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THE EVOLUTION OF
DOMESTIC WATER SUPPLIES AND PUBLIC HEALTH
IN
CYPRUS

by
H. KARAKANNAS

A Master's Thesis submitted in partial fulfilment
of the requirements for the award of M.Phil
of the Loughborough University of Technology

1988

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To the Rural people of Cyprus
 who lived in the heat of the day
 and in the cold of the night
 in the scourge of disease and poverty;
 To the Cypriots who felt the sense
 of unhappiness and uncertainty
 giving way to the dawn of development,
 progress and wealth
 My Thesis is humbly dedicated.

H. KARAKANNAS.

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Currency Equivalents

(As on 1st July 1984)

Currency Unit - Cyprus Pound (C£) = 100 Cents
C£ 1.00 = U.S.\$ 1.85
C£ 1.00 = £Stg. 1.23

Measures and Weights

1 mile	= 1.61 kilometre (km)
1 square mile	= 2.59 sq. kilometre (km ²)
1 metre (m)	= 3.28 feet (ft)
1 cubic metre (m ³)	= 35.21 cubic feet (cu.ft)
1 MCM	= 1 million cubic metre.
1 metric ton (in ton)	= 0.984 long ton (ton)
1 litre	= 0.220 imperial gallons
1 oke	= 1.28 kilograms (kg)
1 kilogram (kg)	= 2.205 pounds
1 metric ton (in ton)	= 2.205 pounds
1 litre per second (l/s)	= 0.035 cubic feet per second (Cfs)
1 hectare (ha)	= 7.5 donums
1 hectare (ha)	= 45 acres
1 square mile	= 1936 donums

PREFACE

The purpose of this Thesis for Master of Philosophy of Loughborough University of Technology, is to illustrate objectively and realistically the environmental conditions relative to the Water Resources of Cyprus, a developing British Colony, in 1936 and thereafter the evolution of water development until 1980. At that time Cyprus was suffering from poverty, water borne diseases and ill health, and lack of safe domestic water supplies.

This Thesis will confirm how the British Colonial Water Engineer, and Geologist helped by other scientists, worked to develop the island's Water Resources to overcome poverty, free the peasant from disease and thus improve his health and raise the standard of living of the cypriots and in general, how the local people responded and contributed willingly to the success of all the Water Development Programmes, implemented during the period 1936-1980.

For a clearer conception of the evolution in the development of the Water Resources, so necessary for the welfare and prosperity of the country, and the freeing of the rural population from the scourge of malaria and water borne diseases, I have sub-divided the period 1936-1980 into three namely:

(1) First Period 1936-1945

At the beginning of this period particular attention was given by the Cyprus Government to a start in implementing continuous and intensive water development programmes, for improving public health and thus raising the prosperity and welfare of the Cypriot people. Priority was given to the implementation of Water Projects, in the rural areas in particular. Within this period the Second World War began and ended.

This War affected the Water Development Programmes.

(ii) Second Period 1946-1960

This was a period of intensive water development work. It was the period of intensive work in providing piped safe domestic water supply to villages in particular. The results were outstanding. In 1959, of the total of 627 villages, 525 villages, representing 83.7 of the rural population, were enjoying a safe piped supply, through public reinforced cement concrete fountains.

Extensive irrigation works were carried out, such as lining of irrigation channels in concrete for saving water, diversion of stream flow, construction of concrete dams and river training, hydrological work and underground water investigations.

In 1960, the British Administration of Cyprus ended. The implementation of the British Engineering Code of Practice for the successful Water Development Programmes during the period 1936-1960 has proved to be most valuable and most necessary for the continuation of the Water Development Programmes during the period of the independence of Cyprus, 1960-1980.

(iii) Third Period 1960-1980

This was a period of major surface water development projects, both irrigation and domestic supplies. Extensive ground water investigations, and hydrological mapping were carried out.

A synoptical illustration of the above periods is given below:

First Period 1936-1946

1.1 Prevalence of Malaria in Cyprus

A period of poverty, disease and ill health and poor agriculture. The Water Engineer and Health Services worked jointly and successfully for the elimination of malaria, and to increase food production.

- 1.2 A description in outline of the prospects and conditions for domestic water supplies, and how the problems of both malaria and drinking water were correlated and interlocked.
- 1.3 This period covers the outbreak and termination of the Second World War. The War disrupted the development programmes and retarded the work on development in the island.

POST WATER PERIOD 1946-1960

The Dawn of Water Development

- 2.1 For the post war period 1946-1960 an outline is given of how Great Britain decided to embark on a major Water Development Programme with particular priority to rural water supplies and irrigation in Cyprus.
- 2.2 The dawn of water development was appearing over the horizon of Cyprus. Funds were allocated by the British Government under the Colonial and Welfare Acts, for water development and use. Particular priority was given to development of domestic supplies and minor irrigation works.
- 2.3 During the above period malaria was eradicated, enteric water borne disease eliminated almost totally, and the hygienic life of the people greatly improved. The rural domestic supplies, in parallel with minor irrigation works, reached an outstanding development level. By 1960, 84 per cent of the rural population of Cyprus enjoyed a hygienic piped supply from natural springs and boreholes.
- 2.4 From 1955-1960 Cyprus experienced serious violent political turbulence and setbacks. British and Greek blood was shed and strong passions were created and built up. In spite,

however, of the great bitterness, the water engineers and geologists both British and Cypriots, worked harmoniously together in friendship and respect, for the successful execution of the Water Development Programme.

2.5 In 1960, the British Colonial Administration of Cyprus was terminated. The British Engineers and Geologist were removed and the work was handed over to the Cypriot Engineers and Geologists, who continued development work on the foundations of the water engineering practice which were laid by the departing British Scientists, Water Engineers and Geologists.

(I feel strongly that it is my duty as one of the first few persons staffing the Newly Borne Water Development Department constituted in 1939, to mention herewith, that the British Water Engineers and Geologists used their Scientific Knowledge and experience in implementing the Water Development Programme in conformity with the British Engineering practice and standards, and showed responsibility towards the prosperity and welfare of Cyprus.

They left their Water Engineering knowledge here in Cyprus, and they have laid the engineering foundation for the continuation of a sound Development Programme to be executed after the Independence of Cyprus).

THIRD PERIOD 1960-1980

3.1 The Third Period marks a climax in Water Development from the existing foundation of British Engineering practice. It is a period of major projects for both irrigation and domestic water supplies.

3.2 Paradoxically, this is the period of violent political turbulence and tension, of clashes

and strife between the two Cypriot communities, Greeks and Turks, and eventually the invasion of the island by Turkey in 1974 and occupation of up to 40% of its total area. Yet, in spite of the involuntary movement of population from north to south and from south to north, the loss of lives and extreme strife, the water development programme was kept away from politics and as such has greatly benefitted the people of Cyprus on the whole, irrespective of race, belief and religion.

The above picture and thoughts of over 40 years continuous work on water development in Cyprus nesting in my mind, have encouraged and guided me in the preparation of my Thesis on the Evolution of Water Development and Health, in the semi-arid developing island of Cyprus.

In the word of Maridi ("Travels in Cyprus, 1729") CYPRUS yields to no other island in excellence.

H. KARAKANNAS.

CHAPTER ONE

SOURCES OF WATER

1.1

Water was first accumulated in the earth's depressions and formed the oceans and seas, which now cover three quarters of the surface of earth. The oceans and seas contain 94 per cent of the earth's water estimated at some 1400 million cubic kilometres. About 4 per cent (60 million km³) is at inaccessible depths. One and a half per cent (22 million km³) is either frozen as ice or snow, and the other 0.5 per cent (7.45 million km³) is the fresh water available in flowing rivers, lakes and underground aquifers, that can be used by man. (*United Nations Water Conference, 1976*)

1.2 Use of water

Man has made use of water for his welfare and economic prosperity, wherever it may be, in oceans, seas and lakes, in flowing rivers, springs or aquifers.

Fresh water is needed for domestic use, agriculture, industry and the natural green environment.

1.2.1 Geographical availability of fresh water

If we look at the map of the world we shall observe that abundance of water resulting from high precipitation is available in countries of the Northern Hemisphere located between 40-90 degrees, latitude North, and in certain places North and South of the equator, such as in South America and in West Africa (Fig. 1.1).

Other countries of the world have annual precipitations of less than 1000mm and in large areas of Africa, the Arab peninsula, and most of Australia, the precipitation is less than 500mm per annum or in certain areas less than 5mm creating desert environmental conditions.

1.2.2

We have seen that the availability of fresh water in its natural condition has not as yet been disturbed by man to a conspicuous degree, particularly by the developing countries of

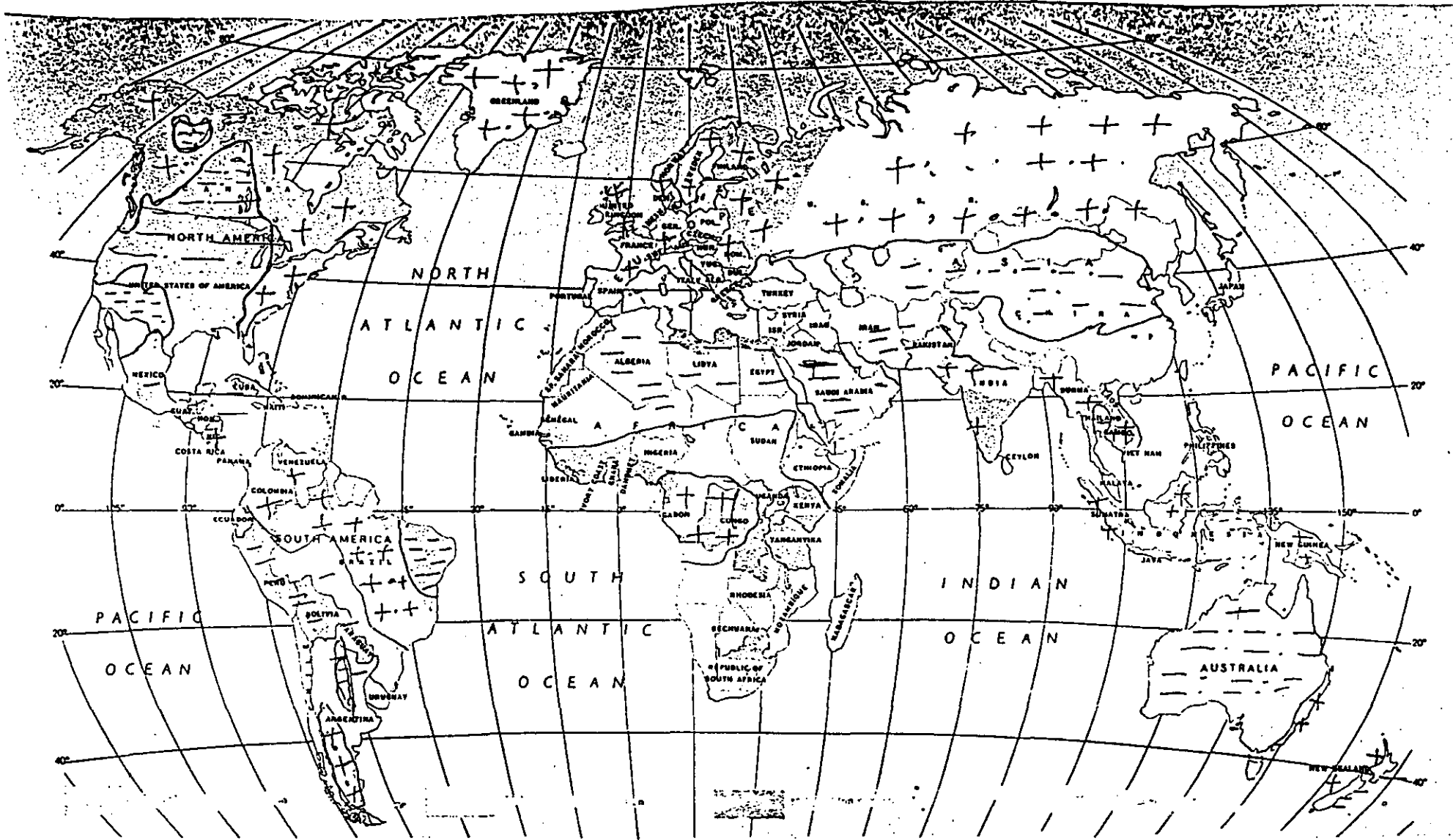


Fig. 1.1 Map showing the zones of the world with high precipitation having water surplus (+) and zones with low precipitation having water deficiency (-)

Source: The Reader Digest Great World Atlas.

our globe.

The task of using the water available where and at what time of the year it is needed, and at what quantity, is a vast one, demanding scientific knowledge, hydrological information and data, economic assistance, will and determination for water development by all concerned.

1.3 Worldwide availability of fresh water

Hydrological studies carried out for a number of years by scientists and hydrologists give an indication that 525,000 km³ evaporates from the seas, oceans and land annually and returns back to earth as rain and snow.

Of the above total estimated quantity of 525,000 km³, about 80% precipitates over the surface of oceans and seas. The balance (20%) precipitates as rain or snow over the land surface, worldwide.

1.3.1 Run off

It has been assessed that about 40 per cent of the 115,000 km³ precipitation over land surface returns to the sea as run off through rivers. This amounts to 46,000 km³.

Another part of the precipitation over the land areas is lost through evaporation from lakes, reservoirs, wet ground and evapotranspiration from plant life. This amounts to 29,000 km³.

The balance of 40,000 m³ of the average annual precipitation is left for mankind.

Table 1.1, derived from the United Nations Water Conference, Bucharest 1976, indicates roughly the availability of fresh water in each continent.

TABLE 1.1 Worldwide Water Availability

Continent	Water Availability km ³ /per hydrological year	Percentage of Total %
Africa	4,500	11.25
Asia including USSR	14,500	36.25
Australasia	2,000	5
Europe	2,500	6.25
North America	6,000	15
South America	<u>10,500</u>	<u>26.25</u>
Total worldwide	<u>40,000</u>	<u>100</u>

1.3.2 Average share per capita of the world's population

If we consider the present population of three developing continents, Africa, Asia and South America, and the estimated quantity of water runoff during each hydrological year, it will be observed that the availability of water per capita would be as in Table 1.2:

TABLE 1.2 Share per capita on annual runoff

Data	Africa	Asia Excluding USSR	South America	Cyprus
<u>Estimated</u>				
Population (Millions)	550	2500	450	0.650
Annual Run off (km ³)	4500	9500	10500	950mm ³
Share per million people (km ³)	8.14	3.80	23.33	-
Share per capita per year m ³	8000	3800	23000	1461

Table 1.3 indicates that the water available in the three continents is in abundance, even taking into consideration the increase of population of these continents during the next 40 years, and supposing their population will be more than double of what it is today.

Table 1.3 Share per capita in 2025

Year 2025	Africa	Asia	South America
Population (estimated)	1200 million	41 million	1000 million
Runoff per annum (km ³)	4500	10000	11000
Share per million people (km ³)	3.750	2.13	11
Share per capita per annum (m ³)	3.75	2130	11000

1.3.3 Potential use of water

If we assume that Water Development in the above three continents will be given top priority for raising the standard of living, and consider that up to 20 percent of the water available is utilised for the needs of the people, it is safe to assume that the water available will last them possibly for over a century from now. The problem arising is where the water resources are located, how the water will be conveyed to the areas where it is needed, and at what cost.

What climatological, topographical, social, environmental, legal and even political problems are involved? Nowadays in some developing countries the runoff causes floods and destruction. In other countries the runoff is negligible, resulting in droughts, causing famine, disease, misery and death. It is also accepted that water problems are the most difficult to solve.

Therefor the water problems of all developing countries are challenging not only the countries concerned but also the developed countries, which can offer their scientific knowledge and economic assistance, absolute necessities for water development programmes in the Developing World.

CHAPTER TWO

WATER SUPPLY IN DEVELOPING COUNTRIES

2.1

The present thesis "THE EVOLUTION OF DOMESTIC WATER SUPPLIES AND PUBLIC HEALTH IN CYPRUS" describes what has been achieved in Cyprus during a period of 45 years 1936-1980.

The successful results in the field of water development, and in consequence the disappearance of all water borne diseases, which were endemic in Cyprus in the year 1936, were a great contribution to the rise in the prosperity and welfare of this small country.

In the chapters to follow, I will endeavour to give a clear illustration of what has been achieved in Cyprus, in the hope that certain parts might be of use to other developing countries which are planning their water development programmes.

As Cyprus has been on the list of developing countries, it is worth including in this Thesis some descriptive notes, with particular reference to developing countries of the Sahel zone in Africa, which are semi-arid, and have some meteorological similarity with Cyprus. By doing so I believe it will convey to the reader, a clearer conception of the importance of water supply and sanitation for the survival of these developing African countries.

2.2 Developing countries

The developing Countries occupy up to two thirds of the Earth's surface. These are the countries of Africa, South America and of the southern part of Asia. They differ in climate, terrain, culture, heritage, religion, ways of life and thoughts. They all, however, have one problem in common, that of water development and sanitation.

2.2.1

The provision of adequate pure safe domestic water to the Developing Countries, and the improvement of sanitation, will enable them to fight disease, improve health, overcome poverty and raise their prosperity and standard of living.

Water should also be developed for irrigation for the production of food for these countries where under-nutrition and

malnutrition are most prevalent, particularly in young children and expectant and nursing mothers.

2.2.2

The undesirable primitive and poor water supply and sanitation conditions existing in most developing countries, and the famine and disease that fell on countries of Africa, as a result of periodic drought, have stirred and promoted the interest, sympathy and help of all developed countries towards their people. The catastrophe seems now to be in recess, but the water problem is there, unsolved.

In view of the above, I thought it was advisable to include some notes derived from a Regional Symposium on "Rural Community Water Supply Development, Fact Finding", held in Addis Ababa, Ethiopia in 1964.

It is hoped the notes will give to the reader the feeling of what progress in rural community water supply has been made during the last twenty years, and what lies ahead to be done in this field.

2.3 Rural community water supply fact finding Addis Ababa - 1964

In July, 1964, a three week symposium on "Rural Community Water Supply, Fact Finding" was held in Addis Ababa, Ethiopia. The symposium was sponsored by the USAID (AID) Cyprus, and AID Washington.

2.3.1

The participants were from countries of Africa, of the Eastern Mediterranean (Europe) and Asia. Those countries were:

- | | |
|----------------|-----------------------|
| 1. Burundi | 15. Nigeria |
| 2. Cameroon | 16. Northern Rhodesia |
| 3. Cyprus | 17. Pakistan |
| 4. Ethiopia | 18. Rwanda |
| 5. Ghana | 19. Sierra Leone |
| 6. Greece | 20. Senegal |
| 7. Iran | 21. Somalia |
| 8. Israel | 22. Sudan |
| 9. Ivory Coast | 23. Tanganyika |
| 10. Jordon | 24. Turkey |
| 11. Kenya | 25. Uganda |
| 12. Liberia | 26. Upper Volta |
| 13. Malawi | 27. Yemen |
| 14. Niger. | |

The above countries represented a population of over 200 million.

Cyprus was represented by three participants, headed by Mr H. Karakannas.

From the synoptical reports of participants, it was discovered that certain developing countries had done substantial work in water development, other countries had just commenced such work, and a number had not even embarked on the tasks of water development and use.

2.3.2 Symposium findings

During the symposium all aspects of water development for communities in developing countries were discussed and considered at length at the meetings of the groups of participants.

The findings were as follows:

- a) It was generally accepted that water development is the foundation of all other development programmes in every

country, and as such, it should be given preference and priority.

- b) It was realised that water development and rural water supplies is a complicated and difficult problem, influenced by many factors such as spread and distribution of population, topographical and quantitative availability of the water needed, technical and financial abilities, and educational, social and environmental aspects prevailing in each developing country.
- c) At the symposium, it was found that, unlike Greece, Cyprus, Israel and Jordan, where the rural population is organised and well integrated with the Central Government, most of the participating countries had to deal with people living a nomadic life. Such people are scattered over hundreds of miles, with very poor communication facilities, living in isolation. Millions of people are without education living in a primitive way, in conditions fraught with disease and malnutrition. Most of the countries participating were very poor, and as mentioned at the symposium their annual national gross income was below one hundred U.S. Dollars per capita.
- d) It was confirmed that some developing countries had just embarked on water development for their rural communities. In other countries very little or nothing was done along these lines.

2.3.3 Water resources

With regard to the water resources it was proved at the symposium that Africa and Asia overall have abundance of fresh water. It is agreed that some regions have abundance of water while other regions have less fresh water or suffer from droughts. All over the world, the developing countries, particularly the ones at the arid zones, are at the mercy of their water supply environment.

In African such arid countries, with an average annual precipitation of 100-400mm, are located south of the Sahara desert and north of Gambia reaching the western side of the Ethiopia massif plateau. They form the well known Sahel dry

zone. This complex of arid countries consists of Chad, Mali, Mauritania, Niger, Upper Volta, parts of Sudan, Ethiopia, Kenya and Somalia. The climate of these countries is semi-desert with intermittent rainfall, droughts and high temperatures.

To alleviate the water shortage that prevails in these arid regions, it is imperative to convey water from distant water sources. It may also be feasible to resettle the people in places where fresh water is plentiful, or can be made available more economically. This is a matter of good planning to be carried out by consulting experts in this field.

2.3.4 Planning

The developing countries will be able to deal with their water development problem only through proper continuous planning, design, financing, execution and management. Legislation and administration should also go on parallel with the above activities, as they are an essential part of any development work.

2.3.5. Financing

At the symposium it was maintained by the participants of the African countries that an Africa Development Bank was established with a capital of £300 million pounds sterling. An amount of £40 million pounds sterling would be spent on development programmes including water development, with priority on rural water supplies.

If we reckon, however, that the capital expenditure on domestic water supplies to meet the African standards, say a quantity of 25-50 litres per capita per day, for domestic use and livestock, is estimated to be 40 U.S. Dollars per head of the population, then the amount needed for the 450 millions as roughly estimated in 1970 would be in the region of 18 billion U.S. Dollars, showing a trend towards reaching 36 billion of U.S. Dollars by the year 2000 when the population will possibly be doubled.

It appears, therefore, that an estimated annual expenditure of almost one billion U.S. Dollars will have to be incurred until the year 2000 for water development in Africa. This amount represents an annual expenditure of less than 2 U.S.

Dollars per capita of the population, which is feasible. Nevertheless, with malice no one, it may be that the people of Africa have not so far been conscious of the importance of water and as such they have not given the necessary priority to water development.

2.3.6 Cyprus-priority on water development

In Cyprus, a semi-arid country having an average annual precipitation of 504 mm, water development absorbs up to 25% of the total development budget.

The share per capita of the Cyprus population (650,000 as per the 1980 census) in capital expenditure on water development rises to as much as 15 U.S. Dollars per annum.

Both community and governing bodies have always given top priority to water development, and it is worth mentioning that during a period of 40 years of systematic work on water development, we have managed to bring under control up to 70% of our water resources.

In total about 400 cubic metres per person per year is used for domestic purposes, and for irrigation, in a highly effective way.

2.4 Progress on water development in Africa since 1964

It is very unfortunate that after a period of 20 years, since the symposium for the rural water supplies development was held in Addis Ababa in 1964, very little work has been done in this field in the developing countries of Africa.

For over a year now news reaching us through the press, radio and television, has given the sad picture that in Ethiopia, Sudan, Chad and other semi-arid or arid countries, thousands of people, mostly children have died from hunger, disease and thirst, from lack of water supply. This unfortunate condition is inconceivable and most regrettable to the majority of people of other countries in the world.

It appears that most of the developing countries have a long way to go before they will be able to tackle their water supply in a satisfactory way, to their standards. Developing countries have received millions of U.S. Dollars, as free grants or loans, from the developed countries, but unfortunately the

results on water development programmes have been discouraging.

From the above it is apparent that the solution of the water problem in the developing countries is beyond their understanding, technical, financial capacity, and will. Administrators and communities should be prepared and determined to give priority to water development in their country, if they desire to remove poverty, ill health, disease and famine.

The substance of this Thesis is water development in Cyprus. We have gone through the various stages of water development since 1936, and we hope the reader of the Thesis will welcome our suggestions and comments on water development in developing countries of Africa, some of which have meteorological similarities with Cyprus.

2.5 Suggestions and comments for water development programmes in developing countries

The developing countries should pursue the following:-

- a) Seek and be ready to have technical and financial assistance from the developed industrial countries, with preference to the countries with which the beneficiary country can communicate through language, culture etc.,
- b) It should be appreciated that an expert scientist from a developed country has to work under the most difficult and undesirable conditions in a developing country, bad climate, tropical communicable diseases, lack of pure safe water, no amenities and recreation. Thus the community of the developing country should show understanding and treat him as a friend, stimulating his enthusiasm towards his work on water development under the adverse conditions.
- c) In the absence of adequate topographical information and data, development work has to be concentrated on small simple projects, which can be managed by the local technical people, who will be educated and trained for this purpose.
Such projects should be economical, and designed to match the general way of life and environment of the country concerned.
- d) It is imperative to train and educate local technicians

and skilled labourers so that they will be able to build and undertake some form of responsibility in the implementation of the water development programme.

- e) Water legislation must be enacted to work parallel with the planning, designing and execution of the water development programme.
- f) The possibility of creating new central settlements in suitable areas, and providing satellite small settlements around each central one, should be given deep thought by the Administering Authorities of each developing country.
- g) Water and hygiene education of the people is very important. This can be done either at school, or by radio.

The educational material should be in simple language, understandable to the people. It should be continuous and methodical, prepared in a scientific way, to meet the social and mental preference of the people.

- h) Appropriate water development and affiliated departments should be created. These departments should be staffed adequately in quality and number.
- j) Above all, politics should be kept out of water development.

2.6 Comments

It is our hope and desire that all countries concerned, developing and developed, will work together in mutual understanding and goodwill, and determination for the implementation of water development programmes.

The developing countries should abandon their apathy towards water development, which is a vital ingredient of their life, and simultaneously the developed countries should encourage such water development programmes, by offering liberal technical and financial help.

Water development in a country is part of the concern of all countries.

CHAPTER THREE

CYPRUS - A DEVELOPING COUNTRY

3.1 Synoptical geographical notes

Cyprus, an island in the eastern Mediterranean sea, lies at longitude 33° 30" and latitude 35° 00'.

It has a circuit of 966 kilometres, and an area of 9254 square kilometres. Its length is 322 kilometres and its width varies from 21 to 168 kilometres.

In area Cyprus is larger than either Crete or Corsica and is more or less identical with the combined areas of Devon and Dorset. (Figure 3.1).

3.2 Morphological regions

The island is crossed and divided by a range of mountains running from East to West, namely:

3.2.1 The Troodos Massif

The Troodos Massif is the highest old igneous range of Cyprus. Mount Olympus is the highest peak, rising to 1953 metres above sea-level. Topographically Troodos is an imposing mountainous assemblage.

The geological formation of the Troodos Massif consists of plutonic rocks, forming the crest of the range, in the centre, and surrounded by gabbro formation. (Figure 3.2).

The igneous outcrops of the island, consisting mainly of diabase and pillow lavas, all along the foothills, cover an area of about 3200 square kilometres or one third of the total area of Cyprus.

Geological and geophysical data indicate that the Troodos Massif is a mesozoic volcanic complex. It has no floor. The tectonic movement at the time of extension was tensional, and now it is a block-folded mass.

The Troodos range is rich in mineral deposits, some of which have been exploited since ancient times. The principal minerals are asbestos, chrome, and copper pyrites.

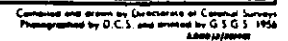
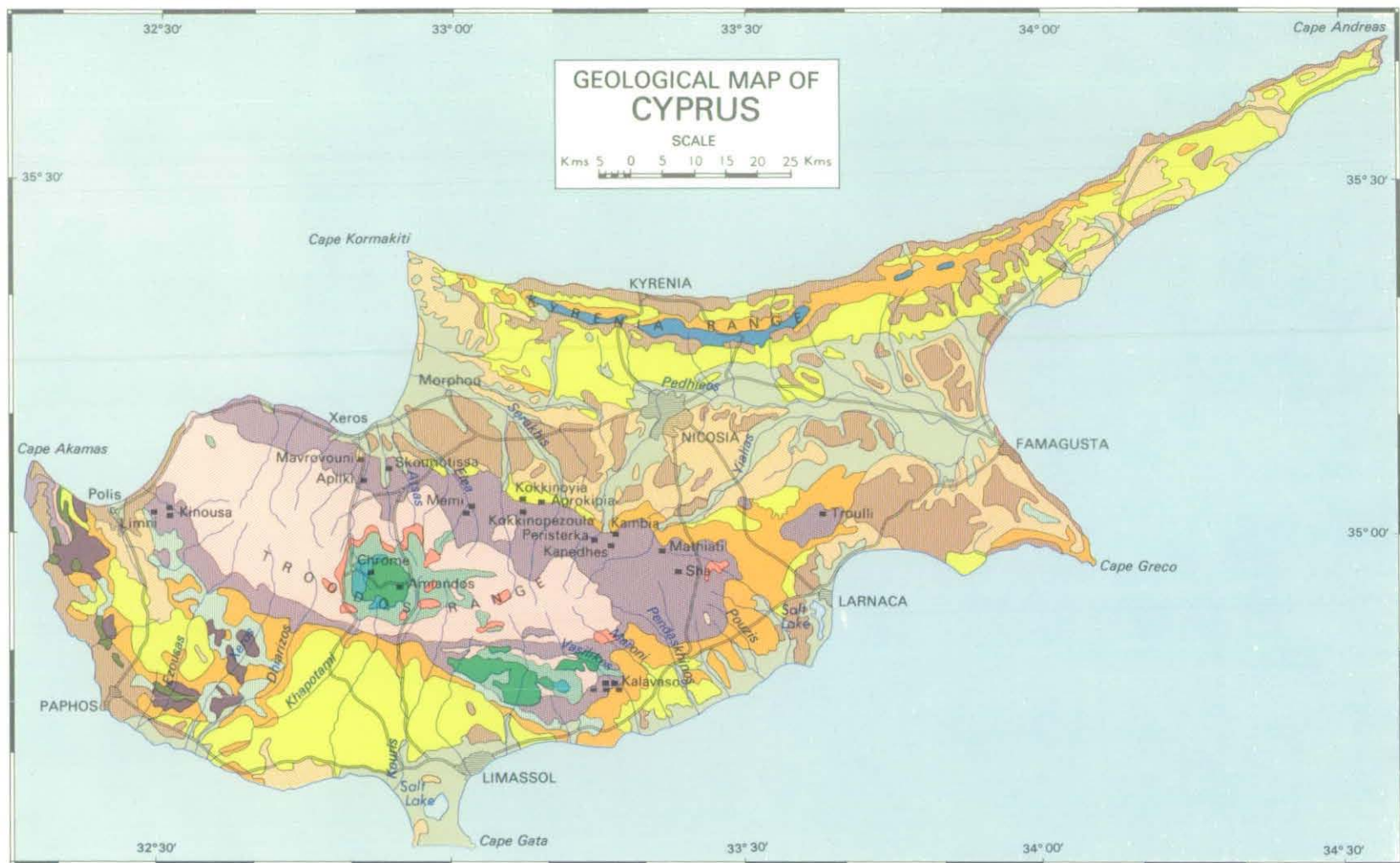


FIGURE 3.1






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LEGEND

SEDIMENTARY FORMATIONS

	Alluvium	RECENT
	Fanglomerate, Terrace Deposits	PLEISTOCENE
	Nicosia - Athalassa Formations	PLIO-PLEISTOCENE
	Kalavassos, Koronia, Pakhna and Kythrea Formations	MIDDLE-UPPER MIOCENE
	Terra, Lefkara, Ardana-Kalogrea and Lapithos Formations	MAESTRICHTIAN -LOWER MIOCENE
	Moni, Kannaviu and Perapedhi Formations	CAMPANIAN-MAESTRICHTIAN
	Hilarion, Sykhari, Dhikomo and Kantara Formations	PERMO-CARBONIFEROUS TO LOWER CRETACEOUS
	Mamonia Complex	TRIASSIC TO LOWER CRETACEOUS

TROODOS OPHIOLITE (PRE-CAMPANIAN)

	Upper and Lower Pillow Lavas and Basal Group	PILLOW LAVA SERIES
	Diabase	SHEETED DYKE COMPLEX
	Plagiogranite	PLAGIOGRANITE
	Gabbro	GABBRO
	Pyroxenite, Wehrlite, Dunite	} ULTRAMAFICS
	Harzburgite, Serpentinite	
	Serpentinite (Mamonía Complex)	
	Mine	

3.2.2 The Kyrenia range

The Kyrenia range constitutes the second highest mountains, the northern range extending for a length of nearly 90 kilometres from east to west along the northern part of Cyprus. The highest peak of the Kyrenia range rises to 1023 metres above mean sea-level.

In contrast to the Troodos igneous massif, the Kyrenia range is composed mainly of Hilarion and Syrkhari limestone of an upthrust nature, standing vertically. The large scale low angle thrusting of the limestone masses, began during the late Cretaceous and they are overlaid by the Lapithos and Kythrea sediments. (*Frank Dixey 1972. Notes on the geology of the Kyrenia Range*).

The total area of the limestones in the centre of the range is 85 square kilometres, receiving on average annual precipitation varying from 500 to 560 millimetres, amounting to a total of about 45 km³.

Experiments carried out by the Water Development Department in the year 1951-1952, proved that the runoff from the Kyrenia limestone area is not more than 10% and having allowed 60% evaporation and evapotranspiration, we can safely consider the 30% of the total precipitation percolates into the limestone aquifer.

Considering that the limestone surface area is about 85 km², the expected annual quantity of precipitation which replenishes the Kyrenia limestone squifer is in the region of fourteen million cubic metres/annum.

Kyrenia has a rich limestone unconfined aquifer. (Figure 3.3). The biggest springs in Cyprus issue from this squifer and discharge on the surface through the Kythrea and Lapithos geological formations. Such springs are the Kythrea spring, the Lapithos and Karavas springs and ten others, in total discharging an average annual quantity of seven million cubic metres. This indicates that the discharge from the Kyrenia springs is the overflow from the unconfined limestone aquifer.

The storage capacity of the Hilarion Kyrenia limestone, is estimated to be 7 million cubic metres. The



L E G E N D

A. EXTENSIVE GROUNDWATER BODIES IN ALLUVIAL SAND AND GRAVEL, CONGLOMERATE, SANDSTONE AND CALCARENITE

- Alluvial deposits**
- 1 Unconfined water generally at shallow depth in connection with riverbeds, deltaic gravel-sand deposits and coastal sand including estuarine deposits.
 - 2 Water in alluvial deposits with impermeable to semi-permeable surface.
 - 3 Clay and silt of undefined thickness containing water-bearing lenses of sand, underlain by generally impervious marl or siltstone.
 - 4 Dune sand, forming part of aquifer systems.
 - 5 Dune sand, normally shallow on Kythrea beds.

Pleistocene sand, gravel and silt deposits

- 6 Unconfined water in marine and terrestrial conglomerate and terrace formations, locally including calcarenite.
- 7 Very shallow ground water controlled by the configuration of underlying silt, clay or marl, in some formations as above.
- 8 Confined ground water in gravel deposits (Akrotiri Peninsula)

Pliocene and Upper Miocene sandstone, calcarenite, and connected fragmental limestone

- 9 Unconfined } ground water in sandstone, sandy marls and calcarenite (i.e. Nicosia Formation)
- 10 Confined }
- 11 Shallow unconfined ground water controlled by the configuration of underlying impervious or semi-pervious strata, in some formations as above

Middle Miocene sandstone

- 12 Unconfined } ground water in sandy parts of Middle Miocene (Pakhna Formation).
- 13 Confined }

B. EXTENSIVE GROUNDWATER BODIES IN FRACTURED AND KARSTIC LIMESTONE, DOLOMITE, GYPSUM, CHALK AND MARLY CHALK

- 14 Unconfined ground water in reef, detrital and crystalline, brecciated and somewhat karstic limestones (Koronia Limestone, Terra Limestone and Hilarion Limestone).
- 15 Confined ground water in reef limestone and detrital limestone. (Koronia Limestone, Terra Limestone).
- 16 Unconfined } ground water in gypsum aquifers.
- 17 Confined }
- 18 Unconfined ground water in aquifers of secondary importance of mainly massive, highly retentive chalk and cherty, locally marly chalk. (Chalks of the Lapithos Formation of the Kyrenia Range included).
- 19 Confined ground water in aquifers of secondary importance consisting of cherty, locally marly chalk, sometimes including strata of massive chalk. (Chalks of the Lapithos Formation of the Kyrenia Range included).
- 20 Ground water in highly retentive rocks such as chalk interbedded with marls. (Pakhna Formation and Lapatza Formation)

C. LOCAL AND SMALL DISCONTINUOUS GROUNDWATER BODIES IN COMPLEX SEDIMENTARY AND IGNEOUS UNITS

- Units with alternating semi-permeable or impermeable beds and permeable beds including chalk or limestone of minor importance
- 21 Clay, marl, siltstone, greywacke and shale (Mainly rocks of the Mesaoria Group locally including marl, silt and clay of the Alluvium and clay, siltstone, greywacke and shale of the Kythrea Formation).
 - 22 Mamonnia Complex, including serpentine.

Igneous rock units

- 23 Volcanics with dominantly submarine pillow lavas, heavily fractured intrusive rocks and plutonic rocks

CONVENTIONAL SIGNS

- 24 River, perennial and seasonal.
- 25 Dam
- 26 Spring, yielding 500,000 m³/year
- 27 Fault, (downthrown side indicated)
- 28 Thrust (teeth on upper plate)

flowing springs in years of rainfall above normal have an increased flow in winter and drain the aquifer from April to November. When the aquifer is over replenished, new springs appear which flow for some time. In years of drought the aquifer is losing substantially its storage. Moreover pumping reduces greatly the storage capacity. We are informed from Kyrenia that the big springs of Kyrenia range are greatly affected by the overpumping from boreholes. The aquifer is steadily declining, and the flow from springs substantially decreased due to overpumping.

3.2.3 Mesaoria Plain

In between the two ranges of Troodos and Kyrenia, and right across the northern half of the island from Famagusta in the east, to Morphou bay in the west, lies the plain of Mesaoria. (Figure 3.3). Mesaoria is a Greek word meaning "in between two mountains". The plain is 106 kilometres long and 24 kilometres wide, on average. It is divided into east Mesaoria, commencing from a Nicosia-Ovgos line at an altitude of about 280 metres and reaching Famagusta to the east and west Mesaoria reaching Morphou bay to the west. The dividing line was originally submerged and divided the two basins into two sedimentary shallow lakes.

Mesaoria ranges in age from upper miocene to lower pleistocene. It comprises mainly the calcarenite and marl of the Nicosia formation, and the calcarenite and conglomerates of the Athalassa formation. (Figure 3.3). The calcareous rocks of the central Mesaoria are up to 60 metres thick.

In the old times eastern Mesaoria was the main grain producing district of Cyprus. So fifty years ago the runoff from the rivers Yialias and Pedieos conveyed water for spate (flood) irrigation of cereals.

Nowadays the runoff from the catchment area of the above two rivers does not reach central Mesaoria because of water development works carried out higher up in the watershed of the two rivers.

Western Mesaoria has a rich aquifer having a total catchment area of 485 square kilometres. Its useful water in storage as assessed in the year 1969, after a survey of the island's water resources under the United Nations Development Programme, was 130 m³. The annual replenishment was assessed to be 62 million m³, while the annual extraction from wells and springs was estimated to be 80 million m³, resulting in a deficit of 18 million m³ in the useful storage.

For the prevention of the deficit in the Morphou aquifer's useful water storage, two recharge earth dams were constructed in 1962 and 1973. Each dam had a total capacity of four million cubic metres.

Over forty per cent of the ground surface of the Morphou aquifer is covered with citrus orchards, which until the year 1974 constituted 30% of the agricultural exports of Cyprus. (Since 1974 this area has been part of the Turkish occupied land of Cyprus).

3.2.4 Coastal zone

Between the surrounding sea and the foothills of the mountains is the flat narrow coastal zone. Its width varies from 5-13 kilometres.

This coastal zone consists of alluvium gravels, terrace deposits, conglomerates and clays, all geological material conveyed from the Troodos mountains and to a lesser degree from the Kyrenia range, by the rivers flowing at spate in winter.

In the coastal zones part of the Morphou aquifer is also included. Though the average annual precipitation over the coastal zone does not rise above 500 mm, the zone has good water aquifers of appreciable area and depth. These aquifers were not disturbed by man before 1945. For centuries they were over recharged by the nearby flowing rivers with the result that the water table reached the surface in certain low zone belts, and created marshy areas.

C Y P R U S

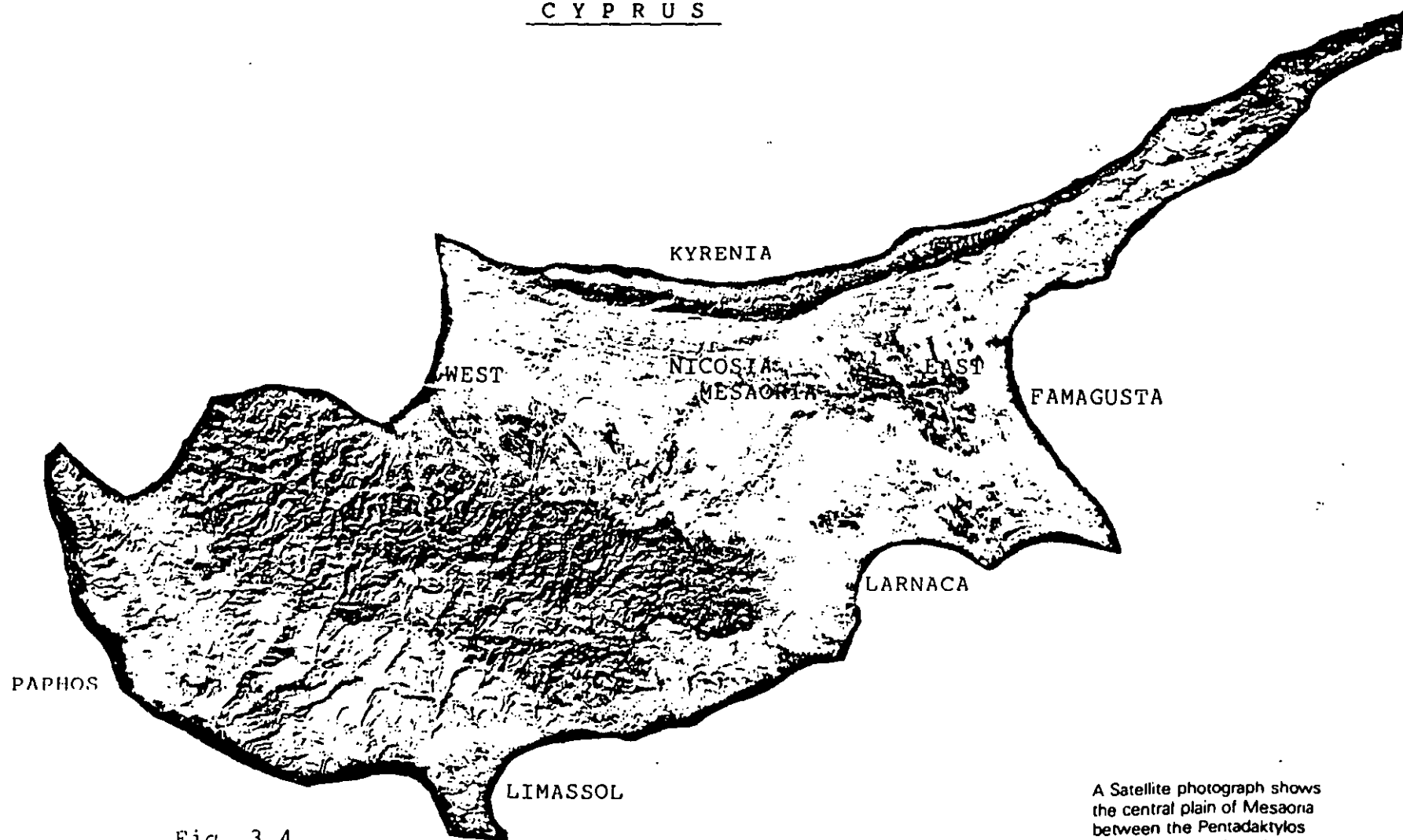


Fig. 3.4

Source: United Nations Development Programme Cyprus 1970.

A Satellite photograph shows the central plain of Mesaoria between the Pentadaktylos range to the north and Troodos to the south

3.2.5 Salt lakes

Cyprus has two salt lakes namely:

1. Larnaca Salt Lake
2. Limassol Salt Lake.

1. At present the Larnaca Salt Lake next to Larnaca Town and part of its south surrounding area has been developed to accommodate the Larnaca International Airport. Its old circumference was 12 miles (19 kms) but in the course of time it has been reduced by cultivation. Larnaca Lake receives its water by the runoff from the white chalks formation of the drainage lowland region north of the lake.

Before the construction of Larnaca International Airport in 1975, the lake, being 1.83 metres below mean sea level, was receiving sea water through the raised beach consisting of sand-dunes and coarse pebbles. When Larnaca airport was constructed, it was necessary to stabilize the landing area, and thus due to heavy compaction the infiltration of sea-water into the lake stopped.

As the lake is the main source of salt for the requirements of all Cyprus, a pumping scheme has been installed, and sea water is pumped into the lake when the year's water precipitation over the drainage basin of the lake is below the average of 340 mm, as such a low runoff into the lake would be inadequate to produce a thick layer of sodium chloride for collection.

2. The Limassol Lake is at present part of the British Sovereign bases in Cyprus. Its area is 16 square kilometres and its circumference 14.50 km².

The bottom of the lake is 2.44m below mean sea-level. The Limassol Lake receives part of the water from the Kouris river and part from the sea by storm waves. During the Venetian occupation of Cyprus, the Limassol Lake was used as a fish breeding place. It appears the Venetians had a form of masonry intake through which sea-water was

allowed to fill the lake by means of penstocks. Some remains of the masonry intake wall can be seen even today.

On top of this masonry intake wall, Lord Kitchener established the bench mark known as "Ktista" (Greek: meaning "Masonry"), in the year 1882. Its value is 1.49 metres above mean sea-level.

CHAPTER FOUR

CLIMATE

4.1 Introduction

Cyprus has a mediterranean climate - a warm summer, and a mild winter.

Cyprus is located in the north eastern part of the Eastern Mediterranean Sea, and 3000 kilometres from the Atlantic Ocean. It is surrounded by large land masses which influence its climate, by their air currents reaching Cyprus.

Its climate is partly influenced also by the oceanic current travelling through the narrow corridor south of Crete.

Because of the geographical factors the climate of Cyprus shows a great variation in air temperature over the Central Mesaoria plain, the coastal zone and the mountainous regions. The summer day air temperature averages 35 degrees centigrade in the plain, 30°C in the coastal zone, and 24°C in the Troodos area.

The mean winter day temperature is 17°C in the plains and sea coast.

In Table 4.1 the mean maximum and minimum air temperatures in degrees centigrade are given as recorded for the last 44 years, 1941-1984, by the Meteorological Services.

Table 4.1 Mean Maximum and Minimum Air Temperature in degrees centigrade (1941-1984).

Station	Season Elevation MSL (m)	Winter Dec, Jan, Feb,		Spring Mar, Apr, May		Summer Jun, Jul, Aug,		Autumn Sep, Oct, Nov,	
		Max,	Min,	Max,	Min,	Max,	Min,	Max,	Min,
Troodos	1600	5,4	-1,0	11,8	4,14	22,57	13,77	27,57	8,5
Prodramos	1400	6,93	1,20	14,70	6,53	25,77	16,00	18,37	15,0
Nicosia	236	16,06	5,93	24,0	10,39	35,65	20,57	27,57	14,8
Larnaca Airport	5	17,63	5,40	22,37	10,93	30,87	19,66	26,43	15,5
Paralimni	150	16,53	7,67	22,13	11,73	29,97	20,80	25,77	16,4
Akrotiri	80	17,63	8,40	21,93	12,93	29,33	20,63	26,00	16,2
RAF SBA									
Polis	1400	16,97	7,67	21,73	11,13	31,20	18,80	25,77	15,0

Source: Meteorological Service Department, Cyprus.

Table 4.2 Mean Relative Humidity in Percentages at 0800 and 1400 hours Total Time

Period: 1941-1984

Station	El	Winter Dec-Feb	Spring Mar-May	Summer Jun-Aug	Autumn Sep-Nov
Nicosia	236	71.66	53.17	40.33	54.17
Famagusta	50	73.50	65.83	58.00	65.33
Larnaca Airport	5	69.33	63.00	61.00	60.50
Kato Phaphos RAF	10	68.00	67.83	69.67	62.83
Prodomos (Troodos)	1400	79.17	58.00	38.00	57.83
Akrotiri SBA	80	74.00	66.67	63.67	64.5

Source: Meteorological Service Department, Cyprus.

4.2. Evaporation

Because of the dry mediterranean climate of the island, evaporation is relatively high, varying from 1450-1900 millimetres. In view of this, evaporation is seriously considered in the planning of water development.

Table 4.3 indicates in outline the monthly evaporation as recorded by the Meteorological Services at selected measuring places.

Table 4.3 Evaporation

Total monthly and yearly evaporation (in mm)

Station	Nicosia	Yermasoyia	Polemidhia	Akhelia	Prodrom
Month	236m	60m	150m	30m	1400m
EL. AMSL					
October	132mm	156mm	147mm	157mm	89mm
November	79	99	119	117	83
December	41	63	75	85	27
January	36	57	63	80	40
February	49	65	65	75	60
March	78	93	92	77	70
April	128	125	131	117	112
May	257	232	212	194	193
June	300	287	251	225	214
July	339	315	288	238	260
August	267	248	230	212	201
September	191	188	186	180	128
Annual Total	1897	1928	1859	1757	1457

Source: Meteorological Service Department, Cyprus.

4.3 Precipitation

The importance of water for the prosperity and welfare of Cyprus has been deep in the consciousness of her people since ancient times.

All the island's water comes from precipitation which is cyclonic and orographic. Cyclones are infrequent in late spring and early autumn, and very rare in summer. As a result of this the bulk of the annual precipitation comes from October to March. Thus the hydrological year in Cyprus commences in October. Systematic measurements taken by the Meteorological Office since 1941 give the following mean percentages of the seasonal precipitation for the above period.

Month	% Precipitation	Depth of average annual Precipitation (508 mm)
October-March	91%	462mm
April-March	7%	36mm
June-September	2%	10mm
TOTAL	100%	508mm

July and August are considered dry months.

4.3.1 Areal distribution of precipitation

The distribution of precipitation is not uniform in all areas of Cyprus, but is influenced by the topography of the island. We have the Troodos massif in the middle south west rising to 1953 metres above mean sea-level, the Kyrenia range in the north rising to 1023 metres AMSL, and the Mesaoria plain in between the two mountain ranges touching Famagusta bay in the east and Morphou bay in the west rising to less than 750 metres.

As a result of the complexity of the island's topography, the amount of annual precipitation reaches 1190 millimetres over the crest of the Troodos mountains, and between 250-350 millimetres over the eastern and western Mesaoria, showing a rain shadow pattern. (Figure 4.1).

4.3.2 Average annual precipitation

An analysis of the distribution of the annual average precipitation over land districts of the island, as recorded by the Meteorological Service Department, is in Table 4.4.

4.3.3 Annual quantity of precipitation

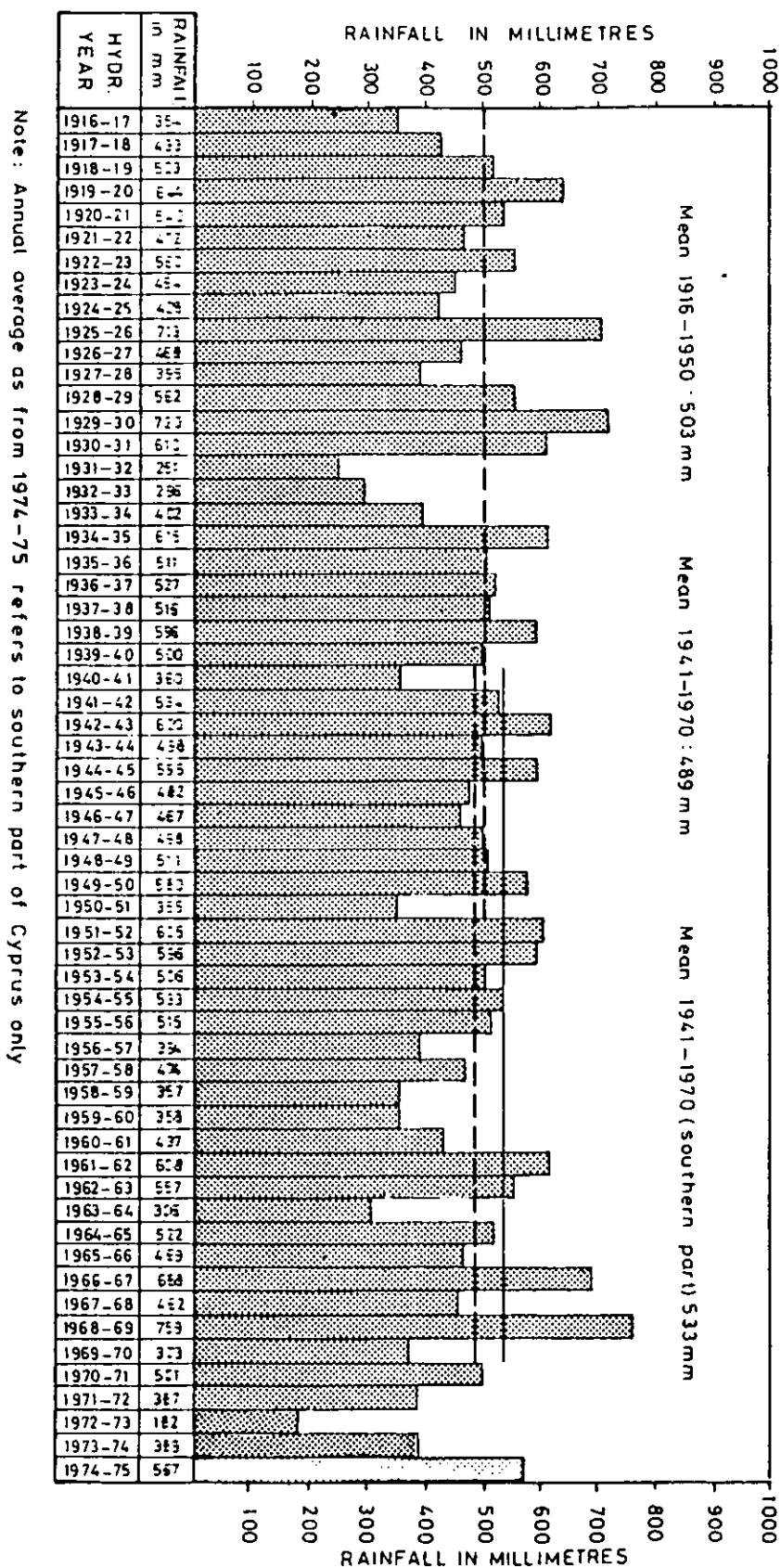
The annual average precipitation of Cyprus, as recorded from 1916-1978, is 508 millimetres, as illustrated in Figure 4.1 and 4.2.

Table 4.4 Annual Precipitation Averaged Over Land Districts of the Island

Ser. No.	Land District	Area km ²	Annual Precipitation average 1941-70 mm	Percentage of annual average %
1	North coast and Kyrenia range	974	483	97.00
2	Karpas Peninsula	476	492	96.85
3	Northern Troodos	569	429	84.45
4	Western Mesaoria	479	318	62.60
5	Central Mesaoria	565	340	66.93
6	Eastern Mesaoria	840	343	67.52
7	Eastern Coastal	713	363	71.46
8	Western Coastal	414	493	97.05
9	Western Troodos	653	599	117.91
10	Western Troodos mountains	819	770	151.57
11	Eastern Troodos mountains	790	681	34.06
12	Eastern Troodos slopes	727	425	83.66
13	Southern Troodos slopes	497	548	107.87
14	Southern coastal	<u>738</u>	<u>444</u>	<u>87.40</u>
	Average annual precipitation Island wide	9254	508	

Source: Meteorological Services Department, Cyprus.

ANNUAL AVERAGE RAINFALL OF CYPRUS FROM 1916-1975



Note: Annual average as from 1974-75 refers to southern part of Cyprus only

FIGURE 4.2

The mean annual precipitation of 508 millimetres over the whole island represents a total quantity of 4627 million cubic metres over the total surface area of the island. Because of the dryness of the Cyprus climate a high rate of up to 80% returns to the atmosphere from evaporation and evapotranspiration from vegetation and plants.

The balance left as usable water supply amounts to 920 million cubic metres. Of this quantity about 30% is estimated to infiltrate into the ground, replenishing the aquifers, leaving a balance of say 650 million cubic metres surface runoff.

During the period of 62 years, 1916-1978, we have had a period of 25 years showing an average annual deficiency of 1035 million cubic metres. During the above period we have also 19 years when the precipitation was above the average, by an average annual quantity of 966 million cubic metres.

As the period of low precipitation varies from one to two consecutive years followed by 7-9 consecutive years of normal or above average precipitation, the deficit occurring in dry years is balanced and a natural equilibrium of annual precipitation is maintained.

Most important is the construction of 85 dams in most of the rivers. These dams have a storage capacity of 250 million cubic metres and this has helped in capturing the runoff from the respective river catchment areas, before it discharges into the sea. The major dams are situated at the 80 metre contour line above mean sea-level.

4.4 Water sheds

From the classification map (Figure 4.3) it is seen that the island is divided into nine topographical regions, containing 69 water sheds.

Nineteen rivers, Table 4.5, constitute the main drainage area of the massif Troodos igneous range. These rivers are seasonal, and they have appreciable surface flow during winter and early spring (December-March). During summer, the rivers have a much reduced flow in their upper sections. In their lower sections in the coastal zone their reduced surface flow disappears in the river gravels which in places are very wide

and deep.

4.4.2 Catchment areas

The major river water catchment areas are as in Table 4.5.

Table 4.5

Serial No.	River	Elevation m	Catchment Area km ²	Average precipit.	Quantity 10 ⁶ m ³
1	Yiallia	240	93.3	508	47.4
2	Pedhiedos	400	29.5	597	17.6
3	Vasilikos	3	191.4	597	114.3
4	Kryos	250	67.4	762	51.4
5	Maroni	160	53	641	34.4
6	Yermasoyia	100	109.8	648	71.2
7	Kouris	230	100.0	660	86.0
8	Kha-potami	8	110.9	699	77.5
9	Dhiarizos	22	263.7	759	220.0
10	Xeros	85	203	701	142.3
11	Khrysokhou	90	67.3	613	41.3
12	Karyotis	400	63.2	653	54.0
14	Ezuza	27	211.3	657	138.8
15	Peristerona		78.5	766	60.1
16	Akaki		92	608	56.2
17	Mylou	220	31.8	509	16.2
18	Syrgates	90	131.1	573	75.0
19	Evredhou	130	92	784	14.4
Total average precipitation in major river catchment areas.			2082 km ²	669mm	1374 mm ³

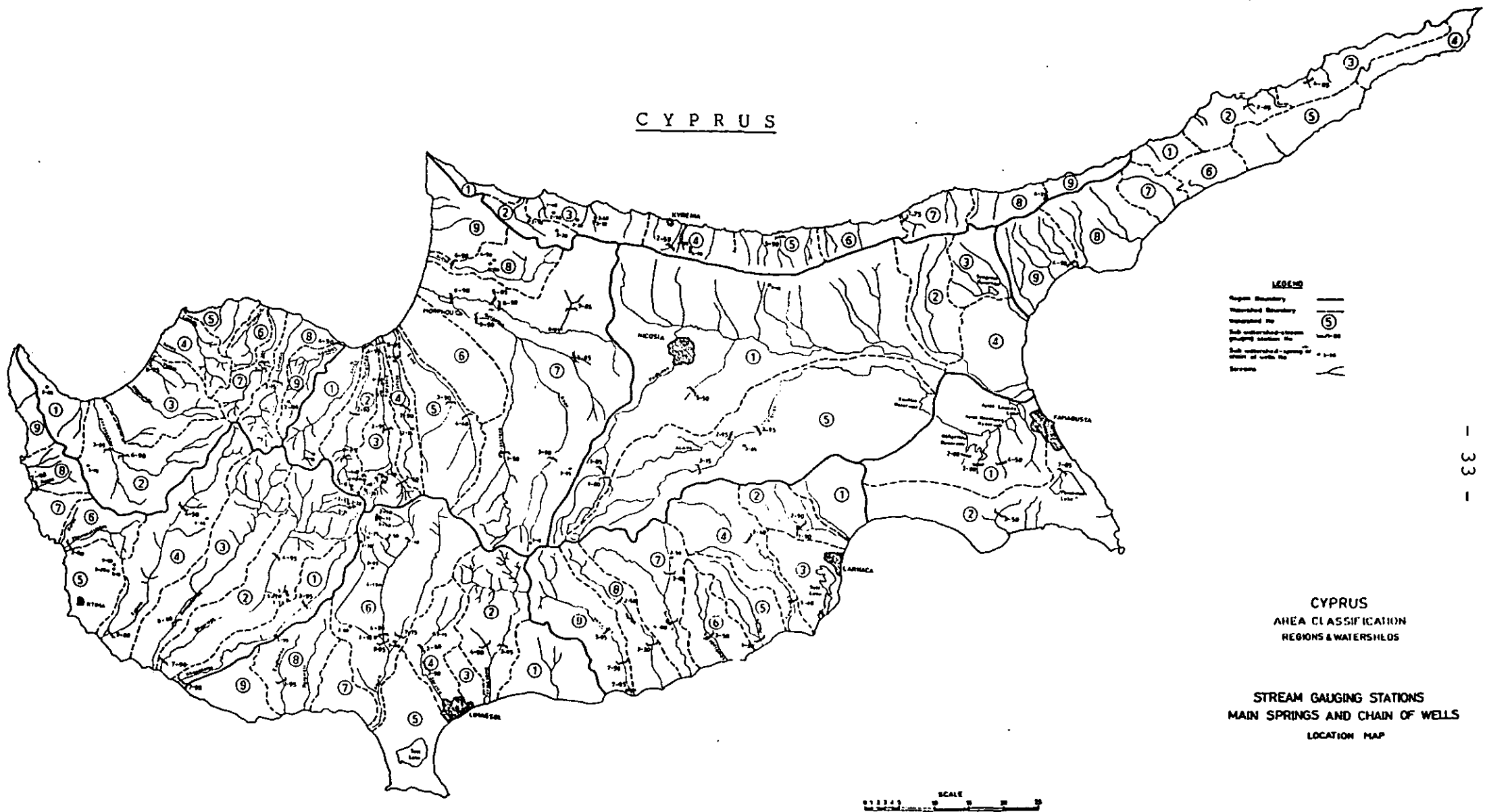


Fig. 4.3

Source: Water Development Department.

4.4.3 Runoff

The runoff from the above 19 major river drainage areas has been studied and measured by the Water Development Department since 1955.

The mean runoff has been found to be about 30% of the total annual precipitation 1374 mm³ as Table 4.5. This amounts to 412 million cubic metres of the mean annual runoff, which can be collected in dams.

Eight major dams, including Kouris Dam which is under construction, will store about 250 million cubic metres or sixty per cent of the runoff of the major river catchment areas.

4.5 Forests

The total area of forests in Cyprus is 1732 square kilometres which represents 18.7% of the total area of the island being 9254 square kilometres.

In the ancient times the plains were full of wood, in fact uncultivated and choked with undergrowth. (*History of Cyprus by Kyprianos, 1788*).

The main Troodos pine forests of Cyprus extend westwards from the Troodos igneous massif, to the north reaching the coastal zone, and to the south reaching the coastal zone, and the 760 metres contour line. The Aleppo pine (*Pinus halepensis*) is the best developed on the west side of Troodos Massif.

The second important forest is that of Kyrenia situated in the Kyrenia range and extending to the east as far as the Karpas peninsula. The Kyrenia range forest is dominated by the Mediterranean Cypress (*Cypripessus Sempervirens*).

The forest reduces runoff to a certain extent and contributes to the replenishment of the spring aquifers of the Troodos igneous massif. The runoff from the major river catchment areas, consisting of igneous impervious rocks, is the highest, averaging some 30-35 per cent as recorded since 1955. Vide para 4.4.3.

In contrast there is no significant runoff from the river catchment areas of the Kyrenia range.

Practically all precipitation over the Hilarion limestone, percolates into the limestone formation at a high

speed. The runoff occurs at the outcrops of the Lapityhos and Kythrea formations, but it never rises above 10 per cent of the precipitation.

CHAPTER V

THE PEOPLE OF CYPRUS

5.1 First settlers

Continuous archeological excavations and research, carried out since the 1930's reveal that Cyprus was first inhabited during the Neolithic Age around 7000 BC.

Some people of the Neolithic Age began to cultivate wheat and other plants, and to breed sheep, goats and other animals. Food production and the keeping of animals obliged the Stone Age men to create the first settlements, a number of which have been uncovered in Cyprus.

Sir David Hunt in his book "Footprints in Cyprus 1982" comments:

"Suffice it to say that well before 6000 BC. there emerged in Cyprus a remarkable series of related communities, which disappear from our records after only a few centuries in circumstances that are as mysterious as are their origins".

5.2 Khirokitia settlement

The largest of the Neolithic Settlements was Khirokitia, situated on a small hill on the right bank of the Maroni river (Figure 5.1). Khirokitia is the oldest to be discovered so far. The estimated population of the settlement was in the region of 2000 inhabitants. (Hunt, "Footprints in Cyprus 1982"). On the hypothesis that fourteen such settlements are known at present, and that Khirokitia was the largest, one can guess that the population of Cyprus in the sixth millennium BC. could be up to 15000 persons.

The settlements existed near streams or springs, from where they derived their water. The most important characteristic of these settlements was that almost all of them were not far from the sea, indicating their overseas origin.

(Ancient Monuments)

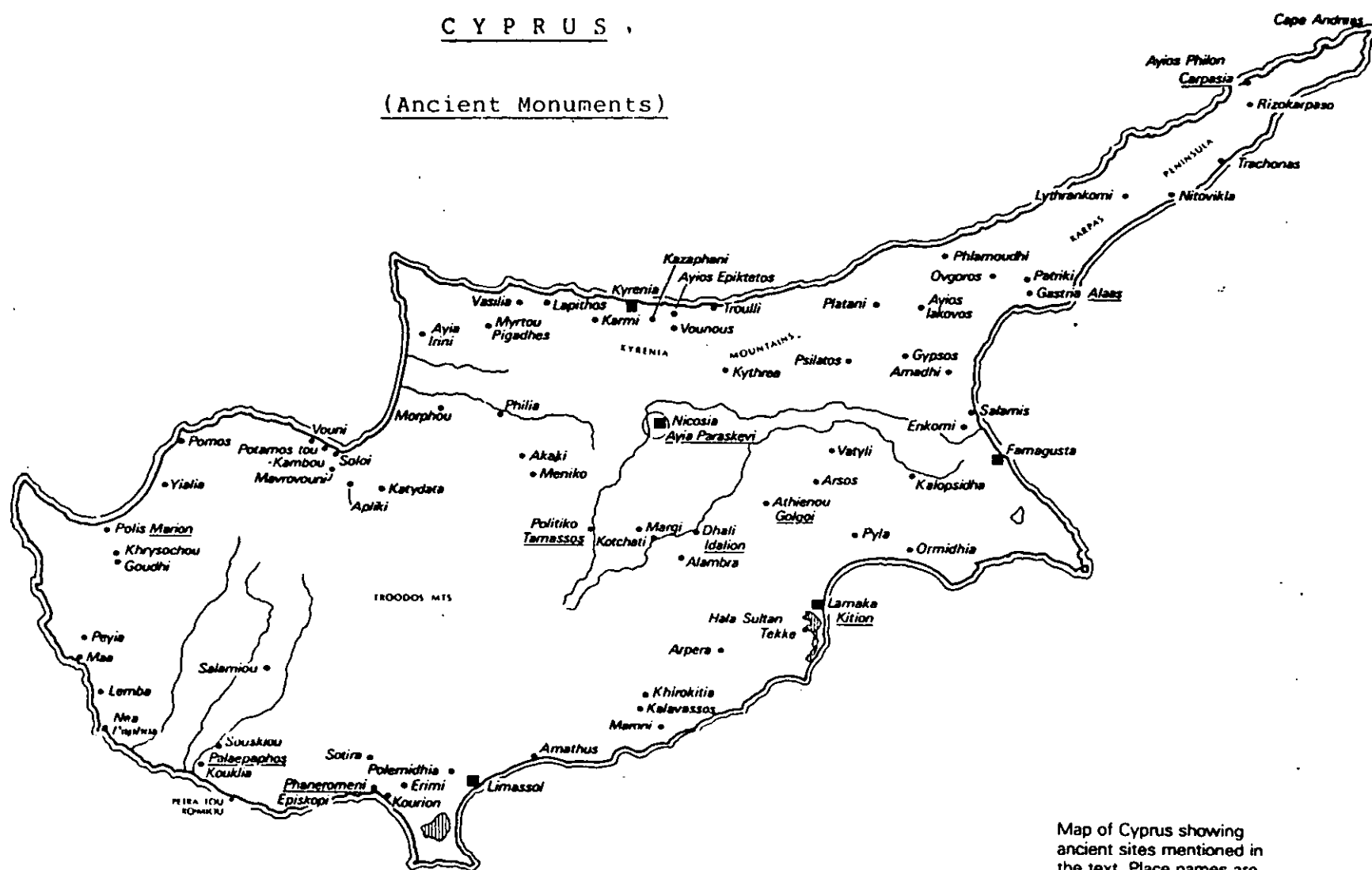


Fig. 5.1

Map of Cyprus showing ancient sites mentioned in the text. Place names are italicised where they coincide with a modern village

5.2.1 Origin of the people of Khirokitia

J. Lawrence Angel of the Institute of Anatomy of the Philadelphia Jefferson College writes:

"The Khirokitia population is unlike any equally early group so far known in Anatolia, Syria, Palestine, and Iran. As things stand now, the Khirokitia series represents an isolated focus of near-eastern Brachy-cranly and the social possibilities of the Khirokitians must have been limited by such biological factors as a short life span, high infant mortality, inadequate food intake, and quite possible psychological uniformity in an inbred and isolated group".

Lawrence Angel gives the age from the 39 skeletons of male adults as 35.2 years, and of the 35 female adults as 33.6 years. (*Cyprus in History* by Dhoros Alastos, pages 15,16). The dwellings at Khirokitia were circular of the "Tholos" or beehive type, built of limestones, of site origin. The inhabitants made their vessels of stone and some of these are of excellent craftsmanship. Their tools were of flint and bone.

5.3 Sotira settlement (Neolithic)

Following Khirokitia the Sotira group appeared between 4500-4000 B.C. These settlers in all probability put an end to the culture of Khirokitia. Dhoros Alastos, in his book "Cyprus in History", writes: *"The offshoot from the culture of Khirokitia can be traced both in the architecture of dwellings, and the pottery found in sites of the Neolithic II period at Kalavassos, Sotira and Troulli reaching down to 3200 BC."*

5.3.1 Bronze Age (2700 B.C.)

Bronze Age human settlements are found in almost all parts of Cyprus and the island begins to assume increasing importance in Mediterranean affairs in this era. A continuous evolution of civilisation and conquest continued, until the Hellenic classical period 475-325 BC. Cyprus was greatly influenced by the Minoan civilisation 2000 BC and by the Mycenaean in 1400 BC.

During this time Cyprus became an important centre of Mycenaean trade and enterprise in the Middle East.

5.4 Population

No figures of value have come to light about the population of Cyprus before the 15th Century AD. Archimandrite Kyprianos in his book "History of Cyprus 1788" mentions that the population of Cyprus in classical times was ten times what it was then, giving the crude estimate of two million. D.A. Percival in his 1946 Report "Census of Population and Agriculture" makes the following comment on the past population of Cyprus: "*Sober authorities place the population in classical times at 300,000 to 400,000*".

Mr A.H.S. Megaw, Director of Antiquities, has written "*The monuments and documents indicate a great prosperity in the 14th century and one may assume a correspondingly large population, though I should be disinclined to put it above 400,000*".

The population was continuously declining throughout the 14th and 15th centuries. At a count carried out by the Venetians in 1491, the total estimated population was 168,000. The decline of population from 400,000 in 1400 AD to 168,000 in the year 1491, was the result of disasters and invasions, disease and indifference of the administration. During the Venetian period, 1491-1571, the population was boosted by Venetian settlers.

When the Turks conquered Cyprus from the Venetians in July 1571, the population was estimated at 290,000.

The war of 1570-71 swept away both the Latin regime and the Latin community in Cyprus. The Greek population also suffered greatly. Thousands were massacred or carried away as slaves. ("*Cyprus in History*" by Dhoros Alastos, 1955).

5.4.1 Population before and after the British Rule Ottoman Rule (1571-1878)

The Turkish rule over Cyprus lasted from 1571 to 1878, a period of just over 300 years.

Regretfully it was a period of growing decay and impoverishment. Trade deteriorated, productivity was decreasing and the population declining.

The Cyprus population decreased from 290,000 in 1571 to 186,000 in the year 1891 as per the first census carried out by the British Administration.

Under the Ottoman rule both for administrative and taxation purposes the community was divided into "Mohammedams" i.e. Turkish officials, soldiers and settlers, and Rayahs, second class citizens, devoid of political rights. The Rayahs were the taxable population of some 85,000 Greeks, including a very small percentage of Armenians and Maronites. All the Rayahs from the ages of 14 to 60 were made to pay an annual capitation tax for the liberty of practising their religion. The amount collected was sent to the imperial treasury in Constantinople.

In addition there were land taxes, rents for using the river waters, and of course others on the agricultural produce. The plight of the people of Cyprus aroused the sympathy and interest of the people of Europe, particularly of Great Britain who at times during the Ottoman rule visited Cyprus and left on record their travel findings:

Sir Antony Sherley, who visited Cyprus in 1599, writes that he found "slaves to cruel masters, or prisoners shut up in divers prisons. So grievous is the burden of that miserable people, and so deformed is the state of that Noble Realm" (*Sir Antony Sherley: "His Relation of His Travels" (1613 p.6)*)

The Dutchman, Professor Cotovicus also visited Cyprus in 1598 and 1599, and painted a similar depressing picture of "uncultivated neglect, desert towns and villages lie desolate and forsaken". (*Excerta Cypria. Dhoros Alastos "Cyprus in History" 1955*).

5.4.2 The British Occupation

The distress and misfortunes of the Cyprus people for over three centuries caused by the incompetent

Ottoman administration of justice was put to an end on 12 July 1888, when the island was leased to Great Britain by the Ottoman Empire. On this day, the British flag was hoisted in Nicosia (Figure 5.2) and ten days later Sir Garnet Wolseley reached the island to take up his duties as High Commissioner. (Figure 5.3).

The taking over of the administration of Cyprus by Great Britain was greeted with enthusiasm by all the people of Cyprus, not excluding the Turkish settlers. The whole population was looking to a hopeful future of security, welfare and prosperity. Great Britain was a Christian nation, and a liberal democratic country, through which the Cyprus people would enjoy a true civilisation and a just rule.

5.4.3. Administrative reform

The first Commissioner, Sir Garnet Wolseley, took over from the Turkish Administration in July 1878, and in 1879 he became Field-Marshal and Commander in Chief of the British Army.

He made great efforts to eradicate the inheritance of the past and bring security and swift justice to the people. Such measures were:

a) Taxes

Tax farming was abolished, and replaced by taxation on immovable property.

b) Land Registry

Lord Kitchener worked intensively for three years, and completed a survey of the island in 1882. This survey became the basis for an equitable system of land taxation.

c) High Court of Justice

One very important step taken by the High Commissioner was to establish a High Court of Justice.

d) Education

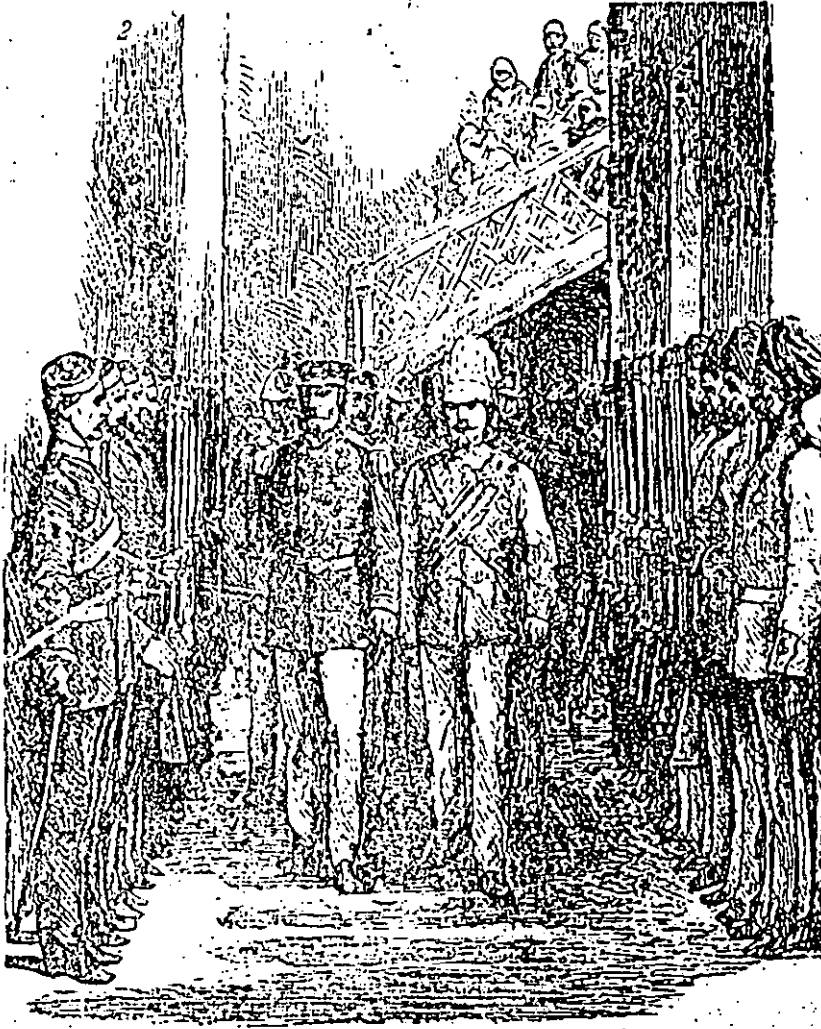
Primary schools were opened, and schooling for children was promoted. In 1881 the number of primary school children were less than 7,000 but by

SIR JOHN TENNIEL'S
CARTOON IN *PUNCH*
ON THE CONCLUSION
OF THE CYPRUS
CONVENTION, 1878
[See p. 86.]



HOISTING THE BRITISH
FLAG IN NICOSIA ON
THE 12th JULY 1878
From the Illustrated London News.
[See p. 87.]

FIGURE 5.2



The arrival of Sir Garnet Wolseley, first British High Commissioner in Cyprus, for his swearing-in ceremony at Nicosia. (Reproduced from "The Graphic" of 17th August, 1878, by kind permission of "The Illustrated London News.")

FIGURE 5.3

1929 there were 46,000 children attending the schools.

Parliamentary paper C 3477. Reply by the Colonial Secretary Lord Passfield, 28 November 1885).

e) Communication

Intensive work was undertaken for the construction of motor roads for communication between towns and villages.

f) Medical Services

Medical facilities were provided for the treatment of diseased people and gradually these facilities were extended to all towns.

During the Ottoman rule there were no medical facilities at all.

g) Increase of Population

The favourable social and advantageous living conditions which were created by British Rule contributed to an increase in revenue, and helped the individual to live in security and work for the welfare and prosperity of his country.

Between 1878 and 1914 Cyprus was part of the Ottoman Empire administered by Britain. Nevertheless the Sultan's authority disappeared completely from Cyprus and Britain did not consult the Sultan on any measure she took for the welfare of the island.

Water resources were not the direct concern of the British Administration because all water belonged to the High Vizier in Constantinople, and to his Pashas. The health of the people was susceptible to water borne diseases, but this did not prevent the physiological growth of the population which was promoted by the improvement of living conditions and the medical facilities established in the towns.

In the year 1931 a census of the population was prepared in a correct scientific way. This was the first census prepared after 1925 when Cyprus was declared a Crown Colony in accordance with the 1931 Census the population of the island was 347,959 showing an increase of 161, 786 since 1881. The population had thus doubled

during a period of 50 years of British rule of Cyprus.

The two graphs Figures 5.4 and 5.5 give a clear illustration of the growth in the population of Cyprus from 1400-1878 and from 1881-1980, respectively.

Both graphs indicate how the population was directly affected by the misrule of the conquerors during the middle ages, and the rule of Law and order during the 80 years of British Administration.

5.5 Distribution of Population

For administrative reasons the island was divided into six Districts, each district being administered through its respective town (Figure 5.6).

The six districts were:

Nicosia, Kyrenia, Famagusta, Larnaca, Limassol and Paphos Districts. The population of each district was distributed in the respective town as 'urban' and in villages classified as 'rural' or farming population.

Accepting the strict classification of 'urban' and 'rural' population, it may safely be accepted that over 90% of the population could be classified as rural. The six towns of Cyprus, were looked after by their respective Municipal councils which had legal authority over small Municipal zones. The people of the smallest towns, Kyrenia, Paphos and Larnaca and even Famagusta were occupied mostly in agriculture, supplemented by a few handicrafts.

Until the year 1946, Census reports divides the population of the island, totalling 450,114, into 353,145 (78.4 per cent) village population and 96,969 (21.6 per cent) town population.

POPULATION OF CYPRUS

Since Middle Ages

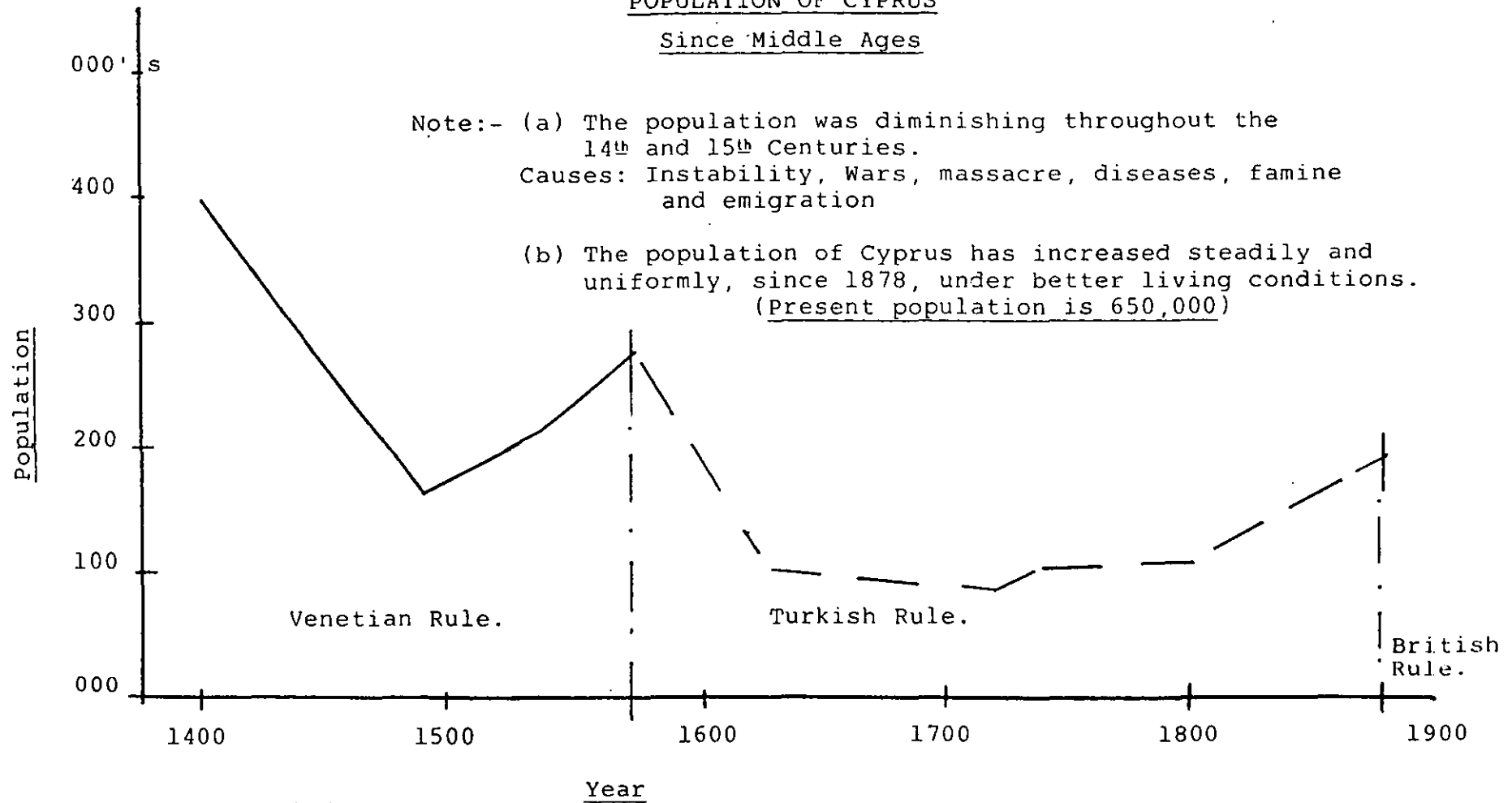


FIGURE 5.4

Source: Report by D.A.Percival
Census 1946

1881-1980

CYPRUS



FIGURE 5.5

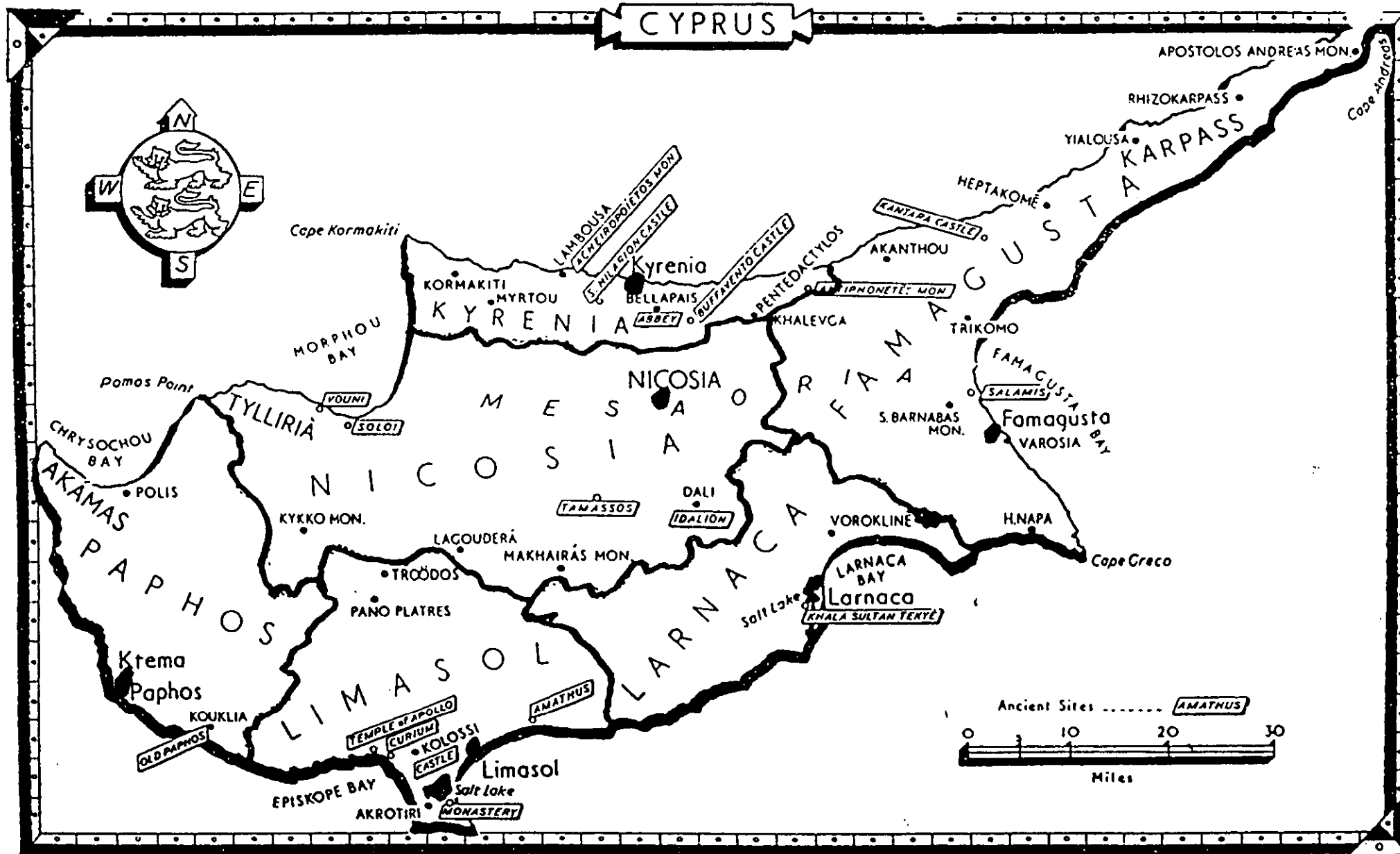


FIGURE 5.6 ADMINISTRATION DISTRICTS

Table 5.1 Comparative Urban Population By Districts at Census Years

A.

District	1891	1911	1921	1931	1946	1960	1973	1980
<u>Urban Areas</u>								
<u>Towns</u>								
Nicosia and suburbs	16224	21921	25438	33497	53324	25343	115718	
Kyrenia	1322	1726	1910	2137	2916	3441	3892	
Famagusta	3367	5327	6980	8979	16194	34752	38960	
Larnaca	7593	9262	9765	11872	11872	19807	19608	
Limassol	7388	10302	13302	15349	22799	43561	76641	
Paphos	2801	3435	4117	4517	5803	90979	8984	
TOTAL	38695	51973	61512	76351	115808	205983	266803	
Average Annual Rate of Growth	1.45	1.65	1.95	2.50	3.50	2.80		

B.

Rural Areas
626 Villages
by Districts

Nicosia	45471	59576	68327	76513	92641	108940	116984	
Kyrenia	13682	18026	19705	20522	25258	27505	28694	
Famagusta	38056	53203	56775	62493	78280	79557	84896	
Larnaca	16167	20475	25153	30336	37417	38812	41896	
Limassol	28342	35782	41030	42492	52622	63701	45214	
Paphos	28873	35073	38213	39252	48088	49068	480981	
Total Rural Population	170591	222135	249203	271608	334306	367583	364975	
Average Annual Rate of Growth	1.35	1.30	0.90	1.40	0.70	-0.10		

The average annual rate of growth is based on the formula $P_n = P_0 (1+r)^t$ where P is the population, t is the period of time in years, r is the average annual rate of increase, and P_n is the population at the end of the period.

Source: Department of Statistics and research.

5.6 Fertility and mortality

In accordance with the demographic report of 1982, published by the Department of Statistics and Research, Ministry of Finance, the Multi-Round Demographic Survey 1980/81 shows the total fertility rate to be 2.33 births per woman.

These births are mainly of first and second children, the percentage of which was 79 in 1982.

The low percentage of third and fourth births is not influenced by the good health and long life enjoyed by the women of Cyprus, due to the high grade of domestic supplies available to households, the high standard of the existing medical facilities and the general prosperity of the island, but to their high educational standard and the social patterns which are followed nowadays.

5.6.1 Mortality

The eradication of all water borne communicable diseases, and the availability of potable pure domestic supply in every house of every village and town of Cyprus, coupled with the improvement of health services and the general welfare and prosperity of the individual, has lowered the crude mortality rate to 8 deaths per thousand population.

The infant mortality also has dropped to a low level. For the year 1982 the infant mortality rate was estimated at 17.2 infant deaths per thousand live.

The age structure and demographic characteristics of the population of Cyprus are far closer to those observed in European countries than those of other developing countries in the Middle East. Expectation of life at birth is estimated to be about 72.3 years for males, and 76.0 for females.

An illustration of the above in outline is given in Table 5.2 produced by the Department of Statistics and Research, Ministry of Finance.

From the table it is observed that the Cypriot males expect a life at birth of 72.3 years, which is higher not

only than the expectant life at birth in countries of the Middle East but also in developed countries of Europe.

When the administration of Cyprus was undertaken by the British in 1878, primary education of the Cyprus children was given top priority and encouragement.

Thus, while in the year 1877 very few children were receiving primary education, mostly by priests, in the year 1946 over 70 per cent of children of school age were attending primary schools. The principles of hygiene were taught to the children who became conscious of the endemicity of water borne diseases and the importance of using adequate water and soap for their personal hygiene.

By the year 1960, when the British Administration of Cyprus was terminated, every child of school age was receiving primary education.

b) Secondary Education

Secondary education was also promoted after 1946, and now every boy or girl when they complete their primary education continue and complete their secondary school studies in the field of classics, commercial science or technical education.

c) University Professional Qualifications

Cypriots are by nature thirsty for education. Financial difficulties however have prevented university education for the majority of the people so Cypriot professional people were very few until 1960.

After 1960, rapid expansion of tourism and the growing prosperity of the country on the one hand, and the granting of overseas scholarships on the other hand, produced an exodus of students for university education in all countries of Europe, mostly in Greece and the United Kingdom.

The exodus for university studies has brought to the island adequate scientific knowledge, which has contributed greatly to the general welfare and development of the island in all fields.

VITAL STATISTICS

MORTALITY TABLE

BIRTH AND DEATH RATE

YEAR	ESTIMATED POPULATION	BIRTH RATE PER 1,000 OF POPULATION	CRUDE DEATH RATE PER 1,000 OF POPULATION :	INFANTILE MORTALITY RATE PER 1,000 LIVE- BIRTHS
1936	441,405	33.10	12.60	102.50
1947	456,489	33.21	8.49	65.51
1950	484,306	29.97	8.17	63.37
1954	513,700	27.04	7.15	51.97
1960	563,000	25.75	8.40	29.86
1970	631,000	19.20	9.80	29.10
1980	650,700	21.70	9.10	17.20

Source: (i) Annual Medical and Sanitary Reports 1936, 1947, 1950, 1954 1960, Cyprus.

(ii) Demographic Report 1982, Department of Statistics and Research, Cyprus.

Table: 5.2

Table 11.-Comparative Table of Demographic Indicators for 1981 (or nearest available year) for Selected Countries

Country	Crude Birth Rate	Total Fertility Rate	Expectation of life at birth		Infant Mortality Rate	Age structure % in age-group			Dependency Ratio	Annual growth rate 1979/80
			Males	Females		0-14	15-64	65+		
Cyprus	21.7	2.41	72.3	76.0	17.7	24.5	65.2	10.3	52.6	1.3
France	14.8	1.95	70.3	78.9	9.5	21.8	65.0	13.2	53.9	0.5
Greece	15.4	2.23	70.1	74.6	15.0	22.8	64.0	13.2	56.1	1.6
Un. Kingdom	12.8	1.87	70.0	76.2	11.1	20.6	64.3	15.1	55.4	0.0
Italy	10.5	1.56	69.7	75.6	14.1	21.7	64.8	13.5	54.5	0.2
Spain	13.4	1.99	70.4	76.2	10.3	25.1	63.9	11.0	56.6	0.7
Malta	18.3	2.10	69.1	74.0	14.9	24.4	67.5	8.1	48.1	0.9
Portugal	15.4	2.17	67.4	74.7	26.0	26.1	63.5	10.4	57.5	0.5
Egypt	41.0	..	53.6 ⁺	56.1 ⁺	90.0	39.9	56.5	3.6	77.1	2.5
Jordan	39.6 ⁺	6.20	62.4 ⁺	66.0 ⁺	..	50.7	46.5	2.8	115.1	3.2
Iraq	43.0	4.13	53.6 ⁺	56.7 ⁺	..	49.0	47.0	4.0	112.8	2.4
Syria	43.7	..	63.0 ⁺	65.4 ⁺	81.0	47.9	49.0	3.1	104.1	3.8
Turkey	30.6	4.00	60.1	65.0	83.0	37.9	57.2	4.4	73.2	2.5

+Refers to 1975-80

.. Not available

Sources: 1. Demographic Yearbook, U.N. 1980

2. Recent Demographic Developments, Council of Europe, 1981

3. World Population 1979, U.S. Bureau of the Census.

Table: 5.2

The success of the ambitious Water Development Programmes completed during the last twenty-five years, 1960-1985, was facilitated principally by the availability of adequate professional knowledge in the Water Development and the Geological Surveys Departments.

This scientific knowledge has been an appreciable supplement to the work of the foreign consultants and experts who have worked for the implementation of the various Government Development Programmes during the above period.

5.7 Education as an element in Water Development

From the above it will be noticed that education has been given emphasis and importance. It is my belief that the people of a country have to play a major role in its development programmes and particularly those of water development and health. These development programmes are social and form the basis for the welfare and prosperity of the people as a whole. Therefore a water development programme, which is a necessity and which should be given top priority, can only be implemented successfully when the people of the developing country to be served possess a standard of education sufficient to be able to help and appreciate the great benefits brought to them by such water development work.

5.8 Urbanisation

It will be observed from the Figure 5.5. that in the year 1974 the rural population showed a steep fall, while the urban population showed similarly a steep rise.

This anomalous behaviour in the growth of the two populations, rural and urban, is the regrettable outcome of the military invasion of Cyprus by Turkey, in July 1974, and the compulsory movement of the Greek population from the north to the south part of Cyprus, and their settlement in the four free towns namely Nicosia, Limassol, Larnaca and Paphos.

The abnormal instantaneous rise of the urban population in the above four towns from 80 up to 330

thousand, reaching more than half of the total population of the island, created severe water problems.

The water shortage was faced quickly and decisively by the Government and the Water Development and Geological Surveys Department. Their action was coupled with the availability of funds at short notice.

Emergency boreholes were dilled in selected areas, and emergency water supply schemes and distribution networks for the refugee settlements within the four towns were implemented in a short period. These emergency water supplies, served a population of up to 200,000 to a most satisfactory standard.

5.9 Movement of population from villages to towns

After 1960 tourism developed in the coastal zones of Cyprus, demanding substantial labour services. Light industry was created in the four towns, and agriculture in the coastal zones was greatly industrialised. These developments attracted the young peasant males and females to leave their villages and establish themselves in towns, where the demand for labour was great and employment with high wages was secured. Education and medical facilities available, coupled with general amenities offering a more steady and comfortable life, were also strong attracting factors for urbanisation.

Another strong attraction for the peasant to move from his hilly village to the coastal zones, and settle himself in the suburb villages of the town, is the mechanisation of agriculture, resulting in an increase in efficiency and saving of time.

The south coastal zones have rich aquifers for extraction of water, and moreover they are commanded by several earth dams which trap the surface runoff for their respective catchment areas.

In the south western coastal zone, major irrigation projects have been completed and irrigated areas planted with high-value crops. Advanced farm irrigation systems have been provided. The above development and improvement have helped the agricultural residents of the

town suburbs to travel to and from their farms and orchards every day, covering a distance varying from 10-20 kilometres.

CHAPTER SIX
DOMESTIC WATER SUPPLIES IN CYPRUS
Since Ancient Times

6.1 Synoptical notes

The domestic water supply in Cyprus will be dealt in detail for the period when Cyprus was ruled by Great Britain 1878-1960 and from 1960-1980 when Cyprus became an independent Republic.

However for a wider conception of the subject by the reader of this Thesis, it has been thought advisable to go back to the period of the first settlers in the Neolithic Age about the year 5800 BC.

6.2 Neolithic age

Systematic archaeological research and excavations carried out by the Department of Antiquities, in co-operation with foreign archaeological missions since 1883 when the Cyprus Museum was established, have uncovered sites of early human settlements belonging to various stages of neolithic development.

Fossils from the Khirokitia diggings by Dr. P. Dikaeos (1931-1935) reveal that Cyprus was inhabited by a numerous and to some degree civilized people by the mid-sixth millenium, perhaps earlier.

The majority of the early settlements were located near streams or springs from where they could derive drinking water supply. It is not known whether these people had any idea of the rules of cleanliness or health and whether they washed their bodies.

Because however, of the necessity of water, the neolithic settlements were built on the low hills round the south and west coasts of the islands, and along the foothills of the Kyrenia mountains both north and south, where there was water available at very close proximity.

The fact is that drinking water was a prerequisite for the building of a settlement which these people took into account. This is supported by the fact that such settlements have not been discovered as yet, in the Mesaoria plain, which was arid and had no perennial

flowing springs or streams. The neolithic people were not conscious of underground water, which it appears was beyond their conception and need.

A form of stone bowls found in their living places, suggests that these people conveyed water from springs or streams in skin flasks, and stored it in the stone bowls.

The settlers were hunters living mostly in the open, and as such they drunk water direct from the stream or nearby flowing spring.

6.3 Early Bronze Age (2600-1100 BC)

The Bronze Age covers the whole period from the Neolithic to the Iron Age. Sir George Hill places it between 2600 and 1000 BC. Bronze Age settlements were formed in almost all parts of the island, particularly the south coast and the northern foothills of Troodos igneous mountains.

During the Bronze Age, the exploitation, primarily, of copper, by specialist miners and smiths, was followed by trade, and Cyprus acquired a high reputation overseas.

Agriculture and stockbreeding also became important, particularly with the innovation of the wooden plough pulled by two oxen. The mining industry and agriculture during the Bronze Age is illustrated by a terracota model of a ploughing scene exhibited in the Cyprus Museum. It belongs to the last quarter of the third millenium.

The local treatment of copper ores was sited as a rule very close to a flowing stream or river, the water of which was used for the copper industry. Also the water from the river or spring was used for the domestic requirements of the new class of non-food producing people, the industrial class.

During this time the population of Cyprus increased greatly and this is confirmed by the comparatively large necropolis found in the Vounous-Bellapais cemetary, Kyrenia.

The domestic water supply of the inhabitants was derived mostly from springs issuing out of the Troodos igneous strata and from the Kyrenia limestone.

The natural springs of these two mountain ranges, attracted the creation of human settlements along their foothills. Pottery , though of an inartistic kind was known in Cyprus.

Thus it can safely be assumed that the drinking water was fetched to their homes and stored for domestic use in clay amphoras.

With the closing of the late Bronze Age 1600-1000, and the coming of the Iron Age, the settlers of Cyprus must have opened wells, from where they bailed water for domestic use.

Sir Harry Luke, in his book ("Cyprus" 1965) writes: *"And the rivers bewail the sorrows of Aphrodite, and the wells are weeping Adonis on the mountains"*.

The shrine of Aphrodite at Kouklia (Old Paphos) was built on the hill near the Dhiairizos river, from where water was derived not only for domestic use, but also for the irrigation of the holy gardens of Aphrodite.

6.4 Greek Colonization 1400-1000 BC

During the period 1400-1000 BC Cyprus received waves of Greek settlers from Nycenae. This is testified by the rich Mycenaean cemeteries discovered in the island. Cyprus became an important centre of Mycenaean trade and enterprise in the Middle East.

Sir George Hill in his book "History of Cyprus" Vol.1 p.83, writes:

"The immense quantity of wares imported from the west, which appears in Cyprus at this time, cannot have been without its accompanying settlers".

The Archaean settlers established themselves all over Cyprus in areas where water was available.

It was a time when water could be conveyed to their settlements from a spring or streams through baked clayey pipes. Excavations at Salamis, Engomi and recently at Curium, have uncovered systems of water pipes varying from 150 to 100mm in internal diameter. These pipes are 500mm long and are of the spigot and socket type, a design used up to this day. The joint was sealed off by

means of lime mortar which was very effective against water leakage. Lime mortar has some elasticity and can last longer than cement mortar. Shallow masonry ground reservoirs were also provided for storing water. Tubs suggest that the people of this period were using water for washing their bodies, considering it as one of their obligations. Public baths were common, and were used mostly by the athletes of the Olympic Games. With the influx of Archaean Greeks (early 14th Century) Cyprus became a commercial and cultural exchange centre between east and west.

The rich finds in the tombs of this period 1400-1200 BC, testify to its prosperity which could support a growing population.

D.A. Percival in his report on the Census of population and agriculture 1946, page 3, writes:

"No figures of value have come to light about the population of Cyprus before the late 15th century..... He mentions that sober authorities place the population in classical times at 300,000 to 400,000".

At the end of the Trojan War (1194-1184) Greek legendary Heroes, returning from Troy, found refuge in Cyprus, where their warlike virtues would help them for personal advancement. Agapinor, King of Tegea, landed at Paphos and built the Nea Paphos. Salamis, to the north of present-day Famagusta, was built by Teucer son of Telamon, King of Salamis in Greece.

Salamis was built on the Greek classical pattern. The buildings, the columns, the marble gods, and the open air theatre uncovered by archaeological excavations during the British rule of Cyprus, brought to light a masterpiece of architecture and engineering.

6.4.1 Salamis water supply

The designers and builders of Salamis City did not fail to provide the city with adequate water supply.

Near Salamis there was no water running from springs, and thus they conveyed the water from the Kythrea spring through a masonry aqueduct from a distance of 55 kilometres north west. The Kythrea spring or Kephelopvryso (Greek headspring) issues through the Kyrenia limestone, at an elevation of 264 metres above mean sea-level (Figure 6.1).

The discharge of Kythrea spring has been measured regularly by the Water Development Department since 1945. The average discharge has been found to be 149 litres per second, equivalent to $12.83 \times 10^3 \text{ m}^3/\text{day}$.

Figure 6.2 indicates the discharge from Kythrea spring during the hydrological year 1967/68. The graph and tables of the figure indicate that the average discharge recorded from the Kythrea spring during the hydrological year 1967/ 1968 was 134 l.s equivalent to a daily yield of 11,577 m^3/day . When the precipitation over the Kyrenia limestone aquifer feeding the spring, was slightly below the average of 500 mm.

The water of the spring was conveyed to Salamis, the city of Teucer, through a masonry aqueduct, the size of the which has not been preserved. Some remains can be traced which suggest that the size of the aqueduct might have been 2 x 1.5 feet.

If we reckon that the water flowed by gravity to Salamis at a hydraulic gradient of 0.003, and using a coefficient of say 80 derived from the Bazin's formula;

$$C = \frac{157.6}{1 + \frac{g}{m}}$$

Where C = coefficient, 80 for masonry channel and

m = Area/wetted perimeter

we find that a quantityt of 8.91 cusecs
= 21.994 cubic metre per day flow.

Using the Chezy formula (Hydraulics by E.H. Lewitt)

$V = C \quad m^j$ and $Q = AV$ in cusecs

where j = hydraulic gradient



Measuring the Water velocity and flow with a current meter
at the outlet of Kephlovrysos Spring at Kythrea.



Taking sample of Water from Peristerona river for chemical
and Suspended Sediment Analysis

Fig. 6.1

Source: Department of Water Development, Cyprus.

SPRING: KEPHALOVRYSSOS

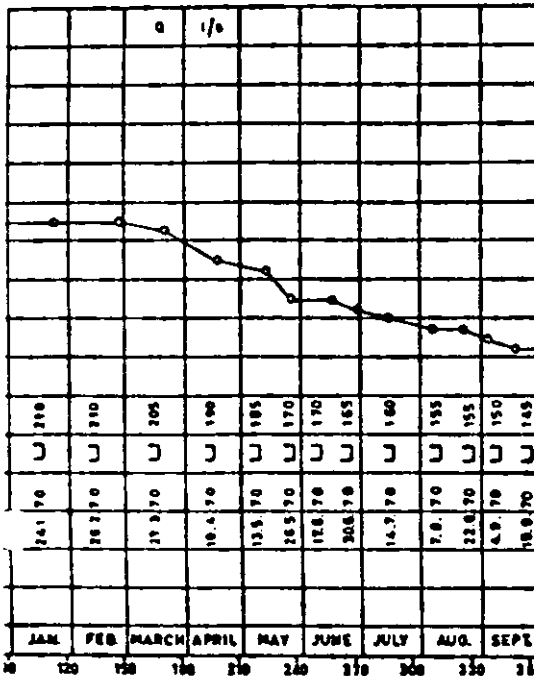
YEAR: 1969-70

1-7-15

VILLAGE/AREA: KYTHREA

CO-ORDINATES: WE 445030

ELEVATION: 111.8 m



MONTH	Q	
	l/s	TO m
OCTOBER	225	603
NOVEMBER	215	557
DECEMBER	210	562
JANUARY	210	562
FEBRUARY	210	508
MARCH	205	543
APRIL	190	492
MAY	180	482
JUNE	170	441
JULY	160	479
AUGUST	155	415
SEPTEMBER	145	376
TOTAL		5976
DAY	190	5980

	Q: l/s	DATE
KNOWN MAXIMUM	200	14.8.45
KNOWN MINIMUM	82	10.11.64
AVERAGE	153	45/46-69/70

CHEMICAL DATA					
PH	COND. (μmhos/cm)	TOTAL SOLIDS (p.p.m)	CL (p.p.m)	TOTAL HARDN.	DATE
7.2	190		50		21.3.70
7.3	588	440	57	250	10.9.70

METHOD OF DISCHARGE MEASUREMENT
 VOLUMETRIC V
 BY WEIR L
 BY CURRENT METER X
 BY FLOATS S

DISCHARGE MEASUREMENTS ○
 FLOW DURATION CURVE ---

SPRING: ATHANASIS CHAIN OF WELLS

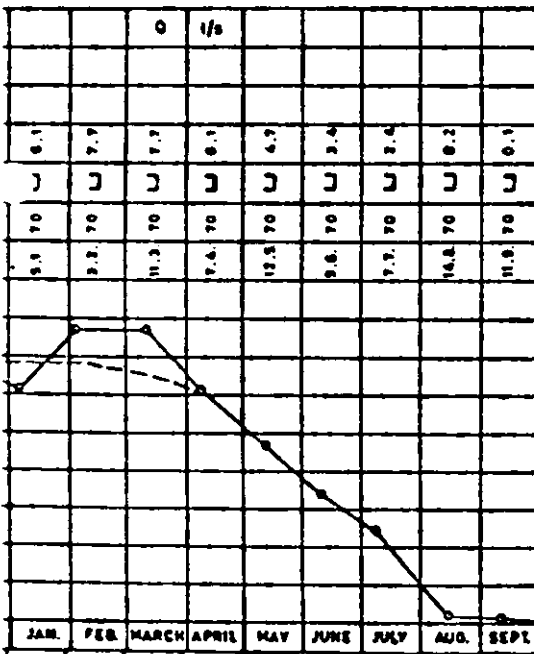
YEAR: 1969-70

5-3-85

VILLAGE/AREA: POTAMIA

CO-ORDINATES: WD 430798

ELEVATION: 158 m approx.



MONTH	Q	
	l/s	TO m
OCTOBER	8.9	18.5
NOVEMBER	6.8	17.9
DECEMBER	8.6	17.7
JANUARY	6.7	17.9
FEBRUARY	7.9	18.8
MARCH	7.3	19.6
APRIL	5.8	19.0
MAY	4.5	12.3
JUNE	2.2	8.2
JULY	1.8	8.1
AUGUST	0.4	1.1
SEPTEMBER	0.1	0.2
TOTAL		152.1
DAY	4.8	150

	Q: l/s	DATE
KNOWN MAXIMUM	57	11.2.60
KNOWN MINIMUM	oozing	
AVERAGE	11.0	64/65-69/70

CHEMICAL DATA					
PH	COND. (μmhos/cm)	TOTAL SOLIDS (p.p.m)	CL (p.p.m)	TOTAL HARDN.	DATE

METHOD OF DISCHARGE MEASUREMENT
 VOLUMETRIC V
 BY WEIR L
 BY CURRENT METER X
 BY FLOATS S

DISCHARGE MEASUREMENTS ○
 FLOW DURATION CURVE ---

FIGURE 6.2

If we consider that the aqueduct was a closed channel, and had possible leakages along its route, we can safely assume that a daily quantity of 12,000 m³ was conveyed to Salamis.

An open air theatre in perfect condition and having excellent acoustic characteristics was uncovered from the sandy covering layers in the year 1950, by archaeological excavations.

Considering the capacity of the open theatre up to 15,000 persons, and the aqueduct supplying water to Salamis from the Kythrea spring, it can be estimated that the city population was between 80,000 and 100,000 persons.

On this hypothesis the water conveyed from the Kythrea spring was giving a share of about 100 litres per capita per day, which would be most satisfactory in those days.

The trade association of Cyprus with Babylonia and Egypt, Syria and Phoenicia, and the direct commercial and cultural connection with the Greek mainland, must have brought to Cyprus empirical knowledge for surface and underground water engineering.

It is worth mentioning that in the time of Pysicratus the dictator, ruler of Athens 650 BC, many of the houses were provided with deep wells lined in masonry.

Butler H.C. in "The story of Athens 1902" p. 74-75 writes: *"In the wider streets of Athens are public wells of great depth, covered with stone slabs, with small apertures the necks of which are well furrowed by the ropes which for centuries have drawn the dripping buckets from their cool depths. Some of them are again in use".*

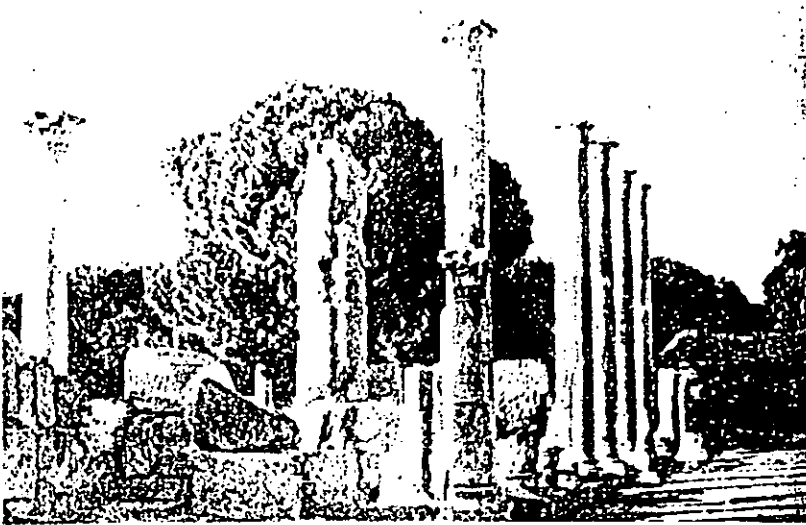
It has been commonly accepted that the wells were the centre of urban and rural life, of feminine activity and gossip.

Cyprus at the time of Pysicratus (670 BC) had the Kingdoms of Salamis, Paphos, Soloi and Lapithos, Curium and Marium all of Greek civilization and language. All the above Kingdoms had a gravity domestic supply through

THE ANCIENT THEATRE OF SALAMIS EXCAVATED EARLY IN 1960
BY THE DEPARTMENT OF ANTIQUITIES, CYPRUS.



Photo, courtesy Antiquities Department.



SALAMIS:- THE GYMNASIUM-PALAESTRA PUBLIC BATHS

clayey pipes or masonry channels. The system of drawing water from wells in the plain areas must have been in use.

6.5 Roman Period (58 BC - 395 AD)

Cyprus was conquered by the Romans in the year 58 BC from the Ptolemies.

In the year 52 BC Julius Caesar returned the island to the Ptolemies, as a gift to Cleopatra, who received the revenue from the island, and in 36 BC Mark Antony confirmed the possession of Cyprus by Cleopatra, who allocated it to her sister Arsinoe. However, with the defeat of Antony in 31 BC and the death of Cleopatra in the following year, Cyprus reverted to the Roman rule.

The Romans do not appear to have disturbed the rhythm of social and political life as it prevailed under the Ptolemies, municipal self-government maintenance of education, and water supplies. The Romans transferred the seat of Government from Salamis to Paphos because Paphos was the nearest coastal town approached from the west.

Under the Roman rule Paphos, the new capital of Cyprus, gained prosperity and importance.

Sir Harry Luke in his book "Cyprus", page 32 writes:

"During the Roman period Cyprus was prosperous and recent archaeological excavations in Paphos indicate that the Roman culture had been amalgamated with the previous Greek culture, following the same pattern of civilization and progress."

With regard to domestic water supplies the Romans used water from nearby springs discharging from the limestone hills, public wells and cisterns. They had the Roman baths, and in the Palaces they had an internal distribution of water.

Socket and spigot clayey pipes of 10-15 millimetres internal diameter and 30mm long were used, similar to those used during the Hellenistic period. The Romans worked the mines, constructed roads and conveyed the water from springs through closed masonry channels and aqueducts.

6.5.1 Dawn of Christianity

During the Roman period, in the year 45 AD, Paul and Barnabas landed at Salamis (of which city Varnavas was a native) and travelled to Nea Paphos, which was the Capital of Cyprus. In Paphos Paul and Barnabas converted to Christianity Sergius Paulus the Roman Governor, thus giving to Cyprus the distinction of being the first country in the world to be governed by a Christian ruler.

Cyprus remained under Roman rule until the year AD 395, when the Empire was divided between the two sons of Theodosius the Great into its western and eastern halves. In consequence Cyprus was placed in the east and passed to the Emperors of Constantinople.

6.6 Byzantine Period (395-1192 AD)

The Byzantine period commences with division of the Roman Empire in 395 AD and ends in the year 1191.

Under the rule of Byzantium Cyprus entered the stream of the Christianised World and was losing touch with Rome which seemed to be a distant city of no importance to her.

Very little information is available about the early Byzantine life of Cyprus. Arab invaders in the seventh century looted much of its wealth and destroyed many churches. The little information preserved shows that during the fifth and sixth centuries Cyprus enjoyed a high level of civilization and prosperity.

Archaeological excavations of Basilica in Constantia (Salamis) brought to light exquisite silver trays, an impressive head of Christ, and a holy well with mosaics.

The new church culture and civilization under Bysantium, turned towns into cathedral cities, and churches, monasteries and castles were built. The monasteries were built on the hills as a rule, where springs water was available. The water supply of monasteries that were built on top of a hill was collected from rain falling on the tile roof and was stored in underground tanks.

By the middle of the sixth century, Cyprus was exporting wine and dried figs to neighbouring countries. Aqueducts built by the Romans were restored and the Roman road system was extended to remote mountain villages.

Water mills were constructed for the corn-grinding, in rivers in all watersheds of the island.

The Church was the dominating life element and religion became the power and authority for the round of duties and demands, financial and spiritual.

From the national point of view Cyprus had found freedom in the Byzantine Empire. For three hundred years, its inhabitants lived in conditions of peace, while the economy advanced considerably. From the middle of the 7th century to the second half of the 10th century, Cyprus underwent a series of Arab invasions, which brought her exhaustion, bleeding and poverty.

Churches were destroyed, people were killed and enslaved to Syria and finally there was heavy taxation of the survivors.

Cyprus remained a part of Byzantine Empire until 1184. In that year Isaac Comnenos proclaimed himself Emperor of Cyprus and continued as such until the Cypriots were relieved from this despot by Richaard the Lionheart, King of England.

The Lionheart, on his way to Acre during the third Crusade, landed at Limassol to punish the Emperor and despot Isaac Komnenos, who had behaved in an unchivalrous fashion to his fiancée Berengaria and Richard's widowed sister Joanna, Queen Dowager of Sicily.

The two ladies were on board one of the vessels of the fleet, and because of storm their vessel was cut away from the dispersed fleet.

King Richard captured Isaac and confined him in the castle Margat. Meanwhile on the 12th May 1191, a Sunday and the feast of St. Pancras, Richard and Berengaria were married in the chapel of the fortress of Limassol.

Richard was the King of Cyprus from May to June 1191, when he sold it to the Knights Templars. The method of government employed by the Templars was

unsuccessful and soon they decided to return the island to King Richard. The rule of Cyprus by the Templars was terminated in May 1192.

6.7 The Lusignan Period (1192-1489)

The Latin dynasty of the house of Lusignan has its genesis in Cyprus, in May 1192. Guy de Lusignan, who had lost his kingdom of Jerusalem, purchased the island from the Templars, by paying the balance of their debt to King Richard, amounting to 100,000 gold besants. Guy de Lusignan did not call himself King of Cyprus, but chose to remain a feudal overlord. (Gordon Home "Cyprus Then and Now" page 58).

Under the Lusignan rule, the island was divided into twelve baronial counties and a feudal system was established. Land was granted to some three hundred knights and two hundred Esquires whom Guy brought over to his new possession. Strong Latin settlements were established in the best agricultural areas where spring and river water was available.

The 500 knights and Esquires, owners of large Estates irrigated from river intakes and big springs such as Kythrea Kephlovryso, produced olive oil, sugar, cotton, wool, precious wine, wheat and barley. Big quantities of agricultural products were exported to Europe, particularly France, bringing to the knights adequate revenue.

Over the years a considerable number of immigrants settled in the island, taking over the wealth and the economic running of the community. The majority of emigrants were Genoese and Venetians. The Lusignans administered the island through a feudal legal system, and the community was divided into feudal masters and slaves. The Cypriot peasant could not leave his village and work somewhere else. Both he and his family were bound to the lord who could also sell them along with the land. In general the Lusignans have reduced the entire Cyprus population to tenant farmers. (Doros Alastos "Cyprus in History").

The water resources of the island (springs and rivers) belonged to the Frankish Dynasty.

The famous Frankish monastery of Bella Baise was built on a commanding plateau, close to the Bella Baise spring issuing out through the Kyrenia limestone. In other parts of Cyprus, where the Frankish Duke and Regina had their estates, spring water was available.

A masonry irrigation tank, covering an area of almost two acres, is still in existence in the village of Kyra, 12 kilometres west of Nicosia. The tank was used to store water flowing from a spring issuing through the calcarenite stratum of the nearby plateau.

Economically, socially and culturally the island was administered and ruled by the Lusignan Latin Dynasty of French origin.

It may be accepted that the dynasty of Lusignan had improved the water resources by building aqueducts and river intakes and excavating shallow wells but on the whole for their own lordship interests.

The local people were living in despair and unhappiness.

The Lusignan period ended in the year 1489, after a period of 300 years.

It was a civilization with technical skills with art, engineering and architecture. Until this day remains of the Lusignan period are conspicuous all over Cyprus. The excellent architecture adopted in the construction of Bella Baise abbey in Kyrenia, is still today a testimony of that period.

In contrast to the cultured and luxurious life of the Lusignans in Cyprus, it can be said that the island itself for almost three hundred years was a stormy sea, lashed by a gale.

6.8 The Venetian Period (1489-1571)

The Venetians took over the administration of Cyprus from the Lusignans in the year 1489. To the Cypriots the change from Lusignan to Venetian control made very little difference as the majority of the people were still serfs

to the nobles and devoid of any rights whatsoever.

The Venetian occupation of Cyprus, was purely military, and indifference was shown to the welfare of the inhabitants. The people were overtaxed, and every man was bound to work for the State for two days a week. (*Gordon Home - Cyprus Then and Now, page 68*).

The Venetians constructed roads for easy communication and built vast defensive walls around Nicosia and Famagusta and castles in the Harbours of Kyrenia, Larnaca and Paphos, for the defence of the island against the increasing power of the Turks.

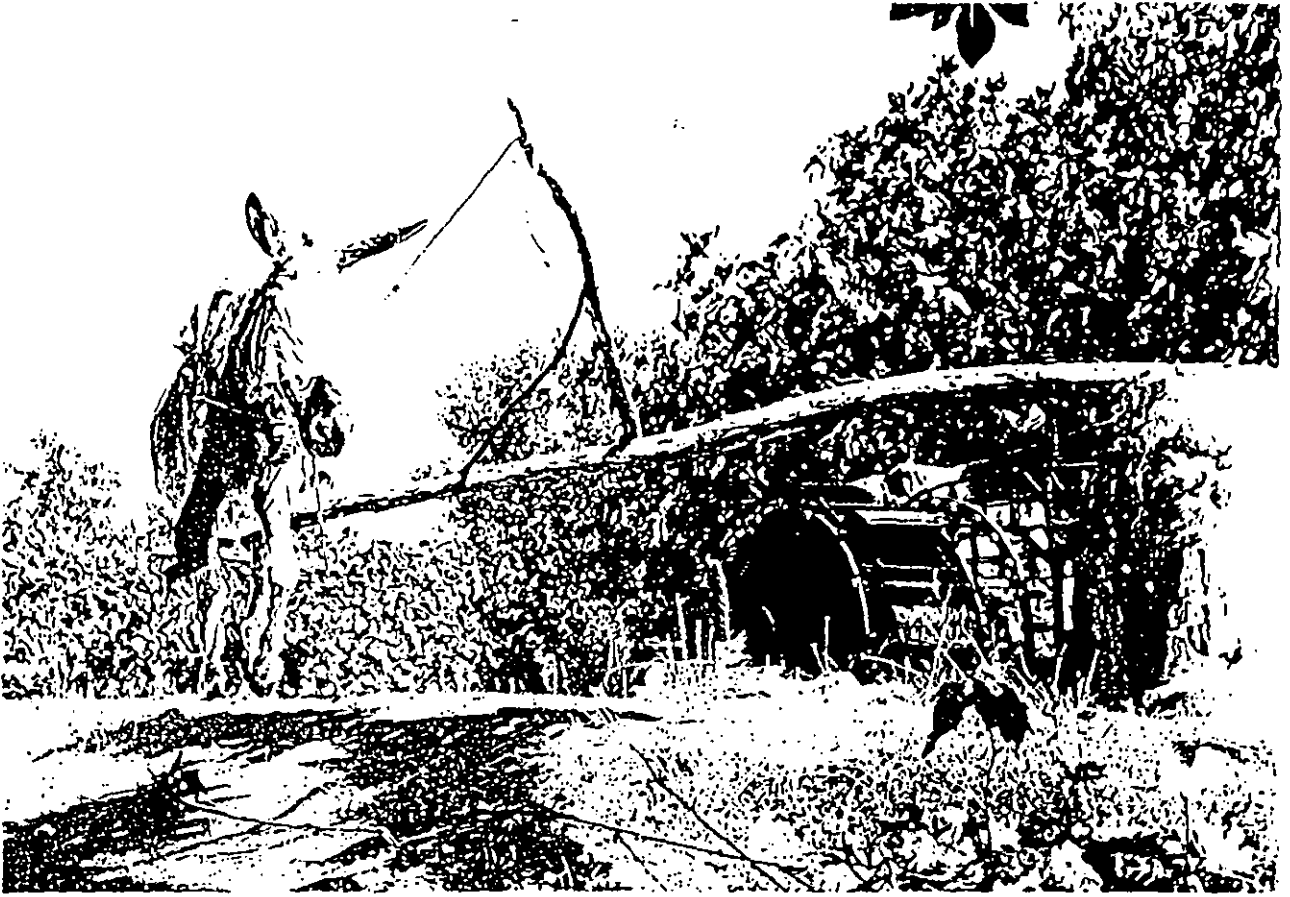
The rulers lived mostly within the fortified towns. They faced shortage of domestic water supply, and to augment the water supply they made use of rain, spring and underground water bailed from shallow wells within the walls of Nicosia and Famagusta.

They developed and extended the system of chain-of-wells, all wells being connected by a tunnel 2 feet wide and 4.5 feet high. By this process water was tapped within the aquifer, and gravitated to the surface through the tunnel. The uncontrolled gravitation of water to the ground surface was draining the aquifer, with adverse effects.

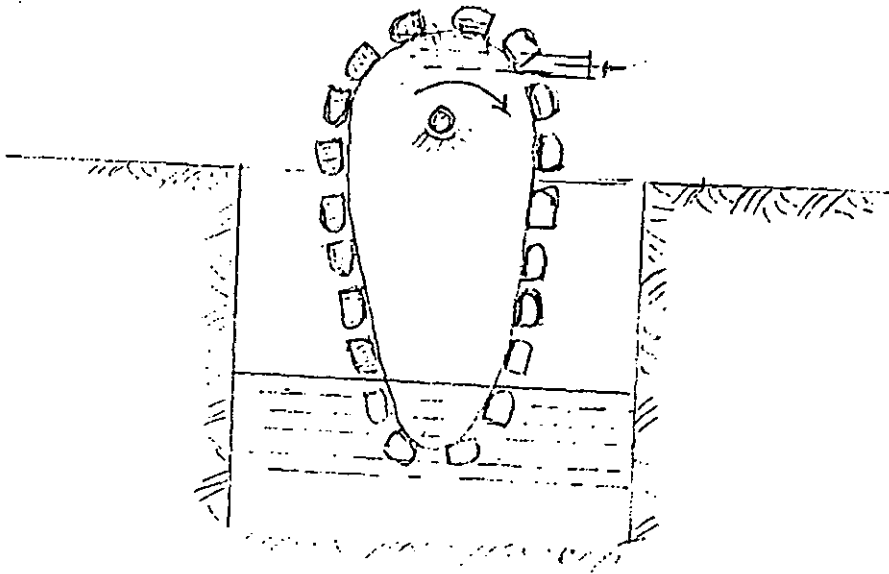
The Venetians developed also the "alakati" or "Persian Wheel", a method of raising water from a shallow well through a chain of buckets. By this system of water raising, a chain of dripping buckets passes over a wheel mounted on a horizontal shaft, which is driven through a gearing from a vertical shaft. To the outer end of a radial arm projecting from the vertical shaft, an animal, usually a donkey, provides the motive power. (Figure 6.4).

6.8.1 Capacity of Alakati (Persian Wheel)

This system of drawing water from unconfined aquifers was used mostly in the case of shallow wells, opened in pillow lavas and thin strata of alluvium and conglomerates. The depth of the shallow well varied from 13 to 20 metres. In cases where the flow into the opened



Persian Wheel



Chain of buckets

Fig. 6.4

Source: Photo, public information office Cyprus

well was small due to low water table or to low impermeability, a tunnel 1.5 metres in height and 0.80 metres wide was excavated sideways into the aquifer from the bottom of the well, so as to increase the area of infiltration. The tunnel also provides storage.

The water extracted was stored in an open shallow masonry tank of average depth one metre, and average area 15m^2 . The quantity of water extracted by the system of Alakati, was in the order of $10\text{m}^3/\text{day}$. The blindfolded donkey walked round and round along the coping platform of the well for a total of about 4 hours per day of 8 hours.

The increasing power of the Turks was a cause of concern to Venice, which foresaw the danger of losing her eastern most possession by invasion from the Ottoman Empire.

As a precautionary measure, they strengthened the old Lusignan fortification, and most important, they constructed the circular fortifications round Nicosia and Famagusta.

In contrast to the militaristic views and talent and the construction of very sound engineering defence works, which to this day are very much as they were built and constitute an impressive monument to the engineer, they failed in administration, which was selfish and heavily criticised by the west. They showed indifference to the welfare of the inhabitants, the majority of whom were still serfs to the nobles and devoid of any rights.

Trade diminished, agriculture was neglected, and the population was reduced through emigration. In general the peasant showed widespread discontent.

6.8.1 The Turkish Conquest

All through the Venetian period the Turkish threat hung over Cyprus.

On the 27th June 1571 the Turkish forces invaded the Island through Larnaca and thence they proceeded and attacked Famagusta and Nicosia. On 22 September, Lala Moustafa made a triumphant entry into Famagusta. The

Venetian Rule over Cyprus came to an end, and Cyprus passed under Turkish control.

The island's connection with western Christian Europe which had lasted for 380 years was severed and the western lights went out. Paradoxically western Europe remained apathetic and made no effort to prevent the conquest of Cyprus, an island that had been in western hands since Coeur-de-Lion's conquest in 1191.

A great part of the old civilised world in Cyprus passed behind the curtain of a new despotism which strangled knowledge, art and progress. Cyprus became an insignificant province of the despotic Ottoman Empire.

6.9 Turkish Rule (1571-1878)

The Turkish rule over Cyprus lasted for a period of just over 300 years. It was a period of misrule and incompetence which brought general degradation to the island. Gordon Home in his book "Cyprus Then and Now" 1960, page 90 writes:

"The Turkish method of Government reduced Cyprus from declining prosperity to stagnation. The famous port of Famagusta lost much of its trade and steadily decayed. Within its walls, the majority of the great buildings of the Middle Ages and earlier became partial or complete ruins. The population of the island was greatly reduced in numbers, and very large areas became a wilderness of prickly undergrowth, with roads to a great extent lost, and forests wantonly destroyed. Cyprus, impoverished and half depopulated, gradually fades from contemporary records. In place of a history that was often of European consequence, the island's affairs became but rarely of more interest than those of an obscure^m province".

6.9.1 Water resources development

The conquerors were aware of the value of water for both irrigation and domestic use, and thus all land that could be irrigated was confiscated and given to the Aghas who became big landowners.

The governors of each chief town held the rank and title of "Pasha". The Pasha of Paphos, walked along the route of the two rivers Diarizos and Xeros, and, by a Firman from the Great Vizier, was given the right of ownership of the surface flow of these two rivers. He confiscated and took ownership of the coastal land irrigated by these two rivers. All property of over 2000 acres, known as the Paphos chiftliks, belonged to the family of the Pasha of Paphos.

In Lusignan-Venetian times some of these estates had belonged to the Royal families.

In the year 1861 the estates passed to the Kibrisli Pasha's daughter and remained so until the year 1947, when the Cyprus Government bought them and the Pasha's ownership of land and river water was terminated.

It should also be mentioned that to the owners of the chiftlicks situated at the mouth of the Dharizos, Xeros, and Ezuza rivers belonged also owned the surface flow of these rivers. Owners of land bordering the rivers above the chiftlicks were obliged to pay rent to the Sultan's family for the water which they used for irrigation.

The users of the Kouris river water, in the Episkopi, Limassol and Marathasa river, Lefka areas paid water rents to the Pashas of Limassol and Nicosia also.

The Pashas of Nicosia and Larnaca carried out some work on the domestic supplies of their towns, but always on a private ownership basis.

a) Arab-Ahmet, the Pasha of Nicosia, was responsible for the Government of the island and he had the title of "Muzaffar" a Pasha of three tails. He wanted to raise his personal revenue by the sale of water to the people of Nicosia. For this purpose, he had a chain-of-wells excavated along the banks of Pedieos river, tapping the water of the river gravels and conveying it to the surface at the outskirts of Nicosia town. From the outlet of the chain-of-wells the water discharge flowed along a

masonry covered channel to certain parts of the town, from where the inhabitants fetched their drinking water on annual payment to Arab Ahemt. The chain-of-wells was named the Arab-Ahmet chain-of-wells, and it is so known until this day.

The chain-of-wells extended for 6.5 kilometres. In some places the Pedieos river was crossed by the wells, which at places reached a depth of up to 25 metres.

b) Larnaca

The Pasha of Larnaca, Abu-Bekir Pasha, constructed another chain-of-wells along the Banks of the Trimithos river, through an aquifer consisting of gravels and sandstone, in the year 1745.

The discharge from the Abu-Bekir chain-of-wells flowed to Larnaca through a closed rectangular channel of average size 45 x 40 cm. At the outskirts of Larnaca Town an aqueduct was built to convey the water across a stream bed and low ground. The aqueduct is still in existence and in good condition, but not in use any more. Having regard to the size of the aqueduct, which is 40 x 40 cm, and the hydraulic gradient of 1/1200, we can estimate that a quantity of 11,000 cubic metres per day could be conveyed to Larnaca Town. This quantity was adequate for domestic use and irrigation within the town. Water rates were paid to Abu Bekir Pasha for the use of water from the chain-of-wells.

6.9.2 Water rights

The Sultans together with the Aghas, the rich land owners, succeeded in obtaining Imperial Firmans from the Great Vizier of Constantinople conferring on them, by name or in groups, large water rights over the flowing rivers, such as Kouris, Dhiarios, Ezuza, Khysokhou, Solia and Marathasa.

To the Cypriots these people, on whom water rights were conferred, were known as the "dragons of the water". (This popular nickname continued to be used during the

"British Occupation of Cyprus" for men working on the distribution of municipal water supplies. Because of shortage of water and lack of storage the water was cut off for some period of the day and the consumer was expecting the dragon to allow the flow of water again).

All the rivers and water rights were regulated by Ottoman Civil Law. The Ottoman Law classified the rivers of Cyprus into three categories.

- a) The Public rivers which were common property.
- b) The common rivers which were used by certain individuals or groups.
- c) Private rivers, in private ownership.

The users of the flowing water of the public and common rivers claimed ab-antiquo rights not only on the flowing rivers but also on the springs feeding the respective rivers.

In accordance with the Ottoman Law, which in some cases is still in force in disputes as to rights of watering crops and animals or irrigation only "ab-antiquo" usage is taken into account.

Cases of disputes between users of river and spring waters were heard at court during the British Occupation of Cyprus after 1880. Defining the water rights which have been regulated by long established customs and confirmed by Firmans granted by Sultan before the British Occupation in 1878 has been most difficult and a strong headache to the courts, which in some cases have been unable to issue a decision, with the result that such cases have been pending for almost a century.

The ab-antiquo rights regulate the share of water to the users in complicated ways such as "the lengths of a man's shadow", "The rise of Pleiad or Orion, by days and hours per week or fortnight".

The ab-antiquo rights and titles to water in Cyprus established during the Turkish Rule retarded water development programmes during the early years of the British Occupation of the island. The intensive and major water development work carried out during the last fifty years has neutralised and even extinguished these

inherited water rights and titles, for the prosperity of the island as a whole.

6.9.3. Western interest

After the elapse of three centuries of Turkish rule over Cyprus the Ottoman Empire was showing signs of decay, and the west began to abandon its apathetic attitude and show political interest in the east.

During the 1840's it was rumoured that the Porte in Constantinople intended to hand over the island to Great Britain as a guarantee for the raising of loans on the British market.

France also turned her eyes to Cyprus which was regaining its importance after the opening of the Suez canal.

The British interest was also stimulated, and on 21 February 1861, the Foreign Secretary, Lord Russell, declared openly that:

"Britain did not want to create a new Papal State in the east and to give France a new pretext for indefinite occupation". (Cyprus in History, by Doros Alastos, 1976).

After several reforms in the Turkish administration, and the end of the Crimean War, on 4th June 1878, a "Convention of Defence Alliance" was signed between Great Britain and the Ottoman Empire, through which His Imperial Majesty the Sultan consented to assign the island of Cyprus to be occupied and administered by England. As a result of the above convention the Turkish rule over Cyprus was terminated, and the administration of the island passed to Great Britain.

CHAPTER SEVEN

WATER DEVELOPMENT 1878-1936

7.1 Termination of Turkish Rule 1878

Following the signing of the Convention by the two countries, (England and Turkey), Sir Garnet Wolseley took up his duties as High Commissioner on 22 July, 1878.

7.2 Setting up of Administration Authorities

The first efforts made by the High Commissioner and his staff were to eradicate the evils left behind by the incompetent Turkish administration, re-instate the honour and prestige of the individual, and also provide for the administration of justice. For this purpose a High Court of Justice was set up consisting of the High Commissioner, a Judicial Commissioner and a Deputy Commissioner.

Government Departments were set up, to undertake responsibility and work within the Department's specialisation and competency: Priority was given by the authorities for the improvement of transport and communications in general, the raising of the standard of education, securing and maintaining security and justice, surveying and recording ownership of land and improving agriculture.

7.3 Water development

The British Administration were aware that water was most necessary for the improvement of agriculture and the health of the people, and attempted to deal with the water problem so as to benefit the island's community as a whole.

With the setting up of various administration authorities, water supplies came under the jurisdiction of the Corps of Royal Engineers stationed in the island. The Royal Engineers constructed minor water supplies, and carried out maintenance to existing works, over and above their other engineering activities (road works, harbour facilities, government buildings).

7.3.1 Water for irrigation

The Royal Engineers were responsible for all public works from 1878 to 1896, after which the Department of Public Works was created and took over the responsibilities for public works.

This department thus took control of the water supplies and general water development all over the island. The Department was headed by a Director and Assistant Director, both English. All other subordinate staff were Cypriots.

At that time the rural population constituted four fifths of the total population of the island. The peasants were farmers, occupied mostly in dry farming, producing cereals, wheat and barley. Wheat was used for feeding the population and barley for feeding the animals. Surplus of barley, in years of good crop, was exported to Europe.

Dry farming depended on the annual rain for its growth, and as such it was vulnerable because rain varied from year to year. In dry years, there was inadequate water to complete the irrigation needed for the full growth and maturing of the cereal crops.

The year's harvest of cereals was an important factor affecting the food requirements of the island. To the people of Cyprus Mesaoria was the basis of their corn supplies and prosperity.

The common saying among the people of those times was:-

"If Masaoria has a good year's corn crop, mothers and children will have ample food. If not then all should take their personal belongings and be lost".

7.3.2 Efforts made by the Cyprus administration

The Cyprus Government, received petitions from the farmers, who demanded more water for irrigation and domestic use. The Government responded to the demands of the people in an effort to promote the production of food and improve the health of the people. Towards this goal, they called from England a water engineer, R. Russel to study the water resources, and the problem of water

supplies. Russel studied and measured the discharge of springs issuing from the Kyrenia limestone range and through the Troodos igneous complex.

After a short period of studies and observations, he reported that the central Mesaoria between the two mountain ranges Kyrenia and Troodos consisted of an artesian aquifer, and that it was possible to tap adequate artesian water by means of deep drilling.

The proposal of Russel, for deep boreholes in central Mesaoria, did not materialise firstly for the lack of funds, and the availability of the appropriate equipment, and secondly because his report was not very convincing.

At a much later date, in the 1950's and 1960's deep boreholes were drilled in Central Mesaoria, but no artesian water was tapped. Between 1964 and 1968 two deep boreholes of 918 metres and 740 metres were drilled near Lefkoniko and Vatili villages of Central Mesaoria. No water was tapped at all (Table 7.1).

TABLE 7.1 Details of two boreholes in Mesaoria

Bore-hole	Site coordinates	Type of drilling	Depth metres	Casing diameter	Yield Cm^3
BB 46	Milea (VE68520110)	Rotary	918	170 mm	nil
BB 47	Vatili	Rotary	740	150 mm	nil

Source: Survey of Ground Water and Mineral Resources, Cyprus UNDP pp.227

7.3.3 Earth reservoirs

Since the Mesaoria plain was the main grain producing region of the island, and water was needed to irrigate the crop, the farmers forwarded petitions to the Government demanding the construction of water reservoirs in the Mesaoria plain. The reservoirs would collect the flood flow of the two rivers Pedhieos and Yiallias which travers Mesaoria and discharge into Famagusta bay.

The two rivers have an average annual discharge of 5

$\times 10^6 \text{ m}^3$ in normal years of precipitation, as recorded by the Water Development Department at gauging station No. 6-5-3-15 (Figure 7.2) and gauging station No. 6-1-1-85 (Figure 7.1) about 60 kilometres upstream from Kouklia reservoir.

The flood water of the two rivers, was used to irrigate cereals planted in village areas along the route of the two rivers. The flood water was guided to the land for irrigation through diversion intakes and earth channels, opened by means of pick and shovel. The intake weirs were constructed at intervals of 5-6 kilometres along their valleys, commencing from the highest village area, outside the State Forest boundary, and terminating at the last village area in the Eastern Mesaoria, near Famagusta Bay coastal zone.

The Cyprus Government was aware of the importance of water for the irrigation of the Mesaoria plain. In their effort to develop the island's water resource for domestic use, and also to meet the demands for more irrigation water put forward persistently by the farmers, the administration in 1898 engaged Mr I.A. Medlicott, an irrigation engineer serving in India, to study the water problem of Cyprus, giving priority to the irrigation of central and eastern Mesaoria. Medlicott, being an irrigation engineer serving in India, a country with abundance of surface flood water, saw the problem from a storage point of view, and so recommended the construction of several earth reservoirs in the eastern Mesaoria plain to catch the flood flows of the Yialias and Pedhieos rivers.

The recommendations of Medlicott were approved by the British Administration in Cyprus, and the first two reservoirs, namely Kouklia and Akheriton, were constructed between the years 1899 and 1901.

Kouklia reservoir has a circumference of about 10 kilometres and a bank 20-25 feet high (6-7.6m). Its capacity is $11,400 \times 10^6 \text{ m}^3$.

The Akhyritou reservoir was built at a lower level below Kouklia for the purpose of collecting the overflow

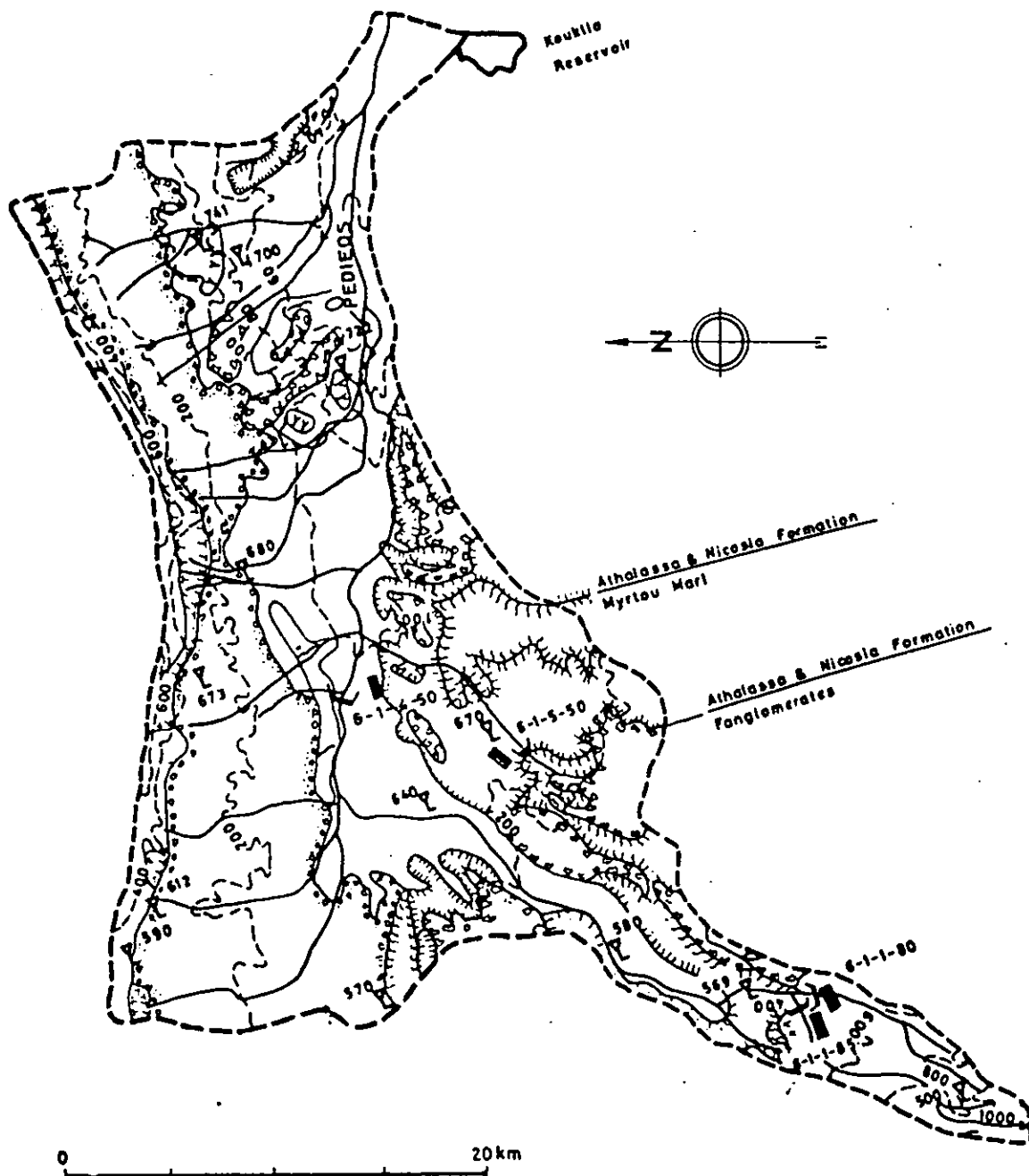
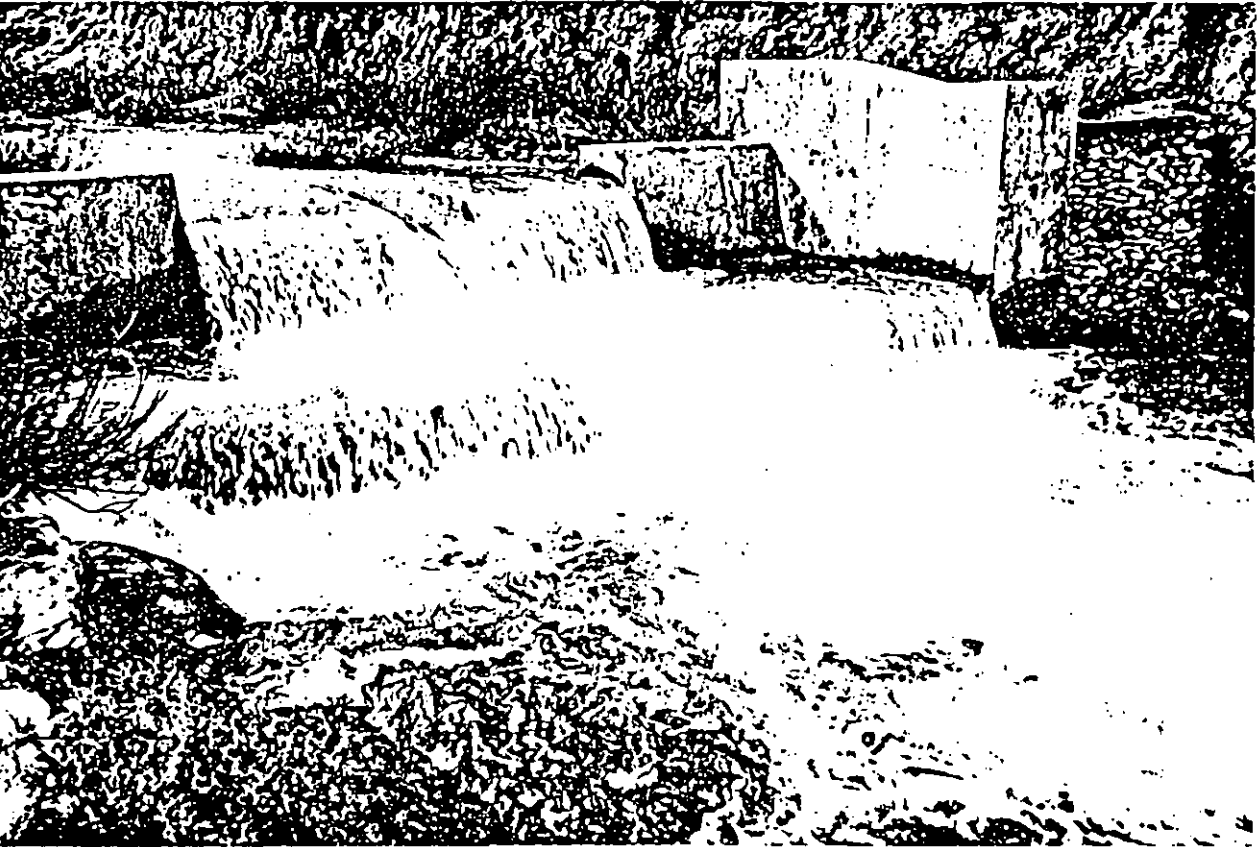


Fig. 7.1 **PEDIEOS RIVER WATERSHED**

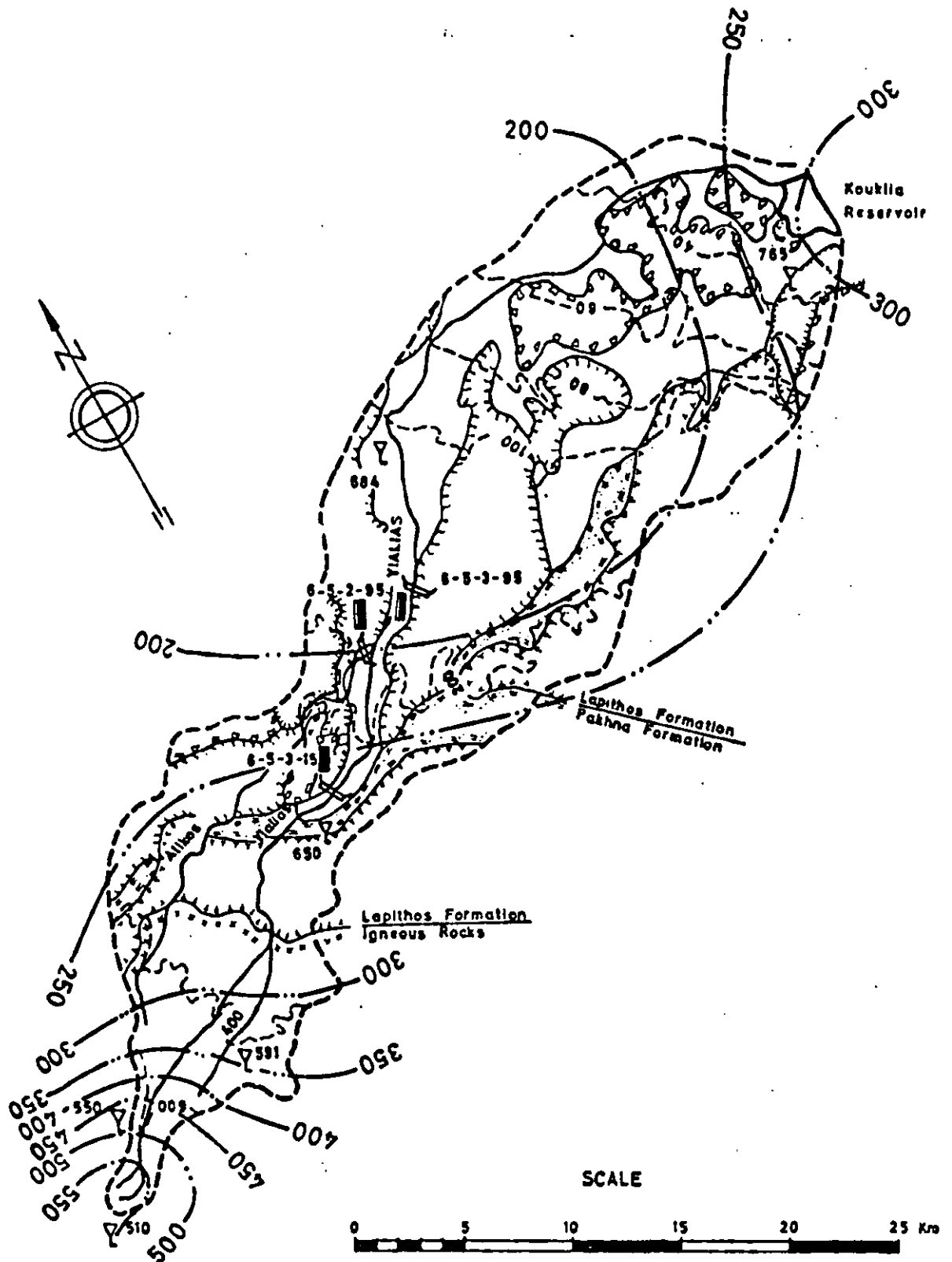
Source: Hydrological Report 1973. Water Development Department
CYPRUS



Flow gauging station equipped with automatic
water level recorder on Pedhieos river near
Kambia

Fig. 7.2

Source: Photo Water Development Department Cyprus



YIALIAS RIVER WATERSHED

Fig. 7.3

Source : Hydrological Report 1973. Water Development Department
Cyprus

from Kouklia. The construction of the two reservoirs took an army of workers two years. After the reservoirs were completed, the winter of 1901 was good and precipitation was much above the average. Of course hydrological data were unknown at that time. Luckily Kouklia reservoir collected water, and the farmers rejoiced in the fruitful results of the reservoirs.

The fact that Cyprus is a semi-arid country, susceptible to droughts, and that climatologically Mesaoria plain is a rainshadow area, was not considered by Medicott. It is also apparent that Medicott failed to consider the fact that the flow of the two rivers was used for the irrigation of cereals in the upper central Mesaoria, and that in dry years little water could reach the reservoirs.

During the hydrological year 1901-1902 the precipitation over the catchment areas of the two rivers was low, and no water reached the Kouklia reservoir. The farmers of the area saw that the reservoirs were dry and disappointment grew.

It was realised that the two reservoirs did not fulfill their purpose successfully, even if they had water stored after a year of high precipitation which occurs once every five years, as proved from meteorological records.

Moreover disappointment was created by the following causes:

- a) The seepage of water through the earth banks, which had no clay core and which were not compacted during their construction, created swampy areas around the reservoir.

The owners of such land voiced strong objections, and they illegally broke the banks to let the water flow away to enable them to plant cotton, which was growing well, in the clayey fields.

- b) Disputes about water rights.
- c) The water area and the swamps created by the seepage greatly promoted the breeding of Anopheles mosquitoes, and Malaria incidence increased in the

Eastern part of Mesaoria.

The British Administration in Cyprus was then confronted with an undesirable situation resulting from the failure of the reservoirs.

Pressed by persistent complaints, the Government appointed a commission to report on the failure of the two reservoirs, and their report was published in 1909. (*Dr D. Christodoulou: The Evolution of the Rural Land Use Pattern*).

The disappointment over the early reservoirs, and the report of the Commission procedure a setback for such water development works. For a period of almost half a century after 1900 no significant work on water development for irrigation was undertaken by the Government.

It was only after the end of the Second World War that the building of masonry and concrete dams was considered by the newly created Water Supplies and Irrigation Department.

7.3.4 Was Medlicott right or wrong?

a) Medlicott saw Mesaoria producing dry crops, in the same way as saw India doing so. But while India derives large amounts of precipitation from the monsoons, Cyprus is a semi-arid country having limited quantities of precipitation fluctuating from year to year. The two rivers Viallias and Pedieos flowed in winter only, and depended solely on the incidence and intensity of precipitation over the rivers' catchment areas.

b) It appears that Medlicott did not elaborate his recommendations, which were put forward in a hasty way. He came to Cyprus in 1898, and in 1899 the construction of the reservoirs was commenced.

The British Administration wanted to do something to meet the complaints and demands of the farmers of the eastern Mesaoria, and Medlicott having been influenced, possibly emotionally recommended the construction of the reservoirs.

- c) The sites of the two reservoirs were good from a storage point of view. But an empty reservoir or a full reservoir submerging good agricultural land, creates discontent. All other adverse factors mentioned above created disappointments and anger. Even today two earth reservoirs (Lefkara and Agros Dams) built after 1960 and designed by consultants, do not collect adequate water which is much needed for domestic use, and criticism is outspoken.
- d) In fairness to Medlicott it may be said that even to day dams and reservoirs may be built without due consideration of rainfall, of runoff from the dam catchment area and without correct and adequate hydrological data.
- Any possible future interference to environmental equilibrium by man should also be considered.
- e) Medlicott failed to consider that the flow of the two rivers was used to irrigate the central part of Mesaoria before it reached the site of the reservoirs. It is accepted that no hydrological data of any sort were available in those times, but in my opinion an engineer should investigate a river from its source and throughout its length before making changes.
- Empirical information from farmers is also useful, and can be evaluated by site observations, water marks, sectional areas, and duration of time flow.
- f) In the case of semi-arid countries the storing and use of water is very susceptible to other development changes occurring in the area.
- It can be shown that the importance of an area may fade away or increase following the trend of the general development of the country. Such developments are industry, tourism and movement of population.
- g) It is my opinion that a water planning and design engineer should first locate the water and second design the storage.
- Planning and designing should be governed by

adequate data, both scientific and empirical and amalgamation of specific factors, social, economic, and environmental, coupled with common sense and imagination. An engineer, particularly if he is dealing with developing countries, should spend most of his time out of the office, for a study of the topographical environment, meeting the people, hearing and evaluating, taking notes, and collecting information from other allied scientists as much as possible.

7.3.5 Deep drilling and adits

After the departure of Medlicott, the Cyprus Government reverted to the concept of deep drilling in the Mesaoria plain, and in 1905 they called to Cyprus the British Geologist, Clement Reid, to study the possibilities of developing underground resources, following the earlier proposal by Russel. After geological studies and investigation Reid decided against deep drilling for artesian water.

He did however, recommend driving adits into the Kyrenia limestone range, to tap and gravitate water to the surface, and also drilling boreholes in western Mesaoria, particularly in the Morphou area.

7.3.6 Adits into the Kyrenia limestone range

Reid's recommendation for the opening of adits in the Kyrenia limestone range was accepted by the Cyprus Government, in order to augment the water supply of Nicosia.

After geological studies of the area, he selected a favourable site at Pileri not far from Kythrea spring, for the excavation of the adit.

Work was put in hand in the year 1908, but unfortunately with the primitive means available at that time, it was impossible to open the adit through the hard limestone. All casual attempts to drive the adit were unsuccessful, and after a period of 25 years, of intermittent efforts, work on the adit had to be suspended.

In the same year, 1934, a new site was selected near the village of Sykhari, five miles west of Kythrea spring. Here again the work was unsuccessful, and after two years, in 1936 the work was closed temporarily.

(C. Raeburn: *General Report on Water Supplies in Cyprus, 1945*).

7.3.7 Construction of dams and boreholes

The Cyprus Government, and the island's people in particular, were very conscious of the necessity of exploiting the water resources of our semi-arid country, where acute shortage of water, due to regular droughts, was experienced.

It was very disappointing for everybody to see the rivers discharging their winter flows into the sea. Pressure was put on the Government demanding the construction of dams and diversion weirs to prevent river flow reaching the sea, and also the drilling of boreholes for the extraction of ground water from wherever it was available.

Responding to the demands and pressure from the farmers, constituting over eighty per cent of the population, and the disappointment stored, due to the completion of the Pileri adit only after work over a long period of years (1908-1921).

The Cyprus Government in 1921 sought the services of Colonel W.N. Ellis, irrigation engineer in India, who was posted to Cyprus to study the irrigation problem.

He completed his report within a period of one year. Ellis saw and studied the water problem of Cyprus from an engineering perspective and like Medlicott recommended the construction of dams for storing the flood river water, and the drilling of boreholes for irrigation by private people. Ellis was very reluctant to make recommendations but in the end he proposed the diversion of rivers discharging into west Mesaoria to east Mesaoria for irrigation.

Ellis failed to consider that the rich and extensive Morphou aquifer was recharged by these rivers. The crude

report of Ellis was shelved for years.

After the visit of Colonel Ellis in 1921 the geology of Cyprus was studied by Bellamy and Brown and others, and an adequate knowledge of the hydrology of the island was acquired. A number of prospecting boreholes were drilled in western Mesaoria and much information was gained. (*C. Raeburn: General report on Water Supplies in Cyprus, 1945*).

7.3.8 Conclusions. (Period 1878-1936)

From the above short notes it is obvious that after the occupation of Cyprus in the year 1878, continuous efforts were made by the Cyprus Government, resulting from pressures exercised in Cyprus and London, for increasing and improving the water supplies for domestic and irrigation purposes.

Geologists and water engineers have come and gone. But the water problem was not tackled effectively, from a practical point of view, simultaneously with the academic consideration of the subject.

The experts prepared their reports and made recommendations in a hasty way, without the support of long and deep investigations and studies of the natural environmental conditions of the country. Moreover the experts did not stay in Cyprus long enough to become acquainted with local conditions and needs.

Apparently none of the experts realised that Cyprus is a small semi-arid island, having limited water resources, and small and cheap projects would have been successful and profitable.

Another major reason why water development was retarded was lack of money.

Under an annex to the convention of 4th June 1878, Great Britain was obliged to pay the Government of the Sultan the annual amount of £92,799. 11s 3d, as a tribute for the lease of the island. The total annual gross revenue of the island was only about £140,000. The balance left after the payment of the tribute was needed to cover the cost of administration, and thus very little

money was left for internal development.

The payment of tribute lasted for 49 years, until 1927 when that great Liberal man, Sir Winston Churchill, in his capacity as Chancellor of the Exchequer, used his authority to relieve the island of the tribute.

It should also be realised that development was in the hands of the Public Works Department, the main activities of which were the construction of roads, public buildings and harbours. Water Development was of secondary importance to the Public Works Department.

Sir Ralph Oakden, in his report on the general development of the island, in 1934, summing up the position regarding water development, writes:

"...There has been a want of water: There has been no want of reports and experts". (Dr. D. Christofhoulou: "The Evolution of the Rural Land Use Pattern in Cyprus").

It was on the recommendations of Sir Ralph Oakden that the Water Supply and Irrigation Department was created in 1938. At last the water problem was being dealt with by a competent Department in the correct perspective, a department to which the Colonial Office and the Cyprus Government gave their full support and encouragement.

CHAPTER EIGHT
THE DAWN OF WATER SUPPLIES
(Period 1936-1945)

8.1 Introduction

The year 1936 is considered the dawn of a spring sunny day of water development in Cyprus.

It was the time when the Colonial Office had decided that by improving the water resources in the rural areas for domestic use and irrigation, it would free the peasant from water borne communicable disease, raise his standard of living and prosperity and most important relieve him of his heavy indebtedness to illicit money lenders stationed in the six towns of Cyprus and his exposure to the worst forms of usury by those horse-leeches.

For this purpose, the Colonial office in 1934 detailed Sir Ralph Oakden to visit the island and report on the existing condition of finances and economic resources of the country, giving particular emphasis on rural development.

Sir Ralph Oakden in his report "Finances and Economic Resources of Cyprus, 1935" London (*Crown Agents for the Colonies*) strongly recommended the enactment of the Agricultural Debtor's Relief Law, and the creation of a Water Department to be responsible for the development of all surface and underground water resources for domestic use and irrigation in order to boost the prosperity of the rural areas.

The Colonial Office considered favourably the Oakden Report, and in the year 1938 the Water Supplies and Irrigation Department was set up.

In consequence, all Government work on water supplies in Cyprus, and all activities covering the whole field of water resources development, were automatically removed from the jurisdiction of the Public Works Department, and passed into the hands of the newly created Water Supplies and Irrigation Department. The New Water

Department was greeted with exceptional enthusiasm by the people of Cyprus.

At last the inhabitants of villages and towns, would have a Department to which they could communicate direct for the solution of their water problems, and with which they could co-operate side by side.

8.2 Domestic water supplies as existing in 1936

8.2.1 Sources of supply

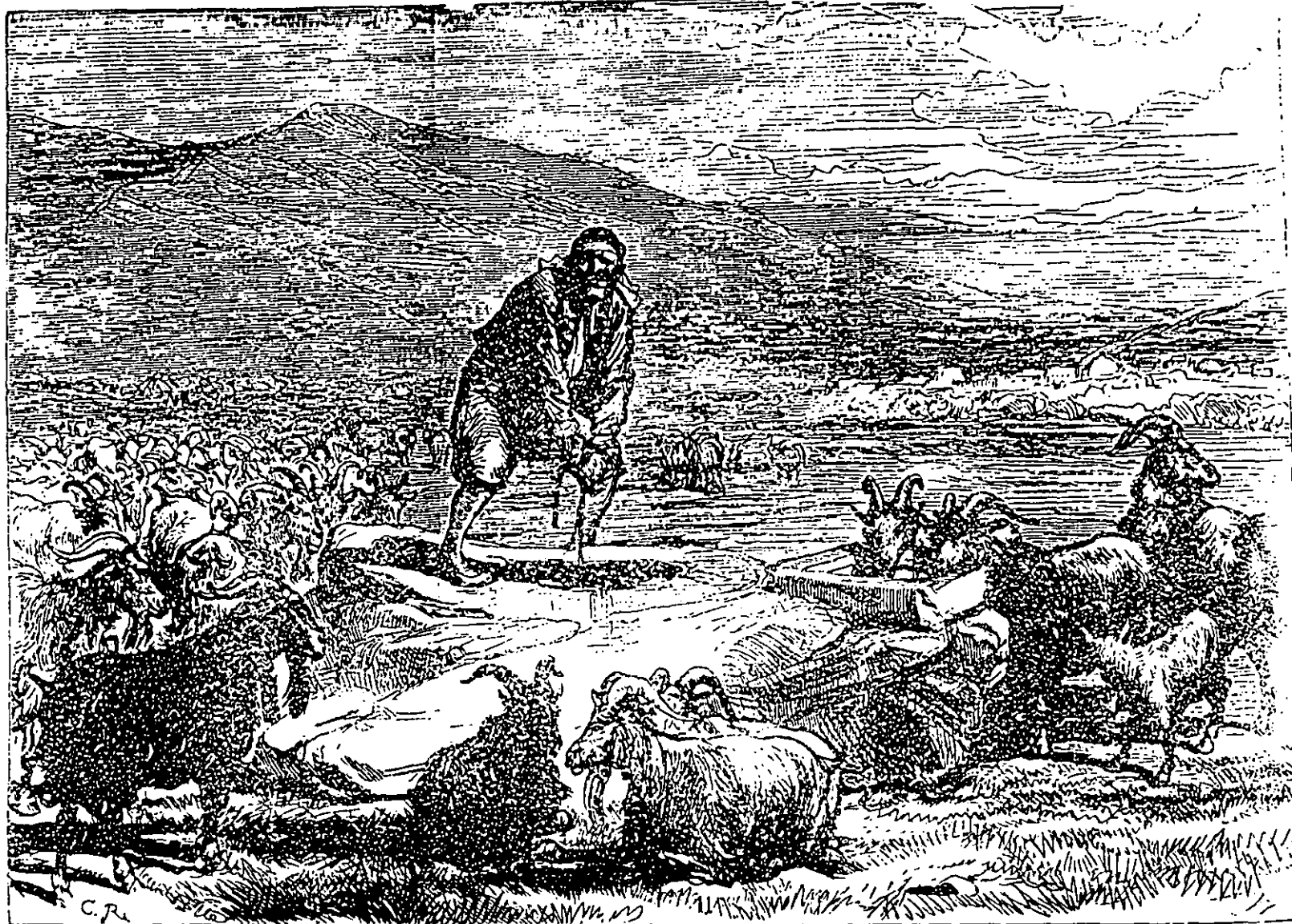
- a) The six towns of Cyprus, namely Nicosia, Larnaca, Famagusta, Limassol, Kyrenia and Paphos obtained their water supplies from chain-of-wells, individual private shallow wells and four small springs.
- b) The rural water supplies were obtained from the following sources:
 - 1) All the hilly villages, situated in the foothill zones of the Troodos igneous complex and Kyrenia limestone range, transported their domestic supply home, from natural perennially flowing springs.
 - ii) The villages located in the lowlands and coastal zones obtained their domestic water supply from private wells opened in the yards of the houses, or transported it from a central public well in which a hand pump was usually installed. (Figure 8.1)

8.3 Municipal water supplies (Year 1936)

8.3.1 Nicosia water supply

Nicosia town was enclosed by defence walls, which were built by the Venetians.

For its domestic supply Nicosia was totally dependent on the water discharging from the Arab chain-of-wells.



Cypriot shepherd Drawing water from
a shallow well.
Goats drink water from stone trough
- 1878 -

Fig.8.1

Source: Photo Drawing, the illustrated London News 1878

Arab Ahmet water supply was administered by the Water Administration Committee of Nicosia, which was set up under the Law 22 of 1919, by Law 21 of 1933.

During the period preceding 1936, the discharge from the chain-of-wells gradually diminished in summer because of losses along its route, lack of maintenance and the increasing use of water for irrigation, higher up in the valley, by the villages neighbouring Pedhieos river.

The water from the outlet of Arab Ahmet chain-of-wells was conveyed to Nicosia town, within the walls, through a masonry aqueduct. Water from the aqueduct flowed at certain masonry public fountains from where the female members of the family transported water to their house, for domestic use.

When, in the year 1933, the Nicosia Water Committee was set up, it was decided to replace the aqueduct by a pipeline in order to avoid the losses through the sides of the masonry aqueduct, and also to prevent the susceptibility of the water to surface pollution and contamination.

As a result of this decision the Committee contracted a loan of £8,000 and the water was piped all along the defence walls, encircling Nicosia.

At regular distances along the walls, water was allocated to purchasing customers, through concrete distribution boxes built for this purpose. The share of water to each customer, who had purchased a quantity of water (known as saccorafi) from the Arab Ahmet water supply, was separated through brass partition boxes, built within the small distribution tank. Saccorafi is a measure equal to the quantity of water that can pass through a hole of 2mm diameter, at a constant back water pressure of 150mm (Greek saccafori means big niddle). For Nicosia town the saccorafi measure was equivalent to 1.5 litres per minute.

In winter the flow of water allocated to each consumer was kept running for 8 hours, and in summer from 4-6 hours daily, a quantity of about 500 litres per day.

The time during which water from Arab Ahmet was flowing to each zone of supply depended on the discharge from the chain-of-wells. No central storage of water was provided; the discharge from the chain-of-wells was directly piped into a number of distribution boxes at a time.

Every owner of a saccafori stored the water in a small tank of one cubic metre capacity built in the yard of the house or in twin barrels usually of 200 litres capacity.

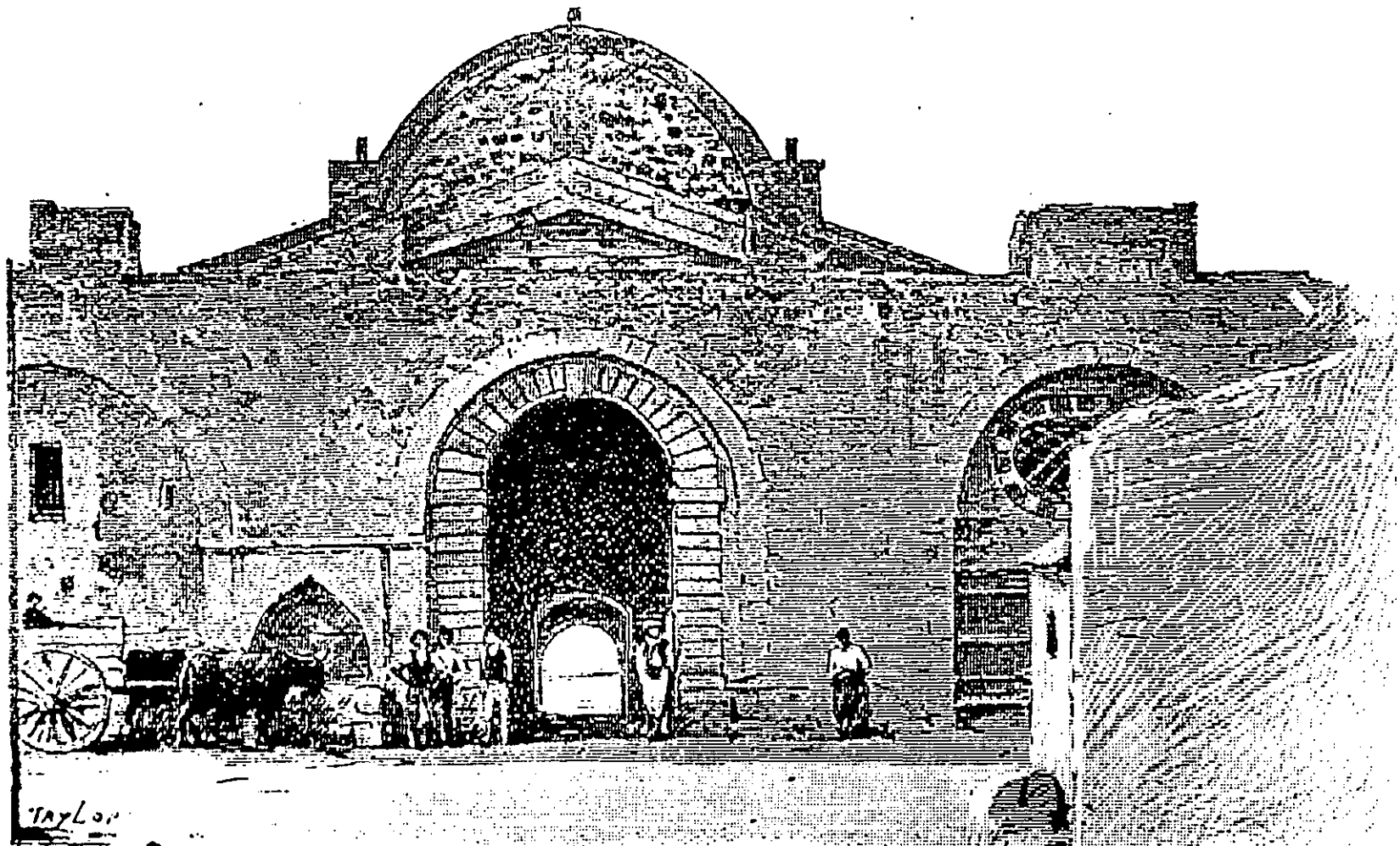
All those consumers, however, who were not owners of saccorafi, were obliged to congregate at the public fountain (Figure 8.2) to fill a four gallon rectangular galvanised steel receptacle and carry it to the house. The carrying of domestic water from public fountains was a hard job for the wives and young children, who at times waited all night at the public fountain to obtain the domestic water supply for the family, the quantity of which was also inadequate for their hygienic life. From information collected the share of water transported from the public fountain was 80-100 litres per day.

Several other private establishments supplied water to Nicosia and its suburbs from a series of chain-of-wells opened through a sandstone aquifer south of Nicosia. They supplied water to about 800 consumers on the outskirts of Nicosia through saccorafi.

8.3.2 Larnaca Water Supply (Year 1936)

Larnaca obtained its domestic water supply from the Abu Bekir Pasha chain-of-wells, opened and built in the year 1745, by Bekir Pasha, administrator of Larnaca town.

The distribution and administration of the Larnaca Water Supply was in the hands of Evgaf. Evgaf was set up by the Cyprus Government by order in Council, for the administration and control of the Moslem Religion Properties, to which the Bekir Pasha chain-of-wells belonged.



Famagusta Gate Nicosia.
Oxen drink water from trough of fountain
(Photo by Taylor 1879)

Fig.8.2

Source: CYPRUS of yesterday 1982, by A.Pavlidis

The outlet of the chain-of-wells was 3.5 miles (5.6 kms) west of Larnaca and the discharge of water was conveyed to Larnaca for distribution through a masonry aqueduct arched in valleys. It was built on the Roman pattern (Figure 8.3).

C. Raeburn the Director of the Water Supplies and Irrigation Department in his "General Report on Water Supplies 1945" mentions that a quantity of 4,000 cubic metres per day was estimated to represent the discharge from the chain-of-wells, at its minimum. He also mentioned that 350 litres per day per capita was available in Larnaca.

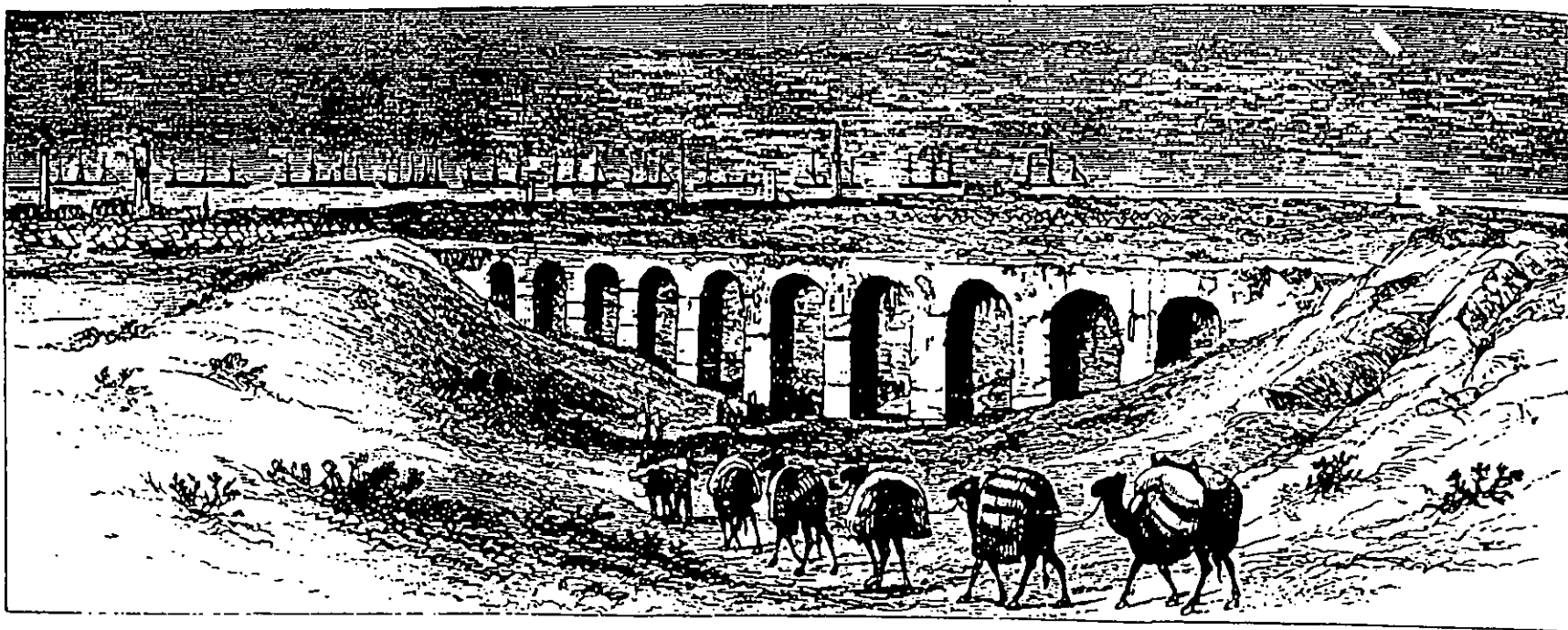
Apparently this was very optimistic and possibly represented the discharge from the chain-of-wells during the short duration of the Trimithos flood winter surface flow, infiltrating into the chain-of-wells crossing the bed of the Trimithos river.

The catchment area of the Trimithos river is 141.8 km² (58 km²) taking an annual average precipitation of 59 million cubic metres. (*Hydrological report of WDD for 1973*).

The total discharge, as recorded at the gauging station at a point where the Trimithos river crosses the Larnaca Limassol road, is 1.2×10^6 m³ or 2.4% of precipitation. This indicates that the summer supply to Larnaca was very inadequate, having regard to the fact that the Trimithos river surface flow dries up in late spring, and remains so until November when the first rains fall.

In the year 1936, the population of Larnaca was 14,000, needing a daily quantity of 1500 cubic metres per day reckoning a daily share of 112 litres per capita, which at that time was considered satisfactory.

Most important, however, the Abu Bekir Pasha chain-of-wells as all other chains, was excavated through a shallow river aquifer usually of gravels, and as such its discharge was influenced greatly by the river flow and the year's rainfall. Its yield depended on the stability of



Larnaca Aqueduct Built by Romans
In the horizon the British ships, which
brought the first troupes to Cyprus 1878
(Photo-Drawing in English Press 1878)

Fig.8.3

Source: CYPRUS of yesterday 1982, by A.Pavlidis

the water table in the aquifer, its replenishment, and the interference by pumping for irrigation.

For these reasons the people of Larnaca and the Municipal Council worried a lot about the uncertainty in the water production of their source of supply, and were continuously referring their water problem to the Government, and later to the Water Supplies and Irrigation Department when it was constituted in 1939, for solution.

As in the case of Nicosia, no storage was provided, either for the water and its use during peak demand, or maintaining a steady flow into the distribution mains.

The water to each consumer was tapped direct from the main, and the quantity was controlled by the saccorafi system through the 2mm orifice. In this case the back pressure was unsteady. Therefore the quantity passing through the saccorafi depended on the water pressure within the mains, but it was of no importance, because the annual rates were fixed per saccorafi and not by the quantity of water that was consumed.

8.3.3 (1) Quantitative Value of Saccorafi

The quantitative values of a saccorafi accepted as a measure, in each town, were estimated to be:

- 1) Nicosia 0.33 gallons per minute = 1.50 litres per minute
- 2) Larnaca 1.00 gallons per minute = 4.50 litres per minute
- 3) Limassol 0.42 gallons per minute = 1.80 litres per minute
- 4) Famagusta 0.33 gallons per minute = 1.50 litres per minute
- 5) Paphos 0.67 gallons per minute = 3.00 litres per minute
- 6) Kyrenia 0.33 gallons per minute = 1.50 litres per minute

The above values of saccorafi represent the estimated quantity of water that would be allocated to each consumer.

In Nicosia the quantity would be steady and fixed, as the water to the consumer was passing through the 2mm hole at a steady head of 150 mm kept up by a ball valve in the distribution balancing box. In the case of the other five towns the quantity was estimated, and was variable

depending on the water pressure within the mains from where water was drawn through the saccorafi.

In reality saccorafi is a form of flow control other than a measure of cumulative quantity. The length of time during which the water was allowed to flow to the consumer was variable, depending on the volume of discharge from the chain-of-wells. Also, during summer, the distribution of water to the town was rationed, flowing to isolated zone areas only for certain hours of the day.

The rationed distribution of water is still imposed even nowadays in all towns, for days in summer after a winter of subnormal precipitation.

8.3.4 Limassol - Famagusta - Paphos - Kyrenia Water Supplies (Year 1936)

In the year 1936 the domestic supply of the above four towns was in the hands of their respective municipal councils.

These four towns obtained their water supply from natural springs and wells. They experienced acute shortage of water and their problem was under continuous consideration by the Cyprus Government.

A rough outline of the water supply of each town as existing in the year 1936 is given hereunder:

a) Water supply of Limassol town

In the year 1936 Limassol had an estimated population of 20,700 persons. (*D. Percival, Census of 1946*).

Limassol people were merchants and industrialists engaged particularly in the wine industry. Limassol was the town of the vine growing villages of Cyprus. The production of 159,000 acres in the Limassol chalk plateau under vines was treated by the wine factories of Limassol. (*Department of Agriculture Annual Report for 1938*).

b) Sources of Domestic Water Supply

The Limassol watersupply was derived from three separate sources:

a The Kitomili spring, excavated and extended as a chain-of-wells along the banks of Garilli river.

b) The Chiftlikoudhia collecting gallery excavated in the coastal zone west of Limassol.

This collecting gallery was about 20 metres deep and 200 metres long. It was excavated through sandstones and gravels and the water was collected into the main well on which a reciprocating pump was installed. The pump was operated by means of an old fashioned diesel engine, National make, having a flat pulley and flywheel. It is unfortunate that no records of the B.H.P. of the engine and the capacity of the pump can be traced. The water was pumped into an elevated steel tank about 15 metres high, and of about 10 m³ capacity. The water stored in the tank was distributed to the old Limassol town. No records could be traced of when this pumped water supply was installed.

By the year 1936, the cast iron distribution pipes were encrusted and had deteriorated, and their replacement and extension was necessary. The yield of the Chiftlikoudhia chain-of-wells was decreasing. Moreover the salinity and total dissolved solids of the water was increasing at a prohibitive rate.

c) As a relief measure for the acute water shortage faced by Limassol town, the British garrison stationed at Polemidhia, 3 miles north of Limassol, allowed the overflow from their spring known as Ayia Irini to be conveyed to Limassol. When the Polemidhia camp was vacant of troops all the flow from Ayia Irini spring was allowed to flow for Limassol's domestic needs. The Ayia Irini

discharged through the chalk banks formation of the Polemidhia river, and its discharge increased greatly in winter, to over 600 cubic metres per day, influenced considerably by the flowing river.

In the summer the discharge from the spring diminished substantially. Chalk formations are poor aquifers.

In the year 1936 the water supply of Limassol was

a) Kitromili chain-of-wells,	225 cu. metres per day (average)
b) Chiftlikoudhia collecting gallery	225 cu. metres per day (maximum)
c) Ayia Trini overflow	225 cu. metres per day (average)
<u>Total</u>	<u>675 m³/day</u>

The above quantity gave a share of only 36 litres per capita per day, which was most inadequate for the town of Limassol. Also the wine industry needed large quantities of fresh water.

As a matter of fact, K.E.O. Ltd., a leading wine company built two factories at Perapedhi and Malia. These villages were situated at an altitude of 760m and 610m respectively. One of the decisive factors for building two factories in the above villages was the availability of adequate water supply from springs issuing through the Troodos igneous formation. The chemical analyses of the water used by the two factories showed the following chemical data:

pH	7.4
TDS	455 ppm
Cl	31 ppm
Total hardness	160 ppm

The people of Limassol were pressing the Government for additional adequate water supply. Unfortunately the water problem of Limassol was not considered in the proper decisive scientific way, and it was dragged along without solution.

In my opinion Limassol town should not have had a water problem in 1936. The town was privileged to be commanded by two rivers flowing from the Troodos igneous complex namely Kouris and Yermasoyia. Both rivers convey down to the coastal zone an average quantity of over 70 million cubic metres per annum.

Kouris river recharged a rich aquifer as close as 6 miles west of Limassol and the rise of the water table and springs formed the well known Limassol marshes. The aquifer was shallow, about 80 feet deep, of open type and of high yielding capacity.

Limassol needed a daily quantity of say up to 4500 cubic metres 20,000 persons at 225 litres per capita per day. This quantity could have been secured from two boreholes drilled in the rich Cherkez and Fasouri aquifers, which could produce up to 20 MCM of water, of very low salinity and hardness, per annum.

A second solution would have been the construction of a subsurface dam or gallery, higher up in the Kouris river gravels, say at an elevation of 200 metres above mean sea level, where the needed quantity of 4000 cubic metres per day could safely be tapped and gravitated to Limassol. (At this site the big Kouris Dam is now being built).

It might have been most feasible and economical to have a combination of a gravity supply from the Kouris river gravels flowing during winter and spring, and pump water from boreholes drilled in the Zakaki area during summer and early autumn only.

In view of the above, the fact that Limassol was living in the plight of acute shortage of water, is nowadays inconceivable. The reasons are:

- a) Until 1939 when the Water Development Department was created, the water problem could not be solved. Then available engineers were not specialised in water engineering.
- b) The inhabitants of the towns favoured a gravity supply instead of a pumped one, for fear of paying

high pumping and maintenance costs, which were not subsidised by the Government. I believe this fear could have been removed by a sound and satisfactory pumped supply.

- c) The water problem was in the hands of the two or three civil engineers staffing the Public Works Department. This Department treated the branch of Water Development as of second priority.
- d) Also I believe that both technical and financial facilities in Cyprus were inadequate to deal with major water supply projects, in those years.

8.3.5 Water supply of Famagusta town

Famagusta, the eastern coastal town of Cyprus, famed in the classics and Shakespeare's Othello, was also facing acute shortage of water in the year 1936.

Famagusta was an agricultural town in the general aspect, and was the main citrus producing region of the island. The town was surrounded by a good aquifer consisting of Pliocene beds bearing the characteristics of Kafkalla Plateaus.

Most of the town's houses were built in citrus orchards, which were irrigated commonly by means of windmills pumping water from shallow wells. The water pumped was also used for domestic purposes. A 4 metres windmill could pump a quantity of up to 5m³/per hour depending of course on the velocity and frequency of the wind. It could irrigate 8-10 donnums of orchards. From the records it is shown that over 1000 windmills were operating in Famagusta town during the period 1936-1945.

In the year 1936, the population of Famagusta was estimated at 12,000 persons. The town depended on Panayia spring for its water supply. Panayia spring was issued from the shallow calcarenite and fragmental limestone formation outcropping in places between Ayia Napa and Paralimni. It was excavated and built during the Venetian times, and extended into the lime formation, north east of Cape Grego. The water discharging from Panayia spring

conveyed to Famagusta through a masonry aqueduct about 16 kilometres long. The summer discharge from the spring, as measured in July 1937, was 440 cubic metres per day. (*Raeburn: Water Supplies 1945*).

Two boreholes drilled through the calcarenite and sandstone formation constituting the aquifer south west of Famagusta town were producing a quantity of up to 680 cubic metres per day.

The available water supply, averaging 1100 m³/day, might have been considered satisfactory then, in view of the fact that a large number of consumers were using for their domestic needs the water pumped by their own windmills.

However, because of the building of houses at close proximity to the two public boreholes, this source of supply deteriorated and could not be used safely. Moreover the water of this shallow aquifer was also showing signs of increase in its hardness and salinity, resulting from excessive pumping and lowering of the water table.

The only safe water supply was from Panayia spring, but this supply was also decreasing, as a result of overpumping of the small shallow aquifer, by the windmills, for irrigation.

At that time Famagusta town with its suburb area was known as the town of windmills.

The domestic water available gave a share of not more than 50 litres per capita per day, so the water situation was causing alarm to the Municipal council, which in return was pressing the Cyprus Government for additional safe water supply.

8.3.6 Water supply of Paphos and Kyrenia towns (Year 1926)

In 1936 these two small coastal towns, having a population of 5945 and 2390 respectively, obtained their domestic water supply from natural springs issuing from the Chalky hills commanding Paphos and from the Karstic

limestone of the Kyrenia range, commanding Kyrenia town, in the north.

Though these two towns were administered by municipal councils, their people were still engaged mainly in agriculture. As such, in the case of their domestic water supply they enjoyed a Government subsidy of fifty per cent as in the case of village water supplies.

The spring supplying water to the above two towns were:

a) Paphos water supply

The two springs Kourkas and Kalamos issuing from the Tsada chalky hill, were piped by gravity to Paphos, through steel pipes. Their combined average summer discharge was in the region of 225 cubic metres per day, giving a daily share of 45 litres per capita per day.

It should be mentioned that springs issuing from chalk formations have their maximum discharge in late winter and early spring. The discharge diminishes by over 60% in late summer and autumn due to the high coefficient of permeability presented by chalky formations.

The distribution of water within the town was effected through a small masonry tank of about 15 cubic metres capacity and an old deteriorated distribution system serving the central part of the town.

The water supplied to a number of houses was controlled by means of the saccorafi system. The supply to each consumer was about 3 litres per minute, but in view of the high inefficiency of the distribution system, some people living in low quarters of the town were receiving much more water than those living in the higher level quarters, who at times in summer had no water at all. The absence of storage also adversely affected the distribution of water.

b) Kyrenia water supply

Kyrenia water supply was obtained from three springs, having a total summer discharge of about 170 cubic metres per day. The share per head of the population at that time estimated at 2390 persons, was on average 70 litres per capita per day.

To augment the municipal water supply of Kyrenia prospecting drilling was carried out in the Hilarion limestone, at an elevation of about 240 metres above mean sea-level in the locality of Boghaz north of the range. The drilling was carried out by means of a Ruston Bucyrus percussion drilling rig. It was most difficult to penetrate into the limestone formation because caves were met during drilling. Grouting the caves was uneconomical and also it was not always successful. Thus the depth of borehole reached was not more than 100 metres. The water tapped was not of significant quantity, and the water problem of Kyrenia was not solved.

Some form of distribution system was operating within this small town, supplying water to the existing two hotels, and to a number of houses. The masonry tank available was not more than 10 cubic metres capacity. The distribution of water was controlled through the saccorafi system and the share of water to each consumer was anomalous.

In a large number of houses shallow wells were excavated through the Kyrenia limestone (calcarenite) and water was drawn for domestic use and the irrigation of trees planted in the house yard.

8.4 Village domestic supplies

The rural population of the island lived in 627 villages well established all over the island.

The villages were situated up to five kilometres apart, and on average the population of each village was 466 persons. A number of villages in the lowland had a

population of from 1500-2000. Topographically the distribution of the 627 villages can be divided into four categories.

a) Troodos mountain villages

About 159 villages, representing 25% of the total, were situated on the slopes of the Troodos mountains, in river valleys at an altitude varying from 600-1200 metres above mean sea level.

The source of domestic supply for these villages was natural springs issuing from the igneous formation of the range and feeding the flowing streams. The spring or springs from where water was transported to the householder were located up to one mile from the village.

b) Another 163 villages, representing another 25% of the rural population, were situated in the foothill belt consisting mainly of marly chalk with or without gypsum and limestone. The springs issuing from these formations are generally found in the river banks or stream beds.

They have a big flow in winter, because of their high permeability due to the sedimentary geological formations, and a substantially reduced discharge late in autumn.

c) Kyrenia range villages

The 47 villages of the Kyrenia range having a population of 20,430 in 1936 obtained their domestic water from natural springs discharging through the Kyrenia limestone formation.

The Kyrenia limestone range consists of one single crest generally not exceeding an elevation of 750 metres. On both sides of the range, elevations drop abruptly to 100-200 metres.

The total area of limestones in the centre of the range is 85 square kilometres, receiving an annual rainfall varying from 500 to 600 millimetres. From the Kyrenia range of limestones numerous springs flow out. Every village has its own spring, the

water of which is used for irrigation and the domestic needs of the village householders.

- d) All other villages of the central plain (parts of Nicosia, Famagusta and Larnaca and the south coastal parts of Larnaca, Limassol and Paphos) numbering 369, with a population of about 121,000 obtained their domestic supply mostly from private or public wells, and chain-of-wells excavated through the river alluvium.

8.4.1 Chemical Analyses

The quality of spring water issuing from the Troodos igneous rocks and the Kyrenia limestone is classified as very satisfactory for domestic use.

TABLE 8.1 Typical chemical characteristics of spring water

i) Springs discharging from the Troodos igneous formation

	pH	total solids	CL ppm	Total hardness
1. Kaledomia spring (Troodos) Elevation 1400m approx.	8.1	390	18	222
2. Kephlovrysos (Pano Platres) Elevation 1280m approx.	7.3	452	18	265
3. Loumataton Aeton (Troodos) Elevation 1630m approx.	7.7	466	13	295
4. Arkolahania (Mesapotamos) Elevation 1120m approx.	8.2	400	18	286

ii) Troodos foothills zone Chalky Hills

	pH	Total Solids	CL ppm	Total Hardness
1. Krya Pyghadhia (Silikou) Elevation 510m approx.	7.3	625	40	252
2. Klimataria & Kourkas Elevation 490m approx.	7.3	575	84	277
3. Mylari (Tala) Elevation 305m approx.	7.6	570	98	250

Total hardness is expressed as calcium carbonate.

If either NaCl or CaCO₃ content was greater than 400 parts per million the water was classified as not satisfactory for domestic use.

Source: Annual Hydrological Reports. Water Development Department.

8.4.3 Villages in lowlands

- (i) The villages located in the Central Mesaoria Plain, were 21 in number and had a combined population of 20,000 in 1936. They obtained their domestic water supply mostly from shallow wells, varying in depth of from 40 to 60 feet (12-18m).

The precipitation in this plain averages 350mm only. The isolated small aquifers in this plain consist of recent deposits of silt river gravels, marls and chalks, and have very low porosity and replenishment. A deeper gypsum aquifer had a store of saline water with as high as 3000 ppm of chloride.

The shallow wells had a very poor water production and most of them dried up in late summer.

Although central Mesaoria was thickly populated and was the main cereal producing area of Cyprus, its population faced acute shortage of potable domestic water supply.

People of big villages such as Lefkoniko and Prastio, having a population of 2450 and 1000 respectively, had to convey their domestic supply from sources up to 3 miles away, where river gravels and clastic aquifers were present, producing some quantities of good potable water.

- (ii) Coastal Zone. (Kouris valley, Morphou bay, Paphos-Polis Coastal Zones).

In the above coastal zones, rich aquifers were present. These aquifers were mostly unconfined, shallow, about 30 metres thick and consisted of gravels, silt, sand and thin lenses of silt and



Fig. 8.4 Village Girls fetching drinking water home

Source: Photo Public Information Office Cyprus



Village woman
conveying domestic
water home.

Fig. 8.5

Source: Photo Public Information Office Cyprus

marly clay of the pleistocene age. The hand-dug wells opened through the coastal aquifers produced ample and wholesome drinking water. They were of shallow depth up to 20 metres, and had a masonry coping on top for protection against surface pollution and contamination.

The water was bailed out by means of a steel bucket of 13 litres capacity, drawn by a one inch rope, turned round a wooden hand driven drum rotated by means of horizontal steel axle. The axle was supported on a wooden trestle, 4 feet high (Figure 8.2).

In the yard of most houses, a well was sunk, and the water was drawn out by the above method. In some public and private wells handpumps were installed. In cases where the water was used for irrigation windmills were built.

Thus in the year 1936 the rural population obtained its domestic supply from two main sources, namely springs and wells.

a) Springs

- i) Springs discharging from the various geological strata forming the hills of island were producing water of very satisfactory quality and of adequate quantity. The discharge from the springs was collected behind an arched masonry wall. On the front face of the wall a trough was built, usually 2½ feet high and 2 feet wide, for the watering of the animals.

ii) Transport of water from spring to consumer

As an accepted practice, every woman over the age of 13 had to convey water from the spring to the house. The spring was up to one kilometre from the consumers, and in practically all cases at a much lower level than the village.

Transporting water from the spring to the village, was not an easy task for the women of the village. They had to make one or two trips to and from the spring every

day, and carry the amphora weighing 21 kilograms when it was full of water on their shoulders. (Figure 8.4). The amphoras were made of pulverised terra rosa, properly mixed with water and worked into shape. Finally they were baked in proper kilns. The amphoras had an oval to circular shape, with two handles.

Although the village women experienced hardship from the customary transport of water from the village spring to their houses, the spring to them was the meeting place, where early in the morning women from all quarters of the village would gather. They would gossip and exchange views with regard to the day's news and problems of their village. The village spring was also the place where a young girl could look at the young boy of her taste and speak to him in happiness.

It is worth mentioning also, that each family had one or two donkeys or mules, a necessity for their agricultural work. Mules are stronger than horses and donkeys, and they were used for pulling the cart or for other heavy work.

The animals used for agricultural work, donkeys, mules, oxen and horses had to be watered twice daily, thus a male member of the family had to take these animals to the spring for watering daily. On his return he conveyed water from the spring to his home, by loading on the donkey, mule or horse four tin receptacles. These were used petrol tins of size 25 x 25 x 35 cm equal to 20 litres capacity. Thus an additional quantity of about 80 litres was transported by each animal to the house.

We may, therefore, say that the total daily quantity of domestic water conveyed from the spring to the house was in the region of 150 litres.

Dividing this quantity by 4.6 the average number of family members, it may be stated that the average water consumption per capita of the rural population, per day, would be in the region of 30 litres.

Time consumed in transporting domestic water

Irrespective of the hygienic conditions secured by the availability of wholesome and safe water from the springs for domestic use, one should not fail to accept the great hardship and the appreciable loss of time involved in transporting water to the house.

If it is reckoned that one member of each family had to be occupied daily in conveying water to the house from the spring, then one can accept that up to twenty per cent of the male and female village wage earners were engaged for conveying domestic water supply home. This time loss is considered very significant from a financial and social point of view.

8.5 Water environmental conditions in 1936.

In the year 1936 the natural environmental water conditions may be summarised as hereunder:

a) Water resources

- 1) All flowing rivers and streams lay in their natural condition. Interference in their winter flows by man had been very insignificant and primitive.

The surface flow of the rivers was used for the irrigation of land, within the river valleys, through earth channels in which ab-antiquo rights were vested.

In winter the surface flow of the rivers and the overflow from the eastern irrigation channels overcharged the coastal zone aquifers, and marshy conditions were created by the high water table, causing seepage effluent through the lower ground surface, forming localised effluent springs.

These marshes created by the outcrop of the water table of the rich aquifers in Limassol (Akritiri), Morphou (Syrianokhori), Paphos (Xeros) and Politis-Chrysohou and Larnaca (Vlakhos marshes) were the ominous breeding places of anopheline mosquitoes, the partner and host for the spread of malaria from man to man.

These rich coastal aquifers had not been exploited for irrigation or as a source for municipal and village domestic water supplies.

ii) There was no storage and distribution of piped water for domestic use in the rural areas. The Municipal water supplies were inadequate, and the distribution mains were encrusted, in poor condition and out-dated. Water storage and control facilities were not provided.

iii) Half of the rural population, residing in villages of the central plain and the coastal zones obtained their domestic water supply from their own wells excavated in the yard of the house, or from central public wells, excavated and built by the Government at suitable places within the village.

In years of drought, wells in the central Mesaoria dried up in late summer and early autumn. The people of these rural areas were obliged to use and drink water liable to pollution and in many cases contaminated and quite unsatisfactory, both chemically and bacteriologically, for domestic use.

The above rough outline of the 1936 conditions relating to the water resources of the island and their exploitation indicates vividly the necessity for the creation of a Water Development Department, which would undertake the study and solution of the water supply problems from an authoritative and specialist point of view.

CHAPTER NINE

WATER SUPPLIES AND IRRIGATION DEPARTMENT FORMATION

9.1 In the year 1936 the British Government took the decision to accelerate the general development of the Colony of Cyprus, advising that particular priority should be given to activity in water development covering the field of domestic supplies and irrigation in the rural areas.

The Colonial Office having given favourable consideration to the report of Sir Ralph Oakden, which he submitted in 1935, advised the Cyprus Government to proceed with the creation of the Water Supplies and Irrigation Department.

In pursuance of the above decision, in March 1937 the British Colonial Office transferred from Tanganyika to Cyprus Dr C. Raeburn, OBE, a well known and reputable geologist, in order to take charge of all water development work in the island. On his arrival on the island, he was given the status and title of Water Engineer, and was housed in the Water Engineer's Office.

9.1.1 Staff

The primary task of Dr Raeburn, in his status as the Water Engineer of Cyprus, was to staff the Department, and to resurvey the island's water resources.

In the progress Report for 1937, he writes:

"The field staff dealing with the island's water supply consists of the Water Engineer, two Inspectors of water supplies, and the necessary drill foremen and foremen artisans"

The office staff includes one Fourth Grade Clerk from the General Clerical Staff, and two temporary clerks:

9.1.2 Activities of the Water Engineer's Office

The activities of the Water Engineer's office were concentrated on prospecting drilling, building work at springs for their protection against surface pollution,

and the piping of water to public fountains in the villages in those cases when the spring was located at a level higher than the village.

In the case of the villages obtaining their water supply from private or public wells, Raeburn in his 1937 report writes:

"Many villages are still using water from unprotected contaminated wells in the village square.

The bacteriological analyses of water from such wells indicate extreme pollution and it is a matter of congratulation that cases of water borne typhoid are not more numerous. It is essential that some improvement in conditions should be made at an early date. Such villages are usually poor and unable to do much to help themselves. They are situated mainly in the eastern Mesaoria, but there are examples in Paphos district, along the Karpas and in the Tillyria".

9.2. Expenditure in the year 1937

The total expenditure on prospecting and investigational work on water supplies, including drilling, was 6000 pounds sterling during the year 1937.

All this amount was borne by the Colonial Development Fund. The villages which benefited from the water supply schemes executed offered free labour up to fifty per cent (50%) of the cost of the scheme, as their beneficiaries' contribution.

9.3. Setting up of the Water Supplies and Irrigation Department

In the year 1938, the Water Supplies and Irrigation Department was formed, and Dr Raeburn, was given the status of Director of the new Department. Early in 1939 the Department was constituted, and all Government water supply work was placed in the hands of the Director of the Water Supplies and Irrigation Department.

Dr. Raeburn associated himself with the people of the island, believing that for a successful water

development programme, particularly in a small island such as Cyprus, mutual dependence and liberal co-operation of the people with the Authorities was vital.

9.3.1. Water work policy

Dr Raeburn studied and evaluated the numerous water supply reports prepared by the visiting experts since the first day of the British rule in Cyprus.

In his 1937 progress report he writes:

"From the reports, it was apparent that many valuable suggestions have been made from time to time but that few of the schemes initiated, mostly on paper, have been investigated thoroughly and put forward to a conclusion".

When, in 1938, the Office of the Water Engineer was set up, work on water supplies was negligible.

The Director of the Water Supplies and Irrigation Department together with the Administrative Secretary's office in Cyprus, were of the opinion that major projects had proved to be a failure. Thus a new policy governing the development of the island's water resources would be followed. This policy was to design and execute small water projects in all parts of Cyprus, which would serve the area villages and would meet the wishes of the rural population. Small area water supply schemes would be simple in design and as such the local beneficiaries could operate and maintain them through the experience they would have gained during the construction of such projects.

On the whole, the small projects were of great importance, since the water resources of the island were small and unstable, being susceptible to subnormal precipitation and droughts.

The new policy of small projects designed on the availability of water in each village area, proved to be the correct one in the light of the environmental conditions in Cyprus. Moreover the policy of having small, widespread water development projects had the

approval and appreciation of the rural population. The rural people became very ambitious and confident with the set up of the Water Supplies and Irrigation Department.

Applications requesting the preparation and execution of water supply schemes were coming to the Department in increasing numbers, from the village authorities through the respective District Commissioner. The District Commissioner was ex-officio the President of the Village Authorities.

It was officially and socially accepted that the provision of piped potable and safe domestic water supply was an asset confirming great benefit to the community. A piped water supply would reduce the infection from water borne diseases and help the rural population to acquire better health, higher efficiency in their work, and a higher standard of living.

9.3.2. Domestic Water Supplies - Recruitment of Technical Personnel

When the Water Supplies and Irrigation Department was set up its section dealing with village domestic supplies was staffed with an inspector, two technical assistants and two foremen masons. Casual skilled masons and unskilled labourers, both men and women, were employed from the village where the water supply scheme was being carried out.

For the recruitment of artisans, who would be trained to become foremen in the Department eventually, preference was given to promising masons. A mason could excavate and build a spring, construct RCC fountains and storage tanks and at the same time be easily trained in the laying of pipelines. These masons were given permanent status and were classified as field workers. They moved from village to village where water supply schemes were approved for construction. Eventually they were promoted to foremen.

The local unskilled labourers were employed in rotation for a period of two weeks, due to unemployment in

the area. In certain areas unemployment was a seasonal phenomenon.

The unskilled labourers were used for the excavation and filling of the pipeline trenches, which had a depth and a width of up to 60 centimetres. They assisted in the excavation and building of the spring and RCC fountains and in the laying of the pipelines. As a general rule the pipelines were of mild steel, of the E.S.S. for Class B (Medium series). Their size was from 15-100 millimetres in diameter.

Certain ambitious labourers were acquiring experience in the development of springs, and they became well conversant with this important job. These semi-skilled labourers working underground, were encouraged to join the gang of field workers, who were posted to work in any region of the island. Each such gang consisted of one foreman, two skilled builders and one semi-skilled labourer.

This team of artisans was acquiring specialisation in the construction of village domestic water supply schemes, and they could work on their own in isolated villages, without having regular technical supervision from the Headquarters in Nicosia.

The limited number of higher technical supervisory staff at Headquarters was occupied in planning, designing and inspecting the works in hand. For this reason, inspection visits to isolated areas were not very regular, and the foreman had to do a lot on his own having at the same time full support and assistance from the villagers.

9.4. Gravity domestic water supplies

During the period 1936-1945, the villagers would approve a gravity water supply from a spring only.

As it was also the beginning of the work of the Department for the improvement of the rural domestic water supplies, the activities of the water supplies section were concentrated mostly in the villages of Troodos and Kyrenia mountains, where a spring of perennial discharge

and of adequate quantity to meet the domestic requirements of the village were available, and were free to be developed and used.

The daily share of water per capita of the rural population was rated at 45 litres. This quantity was satisfactory for the rural areas.

Domestic water should be satisfactory both chemically and bacteriologically. It should meet the standards for domestic supplies adopted by the World Health Organisation.

With the exception of a few mineral springs discharging from the depths of the Troodos igneous formations, all other springs were producing water of the best quality. Every spring the discharge of which was used for domestic purposes was properly excavated and built, against surface pollution and contamination. Practically all springs were located in river valleys and stream gulleys away from human habitations or other source of contamination.

The only source of pollution was the rain water during winter but this was completely avoided by excavating and building the spring deep into the aquifer, thus securing thick cover of ground over the roof of the spring. Bacteriologically the spring water was always safe.

9.4.1. Spring Supplies

Chemical analysis of certain springs discharging from representative geological formations.

Table 9.1 DETAILS OF SPRINGS

Spring	Springs issuing from Troodos igneous complex.					
	Elev AMSL	Chemical Data		Chloride ppm	Total Hardness ppm	Average Discharge Q: l/s
		pH	Total Dis. solids			
Hardji	1450m	8	260	11	190	11.3
Platania	1300m	8.2	370	18	235	2.9
Koshinas	300m	7.4	245	18	105	19.0
(ii) Springs issuing from Kyrenia limestone range						
Kythrea spring	290m	7.4	380	50	240	149
Lapithos spring	320m	7.3	340	71	240	184
Bellabaise spring	250m	7.3	350	42	245	7
(iii) Springs issuing from chalk with limestone formation						
Ayia Moni	840m	7.2	320	43	240	4.8
Kourgas	490m	7.5	470	78	235	2.5
Loutratis Aphroditis	40m	7.5	660	117	430	8

Source: W.D.D. Hydrological Year Book 1971.

In accordance with Meinzer's classification of springs according to their size, our larger springs in Cyprus are of the following orders:

TABLE 9.2 <u>THE LARGER SPRINGS IN CYPRUS</u>			
Spring	Geological formations	Magnitude	Average discharge l/second
Kythrea	Kyrenia limestone	third order	149
Lapithos	Kyrenia limestone	third order	184
Arkolahania	Troodos igneous complex	third order	35
Khardji	Troodos igneous complex	fourth order	9.5
Yerovasa	white chalks sedimentary	third order	38
Loutra-tis Aphroditis	limestone chalks	fourth order	8

9.4.2. Characteristics of springs in Cyprus

The springs in Cyprus may be grouped into the following categories, depending on the geological formation through which they issue out.

- a) Springs issuing out through the solution openings and caverns mostly in the Kyrenia limestone range.
- b) Springs issuing out from fractures and geological faults in the Troodos igneous complex.
- c) Springs issuing from lavas, having considerable permeability and underlying an impervious formation, on the north and south slopes of the Troodos igneous complex. In lava plateau, feeding channels of sandy gravel buried under the pillow lavas, in the lowland zone of igneous.
- d) Springs issuing from thick pervious formations of alluvial deposits, and sedimentary formations composed of white chalks, in the south western low hills in Limassol and Paphos districts.

These springs occur at the intersection of the water table and the surface, and are called water table springs. They are very common in valleys and at the foot of cliffs, and in any depression reaching below the free water table.

In cases of alluvial fans, increasing fineness of water bearing materials forces water to the surface.

Such cases have been met in the Kissoussa spring, discharging through the Khapotami river bed near Kissoussa village. The discharge from Kissoussa spring was piped to the British Bases at Episkopi (Akrotiti) in 1953.

On the whole the aquifers feeding the springs are relatively small. Because of this the flow of the springs is unstable, depending on the hydrological year's water precipitation. The discharge of springs is at its maximum in late spring and at its minimum in late Autumn.

Artesian flows

In Morphou coastal zone, west of Syrianokhori village, boreholes drilled in the year 1941-1942, up to a depth of 100 metres, tapped artesian flows. This was the most important aquifer of the island, consisting of gravel, sand and calcareous sandstone with intercalations of silt and clay layers and lenses contributing to artesian flows. This stratum rests on a half bowl and reaches a depth of over 100 metres. (*Survey of Ground Water and Mineral Resources - CYPRUS - United Nations Development Programme*)

In 1940-1941 three boreholes were drilled close to the seashore near the Serakhis Delta. Two of the boreholes at close proximity to each other had an artesian flow through the 200 mm casing and at 600 mm above ground surface of about 180 cubic metres an hour.

In 1944 a four inch borehole drilled near the seashore to a depth of 100 metres was discharging artesian flow of about 60 m³/hour, at a height of one metre above ground level. The discharge from this borehole was used to fill a reservoir for breeding carp fish. It was operated by the Agriculture Department, as a pilot project for food protein in war time. We carried out volumetric measurements of the artesian flow through the 100 mm steel casing, at one hour intervals for 24 hours. No records have been kept, but we can recollect that the discharge showed an increase during the night of maybe up to five per cent. This increase might be attributed to the fact

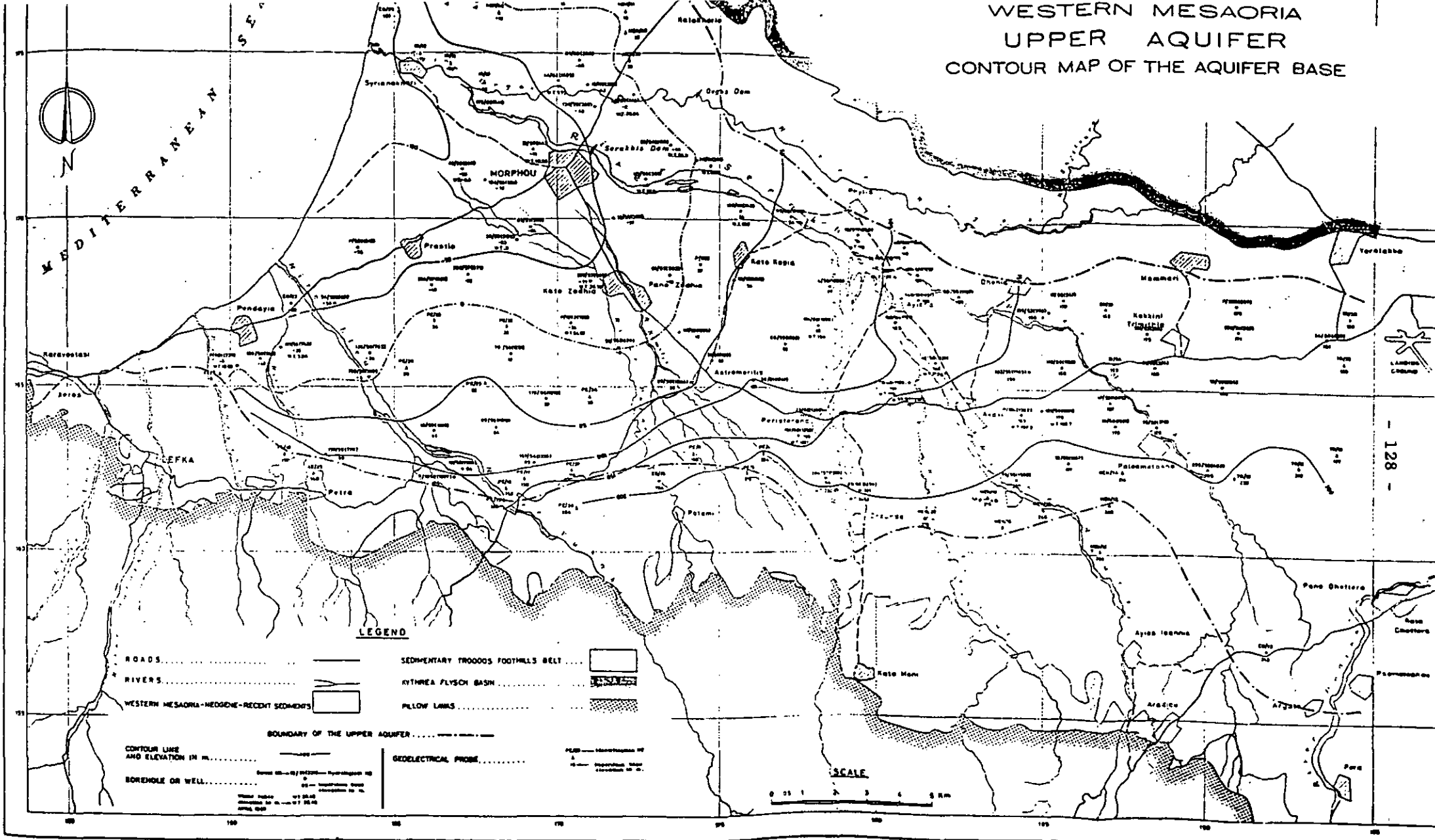


Fig. 9.1 Source: Survey of Ground Water and Mineral Resources CYPRUS
U.N.D.P. 1970

that during the night the very few irrigation pumps were not operated, and that there was no nocturnal evapotranspiration.

It may be interesting for the reader to know that the growing rate of pumping from this aquifer after the end of last World War not only dried up the artesian flows but also lowered the water table to a prohibitive level.

The contour map of the Upper Aquifer base, western Mesaoria, from the Survey of Ground Water and Mineral Resources Cyprus, United Nations Development Programme is illustrative of the resulting facts. (Figure 9.1).

9.4.3. Development of springs for domestic supplies

Every spring that was earmarked for the domestic water supply of a village, the use of which was not prevented by private ownership or other objections by local irrigators using the water of such springs was developed by the Water Supplies and Irrigation Department. The development of a spring included:

Excavation

All springs in Cyprus issue out through the ground in river valleys or stream gulleys. Practically everywhere at the place of discharge of a spring water seeps through the ground at various points away from the main point of discharge. These seepages, which in some cases are very appreciable, are part of the flow from the spring aquifer, and are dispersed within the pervious ground before they seep out to the ground surface.

The spring was therefore excavated for the purpose of collecting all seepages further into the spring ground outcrop, and also for the protection of the spring against surface pollution and contamination.

As a general rule the excavation was commenced at the point and level of the main spring discharge and was in the form of cutting followed by a small gallery driven into the sloping ground. The spring gallery was not less than 0.80m wide, and not less than 1.60 in height.

The excavation followed the direction along which the spring water was flowing out. Usually the seepages were cut off by the excavation of the spring gallery and directed into the outcrop of the aquifer. In certain cases the gallery was extended into a 'Y' direction.

Excavation of a spring demands special skill and caution, depending on the geological strata through which the spring issues out.

The intention of the excavation of a spring is to tap the water at a distance into the sloping ground, in order to secure a cover of earth above the roof of the tunnel near its outlet, of not less than 2.5 metres for the prevention of rain water percolating into the spring gallery in winter.

At the outlet of the gallery a rectangular manhole, having internal dimensions of 1.25 x 1.25 metres, is cast in reinforced cement concrete. The top of the manhole is covered with an RCC slab. The sides of the gallery are usually lined in cement concrete and roof slabs rest on the two sides, providing water-proofing against possible surface water percolation.

The floor of the tunnel is not lined at all, for the free flow and filtration of the spring water out of the aquifer.

One should be very careful in the excavation of a spring issuing from solution openings and formation of lavas overlain alluvial material.

It may happen, that in the excavation of a spring issuing from solution channels, the extension of the gallery beyond the point of effluent from the solution opening feeding the spring will traverse a solution opening of another spring and thus disturb the natural equilibrium of the subterranean flow feeding several springs.

- (1) Such an example was experienced in the year 1945, in the case of two springs issuing through the Kyrenia limestone at the village Larnaca-tis-Lapithou.

The two springs were roughly on the same level, and about 100 metres apart.

One of the springs was public, supplying water to Kondemenos village, and the other spring was privately owned by a Cypriot judge of Court, a land owner in the area.

In the year 1945, the Water Development Department carried out cleaning and a short extension of the gallery of the village spring.

The judge, not being professionally aware of the danger involved in the extension of the gallery of his spring to increase its discharge, had it extended, without first having consulted the Department of Water Supplies and Irrigation.

During the extension of the judge's spring gallery, the solution opening feeding the spring of the village was crossed by such extension. Instantaneously, the village spring flow was diverted into the spring gallery belonging to the judge, and the village spring ceased flowing.

The villagers were furious, being left without domestic water supply. Of course, the judge and the village requested the help of the Water Supplies and Irrigation Department.

We extended the village water pipeline to the outlet of the judge's spring in order to restore the flow of water to the village. We tried hard to reinstate the flow from the village spring, but we did not succeed.

As a result of this interference with the natural balance in the flows of the two springs, the matter had to be settled at Court.

After many hearings at Court, consuming a lot of time, and after consideration of water data and witness information on the autumn and spring discharges from the two springs, it was amicably agreed that:

- (i) The village was to receive 60 cubic metres per day.
- (ii) The judge was to receive 30 cubic metres per day.
- (iii) The total surplus in the discharge, over the 90 cubic metres was to be shared between the village and judge at the ratio of 2.1.

The above shares of water as agreed at Court were controlled through a distribution box constructed at the outlet of the judge's spring gallery.

- (ii) On another occasion we had a public spring from where Kalokhorio village transported water for domestic use. The discharge of the spring flowed into an irrigation tank and was used by certain landowners for irrigation.

An irrigation tank is essential in the case of spring flow. During the night the spring discharge is stored in the irrigation tank and in daytime it is used for irrigation. By doing this, we have a saving of water which would be wasted at night and also water can be withdrawn from the tank in bigger quantities for effective irrigation.

In 1952 it was decided to excavate and carry out building work on the spring for its protection against surface pollution, in view of the fact that part of its discharge was used by the village for domestic purposes.

This spring issued from a lava formation, overlaying an impervious stratum near the river bed which caused pressure on the water, so that it rose and flowed into the irrigation tank. When the impervious stratum was excavated, the discharge from the spring increased, but it could not rise to the level of the irrigation tank.

As a result of this, we had to accept the lower level of the spring and build properly at that level. A new irrigation tank was built at the new

low level of the spring. All land commanded by the new irrigation tank was irrigated by gravity.

A small centrifugal pump was installed to raise water from the new low level tank to the high level existing one, in order to irrigate the high level fields.

The excavation of a spring issuing from igneous formations is simpler, but it is more difficult to penetrate into the igneous stratum. The gallery excavated does not penetrate deep into the igneous formation, once the crevice through which the water flows out is exposed. These crevices are the result of faulted gabbros.

9.5. Pumped water supplies

The period 1936-1945 was the period of gravity water supplies using springs of perennial flow. Pumping water for domestic use was not favoured at all by the rural population or the Municipal Councils.

The villagers were adamant, refusing to accept and approve a village pumped supply for the following reasons:

- a) The pumping plant used for a pumped water supply consisted of either a reciprocating deep well pump or a centrifugal one used for shallow wells. Both types of pump were primed by means of a diesel engine having a governor flywheel. The rotation of the pump was effected through long flat belts, which had low efficiency. In hot weather they became soft and slippery round the flat pulley.
- b) The diesel engines were bulky. A large pumping room had to be built, and it was costly.
- c) The use of gas oil and lubricating grease contaminated the water of the well or borehole, and the consumers disliked the thought of having a pumped water supply polluted from leakage of gas oil. Gas oil was imported in barrels of 200 kilos capacity each, and thus their transport and storage was a problem.

- d) Most important of course, was that the operation and maintenance of the pumping plant needed the continuous services of skilled artisans, parallel with the cost of fuel and lubricants. The expenditure incurred for the above operational requirements of the pumping plant was not subsidised by the Cyprus Government by fifty per cent as it was in the case of the capital expenditure for the construction of village water supply schemes.

In the case of pumped water supplies all operational and maintenance costs had to be borne by the beneficiaries.

For the above reasons, the villagers did not favour and refused to approve a pumped water supply. Instead they pressed for a gravity water supply from a spring, irrespective of its distance from the village.

The department showed understanding of the views and objections of the villagers against the implementation of pumped water supplies.

Having regard also to the fact that there was so much to be done in the rural areas where spring water was available, the Department concentrated its efforts and activities in villages and readily available to be used for a gravity water supply.

9.6 Preparation of a domestic supply scheme

During the period 1936-1945, a domestic supply scheme was composed of:

- a) The spring, source of water supply.
- b) The main water pipeline from the spring to the village.

The pipeline was of galvanised mild steel, class B (Medium series) in conformity with B.S.1387. The capacity of the main pipeline was calculated to be capable of delivering to the storage tank in the village the total quantity of water specified in the water supply scheme, which was approved by the village.

The size of the pipeline depended on the quantity of water and the hydraulic gradient existing between the spring and the place in the village where the storage tank was constructed.

- c) The storage tank was calculated to have enough capacity for one day's supply.

During the period 1936-1945, most of which was taken up by World War Two, the few storage tanks were of masonry construction. The stone was extracted from local quarries. Lime mortar was used for the building of the storage tank. Cement was imported, and being scarce because of war conditions, it was used only for the reinforced cement concrete roof slab of the storage tank.

- d) In small villages a reinforced cement concrete storage tank of size 2 x 2 x 1.80 metres was constructed. Troughs were provided along its sides for watering the animals, and taps for filling the water jars or other containers such as galvanised petrol tins. (Figure 10.1).

In bigger villages distribution pipelines were laid from the storage tank to a small number of RCC fountains, with trough and soakaway pit, each fountain serving a quarter of the village.

9.6.1. Outbreak of World War Two

The Water Supplies and Irrigation Department was constituted in March 1939.

During the first short period of its existence, the Department was being organised and programming its activities on water development in the island. The ambitious programming, however, was bound to be disrupted by the outbreak of the Second World War between Germany and Great Britain on 3rd September 1939. The war calamity stopped all development work in the island, not excluding work on domestic water supplies and irrigation.

The Government and the people of Cyprus became war-minded. Activities were diverted to the construction of

defence works, and the atmosphere of war was prevalent. A Volunteer Force was established and most of the Government Officers and employees joined the Force, for the defence of the island. The Director of Water Supplies and Irrigation Department was one of the Commanding Officers of the Cyprus Volunteer Force.

Towards the end of 1940, the Cyprus Regiment was established to serve overseas. Over 17,000 men of all useful ages joined the regiment. This resulted in the creation of a vacuum in the produce of food for the people which was of vital importance in war time. Because of the creation of a shortage in the labour force due to the enlistment of useful male workers in the Cyprus Regiment, and the fact that adequate British Military Forces had been posted to Cyprus, the Cyprus Volunteer Force was dissolved, and all Government employees returned to their posts. Defence and food productivity works were given top priority.

The water supply work was the main activity and interest of the Cyprus Government, which strongly believed that local food increase depended on the availability of water.

Therefore the Water Supplies and Irrigation Department had the full support of the Government in the implementation of its water development programme, and funds were made available by the British Government under the Colonial Development and Welfare Law. An amount of £484,580 was granted for the construction of gravity irrigation and domestic water supply schemes. A further sum of £103,180 was granted to the Water Supplies and Irrigation Department for the draining of the Morphou Syrianokhori marshes, as part of the project for the eradication of Malaria. (*"Water Supply in Cyprus" General Report 1945, by R. Raeburn, CBE*)

Next to the slogans used for the promotion of confidence in winning the war, there was another slogan used in Cyprus.

"Water for food for life"

The activities of the Department during the war period 1939-1945 were concentrated on:

a) Drilling

It was the decision of the Government, in consultation with the Director of the Water supplies and Irrigation Department, to carry out prospecting drilling for the purpose of bringing new areas under irrigation, and also to provide domestic water supply for the villages.

Six percussion drilling rigs, Ruston Bucyrus, were indented by the Department for prospecting drilling.

Boreholes drilled for private individuals for domestic use and irrigation were subsidised by the Government at a cost of only £32.105 only. Such subsidised boreholes were drilled in western and south eastern Mesaoria.

A number of boreholes were drilled for the War Department for military camp purposes. In Famagusta and Xylotymbou boreholes were drilled to provide domestic water supply for the Jewish Immigrant's Camp.

The following table shows the numbers of boreholes drilled during the quinnium 1942-1946 for private individuals, for Government and for the War Department.

TABLE 9.3 NUMBER OF BOREHOLES DRILLED

	1942	1943	1944	1945	1946
Private Individuals	17	25	34	56	61
Government	18	20	23	16	3
War Department	<u>16</u>	<u>10</u>	<u>4</u>	<u>-</u>	<u>19</u>
TOTAL	<u>51</u>	<u>55</u>	<u>61</u>	<u>72</u>	<u>83</u>

Source: Water Supply in Cyprus. Annual Report 1946. by C. Raeburn CBE, D.Sc.

b) Domestic supplies and irrigation

The activities of the Department in these two fields was concentrated on small schemes, where local building

materials could be used. Steel pipes and cement could not be made available in big quantities because of military requirements for these materials.

In view of this situation, work was concentrated on improving the springs to increase their discharge, and at the same time protecting them against surface contamination.

The spring was excavated and properly built. A spring outlet steel pipe was laid from the spring gallery through the protecting wall and discharged into a trough which was used for watering the animals.

As usual the village women obtained their domestic water from the spring delivery pipe.

It was also customary to build a masonry or cement concrete floor in front of the spring, in order to avoid muddy conditions in winter, so that the village women could step and stand in front of the spring on dry clean ground.

The surplus of the spring discharge overflowing from the trough was conveyed by a pipeline or masonry channel into an irrigation tank built close or adjacent to the spring, where it was stored during the night. the size of the irrigation tank was variable depending on the quantity of the night spring flow. Its usual depth was 1.60 metres and its shape rectangular, to suit the available ground space.

The benefit derived from the provision of a storage tank to accommodate the spring discharge during the night was twofold:

First irrigation during the under the light of the kerosene lanterns, was most inefficient. At the same time it was causing great hardship to the irrigations.

Secondly, it was most difficult and time consuming to irrigate, using the small discharge from the spring.

When in the morning the irrigation tank was full, the outflow through the discharge pipe, which was 100 or 150 millimetres in diameter, could be adjusted through a

sluice valve, in bigger quantities, for effective irrigation during the day, and with less time consumed.

The above combined scheme, which included the improvement of the spring and the construction of an open irrigation tank, was the pattern of water development in the rural areas during the period 1936-1945. The purpose was to secure pure, safe water for domestic use, and more water for irrigation for greater food production.

(c) Preliminary investigations for domestic supplies

During the war, it was a usual practice for the villages to apply through their District Commissioner indicating a spring which in their opinion was suitable for their domestic supply.

Of all the springs indicated, some were privately owned, others were small springs not used and allowed to accumulate in a swamp, and others were small springs having effluent seepages.

All springs indicated were measured regularly every month during the summer.

The measurement was carried out volumetrically, by recording the time taken to fill a steel measuring container of 20 litres. The temperature of the springs was also recorded. It was found to be consistent all through the year, day and night. The temperature of the springs issuing from the Troodos igneous formation at an altitude of 1000 metres and above was varied from 14-17 degrees centigrade. Springs issuing at lower levels, through igneous and limestone formations, had an average temperature of 20 degrees centigrade.

In the first instance, certain springs were excavated, usually in late summer and autumn, when their discharge was at low level. The expenditure incurred for the excavation was borne in full by the Department.

The discharge of the springs excavated was measured volumetrically once every month. If, after a series of measurements, the Department considered that the spring could meet the domestic requirements of the village, rated

at 45 litres per capita per day, then a scheme for piping the water from the spring to the village was prepared with an estimate of cost and submitted to the District Commissioner for approval by the inhabitants of the village. The expenditure incurred for the preliminary investigations regarding the spring was included in the headworks item of the proposed water supply scheme.

It is worth mentioning that in cases where we tried to carry out preliminary excavation in a spring close to a river, the flow of which was used for irrigation of land lower than the locality of spring, we faced the strong hostile objections of the owners of the land irrigated by the flow of the river, and the result was suspension of the work.

On other occasions the people of a village strongly objected to the conveyance of a spring to another village area. It was summer, and early in the morning before the foreman arrived at the site to commence the day's work on excavating the spring, the village children were lying on their backs in the trench and cutting, thus preventing the execution of work.

Because of this pathetic objection the preliminary excavations were stopped, until the case was examined and legally considered further.

d) Transport of materials to the site of work

As a general rule, all springs which were developed during the period 1936-1945 were located in isolated areas, and no approaching motor roads were available.

The materials used for the building of the spring, the irrigation tank and channels were:

- i) Stone - quarried locally. It was sandstone, limestone or igneous boulders.
- ii) Sea sand gravel, conveyed to and unloaded by the side of the spring.

From this place, the materials were transported to the site of the spring by

donkeys. A donkey could carry a load of 120 kilogrammes.

- iii) Slaked lime was used for mortar in place of cement, which was hardly scarce. Cyprus has an abundance of very good limestone, particularly in the Kyrenia limestone range. Limestones were quarried and burnt in limestone kilns for producing calcined crumbled lime.

The crumbled lime was pulverised and stored in sacks, or left in the condition in which it was taken out of the kiln. The lime had to be slaked in water before it was used for the mortar mix. A rich lime cream was produced, and this was mixed with sea-sand properly washed in the proportion of 1:3, to produce the lime mortar. A good lime mortar looked homogeneous, and had a paste flowing characteristic. Although lime takes 3-6 months to mature fully, it last for centuries.

e) Antimalaria work

As all water resources were in the hands of the Water Supplies and Irrigation Department, money was allocated, and in 1944-1955 the department carried out drainage works in the Morphou Syrianokhcri marshes.

The drainage ditches were open trapezoidal with semi-circular concrete inverts. The gradient of the ditches varies from 1/500 to 1/2000. The outfall of water into the sea from five main ditches was about 3000 cubic metres per day. In total 33 kilometres of drainage ditches were excavated and the result was that the marshes dried up.

f) Legislation

In the year 1936, there was no Law dealing with domestic water supplies.

The Government water Works Law of 1928 provided the following;

- 1) It gave to the Government ownership of:
 - i) All underground water supplies including the semi-artesian flows.
 - ii) All lost water from rivers, springs, or streams
 - iii) All waters that flowed to waste.
- 2) The Law gave power to the Cyprus Government:
 - i) To undertake and execute water works, in any rivers, springs or streams, or in any other water source on which there were not water rights.
 - ii) To enact regulations for the administration of such water works, and impose rates and taxes in relation to the financial aspect of the administration.

The above Law, though inadequate in details and purpose, did not produce serious difficulties in the use of water for domestic purposes.

g) Financing

Towards the total cost of a village domestic supply, it was usual for the Government to contribute one half and the interested village the other half.

In the case of poor villages, the District Officer recommended an increase in the Government's contribution to the cost of the proposed village scheme from one half to two thirds.

The share of the village was secured by means of a long term loan (15-20 years) at low interest from the Loan Commissioners, in accordance with the Villages Obligation Law of 1939.

In the absence of a specific Law relating to domestic supplies, the provision of water supply for drinking and other domestic purposes depended on the administrative measures taken by the District Officer's office, and the initiative of the village concerned.

During the period 1936-1945, there was no law requiring the Government Authorities to implement domestic

supplies in villages where the hygienic conditions required the immediate provision of piped water supply.

9.7. Summary

The results in the field of water development in Cyprus during the period 1936-1945 can be summarised as below:

a) Staff

The Water Supplies and Irrigation Department taking charge of all Water resources and their development, was set up in 1938 and constituted in 1939. In 1937 its staff consisted of the Water Engineer, two inspectors and two clerks by 1945, the staff consisted of:

i. <u>Expatriate staff</u>	No.
Water Engineer Director	1
Assistant Water Engineer	1
ii. <u>Cypriot staff</u>	
Superintendant of Works and skilled workmen	3
Inspector of works	9
Technical Assistants	50
Clerical staff	7
TOTAL	71

The monthly expenditure on labour wages was £8950

b) Domestic water supplies

Although the last war greatly retarded work on water supplies, appreciable work was effected in the improvement of springs and small irrigation works. During 1936-1945, the domestic water supply of 158 villages was improved. The improvement included the excavation and building of the village spring only. In some cases, a short length of pipeline was laid to improve the approach to the spring flow. In the year 1945, 547 villages, representing 85 percent of the total 647 villages, and the six towns of Cyprus, needed a new and improved domestic water supply.

c) Prospecting drilling

Work on prospecting drilling was intensified and new aquifers were discovered for irrigation and domestic purposes. The Government subsidised the drilling, for the purpose of bringing new areas under irrigation for production of food, so much needed during the period of last war.

d) Subsidy

All domestic water supplies and irrigation schemes were subsidised by the Government. The contribution by the Government for domestic water supplies was fifty per cent of the total cost. For irrigation schemes, the Government's share was two thirds (66%) of the total cost.

In exceptional cases, when the villages were very poor, on the recommendation of the respective District Commissioner the Government's share could be increased to three quarters (75%). The beneficiaries were allowed to offer their contribution in free labour.

e) Irrigation

The minor irrigation works included masonry diversion weirs, lining of irrigation channels in masonry and the construction of Lythrodonta and Lymbia masonry gravity dams, of capacities 32,000 and 18,000 cubic metres respectively. These dams were low in height, up to 10 metres. Their stored water is still used today for the irrigation of spring crops which mature in May and early June.

f) Antimalaria work

The activity of the Department was extended to the drainage of marshes, which in my opinion was the first step towards the early eradication of malaria.

g) Expenditure

The total expenditure on water development during 1936-1945 was in the region of £650,000, excluding the

contribution of the beneficiaries in free labour. (*Water Supply in Cyprus - General Report by C. Raeburn, CBE*).

h) Knowledge and Experience

The construction of simple minor schemes for domestic supplies and irrigation has provided ample empirical knowledge and adequate experience to technical officers, technicians and skilled workmen staffing the Department.

i) Results

Lastly, the successful results of the water works carried out during the early years of the Water Supplies and Irrigation Department have stirred up the interest and enthusiasm of the people and constituted a sound foundation for major and intensive post war work on domestic supplies and irrigation.

CHAPTER TEN DOMESTIC WATER SUPPLIES

Period 1946-1960

10.1 Post War water development

In 1945, Germany was defeated by Great Britain and her allies, and the Second World War was ended.

A new era of freedom, development and progress was opened up for all countries of the world.

In 1946 the British Labour government, under the leadership of the Prime Minister, C.R. Atlee, took the decision to accelerate the economic development of Cyprus, by offering substantial technical and economic assistance.

The file of Cyprus was removed from the shelf and put on the table for action.

In October 1946, Mr Greech Jones, the Secretary of State for the Colonies, in a statement to the House of Commons said that H.M. Government had decided that a ten year plan for the economic development of Cyprus would be initiated, and put into effect immediately.

In the year 1947, the British Government nominated the Right Honorable the Lord Winster P.C. to be the Governor and Commander-in-Chief of the Colony of Cyprus and on the 27th he assumed office. Apart from his activity in the political field in the setting up of a Consultative Assembly, which began work on 1st November 1947, Lord Winster showed exceptional interest in the provision of domestic water supplies to all villages, during the ten-year plan for economic development of the island. In this respect he visited villages, spoke to the villagers and their village committees and ordered the provision of piped water supplies to villages in the shortest time possible.

10.1.1. Visit of the Governor, Lord Winster to Kouklia (Old Paphos)

One of the villages Lord Winster first visited was Kouklia (the Palea Paphos) where the stone foundations of

the Temple of Aphrodite are preserved as an archaeological monument. Lord Winster met the Kouklia people in the village square. All officials were seated round the table, in the open. The first request put forward by the village committee was for the piping of water from Ayios Savvas spring to the village, and its distribution to public fountains.

Lord Winster responded to the request of the Village Committee and asked them to put in an application through the District Commissioner, who was present, so that the rules and legal aspects would be followed.

One of the leading members of the village addressed Lord Winster as follows:

"Your excellency.

It happens that when someone applies to the Government, the application has to pass and be considered through the labyrinthine bureaucracy of the various departments, and the answer to the application comes to the applicant after his death.

We hope this time our application will be given due consideration at the earliest possible time"

The Governor received the comment with some apparent humour, and in answering he confirmed that in this case work on the piping of the spring water would start in fifteen days.

The next day, instructions from the Government house were received at the Water Supplies and Irrigation Department, for the preparation of the domestic water supply scheme for Kouklia, and work was to commence within fifteen days time.

The same instructions were addressed to the District Commissioner, Paphos, for the preparation of all administrative formalities, including the village loan from the Loan Commissioners.

10.1.2 Preparation of the village domestic water supplies scheme

Ayios Savvas spring was located 18 kilometres away from Kouklia, issuing in the Dhiarizos river valley, near Prastio villages. The spring was issued out from a stratum of disintegrated limestone overlain the Mamonia clay.

The spring was owned by Ayios Savvas Monastery which was using its discharge for irrigation.

The Water Supplies Department, by using a dumpy level, took levels from the spring to the proposed site of the storage tank at the highest point of the village, for the purpose of ascertaining the existing hydraulic gradient, and fixing the highest points along the route of the proposed conveyor pipeline for the installation of air vents.

The route of the pipeline was as far as possible to follow the existing road and easily accessible landscape.

The length of the proposed pipeline was also measured. As a practice we added 5% to the total length for contingencies.

The main conveyor pipeline used for gravity water supplies, was of galvanised mild steel Class B of B.S.1387. The pipes were indented through the Crown Agents, and were manufactured by Steward and Lloyds, England.

In the case of Kouklia the main pipeline was galvanised mild steel and two inches in diameter.

The size of each main conveyor pipeline was calculated by using the discharge and loss of head chart for new steel pipes extracted from the KEMBES Year Book.

The chart was prepared using the Chezy formula, $V=C m_1$, for pipes and pipe systems.

The levelling from the spring to the village through rough country took us two days. On the third day we had to be at Nicosia, so we measured the distances for the siting of the public fountains within the villages, at about 200 metres apart. We continued work after sunset

and worked during the early hours of the night to complete the work.

In those years, there was no electricity serving the villages and we had to use the kerosene lanterns as a source of light for our work. All the village people, men and women, were most helpful to us.

In one week the domestic water supplies scheme for Kouklia (Palea Paphos), with estimate of cost, was ready and submitted to the Commissioner, Paphos.

The Commissioner saw that the scheme was approved by the village inhabitants who were of 21 years and above. The loan to the village was granted, and at the end of the 15 day period, the Water Supplies and Irrigation Department foreman was sent to Kouklia village to put work in hand.

A village domestic water supply scheme was supposed to be completed within the shortest period of time, in order to cope with the great demands put forward by the villages. For this purpose, work was carried out at the spring, on the laying of the pipeline, and on the distribution of water within the village simultaneously. Therefore, the designing of the scheme had to be prepared with much care, correct levelling and correct calculations.

The villagers approved the scheme at a public meeting by vote. This was necessary in conformity with the Law. The scheme was read and explained in detail to the people before their voting for or against. It was, therefore, an absolute prerequisite that the total quantity of spring water provided for in the approved scheme, was gravitated to the storage tank in the village.

I have quoted the case of Kouklia domestic water supply, in order to convey to the reader, a feeling of the magnitude of the interest taken by the British Colonial Office, the Cyprus Government and the Cypriots in the field of domestic water supplies.

10.1.3 Commencement of improvements in domestic water supplies

The situation regarding the supply of steel pipes and cement through the Crown Agents, showed considerable improvement after the initiation and commencement of the Ten Year General Development Plan of Cyprus. This helped work on domestic water supplies greatly. By the year 1948, it seemed certain that considerable headway could be made with the scheme to provide domestic water to all villages and towns in the island.

With regard to domestic supplies, the Annual Report to Cyprus for the year 1947, prepared by the Colonial Office, page 4, states:

".....more attention has been given to irrigation works than to the much needed improvement of village domestic water supplies owing to the inability to obtain delivery of materials, principally pipes, pumps and engines. During the same period, the installation of piped domestic water supply with storage tanks and fountains has been completed in 26 villages, and 15m schemes are still in hand, but several hundred await action"

10.1.4. Staff structure modification

The launching of the Ten-Year Water Development Programme, in March 1946, demanded the enlargement and reorganisation of the Department, in order to cover all aspects of professional requirements of the ambitious programme for the prosperity of the island.

For the ten year period 1938-1948 the Director of the Department was a Geologist by profession. The Assistant Director was also a Geologist.

Towards the end of 1947, the Director, C. Raeburn, CBE, D.Sc, was transferred to Nigeria, as Head of the Geological Department of that country.

Towards the end of 1948, I.L. Ward, Director of the Water Department in Palestine, was transferred to Cyprus and assumed office as Water Engineer and Director of the

Water Supplies and Irrigation Department. I.L. Ward was a civil engineer by profession. He enjoyed the reputation of a hardworking engineer, and of a methodical organiser. When he took office he followed the same pattern of simple and small projects as was initiated by his predecessor, Dr Raeburn. The Ten-Year Water Development Programme had commenced, adequate quantities of materials, principally steel pipes, steel rods and cement, were delivered to the Government stores, and work on water supplies was expanded.

Mr Ward was the first to come to the office in the morning, and the last to go home in the late afternoon.

The staff of the Department was increased to cope with the enlargement of the volume of work on domestic water supplies. An Assistant Head of the Department, a professional geologist, Dr Burdon was appointed. Four British civil engineers also joined the Department. The local technical and clerical staff of the Department was also increased.

10.1.5 Labour

For the purpose of implementing the ten-year programme of water development, it was advisable and necessary to set up a skeleton of departmental skilled labour force which would exist on a permanent basis. This force would acquire all the skill and experience needed for the execution of the proposed water works. Moreover, with the skilled labour force having a form of permanent regular employment, the risk of disruption of the development programme through labour disputes was to a large extent eliminated. The regular labour employees of the Department were classified into three categories:

- a) Special Grade (Foremen)
- b) Skilled men (Masons, who had acquired some skill in their work)

- c) Semi-skilled men (Labourers, who had acquired some skill in their work)
(Women wage earners were not given regular status in 1947).

At the end of 1947, the wage rates paid to Government wage-earners according to the degree of skill stood at the following levels.

Regular Earnings per week

- | | | |
|----|-------------------------|-----------------|
| a) | Special Grade (foremen) | 75s.8p - 96s.7p |
| b) | Skilled men | 42s.80 - 73s.3p |
| c) | Semi-skilled | 40s.6p - 42s.8p |

The average daily earnings of women workers ranged from 4s. to 6s. (Source: Colonial Annual Report - cyprus 1947)

It is of interest to note that before the outbreak of the second World War, the wage-earner was working from sunrise to sunset, all the year round. During the war, in the year 1940, the duration of the day's work for the wage earner was reduced to ten hours.

After the end of the war, in the year 1947, trade unions pressed their demand for a 44 hour week.

The Colonial Annual Report, for Cyprus, 1947 page 8 states:

"It has been observed that while primarily pressing for higher wages workmen have also sought to obtain improvements of a more permanent character, viz. shorter hours of work holidays with pay, sickpay, notice of discharge, and especially social insurance.

During the year trade unions pressed their demand for a 44-hour week in as many undertakings as possible. The government decided to accept in principle the introduction of the 44-hour week for its own employees...."

10.1.6 Legislation

For the successful implementation of village domestic water supply schemes, it was an absolute necessity that a law would be enacted, which would make provision for the supply, maintenance and control of such village water schemes.

For this purpose the "Water (Domestic Purposes) Village Supplies Law (CAP 349) (dated 29th July 1948)" was enacted.

The main provisions of the above Law are:

a) Application of the Law

It vests power in the District Commissioner and Assistant Commissioner to enforce the Law.

b) Village Water Commission

In every village to which the Law applies a Village Water Commission should be constituted with the Mukhtar (village headman) should be constituted for the purpose of the Law.

c) Duty of the Village Water Commission

It is the duty of the Village Water Commission to provide and maintain an adequate supply of pure and wholesome water for the domestic purposes of the village.

d) Preparation of the Water Supply Scheme

The Director of Water Development on the application in writing is to prepare the domestic water supply scheme, showing specifications and estimates for the intended work, including plans showing any immovable property which might be affected.

e) Householders meeting

The Commissioners shall call a public meeting of the householders, to approve or reject the proposed water supply scheme.

f) Acquire immovable property

The Law was given power to the Village Water Commission to acquire immovable property, by agreement on such terms and conditions as the Commissioner might approve.

g) Laying of pipes

The most important provision of the "Water (domestic purposes) Village Supplies Law", was section 15. It gives power for the laying of pipes on or under any land, and it should not be necessary to acquire any land in connection with the laying or repair of the pipeline. Before laying such pipes, however, or repairing or renewing any such pipes, there must be served on the owner and on the occupier of the land, or affixed on the land by means of a notice board, a notice of the intention and description of the intended work.

It is worth mentioning that we have never faced the obligation to serve or affix a notice board for the laying of pipes in any land. A good humorous inspector of the Department, always said to a landowner whose land was on the route of the pipeline:

"Water and cart follow their own suitable route"

h) Obligations and Contracts

The law has given power to the Village Water Commission to contract loans which are necessary for carrying out the purposes of the Law. Also the Village Water Commission has been given power to collect water rates and have a village commission fund. prepare and keep accounts, and other powers for the maintenance of the village domestic water supply.

The Cyprus Water (Domestic Purposes) Village Supplies Law Chapter 349, was printed by: *C.F. Rowworth Limited, 54 Grafton Way, London W.1. (1959)*

A second Law for municipal water supplies was enacted in 1951. This Law was the "Water Supply (Municipal and other Areas) Law, Cap 350".

The main provisions of the above Law are:

a) Interpretation

A Water Board is established under this law. The water boards consists of three persons appointed by Governor and three persons form the municipal council.

Such water boards have been established in Nicosia, Famagusta, Limassol and Larnaca. Area of supply water under the provision of this Law.

b) Duties of Boards

- (i) It shall be the duty of every board within the area of supply to provide and maintain a good and sufficient supply of water.
- (ii) To lay pipes and ensure that every house and other buildings has available a sufficient quantity of water.
- (iii) To impose water rates or charges for the supply of water and any water undertaking wherever situated.

In a general outline the "Water Supply (Municipal and Other Areas) Law of 1951" Chapter 350, is identical with the "Water (Domestic Purposes) Village Supplies Law of 1948, Chapter 349".

10.2 Progress on domestic supplies during the Colony's ten-year Development Programme. (1946-1956)

The arrival of large quantities of steel pipes, cement and pumping equipment on the island during the year 1948 gave substantial momentum to the development of domestic water supplies.

Applications for new gravity village domestic supplies were received at the Water Supplies and Irrigation Department, through the District Commissioners, from an increasing number of villages.

The Department was short of staff, and in order to cope with the immense work involved in the provision of piped domestic water to all villages and towns, it was necessary not only to organise the Department but also to standardise the work. This having been done the foremen would acquire the necessary experience and knowledge of the waterworks as standardised, thus reducing supervision from senior technical staff to a minimum. The control of the work would be much simplified in that the materials needed and the cost involved could be known and evaluated

to a high degree of accuracy before the commencement of the work.

10.2.1 Standardisation of Domestic Water Supplies

A gravity domestic water supply included:

- a) Improvement of the spring.
- b) Main pipeline from the spring to the village.
- c) A storage tank built on a high site commanding the village.
- d) Construction of public fountains, built at central sites within the village. The distance between fountains was about 300 metres or less, serving 10 houses on average.

10.2.2 Classification of Artisans

- a) Selected foremen were detailed for the improvement of springs (excavation and building) and for the excavation of wells and exfiltration galleries.
These foremen were trained to understand and be conversant with the various geological strata through which the springs were issuing out. Through their work in improving springs all over the island, these foremen acquired experience, and supervision from Headquarters in Nicosia was kept to a minimum.
- b) Another class of foremen were the pipelayers. A pipelayer foreman gained experience in the laying of the pipeline, the bending of pipes on site by using the trunks of trees or pieces of wood, and most important in finding out the best route for the pipeline, for saving in excavation and for the convenience of maintenance.
- c) The foremen (masons) built storage tanks and public fountains. They also laid the distribution pipelines connecting all fountains.
A very small number of foremen who had acquired adequate training in their construction work, and who proved to have excellent records, were appointed as Chief and Assistant Chief Foremen, and were

posted to the Department in Nicosia. They visited the works in hand at least once a month, guided the foremen in their work, and also maintained general control over the use of material, expenditure and employment of casual skilled and unskilled labourers.

In the 1950's we had three chief foremen and six assistant chief foremen. They also helped in the planning and designing of simple projects.

10.3. Standardisation of storage tanks and fountains

In every gravity domestic water supply scheme, storage of not less than one day's supply, at 50 litres per capita per day, was provided. Storage is very important, in that it feeds and helps the distribution system to have a steady residual pressure at all points of delivery, subject of course to its being properly designed for an adequate capacity.

The storage in the case of the village water supply fed the public fountains. In the afternoon, on week days and on Saturdays, the water drawn through the public fountains was excessively high. If for any reason the water stored was exhausted and certain fountains could not produce water because of difference in their location contour line, the women would become very irate.

The standardisation of storage tanks was an absolute necessity, following the expense of work on domestic supplies, and the arrival of cement and steel rods in big quantities. In view of this situation, the Department prepared designs and drawings for circular reinforced cement concrete tanks of the following capacities:

25m³, 50m³, 90m³, 135m³, 270m³ and 450m³.

A wooden mould for each of the above sized storage tanks, was constructed. The respective moulds of the above storage tanks were kept by each foreman for a period of six weeks, and were sent to where they were needed.

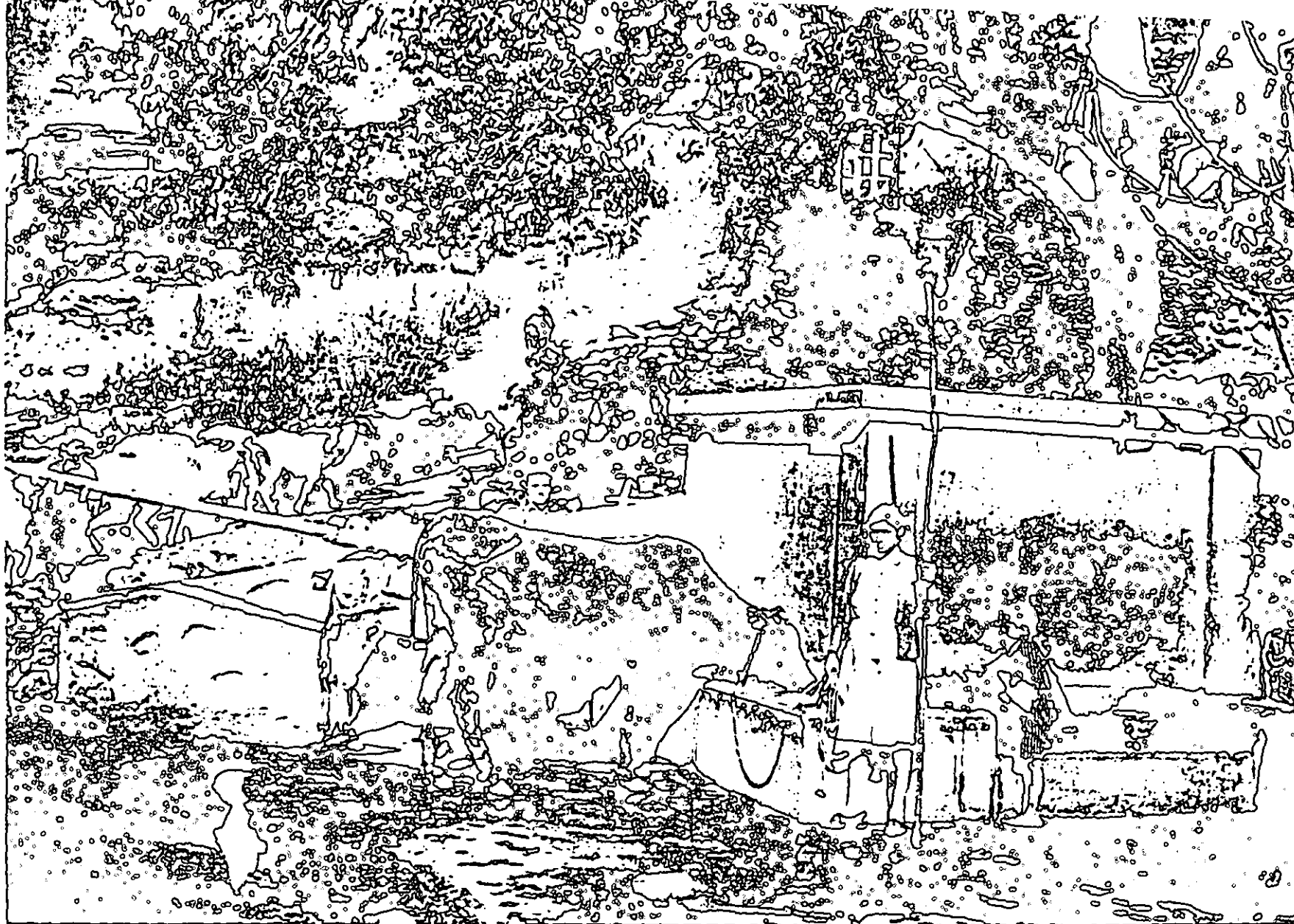


Fig. 10.1 Typical Storage Tank, fountain and animal watering Trough 1946

Source: Public Information Office Cyprus



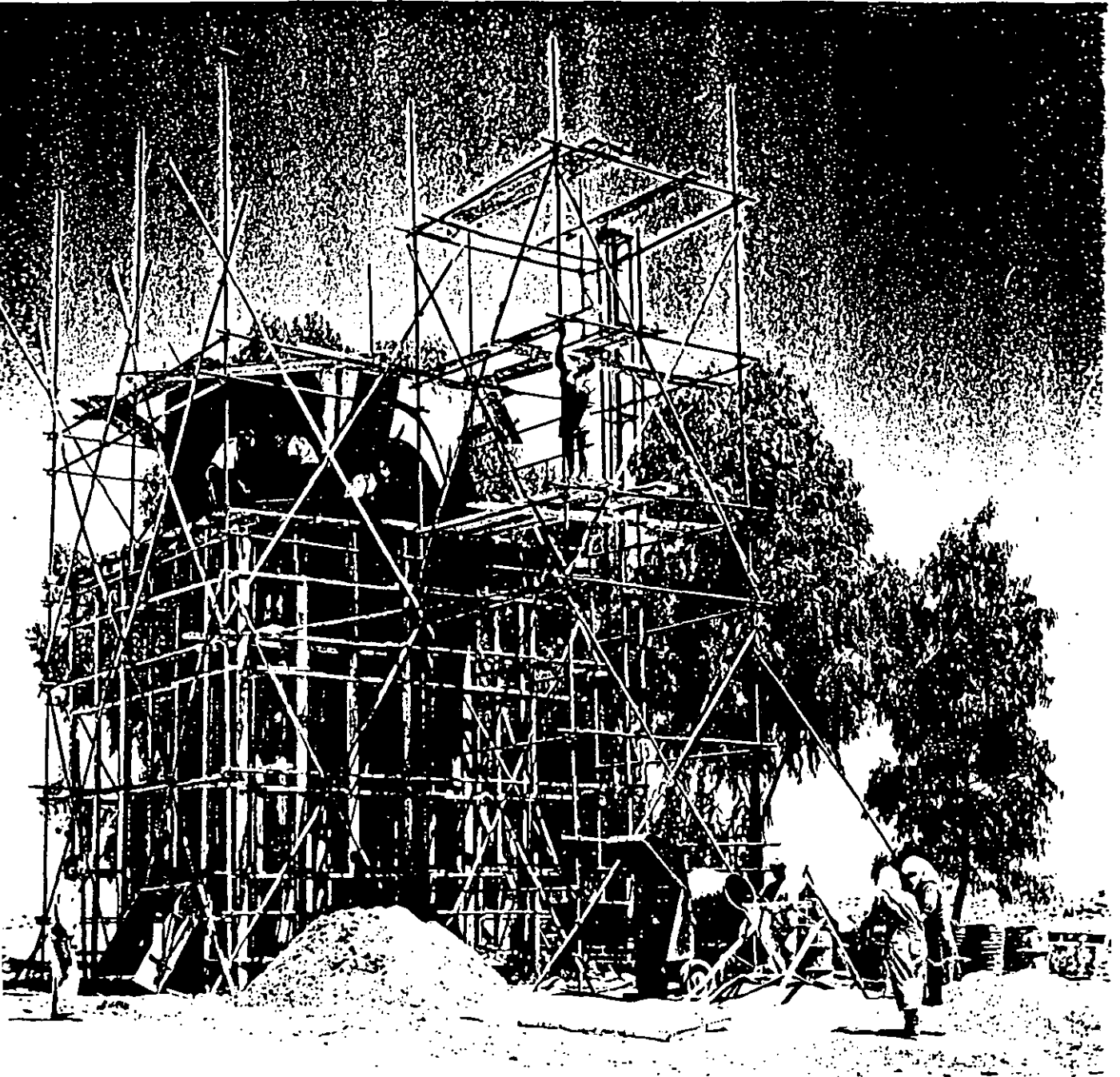
Moutayiaka Reg. Pump Scheme
Fig.10.2 Source: Water Development Department



Fig. 10.3

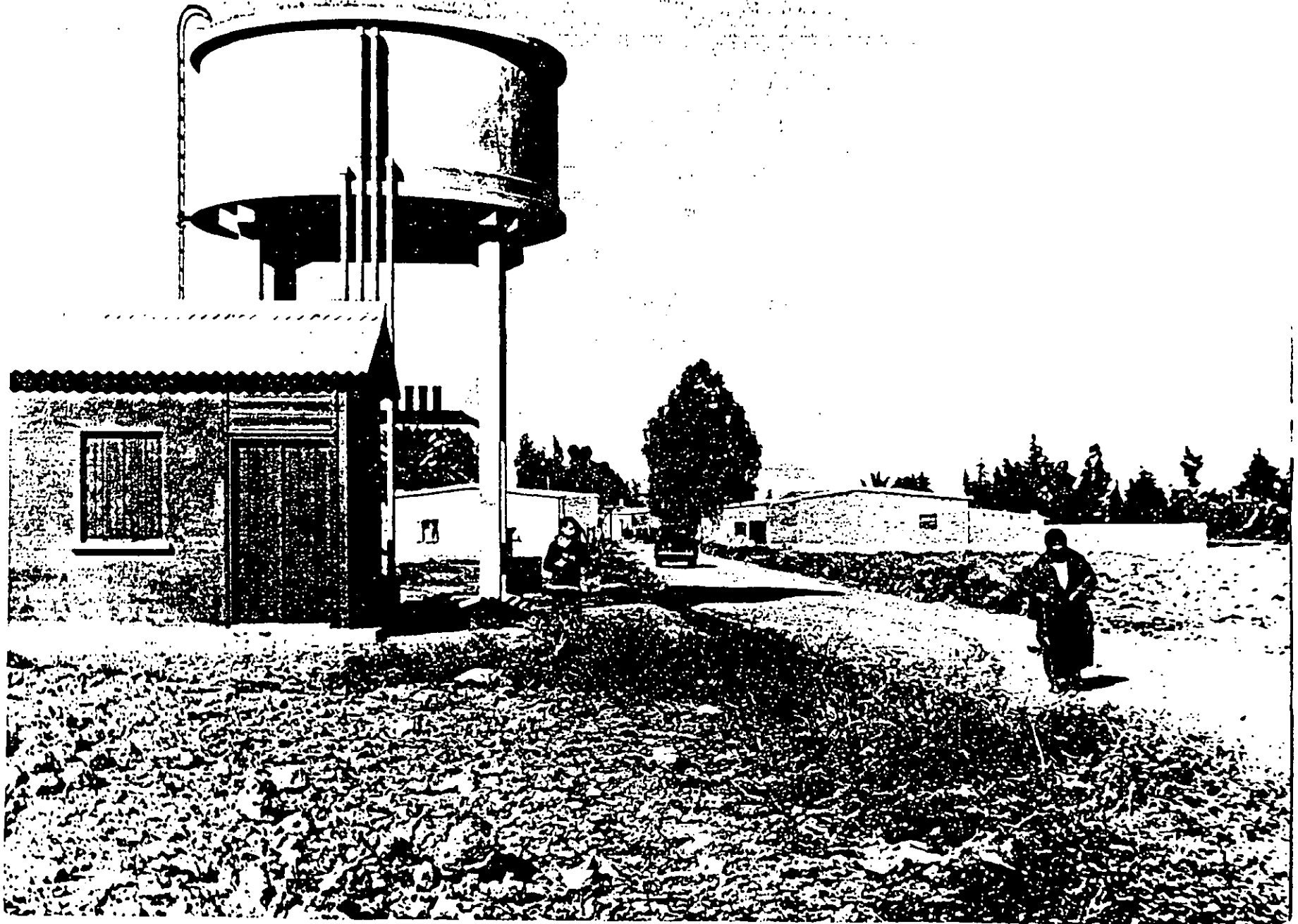
Pumping Station
Village Domestic Supply

Source: Water Development Department

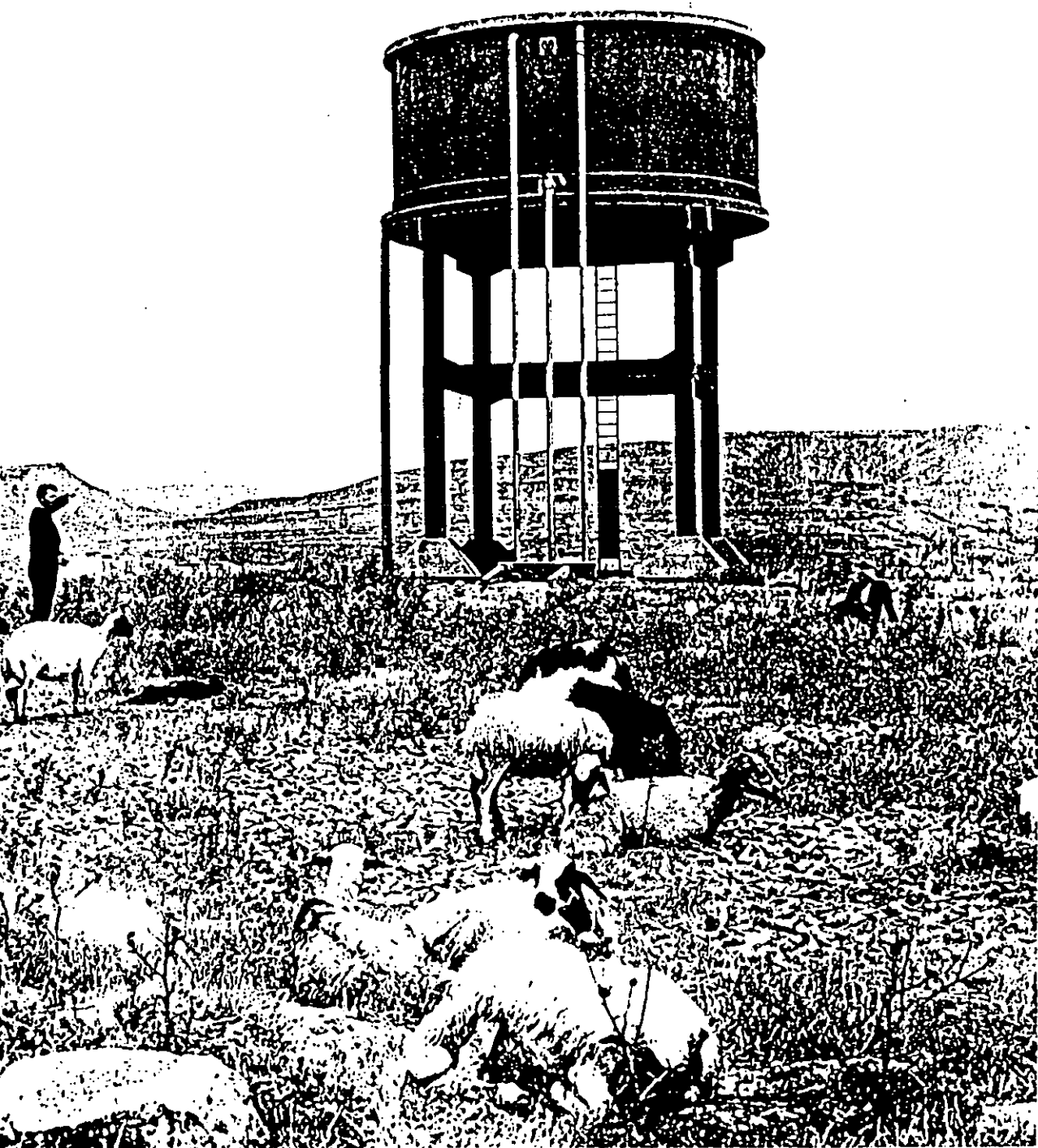


RCC Trestle under construction for support of RCC
Circular Storage Tank

Fig.10.4 Source: Water Development Department CYPRUS



Typical Elevated RC Storage Tank Serving a village in the Mesaoria Plain
Fig.10.5 Source: Water Development Department



Typical Elevated RC Storage Tank Serving
a village in the Mesaoria plain.

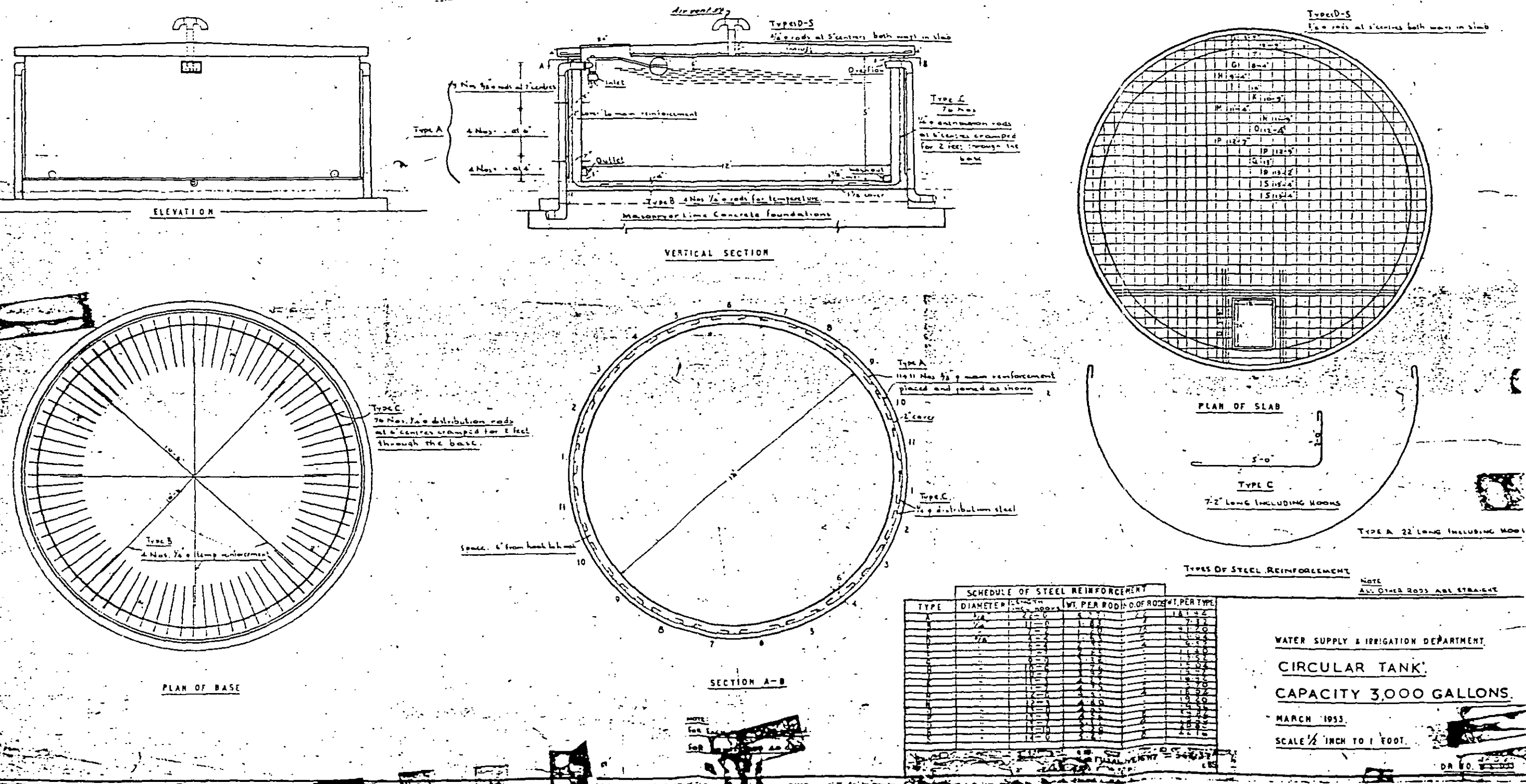


FIGURE 10.6

Eventually the wooden moulds were replaced by moulds made of rectangular thin pipes, forming the skeleton of the panel, and galvanised steel sheets of 3mm thickness.

The steel moulds could be more easily erected, and lasted much longer. In the long run they proved to be more economical than wooden ones. The above circular R.C.C. tanks, without R.C.C. roofing slabs, were also constructed for storing irrigation water.

The design of the R.C.C. circular tanks was simple. The tank rested on a mass concrete foundation cast in alternative layers. The tank was separated from the foundation by a thin layer of bituminous coating. The roof slab was simply supported. (Figure 10.6)

The public fountains were also standardised. The types of R.C.C. fountains were cast:

- a) One with a rectangular trough for watering the animals.
- b) One with square trough for filling the amphoras only.

10.4 Advantages of standardisation

- a) When the ten-year Development Programme was launched, the Water Supplies and Irrigation Department staff was inadequate to cope with the expansion of water development work, planning, designing and construction, and the few foremen and other artisans were still gaining experience and had to do a lot on their own.
- b) The training of foremen to deal with one specific part of the domestic supply scheme, and their classification and detailing to that job, gave the foremen ease and confidence in the execution of their work on schemes which were mostly of similar nature.
- c) The spring foreman was trained to know how much to excavate the spring through the various geological strata, how far to excavate and when to stop, how to

protect the collapsing ground if this happened in the cutting, and how to build and protect the spring against surface pollution.

- d) The pipelayer foreman was trained to trace and follow the best alignment of the main pipeline across rough country. He was conversant with the various pipe fittings and their use, and could bend the pipes to follow the uneven ground by using the trunks of trees or other on-site devices.

The water distribution foreman, by using the drawings of the standard reinforced cement concrete circular tanks, was experienced in cutting and sorting out the lengths and shapes of the various types of reinforcement, in laying them and in casting the foundation and the tank.

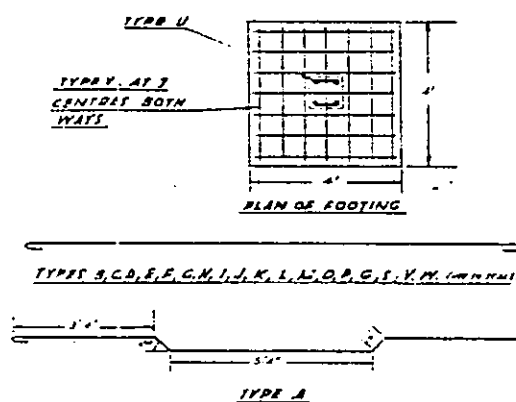
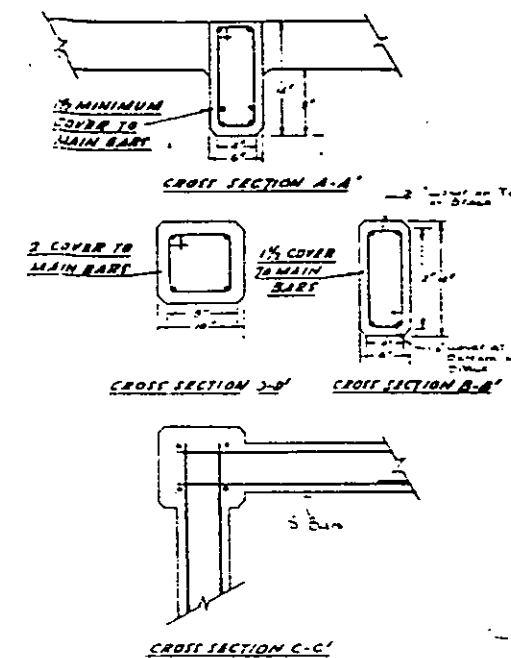
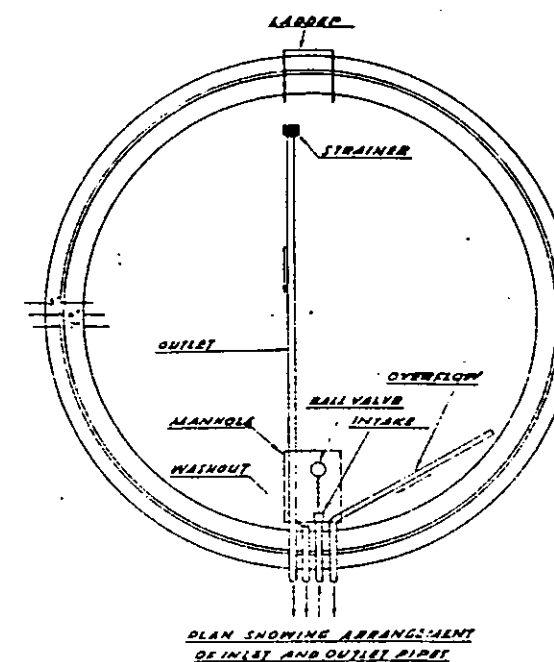
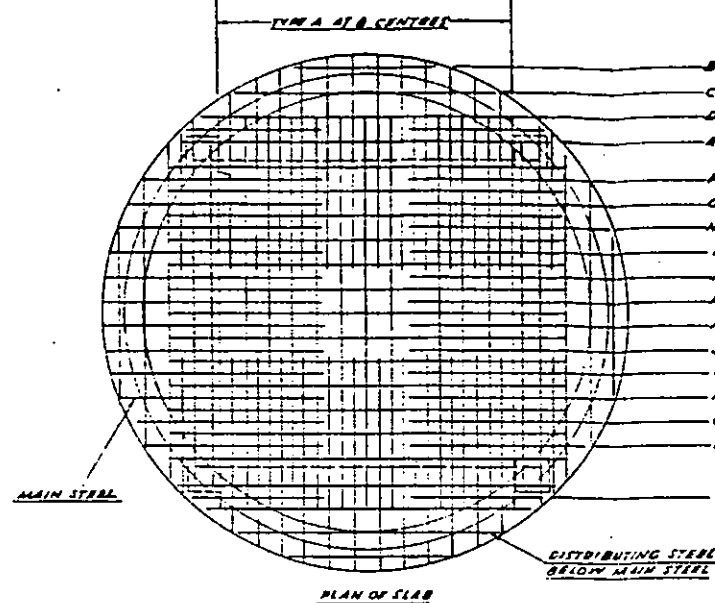
The casting of the public fountains was also routine work to him. The same foreman laid the distribution pipes connecting all fountains.

The distribution system in all villages was similar in most respects and the whole work was greatly simplified by an efficient foreman. In view of the nature of the work being carried out within the villages, we detailed for this work foreman of good standing, who would be sociable, patient and inspire the confidence of the villagers.

- e) All foremen were accompanied by two or three regular skilled workers, usually masons and pipelayers. They moved from village to village and were classified as field workers. They formed a gang of field workers, and were paid 15% extra over their wages for the hardships they experienced moving from village to village and being away from their families.

- f) In the early 1950's light machinery such as diggers and earth moving equipment was very scarce in Cyprus. For this reason, the mason foremen were each supplied with one concrete mixer of size 5/3 and 7.5/5. The equipment for each mason gang was:

PLAN OF FOOTINGS AND BEAMS



SCHEDULE OF REINFORCEMENT					
TOTAL WEIGHT OF REINFORCEMENT BARS USED IS "					
TYPE	DIAM.	NO. OF RODS	LENGTH IN FT. APPROX.	WEIGHT PER FOOT (LBS)	TOTAL WT. (LBS)
A	1/2"	26	14.10"	0.85	256.10
B	"	4	4.10"	3.20	12.80
C	"	4	7.10"	5.20	20.80
D	"	4	9.10"	6.54	26.16
E	"	4	11.4"	7.54	30.16
F	"	8	5.8"	3.74	29.92
G	"	8	6.0"	4.00	32.00
H	"	8	6.4"	4.20	33.60
I	"	8	6.6"	4.34	34.72
J	"	8	6.8"	4.47	35.76
K	"	8	6.10"	4.34	34.72
L	"	8	6.6"	5.00	40.00
M	1/2"	8	10.6"	10.93	87.44
N	3/8"	84	3.10"	0.73	61.32
O	3/8"	8	8.4"	3.66	29.28
P	"	16	4.0"	4.17	66.72
Q	1/2"	16	27.0"	31.34	501.44
R	3/8"	104	2.1"	0.22	22.96
S	3/8"	16	13.9"	2.5	40.00
T	3/8"	64	2.5"	0.24	15.36
U	1/2"	8	9.0"	6.47	51.76
V	1/2"	36	4.8"	5.07	182.52
W	1/2"	8	10.9"	10.13	81.04

NOTE :

<u>WEIGHT OF TANK, EMPTY</u>	<u>11.7 TONS</u>
<u>WEIGHT OF TANK, FULL</u>	<u>85.0 TONS</u>
<u>WEIGHT OF FRUSTLE AND DECK INCLUDING FOOTINGS</u>	<u>13.9 TONS</u>
<u>MAXIMUM FOUNDATION PRESSURE AT X'-X'</u>	<u>1.25 TONS</u>
<u>PER SQ. FT. FOR WIND OBSTACLE OF 30 LBS. PER SQ. FT.</u>	

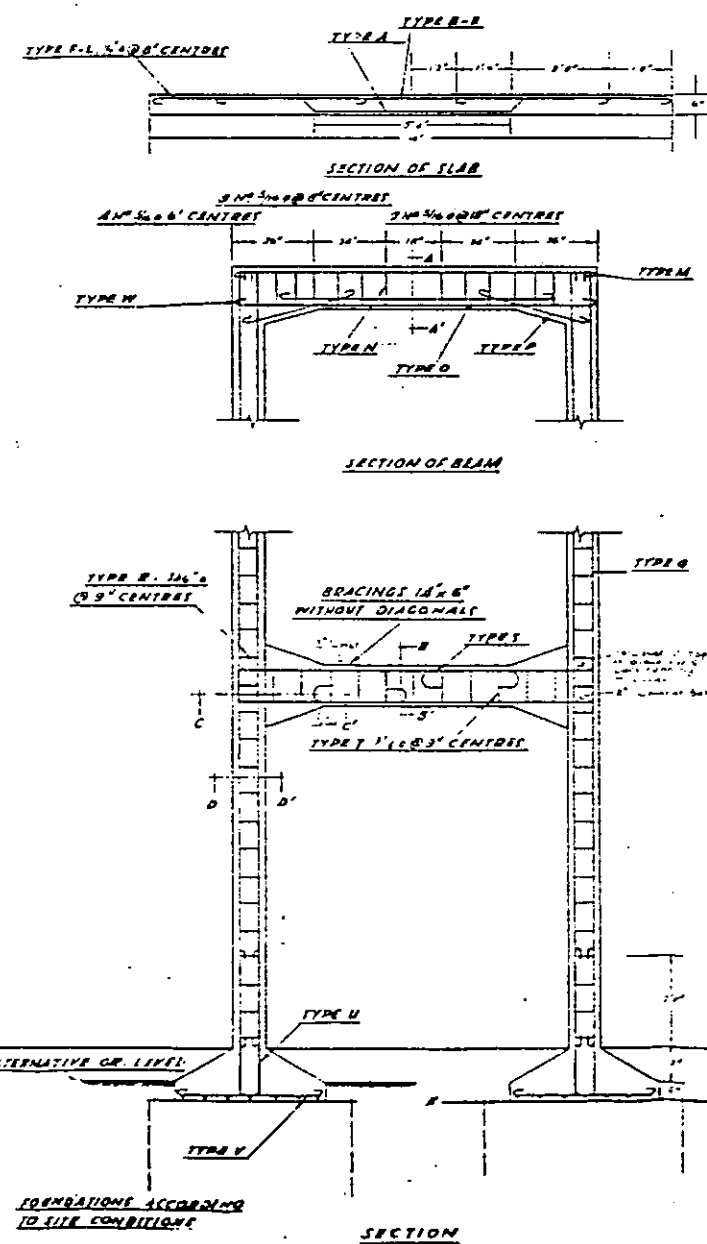
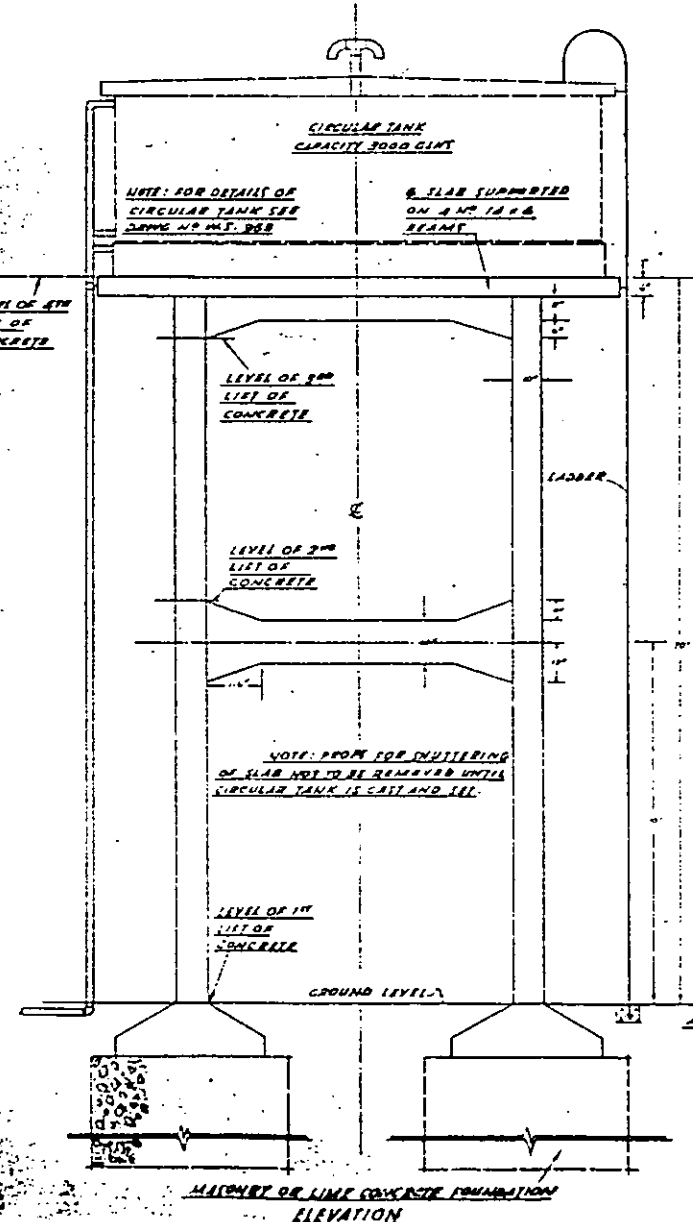
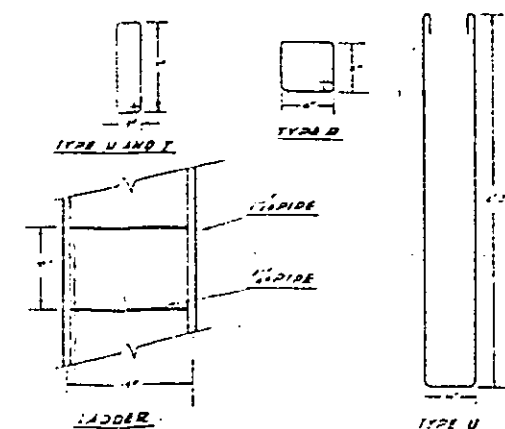


FIGURE 10.7

DEPARTMENT OF WATER DEVELOPMENT
TRESTLE FOR 3000 GINS CIRCULAR TANK
HEIGHT 20 FEET.

APRIL 1956 SCALES $\frac{3}{8}$ " = 1' & 1" = 1' DWG NO. ^{AF/G/C/7} 11-5-547

Concrete mixer, wheel barrows, picks and shovels and all other tools needed for cutting and threading the steel pipes (15-100 millimetres in diameter) and laying the pipeline.

10.5 Preparation of a Gravity Water Supply Scheme

The domestic water supplies section was responsible for taking regular measurements of all known springs in the island. The measurements of the discharge from the springs were recorded monthly, from March to November. As a general rule the spring discharge was measured volumetrically. Few bigger springs were measured by means of V-notches or small rectangular weirs.

The chemical quality of the spring water was also ascertained before a village or town was considered for domestic water supply.

10.5.1 Design

In accordance with the Water (Domestic Purposes) Village Supplies Law, the village commission applied to the Water Development Department, through the respective District Commissioner, indicating that the water of a nominated spring should be conveyed to their village for domestic purposes. The Domestic Water Supplies Section of the Department had records of the discharge of the spring indicated.

Any ownership or water rights over the flow of the springs were ascertained by the Land Registry Office and the District Commissioner.

Our primary action on water development was to prepare the gravity water supply spring. Our procedure is described below:

- a) It was first necessary to ascertain the altitude of the spring and the difference of level between spring and village.

In most cases, the spring was located in the forest of the Troodos igneous complex and the Kyrenia

limestone range. The spring could be up to 40 kilometres away from the village, and out of sight.

- 1) In the first instance we established the level of the spring by the use of two aneroid barometers. The two barometers were set at the same reading at the site of the proposed storage tank in the village. A technical officer went to the spring taking with him one of the two barometers, while the second one was left at the site. When the officer was at the spring he recorded the reading of his barometer.

When he returned to the site of the proposed storage tank the readings of both barometers were again recorded, and it was expected that the two readings would be identical. This method was of a preliminary nature.

- 11) The second step was to take levels along the possible route of the main pipeline to the site of the proposed storage tank in the village.

The route of the pipeline was fixed roughly, by following as far as possible existing earth roads or footpaths, and through the experience of the technical officer and the foreman, who carried a reconnaissance of the area on foot.

Cadastral maps of Cyprus on the scale of 1:5000, showing contour intervals of 20 metres, were prepared by the Ministry of Defence, United Kingdom, after 1955. These maps have been extremely useful for the preliminary investigation on the elevation of the spring relative to the village datum, fixing the route of the pipeline, and calculating its approximate length. While the levelling from the spring to the village was carried out, the experienced pipelayer foreman with two labourers measured the length of the proposed main pipeline.

Because of great pressure for the preparation of more water supply schemes for the villages, we had to carry out flight levelling to gain time. In one

case we levelled from the spring along the proposed pipeline route and we reached a point from which we could see the village school. We fixed a bed sheet on the roof of the school, and continued levelling along a vertical contour until the horizontal axis of the telescope was in line with the white linen sheet.

We decided to do so because the intervening valley was deep, and if we followed the contour lines, it would take us a lot of valuable time. Also, a difference of a few feet plus or minus in the fall from the spring to the village did not interfere with the hydraulic gradient for long distance. If from a point we could look at the village and see the sea on the horizon, we were sure that point was higher than the village.

- b) The storage tank was of standard design and capacity, and its cost was known.
- c) The sites of the public fountains were fixed on site, in consultation with the village water commission. As the fixing of the site might cause grievances and objections from certain inhabitants of the village because of distance from the houses and for other reasons, we obtained the written decision of the village water commission in this respect. The sites of the proposed fountains were named in the written decision.

This having been done, the foreman could build the public fountains without disruption. Certain villages were sited on sloping land, and the difference in level between the high and lower level quarters of the village could be up to 180 metres. In view of this we had two mains starting from the storage tank, feeding the high level and low level fountains separately.

In some cases, we had to build an independent storage tank to serve the lower quarters to keep a residual head pressure of not more than 60 metres.

The provision of a low level storage tank was imperative in order to protect the taps, gate valves and other fittings against the excessively high water pressures which would be over the design operational pressures of such fittings. As usual we envisaged a residual pressure of not more than 80 metres maximum.

The fountains were provided with a 20mm bronze tap, and flow was regulated, by means of 25mm gate valve, to 20 litres per minute. The valve was installed in a rectangular cabinet on the top wall of the fountain and was protected by a locked steel cover.

d) Soakaway pit

The washout water and overflow from the trough of the public fountain were directed into a soakaway pit excavated near the fountain. The pit was on average 5 metres deep, and was covered by a roofing of reinforced concrete slab deposited on a cement concrete pit collar 0.20 metres below the ground surface.

The soakaway pits created problems because they overflowed due to the following:

- i) Some pits were excavated through a clayey stratum and had very low permeability and absorption.
- ii) The tap was left flowing to waste by some people, causing not only filling of the soakaway pit, but also emptying of the storage tank.

To prevent this negligence we installed self-closing taps. However, the women and other people did not like to hold the tap open until the amphoras or other receptacles were filled. So they tied a stone over the knob of the tap, which kept the tap open and flowing.

- iii) In cases where the soakaway pits were opened through pervious ground such as chalk formations with solution crevices and

disintegrated limestone, the water from the soakaway pit would percolate and reach the walls of houses located at a lower level in the case of hilly villages. This incidence caused real problems and strong complaints from the owners of houses affected by dampness.

- iv) In other cases, where a public fountain was located on the outskirts of the village, it was customary for the householders served by the respective fountain to use the tap water for irrigating trees and vegetables planted in the yards of their houses during the night. This interference emptied the storage tank during the night. In the morning when there was very little water flow at the public fountains and in some fountains no flow at all.

The implementation of a house-to-house water distribution service, and the disuse of the public fountains was the ideal solution, but in the 1950's the majority of villages were not ready to accept this innovation.

The letter, a standardised A6 form, is quoted hereunder:

Quote:

File No. Water Development Department
Nicosia.

Village Water Commission
of

Sirs,

You are hereby informed that on _____ a suitable
 forman will be sent to your village, to commence work on
 the Domestic Water Supply Scheme, for which the amount of
 £ _____ has been approved.

You are requested to secure suitable accommodation for the foreman and his staff.

If the above date is not suitable please communicate with this office immediately.

If by we have not received your answer, it will be considered that there are no obstacles and I will proceed with commencement of the work.

Yours faithfully,

Director

Copy to: Commissioner Water Development Department

10.5.2 Departmental Construction and Overall Control
Forms

In the period after 1948 there was significant momentum in the construction of domestic water supply schemes. It was therefore necessary to prepare construction forms, which would constitute the basis for controlling the works in hand and the expenditure. For this reason, a number of Departmental forms were prepared and put into circulation to all foremen. They have proved to be practical and useful records, as a supplement to the whole structure of standardisation.

10.6 Regional Domestic Water Supplies

The average distance between villages in Cyprus is 5 kilometres and each village had an average population of 563 persons as per the 1946 Census of population.

In cases where there was a small spring not far from a small village, an independent gravity domestic water supply scheme was prepared and constructed for that village.

In most cases, however, there was no suitable spring for bigger villages, because of their geographical situation, and due to the fact also that a pumping scheme was totally unacceptable to the villagers in those years.

It was, therefore, found necessary to use the discharge of bigger springs, irrespective of the distance involved, for a group of villages.

The high cost of headworks in such a regional gravity scheme was justified, being apportioned among the villages served. The share of each village in the cost of the scheme and in the quantity of water, was calculated on the basis of the population of each village as per the census of 1946.

Big unused springs were located within the state forest of the Troodos igneous complex, and were free from private ownership or water rights over their water discharge.

The forest springs in the island were also completely free of surface pollution and contamination, in the absence of human habitation within the forest.

10.6.1 Rough outline of regional water supply schemes completed

In an endeavour to convey to the reader of this Thesis an outline of regional village domestic supplies, a short description of selected regional schemes, covering wide regions is given below.

1) Papaloukas spring (Khyrsoroyiatissa Monastery)

Regional scheme

Papaloukas spring was the property of Khyrsoroyiatissa Monastery, situated at an altitude of 820 metres above mean sea level. It is 2.5 kilometres from Panayia village.

(As a parenthesis we would mention that Archbishop Makarios, First President of the Cyprus Republic, was born in Panayia village, where he lived the life of a shepherd boy before he was accepted at the Kykko Monastery).

The Papaloukas spring was first executed by a monk of the Monastery named Papaloukas and because of this, the spring was named after him.

The spring issues at the contact between the Lefkara chalk forming the Ayios Elias plateau reaching an altitude of 1138 metres above sea level, and the underlain formation of mamonia groups. The discharge of the spring was averaged 650 cubic metres per day in the 1950's.

In the year 1946, a group of villages, namely Phiti, Lassa, Ayios Demetrianos, Kathikas and Polemi, purchases part of the water from the Monastery for their domestic requirements. The purchase price of water was fixed at £10 per cubic metre of flow.

The quantity purchased was allocated and paid for by each village in accordance with its population, which in 1946 was as follows:

Table 10.1 Water Quantity Allocation

Village	Population in	Quantity
	1946	Allocated m ³ /day
Phiti	188	13
Lassa	242	17
Ayios Demetrianos	188	13
Polemi	304	20
Kathykas	355	24
Psathi	<u>35</u>	<u>3</u>
TOTAL	<u>1312</u>	<u>90 m³/day</u>

The share of the above villages was separated at the spring through a rectangular sharp edged weir, installed in stilling concrete box built at the point of discharge of the spring. The static head of water above the crest of the weir was kept at 150 millimetres.

The surplus quantity of water over the quantity of 90 cubic metres per day which was sold to the villages, discharged into an open rectangular masonry irrigation tank. The tank was built from Government funds, as a Government subsidy to the regional domestic water supply scheme. It was also considered that the storing of the overflow from the spring, in the irrigation tank during the night would give a substantial saving of water, which otherwise would flow to waste during the night. Thus the monastery was not deprived of its water supply by the sale of a small part of the discharge from the Papaloukas spring to the six villages. The share of each village was also effected through reinforcement cement concrete distribution boxes built at suitable places commanding the villages.

The main conveyor pipeline for the regional village domestic supplies was of galvanised mild steel to B.S. 1387 and of 100 millimetres diameter.

For the distribution system within each village the size of pipes varied from 80 to 25 millimetres in diameter. Storage tanks and public fountains were also constructed.

11) Appidhes Spring Regional Gravity Water Supply Scheme

In the Panayia Region of Paphos a number of villages were desperately in need of a new piped water supply. Until 1951 they were transporting their domestic water supply from small springs, most of which were located at a distance and at a lower level than the village.

In the year 1951, we visited Panayia village to examine springs which could be used for the domestic water supply of Panayia and other villages.

In parenthesis I should mention that for centuries before 1950 goat herds with their flocks of goats were

living in the Paphos State forest. Because of outbreaks of forest fires and for other administrative reasons the shepherds were removed from the state forests by the Government and elsewhere.

These shepherds were authorities in knowing all springs issuing out in the forest, much better than the Government forests knew. We thus used the services of an aged shepherd of Panayia, and with his assistance we traced the Appidhes spring in the Paphos state forest, issuing at a higher elevation than Panayia village (about 950 metres above mean sea level).

Regular measurements of the discharge from the Appidhes spring showed an average discharge of 17 litres per second, equal to 1470 cubic metres per day.

The chemical characteristics of the Appidhes spring water are:

pH	Total solids ppm	Cl ppm	Total hardness
7.8	195	43	175

All springs located within the state forests are free from pollution and contamination. There are no human habitations within the forest and the few wild animals living within the forest cannot in any way pollute a flowing spring.

On the basis of the above average discharge from Appidhes spring, (1470 cubic metres per day), a regional domestic water supply to serve 16 villages was prepared in the year 1951, at an estimated cost of £92,000. The scheme was approved by the villages which were included in the proposed scheme and work was put in hand towards the end of the same year.

The proposed regional domestic water supply scheme included the excavation and building of Appidhes spring, the laying of 62 miles of galvanised mild steel pipes of 100 and 80 millimetres diameter across precipitous rough country, and the construction of a distribution system consisting of

R.C.C. circular storage tanks, distribution mains and public fountains in each of the sixteen villages.

The villages served by the Appidhes scheme were:

Table 10.2 **Villages served by Appidhes Scheme**

Village	Population as per census 1946	Quantity of water allocated m ³ /day
Pano Panayia	382	35
Statos	322	30
Ayios Photios	120	11
Phalia	83	8
Pendalia	267	25
Amargeti	319	30
Eledhio	70	7
Axylou	66	6
Asproyia	134	13
Kannaviou	46	5
Mamoundali	78	7
Lapithion	<u>86</u>	<u>8</u>
TOTAL	<u>1973</u>	<u>175</u>

The above allocation of water to each village was calculated at 90 litres per head of the population as per the 1946 Census. This quantity was found to be very satisfactory for the domestic requirements of the villages, the inhabitants of which were occupied mainly in agriculture.

(Figure 10.6.2. illustrates in outline the Appidhes spring regional domestic supplies scheme, which was completed in the year 19 .

111) Arkolahania spring-regional gravity domestic water supply scheme

After the implementation of Papaloukas and Appidhes springs regional domestic water supply schemes the policy of water development was to give more consideration to regional schemes, by using springs issuing from the Troodos igneous range cone cap.

Such springs are:

1) Arkolahania spring (Mesapotamos Area)

Elevation 1120 metres above mean sea level.

Average discharge 37l/s = 3200 cubic metres per day .

Chemical data

pH	Total Solids	Cl ppm	Total Hardness
8.6	360	11	250

Water from Arkolahania spring has been piped to 14 villages which are situated in the chalky hills zone of Limassol district, constituting the wine producing area.

Inhabitants of some of these villages had to transport water from low level springs at an appreciable distance, and some villages did not even have a spring available within a radius of 3 kilometres from the village.

The water tapped from the spring was calculated at the rate of 100 litres per capita per day. In total a daily quantity of 1035 cubic metres or 30% of the average discharge from the spring was conveyed to 14 villages having a combined population of 11,327 persons.

Table 10.3 Villages supplied from the Arkohabania

Village	Population as per census of 1946	Allocation of water m ³ /day
Moniatis	334	30
Kouka	42	5
Lophos	1237	115
Ayios Georghios	173	15
Dhoros	327	30
Monagri	493	45
Ayios Therapon	354	30
Pakhna	1569	145
Pera Pedhi	445	40
Kilani	1684	155
Vouni	1391	125
Mandria	542	50
Omodhos	1208	110
Arsos	<u>1528</u>	<u>140</u>
	<u>11327</u>	<u>1035</u>

At the end of 1952, the progress of work on village domestic supplies was as follows:

		Estimated population in 1952	Per cent %
- Total number of villages listed in the 1946 census	627	389,000	100%
- Villages provided with pipes water supply	250	155,000	40%
- Villages without piped supply	377	233,740	60%

Source: Colonial Reports Cyprus, 1952.

During the period 1952-1960, work on domestic supplies for the villages and towns was much intensified.

For the rural water supplies, springs located in the state forest were mostly used, and these constituted the source of water supply for regional domestic water supply schemes.

Pumped water supplies were also constructed in villages where electricity could be made available after the completion of the first phase of the island-wide electricity grid scheme in 1953.

The source for pumped supplies were prospecting boreholes.

Prospecting boreholes which could produce five cubic metres of water per hour and over were designated as "successful". Electrosubmersible pumps were generally used in areas where electricity could be made available from the Electricity Authority's supply grid.

10.7 Pumped water supplies

The drilling of boreholes in water bearing village areas proved to be a safe source of water for the domestic requirements of these respective villages.

After 1950, electrosubmersible pumps were imported and installed in boreholes. The borehole was made safe against surface pollution while the priming of the motor pump by electric current removed the risk of pollution of the water by the use of diesel engines.

The new system of pumping water from boreholes in shallow aquifers satisfied the consumers as to the purity of their domestic water supply.

Most important the cost of pumping was low because of the high efficiency of the electrosubmersible pumps being up to 75 per cent. In 1950 the aquifers were shallow, providing lower manometric pumping head and in consequence lower electricity consumption. Maintenance and supervision expenditure for pumped supplies could be kept at the minimum, due to automation and the use of cheap electricity during off peak hours.

Electrosubmersible pumps, apart from their high efficiency in boosting water, can have a high dynamic head and can be installed at depths up to 180 metres and even more. They are easily and cheaply installed and can operate continuously for long periods, when the drawdown of water is steady and not complete.

In general, electrosubmersible pumps have many advantages in their use for pumped supplies from boreholes.

10.8 Underground water resources

Prior to 1950m no aquifers in any water bearing areas had been exploited by man. They existed in their natural state of underground storage equilibrium free from human interference. Fourteen such aquifers, having an outcrop area of the island were left undisturbed prior to the year 1950.

An investigation carried out under a United Nations Development Programme "Survey of Underground Water and Mineral Resources of Cyprus 1970", has revealed that the total water in storage in the main aquifers could be in the region of 800 million cubic metres. Apparently this was so in the year 1950.

The annual replenishment is estimated to be in the region of 350 million cubic metres.

The overflow from the replenished aquifers had caused surface ground springs, creating swamps and marshy conditions in most of the main aquifers of the island, and artesian flow conditions. In the western Mesaoria, Morphou Syriannokhori coastal zone, 8-inch boreholes drilled to a depth of up to 25 metres had a flow of over 60 cubic metres per hour at an artesian head of two metres above the ground surface level.

The exploitation of the underground resources, for domestic use and pumped irrigation, was most desirable in the 1950's. Agriculture, the main source of prosperity of the island, had to be mechanised and improved under the Ten-year Development Programme (1946-1956).

The use of the underground surplus water by extraction through pumping and keeping a lowered water table within the safe limits of replenishment too, was most desirable and advisable for agricultural production, domestic water use, and the extermination of malaria and water borne communicable diseases.

The keeping and maintaining of the island's underground water inventory was not an easy task. It needed a positive action programme embracing a technological and administrative water policy for the control and management of the underground resources of the island, maintaining a safe level of water extraction.

The co-ordination of all scientific and technical departments concerned with the development and the use of water, the enactment of adequate legislation for the control of extraction of underground water and its use, and the efficient and firm application of the Law by the District Administration Authorities and the Court of Justice were the vital elements for the achievement of efficiency in the control and management of the underground resources of the island.

The management of the underground water resources demanded decisive, realistic and constructive action from all Authorities concerned.

10.8.1 Methods of pumping water (1950)

Since ancient times water has been extracted from the aquifers through hand-dug wells opened to an average depth of 15-20 metres below the ground surface. Such wells were excavated in all coastal zone lowlands and in the water bearing areas of the plain. The mechanical means used for lifting water to the surface can be analysed as below, based on information produced in the 1946 census:

1) Water wheel (Gr. Alakati)

According to the 1946 Census there were 4830 water wheels in operation in the whole island. The water extracted was used for the irrigation of small vegetable

gardens or orchards. It was also used for drinking and other domestic purposes.

If we reckon that each water wheel could extract 12 cubic metres per day then a daily quantity of 50,000 cubic metres on average was extracted and used for irrigation and domestic purposes.

In the 1930's and 1940's water wheels were particularly concentrated in areas capped with the Kafkalla (Kokkinokho and Kokkinotrimithia plateaus), in great numbers in the middle Pedieos and Yiallias valleys, and in the Larnaca, Limassol, Paphos and Kyrenia lowlands.

ii) Windmills

Extraction of water from shallow aquifers was also effected by windmills which were imported to Cyprus from the end of the nineteenth century. They were used particularly in the Famagusta town coastal zone and its suburb village areas. In total 1,107 windmills were recorded all over the island by the 1946 Census, of which 944 or 85 per cent were installed in the Famagusta district area.

The total extraction of water through the operation of windmills was roughly estimated to be in the region of 25,000 cubic metres per day.

iii) Engine pump

By the end of 1946 a number of successful boreholes were drilled in water bearing areas having shallow aquifers. In these shallow aquifers farmers who could afford it installed small reciprocating pumps, tapping the first water. Such pumps were installed in the Famagusta, Morphou and Limassol citrus areas.

According to the 1946 Census 1394 diesel pumps were installed in open wells and boreholes all over the island. If we reckon that each low capacity pump was extracting an average daily quantity of 80 cubic metres then a total daily quantity of about 110,000 cubic metres was extracted through the operation of diesel engine pumps.

In total the daily extraction of water form the shallow aquifers of the island during the period 1940-1950 was:

Table 10.5 Total Daily Extraction of Water From
Shallow Aquifers During 1940-1950

Means of pumping	Extraction per day	Extraction per year (200 days)
i) wheel wells	60,000 m ³ /day	12M/m ³ (millions)
ii) windmills	25,000 m ³ /day	5M/m ³ (millions)
iii) diesel engine /pumps	110,000 m ³ /day	22M/m ³ (millions)
	-----	-----
Total estimated	195,000 m ³ /day	37M/m ³ (millions) 12 million m ³ etc.

According to the investigation of the United Nations development Programme "Survey of Underground Water and Mineral resources of Cyprus 1970" the annual replenishment of the aquifers of the island was estimated to be 450 million cubic metres.

If, in 1946, the total water extraction from all aquifers was roughly estimated at 37 million cubic metres per year, representing only eight per cent of the total estimated aquifer replenishment during the hydrological year, it shows clearly that the aquifers were virgin as late as in 1950, and it would be profitable to allow the extraction of more water within the safe limits between ground water replenishment and water extraction from the aquifers for irrigation.

Unfortunately the inventory of our national underground resources has not been prudently and decisively kept in proper prospective. The issue of permits by the respective authorities to private people for the drilling of boreholes, without restrictions to the quantity of extraction of water was effected in a liberal way and without the due consideration for the long term preservation of the stability of the aquifers.

The illegal drilling by private farmers was viewed by the District Administration and other Authorities with a certain amount of tolerance, and the law against illegal drilling for water was not applied decisively and effectively.

It should be stressed that while in 1946 the total area irrigated from shallow underground water was in the region of 50,000 donums (16,500 acres) by the year 1966, after a period of just over 10 years of intensive agricultural production and a fast rate of the increase in the living standards of the people, the land under perennial irrigation from boreholes had increased to 200,000 donums (66,000 acres).

In 1946, the quantity of underground water used for irrigation was about 27 million cubic metres per hydrological year. In 1966, the quantity of pumped underground water used for irrigation was 160 million cubic metres, showing an increase of 600 per cent since 1946.

The underground water used for domestic purposes represents about 45% of the quantity of water used for irrigation, being equal to about 70 million cubic metres per year.

If the above two estimated figures are added together, then a total quantity of about 230 million cubic metres was extracted from the aquifers in 1966. This represented 66% of the average yearly replenishment of the aquifers.

The lowering of the water table up to 14 metres during a period of 12 years (1954-1966) caused grave concern and presented a need for the taking of strict and practical measures by the authorities for the control of overpumping of the aquifers.

The rich aquifers constitute a steady and safe source of domestic water supply for the main towns and their suburbs and villages of the lowlands.

Expensive major pumped domestic water supply projects, having as a source of water supply the Kokkinotrimithia and Morphou aquifers, with a manageable volume of $70 \times 10^6 \text{ m}^3$ and

30 x 10⁴,^m respectively were constructed for Nicosia Water Board during 1952-1958. Both aquifers were substantially exhausted by 1966 and new sources of water demanding millions of pounds to be spent had to be used for augmenting the municipal water supply of Nicosia.

A pumped supply project was completed for Famagusta town in 1952. The sources of water were four boreholes drilled in the aquifer of West Phrenaros. By 1966, the west Phrenaros aquifer was almost exhausted by the illicit extraction of water for irrigation, and new sources of water had to be found to augment the domestic water supply of Famagusta town.

Although it may be accepted that control of the extraction and use of groundwater by the individuals involves administrative, social and even political elements causing difficulties, it must also be accepted that the underground water resources belong to the state, and it is the duty and obligation of the Authorities to take effective measures for the protection and preservation of the underground water balance.

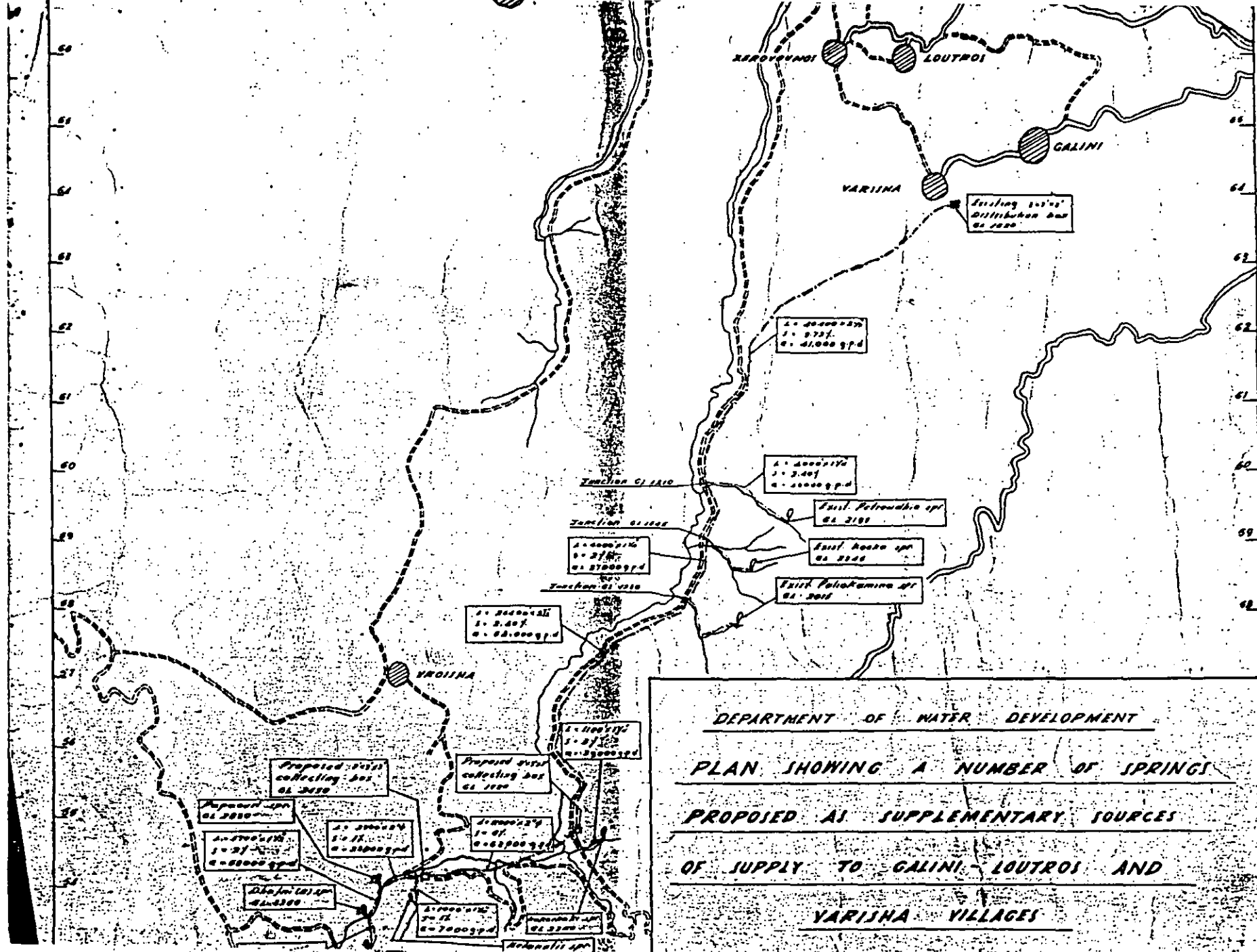
Below is an abstract from a lecture delivered at the Cyprus United Natipons Association in January 1967, on "Water Conservation Control and Planning" by Y. Hjistavrinou, Director of the Geological Surveys Department.

Page 4: "A problem associated with groundwater is the illegal drilling that has taken place. A vast number of such unlicensed wells and boreholes exist in Famagusta, Larnaca and Nicosia Districts.

Up to now, there has been very little or no planning in the exploitation of our groundwater resources. People have been allowed to pump their boreholes at whatever rate they felt like, and for as many hours as they possibly could. The result is that there has been uncontrolled extension of plantations.

Even today, in a number of areas where the groundwater situation is very serious, there is a fantastic extension of plantations going on.

Fig. 10.8 Source: Water Development Department Cyprus





PAPHOS WATER SUPPLY
(Storage Tank & Chlorination building)

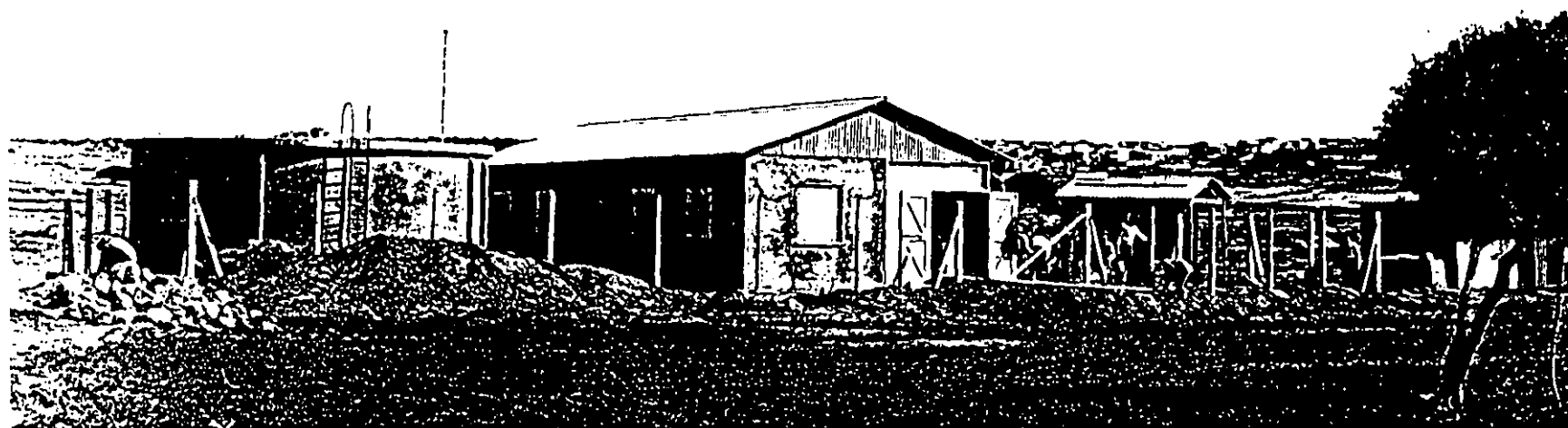


Figure 10.9 Pumping Station under construction
Source: Water Development Department

The result is, as already stated, that a number of our water producing areas have been invaded by the sea, and others have gone or are going saline because the water table has fallen to a very low level, where the mineralisation in the aquifers is high".

Summarising all the above we may say:

All underground water resources of the island belong to the state. The inability to control and prevent the practice of overpumping thus depleting the aquifer, and the illicit use of underground water for the irrigation of extensive areas to the detriment of the whole, are really most undesirable and disappointing, showing signs of luxurious inefficiency and poor management from all concerned.

10.9 Municipal water supplies

In antithesis to the well organised programme for providing piped water supply from springs for domestic purposes to the hilly village, and most important in a regional pattern serving a group of area villages, the programme for the development of municipal water supplies demanded much thought and investigation for underground water resources, by prospecting drilling.

The main towns, such as Nicosia, Famagusta, and Limassol, were in desperate need of additional water, coupled with the extension and innovation of their outdated distribution system.

Towards this goal, geological investigations and prospecting drilling were intensified, with the view to providing domestic water to the towns through pumping from nearby water bearing areas.

The population of the towns in mid 1952 was estimated to be:

Nicosia (excluding suburbs)	40,000
Limassol	27,000
Famagusta	20,000
Larnaca	16,000
Paphos	6,000
Kyrenia	3,000

10.9.1 Famagusta town water supply

In the year 1950, the water problems of Famagusta needed immediate attention (Vide para 9.34 page 86). The only solution was to convey additional domestic water to the town by pumping from underground water resources.

Towards this end prospecting drilling was carried out, and in 1952 a rich free aquifer, in the Phrenaros area, south west of Famagusta, was discovered. Several boreholes were drilled through this aquifer, at the average contour line of 55 metres above mean sea level. The general lithology of the prospecting boreholes was:

Table 10.7 General Lithology of Famagusta Boreholes

<u>Depth</u>	<u>Geological Strata</u>
0.25 metres	white chalk
25-38 metres	Water bearing sandstone
38-55 metres	White hard sandstone composed of cemented shell fragments
50-55 metres	Black clay

Yield of Boreholes

The prospecting boreholes, after a long test pumping, proved to have a safe yield of 25 cubic metres per hour with a drawdown of two metres.

The quality of the underground water was very satisfactory showing NaCl 114 ppm, and low total hardness (as Ca CO₃).

In 1952, the static water level in the aquifer was 28 metres above mean sea level, showing a depth of 24 metres below the ground surface.

On the basis of the tested average yield of each prospecting borehole (25 cubic metre per hour), four boreholes were drilled at a distance of 300 metres apart and developed as the source of domestic water supply for Famagusta town.

In 1952 Famagusta had an estimated population of 20,000 persons needing a daily water supply of 2,700 cubic metres for domestic purposes.

The existing municipal water supply of Famagusta was derived from two shallow wells in the Stavros locality and the Panayia spring issuing from the thin limestone formation near Cape Greco, in the Paralimni village area.

i) Stavros wells

The two wells at Stavros were the main source of domestic water supply for Famagusta. A daily quantity of about 600 cubic metres was pumped from the two wells in the years 1945. By the year 1952, the yield of the two wells was declining steadily, showing also high chloride contents due to increasing pumping for new orchards. Most regrettable was the building of residential houses in very close proximity to the two wells, which constituted a real danger of pollution and contamination of the shallow aquifer, through which water was infiltrated into the two wells at Stavros.

ii) Panayia Spring

Panayia Spring was excavated and developed during the Venettian period (1489-1571). The discharge of the spring, averaging 300 cubic metres per day, was conveyed to Famagusta through a closed masonry aqueduct.

In 1950, the Panayia aqueduct was replaced for the greater part of its length by the laying of steel pipes, 200mm in diameter, in the order to prevent the water loss from leakages through the masonry aqueduct.

The total water available for Famagusta Town from the two water sources, namely Panayia spring and Stavros wells, was in the region of 900 cubic metres per day in the period 1945-1950. At that time Famagusta was to an appreciable extent an agricultural town with citrus orchards. Each orchard was irrigated by means of a windmill or windmills, depending on the size of the land holding. The farmer built his house among the orchards. The water pumped by the windmill was also used for the domestic requirements of the family or families living within the citrus orchards.

Bearing in mind that within Famagusta municipal limits over five hundred windmills were in operation it may be considered that Famagusta residents representing 15-20 per cent of the total population were obtaining their domestic water by means of windmills. In the 1940's Famagusta was known as the "Town of Windmills". By the year 1950, the aquifer within Famagusta municipal boundaries was declining, and the water was polluted by the extension of the residential area, resulting from the fast growing urbanisation.

In order to solve the declining domestic water supply problem and that of pollution of the shallow aquifer by the infiltration of sea water, there was a pressing necessity for a new water supply, demanding that a scheme be prepared for the conveyance of a new water supply through pumping from four boreholes drilled for this purpose through the Phrenaros west aquifer.

In 1951, the Famagusta Water Board was set up, under the "Water Supply (municipal and other areas) chapter 250 of the Laws of 1951. The Board consisted of three persons appointed by the Governor to hold office for four years, and three ex-officio members, the District Officer, the Director

of Water Development and the Accountant General. The District commissioner was the President of the Board.

The responsibilities of the Municipal Council regarding the water supply of the town were passed over to the Water Board.

During 1951-1952, the first phase of the Phrenaros west pumping scheme was designed and approved by the Board, and work was put in hand. The first phases was completed in 1952.

The pumping scheme involved the following:

- Electricity was provided at each borehole and four Beresford electrosubmersible pumps of semi-acial type were installed in the four boreholes. The capacity of each pump was 25m³/hour against a total manometric head of 50 metres.
- The water from the four boreholes was collected in a balancing tank built on the 75 metres contour line near Phrenaros village.
- A steel conveyor pipeline of 200 millimetres diameter and 11.5 kilometres long was laid from the balancing tank at Phrenaros to a masonry storage tank, built at the high ridge site of Stavros in Famagusta, where the two wells were located. The storage reservoir had a capacity of 900 cubic metres.
- Simultaneously, with the conveyance of additional domestic water to Famagusta, a new distribution system was installed within the municipal area of Famagusta town. The grid consisted of asbestos-cement-pressure pipes the minimum size of which was 100 millimetres.

A 300 millimetre ring main was laid from the storage reservoir, and the zones of water supply into which the municipal area was divided, were connected on to the ring main.

All residential houses, hotels and public buildings were connected to the water distribution system.

The cost of house connections, including the service pipes and the water meter, was borne in total by the consumer.

The quantity of water conveyed to Famagusta town by the pumping scheme, completed in 1953, was in the region of 2000 cubic metres per day.

If we reckon that the population of Famagusta in 1952 was 20,000 persons, then the additional share of water per capita per day was 100 litres. An additional supply of 15 litres per capita per day was conveyed from the existing source of Panayia spring, which was a bacteriologically safe supply and was producing an average daily quantity of 300 cubic metres.

A wall mounted chlorine gas chlorinator, manufactured by Paterson U.K, was provided for the sterilization of all domestic water before it flowed into the storage reservoir.

The chlorination of water made it possible to use the two wells at times of peak consumption.

During the period 1953-1955, a second pumping scheme was constructed from new boreholes drilled in a new aquifer north of Phrenaros. An additional water supply of 2250 cubic metres per day was conveyed to Famagusta. Two new storage reservoirs and extension of the distribution systems were constructed as part of the new pumping scheme.

The new pumping scheme was constructed for the Water Board by the Water development Department at a total cost of £290,000.

The total water available during the year 1960 was in the region of 4,500 cubic metres per day. In this year Famagusta town had a population of 35,000 persons.

The above daily quantity of 4,500 cubic metres gave a share of 128 litres per capita per day.

In 1960 Famagusta embarked on the tourist industry, new hotels were being built and an acute shortage of water was experienced during the summer. In order to alleviate the shortage, the supply was cut off during the night and only

in the coastal zone where the hotels were located was the supply continuous.

Another effective control measure, taken on our directions was the application of the saccoraphi system, reducing the flow through all 15 millimetre meter. Such a meter will allow a flow of 3-5 cubic metres per hour, depending on the pressure in the service pipes. By inserting two bronze discs having an orifice of only 2 millimetres within the couplings of the meter, they act as flow limiters and the quantity of water passing through the meter is greatly reduced. The reduction in the rate of water delivery to the consumer prevents excessive water withdrawal at peak hours of consumption and keeps the pressure in the mains constant as far as possible, and the water takeoff from storage reservoirs is more stabilised.

Our experimental saccoraphi system of control in Famagusta in 1955-1959 has not found support from other Water Boards such as Nicosia, where there has always been acute shortage of domestic water supply.

Famagusta in 1960, was in need of additional water supply. The expansion of tourism causing rapid increase of the town's population, and also the continuous decline of the Phenaros aquifer, demanded additional water supply from new sources.

It was apparent that the water sources of Famagusta town in 1960 could not survive for long, in view of the steady lowering of the static water level in the Phrenaros aquifer, resulting from overpumping for irrigation.

10.9.2. Nicosia water supply

Prior to 1950, the water supply of Nicosia was obtained from the Arab-Ahmet chain-of-wells, and shallow wells opened through the Kafkalla limestone-capped plateau and the Nicosia sandstone plateau. In total 12 private water companies were supplying water to the residential area outside the Venetian Walls surrounding Nicosia old town.

The domestic water supply of Nicosia in 1950 was most inadequate; the average share per capita per day was less than 25 litres, and there was no water distribution system in the real sense. The twelve private companies were supplying water susceptible to pollution and contamination without it being sterilized through chlorination or other means.

It was therefore imperative that a new water supply was conveyed to Nicosia, a new distribution system was installed, and that the administration and maintenance was undertaken by a central authority, having regard to the fact that a domestic water supply cannot be left in the hands of incompetent private companies. Towards this goal, the Nicosia Water Board was set up in 1951 for the purpose of supplying water within the Water Board area, including the whole municipal area, and part of the suburb area. All the twelve private companies were acquired in 1953.

10.9.2. Water Projects for Nicosia (1952-1959)

During the period 1952-1959, the Water Development Department designed and constructed two major water supply projects, the first for the Nicosia Water Board, and the second as a Government Project. The first project (1952-1955) included the conveyance of water from boreholes drilled in the Kokkini Trimithia plateau aquifer, the upper Arab Ahmet, boreholes at Laxia and Makedonitissa. A masonry reservoir of 3,500 cubic metres capacity was built on the bypass high ground of Nicosia (elevation 200 metres above mean sea level).

Also a distribution system was installed within Nicosia Water Board area of water supply. The supply of water to each consumer was controlled through the installation of water meters.

The second water project was designed and executed during the period 1956-1959. This water project included the conveyance of water from boreholes drilled through the Sykhari Kyrenia limestone aquifer and in Dali village,

Yiallias river alluvial valley, on the northern outskirts of the village towards Potamia.

New storage reservoirs were constructed on the high ground of Engomi, Lakatamia and Hamit Mandres villages. The 1956 water supply project was constructed from Government funds, and was administered by the Water Development Department. It supplied water to the Greater Nicosia Water Supply Area, which included also the suburbs of Nicosia town.

The Water Board looked after the two Nicosia Water Supply Areas, and the control of distribution and collection of water rates was in the hands of the Board.

In the summer of 1959, the total daily quantity of water supplied to Nicosia consumers was in the region of fourteen thousand cubic metres. In accordance with the Demographic Report of 1982, in the Census year of 1960, the population of Nicosia, including the suburbs, was 95,000. So the share per person per day was 150 litres.

10.9.2.2 Morphou Bay project

By the year 1960, the Kokkini Trimithia aquifer was showing signs of decline, resulting from uncontrolled pumping. This aquifer constituted the major source of domestic water for Nicosia, and its decline was a serious warning to the Water Development Department that plans for new additional water supply for Nicosia should be given serious and early consideration.

A safe source of supply was offered by the rich aquifer of western Mesdaoria Morphou Syrianokhori coastal zone.

In 1956 the Cyprus Government engaged Howard Humphreys and Sons, Westminster Consultants, for the Morphou Bay, Nicosia Pumped Water Supply Project.

The design of the water project was completed in 1957. It included the installation of electrosubmersible pumps in boreholes to be drilled along a zone parallel with the seashore and the construction of the main pumping station

from where the water would be pumped to Nicosia through a 39 kilometre steel pumping main 450 millimetres in diameter at the total manometric head of 244 metres.

In 1958 the Cyprus Government gave orders for the supply of the pumping plant, the 450mm, nominal diameter steel pipes, and all pipe fittings and other accessories.

Through the first phase of Morphou Bay Pumping Project, an additional 9,000 cubic metres per day of water were conveyed to Nicosia.

However, the continuous decline in both aquifers, Kokkinitrimithia and Morphou Bay, resulting from uncontrolled and illicit overpumping for unlimited areas of irrigation, was causing serious concern to the Authorities. They were becoming conscious of the adverse conditions created by the illicit use of the underground water resources by the few for their economic interest to the detriment of the general public and the country.

The underground water resources of the island were limited. The replenishment of the aquifers was restricted, being influenced by the hydrological year's precipitation, averaging only 505 millimetres.

Prudent and efficient management of our rich underground water resources, has been a serious challenge to all concerned.

10.9.3 Limassol water supply

Until the year 1953, Limassol town was supplied with water from the Chiflikoudhia chain-of-wells and two small springs.

In 1951 a Water Board was set up in Limassol, for the purpose of taking over all responsibility for the domestic water supply of the town.

After the setting up of the Limassol Water Board the Water Development Department designed and executed a new gravity water supply project which was completed in 1955. The project included the conveyance of the discharge from three springs, namely Kephalovrysos, Kria Pighadhia and

Mavromatas. All these springs discharged through the white chalky banks of Kouris river, where a major dam is now being built.

A 300mm steel pipe 22 kilometres long, was laid from the springs to Limassol, where a rectangular masonry reservoir was built on high ground (65 metres above mean sea level).

A new distribution system was installed within the Limassol Water Board area of supply and all consumers were supplied with a pressurised water supply. The consumption of water was controlled through multijet inferential 15mm water meters installed in all house connections.

The daily quantity of water that could be gravitated through the conveyor pipeline and flow into the storage reservoir was seven thousand cubic metres.

In 1955, Limassol had a population of 35,000 persons. The average summer share of domestic water to each person was almost 200 litres per day. During winter, when the water consumption was at its maximum, the surplus was directed into the Chiftlijoudhia chain-of-wells, the old source of supply, for its recharge.

The gravity water supply of Limassol was quite satisfactory until the year 1960, when the population was 543,500 persons (census of 1960).

The discharge from the springs was not affected by human interference as happened in the case of the underground water resources. The hydrological behaviour of the three springs supplying water to Limassol was in the state of equilibrium reached after thousands of hydrological years.

10.9.4 Larnaca, Paphos, and Kyrenis Towns Water supply

As late as 1963, the domestic water of Larnaca town came from the very old Abu Bekir Pasha chain-of-wells, excavated in the year 1945.

The water supplied to Larnaca from the chain-of-wells was administered by Evcaf, a Turkish religious institution. The water rates collected went to the Evcaf treasury.

No significant work was carried out for the improvement of the Larnaca water supply from 1945-1960.

This was due to the fact that Evcaf did not have adequate funds for major water developments and most important, the supply and administration of the town's domestic water supply by Evcaf was creating stagnancy in public water improvement, inefficiency and legal problems for updating and augmenting the Larnaca water supply in general.

A good step towards the improvement of the Larnaca domestic supply would have been the setting up of a Water Board in Larnaca, but this proposal could not materialise, because of strong objections from Evcaf. In view of the above, the water problem of Larnaca was not tackled until 1963.

10.9.4.1 Paphos and Kyrenia water supply

Some minor improvements were carried out to the distribution system of these two small towns between 1946 and 1960. They had a combined population of less than 10,000 persons (Paphos 5803, Kyrenia 2616) as per the 1946 census rising to 13,020 (Census of 1960).

The municipal council wanted to have a gravity water supply from springs irrespective of distance.

A scheme to convey 1340 cubic metres of water to Paphos from Trozana springs, 40 kilometres from Paphos, at a cost of £200,000, did not materialise.

In the case of Kyrenia, the Municipal Council were pressing for the conveyance of water from Lapithos and Karavas springs, but this proposal met the strongest objections from the two villages Lapithos and Karavas, owners of the springs, and because of these objections, and the fact that as an alternative water could be pumped from

the Kyrenia limestone aquifer, the water supply problem of Kyrenia was not solved until 1964-1965.

CHAPTER ELEVEN

EPILOGUE

11.1 End of British rule in Cyprus

The British rule over Cyprus came to an end on the 16th August 1960 after a period of 82 years (17th April 1878 - 16th August 1960). (Figure 11.1).

By the Zurich and London Agreements signed on February 11th 1959 and February 17th 1959, Cyprus was proclaimed an Independent Republic at midnight 15th August 1960. In the morning Archbishop Makarios was invested as President of the Cyprus Republic, and on the same day Sir Foot sailed from Famagusta on board H.M.S. Chichester.

The overseas British officers were progressively released from the Public Service, and their senior posts were taken over by Cypriot Officers. Sir Hugh Foot, on his departure, commented that he was leaving behind a most efficient and highly trained Cypriot Civil Service, capable of taking over the Civil Service responsibilities.

11.2 Progress on domestic supplies (1946-1960)

During the above period, under the Water Development Programme, the supply of piped water to the villages and towns was outstanding.

11.2.1 Rural water supplies

In 1946, very few villages had a piped supply, and this was only available in a rectangular storage tank with troughs along its sides in the square of the village.

At the end of 1959, out of the total of 627 villages named in the Census of 1946, piped supplies and public street fountains were provided in 525 villages, serving 83.75 per cent of the rural population. Of the total 525 villages which had a safe piped domestic water supply, 380 villages, or 60 per cent of the total rural population, had

a supply of over 50 litres per capita per day. (Table 11.1).

Table 11.1 Number and percentage of villages with piped domestic supply end of 1959

Villages with piped water			Villages with no piped water	Total villages as per 1946 Census
Satisfactory	needing improvement	Total		
No	No	No	No	No
Total 380	145	525	102	627
% 60,60	23,13	83,75	16,25	100

Note: The above figures have been extracted from the last Colonial Annual Report ("Cyprus 1959" p.69).

- A piped water supply was considered satisfactory when the share of water at the public fountains was over 50 litres per capita per day of the village population.
- In villages where the standard of living was rising, demanding better housing with adequate hygienic facilities, the quantity of water needed for a satisfactory supply was 100 litres per capita per day. Therefore some supplies that were previously satisfactory needed augmentation and improvement.

There were 145 villages needing fundamental repairs to their domestic water supply, extension and additional water.

There were also 102 villages still without piped supply. These villages were on the whole situated in the Plains far from reliable water sources, such as springs.

11.2.2 Urban water supplies

By the year 1960, Nicosia, Famagusta and Limassol had a new water supply and a new distribution system, coupled with a house-to-house service. The water supplied was



The arrival of Sir Garnet Wolseley, first British High Commissioner in Cyprus, for his swearing-in ceremony at Nicosia. (Reproduced from "The Graphic" of 17th August, 1878, by kind permission of "The Illustrated London News.")

Fig.11.1 Source:Cyprus 1959



The departure of Sir Hugh Foot, last British Governor of Cyprus, following the declaration of independence of the Republic on 16th August, 1960

LONDON Her Majesty's stationery office.



*The Governor, Sir Hugh Foot, G.C.M.G., K.C.V.O., O.D.E., with
Archbishop Makarios, President-elect of the Cyprus Republic, and
Dr. Fazil Kutchuk, Vice-President-elect*

FIGURE 11.2 Source: CYPRUS 1959
LONDON Her Majesty's Stationery Office

bacteriologically sterilized through chlorination, and properly metered.

11.2.3 Sub-division of period 1946-1960

The above period may be sub-divided into three periods of activity on domestic water supply projects:

- i) The years 1946-1950 are considered a period of organisation and training in the design and construction of domestic water supply schemes.
- ii) The years 1950-1955 were a period of intensive activity in the design and construction of domestic water supply projects in 380 hilly villages and Nicosia, Famagusta and Larnaca towns.
- iii) The years 1955-1960 constitute a period of political turbulence. However, this political turbulence did not disrupt the intensive domestic water supply programme, which was executed by the British and Cypriot officers staffing the Water Development Department.

11.2.4 Waterworks, remains of the British rule of Cyprus

Cyprus was conquered and culturally influenced by a number of Nations, all of which have left structural remains of their rule, those with a public health importance are given below in historical sequence. They have left:-

- a) The Greek settlers - their pipelines and the cisterns;
- b) The Romans - the aqueducts, the baths and water borne systems;
- c) The British the cement concrete dams, the concrete channels, the circular reinforced cement-concrete water tanks, R.C.C. public fountain and the ex-filtration galleries in river beds and alluvial banks. In the field of water development, they left behind a well organised and efficient team of experts, well qualified in the design and execution of domestic

supplies and other waterworks, in a semi-arid country, where the water resources are limited, needing special development, use and management.

The water development structures in the 627 villages and the six towns of Cyprus, in rivers and springs, on the hills and in the plains will remain there for thousands of years, as a testimony to the British water engineering carried out during the British rule of Cyprus, (1878-1960).

CHAPTER TWELVE
REPUBLIC OF CYPRUS DOMESTIC WATER SUPPLIES
Period 1960-1980

12.1 On 16th August 1960, the Cyprus Republic was established. In accordance with the Constitution of the Republic ten ministries were created namely:

1. Ministry of Finance
2. Ministry of Commerce and Industry
3. Ministry of Labour and Social Insurance
4. Ministry of Agriculture and Natural Resources
5. Ministry of Interior
6. Ministry of Communications and Works
7. Ministry of Health
8. Ministry of Defence.
9. Ministry of Foreign Affairs
10. Ministry of Justice.

The Water Development Department was one of the five Departments constituting the Ministry of Agriculture and Natural Resources namely:

1. Department of Agriculture
2. Department of Water Development
3. Department of Forestry.
4. Department of Veterinary Services
5. Department of Animal Husbandry.

12.1.1 Transitional period

During the transitional period of 1960 the withdrawal of the Overseas British Civil Service Officers, holding the posts of Director, Assistant Director, and all other Senior Administrative posts created an apparent vacuum, which coupled with the change of Government, resulted in a temporary restriction and slackness in all development programmes, including the water development construction work.

The Cypriot technical staff of the Water Development Department in August 1960, consisted of:

Civil Engineer	1
Superintendent of Works	1
Senior Inspectors of works	4
Inspector of Works	8
Chief Foremen	3
Assistant chief foremen	2
Technical assistants	23
Foremen	73
TOTAL	115

The above staff was joined by two Cypriot graduates of British Universities, one in Civil Engineering and the other in Geology. The senior technical staff of the Department were well qualified and able to continue the water development work, particularly in the field of domestic water supplies, minor irrigation works and drilling.

The posts of Assistant Director, Senior Water Engineer and Engineer-Hydrologist were filled by senior professional staff members of the Department, and by the first quarter of 1961 the Department was ready to undertake the first five year water development programme commencing in 1961.

12.1.2 Progress in water development

In the year 1961, funds were made available for a Five-year Development Programme, the implementation of which demanded diligence and exceptional experience, which the Government Civil Service certainly possessed.

12.1.3 Domestic supplies

In the field of planning, designing and execution of domestic supplies the technical officers staffing the Domestic Water Supplies Division of the Department were well qualified

to continue the development programme with efficiency and ease.

These advantageous factors were the result of the standardisation adopted in village domestic water supply projects since 1950, the experience gained by the technicians and artisans through a long period of training and the encouragement and help afforded to the field workers by the supervising technical staff.

The Cyprus Government gave priority to the village water supplies development programme, and had full confidence in the Water Development Programme.

It is worth mentioning that of the total funds amounting to £1,150,000, allocated for water development work in 1951, £830,000 (72%) was allocated for village domestic water supplies. The writer of this Thesis was the most senior officer in the Department when the Overseas British officers left the island. As such he was called to the meeting of the Council of Ministers when the Development Programme was considered.

The Government wanted to boost the construction of village domestic supplies, to offer employment to the people of the rural areas where unemployment was prevalent and also to satisfy the rural people by providing piped water supply to as many villages as it could in the shortest possible time.

Fortunately, we had village domestic water supply schemes worth over £1,000,000 ready in design. These schemes were prepared before 1960 and only the usual administrative formalities were needed, such as approval of the scheme, issue of loan etc.

The President of the Republic, Archbishop Makarios, was very pleased to hear that so many water supply schemes were ready in design, and wanted to know whether the staff of the Domestic Water Supplies Division of the Department could execute the year's programme during the remaining eight months of the year 1961. Our answer was:

"The number of technical staff is inadequate, but the enthusiasm and will is great. It is the opportunity

for all members of the Water Development Department to work hard towards an exceptional activity in order to make the young Cyprus Republic universally enviable".

It was the duty of the few to do so much for the welfare of the many as a gentle contribution to the prosperity of the newly born Republic of Cyprus.

12.1.4 Progress on village water supplies in 1961

The amount of £850,000 was earmarked for the village water supplies by the Council of Ministers and orders were given for the allocation of the funds for this Government activity.

The following extract from the Annual Report of the Republic of Cyprus for the year 1961 is illustrative of the work done during the year on village water supplies.

Quote:

"The work of the village water supply section is confined mostly to water supplies for villages and rural municipalities, but it also includes the towns of Paphos and Kyrenia.

The amount of funds allocated in 1961 for village domestic water supplies was £850,000 which is almost five times the amount spent on village domestic supplies in any other previous year during the life of the Department.

During the year 1961, 106 village water supply schemes serving a population of 75,300 persons, were completed. 358 miles (576 km) of pipes of various sizes were laid. 123 reinforced concrete tanks of a capacity of 1.5 million gallons (6750 cubic metres) and 187 public fountains were constructed. Twenty three pumping houses were also erected. Of the 105 village water supply schemes constructed during the year, 57 were completely new, and the remaining ones were complete replacements to existing supplies that had become unsatisfactory or had deteriorated and were unserviceable.

In addition to the 106 schemes completed in 1961, a further 20 schemes were under construction. Plans have been completed for a further 130 village water supply schemes".

The above outstanding results have been achieved due to the following favourable factors.

a) All members of the technical staff executing the programme, were enthusiastic and determined to offer all their strength for the prosperity and welfare of the newly proclaimed Republic of Cyprus.

b) A substantial contribution was the unlimited help offered by the District Administration and the public. The allocation of funds in the quickest way, coupled with appreciation and assistance from the President of the Republic and the respective ministers was a further factor.

In Cyprus, being a small country, the gap separating the Government, the Department and the public is microscopic.

c) All village water supply schemes were standardised in design and construction. Thus the technical staff were very conversant with the design and construction of domestic water supply schemes, while technicians were experienced in the improvement of springs, pipelines and distribution systems.

The overall knowledge and experience of the technicians and artisans was gained through their engagement in all work activities involved in a gravity or pumped water supply scheme.

12.1.5 Town water supplies

i) Urban population

According to the results of the Census held in 1960, when the Republic of Cyprus was born, the urban population was 206,300 persons.

They lived in six towns as follows:

	Town	Population in 1960
1.	Nicosia and suburbs	95,500
2.	Limassol	43,600
3.	Famagusta	34,800
4.	Larnaca	19,800
5.	Paphos	9,100
6.	Kyrenia	<u>3,500</u>
	TOTAL	<u>206,300 (36%)</u>

- ii) The rural population in 1960 was 371,300 (64%)
Total population of the island was 577,600.

During the year 1961, practically no improvement work was carried out to augment the water supply of the six towns of the island. The migration of the young people from the rural areas into the towns accelerated in the 1960's.

Because of the declining of the aquifers from where water was conveyed to the towns during the period 1950-1960, resulting from uncontrolled overpumping usually by irrigators, the existing towns supplies were becoming inadequate during summer, and after 1960 it was necessary to find new additional water resources and implement new water supply projects.

After 1960, the urban population was expanding and the growth of the tourism industry accelerated, all demanding additional water supply.

The water problem after 1960 had three equally important features. A pre-estimated quantity of water to be

allocated for irrigation and domestic purposes and the keeping of a safe balance in the inventory of water resources represented three sides of a triangle, all of equal importance.

The control and use of the water resources of the island was a serious challenge to the government authorities, creating the necessity for the maintenance of an equilibrium in the consumption of water for domestic and irrigation use.

12.2 Pumped domestic water supplies

The majority of domestic water supply schemes constructed after 1960 were pumped supplies from boreholes.

Most of the springs located within the State forests had been used for Regional gravity village water supplies, and by the year 1960, all hilly villages had a satisfactory domestic water supply.

The villages situated in the lowlands and Mesaoria plain had to be supplied from boreholes, drilled in the water bearing areas of western Mesaoria, south eastern Mesaoria, Akrotiri, Karpas Peninsula, Kouris valley, Kyrenia range, Paphos and Polis.

During the first five years development programme of the Republic, commencing in 1961, work on providing domestic supply to villages by pumping was significant.

A major contribution to this outstanding activity has been the provision of electricity to the pumping stations, from the island-wide electricity grid. Because of the importance of electricity as a factor contributing to activity on pumped water supplies. I think it is worth including in this thesis a historical precis of the Electricity Authority of Cyprus.

12.2.1 Electricity

The question of an island-wide electrification scheme was first considered by the Government of Cyprus in 1944.

During 1949 the Consulting engineers, Sir Cyril Kirkpatrick and Partners, selected a site at Dhekelia in which

the power station was erected. Building work commenced at the Dekelia site on the 20th March 1950.

In conformity with the electricity Development Laws 1952, the Electricity Authority of cyprus was constituted on 30th October 1952.

By the year 1960, when the British rule over Cyprus was terminated, Electricity supply was provided from the Dhekelia Power Station Grid to all towns and 93 village communities. In 1961 the Authority was supplying 104 village communities with Electricity.

At the end of 1959 there were in service 525 kilometres of 66,000 volt transmission lines, 814 kilometres of 11,000 volt lines and cables, and 1158 kilometres of 415 volt lines and cables. In total 72,900 consumers were connected to the supply of 240 volts, AC 50 cycles single phase for lighting and domestic requirements. Supply of 415 volts, three phase 50 cycles AC was provided for power users.

(Source: *Electricity Authority of Cyprus*)

- First Annual Report 1952.

- Cyprus 1959 Her Majesty's Stationery
Office, London.

12.3 Domestic water supplies (gravity and pumped)

The development of domestic water supplies for villages can be divided into two phases, namely:

1) Phase I (Period 1946-1960)

This period was the start, intensification and more or less completion, of village gravity domestic water supplies, using as the source of supply natural springs flowing perennially.

At the end of 1959, 528 villages, most of which were situated on the sloping grounds of the Troodos Igneous Massif, and the Kyrenia Limestone range, enjoyed a piped gravity supply, from flowing springs, safe from contamination and of excellent chemical characteristics.

During the Phase I of development of village domestic water supplies (period 1946-1960), all the 527 village domestic water supply schemes completed were of "Village Standard" type, serving 72% of the rural population.

"Village Standard" means the distribution of domestic water, is effected through street RCC fountains only, and not house service connections on distribution pipelines.

For a group of 5-8 houses a public fountain, with trough and drainage system leading the waste water from the fountain trough to a soakaway pit, was provided.

The water consumption through a village standard distribution system, when the water was fetched to the house from the nearest public fountains, was on the average 70 litres per capita per day.

ii) Phase II (Period 1960-1974).

After 1960, the Department gave more priority to providing water to the villagers, through pumping from boreholes drilled for this purposes in all water bearing areas of the island, in the Mesaoria plain and the coastal zones.

Pumped supplies included the installation of turbine pumps driven by a diesel engine in a number of cases when electricity could not be made available. In the majority of pumped water supply schemes, electrosuimmersible pumps were installed. These pumps were of semi-axial or free flow design, and had an efficiency of up to 75%. In accordance with the EAC regulations the starting current should be 1.5 times the total load current, and as such the starters were of the autotransformer type.

Water from the borehole is pumped into a ground level or elevated reinforced cement concrete tank resting on an RCC trestly, 13 metres high. The function of the storage tank is to provide water storage for 1-2 days supply, and in cases to function as a reservoir from where a continuous quantity of water can be withdrawn.

The largest covered storage reservoir for which we had prefabricated moulds was of 450 cubic metres capacity.

Phase (iia) Control

In all pumping stations automation was provided by the installation of mercury float switches in the balancing tank. This was very practical, and economically useful to the effect that no supervisor was needed at site. A nomina sum was paid to the rural constable of the village, to visit the pumping station once a week for a visual inspection.

In cases where the storage tank is far away from the pumping station, the control of pumping is effected through a pressure switch installed within the pumping station.

A ball valve is installed on the outlet of the delivery pumping main discharging into the tank. As soon as the tank is full, the closing of the ball valve creates pressure at the pressure switch in the pumping station and the current is automatically cut off. In order to prevent a surge of water by the quick closing of the ball valve, a small size bypass pipeline with free outlet is installed on the delivery pipe before the ball valve.

Phase (iib) Electricity supply during off-peak hours

The supply of electricity for power use is sold at very low rates during the off-peak hours of consumption, (1-4 p.m. in daytime and 9-6 at night).

Practically, for all pumped supplies, this very low cost of supply, being 60% of the standard rate for continuous supply, has been used. Technically, this method has been satisfactory for village pumped domestic water supplies.

Phase (iic) House to House distribution system

When the first five year's development plan was put in hand by the Cyprus Republic, and we embarked on the design and execution of pumped water supplies for villages, there was persistent demand for a house-to-house service.

The standard of living was rising steadily and the housing in the rural areas was designed on up to date hygienic requirements. Therefore, a water supply in the house having a water borne sewage system, was absolutely necessary.

With regard to the quantity of water available, there was no problem in the real sense, because the boreholes were producing more water than the domestic requirements of the individual village, even when the pump was operating during twelve off peak hours.

The difficulty was in having available the cost of the house connections and the water metres, when the scheme was put in hand. The estimated cost of the village standard domestic water supply was shared between the Government and the interested village on a fifty-fifty basis. The extra cost of service connections to the house, and the meter, was borne entirely by the householder.

We have overcome this minor problem by including in the estimated cost of the supply and installation of the service pipes, that from the distribution water main to the water meter, as a supplement to the main scheme. This being so, the interested village could obtain a loan from the Government Loan Commissioners at the low 4% interest paid for domestic supplies with the repayment within a period of 15 years.

The village water commission was responsible for the fixing and collection of the rates of the sale of water to each consumer, to pay the annual instalment towards the load and also to pay the cost of operation and maintenance of the pumping scheme.

12.4 Design of the house-to-house distribution system

12.4.1 Rate of water consumption

For the design of a village house-to-house distribution system the optimum rate of supply considered was 130 litres per capita per day, in the year 1963.

If it is reckoned that each family living in a house numbers five, then the daily consumption per household is estimated at 650 litres. For the purpose of design this

figure was increased to 2,000 litres per day to cover the increase of population and the useful life of the pipeline estimated to be 25 years. The figure of two cubic metres per household was decided arbitrarily.

The increase in rural population was seriously affected by the attraction of urbanisation, resulting in a decline in the population of the hilly villages, the young people of which have been continuously moving and settling in villages close to the towns. For this reason, however, and the fact that the housing facilities in villages close to the towns were of high hygienic standard and the figure of two cubic metres per household considered for a house-to-house system has been proved to be suitable.

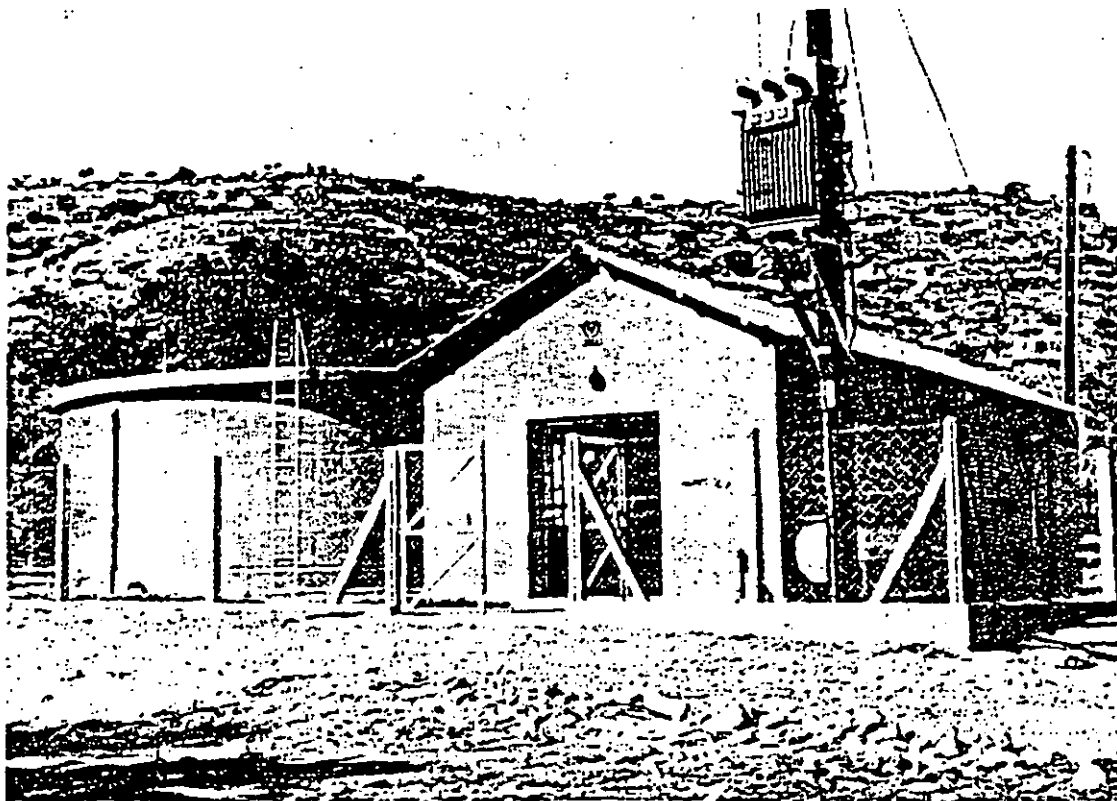
12.4.2 Closed type pressure network system

This type of system has been applied for the design of the house-to-house distribution service.

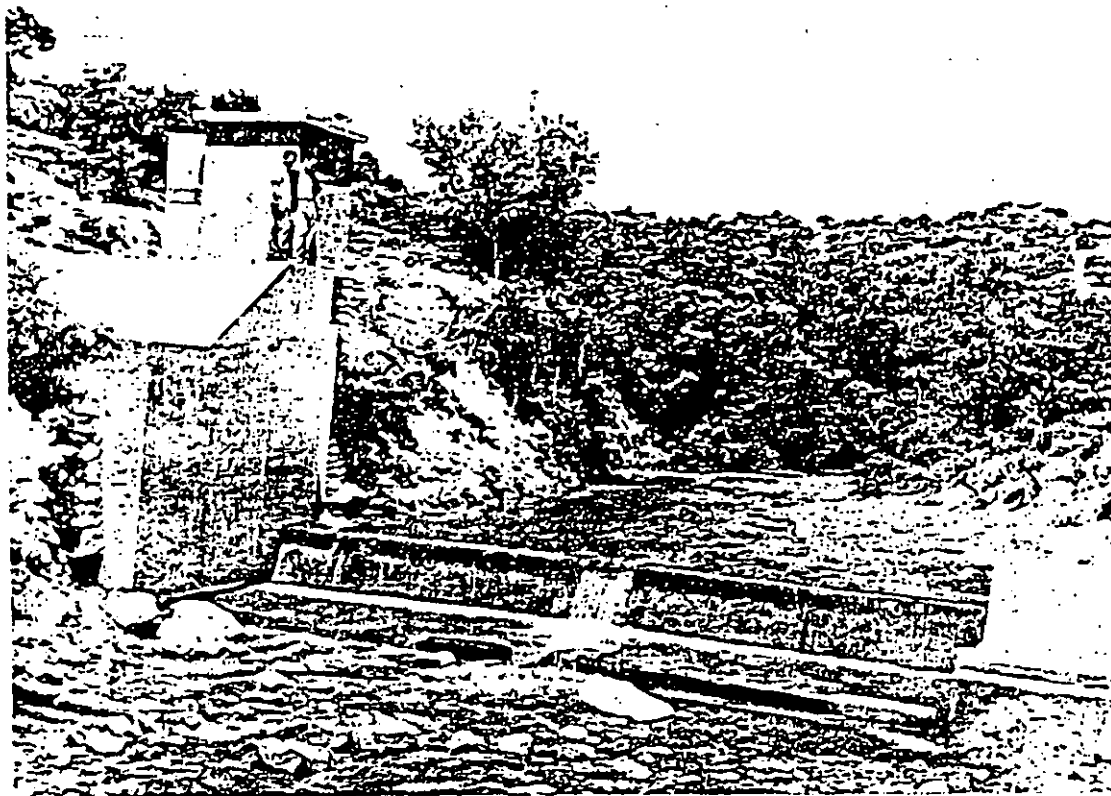
This pressurised closed system has the hydraulic advantage that all distribution mains are interconnected, stabilising the pressure at all points of delivery and also avoiding undesirable dead ends. It provides flexibility in meeting the demand and also enables repairs to be carried out with the minimum disruption to supply. In this practice, a ring of suitable size is laid from the storage tank. At junction points along the route of the ring mains water is connected to zones of supply which are also interconnected.

A steady minimum residual pressure of 10 metres at all points of the distribution pipe grid is considered in the calculation of the pipe sizes. The topography of the land is a controlling factor and due regard must be paid to frictional losses in the pressure head.

In hilly villages where the ground contours were more than 60-70 metres, the distribution system was divided into pressure zones, of higher area and lower area of supply, by breaking the pressures through storage tanks feeding high and low zones of water consumption. By this arrangement excessive pressures at the low points of demand were avoided.



Pump-House of the Yermasoyia Regional Domestic Supply Scheme.



Measuring Weir equipped with Automatic Water Level Recorder on Khirokitia River.

FIGURE 12.1

Source: Water Development Department Cyprus.

For a speedy calculation of the hydraulic data needed for the pipelines optimization study by the designer, the formula $V=140 \text{ RS}$, extracted from the Kembes year book, and tabulated to show the flow in long pipes flowing full in litres per second, has been used. For purposes of design, it is usually aimed to keep the velocities between 1.0-2.0 metres per second. This range has been found to be satisfactory for operational and the respective capital expenditure purposes.

In the gravity closed distribution system the respective parameters are known, and therefore the pipe sizes are calculated directly. The needed data are:

- a) The points at junctions of the village roads numbered and the houses from point to point counted.
- b) The elevations of the junction points above the datum line recorded, by levelling from point to point, and the lengths of the pipeline from point to point measured.
- c) Minimum desired hydraulic level of water at delivery points above datum.
- d) The quantity of water to be delivered at demand points in litres per second.
- e) The head loss derived from the tabulated flow in logn pipes flowing full, showing the sizes of pipes and the hydraulic gradient.

In general the design must satisfy the deliveries at prefixed points and also maintain a steady desired hydraulic pressure at the demand points.

For closed distribution systems in the hilly villages, galvanised mild steel pipes, Class B (medium series of BS 1387), have been used.

In the case where the villages are situated in lowlands, in the plains, cement asbestos pressure pipes have been used, of Class B according to the BS 486/1966 specification for asbestos-cement pressure pipes, Table 12.1.

In accordance with the above BS 486/1966 specification the hydraulic test pressure should be twice the working pressure, as tabulated on the next page.

12.4.3 Typical example of closed distribution system

A typical example of the hydraulic design of a closed network is given below:

In the design to main engineering data were considered:

- Pipe roughness coefficient, $C = 140$
- Maximum velocity in pipe $V_{Max} = 3.0\text{m/sec}$
- Minimum velocity in pipe $V_{Min} = 1.0\text{m/sec}$
- Quantity of water to be delivered at points of demand $Q = 1/\text{sec}$
- The elevation of the demand point in metres above known datum.

The friction hydraulic loss, and the residual hydraulic head, in metres, giving the total hydraulic gradient of the flowing water at the point of demand.

Table 12.1 Mild Steel Pipeline data (hilly village)

Pipe Section Code	Length of Section m	Ground Level at Dem. point AMSL	Q l/sec	Pipe diameter mm	Min Hydraulic gradient	Remarks
19-20	52	589.07	2.50	75	678.10	
20-23	38	596.67	1.84	50	677.50	
23-25	86	605.00	1.86	50	676.54	
25-26	69	607.00	0.78	50	676.22	
37-38	30	620.00	4.02	75	684.32	
38-40	65	613.94	3.94	75	683.36	
23-24	60	605.00	0.16	32	677.35	
20-21	52	625.00	6.28	75	688.96	
41-42	30	604	0.40	75	682.91	
43-22	85	607.00	0.58	75	671.11	

Source: The above figures refer to Galata Village Water Supply as completed. Topography of the village is shown in Figure 12.2.

For the design of village house-to-house service in the plains, the same procedure as above was used.

TABLE 12.2 CLASSIFICATION AND DIMENSIONS (Metric equivalents of Table 4A)*

Nominal size of pipe mm	Class A Test pressure 61m bond			Class B Test pressure 122m bond			Class C Test pressure 183m bond			Class D Test pressure 244m bond		
	Thickness of finished ends mm	Ext.dia. mm	Int.dia. mm	Thickness of finished ends mm	Ext.dia. mm	Int.dia. mm	Thickness of finished ends mm	Ext.dia. mm	Int.dia. mm	Thickness of finished ends mm	Ext.dia. mm	Int.dia. mm
50				9.4	69.1	50.3	9.4	69.1	50.3	9.4	69.1	50.3
75				9.4	95.6	76.8	10.2	95.6	75.2	10.2	95.6	75.2
100				10.7	121.9	100.5	12.7	121.9	96.5	12.7	121.9	96.5
150				11.4	177.3	154.5	15.5	177.3	146.3	17.8	177.3	141.7
200	12.0	232.2	208.2	14.5	232.2	203.2	18.3	232.2	195.6	22.9	232.2	186.4
225	12.7	259.1	233.7	15.3	259.1	228.5	20.1	259.1	218.9	24.9	259.1	209.3
250	13.2	286.0	259.6	16.3	286.0	253.4	21.3	286.0	243.4	27.5	286.0	231.0
300	14.5	333.8	304.8	17.3	333.8	299.2	25.4	345.4	294.6	33.0	345.4	279.4
375	16.0	413.0	381.0	21.3	413.0	370.4	31.5	426.2	363.2			
450	17.5	492.2	457.2	24.1	492.2	444.0	37.3	507.0	432.4			
525	19.1	571.5	533.3	27.9	571.5	515.7	40.6	587.2	506.0			
600	20.3	650.2	609.2	31.7	650.2	586.8	45.7	667.0	575.6			
675				35.3	729.0	657.9	50.8	746.8	645.2			
750				38.1	807.2	731.0	58.67	826.0	714.2			
825				40.6	885.9	804.7	66.56	905.8	783.9			
900				43.2	964.2	877.7	70.37	984.5	854.8			

* The above are metric equivalents only of the measurements given in Table 4A which are the standard dimensions.

TABLE 12.3 TOLERANCES (Metric equivalents of Table 5A)

Thickness of finished ends mm	Tolerance on thickness mm	Nominal size of pipe mm	Tolerance on ext. diameter at ends mm
Not exceeding 11.5	± 1.0	50 to 600	± 0.8
11.6 to 15.0	± 1.3		
15.1 to 19.1	± 1.5		
19.2 to 23.7	± 1.8		
23.8 to 29.2	± 2.0		
29.3 to 38.1	± 2.3	675 to 900	± 1.02
38.2 to 50.8	± 2.5		
51.0 to 63.5	± 2.8		
63.7 to 76.2	± 3.05		

These are the BS486/56 for AC pipes.

Asbestos cement pressure pipes of size varying from the minimum diameter of 100mm to 300mm have been used.

12.4.4 Control of water consumption

a) Constant head regulator

When after 1960, the house-to-house service was encouraged, the water was delivered to the consumer, usually through a constant head regulator, at the rate of 450 litres per day.

The constant head regulator was a cement concrete box of internal dimensions 400 x 300mm. The inflow into the box was effected through a 12 millimetre self-closing ball valve, the arm of which was shortened, to leave space for a partition baffle bronze plate dividing the concrete box into a long and short chamber. Through the dividing bronze plate a 4mm orifice was drilled to allow an outflow quantity of 450 litres per day to the consumer. The head of water in the regulator was maintained by the self-closing ball valve at 150mm above the orifice of the partition plate.

The purpose of using the constant head regulator was that it was cheap to manufacture. It cost only £1.25 against £3.00 for the 12mm water meter. Moreover, someone had to read the water meters every two months and also maintain them. This could be applied only in the case of big villages and rural municipalities, including the towns of Kyrenia and Paphos.

b) Water Meters

When the first Five-Year Development Programme of the Cyprus Republic was commenced, all plant and materials were purchased through public tenders. Thus the purchase of water meters was effected through public tenders creating international competition.

The British Standards were always included in the tender specifications which required that:

"The water meter should be of the multifet inferential or volumetric type, reading direct in cubic metres and litres, and capable of withstanding a treated maximum hydraulic prtessure of 15 Atmospheres".

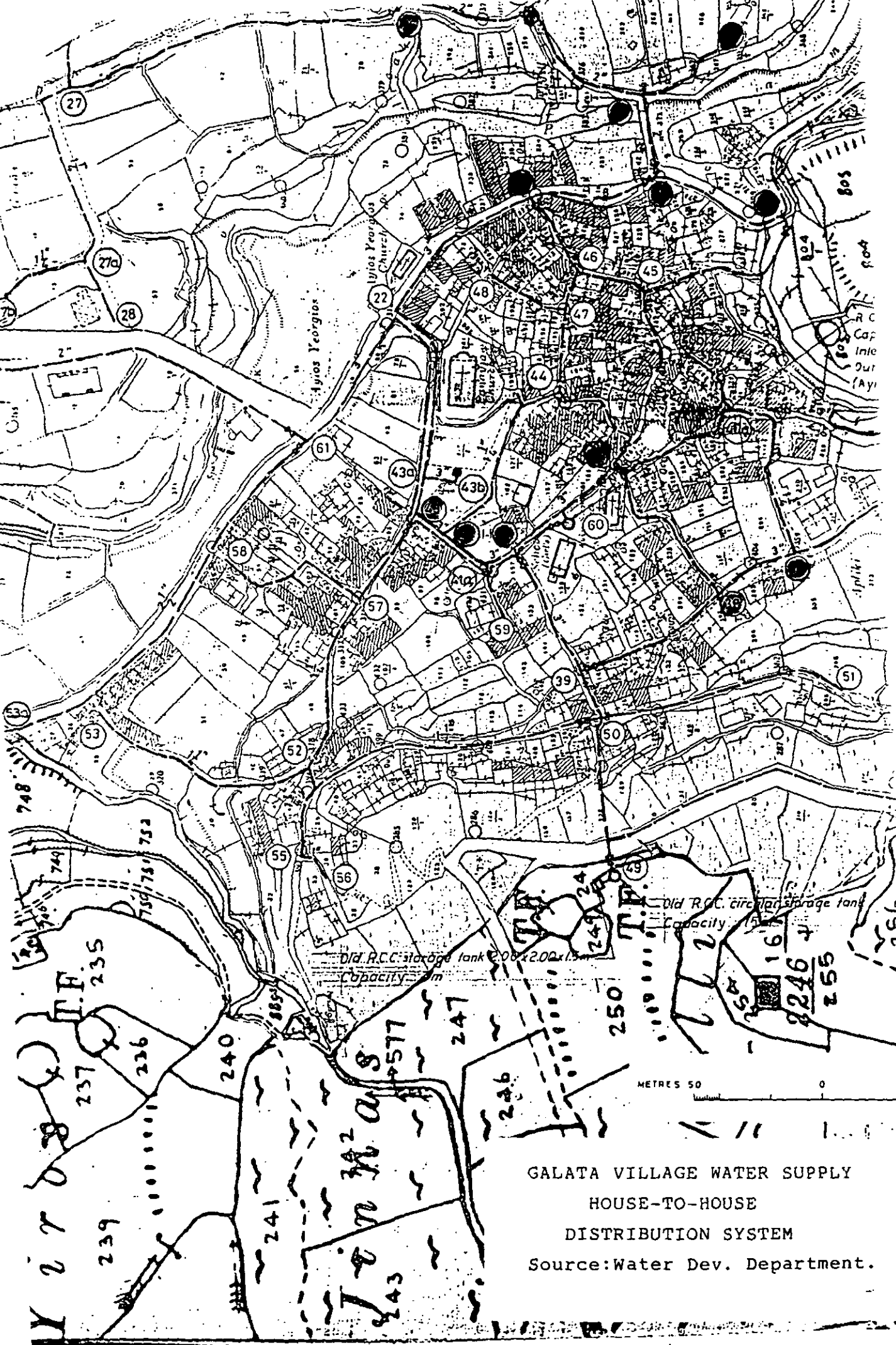


FIGURE 12.2

Water meters of reasonably low price were ordered through tenders from the U.K. and France.

The constant head regulators installed in small villages have been steadily replaced by water meters and at the end of 1963 a house-to-house service system, properly metered was operating in 67 villages, having 15,000 consumers.

12.4.5 Progress in domestic water supplies

During the period 1961-1980

The Government of the newly borne Cyprus Republic continued the same policy in considering water development to be the nucleus of the general economic and welfare development programme of the island. In fulfilment of this policy, priority was given the work on domestic water supplies, which was carried out in a continuous and intensive working programme.

British water engineering has been practised in Cyprus since 1939, when the Water Supplies and Irrigation Department was constituted. This water engineering practice was modified in its form and standardised in its application to match the natural environmental conditions of Cyprus, having climatological conditions of semi-aridity.

This practice left by the British has been the foundation, without any change in its application, for the continuation of the village domestic water supplies programme since 1960.

The progress in domestic water supplies was such that by the year 1968 all 627 villages had a piped supply, together with the four main towns of the island, it can be said that every inhabitant of the country enjoyed a piped domestic water supply.

In addition it may be stated that by the end of 1973, 504 villages, representing 95.10 per cent of the total rural population, were privileged to have water flowing in taps in the yard of the house, or in the majority of cases in the kitchen and the bathroom.

At the end of 1973, the total number of small villages with public fountains was 115, representing 18.34 per cent of the total number of villages, but only 4.90 percent of the total rural population.

The two small towns of Kyrenia and Paphos, which were financially helped by the Government, as in the case of the villages, were provided with a house-to-house service, properly controlled through water meters and administered by the Municipal Councils.

12.4.6 Outline of progress in village domestic supplies 1960-1973

To give the reader of this Thesis a picture of work carried out in the field of village domestic supplies, after 1960 up to the end of 1973, we thought it would be worth quoting extracts from the Annual Report of the Department of Water Development for the years 1963 and 1973.

These two years mark the end of the transitional period and the continuation of the development work on domestic water supply.

The year 1973 was also the last year when in the field of water development the Greek and Turkish communities of Cyprus were working harmoniously together, before the invasion of Cyprus by Turkey in July 1974, which has caused compulsory movement of the rural population from North to south resulting in the separation of the Cypriot communities which have lived together side by side for many years past.

Also 1973 was the last year of the writer's career in the Government service prior to his voluntary retirement in January 1984.

The extracts in the Appendix represent the contribution to the Annual Reports by H. Karakannas, Engineer - Hydrologist, Head of the Village Water Supplies Division of the Water Development Department.

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12.4.7 Comparative tables showing improvements to village water supplies 1960-1973

The improvement in village domestic supplies during the above period is shown in Tables 12.3, 12.4 and 12.5.

12.5 Period 1974-1980

12.5.1 Disruption of domestic water supplies programme

The execution of the programme for the improvement of domestic water supplies, and water development in general, was seriously disrupted in the summer of 1974, as a result of the Military invasion in Cyprus a free independent Republic, by Turkey.

The invading forces occupied the northern part of the defenceless island, representing 33% of its total area, and obliged the Greek residents, numbering about 180,000 persons to abandon their villages and move to the southern free part of the island, the majority of these to the towns of Nicosia, Larnaca, Limassol and Paphos. The domestic water supply of the

above towns was inadequate to meet the additional water requirements for the refugees and the domestic water situation became deplorable.

In order to alleviate the water shortage, additional water had to be provided from new boreholes hastily drilled for this purpose.

The continuous intensive professional and practical efforts, put in by the Geological Surveys Department for spotting and drilling successful boreholes to be used as sources of water supply, and by the Water Development Department for the installation of pumping plants in the successful boreholes, and piping the water to the refugees settlements, alleviated the critical domestic water supply situation within a very short time.

In antithesis to the war with all its hostilities and evils, carried out by Turkey against Cyprus, we believe it is worth mentioning that during these black days, both the Cypriot Greek and Cypriot Turkish water engineers were communicating in a professional and friendly way, for the management of the Nicosia water supply, thus maintaining a continuous supply of water to all consumers living within the whole area of water supply of Nicosia and suburbs.

Cypriot Greek and Turkish water engineers had worked together in the Water Development Department side by side in harmony and friendship for many years, and apparently the ill feeling arising from the hostilities were diluted in the field of domestic water supplies, a field which preserves human life and the human rights on Earth.

12.5.2 Progress during 1974-1980

At the end of 1973, 95.10% of the total rural population of Cyprus enjoyed a house-to-house domestic water service. The villages with public fountains were small and isolated, and represented only 4.90% of

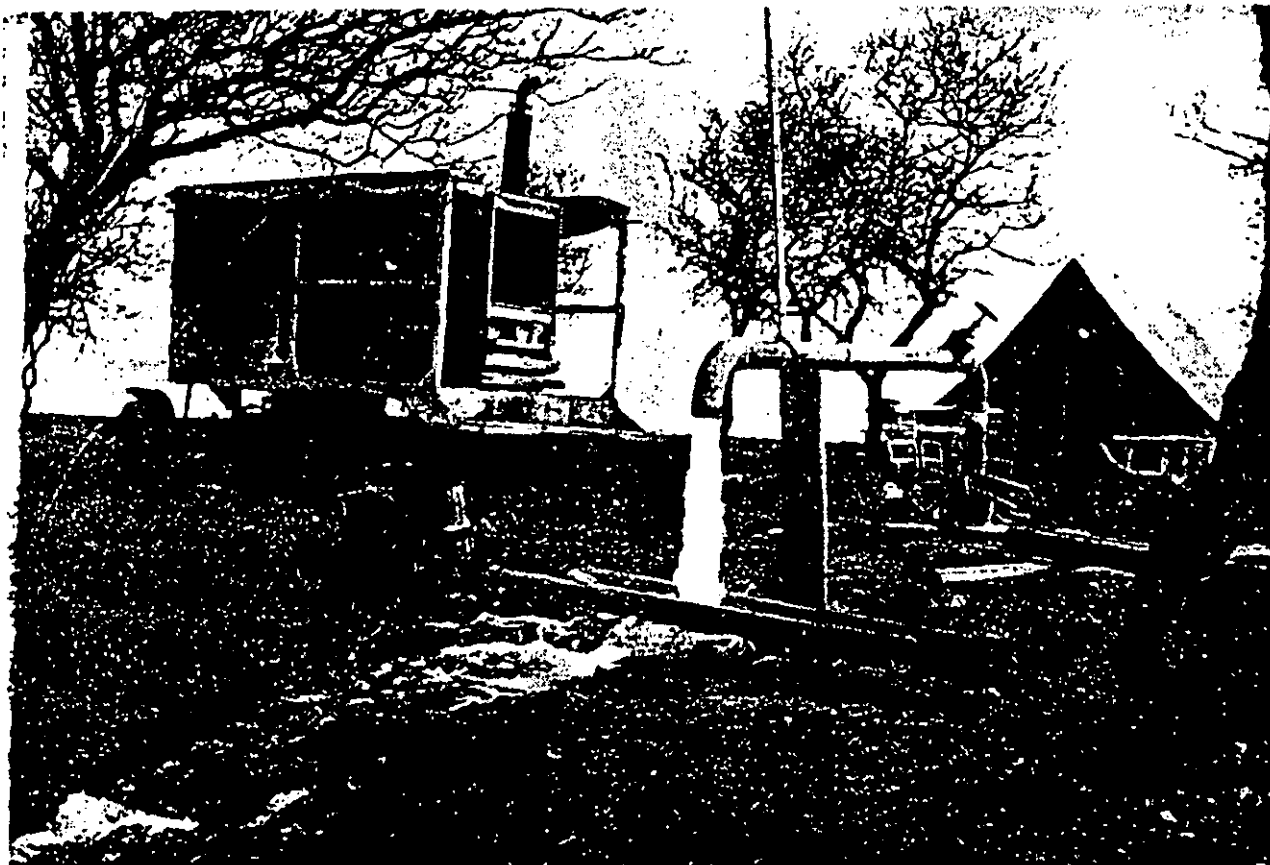


PLATE I. The borehole yield, and hydrogeological parameters of the aquifers are determined by pumping tests. Above a mobile pumping test unit equipped with a generator and electrosubmersible pump carrying out a step drawdown pumping test.

TABLE 12.4.1 VILLAGE WATER SUPPLIES 1960-1973

Year	Villages with house-to-house distribution				Villages with public fountain			Villages without a piped supply		Population	Total No. of villages
	Schemes completed	Total No. of Villages	Villages	Population	Total No. of villages	Villages	Population	Total No. of villages	Villages		
1960		90	14.33		441	70.23		97	15.44		628
1961	41	131	20.86		428	68.19		69	10.95		628
1962	59	190	30.25		380	60.55		58	9.20		628
1963	67	257	40.90		324	51.60		47	7.50		628
1964	39	296	47.13	66.71	323	51.43	32.29	9	7.44	1.00	628
1965	5	301	47.93	68.86	321	51.11	30.44	6	0.96	0.70	628
1966	7	308	49.05	69.81	316	50.31	29.95	4	0.64	0.24	628
1967	11	319	50.80	71.40	307	48.88	28.46	2	0.32	0.14	628
1968	27	346	55.10	75.72	282	44.90	24.28				628
1969	14	360	57.32	78.60	268	42.68	21.40				628
1970	32	392	62.42	83.23	236	37.58	16.77				628
1971	16	408	64.95	85.42	220	35.05	14.58				628
1972	29	437	69.60	88.70	191	30.40	11.30				628
1973	67	504	81.40	95.10	115	18.60	4.90				619

Source: Water Development Department Annual Report 1973.

TABLE 12.5 WATER SUPPLY SITUATION AT THE END OF 1973

	Satisfactory piped supply (Supply rate 130 lit/head/day)								Satisfactory piped supply (Supply rate 130 lit/head/day)								Total number of villages	Total population 1969
	Villages with house-to-house				Villages with fountains				Villages with house-to-house				Villages with fountains					
	No.	%	Popul.	%	No.	%	Popul.	%	No.	%	Popul.	%	No.	%	Popul.	%		
Nicosia	104	61.5	94,127	75.7	9	5.3	1,809	1.5	37	21.9	25,470	20.5	19	11.3	2,890	2.3	169	1,24296
Kyrenia	40	85.1	31,882	96.8	1	2.1	70	0.2	1	2.1	55	0.2	5	10.7	920	2.8	48	32,927
Famagusta	40	40.8	34,135	38.0	1	1.0	0	0	48	49.0	54,369	60.6	9	9.2	1,213	1.4	98	89,717
Limassol	71	62.3	62,969	85.0	11	9.6	2,264	3.0	23	20.2	7,552	10.2	9	7.9	1,323	1.8	114	74,108
Paphos	42	31.8	23,322	45.1	19	14.4	3,796	7.3	47	35.6	20,323	39.3	24	18.2	4,254	8.3	132	51,695
Larnaca	35	59.3	27,223	67.1	1	1.7	150	0.4	16	27.1	11,837	29.2	7	11.9	1,324	3.3	59	40,534
TOTAL	332	53.6	273,658	66.2	42	6.8	8,089	2.0	172	27.8	119,606	28.9	73	11.8	11,924	2.9	619	413,277

Source: Water Development Department Annual Report 1973.

the total rural population.

During the period 1974-1980, all development work on rural domestic water supplies was concentrated on house-to-house distribution systems, extensions of existing water systems, and supply of water to new refugee villages.

In 1980 out of the total number of 619 villages, 560 villages, constituting 98.04 per cent of the total population, had a house-to-house distribution properly controlled and metered.

Fifty nine small isolated villages representing 1.96% of the total population had public fountains.

The average water consumption per capita of the rural population was 90 litres per day.

Table 12.5 is illustrative of village water supplies progress, at the end of the year 1980.

12.5.3 Completion of rural domestic water supply programme

At the end of 1980, the programme of providing or improving the village domestic water supplies can be considered as completed.

Work was concentrated on providing additional domestic water supply for the newly developed areas in the suburbs of the main towns of Nicosia, Larnaca, Limassol, Paphos and Ayia Napa, where the tourism industry is highly developed.

The hilly villages, where one's living is more healthy but more hard, have been slowly but constantly depopulated.

In most hilly villages where spring water was provided at the rate of 100 litres per capita of population between the years 1950 and 1970, the population has decreased by over sixty per cent. Therefore there is a big surplus of domestic water supply available which is used for irrigation by the elderly inhabitants of the villages.

The younger inhabitants of useful working age

of 20-45 years are leaving their hilly villages, and are establishing themselves in the towns and suburbs.

A vivid example of the depopulation of the hilly rural areas is the shortage of primary school children. Primary schools in a number of villages have been closed down because of absence of school children to justify the employment of even one school teacher.

12.5.4 Major projects

In view of the expanding urban population in all towns and suburbs, major domestic water supply projects were designed and constructed after 1970.

(i) One such scheme was the construction of the Lefkara Dam and Khirokitia Treatment Works for Larnaca and Famagusta towns. The consultants to the project were Howard Humphreys of Surrey, England.

Water from the Khirokitia treatment works is conveyed to Famagusta and Larnaca towns through an asbestos cement pressure pipes conveyor.

This project was commissioned early in the summer of 1974. Two months later came the July Turkish invasion, and the uprooting of the Greek people of Famagusta town from their houses.

Since then Lefkara - Khirokitia project has served the town of Larnaca, the Ayia Napa village area, and the Turkish Sector of the old town of Famagusta and its outer area.

The total quantity of water treated at the Khirokitia treatment plant during 1980 reached the figure 210 million cubic metres. Treated water is supplied free of charge to Famagusta town for the domestic requirements of the Turkish inhabitants and the Turkish troupes stationed in the area.

(ii) Nicosia town was facing shortage of water particularly after 1974, when the population within its area of supply had been doubled.

In order to alleviate the domestic water shortage a major water supply project using the runoff

of Vasilikos and Pendaskinos rivers was prepared and constructed. The consultants were Lemon and Brizzard and Rofe Kennard and Lapworth of the United Kingdom.

Phase I, Vasilikos - Pendaskinos Pumping Project was completed at the end of 1980, and a quantity of 5 million cubic metres of water per annum was conveyed to Nicosia.

(iii) In 1980 Limassol had a satisfactory supply from existing sources, consisting of two springs in the Kourris river and three boreholes drilled in the Yermasoyia river gravels.

12.6 Yearly consumption of water in Water Board areas

The total water consumed in each Water Board area during the year 1980 is tabulated below:

Table 12.6 Municipal water used in each Water Board area during 1980

Water Board of town	Consumers Number	Total Quantity m ³ /annum	Average share per capita litres	Max. daily consumption in summer per capita litres
Nicosia	39,450	9,152,909	148	257
Limassol	26,416	7,340,414	178	248
Larnaca	11,776	2,666,270	140	297

Source: Water Development Department Annual Report, 1980.

12.7 Domestic water supply planning

Water planning is a continuous process. As long as human life exists and the population of a village, town or city increases and as long as the standard of living of the individual rises, domestic water supply will be the serious concern of the people of the community and of the Government of the country in particular.

Continuous water supply planning, construction

and management should be the basic foundation on which human life and the prosperity of the community rests.

All work for the above purpose can be advantageously effective only when it is adapted to the natural environment, the physical, economic, social and cultural conditions of the individual country. In Cyprus it has been adapted successfully and in the most co-operative way by all concerned, both local and foreign, during the last 40 years, (1946-1986).

12.8 Water development - Major contribution to public health

Water will always be an essential ingredient of life and a major contributory element for human health and prosperity.

In our country, water development was started in a specialised technical and systematic way in the year 1938, when the Water Supplies and Irrigation Department was set up.

The development of our Water resources provided the piping of pure potable water supply to the community from boreholes, masonry and concrete dams, river intakes and reinforced concrete irrigation channels for the conveyance of water to the fields, for food production.

This water development work, carried out by the Water Department as it was known by the public, had a direct bearing on the health of the Community.

It was a major contribution to the eradication of malaria in the 1950's, and to the steep rise in the standard of hygienic living conditions of the people. Also the development of piped water supplies has been a major contribution to the steady improvement of sanitation in both urban and rural areas of the island.

In the view of the vital role of water development for the health, welfare and prosperity of

the community and of the country overall, it has been considered useful to include Chapter Fourteen "Malaria, its control and eradication, 1936-1955" and Chapter Fifteen "Rural sanitation", as Part II of the Thesis.

It is believed that these two chapters will convey a clear conception and analysis of the axiom that water is the most vital element for public health, and that international technologists, scientists, economists, and their Governments, should join together in tackling the water problems of countries needing technical and economic assistance in this area.

It is also hoped that the developed countries will offer in a general way technical and economical assistance for the development of water resources in the developing countries, and that the countries receiving such assistance will offer their maximum co-operation, in order that all combined efforts towards water development will be successful, for the improvement of public health and the elimination of human suffering.

PART II

WATER DEVELOPMENT

A VITAL ELEMENT FOR THE
ERADICATION OF MALARIA
AND IMPROVEMENT OF SANITATION
IN CYPRUS

CHAPTER THIRTEEN
MALARIA (CONTROL AND ERADICATION)
CYPRUS (1936-1955)

13.1 Introductory notes

Malaria has been the scourge of all countries, having moderate climate since the time of early human life.

It is unfortunate that man has not yet been able to exterminate malaria or even reduce its incidence to a satisfactory safe degree in most developing countries of our globe.

Thousands of people in the developing countries, Asia, Africa, and South America where the disease is endemic and widely spread, are the victims of malaria every year.

In ancient times travellers noticed that seasonal fevers were caused by the bites of mosquitoes, when they visited countries having warm climates.

Clever and observant travellers vaguely believed that there was some inter relation between malaria and the mosquito. Experimental work carried out by King and Mason in the 18th century produced some illustrating induction, regarding their interrelation. But it was as late as 1898, when Sir Ronald Ross experimented and demonstrated every stage of the malaria parasite's development in the mosquito and thus affirmed the vital connection between mosquitoes and malaria parasites. Experimental and research work continued by Ross proved that the parasites develop in the stomach of a certain species of mosquitoes known as "Anopheles".

(Greek: Ανωφελης = unprofitables)

It was also discovered that the parasites of malaria develop and multiply not only within the mosquito, but also within the body of a patient, where they live in the red blood cells. Here the parasites multiply asexually by schizogony.

So, malaria parasites must be incubated and cultured within man and the female anopheline mosquito, both being the hosts for the reproduction of the parasites. Therefore

man and anopheline mosquito are the two links required for the spread of the disease. Figure 13.1 is illustrative of the life cycle of malaria parasites in human blood and in anopheline mosquito. Source: Malaria Control for Engineers, United States Public Service, 1936).

In view of the way in which malaria is spread, in order to eradicate this disease it is absolutely necessary to give medical treatment to the human patient and simultaneously to eradicate the female anopheline mosquito in its larvae and adult stages. In this way the link between the two hosts needed for the culture of malaria parasites is broken.

Only the female mosquito lives on blood, which it sucks from man or animal. The male lives by sucking juices from bushes or green vegetation growing near its breeding place. It is strange that malaria parasites develop, mature and are reproduced only in Figure 13.1 the red blood cells of man, and not the blood cells of animals or birds.

13.2 Control and extermination of Anopheline Mosquitoes

Mosquitoes breed only in water. The life cycle and the stages of their development are the same in all groups and species of mosquitoes. The female mosquito flies down and lays her eggs on still water which will not wash them away. She may lay from 40 to several hundred eggs at a time.

From the eggs come the larvae, which feed on organic matter, and must come to the surface of the water to breathe air. After one week to ten days, depending on the air temperature, the larvae becomes pupae, and after several days the adult mosquito emerges. It rests for a while and then flies away in search of blood.

The life cycle for all species of mosquitoes is the same: eggs, larva, pupa, adult. Therefore, knowing the breeding places of anopheline mosquito and its habits, we must fight it on land and water, but principally in water, at its larval stage.

When the mosquito emerges from its pupa stage, and flies for search of food (human or animal blood), it can

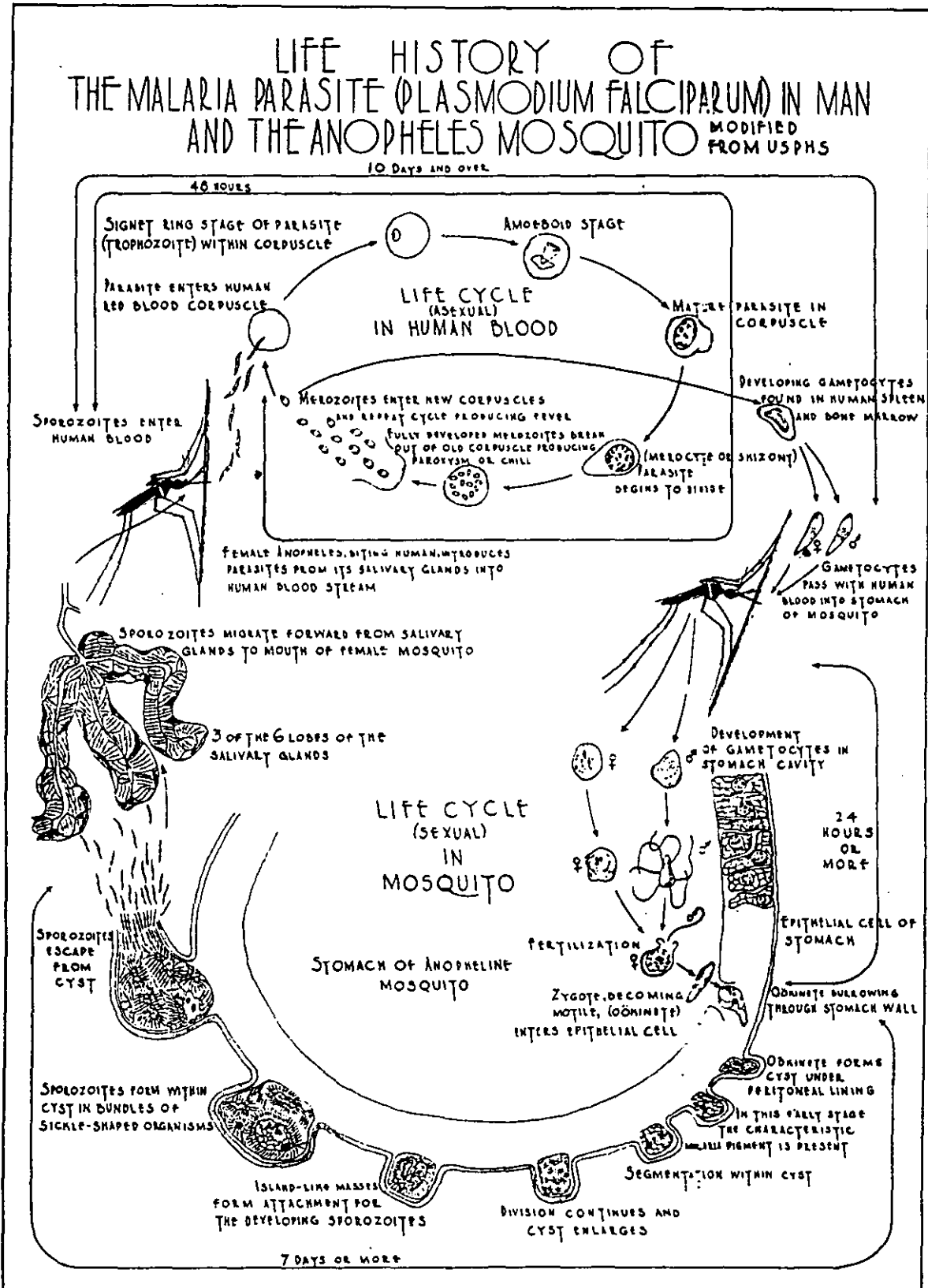


Fig. 13.1

Source: Malaria Control for Engineers 1936
USPHS

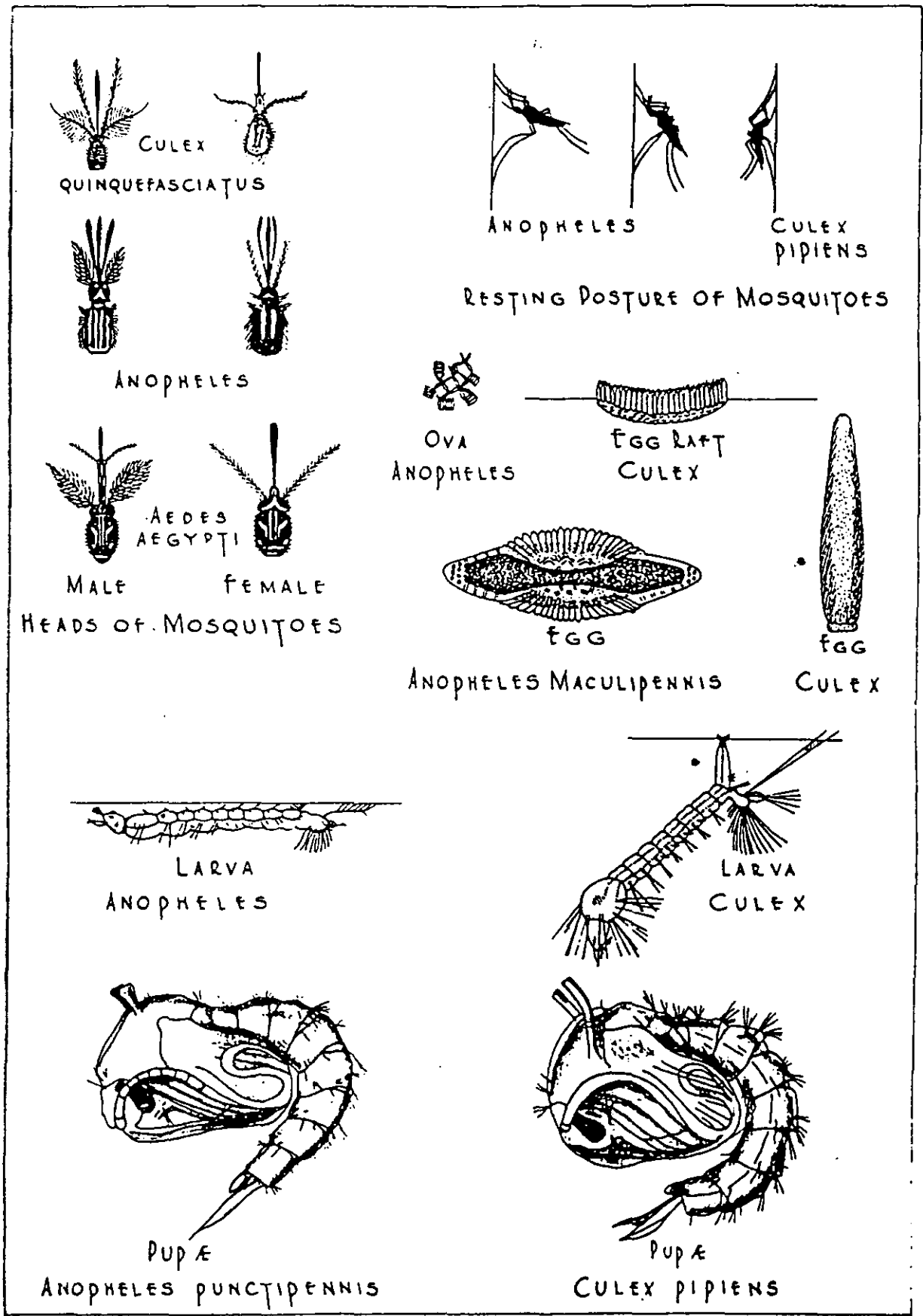


Fig.13.2 Source: Malaria Control for Engineers 1936
USPHS

hide and protect itself. In daytime, at sunrise, it hides itself in dark corners of rooms, stables, sheepfolds, and caves. After sunset and during the night it is active in search of food.

At its larvae stage, it can be destroyed more easily and in large numbers, since larvae group together in stagnant waters. The killing is effected by the spreading of larvicides, which larvae eat, or through suffocation by the spread of petroleum oil over the water surface every week or ten days, during the development time of the water life of mosquitoes. In the two active aquatic stages, that is the larval and pupal stages, the oil poisons their system by entering through their breathing tubes.

A third method of exterminating the mosquito larvae is to stock ponds, reservoirs and other suitable water storage areas with *Cambusia affinis*. *Cambusia* multiply very rapidly during the warm season. They are top feeders and are exceedingly fond of mosquito larvae.

13.3 Malaria endemicity in Cyprus

Malaria was endemic in Cyprus from the archaic times, prior to its eradication in 1952-1953.

Giovanni Mariti, in his book "Travels in the Island of Cyprus, (1769) translated from the Italian by Claude Delaval Gobham, . commissioner of Larnaca, in 1895, page 3, writes:

"Strabo, Geography XIV, 20, says of the island,

"ναρ' ἀρετὴν οὐδεμίαν τῶν νησῶν λείπεται;"

- It yields to no other island in excellence -

Many ancient historians have thought that the air was bad and unwholesome, a prejudice which causes foreigners to stay here a short time so that they cannot fully test its climate. But it is the general opinion of all who have lived here some few years that the air is good.

The tertian and quartan fevers which are seen to prevail so frequently and for so long a time not only in Cyprus but also throughout Levant, spring from causes other and more available than the air".

Note: Tertian fever is caused by the malaria parasite Plasmodium vivax. The schizogony reproduction causing the fever occurs every three days.

Quartian fever is caused by the Plasmodium Malariae and the schizogony occurs every four days.

Although the bad air referred to by Maridi was not the direct cause of the tertian or quartian fevers, still it is certain that something was related to the bad air particularly during the summer months when the air temperature was high, above 30 degrees centigrade.

During summer, the winds are usually westerlies, and passing over the existing marshes around the nearby lakes, they were contaminated by the odours produced by the growth of the algae and the decaying vegetation within the swampy water.

The fact was that the swamps were the ideal breeding places of the anopheline mosquito, the malaria vector infesting the neighbouring villages and towns.

People of these times believed that malaria was the scourge of an angry God upon man.

It was as late as in the year 1898 that Sir Ronald Ross affirmed the vital connection between mosquitoes and malaria parasites. (Entomology for Medical Officer, A. Alcock, 1920).

Thereafter research on malaria disease infection of man and the modes of its spread was intensified, and the water problem was gaining recognition because this disease was seriously hindering the progress of semi-tropical, tropical and other countries having temperate hot climates.

Eighteen years after the findings of Sir Ronald Ross regarding the connection between mosquitoes and malaria, and subsequent research, a permanent organisation designated the National Malaria Committee was set up in Washington, D.C. The purpose of the Committee, was to study malaria and stimulate scientific and practical interest in its cause, prevalence, prevention and treatment. The National Committee was constituted in 1930.

In view of the recognition of the importance of the malaria problem in South America, the subject of malaria

disease, its causes and its prevention and control by the engineer, was taught in engineering colleges and universities throughout the country. (Report of National Malaria Committee, 1936).

13.3.2 Incidence of malaria in 1936

The incidence of malaria was considered simultaneously with Water Development in a scientific and practical way in the year 1936 in Cyprus.

The disease was endemic and widespread among the agricultural population living in villages situated below the 750 metres contour line above mean sea level.

People engaged in agriculture in the lowlands were suffering from malaria from May to November, when the weather was warm, above 20 degrees centigrade, helping the breeding of Anopheline mosquitoes. A number of adult mosquitoes stay over winter in or near villages, living in stables, caves and other warm, covered places.

In Cyprus the death rate resulting from the incidence of malaria either directly or indirectly was causing alarm. The disease was also causing a rapid decrease in the efficiency of the farm worker, and a lowering of the body's resistance to other communicable diseases.

Examples illustrating the hindrance to agricultural development by the high incidence of malaria are quoted below:

1) Cyprus Palestine Plantations Ltd

In the year 1934, a company was formed to develop the marshy area near the Limassol - Akrotiri Salt Lake, seven miles west of Limassol town - into citrus plantation. (This area is known as Phasouri and since 1960 it has been part of the Akrotiri British Sovereign Base Area). The company was registered as "The Cyprus Palestine Plantations Ltd". The shareholders were Cypriots and overseas Jews. The company employed daily over 100 agricultural workers in the absence of agricultural machinery.

Because of malaria infection, however, about 40 per cent of the workers did not turn up for work, staying at home every third day with high fever caused by the schizogony of the malaria parasites, which lived and reproduced in the red blood cells of the malaria patient.

ii) The Cherkez Chiflik

Prior to the creation of the Cyprus Palestine Plantations Company, in the year 1930 Russian Refugees came to Cyprus and purchased the marshy land known as "Cherkez" with the view to developing it into agricultural land.

They also faced the problem of malaria, and before they did any noticeable work, they sold the land, an area of up to 1500 hectares.

13.3.3 Bureau of malaria control

The Cyprus Palestine Plantations Ltd., and other Jewish companies working on land development for agriculture near the swampy coastal areas of the island, had stimulated the interest of the Cyprus Government to include in the proposed medical and public health reorganisation scheme a programme for the control and eradication of malaria.

In pursuance of this object, after arrangements with the Cyprus Government, the International Health Division of the Rockefeller Foundation, USA, decided to carry out malaria control work, in cooperation with the Medical Department, in 1935.

In February 1936, the famous malarialogist Dr D.W. Startman - Thomas and Dr Barber arrived in Cyprus and later Mr J.C. Carter, sanitary engineer, joined them.

They organised and set up their office known as "The Bureau of Malaria Control". Additional staff were recruited locally. They consisted of:

- 1 Civil Engineer
- 2 Health Officer
- 4 Sanitary Inspectors

- 2 Laboratory Technicians (female)
- 1 Secretary
- 1 Driver

13.3.4 Activities of the Bureau of Malaria Control - Cyprus

The activities of the Bureau of Malaria Control were concentrated and carried out in two fields simultaneously, namely:

- i) Malaria control through engineering practices, drainage, and application of larvicides.
- ii) Spleen and blood surveys throughout the island and preparation of statistics.

13.3.5 (i) Malaria control by the Engineer

Malaria control implies mainly the extermination of the anopheline mosquito. The engineer has to be conversant with the species of anopheles produced in a specific area and its breeding places, winds and climatic environmental conditions.

a) Species of anopheline mosquitoes in Cyprus (Identification)

In every country and in every region of such country, different species of anopheles exist. All species lay their eggs in water of their preference, which may be in marshes, streams, rivers, ponds and other places where water is collected and remains stagnant.

Dr. M. A. Barber, of the International Health Division of the Rockefeller Foundation, in the year 1935-1936, identified three species of anopheles in Cyprus, namely:

- i) A Elutus, (Greek "Elos" = Swamp) breeding in swampy water of marshes in the coastal zones, near the sea.
- ii) A Superpictus, breeding in clear water of streams, river and perched water, up to an altitude of 600 metres, where the summer air temperature is not lower than 25 degrees centigrade.
- iii) A Bifurcatus, breeding in wells and mountain streams in the Troodos and Kyrenia ranges. Its reproduction is limited due to colder weather in the areas where it breeds and a non-significant malaria vector.

13.4.1 Activity of the Engineering Division of the Bureau of Malaria control

The object of the engineering section of the Bureau of Malaria Control was to fight the Anopheline mosquito by spotting and eliminating its breeding places, and at the same time rendering the application of larvicides easier and more effective.

Therefore it was important to study and make a reconnaissance survey of the marshes and swamps and the rivers and streams having surface flows during the summer, where the two species of Anopheles, namely Elutus and Superpictus were breeding.

13.4.2 (A) Drainage of Marshes

In all coastal zones of Cyprus extensive areas of marsh and swamp constituted the natural environment. These areas were the ideal breeding places of A. Elutus, and in consequence malaria disease was prevalent among the neighbouring villages.

Thus priority was given to the survey of Limassol and Syrianokhori marshes, which covered extensive areas, the drainage of which would not only eliminate the high incidence of malaria in these two areas but also reclaim the land for its development into citrus plantations.

Drainage of marshy areas has been accepted to be the most effective weapon against the Anopheline mosquito, Elutus.

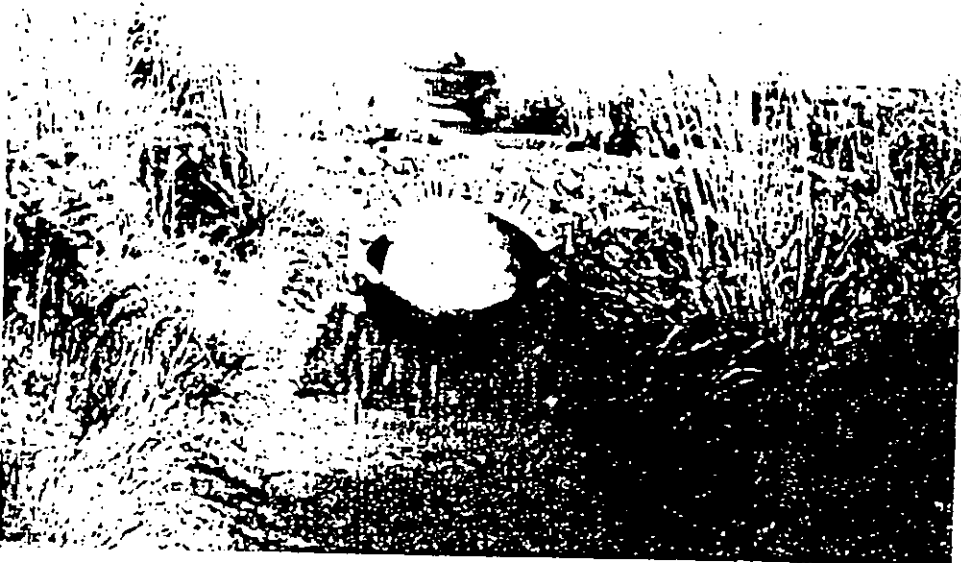
(B) Control of Superpictus

Superpictus breeds in streams. Therefore it was considered that streams should be trained by narrowing their flow through a channel excavated along the stream bed. The channel would be of temporary nature, existing only during summer.

The purpose was to confine the stream flow, which of course was not very much, in the temporary channel, thus increasing the velocity of flowing water making breeding difficult, avoiding the formation of small pools with



LIMASSOL MARSHES
Antimalaria Drain



LOWER MARSH
Masonry Culvert
over Drain

CYPRUS 1:50,000

CADASTRAL SHEET-EPISKOPI

(D. Survey Ministry of Defence U.K. 1968)

Map of Limassol Marshes

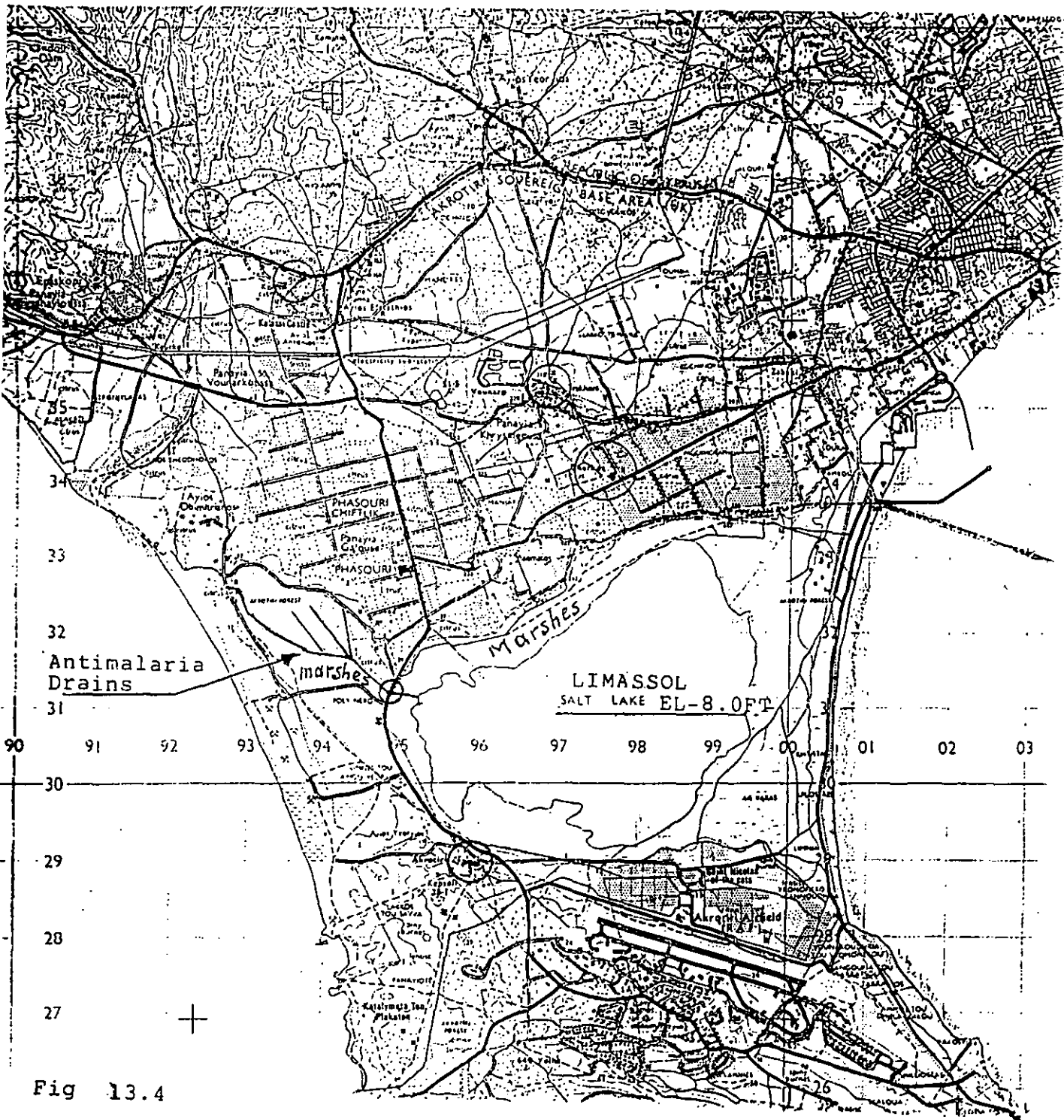


Fig 13.4

stagnant stream water, and also reducing the area of application of larvicides.

13.4.3 Topographical survey of the marshes in the vicinity of the Limassol Salt Lake

The Limassol marshes boundary the Limassol Salt Lake to the north west. (Figure 13.4). They are divided by a motor road into the upper marsh and lower marsh. These marshes were covered with thick growing reeds and the topographical work was most difficult. It was necessary to open footpaths by cutting the reeds and other thick vegetation, for taking ground levels and fixing of bench marks.

The most difficult and dangerous problems encountered during the survey work were the venomous snakes living in the marshes, and the pocket springs flowing through the top soil formation of the marshes, reinforced by the roots of the growing vegetation. The Limassol marshes were part of the Kouris River Delta, and consisted of alluvium river deposits. The excessive recharge from the nearby flowing Kouris river, and the flooding of the area by the river overflow in winter, created the marshes and the pocket springs. The previous soil deposit, underneath the top surface soil reinforced by the roots of the reeds, was a layer of clayey silt with a high rate of liquidification, offering no support to objects falling through the mouth of the spring. In the unfortunate event that a man or animal fell into one of these springs, there was no hope for hard subsoil support. One had to stay motionless and wait for help.

As a precautionary measure, the chainmen and surveyors had to take a ranging rod, and hold it horizontally on the reinforced ground surface in the event of an accident.

The survey of the Limassol Lake marshes was completed in the year 1936 and early 1937. The survey revealed that the elevation of the lower marsh was on average 1.53 metres below mean sea level. The elevation of

the upper marsh varied from minus 1.50 metres rising to zero (sea level) inland.

When the topographical survey of the Limassol Lake marshes was completed their drainage was recommended.

The proposal was to drain the surface water lying in the upper and lower marshes into the salt lake by means of open trapezoidal ditches, designed to keep both marshes dry during the mosquito breeding season. Of course the efficiency of the ditches depended on the water level of the lake, which rises to minus 1.85 metres below sea level in winter. The advantage was that during the mosquito breeding season the water level in the salt lake was lowered substantially by evaporation, and late in summer it dried up. So the water available from the drainage of the marshes could be gravitated into the salt lake, without the need of any mechanical means for lowering the water level of the lake.

13.4.5. Syrianokhori (Morphour Bay) marshes

The Syrianokhori marshes were in the form of a swamp, about 2½ kilometres wide from the sea shore. They extended from the Delta of the Serakhis river near Syrianokhori roughly parallel to the sea shore and almost reached Prastio village to the south, a length of about 5 kilometres. Some areas of the marsh were wet until the end of July and other areas remained perennially wet.

The topographical survey of the Syrianokhori marsh was completed in 1936, and it was proposed to drain the marsh by means of open drain ditches discharging into the sea.

13.4.6 Drainage of rivers and streams

The engineering section of the Bureau of Malaria Control, Cyprus considered elimination of mosquito breeding places from an engineering angle.

It was decided to carry out experimental drainage work in certain rivers and streams by laying underground, in the river bed, open jointed concrete pipes. The purpose

was to infiltrate the river surface flow into the underground open jointed pipeline, having a positive outlet, and thus dry the river surface flow.

The first experiment was undertaken in the Yiallias river, near Pyroi village, 20 kilometres south of Nicosia. The river bed at the section of the river where the experimental sub-drainage was carried out was formed of boulders, gravels and sandy soil. Concrete pipes 300 millimetres in size were laid at an average depth of one metre. The river surface flow percolated into the sub-soil concrete pipeline, which had a length of up to 1.6 kilometres.

This experimental work proved costly and of low efficiency for the following reasons:

a) Malaria season

In Cyprus the malaria season commences early in Spring. Dr M.A. Barber of the Bureau of Malaria Control, spotted Anopheles larvae in the Yiallias river on the 7th March 1936. Also larvae were found in the Limassol marshes on the 13th March 1936.

Abundant breeding of both Elutus and Superpictus occurred early in the spring season in certain warm localities, when the air temperature was above 20 degrees centigrade. (Annau Medical and Sanitary Report, 1936).

Early in spring the rivers have high surface flows, much more than what the 300mm sub-soil pipeline could accommodate. Therefore until the end of spring there was surface river flow constituting a breeding place for A mosquitoes. The surface flow was disappearing into the river gravels and the sub-soil open jointed concrete pipeline only in July, August and September.

A 300mm pipeline was laid at the existing hydraulic gradient of 0.005 could discharge a quantity of only 0.1 m³/sec, which was a small part of the river surface flow during the spring season averaging to 0.3m³/sec. Also the construction and laying of the drainage pipeline was uneconomical in view of the lack of machinery for excavation in the river bed and laying of the pipeline, all done by human labour.

b) Depth of drainage pipeline

In winter our rivers come down in full flow bank to bank, after heavy rainfall over the river catchment area. Their flood has a high velocity and turbulence, causing change of their direction in the lowlands from year to year. Their high velocity causes erosion and scouring at the river alluvial bends to a depth of over 1.5 metres. The scouring at the river bends uncovered and uplifted part of the pipeline, causing substantial damage through the blockage of the pipeline by the entering gravel. It was therefore found necessary that laying a pipeline at a depth of one metre in the river bed was a mistake. The safe depth was two metres, but this was most difficult and very uneconomical by manual labour.

c) Legal aspect

Ab-antiquo water rights exist over the surface flow of the rivers, and sub-soil drainage work faced legal proceedings from the irrigators having interests in the river surface flow. In view of the above the experimental sub-soil drainage of the rivers was abandoned.

13.4.8 Automatic siphons. (Flushing system)

A flushing system, by the installation of siphons with a view to creating an intermittent river flow, was also experimented on. The purpose was to create intermittent flow conditions, and stream flow turbulence by automatic flushing in steep gradient streams. By doing so the larvae would be washed away and die, while the eggs of the anophelines would be broken. Across the bed of the stream a concrete wall two metres high was built. In the centre of the length of the siphon was installed. The siphon was built in reinforced cement concrete and its walls were three inches thick. It was cast in two pieces.

- a) The inner case of the siphon was 24 inches wide and 36 inches high. On the downstream side the inner crest rose to form a rectangular seal of 24" x 4".

b) An outer concrete dome was fixed over the inner spillway crest, and allowed a crown space of 4 inches, while at the lower side it creates a water seal 24 x 4 inches.

If we use the formula $Q = C \alpha \sqrt{2gh}$ where a Q is the discharge we have:

a = area $0.096m^2$ h = operational head 0.90m

C = .65

$Q = .65 \times 0.10 \times .60 \sqrt{2 \times 32.2 \times 0.90} = .30m^3/sec.$

This quantity is sufficient to break the eggs of mosquitoes in small streams and kill the larvae in small pools.

This method was tried in small streams and it worked satisfactorily as long as there was water flowing to reach the site of siphon. In middle and late summer when the water flow in the streams was very little, forming small pools only, or flowing on the surface at odd places, the method of siphoning would not work. Moreover, after winter the stream bed behind the siphon wall was silted up by the runoff, and the siphon could likewise not operate.

In 1938, a number of these siphons were installed in the streams flowing along the north side of the Kyrenia Range, but as a result of the above mentioned drawbacks, this method of malaria control in our country was proved to be impractical.

It is worth mentioning here that a siphon was installed in a stream, the water of which was used to operate a flour mill. As the flow was intermittent because of the installation of the siphon, the operation of the flour mill was disrupted, and a legal problem was created.

In view of the above mentioned drawbacks in the experiments on sub-surface drainage and siphoning, it was found necessary to concentrate efforts only on the drainage of marshes by means of open trapezoidal channels. The purpose was not only to lower the water table but also to concentrate the water into channels with footpaths on either side, enabling the treatment of the water with gas oil and Paris green solution.

Until adequate funds were obtained for the draining of the marshes, the efforts were turned to controlling the breeding places by means of larvicides and insecticides.

13.4.9 Flight of mosquitoes

The distance of flight of the two species of anopheline mosquitoes, Elutus and Superpictus, prevailing in Cyprus, was very important in the control operations and the protection of the human population from malaria.

The engineering branch of the Bureau of Malaria Control, Cyprus, carried out A. Elutus flight experiments, by staining and liberating thousands of adult Elutus. Collection of Elutus were made in the villages neighbouring the marshes, and after three days of collection, one stained Elutus was caught at Ypsonas village, covering a flying distance of 3.5 kilometres.

Flight experiments were also carried out for A. Superpictus and it was ascertained that few can fly up to a distance of 3.5 kilometres, as in the case of Elutus.

It should be pointed out that mosquitoes are very delicate insects. They do not fly against the wind and they cannot survive in adverse climatic conditions. Therefore usually they do not fly in big numbers far from their breeding places and cannot cause alarm in distant villages unless the mosquito is infected with malaria plasmodia.

The effective distance from the breeding of the A. mosquito could be up to two kilkometres.

It may be worth mentioning that though Akrotiri village bounded the Limasol marshes, and the Elutus breeding place was very close to the village, is believed that no Anopheline Elutus had ever visited this village, due to the fact that in summer westerly winds are always blowing from the sea the mosquitoes cannot fly against the wind.

13.5. Outbreak of World War Two

The Bureau of Malaria Control carried out studies and experiments, and gave methods and ways in which the malaria problem could be tackled radically for its complete eradication.

The work done and recommendation made can be summarised as follows:

- a) Topographical surveys of all marshes.
- b) Mapping of all surface water flowing in streams, rivers, springs and pools below the altitude of 750 metres above sea level, seasonably and monthly.
- c) The whole island to be divided into topographical zones and subzones for easier control and protection of the population.
- d) Systematic blood and spleen surveys to be carried out showing the results of the antimalaria work.
- e) It was recommended that Paris green should be used, after the successful results obtained by its use as a lavacide.
- f) A number of sanitary labourers in the field of malaria control to be educated and trained.

Before the Bureau of Malaria Control, Cyprus, of the International Health Division of the Rockefeller Foundation completed their experiments and expanded their antimalaria programme, Germany declared war against Great Britain on the 3rd September 1939.

One week after the outbreak of the Second World War, the Headquarters of the International Health Division of the Rockefeller Foundation decided to close their office in Nicosia, and thus the antimalaria programme was disrupted and brought to a standstill.

The copper and asbestos mines closed down, and thousands of miners were out of work. Agriculture was disrupted and the rate of unemployment was rising steeply and steadily. The Cyprus Government had to face the unemployment crisis and in the absence of a social and employment office, or labour legislation, the problem of employment was seriously considered.

As a relief measure, the government decided to allocate funds for the drainage of the Limassol Lake marshes, first to offer employment to wage workers, and at the same time eliminate malaria in the area, where extensive agricultural work was carried out by the Cyprus Palestine Plantations Company Ltd.

The necessary funds for the drainage of the marshes were allocated, and after the usual preparations, work was put in hand. The topographical and contour drawings we prepared earlier in 1936-1937, and in accordance with the design of the Bureau of Malaria Control, the drainage was carried out. The depth of the trapezoidal ditches was one metre on average and discharge into the salt lake was at an elevation of 1.80 below mean sea level. The gradient of the main drain was 1/2000.

For this work an average number of 80 labourers per day were employed.

By the end of 1942 the marshes were drying up, and the reeds losing their growth. The drainage was successful and no pumping was found necessary.

13.5.1 Legal implications, as a result of the drainage of the marshes

Akrotiri, the nearest village to the marshes, having a population of about 400 persons in 1943, exploited the marshes by using the reeds for the making of baskets. It was a profitable occupation for the Akrotiri people. The baskets were made mostly by women.

When they observed that the reeds were not growing because of the drainage, they flooded the marshes by diverting the winter flow of the Kouris river flowing nearby. They were lucky not to have malaria, because the adult mosquitoes were flying north east with the prevailing wind, and in daytime when the Akrotiri women were working in the marshes the mosquito was inactive resting in dark cool places.

For the flooding of the marsh, the whole village was brought to Court and fined by the nominal amount of one shilling. They claimed that they had a privilege to exploit the marshes granted to them by St. Helena, mother of Constantine the Great in the year 306 AD, on her return from Jerusalem where she went and found the Holy Cross. (She landed in Cyprus and built churches. She also brought many cats to eat the snakes which were in abundance in the

Akrotiri Forest, the cape of which has been given the name of Capte Gatta).

Nowadays, the Limassol marshes are a good state forest, and lie within the British Akrotiri baseArea. The Akrotiri people are employed by the British Bases, and they are very happy without the reeds which nowadays are of no value to them.

13.5.2 Malaria Board

Early in 1944 the Government of Cyprus set up a Malaria Board for the purposes of eradicating malaria from the island, completely and swiftly.

The Malaria Board was composed of:

1. The Director of Medical Services, as Chairman.
2. The Director of the Water Supplies and Irrigation Department.
3. The Mayor of Nicosia.
4. A representative of the Cyprus Administrative Secretary.
5. The chief Sanitary Inspector.

At the end of the Second World War, the Malaria Board decided to put into effect the malaria eradication programme using the experience and experimental results gained by the antimalaria work carried out by the Bureau of Malaria control, between the years 1936 and 1939.

Parallel to the activities of the Public Health Division of the Medical services and Sanitary Department for the eradication of the Anopheline mosquito through the application of larvacides in the breeding places and the killing of the adult mosquito with insecticides, the Water Supply and Irrigation Department was to undertake the engineering side of the eradication, which included:

- a) Completion of the drainage of all marshes in the island.
- b) At the places in the rivers where water was led to the intakes of earth channels by the provision of temporary earth barriers reinforced with bushy wood, proper concrete weirs with intakes to the earth

irrigation channels were to be constructed. All earth irrigation channels were not properly graded, but were rough and uneven with weeds growing at places along their length and having a low flow coefficient. Moreover water was leaking through the sides of the earth channels thus creating swamps on low ground, which were ideal breeding places for the Anopheline Superpictus.

- c) The encouragement of drilling private boreholes and shallow wells with galleries in the river alluvium strata, for irrigation, has contributed towards the dryness of the river and stream surface flows during the irrigation season mid-April to end of October, this period being also the anopheles breeding season.
- d) All springs flowing to waste were to be developed, and their discharge piped to the villages for domestic purposes.
- e) The construction of dams collecting the river surface flow.

13.5.3 Malaria eradication programme

The Malaria Board, set up for the complete eradication of this disease in Cyprus early in 1944, at their meeting on 7th April 1946, considered and decided that malaria was the scourge of Cyprus and that the general debility caused by this disease was one of the chief obstacles to progress in education, agriculture and general welfare in the rural areas. It was also assessed that the economic loss to the Colony even at a conservative estimate must have been several hundred thousands of pounds.

The programme to eradicate malaria was approved by the Cyprus Government, and an amount of £300,000 was allocated under the Colonial Development and Welfare Act (Allotment 390).

After the allocation of funds, the Malaria Board, at its meeting on the 7th April 1946, was unanimous in

recommending that the programme of Anopheles eradication be put into operation at the earliest opportunity.

13.5.4 (i) Commencement of eradication campaign

The eradication campaign was put in hand in the spring of 1946. Work was carried out simultaneously by the Sanitary Division of the Medical and Health Department for the killing of larvae and the adult mosquito, and the Water Development Department for the elimination and eventual eradication of all mosquito breeding places.

The activities of the two Departments are summarised below:

(A) Activity of Sanitary Section of the Medical and Health Department

For systematic control and effective eradication, the island was divided into districts, zones and subzones and blocks. In total 556 blocks were marked off, each block having an area of 1.75 km².

The application of larvicides, and the killing of the adult mosquitoes was carried out by a force of 450 sanitary labourers.

The larvicides used were gas-oil, Malariol, Paris Green and kerosene for the D.D.T. insecticides.

After a period of five years of systematic and intensive work on anopheles eradication both in their larvae and adult stages, by the use of larvicides and insecticides, principally D.D.T. and Paris Green, the eradication programme came to an end.

Out of the 556 blocks checked for adult anopheles at the end of 1949, 519 blocks showed negative (92.34 per cent). The 7.66 per cent of blocks showing positive results demanded the continuation of a maintenance service, working vigilantly otherwise reproduction of A. mosquitoes would increase by geometrical progression to an alarming degree.

The Director of Medical and Health Services in his Annual Report for the year 1950 writes:

"Anopheles larvae were discovered in 30 out of 556 blocks into which the Island is divided for control

purposes. Certain of these breeding places were near the sea and others close to the airport. In each case prompt action was taken to deal with the situation and further breeding prevented".

The average spleen and parasite indexes from 1944 up to 1950 are tabulated below:

TABLE 13.1 Spleen and Parasite Indexes.

Year	Remarks	Total No Examined	Spleen Index	Parasite Index
1944	Prior to Eradication	4359	32.4	51.9
1946	500 sq. miles under eradication	4960	9.5	13.1
1947	2000 sq. miles under eradication	5447	18.3	4.5
1948	Island wide eradication	4461	4.2	0.2
1950	Island wide eradication	2549	4.5	0.2

Source: Annual Medical & Sanitary Report 1950.

The Director of Medical and Health services in his Annual Report of 1950, page 1, does not exclude the danger of possible reinfestation of the island by A. Mosquitoes brought to the island by visiting ships. Anopheline superpictus were found in ships visiting the island from Syria and Turkey. Even under the pilot's seat in an aircraft from Lebanon, a female A. Superpictus was found, indicating that a vigilant maintenance service had to operate for an indefinite period of time.

(B) **Activity of Department of Water Development**

Cyprus is a semi-arid country with a short winter and a long summer. In the year 1946, under the Colonial 10 year water development programme every water resource either surface or underground was to be developed and used for the production of food and provision of adequate safe water supply for the people of Cyprus.

It is a fact that all methodical and intensive work on water development carried out during the period 1944-1950 has effected the disappearance of the extensive marshes of Cyprus, and has also reduced substantially the

surface stagnant water in the rivers and streams, thus eliminating the breeding places of the Anopheline mosquitoes.

Therefore it can be safely commented that the contribution of water development towards the eradication of malaria has been substantial and most effective. The work carried out by the Department of Water Development during the period 1944-1950 is summarised below:

(1) Drainage of the Syrianokhori-Ghaziveran marshes

During the second half of the year 1944 the British Colonial Office made a free grant of £103,180 for anti-malaria work in the above marshes. This amount was to be spent by the Water Supplies and Irrigation Department, for the drainage of the marshes.

The work was put in hand late in 1944 and was completed in the year 1946. All the marshes extending from Syrianokhori village as far as Prastio and Ghaziveran were drained, under the supervision of the writer of this Thesis.

The drains were of a trapezoidal shape, having an invert two feet wide and side sloping 1:1 (45 degrees). A length of about 6.5 kilometres of drains was excavated and the water collected into the drains was discharged into the sea at an elevation of + 0.33 metres AMSL.

The Syrianokhori marshes were formed by the overflow from the Morphou-Syrianokhori aquifer, appearing at various places in the marshes in the form of springs. When the drainage of the marshes was completed in 1946, the springs discharged into the drains and thus the marshes dried up.

Towards the 1950's when systematic pumping of the Morphou aquifer was carried out for citrus plantations in this area the water table in the aquifer was lowered, and the marshy springs dried up, in the absence of overflow from the aquifer.

The rapid extension of the plantations in the Morphou areas and the continuation of overpumping resulted also in the stoppage of the artesian flows between Syrianokhori village and the sea.

From the above, it is observed that the breeding places of the notorious Anopheline Elutus in the Syrianokhori Prastio and Ghaziveran villages are were finished once and for all. Before the drainage of these marshes the incidence of malaria in Syrianokhori village and parasite indexes were over 80 per cent. Schistosomiasis, which was transmitted to man through snails living in the wet marshes was eradicated also. Thus, the permanent drainage of all marshes existing in Cyprus, coupled with the extraction of water from the nearby aquifers for irrigation, has dried the swampy areas and thus eradicated the Anopheline Elutus, freeing the people from malaria.

(11) Minor water works

The main methods for the exploitation of all surface water resources of the island, since the set up of the Water Development Department in 1939 have been the following:

- a) The lining of the earth irrigation channels, for the prevention of water losses along the route of the channels from the water source to the irrigated fields.
- b) The building of concrete weirs and intakes to guide the river surface flow into the main irrigation channel.
- c) The piping of water from springs to the villages for domestic purposes.
- d) The storage of surface water in dams, built at suitable places in river beds.

The above methods of surface water exploitation have substantially reduced the breeding places of the Anopheline superpictus, and have constituted an effective and decisive factor for the eradication of malaria.

Anopheline superpictus breeds in stagnant water in rivers and streams, below the elevation of 750 metres above mean sea level.

The irrigation works were executed in areas between this altitude and the coast land.

In Cyprus the irrigation season commences in late spring and ends in late autumn, coinciding with the malaria season, as can be observed from Table 13.2. below:

TABLE 13.2 Mosquito Dissections - 1937

Month	A. Superpictus						A. Elutus					
	Glands			Stomachs			Glands			Stomachs		
	No. Dsctd	No. Pos	% Pos	No. Dsctd	No. Pos	% Pos	No. Dsctd	No. Pos	% Pos	No. Dsctd	No. Pos	% Pos
05												
January	-	-	-	-	-	-	-	-	-	-	-	-
February	320	-	-	-	-	-	174	-	-	-	-	-
March	724	-	-	318	-	-	409	-	-	97	-	-
April	825	-	-	316	-	-	1392	2	0,1	509	-	-
May	1250	4	0,3	1020	1	0,1	1637	2	0,1	1382	2	0
,1												
June	1315	15	1,1	786	5	0,6	1480	23	1,5	1071	3	0
,2												
July	1335	39	2,9	477	8	1,4	484	12	2,4	307	2	0
,6												
August	594	7	1,9	167	-	-	353	2	0,5	166	1	0
,6												
Total	6363	65	1,0	3084	14	0,4	5929	41	0,7	3432	8	0
,2												

Source: Annual Medical and Sanitary Report 1937.
Report of the work of the International
Health Division of the Rockefeller
Foundation in Cyprus, 1937.

The diversion of the existing surface flow in rivers and streams in spring and early summer for irrigation creates dry conditions in the beds of rivers and streams thus restricting greatly the water breeding places of the Anopheline superpictus.

Moreover the concrete lining of the earth irrigation channels increases the water flow velocity to 1-2 metres per second. In flowing water and particularly with high velocities, the female mosquito cannot lay her eggs on the water surface in irrigation channels.

Also in subsidiary irrigation channels the water is diverted to different areas every ten days and certain

channels remain dry by rotation, offering no possibilities for the formation of mosquito breeding places.

By the year 1952, a length of about 200 kilometres of earth irrigation channels was lined in cement concrete. (Figures 14.1, 14.2, 14.3 illustrate systems of irrigation water works).

13.5.5 Results of water development towards the eradication of malaria

The programme of the Department of Water Development was to exploit all surface water resources for irrigation and domestic use. The purpose was to bring under irrigation new areas for agriculture, which was the main source of revenue and food for the country.

The intervention of the water engineer in the environmental conditions by the development and use of the water resources has benefited the island in prosperity by increasing its agricultural revenue, raising the hygienic standard of the population, and most important offering a permanent and most effective contribution to the eradication of malaria of all water borne diseases, and all other helminthic diseases, associated with snails living in stagnant water.

13.5.6 (1) Extinction of A. Elutus

The drainage of all marshes existing near the sea coast of the island, under the water development programme carried out by the Department of Water Development, and their improvement for agriculture, has resulted in the extinction of the Anopheline Elutus, which was breeding in the marshes.

It must be appreciated that each species of mosquitoes breeds only in its favourable natural water environment, and it cannot adapt itself to new environmental conditions where other species breed. Thus, when the marshes became dry, A. Elutus could not adapt itself to different environmental breeding places, rivers and streams, where A. Superpictus was breeding, and in consequence was eradicated.

(ii) Eradication of Anopheline Superpictus

Anopheline superpictus was breeding in stagnant water in rivers, streams, perched spring waters, and pools. The water development works executed by the Department of Water Development interfered with the water environmental conditions and created dry conditions, restricting the breeding places of A. Superpictus to odd places and in areas where no water development works had been carried out before 1950.

In the year 1950, the antimalaria campaign came to an end and the Anopheline Superpictus was eradicated in 92 per cent of the total area of Cyprus. A vigilant maintenance team of experienced people carried out antimalaria application of larvicides and insecticides.

This method of fighting the Anopheline Superpictus is well proved and recommended. But in view of the rapid and thorough geometrical progression in the reproduction of mosquitoes, it is important to take radical measures for their extermination by means of drying up and bringing under control all water breeding places, in a permanent way. This can be effected only through water development for irrigation and domestic use, particularly in semi-arid countries.

CHAPTER FOURTEEN
SANITATION IN CYPRUS
Period 1936-1960

14.1 Introduction

It is an axiom that a high level of sanitation in a country is essential to the people's good health, and to the well-being, prosperity and efficiency of the community.

Cyprus has been privileged to have a healthy climate of moderate temperatures, and to enjoy abundance of sunshine almost all the year round.

In antithesis to the good climate and the adequate sunshine, the people of the island, and the rural population in particular, representing 87.4 per cent of the total population, were living in the plight of poverty and disease in the 1930's prior to the outbreak of the Second World War.

The rural population of the island was engaged mostly in agriculture. The people were farmers and cultivators, ploughmen and agricultural labourers, gardeners and shepherds.

The people of Cyprus kept their bodies and houses clean, but the general sanitation and public health hygiene was of a rather poor standard prior to 1936.

The incidence of sub-tropical diseases such as malaria, typhoid fever, dysentery, intestinal parasitism and trachoma was high. The above diseases were endemic and their spread among the population was mostly helped by the absence of safe piped domestic water supplies in the rural and urban areas.

The incidence of communicable diseases as recorded by the Medical and Health Services in the year 1937 is given in Table 14.1.:

TABLE 14.1 Water Borne Diseases

Year	Malaria		Typhoid		Dysentery		Trachoma	
	No of cases reported	Rate per 1000	No of cases reported	Rate per 1000	No of cases reported	Rate per 1000	No of cases reported	Rate per 1000
1935	17917	48,7	548	1,50	-	-	-	-
1936	12779	34,8	667	1,80	51	0,14	-	-
1937	18273	49,8	666	1,80	84	0,26	15865	43,2

Note: The above figures represent cases reported at the medical treatment centres. In 1937 the number of reported out-and-in patients suffering from communicable water borne diseases was 34,888, representing 9.50 per cent of the total population, 367,216 persons.

It should be mentioned, that a much higher number of patients received treatment at home, and did not attend the medical centres.

Source: Annual Medical & Sanitary Reports, 1936-1937.

14.2 Typhoid Fever

This disease was endemic in Cyprus, and at times due to a contaminated water supply from wells, and helped by the abundance of house flies, this disease in certain villages was becoming epidemic causing alarm to the Medical and Health Authorities and the District Administration.

In the farming villages, it was the practice to keep the animal manure in the yard corner of the house, thereby providing fertile breeding places for flies, which transported the microbes of typhoid fever and other intestinal diseases, on their legs to human foodstuffs. Lack of latrines in the village houses and the contamination of the wells from where water was drawn for domestic use were responsible for keeping this disease endemic, particularly in the rural areas.

Statistics prepared by the Medical and Health Services for the years 1933-1937, indicate that the average rate of endemicity of typhoid fever was 14.63 per 10,000 population.

The rate by Districts is given in Table 14.2.

TABLE 14.2 Typhoid fever 1933-1937 (Rate per 10,000 population)

Year	Nicosia	Larnaca	Limassol	Famagusta	Paphos	Kyrenia
1933	10,2	19,1	39,4	4,5	8,6	11,3
1934	7,4	38,6	12,3	5,1	7,2	3,9
1935	19,4	20,7	12,6	11,3	9,0	11,6
1936	26,08	12,61	15,58	14,17	15,7	14,50
1937	23,16	19,04	12,16	14,03	13,21	25,70
Average rate	17,25	22,07	18,08	9,82	10,78	13,00

Source: Annual Medical and Sanitary Report, 1937

14.2.1 Mortality of Typhoid Fever in 1937

During 1937, in all, 666 cases of typhoid were reported all over the island. The average morbidity rate in 1937 was 1.8 per 1000 population. (Total population 370,935). In all, 55 cases out of 666 were fatal, giving a mortality percentage of 8.25%.

An age group analysis of the fatal cases indicates that a high mortality was observed amongst the older ages, being 26.6% in the group 45-54 and 25% in the group over 55 years of age. The group under 5 years had a mortality of 9.5%. (*Annual Medical and Sanitary Report, 1937*)

Typhoid fever is both a water borne and a fly borne disease. While one could not exclude the role of the house fly (*Musca domestica*) in the spread of typhoid fever, dysentery and other intestinal diseases, it is my opinion that the commonest source of infection is the use of contaminated drinking water from shallow wells.

The highest incidence of typhoid fever and in its epidemic form was observed in the villages situated in the zone of lowlands and plains, using water bailed from shallow wells in the yards of the houses, or from public wells, on which hand pumps were installed. The wells were not always properly built and protected against surface pollution and

contamination, and at times these water sources were the cause of epidemics of water borne diseases.

Dr.C.S. Markides, the Government Health Officer, in his contribution to the Annual Medical and Sanitary Report of 1937, page 85, writes on the outbreaks of typhoid fever epidemics:

"In the case of the water borne epidemics, in the vilalges of Ayia Varvara Nicosia, and Ora Larnaca the disinfection of wells - the only source of water supply - put an immediate stop to the epidemic, and no case was reported after this measure was taken. However, in view of certain difficulties encountered in controlling the outbreak at Ayia Varvara, a temporary isolation hospital had to be established there".

In the villages situated on the Troodos hills the houses were infested with flies, breeding in the manure heaps kept in the yards of the farm houses. Yet in spite of the large number of house flies in the houses and stables, typhoid fever and other enteric disease were sporadic and rare. In my opinion this can be attributed to the fact that their domestic water supply was fetched from natural springs safe against contamination.

14.3 Sewage disposal

Until the year 1936 pit latrines, the commonest method of dry sewage disposal were unknown in the rural areas. Pit latrines were found in towns only. In the absence of a piped water supply the Health Authorities encouraged the provision of pit latrines as the only solution for an acceptable form of sanitation.

In the designing of new houses in the towns, septic tanks were provided but they were not in operation since there was no waster available for such a water borne system.

At that time the Cyprus Government took several measures to encourage the provision of pit latrines in all rural houses, but the villagers on the other hand considered it was unwise and unhealthy to have a pit latrine opened in the yards of their houses.

It is worth mentioning that each rural house had a stable for the oxen and donkeys which were used for ploughing the fields. The family mixed their wastes with the animal manure which they scavenged at regular intervals as fertiliser for their fields.

14.3.1 Pit latrines

The Cyprus Government thought of obliging every householder through legislation to open a pit latrine in his house yard, but again whether the pit latrines would be used was uncertain. So it was decided to promote that idea through education and propaganda. Educational lectures on the subject were given regularly by the Health officers, particularly in the villages where typhoid fever was prevalent.

As an incentive precast latrine floor slabs were given free of charge to villages, but the success of the whole project was unfortunately negligible.

One could see some point in the negative attitude of the villagers to the idea of having a pit latrine in the yard of their house.

- a) For many generations the rural people used the animal stable as the place for the defecation.
- b) In most houses of the lowlands, and particularly in the coastal zone, which was thickly populated, a hand dug shallow well was excavated and its water bailed for the domestic needs of the family. No piped water supply was available at that time. The people were conscious of the probability of contamination of their drinking water supply by the excavation and use of a pit latrine at close proximity to their well. The idea of defecating in the pit latrine over their water aquifer was not in the least agreeable to them.
- c) At short regular intervals they collected and conveyed their animal manure with all other human and food wastes to their agricultural land for its use as a fertilizer. In their opinion this method of dry sewage disposal was the correct one, since their

human wastes were treated in conjunction with their animal wastes.

14.3.2 Borehole latrines

In the year 1937, at the request of the Director of Medical services, the Bureau of Malaria Control, a branch of the International Health Division of the Rockefeller Foundation operating in Cyprus for antimalaria work, undertook to drill borehole latrines in Deftera village situated 8 miles south west of Nicosia. This undertaking would serve as a demonstration for the purpose of extending this programme to other villages.

Deftera village is built on top of a shallow open aquifer, recharged from the nearby flowing river, and in every houseyard there was a shallow well, the water of which was used for drinking and other domestic needs of the family. The aquifer was composed of river alluvium, gravels, sands, and sandy clay, and the water table was 40-50 feet below ground surface.

The risk of contamination of the aquifer by the drilling and use of borehole latrines was considered, and a distance of 60 feet between the latrines and the well was arbitrarily fixed. Of the total of 237 houses in the village, 157 houses could meet the above condition of 60 feet distance between well and pit latrine. As an experiment and with the consent of the householders, over 100 borehole latrines were drilled.

The latrines were bored by means of an auger 16 inches in diameter operated by two labourers, using two long chain spanners for turning the rectangular tubing of the auger.

The soil encountered was a stratum of soil and clay 10-15 feet overlaying a layer of alluvium material, river gravel and sand. The latrines were bored up to 20 feet below the ground surface.

As stated before, the householders did not like to defecate in a hole on top of their aquifer and at close proximity to their drinking water wells. Thus in spite of the fact that they had given their consent for the

construction of the latrines in the yards of their houses, in order to show their goodwill to the authorities; in practice they never used them.

The above case of borehole pit latrines in the Deftera village would look absurd to the public health engineer of today. Deftera village is situated over a rich open shallow aquifer, having a surface area of over 25 square miles. A hand dug well or a shallow borehole, in a place outside the village away from the inhabited village area, would be the best solution. A small pumping scheme could be constructed to supply water to a few street standpipes in the village.

Electricity was not available at that time and pumps driven by means of a diesel engine were not well known in Cyprus. Of course a windmill could have safely provided the quantity of water needed for the domestic requirements of Deftera at that time. Moreover, it may be mentioned that prior to the year 1937, no Water Development Department was in existence, in Cyprus. The medical and health authorities were looking at the problem of sanitation from a health point of view only. They were not conscious of a public health engineering conception.

In parenthesis, it is worth mentioning that nowadays Deftera village is considered one of the most progressive villages neighbouring the town of Nicosia, enjoying a hygienic piped water supply distributed to all village houses and properly metered and quality controlled. The source of supply is two boreholes drilled in the Deftera village aquifer at a distance from the inhabited area of the village. The water is extracted by means of two electrosuimmersible pumps, 20 H.P. suitable for a current of 415 volts, 3 phase, 50 HZ AC, tapped from the main grid of the Electricity Authority of Cyprus.

As a result of the adequate piped supply serving the domestic requirements of Deftera village, practically all houses have a proper water borne sewage disposal system, consisting of a septic tank and a soakaway pit.

14.4 Legislation

The Government in its endeavour to promote sanitation in general, enacted the Public Health (villages) Law of 1937.

By this Law any new house built had to have a building permit issued with the approval of the interested authorities. Proper architectural drawings were submitted and in the building permit granted there was the condition for the construction of a pit latrine for the use of the family.

Slowly the people became used to this practice and by the year 1946 latrines were in use mostly in the hilly vilalges where they obtained their domestic water supply from nearby springs. The availability of piped supplies to over 500 villages and the provision of latrines to a number of villages have contributed a steep decline in the incidence of typhoid fever.

By the year 1956 significant progress in the field of sanitation in the rural areas was effected. About 300 villages, representing the one half of the rural population, were using the pit latrine. About 40,000 pit latrines were in service. (*Medical Annual Report, 1956*).

It is worth mentioning that the main encouraging factor for the provision and use of pit latrines and the general improvement in sanitation in the rural areas was the outstanding achievement in providing villages with adequate pure piped water supply for domestic use. This has helped the improvement of personal hygiene and the eradication of trachoma of which in the year 1939 there were approximately 30,000 cases in Cyprus.

By the year 1960, trachoma had disappeared and since then it has not been mentioned in the Annual Reports of the Ministry of Health.

14.5 Summary

From the foregoing pages it is seen that during the last 40 years, the most serious communicable diseases, insect and waterborne, which were endemic and adversely affecting the health of the people of Cyprus, have been

eradicated for good or eliminated to a degree worth of no consideration. Such diseases were malaria, typhoid fever, and other enteric diseases, including schistosomiasis and trachoma.

The main factors in the successful eradication of above diseases are:

- a) The provision of piped domestic water to every house in each village and town of Cyprus.
- b) The promotion of a high standard of sanitation in villages and towns, simultaneously with the provision of domestic supply, and the upgrading of personal hygiene.
- c) The raising of the standard of education of the people, who became well conversant with the spread of these diseases and their desire for a better standard of living together with their cooperation with the authorities concerned in the battle against the communicable diseases.
- d) The British Colonial Administration of Cyprus, took the right decision to eradicate malaria, and gave priority to water supplies and sanitation. The people were willing to cooperate in these fields, and from 1946 to 1960, when the British Administration in Cyprus was terminated, the work done and the result achieved were outstanding.
After 1960, the Cyprus Government continued the development programmes in all fields, and by 1980, Cyprus became to some extent a developed country, without communicable diseases and with all its people enjoying very good health.
- e) One may argue that Cyprus is a small island and development programme undertaken can be completed successfully. It is believed and accepted that development projects in any country should cover as a priority, water and sanitation and the eradication of communicable diseases.

Such development programmes take years to complete. Man can however, bring under control water resources, and

get rid of water borne diseases. This can be done if the Government of any developing country takes the decision to embark on such projects and also, deciding to have healthy children and happy young men they make a start and seek the help of the other developed countries for financing and technical assistance and they all work side by side with goodwill and close cooperation. In this way, it is certain that a slow but sure water development achievement will be effected for the prosperity and welfare of such a country.

Water, health, prosperity and happiness are linked together.

"Οὐν ἐρ'θ υἱεῖαζ νπεῖρων οὐδεν ἐν βίῳ" (In life there is no better thing than health).

From Menardos: Gnomes Monostihí.

APPENDIX 1

(1) ANNUAL REPORT 1963 - Water Development Department
Chapter 13. Page 56.

REPORT ON VILLAGE WATER SUPPLIES

by H.P. Karakannas, Engineer-Hydrologist.

The work of the Village Domestic Water Supply Section is confined to the domestic supplies for the villages, but it also includes the Towns of Paphos and Kyrenia, all representing a population of 392,000 persons or 66% of the the total population of the island. The Section deals with all aspects of waterworks: the investigation and development of springs, the laying of supply and distribution water mains, and the construction of storage reservoirs, pumping stations and public fountains.

Practically in every village to which nowadays water is provided a house-to-house service is implemented. The cost of the scheme is shared between Government and the village on a fifty-fifty basis, while the extra cost for a house-to-house service is borne entirely by the village. The supply to the consumers is controlled by means of water meters or break-pressure and distribution boxes. The daily satisfactory supply per capita is now considered as 20 gallons, but it will have to be raised to 25 gallons, or even 30, as the standard of living is rising steadily and rapidly.

The sources of village domestic supplies may be springs, boreholes, filtration galleries or dams. Practically all the schemes executed during the year in Nicosia, Famagusta and Larnaca districts have as sources of supply successful boreholes. The stability or deterioration of the aquifers in these districts has a direct influence on the domestic supplies, which should be maintained to a satisfactory degree. In the case of the hilly areas, such as Pitsillia dry villages, it may be found necessary to use water from the springs and compensate any irrigation losses by the construction of dams or other irrigation works that will be designed under the development programme of the watershed areas.

In the case of pumped supplies, turbine pumps are installed, driven by a diesel engine, or motor where electricity is available. Water is pumped into a ground level or elevated reinforced concrete tank, the function of which is to provide at least one day's storage, and in some cases to act as a reservoir from where a steady continuous quantity of water can be withdrawn.

Most of the remaining villages without piped or satisfactory water are in the area northwest of Salamis and Boghaz. Famagusta and on the northern side of the Kyrenia range. A team of German experts is now carrying out exploratory investigations and drilling for the purpose of tapping new aquifers from where water may be withdrawn for domestic purposes.

An amount of £640,000 was allocated for village domestic supplies during 1963, and the approved programme of village water supply schemes serving a population of 58,684 persons was completed. It is worth mentioning that 293.74 miles of pipes varying from $\frac{1}{2}$ to 10 inch diameter have been laid. Moreover 76 reinforced concrete tanks, 12 pumping stations and 16 public fountains have been constructed. A house-to-house service has been provided in 67 villages and 11,600 house connections made. It is estimated that an area of about 1,000 donums of land within the village areas has been brought under irrigation by the use of the surplus water over their domestic requirements. This brings a very high return to the villagers.

At the end of 1963, of the total of 627 villages of the island, the number with piped supplies was 580 or 92.50%. 432 or 68.90% are considered satisfactory and supplementary supply. 204 villages with a population of 226,000 persons, or 61.41% of the rural population of the island, have a house-to-house service, conforming with universal standards.

Because of the increase in population, rise in the standard of living, the subnormal rainfall, and the overpumping of the aquifers, water supplies that were formerly considered satisfactory are now in need of

improvements or additional supply. The 47 villages without piped supply are on the whole situated far from suitable and reliable sources of water supply, but every effort is being made to solve their water problems, even if the cost of supplying them from distant sources is made higher than in past schemes.

In addition to the 84 schemes completed in 1963, a further 13 schemes were under construction in their final stage at the end of the year. Plans were prepared for 161 schemes, all estimated to cost £1,156,523.

The following table gives an outline of the work executed during the year.

Length of pipes laid in 1963 (Galvanised mild steel pipes)

Size ND								
1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"
0,835	2,875	46,390	40,611	54,113	36,007	10,840	11,970	20,337

Total Miles 224.801 (362 km)

Asbestos-cement pressure pipes

Size Nominal Diameter	2"	3"	4"	6"	8"	10"
Length in miles	17.568	16.770	19.347	12.300	2.080	0.874

Total miles 68.939 (111 km)

Reinforced concrete tanks:

Elevated tanks	10 (3,000 gallons capacity)
Ground tanks	66 (2,000,000 gallons capacity)
School tanks	37
Pumping stations	12
Fountains	16
House connections	67 villages (15,000 consumers)
Area of land bought under perennial irrigations	1000 donums approximately

The Schemes completed may be classified as shown below:

"Village standard" means that the distribution of the water is effected by street fountains only, and not by house connections. A public fountain with a thorough and proper drainage system serves 6-10 houses.

"House-to-house" means that the distribution of the water is effected by individual house connections. Distribution mains are laid in all inhabited areas, and the consumer bears the cost of the service connections. The supply is controlled by means of water meters, or break-pressure regulators securing an equal quantity of water to all houses, in those cases where the supply is fixed and limited. In practically all the new schemes in Nicosia, Famagusta and Larnaca Districts water meters are installed.

Successful drilling carried out during the year made it possible to provide many villages in Nicosia, Famagusta, Larnaca and Limassol districts with domestic water.

a) An important pumping scheme providing Yerolakkos, Ayios Vasilios and Skylloura with adequate water has been completed during the year. It may be worth mentioning that these three villages were supplied with water by tankers before the pumping scheme. The new source of supply is a successful borehole near Avlona village using a pumping unit at the rate of 12,000 gallons per hour into a tank.

From this balancing tank a 6 inch diameter asbestos cement pipeline 7.5 miles in length conveys the water by gravity to Yerolakkos. Another 4 inch diameter asbestos cement pipeline 7.5 miles in length conveys the water by gravity to the other two villages. A house-to-house service has been provided for all the villages, and 900 house connections controlled by water meters have been installed.

b) A major pumping scheme executed during the year in Famagusta District is the Rizpkarppasso scheme. The sources of supply are two successful boreholes from where water is pumped at the rate of 5,000 gallons per hour from

each into a 100,000 gallons capacity reinforced concrete reservoir. The water is distributed throughout Rizonkarpasso by means of 37 miles of distribution mains varying from 10 inch to 2 inch in diameter. Nine hundred house connections controlled by water meters have been installed.

c) Another major pumping scheme executed in the Famagusta District is the Lefkoniko scheme. The source of supply is a borehole in the Kyrenia Range from where water is pumped into a 100,000 gallons capacity reinforced concrete reservoir through a 4 inch diameter asbestos cement pipeline. A house-to-house service consisting of 700 house connections has been installed.

d) A pumping scheme for Kiti village was completed in the Larnaca District. The source of supply is an infiltration gallery in the Trimithos river, from where water is pumped at the rate of 6,000 gallons per hour into a 30,000 gallons capacity reinforced concrete elevated tank. A house-to-house service including the installation of 300 water meters has been completed. This village had no piped water before the implementation of this scheme.

e) A big regional gravity supply scheme was completed in the Limassol District. This scheme serves 5 villages, namely: Mandria, Kato Platres, Arsos, Omodhos and Potamou, having in all a population of over 4,000 persons.

The source of supply is part of the water of the big "Arkolakhanía" spring situated in the Mesapotamos river. About 15 miles of galvanised mild steel mains varying from 4 to 2 inch diameter have been laid from the spring to the five villages. In all the villages a house-to-house service with break-pressure regulators has been installed.

f) Another scheme executed during the year in the Limassol District is the new distribution system of Pano Platres, which is the biggest Summer Resort of the island. The water consumed is controlled by meters.

g) A mass concrete weir 15 feet high was constructed in the Stavros-ti-Psokas river, whereby the river water is filtered and used as a supplementary source of supply during the later summer when the yield of Xeropiyi spring is low, and by this arrangement the supply to the eight Paphos villages (Lyso, Instinjo, Melandra, Meladhia, Pelathousa, Philousa, Zakharia, Peristerona) is kept at a very satisfactory standard all through the year.

APPENDIX 2

(2) ANNUAL REPORT 1973. WATER DEVELOPMENT DEPARTMENT

V. DIVISION OF CONSTRUCTION

by H. Karakannas, Head of Division.

5.1 The functions of the Division involve mainly the planning, construction, supervision and control of all waterworks undertaken by the Department either by direct labour or direct contract in the field of domestic water supplies and irrigations works and in the capacity of minor and major projects.

In addition the Division deals with the checking of designs and estimates of schemes prepared by the Small Project Division, the preparation of specifications for tenders of materials and machinery, as well as with the utilization and administration of the construction plant and the Department's workshop respectively.

The numerous functions of the Division and the various skilled trades involves necessitate the staffing of the Division with widely experienced personnel.

The staff of the Division during 1973 consisted of:

- 1 Engineer Hydrologist - Head
- 1 Mechanical Engineer
- 3 Senior Inspectors of Works
- 6 Inspectors of Works
- 3 Chief Foremen
- 9 Assistant Chief Foremen
- 1 Technical Assistant
- 90 Monthly and Weekly paid Foremen
- 368 Weekly paid regular Artisans
- 482 in total

Although the supervising staff of the Division was rather small in number and while only one Technical Assistant was available, still the staff worked efficiently without in the least relaxing their vigilance, and carried out the programme of works, responding simultaneously to the great demand for the execution of emergency schemes to

cover the essential needs of towns and villages as a result of the greatest ever recorded drought in the island's history. Such emergency water supply schemes were executed for most of the towns and a number of villages. It may be worth mentioning that in order to meet the great demand plans were introduced to supply a number of villages with the urgent water supply needs by means of tankers.

The originally approved programme for 1973 included 188 schemes of a total estimated cost of £2,585,191. This programme of works was later altered by the Council of Ministers as a result of the unprecedented drought. A number of major and minor irrigation schemes considered not of first necessity were frozen, so as to secure additional funds for the implementation of emergency water supply and irrigation schemes, as well as to use funds for the relief of the so badly stricken farmers of the island.

5.2 Labour force

For the execution of all 401 schemes mentioned above, the Construction Division has made use of the 368 regular employees and a number of casual artisan employees that were recruited from the areas where the works were executed. during 1973, in addition to the 368 regular employees of the Department, a daily average of 568 casual employees were engaged for the construction of the works. In total during 1973 an average of 936 regular and casual employees were engaged daily by the Construction Division of the Department. The overall expenditure on wages for the construction of domestic water supplies for the year reached £544,252.

It is worth mentioning that for the execution of works and the implementation of the construction programme of 1973 enormous difficulties were faced in some areas in the securing of adequate skilled and unskilled labour force.

Such difficulties were mostly encountered near the urban areas and especially in the Kyrenia and Nicosia areas where the rapid development in the private sector absorbs all the local labour force. In most cases casual labour

had to be recruited from other isolated areas and be transported to the site of the works under construction.

In spite of the great efforts made by the staff of the Division for the securing of sufficient labour force for the completion of the construction programme within the specified timetable, some schemes had to be suspended due to shortage of labour force.

5.3 Constructed plant

For the execution of the works included in the Construction Programme of 1973, the Departmental and Government machinery was used primarily. In cases, however, where the Departmental machinery could not meet the demand, and especially in the field of heavy machinery, the Division had to hire such machinery from private owners through open tenders. In total during 1973 machinery was hired for 15,420 working hours at an expenditure of £20,915. Also during the year machinery was hired for the excavation of 88,000 running metres of trenches for the laying of pipes at a cost of £12,066. Land Rovers and other vehicles had also to be hired for 7,220 working days at a cost of £14,669 from private owners, to be used for the transportation of employees and materials to the site of the works.

5.4 Materials

Most of the materials used for the construction of the projects were purchased from the Government Central Stores. Such materials are pipes, pipe fittings, steel pumping units, water meters, timber etc. Building materials, however, such as gravel, sand, aggregate etc., were purchased through tenders. During 1973 the Construction Division awarded 69 such tenders for the purchase of 19,532 cubic meters of such materials at a cost of £30,304. The needs of the Division in cement were purchased through a Government general contract from the Vassiliko Cement Factory. During 1973, 2,970 tons of cement valued at £20,025 were purchased for the works executed by the Division.

During 1973 a total length of 352,335 metres of pipes of all types i.e. steel victaulic galvanised iron and asbestos cement, were laid by the Division for domestic water supply and irrigation schemes. In addition for all the rural water supply schemes 5,967 water meters of ½ inch in diameter were purchased and installed by the Division.

Tables shown in details the pipes and other materials used by the Division for the works executed during 1973 are given below:

(i) List showing all types of pipes laid during 1973.

Nominal diameter in inches	Galvanised Steel Class B	Steel Class B	Asbestos cement Class B	Asbestos cement Class B	Total length of pipes
	Running metres	Running metres	Running metres	Running metres	Running metres
½"	28,650	-	-	-	28,650
¾"	300	-	-	-	300
1"	15,804	-	-	-	15,804
1½"	32,352	-	-	-	32,352
1½"	23,490	-	-	-	23,490
2"	43,200	-	-	-	43,200
2½"	12,696	-	-	-	12,696
3"	27,414	-	39,172	1,533	68,119
4"	54,960	-	27,928	1,950	84,838

6*	-	4,530	25,296	2,764	32,590
8*	-	1,530	5,280	-	6,630
10*	-	60	2,172	1,434	3,666
Grand totals	238,866	5,940	99,848	7,681	352,335

(ii) List showing other materials and hired machinery used during 1973

Ser No.	Description	Quantity	Expenditure incurred in £
1	Cement	2,970 tons	20,015
2	Water meters ½" ø	5,967	20,884
3	Heavy machinery	15,420 working hours	20,915
4	Land Rovers etc	7,220 working hours	14,669
5	Excavation of trenches	88,000 running metres	12,066
6	Sand	11,493 m³	17,239
7	Shingle	4,575 m³	5,718
8	Aggregate	3,464 m³	3,464
9	Soil	45,209 m³	3,883
	TOTAL		£118,853

5.5 Rural domestic water supply schemes

The construction programme for 1973 included 93 rural domestic water supply schemes of an estimated cost of £813,607. Out of these schemes 47 were completed during 1973, 34 were put in hand but could not be completed by the end of the year and were carried over for completion in 1974, and 12 schemes could not be put in hand for various difficulties and those that were not rejected were carried over for execution in 1974.

The cost incurred on all the rural domestic supply schemes reached the amount of £480,347 thus exceeding the 1972 expenditure by approximately £180,000.

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