUND FLOOR SECTIONAL PLAN

LEGEND:

× CEILING LAMP

×⊣ WALL LAMP

WALL SWITCH

WALL MOUNTED INFRA-RED RADIATOR

SOCKED BOX

FLUORESCENT LAMP

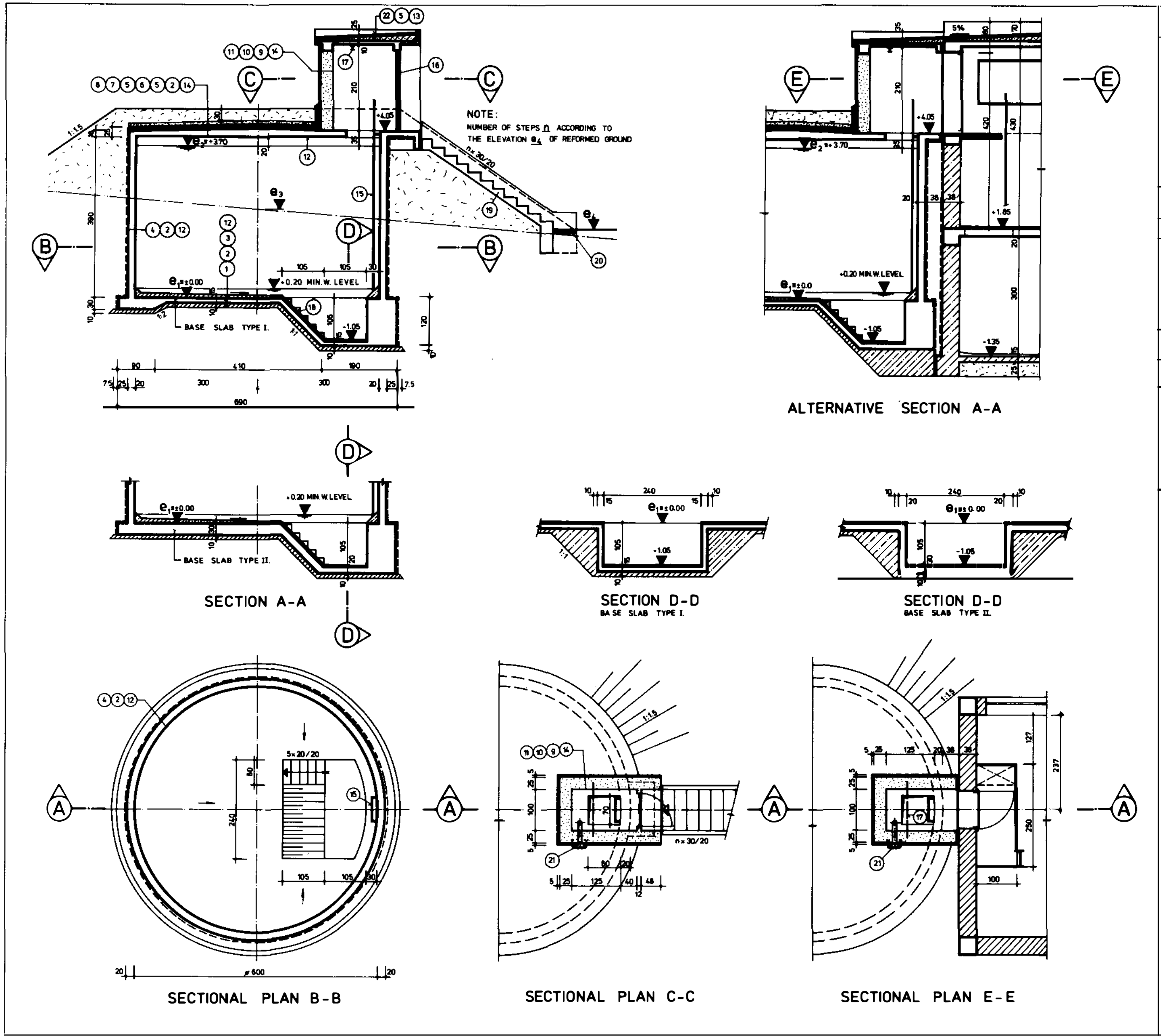
DESIGNA-TION	ROOM	FLOORAGE (m^2)	ILLUMINATION (LUX)	ENVIRONMENT
01	CORRIDOR	9.0	100	1
02	OPERATOR ROOM	5.1	200	1
03	WASH ROOM	1. 3	100	1
04	WC	0 8	60	1
05	CHEMICAL STORE	5. 3	40	1, 11
06	CHEMICAL DOSING ROOM	14.3	200	1, 11
07	MACHINE ROOM	28.4	160	1, 8
08	FILTER HALL	307. 8	60	6
09	PIPE CORRIDOR	20.5	40	6, 8

ENVIRONMENT:

1 - STANDARD
6 - HUMID
8 - CONDUCTIVE MEDIUM
11 - CORROSIVE

0 1 2 3m
SCALE

Fig. 28. A 100 m³ water tank



ELEVATION RELATIONS

BOTTOM	$e_1 = \pm 0.00$
MAX. W. LEVEL	e_2
EXISTING GROUND	e_3
REFORMED GROUND	e_4

BASE SLAB

TYPE I.	TYPE II.
FOR NON COMPRESSIBLE SOILS (ROCK, COMPACT, GRAVEL e.t.c. ACC. TO GEOLOG. INVESTIGATION)	FOR COMPRESSIBLE SOILS (CLAY, SOFT SOIL e.t.c. ACCORDING TO GEOLOG. INVESTIGATION)

WATER TANK

WITH SEPARATE VALVE CHAMBER	WITH VALVE HOUSE
VALIDITY OF SECTIONS	VALIDITY OF SECTIONS
SECTION A-A	ALT. SECTION A-A
SECTIONAL PLAN B-B	SECTIONAL PLAN B-B
SECTIONAL PLAN C-C	SECTIONAL PLAN E-E
SECTION D-D	SECTION D-D
NUMBER OF STEPS n	

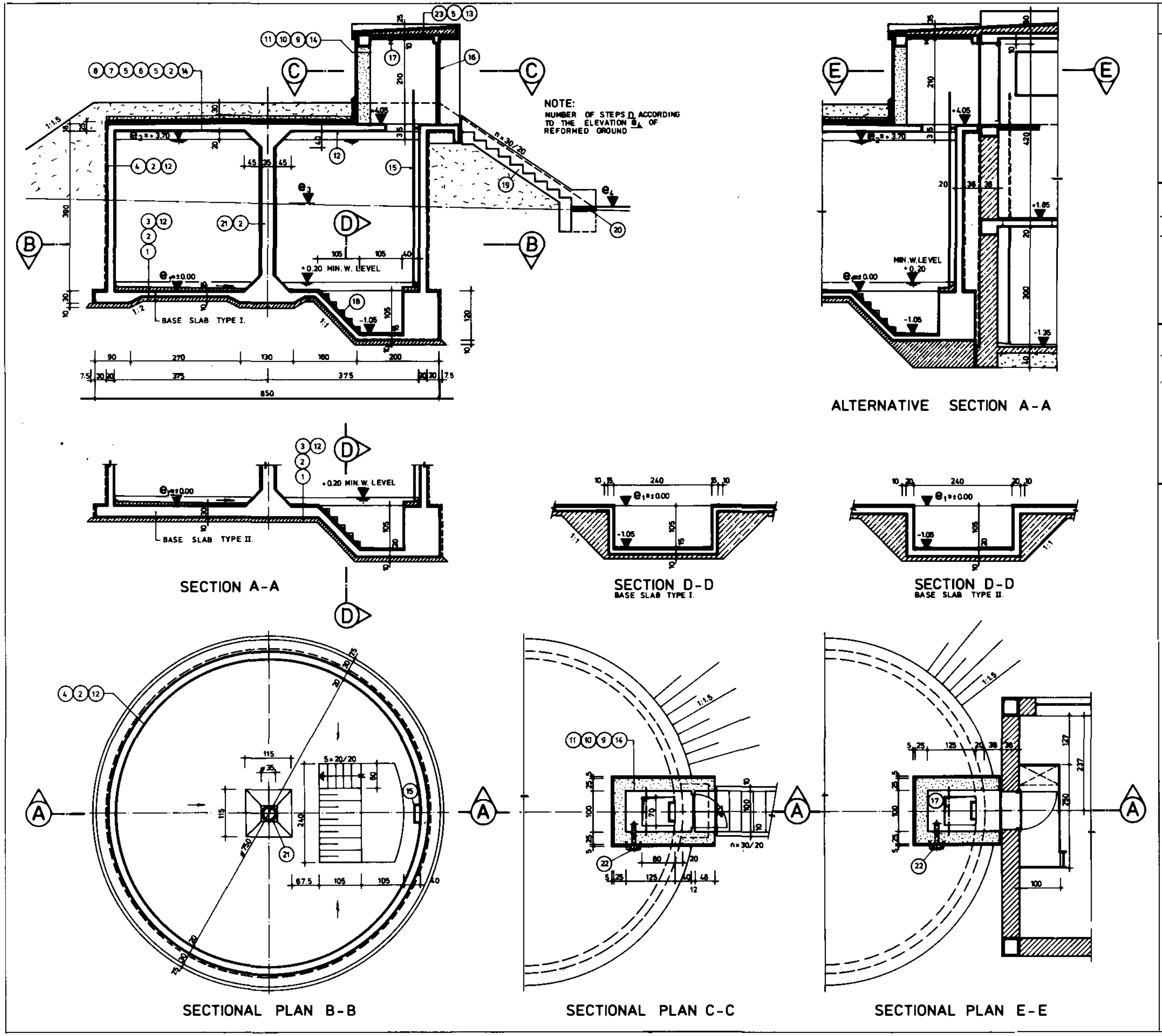
LEGEND:

1. BLINDING CONCRETE
2. WATERTIGHT REINFORCED CONCRETE
3. BENCHING TO GRADIENT
4. MOISTURE INSULATION
5. CEMENT SCREED
6. TWO ASPHALT SHEETS AND THREE ASPH. PAINT COATS
7. INSULATION WITH PROTECTION
8. FILL AND HUMUS
9. HOLLOW BRICKWORK
10. INSULATING SHEET
11. EXTERNAL PLASTER
12. STERILIZATION PAINT
13. ROOF SHEETING OR BITUMINOUS COVERING
14. CEMENT PLASTER
15. STEEL LADDER
16. STEEL DOOR WITH INSULATION
17. GANTRY BEAM No 16
18. STEPS - PLAIN CONCRETE
19. EXTERNAL STEPS - REINFORCED CONCRETE
20. CONCRETE TILES LAID ON SAND BED
21. VENTILATION TUBE
22. SLAG OR FOAM CONCRETE

0 1 2 3 4m

SCALE

Fig. 29. A 150 m^3 water tank



ELEVATION RELATIONS

BOTTOM	$e_1 = \pm 0.00$
MAX. W. LEVEL	e_2
EXISTING GROUND	e_3
REFORMED GROUND	e_4

BASE SLAB

TYPE I	TYPE II
FOR NON COMPRESSIBLE SOILS (ROCK, COMPACT, GRAVEL e.t.c. ACC. TO GEOLOG. INVESTIGATION)	FOR COMPRESSIBLE SOILS (CLAY, SOFT, SOIL e.t.c. ACCORDING TO GEOLOG. INVESTIGATION)

WATER TANK

WITH SEPARATE VALVE CHAMBER		WITH VALVE HOUSE	
VALIDITY OF SECTIONS		VALIDITY OF SECTIONS	
SECTION	A - A	ALT. SECTION	A - A
SECTIONAL PLAN	B - B	SECTIONAL PLAN	B - B
SECTIONAL PLAN	C - C	SECTIONAL PLAN	E - E
SECTION	D - D	SECTION	D - D
NUMBER OF STEPS	n		

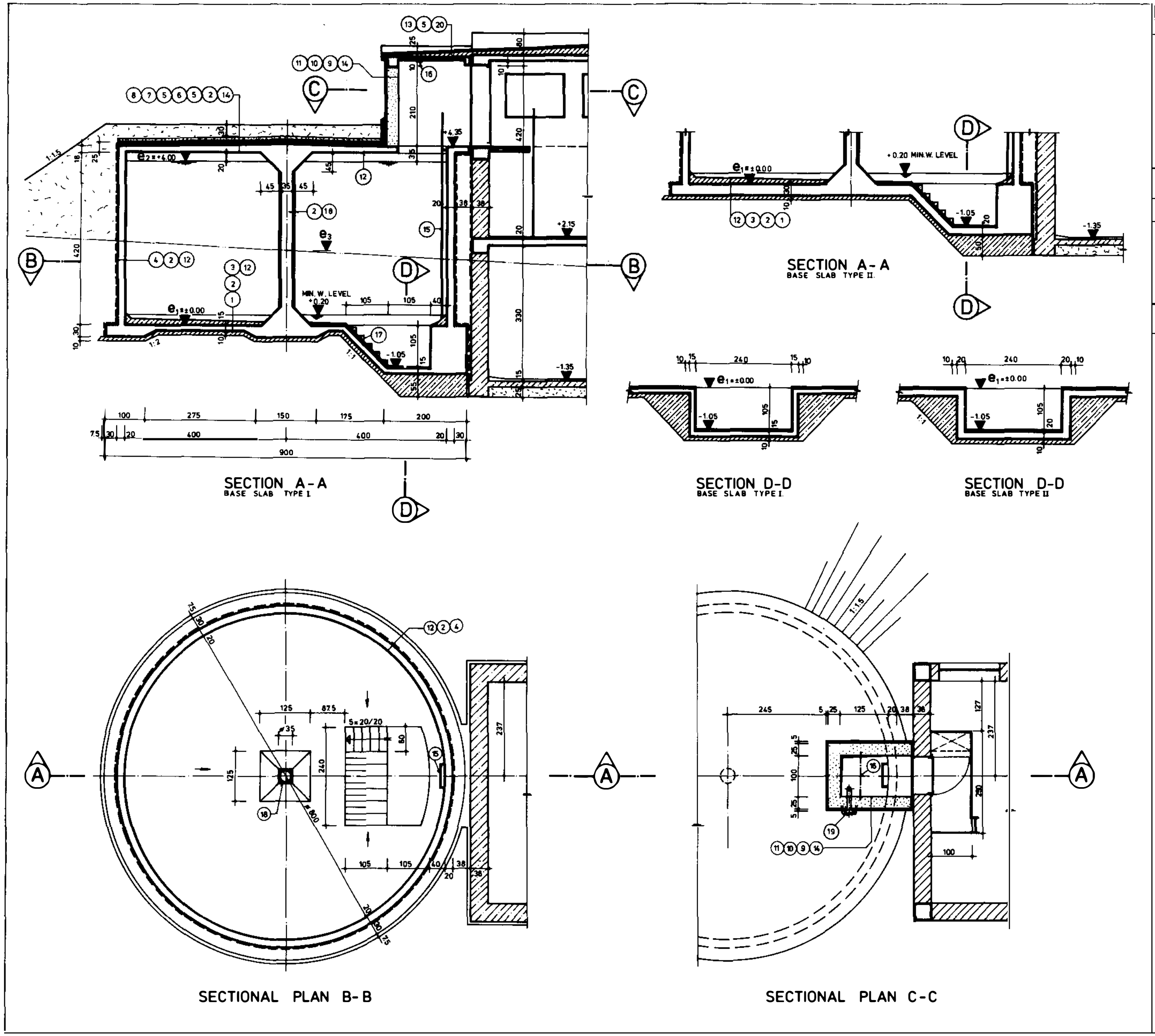
LEGEND:

1. BLINDING CONCRETE
2. WATERTIGHT REINFORCED CONCRETE
3. BENCHING TO GRADIENT
4. MOISTURE INSULATION
5. CEMENT SCREED
6. TWO ASPHALT SHEETS AND THREE ASPH. PAINT COATS
7. INSULATION WITH PROTECTION
8. FILL AND HUMUS
9. HOLLOW BRICKWORK
10. INSULATING SHEET
11. EXTERNAL PLASTER
12. STERILIZATION PAINT
13. ROOF SHEETING OR BITUMINOUS COVERING
14. CEMENT PLASTER
15. STEEL LADDER
16. STEEL DOOR WITH INSULATION
17. GANTRY BEAM No 16
18. STEPS - PLAIN CONCRETE
19. EXTERNAL STEPS - REINFORCED CONCRETE
20. CONCRETE TILES LAID ON SAND BED
21. A.C. PIPE ⌀ 350 mm - SUCRIFICED FORM
22. VENTILATION TUBE
23. SLAG OR FOAM CONCRETE

0 1 2 3m

SCALE

Fig. 30. A 200 m^3 water tank



ELEVATION RELATIONS

BOTTOM	e_1 = ± 0.00
MAX. W. LEVEL	e_2
EXISTING GROUND	e_3
REFORMED GROUND	e_4

BASE SLAB

TYPE I	TYPE II
FOR NON COMPRESSIBLE SOILS (ROCK, COMPACT GRAVEL e.t.c. ACCORDING GEOLOGICAL INVESTIGATION)	FOR COMPRESSIBLE SOILS (CLAY, SOFT SOIL e.t.c. ACCORDING TO GEOLOGICAL INVESTIGATION)

WATER TANK WITH VALVE HOUSE

LEGEND:

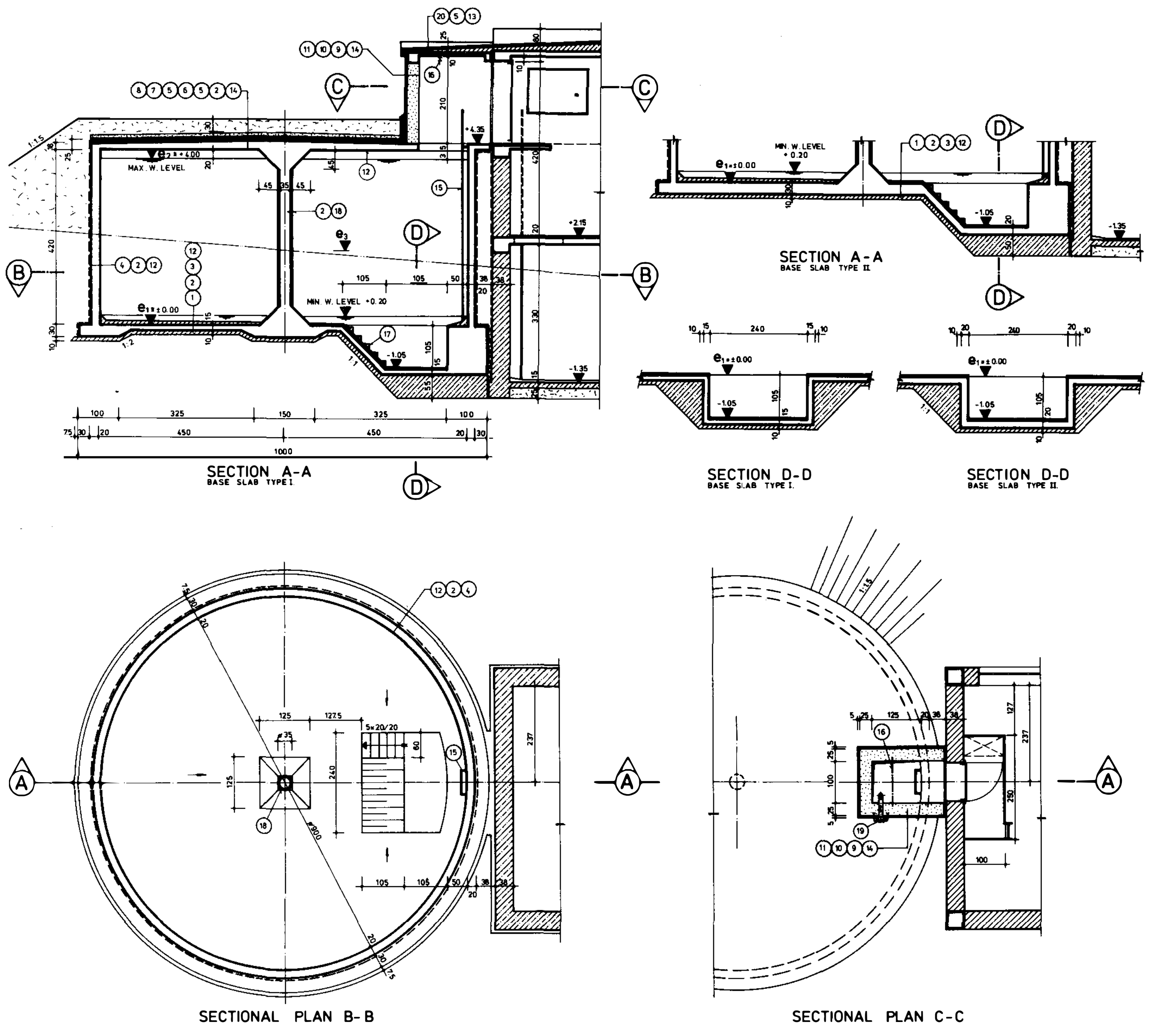
1. BLINDING CONCRETE
2. WATERTIGHT REINFORCED CONCRETE
3. BENCHING TO GRADIENT
4. MOISTURE INSULATION
5. CEMENT SCREED
6. TWO ASPHALT SHEETS AND THREE ASPH. PAINT COATS
7. INSULATION WITH PROTECTION
8. FILL AND HUMUS
9. HOLLOW BRICKWORK
10. INSULATING SHEET
11. EXTERNAL PLASTER
12. STERILIZATION PAINT
13. ROOF SHEETING OR BITUMINOUS COVERING
14. CEMENT PLASTER
15. STEEL LADDER
16. GANTRY BEAM No 16
17. STEPS - PLAIN CONCRETE
18. A.C. PIPE ϕ 350 mm - SUCRIFICED FORM
19. VENTILATION TUBE
20. SLAG OR FOAM CONCRETE

NOTE:

WHEN VALVE CHAMBER IS INCORPORATED TO THE TANK RESPECTIVE ACCESS STAIRCASE AND LOCKED DOOR SHALL BE USED (SEE Fig 28 or 29)

0 1 2 3m
SCALE

Fig. 31. A 250 m³ water tank



ELEVATION RELATIONS

BOTTOM	$e_1 = \pm 0.00$
MAX .W. LEVEL	e_2
EXISTING GROUND	e_3
REFORMED GROUND	e_4

BASE SLAB

TYPE I	TYPE II
FOR NON COMPRESSIBLE SOILS (ROCK, COMPACT GRAVEL e.t.c. ACC. TO GEOLOG. INVESTIGATION)	FOR COMPRESSIBLE SOILS (CLAY, SOFT SOIL e.t.c. ACCORDING TO GEOLOG. INVESTIGATION)

WATER TANK WITH VALVE HOUSE

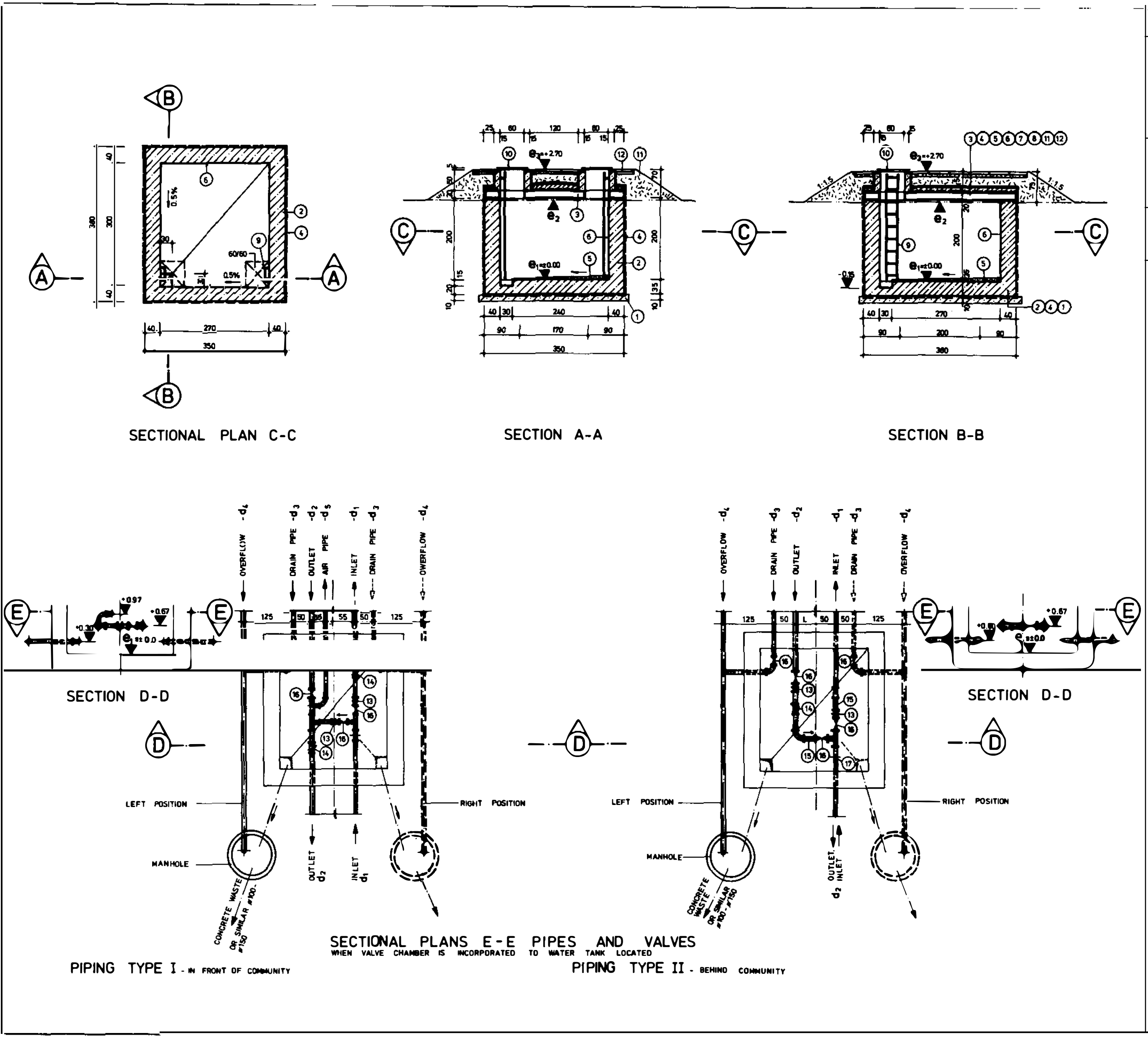
LEGEND:

1. BLINOING CONCRETE
2. WATERTIGHT REINFORCED CONCRETE
3. BENCHING TO GRADIENT
4. MOISTURE INSULATION
5. CEMENT SCREED
6. TWO ASPHALT SHEETS AND THREE ASPH PAINT COATS
7. INSULATION WITH PROTECTION
8. FILL AND HUMUS
9. HOLLOW BRICKWORK
10. INSULATING SHEET
11. EXTERNAL PLASTER
12. STERILIZATION PAINT
13. ROOF SHEETING OR BITUMINOUS COVERING
14. CEMENT PLASTER
15. STEEL LADDER
16. GANTRY BEAM No 16
17. STEPS - PLAIN CONCRETE
18. AC. PIPE ⌀ 350 mm - SUCRIFICED FORM
19. VENTILATION TUBE
20. SLAG OR FOAM CONCRETE

NOTE:
WHEN VALVE CHAMBER IS INCORPORATED TO THE TANK RESPECTIVE ACCESS STAIRCASE AND LOCKED DOOR SHALL BE USED (SEE Fig 28 or 29)

0 1 2 3m
SCALE

Fig. 32. The valve chamber for a water tank



ELEVATION RELATIONS

BOTTOM	e_1 = ± 0.0
EXISTING GROUND	e_2
REFORMED GROUND	e_3

PLAN OF PIPES - TYPE I LEFT / RIGHT POSITION

- TYPE II LEFT / RIGHT POSITION

DIAMETERS OF PIPES : d1, d2, d3, d4, d5 (IN mm)

NOTE : L - ACCORDING TO DIAMETER OF PIPES

LEGEND:

1. BLINDING CONCRETE
2. PLAIN CONCRETE
3. REINFORCED CONCRETE
4. MOISTURE INSULATION
5. BENCHING TO GRADIENT
6. WATERTIGHT PLASTER
7. WATERPROOF INSULATION
8. PROTECTING CEMENT SCREED
9. STEEL LADDER
10. CAST IRON COVER
11. COMPACT FILL AND HUMUS
12. CONCRETE TILES LAID ON SAND BED
13. MAKE-UP PIECE
14. WATER METER
15. NON RETURN VALVE
16. VALVE
17. AIR VALVE ⌀ 25mm

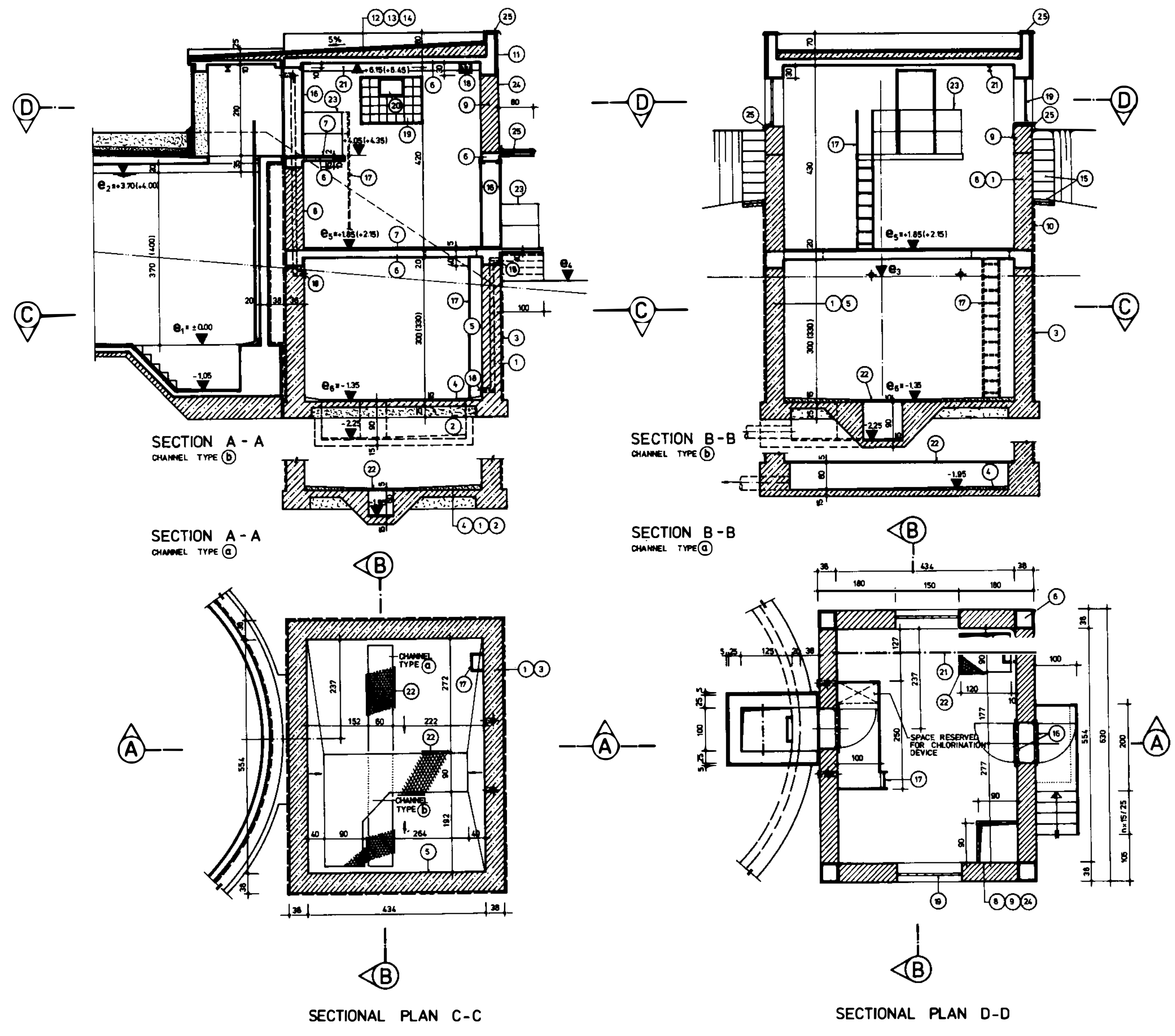
DIAMETERS OF PIPES FOR BOTH TYPES OF VALVE CHAMBER, WHICH IS INCORPORATED TO THE FOLLOWING WATER TANKS.

(mm)	100 m³	150 m³	200 m³	250 m³
⌀ d_1	60	60	80	80
⌀ d_2	100	100	125	125
⌀ d_3	60	60	80	80
⌀ d_4	80	80	80	80
⌀ d_5	25	25	25	25

NOTE:
FOR PIPING TYPE II ⌀ d_5 MEANS DIAMETER OF AIR VALVE

0 1 2 3m
SCALE

Fig. 33. A valve house for one water tank



ELEVATION RELATIONS

BOTTOM	e_1 = ± 0.0
MAX. W. LEVEL	e_2
EXISTING GROUND	e_3
REFORMED GROUND	e_4
GROUND FLOOR	e_5
UNDERGROUND FLOOR	e_6

NOTE:

THE ELEVATIONS AND FIGURES IN BRACKETS APPLY FOR VALVE HOUSE INCORPORATED TO WATER TANK 200m^3 OR 250m^3 OF STORAGE CAPACITY (DEPTH OF WATER IN THE TANK IS 400cm)

VALVE HOUSE - WASTE CHANNEL ARRANGEMENT

TYPE ⓐ	TYPE ⓑ
VALVE HOUSE AT WATER TANK WHICH IS FED GRAVITATIONALLY	VALVE HOUSE AT WATER TANK WHICH IS FED BY PUMPING

LEGEND:

1. PLAIN CONCRETE (FOUNDATIONS AND WALLS)
2. GRAVEL FILL
3. MOISTURE INSULATION
4. BENCHING TO GRADIENT
5. CEMENT PLASTER
6. REINFORCED CONCRETE
7. CEMENT SCREED
8. CEMENT - LIME PLASTER
9. BRICKWORK
10. CEMENT PLASTER WITH MOISTURE INSULATION
11. INSULATING SHEET
12. SLAG OR FOAM CONCRETE
13. PROTECTIVE CEMENT SCREED
14. ROOF SHEETING OR BITUMINOUS COVERING
15. CONCRETE TILES LAID ON SAND BED
16. STEEL DOOR
17. STEEL LADDER
18. VENTILATION COVER
19. GLASS CONCRETE WINDOW
20. STEEL WINDOW
21. GANTRY BEAM No 16
22. DUCKED COVER
23. STEEL HANDRAIL
24. EXTERNAL PLASTER
25. FLASHING

NOTE:

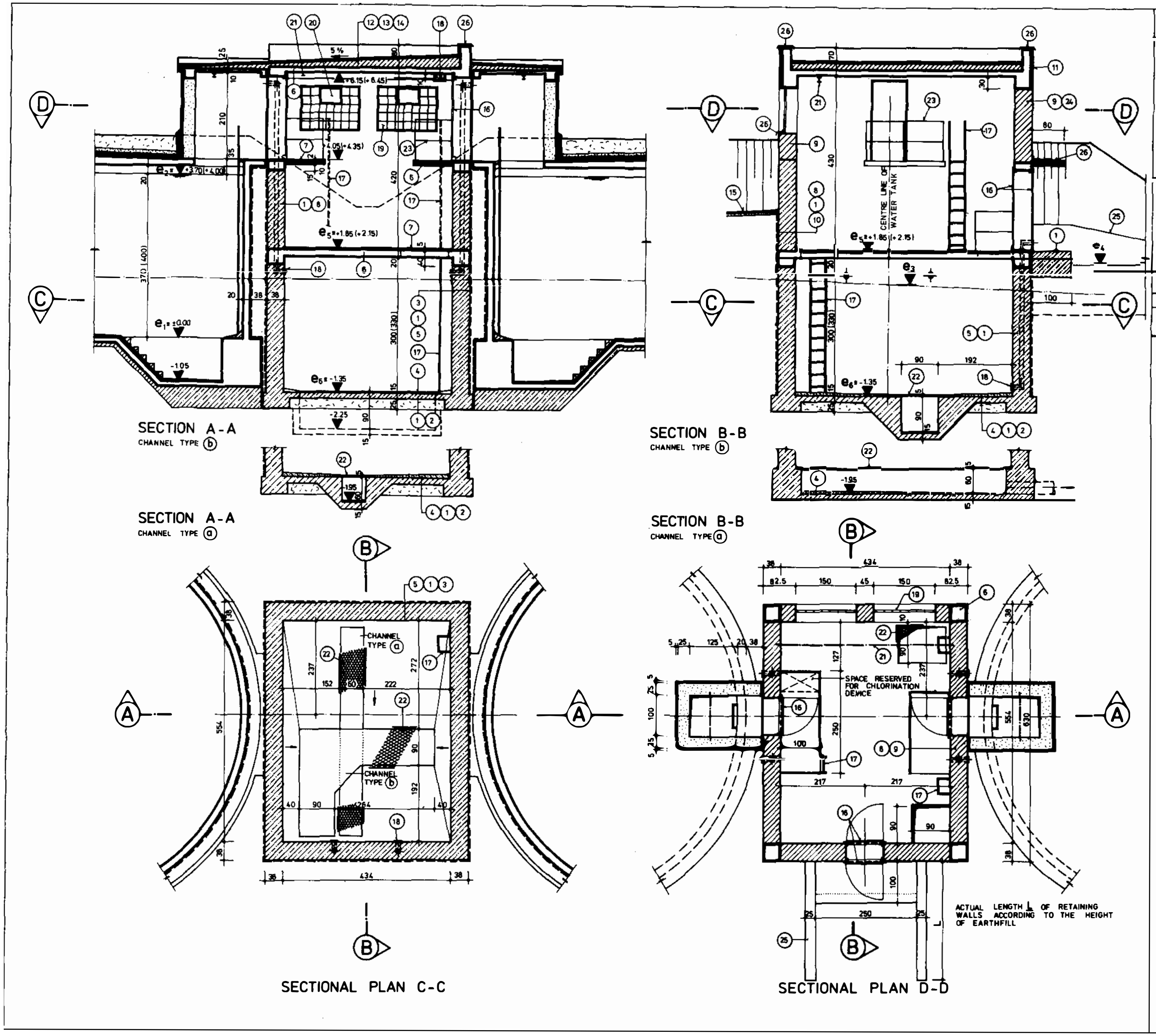
LOCATION OF HOLES IN VALVE HOUSE FLOOR FOR PIPES AND VALVE CONTROL RODES SHALL BE FIXED ACCORDING TO THE TYPE OF PIPING

NUMBER OF STEPS WILL BE ACCORDING TO REFORMED GROUND ELEVATION (e_4)

0 1 2 3m

SCALE

Fig. 34. A valve house for two water tanks



ELEVATION RELATIONS

BOTTOM	$e_1 = \pm 0.00$
MAX. W. LEVEL	e_2
EXISTING GROUND	e_3
REFORMED GROUND	e_4
GROUND FLOOR	e_5
UNDERGROUND FLOOR	e_6

NOTE:

THE ELEVATIONS AND FIGURES IN BRACKETS APPLY FOR VALVE HOUSE INCORPORATED TO WATER TANK 200m^3 OR 250m^3 OF STORAGE CAPACITY (DEPTH OF WATER IN THE TANK IS 400cm)

VALVE HOUSE - WASTE CHANNEL ARRANGEMENT

TYPE (a)	TYPE (b)
VALVE HOUSE AT WATER TANK WHICH IS FED GRAVITATIONALLY	VALVE HOUSE AT WATER TANK WHICH IS FED BY PUMPING

LEGEND:

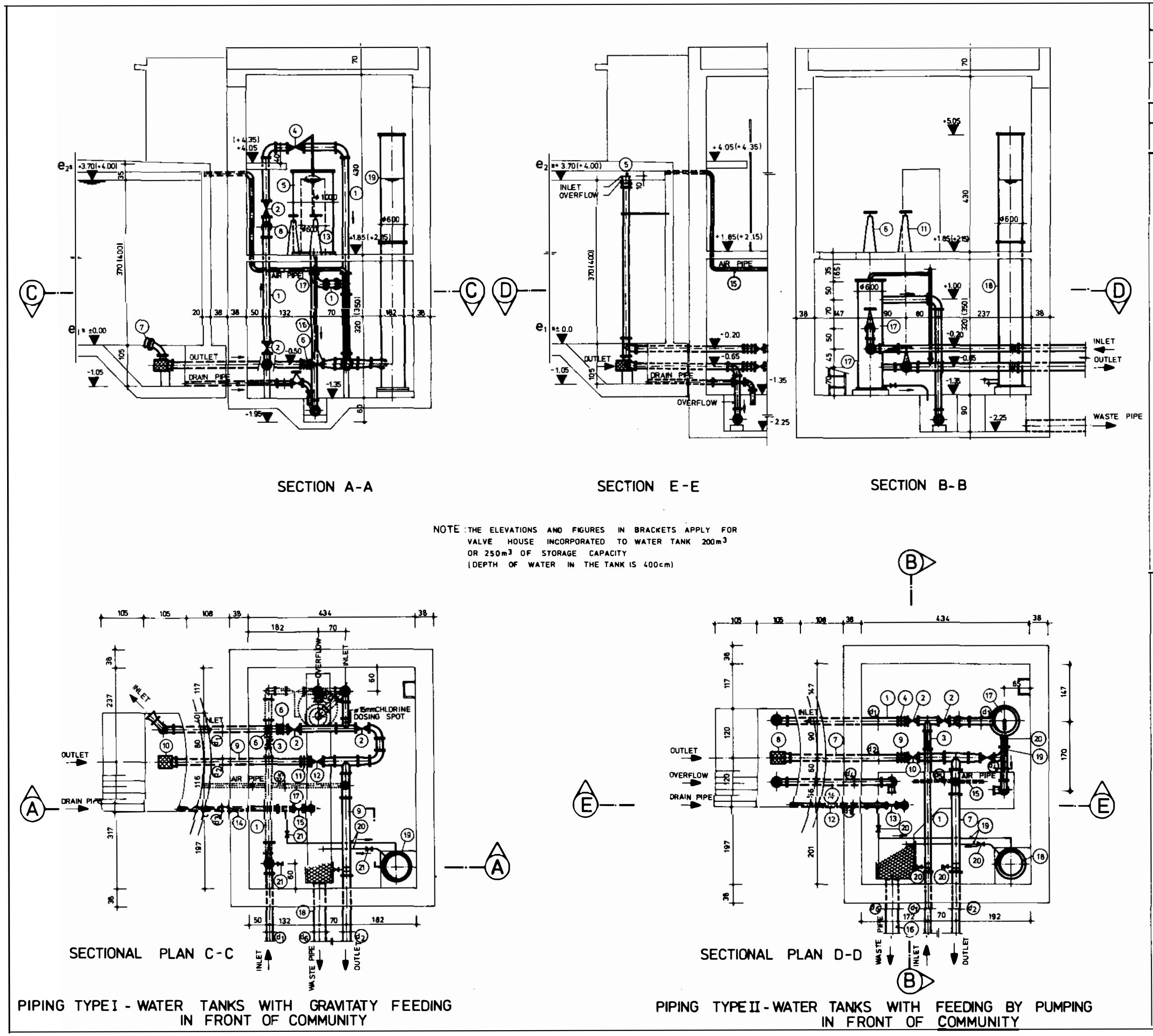
1. PLAIN CONCRETE (FOUNDATIONS AND WALLS)
2. GRAVEL FILL
3. MOISTURE INSULATION
4. BENCHING TO GRADIENT
5. CEMENT PLASTER
6. REINFORCED CONCRETE
7. CEMENT SCREED
8. CEMENT - LIME PLASTER
9. BRICKWORK
10. CEMENT PLASTER WITH MOISTURE INSULATION
11. INSULATING SHEET
12. SLAG OR FOAM CONCRETE
13. PROTECTIVE CEMENT SCREED
14. ROOF SHEETING OR BITUMINOUS COVERING
15. CONCRETE TILES LAID ON SAND BED
16. STEEL DOOR
17. STEEL LADDER
18. VENTILATION COVER
19. GLASS CONCRETE WINDOW
20. STEEL WINDOW
21. GANTRY BEAM No 16
22. DUCKED COVER
23. STEEL HANDRAIL
24. EXTERNAL PLASTER
25. RETAINING WALL
26. FLASHING

NOTE:
LOCATION OF HOLES IN VALVE HOUSE FLOOR FOR PIPES AND VALVE CONTROL RODES SHALL BE FIXED ACCORDING TO THE TYPE OF PIPING

0 1 2 3m

SCALE

Fig. 35. Type I and II pipework in a valve house for one water tank



VALVE HOUSE FOR ONE WATER TANK

ELEVATION RELATIONS

BOTTOM	e_1 ±± 0.0
MAX. W. LEVEL	e_2

DIAMETERS OF PIPES - $d_1, d_2, d_3, d_4, d_5, d_6$

MATERIAL OF PIPES (d_1-d_5) - STEEL OR CAST IRON, (d_6) - CONCRETE

LEGEND - PIPING TYPE I

INLET (d_1)

1. FLANGED PIPES AND FITTINGS
2. HAND OPERATED VALVE
3. WATER METER
4. FLOAT VALVE
5. FLOAT SHAFT, STEEL PIPE ø1000, INSIDE ø600mm
6. MAKE - UP PIECE
7. OUTLET PIECE
8. HEADSTOCK

OUTLET (d_2)

9. FLANGED PIPES AND FITTINGS
10. INLET STRAINER
11. MAKE - UP PIECE
12. HAND OPERATED VALVE
13. HEADSTOCK

DRAIN PIPE (d_3)

14. FLANGED PIPES AND FITTINGS
15. HAND OPERATED VALVE

OVERFLOW (d_4)

16. FLANGED PIPES AND FITTINGS

AIR PIPE (d_5)

17. WELDED PIPE

WASTE PIPE (d_6)

18. CONCRETE PIPE

19. FLOAT SHAFT, STEEL PIPE ø 600 mm
20. THREADED PIPE ø 25mm (GALVANIZED STEEL)
21. VALVE ø 25mm

LEGEND - PIPING TYPE II

INLET (d_1)

1. FLANGED PIPES AND FITTINGS
2. HAND OPERATED VALVE
3. NON RETURN VALVE - FOR INLET PIPE AT BOTTOM OF TANK ONLY
4. MAKE - UP PIECE
5. OUTLET PIECE
6. HEADSTOCK

OUTLET (d_2)

7. FLANGED PIPES AND FITTINGS
8. INLET STRAINER
9. MAKE - UP PIECE
10. HAND OPERATED VALVE
11. HEADSTOCK

DRAIN PIPE (d_3)

12. FLANGED PIPES AND FITTINGS
13. HAND OPERATED VALVE

OVERFLOW (d_4)

14. FLANGED PIPES AND FITTINGS

AIR PIPE (d_5)

15. WELDED PIPE

WASTE PIPE (d_6)

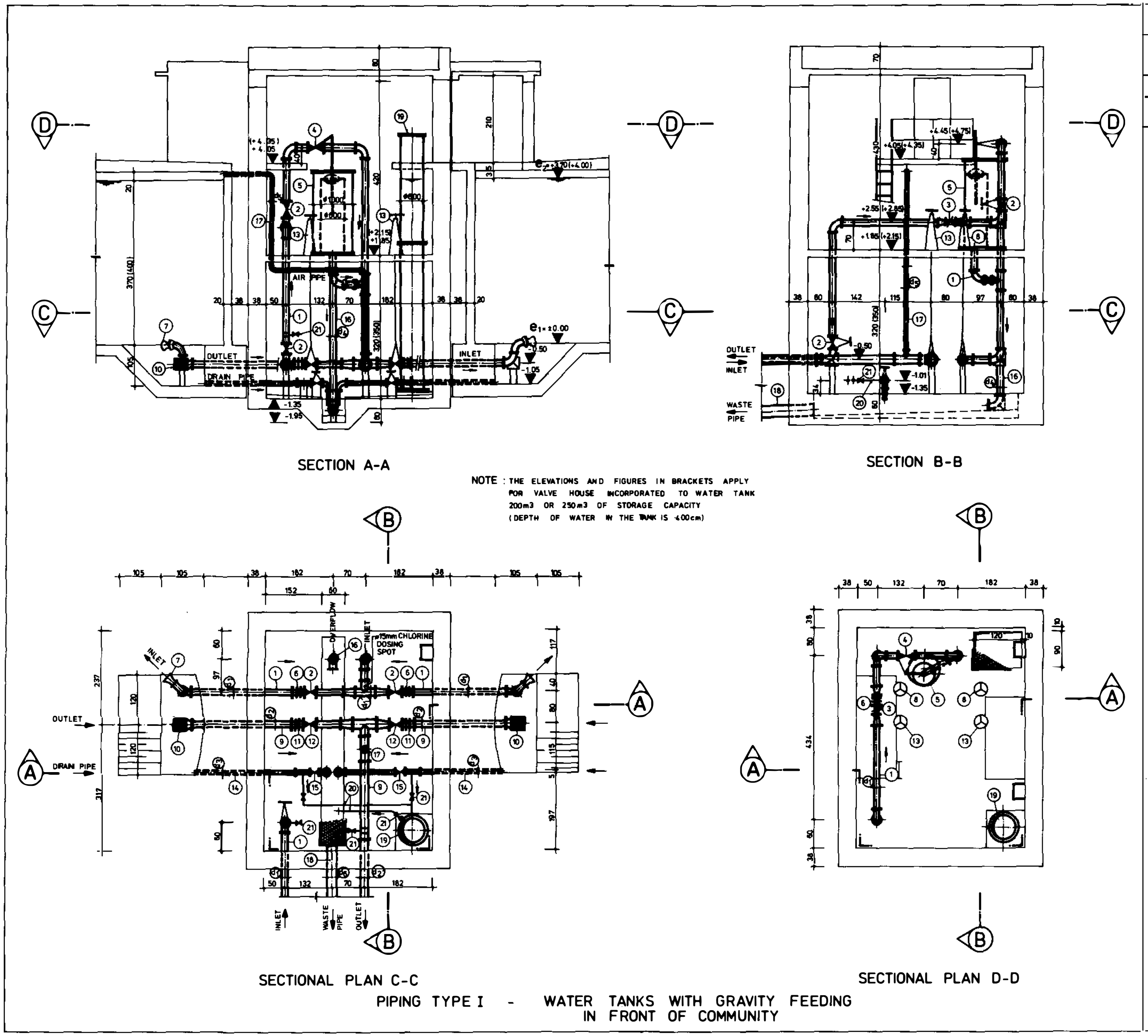
16. CONCRETE PIPE

17. PRESSURE BREAKING SHAFT, STEEL PIPE ø 600mm
18. FLOAT SHAFT, STEEL PIPE ø 600mm
19. THREADED PIPE ø 25mm (GALVANIZED STEEL)
20. VALVE ø 25mm

0 1 2 3m

SCALE

Fig. 36. Type I pipework in a valve house for two water tanks



NOTE : THE ELEVATIONS AND FIGURES IN BRACKETS APPLY FOR VALVE HOUSE INCORPORATED TO WATER TANK 200m3 OR 250m3 OF STORAGE CAPACITY (DEPTH OF WATER IN THE TANK IS 400cm)

PIPING TYPE I - WATER TANKS WITH GRAVITY FEEDING IN FRONT OF COMMUNITY

ELEVATION RELATIONS

BOTTOM :	$e_1 = \pm 0.00$
MAX. W. LEVEL :	e_2

DIAMETERS OF PIPES $d_1, d_1', d_2, d_2', d_3, d_4, d_5, d_6$

MATERIAL OF PIPES (d_1 - d_5) - STEEL OR CAST IRON
(d_6) - CONCRETE

LEGEND :

INLET (d_1, d_1')

1. FLANGED PIPES AND FITTINGS
2. HAND OPERATED VALVE
3. WATER METER
4. FLOAT VALVE
5. FLOAT SHAFT , STEEL PIPE ● 1000, INSIDE ø 600mm
6. MAKE - UP PIECE
7. OUTLET PIECE
8. HEADSTOCK

OUTLET (d_2, d_2')

9. FLANGED PIPES AND FITTINGS
10. INLET STRAINER
11. MAKE - UP PIECE
12. HAND OPERATED VALVE
13. HEADSTOCK

DRAIN PIPE (d_3)

14. FLANGED PIPES AND FITTINGS
15. HAND OPERATED VALVE

OVERFLOW (d_4)

16. FLANGED PIPES AND FITTINGS

AIR PIPE (d_5)

17. WELDED PIPES

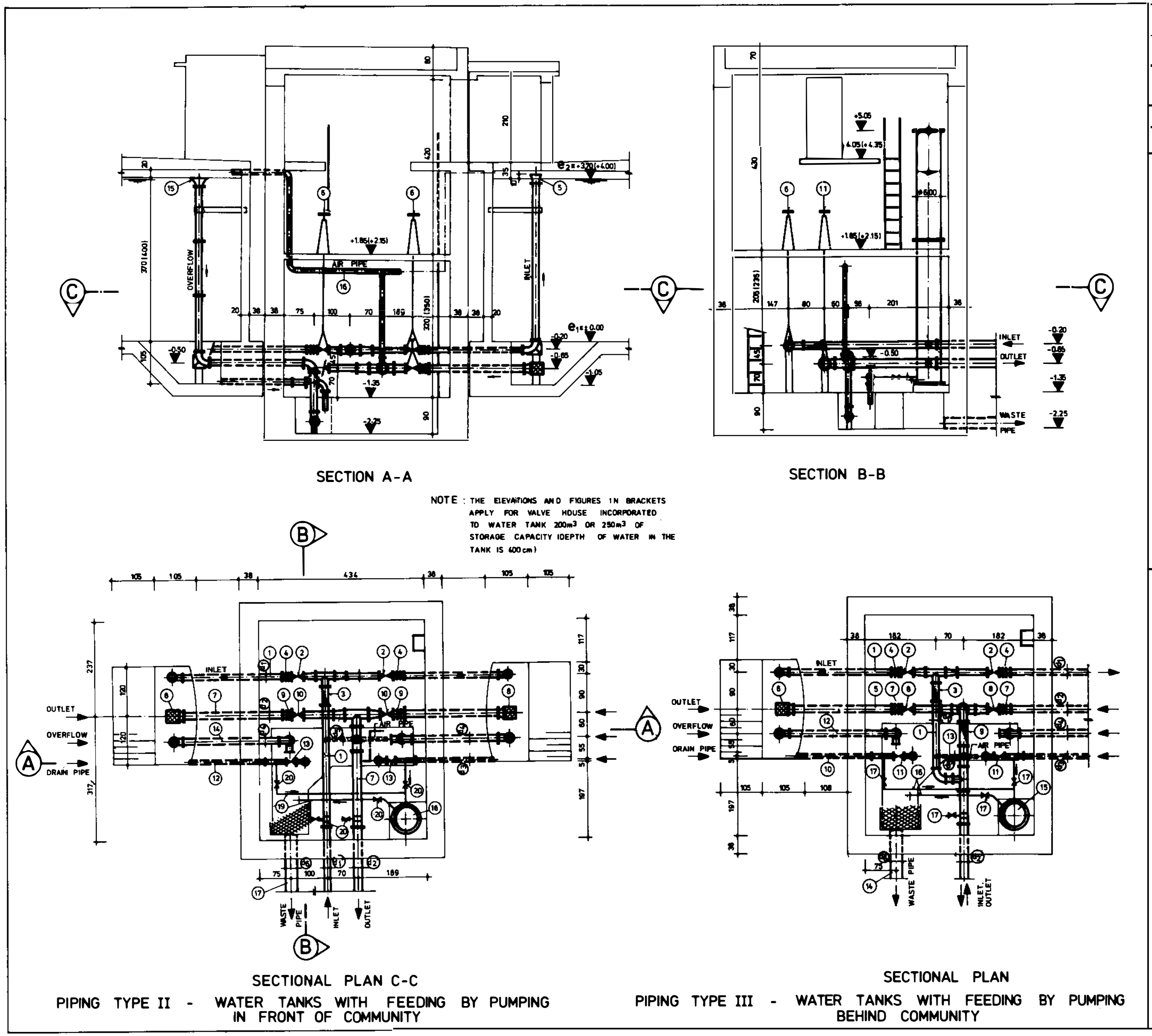
WASTE PIPE (d_6)

18. CONCRETE PIPE

19. FLOAT SHAFT , STEEL PIPE ● 600mm
20. THREATED PIPE ø25mm (GALVANIZED STEEL)
21. VALVE ø25mm

0 1 2 3m
SCALE

Fig. 37. Type II and III pipework in a valve house for two water tanks



NOTE : THE ELEVATIONS AND FIGURES IN BRACKETS APPLY FOR VALVE HOUSE INCORPORATED TO WATER TANK 200m3 OR 250m3 OF STORAGE CAPACITY (DEPTH OF WATER IN THE TANK IS 400 cm)

VALVE HOUSE FOR TWO WATER TANKS

ELEVATION RELATIONS

BOTTOM	e_1=±0.0
MAX. W. LEVEL	e_2

DIAMETERS OF PIPES $d_1, d_1', d_2, d_2', d_3, d_4, d_5, d_6$

MATERIAL OF PIPES (d_1-d_5) - STEEL OR CAST IRON
(d_6) - CONCRETE

LEGEND - PIPING TYPE II

INLET (d_1, d_1')

1. FLANGED PIPES AND FITTINGS
2. HAND OPERATED VALVE
3. NON RETURN VALVE -FOR INLET PIPE AT BOTTOM OF TANK ONLY
4. MAKE - UP PIECE
5. OUTLET PIECE
6. HEADSTOCK

OUTLET (d_2, d_2')

7. FLANGED PIPES AND FITTINGS
8. INLET STRAINER
9. MAKE - UP PIECE
10. HAND OPERATED VALVE
11. HEADSTOCK

DRAIN PIPE (d_3)

12. FLANGED PIPES AND FITTINGS
13. HAND OPERATED VALVE

OVERFLOW (d_4)

14. FLANGED PIPES AND FITTINGS
15. BELLMOUTH OVERFLOW

AIR PIPE (d_5)

16. WELDED PIPE

WASTE PIPE (d_6)

17. CONCRETE PIPE

18. FLOAT SHAFT, STEEL PIPE ⌀ 600 mm
19. THREADED PIPE ⌀25mm (GALVANIZED STEEL)
20. VALVE ⌀25mm

LEGEND - TYPE III

INLET (d_1, d_1')

1. FLANGED PIPES AND FITTINGS
2. HAND OPERATED VALVE
3. NON RETURN VALVE -FOR INLET PIPE AT BOTTOM OF TANK ONLY
4. MAKE - UP PIECE

OUTLET (d_2, d_2')

5. FLANGED PIPES AND FITTINGS
6. INLET STRAINER
7. MAKE - UP PIECE
8. HAND OPERATED VALVE
9. NON RETURN VALVE

DRAIN PIPE (d_3)

10. FLANGED PIPES AND FITTINGS
11. HAND OPERATED VALVE

OVERFLOW (d_4)

12. FLANGED PIPES AND FITTINGS

AIR PIPE (d_5)

13. WELDED PIPE

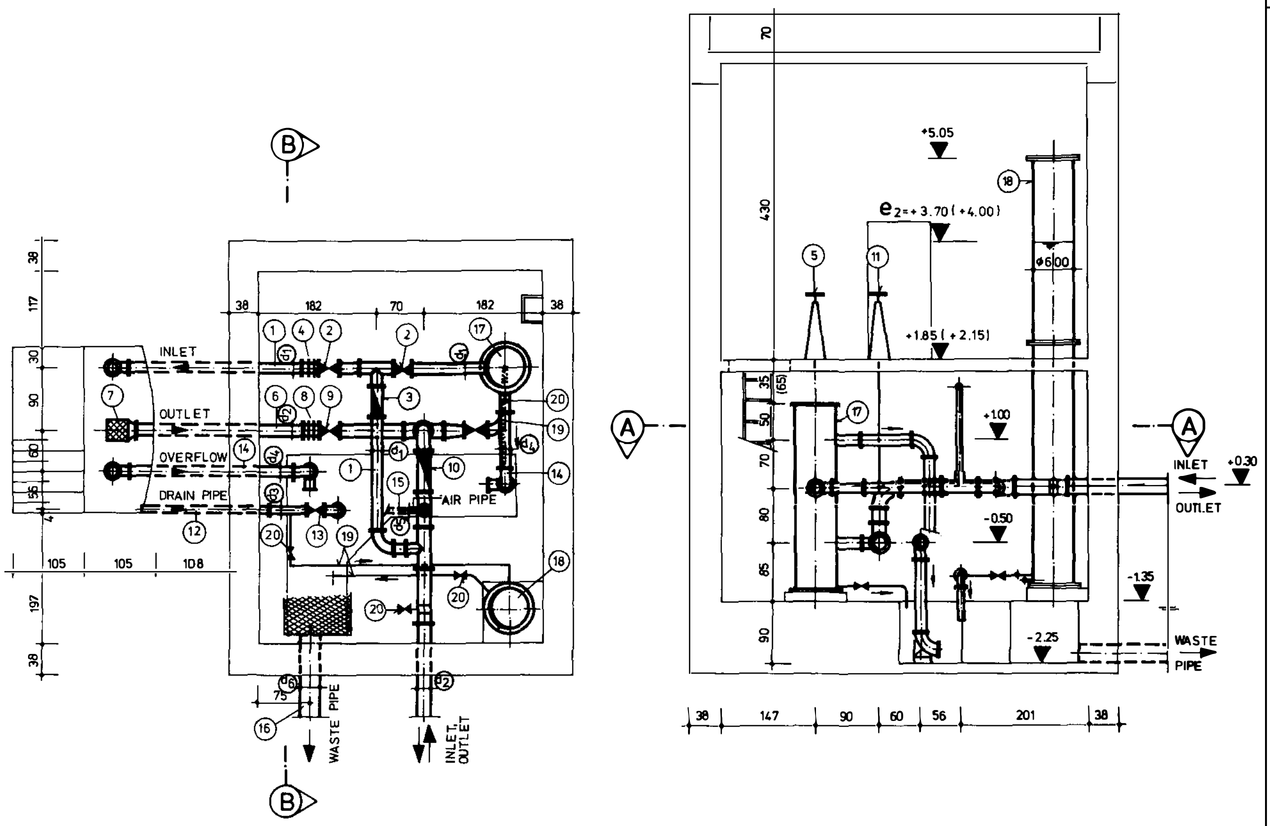
WASTE PIPE (d_6)

14. CONCRETE PIPE

15. FLOAT SHAFT, STEEL PIPE ⌀ 600 mm
16. THREADED PIPE ⌀25mm (GALVANIZED STEEL)
17. VALVE ⌀ 25mm

0 1 2 3m
SCALE

Fig. 38. Type III pipework in a valve house for one water tank



SECTIONAL PLAN A-A

SECTION B-B

PIPING TYPE III - WATER TANKS WITH FEEDING BY PUMPING BEHIND COMMUNITY

VALVE HOUSE FOR ONE WATER TANK

ELEVATION RELATIONS

BOTTOM OF TANK	$e_1 = \pm 0.0$
MAX. W. LEVEL	e_2

DIAMETERS OF PIPES - $d_1, d_2, d_3, d_4, d_5, d_6$

MATERIAL OF PIPES (d_1-d_5) - STEEL OR CAST IRON
(d_6) CONCRETE

LEGEND - PIPING TYPE III

INLET (d_1)

1. FLANGED PIPES AND FITTINGS
2. HAND OPERATED VALVE
3. NON RETURN VALVE - FOR INLET TERMINAL AT BOTTOM OF TANK ONLY
4. MAKE - UP PIECE
5. HEADSTOCK

OUTLET (d_2)

6. FLANGED PIPES AND FITTINGS
7. INLET STRAINER
8. MAKE - UP PIECE
9. HAND OPERATED VALVE
10. NON RETURN VALVE - FOR INLET TERMINAL AT BOTTOM OF TANK ONLY
11. HEADSTOCK

DRAIN PIPE (d_3)

12. FLANGED PIPES AND FITTINGS
13. HAND OPERATED VALVE

OVERFLOW (d_4)

14. FLANGED PIPES AND FITTINGS

AIR PIPE (d_5)

15. WELDED PIPE

WASTE PIPE (d_6)

16. CONCRETE PIPE

17. PRESSURE HEAD BREAKING SHAFT, STEEL PIPE ф 600mm
18. FLOAT SHAFT, STEEL PIPE ф 600mm
19. THREADED PIPE ø25mm (GALVANIZED STEEL)
20. VALVE ø 25mm

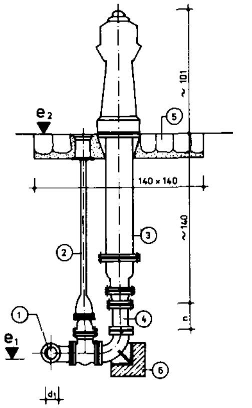
NOTE:

THE ELEVATIONS AND FIGURES IN BRACKETS APPLY FOR VALVE HOUSE INCORPORATED TO WATER TANK200m³ OR 250m³ OF STORAGE CAPACITY.
(DEPTH OF WATER IN THE TANK IS 400 cm)

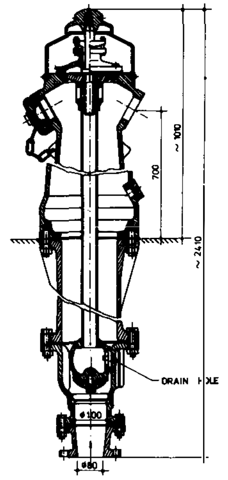
INLET BELLMOUTH TO BE AT THE ELEVATION OF +3.80(+4.10) ACCORDING THE TYPE OF WATER TANK BEEING INCORPORATED TO

0 1 2 3m
SCALE

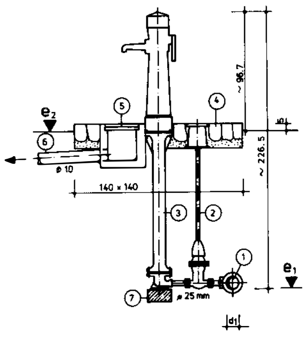
Fig. 39. A fire hydrant, a standpipe and a house connection



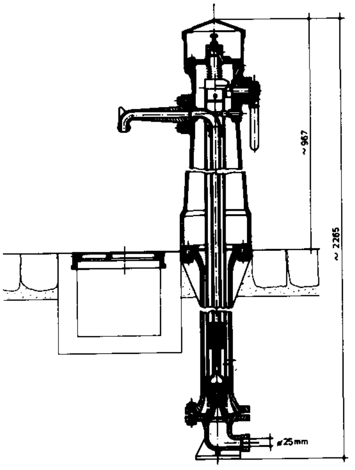
CONNECTION OF OVERHEAD FIRE HYDRANT
(DIMENSIONS IN cm)



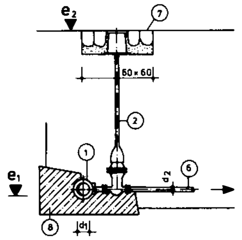
OVERHEAD FIRE HYDRANT - DETAIL VERTICAL SECTION (DIMENSIONS IN mm)



CONNECTION OF WATER STANDPIPE
(DIMENSIONS IN cm)

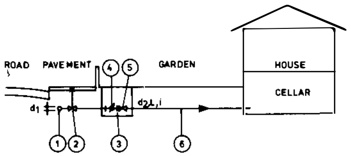


WATER STANDPIPE - DETAIL VERTICAL SECTION
(DIMENSIONS IN mm)



HOUSE CONNECTION

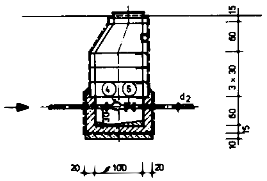
DETAIL OF CONNECTION TO DELIVERY MAIN
(SYSTEM OF THE CONNECTION DEPENDS ON MATERIALS AND SPECIAL PIECES AVAILABLE)



NOTE: IF LOCATION OF WATER METER AND VALVE IN CELLAR OF THE HOUSE IS POSSIBLE MEASURING CHAMBER WILL NOT BE BUILT.

HOUSE CONNECTION

GENERAL ARRANGEMENT - SKETCH



HOUSE CONNECTION

MEASURING CHAMBER

OVERHEAD FIRE HYDRANT

ELEVATION RELATIONS

LEVEL OF DELIVERY OR PUMPING MAIN : e_1
EXISTING GROUND LEVEL : e_2

DELIVERY OR PUMPING MAIN - DIAMETER : d_1
LENGTH OF DISTANCE PIECE : n

LEGEND:
① DELIVERY OR PUMPING MAIN (min. ød = 100 mm)
② UNDERGROUND VALVE WITH VALVE COVER ø 80mm
③ OVERHEAD FIRE HYDRANT ø 80mm
④ DISTANCE PIECE
⑤ STONE PAVING
⑥ CONCRETE SUPPORTING BLOCK

WATER STANDPIPE

ELEVATION RELATIONS

LEVEL OF DELIVERY MAIN : e_1
EXISTING GROUND LEVEL : e_2

DELIVERY MAIN - DIAMETER : d_1

LEGEND:
① DELIVERY MAIN
② UNDERGROUND VALVE WITH VALVE COVER
③ WATER STAND
④ STONE PAVING
⑥ CONCRETE DRAIN PIT WITH CAST IRON GRATE
⑥ DRAIN PIPE
⑦ CONCRETE SUPPORTING BLOCK

NOTE: TYPE OF HYDRANT AND WATER STANDPIPE PRESENTED ON THIS DRAWING ARE SHOWN FOR GENERAL INFORMATION ONLY. LOCAL PRODUCTS OF SIMILAR DESIGN WILL BE USED IN THE SAME ARRANGEMENT WITHIN THE FRAMEWORK OF STANDARD MODEL DESIGNS.

HOUSE CONNECTION

ELEVATION RELATIONS

LEVEL OF DELIVERY MAIN : e_1
EXISTING GROUND LEVEL : e_2

DELIVERY MAIN - DIAMETER : d_1
HOUSE CONNECTION - DIAMETER : d_2

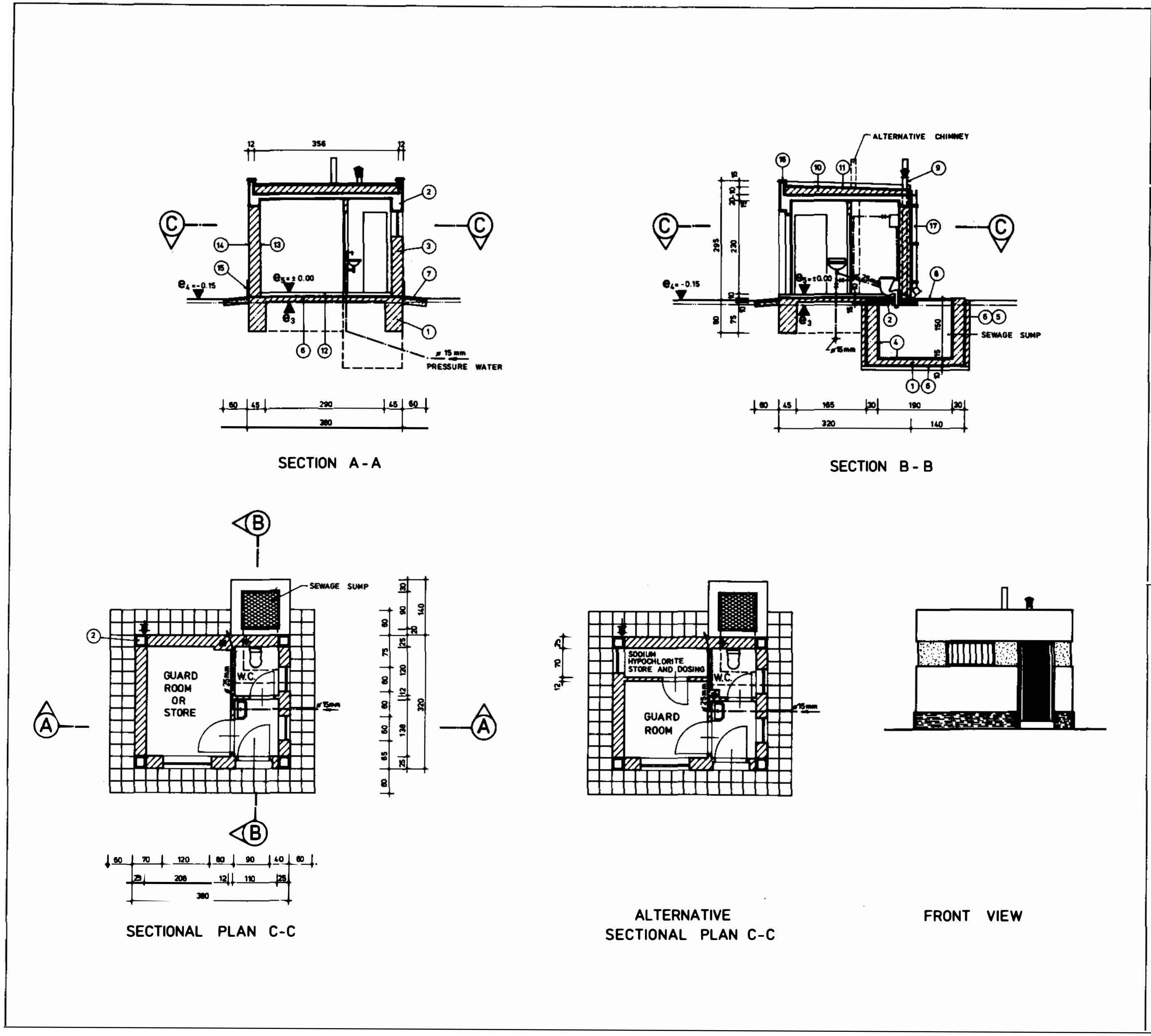
LEGEND:
① DELIVERY MAIN
② UNDERGROUND VALVE WITH VALVE COVER
② MEASURING CHAMBER
④ WATER METER
⑥ VALVE WITH DRAIN COCK
⑥ PIPE OF HOUSE CONNECTION
⑦ STONE PAVING
⑧ CONCRETE SUPPORTING BLOCK

NOTE: LENGTH (L - m) AND GRADIENT (i - %) OF HOUSE CONNECTION PIPE WILL BE DESIGNED FOR LOCAL CONDITIONS

DETAILED DATA (LEVELS AND DIAMETERS) ON THE INDIVIDUAL ITEMS SHOULD BE OF TABULAR FORM TO ADD THE DETAILED DISTRIBUTION NETWORK DESIGN

DRAWING IS
NOT TO SCALE

Fig. 40. A general service building



SECTION A-A

SECTION B-B

SECTIONAL PLAN C-C

ALTERNATIVE SECTIONAL PLAN C-C

FRONT VIEW

ELEVATION RELATIONS

GROUND FLOOR $e_5 = \pm 0.00$
EXISTING GROUND e_3
REFORMED GROUND $e_4 = -0.15$

LEGEND:

1. FOUNDATION CONCRETE
2. REINFORCED CONCRETE (OR PRECAST SLABS)
3. BRICKWORK
4. WATERTIGHT PLASTER
5. RECEPTION WALL
6. ASPHALT SHEET AND TWO ASPH. PAINT COATS, FOR SEWAGE SUMP TWO SHEET AND THREE ASPH. PAINT COATS
7. CONCRETE TILES 30/30 LAID ON SAND BED
8. WATERTIGHT CHECKERED PLATE COVER
9. VENTILATION
10. SLAG OR FOAM CONCRETE
11. BITUMINOUS COVERING
12. EARTHENWARE FLOOR TILES
13. CEMENT-LIME PLASTER
14. EXTERNAL PLASTER
15. EXTERIN SKIRTING
16. FLASHING
17. RAIN WATER CONDUIT

NOTE :

WHEN BUILDING IS USED FOR SODIUM HYPOCHLORITE DOSING SET INSTALLATION, THE ALTERNATIVE ROOM ARRANGEMENT SHOULD BE USED. (SEE ALTERNATIVE SECTIONAL PLAN C-C)

0 1 2 3m
SCALE

Fig. 41. Some structural details of a general service building

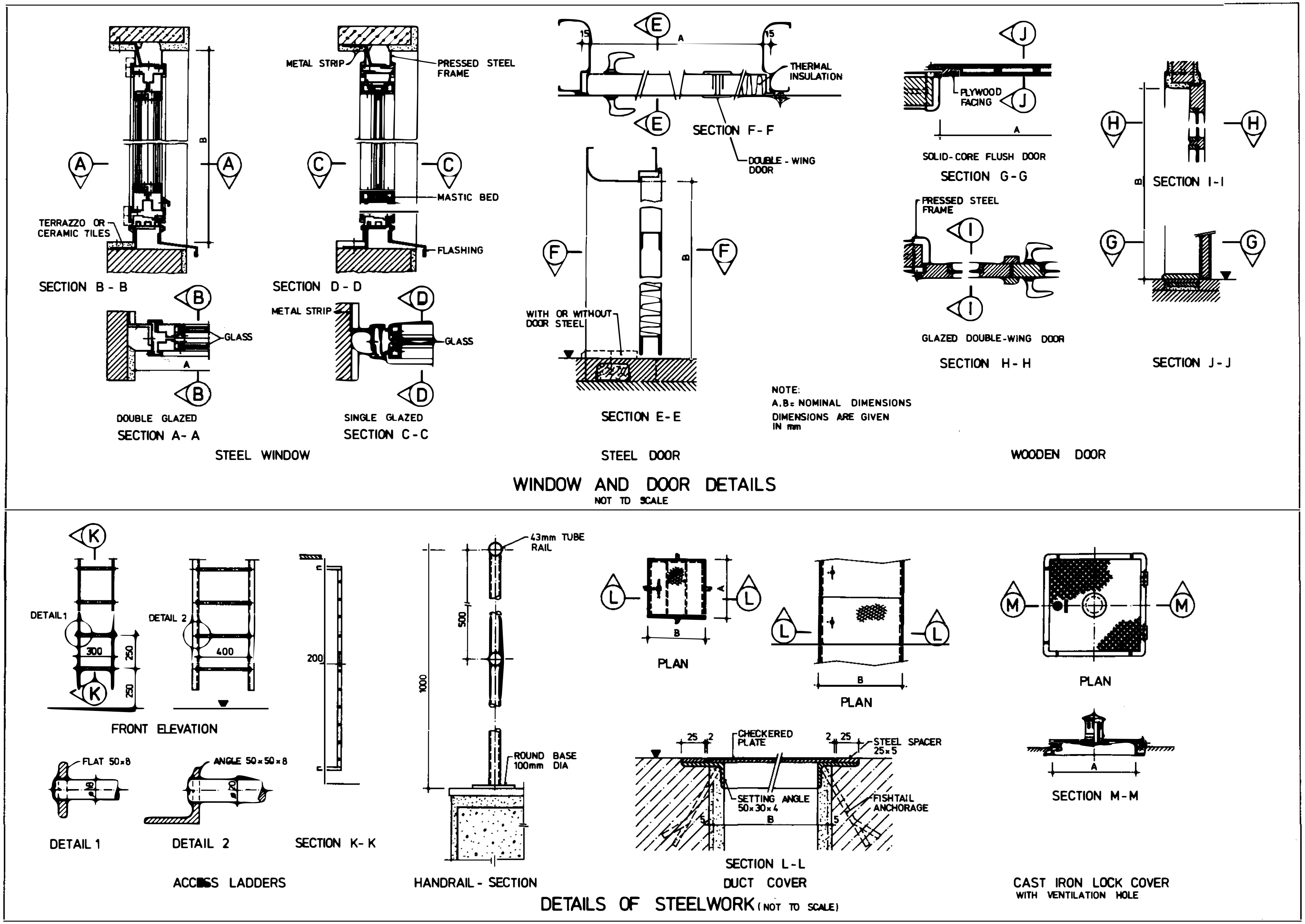
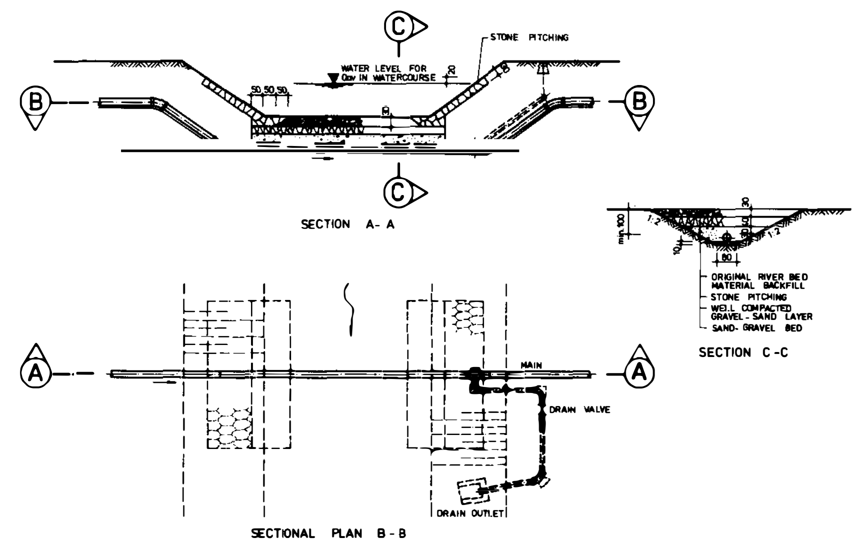
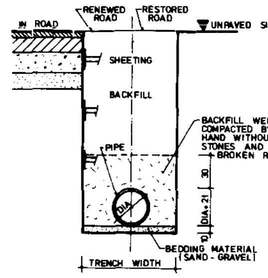


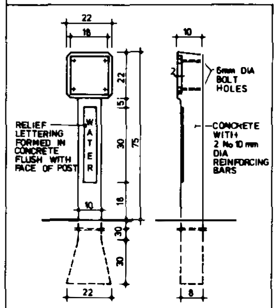
Fig. 42. Some construction details of a general service building



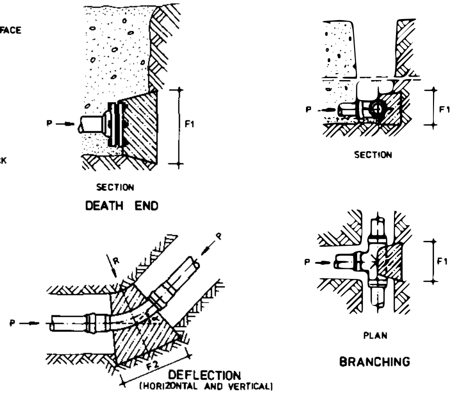
TYPICAL WATERCOURSE CROSSING



EXCAVATION AND PIPELAYING SECTION



PRECAST INDICATOR POST



DEFLECTION SUPPORTING BLOCKS — TABLE 1

DIAMETER OF PIPE (mm)			50	66	80	100	125	150
P (kp)			468	663	954	1,425	2,308	3,015
α = 90°	R (kp)		662	938	1,349	2,016	3,264	4,264
	F2 (cm2)	P_1 = 1 kp/cm²	662	938	1,349	2,016	3,264	4,264
		P_1 = 2 kp/cm²	331	469	675	1,008	1,632	2,132
		P = 0.4 kp/cm²	1,655	2,345	3,373	5,038	8,160	10,660
α = 45°	R (kp)		358	507	730	1,091	1,767	2,308
	F2 (cm2)	P_1 = 1 kp/cm²	358	507	730	1,091	1,767	2,308
		P_1 = 2 kp/cm²	179	254	365	546	884	1,154
		P_1 = 0.4 kp/cm²	895	1,268	1,825	2,728	4,418	5,770
α = 30°	R (kp)		242	343	494	738	1,195	1.561
	F2 (cm2)	P_1 = 1 kp/cm²	242	343	494	738	1,195	1.561
		P_1 = 2 kp/cm²	121	172	247	369	598	781
		P_1 = 0.4 kp/cm²	605	858	1,235	1,845	2,988	3.903
α = 22°	R (kp)		179	253	364	544	881	1,151
	F2 (cm2)	P_1 = 1 kp/cm²	179	253	364	544	881	1,151
		P_1 = 2 kp/cm²	90	127	182	272	441	576
		P_1 = 0.4 kp/cm²	448	633	910	1,360	2,203	2,878
α = 11°	R (kp)		90	127	183	273	442	578
	F2 (cm2)	P_1 = 1 kp/cm²	90	127	183	273	442	578
		P_1 = 2 kp/cm²	45	64	92	137	221	289
		P_1 = 0.4 kp/cm²	225	318	458	683	1,105	1,445

NOTE:
FOR CONVERSION TO SI UNITS (SYSTEME INTERNATIONAL D'UNITÉS) THE FOLLOWING RELATIONS ARE VALID:
FORCE: 1kp = 9.806 65N (1kp ≙ 0.01 kN)
PRESSURE: 1kp/cm² = 9.806 65 × 10^4 Pa (1kp/cm² ≙ 0.1 MPa)

DEATH END AND BRANCH SUPPORTING BLOCKS — TABLE 2

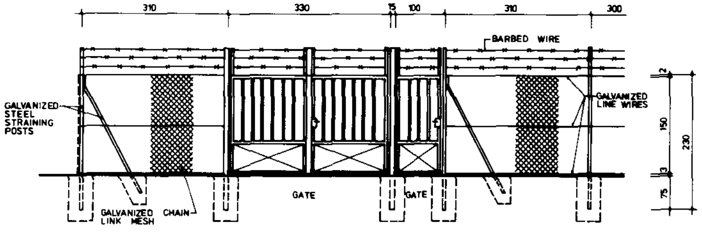
DIAMETER OF PIPE (mm)		50	65	80	100	125	150	200
P (kp)		468	663	954	1,425	2,308	3.015	5.962
F_1 (cm2)	P_1 = 1 kp/cm²	468	663	954	1,425	2,308	3.015	5.962
	P_1 = 2 kp/cm²	234	332	477	713	1,154	1,508	2.981
	P = 0.4 kp/cm²	1,170	1,658	2,385	3,563	5,770	7,538	14,905

SUPPORTING BLOCKS AREA TABLES FOR PVC (BOVIDUR) PIPES ARE PREPARED ACCORDING TO "VIOLETA - SKOPJE" OFFICIAL HANDBOOK FOR PVC PIPELAYING IN TRENCHES.

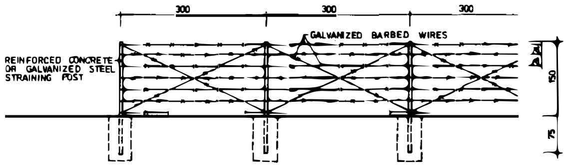
SYMBOLS EXPLANATION:

P = TEST PRESSURE RESULTING FORCE IN THE PIPELINE CROSS SECTION (TEST PRESSURE 15 kp/cm2)
P_1 = SOIL BEARING CAPACITY
R = RESULTING FORCE $R = 2P \times \sin\frac{\alpha}{2}$
α = DEFLECTION ANGLE
F_1, F_2 = BLOCK SUPPORTING AREA NEEDED

PVC PIPES TYPICAL PIPELAYING DETAILS

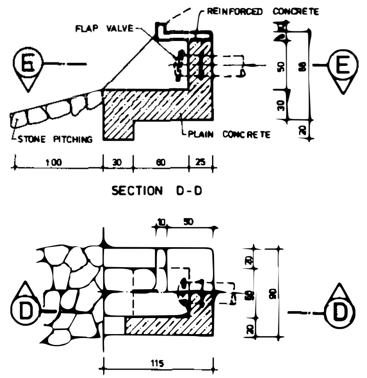


CHAIN LINK MESH FENCE WITH GALVANIZED STEEL POSTS



GALVANIZED BARBED WIRE FENCE (SIMPLE WIRE FENCE)

TYPICAL FENCES



TYPICAL DRAIN OUTLET STRUCTURE

NOTE:
DRAWING IS NOT TO SCALE;
DIMENSIONS ARE GIVEN IN cm

PART II

APPLICATION OF STANDARD MODEL DESIGNS TO 12 COMMUNITIES

PART II. APPLICATION OF STANDARD MODEL DESIGNS TO 12 COMMUNITIES

Mamuša

Basic Data

The community of Mamuša lies in the commune of Prizren, about 13 km in a direct line, and about 20 km by road from the commune centre of the same name. Access to the community is possible throughout the year by means of a well maintained asphalt road.

The buildings are concentrated along the sides of the main street that passes through the town on the right bank of the Topluga River, flowing along its south-eastern edge. Mamuša has a school and health centre but no industry (see Fig. 43).

In 1971, the national census found the population of the community to be 2037 and, following detailed discussion with the provincial planning authorities, it was concluded that Mamuša would grow during the design period so that a population equivalent of 3900 would be used for the water supply system. Most of the population is employed in agriculture.

In accordance with the design critiera, a per capita water consumption of 260 litres per day was adopted. This resulted in the following daily water requirements (see p. 4).

Total		90% (reduced for design)	
m^3/day	litres/second	m^3/day	litres/second
1014	11.7	913	10.6

Water Resources

An investigation of the area surrounding Mamuša indicated two possible sources of water. One is the alluvium of the Topluga River, near the community. The other is a karst spring with a recorded yield of 14–42 litres per second, located some distance away.

Because of its proximity to the centre of consumption, the groundwater from the river valley was selected after water sample analyses from both sources had indicated that no additional treatment would be necessary. Also, the water from the karst spring was found to be of inferior quality to the river valley groundwater.

The hydrogeological investigation of the proposed groundwater extraction area found that the fluvial sediment was 5.1 m deep and 2.9 m of this were considered to be water-bearing gravel/sand strata suitable for water extraction. The average water table line was found 1.6 m below ground level.

The overlying fluvial deposits contained fine-grained sand and clay loam, 2.3 m thick, that provided a good protective cover and minimized the possibility of direct contamination of the source from the surface.

Pumping tests proved that 4 litres per second of water could be extracted from one well located 100 m from the river bank, so the system was designed with two bored wells at the same distance from the river and 100 m apart.

No further details on the specific hydrogeological conditions or pumping tests are presented in this publication since its purpose is to describe the application of the standard model designs. However, the tests performed and general results found have been mentioned because they are critical for the design.

The wells should be bored down to the top of the impermeable subsoil underlying the granular water-bearing strata. The inner diameter of the well screen will be determined by the pump and suction strainer design but a 30 cm minimum is recommended. The bore diameter depends on the outer diameter of the well screen and the recommended 10 cm thickness of the packing material. Taking this into consideration, a bore diameter of 50 cm was selected.

The perforated well screen will reach from 10 cm below the maximum draw-down level of the aquifer during pumping to the well bottom on top of the impermeable substrata. The area of perforation in the active screen length should be at least 20% of the total screen area, while the grain size of the filtration fill material will be determined on the basis of the grain size distribution of the water-bearing strata and the filter screen perforation size. For this purpose, a detailed investigation of the grain size distribution of the aquifer is necessary.

To ensure that hygienic conditions prevail at the wellfield, a protection zone with strict access control should be established, covering an area extending about 100 m from the well. A secondary protection zone was recommended, extending a distance equivalent to 180-day groundwater flow time. The establishment of this secondary zone of restricted activity should safeguard the wells from contamination by pathogens.

The main characteristic of the groundwater is its degree of mineralization; its total hardness due to the presence of calcium and magnesium was 185 mg/l calcium carbonate. Water of this quality is within the medium range of hardness and can be classified as very suitable for public water supply.

During the pumping tests, the salinity of the water dropped slightly from 250.2 mg/l to 243.1 mg/l; 186 mg/l of this were the monovalent cation salts sodium and potassium. Also, from the low alkalinity and low concentrations of mineral acid anions, especially chlorides and nitrates, it is evident that the groundwater is little affected by pollution resulting from human or agricultural activity.

The water was also found to be exceptionally pure, as illustrated by the very low chemical oxygen demand recorded. Thus little organic oxidizable matter is present. The same is true of ammoniacal nitrogen and nitrites. The minute nitrate values indicate that the water is not subjected to the usual sources of groundwater pollution.

These data, as well as physical characteristics such as clarity and freedom from colour, turbidity and odour, make this groundwater a most acceptable source for public water supply and consumption.

The water contains some free carbon dioxide and disinfection will have to be provided to ensure the bacteriological quality of the supply. Since the community of Mamuša plans a connection to the regional water supply system of Prizren-Suva Reka in the future, only dosing with sodium hypochlorite, within the range of 1.5–3 g of commercially available solution per m^3 of water is anticipated at this stage. Carbon dioxide removal would be necessary only if the planned connection to the regional system could not be made and the wellfield had to be extended as a result.

Water Supply System

The water should be extracted from the aquifer using two bored wells 7 m deep. Because of the relative elevation of the water source and the area of consumption, a pumping station will lift the water to a service tank situated behind the area of consumption, so that the water is pumped to the tank through the distribution system. Water flow will be measured by a meter located in the pumping station. For a community of this size, a tank of 250 m^3 capacity is required.

Basic hydraulic calculations are presented in Fig. 44 and the longitudinal profiles in Fig. 45.

Fire hydrants also used for air release and sludge removal will be installed on the distribution network. The network will be made of PVC; only one pressure zone is required.

Standpipes are proposed for public water supply, with service connections to the school, health centre and other public buildings.

The pumping station will be supplied with power from a 10 kV high-voltage line leading towards the school. The supply will be carried overhead for 800 m to a 30 kVA, 10/0.4 kV pole transformer at the pumping station. The required installed capacity will be 44.6 kW with a power demand of 19.8 kW.

A signalling and control cable for automatic pump operation will be laid to transmit the level signals from the water tank to the pumping station.

Technical Specifications

Bored deep wells

There will be two standard bored deep wells 7 m deep, with a screen diameter of at least 300 mm, an arrangement of screen and filtration fill according to the hydrogeological investigation and a suction pipe of 80 mm diameter with suction strainer and a hand-operated isolating valve of the same diameter. See Fig. 46 and 47, and the standard design in Fig. 7.

Pumping station

A standard Type 1.1 pumping station, without a wet sump, will be built with the following machinery and electrical equipment:

— 2 horizontal pumps with a capacity of 5.4 litres per second and total delivery head of 73 m;

— 1 set of standard air release equipment;

— 1 standard water hammer damping device;

— 1 set of standard sodium hypochlorite dosing equipment;

— 1 standard switchboard, prepared for the connection of a subdistribution switchboard for the aeration station later;

— 1 set of standard lighting equipment, including light fittings, switches, socket outlets and cable installation; and

— 1 pole-type transformer with a capacity of 30 kVA, 10/0.4 kV, 900 m of overhead high-tension feeding line, and 910 m of control and signalling cable line between the pumping station and the water tank.

The pumps can be operated manually from the local switchboard and automatically by the levels in the service water tank.

The electrode switch-off level will be 393.95 m above sea level, and the switch-on level 393.0 m above sea level. The shut-off electrodes will be located at 327 m above sea level in deep well No. 1 and at 326.5 m above sea level in well No. 2. See Fig. 46–49 and the standard designs in Fig. 9, 11, 12 and 41.

Water tank

There will be one standard water tank with a capacity of 250 m^3 and Type II base slab. The maximum water level will be 394.0 m above sea level and the bottom level will be 390.0 m. See Fig. 50 and the standard designs in Fig. 31.

Valve house

A standard valve house with one water tank will be built, with Type III piping. See Fig. 50 and the standard designs in Fig. 33, 38, 41 and 42.

Distribution network

The distribution network will include PVC piping with cast-iron fittings and adapting pipes, isolating valves with valve boxes for control from the ground, 30 fire hydrants and 13 water standpipes for a nominal pressure of 1.0 MPa. There will be one house connection for the school and pipes of 100 mm diameter and a total length of 3175 m. See Fig. 43 and the standard designs in Fig. 39 and 42.

Fig. 43. Layout of distribution system

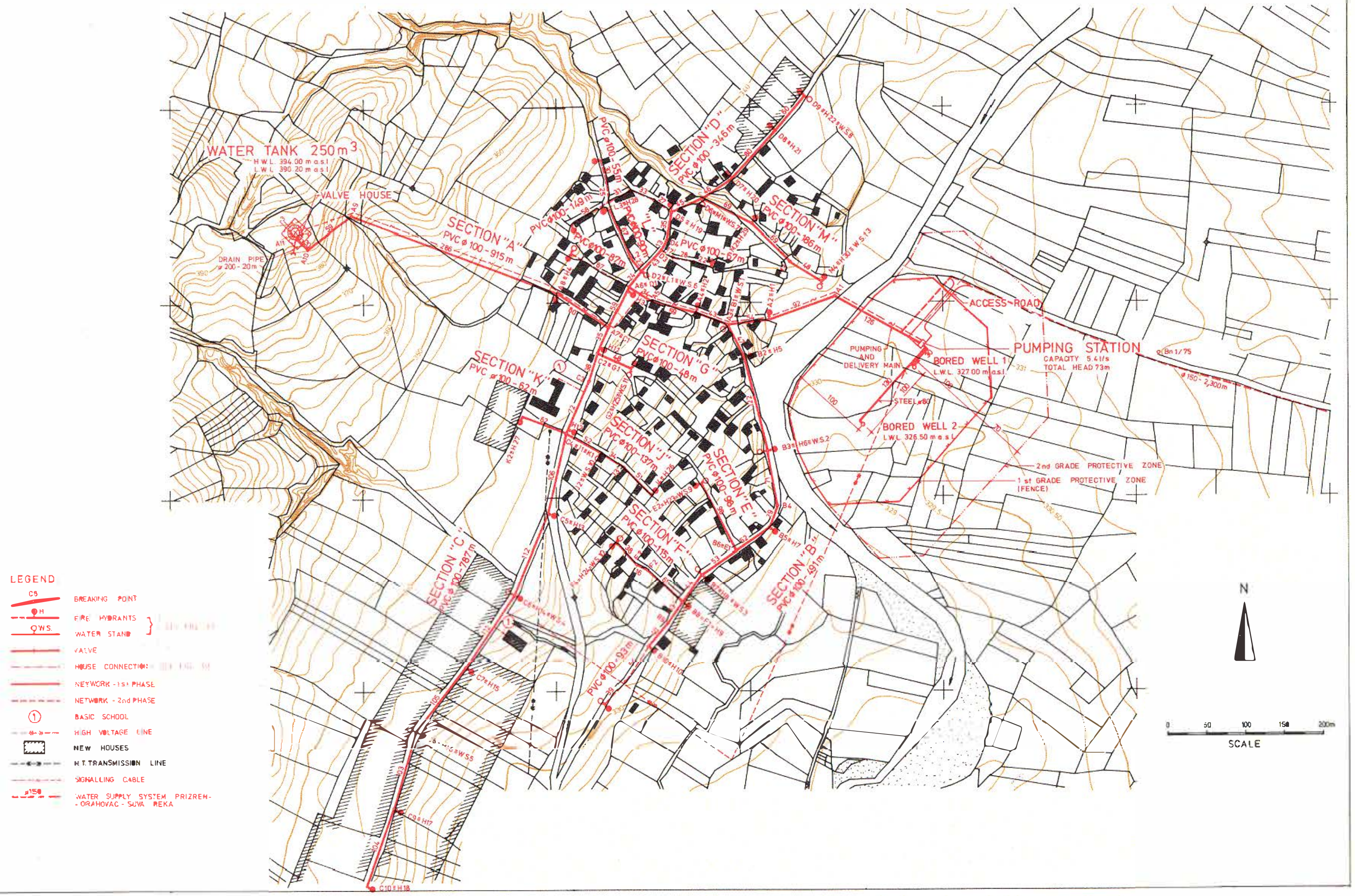
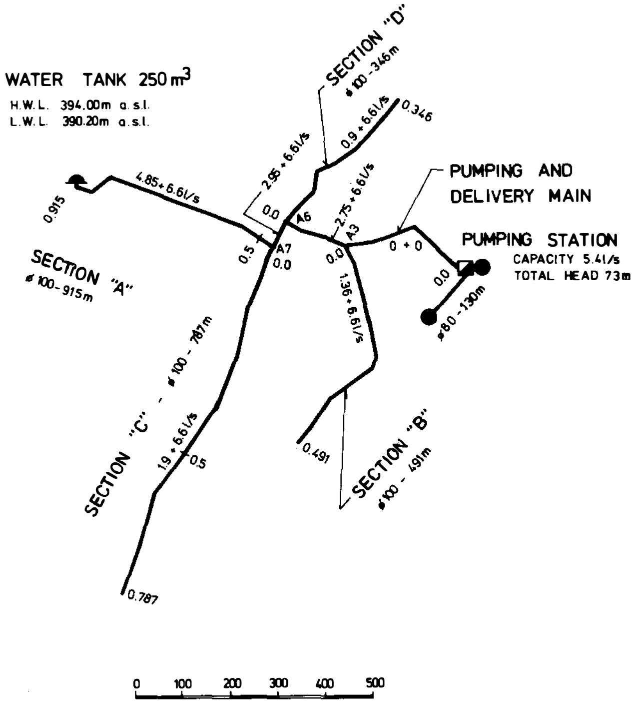


Fig. 44. The flow scheme and some basic hydraulic calculations



FLOW SCHEME

max Qd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES C	ø PVC k=0.01 mm	J %	v m/s	PRESSURE LOSSES C× J× L m	TOTAL HEAD m
5.4	915	1.05	100	0.5602	0.74	5.38	394.0-326.5+5.38= =72.88

PUMPING MAIN

FEEDING OF WATER TANK AT NIGHT, CONSUMPTION = 0

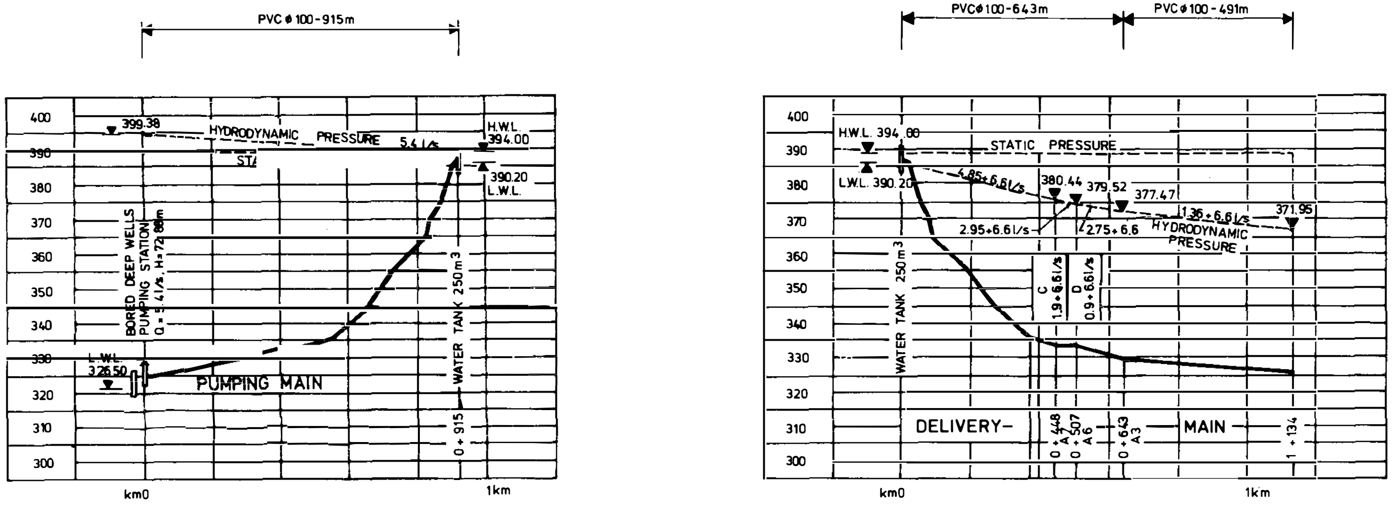
max Qd l/s	maxQh l/s	SECTION	max Qh/2 l/s	FLOW TOTAL max Qh/2 l/s	Qf l/s	TOTAL Q Qh/2+Qf l/s	LENGTH L m	ø PVC k=0.01 mm	J %	v m/s	PRESS. LOSS J× L m	ELEVATION OF HYDROOYNAMIC PRESSURE m
5.4	5.4×1.8= =9.72	A(WT.-A7)	0	4.85	6.6	11.45	448	100	2.1793	1,53	9.76	390.20 - 9.76= = 380.44
		A (A7-A6)	0.20	2.95	6.6	9.55	59	100	1.5672	1.28	0.92	380.44 - 0.92= = 379.52
		A(A6-A3)	0.50	2.75	6.6	9.35	136	100	1.5080	1.25	2.05	379.52 - 2.05= = 377.47
		C	1.90	1.90	6.6	8.50	787	100	1.2686	1.14	9.98	380.44 - 9.98= = 370.46
		D	0.90	0.90	6.6	7.50	346	100	1.0120	1.01	3.50	379.52 - 3.50= = 376.02
		B	1.36	1.36	6.6	7.96	491	100	1.1242	1.07	5.52	377.47 - 5.52= = 371.95

DELIVERY MAIN

NOTE: THIS CALCULATION IS PERFORMED FOR THE FIRST STAGE FLOW QUANTITIES. THE CALCULATION FOR THE SECOND STAGE WILL BE DONE ON THE BASIS OF FEEDING OF THE WATER SUPPLY SYSTEM

HYDRAULIC CALCULATIONS

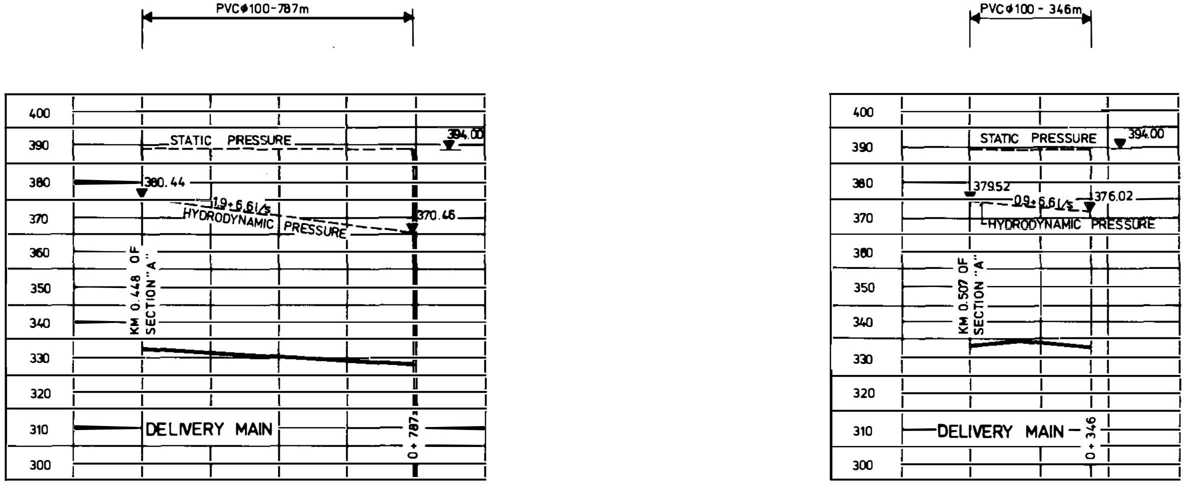
Fig. 45. Longitudinal profiles



SECTION "A"

FEEDING OF WATER TANK AT NIGHT, CONSUMPTION = 0

SECTION "A" SECTION "B"



SECTION "C" SECTION "D"

Fig. 46. The wellfield area

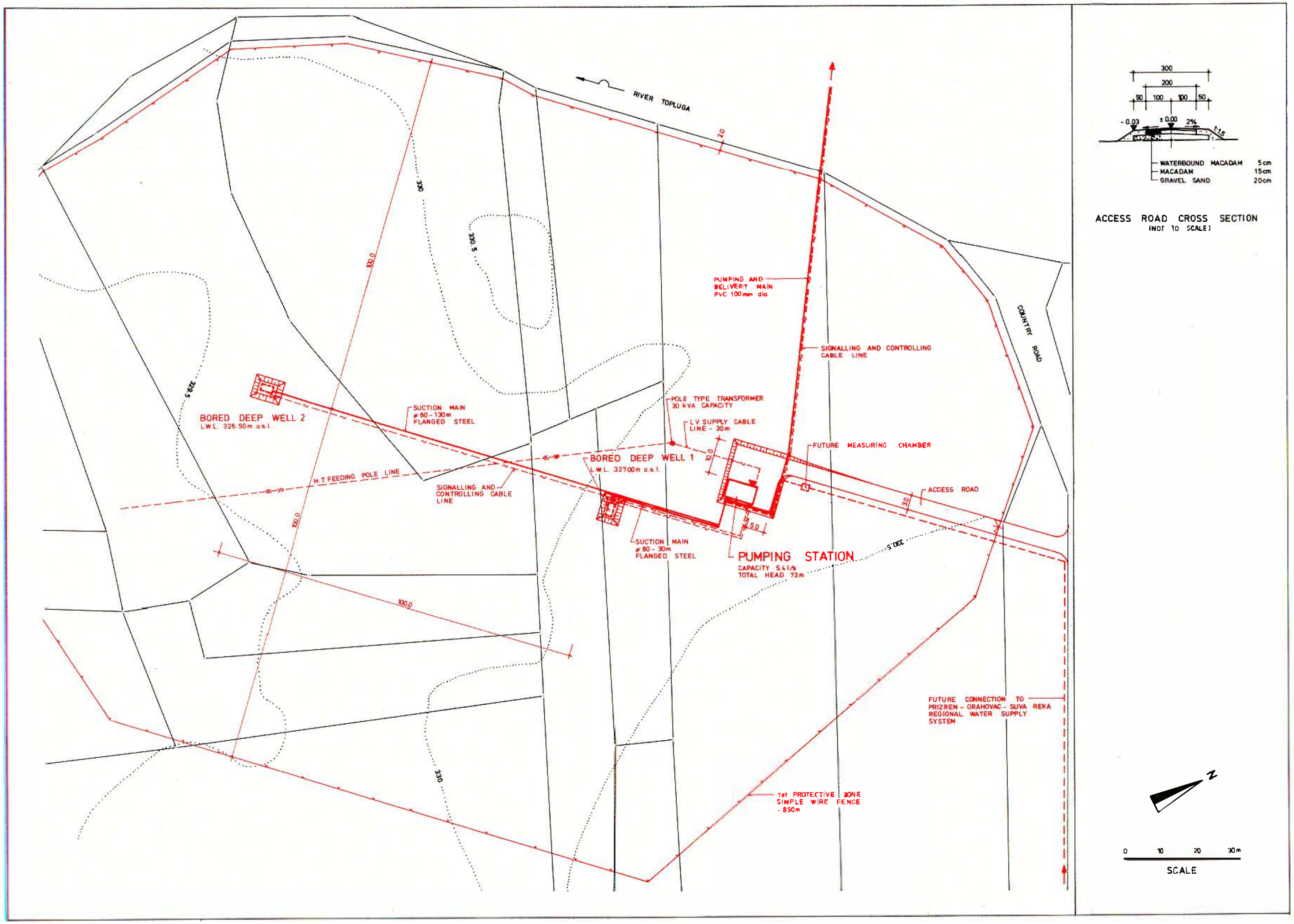
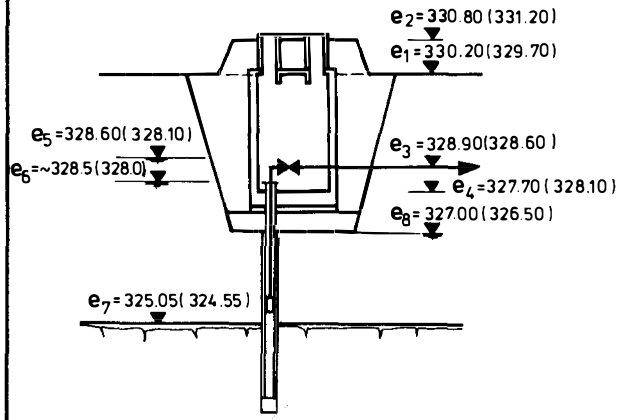


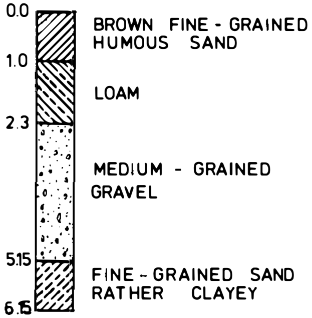
Fig. 47. Bored deep wells and pumping station

BORED DEEP WELLS

ELEVATION RELATIONS



TRIAL BORE HOLE Bn 1/75
(FOR LOCATION SEE FIG. 43)



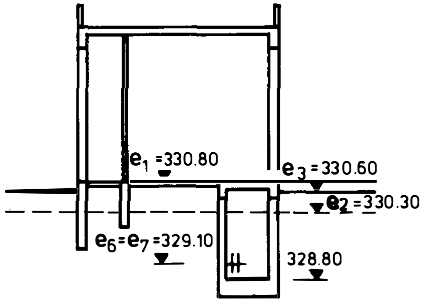
FIGURES IN BRACKET ARE VALID FOR DEEP WELL N°2

NOTE: ELEVATION e_1 TAKEN OVER FROM ORIGINAL MAP

	N° 1	N° 2
DRAWING		
BORED DEEP WELL		FIG. 7
DIAMETERS OF PIPES		
SUCTION PIPE	⌀d_1 = 80 mm	⌀ d_1 = 80mm
SCREEN	D = 300 mm	D = 300mm
FILTRATION FILL	d = 100 mm	d = 100mm

PUMPING STATION

ELEVATION RELATIONS



NOTE: ELEVATION e_2 TAKEN OVER FROM ORIGINAL MAP

DRAWINGS

PUMPING STATION - CIVIL CONSTRUCTION (TYPE 1.1)	FIG. 9
PUMPING STATION - MACHINERY	FIG. 11
PUMPING STATION - ELECTRICAL EQUIPMENT	FIG. 12

DIAMETERS OF PIPES

SUCTION PIPE	⌀d_1 = 80mm
PUMPING MAIN	⌀ d_2 = 100mm
CONNECTION OF PRESSURE VESSEL TO PUMPING MAIN	⌀d_3 = 80mm

Fig. 48. The operation scheme

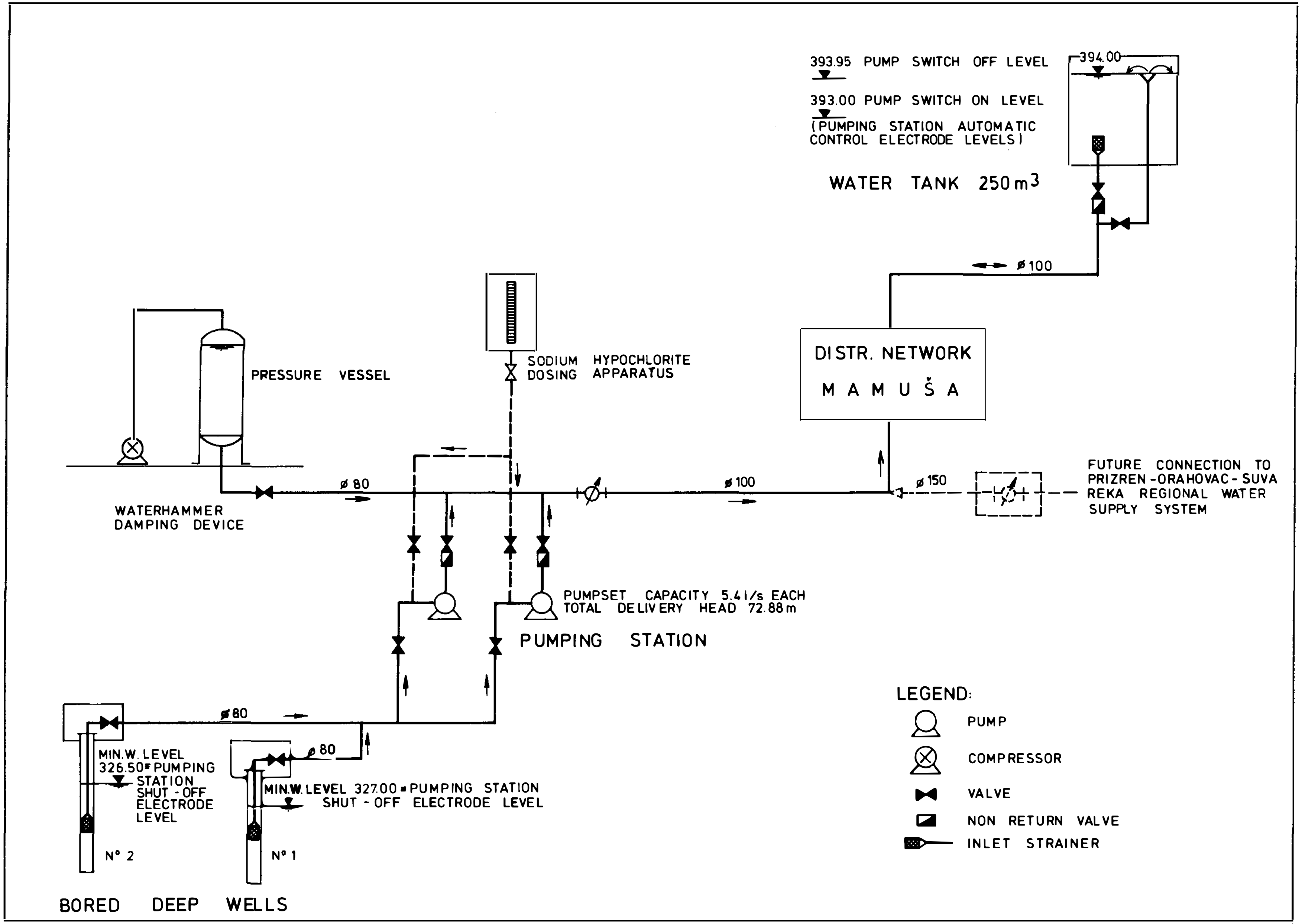
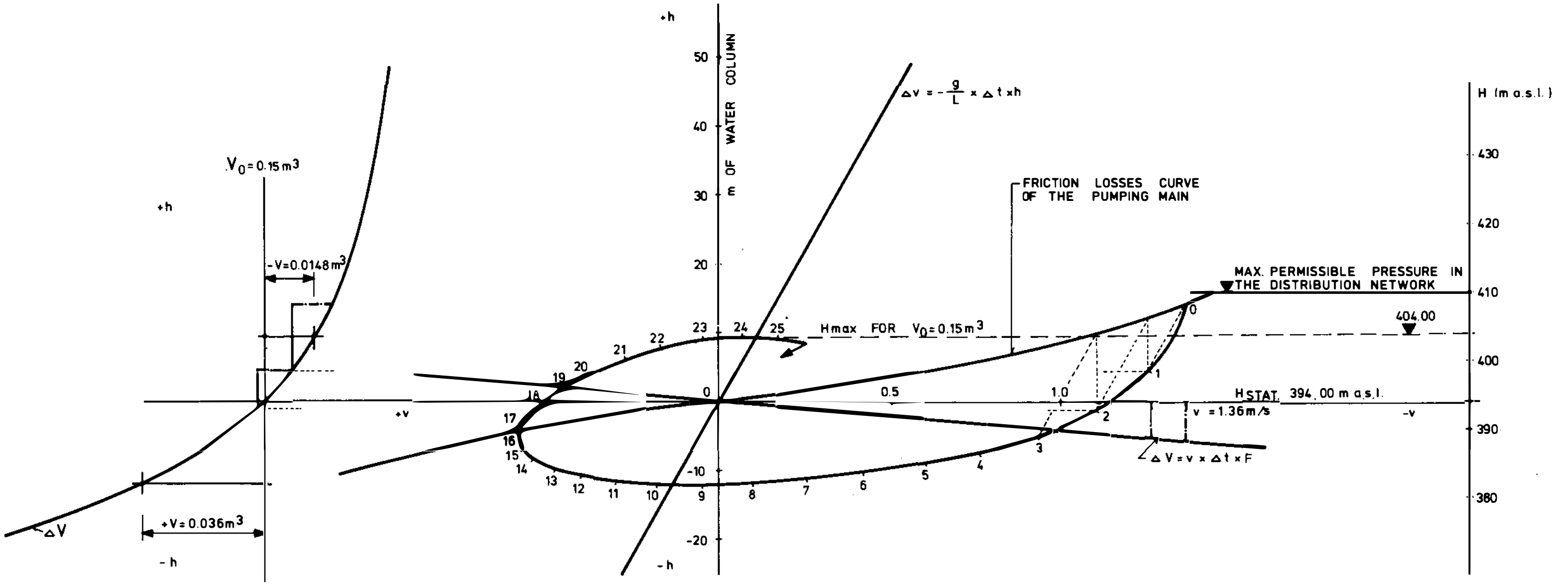
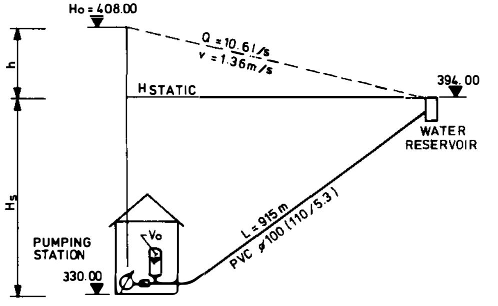


Fig. 49. Graphical check of water hammer damping



GRAPHICAL CHECK OF PRESSURE VESSEL VOLUME BY EQUIVALENT SURGE TANK METHOD



CALCULATION SKETCH

BASIC DATA FOR THE GRAPHICAL CALCULATION

2nd STAGE QUANTITY OF FLOW	Q_o = 10.6 l/s
LENGTH OF PUMPING MAIN	L = 915 m
INSIDE DIAMETER OF PIPE LINE	D = 100 mm
OUTSIDE DIAMETER AND WALL THICKNESS OF PIPE LINE	D'/s = 110/5.3 mm
MODULUS ELASTICITY OF PVC PIPES	E = 3×10^3 MPa
INITIAL VELOCITY IN THE PUMPING MAIN	v = 1.36 m/s
ACCELERATION OF GRAVITY	g = 9.81 m/s^2
WAVE VELOCITY	a = 943 m/s
ESTIMATED AIR VOLUME IN THE PRESSURE VESSEL UNDER STATIC CONDITIONS	V_o = 0.15 m^3
INTERVAL OF TIME	Δt = 1.025 s
STATIC PRESSURE	H_s = 64 m
BAROMETRIC PRESSURE	H_b = 10 m
CROSS SECTIONAL AREA OF PUMPING MAIN	F = 0.007 85 m^2

AIR VOLUME CHANGE ΔV IN THE PRESSURE VESSEL

$$\Delta V = \frac{1}{\varkappa} \times \frac{V_o (H_s + H_b)^{\frac{1}{\varkappa}}}{(H_s + H_b + \Delta H)^{1+\frac{1}{\varkappa}}} \times \Delta H$$

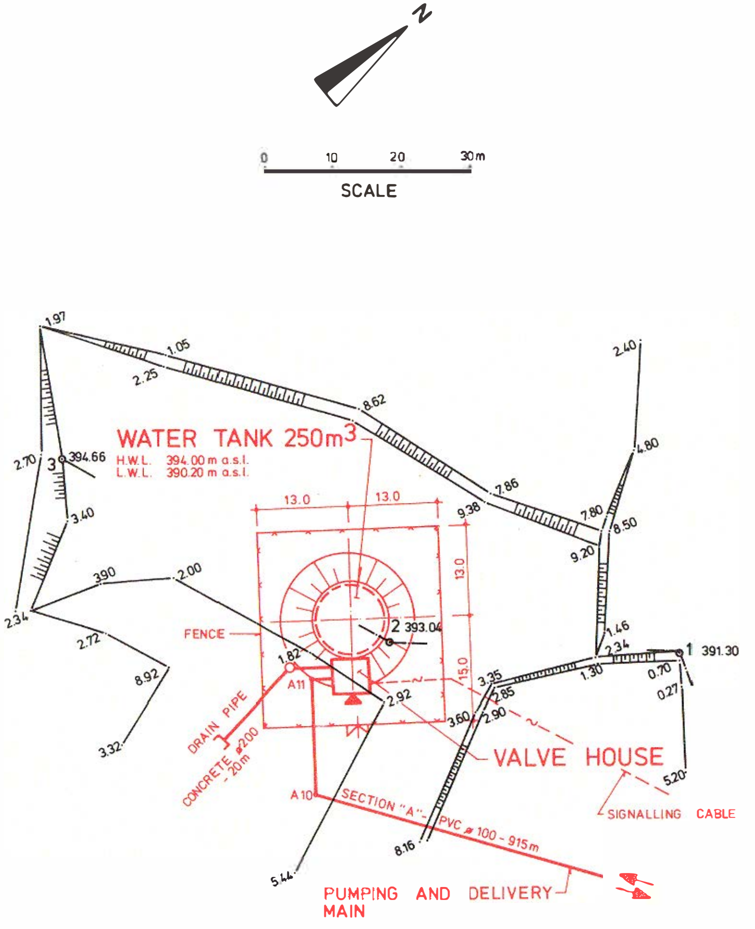
$\varkappa \doteq 1$ FOR ISOTHERMIC EXPANSION

$$\Delta V = 1 \times \frac{0.15\ (64 + 10)^1}{(64 + 10 + \Delta H)^{1+1}} \times \Delta H$$

ΔH	74 + ΔH	$(74 + \Delta H)^2$	$\frac{11.1}{(74 + \Delta H)^2}$ ×	ΔH
10	84	7 030	0.00158	0.0158
20	94	8 800	0.00126	0.0252
30	104	10 800	0.00102	0.0307
40	114	12 980	0.000854	0.0341
50	124	15 390	0.000722	0.0361
- 10	64	4 090	0.00271	- 0.0271
- 20	54	2 910	0.00381	- 0.0762

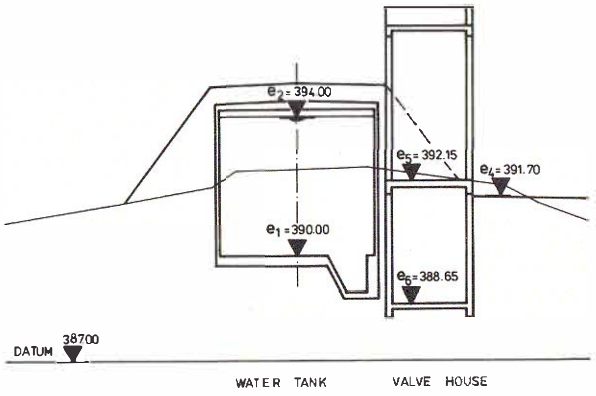
RESULT: FOR THE PROTECTION AGAINST WATERHAMMER THE PRESSURE VESSEL TOTAL VOLUME OF $0.5 m^3$ WITH AIR VOLUME OF $0.15 m^3$ UNDER STATIC CONDITIONS IS SUFFICIENT.

Fig. 50. Layout of the 250 m³ water tank



REFERENCES TO STANDARDIZATION

ELEVATION RELATIONS



DIAMETERS OF PIPES

INLET	ød_1	= 80mm
OUTLET	ød_2	=125 mm (OUTSIDE THE VALVE HOUSE ød_2 =100mm SEE LAYOUT)
DRAIN PIPE	ød_3	= 80mm
OVERFLOW	ød_4	= 80mm
AIR PIPE	ød_5	= 50mm
WASTE PIPE	ød_6	=200 mm

DRAWINGS

WATER TANK 250m³ (TYPE II OF BASE SLAB SUPPOSED)	FIG. 31
VALVE HOUSE FOR ONE WATER TANK - CIVIL CONSTRUCTION (WASTE CHANNEL ARRANGEMENT TYPE b)	FIG. 33
VALVE HOUSE FOR ONE WATER TANK - PIPING TYPE III.	FIG. 38

Ogošte

Basic Data

The rural community of Ogošte is situated in the commune of Kosovska Kamenica, 9 km in a direct line from the commune centre of the same name. The Ogoska River flows through the centre of the community whose houses are built upon the lower valley slopes along both banks.

In 1971, the national census found the population of the community to be only 1038. However, due to steady growth during the 1970s, the population was estimated to be 2750 by 1980, and by 1990 the population was expected to be 3500.

The population of Ogošte lives by agriculture, both crop production and livestock grazing. Ogošte has a secondary school, a health centre and local administration offices. It has no industry and none is planned.

In accordance with the design criteria, a per capita water consumption of 260 litres per day was adopted. This resulted in the following daily water requirements.

Total		90% (reduced for design)	
m^3/day	litres/second	m^3/day	litres/second
910	10.5	819	9.5

Water Resources

During field reconnaissance, two possible sources of water for Ogošte were identified. One was the surface water of the Ogoska River upstream of the community, and the other the groundwater from the river valley alluvium downstream of the community. After consideration of both alternatives, the first was chosen because of the relatively high quality of the source, the continuity of sufficient flow and the extremely scarce population and agricultural activity in the catchment area upstream of the community. Also, it eliminated the cost of hydrogeological investigations necessary to ensure that the alluvial deposits would yield sufficient water. Investigation would have been particularly important in this case since tests in the same alluvium for the supply to a neighbouring community had shown insufficient yield.

Information on the flow in the Ogoska River at the proposed extraction point was found to be scarce. Only the results of some random measurements were available, although these were supplemented by adopting more comprehensive values for a nearby stream with a catchment area of similar type and size. The calculations were checked by several control measurements and were judged to be adequately reliable.

It is very important to check the minimum capacity of any prospective water source before taking the project any further.

The annual average rate of flow at the proposed extraction profile was estimated to be 0.35 m^3/s on the basis of an average run-off of 6.7 litres per second per km^2 from the catchment area upstream. Large seasonal fluctuations in flow are anticipated, with maximum values as high as tens of m^3/s and an estimated minimum flow in late summer of only 0.01 m^3/s. This minimum flow is slightly below the required amount for consumption but since the deficiency was small and expected to be infrequent, it was not considered important.

The water was found to be aesthetically acceptable, with pH slightly on the alkaline side of neutrality. The dissolved oxygen level was about at saturation and there was a complete absence of free carbon dioxide. This indicates a non-aggressive water. Since no nitrates or phosphates were found, it could be assumed that the water was not polluted. The water hardness was also found to be very low, although the ferrous form of the iron content could be troublesome to white laundry. In general, the water was of high quality and suitable for drinking.

Water Supply System

On the basis of the site investigation it was decided that the surface water from the Ogoska River could be collected by means of a riverbank intake structure situated on the left bank of the river about 1.8 km upstream of the community.

The water will be transported through a pipe 125 mm in diameter and 276 m long to a treatment plant with a horizontal settling tank, slow sand filters and disinfection facilities. The treated water will be pumped from the filter station to a 250 m^3 capacity tank situated above the community.

Basic hydraulic calculations are given in Fig. 51 and longitudinal profiles in Fig. 52.

All elements of the system have been designed for the final anticipated water requirement of 34.13 m^3/h except for the pumps in the filtration plant. These will have an initial installed capacity of 18.33 m^3/h but can simply be upgraded at a later date. Treatment plant loadings are shown in Table 13.

During the early years of operation only two of the three slow sand filters will be needed, so the third can be used to store sand.

The raw water flow will be measured by a meter installed on the inlet pipe at the filter station, while the meter for treated water will be in the valve house of the water tank.

The treatment plant will be supplied with power from a transformer serving the community through an overhead pole line 2.5 km long. The installed capacity will be 78 kW while the calculated power demand will be 28 kW. This will be provided through a 50 kVA, 10/0.4 kV pole-type transformer located near the treatment plant.

The operation of the pumping station will be regulated automatically by the water levels in the water tank. The signals will be transmitted from the tank to the pumping station by a ground cable line.

The treatment plant will be run by an operator who will make a routine check of the chlorine dosing and sample the water every day.

Table 13. Treatment plant loadings

Characteristics (maximum quantity/day)	First stage ($18.33\ m^3/h = 440\ m^3/d$)	Final stage ($34.13\ m^3/h = 819\ m^3/d$)
Sedimentation tank (see Fig. 21 and 22)		
width at the bottom	1.40 m	1.40 m
width at the water level	4.80 m	4.60 m
average width	3.10 m	3.00 m
length	20 m	20 m
depth of water	1.70 m	1.60 m
settling area	62 m^2	60 m^2
cross-sectional area	5.27 m^2	4.8 m^2
volume of water	105.4 m^3	96 m^3
retention time	5.75 h	2.81 h
horizontal velocity	3.48 m/h = 0.97 mm/s	7.11 m/h = 1.98 mm/s
surface loading	0.30 m/h = 0.08 mm/s	0.57 m/h = 0.16 mm/s
(width of tank) : (length of tank)	1 : 6.45	1 : 6.67
(depth of water) : (length of tank)	1 : 11.8	1 : 12.50
Slow sand filters (see Fig. 23)		
filter bed length	24.60 m	24.60 m
number of units in operation	2	3
filtration area	177.12 m^2	265.68 m^2
filtration velocity	2.48 m/d = 0.103 m/h	3.08 m/d = 0.128 m/h

As the demand increases, the single 250 m^3-capacity water tank will be supplemented by a second tank and the valve house and pipework arrangements will be adapted accordingly.

The distribution system is designed to include standpipes, fire hydrants and house connections. At first, only the school, health centre and local administration building will have such connections.

Technical Specifications

Intake structure and raw water feeding pipeline

A non-standard river intake structure, including an inlet bar screen and a pipe strainer 125 mm in diameter, river-stone bedding and 120 m of protective wire-mesh fence, will be required, along with a raw water feeding pipeline of PVC, 125 mm in diameter and 267 m long, for the nominal pressure of 1.0 MPa. See Fig. 51–54.

Water treatment plant

The plant must have: a standard sedimentation tank for a capacity range of 5.1–9.5 litres per second, with a settling compartment 20 m long and a water depth of 1.7 m, and a standard slow sand filtration plant with a capacity of 5.1 litres per second. Three filter units should be constructed and, of those, one should be kept in reserve. The filter bed should be 24.6 m long.

The following filter plant pumping machinery and electrical equipment will be needed:

- 2 horizontal self-priming pumps with a capacity of 5.1 litres per second and total delivery head of 43 m;
- 1 set of standard sodium hypochlorite dosing equipment;
- 1 set of standard sodium carbonate dosing equipment;
- 1 standard domestic water supply booster station;
- 1 standard switchboard for the operation and control of the machinery mentioned above;
- 1 set of standard lighting equipment, including light fittings, switches, socket outlets and cable installation;
- 1 pole-type transformer of 50 kVa, 10/0.4 kV;
- 2500 m of overhead high-tension feeding line; and
- 2000 m of control and signalling ground-cable line between the plant and the water tank.

The pumps can be operated manually from the local switchboard, or automatically by the levels in the water tank.

The electrode switch-off level will be at 578.95 m above sea level, and the switch-on level will be at 578.00 m above sea level, while the shut-off electrode in the wet sump will be set at 547.9 m above sea level. See Fig. 55–57 and the standard designs in Fig. 21–27 and 41.

Pumping main

A 100 mm-diameter PVC pipeline, 2242 m long, for nominal pressure of 1.0 MPA, and including standard ancillary chambers (one air chamber and two drain valve chambers), will be necessary for the pumping main. See Fig. 51–53 and 58, and the standard designs in Fig. 18, 19 and 42.

Water tank

A standard water tank with a capacity of 250 m^3 and Type I base slab is required, with a maximum water level at 579.0 m above sea level and the bottom level at 575.0 m above sea level. See Fig. 59 and the standard designs in Fig. 31.

Valve house

A standard valve house for two water tanks, with Type II piping, for tanks located in front of the distribution area is required. Drain-pipe and fencing are also needed. See Fig. 59 and the standard designs in Fig. 34, 37, 41 and 42.

Distribution network

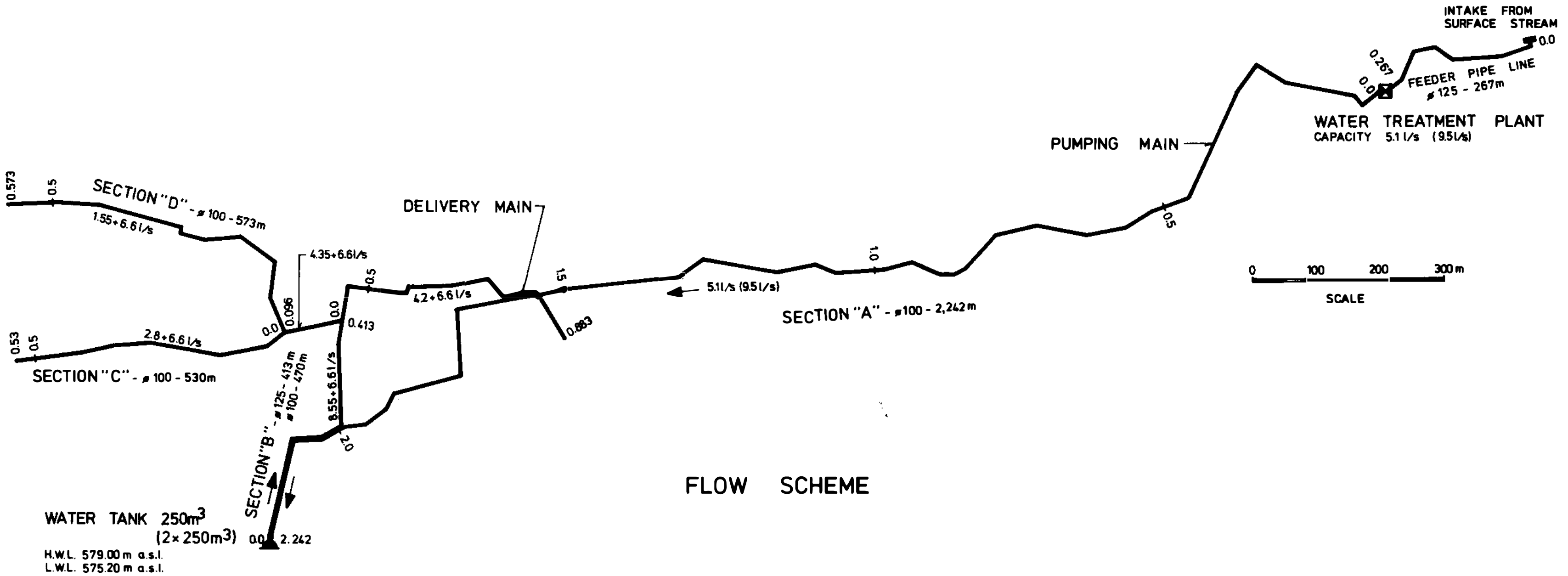
Necessary equipment includes PVC piping, cast-iron fittings and adapting pipes and isolating valves with valve boxes for control from the ground. There should also be fire hydrants and water standpipes for a nominal pressure of 1.0 MPa.

The following equipment is required:

- 413 m of pipe 125 mm in diameter
- 1752 m of pipe 100 mm in diameter
- 23 fire hydrants
- 13 water standpipes
- 3 house connections.

See Fig. 51–53 and 58, and the standard designs in Fig. 39 and 42.

Fig. 51 The flow scheme and some basic hydraulic calculations



max Qd l/s	max Qh l/s	SECTION	maxQh/2 l/s	FLOW TOTAL max Qh/2 l/s	Qf l/s	TOTAL Q= Qh/2+Qf l/s	LENGTH L m	ø PVC k=0.01 mm	J %	v m/s	PRESS. LOSS J×L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
9.5	9.5×1.8 = 17.10	B	4.20	8.55 4.20	6.6 6.6	15.15 10.80	413 470	125 100	1.1274 1.9595	1.25 1.45	4.66 9.21	575.20 - 4.66= 570.54 570.54 - 9.21= 561.33
		C	2.80	4.35 2.80	6.6 6.6	10.95 9.40	96 434	100 100	2.0092 1.5225	1.47 1.26	1.93 6.61	570.54 - 1.93= 568.61 568.61 - 6.61= 562.00
		D	1.55	1.55	6.6	8.15	573	100	1.1759	1.09	6.74	568.61- 6.74= 561.87

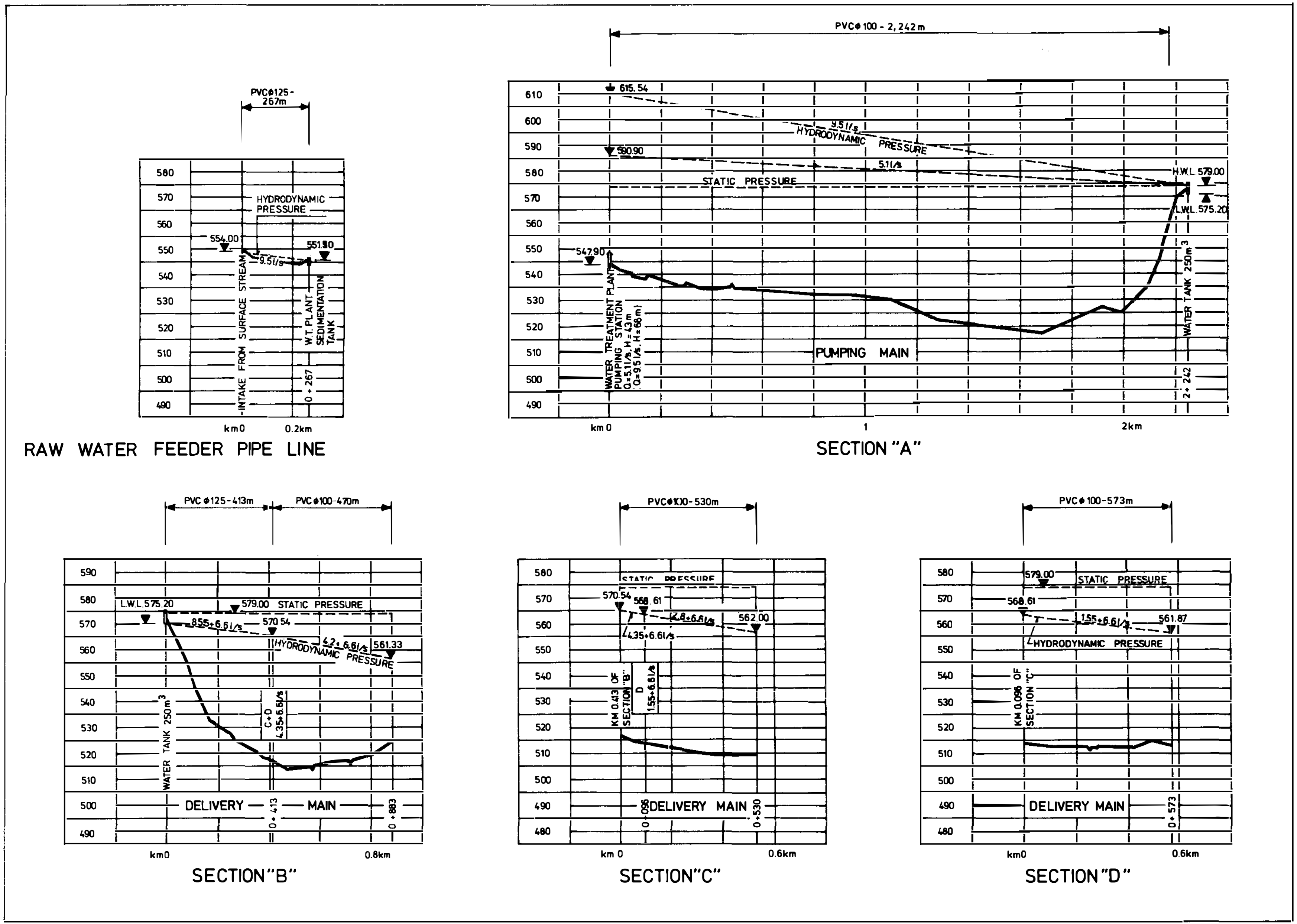
DELIVERY MAIN

maxQd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES C	ø PVC k=0.01 mm	J %	v m/s	PRESS. LOSSES C×J×L m	TOTAL HEAD m
9.5	2,242	1.05	100	1.5523	1.27	36.54	579.00 -547.90 + 36.54= =67.64
5.1	2,242	1.05	100	0.5056	0.67	11.90	579.00 - 547.90 + 11.90= =43.00

PUMPING MAIN

HYDRAULIC CALCULATIONS

Fig. 52. Longitudinal profiles



RAW WATER FEEDER PIPE LINE

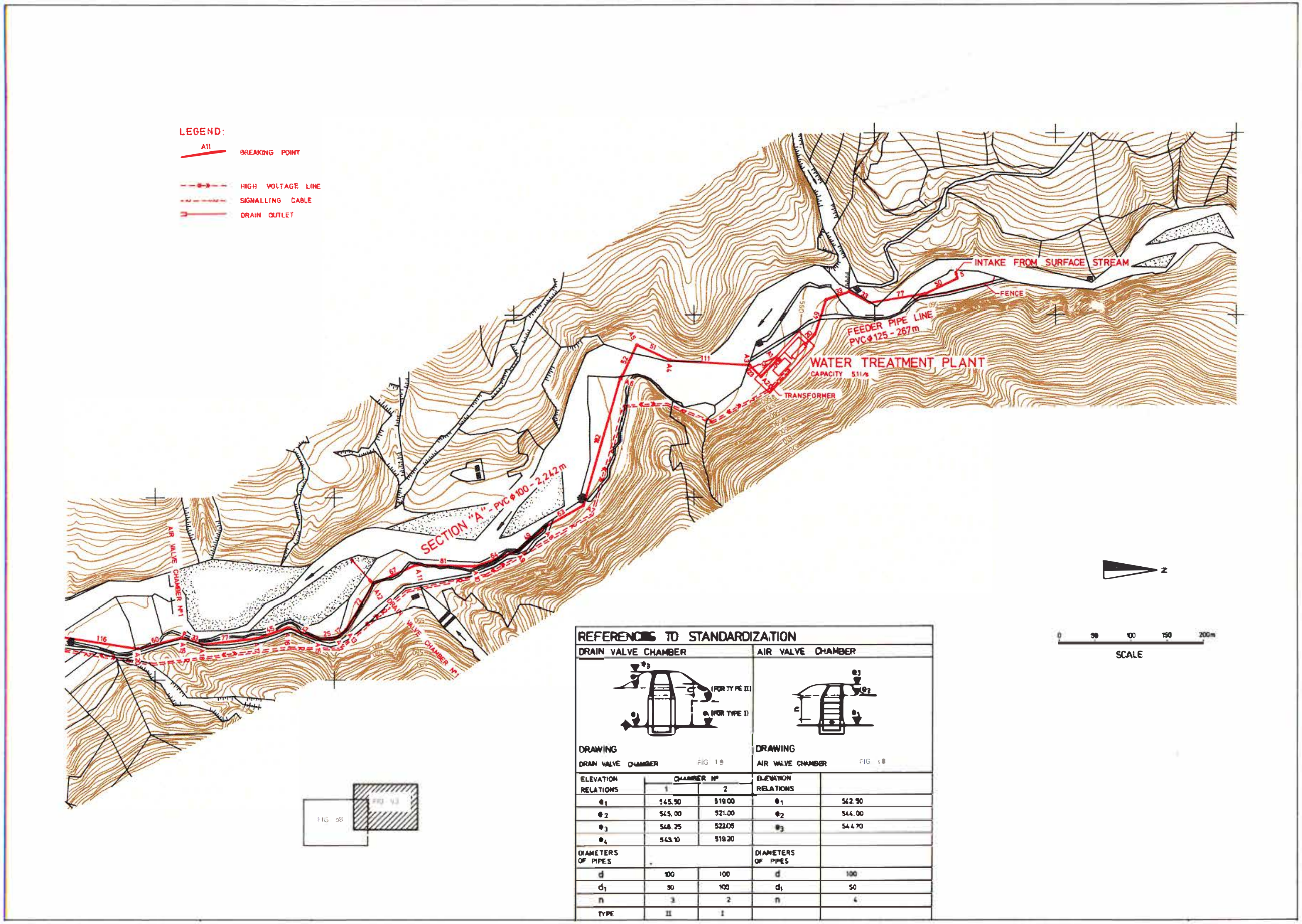
SECTION "A"

SECTION "B"

SECTION "C"

SECTION "D"

Fig. 53. Layout of the pumping main



REFERENCES TO STANDARDIZATION

DRAIN VALVE CHAMBER			AIR VALVE CHAMBER	
DRAWING DRAIN VALVE CHAMBER	FIG. 19		DRAWING AIR VALVE CHAMBER	FIG. 18
ELEVATION RELATIONS	CHAMBER Nº		ELEVATION RELATIONS	
	1	2		
e₁	545.50	519.00	e₁	542.50
e₂	545.00	521.00	e₂	544.00
e₃	548.25	522.05	e₃	544.70
e₄	543.10	519.20		
DIAMETERS OF PIPES			DIAMETERS OF PIPES	
d	100	100	d	100
d₁	50	100	d₁	50
n	3	2	n	4
TYPE	II	I		

Fig. 54. Layout of the intake structure

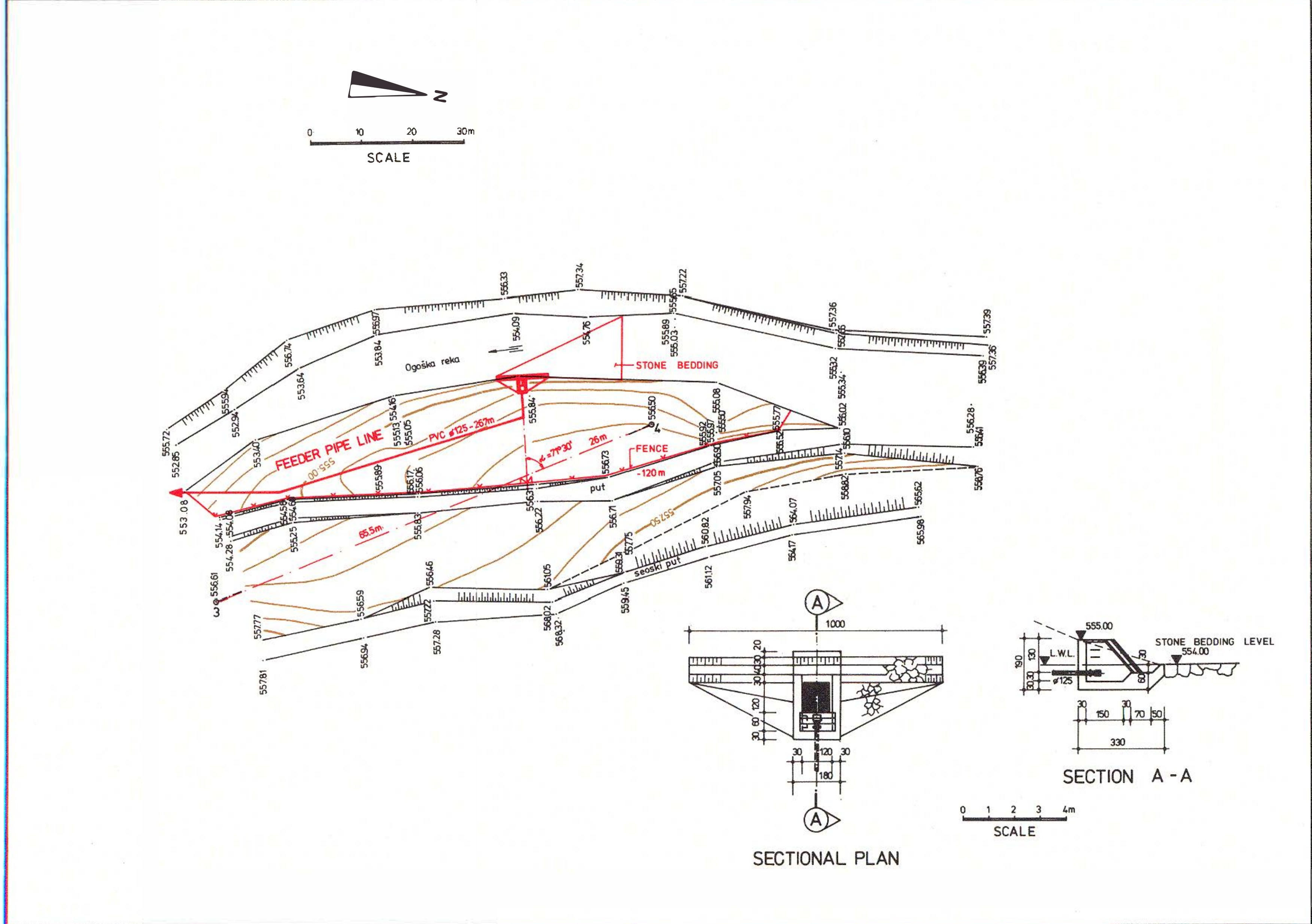


Fig. 55. Layout of the water treatment plant

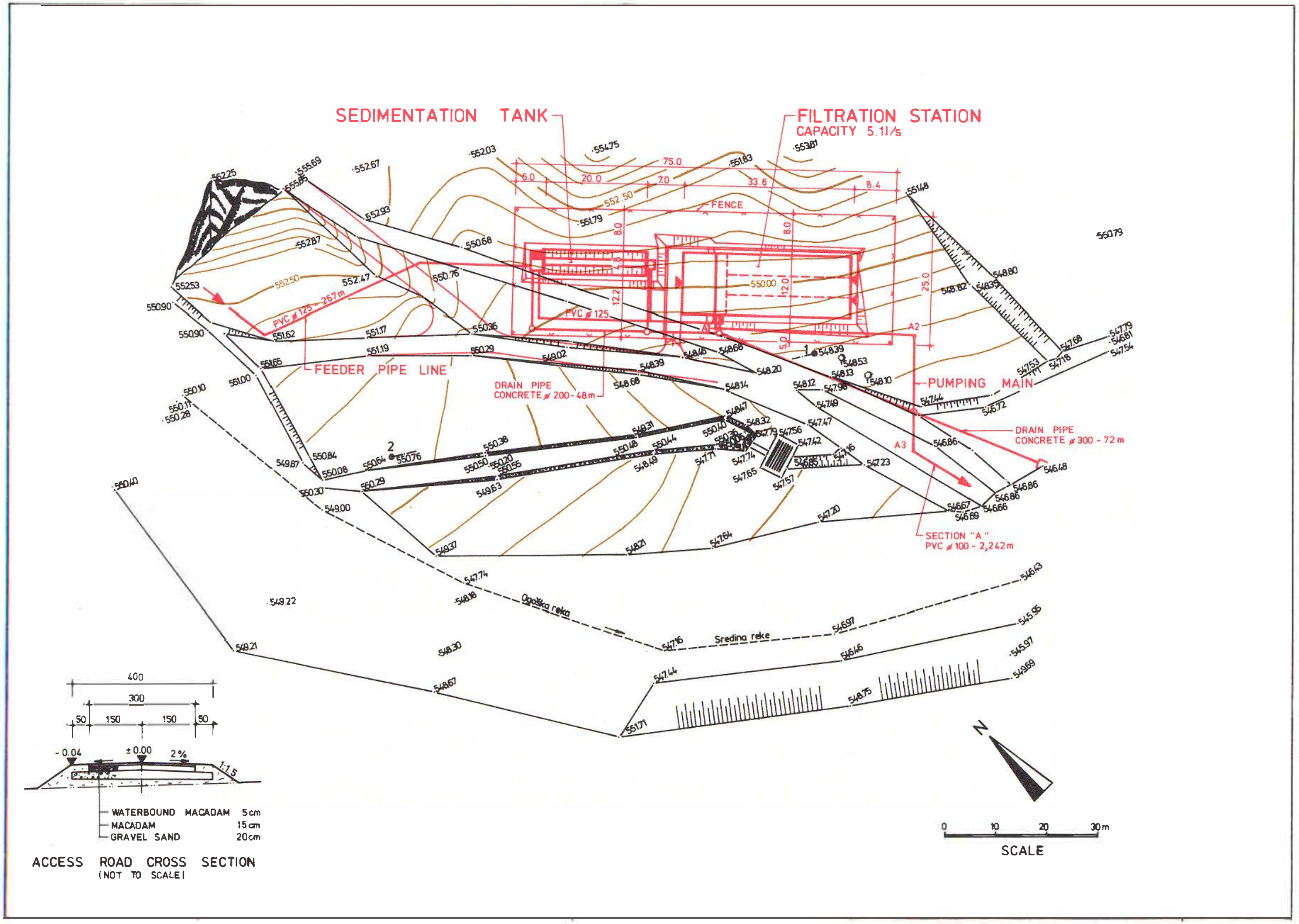
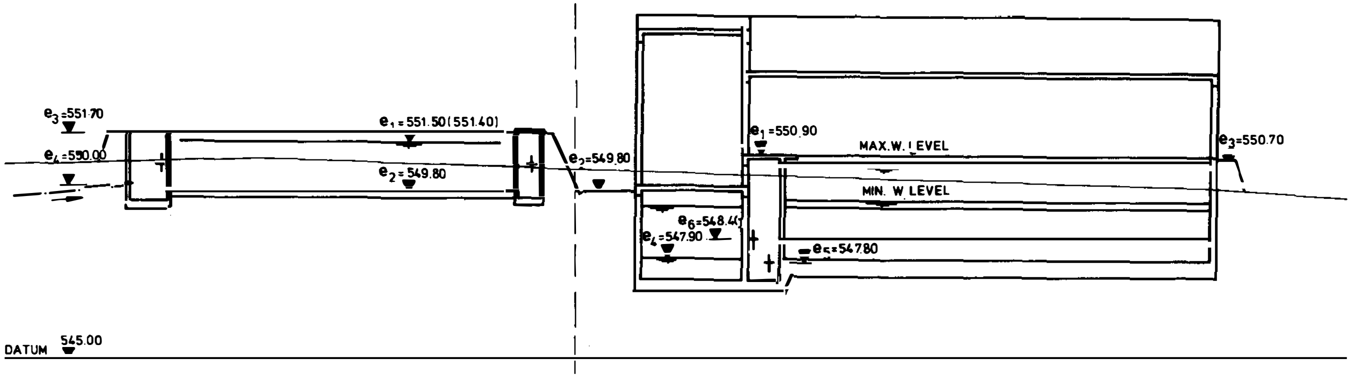


Fig. 56. Water treatment plant, with reference to standard designs

SEDIMENTATION TANK | **FILTRATION STATION**

ELEVATION RELATIONS



DRAWINGS

SEDIMENTATION TANK	FIG 21 AND 22

FILTRATION STATION - CIVIL CONSTRUCTION	FIG 23
FILTRATION STATION - VIEWS	FIG 24
FILTRATION STATION - MACHINERY	FIG 25
FILTRATION STATION - ELECTRICAL EQUIPMENT	FIG 26 AND 27

DIAMETERS OF PIPES

INLET	ød1 = 125 mm
OUTLET (BYPASS)	ød2 = 125 mm
OVERFLOW	ød3 = 150 mm
DRAIN PIPE	ød4 = 80 mm

RAW WATER INLET	ød1 =125mm
PUMPING MAIN	ød2 =100 mm

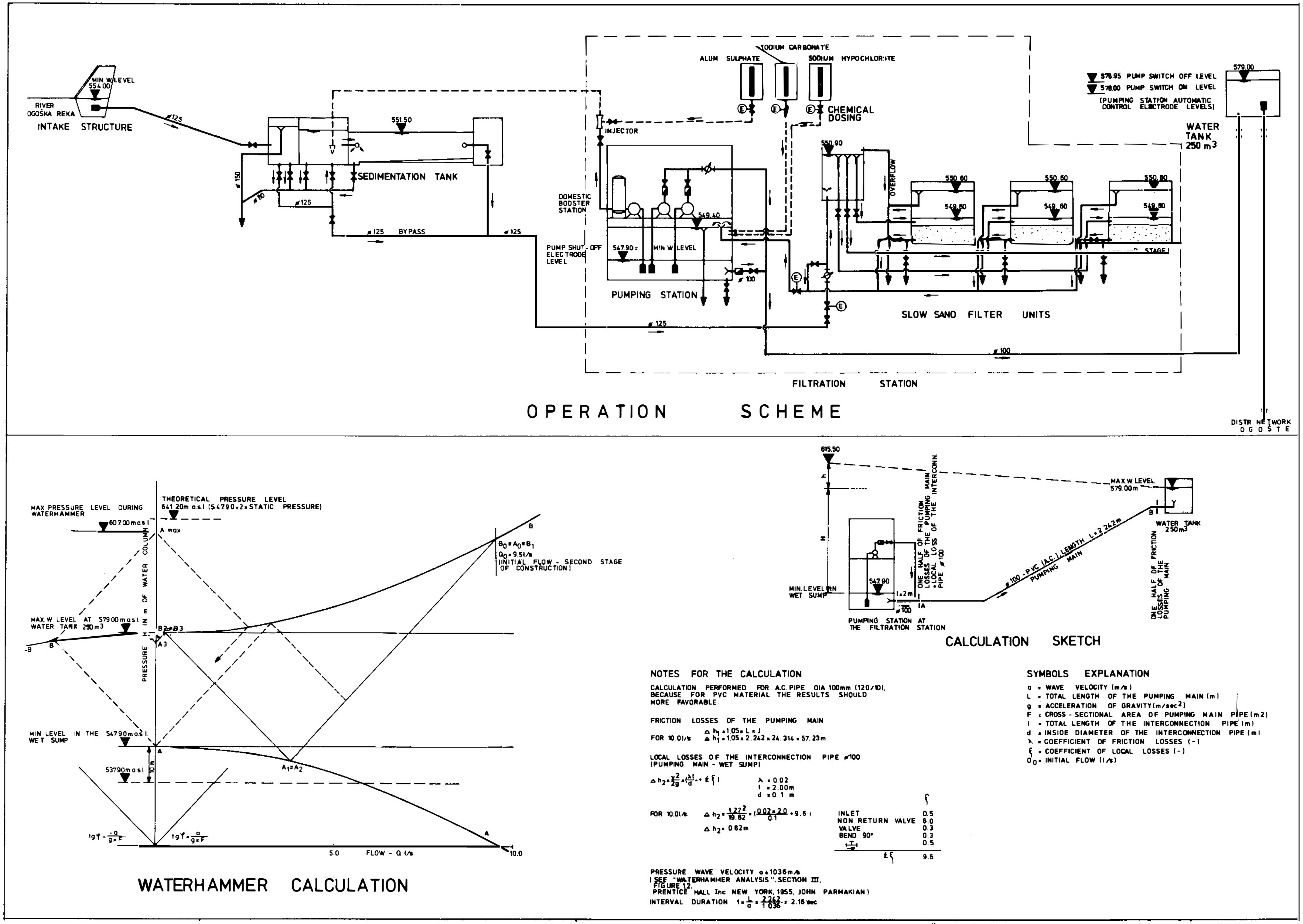
CONNECTION OF PRESSURE VESSEL TO PUMPING MAIN ød3 DELETED, BECAUSE OF OTHER SYSTEM OF THE PROTECTION AGAINST WATERHAMMER IS USED (SEE FIG 57)

BASIC DIMENSIONS

GROUND WIDTHS	b1 = 200 cm b2 = 540cm
DEPTH OF WATER	h = 170cm (160cm IN THE SECOND STAGE)
LENGTH	L = 200 m

FILTER BED LENGTH	L1 = 24.6 m
TOTAL LENGTH OF FILTRATION STATION	L2= 33.6 m
FILTER GALLERY LENGTH	L3= 27.0 m
NUMBER OF SECTIONS	n = 6

Fig. 57. Operation scheme and water hammer calculation



NOTES FOR THE CALCULATION

CALCULATION PERFORMED FOR A.C. PIPE DIA 100mm (120/10), BECAUSE FOR PVC MATERIAL THE RESULTS SHOULD MORE FAVORABLE.

FRICTION LOSSES OF THE PUMPING MAIN

$\Delta h_1 = 1.05 \times L \times J$

FOR 10.0 l/s $\Delta h_1 = 1.05 \times 2.242 \times 24.314 = 57.23$ m

LOCAL LOSSES OF THE INTERCONNECTION PIPE ø100
(PUMPING MAIN - WET SUMP)

$\Delta h_2 = \frac{v^2}{2g} \times \left(\frac{\lambda l}{d} + \Sigma \xi\right)$

$\lambda = 0.02$
$l = 2.00$ m
$d = 0.1$ m

FOR 10.0 l/s $\Delta h_2 = \frac{1.27^2}{19.62} \times \left(\frac{0.02 \times 2.0}{0.1} + 9.6\right)$

$\Delta h_2 = 0.82$ m

	ξ
INLET	0.5
NON RETURN VALVE	8.0
VALVE	0.3
BEND 90°	0.3
⊥	0.5
$\Sigma \xi$	9.6

PRESSURE WAVE VELOCITY a = 1036 m/s
(SEE "WATERHAMMER ANALYSIS", SECTION III, FIGURE 1.2.
PRENTICE HALL Inc. NEW YORK, 1955, JOHN PARMAKIAN)

INTERVAL DURATION $t = \frac{L}{a} = \frac{2\,262}{1\,036} = 2.16$ sec

SYMBOLS EXPLANATION

a = WAVE VELOCITY (m/s)
L = TOTAL LENGTH OF THE PUMPING MAIN (m)
g = ACCELERATION OF GRAVITY (m/sec^2)
F = CROSS - SECTIONAL AREA OF PUMPING MAIN PIPE (m2)
l = TOTAL LENGTH OF THE INTERCONNECTION PIPE (m)
d = INSIDE DIAMETER OF THE INTERCONNECTION PIPE (m)
λ = COEFFICIENT OF FRICTION LOSSES (-)
ξ = COEFFICIENT OF LOCAL LOSSES (-)
Q_0 = INITIAL FLOW (l/s)

Fig. 58. Layout of the distribution system

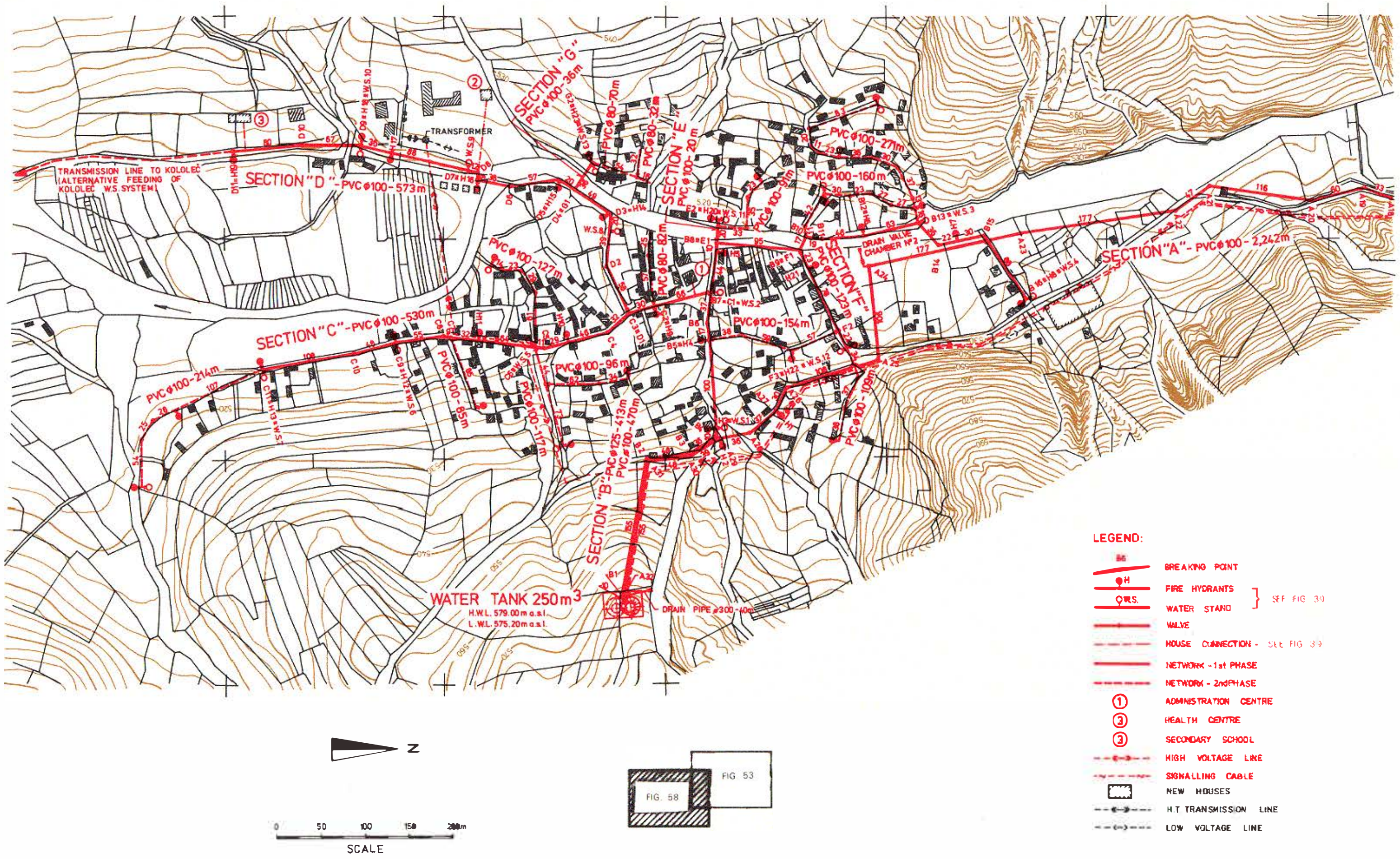
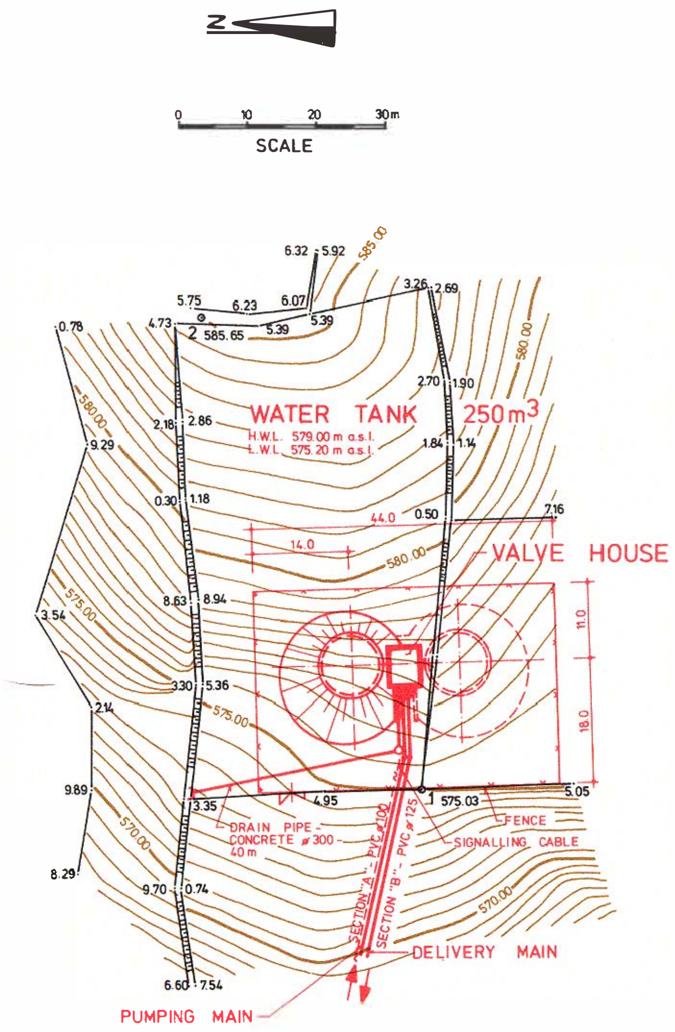
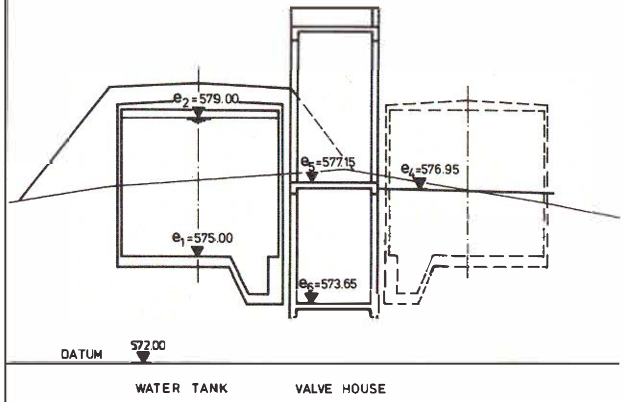


Fig. 59. Layout of the 250 m³ water tank



REFERENCES TO STANDARDIZATION

ELEVATION RELATIONS



DRAWINGS

WATER TANK 250m³ (TYPE I. OF BASE SLAB SUPPOSED)	FIG. 31
VALVE HOUSE FOR TWO WATER TANKS - CIVIL CONSTRUCTION (WASTE CHANNEL ARRANGEMENT TYPE b)	FIG. 34
VALVE HOUSE FOR TWO WATER TANKS - PIPING TYPE II. (IN THE FIRST STAGE INLET AND OUTLET PIPES SHALL BE INTERCONNECTED INSIDE VALVE HOUSE ACCORDING TO THE PIPING TYPE II. FOR ONE TANK SEE FIG. 35)	FIG. 37

DIAMETERS OF PIPES

INLET	ød_1 = ød_1'	= 100mm
OUTLET	ød_2 = ød_2'	= 125mm
DRAIN PIPE	ød_3	= 100mm
OVERFLOW	ød_4	= 100mm
AIR PIPE	ød_5	= 60mm
WASTE PIPE	ød_6	= 300mm

Ratkovac

Basic Data

The rural community of Ratkovac is located about 5 km in a direct line from the commune centre of Orahovac, although the distance is three times longer by road. It can be reached throughout the year by an asphalt road.

Ratkovac stands on the eastern side of the Beli Drim River. Part of the community is built on a plain and part on the lower slopes of neighbouring hills.

The population of Ratkovac at the time of the 1971 census was found to be 2076. This number was expected to rise to 2800 by 1980 and to 3600 by 1990.

In accordance with the design criteria, a per capita water consumption of 260 litres per day was adopted for design purposes. This resulted in the following daily water requirements.

Total		90% (reduced for design)	
m^3/day	litres/second	m^3/day	litres/second
936	10.8	842	9.7

Water Resources

A regional water supply system is proposed as part of a master plan for water supply for the whole subregion of Metohija towards the end of the century. When the plan is realized, Ratkovac should be able to tap one of the delivery mains that will pass near the community. In the mean time, an alternative source will have to be developed, but the system should be designed so that it can be modified to accept the new source as easily as possible.

The studies and hydrological investigations performed indicated that the alluvium on the left bank of the Beli Drim offered the only feasible interim solution. After Ratkovac is connected to the regional water supply system, the bored well could be retained as a stand-by supply during maintenance or breakdown of the regional system.

The total thickness of the alluvium in the area close to Ratkovac was found to be from 2.5 m to 7 m, with the depth of gravel/sand aquifer varying from 1.1 m to 3.4 m and a 1.4–4.7 m layer of impermeable or slightly permeable material on top.

The spot selected for the extraction borehole had the following characteristics.

0–2.4 m: impermeable/semi-permeable top layer of loam

2.4–5.4 m: gravel/sand aquifer layer

5.4–7.4 m: impermeable clayey loam

The natural groundwater table was found 2.5 m below the ground level. Pumping tests proved that with a draw-down of 1 m a yield of 5.5 litres per second was possible and this could be increased to 8.0 litres per second corresponding to a draw-down of 1.5 m.

One borehole will therefore be sufficient to satisfy water requirements during the early years of development. Should the development of the regional supply system be delayed for any reason, a second well can be bored about 100 m from the first to meet increasing needs.

The extraction well will be the same well that was used for the hydrogeological investigations, bored to the bottom of the water-bearing strata.

Water was taken from the well during pumping tests after a steady condition had been reached. Physical and chemical analysis showed that it was free from iron and manganese and had a neutral pH and no aggressive characteristics. The water was of temporary and moderate hardness and therefore no scaling problem was expected. The water was considered to be of very good quality and suitable for drinking.

Water Supply System

Because of the relative elevation of the bored well and the area of consumption, it will be necessary to pump the water from the well to a service tank in front of the distribution area.

Basic hydraulic calculations to determine the pumping delivery head are presented in Fig. 60 and longitudinal profiles of the pumping main in Fig. 61.

The proposed water tank has a capacity of 250 m^3. This represents 56% of the maximum daily demand. Since the pumping station is to be temporary, it was not considered worthwhile to provide automatic control of the pumps. Instead, someone can operate them manually each day on a schedule based on experience gained during the early period of operation. If the wellfield is extended at a later stage as water demand increases, automatic control equipment should be installed when the pump sets are upgraded, and a ground cable should be laid between the pumping station and the water tank.

There will be a protection zone of 100 m radius around the well. The well should also be fenced in, with a secured access gate. An existing country road will have to be diverted to avoid the protection zone, as shown in Fig. 62.

The construction of the bored well is the same as described for Mamuša, on p. 92.

A standard pumping station will be located adjacent to the well and will include pumping units, an air release device and chlorine dosing equipment. No aeration is considered necessary because a dissolved oxygen level of 6–7 mg/l was found in the raw water.

The water will be delivered from the pumping station to the service tank by a pipe 150 mm in diameter. This is large enough for both the future water demand and the connection to the regional water supply system. The diameter also provides water hammer protection because of the low velocity of the pumping main.

The water tank of 250 m^3 capacity will have a valve house. It is anticipated that another tank of 400 m^3 capacity will be needed before the turn of the century. Pipework to serve both tanks would then be installed.

The amount of water delivered to the area of consumption will be measured by a meter located in a standard chamber on the gravity supply main from the tank and before the area of consumption.

Fire hydrants will be installed on the distribution network and used for air release and sludge removal. Standpipes will supply water to the community. They will be located at suitable points on the distribution network, along with individual connections to the school, health centre and local administration building. As demand develops, house connections can be provided.

The pumping station will be supplied with power from a 10 kV high-voltage overhead line passing about 800 m east of the proposed wellfield via a 30 kVA, 10/0.4 kV pole transformer located at the pumping station. The transformer will have to be replaced by one of larger capacity when the pumping station is upgraded. At first, the installed capacity will be 35 kW while the calculated power demand will be about 16 kW.

Technical Specifications

Bored deep well

A standard bored deep well, 7 m deep, with a screen diameter of 300 mm and a suction pipe diameter of 100 mm, is required. See Fig. 62–65 and the standard designs in Fig. 47.

Pumping station

A standard Type 1.1 pumping station, without a wet sump, is required, containing the following machinery and electrical equipment:

- 2 horizontal pumps with a capacity of 5.2 litres per second and total delivery head of 67 m;
- 1 set of standard air release equipment;
- 1 set of standard sodium hypochlorite dosing equipment;
- 1 standard switchboard;
- 1 set of standard lighting equipment, including light fittings, switches, socket outlets and cable installation;
- 1 pole-type transformer of 30 kVA, 10/0.4 kV; and
- 780 m of overhead high-tension feeding line.

The pumps will be operated manually from the local switchboard, according to the time schedule of pumping. The shut-off electrode in the well will be located at 327.50 m above sea level. See Fig. 62, 65 and 66 and the standard designs in Fig. 9, 11, 12 and 41.

Pumping main

The pumping main will require a 150 mm-diameter PVC pipeline 1245 m long, for a nominal pressure of 1.0 MPa. A typical protection sleeve and an arrangement of isolating valves at the site of a railway crossing will be included. See Fig. 60, 61, 63 and 67 and the standard designs in Fig. 42.

Water tank

A standard water tank with a capacity of 250 m^3 and Type II base slab is required, with a maximum water level at 393.0 m above sea level, and a bottom level at 389.0 m above sea level. See Fig. 68 and the standard designs in Fig. 31.

Valve house

A standard valve house for two water tanks with a Type II piping arrangement is required for the tanks located in front of the distribution area. A drain-pipe, access road and fencing will be included. See Fig. 68 and the standard designs in Fig. 34, 35, 37, 38, 41 and 42.

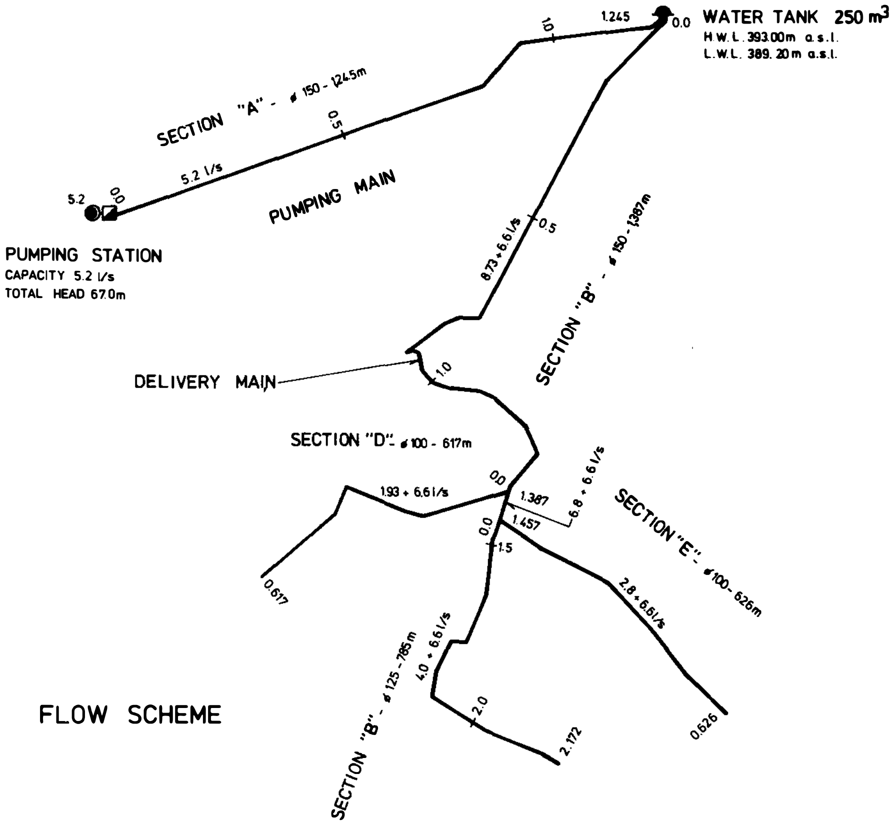
Distribution network

Piping of PVC with cast-iron fittings and adapting pipes, isolating valves with valve boxes for control from the ground and fire hydrants and water standpipes constructed for a nominal pressure of 1.0 MPa will be installed. The following equipment is required:

- 477 m of 150 mm-diameter pipe
- 785 m of 125 mm-diameter pipe
- 1757 m of 100 mm-diameter pipe
- 30 fire hydrants
- 15 water standpipes
- 1 standard water-meter chamber.

See Fig. 60, 61, 63 and 64 and the standard designs in Fig. 20, 39 and 42.

Fig. 60. The flow scheme and some basic hydraulic calculations



max Qd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES C	ø PVC k=0.01 mm	J %	v m/s	PRESS. LOSSES C x J x L	TOTAL HEAD m
5.2	1245	1.05	ø150	0.0871	0.33	1.14	393.00 - 327.50 + 1.14 = = 66.64

PUMPING MAIN

max Qd l/s	max Qh l/s	SECTION	max Qh/2 l/s	FLOW TOTAL max Qh/2 l/s	Qf l/s	TOTAL Q=Qh/2 + Qf l/s	LENGTH L m	ø PVC k=0.01 mm	J %	v m/s	PRESS. LOSS J x L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
9.7	9.7 x 1.8= = 17.46	B	4.00	8.73	6.6	15.33	1387	150	0.6044	0.97	8.38	389.20-8.38=380.82
				6.80	6.6	13.40	70	125	0.9021	1.10	0.63	380.82-0.63=380.19
				4.00	6.6	10.60	715	125	0.5904	0.88	4.22	380.19-4.22=375.97
		D	1.93	1.93	6.6	8.53	617	100	1.2686	1.14	7.83	380.82-7.83=372.99
		E	2.80	2.80	6.6	9.40	626	100	1.5225	1.26	9.53	380.19-9.53=370.66

DELIVERY MAIN

HYDRAULIC CALCULATIONS

Fig. 61. Longitudinal profiles

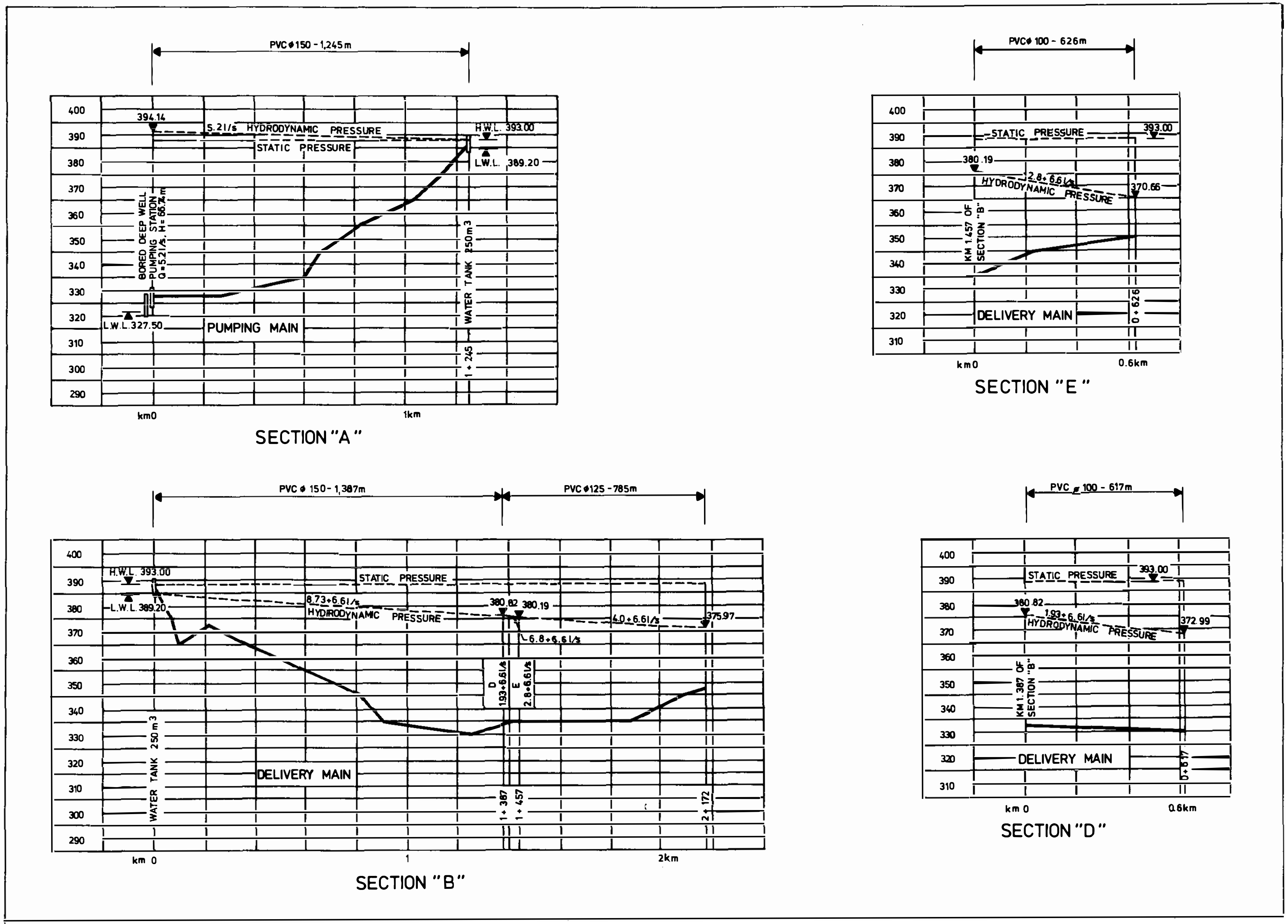


Fig. 62. The wellfield area

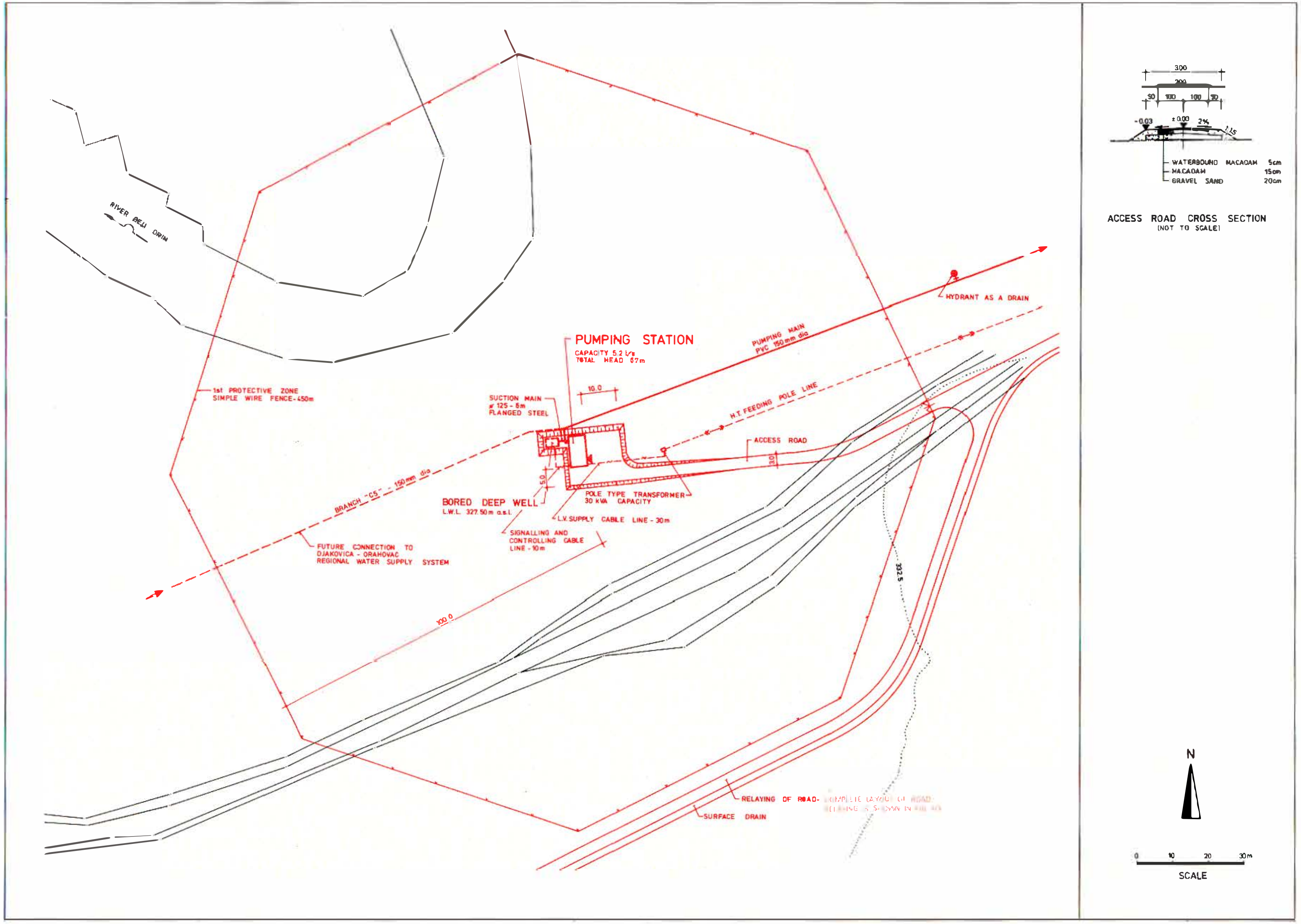
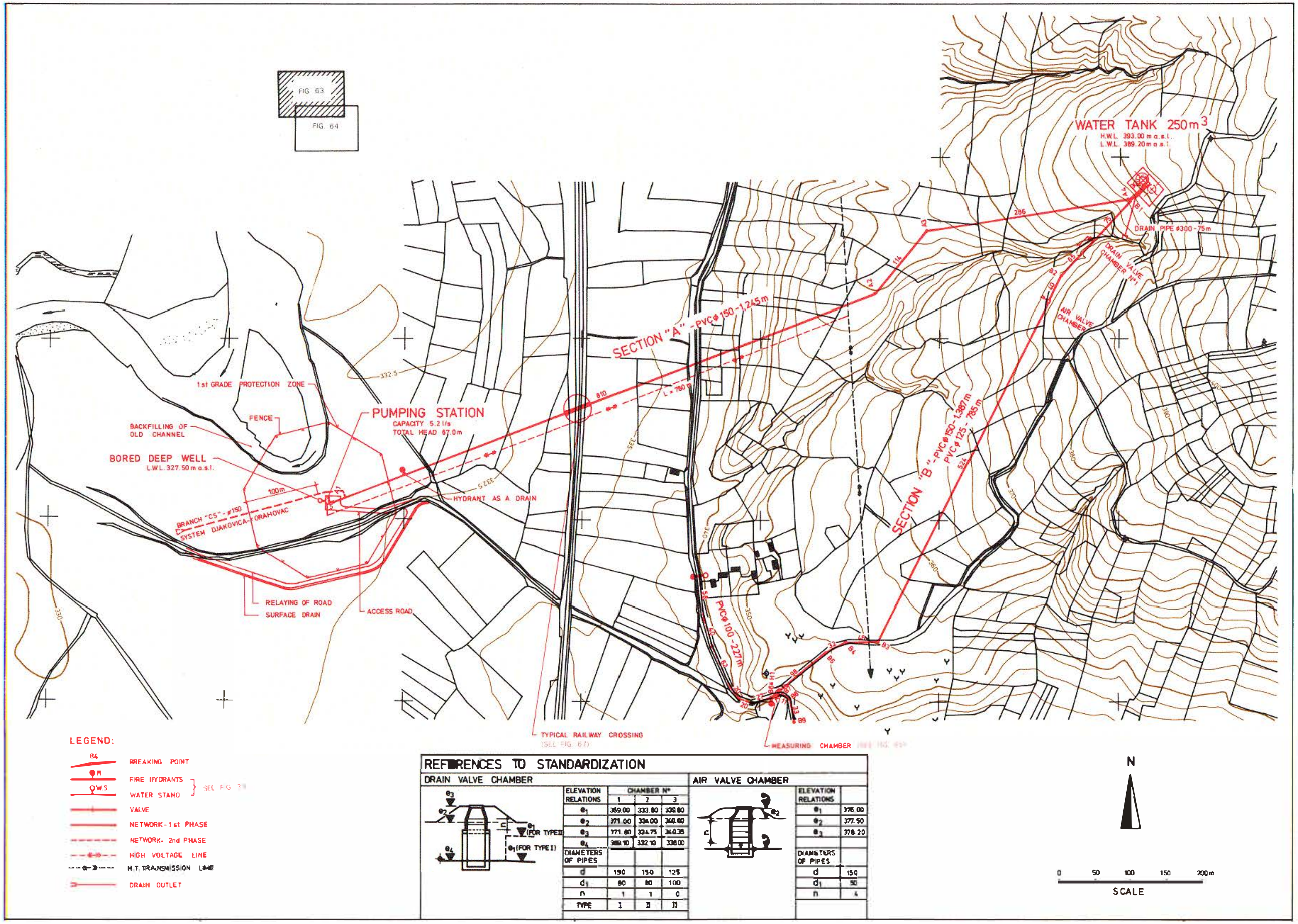


Fig. 63. Layout of the pumping main



REFERENCES TO STANDARDIZATION

DRAIN VALVE CHAMBER

ELEVATION RELATIONS	CHAMBER N°		
	1	2	3
e1	369.00	333.80	339.80
e2	371.00	334.00	340.00
e3	371.60	334.75	340.35
e4	369.10	332.10	338.00
DIAMETERS OF PIPES			
d	190	150	125
d1	80	80	100
n	1	1	0
TYPE	I	II	II

AIR VALVE CHAMBER

ELEVATION RELATIONS	
e1	376.00
e2	377.50
e3	378.20
DIAMETERS OF PIPES	
d	150
d1	50
n	4

Fig. 64. Layout of the distribution system

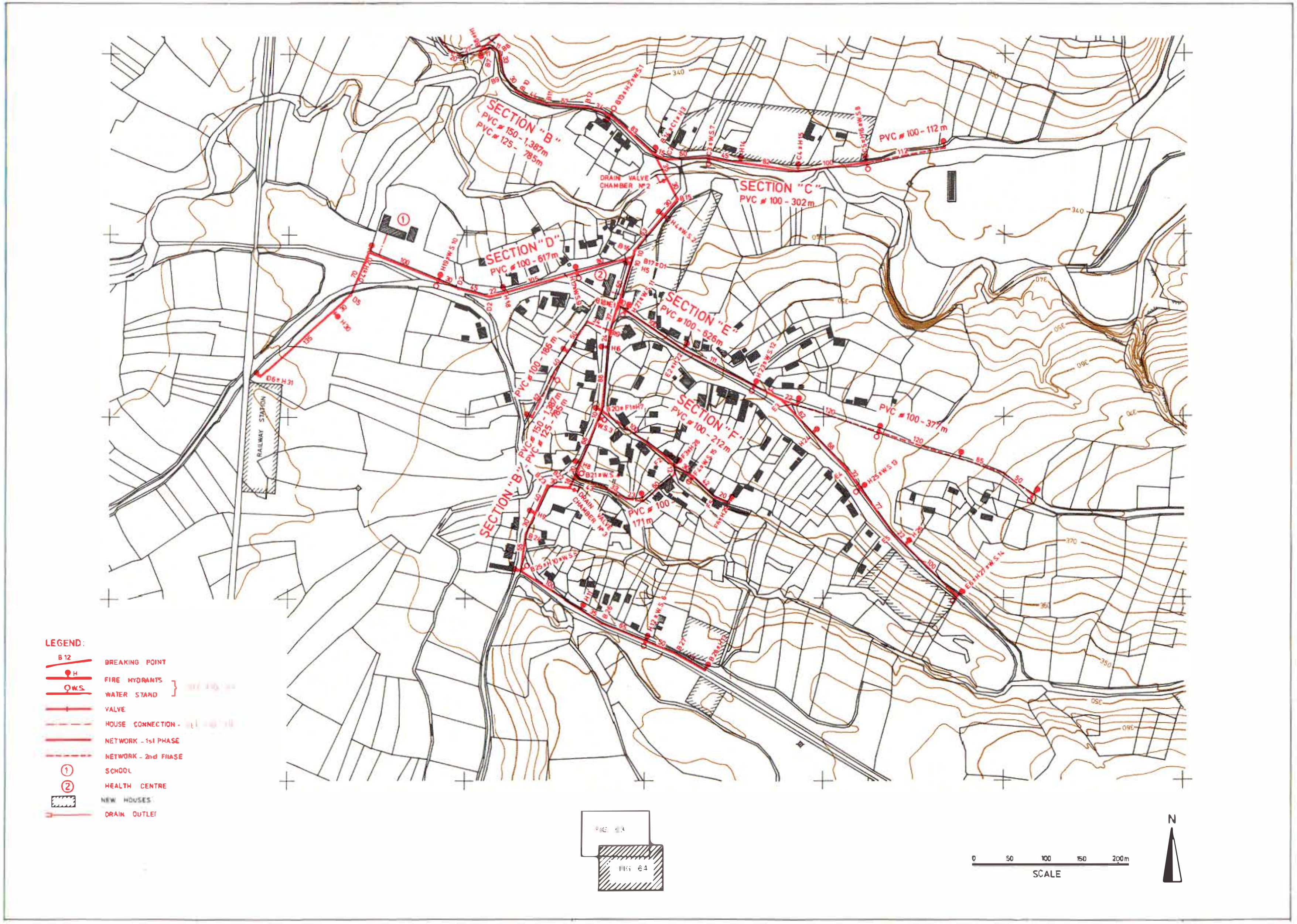
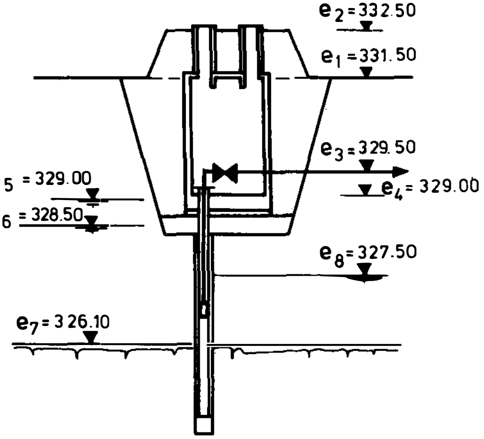


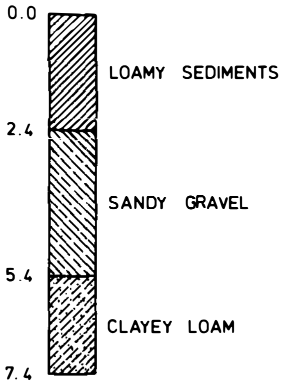
Fig. 65. Bored deep well, pumping station and measuring chamber

BORED DEEP WELL

ELEVATION RELATIONS



TRIAL BORE HOLE OBR - 1



NOTE: ELEVATION e_1 TAKEN OVER FROM ORIGINAL MAP

DRAWING

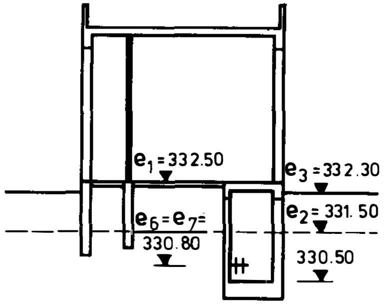
BORED DEEP WELL	FIG. 7

DIAMETERS OF PIPES

SUCTION PIPE	ϕd_1 = 100mm
SCREEN	D = 300mm
FILTRATION FILL	d = 100mm

PUMPING STATION

ELEVATION RELATIONS



NOTE: ELEVATION e_2 TAKEN OVER FROM ORIGINAL MAP

DRAWINGS

PUMPING STATION - CIVIL CONSTRUCTION(TYPE 1.1)	FIG. 9
PUMPING STATION - MACHINERY	FIG. 11
PUMPING STATION - ELECTRICAL EQUIPMENT	FIG. 12

DIAMETERS OF PIPES

SUCTION PIPE	ϕd_1 = 100mm
PUMPING MAIN	ϕd_2 = 150mm

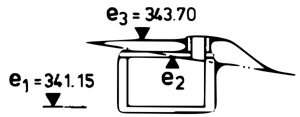
MEASURING CHAMBER

DRAWING

MEASURING CHAMBER	FIG. 20

DIAMETERS OF PIPES

MAIN PIPELINE	d_1 = ϕ 150mm
WATER METER	d_2 = ϕ 100mm
BYPASS	d_3 = ϕ 100mm



NOTE: ELEVATION e_2 TAKEN OVER FROM ORIGINAL MAP

Fig 66. The operation scheme

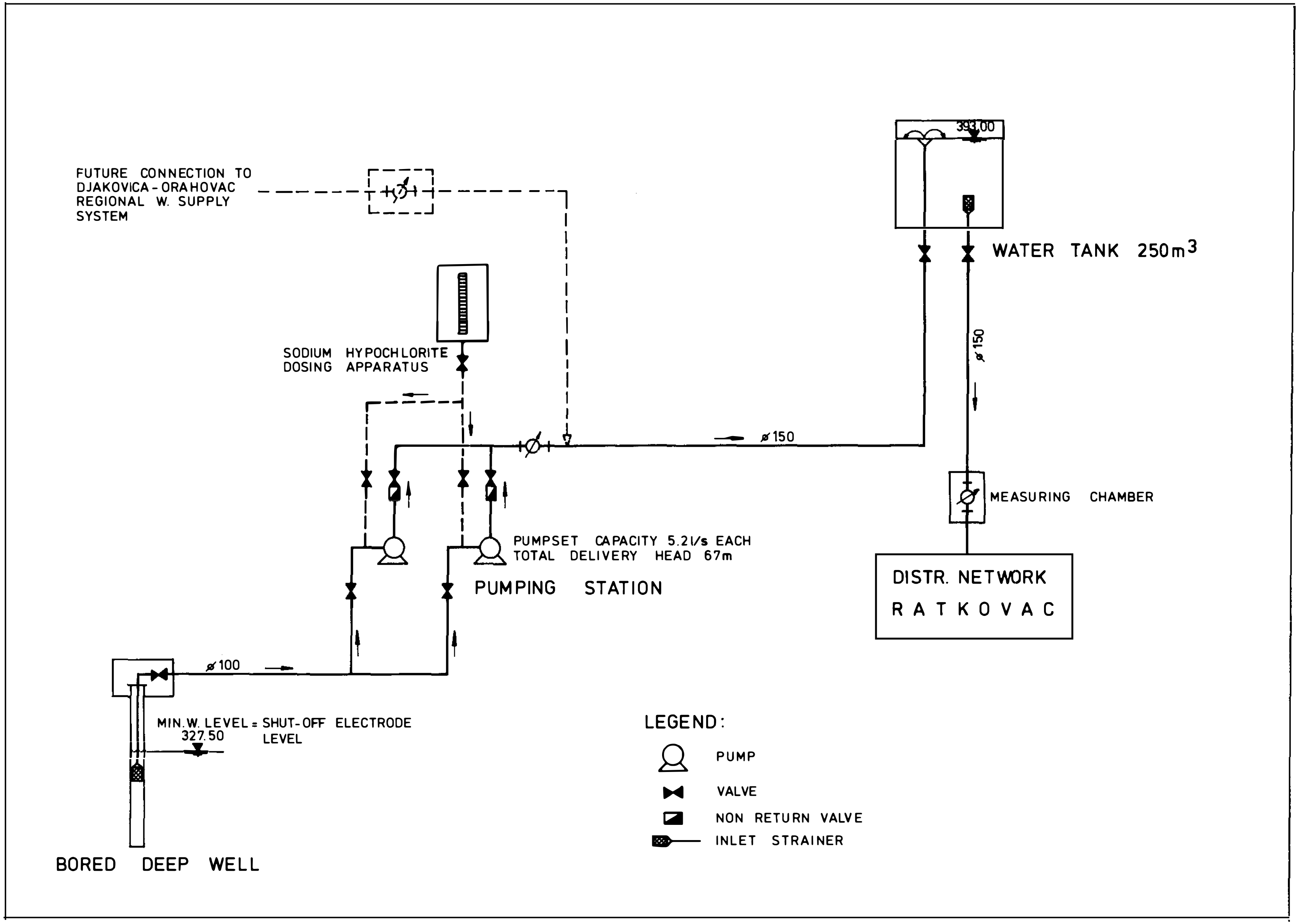


Fig. 67. A typical railway crossing

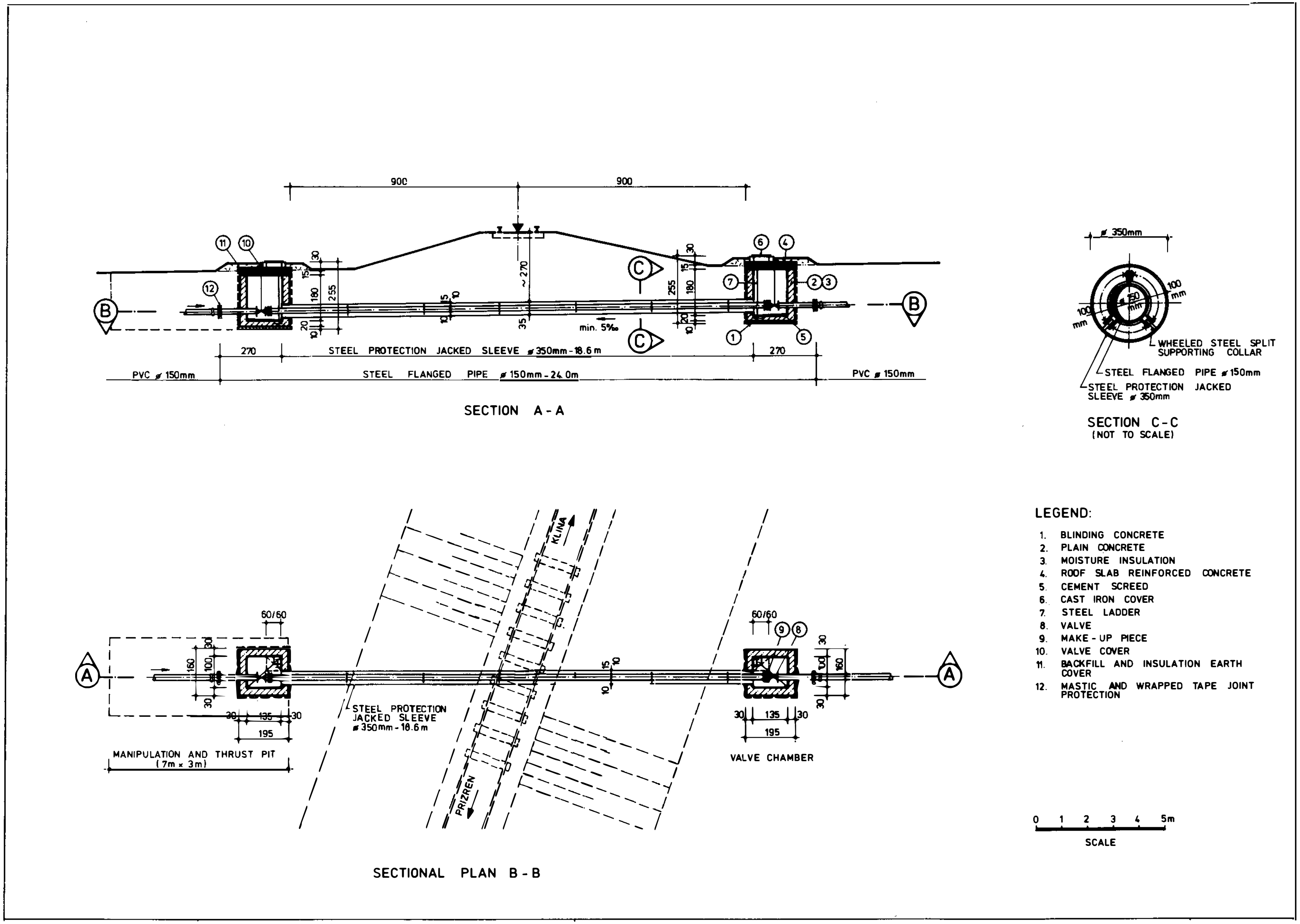
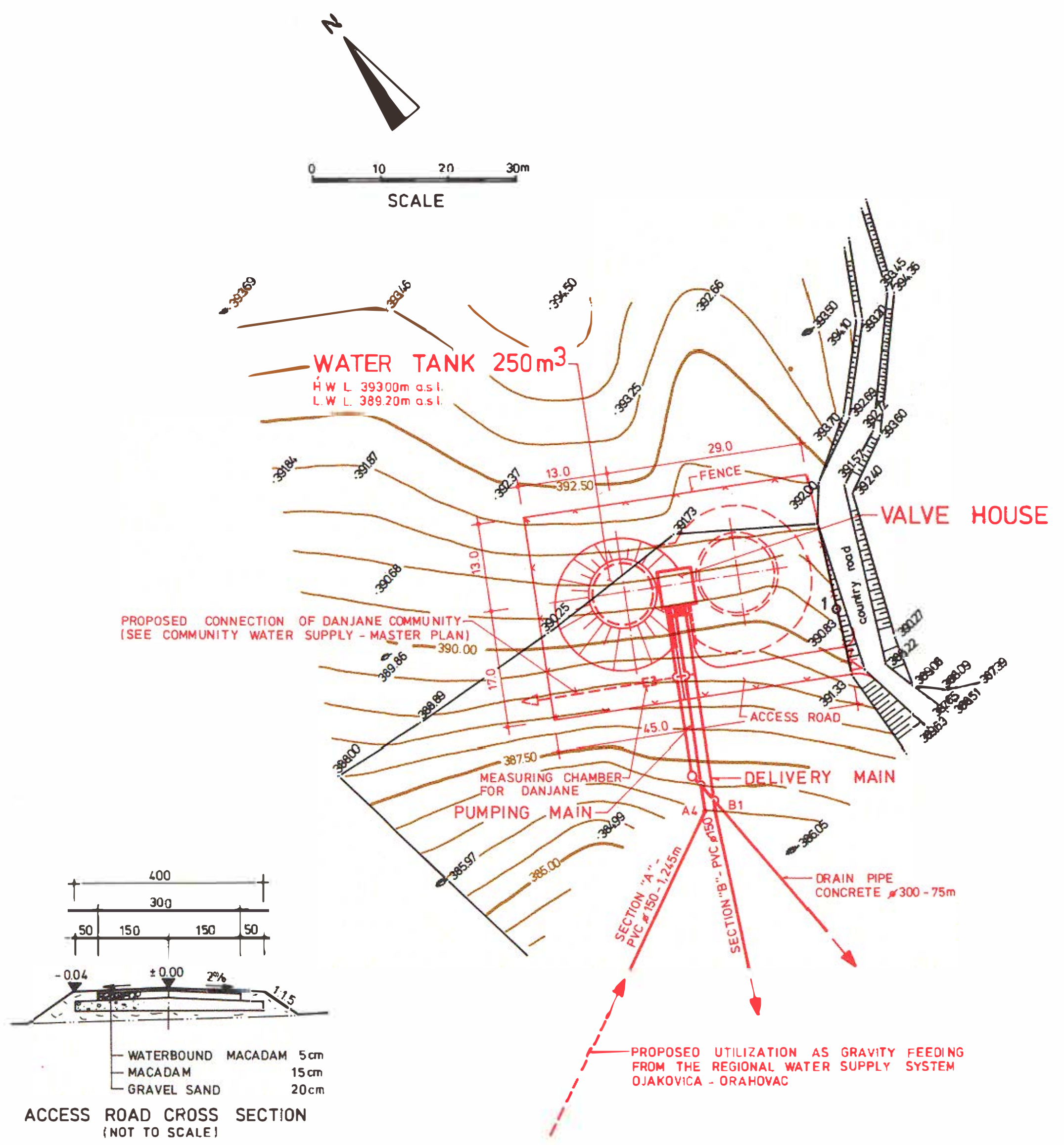
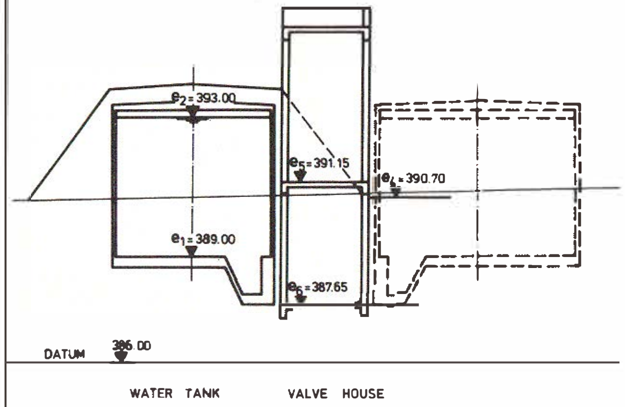


Fig. 68. Layout of the 250 m³ water tank



REFERENCES TO STANDARDIZATION

ELEVATION RELATIONS



DRAWINGS

WATER TANK 250m³ (TYPE II. OF BASE SLAB SUPPOSED)	FIG. 31
VALVE HOUSE FOR TWO WATER TANKS - CIVIL CONSTRUCTION (WASTE CHANNEL ARRANGEMENT TYPE b)	FIG. 34
VALVE HOUSE FOR TWO WATER TANKS - PIPING TYPE II. (IN THE FIRST STAGE INLET AND OUTLET PIPES SHALL BE INTERCONNECTED INSIDE VALVE HOUSE ACCORDING TO THE PIPING TYPE II FOR ONE TANK SEE FIG. 35. AFTER CONNECTION TO DJIAKOVICA - ORAHOVAC REGIONAL WATER SUPPLY SYSTEM, THE PIPES SHOULD BE RECONSTRUCTED ACCORDING TO FIG. 36)	FIG. 37

DIAMETERS OF PIPES

INLET	$\phi d_1 = 100$mm	$\phi d_1' = 150$mm	(ONLY IN CASE IF ADDITIONAL TANK 600 m³ CAPACITY IN FUTURE IS CONSTRUCTED)
OUTLET	$\phi d_2 = 125$mm	$\phi d_2' = 150$ mm	
DRAIN PIPE	$\phi d_3 = 100$ mm		
OVERFLOW	$\phi d_4 = 100$mm		
AIR PIPE	$\phi d_5 = 60$mm		
WASTE PIPE	$\phi d_6 = 300$mm		

Doganovič

Basic Data

The rural community of Doganovič is located about 3.5 km in a direct line, and 4 km by road, from the commune centre of Kacanik. It is accessible all the year round since it is located on a main road.

Most of the community is located in the valley along the Lepenac River, although some buildings are scattered up the sloping ground further from the river. The total built-up area is 0.25 km^2 of relatively rugged terrain.

In 1971, the national census found the population of the community to be 825, but, according to the available development plans, the population should reach 1400 by 1980 and 2000 by 1990.

In accordance with the design criteria, a per capita water consumption of 260 litres per day was adopted. This resulted in the following daily water requirements.

Total		80% (reduced for design)	
m^3/day	litres/second	m^3/day	litres/second
520	6.0	416	4.8

Water Resources

An investigation of available water resources found that a spring, Crni Kamen, that will supply the neighbouring community of Dubrava has enough water to supply Doganovič also. Further, supply by gravity would be possible for both rural communities. No other source in the area had acceptable water quality or could be used without treatment and/or pumping.

All data on the water quality and yield of the spring are included in pp. 197–198, concerning the water supply of the community of Dubrava.

Water Supply System

Because of the relative elevation of the water source and the areas of consumption, the whole system will be operated by gravity.

All elements of the water supply system for both communities, starting from the spring intake structure and serving Dubrava first, such as the feeding main, the 100 m^3 water tank, disinfection equipment and the distribution network at Dubrava are described on pp. 198–199 (see Fig. 115). The part of the system that will supply only Doganovič begins with a measuring chamber on the pipeline from Dubrava to Doganovič. The water-meter for Doganovič is located here. Water will flow from this chamber through a PVC pipeline, 504 m long and 80 mm in diameter, to a service tank of 150 m^3 capacity. This can be doubled later as the water requirements of the community increase. Water can also be disinfected in the tank if necessary (see Fig. 69).

The distribution system will include fire hydrants also used for air release and drainage. The population will be served by standpipes; house connections will supply the local school and health centre. Basic hydraulic data on the system are given in Fig. 70 and 71.

The whole system requires no electric power.

Technical Specifications

Measuring chamber
A standard measuring chamber, including a standard pipe and valve arrangement, main pipeline and a bypass pipe 80 mm in diameter with a measuring range of 5–25 m^3/h, is required. See Fig. 69 and the standard designs in Fig. 20.

Water tank
A standard water tank with a capacity of 150 m^3 and a Type I base slab, with a maximum water level of 625 m above sea level and a bottom level at 621.3 m above sea level, is required. See Fig. 72 and the standard designs in Fig. 29.

Valve house
A standard valve house for two water tanks, with Type I piping for the gravity feeding, is required. The tank will be located in front of the consumption area. See the standard designs in Fig. 35, 36, 41 and 42.

Distribution network
The distribution network includes PVC piping with cast-iron fittings and adapting pipes, isolating valves with valve boxes for control from the ground, fire hydrants and water standpipes for a nominal pressure of 1.0 MPa and pipes of 100 mm diameter and a total length of 1850 m. There will be 17 fire hydrants, 9 water standpipes and 2 house connections. See Fig. 69 and the standard designs in Fig. 39 and 42.

Fig. 69. Layout of the distribution system

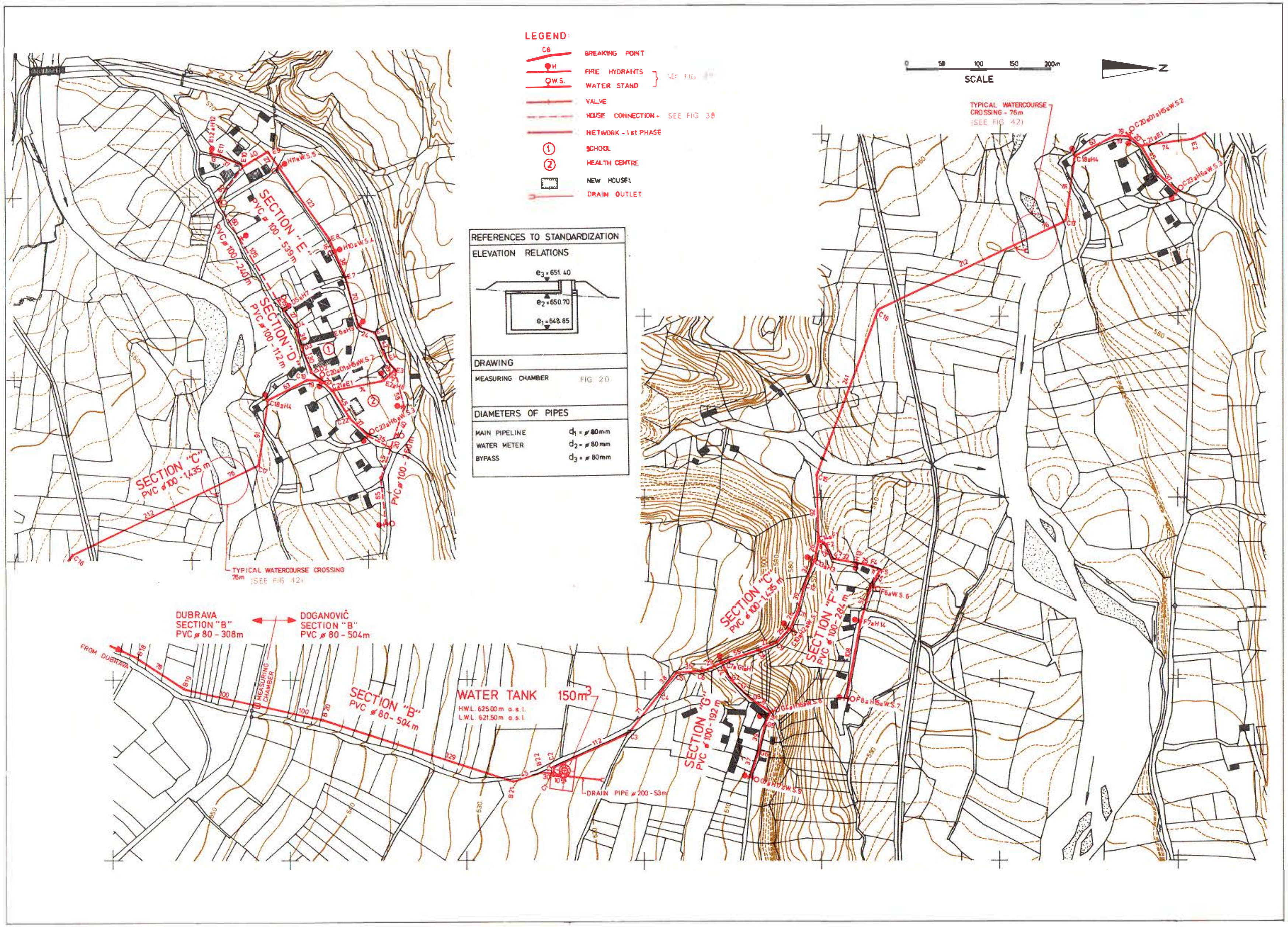
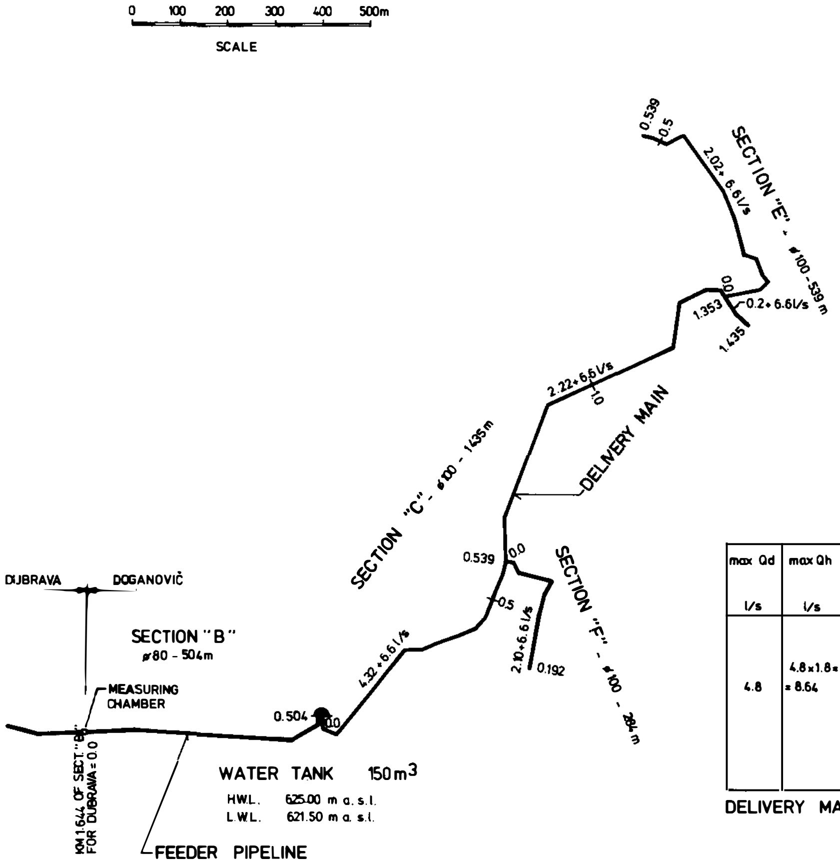


Fig. 70. The flow scheme and some basic hydraulic calculations



FLOW SCHEME

NOTE:

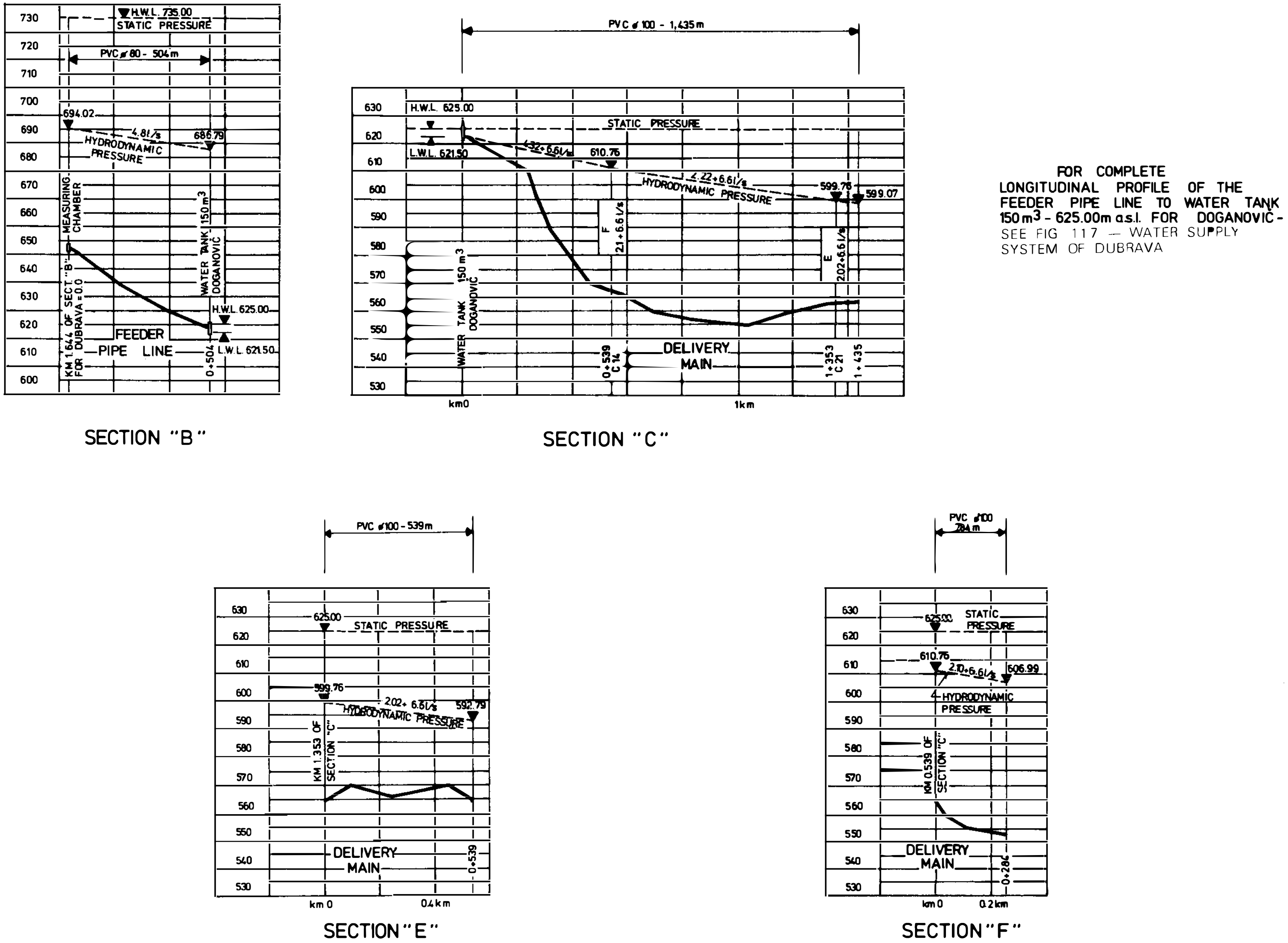
FOR HYDRAULIC CALCULATION OF THE FEEDER PIPE LINE (FROM DUBRAVA W.S. SYSTEM TO WATER TANK $150 m^3$ - 625.00m a.s.l. FOR DOGANOVIČ) SEE HYDRAULIC CALCULATIONS OF THE DUBRAVA W.S.SYSTEM FIG. 115

max Qd l/s	max Qh l/s	SECTION	FLOW TOTAL max Qh/2 l/s	Qf l/s	TOTAL Q= Qh/2+Qf= l/s	LENGTH L m	ø PVC k=0.01 mm	J %	v m/s	PRESS. LOSS J× L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
4.8	4.8×1.8= = 8.64	W.TANK- -C14	4.32	6.6	10.92	539.0	100	1.9924	1.46	10.74	621.50 - 10.74 = = 610.76
		C14-C21	2.22	6.6	8.82	814.0	100	1.3509	1.18	11.0	810.76 -11.0 = = 599.76
		C21-C23	0.20	6.6	6.80	82.0	100	0.8415	0.91	0.69	599.76- 0.69 = = 599.07
		E	2.02	6.6	8.62	539.0	100	1.2925	1.15	6.97	599.76- 6.97 = = 592.79
		F	2.10	6.6	8.70	284.0	100	1.3270	1.17	3.77	610.76 - 3.77 = = 606.99

DELIVERY MAIN

HYDRAULIC CALCULATIONS

Fig. 71. Longitudinal profiles



SECTION "B"

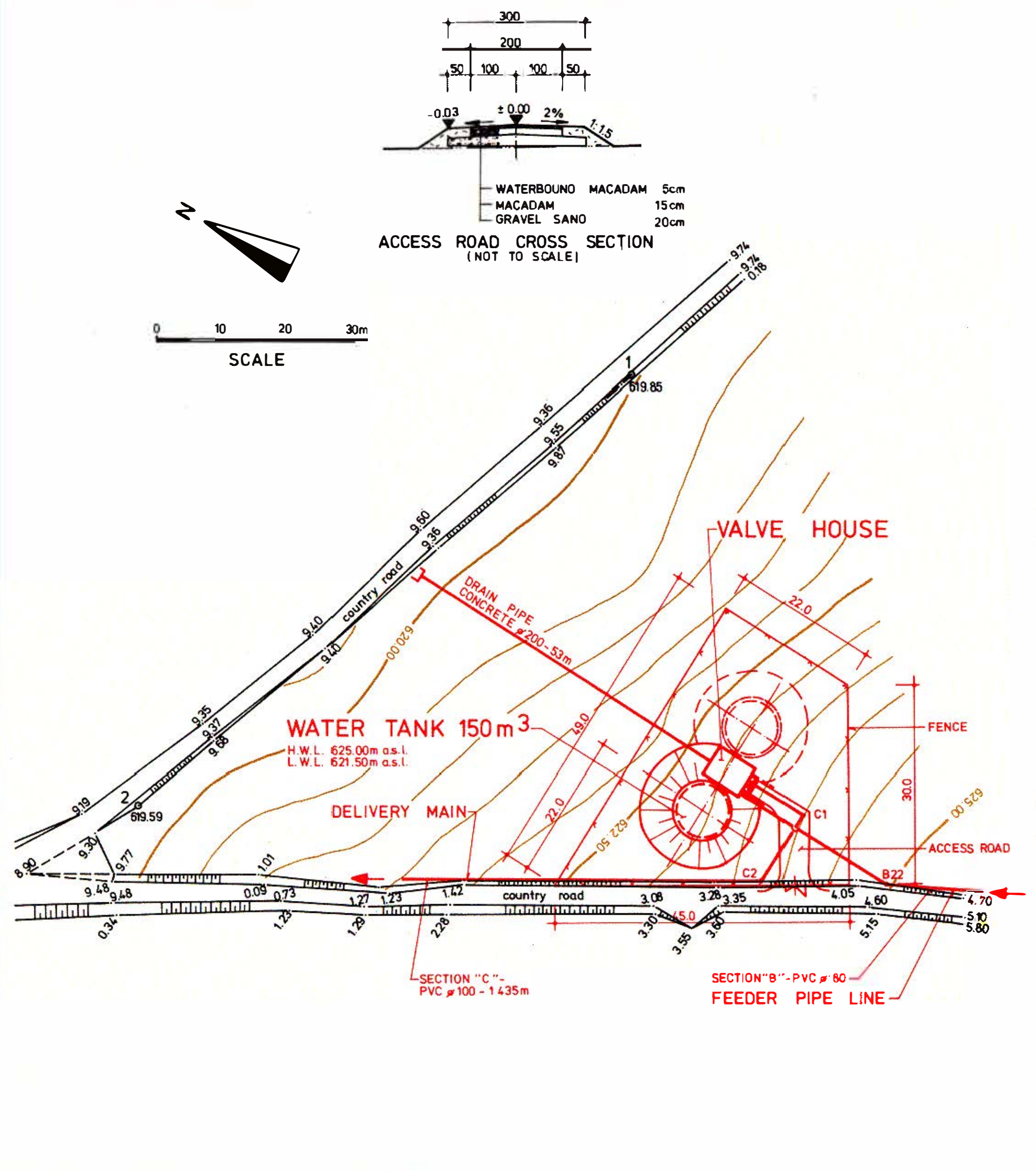
SECTION "C"

SECTION "E"

SECTION "F"

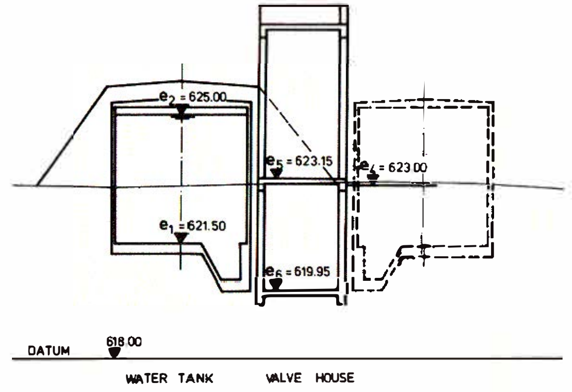
FOR COMPLETE LONGITUDINAL PROFILE OF THE FEEDER PIPE LINE TO WATER TANK 150 m3 - 625.00m a.s.l. FOR DOGANOVIĆ - SEE FIG 117 — WATER SUPPLY SYSTEM OF DUBRAVA

Fig. 72. Layout of the 150 m³ water tank



REFERENCES TO STANDARDIZATION

ELEVATION RELATIONS



DRAWINGS

WATER TANK 150m³ (TYPE I. OF BASE SLAB SUPPOSED)	FIG. 29
VALVE HOUSE FOR .TWO WATER TANKS-CIVIL PART (WASTE CHANNEL ARRANGEMENT TYPE a)	FIG. 34
VALVE HOUSE FOR TWO WATER TANKS-PIPING TYPE I. IN THE FIRST STAGE INLET AND OUTLET PIPES SHALL BE INTERCONNECTED INSIDE VALVE HOUSE ACCORDING TO THE PIPING TYPE I. FOR ONE TANK (SEE FIG. 35) AND DIRECTION OF WASTE PIPE SHOULD BE CHANGED ACCORDING TO LAYOUT OF THE TANK AND VALVE HOUSE ON SITE.	FIG. 36

DIAMETERS OF PIPES

INLET	$\phi d_1 = \phi d_1'$	= 80mm
OUTLET	$\phi d_2 = \phi d_2'$	= 100mm
DRAIN PIPE	ϕd_3	= 80mm
OVERFLOW	ϕd_4	= 100mm
AIR PIPE	ϕd_5	= 50mm
WASTE PIPE	ϕd_6	= 200mm

Kijevo

Basic Data

The rural community of Kijevo is located in the commune of Klina, 13 km in a direct line from the commune centre and 18 km by road. Since the community lies a short distance off a main asphalt road, it is accessible throughout the year.

The built-up area is concentrated on the gently sloping terrain on the southern side of the main road from Pristina to Pec, but is not located near a large river or any other body of water.

In 1971, the national census found the population of the community to be 1318 and this figure is expected to increase to about 2400 by 1990.

In accordance with the design criteria, a per capita water consumption of 260 litres per day was used in the design of the system. This resulted in the following daily water requirements.

Total		90% (reduced for design)	
m^3/day	litres/second	m^3/day	litres/second
624	7.2	562	6.5

At present, the community is supplied with water from a spring that yields about 1 litre per second and is situated almost in the centre of the community. This is not acceptable from a hygienic standpoint. Even if expensive hygienic measures were taken, it would be difficult to guarantee the protection of the source.

Water Resources

An investigation of the neighbouring countryside indicated that there was only one source close enough to the community. Although this was found to yield less water than was hoped, it was cheap to use and the pipework could be used at a later date for the connection to a more abundant but more distant source of supply. Such a source could be the alluvium aquifer at both sides of the Klina River about 4 km north of the proposed water tank.

The spring selected for initial development issued from a relatively flat field area in three main points. This called for special measures to be employed for the water intake.

The soil characteristics of the spot were as follows:

0–1 m: black humus clay

1–6.4 m: yellow/brownish clay with calcite concretions

with a thin sandy layer at a depth of 1.5–1.8 m under the ground level.

The yield of the spring was measured and found to be a minimum of 1 litre per second.

Another trial collection trench 1.5 m deep and 10 m long was dug and a pumping test showed a possibility of collecting an additional 0.5 litre per second of water.

The results of the tests indicated that a collection trench in the spring field about 2 m deep and 250 m long, to which all springs would be connected at an altitude of 584.70 m above sea level, could develop a guaranteed minimum yield of 2 litres per second.

The water was colourless under natural seepage flow conditions but during pumping tests a slight increase in turbidity occurred. The water was also completely free from odour and adequately oxygenated. The total hardness approached 285 mg/l calcium carbonate, so it is rather hard for public supply. However, most of the hardness is temporary.

Although it was not considered necessary to treat the water before distribution, contamination with trace amounts of both iron and manganese may cause some problems. These could be solved by aeration but economic considerations may weigh against it, since aeration would be necessary only for very short periods in the year. The concentration of nitrate and the absence of ammoniacal nitrogen and nitrite indicated that the water source was not subject to either domestic or agricultural pollution.

Other dissolved salts were present in negligible amounts. This, along with the fact that very little organic material was present, suggested that the water should require no chemical treatment and/or aeration other than disinfection.

It was decided to proceed with this design as an emergency health measure on the understanding that, as soon as conditions permitted, the supply would be supplemented by a connection from the alluvium in the valley of the Klina River near the rural community of Dobra Voda.

Water Supply System

Following proposals of the master plan for Kosovo, the water supply for Kijevo will be the source of a larger system also supplying other communities in the vicinity such as Cabic, Zabrde, Stepenica, Iglarevo and Cerovik. The larger system will be constructed when the use of alluvium groundwater of the Klina River valley is justified (see Fig. 73).

The community of Kijevo will be supplied with water extracted from the spring field near the community of Stepenica only temporarily.

Since it is not possible to use the standard intake structure for the water captation in this case, a special non-standard system of collection trenches has been proposed, including inspection manholes and fencing, as presented in Fig. 74.

The water will be collected from section A of the main trench that forms the spine of the system, from the existing well bored during the hydrogeological investigation and from four other short branch collectors by perforated fire-clay pipes. Their diameter is calculated on the basis of the gradient of the impermeable subsoil and the calculated extract flow necessary to maintain the velocity in the drain at about 0.5 m/s.

The trenches should be dug to a depth of20 cm below the top level of the impermeable strata below the aquifer. The pipes laid on the bottom of the trench will be protected by flat slate stones that are locally available and not easily eroded. Every fourth pipe will be a plain pipe without perforations, with a baffle of concrete around it as shown in Fig. 75.

Up to 20 cm above the top level of the water-bearing strata, the collection trench will be filled with a filter material comprising a washed gravel whose grain size distribution should be designed according to the soil material of the aquifer layer. The filter backfill in turn will be covered with a sand layer that is topped with a protective clay cover to prevent direct infiltration of unnecessarily contaminated surface water. The rest of the trench will be backfilled with the ordinary excavated material.

Inspection manholes will be constructed at all points where the pipe direction changes, where pipelines join, or between 30 m and 40 m apart. They will have cast-iron pipes and fittings for cleaning the system. The manholes are of plain concrete and have a roof slab of reinforced concrete with a watertight bitumastic coating. Their cast-iron access covers can be locked and should be raised 50 cm above the existing ground level (see Fig. 74 and 76).

The extracted water will be collected in the wet sump of a standard pumping station with a capacity of 3.4 litres per second and total delivery head of 56 m. The standard design will be modified in the following ways to suit the system to local conditions. The wet sump will be 35 cm deeper. The pumps will be self-priming, with a flap valve suction strainer. A concrete wall 55 cm high in the wet sump will separate the inlet pipe from the pump suction pipes. This compartment will serve as a settling chamber and will reduce the amount of sand and other settleable material reaching the pump suction. A 100 mm-diameter overflow pipe will also be provided in the wet sump for safety purposes. Finally, the machinery will be completed with a portable submersible sludge pump of 1 litre per second and 8 m head capacity.

After disinfection with sodium hypochlorite the water will be pumped through an 80 mm diameter PVC pipeline to a standard water tank of 250 m^3 capacity, with the maximum water level at 628.00 m above sea level. A 125 mm-diameter PVC delivery pipeline will convey the water to Kijevo.

The pumping station will be supplied with power through an overhead 10 kV high-voltage line linked to the existing line passing near the community of Stepenica.

Since PVC pipes with a nominal pressure of 1 MPa are proposed, the water hammer calculations indicated that in this case no water hammer protection equipment is needed. If other pipe materials are used, however, the need for such equipment must be assessed.

Under normal operating conditions, the pumps will be automatically controlled by electrodes installed in the water tank and in the wet sump of the pumping station.

The modified arrangement and level differentials of the pumping station as well as the remainder of the water supply system are shown in Fig. 77.

Technical Specifications

Spring field

Collection trenches (sections A, B and C) 244 m long, with inspection manholes and PVC connection pipes of 125 mm and 150 mm diameter and 105 m and 35 m long, respectively, a protection ditch 360 m long, a 125 mm-diameter PVC drain 120 m long including manholes and outlet structure with back-water flap and 1145 m of chain-line mesh fence are required. See Fig. 74–76 and 78.

Pumping station

A modified standard Type 3.2 pumping station, with wet sump, is required, consisting of the following machinery and electrical equipment:

- 2 horizontal self-priming pumps with a capacity of 3.4 litres per second and total delivery head of 56 m
- 1 set of standard sodium hypochlorite dosing equipment;
- 1 portable submersible pump with a capacity of 1 litre per second and delivery head of 8 m;
- 1 standard switchboard;
- 1 set of standard lighting equipment, including light fittings, switches, socket outlets and cable installation;
- 1 pole-type transformer of 30 kVA, 10/0.4 kV;
- 210 m of overhead high-tension feeding line; and
- 1240 m of control and signalling cable line between the pumping station and service water tank.

The pumps can be operated manually from the switchboard, or automatically by the water levels in the service water tank.

The electrodes will switch off at 627.95 m above sea level and switch on at 627.00 m above sea level. The shut-off electrode in the wet sump will be located at 581.5 m above sea level. See Fig. 74 and 77 and the standard designs in Fig. 10–12 and 41.

Pumping main

An 80 mm-diameter PVC pipeline, 1236 m long, for a nominal pressure of 1.0 MPa is required. See Fig. 78–80 and the standard designs in Fig. 42.

Water tank

A standard water tank with a capacity of 250 m^3 and a Type II base slab is required. The maximum water level will be at 628.0 m above sea level and the bottom level will be at 624.0 m above sea level. See Fig. 81 and the standard designs in Fig. 31.

Valve house

A standard valve house for two water tanks located in front of the distribution area is required, with Type II piping arrangement and including a drain-pipe, an access road and fencing. See Fig. 81 and the standard designs in Fig. 34, 37, 41 and 42.

Distribution network

Piping of PVC with cast-iron fittings and adapting pipes, isolating valves with valve boxes for control from the ground and fire hydrants and water standpipes for a nominal pressure of 1.0 MPa will be required in the following measurements and numbers:

- 1048 m of pipe 125 mm in diameter;
- 1115 m of pipe 100 mm in diameter;

- 22 fire hydrants;
- 12 water standpipes;
- 6 house connections for the restaurant, school, health centre, shop, grammar school and local administration building;
- 20 m of steel pipe with jacked sleeve joints for the Pristina–Pec highway crossing, including supporting collars and flanged steel pipes of 125 mm diameter;
- 1 standard drain valve chamber; and
- 1 standard air valve chamber.

See Fig. 78–80 and 82–84 and the standard designs in Fig. 18–20, 39 and 42.

Fig. 73. Longitudinal profile of a pumping main

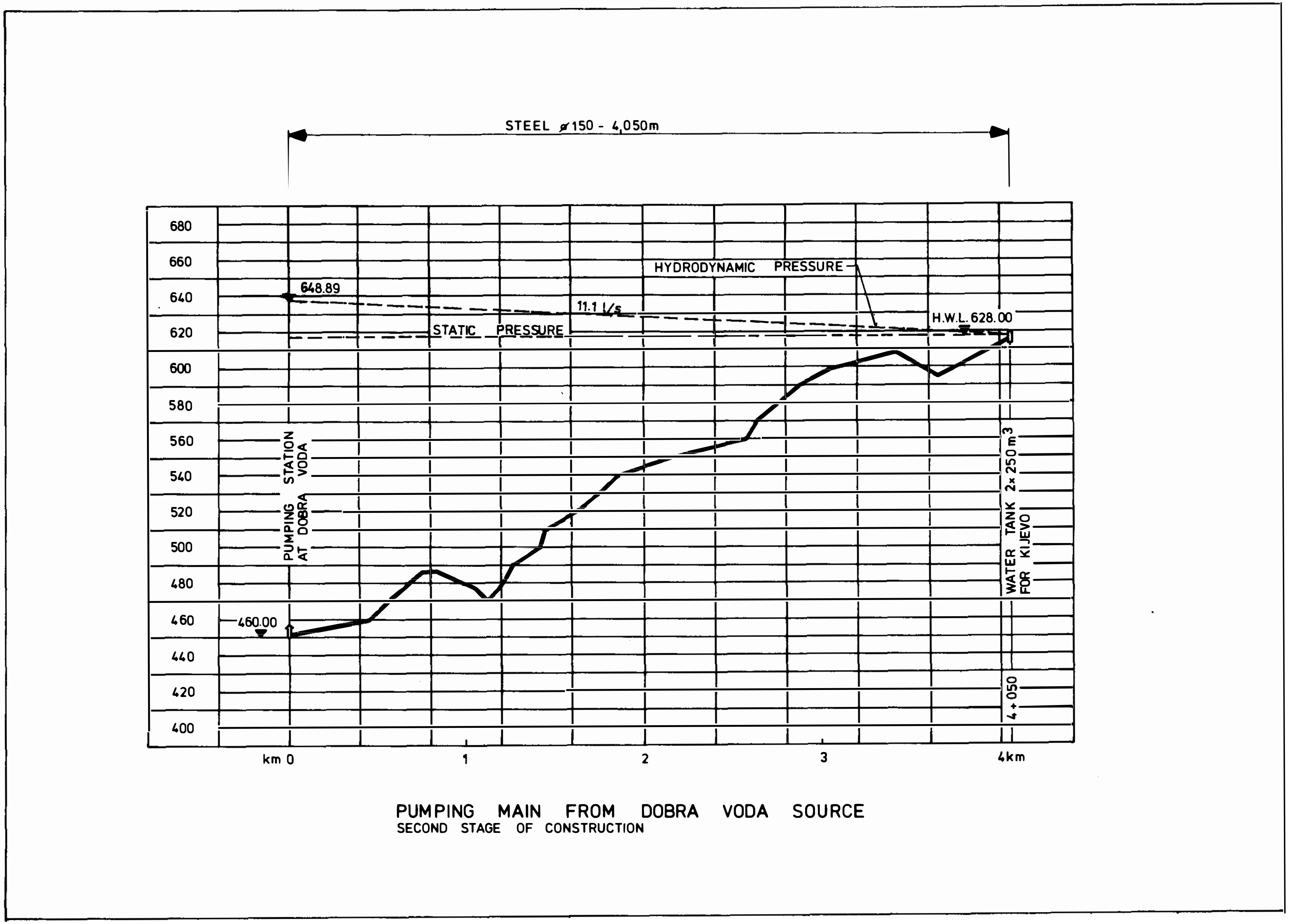


Fig. 74. The wellfield area and some longitudinal profiles

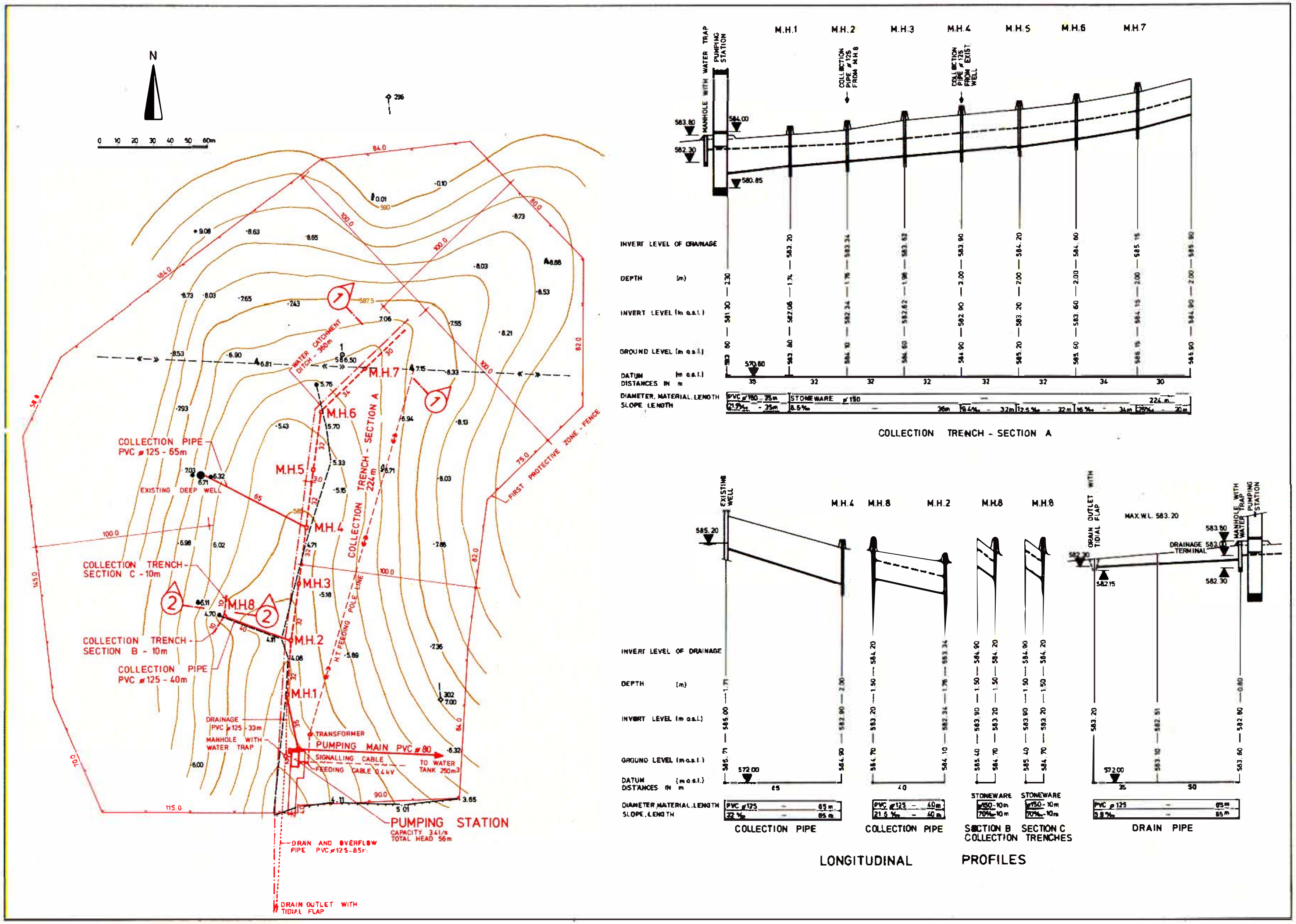


Fig. 75. Collection trenches in cross-section

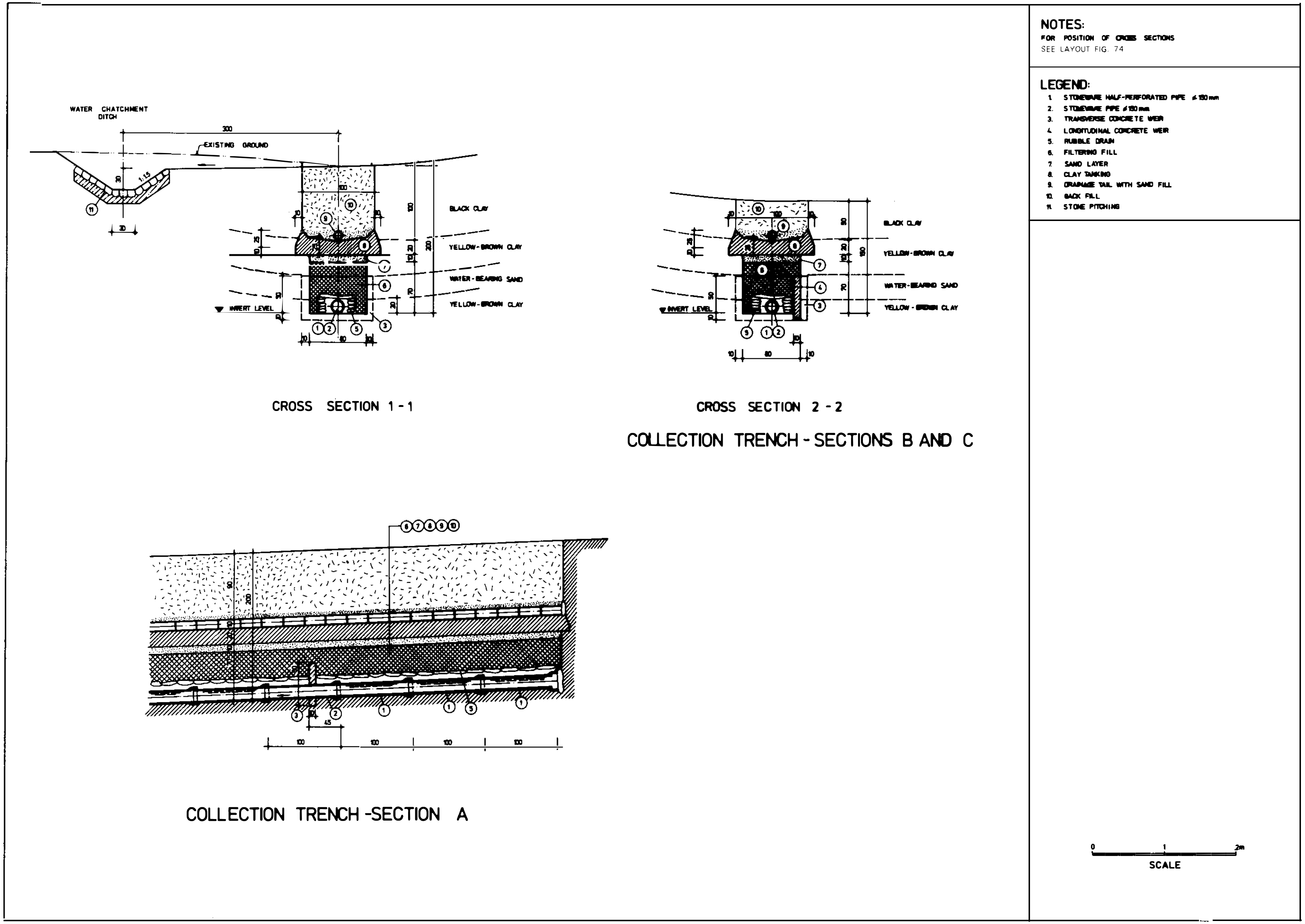
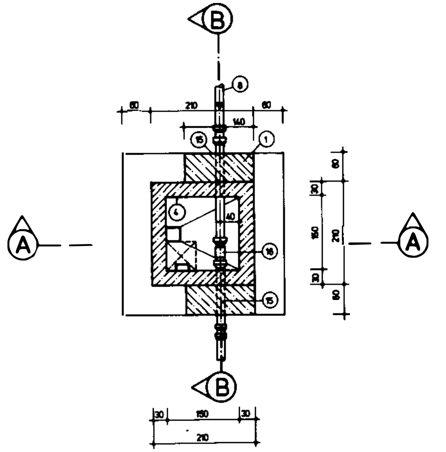
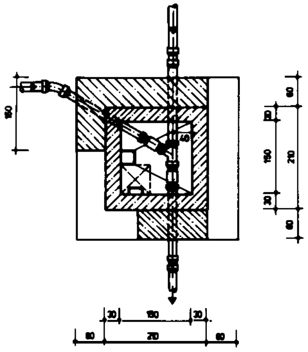


Fig. 76. Inspection manholes



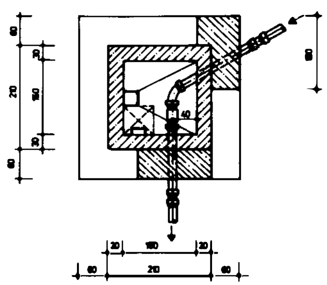
SECTIONAL PLAN C-C

MANHOLE TYPE a



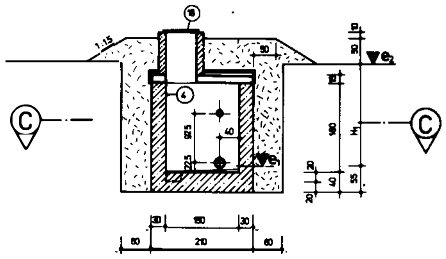
SECTIONAL PLAN C-C

MANHOLE TYPE b

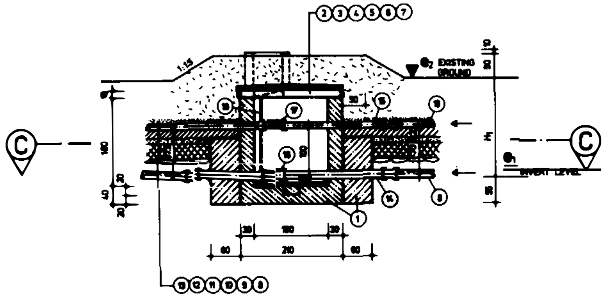


SECTIONAL PLAN C-C

MANHOLE TYPE c



SECTION A -A



SECTION B- B

LIST OF MANHOLES:

No	TYPE	INVERT LEVEL e1 m a.s.l.	EXISTING GROUND e2 m a.s.l.	H1 m
1	a	582.06	583.80	1.74
2	b	582.34	584.10	1.78
3	a	582.62	584.60	1.98
4	b	582.90	584.90	2.00
5	a	583.20	585.20	2.00
6	c	583.60	585.60	2.00
7	a	584.15	586.15	2.00
8	b	583.20	584.70	1.50

LEGEND:

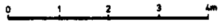
1. PLAIN CONCRETE
2. REINFORCED CONCRETE
3. BENCHING TO GRADIENT
4. WATERTIGHT PLASTER
5. WATERPROOF INSULATION
6. PROTECTING CEMENT SCREED
7. COMPACT FILL AND HUMUS
8. STONEWARE HALF - PERFORATED PIPE ø 150mm
9. RUBBLE DRAIN
10. FILTERING FILL
11. SAND LAYER
12. CLAY TANKING
13. DRAINAGE TAIL WITH SAND FILL
14. CAST IRON PIPE ø 150mm
15. CAST IRON PIPE ø 100mm
16. INSPECTION AND CLEANING ø 150mm PIPE
17. INSPECTION AND CLEANING ø 100mm PIPE
18. STEEL OR CAST IRON LOCKED COVER
19. STEEL LADDER

NOTES:

FOR POSITION OF MANHOLES SEE LAYOUT FIG 74

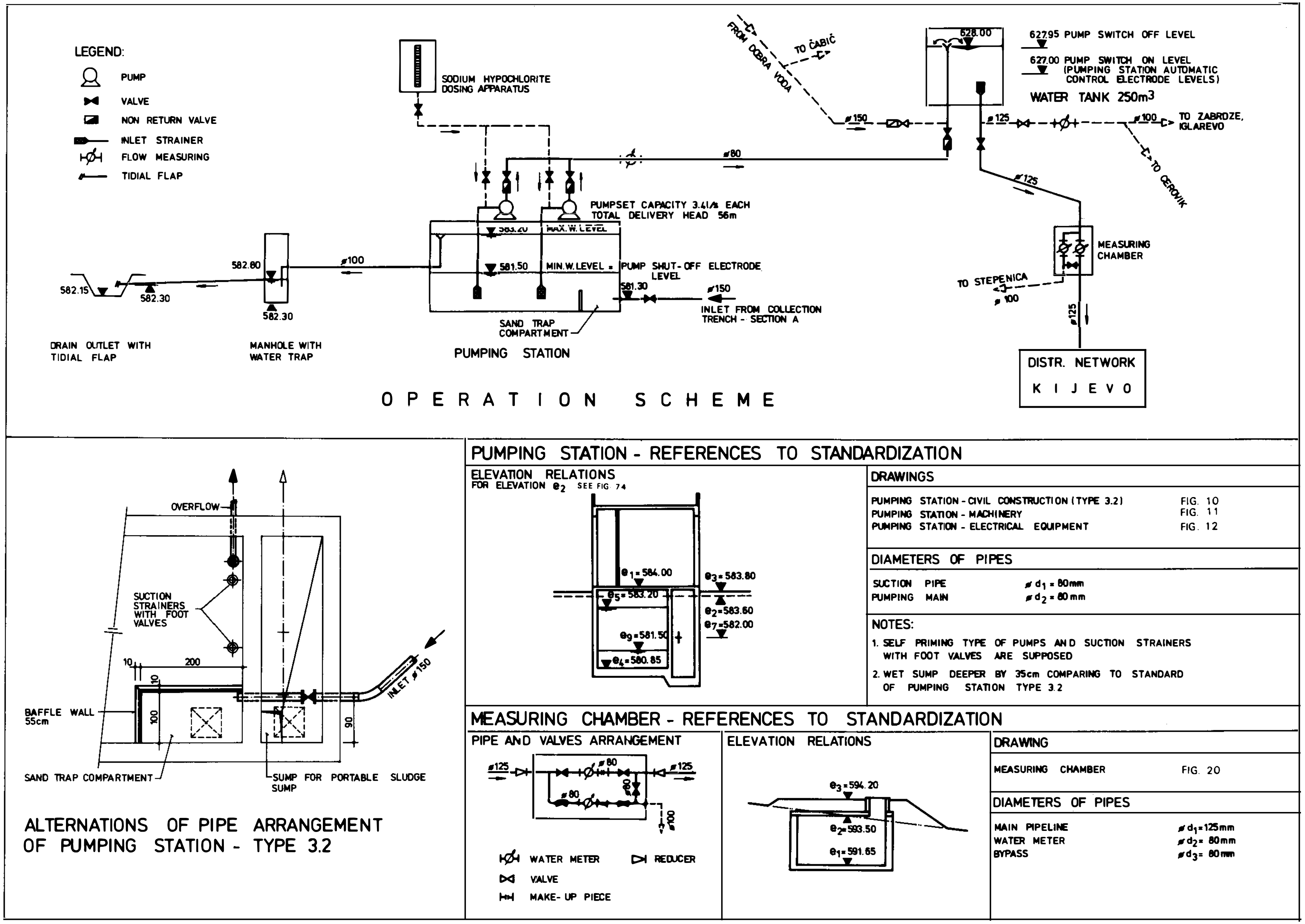
FOR MANHOLES TYPE b AND TYPE c SECTIONS A-A AND B-B SHOULD BE ADOPTED ACCORDINGLY

FOR ELEVATION e_2 SEE FIG. 74



SCALE

Fig. 77. Operation scheme, pumping station and measuring chamber



PUMPING STATION - REFERENCES TO STANDARDIZATION

DRAWINGS

PUMPING STATION - CIVIL CONSTRUCTION (TYPE 3.2)	FIG. 10
PUMPING STATION - MACHINERY	FIG. 11
PUMPING STATION - ELECTRICAL EQUIPMENT	FIG. 12

DIAMETERS OF PIPES

SUCTION PIPE	ø d_1 = 80mm
PUMPING MAIN	ø d_2 = 80 mm

NOTES:

1. SELF PRIMING TYPE OF PUMPS AND SUCTION STRAINERS WITH FOOT VALVES ARE SUPPOSED
2. WET SUMP DEEPER BY 35cm COMPARING TO STANDARD OF PUMPING STATION TYPE 3.2

MEASURING CHAMBER - REFERENCES TO STANDARDIZATION

DRAWING

MEASURING CHAMBER	FIG. 20

DIAMETERS OF PIPES

MAIN PIPELINE	ø d_1 = 125mm
WATER METER	ø d_2 = 80mm
BYPASS	ø d_3 = 80mm

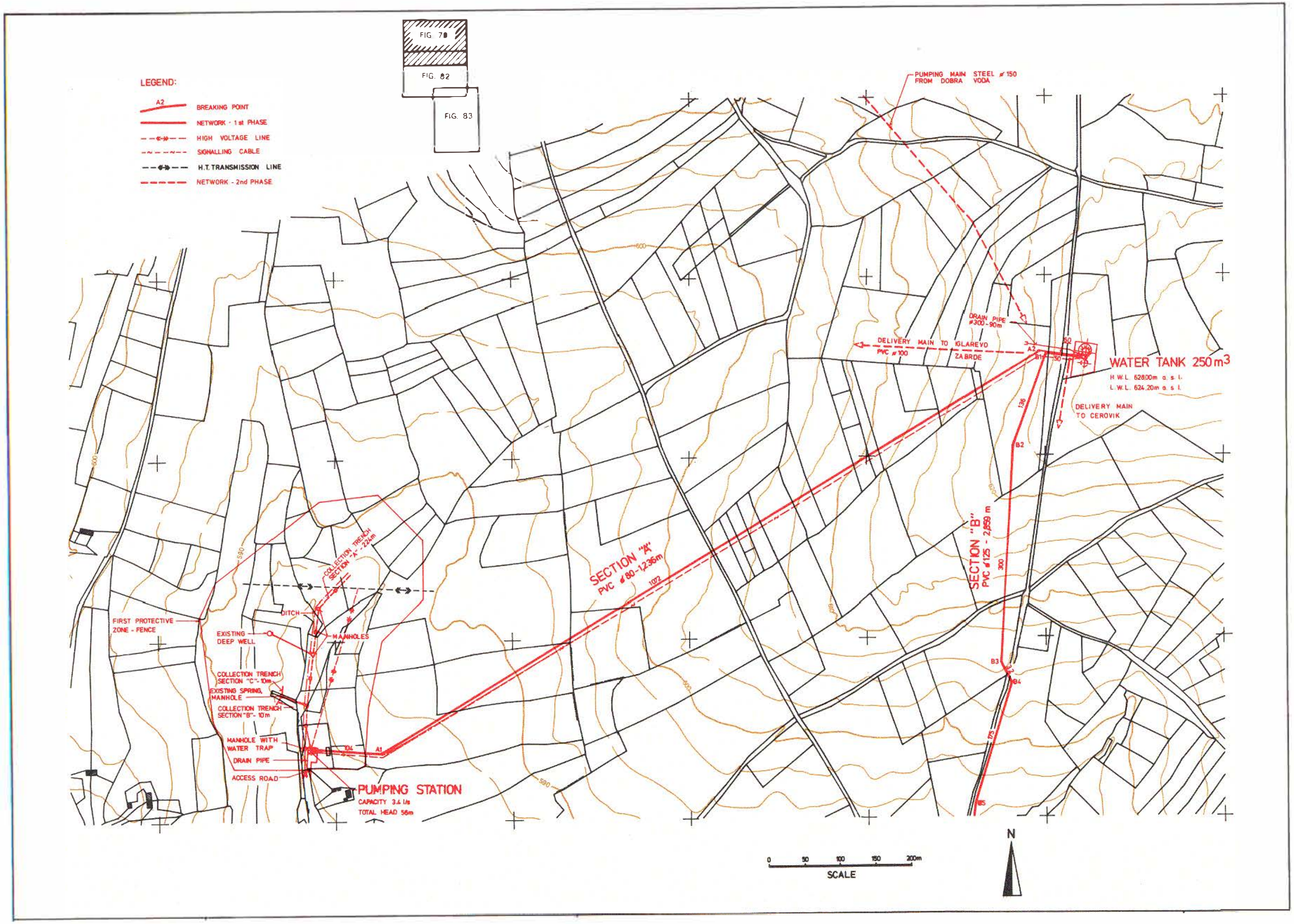
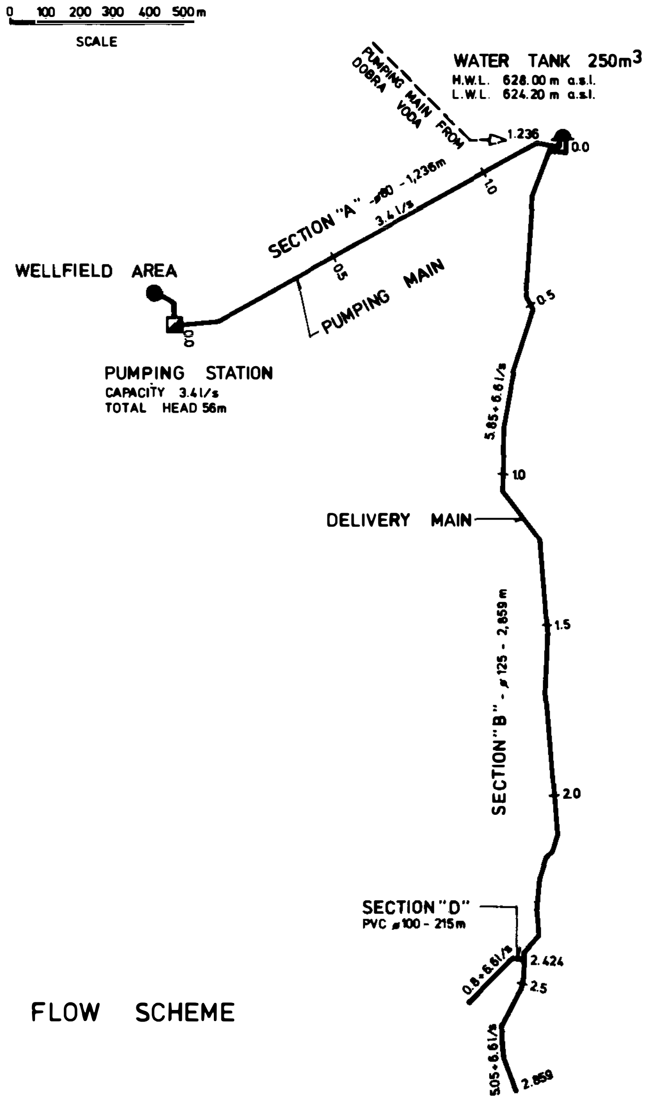


Fig. 78. Layout of the pumping main

Fig. 79. Flow scheme and some basic hydraulic calculations



FLOW SCHEME

max Qd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES C	ø PVC k=0.01 mm	J %	v m/s	PRESSURE LOSSES C×J×L m	TOTAL HEAD
3.4	1,236	1.2	80	0.6430	0.68	9.55	628.00 -581.50 + 9.55= =56.05

PUMPING MAIN

max Qd l/s	max Qh l/s	SECTION	FLOW TOTAL max Qh/2 l/s	Qf l/s	TOTAL Q= Qh/2+Qf l/s	LENGTH L m	ø PVC k=0.01 mm	J %	v m/s	PRESSURE LOSS J×L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
6.5	6.5×1.8 =11.7	W. TANK -B19	5.85	6.6	12.45	2,424	125	0.7085	1.03	19.14	624.20 - 19.14 = 605.06
		B19 -B27	5.05	6.6	11.65	435	125	0.7002	0.96	3.05	605.06 - 3.05 = 602.01
		D	0.80	6.6	7.40	215	100	0.9677	0.98	2.12	605.06 - 2.12 = 602.94

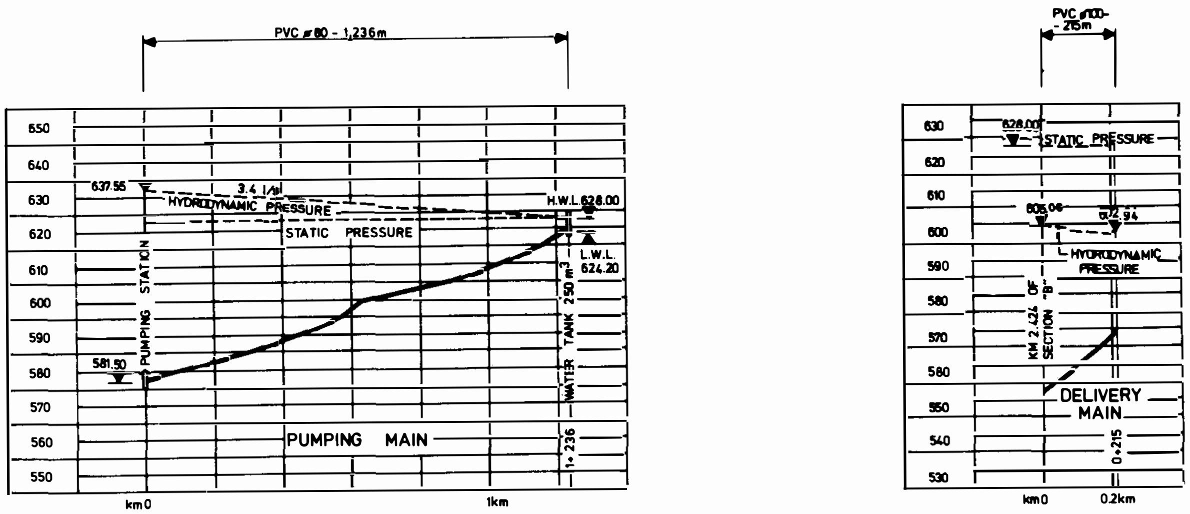
DELIVERY MAIN

max Qd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES C	ø STEEL k=1.0 mm	J %	v m/s	PRESSURE LOSSES C×J×L m	TOTAL HEAD
11.5	4,050	1.05	150	0.4912	0.65	20.88	628.00-460.00+20.88 =188.88

PUMPING MAIN FROM DOBRA VODA SOURCE
SECOND STAGE OF CONSTRUCTION

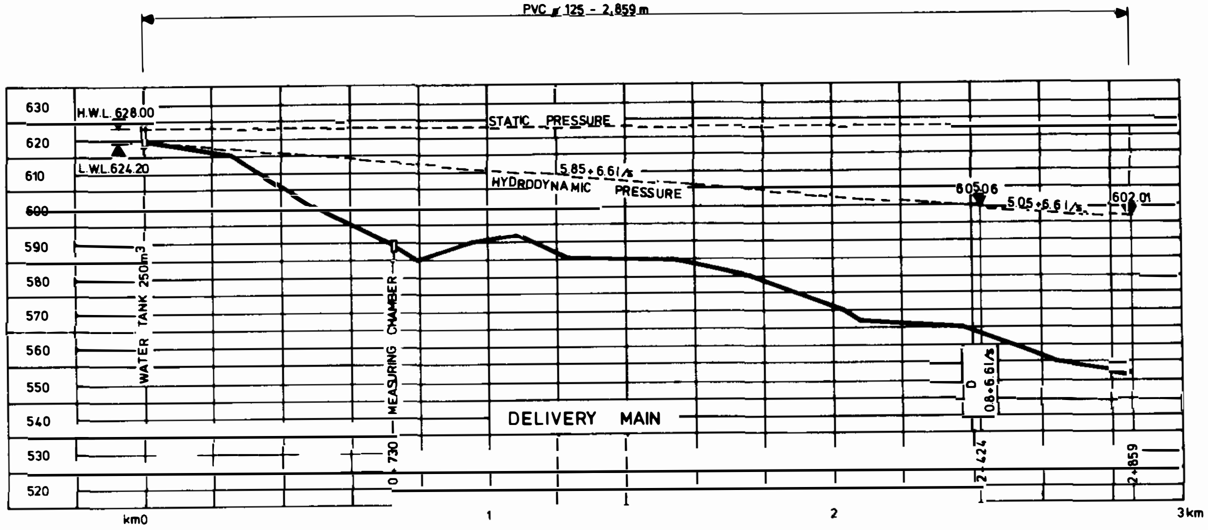
HYDRAULIC CALCULATIONS

Fig. 80. Longitudinal profiles



SECTION "A"

SECTION"D"



SECTION "B"

Fig. 81. Layout of the 250 m³ water tank

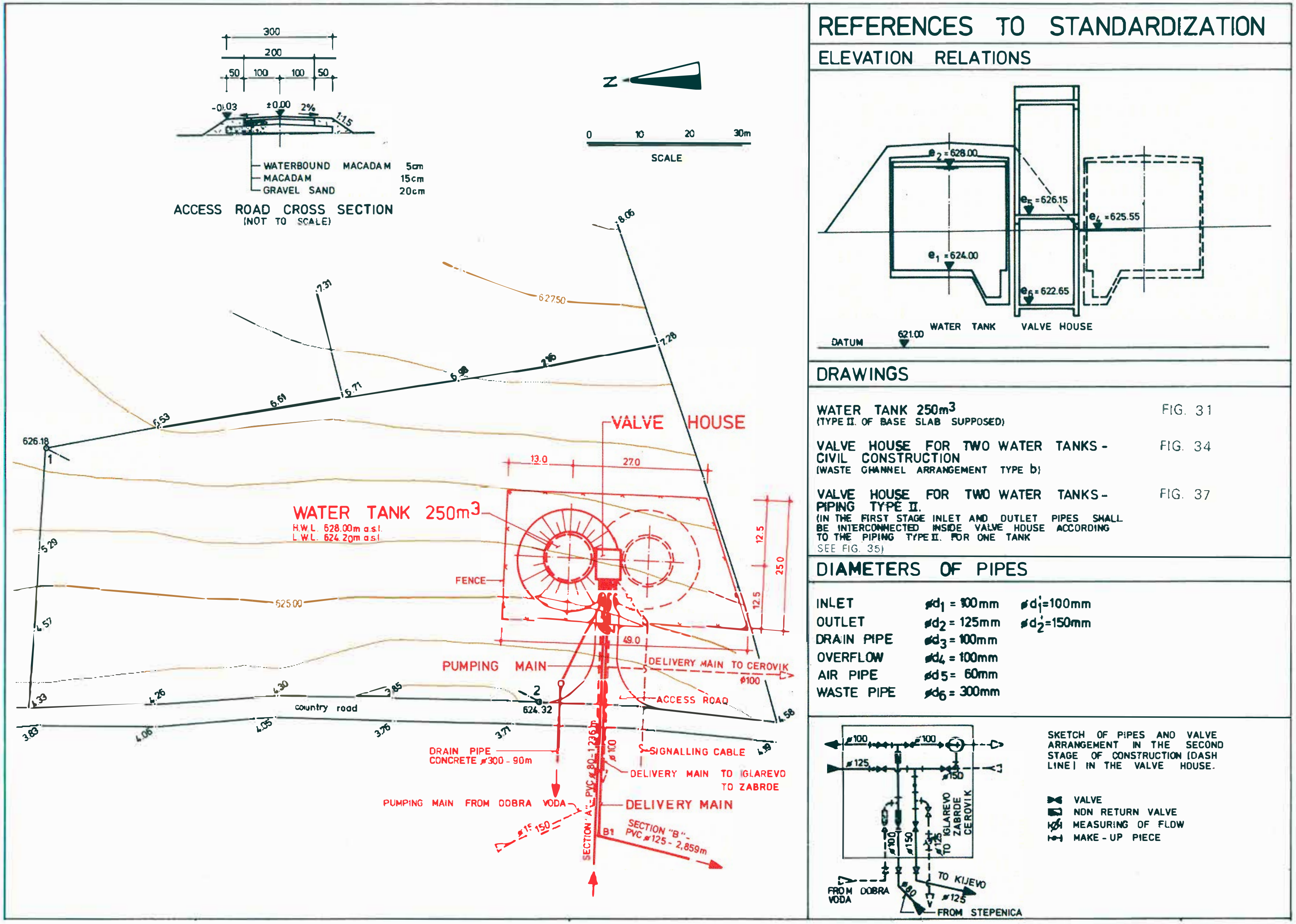
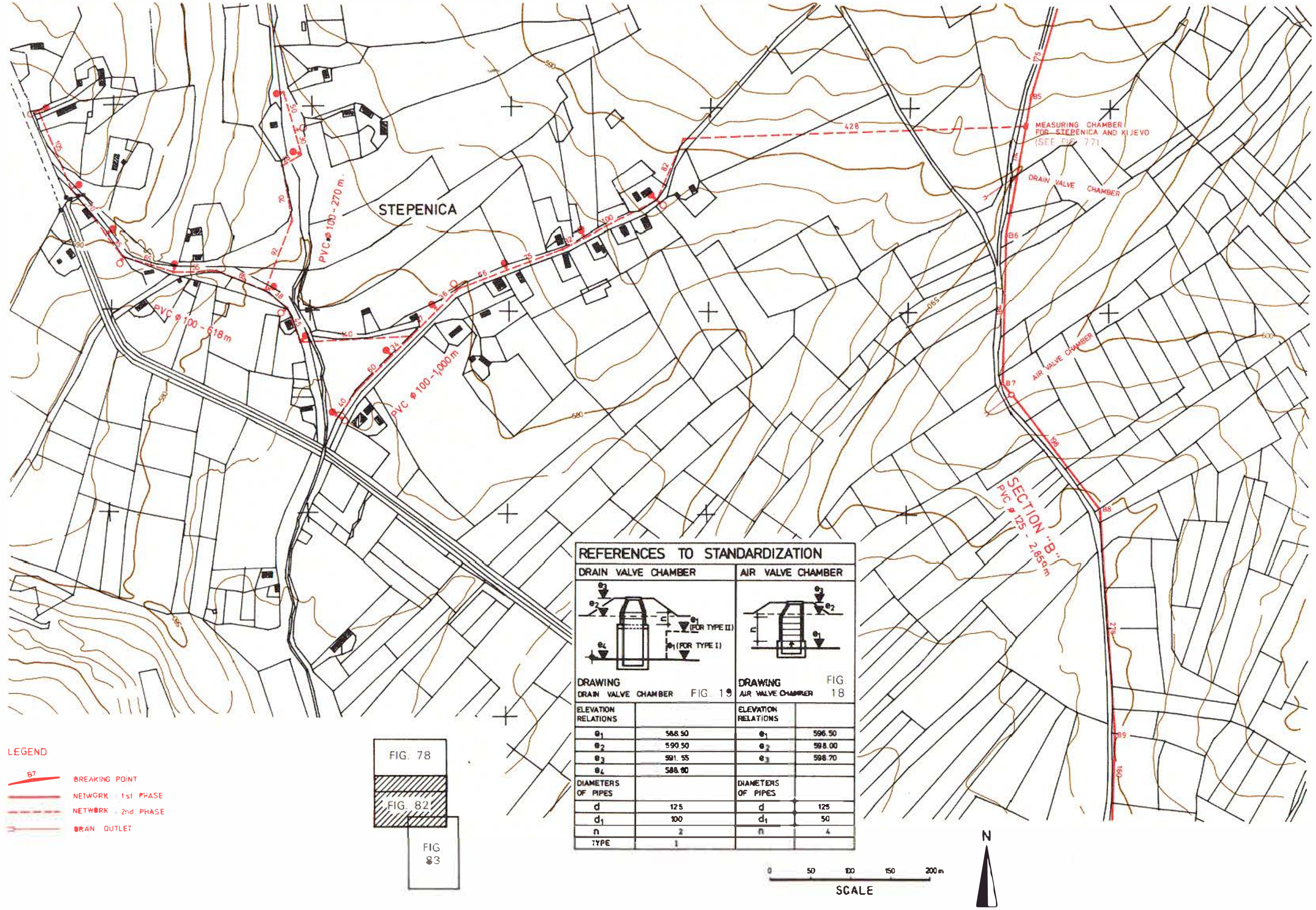


Fig. 82. Layout of the delivery main



REFERENCES TO STANDARDIZATION

DRAIN VALVE CHAMBER		AIR VALVE CHAMBER	
DRAWING DRAIN VALVE CHAMBER	FIG. 19	DRAWING AIR VALVE CHAMBER	FIG. 18
ELEVATION RELATIONS		ELEVATION RELATIONS	
e_1	588.50	e_1	596.50
e_2	590.50	e_2	598.00
e_3	591.55	e_3	598.70
e_4	588.80		
DIAMETERS OF PIPES		DIAMETERS OF PIPES	
d	125	d	125
d_1	100	d_1	50
n	2	n	4
TYPE	1		

Fig. 83. Layout of the distribution system

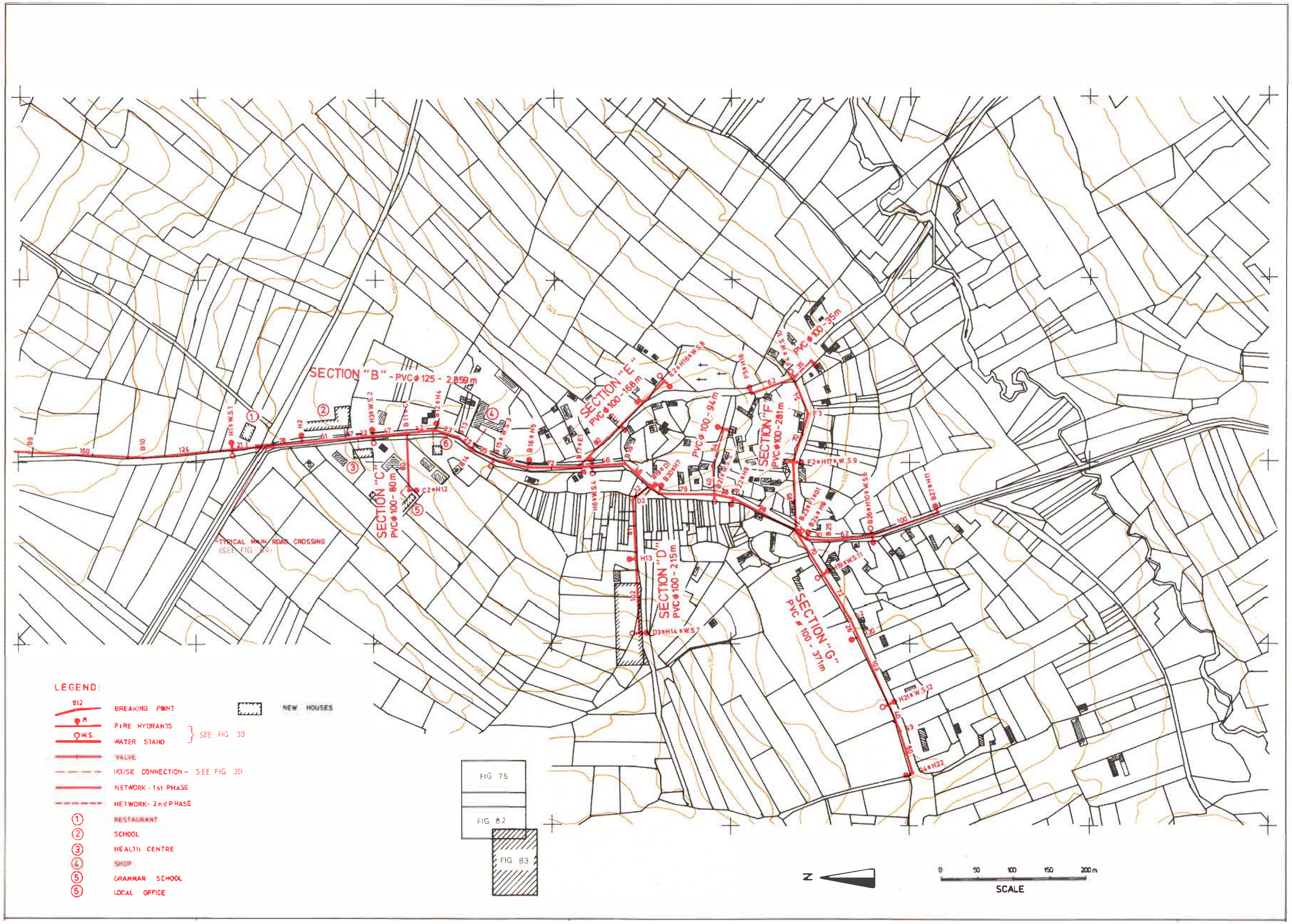
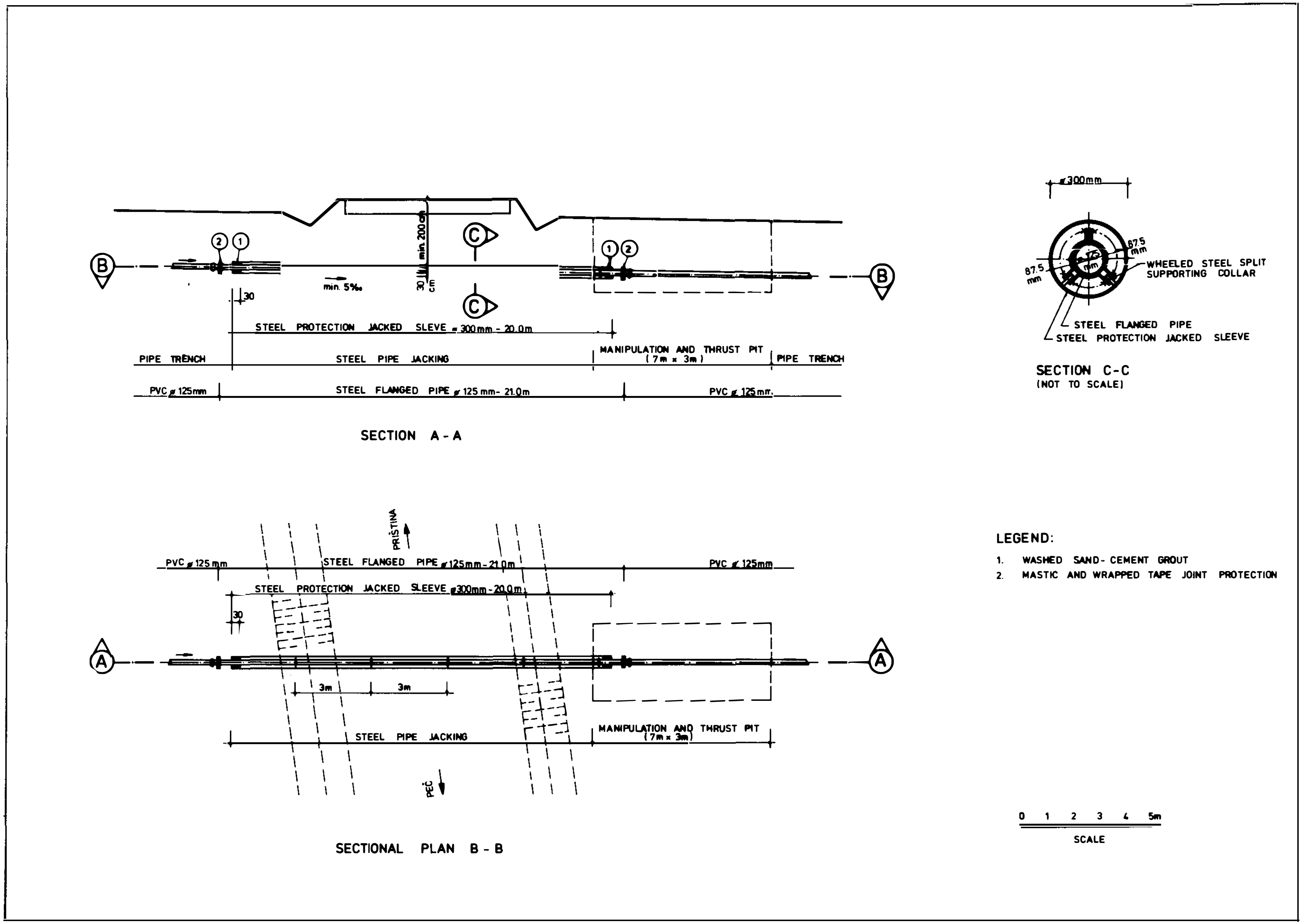


Fig. 84. Typical main road crossing



Ranilug

Basic Data

The rural community of Ranilug is situated in the commune of Gnjilane, about 10 km in a direct line from the commune centre. The community is reached by a subsidiary road branching off the main road from Gnjilane to Kosovska Kamenica.

The built-up area extends along the valley of the Binacka Morava River and joins the smaller community of Glogovce to the south-west. The latter community did not share in the water supply at this stage but could be connected to the system in the future.

The inhabitants of Ranilug are employed in agriculture. The town has a school, a local administration building and a health centre.

In 1971, the national census found the population of Ranilug to be 974 and, from information provided by the provincial planning authorities, it was expected to increase to 1350 by 1980 and to 1700 by 1990.

In accordance with the design criteria, a per capita water consumption of 260 litres per day was adopted for design purposes. This resulted in the following daily water requirements.

Total		90% (reduced for design)	
m^3/day	litres/second	m^3/day	litres/second
442	5.1	398	4.6

Water Resources

No regional water supply system is to be constructed near the community, and there is no natural spring in its environs with a yield sufficient to satisfy the population's needs. The only available source of water is groundwater from the alluvium on the left bank of the Binacka Morava River near the community.

The results of preliminary hydrogeological investigations of the alluvium in 1975 indicated that the gravel/sand was water-bearing throughout its whole depth and the groundwater was under pressure from the overlying clay layer. The soil characteristics of a test borehole were as follows:

0–3.5 m: impervious sandy loam

3.5–4.0 m: gravel/sand

4.0–6.2 m: coarse-grained gravel/sand

6.2–6.4 m agglomerate

At the time of investigations the static water level was found 2.2 m below ground level and 1.3 m above the top of the water-bearing strata.

The pumping test indicated that the maximum off-take from one borehole was 1.6 litres per second and that this produced a draw-down in the well of 2.0 m. It was therefore proposed to construct one bored and one dug well to satisfy the calculated water demand of 4.6 litres per second. On the basis of the field studies it was decided to space the wells 50 m apart, and, for security against possible contamination, the nearest well should be 50 m from a public footpath and 70 m from the bank of the river. The latter distance should provide sufficient natural filtration to avoid the serious danger of pollution from the river water.

Unfortunately, the borehole used for the hydrogeological investigations could not be used as one of the final extraction wells because it caved in during the final stages of the field test. Under normal conditions it would have been used and hence reduced the construction costs of the final scheme.

The test borehole had not extracted river infiltration water but the hard calcium-bicarbonate water flowing by gravity from the surrounding valley towards the river.

The chemical analyses indicated a water with a total hardness of 400 mg/l calcium carbonate. This is a very hard water, on the limits of acceptability for public water supply. Magnesium and sulfate levels were also found to be relatively high, at 18 mg/l and 48 mg/l, respectively. The water was undersaturated with oxygen and had a medium concentration of free carbon dioxide, most of this being in an aggressive form. Without water softening, scaling will be experienced in cooking utensils, although this will not be a general problem for the time being since central heating is not used in the community.

The water was therefore considered acceptable for drinking because of the lack of an alternative source and because of the water-using practices and household facilities of Ranilug. However, the removal of excess carbon dioxide and simultaneous saturation with oxygen in an aeration process was advised.

Water Supply System

On the basis of the field investigations, it was decided that at this stage two wells should be sunk 70 m from the bank of the Binacka Morava River. One of them will be a dug well of 2 m diameter that would act as a collection and captation well, and the other, a bored well, would serve purely for captation. Its water would be conveyed to the collection well by siphon.

The first protection zone will be surrounded by a wire-mesh fence allowing no access within 50 m of either well. No secondary protection is proposed because the impermeable nature of the top layer of 3.5 m thick sandy loam is considered to provide sufficient protection. The site layout and extent of the fenced-in area are shown in Fig. 85.

The water from the collection well will be pumped to an aeration station and collected in the wet sump of the standard pumping station. The standard aeration station has been designed for its ultimate capacity while the pumps in the pumping station, designed with a capacity of 2.5 litres per second and total delivery head of 73 m, will have to be upgraded later. An automatic air release system is included in the design to control the operation of the siphon, and sodium hypochlorite dosing is provided to disinfect the water.

The water hammer calculations proved that, providing the pumping main is made of PVC, no water hammer protection of the system is necessary (see Fig. 86).

The operation of the pumping station is automatically controlled by the water level in the water tank that is located between the wellfield and the distribution system. In addition, a shut-off electrode will be fixed in the wet sump to protect the pumps against dry running.

Between the pumping station and the water tank a control and signalling cable will be laid down as shown in Fig. 87 and 88.

The aeration station will also operate automatically. The aeration station pumps will be switched off by electrodes installed in the wet sump of the pumping station, while the shut-off electrode will be located in the collection well to avoid the possibility of the pumps working when dry.

The pumping and aeration station will be supplied with power from a pole-type transformer of 50 kVA, 10/0.4 kV that will be fed by an overhead high-tension 10 kV line 190 m long (see Fig. 87).

The water tank, with a capacity of 200 m^3, will be constructed at this stage and fed by direct pumping from the pumping station. The rate of flow will be measured by water-meters installed on the pumping main in the pumping station and on the delivery pipeline in the valve house at the water tank.

The community of Glogovce will be connected to the system after the wellfield capacity is extended by adding a third well and upgrading the pumps in the aeration and pumping stations.

Technical Specifications

Wellfield

A standard bored deep well, 7.7 m deep and with a screen diameter of 300 mm, an arrangement of screen and filtration fill according to the hydrogeological investigation and a siphon pipe and suction strainer of 50 mm diameter are required. See Fig. 85 and 89 and the standard designs in Fig. 7.

A standard dug well, with 2.0 m inside diameter and 8 m deep, will be constructed as a captation and collection well. It will require filtration fill according to the hydrogeological investigation, a siphon pipe connected to the standard automatic air release equipment and a suction pipe of 125 mm diameter for the aeration station pumps. See Fig. 85 and 89 and the standard designs in Fig. 8.

Aeration station

A standard aeration station is required, including the following standard machinery and electrical equipment: pumps with a capacity of 2.5 litres per second and an aerator with a capacity of 5.0 litres per litre.

The pumps can be operated manually from the local switchboard or automatically by the levels in the wet sump of the pumping station.

The switch-off level of the electrodes will be 434.5 m above sea level and the switch-on level will be 433.5 m above sea level. A shut-off electrode will be located in the dug well at 429.56 m above sea level. See Fig. 85, 89 and 90 and the standard designs in Fig. 14–16 and 41.

Pumping station

A standard Type 2.2 pumping station, with wet sump, is required, consisting of the following machinery and electrical equipment:

- 2 horizontal pumps with a capacity of 2.5 litres per second and total delivery head of 73 m;
- 1 set of standard air release equipment;
- 1 set of standard sodium hypochlorite dosing equipment;
- 1 standard switchboard designed for the connection of the aeration station subdistribution switchboard;
- 1 set of standard lighting equipment, including light fittings, switches, socket outlets and cable installation;
- 1 pole-type transformer of 50 kVA, 10/0.4 kV;
- 190 m of overhead high-tension feed line; and
- 1650 m of control and signalling cable line between the pumping station and the water tank.

The pumps can be operated manually from the local switchboard, or automatically by the levels in the water tank.

The electrode switch-off level will be at 502.95 m above sea level and the switch-on level will be at 502.00 m above sea level. There will be a shut-off electrode in the wet sump, located at 432.70 m above sea level. See Fig. 85, 89 and 90 and the standard designs in Fig. 10–13.

Pumping main

A 100 mm-diameter PVC pipeline for a nominal pressure of 1.0 MPa is required. It must be 1643 m long and include two standard ancillary air chambers and three standard ancillary drain valve chambers. See Fig. 86–88 and 91, and the standard designs in Fig. 18, 19 and 42.

Water tank

A standard water tank with a capacity of 200 m^3 and a Type I base slab is required. The maximum water level will be 503.0 m above sea level and the bottom level will be 499.0 m above sea level. See Fig. 92 and the standard designs in Fig. 30.

Valve house

A standard valve house for two water tanks with a Type II piping arrangement is required for a tank located in front of the distribution area. Drain-piping, an access road and fencing are also needed. See Fig. 92 and the standard designs in Fig. 34, 37, 41 and 42.

Distribution network

The distribution network requires PVC piping with cast-iron fittings and adapting pipes, isolating valves with valve boxes for control from the ground, 26 fire hydrants and 11 water standpipes for a nominal pressure of 1.0 MPa, piping 100 mm in diameter and 2475 m long and 3 house connections for the administration and health centres and the school. See Fig. 86, 88 and 91 and the standard designs in Fig. 39 and 42.

Fig. 85. The wellfield area

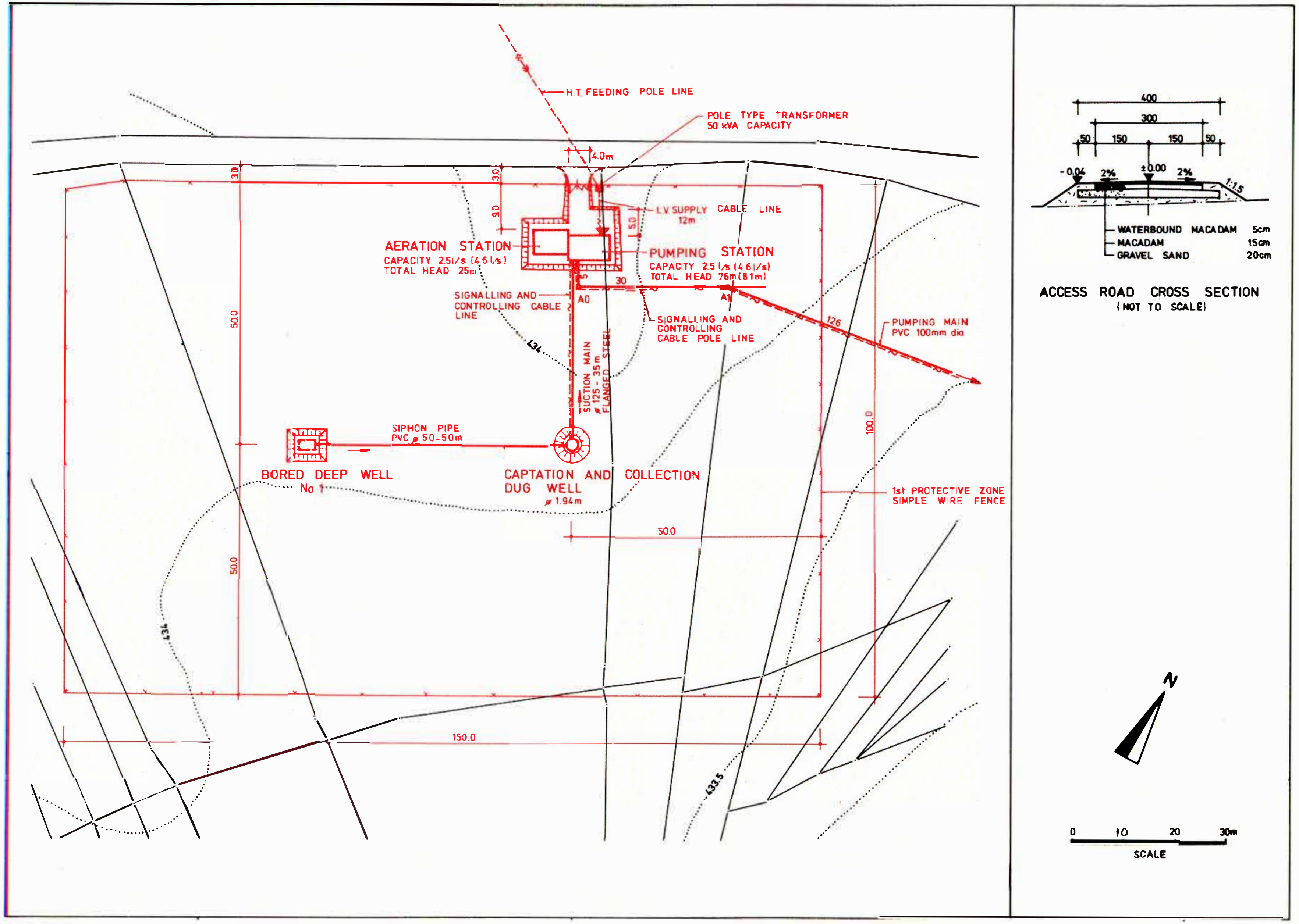


Fig. 86. Longitudinal profiles

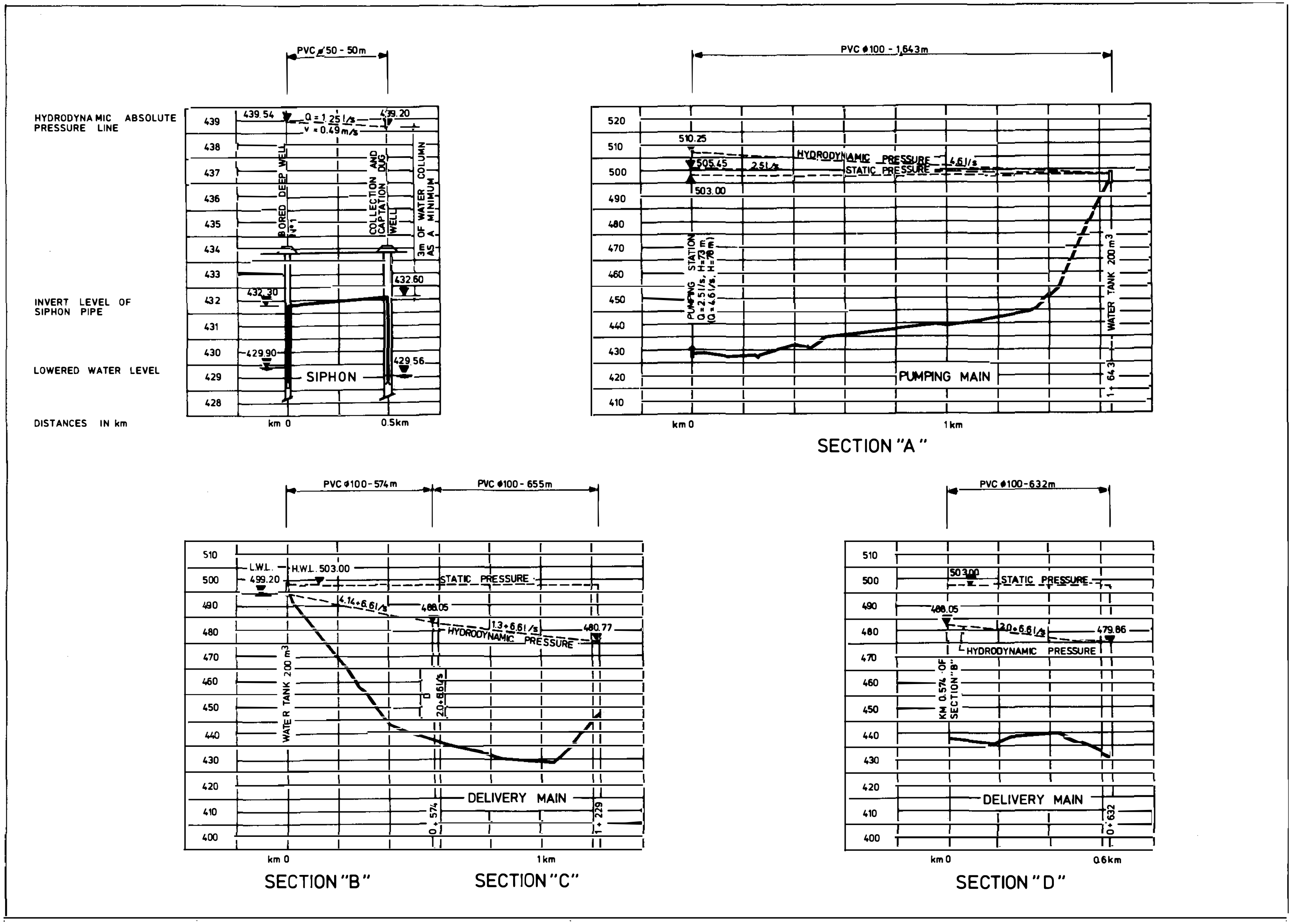
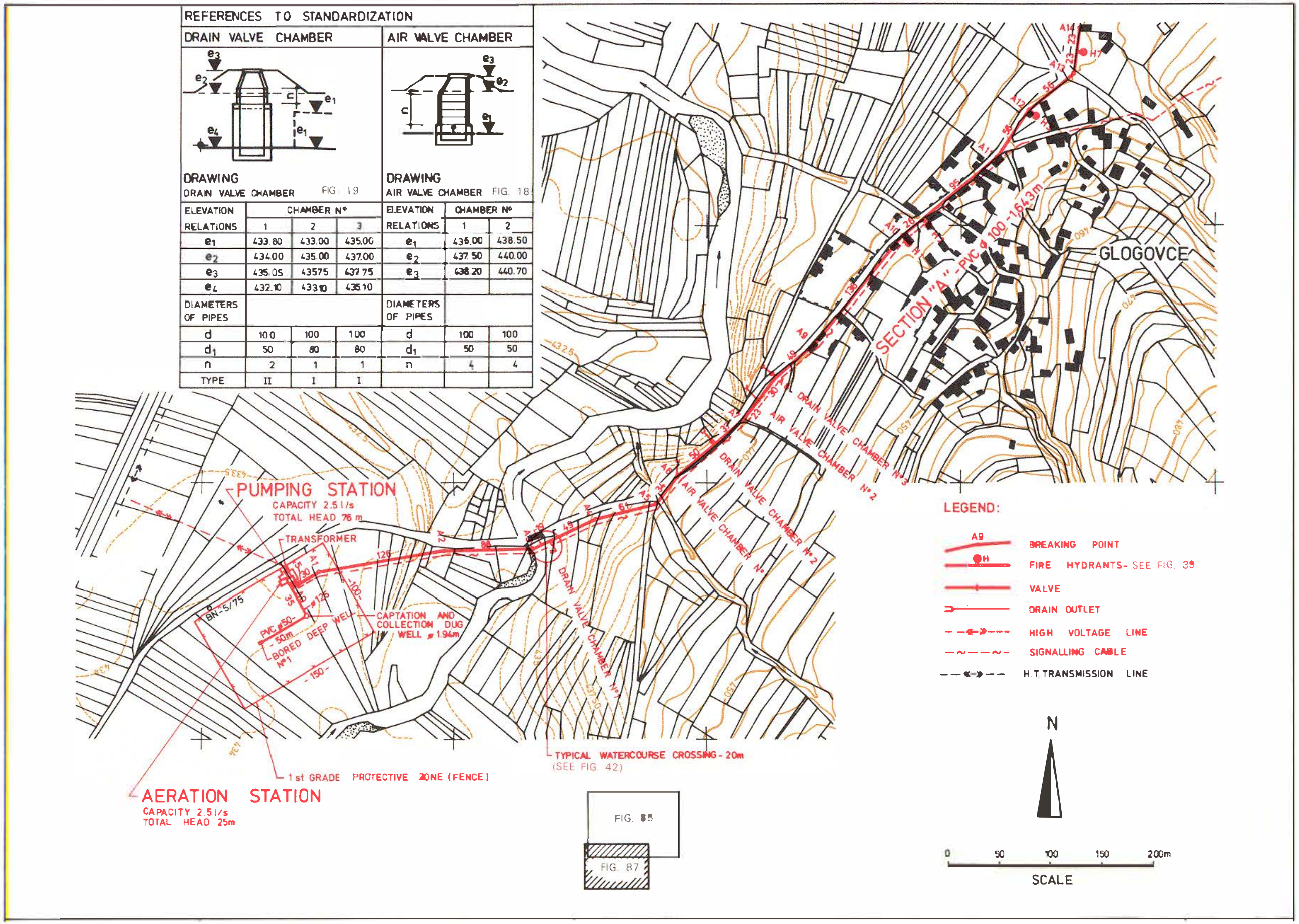


Fig. 87. Layout of the distribution system (south-west)



REFERENCES TO STANDARDIZATION

DRAIN VALVE CHAMBER

ELEVATION RELATIONS	CHAMBER Nº 1	2	3
e_1	433.80	433.00	435.00
e_2	434.00	435.00	437.00
e_3	435.05	43575	437.75
e_4	432.10	43310	435.10
DIAMETERS OF PIPES			
d	100	100	100
d_1	50	80	80
n	2	1	1
TYPE	II	I	I

AIR VALVE CHAMBER

ELEVATION RELATIONS	CHAMBER Nº 1	2
e_1	436.00	438.50
e_2	437.50	440.00
e_3	438.20	440.70
DIAMETERS OF PIPES		
d	100	100
d_1	50	50
n	4	4

Fig. 88. Layout of the distribution system (north-east)

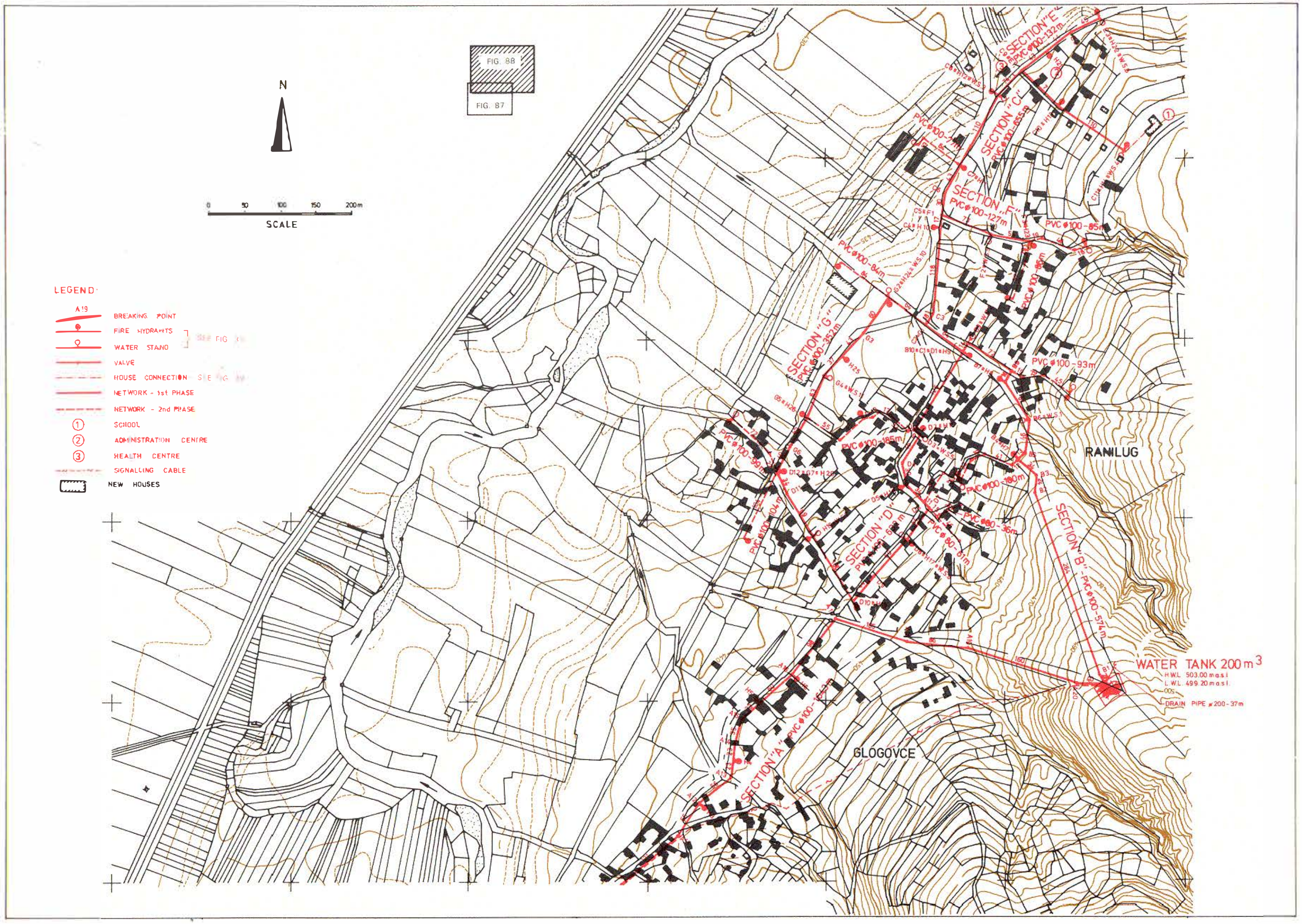


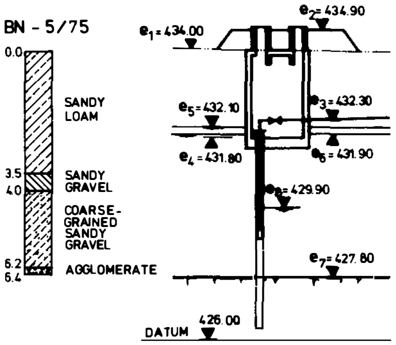
Fig. 89. Bored deep well, captation and collection dug well, pumping station and aeration station

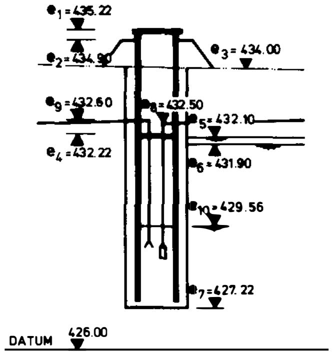
REFERENCES TO STANDARDIZATION

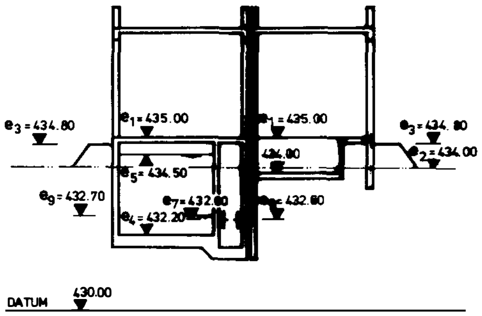
BORED DEEP WELL No1 | CAPTATION AND COLLECTION DUG WELL | PUMPING STATION | AERATION STATION

ELEVATION RELATIONS

(EXISTING GROUND ELEVATIONS TAKEN OVER FROM ORIGINAL MAP SCALE 1:2 500)







DRAWINGS

BORED DEEP WELL	FIG. 7	DUG WELL	FIG. 8	PUMPING STATION - CIVIL CONSTRUCTION-TYPE 2.2	FIG. 10	AERATION STATION - CIVIL CONSTRUCTION	FIG. 14
				PUMPING STATION - MACHINERY	FIG. 11	AERATION STATION - MACHINERY	FIG. 15
				PUMPING STATION - ELECTRICAL EQUIPMENT	FIG. 12	AERATION STATION - ELECTRICAL EQUIPMENT	FIG. 16

DIAMETERS OF PIPES

DIAMETER OF SIPHON PIPE $\varnothing d_1$ = 50mm
DIAMETER OF SCREEN D = 300mm
THICKNESS OF FILTRATION FILL d = 100mm

DIAMETER OF SUCTION PIPE $\varnothing d_1$ = 125mm
DIAMETER OF SIPHON PIPE $\varnothing d_2$ = 50mm

FIGURES
L_1 = 4.68m
L_2 = 0.20m
L_3 = 2.00m
L_4 = 6.80m
L_5 = 2.60m

SUCTION PIPE $\varnothing d_1$ = 80mm
PUMPING MAIN $\varnothing d_2$ = 100 mm

Fig. 90. The operation scheme

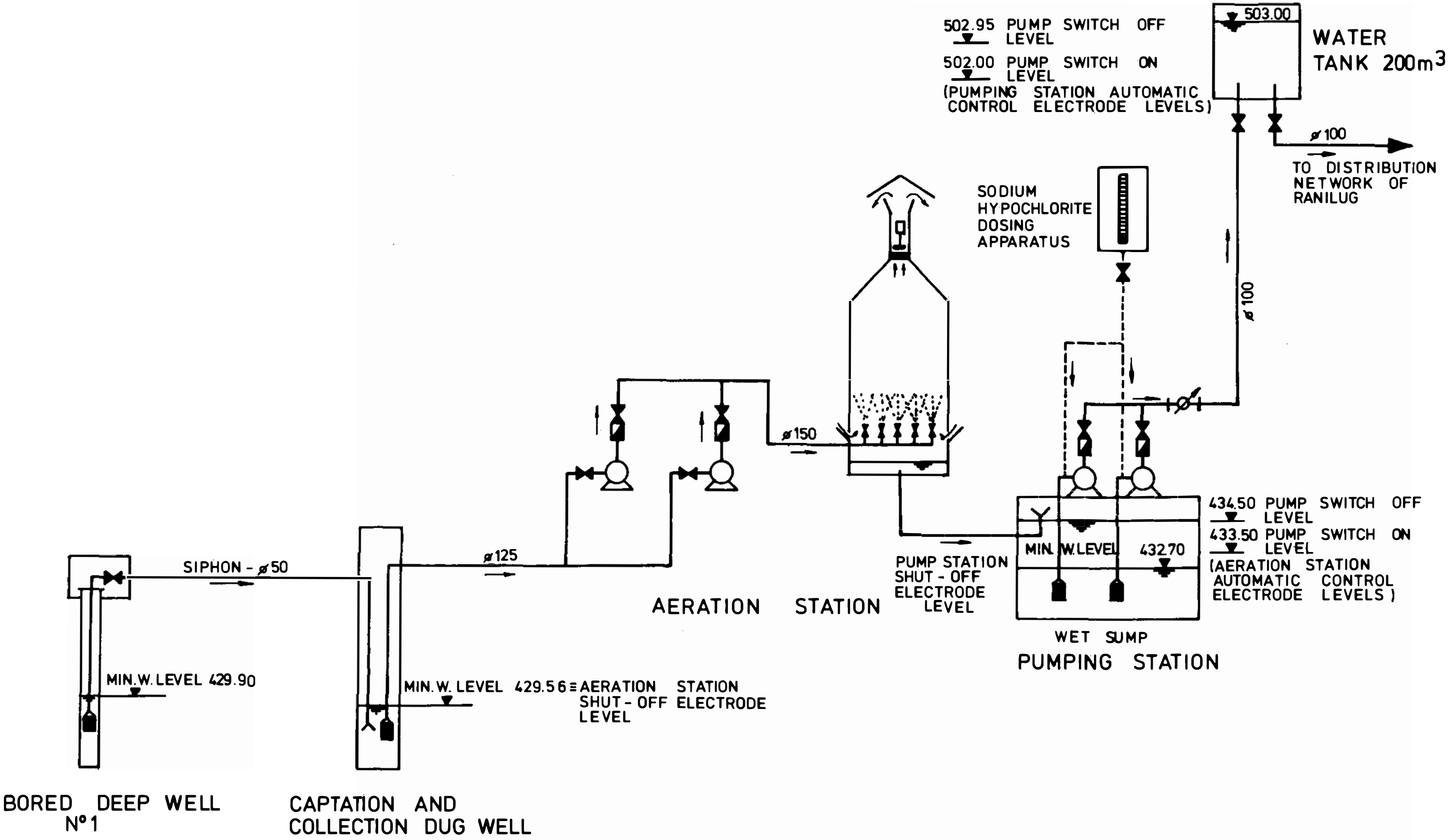
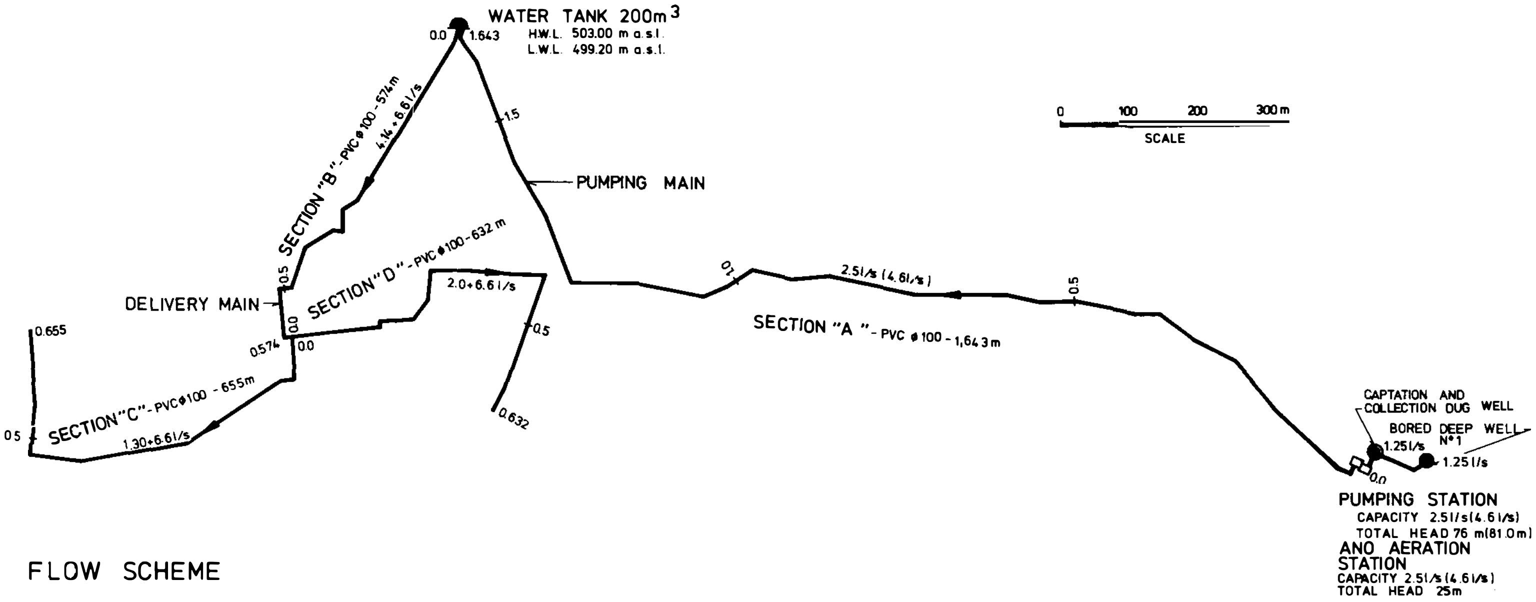


Fig. 91. Flow scheme and some basic hydraulic calculations



FLOW SCHEME

maxQd l/s	max Qh l/s	SECTION	maxQh/2 l/s	FLOW TOTAL maxQh/2 l/s	Qf l/s	TOTAL Q Qh/2+Qf l/s	LENGTH L m	ϕ PVC k = 0.01 mm	J %	V m/s	PRESS LOSS J×L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
4.6	4.6×1.8= 8.28	B	0.84	4 14	6.6	10.74	574	100	1 9431	1.44	11.15	499.20 -11.15= = 488.05
		C	1.30	1.30	6.6	7 .90	655	100	1.1113	1 06	7.28	488.05 - 7.28= =480.77
		D	2.00	2.00	6.6	8 .60	632	100	1.2960	1.15	8.19	488.05 - 8.19= =479.86

DELIVERY MAIN

maxQd l/s	LENGTH m	COEFFICIENT OF LOCAL LOSSES c	ϕ PVC k= 0.01 mm	J %	V m	PRESS. LOSSES C×J×L m	TOTAL HEAD m
4.6	1,643	1.05	100	0.4201	0.61	725	503.0-432.70+725= 77.55
2.5	1,643	1.05	100	0.1419	0.29	2.45	503.0-432.70+2.45= 72.75

PUMPING MAIN

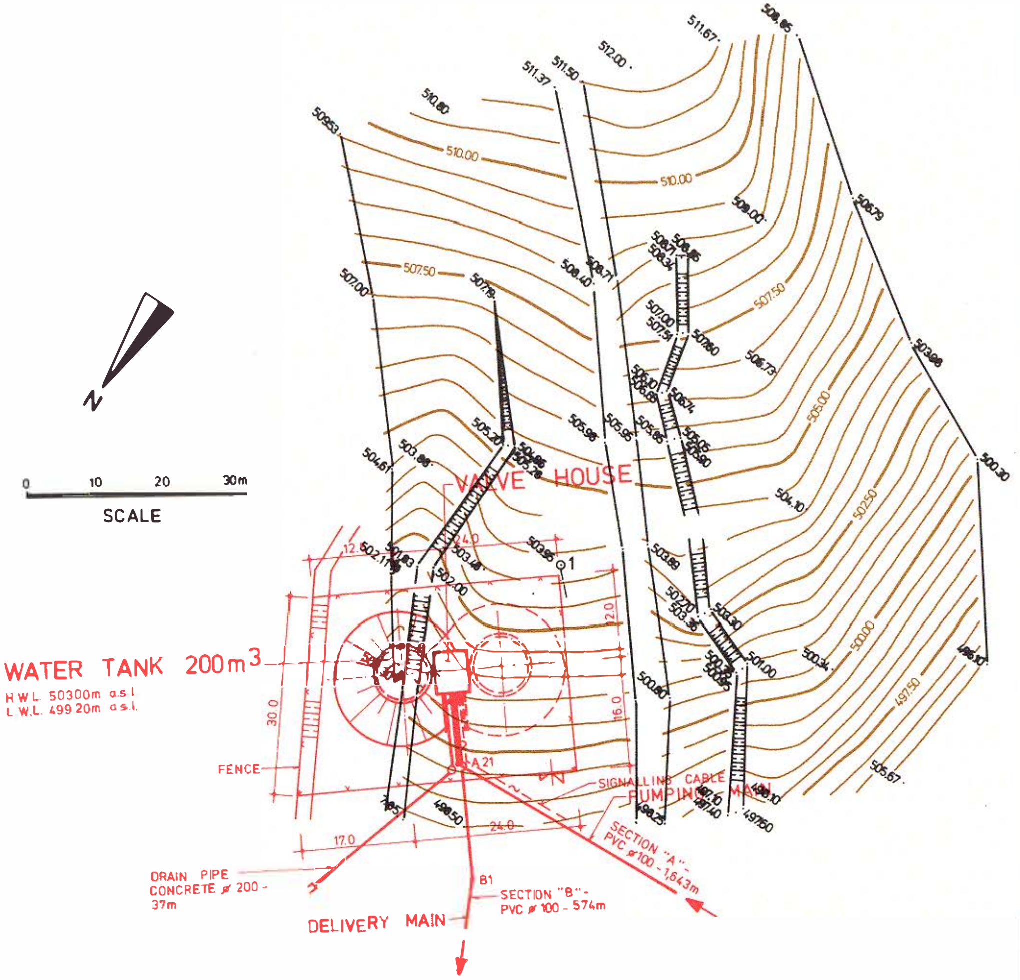
HYDRAULIC CALCULATIONS

maxQd l/s	LENGTH m	COEFFICIENT OF LOCAL LOSSES c	ø PVC k= 0.01 mm	J %	v m	LOSS OF PRESSURE h m
1.25	50+2×3	1 10	50	0.5454	0.49	0 34

SIPHON PIPE

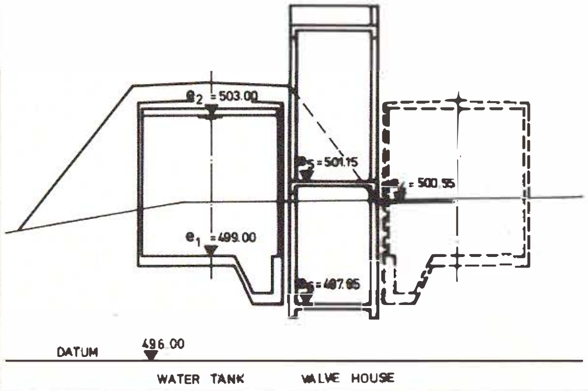
SPRING AREA LOCATION	~ 435 m a.s.l
WATER TEMPERATURE	max. 15°C
BAROMETRIC PRESSURE	9.81m OF WATER COLUMN
VAPOUR TENSION	0.17m OF WATER COLUMN
ABSOLUTE PRESSURE	9.64m OF WATER COLUMN

Fig. 92. Layout of the 200 m³ water tank



REFERENCES TO STANDARDIZATION

ELEVATION RELATIONS



DRAWINGS

WATER TANK 200m³ (TYPE I. OF BASE SLAB SUPPOSED)	FIG. 30
VALVE HOUSE FOR TWO WATER TANKS-CIVIL CONSTRUCTION . (WASTE CHANNEL ARRANGEMENT TYPE b)	FIG. 34
VALVE HOUSE FOR TWO WATER TANKS-PIPING TYPE II. (IN THE FIRST STAGE INLET AND OUTLET PIPES SHALL BE INTERCONNECTED INSIDE VALVE HOUSE. ACCORDING TO THE PIPING TYPE II. FOR ONE TANK SEE FIG. 35)	FIG. 37

DIAMETERS OF PIPES

INLET	$ød_1 = ød_1'$	= 80mm
OUTLET	$ød_2 = ød_2'$	=100mm
DRAIN PIPE	$ød_3$	= 80mm
OVERFLOW	$ød_4$	=100mm
AIR PIPE	$ød_5$	= 50mm
WASTE PIPE	$ød_6$	=200mm

Opteruša

Basic Data

The rural community of Opteruša is situated in the commune of Orahovac, 3 km in a direct line and about 5 km by road from the commune centre of the same name. The community is accessible throughout the year by a macadam road from Orahovac and from the town of Suva Reka.

The built-up area of the community is concentrated along the edge of the southern slopes of the Milanovacka Planina mountain range; the terrain is fairly rugged.

The population is employed mainly in cultivation and pastoral farming. The community has an elementary school.

In 1971, the national census placed the population of Opteruša at 1339 and, according to information provided by the provincial planning authorities, the size of the community will grow relatively slowly but steadily and should increase to about 1800 people by 1990.

In accordance with the design criteria, a per capita water consumption of 260 litres per day was adopted. This resulted in the following daily water requirements.

Total		90% (reduced for design)	
m^3/day	litres/second	m^3/day	litres/second
473	5.5	427	5.0

Water Resources

An investigation of water resources available near Opteruša was carried out during the early stages of the study. A natural spring was found, within the boundaries of the community, that was used for drinking as well as watering and washing livestock. Since there is neither a regional water supply system that the community can tap nor plans for one, the spring was investigated as a possible source of water. It is a karst spring emerging along the contact between the karst calcite layers of the Milanovac plain and the relatively impermeable adjacent argillaceous deposits.

During field reconnaissance in September 1974 the yield of the spring was estimated to be 40–50 litres per second. In October of the same year, the flow was measured as 24.2 litres per second, and historical records from 1964 to 1974 indicated the yield range of 24–78 litres per second. The minimum yield is 15 litres per second, far exceeding the demand of 5 litres per second. According to information received from local residents, the spring water sometimes became turbid after periods of heavy rain.

Although the flow of the spring apparently exceeded the required amounts, it was recommended that continuous and more systematic records of the yield be kept in the future.

The water was analysed and found to be very hard, with about 400 mg/l calcium carbonate. It was, in fact, approaching the acceptable limits for a potable supply. The high degree of hardness could result in scaling problems in cooking utensils, although this will not be a general problem since central heating is not used at present. For the time being, water softening has not been included in the design to avoid complicating the operations of a small supply system, but this may have to be considered later.

The pH of the spring water was 6.85 and it had a total solids content of 450 mg/l. The nitrate concentration, at 9.5 mg/l, was acceptable for a potable supply, and no traces of dissolvent iron or manganese were discovered. Bacteriologically, the water was contaminated to varying degrees, depending on rainfall and flow conditions, owing to the connection through the karst system to the surface.

It was decided that the spring should be used to supply water to Opteruša, but because of its quality deficiencies it was necessary to include treatment in the form of sedimentation, slow sand filtration and chlorination. Provision for water dosing with aluminium sulfate is included to deal with periods when the spring water has a high turbidity. The dosing will cause particles in the water to coagulate into flocs.

Another potential water supply source, the Mamuša wellfield, was studied at the preliminary engineering stage (see dashed line in Fig. 93) but this solution was less feasible, so it was not developed in the design.

Water Supply System

Water from the spring will flow by gravity into a treatment plant. After treatment it will be pumped through the distribution network and into a water tank behind the consumption area.

The main elements of the system and their capacities will meet future requirements while the pumping station machinery has been designed for the first stage of development only, with a capacity of 3 litres per second, and should be upgraded at a later date (see Fig. 93 and 94).

Although the whole system consists of standard structures, the standard spring intake structure had to be modified to meet local conditions and needs and to provide necessary hygienic protection to the source.

A new spring intake structure will be constructed to replace the existing one and will include, outside its first protection zone, a cattle-watering structure (see Fig. 95–97).

The whole structure has been designed to cope with a water yield within the range of 15–78 litres per second, while for safety and security reasons the drainage system has been designed to carry away double the maximum anticipated yield. This precaution is recommended particularly when previous maximum spring yields have been estimated on the basis of local information and insufficient records or when regular and systematic measurements have been taken only over a limited period.

The spring intake structure consists of a cylindrical lining of watertight reinforced concrete. It will be founded on the rock sub-base about 2 m below the existing top rock level at the spring. A strainer and a 100 mm-diameter sluice valve will be fitted on the 100 mm-diameter PVC water main inside the spring intake structure, in order to convey the water to the treatment plant located almost 300 m from the spring. The yield of the spring can be measured by a measuring weir inside the intake structure.

This is an example of the need to design a special structure when the standard design does not meet a particular set of circumstances. This is more likely to occur for spring intake structures than wells, because their shape and layout are more susceptible to variation because of geological or topographical conditions.

A 400 mm-diameter drain-pipe will provide water to a specially designed cattle-watering structure. It will also serve as a cattle ford across the outlet channel. The structure will be surrounded by a peripheral wall of plain concrete with a safety railing and an outlet overflow board that also empties and cleans the basin. The bottoms of the channels will be of stone pitching.

The structure is an example of appropriate technology: when a relatively simple structure of a type already familiar to the local population will be provided to satisfy a large part of its water needs.

To protect the spring from direct contamination, a protection zone, including fencing and an open ditch, has been proposed around the point of issue of the flow. A second protection zone is proposed to extend 50 m west and east of the spring, including the part of the community north of the spring and the area above the community up to 300 m above the Suva Reka–Orahovac road.

The intake structure should be visited and checked at least once per month as well as after long periods of rain and after normal high flow conditions such as the seasonal snow melt. During these visits the flow should be checked and carefully recorded and water samples should be taken for physical examination and chemical analysis.

The water treatment plant will consist of a sedimentation tank, a slow sand filter and a pumping station to deliver the treated water through the distribution system to the water tank. Its general layout is presented in Fig. 98.

A standard sedimentation tank has been designed to handle a flow range of 3–5 litres per second. Its main dimensions will be modified according to the parameters presented in the table of treatment plant loadings (see Table 14).

A standard slow sand filter plant has been designed with the same capacity as the sedimentation tank. Due to the water temperature and quality, the filter beds may be constructed without roofing. The main parameters of the plant are presented in Table 14 and in Fig. 97.

The water coming from the Opteruša spring will be dosed with aluminium sulfate and sodium hypochlorite during the treatment process. The aluminium sulfate dosing will facilitate the settling process, but it is anticipated that this will be required only when the spring water becomes turbid after periods of heavy rain.

During periods of medium turbidity it is estimated that an aluminium sulfate dose of 15 mg/l will be required, rising to around 50 mg/l during periods of exceptionally high turbidity. The actual amounts will be determined by operating experience. Initially, a supply of chemical equivalent to a dosage of 15 mg/l for half the year can be used as an annual requirement.

A standard pumping station at the treatment plant has been designed to deliver the treated water to a standard water tank of 250 m^3 capacity located behind the area of consumption.

The hydraulic calculations showed that water hammer protection equipment should be included in the pumping station. A graphical check of the standard damping equipment is presented in Fig. 99.

Table 14. Treatment plant loadings

Characteristics (maximum quantity/day)	First stage (10.8 m^3/h = 259.2 m^3/d)	Final stage (18.0 m^3/h = 432 m^3/d)
Sedimentation tank		
width at the bottom	1.40 m	1.40 m
width at the water level	3.60 m	3.60 m
average width	2.50 m	2.50 m
length	15 m	15 m
depth of water	1.10 m	1.10 m
settling area	37.5 m^2	37.5 m^2
cross-sectional area	2.75 m^2	2.75 m^2
volume of water	41.25 m^3	41.25 m^3
retention time	3.82 h	2.29 h
horizontal velocity	3.93 m/h = 1.09 mm/s	6.55 m/h = 1.82 mm/s
surface loading	0.29 m/h = 0.08 mm/s	0.48 m/h = 0.133 mm/s
(width of tank) : (length of tank)	1 . 6	1 : 6
(depth of water) : (length of tank)	1 : 13.6	1 : 13.6
Slow sand filters		
filter bed length	11.10 m	11.10 m
number of units in operation	2	3
filtration area	79.92 m^2	119.88 m^2
filtration velocity	3.24 m/d = 0 135 m/h	3.60 m/d = 0.15 m/h

The standard machinery and electrical equipment of the pumping station are designed for fully automatic operation. The pumping will be controlled by electrodes in the water tank. The signals will be transmitted from the tank to the pumping station by a ground cable line. The water flow meter will be installed on the delivery pipe inside the pumping station.

A standard gravity dosing system will chlorinate the water with sodium hypochlorite. The required dose will correspond to the quantity of water coming to the treatment plant and the feed control will be manual.

The whole treatment plant area, for security reasons and to avoid contamination through unauthorized access, will be surrounded by a wire-mesh fence similar to that surrounding the spring intake structure. Power for the treatment plant will be supplied from a 10 kV overhead line passing north of Opteruša. A branch overhead line will lead to a pole-type transformer of 30 kVA, 10/0.4 kV located at the treatment plant.

A water tank of 250 m^3 capacity will be located north of Opteruša, with the maximum water level at 452.00 m above sea level. Its capacity will be sufficient to cover the demand of the final design period.

Technical Specifications

Spring intake structure

A non-standard spring intake structure for a capacity range of 15–78 litres per second, including access road, fencing and open ditch, will be required. A non-standard structure for cattle watering is included. See Fig. 95, 96 and 100.

Water treatment plant

A standard sedimentation tank for a capacity range of 3–5 litres per second is required, with a settling compartment 15 m long, a water depth of 1.1 m, a PVC pipeline of 100 mm diameter and total length of 270 m including the bypass pipe.

Also required is one standard slow sand filtration plant for a capacity of 3 litres per second, with three filter units (two of them in operation), an unroofed filter bed length of 11.1 m and a pumping station, with the following machinery and electrical equipment:

- 2 horizontal self-priming pumps with a capacity of 3 litres per second and total delivery head of 70 m;
- 1 set of standard sodium hypochlorite dosing equipment;
- 1 set of standard aluminium sulfate dosing equipment;
- 1 standard water hammer damping device;
- 1 standard domestic water supply booster station;
- 1 standard switchboard for the operation and control of the machinery mentioned above;
- 1 set of standard lighting equipment, including light fittings, switches, socket outlets and cable installation;
- 750 m of overhead high-tension feeding line;
- 1 pole-type transformer of 30 kVA, 10/0.4 kV; and
- 1020 m of control and signalling cable line between the treatment plant and the water tank.

See Fig. 97–99 and the standard designs in Fig. 21–27 and 41.

Water tank

A standard water tank with a capacity of 250 m^3 and a Type I base slab is required, with the maximum water level at 452.0 m above sea level and the bottom level at 448.0 m above sea level. See Fig. 101 and the standard designs in Fig. 31.

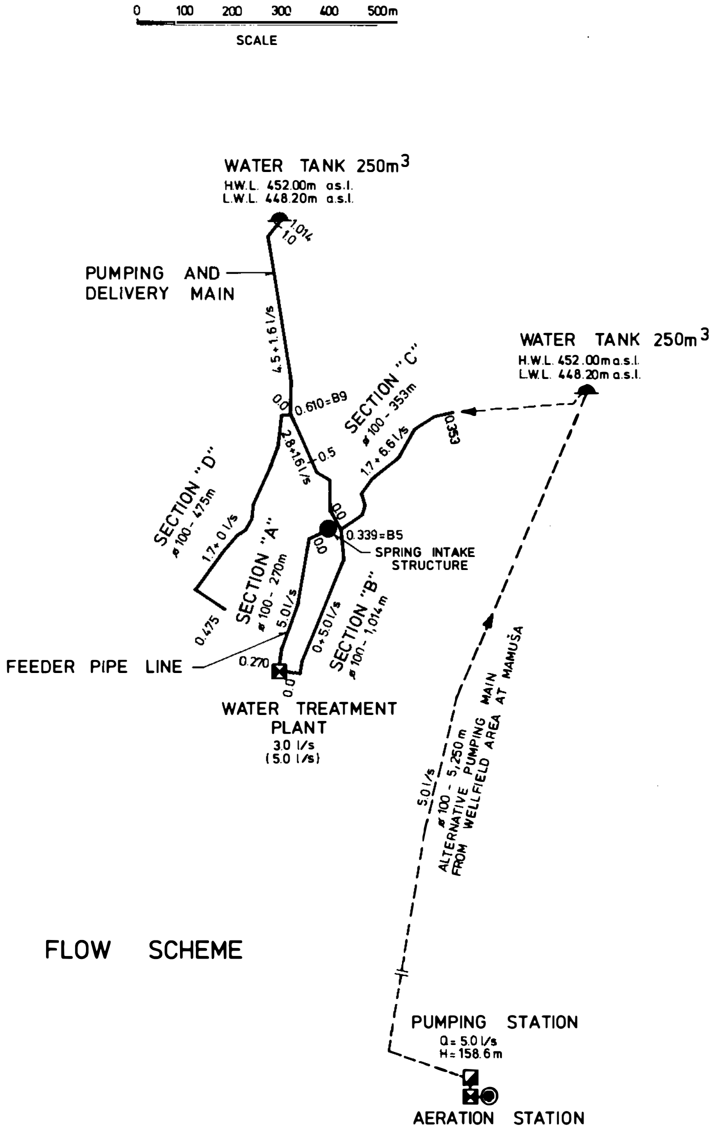
Valve house

A standard valve house for one water tank with a Type III piping arrangement for a tank located behind the consumption area is required, along with a drain-pipe, access road and fencing. See Fig. 101 and the standard designs in Fig. 33, 38, 41 and 42.

Distribution network

The distribution network includes PVC piping with cast-iron fittings and adapting pipes; isolating valves with valve boxes for control from the ground; 20 fire hydrants and 9 standpipes for a nominal pressure of 1.0 MPa; pipe of 100 mm diameter and a total length of 2345 m; and one house connection for the school. See Fig. 93, 94 and 102 and the standard designs in Fig. 39 and 42.

Fig. 93. Flow scheme and some basic hydraulic calculations



max Qd l/s	max Qh l/s	SECTION	maxQh/2 l/s	FLOW TOTAL max Qh/2 l/s	Qf l/s	TOTAL Q= Qh/2+Qf SEE SCHEME	LENGTH L m	ø PVC k=0.01 mm	J %	v m/s	PRESS. LOSS J× L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
5.0	5.0x1.8 =9.0	B(W.T.-B9)	0	4.5	1.6	6.1	404	100	0.6971	0.82	2.82	448.20 - 2.82= = 445.38
		B(B9 - B5)	1.1	2.8	1.6	4.4	271	100	0.3882	0.58	1.05	445.38- 1.05= = 444.33
		C	1.7	1.7	6.6	8.3	353	100	1.2154	1.12	4.29	444.33- 4.29= = 440.04
		D	1.7	1.7	0	1.7	475	100	0.0722	0.22	0.34	445.38 - 0.34= = 445.04
		B(W.T.P-B5)	0	0	5.0	5.0	339	100	0.4880	0.67	1.65	444.33+ 1.65= = 445.98

DELIVERY MAIN (FOR JUDGING OF HYDRODYNAMIC PRESSURE AT THE END OF SECTION "C" THE SIMULTANEOUS WATER SUPPLY FROM THE WATER TREATMENT PLANT AND FROM THE WATER TANK IS SUPPOSED.)

maxQd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES C	ø PVC k=0.01 mm	J %	v m/s	PRESSURE LOSSES C× J× L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
5.0	270	1.2	100	0.488	0.67	1.58	394.065-1.58= 392.485

FEEDER PIPE LINE

max Qd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES C	ø PVC k=0.01 mm	J %	v m/s	PRESSURE LOSSES C× J× L m	TOTAL HEAD m
5.0	1,014	1.05	100	0.488	0.67	5.20	452.00- 387.20+5.20= 70.0

PUMPING MAIN
FEEDING OF WATER TANK AT NIGHT, CONSUMPTION=0

maxQd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES C	ø A.C. k=0.4 mm	J %	v m/s	PRESSURE LOSSES C× J× L m	TOTAL HEAD m
5.0	5,250	1.05	100	0.6273	0.64	34.58	452.00-328.00+34.58=158.6
3.3 (av Qd)	5,250	1.05	100	0.2816	0.42	15.52	452.00-328.00+15.52= 139.5

ALTERNATIVE PUMPING MAIN FROM WELLFIELD AREA AT MAMUŠA

HYDRAULIC CALCULATIONS

Fig. 94. Longitudinal profiles

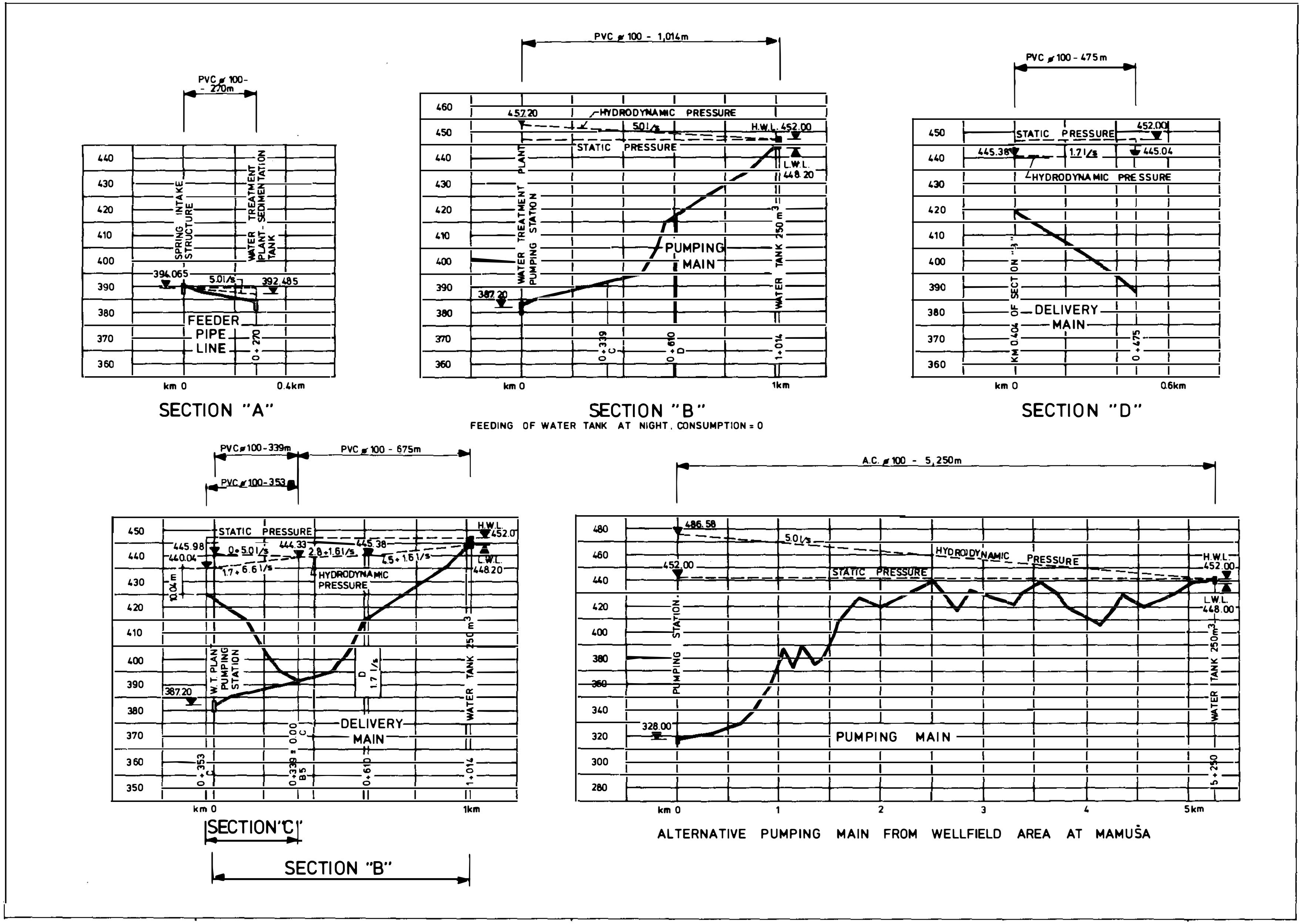


Fig. 95. Layout of the spring intake structure

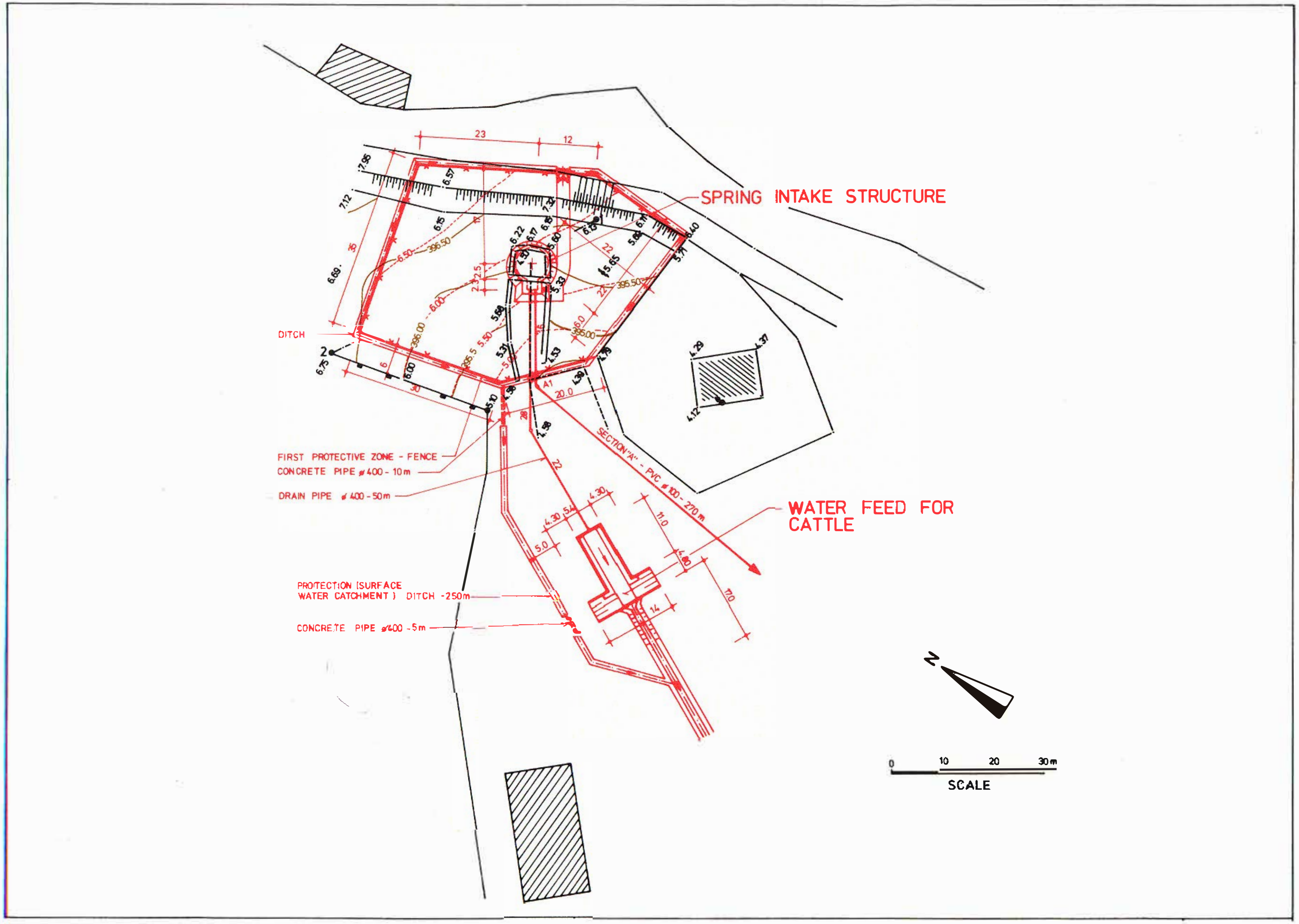
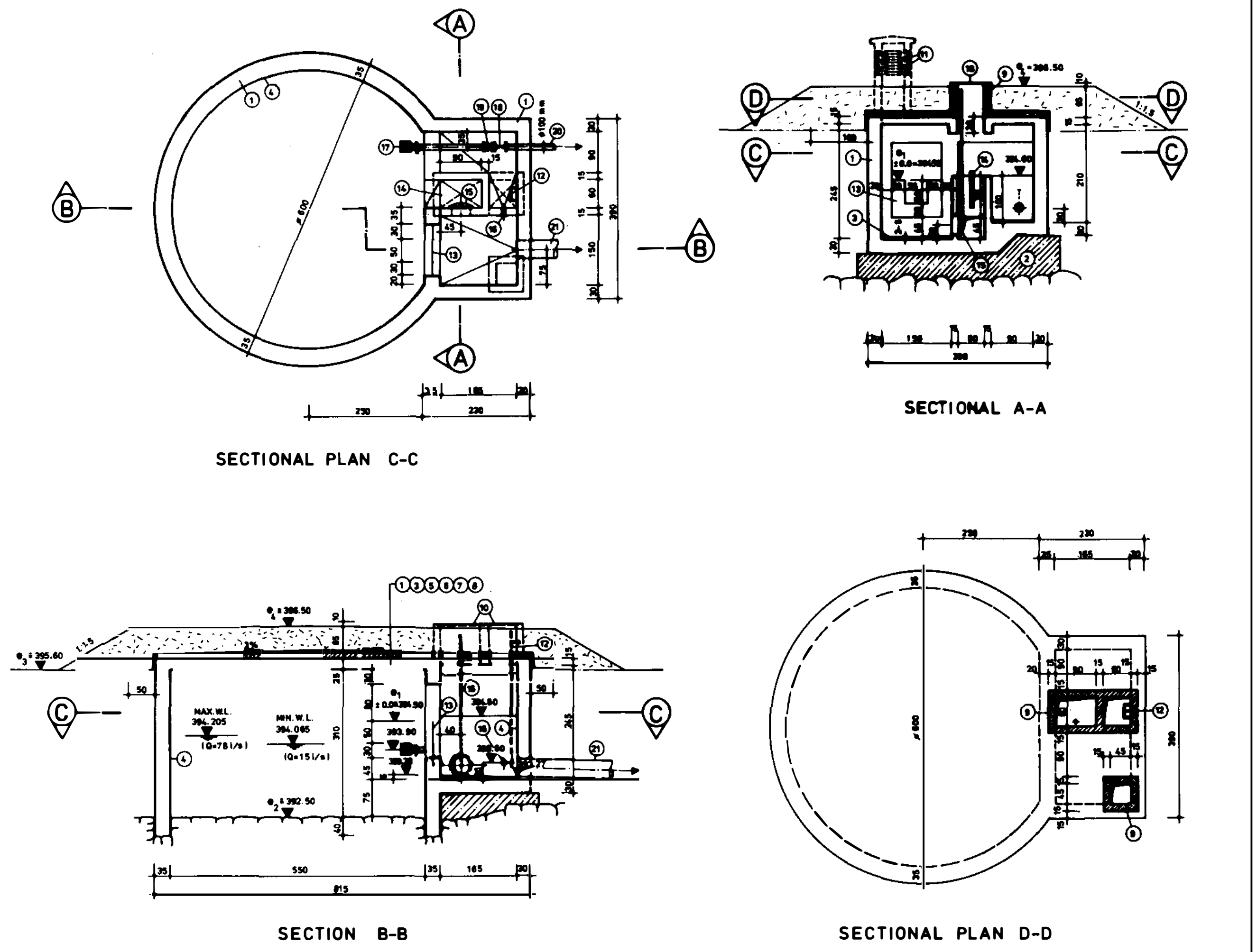


Fig. 96. Cross-sections of the spring intake structure



SECTIONAL PLAN C-C

SECTIONAL A-A

SECTION B-B

SECTIONAL PLAN D-D

ELEVATION RELATIONS

ELEVATION OF EXISTING SPRING: e_1 = 394.50
REFORMED BOTTOM OF SPRING: e_2 = 392.50
EXISTING GROUND: e_3 = 395.60
REFORMED GROUND: e_4 = 396.50

LEGEND:

1. WATERTIGHT REINFORCED CONCRETE
2. PLAIN CONCRETE
3. BENCHING TO GRADIENT
4. DISINFECTION PAINT
5. CEMENT PLASTER
6. WATERPROOF INSULATION
7. PROTECTING CEMENT SCREED
8. COMPACT FILL AND HUMUS
9. PLAIN. CONCRETE
10. CAST IRON COVER
11. VENTILATION
12. STEEL LADDER
13. MEASURING WEIR
14. MEASURING SCALE
15. PENSTOCK ø400 mm
16. DRAIN PIPE ø100 mm
17. INLET STRAINER
18. VALVE
19. MAKE-UP PIECE
20. FEEDER PIPE LINE ø100 mm
21. DRAIN PIPE ø400 mm

MEASURING WEIR, CAPACITY DATA.

h IN cms ON SCALE	FLOW IN l/s	h IN cms ON SCALE	FLOW IN l/s
2.0	2.5	14.0	45.3
3.0	4.7	15.0	50.0
4.0	7.2	16.0	54.8
5.0	10.0	17.0	59.8
6.0	13.1	18.0	64.9
7.0	16.5	19.0	70.0
8.0	20.0	20.0	75.3
9.0	23.6	21.0	80.6
10.0	27.7	22.0	86.1
11.0	31.9	23.0	91.6
12.0	36.2	24.0	97.3
13.0	40.7	25.0	103.0

NOTE:
SCALE ZERO ON THE ELEVATION 394.00

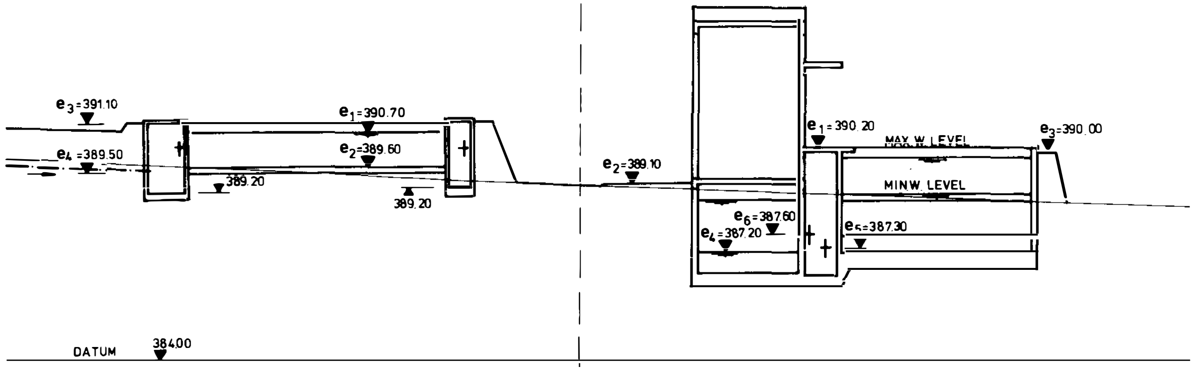
0 1 2 3m
SCALE

Fig 97. Water treatment plant

REFERENCES TO STANDARDIZATION

SEDIMENTATION TANK | FILTRATION STATION

ELEVATION RELATIONS



DRAWINGS

SEDIMENTATION TANK	FIG 21 AND 22

FILTRATION STATION - CIVIL CONSTRUCTION	FIG 23
FILTRATION STATION - VIEWS	FIG 24
FILTRATION STATION - MACHINERY	FIG 25
FILTRATION STATION - ELECTRICAL EQUIPMENT	FIG 26 AND 27

DIAMETERS OF PIPES

INLET	ød_1 = 100 mm
OUTLET (BYPASS)	ød_2 = 100 mm
OVERFLOW	ød_3 = 150 mm
DRAIN PIPE	ød_4 = 80mm

RAW WATER INLET	ød_1 = 100mm
PUMPING MAIN	ød_2 = 100 mm
CONNECTION OF PRESSURE VESSEL TO PUMPING MAIN	ød_3 = 80mm

BASIC DIMENSIONS

GROUND WIDTHS	b_1 = 150 cm b_2 = 440 cm
DEPTH OF WATER	h = 110 cm
LENGTH	L = 15.0m

FILTER BED LENGTH	L_1 = 11.1m
TOTAL LENGTH OF FILTRATION STATION	L_2 = 20.1m
FILTER GALLERY LENGTH	L_3 = 13.5m
NUMBER OF SECTIONS	n = 3

Fig. 98. Layout of the water treatment plant

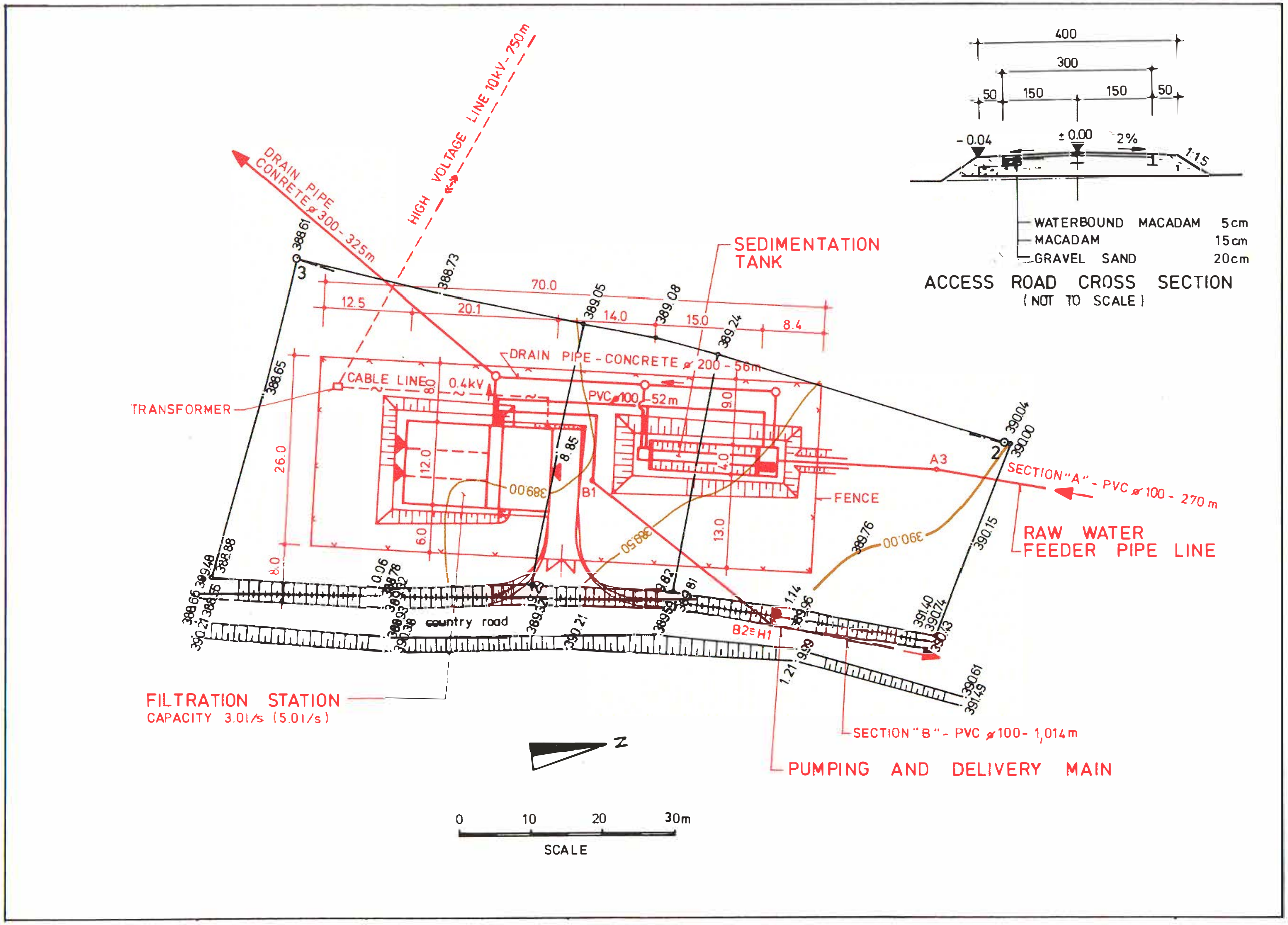
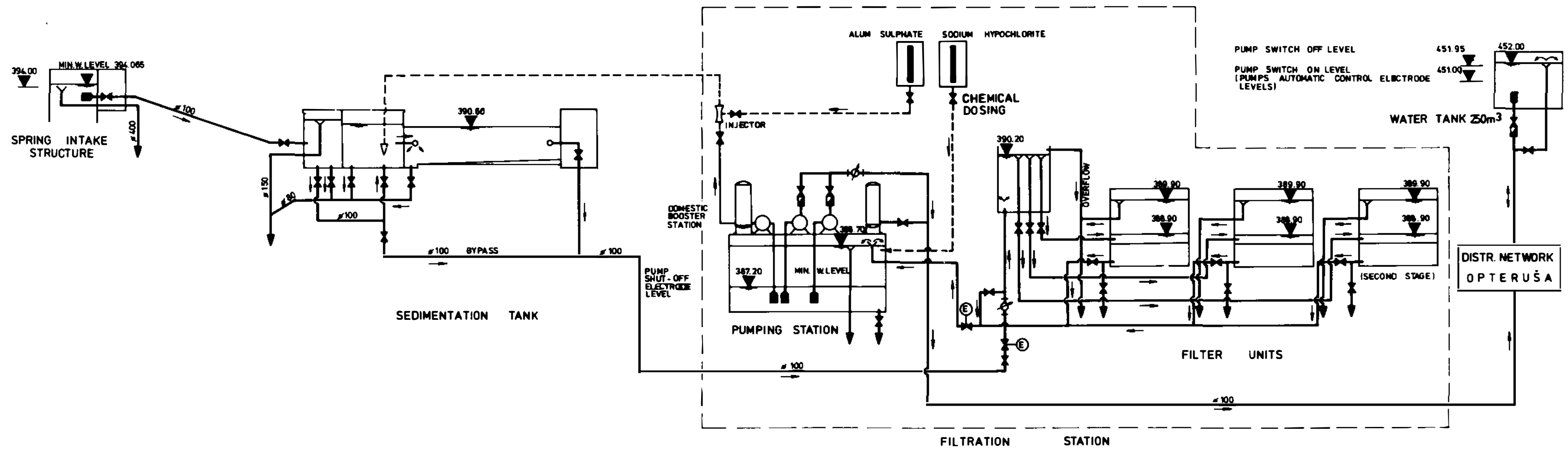
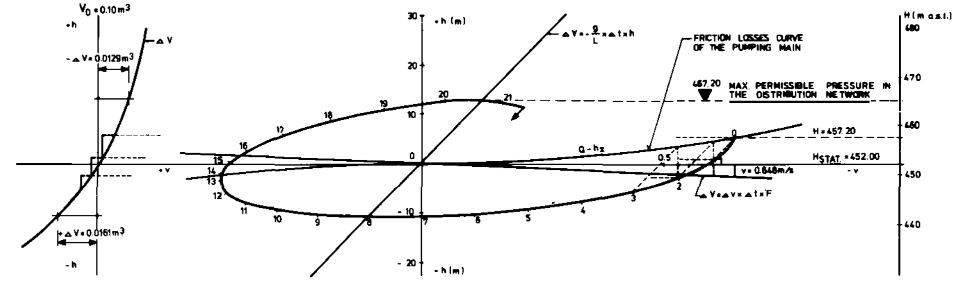


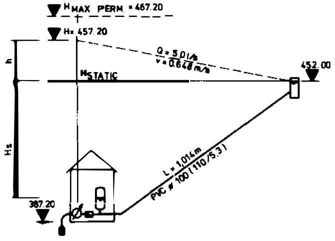
Fig. 99. Operation scheme and water hammer calculations



OPERATION SCHEME



GRAPHICAL CHECK OF PRESSURE VESSEL VOLUME BY EQUIVALENT SURGE TANK METHOD



CALCULATION SKETCH

BASIC DATA FOR THE GRAPHICAL CALCULATION

2nd STAGE QUANTITY OF FLOW	Q_o	= 5.0	l/s
LENGTH OF PUMPING MAIN	L	= 1,014	m
INSIDE DIAMETER OF PIPE LINE	D	= 100	mm
OUTSIDE DIAMETER AND WALL THICKNESS OF PIPE LINE	D'/s	= 110/5.3	mm
MODULUS ELASTICITY OF PVC PIPES	E	= 3×10^3	MPa
INITIAL VELOCITY IN THE PUMPING MAIN	v	= 0.648	m/s
ACCELERATION OF GRAVITY	g	= 9.81	m/s^2
WAVE VELOCITY	a	= 383	m/s
ESTIMATED AIR VOLUME IN THE PRESSURE VESSEL UNDER STATIC CONDITIONS	V_o	= 0.10	m^3
INTERVAL OF TIME	Δt	= 1.012	s
STATIC PRESSURE	H_s	= 64.80	m
BAROMETRIC PRESSURE	H_b	= 10.00	m
CROSS SECTIONAL AREA OF PUMPING MAIN	F	= 0.00785	m^2

AIR VOLUME CHANGE ΔV IN THE PRESSURE VESSEL

$$\Delta V = \frac{1}{\varkappa} \times \frac{V_o (H_s + H_b)^{\frac{1}{\varkappa}}}{(H_s + H_b + \Delta H)^{1+\frac{1}{\varkappa}}} \times \Delta H$$

$\varkappa = 1$ FOR ISOTHERMIC EXPANSION

$V_o = 0.10 m^3$

$H_s = 64.80$

$$\Delta V = 1 \times \frac{0.10\,(64.80 + 10)^1}{\text{[illegible]}} \times \Delta H$$

ΔH	$74.8 + \Delta H$	$(74.8 + \Delta H)^2$	$\frac{7.48}{(74.8 + \Delta H)^2}$	×	ΔH
10	84.80	7 190	0.001410		0.0141
20	94.80	8 999	0.000833		0.0166
30	104.80	10 950	0.000663		0.0205
- 10	74.80	5 610	0.001335		- 0.0133
- 20	54.80	4 200	0.001780		- 0.0356

RESULT: FOR THE PROTECTION AGAINST WATERHAMMER THE PRESSURE VESSEL OF 0.5 m^3 OF TOTAL VOLUME WITH AIR VOLUME OF 0.10 m^3 UNDER STATIC CONDITIONS IS SUFFICIENT

Fig. 100. Structure for cattle watering

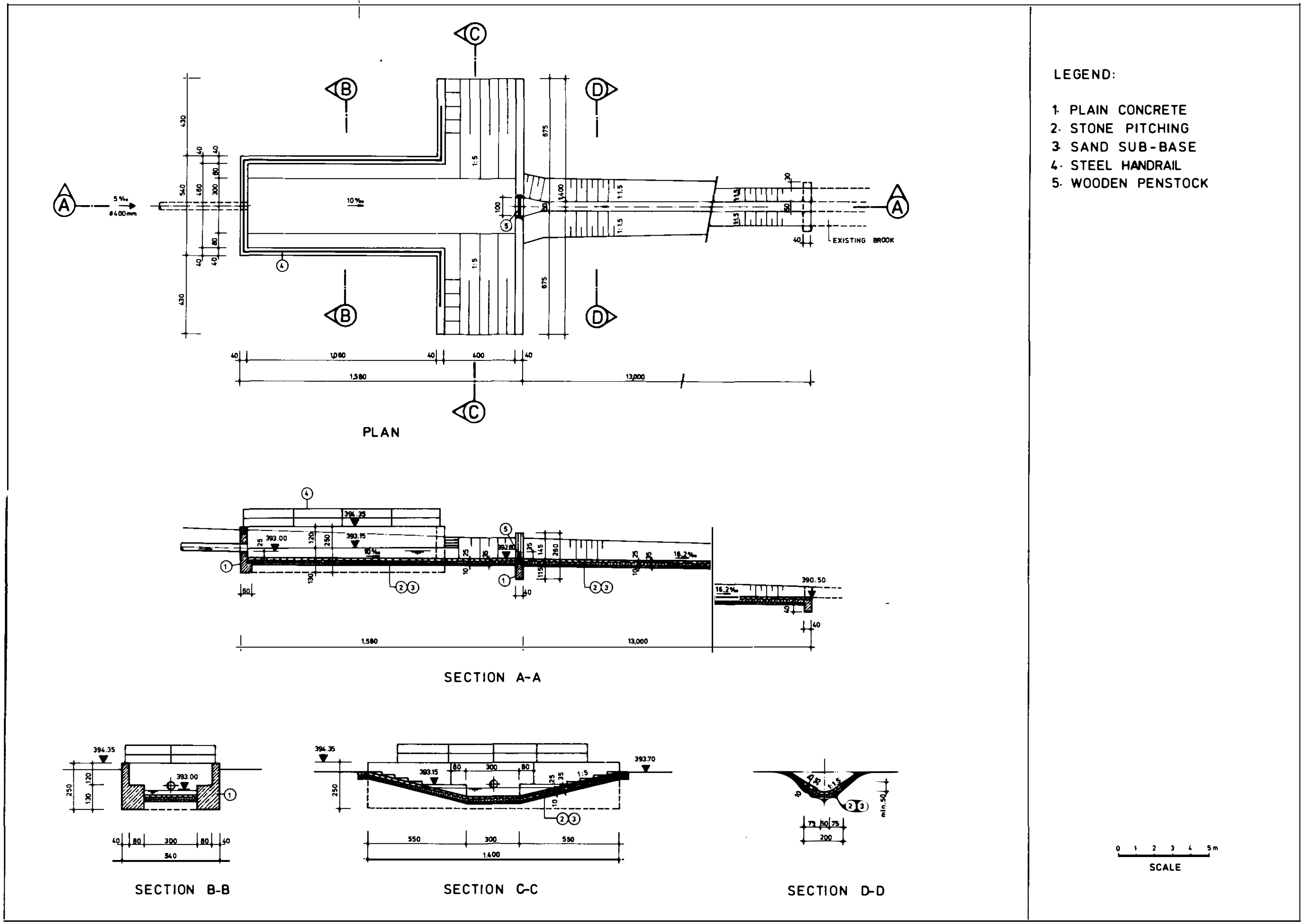
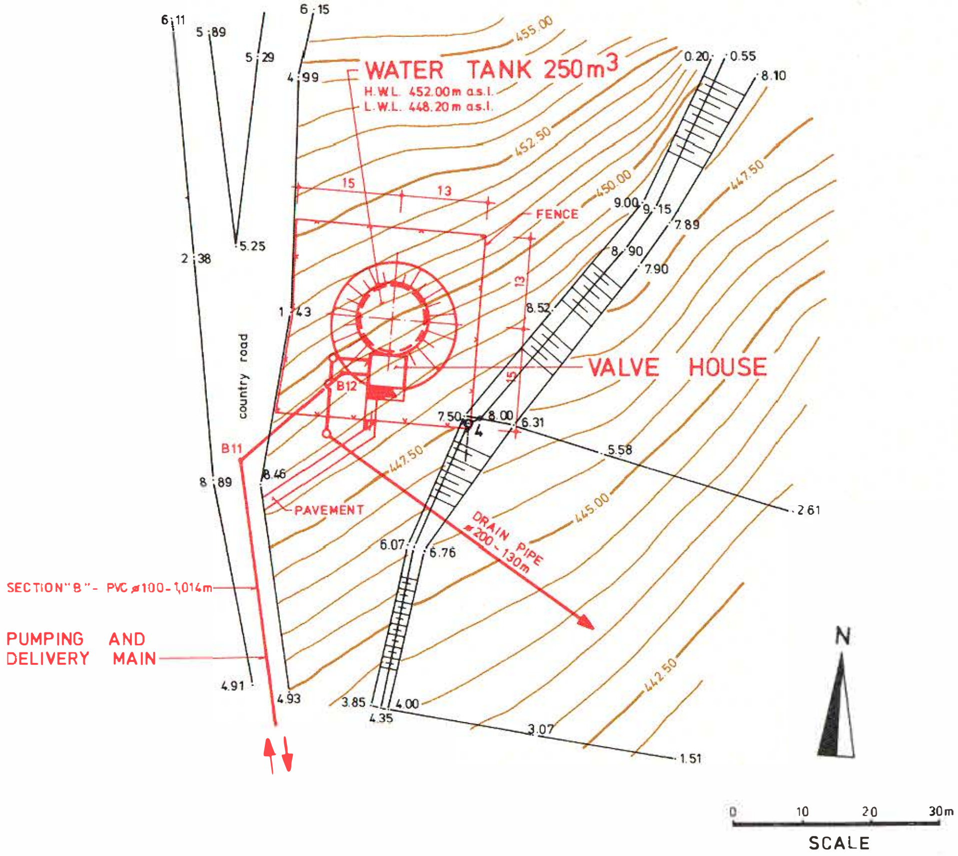
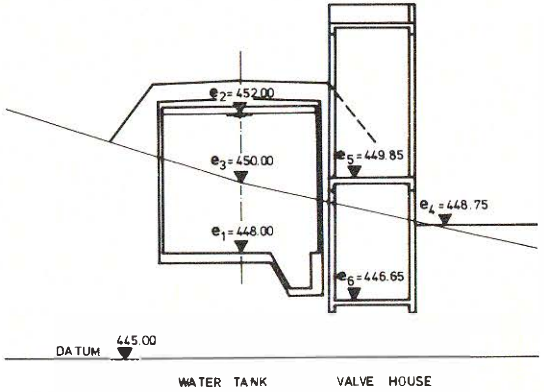


Fig. 101. Layout of the 250 m³ water tank



REFERENCES TO STANDARDIZATION

ELEVATION RELATIONS



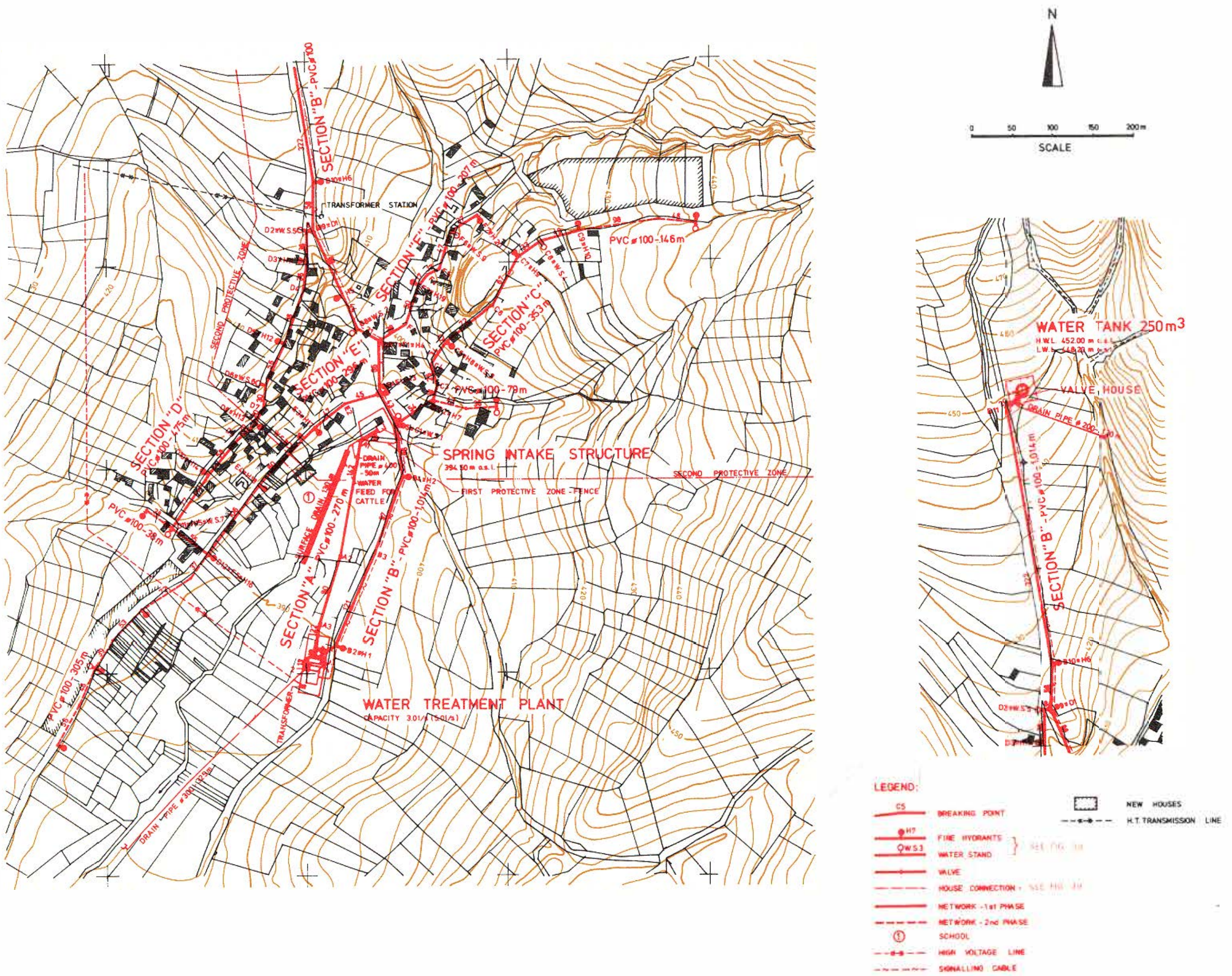
DRAWINGS

WATER TANK 250m³ (TYPE I. OF BASE SLAB SUPPOSED)	FIG. 31
VALVE HOUSE FOR ONE WATER TANK - CIVIL CONSTRUCTION (WASTE CHANNEL ARRANGEMENT TYPE b)	FIG. 33
VALVE HOUSE FOR ONE WATER TANK - PIPING TYPE III.	FIG. 38

DIAMETERS OF PIPES

INLET	$\varnothing d_1$ = 80mm
OUTLET	$\varnothing d_2$ = 125mm (OUTSIDE THE VALVE HOUSE $\varnothing d_2$ = 100mm SEE LAYOUT)
DRAIN PIPE	$\varnothing d_3$ = 80mm
OVERFLOW	$\varnothing d_4$ = 80mm
AIR PIPE	$\varnothing d_5$ = 50mm
WASTE PIPE	$\varnothing d_6$ = 200mm

Fig. 102. Layout of the distribution system



Vranič

Basic Data

The rural community of Vranič is situated in the commune of Suva Reka at a distance of 4.5 km in a direct line, and about 8 km by road, from the commune centre of the same name. The community can be reached only by driving a cross-country vehicle along a field track 6 km long from the neighbouring community of Sopina, located on the main Suva Reka–Prizren road.

The township is built in rather rugged terrain along the valley of the Vranicka Reka River in the northern foothills of the Bukova Glava range. Its single street branches into three in the lower, flatter area. This configuration determined the layout of the distribution system.

The population of Vranič works in agriculture. According to the 1971 census the population of Vranič was 1422 and there were no plans for significant development of the community, although the population was expected to rise to about 1600 by 1990.

In accordance with the design criteria, a per capita water consumption of 260 litres per day was adopted. This resulted in the following daily water requirements.

Total		90% (reduced for design)	
m^3/day	litres/second	m^3/day	litres/second
408	4.7	367	4.2

Water Resources

An investigation of the surrounding countryside and plans for development showed no possibility of connecting Vranič to a regional water supply system. A spring was identified, however, about 5 km east of the community. It is on the slopes of the Bukova Glava range, higher than Vranič, so that water could be supplied by gravity.

In fact there are two springs very close to each other, the Crno Vrelo and the Belo Vrelo. They are situated in a deciduous wood at an altitude of 1300 m, in an area of green slate and metabasalts from the older Palaeozoic era. The water issues from a fissure in the rock structure.

During field surveys undertaken in July 1974, the yield of the Crno Vrelo spring was estimated to be 1.5–2.0 litres per second while that of the Belo Vrelo was found to be in the range of 2.0–2.5 litres per second. In September of the same year, the yield of the Crno Vrelo was found to be 3.5 litres per second while the yield of the Belo Vrelo had risen to 4.5 litres per second.

The springs are not currently used, although the resulting brook downstream is used for the watering of cattle and limited irrigation.

Because 1974 was a dry year, it was assumed that the combined yield of both springs would be able to satisfy the calculated water requirements of 4.2 litres per second under any conditions. It was, however, recommended that regular measurements of the yields of both springs be made, over a period of at least one hydrological year and preferably longer, to confirm these preliminary estimates.

The water from both springs was sampled and chemically analysed to assess its suitability for drinking. Physically, it was found to be cool and relatively colourless, clear, very palatable, slightly acid and highly corrosive, with low mineral content and only a minimum content of organic matter.

People can use the water although, because of its aggressiveness, it may corrode the material of the distribution system. This possibility should be monitored during the operation of the system and, if necessary, the system should include neutralization with lime. Such neutralization was not included in the designs in order to reduce the need for chemicals and the complexity of operations in such a remote area. Because of the corrosive nature of the water, PVC pipes were recommended for the delivery main and distribution system, as well as corrosion-resistant concrete for structures.

Water Supply System

The Crno Vrelo water will be collected by means of a standard Type I spring intake structure. The length of the inlet compartment will be 3 m, although this may have to be modified after excavation of the outflow area. The diameters of the delivery drain and pipes of the structure will be 65 mm and 100 mm, respectively.

The Belo Vrelo water will be collected by means of a standard Type II spring intake structure, with a collection trench 25 m long and pipes of the same diameters as the Crno Vrelo structure.

All excavation work should be done by hand; no explosives should be used. A rainwater catchment trench will be constructed along the fence line of the first protection zone to avoid the possibility of surface run-off contamination.

A protection zone should be established around each spring, preventing access within 25 m of the spring and a second protection zone should be formed at a distance of 100 m uphill of each spring and 50 m on each side. The protection zones are shown in Fig. 103. The first protection zone should be enclosed by a wire-mesh fence.

A standard service building will be constructed close to the Crno Vrelo spring but outside the fenced area, as shown in Fig. 103.

The water will be conveyed from the springs by a 65 mm-diameter PVC pipe through a series of standard pressure head breaking chambers 591 m, 1405 m, 2090 m, 2720 m, 3459 m and 4000 m from the Crno Vrelo spring. These chambers are necessary to avoid excess pressure in the delivery main between the spring level at 1318 m above sea level and the top water level in a water tank at 725.00 m above sea level. The pipeline layout is shown in Fig. 103–105 and the longitudinal profile in Fig. 106. The delivery main will convey the water to the standard water tank of 250 m^3 capacity. A standard valve house will be located in front of the area of consumption.

The disinfection equipment will be located in the valve house. A throttling valve will keep the flow to the tank at as constant a rate as possible. The rate of sodium hypochlorite dosing will be adjusted manually. Because of this arrangement, a small deviation from the standard pipe arrangement is necessary; the inlet control float valve will be removed and the water consumption meter should be installed on the outlet pipe.

Besides the pressure head breaking chambers located on the delivery main, it is necessary to include a pressure reduction valve chamber on section C of the distribution network, since the difference in elevation between the top water level in the tank and the lowest point of the distribution system is 105 m. This non-standard structure is presented in Fig. 107 and its location in Fig. 105.

The construction of this chamber is similar to that of the standard measuring chamber (see p. 36). The pipework and fittings are of cast-iron, with a spring-loaded 100 mm-diameter reducing valve. The valve should reduce the pressure by 0.2 MPa, equivalent to 20 m of water column, at a flow of 8.28 litres per second. This is in keeping with the flow and pressure conditions presented in Fig. 108. In case of failure or during maintenance, a bypass round the reducing valve is included in the design. When this is in operation, throttling the flow to the required pressure reduction must be done manually. A pressure gauge is included in the chamber downstream of the reducing valve and bypass to facilitate pressure control.

The chamber will be drained by a concrete pipe, 150 mm in diameter and 30 m long, to allow free discharge.

The water supply system and basic hydraulic calculations are presented in Fig. 109.

Technical Specifications

Spring intake structures

A standard Type I spring intake structure, including piping, steelwork and fencing, is required, along with a standard Type II spring intake structure also including piping, steelwork and fencing. In addition, a standard building with store-room, guardroom and toilet is necessary. See Fig. 103 and 110 and the standard designs in Fig. 5, 6, 40 and 42.

Feeding pipeline

A 65 mm-diameter PVC pipeline for the nominal pressure of 1.0 MPa, 4925 m long and including six standard pressure head breaking chambers with drain-pipes, is required, along with a standard valve and a standard drain valve chamber. See Fig. 103–106, 108–110 and the standard designs in Fig. 17–19 and 42.

Water tank

A standard water tank, with a capacity of 250 m^3 and a Type I base slab, is required. The maximum water level will be at 725.0 m above sea level and the bottom level will be at 721.0 m above sea level. See Fig. 111 and the standard designs in Fig. 33, 35, 41 and 42.

Distribution network

The distribution network will include PVC piping with cast-iron fittings and adapting pipes; isolating valves with valve boxes for control from the ground; 31 fire hydrants and 17 water standpipes for the nominal pressure of 1.0 MPa; and piping 100 mm in diameter and 2965 m long. A non-standard pressure reducing valve chamber is also required, including piping, isolating valves, pressure reducing valve and pressure gauge. See Fig. 105, 107–109 and the standard designs in Fig. 39 and 42.

Fig. 103. Layout of the feeder pipeline (east)

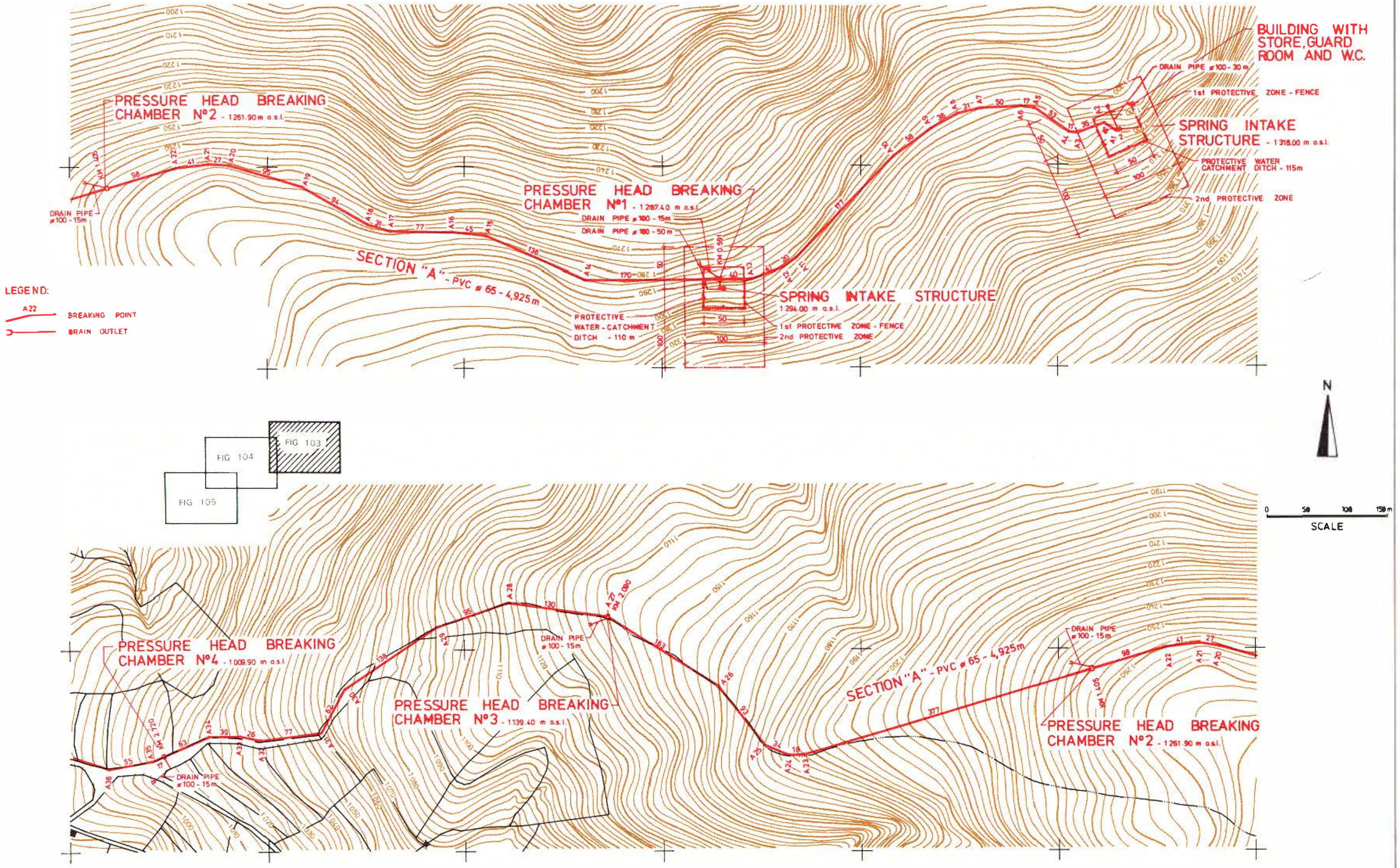
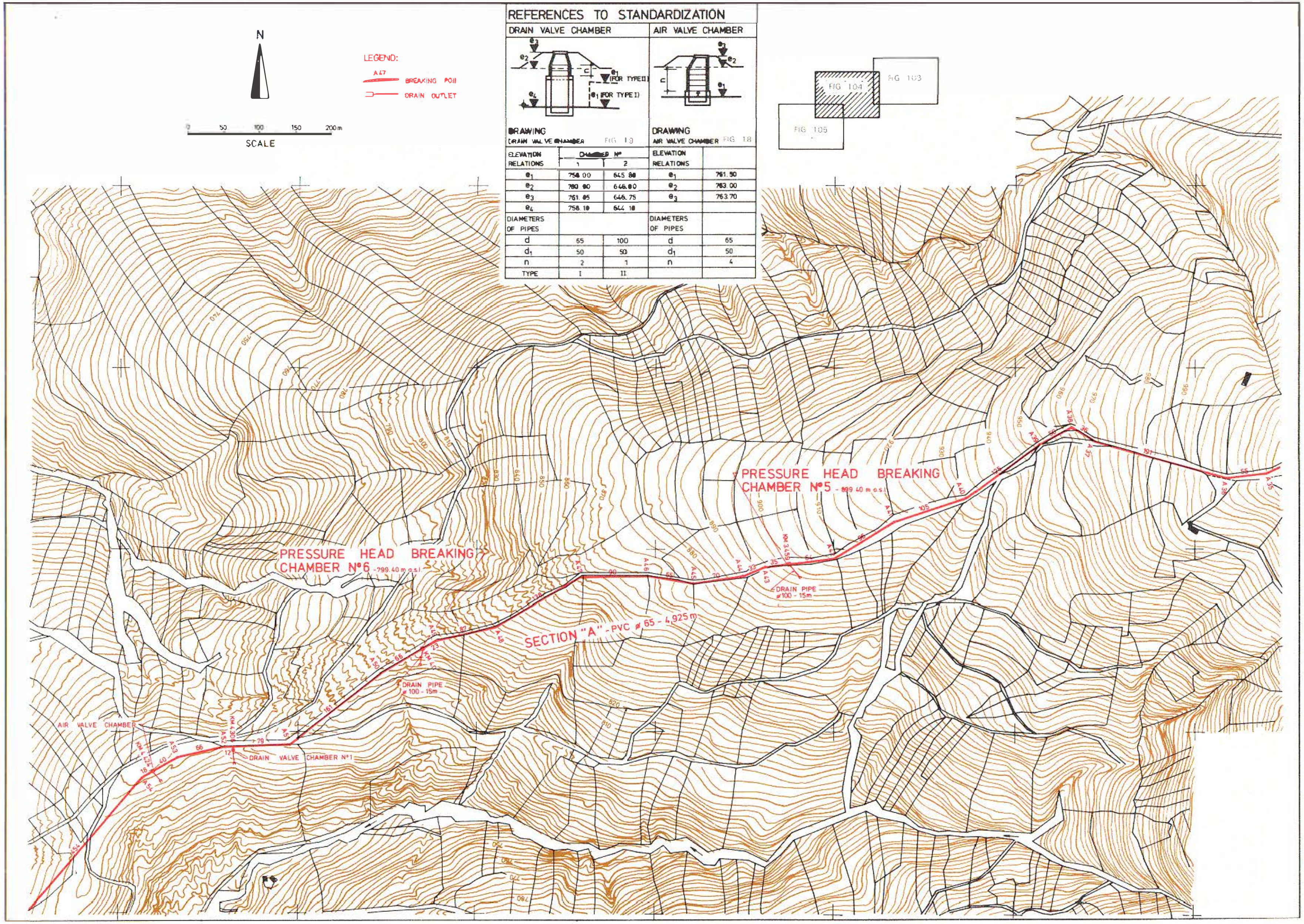


Fig. 104. Layout of the feeder pipeline (west)



REFERENCES TO STANDARDIZATION

DRAIN VALVE CHAMBER			AIR VALVE CHAMBER	
DRAWING DRAIN VALVE CHAMBER FIG. 19			DRAWING AIR VALVE CHAMBER FIG. 18	
ELEVATION RELATIONS	CHAMBER Nº		ELEVATION RELATIONS	
	1	2		
e1	758.00	645.80	e1	761.50
e2	760.00	646.00	e2	763.00
e3	761.05	646.75	e3	763.70
e4	758.10	644.10		
DIAMETERS OF PIPES			DIAMETERS OF PIPES	
d	65	100	d	65
d1	50	50	d1	50
n	2	1	n	4
TYPE	I	II		

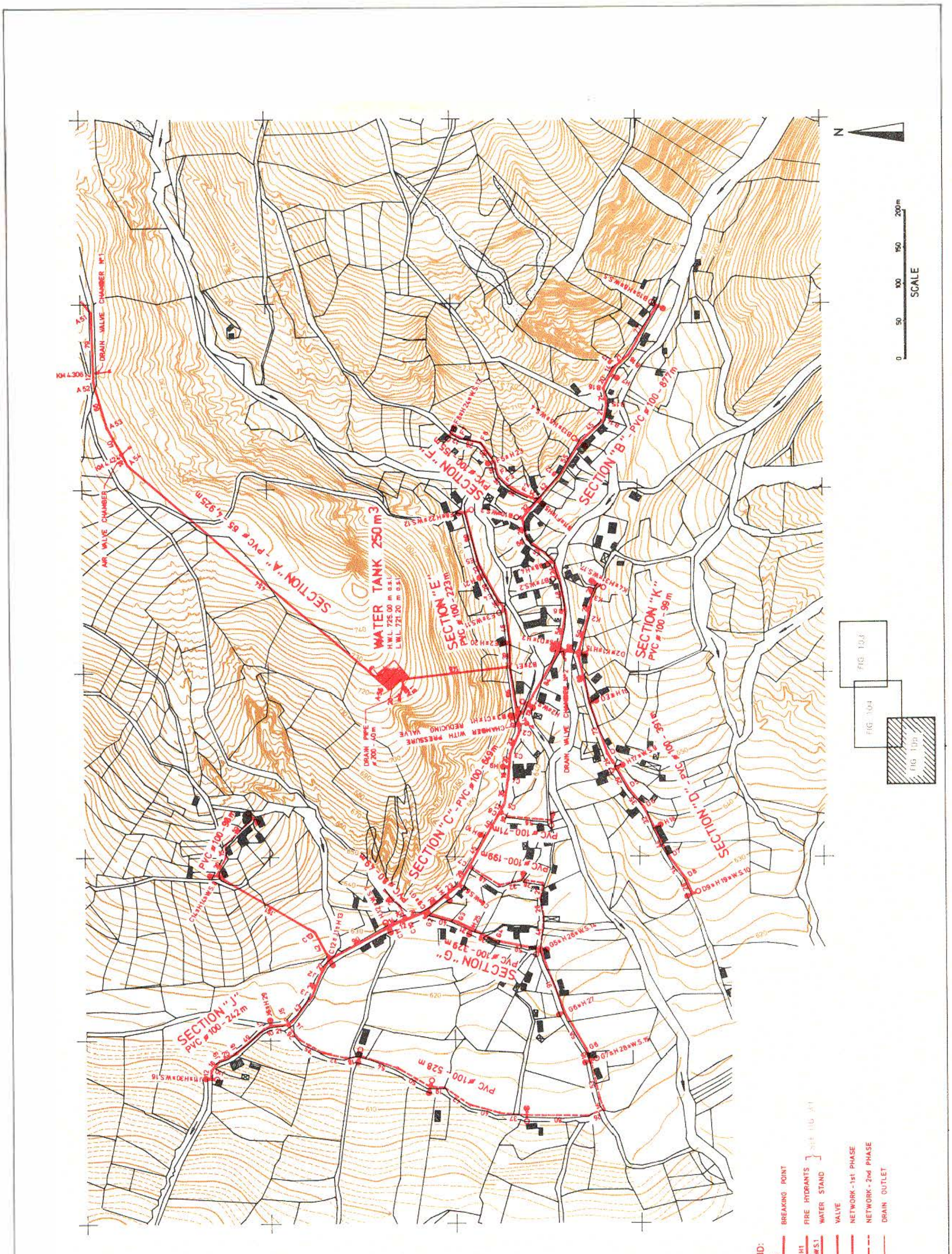


Fig. 105. Layout of the distribution system

Fig. 106. Longitudinal profile, section A

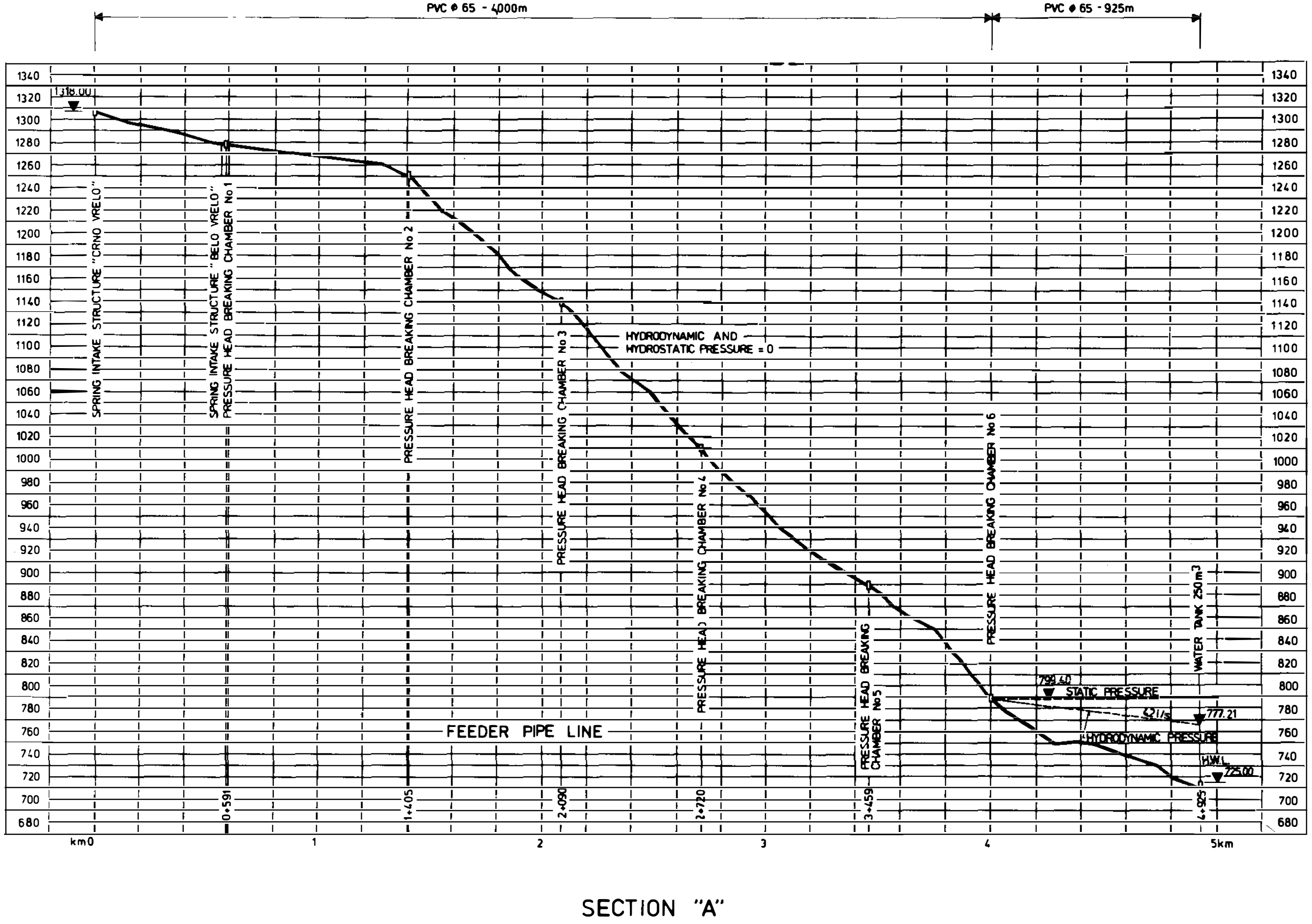
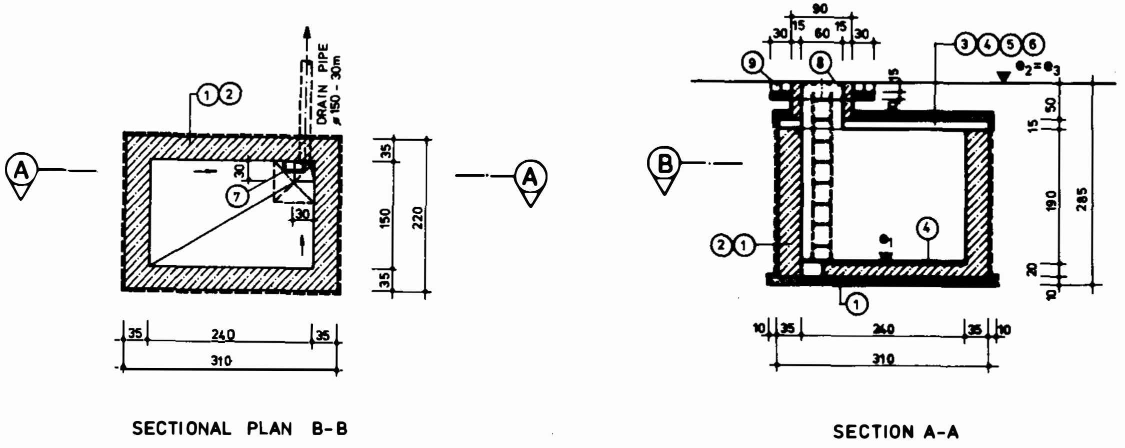
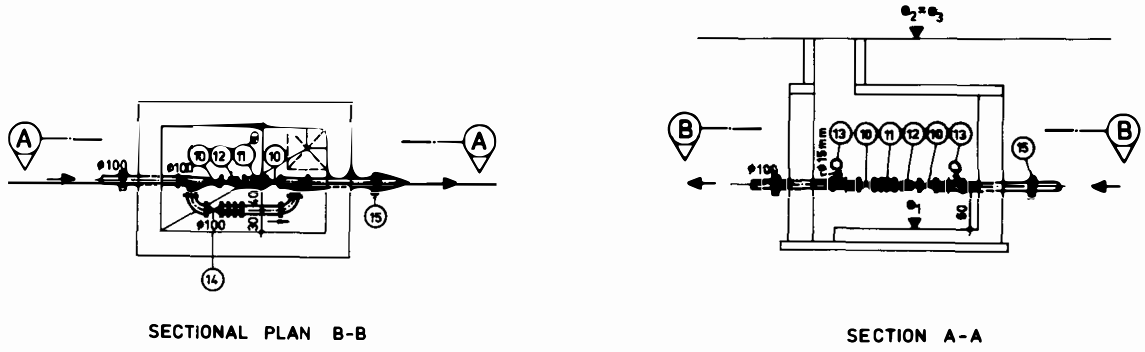


Fig. 107. Chamber with pressure reducing valve



CHAMBER WITH PRESSURE REDUCING VALVE-CIVIL CONSTRUCTION



CHAMBER WITH PRESSURE REDUCING VALVE-PIPES AND FITTINGS SKETCH

ELEVATION RELATIONS

BOTTON OF CHAMBER : e_1 = 643.95

EXISTING GROUND : e_2 = 646.50

REFORMED GROUND : e_3 = 646.50

ELEVATION e_2 TAKEN OVER FROM ORIGINAL MAP

LEGEND :

1. PLAIN CONCRETE
2. MOISTURE INSULATION
3. REINFORCED CONCRETE
4. CEMENT SCREED
5. WATERPROOF INSULATION
6. PROTECTIVE CEMENT SCREED
7. STEEL LADDER
8. CAST IRON COVER
9. STONE PAVING
10. HAND OPERATED VALVE (ISOLATING)
11. MAKE-UP PIECE
12. SPRING LOADED REDUCING VALVE
13. PRESSURE GAUGE
14. HAND OPERATED CONTROL VALVE (FOR AUXILIARY PRESSURE CONTROL IN CASE OF REDUCTION VALVE FAILURE)
15. MASTIC AND WRAPPED TAPE JOINT PROTECTION

SCALE

Fig. 108. Longitudinal profiles, sections B and C

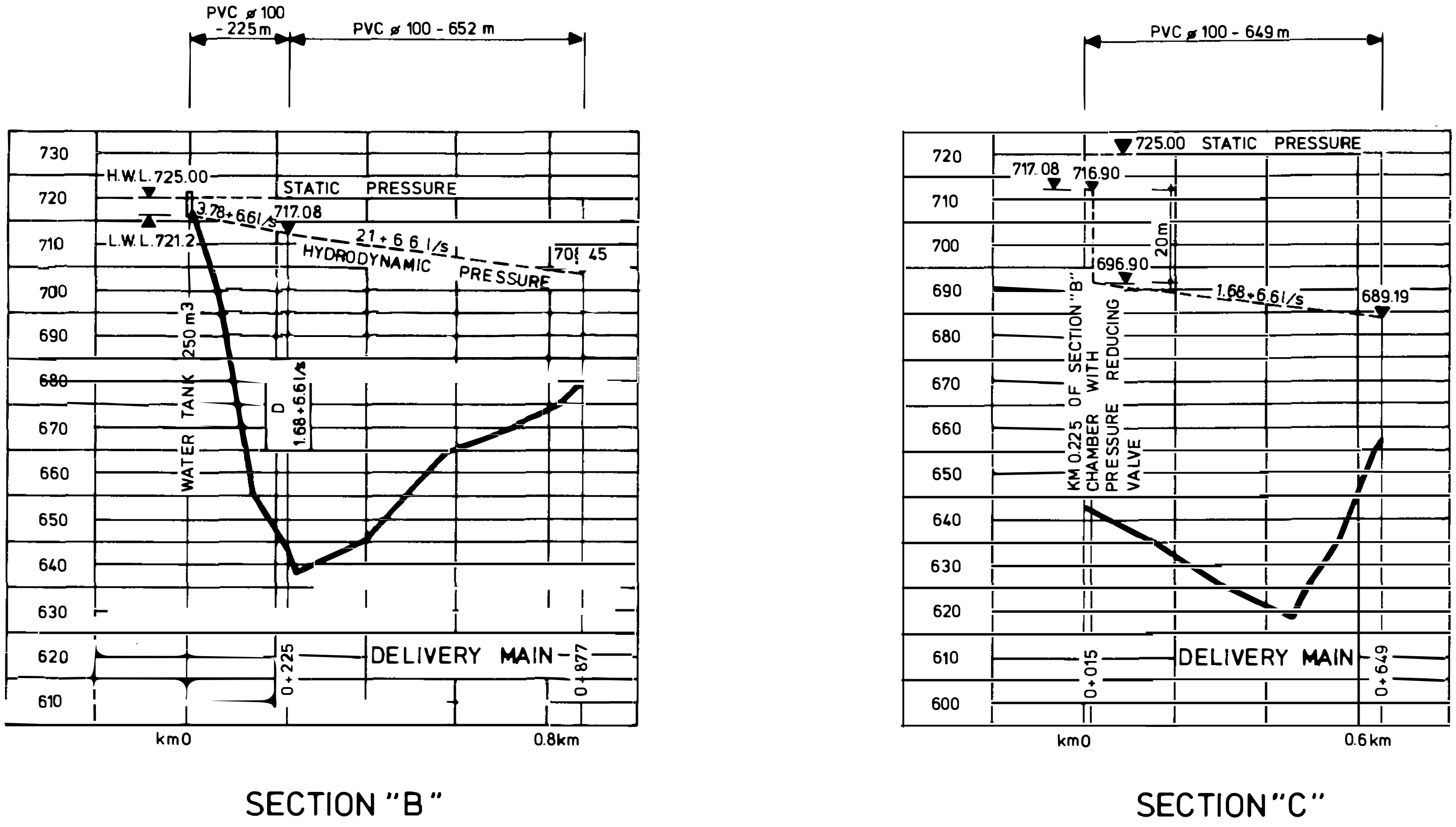
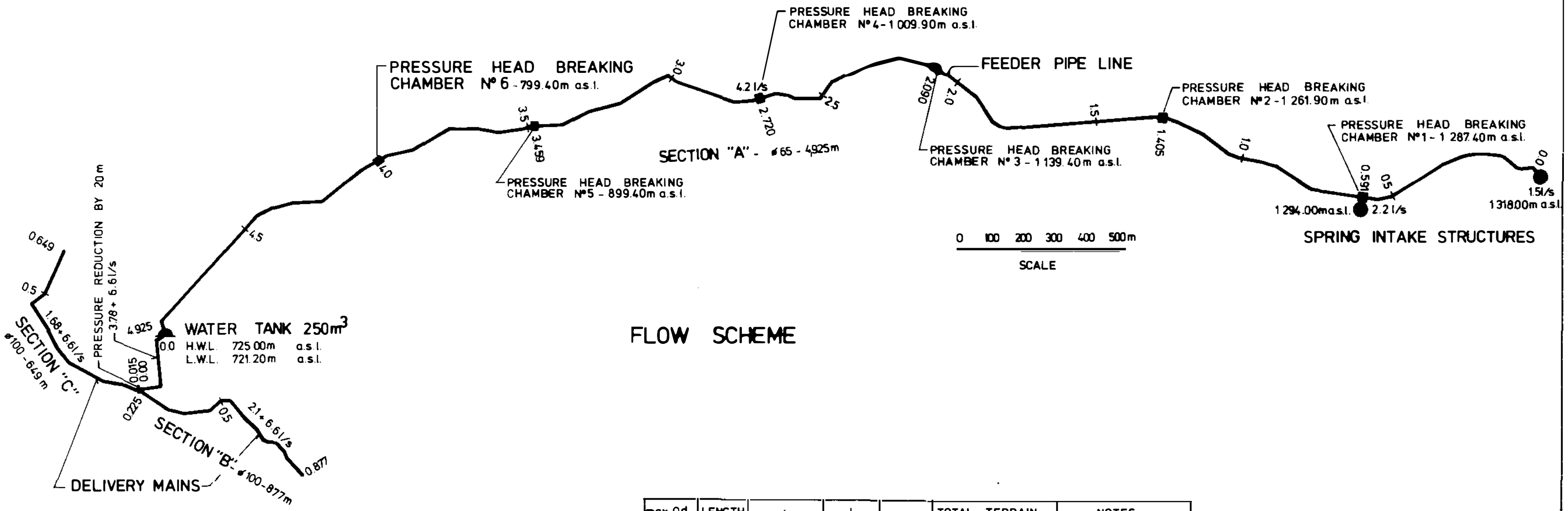


Fig. 109. Flow scheme and some basic hydraulic calculations



max Qd	LENGTH L	ø PVC k=0.01	J	v	TOTAL TERRAIN DECLIVITY	NOTES
l/s	m	mm	%	m/s	%	
4.2	4,000	65	2.2844	1.21	$\frac{1\,318-800}{4\,000} = 12.95$	FLOW WITHOUT PRESSURE

FEEDER PIPE LINE (km 0.00 - 4.00)

maxQd	LENGTH L	COEFFICIENT OF LOCAL LOSSES C	ø PVC k=0.01	J	v	PRESSURE LOSS C× J× L	ELEVATION OF HYDRODYNAMIC PRESSURE
l/s	m		mm	%	m/s	m	m
4.2	925	1.05	65	2.2844	1.21	22.19	799.40 - 22.19 = 777.21

FEEDER PIPE LINE (km 4.00 - 4.925)

maxQd	maxQh	SECTION	maxQh/2	FLOW TOTAL max Qh/2	Qf	TOTAL Q= Qh/2+Qf	LENGTH L	ø PVC k=0.01	J	v	PRESS. LOSS J× L	ELEVATION OF HYDRODYNAMIC PRESSURE
l/s	l/s		l/s	l/s	l/s	l/s	m	mm	%	m/s	m	m
4.2	4.2×1.8 = 7.56	B	2.10	3.78 2.10	6.6 6.6	10.38 8.70	225 652	100 100	1.8296 1.3235	1.39 1.17	4.12 8.63	721.20 - 4.12 = 717.08 717.08 - 8.63 = 708.45
		C	1.68	1.68	6.6	8.28	15 634	100	1.2154	1.11	0.18 7.71	717.08 - 0.18 = 716.90 696.90 - 7.71 = 689.19

DELIVERY MAIN

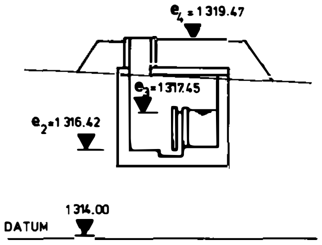
HYDRAULIC CALCULATIONS

Fig. 110. Spring intake structures, the pressure head breaking chamber and a general service building

REFERENCES TO STANDARDIZATION

SPRING INTAKE STRUCTURE-"CRNO VRELO"

ELEVATION RELATIONS



OUTFLOW OF SPRING e_1 = 1318.00
(SURVEYED BY ALTIMETER)

DRAWING

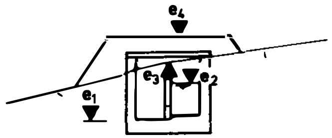
SPRING INTAKE STRUCTURE - TYPE I
FIG. 5

DIAMETERS OF PIPES

OUTLET ϕd_1 = 65 mm
WASTE PIPE ϕd_2 = 100 mm

LENGTH L_1 = 300cm

PRESSURE HEAD BREAKING CHAMBER



DRAWING

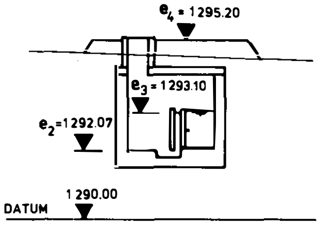
PRESSURE HEAD BREAKING CHAMBER FIG. 17

NOTE: ELEVATION e_3 TAKEN OVER FROM ORIGINAL MAP

CHAMBER No	ELEVATION RELATIONS				DIAMETERS OF PIPES		
	e_1	e_2	e_3	e_4	OUTLET ϕd_1	INLET ϕd_2	WASTE PIPE ϕd_3
1	1286.37	1287.40	1288.00	1288.72	65 mm	65mm	100 mm
2	1260.87	1261.90	1262.50	1263.22	65 mm	65mm	100 mm
3	1138.37	1139.40	1140.00	1140.72	65 mm	65mm	100 mm
4	1008.87	1009.90	1010.50	1011.22	65 mm	65mm	100 mm
5	898.37	899.40	900.00	900.72	65 mm	65mm	100mm
6	798.37	799.40	800.00	800.72	65 mm	65 mm	100mm

SPRING INTAKE STRUCTURE - "BELO VRELO"

ELEVATION RELATIONS



OUTFLOW OF SPRING e_1 = 1294.00
(SURVEYED BY ALTIMETER)

DRAWING

SPRING INTAKE STRUCTURE-TYPE II
FIG. 6

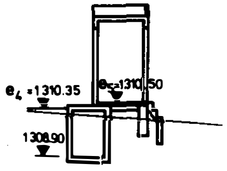
DIAMETERS OF PIPES

OUTLET ϕd_1 = 65mm
WASTE PIPE ϕd_2 = 100mm

LENGTH L_1 = 600 cm
L_2 = 2 500 cm

HOUSE WITH STORE, GUARD ROOM AND W.C.

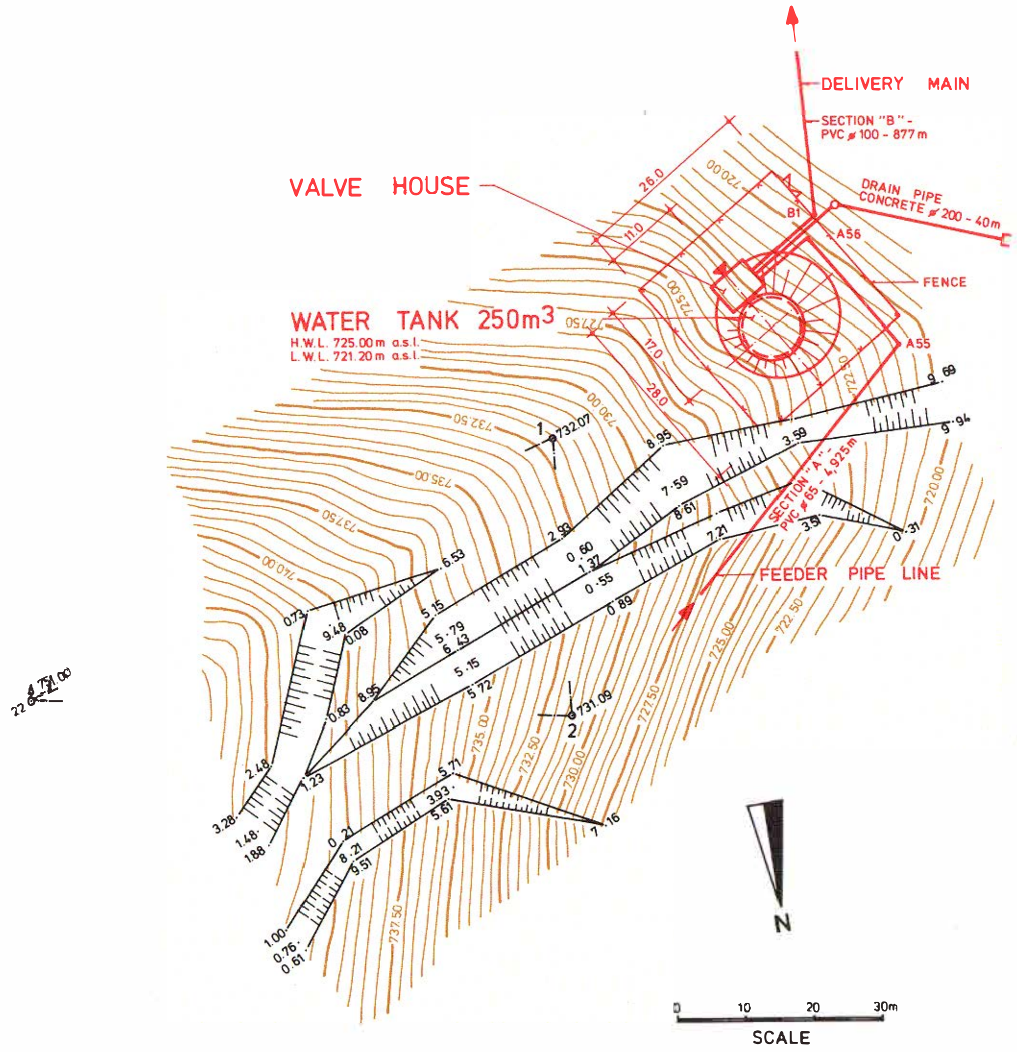
ELEVATION RELATIONS



DRAWING

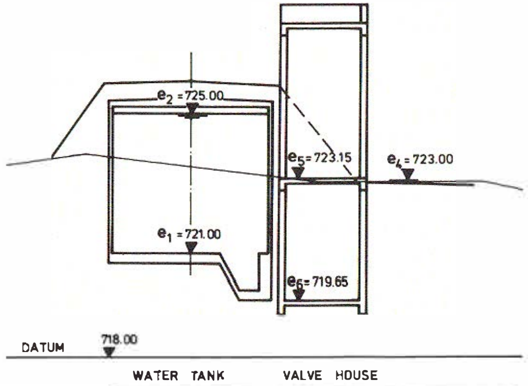
HOUSE WITH STORE, GUARD ROOM AND W.C. -
FIG. 40

Fig. 111. Layout of the 250 m³ water tank



REFERENCES TO STANDARDIZATION

ELEVATION RELATIONS



DRAWINGS

WATER TANK 250m3 (TYPE I. OF BASE SLAB SUPPOSED)	FIG. 31
VALVE HOUSE FOR ONE WATER TANK - CIVIL CONSTRUCTION (WASTE CHANNEL ARRANGEMENT TYPE a)	FIG. 33
VALVE HOUSE FOR ONE WATER TANK - PIPING TYPE I.	FIG. 35

DIAMETERS OF PIPES

INLET	$\varnothing d_1$ = 80mm
OUTLET	$\varnothing d_2$ = 125mm
DRAIN PIPE	$\varnothing d_3$ = 80 mm
OVERFLOW	$\varnothing d_4$ = 80 mm
AIR PIPE	$\varnothing d_5$ = 50 mm
WASTE PIPE	$\varnothing d_6$ = 200 mm

Dubrava

Basic Data

The rural community of Dubrava is situated in the commune of Kacanik, 3 km in a direct line and 6 km by road from the commune centre of the same name. People get to the village only by driving a cross-country vehicle along the improved rough track that runs 2 km from the neighbouring community of Doganovič.

The township is concentrated on the northern slope of Luboten Mountain in the eastern part of the Sar Planina ridge. The community is divided into three groups of farmhouses connected by footpaths and field tracks. Dubrava is on gently sloping ground. The entire population is employed in agriculture.

In 1971, the national census found the population of the community to be 503. Although no development plans for the community exist, the population will probably increase to about 550 in the short term.

In accordance with the design criteria, a per capita water consumption of 220 litres per day was adopted. This resulted in the following daily water requirements.

Total		90% (reduced for design)	
m³/day	litres/second	m³/day	litres/second
121	1.4	103	1.2

Water Resources

During the course of field surveys, the available water resources in the environs of Dubrava were investigated, since no regional water supply system exists or is planned within a reasonable distance of the village. Although the Urosevac–Kacanik regional water supply system will be built within the commune, a combination of the distance of the nearest point for connection and the need for pumping eliminated it as a source for Dubrava. The amount of water could not justify the expense of investment and operation.

Therefore, a local source of water had to be found. Investigations identified a spring, Crni Kamen, located about 2 km from the community. It is located in a deciduous wood on the slopes of the Sar Planina ridge, in a deep erosion trench below the Pristina–Tetovo road at an elevation of 912 m above sea level. Thus the water could be supplied by gravity. The rock in the area of the spring consists of phyllite and sericitic slates with crystalline calcite intrusions. The spring flows from one such intrusion, covered with coarse rocky detritus.

During the field reconnaissance in July 1974, the yield of the spring was estimated to be 8–10 litres per second, and in October of the same year the yield was measured as 13.6 litres per second. According to rain gauge measurements, 1974 was a dry year, while the two previous years were wet. With the low water demand of the community, 1.2 litres per second, the spring can be safely expected to yield more than enough water under all conditions. In fact, the minimum yield of the spring can be expected to stay above 5 litres per second, and in most years it will be above 8 litres per second.

Since at present the spring is not used for any other purposes, it is free for use as a source of drinking-water for Dubrava.

However, it is recommended that regular measurements of the spring yield, the water temperature and its chemical characteristics be made over the course of a complete hydrological year.

Chemically, the water was found to be moderately mineralized. It contains calcium bicarbonate with a total hardness of 96.4 mg/l calcium carbonate. The water can be classified as soft and non-corrosive, with a good clear appearance, negligible alkalinity and strong mineral acidity. There were no iron, manganese, ammonia or oxides of nitrogen detected by laboratory analyses, and the water was found to be almost completely saturated with oxygen. Therefore, the spring water in its natural state was considered to be very suitable as a potable supply. Only disinfection was required, to safeguard the bacterial quality of the water in the distribution system.

Water Supply System

As mentioned in pp. 131–132, the Crni Kamen spring is to supply water to two rural communities: Dubrava and Doganovič. Since Dubrava is located uphill of Doganovič in the direction of the spring, all the main elements of the Dubrava water supply system will have to be structured to meet the requirements of both communities. The measuring chamber on the pipeline from Dubrava to Doganovič is considered as the dividing point between the systems (see Fig. 112).

The water supply system will consist of a spring intake structure, a feeding pipeline with a pressure head breaking chamber because of the elevation difference of 180 m between the spring and the community, a water tank with associated valve chamber and the distribution network.

The standard Type I spring intake structure will include arrangements for overflow and piping sufficient to handle yields up to 30 litres per second. The delivery pipe and drain from the intake structure will be of 80 mm diameter and 150 mm diameter, respectively.

All excavation work for the structure should be done by hand, without the use of explosives. Because of the ground configuration round the spring, it will not be necessary to dig a run-off water catchment trench around the area. However, for security reasons, a wire-mesh fence will be erected around the first protection zone. The zone will have a radius of about 25 m.

The water will flow by gravity from the spring intake structure through an 80 mm-diameter PVC feeding main to a pressure head breaking chamber. This will be located 400 m downstream of the spring at an elevation of 818 m above sea level. The standard chamber has an 80 mm-diameter inlet and outlet pipe and a 100 mm-diameter drain. The water will flow from the pressure head breaking chamber through an 80 mm-diameter pipe 2.2 km long to a water tank. The tank has the minimum standard capacity of 100 m^3 but is large enough to cover future water demand.

The control pipework will be located in an underground valve chamber constructed as seen in Fig. 32.

A standard service building, containing a chlorination station and sodium hypochlorite store-room, will be connected to the water tank. The hypochlorite solution will be fed to the valve chamber by a 15 mm-diameter PVC pipe (see Fig. 113). There is also provision for a guardroom and toilet. This building will be constructed in accordance with the designs in Fig. 40.

Technical Specifications

Spring intake structure

A standard Type I spring intake structure is required, including piping, steelwork, drain and fencing. See Fig. 114 and the standard designs in Fig. 5.

Feeding pipeline

An 80 mm-diameter PVC pipeline, for the nominal pressure of 1.0 MPa and 2602 m long, is required, along with a standard pressure head breaking chamber including piping and drain-pipe and a standard drain valve chamber. See Fig. 112 and 114–116 and the standard designs in Fig. 5, 17–19 and 42.

Water tank

A standard water tank, with a capacity of 100 m^3 and Type I base slab, is required. The maximum water level will be at 735.0 m above sea level, and the bottom level will be at 731.3 m above sea level. See Fig. 113 and the standard designs in Fig. 28.

Valve chamber

A standard underground valve chamber, with Type I piping, drain-pipe and fencing, is required. See Fig. 114 and the standard designs in Fig. 32.

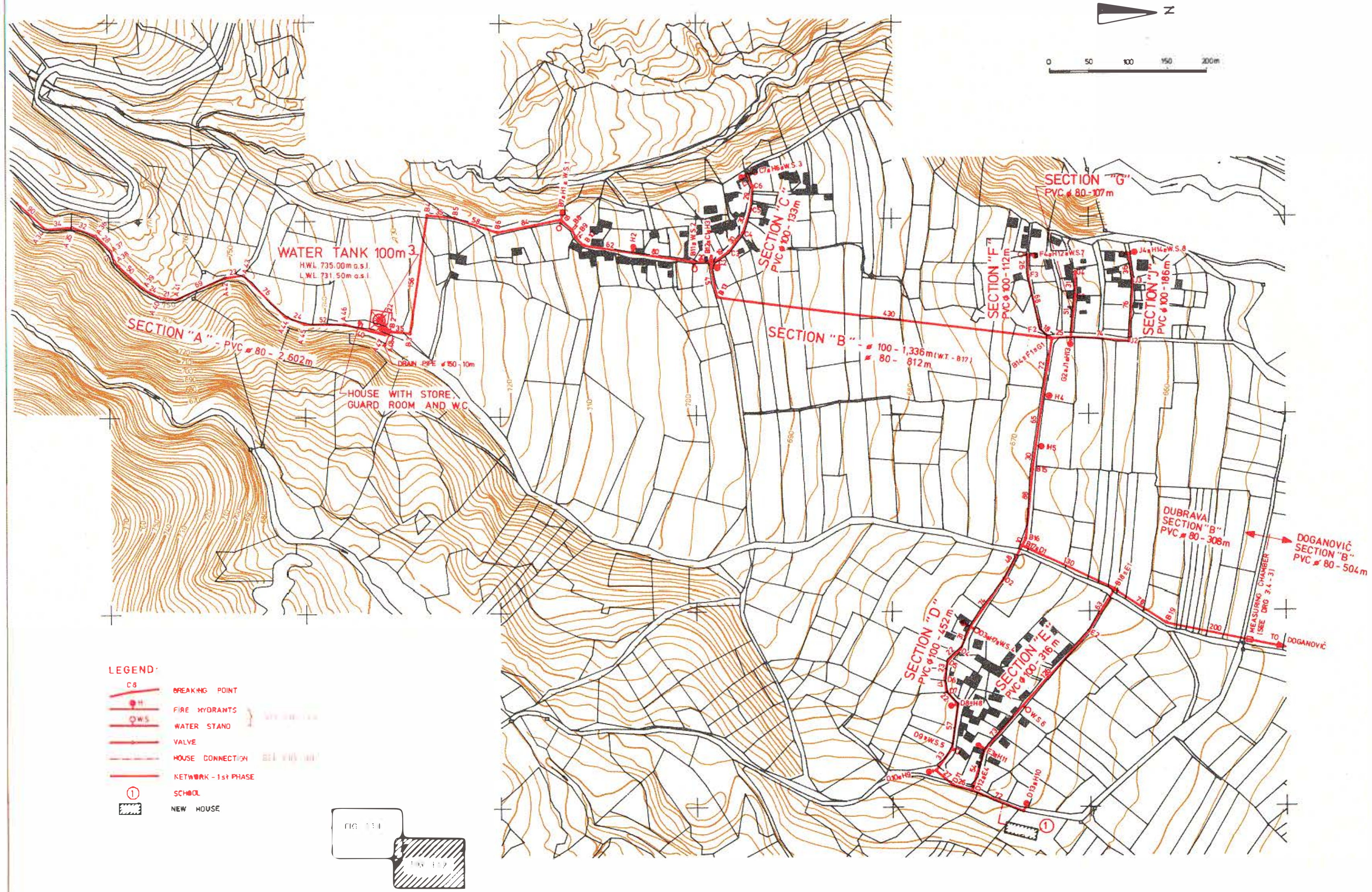
General service building

A standard building structure, including standard sodium hypochlorite dosing equipment and 55 m of PVC dosing pipe of 15 mm diameter is required. See Fig. 113 and the standard designs in Fig. 32, 40 and 41.

Distribution network

The distribution network will include PVC piping with cast-iron fittings and adapting pipes, isolating valves with valve boxes for control from the ground, 14 fire hydrants and 8 standpipes for the nominal pressure of 1.0 MPa and a house connection for the school. There will be 2535 m of 100 mm-diameter piping and 415 m of 80 mm-diameter piping. See Fig. 112, 115 and 117 and the standard designs in Fig. 39 and 42.

Fig. 112. Layout of the distribution system



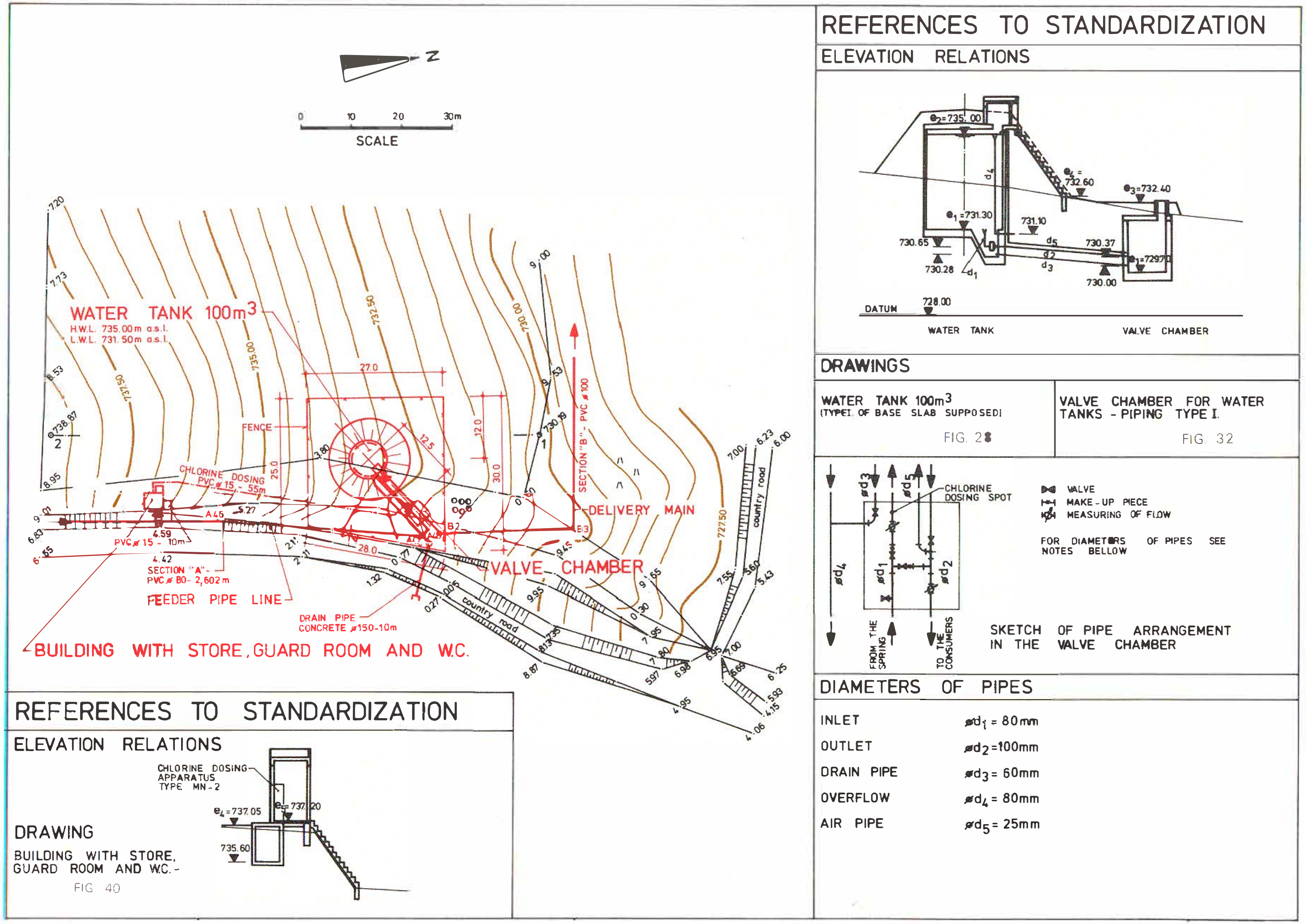
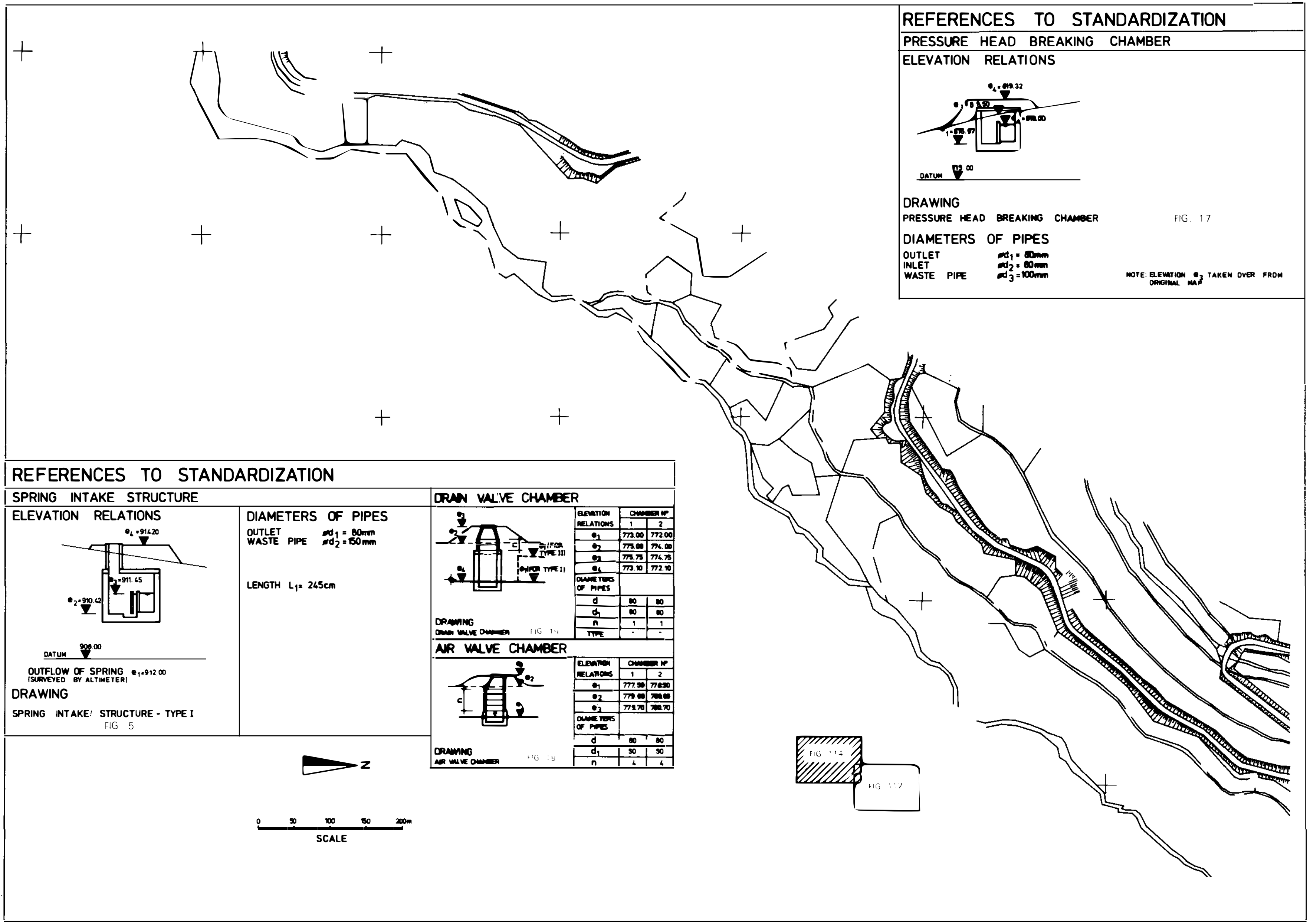


Fig. 113. Layout of the 100 m³ water tank

INLET	$ød_1$ = 80mm
OUTLET	$ød_2$ =100mm
DRAIN PIPE	$ød_3$ = 60mm
OVERFLOW	$ød_4$ = 80mm
AIR PIPE	$ød_5$ = 25mm

Fig. 114. Layout of the feeder pipeline



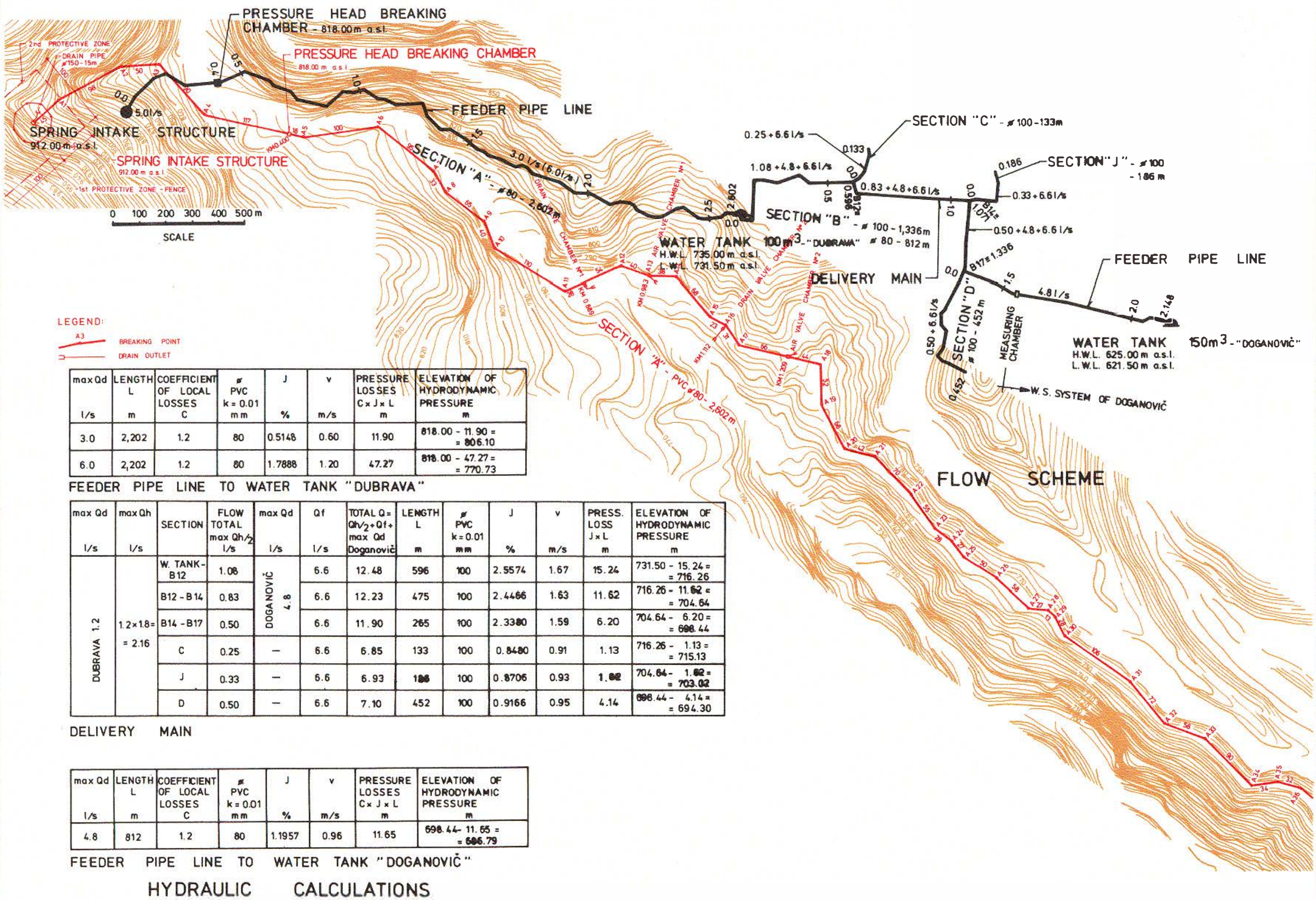
DRAIN VALVE CHAMBER

ELEVATION RELATIONS	CHAMBER Nº 1	CHAMBER Nº 2
e_1	773.00	772.00
e_2	775.00	774.00
e_3	775.75	774.75
e_4	773.10	772.10
DIAMETERS OF PIPES		
d	80	80
d_1	80	80
n	1	1
TYPE	-	-

AIR VALVE CHAMBER

ELEVATION RELATIONS	CHAMBER Nº 1	CHAMBER Nº 2
e_1	777.50	778.50
e_2	779.00	780.00
e_3	779.70	780.70
DIAMETERS OF PIPES		
d	80	80
d_1	50	50
n	4	4

Fig. 115. Flow scheme and some basic hydraulic calculations



max Qd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES C	ø PVC k = 0.01 mm	J %	v m/s	PRESSURE LOSSES C × J × L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
3.0	2,202	1.2	80	0.5148	0.60	11.90	818.00 - 11.90 = = 806.10
6.0	2,202	1.2	80	1.7888	1.20	47.27	818.00 - 47.27 = = 770.73

FEEDER PIPE LINE TO WATER TANK "DUBRAVA"

max Qd l/s	max Qh l/s	SECTION	FLOW TOTAL max Qh/2 l/s	max Qd l/s	Qf l/s	TOTAL Q = Qh/2 + Qf + max Qd Doganovič	LENGTH L m	ø PVC k = 0.01 mm	J %	v m/s	PRESS. LOSS J × L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
DUBRAVA 1.2	1.2 × 1.8 = = 2.16	W. TANK-B12	1.08	DOGANOVIĆ 4.8	6.6	12.48	596	100	2.5574	1.67	15.24	731.50 - 15.24 = = 716.26
		B12 - B14	0.83		6.6	12.23	475	100	2.4466	1.63	11.62	716.26 - 11.62 = = 704.64
		B14 - B17	0.50		6.6	11.90	265	100	2.3380	1.59	6.20	704.64 - 6.20 = = 698.44
		C	0.25	—	6.6	6.85	133	100	0.8480	0.91	1.13	716.26 - 1.13 = = 715.13
		J	0.33	—	6.6	6.93	186	100	0.8706	0.93	1.62	704.64 - 1.62 = = 703.02
		D	0.50	—	6.6	7.10	452	100	0.9166	0.95	4.14	698.44 - 4.14 = = 694.30

DELIVERY MAIN

max Qd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES C	ø PVC k = 0.01 mm	J %	v m/s	PRESSURE LOSSES C × J × L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
4.8	812	1.2	80	1.1957	0.96	11.65	698.44 - 11.65 = = 686.79

FEEDER PIPE LINE TO WATER TANK "DOGANOVIČ"

HYDRAULIC CALCULATIONS

Fig 116. Longitudinal profile, section A

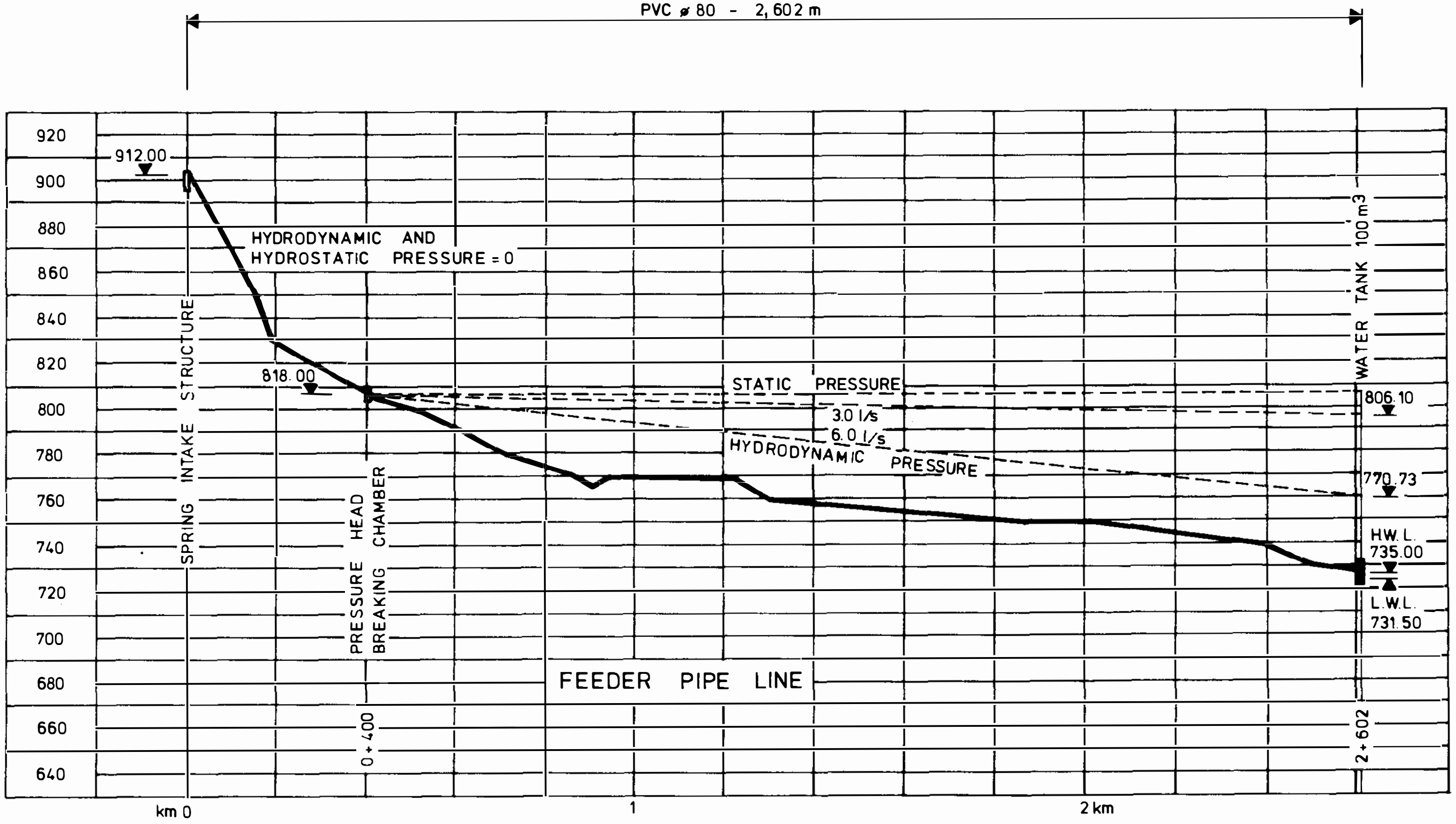
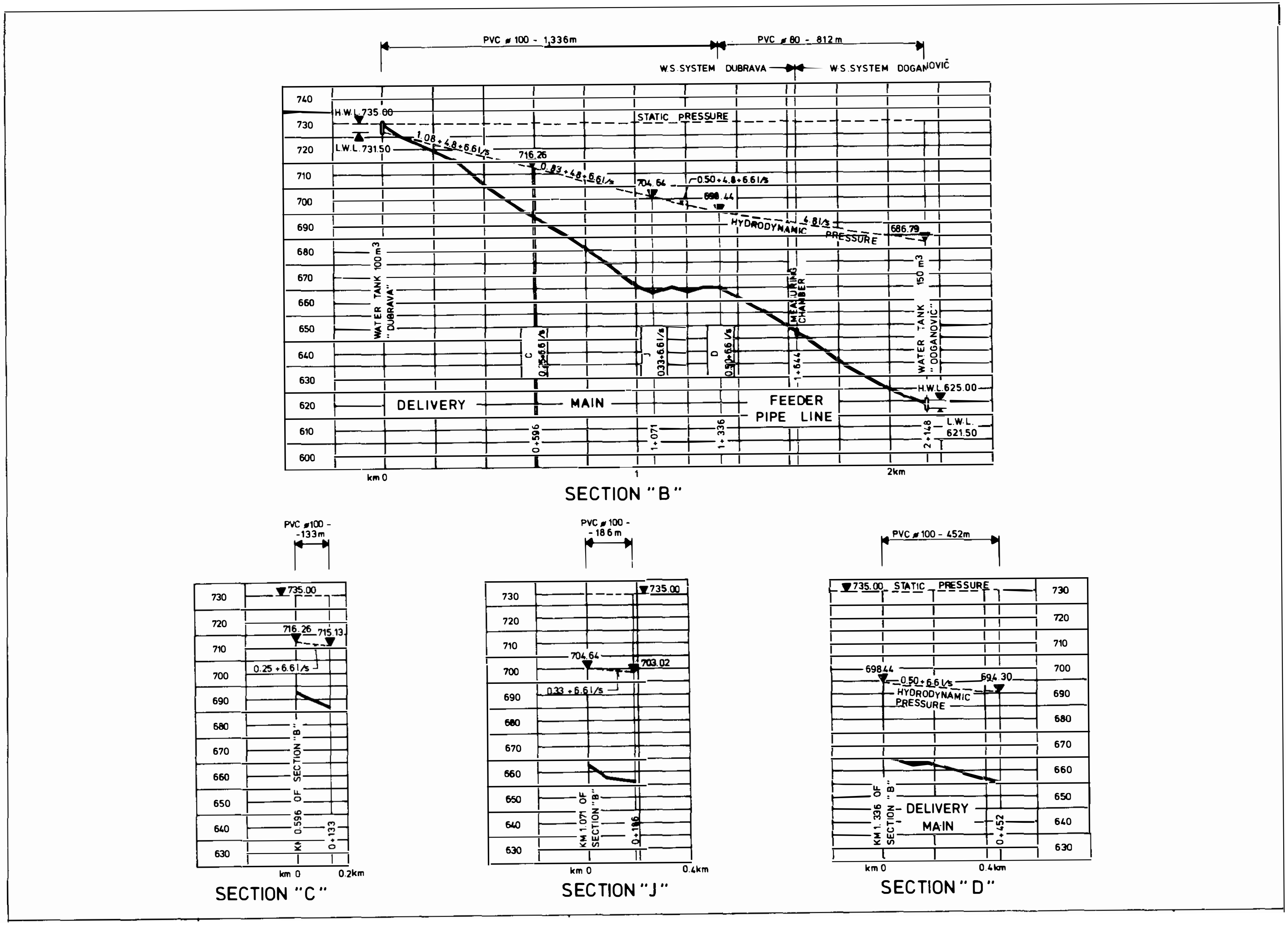


Fig 117. Longitudinal profiles, sections B, C, J, D



Kolo

Basic Data

The rural community of Kolo is situated in the commune of Vucitrn, 5 km in a direct line and about 7.5 km by road from the commune centre. People can get to the village only by driving a cross-country vehicle in dry weather along a country track that branches off the asphalt Vucitrn–Dubovac road.

The community consists of scattered groups of farmhouses, connected by a series of footpaths. Kolo is in rather rugged terrain on the north-eastern lower slopes of the Cicavica hills. The economy of the community is purely agricultural.

In 1971, the national census found the population of Kolo to be about 500. It was not expected to grow in the future.

In accordance with the design criteria, a per capita water consumption of 220 litres per day was adopted. This resulted in the following daily water requirements.

Total		85% (reduced for design)	
m³/day	litres/second	m³/day	litres/second
110	1.3	94	1.1

Water Resources

A field investigation of the area surrounding Kolo was carried out to identify suitable water resources. Only one water source about 3 km from the village was found. It was considered because no regional water supply system existed or was planned. The quality of the water was checked to ensure its suitability for drinking.

The spring, called Vrelo–Koles, is situated at a relatively high elevation of 940.40 m above sea level, over 300 m above the area of consumption. It is located in a deciduous forest on the slopes of the Cicavica hills. Geologically, the area round the spring is composed of phyllite and sericitic slates with crystalline calcite intrusions, circumstances similar to the Crni Kamen spring serving Dubrava and Doganovič.

During field investigation in July 1974, the yield of the spring was found to be 1.0–1.5 litres per second, and in October of the same year 3.1 litres per second was measured. Since 1974 was a dry year and the two preceding years were wet, it was estimated that the yield can be expected to drop to as low as one third of the autumn flow in a dry year, and that this could be 0.7–0.9 litre per second. With the possibility of some small shortage in supply during the late summer in dry years, the yield of the spring was judged adequate. However, it should be stressed that it will be important to perform regular yield measurements in the future to verify the preliminary estimates.

Samples of the water were collected in July and October 1974 and tested for organoleptic and chemical quality. It was a non-corrosive medium-hard water with about 185 mg/l calcium carbonate, with only traces of dissolved iron and manganese, no traces of ammonia or oxides of nitrogen and only very low concentrations of alkaline and salts of the strong mineral acids. The water was almost saturated with dissolved oxygen and was not unpalatable.

It was concluded that the water was suitable for supply to the community if disinfection safeguarded its bacteriological quality.

Water Supply System

The water from the spring will be collected by a standard Type I spring intake structure, with a collecting chamber 2.45 m long. The delivery and drain-pipes will be 50 mm in diameter and 100 mm in diameter, respectively.

All excavation work should be done by hand, and explosives should not be used. A water catchment trench about 30 m long will have to be dug above the spring to prevent contamination by surface run-off during periods of rain. The first protection zone, of about 25 m radius around the spring, will be fenced in.

Because of the large elevation difference of 190 m between the spring and the water tank, a standard pressure head breaking chamber will be constructed on the delivery main 1078 m from the spring at an elevation of 750 m above sea level (see Fig. 118–120).

A 50 mm diameter PVC delivery main, 1199 m long, will convey water from the pressure head breaking chamber to a water tank located in front of the consumption area. A standard water tank of 100 m^3 capacity with a separate underground valve chamber will be sufficient to meet the population's needs. No future expansion is planned (see Fig. 121).

A standard building with store-room, guardroom and toilet is included in the design. It will be located near the water tank, to provide storage for sodium hypochlorite and shelter for operating staff. Sodium hypochlorite dosing equipment will be installed on the wall inside the tank entry room.

The distribution network will be of PVC pipes with fire hydrants and isolating valves located according to need. The standpipes will be installed at convenient places on the network to supply the population with water.

Technical Specifications

Spring intake structure

A standard Type I spring intake structure is required, including piping, water catchment trench, chain-link fencing and drain-pipe. See Fig. 119 and 120 and the standard designs in Fig. 5 and 42.

Feeding pipeline

A 50 mm-diameter PVC pipeline, 2277 m long, for a nominal pressure of 1.0 MPa will be required, including a standard pressure head breaking chamber with piping and drain. See Fig. 118–120 and 122 and the standard designs in Fig. 42.

Water tank and valve chamber

A standard water tank, with a capacity of 100 m^3 and Type I base slab, is required. The maximum water level will be at 674.0 m above sea level and the bottom level will be at 670.3 m above sea level. In addition, a standard valve chamber, with Type I piping arrangement, drain-pipe and fencing, is required. See Fig. 121 and the standard designs in Fig. 28, 32 and 42.

General service building

A standard building structure is required, including 20 m of service connection pipe of 15 mm diameter. See Fig. 121 and the standard designs in Fig. 40 and 42.

Distribution network

The distribution network includes PVC piping with cast-iron fittings and adapting pipes, isolating valves with valve boxes for control from the ground, 15 fire hydrants and 8 water standpipes for a nominal pressure of 1.0 MPa. The pipes will be of 100 mm diameter and 2225 m long. See Fig. 122–124 and the standard designs in Fig. 39 and 42.

Fig. 118. Longitudinal profile, section A

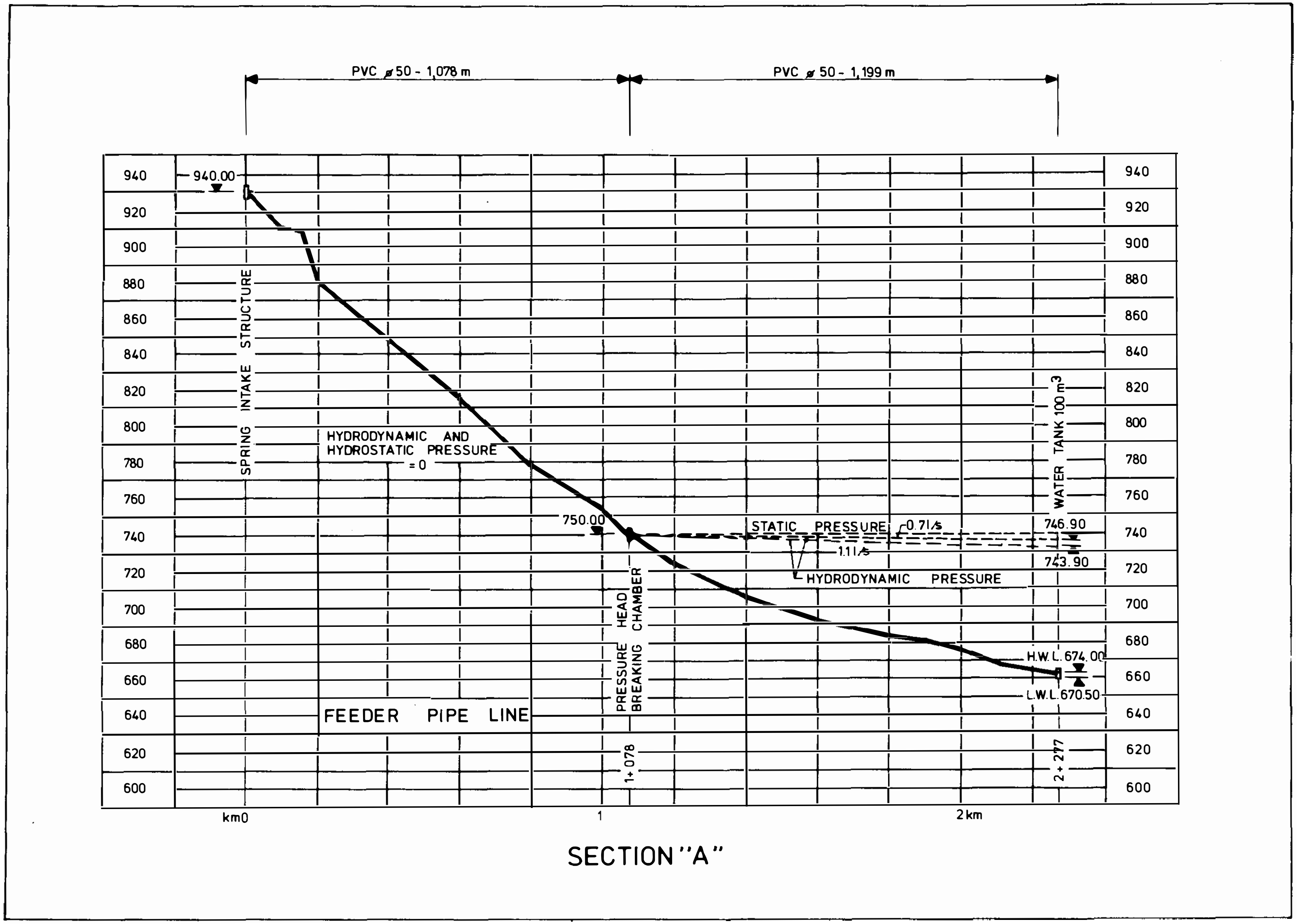


Fig. 119. Layout of the feeder pipeline

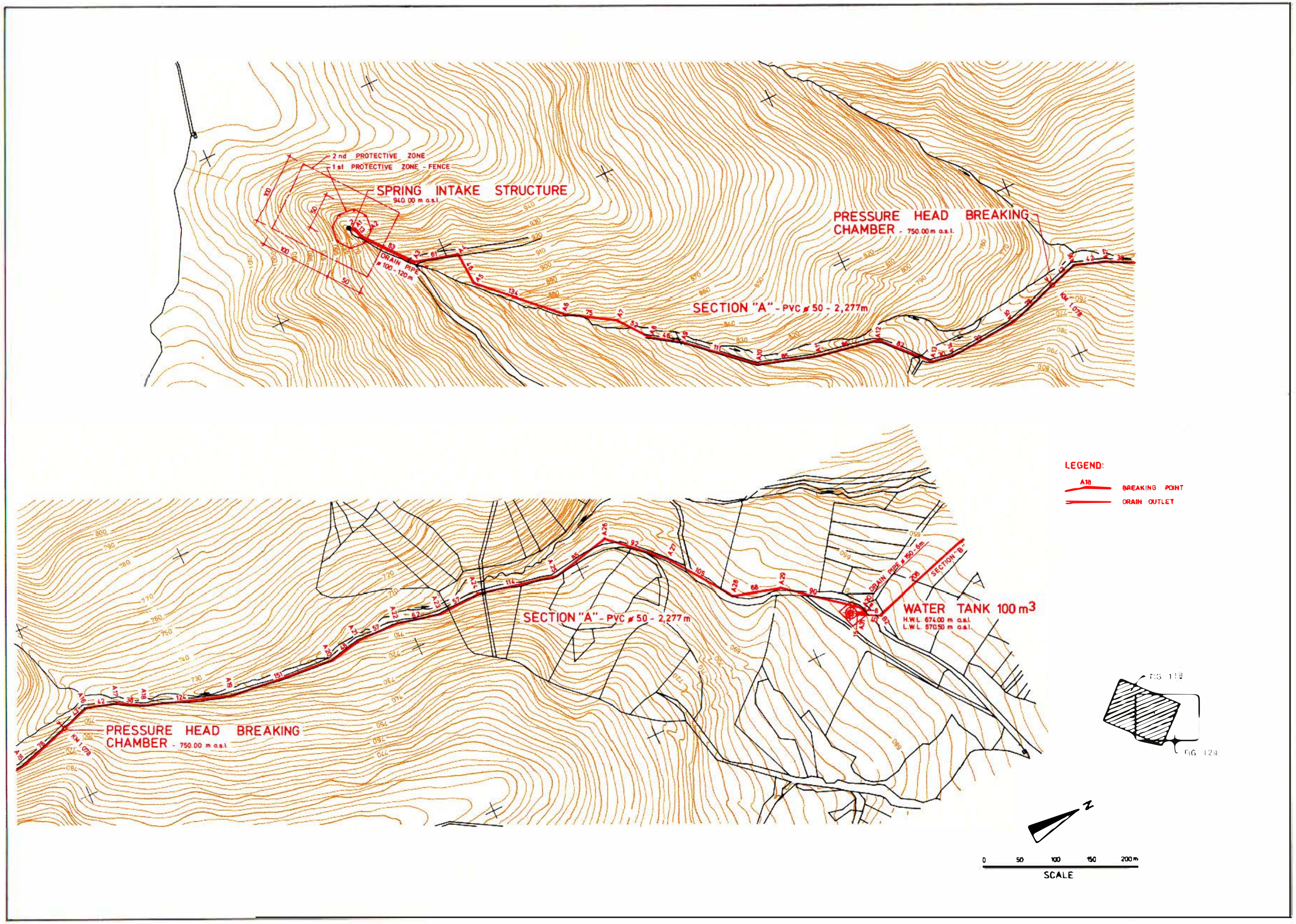
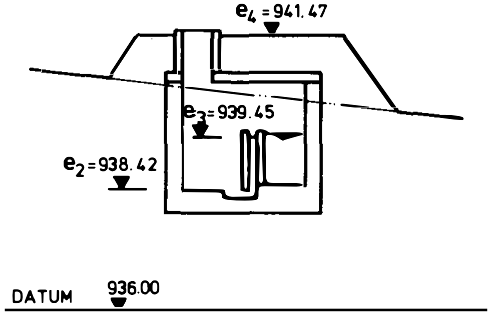


Fig. 120. Spring intake structure and pressure head breaking chamber

REFERENCES TO STANDARDIZATION

SPRING INTAKE STRUCTURE

ELEVATION RELATIONS



OUTFLOW OF SPRING e_1 = 940.00
(TAKEN OVER FROM ORIGINAL MAP)

DRAWING

SPRING INTAKE STRUCTURE - TYPE I. FIG. 5

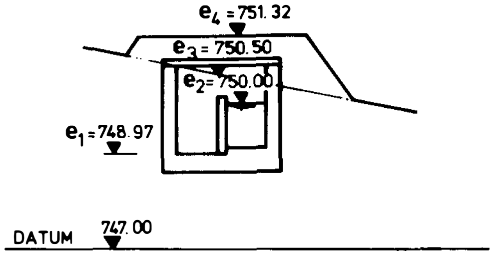
DIAMETERS OF PIPES

OUTLET	$\varnothing d_1$ = 50mm
WASTE PIPE	$\varnothing d_2$ = 100mm

LENGTH L_1 = 245 cm

PRESSURE HEAD BREAKING CHAMBER

ELEVATION RELATIONS



NOTE: ELEVATION e_3 TAKEN OVER FROM ORIGINAL MAP

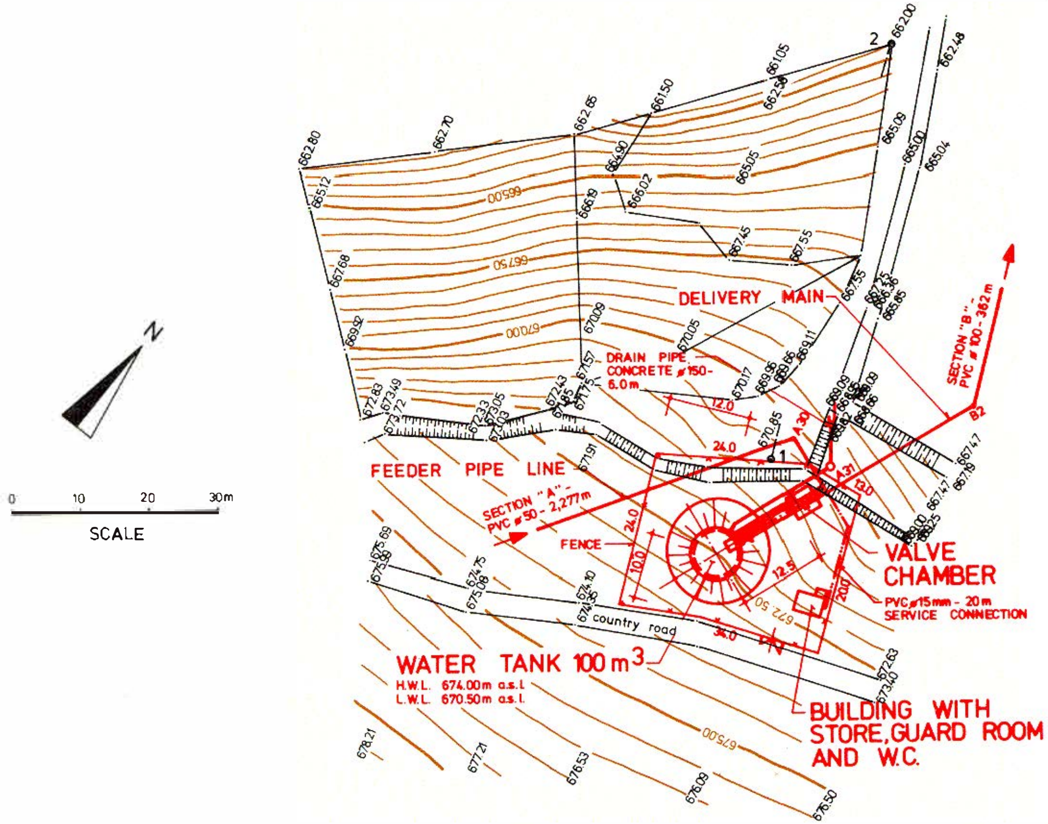
DRAWING

PRESSURE HEAD BREAKING CHAMBER FIG. 17

DIAMETERS OF PIPES

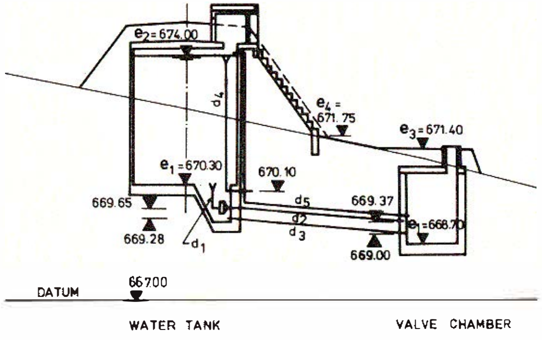
OUTLET	$\varnothing d_1$ = 50 mm
INLET	$\varnothing d_2$ = 50 mm
WASTE PIPE	$\varnothing d_3$ = 100 mm

Fig. 121. Layout of the 100 m³ water tank



REFERENCES TO STANDARDIZATION

ELEVATION RELATIONS



DRAWINGS

WATER TANK 100m3 (TYPE I. OF BASE SLAB SUPPOSED) FIG. 28	VALVE CHAMBER FOR WATER TANKS - PIPING TYPE I. FIG. 32

DIAMETERS OF PIPES

INLET	ød_1 = 50mm
OUTLET	ød_2 = 100mm
DRAIN PIPE	ød_3 = 60mm
OVERFLOW	ød_4 = 80mm
AIR PIPE	ød_5 = 25mm

ELEVATION RELATIONS

DRAWING

BUILDING WITH STORE, GUARD ROOM AND W.C.

FIG. 40

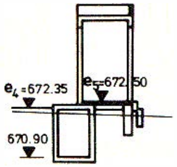
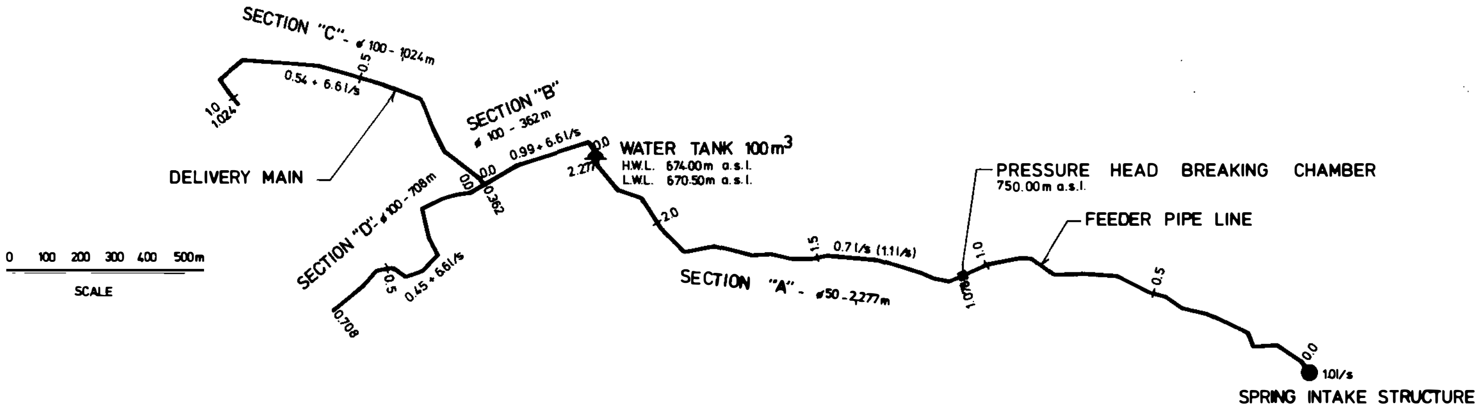


Fig. 122. Flow scheme and some basic hydraulic calculations



FLOW SCHEME

maxQd l/s	LENGTH L m	⌀ PVC k=0.01 mm	J %	v m/s	TOTAL TERRAIN DECLIVITY %	NOTES
0.7	1,078	63/57	0.1963	0.27	$\frac{940-750}{1\,078}=17.62$	FLOW WITHOUT PRESSURE

FEEDER PIPE LINE (km 0.00 - 1.078)

maxQd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES C	⌀ PVC k=0.01 mm	J %	v m/s	PRESSURE LOSSES C× J × L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
0.7	1,199	1.05	63 / 57	0.1963	0.27	-2.47	749.37 - 2.47 = = 746.90
1.1	1,199	1.05	63 / 57	0.4345	0.43	5.47	749.37 - 5.47 = = 743.90

FEEDER PIPE LINE (km 1.078 - 2.277)

maxQd l/s	maxQh l/s	SECTION	maxQh/2 l/s	FLOW TOTAL max Qh/ l/s	Qf l/s	TOTAL Q= Qh/2+Qf l/s	LENGTH L m	⌀ PVC k=0.01 mm	J %	v m/s	PRESS. LOSS J × L m	ELEVATION OF HYORODYNAMIC PRESSURE m
1.1	1.1×1.8 = 1.98	B	0	0.99	6.6	7.59	362	100	1.0362	1.02	3.75	670.50 - 3.75 = = 666.75
		C	0.54	0.54	6.6	7.14	1,024	100	0.9166	0.95	9.39	666.75 - 9.39 = = 657.36
		0	0.45	0.45	6.6	7.05	708	100	0.8932	0.94	6.32	666.75 - 6.32 = =660.43

DELIVERY MAIN

HYDRAULIC CALCULATIONS

Fig. 123. Longitudinal profiles, sections B, C, D

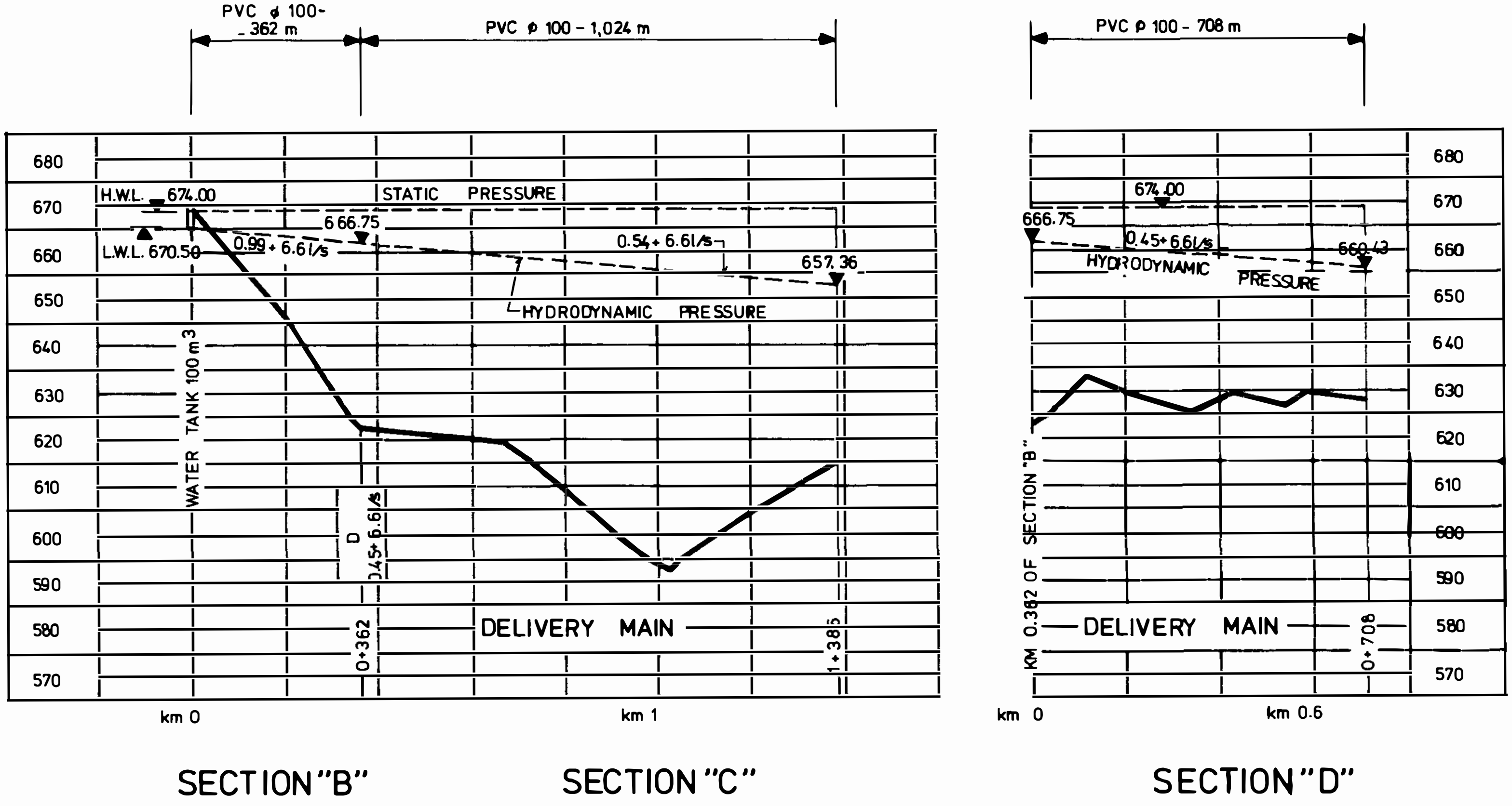
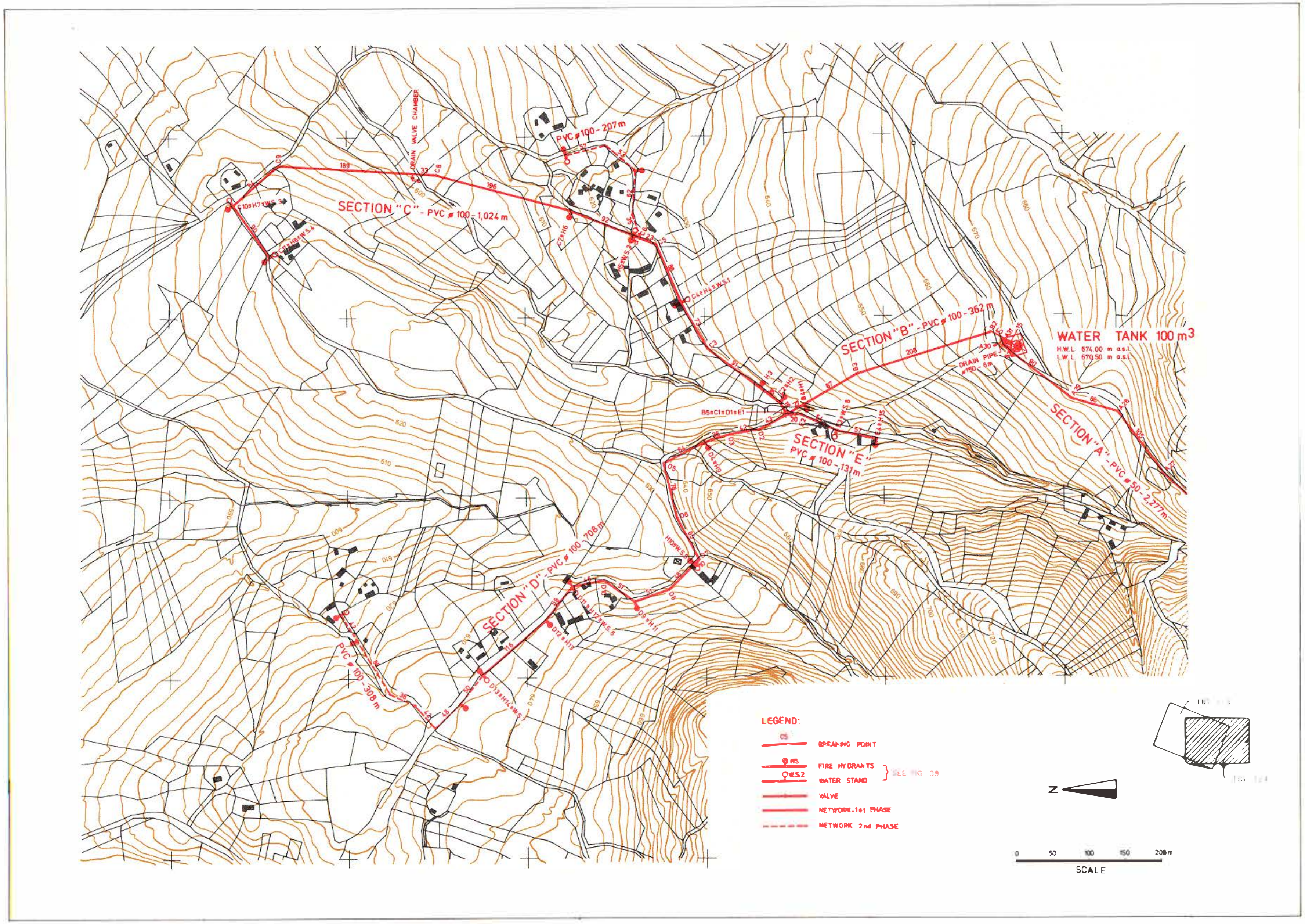


Fig. 124. Layout of the distribution system



Kololeč

Basic Data

The rural community of Kololeč is situated in the commune of Kosovska Kamenica, 5 km in a direct line from the commune centre of the same name. The village is accessible all year round by a minor road that leads out of the Gnjilane–Bujanovac road, forms the main axis of the community and gives it its long narrow shape. To the east of the built-up area, the ground slopes gently to the Ogoska Reka River and to the west it rises quite sharply, forming hilly terrain. The whole community is engaged in agriculture. Kololeč has two schools.

The 1971 census numbered the population at 485 and no increase was anticipated. For this reason a population figure of 500 was used for design purposes.

In accordance with the design criteria, a per capita water consumption of 220 litres per day was adopted. This resulted in the following water requirements.

Total		85% (reduced for design)	
m³/day	litres/second	m³/day	litres/second
101	1.2	86	1.0

Water Resources

A field survey indicated that the most convenient and economical source of water for the community of Kololeč would be groundwater from the alluvium on the right bank of the Ogoska Reka River, just upstream of the town. Before a final decision could be made, however, a hydrogeological investigation was necessary to ensure that the yield would be sufficient and the water quality acceptable.

The hydrogeological investigation, including a bored well and pumping test, was performed in 1975.

The geological profile of the borehole was found to be as follows:

0–1.0 m: silty medium-grained sand, slightly loamy

1.0–2.5 m: loamy silt

2.5–3.0 m: fine- and medium-grained sand with occurrence of gravel

3.0–5.0 m: sandy gravel with stones up to 8 cm

5.0–5.5 m: loam with silty sand

5.5–6.0 m: loam with sand

The groundwater was found in the 2.5 m thick aquifer of gravel/sand and, being under sub-artesian pressure, it rose at the time of investigation to 1.65 m below the ground level.

To avoid inundation during periods of flood, the top of the well had to be raised 1.5 m above ground level and surrounded with an impermeable fill material 10 m in diameter.

The pumping test, as expected, indicated that a well located 50 m from the right bank of the river could provide more than the necessary water yield of 1 litre per second.

Samples of the water flowing at a rate of 1 litre per second were taken for chemical and microbiological analyses during the pumping test. The water was found to have quite different qualities than the water of the adjacent river. This indicated that, contrary to expectation, the water was not infiltrated water from the river.

The water was found to be barely suitable for water supply purposes because of its high hardness of 375 mg/l calcium carbonate and an exceptional manganese concentration of 7 mg/l. However, considering the lack of an alternative source and the need to improve the living conditions of the village, where water is taken directly from the river and used without any disinfection, it was decided to proceed with the scheme. Owing to the low quality of the water, the test borehole was not recommended to be used for the water supply. Since the alluvium of the river is probably relatively narrow in this area, a dug well should be sunk at a distance of only about 20 m from the river bank so as to collect bank filtered water from the river.

On the basis of the chemical and bacteriological analyses of the river water, the infiltrated water should be mechanically and chemically pure and characterized by a favourable low salinity and a negligible content of oxidizable organic substances. The total hardness should be 90–125 mg/l calcium carbonate, without iron and manganese. It is suggested that this water is suitable for drinking. Only sodium hypochlorite dosing, as protection against bacterial contamination, will be needed.

On the other hand, it may be easier to connect the Kololeč water supply system to the water tank of Ogošte, about 5 km away. The water from the Ogošte source is sufficient and its quality is much better. This alternative is shown in Fig. 125–127.

Water Supply System

A dug well 2 m in diameter can be located upstream of Kololeč, 20 m from the river bank, and sunk to the bottom of the water-bearing strata (see Fig. 128). The well will be constructed according to the designs in Fig. 8 and the levels and details determined by the local conditions presented in Fig. 129.

A pumping station with a capacity of 1 litre per second and a delivery head of 52 m will pump water from the well through a 50 mm-diameter PVC pipe 457 m long to a water tank with 100 m^3 capacity. The Type 3.1 pumping station has standard machinery and electrical equipment. The levels and pipe dimensions suitable to this station are presented in Fig. 129.

Standard sodium hypochlorite disinfection equipment is included in the pumping station. The quantity of water extracted from the well will be measured by a meter installed in the pumping station, and the operation of the pumps will be controlled automatically by the water level in the water tank.

The pumping station will be supplied with power by a 0.4 kV low-tension overhead line, consisting of a new pole line 200 m long and a reconstructed pole line 800 m long.

The area of the well and pumping station will be fenced in and accessible by an asphalt road leading off the main Kololeč–Ogošte road (see Fig. 128).

The standard water tank, including a standard valve chamber, is presented in Fig. 130. It will be accessible via a footpath 140 m long.

The water flows from the tank through a 100 mm-diameter PVC pipeline to the distribution network consisting of 100 mm-diameter PVC pipes with fire hydrants, standpipes and isolating valves.

Technical Specifications

Dug well

A standard dug well, 2.0 m in diameter, 5 m deep and constructed as a captation well, is required, with filtration fill according to the results of hydrogeological investigation, a suction pipe of 50 mm diameter and a suction strainer with a valve of the same diameter. See Fig. 128 and 129 and the standard designs in Fig. 8.

Pumping station

A standard Type 3.1 pumping station, without a wet sump, is required, consisting of the following machinery and electrical equipment:

- 2 horizontal self-priming pumps with a capacity of 1 litre per second and delivery head of 52 m;
- 1 set of standard sodium hypochlorite dosing equipment;
- 1 standard switchboard;
- 1 set of standard lighting equipment, including light fittings, switches, socket outlets and cable installation;
- 200 m of low-tension feeding pole line; and
- 457 m of control and signalling cable line.

The pumps can be operated manually from the local switchboard, or automatically by the levels in the service water tank.

The electrode switch-off level will be at 526.95 m above sea level and the switch-on level will be at 526.0 m above sea level. The shut-off electrode in the dug well will be located at 477.05 m above sea level. See Fig. 128, 129 and 131 and the standard designs in Fig. 9, 11 and 12.

Pumping main

A 50 mm-diameter PVC pipeline 457 m long, for a nominal pressure of 1.0 MPa, is required. See Fig. 125–127 and the standard designs in Fig. 42.

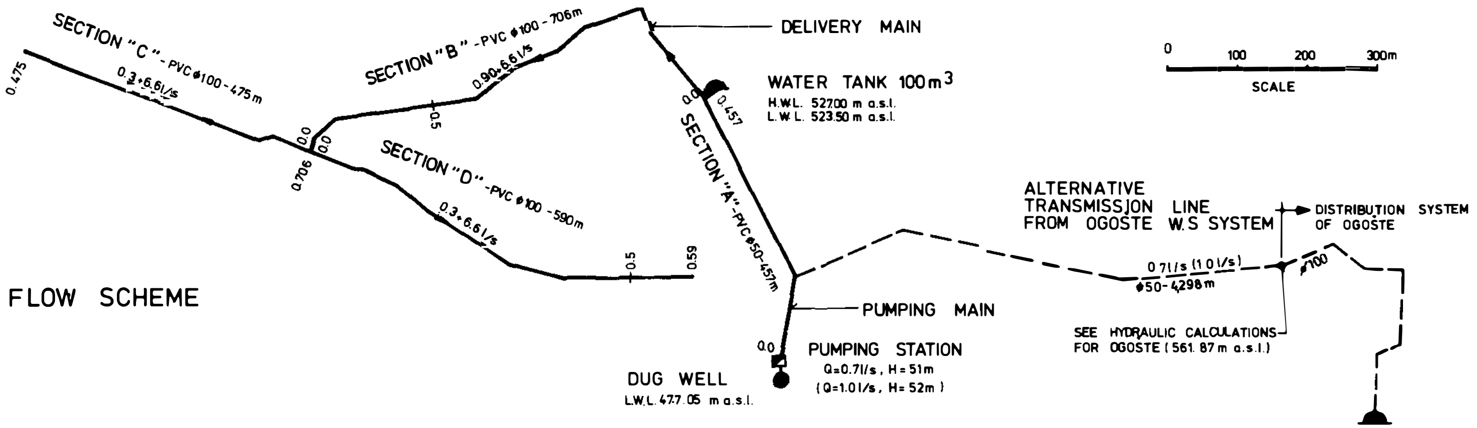
Water tank and valve chamber

A standard water tank, with a capacity of 100 m^3 and Type II base slab, is required. The maximum water level will be at 527.0 m above sea level, and the bottom level will be at 523.3 m above sea level. Also, a standard valve chamber with Type I piping arrangement, drain-pipe, access footpath and fencing, is required. See Fig. 130 and the standard designs in Fig. 28, 32 and 42.

Distribution network

The distribution network includes PVC piping with cast-iron fittings and adapting pipes, isolating valves with valve boxes for control from the ground, 15 fire hydrants and 9 water standpipes for the nominal pressure of 1.0 MPa, pipe 100 mm in diameter and 1881 m long and two house connections for the schools. See Fig. 125–127 and the standard designs in Fig. 39 and 42.

Fig. 125. Flow scheme and some basic hydraulic calculations



maxQd l/s	maxQh l/s	SECTION	maxQh/2 l/s	FLOW TOTAL maxQh/ l/s	Qf l/s	TOTAL Q Qh/2+Qf l/s	LENGTH L m	ϕ PVC k = 0.01 mm	J %	V m/s	PRESS. LOSS J×L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
1.0	1.0×1.8= 1.8	B	0.30	0.90	6.6	7.5	706	100	1.012	1.01	7.14	523.50 - 7.14 = = 516.36
		C	0.30	0.30	6.6	6.9	475	100	0.8706	0.93	4.14	516.36 - 4.14 = = 512.22
		D	0.30	0.30	6.6	6.9	590	100	0.8706	0.93	5.14	516.36 - 5.14 = = 511.22

DELIVERY MAIN

max Qd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES c	ϕ PVC k=0.01 mm	J %	V m/s	PRESS LOSSES C×J×L m	TOTAL HEAD m
0.7	457	1.2	50 (63/57)	0.1963	0.27	1.08	527.0 - 477.05 + 1.08 = 51.03
1.0	457	1.2	50 (63/57)	0.3673	0.39	2.01	527.0 - 477.05 + 2.01 = 51.96

PUMPING MAIN

max Qd l/s	LENGTH L m	COEFFICIENT OF LOCAL LOSSES c	ϕ PVC k = 0.01 mm	J %	V m/s	PRESS. LOSSES C×J×L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
0.7	4,600	1.05	50 (63/57)	0.1963	0.27	9.48	561.87 - 9.48 = 552.39
1.0	4,600	1.05	50 (63/57)	0.3673	0.39	17.74	561.87 - 17.74 = 544.13

TRANSMISSION LINE FROM OGOŠTE TO KOLOLEČ

HYDRAULIC CALCULATIONS

Fig. 126. Longitudinal profiles

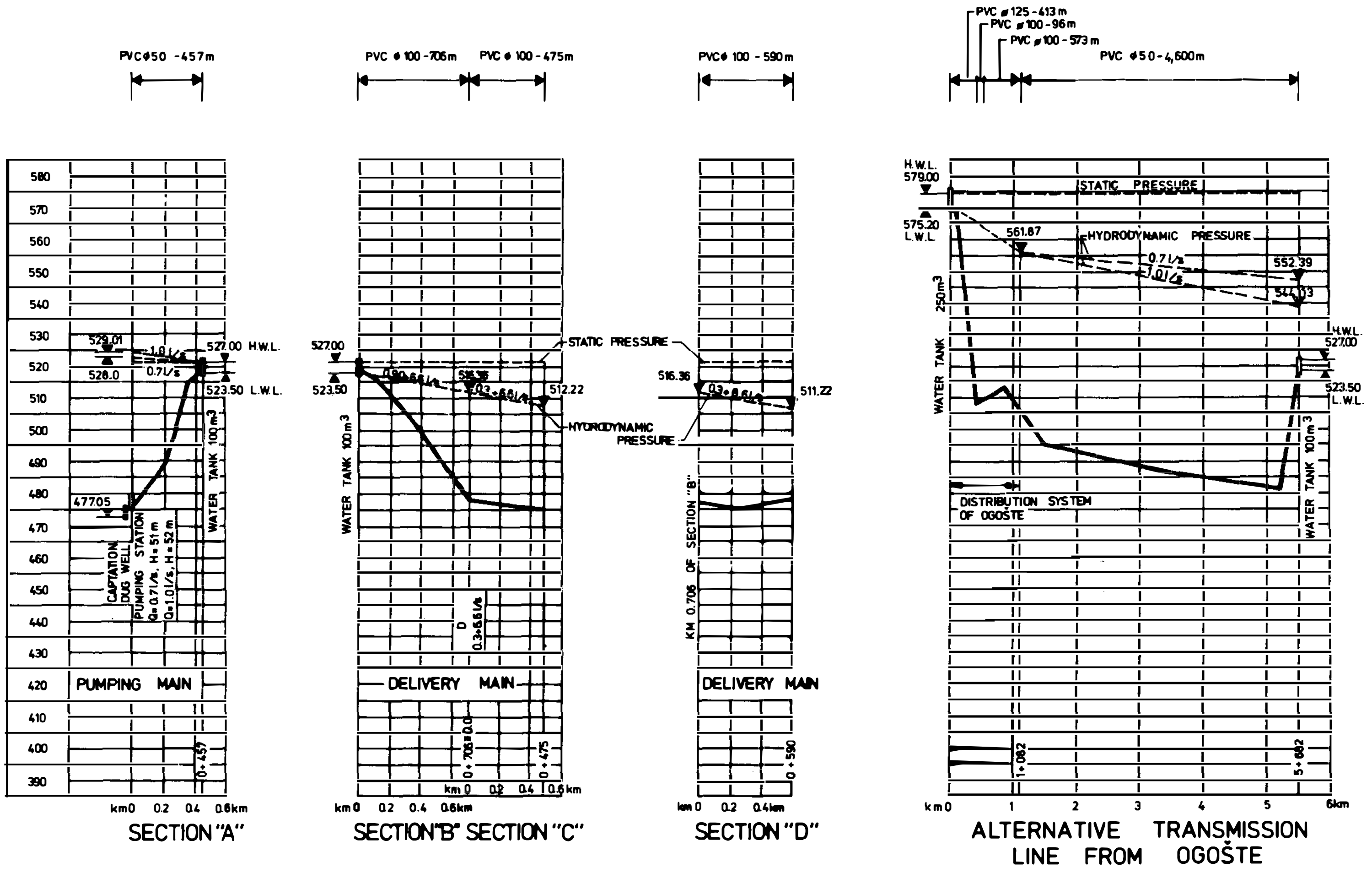


Fig. 127. Layout of the distribution system

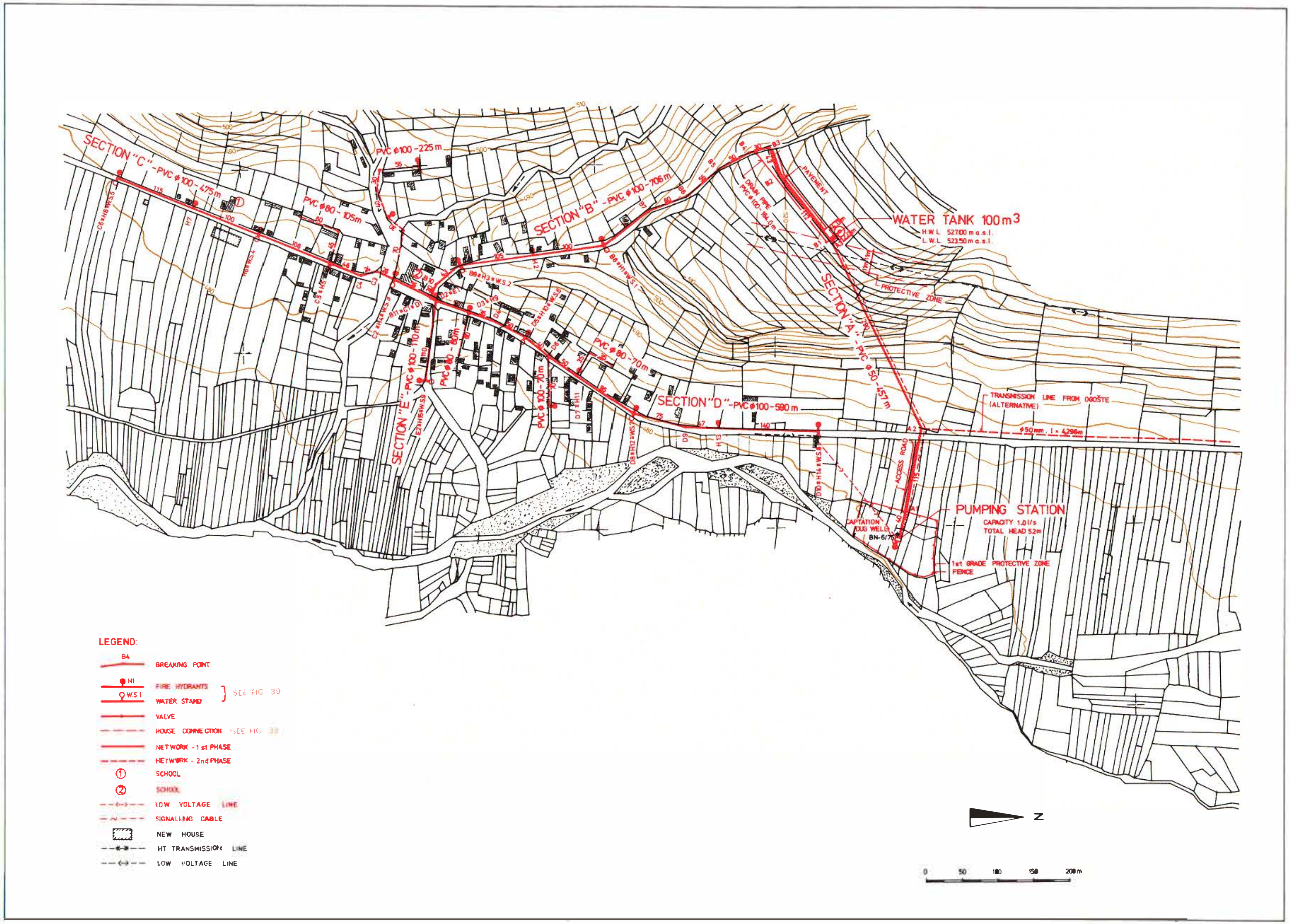
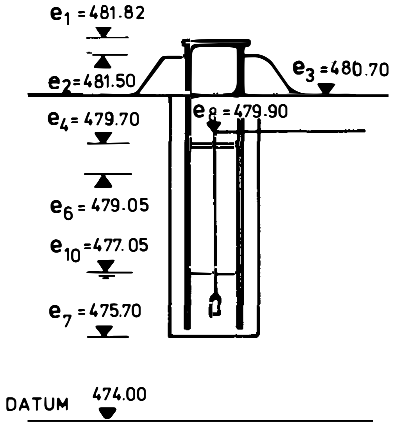


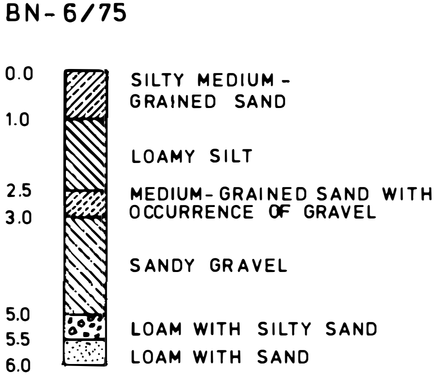

Fig. 128. Layout of the wellfield area

Fig. 129 Captation dug well and pumping station

CAPTATION DUG WELL

ELEVATION RELATIONS





NOTE: ELEVATION e_3 TAKEN OVER FROM ORIGINAL MAP

DRAWING

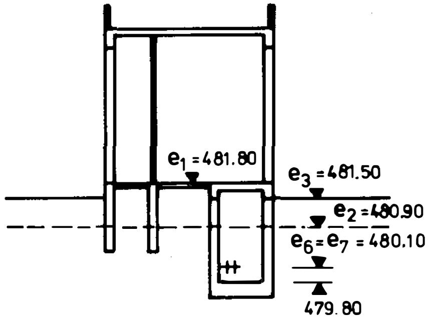
DUG WELL	FIG. 8

DIAMETERS OF PIPES

DIAMETER OF SUCTION PIPES		ϕd_1 = 50 mm
FIGURES	L_1 = 3.35 m L_4 = 5.00 m	

PUMPING STATION

ELEVATION RELATIONS



NOTE: ELEVATION e_2 TAKEN OVER FROM ORIGINAL MAP

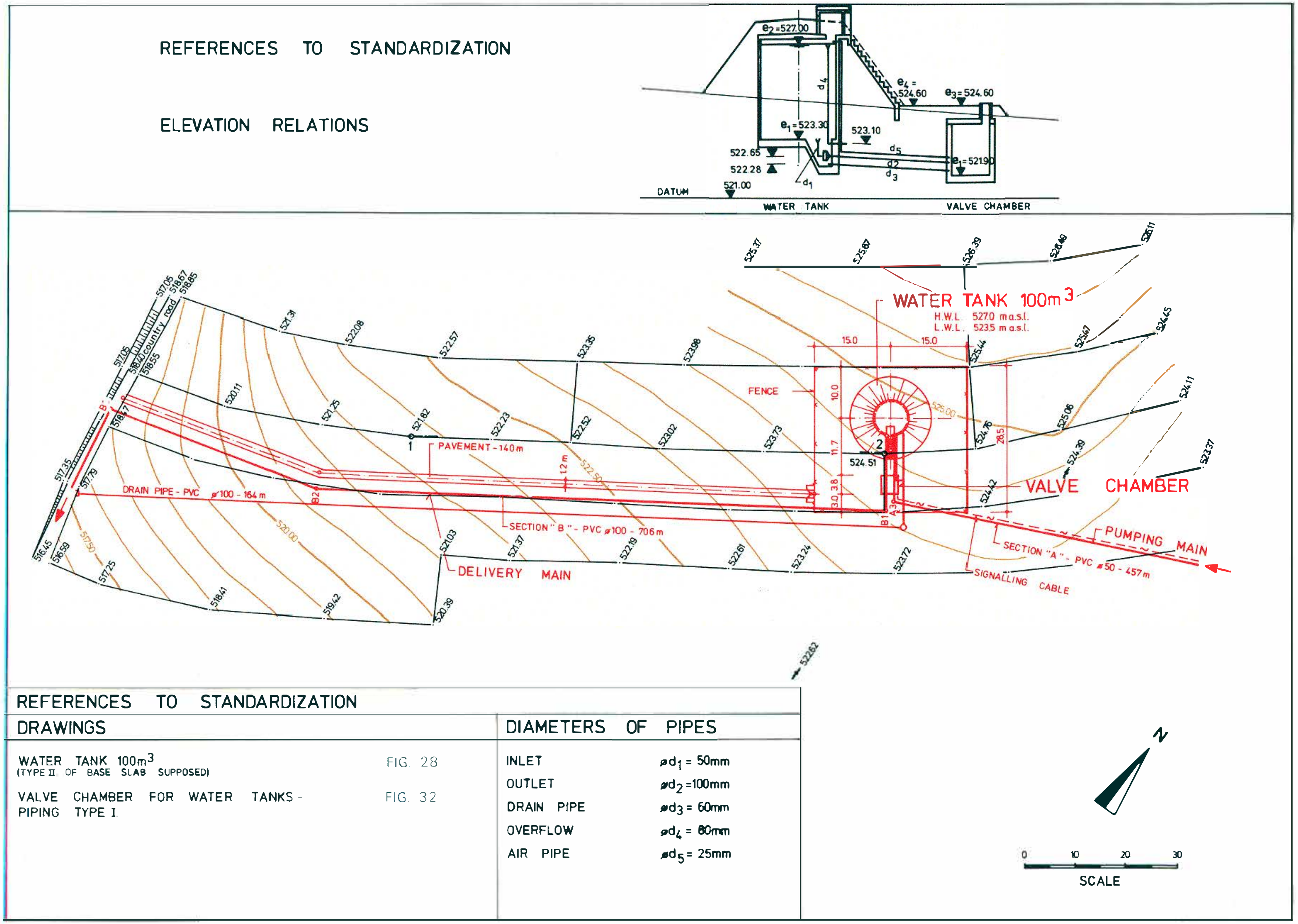
DRAWINGS

PUMPING STATION - CIVIL CONSTRUCTION (TYPE 3.1)	FIG. 9
PUMPING STATION - MACHINERY	FIG. 11
PUMPING STATION - ELECTRICAL EQIPMENT	FIG. 12

DIAMETERS OF PIPES

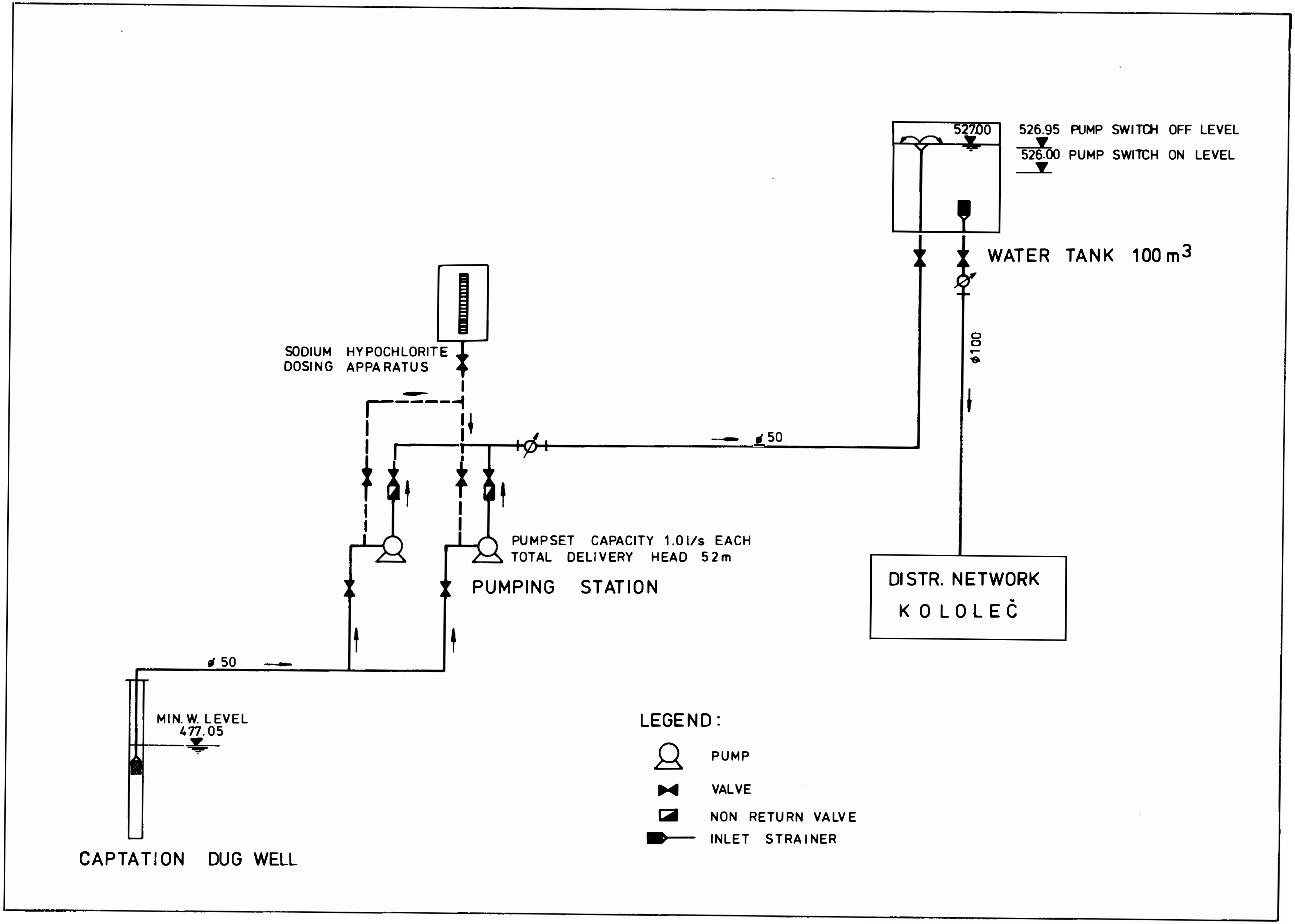
SUCTION PIPE	ϕd_1 = 50 mm
PUMPING MAIN	ϕd_2 = 50 mm

Fig. 130. Layout of the 100 m³ water tank



REFERENCES TO STANDARDIZATION			
DRAWINGS		DIAMETERS OF PIPES	
WATER TANK 100m^3 (TYPE II OF BASE SLAB SUPPOSED)	FIG. 28	INLET	ød_1 = 50mm
VALVE CHAMBER FOR WATER TANKS - PIPING TYPE I.	FIG. 32	OUTLET	ød_2 =100mm
		DRAIN PIPE	ød_3 = 60mm
		OVERFLOW	ød_4 = 80mm
		AIR PIPE	ød_5 = 25mm

Fig. 131. Operation scheme



Srednja Klina

Basic Data

The rural community of Srednja Klina is situated in the commune of Srbica, about 3 km from the town of Srbica. Access to the village is assured throughout the year by the Titova Mitrovica–Srbica asphalt road.

The built-up area of the community is in two parts lying on either side of the relatively new main road. The road had no bearing on the development of the community.

In 1971, the national census found the population of the community to be 485. The provincial planning authorities confirmed that there were no plans for its development, and, in fact, a slight decrease in population was anticipated by the turn of the century. It was therefore decided to design the system for a population of about 460. The village economy is completely based on agriculture.

In accordance with the design criteria, a per capita water consumption of 220 litres per day was adopted. This resulted in the following water requirements.

Total		70% (reduced for design)	
m^3/day	litres/second	m^3/day	litres/second
101	1.2	71	0.8

Water Resources

The community of Srednja Klina is close to the newly constructed Gazivode Dam multipurpose reservoir. It was therefore considered most appropriate that Srednja Klina, along with other villages in the area, be supplied by the regional water supply system with the large modern water treatment plant that was built for the towns of Titova Mitrovica and Zvecan. The Titova Mitrovica–Srbica pipeline has already been designed. It includes a 2 × 250 m^3 capacity water tank located at an elevation that is also suitable for the Srednja Klina water supply.

Water Supply System

The water supply system for Srednja Klina is relatively simple, consisting only of a measuring chamber and a delivery pipe of 100 mm diameter. The pipe will bring water from the water tank that should be constructed to supply water to the community of Srbica. In the future another tank of 1000 m^3 capacity will be added (see Fig. 132).

Since the 100 mm-diameter water main will cross the main road in the centre of the village, a special design for a road underpass has been prepared and is presented in Fig. 133.

The water distribution system, including fire hydrants and standpipes, is shown in Fig. 134.

Technical Specifications

Measuring chamber

A standard measuring chamber, with a standard pipe and valve arrangement, a water-measuring range of 5–25 m^3/h, a 100 mm-diameter main pipeline and a 50 mm-diameter bypass pipe is required. See Fig. 132 and 134 and the standard designs in Fig. 20.

Distribution network

The distribution network includes PVC piping with cast-iron fittings and adapting pipes, isolating valves with valve boxes for control from the ground, 12 fire hydrants and 7 standpipes for a nominal pressure of 1.0 MPa, pipe 100 mm in diameter and 1950 m long and 15 m of steel protection jacket sleeve for the underpass below the Srbica-Gornja Klina road, including supporting collars and flanged steel pipes 100 mm in diameter. See Fig. 133–136 and the standard designs in Fig. 39 and 42.

Fig. 132. Layout of the 2 × 250 m³ water tank

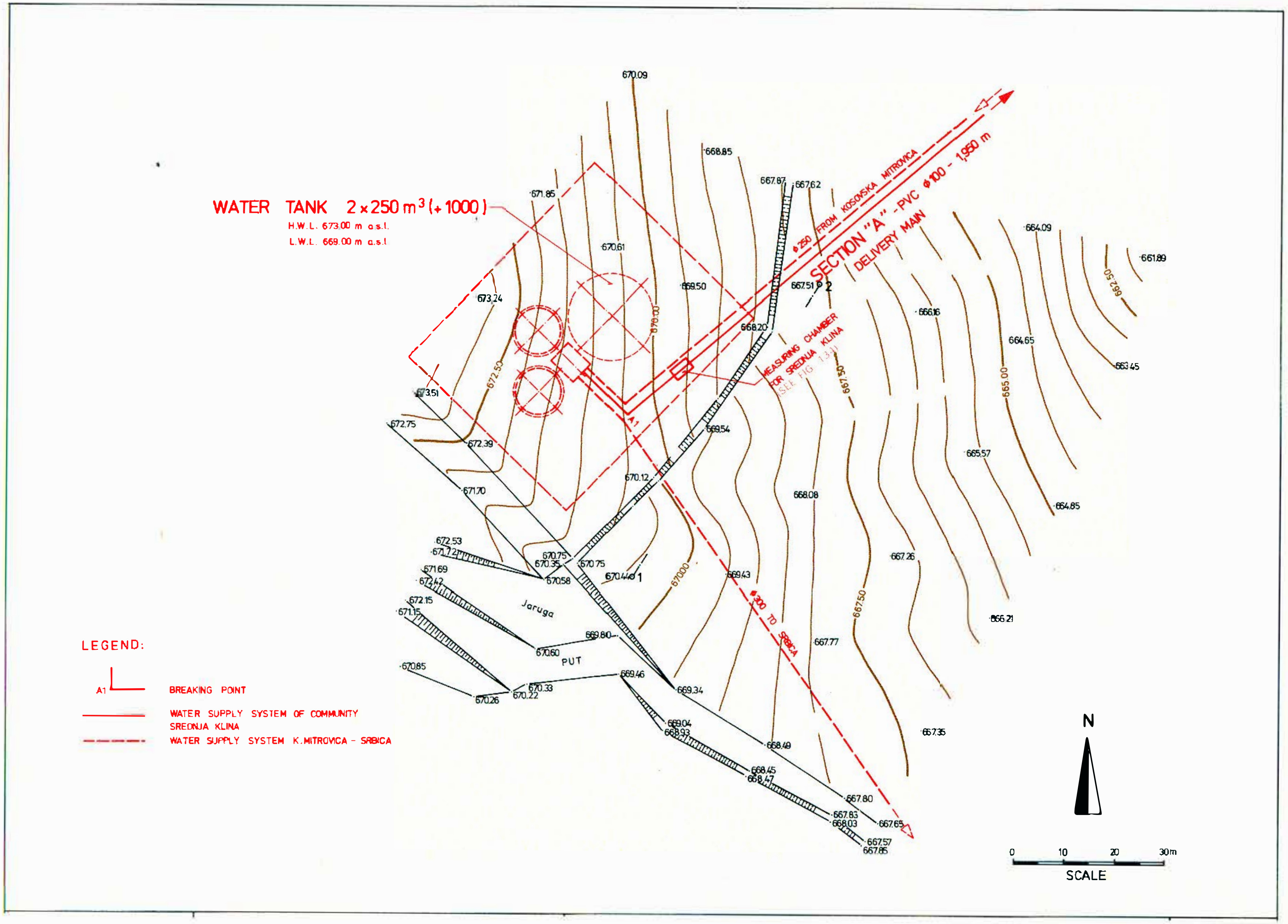


Fig. 133. Typical main road crossing

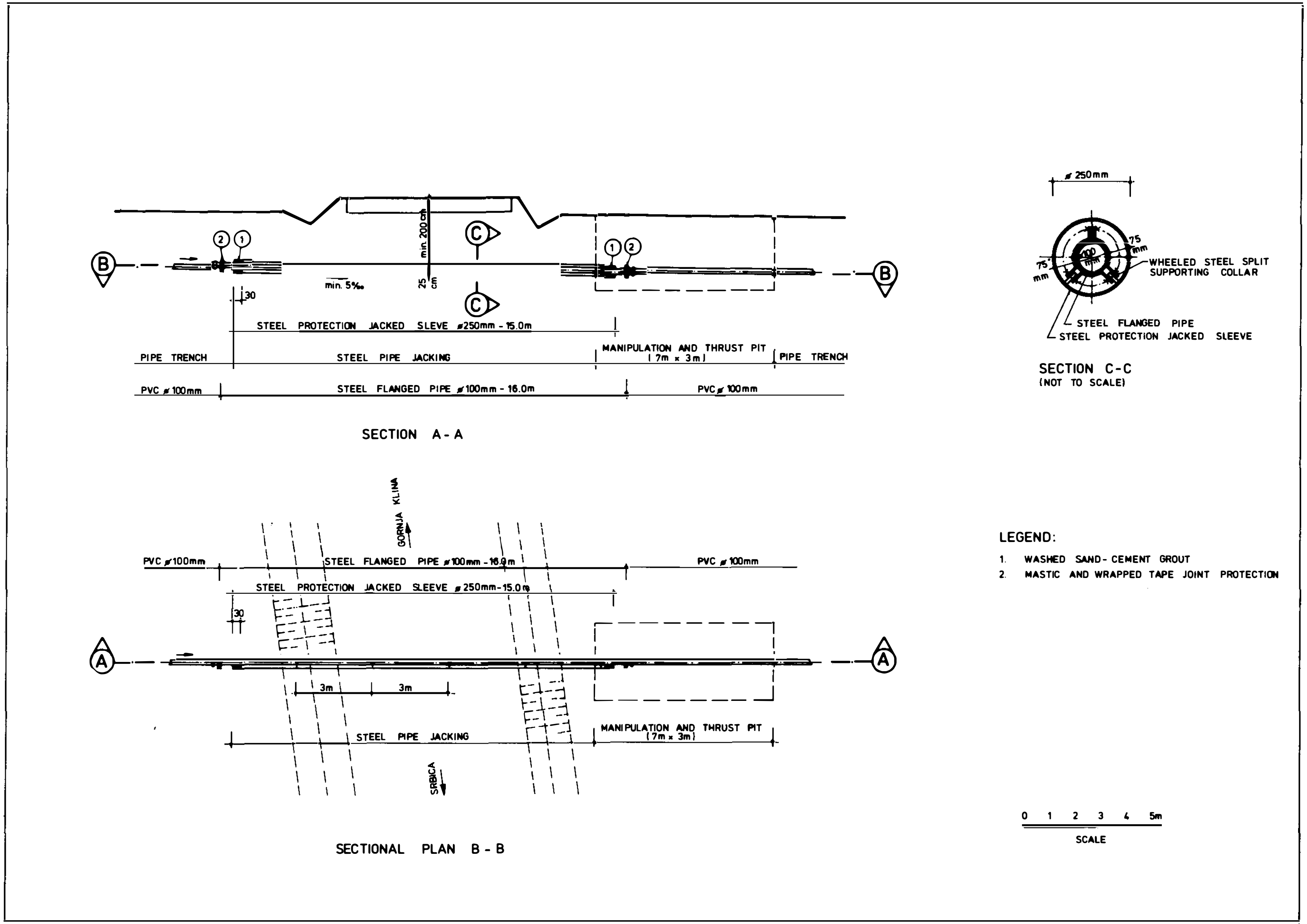


Fig. 134. Layout of the distribution system

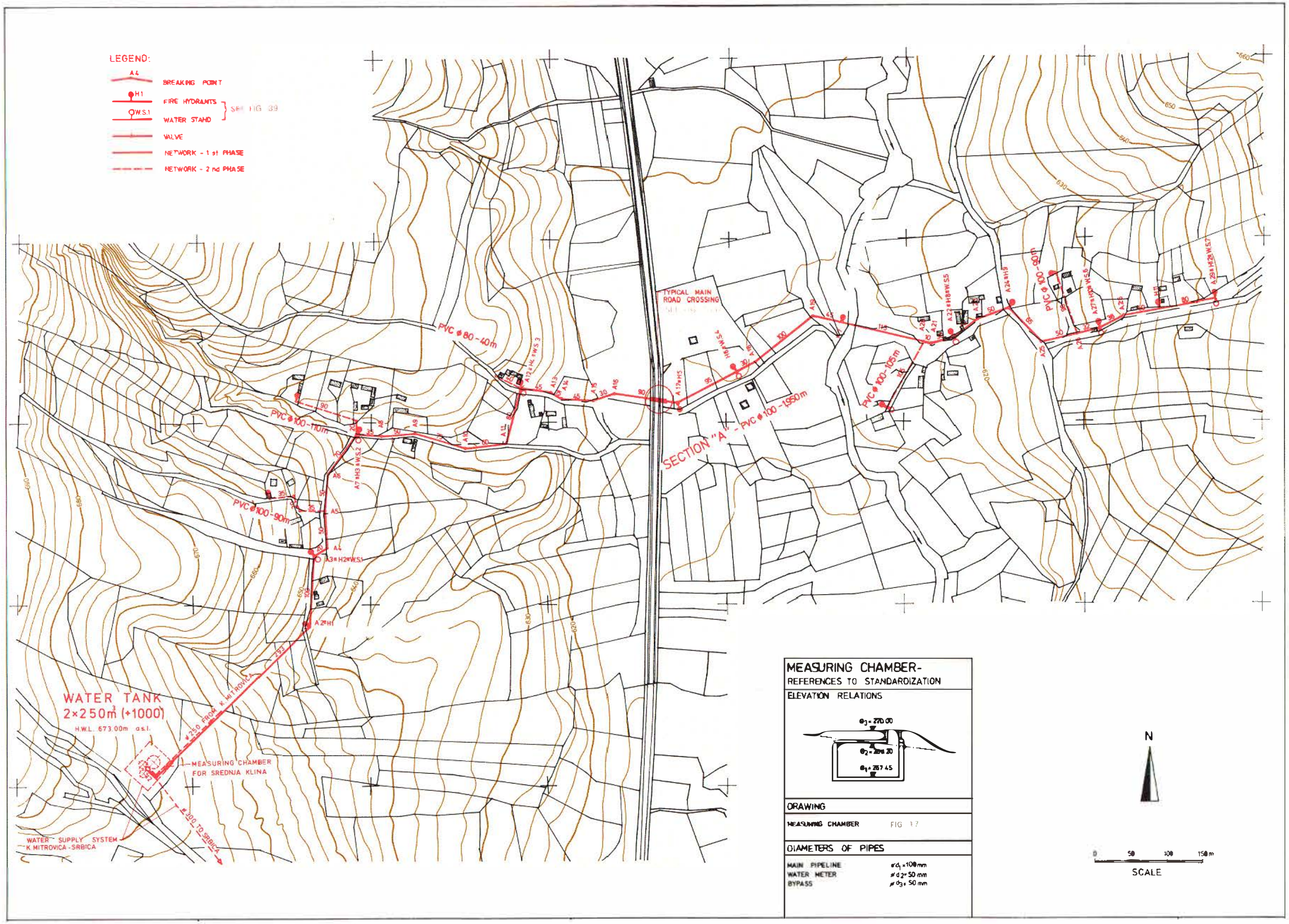
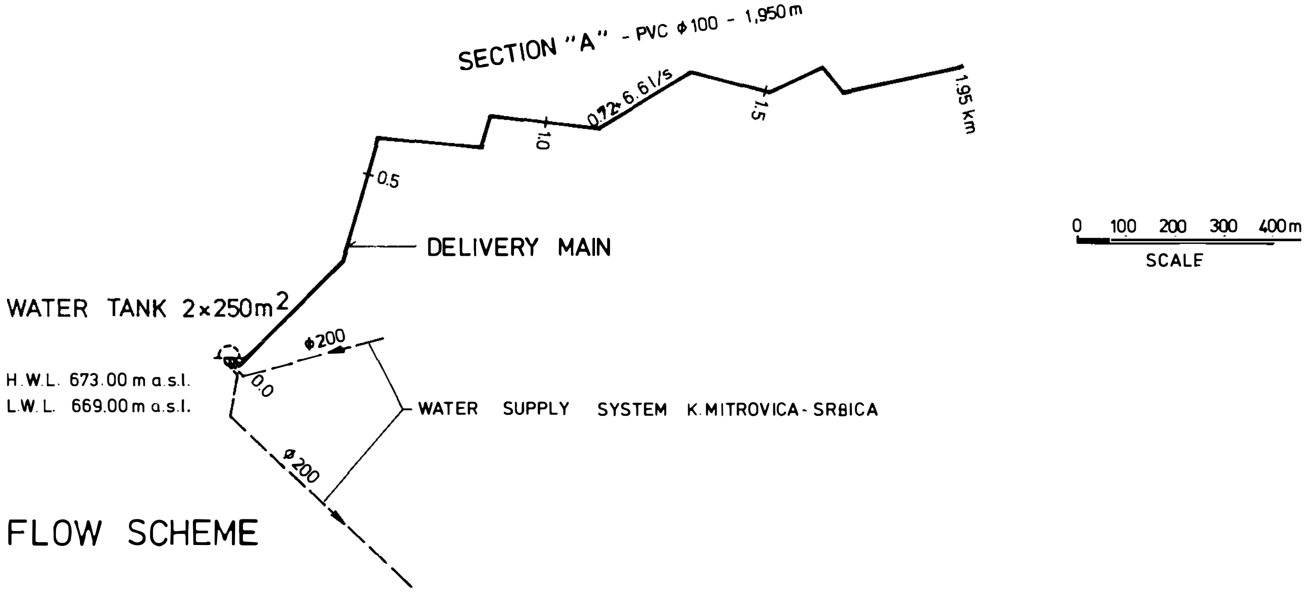


Fig 135 Flow scheme and some basic hydraulic calculations



FLOW SCHEME

max Qd l/s	max Qh l/s	SECTION	maxQh/2 l/s	Qf l/s	TOTAL Q= Qh/2+Qf l/s	LENGTH L m	ϕ PVC K=0.01 mm	J %	V m/s	PRESS. LOSS J× L m	ELEVATION OF HYDRODYNAMIC PRESSURE m
0,8	0.8 ×1.8= 1.44	A	0 72	6.6	7.32	1,950	100	0.9635	0.98	18.79	669.00 - 18.79= = 650,21

DELIVERY MAIN

HYDRAULIC CALCULATIONS

Fig 136. Longitudinal profile