Republic of Cyprus

Ministry of Agriculture and Natural Resources

Water Development Department

50 years 1939-89

50 Χρόνια Υδατικής Ανάπτυξης 1939-1989

MAJOR WATER DEVELOPMENT PROJECTS

- Southern Conveyor Project
- Khrysokhou Irrigation Project
- Vasilikos-Pendaskinos Project
- Paphos Irrigation Project
- Pitsilia Integrated Rural Development Project (Water component)

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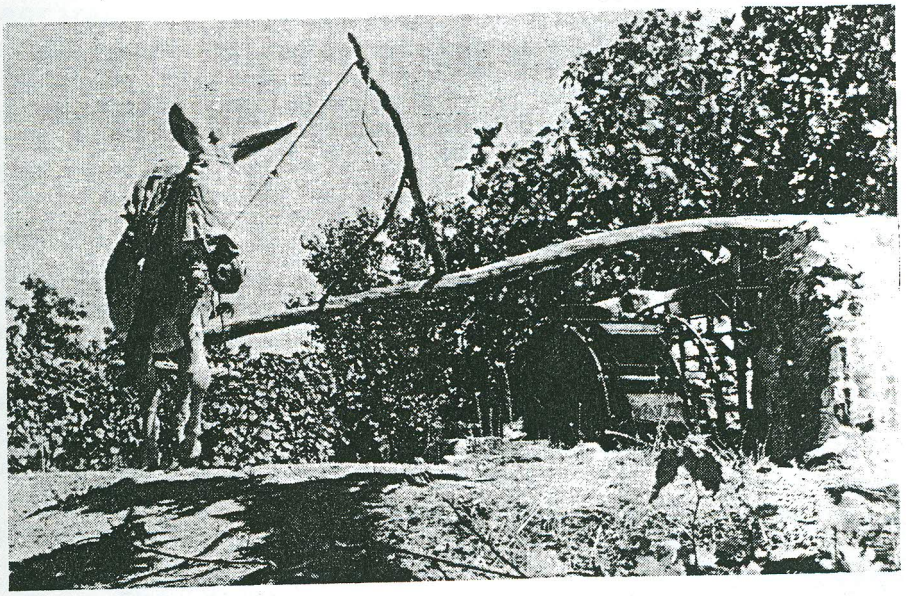


Persian Wheel

ADDRESS
BY THE MINISTER OF AGRICULTURE AND NATURAL RESOURCES

This booklet prepared for the 50th anniversary of the formation of the Water Development Department shows in a concise form how the government of Cyprus has solved one of the most difficult problems, that of the scarcity of water, the element on which the economic development of our country and the standard of living of our people depends.

In 1961 Archbishop Makarios had the right vision about the future development of the Cyprus economy and he considered that the construction of dams and irrigation projects would be the most important task of his Government. A long term programme for development of the water resources was prepared and executed in the shortest time possible in spite of financial difficulties and the Turkish invasion in 1974 which resulted in 200,000 refugees and loss of 40% of our land surface. Each year for the past 29 years the government of Cyprus constantly persisted in the accomplishment of the programme for development of the island's water resources and allocated considerable sums for it. Many items of the government budget during these years were cut or decreased but the programme for the construction of dams and irrigation schemes continued uninterrupted.

The results of such efforts and sacrifices are now evident and rewarding. The total irrigated area from 20,000 ha in 1960 (Including areas in occupied Cyprus amounting to 17,000 ha in 1974) has increased to 32,000 ha in 1987. Water supply for villages and towns is actually assured at least up to the year 2000 as well as for industrial development. The development of agriculture and extensive production of fruit and vegetables at reasonable prices helps in the development of tourism. The tourism industry could not have been realised without having the adequate quantities of water needed for the tourists (up to 1.5 million expected this year in a country with a population of mere 660,000 people).

We are proud of the achievements in the field of water resources development and we are aware that we are one of the leading nations in this part in the Middle East region inspite of the fact that we are one of the smallest countries in size.

We have not achieved this progress alone. We have been assisted technically and financially by many Organisations and Nations to which we are profoundly grateful. I shall mention here the main contributors to our development through the provision of experts and funds.

a. The United Nations Development Programme through the Food and Agriculture Organisations of the United Nations - UNDF/FAO, then IHP Unesco, WMO, IAEA, IGS-UK.

b: British Technical Assistance through UK Overseas Development Administration (ODA).

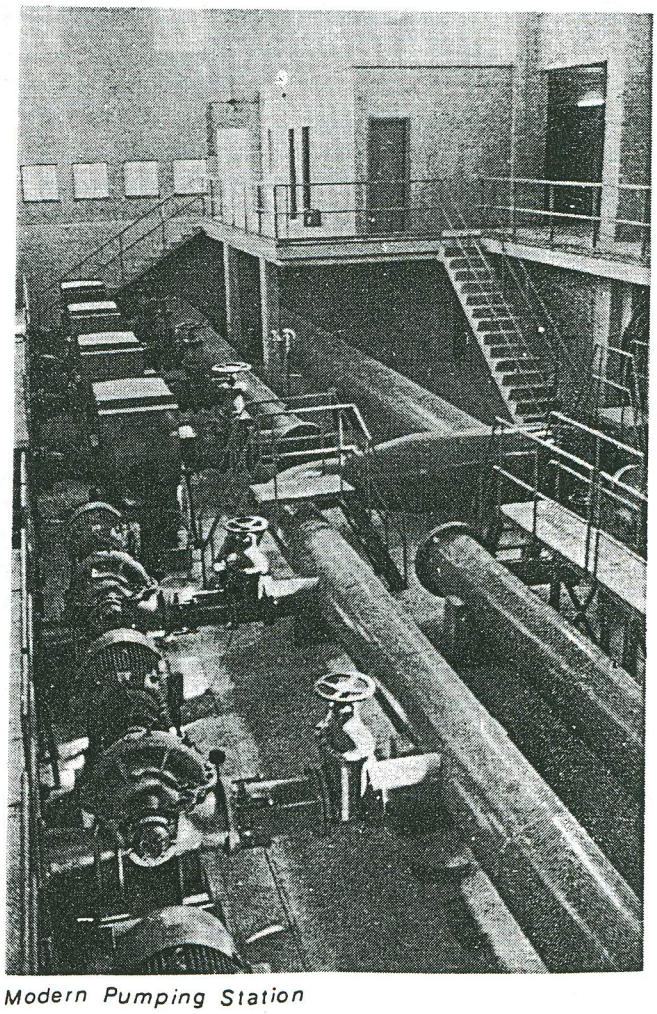
c: French Technical Assistance through SOET.

d: West German Technical Assistance in Hydrological and soil studies.

e: USA - AID Technical Assistance through Bechtel Corp.

Finally I should like to point out that the water resources development of a country is a long complicated process with numerous obstacles. This booklet outlines all the work needed to reach our degree of development by the use of experienced local and international staff.

I believe that this booklet could well be a reference book to all those who are planning a long term development of water resources in newly established states and I am sure that such planning should allow for at least 25 years work with well organised, experienced and efficient technical and administrative staff.



Modern Pumping Station

PREFACE

It is with great pride that we celebrate the 50th anniversary of the establishment of the Water Development Department and Personally I am happy to have served the Department for the past 30 odd years; from 1969 as Assistant Director and from 1980 as Director.

On the occasion of this anniversary I should like to extend my warmest thanks and appreciation to all our retired colleagues who have left their personal mark on our works and to us their valuable experience. Special reference must be made to all ex Directors of the Department and especially I L Ward, the Director of the administration prior to independence and C A C Konteatis, my predecessor, (who was the first Cypriot Director of the Department) and who have left us a truly enviable organisation of the WDD.

The calamity of the Turkish invasion of July 1974 struck the Water Development Department in many ways. First and foremost, ten of our colleagues are still missing having been taken prisoners by the Turkish army and we voice here once again our call for their release or for the ascertainment of their fate. The Turkish invasion posed a great challenge to the staff of the Department, who with great eagerness and determination managed, during those days, to maintain uninterrupted supplies of water to towns and villages and to serve the immediate needs of thousands of displaced persons and ultimately, through emergency schemes, to satisfy the needs for water for refugee housing and for the reactivation of displaced farmers.

It is well known that prior to the implementation of our major water development projects, Cyprus, as a semi arid country was suffering from acute water shortage. We gladly welcomed the call to carry out these projects, considering this as a challenge and an opportunity for us to demonstrate our determination and ability to carry them out, pooling all our resources together. We are now therefore thankful for the broad recognition of our success, with a reminder though, that "Cyprus would have gone thirsty without us".

Although a great deal has been achieved we nevertheless have a lot of work ahead of us on new projects as well as for the proper operation, maintenance and management of our completed works.

Finally I convey to all the staff of the Water Development Department my sincere congratulations with the conviction that the cooperation that has prevailed amongst us all these years will continue thus enabling the Department to contribute to the progress and welfare of our country.

C St Lytras
Director
Water Development Department

April, 1987

WATER DEVELOPMENT DEPARTMENT
50th ANNIVERSARY 1939 - 1989

Not a drop of water
to the sea
Makarios

Introduction

The economic development of Cyprus and the attainment of high living standards of its people (660,000 inhabitants) are closely related to the availability of fresh water needed for drinking, for agriculture, for industry and tourism.

The island of Cyprus has a length of 210 kms and breadth of 590 kms with a total land surface of 9250 sq.kms. The yearly average precipitation of Cyprus is 500 mm which is not evenly distributed, ranging between 200 mm in the eastern plains and 1000 mm on the Troodos massif. Unequal distribution of rainfall results in poor crops in low rainfall areas whereas in the mountainous regions the forests use part of the rainfall for their growth with the remaining water being transported by steep rivers and lost to the sea. It was therefore necessary to construct many dams to retain the water and at the same time to build conveyance systems to transport the water and make it available in needy areas for irrigation, industry and domestic water needs.

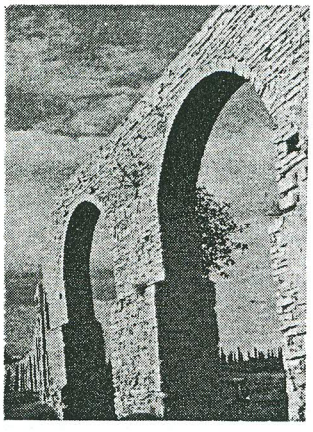
The quantities of fresh water used 50 years ago and those used now show a vast difference. The estimated volume of water stored in dam reservoirs in 1960 was 6 MCM in comparison with 300 MCM now, showing an increase of 294 MCM or 150% per year.

The 50 years life of the Water Development Department are distinguished by the following characteristic periods.

- <u>The pre-independence period 1939-1960</u> during which various preparatory works were carried out such as: hydrometry by constructing flow gauging stations with automatic water level recorders; measurent of spring flow on a more systematic basis and hydrological surveys of the main aquifers. The establishment of the services to carry out the said works were essential preconditions for the future development of the water resources.

Beside these works, training and specialisation of technical staff was proceeding as well as the most urgent works on small irrigation schemes, domestic water supplies and the construction of small dams.

- The period from independence up to the Turkish invasion 1960-1974 the main characteristic of which was the close cooperation of the Government of Cyprus with the United Nations Development Programme (UNDP) through the assignment of UN experts, the carrying out of water development studies and the formulation of a future plan of action on short and long term bases. This is the period during which the Agricultural Research Institute was established in cooperation with the UNDP.



Old Aqueduct

The most important studies were the Cyprus Water Planning Project (CWPP) a UNDP project, the Paphos Irrigation Project with UNDP, the Akrotiri Groundwater Development, and the UN special fund project for Groundwater and Mineral Explorations.

At the same time the services for hydrology, hydrometry and hydrogeological surveys were expanded with related staff increases in all fields. Several dams were constructed such as Pomos, Ayia Marina, Argaka, Yermasoyia, Polemidhia and Mavrokolymbos. There was also extensive activity in construction works and improvement of various irrigation schemes while satisfying the needs for village domestic water supplies.

- The period from the Turkish Invasion to date 1974 - 1989 which has been the all out effort for the implementation of our major water development works making also use of Consulting Engineering firms for the planning and design of works and calling international tenders for their construction. The main achievements are the Paphos Irrigation Project with 5000 ha irrigated area, the Khrysokhou Irrigation Project with 3000 ha, the Vasilikos-Pendaskinos Project with 1500 ha, and the Southern Conveyor Project with 13,535 ha. Mention must also be made of the Pitsilia Integrated Rural Development Project, the Water Development component of which was undertaken by the Water Development Department.

- The period from 1989 onwards is the period during which our efforts will be concentrated on the proper operation and maintenance of all our completed works and the establishment and

operation of a Water Authority of semi governmental standing to deal with all aspects of water development.

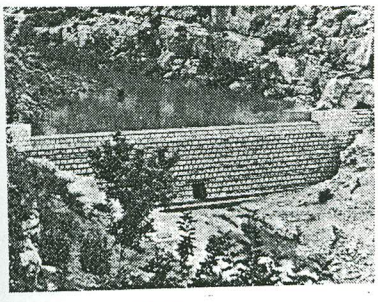
The water development works implemented by the Water Development Department will serve for the supply of water for drinking, irrigation, industry and our tourist development at least upto the year 2000 through the use of the surface and ground water resources of the Island. After the year 2000 desalination of sea water is envisaged although it costs 2 to 3 times more than our natural resources.

The history of the Water Development Department from its establishment to date is described in the following paragraphs.

THE PRE-INDEPENDENCE PERIOD 1939-1960

Establishment of the Department - The First Experts

The Water Development Department was established in 1939 as a separate Department under the name "Water Supply and Irrigation Department". Prior to 1939 water supply and irrigation schemes were the responsibility of a section of the Public Works Department which was established in 1896, but as early as 1878 when the British administration of Cyprus began, Engineers were appointed to look into the day to day water situation and experts were assigned to carry out studies on the prospects of water development in Cyprus.



Kandou Masonry Dam

The general opinion of the experts was that, with the exception of the central Messaoria plain (literally speaking the plain between two mountain ranges - Troodos and Pentadactylos) the geomorphology of Cyprus did not allow for large water storage works. They none-the-less were aware of the potential of ground water and its exploitation by drilling deeper wells and employing mechanical pumping equipment of that time.

Ground Water the First Target

Therefore, at the beginning of our century, after the construction of the first water retaining structures with low, long dam embankments such as the Akhyritou and Kouklia dams investigations were initiated for the location of ground water bearing areas and exploitation of these started between 1920 and 1930 mainly in the Morphou and Famagusta Regions. Great importance was also attached to the development of ground water by the first

Kythrea Spring

Director (Water Engineer as he was then called) of the Department Dr C. Raeburn (1939-1948) as well as by I.L. Ward who was Director of the Department from 1948 to 1959 and during the directorship of whom, in July 1954, the Department was renamed, 'The Water Development Department' and the title 'Water Engineer' was changed to 'Director'. Thousands of boreholes were drilled up to the establishment of the Republic in 1960 in all areas of Cyprus so that during the initial years of the new republic there was a serious threat of depletion of the main aquifers.

Hydrometric Data Collection

Hydrometry was organised on a systematic basis in the fifties when flow gauging stations were established on the main rivers of Cyprus with automatic water level recorders. Measurements of spring flows were also carried out regularly and hydrological surveys were organised of the main aquifers. Thus by the initial years of Independence the Department had at least 10 years of hydrological data on which to base the design of the first post independence storage schemes.

Work Undertaken up to Independence

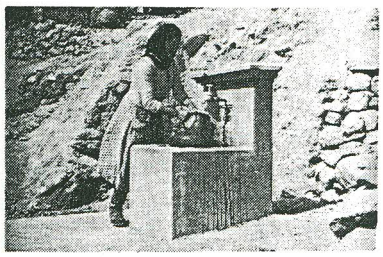
Generally speaking, up to independence work undertaken by the Department was mainly on a first come first served basis. Programmes of work were according to requests by village authorities for schemes such as the development of springs and conveyance of their water for village domestic water supplies and the diversion of stream water and its conveyance for irrigation. At the same time there were instances of schemes which were scheduled to be executed as a matter of policy by the government such as the drive to eliminate losses in conveyance of irrigation water by the lining in concrete of earth channels. Regarding rural domestic water supplies, with the introduction of improved sanitary conditions in villages, it was imperative that drinking water be conveyed from far away sources.

During the latter part of the fifties more systematic work was also done on reconnaissance of sites suitable for dams.

Small Irrigation Works

Up to the forties and fifties the Water Development Department carried out numerous small irrigation schemes throughout Cyprus through the diversion of stream flows with brushwood or more permanent diversion

weirs, small irrigation tanks and conveyance in reinforced concrete channels. Where possible small masonry or concrete gravity dams (Lythrodhonda, Kafizes, Kalokhorio -Klirou, Pyrgos, Trimiklini, Perapedhi etc.) were built in the Troodos mountainous region. As mentioned before, as a matter of policy existing earth channels were lined in masonry or concrete to minimise mater losses. Prominent among these were the Solea valley, Lapithos, Trimiklini and Kythrea. The construction of small irrigation works has been continued after independence and improvements to these schemes will also continue in the future as they are not too costly and they serve a large portion of the rural population and yield very high benefits.



Public Fountain

Domestic Water Supplies

Since the beginning of civilisation human settlements were located in areas of easy access to water such as streams, natural springs and eventually in areas where drinking water could be drawn from shallow wells. This was the case also with Cyprus where, in addition, monasteries and castles on rocky hill tops collected rain water and stored it in cisterns and in the cases of port towns such as Famagusta water was carried from far away springs in aqueducts, in this specific instance from Kythrea spring some 40 km away. Abundant quantities of ground water in the area could not at the time be exploited, due to limited means of pumping.

Drawing Water from Stavrovouni Mon. Cistern

As mentioned already, with the advent of modern hygiene in the forties it became necessary to convey water to villages from far away sources to substitute the use of ground water drawn from shallow wells in the yard of each village home as the introduction of toilet pits posed a pollution threat for these wells.

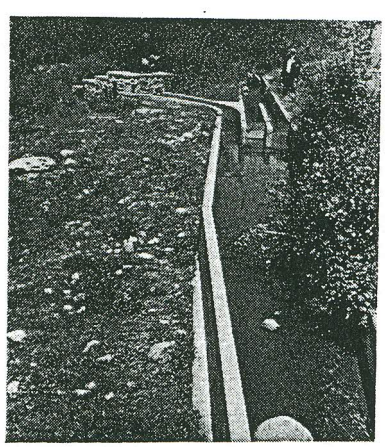
During the fifties a start was made on regional water supply schemes such as the Appidhes Spring Regional Scheme in Paphos and the Mesaoria dry villages scheme using water from Kythrea spring. Originally water conveyed to villages was distributed through public fountains which were placed in strategic spots in village neighborhoods for easy access to as many homes as possible. In some instances these fountains were combined with troughs for watering of animals.

Towards the end of the fifties some villages were provided with house to house water supply schemes through the use of distribution boxes. As from 1960 all new schemes provided for metered house to house supply of water and by the early seventies practically all villages had piped water in the home. Since all domestic water supply sources were from natural springs, wells, chains of wells and subsurface dams in river beds water was pure enough needing only chlorination at the reception storage tanks.

Boreholes

Never-the-less great importance was given to development of groundwater to the point that as from 1946 and up to 1959 there was a government subsidy for the drilling of wells. Farmers deposited a fixed sum of #32-10s for each borehole. This was only natural as the exploitation of ground water is much cheaper than the construction of water impounding works. On the other hand the drilling of wells and their exploitation can be undertaken by the private sector and in fact by each single farmer. Groundwater was in any case to be found in abundance as in the past there was no means of drilling deep wells to reach deep aquatic strata.

Dams



Concrete Channel

In the field of dam construction up to 1960 sixteen dams were constructed of a total capacity of 6.2 MCM including Kouklia and Syngrasi dams of 5 MCM combined storage built in 1900. It should be mentioned here that Syngrasi dam was rebuilt in 1968. Fifteen of the dams which were built in the forties and fifties were small gravity dams as mentioned before. I L Ward who was the last colonial Director of the Department in a paper to the Institution of Civil Engineers pointed out that although dam construction in Cyprus is very costly due to topographical and geological considerations, the fluctuation of river flows and the numerous water rights, yet there were several sites to be found where high dams could economically be constructed. In his final report on Water Development in Cyprus I.L. Ward pointed out several sites for possible dam construction.

Town water supplies

During the fifties extensive work was done on the water supply of practically all towns of Cyprus regarding sources, main conveyance, storage and distribution networks. A good example is Nicosia where all pertinent works

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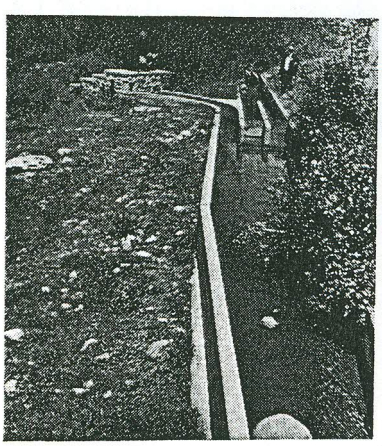


Concrete Channel

Town water supplies

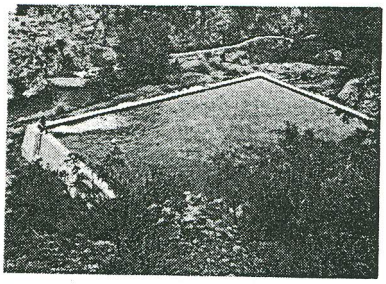
During the fifties extensive work was done on the water supply of practically all towns of Cyprus regarding sources, main conveyance, storage and distribution networks. A good example is Nicosia where all pertinent works

are still functioning with improvements carried out as necessary. Nicosia has a complex water supply scheme with multiple sources of springs, boreholes and since the early eighties receiving treated dam water as well.

THE PERIOD FROM INDEPENDENCE UPTO THE TURKISH INVATION 1960-1974.

Organisation of WDD after Independence

Soon after independence the Department went ahead with the priorities which were primarily the proper staffing of the Department with qualified staff on both the Engineering and the Technician side. Initially the UN and individual countries provided experts and missions in various fields to help bridge the void created by the resignation on independence of the nine UK expatriate Engineers. By 1963 all six government scholars who had been studying in the UK returned to Cyprus, the first three having taken their appointment as early as 1959. Hydrogeological studies and investigations were widened to constitute the basis for future development. A soil mechanics laboratory and soil investigations section were set up with modern instruments and equipment as well as for the concrete laboratory. Regional offices were established for all districts of Cyprus including one for Morphou. The Kyrenia, Famagusta and Morphou offices stopped functioning in 1974 when Turkey invaded Cyprus and the whole Kyrenia District, most of the area of Famagusta District and the Morphou area of Nicosia District were occupied and are still held by the Turkish army. In addition FAO experts looked into our water legislation with a view to strengthening of the already existing legislation regarding the conservation of ground water. Due to extensive drilling throughout the fifties which continued during the initial years of independence the main aquifers of Morphou, Famagusta, Kokkinokhoria and Akrotiri were over exploited and sea water intrusion was observed in several areas as the quantity of water pumped was greater than the natural replenishment through precipitation.



Irrigation Tank

General Objectives

The reorganisation of the Water Development Department was considered necessary within the general policy of the government which sought from the start to establish conditions allowing for the increase of the income of the rural population so as to narrow the gap

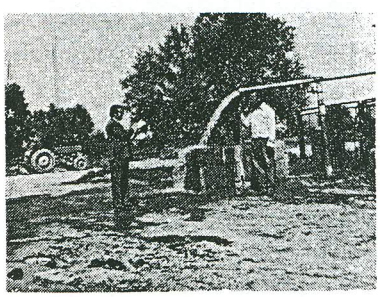
between the farming community income and the income of other groups of the active population and at the same time increase the contribution of agriculture to the gross national product. Aiming towards this end were also the setting up of the Agricultural Research Institute with UNDP/FAO Assistance, the establishment of the Land Consolidation Authority, the subsidy of agricultural products, the setting up of the insurance organisation for agricultural products, the granting of loans to the farmers through the cooperative associations and the setting up of marketing boards for the main agricultural products.

WDD Directors Since Independence

During a transitional period after Independence the Department was headed by Paul De Gruyter (1962-1964) from the Netherlands and J V Kregar (1965-1966) from Yugoslavia, both Engineers provided by the UNDP. C A C Konteatis was the first Cypriot Director of the Department, having served from 1967 to 1979. C St Lytras, the present Director of the Department, took over from C A C Konteatis initially as acting Director and as Director as from January 1980.

Targets on Advent of Independence

With the establishment of the Cyprus Republic in 1960 the importance in development of the country's water resources was fully recognised by the government of the late Archbishop Makarios. On the 21st August, 1961 in his inaugural speech to the House of Representatives (consisting of both Greek and Turkish Cypriot Parliamentarians) on the government's activities and the first five year programme 1962-1967, Makarios outlined the main water development targets of his government, which are quoted below:-



Borehole Test Pumping

- The carrying out of a survey of the total water resources of the island and of research so as to discover and exploit underground reservoirs or currents.

- The replenishment and protection of existing underground water resources.

- The conservation, storing and measured use of rainwater and the prevention of its flow to the sea.

- The supply in sufficient quantities of piped water to all villages and towns for domestic and industrial use.

The above targets were put into effect through consecutive five year plans of the government.

Technical Assistance to WDD Since Independence

The Water Development Department on the establishment of the new Republic requested and immediately received extensive technical assistance from the FAO and UNDP through the appointment of Directors, as stated above, as well as experts in all fields of our work and the institution of Special Fund Projects. Prominent UN experts were Stanley Hsu, dam expert, who stayed with us from 1963 to 1970 and Branko Milinusic who was appointed a UN expert on irrigation from 1963 - 1970 and as Project manager for Paphos Irrigation Project from 1973 to 1982. The Department is also grateful to various individual countries for technical assistance afforded us throughout the past 30 years or so, amongst them the UK, France, USA, West Germany the Netherlands and Sweden. For particulars please see appendix No. 1 on 'Technical Assistance to WDD'.

Evaluation of Water Resources and Planning of Major Projects

In the meantime it was necessary to construct rather large dams for impoundment of water for irrigation and recharge works to counteract the effects of the depletion of the aquifers. At the same time during the latter part of the sixties the Water Development Department initiated, with the United Nations a UNDP/FAO Project for Surveys, Demonstration and Planning of Water Resources Utilisation which followed another UN project, a 'Survey of Groundwater and Mineral Resources'. The conclusions and recommendations of those projects paved the way for the following major water development projects.

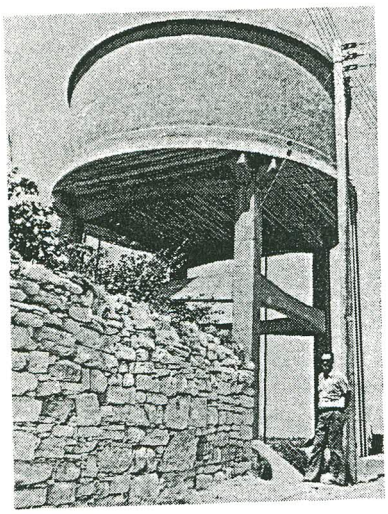
Windmill at Paralimni

- The Morphou-Tylliria Project the feasibility study of which was completed in 1974 but had to be shelved due to the Turkish invasion and occupation of most of the area involved in the project.

- The Paphos Irrigation Project, the construction works for which were completed in 1983 with a total expenditure of #24 million for the irrigation of 5000 ha of land of the fertile southwestern coastal plain.

- The Vasilikos-Pendaskinos Project which was completed in 1986 and is now under full operation. This project cost #27 million and supplies water for the irrigation of some 1,500 ha of land east of Limassol and domestic water supplies for towns and villages as well as the industry and Tourism.

- The Pitsilia Integrated Rural Development Project, the water component works of which were completed in 1984 at a cost just over #7 million. This is a unique project in as much as it is made up of numerous small independent, self contained irrigation schemes scattered all over the hilly area of the central massif of Troodos.



Elevated Tank

- The Khrysokhou Irrigation Project in the Northwestern part of Cyprus. The construction of this project started in 1984 and completion of a second phase is planned for 1992. The final estimated cost for this project is #20 million for the irrigation of an area of 3000 ha.

- Last, but not least, the Southern Conveyor Project which extends from Paphos to Famagusta and is the largest single project ever undertaken by the Government of Cyprus. The feasibility study of the Southern Conveyor Project was carried out with assistance from O.D.A. (UK). Construction of this project started in 1984 and it is scheduled to be completed by the mid nineties at a total estimated cost of #200 million.

Use of Dam Reservoir Water For Domestic Water Supplies

A significant development in domestic water supplies was the use of raw water from dam reservoirs for the first time in Cyprus in 1974 when Lefkara dam water was treated at Khirokitia water treatment works initially for the needs of Famagusta and Larnaca. In 1985 another water treatment plant came into operation, the Kornos Treatment Plant for the water supply of Nicosia. Both treatment plants are now able to draw raw water from several dams namely, Kalavasos, Dhypotamos, Yermasoyia, Kouris as well as Lefkara mentioned above. Furthermore there are plans to build two more water treatment plants within the second phase of the Southern Conveyor Project for Limassol and Nicosia as well as another two for Paphos town and area and an additional plant within the Karyotis Project for Nicosia and district. The two existing plants mentioned above serve, apart from the town of Nicosia, Famagusta and Larnaca, the needs of numerous villages, refugee estates and the tourist industry in the homonymous districts. Mention must be made of the fact that up to the summer of 1986 and before the full effect of Vasilikos-Pendaskinos Project was felt, the main towns of Nicosia and Larnaca as well as

tourist installations had to undergo restricted supplies of water.

Irrigation Schemes

Irrigation in Cyprus can be classified into two basic categories:

- Seasonal irrigation which is practised in winter and spring from spate flows of rivers mainly in the areas of eastern and western Mesaoria.
- Perennial irrigation from:-

  (i) Perennial flow of rivers and natural springs
  (ii) Pumping from the aquifers
  (iii) From water impounded in dam reservoirs.

Drilling of Boreholes

As from the 5th of November 1971 the Geological Survey Dept. was appointed as the competent authority for the drilling of B/Hs for use on a community basis. Non-the-less the Water Development Department has retained the responsibility for the utilization, control and management of the groundwater.

THE PERIOD FROM THE TURKISH INVASION TO DATE 1974-1989

Employment of consultants

The rapid growth in all fields of development from the outset of the Republic, the increase in urban population, the greater demand in water both due to the higher standards of living attained, and the development in industry and tourism necessitated the speedy execution of water development works. It was therefore necessary to employ consulting firms (mainly foreign) to assist with planning, feasibility and design of some of our major projects. At the same time international tenders were sought for the construction of major water works. This is in any case a requirement of the financing organisations. Needless to say that all supply tenders for the same projects are international tenders. A list of the main consulting firms employed by the WDD is given in appendix II.

The Effects of the Turkish Invasion of Cyprus

The Turkish invasion of 1974 resulted in the displacement of 200,000 Greek Cypriots from their homes in the areas occupied by the Turkish army and their settlement in the free areas of Cyprus controlled by the government, has brought about an unforeseen increase in the demand for water both in towns where a lot of these displaced people have settled as well

as in refugee camps. Through consecutive emergency plans the water supply of the affected towns was strengthened and refugee camps were supplied with water. With the erection of refugee housing settlements all over free Cyprus water supply schemes were executed furnishing water to each one of the Refugee homes.

Construction of large dams

In the meantime modern powerful excavating and hauling equipment came into use and with the establishment of the Republic, the Department could go ahead with the damming of surface water flow by erecting large dams. Up to the eighties several large dams were built mainly earth and rockfill dams of capacities up to 50 MCM culminating to the construction of Kouris Dam of 115 MCM capacity in 1988. The total capacity of water that can be impounded in dams now is 300 MCM and Cyprus which has been a member of the International Commission on Large Dams since 1969, has 48 dams listed in the ICOLD register of large dams.

Irrigation through Major Projects

An area of some 25,000 ha of land is estimated to come under irrigation with the completion of the five major projects: Paphos Irrigation Project, Vasilikos-Pendaskinos Project, Pitsilia Project, Khrysokhou Irrigation Project and Southern Conveyor Project. (See table below). Included in this hectarage are areas which in the past were irrigated with water pumped from the aquifers which are now depleted. It is nevertheless envisaged that a recovery of the water table in all aquifers will be achieved in a few years time through natural and artificial recharge and this will be a useful saving to fall back on in years of prolonged drought.

WDD MAJOR WATER DEVELOPMENT WORKS
Giving expenditure in million Cyprus pounds and irrigation area for each project

		Expenditure in million £	Irrigation area in ha.
A.	Completed Projects		
1.	Paphos Irrigation Project	25	5000
2.	Pitsilia Integrated Rural Development Project	7	1280
3.	Vasilikos-Pendaskinos Project	27	1430

	Expenditure in million £	Irrigation areas in ha.
B. Projects under Construction		
1. Southern Conveyor project		
Phase I (Estimate)	95	9200
Phase II (Estimate)	75	4335
2. Khrysokhou Irrigation Project		
1st Phase (Estimate)	20	2000
2nd Phase (Estimate)	617	1100
3rd Phase (Estimate)	10	1200

Irrigation Distribution Systems

All major water development works constructed allow for closed system irrigation distribution networks where pressure must be such as to allow for the use of modern irrigation systems. Where pressure in the networks is not satisfactory pumps are employed to give the necessary pressure and most systems provide irrigation water 'on demand'.

A great improvement that has come about since independence is the abandonment by farmers of wasteful means of irrigation and this is mainly due to the systematic work of the Department of Agriculture through the Agricultural Extension Services and the Water Use Section who have brought home to the farmers the benefits of improved systems of irrigation (mainly sprinkler and drip irrigation) both in the field and under cover. In certain areas of Cyprus this economy has come about as a result of depletion of water sources.

Gross water requirements for various crops

The gross water requirements for various crops in Cyprus calculated on the basis of evaporation from a USWB class A pan by the Water Use Section of the Department of Agriculture are:-

Plantations	m^3/ha
Citrus	5,000 - 8,000
Bananas	11,000 - 12,000
Table grapes	2,000 - 3,000
Deciduous fruit trees	4,500 - 6,000
Vegetables	3,000 - 6,000
Vegetables (in hot houses)	5,700 - 6,700
Spring potatoes	2,100 - 2,700
Autumn potatoes	4,000 - 4,600
Olives	3,000 - 4,800
Peanuts	5,500 - 6,500
Tobacco	4,000 - 4,500

Avocado	5,500 - 8,000
Alpha-Alpha	10,200 - 13,500
Legumes	3,000 - 4,000
Kiwi	5,500 - 6,500
Pistachio nuts	4,500 - 5,500
Pecan nuts	9,500 - 10,500
Others	6,000 - 7,000

Note
Big variations between low and high water requirements for certain crops is due to location in low holter areas as against higher areas with cooler summers.

Sewage Disposal

As from the beginning of the eighties the Water Development Department started to get involved, together with other Government Departments, with the planning, design and construction for sewage disposal, initially for refugee housing involving sewerage and biological stations, extending later to rural areas with special problems. One interesting project is for a septage treatment works for areas of Nicosia not yet connected to the Nicosia sewerage system.

Crops

Mention must be made here of crops produced in Cyprus especially for people who read this text in countries foreign to the environment of Cyprus and the Mediterranean. A table below gives the hectarage of the main categories of crops. These ten categories are:

- Cereals : wheat and barley,
- Food legumes: broad beans, haricot beans, peas, lentils.
- Fodder crops: vicos, vetches, favetta all for seed production and green fodders.
- Industrial crops : tobacco, ground nuts, sesame
- Vegetables : potatoes, water melons, tomatoes, cucumbers sweet melons, carrots cabbages artichokes, beet root, onions marrows and other. By far the biggest hectarage is for potatoes (6,823 in 1987) but early garden produce under cover or otherwise fetch good income.
- Vines : Wine grapes, table grapes.
- Olives & carrobs
- Citrus : Oranges, lemons, grapefruit, mandarins. Lemons being the most prominent with 2,488 ha in 1987.

- Deciduous fruit : Apples, pears, plums, cherries, apricots, peaches, figs-quinces, pomegranates, almonds, hazelnuts, walnuts. Apples being the most prominent in the irrigated category with 1,070 ha in 1987 and almonds being the most prominent in the rainfed category with 4,013 ha in 1987.

- Other fruit: Bananas, avocadoes, loquats strawberries. Bananas being the most prominent with 401 ha in 1987.

IRRIGATED AND NON IRRIGATED CROP AREA, 1987

Crop area	Irrigated ('000 ha)	%	Non-irrigated ('000 ha)	%	Total ('000 ha)	%
1. Temporary crops						
Cereals	2	6	52	48	54	38
Legumes	1	3	1	1	2	1
Industrial crops	1	3	-	-	1	1
Fodder crops	2	6	16	15	18	13
Vegetables	11	35	-	-	11	8
Total	17	53	69	64	86	61
2. Permanent crops						
Vines	3	9	26	24	29	21
Citrus	7	22	-	-	7	5
Fresh fruit	3	10	-	-	3	2
Nuts	-	-	4	4	4	3
Other (olives, carobs)	2	6	9	8	11	8
Total	15	47	39	36	54	39
Grand total	32	100	108	100	140	100

Source: Department of Statistics and Research, Ministry of Finance.

Water charges

The unit total cost of irrigation water from government waterworks Projects is made up of the capital cost component and the annual cost component. The former is calculated using the present worth method by processing the actual or anticipated capital costs and water volume for sale at an interest rate of 9% over a period of 40 years (Economic life of the project). The latter is made up of the operation, maintenance, pumping and administration costs; the annual unit cost for each project is calculated using the anticipated annual costs divided by the volume of water for sale. The table that follows shows the allowed average, maximum and special maximum water charges for all projects (According the Waterworks Law Cap. 341). The water charges, according to the Government Waterworks Law, Cap. 341, para 24 are decided by the Council of Ministers and are ratified by the House of Representatives. The Council of Ministers may make regulations according to the said law which may include various provisions.

ALLOWED
AVERAGE MAXIMUM AND SPECIAL MAXIMUM
WATER CHARGES FOR ALL PROJECTS

Description	Year							
	1988	1989	1990	1991	1992	1993	1994	1995
Weighted Average Unit Cost cent/m^3	16.25	19.38	19.65	19.60	19.95	20.04	20.06	20.29
Weighted Average 1 Unit Charge cent/m^3	6.18	7.36	7.47	7.45	7.58	7.62	7.62	7.71
Maximum Charge 2 Charge cent/m^3	6.50	7.75	7.86	7.84	7.98	8.02	8.02	8.12
Special Maximum 3 Charge cent/m^3	10.56	12.60	12.77	12.74	12.97	13.03	13.04	13.19

1. As per Loan Agreement 38% of Weighted Average Unit Cost.
2. As per Government Waterworks Law 40% of Weighted Average Unit Cost.
3. As per Government Waterworks Law 65% of Weighted Average Unit Cost.

Water Legislation Generally speaking all springs and several surface and ground water sources constitute private property in the form of registered water rights or ab-antiquo rights which accrued through long usage and were granted to private individuals. Some provisions of the Ottoman Law on land and water rights (Mejelle) persisted up to August 1946 when these provisions were substituted by the Immovable Property Law Cap 224 (Tenure, Registration and Valuation).

Up to the establishment of the Republic in 1960 the main water legislation was as follows:-

- Cap 341 of 1928. Government Waterworks Law. To provide for the vesting and control of water, the construction of waterworks and for other purposes relating thereto.

- Cap 348 of 1955. Water (Development and Distribution) To provide for the conservation and use of water resources, for the better distribution of water supplies and for purposes connected therewith.

- Cap 351 of 1946. Wells Law. To make better provision for the sinking or construction of wells and their protection and the protection of water rights.

- Cap 342 of 1938 Irrigation Divisions (Villages). A law to amend and consolidate the irrigation laws.

- Cap 115 of 1949 Irrigation Association. A law to make provision for the formation of Associations for the better regulation and use of common waters.

- Cap 349 of 1948 Water (Domestic Purposes) Village Water Supplies. To provide for the supply, maintenance and control of water supplies in villages, for domestic purposes.

Another six laws were enacted for specific cases and were:- (Cap 347 of 1900). Nicosia Water Supply to manage the Arab Ahmet and Siliktar aqueducts (cap 345 of 1919); Kythrea Water Supply

- Cap 347 of 1900. Polis tis Khrysokhou Water. To provide a proper supply of water for the use of the town of Polis tis Khrysokhou.

- Cap 345 of 1919 Nicosia Water Supply. To provide for the management of Arab Ahmet

and Siliktar aqueducts.

- Cap 344 of 1928 Kythrea Water Supply. To regulate and improve the supply and distribution of water to Kythrea for domestic purposes.

- Cap 343 of 1932 Kephalovryso Water Supply. To regulate and improve supply of water to certain villages for domestic purposes.

- Cap 346 of 1932 Nicosia Water Supply (Special Powers). For relieving of water shortage at Nicosia and prevention from contamination of drinking water supply.

All above laws remain in force under article 158 of the Constitution of the Republic. They have nevertheless undergone several amendments from time to time in order to keep them in line with developments and new requirements of life in Cyprus.

The construction of any government waterworks as well as any other waterworks, their operation, the distribution of water and the use of such water are all governed by the above laws.

In addition to the above laws the Water Supply (Special Measures Law) 32 of 1964 and 35 of 1965 was enacted since independence for the protection of water resources and their conservation in certain areas where water resources are in danger and in areas which constitute the source of water for our major projects. This law gives the Council of Ministers the authority to declare any such areas as controlled areas and to issue regulations for their protection.

Waterworks Management

Responsibilities for waterworks governed by the laws mentioned above are apportioned as follows:-

- The District Water Boards for the administration, management and operation of all government waterworks within each District.

- The Municipal Water Boards under the chairmanship of the District Officer with the Accountant General, the representative of the Director of the Water Development Dept and the Manager of the Water Board as members.
- The Irrigation Divisions which are formed by owners of land for management with the

District Officer as chairman.

- The Irrigation Associations which are formed where the beneficiaries are owners of water.

- The Village Water Commissions which manage rural domestic water supplies under the chairmanship of the District Officer.

Government retains full control over headworks and conveyance of the major water development works (eg dams, main pipelines, canals etc.) for the purpose of proper operation and maintenance of the works and the application of government policy. At the same time the farmers are free to exercise control over their own works through their committees.

Co-ordination of various services

The Director of the Water Development Department chairs a co-ordination committee of various services for the preliminary approval of major water development works, looking into matters such as land consolidation, land levelling, reforestation, soil conservation, geological, engineering aspects and environmental considerations.

Financial Aspects

Financing of major water development works is undertaken by the government which recovers approx. 50% through the sale of water. The government shoulders also the expenditure for operation and maintenance of major works. In the case of minor irrigation distribution networks the beneficiaries undertake to carry out the operation and maintenance work.

Government pays 2/3 of the construction expenses for minor irrigation works and the beneficiaries pay the remaining 1/3 which is made available by the government through the Loan Commissioners with long term law interest loans.

In the cases of town water supply works (Water Boards) government foots the bill for headworks and main conveyance whereas the Water Boards undertake the cost of storage reservoirs and pipeline networks as well as the distribution of water. Government charges the Water Boards with water delivered to their storage reservoirs.

For village water supply government undertakes 50% of the expenditure for the construction of

the water supply head works, storage and pipeline networks. Villages connected to main conveyors feeding town systems such as the Central Distribution System for Nicosia, Famagusta and Larnaca pay for the quantities of water delivered to them.

It must be mentioned here that expenditure on investigation, planning, design and supervision of works is undertaken normally by the government. For the purpose of financing of major water development works the government secures loans from the World Bank and other international financing organisations such as the European Investment Bank, the Council of Europe Resettlement Fund and the Kuwait Fund for Regional Development.

In the case of large supply contracts for materials and equipment, such as pipes and pumping equipment it is possible to arrange financing either through the manufacturing country's government or through a consortium of banks of the manufacturing country.

TO-DAY'S ORGANISATION OF THE WDD

WDD Divisions

The Water Development Department comes under the Ministry of Agriculture and Natural Resources and is now made up of the following Divisions. The Division of Water Resources, the Division of Hydrology, the Division of Planning, the Division of Planning of Routine Works, the Division of Design, the Division of Construction, the Division of Operation and Maintenance (DWS), the Division of Operation and Maintenance (Irrig.) and the Division of Mechanical-Electrical Services.

In addition, after the Turkish Invasion of July 1974, only 3 Regional Offices of the WDD are functioning:-

The Famagusta-Larnaca Regional Office, the Limassol Regional Office and the Paphos Regional Office.

A special unit exists at Paphos Regional Office for the operation and maintenance of Paphos Irrigation Project and Khrysokhou Irrigation Project. Other completed major projects nearer to Nicosia are dealt with from WDD HQs.

Number of staff

The technical staff of the Department today

(Dec' 1988) numbers 372 permanent staff including 66 with university qualifications, plus 55 staff employed on casual basis of whom 17 are university graduates. There are also 67 clerical/accounts supporting staff and 915 regular employees of various trades. On average a force of 150 unskilled labour are employed throughout Cyprus on our construction sites. The above numbers do not include any staff employed by Contractors currently carrying out major projects construction works for the Department.

NUMBER OF STAFF EMPLOYED BY THE DEPARTMENT
(Given in ten year intervals since independence)

	1949	1959	1969	1979	1989
Technical staff	17(2)	57(12)	210(30)	295(52)	427(83)
Foremen	70	79	53	58	57
Labourers (% of unskilled)	805(88%)	761(48%)	1438(61%)	852(21%)	1065(36%)
Clerical-Accounts	20	40	60	62	67

N.B. Numbers in brackets for technical staff denote university graduates.

THE PERIOD FROM 1989 ONWARD

Operation, Maintenance and Management of Completed Works

Great importance is attached to the efficient operation and maintenance of the completed major projects which are equipped with telemetry and remote control systems affording immediate availability of information and swift action especially in emergencies. The upgrading of financial and technical provisions for effective and efficient management, operation and maintenance of the installed works is being given primary importance. To this end, the Mechanical-Electrical Division of the Department functions in close cooperation with the two Operation and Maintenance Divisions of the Department which are responsible for domestic water supply and irrigation works respectively.

With regard to the operation of Government Irrigation Works the Department, apart from its normal responsibilities for the operation and maintenance of the dams, main conveyors, pumping stations and distribution networks, it undertakes the sale of water either directly

to the farmers or to the Irrigation Division where such Divisions were established.

Planning of Works

Planning for new water development works is continuing along with the construction of our major projects as it is possible as yet to develop surface water resources in some areas. Future planning must nevertheless aim at equal distribution of the water resources of the Island so that all areas are benefited by our major projects. At the same time more smaller storage works must be built in the form of small dams and ponds to allow development in areas that cannot be connected to our major projects. A feasibility study has already been completed for Karyotis Project for additional supplies of domestic water for Nicosia and environs as well as irrigation development in the Solea Valley. Design work for another project for the Krasokhoria (vinegrowing) areas of Paphos and Limassol is also under way.

Realisation of targets

We could say that the Cyprus Gavernment's persistence during the past 29 years on studies, planning and construction of water works has realised the wish of Arch. Makarios that "not a drop of water should go to the sea before being utilised". From the total surface flow of 600 MCM the constructed reservoir's retention is 300 MCM of which the average annual inflow is 190 MCM Irrigation by diversion of surface water amounts to 150 MCM so that the losses to the sea are only 260 MCM. To reduce even this amount much further could not be economically justified.

Final Solution of the Water Supply Problem

With the completion in 1988 of the main component of the Southern Conveyor Project namely the Kouris Dam with 115 million cubic meters (MCM) capacity and the Southern Conveyor 1400-800 mm dia, 110 km long DI pipeline and, with the works mentioned above already 'in the pipeline' the solution of the water supply of the areas mentioned is well in sight.

Localised problems which crop up such as the drying up of a village water supply sources can be dealt with by connecting these schemes to the major water development projects main conveyors.

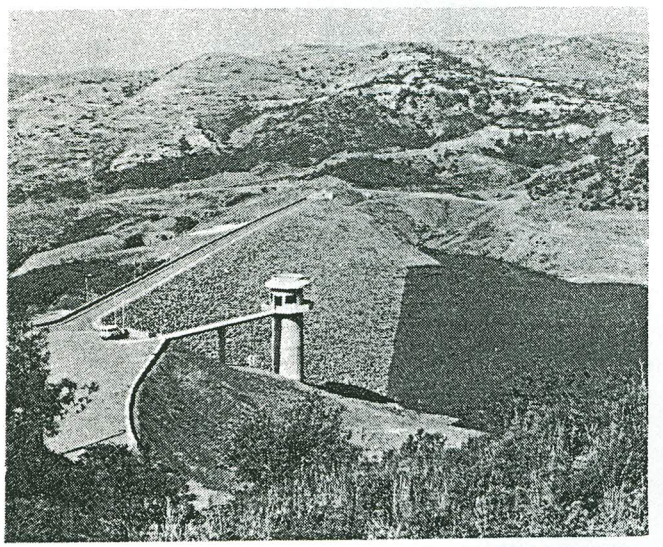
General prospects

While a radical solution to our water problem

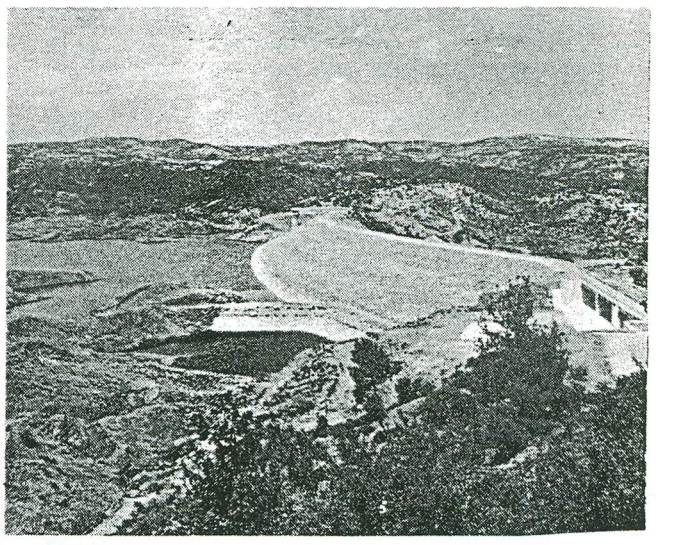
is in sight through the implementation of our major water development works there is still a lot of work ahead of us for the upkeep of our finished works and for future development.

Notwithstanding all the development of the entire water resources, a long-term prospect for a solution of the water problem, at least for potable supplies of the coastal tourism installations, is desalination of sea water. To this end a close watch is kept on development in methods of desalination.

As mentioned already in the introduction of this short text on the 50th anniversary from the establishment of the Water Development Department, the creation of a Water Authority is under serious study aiming at the establishment of an independent authority to undertake the whole spectrum of water development which will function on the basis of balancing expenditure with revenue.

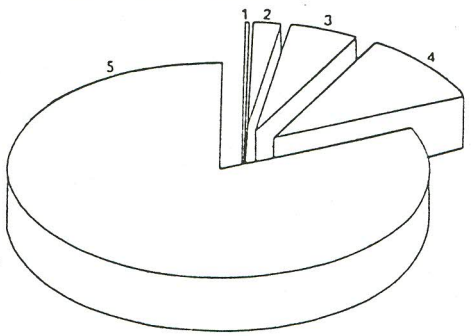


Dhypotamos Dam

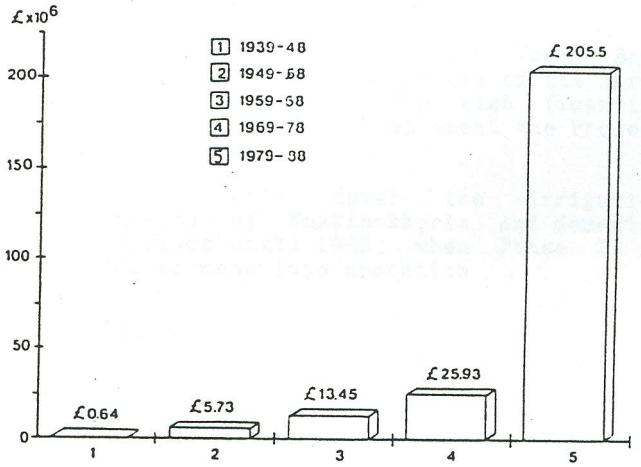


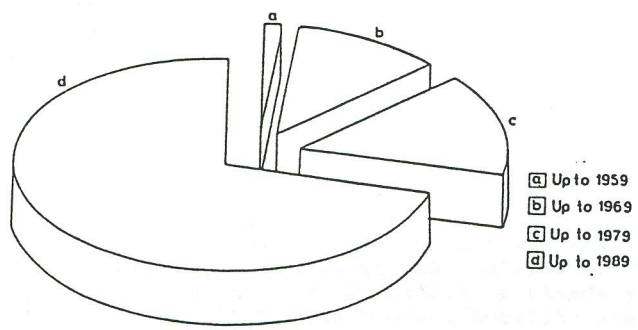
Kalavasos Dam

WATER DEVELOPMENT DEPARTMENT

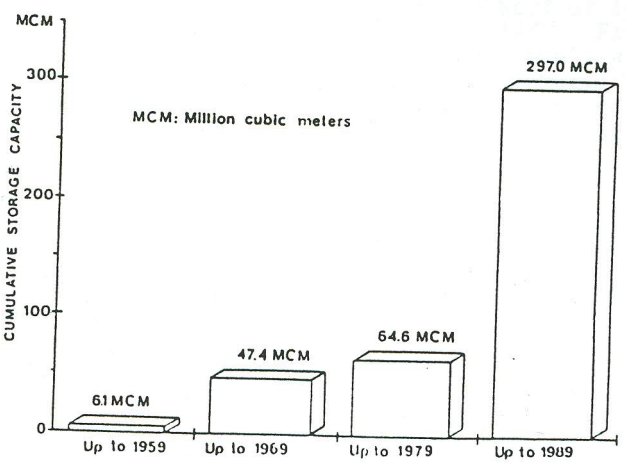


EXPENDITURE 1939 - 1988





PROGRESS IN DAM CONSTRUCTION



THE WATER BALANCE OF CYPRUS

Cyprus has a total surface area of 9250 sq. km. Due to its semi-arid climate, Cyprus always faces a problem of inadequacy of water for both its domestic and irrigation needs.
Both the surface as well as the groundwater resources of the island are fed and replenished in proportion to the quantity of the annual rainfall.

The mean annual rainfall over the island is 500mm which corresponds to 4600 million cubic meters of water over its total surface area. The topography affects the distribution of the rainfall with the result that this is not homogeneously spread over the whole island. At the Kokkinokhoria area this is barely 340mm whereas at the peak of the Troodos Mountain this exceeds 1000mm.

Due to the aridity of the climate a proportion of about 80% of the rainfall returns to the atmosphere as loss by evaporation and evapotranspiration. The remaining, and which can be considered as the mean annual water crop of the island, is about 900 million, cubic meters. This quantity replenishes the streams, infiltrates and recharges the various aquifers and part of it finds its way to the sea as loss from the discharge of the streams or subsurface outflow from the aquifers.

The mean annual water crop of 900 million cubic meters is distributed into 600 million cubic meters of surface runoff (streams) and 300 million cubic meters of groundwater recharge (aquifers and springs).

From the surface runoff of 600 million cubic meters some 150 million cubic meters are diverted from the streams during the winter and early spring and are used for spade irrigation.

With the waterworks constructed by the Water Development Department, artificial recharge works and minor and major dams for water supply and irrigation, the total surface storage capacity is 297 million cubic meters. Annually, though, the available or rated yield of the dams is of the order of 190 million cubic meters, securing thus with the interannual operation of the dams a high degree of reliability in the supply of water. The remaining surface runoff, 260 million cubic meters, flows to the sea.

The major part, 270 million cubic meters, of the quantity of 300 million cubic meters that replenishes the aquifers, is pumped out through wells and boreholes or appears at springs. It is estimated that some 70 million cubic meters flow to the sea through the subsurface of the main coastal aquifers and those area where there is a reduced development.

At the same time though, overpumping of about 40 million cubic meters is occurring on certain aquifers like the Kokkinokhoria, Kiti and at least, before 1974, in the Morphou area.

If a balance is carried out of the water resources of Cyprus then the incoming one may include the mean annual water crop of 900 million cubic meters which can be analysed into 67% surface runoff and 33% groundwater whilst the outgoing one may include 37% of losses to the sea, 30% pumpage and flow from springs, 21% mean annual yield of the dams and 17% as diversions for spate irrigation from the streams.

The above outgoing quantities result to a small deficit of the order of 5% which is caused by the mean annual overpumping of certain aquifers.

MAJOR WATER DEVELOPMENT WORKS

SOUTHERN CONVEYOR PROJECT

The basic objective of the Southern Conveyor Project (SCP) is to collect and store surplus water and convey it by means of a regional water carrier for use in areas where the water is most needed.

In aiming to devise a socially and financially acceptable and economically viable scheme the SCP will promote irrigated farming development in the south coastal region between Limassol and Famagusta that would benefit most from the Project. In addition the SCP will meet the future domestic and industrial water demands up to the year 2010 for the towns of Limassol, Larnaca, Famagusta and Nicosia and numerous village communities, and also supply the needs of touristic development.

Following a pre-appraisal by a World Bank mission in Cyprus and because of the large size of the Project and its high financial cost, it was decided to implement the Project in two phases.

Phase 1 will cover the irrigation requirements of Kokkinokhoria and domestic water demands until 1993, when Phase 2 is expected to come into operation

First Phase

Phase 1 includes the construction of the Kouris Dam, the main conveyor, the Akhna Dam and the Kokkinokhoria Irrigation System. In 1992 just before the operation of Phase 2 the Project is expected to supply 33 MCM out of which 17 MCM will be used for irrigation at Kokkinokhoria and around 16 MCM will satisfy domestic demands. The construction of Phase 1 is expected to be completed in 5-6 years.

The main works of the 1st Phase of the Project are as follows:

Kouris Dam This 115 MCM dam reservoir is the main water storage component and is designed to provide seasonal and interannual storage of the flows of Kouris River and its tributaries. Such storage, by balancing the variable inflows will permit a steady and reliable supply to the project benefit areas via the Southern Conveyor. The Kouris Dam, of zoned earthfill embankment construction is around 110 m high. Its 5 km long reservoir has a surface area of 360 ha. Construction of the dam started in the latter half of 1984 and was completed by the end of 1988. First impoundment was possible in November 87, when the outlet tunnel gates were closed. The contract for the construction of Kouris Dam was awarded to the joint venture -Impregilo (Italy) with J & P (Cyprus) in July 1984 at a contract value of £19,954,512.

Main Conveyor This 110 km long pipeline of diameters ranging from 1400 mm down to 800 mm conveys the stored water to Akhna reservoir. A branch-off is allowed for recharge Yermasoyia river bed boreholes downstream of Yermasoyia Dam. A second branch-off supplements Vasilikos-Pendaskinos Project through a balancing reservoir. Two contracts were awarded to the joint-venture Cybarco (Cyprus) and Shand (UK) in October 1985 of a total contract value of £6,157,031. Installation of the main conveyor started late in 1985 and was substantially completed at the beginning of 1988. As from May 1988 water was supplied for irrigation to Kokkinokhoria and other areas.

Akhna Reservoir A 16 m high earthfill embankment dam retains 5.8 MCM of water, enabling the reservoir to provide balancing storage in the Kokkinokhoria area. Water will be pumped to the nearby irrigation area at times of peak irrigation demand to supplement flows in the main conveyor and thus reduce the size of pipeline otherwise required. Work on the construction of Akhna Dam with a contract value of £1,312,980 started in mid 1986 and was completed by the end of 1987. This contract has been awarded to Iacovou Brothers, Cyprus.

An area of approx. 9000 ha in the Kokkinokhoria region will be irrigated through the 1st Phase of SCP. The works for the **Kokkinokhoria irrigation network** consist of:

The laying of 30 km long main conveyors by direct labour of the Water Development Department at an estimated cost of £897,000 was completed in June '87.

The construction of four irrigation balancing reservoirs was awarded in April 1987 to G.P. Zachariades, Cyprus for a contract value of £1,416,964 and was substantially completed within the first quarter of 1989.

The construction of 15 central distribution points (CDP) reservoirs was awarded in April 1987 to Cybarco, Cyprus for a contract value of £2,179,600 and was substantially completed within the first quarter of 1989.

The construction of 15 CDP pumping stations and 4 other main pumping stations was awarded in March '87 to China Water + Electric of China for a contract value of £1,649,000 and is scheduled to be completed by the end of 1989.

The construction of the secondary distribution system of a total length of some 300 km has been undertaken by WDD direct labour. The estimate for this work is £4,500,000. Work commenced in January 1987 and is estimated to be completed in 1990.

A tertiary system has been approved in the meantime of a network reaching all farm parcels. Construction for this work will start in mid 1989 and completion is scheduled for the end of 1190.

The main supply contracts of the 1st Phase of the SCP are:

Supply of 1400 to 800 mm ductile iron pipes and fittings for the 110 km long main conveyor has been awarded to Pont A Mousson of France for the tender sums of £562,661 (July '83) and £19,382,266 (May '85). Delivery of the pipes and fittings was scheduled for completion by mid 1987.

Supply of various types of valves for the main conveyor and the connection to VPP was awarded in May '85 to Glenfield and Kennedy (UK) - Caramondani (Cyprus) for the tender sum of £664,454.

For the Kokkinokhoria irrigation area the main supply contracts are:-

Supply of pumping plant and ancillary equipment by SPP Projects (UK) for the tender sum of £3,041,177 signed in March '87 to be delivered upto July '89.

Supply of AC pipes 800-200 mm dia by Amiantit SA (Greece) for the tender sum of £890,456, signed in February 1986. Delivery has been completed.

Supply of AC pipes by the Cyprus Pipes Industries (CPI) of a total value of £860,000 was awarded to them by decision of the Council of Ministers to be delivered upto September 1988. In addition AC pipes of a total value of £305,000 were supplied by CPI in 1986.

Various contracts for the supply of various types of valves, flow meters, irrigation hydrants, plastic pipes, fittings etc. were signed in 1985-88 with various EEC, Lebanon and Cypriot manufacturers totalling just over one million pounds.

The total cost of the 1st Phase of the project is estimated at just around £95 million including land acquisition, land consolidation and consultants fees.

Second Phase

The 2nd Phase of the Southern Conveyor Project is estimated to cost around £75 million and will include:-

Dhiarizos Diversion, conveying water from Dhiarizos river (21 MCM/year) to Kouris Dam reservoir through a 16 km long pipeline and tunnel. Prequalified contractors were asked to tender for this work in January 1989.

Irrigation distribution networks for four irrigation areas totalling some 4300 ha - Akrotiri (1755 ha), Parekklisha (320 ha) Mazotos (660 ha) and Kiti (1600 ha). This component will include all connecting and distribution pipes and regulating tanks between the SCP main conveyor and hydrants at farm level. About 2,300 ha of the total area will be consolidated and new farm roads will be constructed therein.

Domestic water supply works will include:

For Limassol: untreated water main from southern conveyor to treatment plant; water treatment works (Limassol plant) and conveyors from treatment plant to service reservoirs.

For Nicosia and Larnaca: untreated water main from southern conveyor to site of treatment plant, water treatment works (Tersephanou plant) and main conveyor from Tersephanou to Nicosia service reservoir at Lakatamia (about 35 km away) including pumping stations and balancing reservoirs.

For Larnaca: storage tank including necessary pipeline connections.

Two rural water supply schemes, in the Limassol area and along the route of the Stavrovouni-Nicosia main pipeline.

The 2nd phase of the Southern Conveyor Project will be constructed over a five year period (1988 to 1992). Priority is to be given to Limassol water supply, the Dhiarizos diversion and Akrotiri irrigation.

In November 1985, an agreement was signed between WDD and Energoprojekt, a Yugoslavian firm of consulting engineers, for the preparation of the detailed designs and contract documents for all engineering components of the 2nd phase of the project, as well as for the supervision of the construction works of these components.

Southern Conveyor Project Data

Feasibility Study
O,D.A. (UK) with Sir William Halcrow and Patners
Jointly with Water Development Department

General Responsibility for Design, Supervision of Construction, Operation and Maintenance ..... Water Development Department

Financing
World Bank - Kuwait Fund - European Investment Bank - Resettlement fund of the Council of Europe

Main Features

— Kouris Dam	115 MCM
— Dhiarizos Diversion tunnel	14.5 km
— Southern Conveyor	110 km
— Akhna Reservoir offering balancing—storage	5.8 MCM
— Limassol Water Treatment plant	40,000-80,000 m^3/day
— Tersephanou Water Treatment plant	60,000-90,000 m^3/day
— Tersephanou—Nicosia pipeline	35 km

Irrigation Distribution Systems for

— Kokkinokhoria Area	)	
— Akrotiri Area	)	
— Kiti Area	)	13,535 ha
— Mazotos Area	)	
— Parekklisha Area	)	

Project Water Sources

— Kouris Dam	43 MCM/year (Av)
— Dhiarizos Diversion	22 MCM/year (Av)

Water Distribution

— Domestic Uses	26 MCM/year
— For Irrigation	32 MCM/year

Southern Conveyor Project
Kouris Dam data

Type		Earth
Constructed		1984–1988
Catchment area		308 km²
Reservoir		
Area		3.6 km²
Capacity		115 MCM
Embankment		
Height above foundation		110 m
Crest length		550 m
Volume		9.4 MCM
Spillway		
Discharge		1925 m³/s
Volume of concrete		60 500 m³
Draw-off works		
Outlet tower	Height	32 m
Outlet tunnel ..... Dia 4.2 m	Length	633 m
Outlet tunnel roller gates (2 No)		1.8 m x 2.3 m
Outlet tunnel roller gates	Discharge	140 m³/s
Penstock for multiple		
Level draw-off pipe ... Dia 1.2 m	Discharge	3.4m³/s
Control tower ..... Dia 5.5 m	Height	111 m
Volume of concrete		16 000 m³
Grouting		
Total drilling		40 000 m
Cement & Bentonite grout		1 550 000 kg

Design	SOGREAH, France with Hydroconsult, Cyprus.
Supervision	SOGREAH, France with Hydroconsult, Cyprus and Water Development Dpt.
Main Contractor	IMPREGILO, Italy and J & P Cyprus, Joint Venture

Sub-Contractors and Suppliers

Grouting	RODIO, Italy
Electro-mechanical	METALNA, Jugoslavia
Instrumentation	Soil Instruments, U.K.
Valves	Erhard, West Germany
Tunneling	Voest Alpine, Austria
Hoists	Stahl, West Germany
Elevator	Dalmine, Italy
Operation & Maintenance	Water Development Dept.

KOURIS DAM – ENGINEERING ASPECTS

Kouris Dam is constructed on the Kouris river some 15 km northwest of Limassol and 6 km north of the village of Ypsonas.

The dam has a central clay core zoned earthfill embankment with a height of 110 metres and a crest length of approximately 550 metres providing a water storage volume of 115 million cubic metres.

The reservoir at 247m above sea level will extend about 5 km upstream of the dam with a surface area of approximately 3.6 km². The village of Khalassa which was located within the reservoir area has been relocated on a site overlooking the reservoir between the Kouris and Limnatis valleys.

The site was originally recommended by the WDD - Cyprus Water Planning Project study of 1968 and the WDD carried out site and fill material investigations during 1970-71.

Various feasibility studies were performed by consultants Howard Humphreys and Partners and the final feasibility report was completed in 1979.

The detailed design was commenced in 1981 by SOGREAH of Grenoble France in association with Hydroconsylt of Cyprus. Further field investigations were performed by the WDD and GSD.

An international panel of experts was appointed as advisers to the WDD and all major decisions concerning design and safety were the subject of discussion and agreement between the panel and the consultants.

A contract for the construction of the dam was awarded in July 1984 to a joint venture comprising IMPREGILO S.p.A of Italy and Joannou and Paraskevaides of Cyprus. Work commenced on the 1st September 1984.

CONSTRUCTION

Recognising the importance of storage of water at the earliest practical moment, construction was programmed so that impounding of the river flows could commence in time for the winter of 1987/88 approximately 10 months before construction was due to be completed.

Despite difficult foundation conditions which necessitated a significant increase in the volume of construction work, the impounding target of the 1987/88 winter was achieved by the use of additional earthmoving equipment.

KHRYSOKHOY IRRIGATION PROJECT

I. INTRODUCTION

I.I Objectives

The basic objective of the Khrysokhou Irrigation Project is the development of the surface and ground water resources of the Polis tis Khrysokhous region in order to ensure irrigation supplies to an area of about 3,100 ha net in the Khrysokhou river valley and the adjacent coastal plain along the Khrysokhou Bay.

1.2 Feasibility Studies

The detailed feasibility study for the Project was initiated in April 1979 with financial assistance from UNDP and executed jointly by the Food and Agriculture Organization (FAO) and the Water Development Department (WDD). This study which was completed by the end of 1981 was based on a regional development approach and has included the development of all water resources of the north western part of Cyprus for the irrigation of a larger area, namely the lowlands of Khrysokhou river valley with the coastal plain of total 3,100 hà net presently under implementation and the uplands of the Yiolou - Stroumbi — Polemi area of 1,200 ha net from a dam on Ezusa river which still remains as a future Project.

1.3 Financing and Implementation

Upon completion, the feasibility reports were submitted to the World Bank for appraisal and financing. The Bank's appraisal mission took place in November 1982. The study was found technically sound and economically viable and in May 1983 a loan agreement was signed by the Government of Cyprus with the Bank for a sum of US$16 million to cover the foreign exchange cost component for the implementation of the main project which includes the Evretou Dam and the Khrysokhou river valley scheme covering an area of about 2,000 ha net. The total cost of this Project was estimated at £18.7 million. Its detailed design was started mid 1983 and construction was completed by the end of 1987. In the meantime the Government has also decided to proceed with the construction of the second phase of the Project covering the adjacent coastal plain area between Argaka and Pomos of 1,100 ha at the cost of about £4 million. Its detailed design and construction has already started and it is planned to be completed in stages between the years of 1988 and 1990.

According to the actual to date expenditure the total cost of the above phases of the Project is now estimated at about £20 million.

There is no definite plan yet as regards the implementation of the third Phase of the Project to cover the areas in the Uplands as there has been no financing secured so far. Its cost was estimated at about £8 million.

2. THE PROJECT AREA

2.1 Location

The Polis tis Khrysokhous region is located in the north-western part of Cyprus. It is bordered by the Mediterranean sea on the north and west and the Troodos mountains on the east and south-east and includes the watersheds of the Stavros tis Psokas, Khrysokhou, Livadhi, Xeros, Yialia and Makounda rivers. The areas to be irrigated of 3,100 ha net extend along the coastal belt from Neokhorio to Pomos and plains of the adjacent major rivers. They rise gently from the sea to about 90m elevation and they are well drained by a number of streams which discharge into the Khrysokhou Bay. The most important rivers are those mentioned above.

2.2 Climate

The climate in the Project area is characterized by hot, dry summers and mild winters, with 85% of the average annual rainfall, of about 600 mm, falling during the period November to March. Spring and autumn are of short duration transitional periods. The climatic conditions in the coastal area favour the growing of early vegetables, lemons, table grapes and deciduous fruit trees. The high inter-annual and seasonal variation of the rainfall and the almost complete use of the scarce water resources during the summer period, make water regulation for irrigation an absolute necessity for any further hydroagricultural development.

2.3 Present Agricultural Development

Most of the Project's cultivated area (75%) is under rainfed agriculture, the main crops being cereals, vines, green and dry fodder. The irrigated area (perennial and seasonal plantations) is about 800 ha net which is about 25% of the total project area. Citrus and bananas are the major perennial crops while vegetables and tobacco are seasonal.

2.4 The Water Resources

Stream discharges constitute the surface water resources of the region. A small part of the flow is stored in three small existing dams. The average annual runoff of the major rivers in the region as well as the capacity of the dams are given in the following table:

River	Run-off MCM	Dam	Storage capacity MCM	Yield
Stavros tis Psokas	12.5	Evretou	25.0	17.5*
Magounda	6.0	Argaka	1.2	1.1
Yialia	1.6			
Xeros	1.0	Ayia Marina	0.3	0.4
Livadhi	3.4	Pomos	0.8	1.0
Total	24.5	Total	27.3	20.0

* Includes 5 MCM diverted water from the three small rivers.

The present use of surface water in the project area is minimal and therefore there is scope for a substantial amount of development. The quality of the surface waters is good and it is suitable for irrigation.

In addition to the above there is some potential for further ground water development of the Khrysokhou river gravel aquifer. At present about 0.6 MCM is extracted per year and it is anticipated that the yield of this aquifer may reach 2 MCM.

3. ENGINEERING ASPECTS

The Project consists of the following main elements:

3.1 Evretou Dam

A rockfill dam with central clay core, Evretou is built on the Stavros tis Psokas river about 9 km from the sea. The dam is about 71 m high above foundation level with a crest length of some 255 m, and creates a storage reservoir with a total capacity of 25 MCM with its full storage water level at 165 m above mean sea level. The reservoir extends about 3 km upstream and will have a surface of 1.2 km^2 at full storage level.

In an average year the contribution of the Evretou dam will be 12.5 MCM from the flow of Stavros tis Psokas. In addition 5 MCM will be diverted during winter run-off from Livadhi, Yialia and Magounda rivers into the Evretou dam reservoir.

The construction works, undertaken by Shephard Hill-Zachariades, Joint Venture, started in January 1984 and were completed at the end of December 1986 with impounding possible as from September 1986. Up to the end of spring 1987 a quantity of 10 MCM was impounded in the dam reservoir.

3.2 Main Conveyance Pipeline, Intakes and Ponds

This includes the main conveyor from Evretou dam to Pomos at the northern end of the Project, with branches to 8 storage ponds, to the three existing small dam reservoirs of Pomos, Argaka-Magounda and Ayia Marina and to the three diversion intake structures on the rivers of Magounda, Yialia and Livadhi. Evretou Dam and the existing reservoirs, as well as river intakes are inter-connected by this conveyance pipeline; in winter the water would flow from the river intakes to the Evretou Dam, and in summer conversely, overnight storage ponds at the head of the irrigation network will be fed. The system will be fully operated in both directions by gravity. Only the groundwater will be pumped into the ponds and a small quantity of water required for the irrigation of about 150 ha located above the dam reservoir will be pumped from a pumping station below the dam.

Some 52 km of pipeline are involved in the main conveyance system of diameters from 200 mm up to 900 mm with peak nominal capacity of 1.6 m^3/sec. The total cost of these works is estimated at £4.5 million.

Construction works for the installation of the initial 23 km length of the conveyor from Evretou Dam up to Magounda diversion as well as the Magounda diversion intake structure and 8 storage ponds commenced in January 1987 for completion by May 1988. The civil works were undertaken by the General Construction Company at the cost of £1,122,000. The remaining parts of the conveyor will be completed in stages between 1989 and 1990.

3.3 Piped Irrigation Networks and Farm Access Roads

This comprises a piped distribution system to cover the new areas to be irrigated of about 2,000 ha net plus farm access roads to cover the whole project area. The above involves the installation of about 160 km of pipelines in diameters between 90 mm and 600 mm and the construction of about 90 km of farm roads. The total cost of these works is estimated at about £4 million.

Construction works for the installation of the irrigation networks to cover about 1,500 ha net and the construction of about 65 km of farm roads started in April 1986 and by the end of August 1987 about half of the irrigation networks became operational. Full completion of the works was expected in Jan. 1988. The civil works were undertaken by G.P. Zachariades Ltd at the cost of £1,428,000. The remaining parts of the irrigation networks and farm roads which are in areas where land consolidation has recently been initiated will be completed in stages between 1989 and 1990.

3.4 Groundwater development

The present groundwater development through existing boreholes in the Khrysokhou river gravel aquifer will continue as part of the whole Project. Its further development by drilling and equipping 8 new boreholes in the area between Khrysokhou and Prodhromi villages is planned for 1990 and 1991 when the full water demand from the fully grown trees will have to be met. The total cost of these works is estimated at about £300,000.

4. AGRICULTURAL ASPECTS

4.1 Soils

The Project area is mostly covered with alluvial soils along the river valleys and colluvial soils in the coastal plain. About 95% of the total area is covered with soils which belong to class I, II and III. About 600 ha of the Class II and III soils have productivity limitations either due to heavy texture soils or to shallow depth. The cropping pattern therefore includes crops that grow on heavy soils like pecans and on shallow depth soils like vegetables without affecting their yields.

4.2 Cropping pattern

In the selection of crops, climate, soils, water and labour resources as well as economic factors were taken into consideration.

The favourable climatic conditions of the Project area allow the inclusion of a great variety of crops. Therefore a wide and highly flexible cropping pattern can be developed with emphasis on the production of earlies: lemons, vegetables and table

grapes. The presence of table olives, almonds, pistachios and table grapes permit a better water management of the whole scheme in dry years due to their ability to survive such a year of strongly reduced water supply rates without permanent damage, thus creating a higher water availability for the water sensitive crops. In case of severe droughts the omittance of summer vegetables could be considered.

Crop	Areas to be planted %	Ha
Citrus	30	930
Avocados	8	248
Bananas	4	124
Table grapes	2	62
Table olives	7	217
Nuts	18	558
Deciduous	6	186
Early vegetables	12.5	387
Summer vegetables	6.25	194
Winter vegetables	6.25	194
Totals	100	3100

4.3 Yields and Benefits

The benefits of the Project can be summarized as follows:

(i) 1,500 farmers with land in the development zone will benefit from the Project and its implementation will allow full employment for about 3,500 persons.

(ii) Strengthening and improvement of the social structure in this agricultural area, stimulated by a rise in future farm incomes of about 6.5 times the present average annual income of £1080.

(iii) The Project at full development will generate net incremental benefits of £11 million annually, of which about £10 million will be in foreign exchange earnings, through the export of high value fruit and horticultural crops.

5. ORGANISATION AND MANAGEMENT FOR PROJECT IMPLEMENTATION

The main instruments of the organisation, management and subsequent operation and maintenance of the Project are briefly described below:

5.1 Policy Level

Project policy and coordination of the activities of all the Government Departments concerned is achieved through a high level body, called the Project Policy and Coordination Committee (PPCC) with the D.G. of the Ministry of Agriculture and Natural Resources as chairman, the Director of the Water Development Department as secretary and other senior members from all Ministries involved with the Project.

5.2 Executive Level

The main executive body of the project during its implementation, operation and maintenance is the Water Development Department. The services of some other Departments are also utilised. The Department of Agriculture will be responsible for the on-farm development work and together with the Agricultural Research Institute will provide agricultural extension and research services. Others involved are the Ministry of Finance, the Planning Bureau, the Accountant General and the Tender Board, the Auditor General, the Geological Survey Department, etc.

5.3 Advisory Level

An advisory body at regional level with knowledge of local affairs representing all interested disciplines has been established under the chairmanship of the District Officer. This body is called the Project Advisory Committee and directly advises the Project Manager on local developments affecting the project and problems faced by the farmers as well as explaining to the farmers the project objectives and advising them on the efficient use of the water resources.

6. OPERATION AND MAINTENANCE

The executive body for the Project Management will be the Department of Water Development through a Manager properly assisted by the Agricultural Department.

All water legislation will be controlled through the Director of the Water Development Department both for the Project areas as well as for all water catchment areas upstream.

7. PRINCIPAL CONTRACTORS

7.1 EVRETOU DAM

Main Contractors—	Shephard Hill-Zachariades (JV)
Sub Contractors:—	
Geotechnical Works	Colcrete Soletanche JV
Intrumentation	Soil Instruments Ltd (UK)
Valves	Glenfield (UK), Ham Baker (UK), Erhard (Germany)
Meters	Kent (UK)

7.2 IRR. NETWORKS AND FARM ROADS

Main Contractor	G. P. Zachariades Ltd (Cyprus)
Supply Contracts	
A.C. Pipes	Eternit (Lebanon)
UPVC Pipes	Kosmoplast (Cyprus) and Lordos Plastics (Cyprus)
Fittings	Nappco (USA) ISI (Italy)
Valves	E. Hawle (Austria) Vanadour (France) Glenfield (UK) VIR (Italy)
Hydrants	APCO VALVE (Greece)
Meters	Schlumberger (France) with Nemitsas (Cyprus) Bermad (USA)

7.3 MAIN CONVEYOR AND PONDS

Civil Works	General Construction Co Ltd (Cyprus)
Supply Contracts	
D. I. Pipes	Pont-A-Mousson (France)
Valves	E. Hawle (Austria), Bermad (USA), Erhard (Germany), Neyrpic (France)
Meters	Meinecke (Germany)

8. PROJECT COST DATA

SUMMARY OF ESTIMATED TOTAL PROJECT COSTS

	£
Evretou Dam	9 200 000
Main Conveyor, Ponds and Intakes	4 500 000
Irrigation Networks and Farm Roads	4 100 000
Ground Water Development	300 000
Land Acquisition	350 000
Administration, Supervision and Consultants Fees	1 300 000
	£19 750 000

KHRYSOKHOU IRRIGATION PROJECT DATA

Feasibility study	FAO—WDD
Financing	Govt. of Cyprus, World Bank
Design and supervision	Sir William Halcrow and Partners,—WDD
Main Contractors	Shephard Hill-Zachariades (JV), G.P. Zachariades, General Construction Co.
Responsibility for design, construction, operation & maint.	Water Development Dept.
Construction period — Phase I	Jan. 1984-Jan. 1988
Construction period — Phase II	1986—1990

Water sources

Evretou Dam (Av. yield)	12.5 MCM/Year
Groundwater (Av. yield)	2.0 MCM/Year
Magounda, Yialia and Livadhi Rivers (Av. yield)	7.0 MCM/Year

Irrigation Networks	Phase I	Phase II
Main conveyors	8 km	44 km
Irrigation network	120 km	38 km
Area irrigated	2000 ha	1100 ha
Storage and balancing tanks	4	4

Land Use

Land consolidation	400 ha
Farm road construction	90 km
Country families benefited	1500

Crops: Citrus, vegetables, avocado, olives deciduous fruit trees, pecan nuts etc.

EVRETOU DAM DATA

Type	Rockfill
Constructed	1984—1986
Catchment area	91 km²
Reservoir	
Area	1.2 km²
Capacity	25 MCM
Embankment	
Height	71 m
Length	255 m
Volume	1.91 MCM
Spillway discharge	360 m³/s
Outlet tunnel (3.6 m dia)	227 m long
Bottom outlet (1.2 m dia) discharge	15 m³/s
Irrigation outlet (0.9 m dia) discharge	1.6—9 m³/s
Diaphragm wall foundation	
Length	97 m
Maximum depth	37 m
Thickness	0.80 m
Volume of concrete	1680 m³
Alluvial grouting	
Total drilling	14 220 m
Cement, bentonite grout	940 tons
Chemical grout	625 tons
Rock grouting	
Total drilling	64 150 m
Cement and bentonite grout	7 820 tons
PLANNING	Water Development Department
DESIGN	Sir William Halcrow and Partners
CONSTRUCTION	Shephard Hill-Zachariades, (J.V.)
OPERATION AND MAINTENANCE	Water Development Department

VASILIKOS–PENDASKINOS PROJECT

1. INTRODUCTION

1.1 Objectives

The basic objective of the Vasilikos–Pendaskinos Project is the development of surface and ground water resources from the Vasilikos, Pendaskinos and Maroni rivers both for the agricultural development of the area and the augmentation of the domestic water supply of Nicosia, Larnaca and Famagusta districts.

1.2 Feasibility Studies

The planning for the utilization of the flows in the three rivers in the Vasilikos–Pendaskinos area for local irrigation and for supplementing the Larnaca–Famagusta domestic water supplies started as early as 1968, when the Cyprus Water Planning Project was initiated by the Goverment in association with U.N.D.P and F.A.O.
The feasibility studies for the Project were undertaken by the Water Development Department (WDD) aided by other Government Departments and completed by the end of 1977.

1.3 Implementation

The Project was implemented in two phases. Design and construction of the first phase was executed between mid 1978 and the end of 1981 at a total cost of about £ 3 million. This provided the means of conveying water from the existing sources in the project area (e.g. Lefkara dam) to Nicosia thereby alleviating to some extent the water supply problems in the capital. On commissioning the second phase works the first phase becomes the means of conveying the augmented potable water supplies from the newly developed sources within the project, to Nicosia.
In January 1981 detailed design of the second phase was started by the Consulting Engineers with responsibility for the design and supervision of the work, Messrs., Rofe, Kennard and Lapworth, with Wallace Evans and Partners (UK) in association with C. Chr. Ioannides (Nicosia).
Construction work on the second phase of the Project started at the end of 1982 and completion of the major components was achieved the end of 1985 with some irrigation works and project ancillary work continuing up to 1989

1.4 Estimated Project Cost

The total cost of the Project including the first phase was estimated in 1981 as 31 million Cyprus pounds. The actual cost of the first phase was about £ 3 million. Competitive prices, lower than estimated price fluctuation, and a substantially increased proportion of the construction work being undertaken by the Construction Division of the Water Development Department (direct labour) has reduced the estimated cost of the second phase to about £ 23.6 million. The total estimated project cost is therefore about £ 26.6 million.

2. FINANCING

2.1 Government secured four loans to cover the foreign exchange cost component of the project.

2.2 First Phase

Toward the cost of the first phase of the project, Government secured a loan equivalent to about £ 1.9 million leaving a Government contribution to cover the cost balance of £ 1.1 million

2.3 The Main Project

Government secured three further loans for the second phase implementation. The largest was from the World Bank for an amount of US$ 9.9 million, the second from the Kuwait Fund for Arab Economic Development was for 2.5 million Kuwait Dinar and the third from the European Investment Bank for about 9.0 million European Currency Units. The total of these three loans is approximately the equivalent of 13.7 million Cyprus pounds leaving the Government to cover the balance of about 9.9 million Cyprus Pounds of the total estimated 23.6 million Cyprus Pounds cost for the second phase.

2.4 Project Manager – UNDP Contribution

In addition to these loans the United Nations Development Programme in Cyprus, through the Food and Agriculture Organisation of the United Nations has committed a grant for the major proportion of the cost of a Project Manager. The amount over about 5 years is about 232,000 US dollars of which a small proportion has been expended on authorised group training.

3.0 THE PROJECT AREA

3.1 Location

The whole Project Area covers about 1805 ha and is located in the southern part of the Island. It is bounded by the sea in the south and by the eastern part of the Troodos region on the north–western part of the watershed where it reaches altitudes of about 1500 m above sea level.
It is made up of 3 main watersheds, the Pendaskinos on the east, the Maroni watershed in the middle and the Vasilikos watershed in the west.

3.2 Geomorphology

Geologically the watersheds are made up of both igneous and sedimentary rocks. Igneous rocks occupy the highest part of the catchment reaching a maximum elevation of 1500 meters a.s.l. and forming steep valleys.

Igneous rocks consisting of multiple diabase dykes, account for 90% of the rock, separated by the occasional thin screen of lava. In the Vasilikos watershed plutonic rocks are also present, being essentially gabbros and serpentines.

Sedimentary rocks overlie the igneous rocks. Lapithos chalks occupy the middle parts of the catchments and consist of chalks and chalky marls. The Lapithos chalks are then underlaid by the Pakhna Formation.

River valleys are overlaid by extensive alluvial deposits running for several kilometers from the two damsites down to the coast.

Carob and olive trees form the main vegetation on the Lapithos and Pakhna formations. The highest parts of the catchment are moderately covered with vegetation including areas of pine trees.

3.3 Climate

The project area enjoys a typical Mediterranean climate with hot dry summers and wet winters. Rainfall in the watershed of the project area occurs during the months November to March and varies between 400 mm at the coast to 800 mm at the highest peaks, at altitudes of 1,500m a.s.l. the average rainfall being 450 mm. Winter temperatures are, as a rule, above 0°C and frost occurrence in the area is very unusual. This climate is suitable for the production of citrus and vegetables. Project evaporation data have been collected using sunken-pan evaporameters at Polemidhia dam station and it has been shown that monthly evaporation exceeds rainfall in all months except those from December to February. The evaporation averages about 1750 mm against a rainfall of 600 mm – 450 mm.

3.4 Original Agricultural Development

Most of the project area was under rainfed agriculture, mainly cereals, carobs and olives. However, irrigation was practised over a small part of the area, in the river valleys of Ayios Theodhoros village (Pendaskinos river), Maroni (Maroni river) Zyyi–Tokhni and in the Kalavasos valley (Vasilikos river). Crops irrigated by private boreholes and piping or public irrigation works covered an area of 298 ha as follows:

Citrus	191 ha
Deciduous	7 ha
Table Grapes	13 ha
Vegetables	87 ha

Citrus orchards continue mainly to be grown in the Pendaskinos valley, below the main Nicosia–Limassol road down to the sea. Vegetables are cultivated in the Maroni and Zyyi–Tokhni area and in the lower part (delta area of the river) of the Ayios Theodhoros valley.

4.0 THE WATER RESOURCES

4.1 Surface Water

The surface water resources of the three basins contributing to the Vasilikos–Pendaskinos Project have been estimated using rainfall records available for every year since 1916 and a mathematical run–off model as follows:

Vasilikos River – Average annual flow 11.0 MCM at Kalavasos Damsite

Maroni River – Average annual flow 3.7 MCM at Maroni Diversion weir

Pendaskinos River – Average annual flow 6.0 MCM at Dhypotamos Damsite

These figures are gross of upstream use.

The engineering structures constructed i.e. Kalavasos and Dhypotamos dams and Maroni Diversion Weir and its conveyor to Dhypotamos Dam have the following nominal capacities:

Kalavasos Dam	17 MCM
Dhypotamos Dam	15 MCM
Maroni Diversion	0.75 m³/s

The estimated safe yield from these sources amount to:

Kalavasos Dam	7.65 MCM per annum
Dhypotamos Dam	6.8 MCM per annum (including 2 MCM diverted from the Maroni River)

4.2 Groundwater

There are three different types of aquifers in the southern part of the project area:

- the gypsum aquifer
- the sandstone aquifer
- the alluvial aquifer

Due to the construction of dams on both rivers the replenishment of these aquifers will decrease rendering them less important though it is planned to augment the volume of water allocated for irrigation for the Pendaskinos area with 0.5 MCM from the aquifer. As originally conceived the Maroni irrigation area, requiring about 1.01 MCM per annum would be served solely from boreholes in the gypsum aquifer. However, in view of the findings of recent work at the Agricultural Research Institute Sub–Station on the Project, which demonstrated the harmful effects of high sulphate water on crops and soil structure, it has been decided to use water from Kalavasos Dam, and later from the Southern Conveyor. It will however be possible to use some borehole water if and when safe dilution levels are proved, and on soil that has previously been irrigated with high sulphate water.

5. ENGINEERING ASPECTS

The Project consists of the following main elements:

5.1 Kalavasos Dam: A rockfill dam on the Vasilikos River, 5.5 km northwest of Kalavasos village and only 250 m upstream of the old Kalavasos Mine Offices of the Hellenic Mining Company to supply 5.65 MCM per year of water to the Vasilikos irrigation area and 2 MCM per year to Khirokitia Treatment Plant for domestic purposes. The dam is about 60 m high above foundation level, with a crest length of some 500 m, and creates a storage reservoir with a total capacity of 17 MCM. The reservoir extends about 2 km upstream

and will have a surface area of 1.0 km² at a full storage level of 178.5 m above mean sea level.
The construction work undertaken by the Joint Venture Messrs Joannou and Paraskevaides with the MEDCON Construction Co Ltd started on 3rd January 1983 and the accelerated impounding date of December 1984 was achieved. The total cost of the Dam is estimated at £ 5,934,000.

5.2 Dhypotamos Dam: This is the other main storage facility within the Vasilikos–Pendaskinos Project to be used mainly for the improvement of the Nicosia domestic water supply with 5 MCM per year allocated annually to the New Kornos Water Treatment Works with an additional 1.8 MCM per year allocated to the Pendaskinos Irrigation Area.
It is a rockfill dam, located on Pendaskinos river a few metres downstream of the confluence of the Syrkatis and Mylou tributaries, 3.3 km north of Skarinou station. The height of the Dhypotamos dam is about 62 m above foundation and the dam crest is about 450 m long. The capacity of the dam will be 15.0 MCM with its full storage top water level at 175 m above mean sea level. The surface area at full storage level would be about 1.3 km². The reservoir would extend about 2.8 km upstream of the dam axis in the Syrkatis tributary and 1.8 km in the Mylou tributary.
The construction works undertaken by the joint venture Shephard Hill Ltd with G.P. Zachariades Ltd. started on 2nd November 1982 with impounding achieved in January 1984. The cost of the dam is estimated to be £ 3,760,000.

5.3 Maroni Diversion: In view of the lack of a technically feasible damsite on the Maroni river, it was decided to divert a proportion of the flow of the river to a point upstream of Dhypotamos Dam. The diversion system comprises a 5 m high mass concrete weir with maximum impounded capacity of about 50,000 m³, on the Maroni river and with diversion works which feed water via a pipeline of 800 and 700 mm dia to Dhypotamos Reservoir at rates of upto 0.75 m³/s, and total 2 MCM annually, i.e. 53% of the estimated mean annual flow of Maroni river. The surplus water of the river will be used for the irrigation of the Maroni river valley downstream.
The construction works undertaken by G. P. Zachariades Ltd started on 2nd May 1984 at a tender cost of £1,255,554 andweredue for completion at the end of July 1985.

5.4 Maroni Irrigation Scheme: This comprises an irrigation network covering about 229 ha of land in the delta area of the Maroni river. It will be served initially with water from Kalavasos dam and later the Southern Conveyor with scope if necessary and acceptable for mixing water from the gypsum aquifer. Construction is by direct labour at an estimated cost of £670,000 for completion in stages between June and August 1985.

5.5 Vasilikos Irrigation Scheme: This comprises a conveyance and distribution system for irrigation from Kalavasos Dam, comprising, main conveyor, break pressure tank, and pipeline networks covering an area of about 837 ha in the Vasilikos valley and delta area. Construction is by Direct Labour at an estimated cost of £2.25 million for completion in stages between August 1985 and autumn 1986 though a proportion will not be completed until land consolidation in the Kalavasos village area is completed in early 1989.

5.6 Pendaskinos Irrigation Area: About 376 ha of irrigation network in the Pendaskinos Valley and delta area are to be served by the Dhypotamos dam and existing boreholes. Construction is by Direct Labour at a cost of about £1.6 million for completion in June to August 1985.

5.7 Kalavasos – Khirokitia Pipeline with Tokhni Pumping Station: This is the main conveyor of water from Kalavasos dam to the existing treatment plant at Khirokitia (via Tokhni pumping station) and of irrigation water from the same source to the Vasilikos irrigation area. Some 18 km of pipeline are involved in diameters up to 900 mm with peak nominal capacity of 940 litres per second. The Contract included an 8500 cu.m. balancing reservoir at the Khirokitia Treatment Plant and a small break pressure tank. The new Tokhni Pumping Station boosts the proportion of dam water required (up to a maximum of 410 litres/sec) for treatment to potable standards at Khirokitia water treatment works. The work, executed by Direct Labour was started on 1st September 1983 and was completed at the end of 1984 at an overall cost of about £2.1 million.

5.8 Nicosia Water Supply – Phase I and II

Phase I:

As described earlier one of the basic objectives of the Project is to augment the Nicosia domestic water supply. The construction of the Skarinou–Nicosia pipeline within the Nicosia Water Supply Phase I Scheme preceded the Vasilikos–Pendaskinos Main Project but as part of the Project. Phase I was completed early in 1982. It includes Dhypotamos Pumping Station, Stavrovouni balancing reservoir, Nissou Break Pressure Tank and the new Lakatamia Reservoir. During Phase I the system is supplied with water from the original Khirokitia–Phrenaros pipeline at Skarinou. Dhypotamos pumping station boosts the water to Stavrovouni balancing reservoir and from there it gravitates through Nissou Break Pressure Tank, and on to Lakatamia reservoir an overall distance of some 40 km. These works commenced in April 1980 and the Civil Engineering Works were undertaken by Messrs Joannou and Paraskevaides at a cost of about £1,000,000. The total cost of the whole of phase I was about £3,000,000.
The consulting engineers responsible for the design and supervision of this phase were Messrs Lemon and Blizard of Southampton, UK.

Phase II:

This Phase utilizes water from Lefkara and/or Dhypotamos dam for treatment to potable standards

up to a maximum of 32,000 cubic metres per day at the new Kornos Treatment Works. Construction here, undertaken by Charilaos Apostolides Ltd. started in November 1983 for completion by September 1985 at a cost of about £2.5 million including the water treatment equipment and the pumps which will lift the treated water to Stavrovouni Balancing Reservoir and the Phase I trunk pipeline at rates up to 495 litres/sec.

6. AGRICULTURAL ASPECTS

6.1 Soils

The project area is dominated by alluvial soils among the river valleys and colluvial soils in the coastal plain. These are deep soils, free from excessive quantities of lime, suitable for the cultivation of most crops.

6.2 Cropping Pattern

The cropping pattern for the Vasilikos–Pendaskinos Project will not only depend on land suitability and climatic conditions but also on market requirements, profitability and labour availability. In the studies so far on average the following cropping patterns have been anticipated by area:

Vasilikos Irrigation Area	
1. Citrus	50%
2 Vegetables	50%
Pendaskinos Irrigation Area	
1. Citrus (Permanent Plantations)	90%
2. Vegetables	10%
Maroni Irrigation Area	
1. Permanent Crops	10%
2. Vegetables	90%

6.3 Benefits

As has been seen the project has two purposes. Firstly about 9 MCM of water per year will be provided for irrigation. Besides the existing irrigated area of 298 ha, new areas of about 1440 ha between the Vasilikos and Pendaskinos rivers will be irrigated. Secondly about a further 7 MCM of water per year will be supplied to augment the domestic needs of Nicosia, Larnaca and Famagusta.

6.4 Land Tenure

Land tenure aspects in any project area are very important as they are critical factors in determining the kind of farms which are likely to develop after the implementation of the project.

In Cyprus land tenure is complicated with problems such as small size of ownership, fragmentation of ownerships and dispersal of plots, ownerships in undivided shares, lack of access to the plots etc.

For all practical purposes the project area can be considered as privately owned land, with land belonging to companies or the State constituting a very small proportion of the total.

Within the areas to undergo land consolidation the small holdings are dominant with the average size of holding being 0.81 ha and the average size of plot or share being only 0.5 ha. The average number of plots or shares per holding is 1.6 and generally, fragmentation increases as the size of holding increases.

6.5 Land Consolidation

Because of the land tenure problems in the area, as well as the need both to improve the infrastructure and facilitate the optimum design of the irrigation networks, the implementation of land consolidation was considered essential.

As experience from other completed land consolidation schemes has shown land consolidation's contribution is substantial towards the enlargement of holdings and the size of plots, the reduction of fragmentation, the elimination of dual and undivided ownerships, the construction of rural roads, the improvement of plot shape, the reduction of the cost or irrigation networks, etc.

Land consolidation in the project area is implemented in three schemes on a total area of about 500 ha within the administrative boundaries of 5 villages. A part of the project area to be irrigated was excluded from land consolidation mainly due to the existence and distribution of Turkish–owned properties. It is the Cyprus Governement's policy not to consolidate land in this category without the consent of their owners.

The plans provide for a total of approximately 34 km of rural roads to be constructed within the areas to undergo consolidation, and approximately a further 16 km in non–consolidated areas.

6.6 Agricultural Research

Research is carried out by the Agricultural Research Institute. The headquarters are in Nicosia, but there are several experimental stations in rural areas mostly concerned with applied, not general research and experimentation.

For the needs of the project, a research sub–station in the project area has been established. The programme includes research in relation to crop and water suitability, production techniques and management, irrigation, fertilization, crop protection, packaging and transportation.

6.7 Agricultural Extension

The extension service of the Department of Agriculture is used for the implementation of agricultural policy. At Project level a District Agricultural Officer is responsible for the supervision and co–ordination of the various beats in his district. Beats are groups of villages under the responsibility of a beat agent who acts as the link between the farmers and the various extension facilities and specialists at the District Office. A Project Beat Officer has been appointed and a team of several other extension specialists e.g. on citrus fruit, vegetables and water use will be completed as the needs of the agricultural elements in the Project require.

7. ORGANISATION AND MANAGEMENT FOR PROJECT IMPLEMENTION

The main instruments of the organisation, management and subsequent operation and maintenance of the Project are briefly describes below:

7.1 Policy Level

Project policy and coordination of the activities of all the Government Departments concerned is achieved

through a high level body, called the Project Policy and Coordination Commitee (PPCC) with the Minister of Agriculture and Natural Resources as chairman, the Director of the Water Development Department (WDD) as secretary and other senior members from all Ministries involved with the Project.

7.2 Executive Level

The main executive body of the Project during its implementation, operation and maintenance is the Water Development Department. The services of some other Departments are also utilised. The Agricultural Department will be responsible for the on-farm development works and together with the Agricultural Research Institute will provide agricultural extension and research services. Other Departments involved are the Ministry of Finance, Planning Bureau, Tender Board and Accountant General and Auditor General, Geological Survey Dept. etc.

7.3 Advisory Level

An advisory body at regional level with knowledge of local affairs representing all interested disciplines has been established under the chairmanship of the District Officer. This body is called the Project Advisory Committee and directly advises the Project Manager on local developments affecting the project and problems faced by the farmers as well as explaining to the farmers the project objectives and advising them on the efficient use of the water resources.

8. OPERATION AND MAINTENANCE

The executive body of the Project Management will be the Department of Water Development through a Manager properly assisted by the Agricultural Department.

All water legislation will be controlled through the Director of Water Development both for the Project Areas as well as for all water catchment areas upstream.

The WDD will also be responsible for selling the water either in bulk to the Irrigation Divisions or to private consumers.

9. PRINCIPAL CONTRACTORS

9.1 KALAVASOS DAM – Joannou and Paraskevaides with the Medcon Construction Co Ltd.

9.2 DHYPOTAMOS DAM – Shephard Hill Ltd. (U.K.) with G. P. Zachariades Ltd.

Sub Contractors – (Both dams)

Grouting Works:	Colcrete Ltd. U.K.
Valves and hydraulic control equipment:	J. Blakeborough and Sons Ltd U.K.
Handrailing and flooring:	Gasco Ltd. U.K.

9.3 MARONI DIVERSION–

Civil Works – G.P. Zachariades Ltd.

Ductile Iron Pipe Supply Subcontractor – Thyssen (Germany)

9.4 TOKHNI PUMPING STATION–

Civil Works – Water Development Department

Pump Plant – Weir Pumps Ltd (U.K.)

9.5 KORNOS TREATMENT WORKS

Civil Works – Charilaos Apostolides Ltd.

Water Treatment Plant – Degremont Laing Ltd. (U.K.)

9.6 KALAVASOS – KHIROKITIA PIPELINE

Civil Works: Water Development Department.

Supply Contracts

Pipes: Thyssen (Germany)
Valves: Guest and Chrimes Ltd. (U.K.)
Flowmeters: Bestobel Sparling Ltd(U.K.)
Float Valves: Glenfield and Kennedy Ltd. (U.K.)
Pressure Sustaining valve: Bayard Exports (France)

9.7 THE VASILIKOS, PENDASKINOS AND MARONI IRRIGATION AREAS.

Civil Works: Water Development Department

Supply Contracts:

A. C. Pipes: Cyprus Pipe Industries Ltd. (Cyprus)
Fittings: Metalicas Fundiciones (Spain).
UPVC pipes: Hellenic (Greece) and Cosmoplast (Cyprus)
Valves: ISI (Italy)
Glenfield and Kennedy Ltd. (U.K.)
Blakeborough Ltd (U.K.)
Hydrants: Schlumberger – Flonic (France)
and
Bayard (France)
Meters: Bestobell Sparling Ltd (U.K.)

PAPHOS IRRIGATION PROJECT

GENERAL INFORMATION

The Paphos Irrigation Project is the largest and most important project in its kind ever constructed in Cyprus. With this project a major part of the water resources of the Paphos District is fully utilized for the purpose of agricultural development by ensuring 36 MCM of water for the irrigation of the fertile coastal plain of Paphos between Khapotami river and Ayios Yeoryios of Peyia amounting to 5,000 ha net.

The first studies of the Paphos water development schemes started in October 1968 and by 1972 the final Project Feasibility Study was completed by Consulting Engineering firms through financement by UNDP and under supervision of FAO. In 1974 the Government of Cyprus entered into an agreement with the World Bank in order to receive a loan of US $14 million for the implementation of the Project.

Construction works which were delayed for 2 years due to the Turkish invation commenced in 1976 and will be fully completed during the first quarter of 1983 at the total cost of C£ 25 million US $65.5 million).

In brief the main features of the Project are the following:

- Asprokremmos Dam on Xeropotamos river of total water storage capacity of 51 MCM and an annual safe yield of 22 MCM. The dam embankment is of zoned earthfill type with central clay core and which is 52 meters high above river bed with a crest length 600 meters. Spillway discharge capacity is 1,484 m3/sec

- 24 boreholes in the river beds of Dhiarizos (13), Ezousas (8) and Xeropotamos (3) which can yield 10 MCM per year. The water pumped from the boreholes is conveyed into the main canal through a wellfield conveyance system comprising of AC pipes and canaletti of 17 km total length.

- The Main Canal which extends from Asprokremmos Dam to Yeroskipos over a distance of 12 km. It has a discharge capacity of 4.2 m3/s at its head and 1.6 m3/s at its end.

- The Western Main Conveyor of ductile iron pipes 21.5 km long and max. diameter of 900mm starting from the end of the main canal and extending as far as the western end of the project in order to supply the western area of the project which covers 1500 ha.

- 14 Pumping Stations which have been constructed along the main canal and western conveyor in order to provide pressurised supplies into the irrigation networks of the project so that farmers will receive water under pressure and apply improved methods of irrigation such as sprinklers, mini sprinklers and drip irrigation.

- For the irrigation networks of all the project area 539 km of AC pipelines have been installed of different diameters.

The main objectives of the Paphos Irrigation Project are the following:

- Extension of irrigated crops over 5000 ha of which 1200 ha was partly irrigated and increase of the agricultural production and especially of high-value fruit crops and vegetables for export. The increase of gross value of annual production is estimated at C£17.9 million.

- The increase of income of 4,800 farm families in the project area and generally the creation of more job opportunities in the area and subsequent raise in the standard of living.

In order to achieve the above objectives a strategy of agricultural development has been followed which includes the following points:

- A detailed soil survey of all the irrigated area.

- Application of land consolidation in 8 villages and the distribution of 319 farm units to landless families under long term leases of government owned land.

- The establishment of the Paphos Agricultural Training Centre for training farmers on matters involved in irrigated agriculture.

Research Institute of two sub-stations at Akhelia for carrying out experimens on various irrigated crops.

- The offer of Government credit facilities to the farmers for installation of farm irrigation systems, green houses etc.

PAPHOS IRRIGATION PROJECT DATA

Commanded area

- Area to be irrigated	5000 ha net
- Eastern area	3500 ha
- Western area.....	1500 ha

Water resources

- Asprokremmos dam (Capacity 51 MCM Safe yield ...22 MCM)	
- Ground water 24 boreholes along river aquifers ...10 MCM) ...	36 MCM
Coastal calcarenite aquifer boreholes ... 4 MCM)	

Conveyance

- Concrete lined main canal	12 Km
Max. flow capacity	4.2 m3/sec
- Main pipelines	25 Km
- Wellfield conveyance systems	17 Km
- Western main conveyor ...	21.5 Km
Max. flow capacity	875 l/s

Pumping Stations (14 No)

- Combined power	7370 HP

Reservoirs

- Storage reservoirs	6 No
- Elevated balancing reservoirs	3 No
- Ground balancing reservoirs	4 No

Distribution networks 17 No

Distribution network pipelines

- Eastern area	389 Km
- Western area.....	150 Km

Land tenure

- Land consolidated	2350 ha
- Farm roads constructed ...	98 Km
- Access farm roads	26 Km

Project beneficiaries

- Farm families (mostly small owners)	3500 No
- Landless families (as seasonal labour)	981 No
- Landless families (leasing government land)	319 No

Cropping pattern

- Permanent plantations: Citrus (47%) avocado (7%) table grapes (8%) Bananas (5%) deciduous fruit trees (5%)	72%
- Seasonal crops: Vegetables (21%) and summer garden produce (7%)	28%

Financing:

- Government of Cyprus–World bank

Consultants:

- Sir M MacDonald and Partners, Cambridge, England for Asprokremmos Dam
- SOGREAH, Grenoble, France, for distribution and conveyance systems

Main Contractors:

- J & P and MEDCON (Joint Venture) of Nicosia for Asprokremmos Dam
- SOCEA—Paris, France for Eastern area distribution network
- Costain Civil Eng. Ltd, Maindenhead, England for construction of pumping stations and western conveyor
- General Construction Company Ltd, Nicosia for main canal construction
- G P Zachariades Ltd, Limassol for Western Area irrigation network
- Cyprus Pipes Industries Ltd, Limassol for supply of AC pipes and fittings

Executive Government Agency for Execution of the Work and Operation and Maintenance:

- Water Development Department Ministry of Agriculture and Natural Resources

Project commencement ... January 1976
Project completion ..... March 1983

Total cost of Project including Asprokêemmos Dam: C£ 25 million (US $65.5 million)

ASPROKREMMOS DAM DATA

Catchment area	224 Km^2
Reservoir area	259 ha
" capacity	51 MCM
Embankment type: Zoned earthfill with central clay core	
Embankment height above river bed	52 m
Embankment length of crest	600 m
volume	2MCM
Crest elevation above sea level	84.5 m

Diaphragm wall foundation

– Length	200 m
– Maximum depth	30 m
– Thickness	0.80 m
– *Spillway maximum discharge capacity*	1484 m^3/s

Alluvial grouting

– Total drilling	36 800 m
– Cement, bentonite and chemical consumption	3 355 tons

Rock grouting

– Total drilling	26 971 m
– Cement and bentonite consumption	370 tons

Outlet tunnel

– Diameter	4 m
– Length	310 m
– Discharge capacity	96 m^3/s

Twin irrigation outlet pipes

– Diameter	800 mm
– Discharge capacity	0.60-4.30 m^3/s
Hydroelectric power generator (one set)	650 KW

Total cost of Asprokremmos Dam: C£ 11 million (US $ 28.8 million)

Planning

Water Development Department

Design
Sir M MacDonald and Partners, UK

Construction

Joint Venture: J & P and MEDCON of Nicosia

Operation and maintenance

Water Development Department
Ministry of Agriculture and Natural Resources

Commencement	May 1978
Completion	Dec 1982

PITSILIA INTEGRATED RURAL DEVELOPMENT PROJECT

Pitsilia Integrated Rural Development Project (PIRDP) is a multipurpose project the main component of which is water development but which includes roads, education, health, agricultural extension services and research, loan facilities for agriculture etc.

The main objective of the PIRDP, is the stimulation of the economically depressed, mountainous region of Pitsilia thus raising the standard of living of the 21,000 inhabitants of some 50 villages of the region and checking the population drain to the towns.

The total cost of the PIRDP has exceeded £10 million of which $10 million represents a loan from the World Bank.

Construction of the water development works started in 1978 and was completed early in 1984 at a total cost of about £7.1 million.

The water development component of the project consists of:

One earth-rockfill dam at Xyliatos of 1.25 MCM water capacity for the irrigation of an area of 308 ha of land.

One small concrete gravity arch dam at Ayii Vavatsinias of 0.054 MCM capacity belonging to Ayii Vavatsinias irrigation scheme.

19 PVC lined off-stream earth of a combined capacity of approx. 2 MCM for the irrigation of 495 ha of land.

20 borehole irrigation schemes for the irrigation of an area of 479 ha.

Rehabilitation of numerous small irrigation schemes involving an area of approx. 250 ha.

Domestic water supplies for various villages of the region.

The ponds are fed with water from diversion weirs which have been constructed on nearby streams through diversion pipelines laid for this purpose. The ponds are filled during the winter and early spring months so that the water can be used during the dry summer months.

The main crops irrigated are vegetables, deciduous fruit trees, citrus and olives. Land consolidation has been applied in some of the areas of the project and irrigation distribution networks have been constructed with farm hydrants reaching all farm holdings.

Data for the dams, ponds and borehole schemes are given on the table that follows.

N.B. Further information on the PIRDP is given on a booklet published by the Ministry of Agriculture and Natural Resources the coordinator of the whole project.

W D D PITSILIA INTEGRATED RURAL DEVELOPMENT PROJECT - BOREHOLE IRRIGATION SCHEMES

Ser No	Scheme	B H Nos	Irrigated area (hectares)	Completed in	Expenditure £
1	Kalokhorio	11/77& 54/76	55.63	1981	56 618
2	Potamitissa	67/76& 69/79B	29.49	1981	47 755
3	Arakapas (Skoli).....	106/76&107/76	24.13	1981	69 790
4	Ayios Theodhoros.....	105/76	12.60	1981	26 988
5	Arakapas (Angoulos)...	124/76	12.73	1982	43 795
6	Polystipos	21/77	9.38	1982	36 520
7	Ayios Konstantinos....	123/76& 8/81	40.21	1983	123 200
8	Kato Amiandos.....	31/76	70.64	1983	207 481
9	Louvaras.....	32/76& 16/81	37.53	1983	91 150
10	Zoopiyi	9/81	13.00	1983	46 450
11	Agros *.....	63/76	47.59	1983	103 332
12	Dhymes	81/80	23.59	1984	74 200
13	Sykopetra.....	48/82	13.94	1984	46 560
14	Agros	21/82	23.46	1984	73 500
15	Askas	98/80	19.44	1984	75 000
16	Alona	46/80	12.73	1984	44 862
17	Lagoudhera.....	53/80	5.76	1984	29 587
18	Dhierona.....	14/82	12.73	1984	50 000
19	Ayii Vavatsinias.....	35/81	14.34	1984	45 450
20	Phterikoudhi	9/82	-	-	-
	TOTAL		478.92		£1 292 238

* Together with Agros Dam

Note: Planning, design and construction of all above projects was carried out by WDD.

W D D PITSILIA INTEGRATED RURAL DEVELOPMENT PROJECT - PONDS AND THEIR DISTRIBUTION SYSTEMS

Ser No	Scheme	Capacity (cub.metres)	Irrigated area (hectares)	Completed in	Expenditure C£	Design	Construction by	Planning, design and supervision of construction
1	Xyliatos* (Dam)	1 250 000	-	1982	1 187 428	WATER DEVELOPMENT DEPARTMENT	General Construction Co	WATER DEVELOPMENT DEPARTMENT
	" Distribution System	-	308.31	1984	654 000		Water Development Dept.	
2	Ephtagonia No.1	92 000	-	1980	83 722		Iacovou Bros	
	" Distribution System	-	20.11	1981	24 509		Water Development Dept.	
3	Khandria	70 000	-	1980	105 940		CYBARCO	
	" Distribution System	-	18.77	1982	26 906		Water Development Dept.	
4	Melini	58 000	-	1980	67 815		Iacovou Bros	
	" Distribution System	-	14.08	1980	15 390		Water Development Dept.	
5	Pelendria & B H No 53/76	123 000	-	1980	132 266		FYSCO Contracting	
	" Distribution System	-	71.98	1981	73 550		Water Development Dept.	
6	Ayii Vavatsinias							
	a) Arch dam	53 500	-	1981	82 252		Water Development Dept.	
	b) Pond No 1	55 000	-	1981	72 330		Iacovou Bros	
	" Distribution System	-	24.13	1981	28 333		Water Development Dept.	
7	Kato Mylos & B H No 66/76	104 000	-	1981	125 000		Phoenix Constructions	
	" Distribution System	-	40.21	1982	71 313		Water Development Dept.	
8	Ephtagonia No 2	127 000	-	1981	162 271		Hadjikonstandis-Fisentzides & Charalambous Co.	
9	Ephtagonia No 3	65 000	-	1981	97 686		Iacovou Bros	
	" Distribution System	-	35.52	1982	66 302		Water Development Dept.	
10	Akapnou-Ephtagonia	132 000	-	1981	177 390		Iacovou Bros	
	" Distribution System	-	24.80	1982	39 084		Water Development Dept.	
11	Arakapas No 1	191 000	-	1982	177 975		Iacovou Bros	
	" Distribution System	-	36.19	1982	49 964		Water Development Dept.	
12	Agridhia	59 000	-	1983	89 510		Iacovou Bros	
	" Distribution System	-	12.33	1983	27 787		Water Development Dept.	
13	Kyperounda No 2	270 000	-	1983	315 314		Iacovou Bros	
	" Distribution System	-	71.05	1983	193 565		Water Development Dept.	
14	Lagoudhera	71 500	-	1983	148 870		Phoenix Constructions-KYKON	
	" Distribution System	-	17.43	1984	14 500		Water Development Dept.	
15	Ora & B H Nos 27/81 & 66/81	60 000	-	1983	104 522		Phoenix Constructions	
	" Distribution System	-	18.10	1983	68 340		Water Development Dept.	
16	Ayii Vavatsinias No 2	43 500	-	1984	97 810		Chr Charalambous	
	" Distribution System	-	7.37	1983	15 710		Water Development Dept.	
17	Pharmakas No 1	21 000	-					
18	Pharmakas No 2	59 000	-	1984	224 210		Iacovou Bros	
	" Distribution System	-	16.76	1983	25 214		Water Development Dept.	
19	Arakapas No 2	119 000	-	1984	155 598		Char Apostolides	
	" Distribution System	-	25.47	1983	45 900		Water Development Dept.	
20	Dhierona	159 000	-	1984	216 200		Char Apostolides	
	" Distribution System	-	40.21	1983	95 500		Water Development Dept.	
	T O T A L	3 182 500	802.82		£ 5 359 976			

* Villages benefiting from Xyliatos Dam are Ayia Marina with 28% of the irrigated area, Khandria 25%, Xyliatos 20%, Kyperounda 9%, Lagoudhera 5% and various other villages 13%

Appendix No.1

Water Development Department

Foreign Technical Assistance provided by international organisations and individual countries

1. UNITED NATIONS AND OTHER ORGANISATIONS

UNDP/FAO Technical Assistance on:

- Water legislation (CYP/TE/LA).
- Cyprus Water Planning Project (CWPP) - UN special fund project, on water resources utilisation (CYP/66/506).
- Morphou/Tylliria Irrigation Project Feasibility Study - (CY/71/513).
- Paphos Irrigation Project (CYP/75/016) & (CYP/81/011).
- Khrysokhou Watershed Irrigation (CYP/77/006).
- Vasilikos-Pendaskinos Project (CYP/79/004).
- Southern Conveyor Project (CYP/87/005).
- Detailed design of Evretou Dam (TCP/CY/2201).
- Southern Conveyor Project (TCP/CY/450(A)).
- Assistance to the Southern Conveyor Project-Ext. (TCP/CY/6654(A))-1986.
- Akrotiri groundwater development. Pre-feasibility study (TCP-6/CYP/01/T).
- United Nations special fund for groundwater and Mineral Explorations (GWMRP) 1962-1969.

- Experts have been provided by UNDP/FAO for:

- Watershed master planning; distribution systems and borehole pumping schemes; investigation problems mainly for damsites, for salinity problems of the Ovgos and Ezusas rivers in connection with the possibility of building dams on these two rivers; the design of dams; hydrological investigations, recharge works and grouting; for dam construction works; contractors supervision; irrigation systems and general planning work; short range planning (preliminary investigations) and dam design; water resources development and water legislation; water balance of western Messaoria; consulting engineering for hydrogeological work.

- Consultants have been appointed by UNDP/FAO for:

- Paphos Irrigation Project, Phase A; for the main hydrogeological work of the Ground Water and Mineral Resources Project; for Morphou Tylliria Feasibility Study; for Paphos Irrigation Project, Phase B; for Khrysokhou Irrigation Project.

IHP/UNESCO Technical Assistance on:

- The computerization of the accumulated hydrological and hydrogeological data in the form of a data storage system for the country's stream gauging stations, main springs, wells and boreholes. - 1975.

UNDP/WMO Technical Assistance on:

- Improvement of hydrological data acquisition and processing (CYP/81/002/A/01/16) 1984-1985.

IAEA Technical Assistance on:

- Environmental isotope Survey of Cyprus (since 1975) to use of isotopes in solving hydrogeologic problems.

INSTITUTE OF GEOLOGICAL SCIENCES (IGS-UK) Technical Assistance on:

- Research in estimation of the recharge of aquifers from rainfall by using lysimeters 1976-1982.

- Several countries such as the Netherland, Sweden, U.S.A, China provided experts through FAO.

2. INDIVIDUAL COUNTRIES

FRENCH Technical Assistance through SCET on:

- Investigations of the important Morphou aquifer (Water balance of Western Messaoria) 1962-1964.

WEST GERMAN Technical Assistance on:

- Hydrogeological and soil study of some part of the island (Kyrenia range) 1963-1965.

U S AID Technical Assistance through BECHTEL corporation on:

- Water supply to Famagusta town 1963-1966.

- Training programme in surveying - 1965.

- Experts have been provided for:

  Watershed and master planning, topography, water resources, soil laboratory investigations, maintenance and operation of dams, contracts and agreements.

BRITISH Technical Assistance on:

- Famagusta Water Supply, Khirokitia Project.
- Vasilikos-Khirokitia aquifer investigations.
- Special foundation problems.
- Kyrenia limestones hydrological studies and drilling explorations.

Through the UK Oversesas Development Administration (ODA) for:

- The development of water resources in the Akrotiri region feasibility study 1970-1973.
- Southern Conveyor Project 1974 and 1977-1982.
- Brackish water desalination 1971-1977.
- Experts have been provided for:

  Famagusta water supply and Vasilikos-Khirokitia aquifer investigations, engineering geology for damsites in the rivers of Pendaskinos Maroni and Vasilikos; grouting works on Yermasoyia dam; on the cracks on Kalopanayiotis dam; on the seepage from Polemidhia dam; on the possibility of constructing a dam at Palekhori; for Kalopanayiotis and Mavrokolymbos movements; for drilling operations on the limestones; desalination studies; development of Water Resources in the Akrotiri region; design of Lefkara dam and Khirokitia Treatment Plant and advice on Khirokitia-Famagusta pipeline ; reverse omosis plant tests.

- Consultants have been appointed for:

- The Development of water resources in the Akrotiri region (through ODA) and for the detail design and contract documents of Famagusta water supply including Lefkara dam and Khirokitia Treatment Plant.

Appendix No.2

CONSULTANTS EMPLOYED BY THE DEPARTMENT

- **Energoprojekt** of Beograd. Yugoslavia for the detail design, contract documents and supervision of construction of Ayia Marina, Pomos, Polemidhia, Mavrokolymbos, Yermasoyia dams and for the design & contract documents of the second phase of the Southern Conveyor Project.

- **I1 Nuovo Castoro** of Florence Italy for the detail design, contract documents and supervision of construction of Tremithos Kiti dam.

- **Technoexportstroy** of Bulgaria for the design of Mavrokolymbos distribution system.

- **Howard Humphreys & Sons of U.K.** for the detail design, contract documents and supervision of construction of Kalopanayiotis and Argaka Magounda dams; in association with IA Theophilou for detail design contract documents and supervision of construction of Vizakia dam.

- **SOGREAH, Grenoble,** France for the design and supervision of Paphos Irrigation Project distribution and conveyance systems; for the final design, contract documents and supervision of construction of Kouris dam, in association with **Hydroconsult**, Nicosia.

- **Sir M MacDonald and Partners,** Cambridge, England for the design, contract documents and supervision of construction of Asprokremmos Dam, Paphos Irrigation Project and for the preliminary studies of 2 dams and main conveyor of Khrysokhou Watershed Irrigation Project together with the KIP team.

- **Sir William Halcrow and Partners,** Swindon, England in association with **Balfours**, London for the feasibility study of the Southern Conveyor Project together with the SCP team of WDD staff and experts of the U.K. Overseas Development Administration; in association with **A Prastitis and Associates**, Nicosia for the detail design and contract documents and supervision of construction of Evretou Dam, KIP.

- **Lemon and Blizard,** Southampton, England for the design, contract documents and supervision of construction of Phase I of the Vasilikos-Pendaskinos Project.

- **Rofe Kennard and Lapworth** jointly with **Wallace Evans** and Partners UK in association with C Chr Ioannides, Nicosia for the detail design, contract documents and supervision of construction of all Engineering components of the Vasilikos-Pendaskinos Project, Phase II; in association with C Chr Ioannides, Nicosia for the feasibility study of the Platys and Xylourikos dams and the detail design and contract documents of the Xylourikos dam (Krasokhoria Project).

- Rofe Kennard and Lapworth in association with Southern Water Authority for the Institutional Study for the establishment of an Entity for the development management and allocation of water resources in Cyprus.

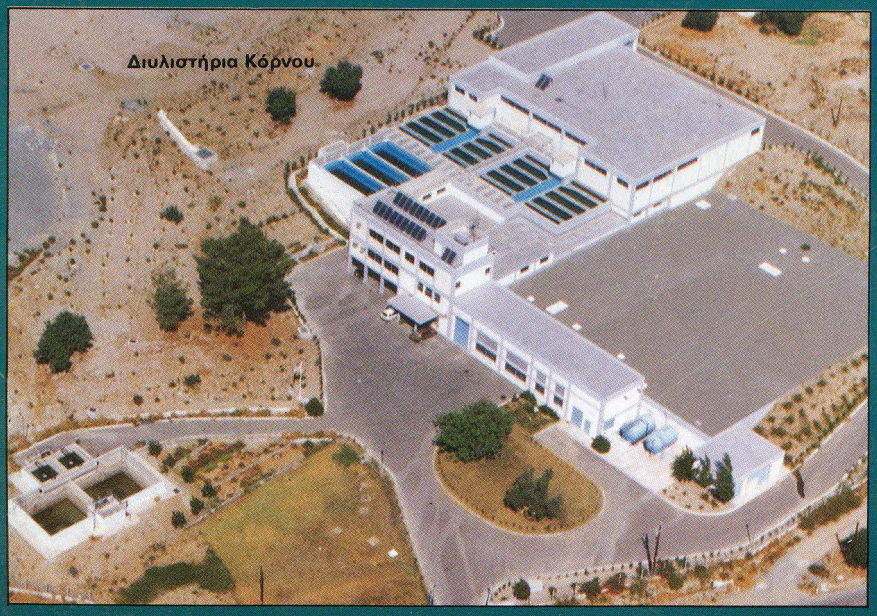
- Soviet organisation "Shelkozpromexport" for the preparation of the feasibility study on utilization of the Karyotis river runoff to supply potable water to Nicosia.

Φράγμα Κούρη

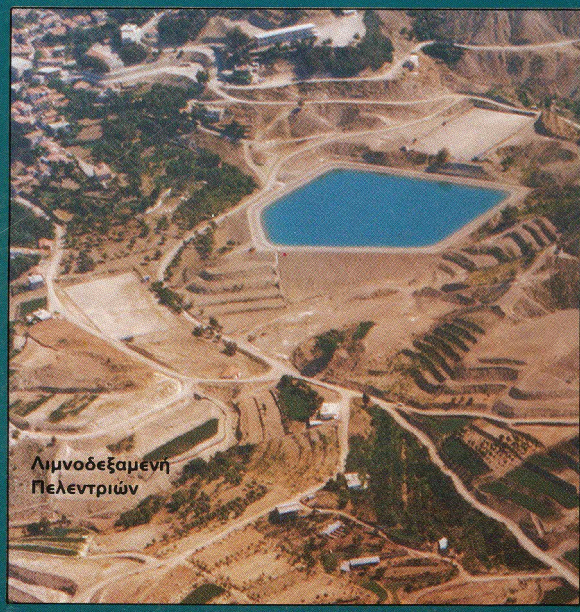
Τοποθέτηση
Νοτιου Αγωγού

Αντλιοστάσιο Τόχνης

Μετρητής ροής στον Ξεροπόταμο Πάφου



Διυλιστήρια Κόρνου



Λιμνοδεξαμενή
Πελεντριών