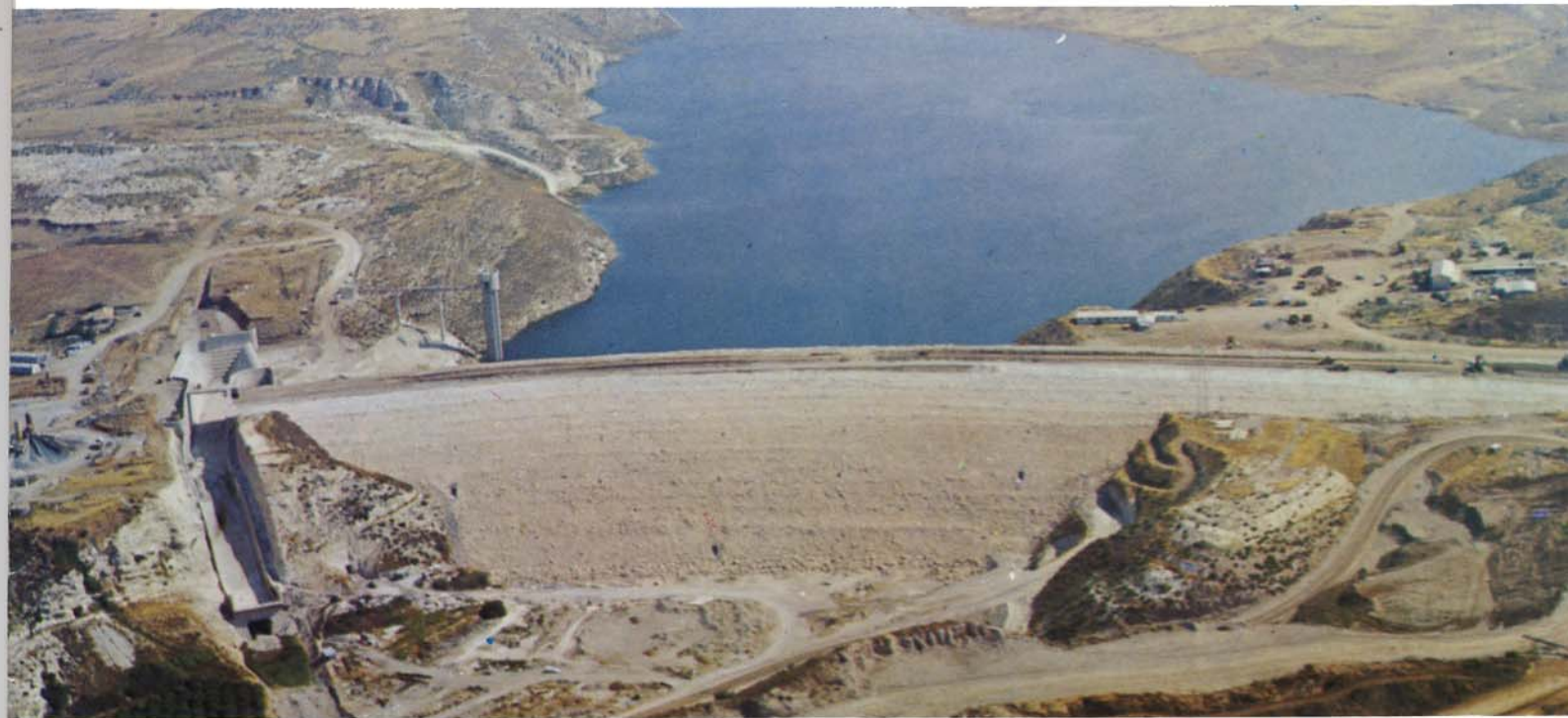


PAPHOS IRRIGATION PROJECT



Republic of Cyprus
 Ministry of Agriculture and
 Natural Resources
 Water Development Dept.



PAPHOS IRRIGATION PROJECT

Prepared by the Project Management of
Paphos Irrigation Project

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Front cover photoes
 Top: Aerial view of Asprokremmos Dam
 Bottom: Aerial view of main canal
 Back cover photoes
 Top: Orange harvest
 Bottom: Potato Harvest

Abbreviations

WDD Water Development Dept
 PIP Paphos Irrigation Project
 UNDP United Nations Development Programme
 FAO Food and Agriculture Organization
 MCM Million cubic metres
 C£ Cyprus pound

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SUMMARY

Agriculture is the third largest economic sector in the Republic of Cyprus providing 21.4% of all employment and contributing 10.7% to GDP and 33.4% to total exports. Irrigation is important to agriculture as the country is located in a low rainfall region and the normal rainfall, 85% of which occurs during November–March, is inadequate for either perennial or summer agriculture. Only 43,000 ha (12%) of the total 360,000 ha cultivated are irrigated.

The Paphos Irrigation Project will provide on-demand sprinkler irrigation to 5,000 ha net. The available water resources for irrigation purposes are 36 MCM. The Project includes installation of about 24 boreholes in well fields along three rivers flowing through the Project area and the construction of a dam on one of these rivers with a gross storage capacity of 51 MCM. The irrigation network consists of a 12 km long concrete-lined canal, a 25 km long main pipeline, 14 pumping stations with a combined capacity of 7,370 horsepower and 17 separate distribution networks with installation of 539 km buried AC pipelines. The Project also includes construction of farm roads, the building for operation and maintenance, staff and vehicles and equipment for use during construction and after completion.

On-farm development is being carried out by the farmers with technical assistance from the Agriculture Department and medium and long-term credit are made available by the Cooperative Central Bank (CCB). The total cost of the Project will be of the order of US \$65.5 million.

The Project was substantially completed in seven years by the Water Development Department in cooperation with other Departments of the Ministry of Agriculture and Natural Resources.

The major economic benefits from the Project are:

- significant increase in the production of high value exportable crops due to the increase of the irrigable area from 1200 ha at present to 5000 ha which will result in:
- an annual foreign exchange earning and higher income for about 3500 farm families and employment opportunity for 1300 landless families in the Project area.
- additional production of vegetables and fruit for domestic consumption and their supply to hotels and restaurants as a contribution to tourist development.
- to contribute positively to the efforts for the improvement of the environment by increasing green area through the expansion of orchards and other plantations.
- lease of 319 plots of the Government owned land to landless farmers.

1.1 Cyprus Area, Population and Income

Cyprus, with an area of 9,251 km², has a population of about 650,000 (mid-1973 estimate) which is increasing at about 1% per annum. About 80% of the population is of Greek origin, while 17% is of Turkish descent and the remaining 3% of various origins. After the Turkish invasion in 1974 the Northern part of the island has been occupied by the Turkish army and Turkish-Cypriots have moved to the north, from where about 200,000 Greek Cypriots were forced to leave their homes and move to the south as refugees. Efforts through intercommunal talks are under-way to find a political solution to the problem. Agriculture is the third largest

sector in the economy. It accounts for 10.1% of the GDP and provides employment for about 45,000 (21.4%) of the total 210,000 economically active population. Agricultural exports make up about 33.4% of the annual exports, which average about C£64.5 million. In addition, agriculture supplies raw materials to local processing industries. The main export crops are citrus, vegetables (notably potatoes) and grapes. Agricultural commodity imports together with capital goods for agriculture, constitute less than 12.6% of the nearly C£490 million annual imports.

At present, the GDP per capita in the agricultural sector is about C£500 per year, which is less than one-third than in other sectors (C£1,700). The Government's present agricultural policy aims at increasing the earning capacity of farmers so that the income gap between agricultural and other sectors is narrowed. To realise this objective, two major constraints need to be removed: the first and most important is the water scarcity, and the second is the size and structure of the farms, which are generally small and fragmented.

1.2 Paphos Irrigation Project (PIP) General

The Paphos Irrigation Project is the largest and most important Project of its kind ever undertaken by the Government of Cyprus. Its aim is to irrigate about 5,000 ha of net irrigable area lying in the south-western coastal plain of Cyprus on both sides of the town of Paphos. The water requirements for the irrigation of this area are estimated to be 36 MCM/year, and will be provided by the Xeropotamos River flow (22 MCM), regulated at Asprokremmos where an earth dam has been constructed and the alluvial aquifers in the main river beds east of Paphos: Dhiarizos, Xeropotamos



PLATE 1



*Asprokremmos Dam.
Aerial view from left abutment.*

*Intake tower and foot-bridge of
Asprokremmos Dam*



(lower reaches only) and Ezousas (10 MCM) and the coastal calcarenite aquifer (4 MCM).

Construction of the civil works of the Project commenced in 1976 and the target date for its full completion was the year 1981 while irrigation supplies from the boreholes in the river aquifers were available to the adjacent areas of the Project by the year 1980. The total cost of the Project is presently estimated to reach up to US\$65.5 million.

The PIP will be fully completed in March 1983 but already for the last three years, farmers are irrigating their fields in the areas where the Project was completed.

2 THE ROLE OF THE UNITED NATIONS

The importance of water development in the national economy of the Republic of Cyprus was stressed out in the report of the first UN Economic Mission financed under the Expanded Technical Assistance Program in 1961 one year after the establishment of Independence. As a result of this report many UN experts have since visited Cyprus on consulting missions and several projects were established. Among these was the Cyprus Water Planning Project (CWPP) which identified Paphos area as one of outstanding potential. Detailed study of the Paphos water development schemes by a contracting consultant was agreed upon in 1967 and was carried out in two phases both of which were financed by UNDP and supervised by FAO as its Executing Agency. Phase A covered detailed assessment of hydrology, hydrogeology, agronomy, dam reconnaissance and overall planning and was carried out between October 1968 and April 1970. Phase B, comprising preparation of the Paphos Irrigation Project feasibility study, was carried out from March 1971 to February 1973. During this period two FAO/IBRD Missions visited Cyprus to carry out an interim project evaluation. Final appraisal of the Project was carried out by a third Bank Mission to Cyprus in May 1973. At that time the estimated cost of the Project was stated as US\$36.2 million of which the foreign exchange component was US\$18.2 million and 77%

of that, ie US\$14 million, was agreed to be financed by the Bank.

The Loan Agreement between the World Bank and the Government of Cyprus was signed in January 1974 but its application was delayed due to the invasion and occupation of the northern 40% of the island by the Turkish Army. Finally, the loan agreement became effective as from October 1975 and from there on the Paphos Irrigation Project entered officially into its implementation phase.

As a further contribution towards the Project implementation, FAO released one of its Senior Irrigation Engineers Mr Branko Milinusic in order to be employed by the Department of Water Development—the executive body of the Project works—as a Project Manager for the supervision of all the Project activities.

During the Project execution from 1976–1981, the FAO contributed 150 man/months of Project Manager, experts and associate experts.

2.1 Consultants

In order to comply with the requirements of the World Bank Loan Agreement the Water Development Department engaged the following two Engineering Consulting Firms for the preparation of the final working drawings and specifications for the various supply and construction contracts.

- (i) Sir M MacDonald and Partners of Cambridge, UK for the Asprokremmos Dam
- (ii) SOGREAH, of Grenoble, France for the whole Distribution System and all irrigation works

During the execution of works both firms appointed their Resident Engineers to supervise works. In this task they have been assisted by local technical staff of the Water Development Department. Sir M MacDonald and Partners had also two civil engineers on site from their main office.

Dr P Creighton, Resident Engineer for Asprokremmos Dam.

Mr. M. Bolze and Mr A Izykowski, Resident Engineers for Irrigation Sector.

3 THE PROJECT AREA

3.1 Location and Topography

The Project area lying in the southwest of Cyprus is a coastal strip some 38 km long by 3 to 4 km wide with the town of Paphos at its centre. The area to the east of Paphos is a regular coastal plain with uniform seaward slope of 2% and contains the largest area of good soils in the Project; they are made up of old fine deposits between more recent river alluvium. This plain is bounded inland by the Kouklia–Yeroskipos escarpment which at its eastern end reaches the coast at the mouth of the Khapotami River. It is dissected by three major rivers, the Ezousas, Xeropotamos and Dhiarizos, the resources of which will provide the major irrigation supply.

The topography to the west of Paphos is more irregular with undulating relief of varying slope and higher elevations. A mosaic of different formations is found, particularly spots of red Mediterranean soils overlying limestone crust scattered throughout the area down to the shore line. Two rivers dissect the western area, the Mavrokolymbos and Xeros, both of which have small catchments and incised valleys which merge into a flat coastal enclave.

3.2 Climate

A typical mediterranean climate prevails in the coastal region of Paphos with hot dry summers from June to September and cool winters from December to March during which much of the annual rainfall occurs with an average record of 425 mm. The uniform and moderate temperatures, attributed to the permanent sea breeze, and the relative humidity are conducive to the production of very early fruit and vegetables for which the reputation of Paphos is well known. Nevertheless, irrigation is indispensable for any appreciable agricultural development in this region.

3.3 The Water Resources

The irrigation supply of the PIP will be provided from:

- Asprokremmos Dam reservoir of 51 MCM gross storage capacity situated on the Xeropotamos river, which is

designed for carry-over storage. The reservoir will supply 22 MCM for the Project each year.

- 24 boreholes drilled in the gravel aquifers of the major river beds Dhiarizos, Xeropotamos (lower reach only) and Ezousas which have a potential extraction of about 10 MCM of water.
- The coastal calcarenite aquifer with a total supply of 4.5 MCM of water.

The calculated reliability factor of water supply is above 92% which is considered as agronomically acceptable. In other words we can expect once every 12 years some deficiency of the water for irrigation.

3.4 Population

The last census, in 1960, showed the population of the Project area to be 18,000. In 1973, the Project area population was estimated at 21,500, with half living in Paphos town and the remainder in about ten villages. The average family size is about 4.5 persons of whom 2.5 are of working age. Of the total of about 4,800 families, 3,500 (73%) own land in holdings of varying sizes. Not all of them are farmers; some 20% (small owners) lease their land to others and work as agricultural labourers. Most non-owners are agricultural workers and a substantial number work either full or part-time in the industrial and services sectors. Local agricultural labour, which is adequate at present, would be in short supply after Project completion, particularly during peak periods. The short distances involved and availability of an effective transport system, which encourages migration of labour, would offset the possibility of a labour shortage.

The Project beneficiaries include 3,500 farm families most of which with small ownerships, 981 landless families in the Project area who will be working as seasonal labour in the Project, and about 319 landless farm families who have received on lease, from the Government, economically viable farm units in the Project area.

4 AGRICULTURAL ASPECTS

4.1 Soils

The major soil types are alluvial

in origin, having been deposited by the five rivers that flow through the area. Due to the calcareous nature of the sediment emanating from the river catchments, a soft calcareous layer called "Havara" is found at varying depths below the surface of these soils. These alluvial soils are fertile, generally medium to heavy texture and relatively low in permeability especially in the eastern coastal plain. River terrace soils are found bordering the rivers Dhiarizos and Xeropotamos and in the areas west of the river Ezousas.

Colluvial soils are found at the foot of steeply sloping areas. They are deep brown soils of clay-loam texture with coarse material and are high in calcium. In the western area most soils are alluvial-colluvial, which are also fertile, as well as red soils overlying a hard limestone crust.

All soils included in the irrigated Project area are suitable for sprinkler irrigation.

4.2 Land Tenure—Land Consolidation

There are four types of ownership in the total Project area, with the following distribution:

Ownership	% of area
Private, individually owned	45%
Private, community owned	34%
Government owned	15%
Owned by religious institutions	5%

As it generally occurs in most privately owned areas all over the island the plots within the Project area have irregular shape and their size has been reduced considerably over the years due to the continuous fragmentation of the private holdings under the laws of dividing the land into several shares if it is requested so. Statistics indicate that the average number of plots per holding, for the whole Project area is 3.2, each of 0.57 ha. Under these conditions it was decided that land consolidation was absolutely essential in order to achieve:

- (a) aggregation of scattered plots
- (b) elimination of ownerships of below 0.27 ha in undivided shares and
- (c) provision of farm access roads the layout of which are compatible with the layout of a modern economical irrigation network and which also form regular blocks of land within which

it is possible to obtain consolidated plots of optimum shape for on-farm water management.

Depending on the quality of the land the economically viable plot sizes have been decided to be 1.2, 1.6 and 2.4 ha with widths always kept as near as possible to 100 metres.

Design of the road network which constitutes the framework of land consolidation has been prepared by the WDD in close cooperation with the Land Consolidation Authority (LCA). In the predominantly Turkish owned areas of Mandria and Timi the Government due to the prevailing political situation has not enforced land consolidation but the layout of the irrigation network was designed to fit in with the requirements of possible future land consolidation.

The land development works such as road construction and drainage which are an essential part of land consolidation were carried out concurrently with the installation of the irrigation pipes. During the construction period the Land Consolidation Authority carried out land consolidation for an area of 2350 ha and up to mid 1982 constructed 98 km of farm roads. The work of the LCA was extremely valuable for the agricultural development in general and particularly for farmers who got proper access to all plots, while in the past only 30% of the plots had some access.

The total cost of farm road construction until mid 1982 was £279,800 of which 50% is paid by the farmers.

4.3 Agricultural Research

The Agricultural Research Institute, which was established in 1961 with UNDP assistance is the centre of research activities in Cyprus. Through its sub-station at Akhelia, the Agricultural Research Institute is responsible for carrying out all necessary research work for providing services to the farmers in the Project area. This sub-station has been in operation since 1966 covering 7 ha and its major activities were concerned with vegetable and fruit culture as well as water use. Its facilities and staff have been strengthened under the Project. A soils and water testing laboratory was added to enable determination of exact

PLATE 2



Canaletti conveyance system from river boreholes to main canal.

Main canal 12 km long.



suitability of various soils to the proposed crops, and an area of 22 ha within the Project area was allocated to the sub-station for the purpose of carrying out experimental field work.

Experiments on various crops of irrigated agriculture concerning the Project area are carried out and the results are continuously fed to the farmers through the agricultural extension services.

At the same time two overseas specialists were recruited on 6 months assignment each and worked with extension and Research Institute staff on matters concerning virus diseases and horticulture.

4.4 Agricultural Development— Extension Work

In order to achieve the best results a strategy of Development was drawn in the early stages of the Project and is since closely followed.

The main points of this strategy are:

4.4.1 From the early stages of the Project implementation the Department of Agriculture expanded its extension services so that the development program for the Project area run parallel with the Project construction work.

In order to achieve this, the District Agricultural Officer of Paphos, was appointed also Deputy Project Manager for agricultural development aspects.

4.4.2 Based on soil classification,

water availability and marketing prospects, a modified cropping pattern was established and is now closely pursued.

This cropping pattern reads as follows:

Citrus—mainly lemons	47%
Avocado	7%
Table grapes—mainly cardinal, perlet and gold	8%
Bananas	5%
Vegetables—early, late and seasonal	21%
Deciduous fruit trees—early apricot varieties, figs etc	5%
Summer crops—mainly ground nuts and beans	7%
Total	100%

4.4.3 A detail soil survey was carried out in order to determine soil suitability and recommend to individual farmers suitable crops within the frame of the above mentioned cropping pattern.

4.4.4 Land reform measures: This aspect included consolidation in 10 villages (see para 4.2 above) and the lease of government owned land (660 ha) to 319 tenants. This was divided into viable units, of average size 1.8 ha and rented to selected tenants for 30 years renewable for further 10–20 years.

4.4.5 In early 1977 an Agricultural Training Centre for farmers was established in Paphos, near the Project main office at Yeroskipos village. The aim of this training centre is to facilitate and expand training of farmers of the Project area in irrigated agriculture.

During the five years period of its operation (1977–1981) some 247 courses were organised with total attendance of 4461 participants or 18 farmers per course. The main subjects of these courses included citrus and avocado cultivation, table grapes, early and seasonal vegetables, water and land use, farm management, animal husbandry, bee keeping, vocational courses for young farmers etc.

4.4.6 The supply of seedlings to farmers from the two government nursery gardens established in the Project area. During the period 1980–1982 farmers were supplied with 24,550 seedlings of citrus, avocado and deciduous fruit trees and with some 10,000 cypress seedlings to be used as wind breaks.

4.4.7 Credit facilities: In order to boost development in the Project area credit facilities were offered to interested farmers for the establishment of on farm irrigation systems such as mini sprinklers, drip irrigation, sprinklers etc.

During the period 1978–1981 some 684 applications covering an area of 1000 ha were approved. It was also decided that the “fruit and vegetable production and marketing” project will be also applied in the Paphos Irrigation Project from January 1982. This project provides credit facilities for:

- erection of green houses for early vegetables
- erection of green houses for early table grapes

CROPS AND YEARLY GROSS VALUES

Crop	Area in ha		production tons/ha		Gross value in 1000 C£/ha		Total gross values in 1000 C£	
	present	future	present	future	present	future	present	future
Cereals*	5 220	—	1.5	—	0.06	—	313	—
Citrus fruit	80	2331	30.0	35.0	2.00	2.9	160	6 760
Table grapes	320	397	12.0	15.0	0.82	2.4	262	952
Seasonal vegetables	340	891	20.0	35.0	1.20	4.2	408	3 742
Early vegetables	—	150	—	80.0	—	20.0	—	3 000
Bananas	40	248	15.0	25.0	1.60	4.0	64	992
Deciduous fruit	—	248	—	15.0	—	3.6	—	892
Avocado	—	347	—	10.5	—	3.6	—	1 249
Summer crops	430	348	1.0	2.5	0.04	1.0	17	348
Total	6 430	4960					1224	17 935

* Rainfed while other crops are irrigated

“Present” means values at the beginning of the project in 1976
“Future” means values of production at full development in 1987

- establishment of orchards
- on farm irrigation systems

At the same time the Council of Ministers, in order to facilitate credit needs of landless farmers or small holders who cannot provide loan security, decided that such loans will be given to them under government guarantee.

4.5 Yield and Benefits

The levels of crop yields in the Project area before construction of the Project were as high as can be achieved under the scanty and seasonally concentrated rainfall and inadequate irrigation. Without the Project, therefore, any further increase in production would be unlikely. With commencement of irrigation under the Project in 1979 a rapid shift from low-value cereal crops, originally covering about 70% of the Project area, to high-value fruit crops and vegetables and summer crops has started.

At full development of the Project the annual crop production in comparison with the "Present" one would be as shown on table p. 6.

The economic benefits from the Project will be the significant increase of gross value of yearly

production from the present C£1.2 million to C£17.9 million in future. The foreign exchange earnings from the exportable crops would be about C£6.8 million. The Project economic rate of return was estimated at 17.3%.

5 ENGINEERING ASPECTS

5.1 The Overall Engineering Scheme

The water resources mobilisation is achieved by the erection of the Aspikremmos dam and the drilling of boreholes in the river gravel aquifers.

The conveyance of the water to the irrigation sectors is done through the following routes:

- The wellfield conveyance system collecting the water extracted from the river wells and supplying the main canal.
- The main canal extending from Aspikremmos Dam to Yeroskipos, fed by the dam reservoir and the river aquifers and commanding the major portion of the eastern plain.
- The western main pipe conveyor originating from the main pumping station at the end of the main canal; the water is raised by 100 m, then

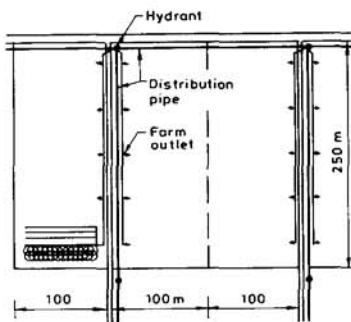
conveyed by a gravity pipeline over some 21.5 km to Ayios Yeoryios.

The Distribution networks covering all the Project area consist of 539 km of buried asbestos-cement pipes which are under pressure.

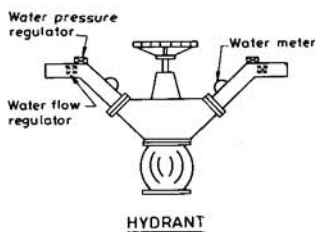
Pressurisation of the water supplied by the main canal and the pipe conveyors is achieved by 14 automatic pumping stations having a mere pump regulation function (eastern area) or a regulation plus storage function (western area). (See the attached map of the Project area.)

Distribution of pressurised water from the pumping stations is ensured by branched pipeline systems.

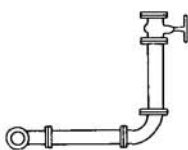
Each pumping station provides pressurised supply to an independent irrigation network. Over the whole Project area there are altogether 17 such irrigation networks. The pipe alignments conform to the road layout, including farm roads, which has been designed in close cooperation with the Land Consolidation Authority. Design of the irrigation networks was prepared with the help of a computer program to minimise the total investment and



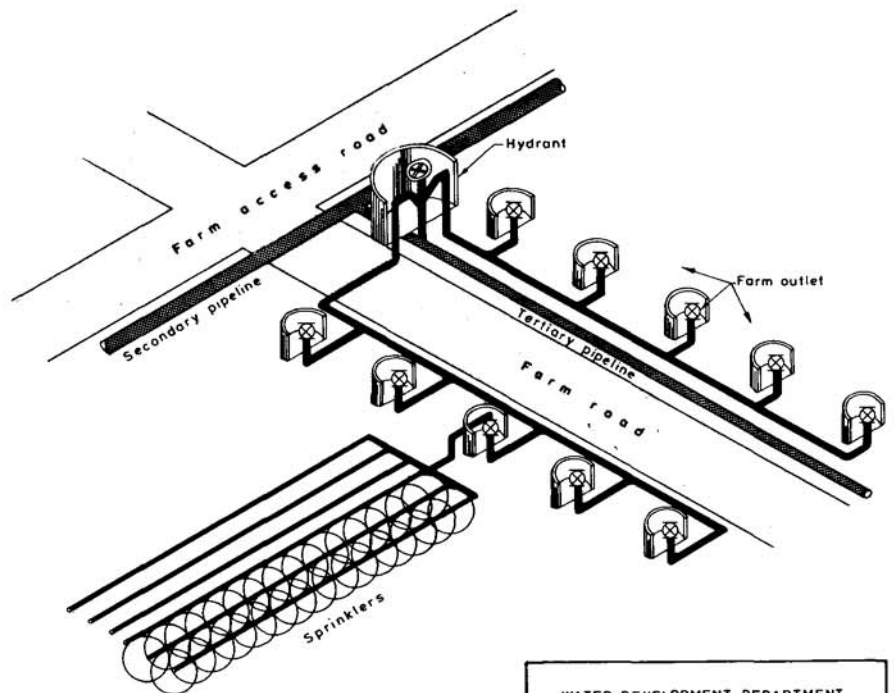
FARM IRRIGATION STANDARD LAYOUT



HYDRANT



FARM OUTLET



WATER DEVELOPMENT DEPARTMENT
 PAPHOS IRRIGATION PROJECT
 TYPICAL IRRIGATION NETWORK
 SCHEMATIC PRESENTATION
 Date: OCTOBER 1982 DRG. No.: UF/IR/348

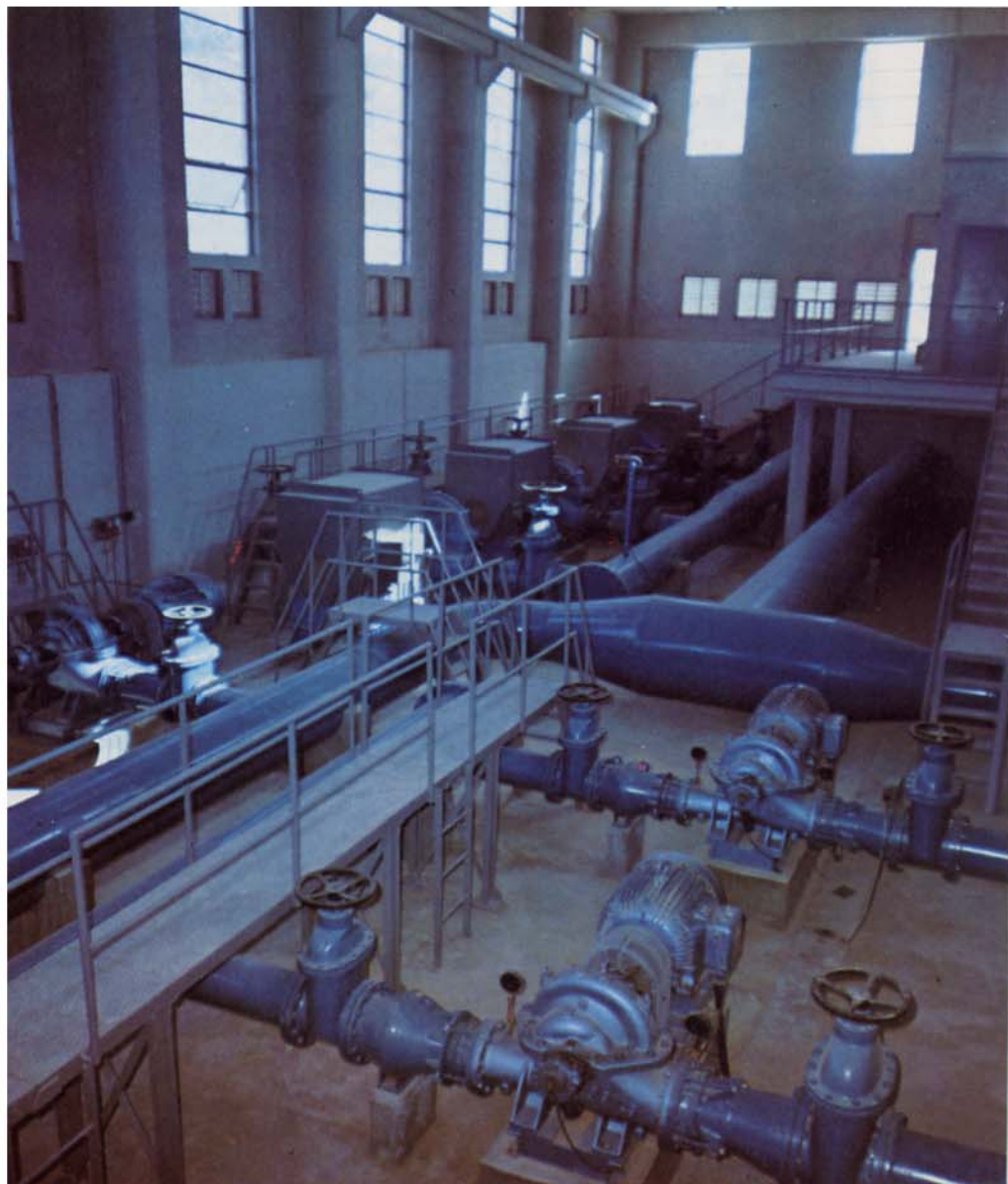


PLATE 3



View of main pumping station at Yeroskipos.

Inside view of main pumping station.



operational costs of pumping and distribution system. Water supplies to the farmers is done through hydrants which ensure constant discharges and pressures not lower than 3.5 atmospheres in order to enable farmers to apply sprinkler or drip irrigation methods. Each hydrant serves an irrigation farm unit of about 2.5 ha.

The farmers are receiving water "on request" and not "on rotation" as it was normally practised in the past in other irrigation projects over Cyprus.

See schematic presentation of the typical irrigation network p. 7.

Projects having distribution systems "on request" are very advanced but more costly. This allows small farm holders to have other occupations and irrigate their field when they are free. On the other hand by using water "on request" a higher yield is obtained over lands having semi-permeable soils, due to the possibility of more frequent irrigation intervals. In this way the losses of water are smaller than in distribution of water by rotation.

5.2 Main Items of Project and Contractors

The construction of the Project was planned to be in 6 years but it took 7 years from 1976-1983 due to unforeseen difficulties in connection with the foundations of the embankment of Asprokremmos Dam.

The Paphos Irrigation Project was constructed by several local and foreign Contractors who have been selected by the Tender Board through international bidding. The same procedure was applied for the selection of the suppliers of various materials. A short description of the structures with other relevant data is given below:

Contract No 1. Main Canal

Contractor: General Construction Co Ltd, Nicosia

The main conveyor of the water through the eastern area is an open canal which has a length of 12 km. It has a trapezoidal section lined with concrete of 10cm thickness. The max. discharge capacity of the canal is 4.2m³/sec at its head and 1.6m³/sec at its end at Yeroskipos. The main canal

is controlled by two Avio hydraulic gates with downstream constant level. Along the main canal 52 structures such as culverts, bridges, watering places, aqueducts and syphons, have been constructed.

Contract No 2. Wellfields

Geological Survey Department for drilling of boreholes and Caramondani Bros Ltd of Nicosia for the supply and installation of submersible pumps

24 boreholes have been drilled in the river gravel aquifers of Dhiarizos, Xeropotamos and Ezousas rivers and they have been equipped with submersible pumps. They can yield a total of 4,750m³/hour.

Contract Nos 3 and 4. Eastern Pipeline and Wellfield Conveyor System

Suppliers: Isasbest Ltd of Israel for supply of AC pipes with fittings and valves and J&P for supply of canaletti. Water Development Department, Construction Division for the installation of pipes and canaletti

Along boreholes of Dhiarizos and Ezousas rivers two conveyors are constructed by canaletti and pipes of 15.0 km and 8.0 km in length respectively. Both conveyors discharge into the main canal. The Dhiarizos conveyor (called the Eastern pipeline) at its last portion of 1.2 km is a pipeline of AC 800 mm diameter.

Contract No. 6. Western Conveyor and Pumping Stations

Contractor: Costain Civil Engineering Ltd of UK as the Main Contractor with Worthington-Simpson Ltd of UK for supply and installation of hydromechanical and electrical equipment and - Pont a Mousson of France as supplier of ductile iron pipes and fittings - Fysko Ltd of Nicosia for civil engineering works. - Karakannas Engineering Ltd for installation of motorpumps. - "A&B" Electrical Engineers for electrical installation

From the main pumping station at Yeroskipos, water is pumped to the western area through the western conveyor constructed of ductile iron pipes 900 to 500 mm,

21.5 km in length ending at Ayios Yeoryios village. The max capacity is 875 l/s. Along the main canal and the western conveyor, 14 pumping stations are constructed and each of them connected with ground or elevated regulating reservoirs. Each pumping station is connected to an irrigation network covering the area of a sub-division. The pumping stations pressurise water in the irrigation networks ensuring such pressure that sprinkler and drip irrigation could be used on any farm. The operation of pumping stations is fully automatic and it is monitored through the remote monitoring system at the central offices of the Project at Yeroskipos.

Contract Nos 5-7. Distribution Networks and Construction of Regulating Reservoirs over Eastern Area

Contractor: Cyprus Pipes Industries Ltd, Limassol as the supplier of AC pipes and fittings. The Main Contractor for installation is SOCEA of France. Mr N Demetriou of Nicosia for the supply of hydrants and Caramondani Bros Ltd of Nicosia for the supply of valves.

These are already in operation. Total length of AC buried pipelines is 389 km having 40,000 fittings, plus hydrants, sluice valves, air valves, water hammer protection etc.

Contract Nos 8-9. Distribution Network and Construction of Regulating Reservoirs over Western Area

Contractor: Cyprus Pipes Industries Ltd Limassol as the Supplier for AC pipes and fittings. The main Contractor G P Zachariades Ltd, Limassol for installation, Mr N Demetriou of Nicosia for the supply of hydrants and Caramondani Bros Ltd of Nicosia for the supply of valves.

The length of AC buried pipelines over this area is approximately 150 km.

Contract No 10. Access Farm Roads in Eastern area

Contractor: A Papaetis of Paphos
The total length of roads is 26 km.

Contract No 11. Main Office Construction and Various Auxiliary Buildings (needed for the con-

struction of the Project such as stores, laboratories etc).

Contractor: Mr Hjidemosthenous Paphos for main office and Construction Division of Water Development Department for auxiliary buildings

Contract No 12. Asprokremmos Dam

Main contractors: Joint Venture-J&P and MEDCON of Nicosia.

- *Colcrete Ltd Strood, England for geotechnical works in association with ICOS G B LTD, London.*
- *Elin-Union, Vienna, Austria for turbine, generator and valves*
- *Newton Chambers Engineering Ltd, Sheffield, England for water control gate*
- *Stanton & Staveley, Nottingham, England for supply of pipework*
- *Soil Instruments Ltd, London for instrumentation equipment*

The Asprokremmos Dam is constructed on the Xeropotamos river, 3.5 km upstream from the coast. It is a zoned earthfill dam with central clay core, having a 52 m high embankment with a crest length of 600 m.

The gross storage capacity of the reservoir is 51 MCM at the maximum retention level. During construction the river was diverted through a concrete lined tunnel, 4.0 m in diameter, in the right abutment. In order to stop seepage of the water through the alluvium strata of the river bed, a diaphragm wall of reinforced concrete has been constructed with max. depth about 30 m having a length of 200 m and thickness of 80 cm.

Two 800 mm diameter steel pipelines, laid at the tunnel invert and concreted in place, with a capacity, of 0.6-4.3m³/s are serving as irrigation outlets. At their downstream end a small power station is being constructed for generating electricity through a 650 kw turbine producing 2,000,000 KWH/year.

The spillway, located on the right bank, consists of an ungated crest with a chute and a flip bucket and would pass a maximum discharge of 1200 m³/sec while routing a maximum probable flood of 2400 m³/sec.

Contract No 13. Electricity Supply for 14 pumping stations and 24 well pumps

Contractor: Electricity Authority of Cyprus

5.3 Cost of the Project

As issue of this publication will be done before the completion of the Project we are giving below the most probable cost of the Project, in C£ and US\$ considering the weighted average rate of exchange for 1 C£=2.61 US\$.

The total cost of the Project to the Government will be of the order of C£25 million (US \$ 64 million)

6 ORGANISATION AND MANAGEMENT FOR PROJECT IMPLEMENTATION

The following committees were established for the implementation of the Project.

6.1 Policy Level

Project policy and coordination of the activities of all Government

Departments concerned is achieved by a high level body called the Project Policy' and Coordination Committee (PPCC) with the Minister of Agriculture and Natural Resources as chairman, the Director of Water Development Department as secretary and members from other contributing Departments.

6.2 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 Paphos District Officer. This body is called the Project Advisory Committee and advises directly the Project Manager on local development affecting the Project and problems faced by the farmers and also explains to the farmers the Project objectives and advises them about the efficient use of the water resources.

6.3 Executive Level

The main executive body of the Project during its implementation,

COST OF THE PROJECT

Item	Description of works	Cost in 1000 C£ (Estimated)	Cost in 1000 US\$ (Estimated)
1	Asprokremmos Dam	11 000	28 754
2	Wellfields	82	214
3	Main Canal	937	2 449
4	Eastern Pipeline and Wellfield conveyors	688	1 798
5	Western pipeline, pumping stations and reservoirs	3 612	9 442
6	Electricity supply	252	659
7	Distribution Networks:		
	- installation	3 188	8 333
	- supply of equipment	2 114	5 526
	- construction of the access roads.....	167	437
	Sub-total Civil Works	22 040	57 612
8	Land acquisition	492	1 287
9	Equipment	147	384
10	Buildings	72	188
11	Engineering and Administrative costs	2 338	6 112
	sub-total	3 048	7 971
12	On-farm development*	2 590	6 770
	Grand total	C£ 27 679	\$ 72 353

* This item represents the loan to the farmers for the purchase of irrigation equipment.

PLATE 4



Farm hydrant.

Sprinkler irrigation.



operation and maintenance is the Water Development Department. The services of some other Departments are also utilized. The Agricultural Department is responsible for the on-farm development works and together with the Agricultural Research Institute is providing agricultural extensions and research services. Other Departments involved are the Geological Survey Department for drilling works, Lands and Surveys Department for land acquisition, the Land Consolidation Authority, the Planning Bureau, the Tender Board and the Ministry of Finance.

During the implementation of the Project the total number of staff was: 150 man/months of FAO experts and associate experts, 357 man/months of Consulting Engineers, 422 man/months of local Civil Engineers, 36 man/months of Mechanical Engineer, 2000 man/months of Technical Assistants, 180 man/months of Foremen, 880 man/months of Drivers and 574 man/months of Accounting and Clerical Staff.

6.4 Project Management

Implementation of the Project was carried out by the Project Management composed of:

Mr C Lytras, Director of Water Development Department

Mr B Milinusic, Project Manager

Mr K Spanos, Deputy Project Manager for engineering

Mr P Michaelides, Deputy Project Manager for agriculture.

7 Operation and Maintenance

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

The Department of Water Development through its Paphos Regional Office will be responsible also for selling the water to private consumers. The charges per cubic meter of water used will be sufficient to pay for all operation and maintenance costs as well as to recover the investment costs over

the Project life of 50 years at 4% annual interest.

The operation and maintenance of the completed works has been going on for the last three years. In 1980 and 1981 6.5 MCM of water was supplied to the farmers and 10.0 MCM in 1982.

After full completion of the works in March 1983 the management staff of the Project for the operation and maintenance of all the works will be a Project Manager, one Executive Engineer and one Mechanical Engineer. 8 Technicians, 12 Water Guards, 1 Chief Foreman, 3 Electricians, 2 Mechanical Technicians, 2 Plant Operators, 8 Drivers, 26 skilled and unskilled workmen, 11 Accounting and Clerical Staff. The estimated cost of the operation and maintenance per year at full development will be: for salaries C£245,000, for electricity cost C£403,000 and for operating cost of the machinery C£53,000. The total estimated yearly cost for the operation and maintenance of the Project will be about 2.2% of the Project cost.

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)	} 36 MCM
- Ground water 24 boreholes along river aquifers ...10 MCM) ...	
- Coastal calcarenite aquifer	
- boreholes ... 4 MCM)	

Conveyance

- Concrete lined main canal	12 Km
Max. flow capacity	4.2 m ³ /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
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Reservoirs

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

Distribution networks

	17 No
<i>Distribution network pipelines</i>	
- 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, Maidenhead, 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 Asprokremmos 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
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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	0.60-4.30m ³ /s

Hydroelectric power

generator (one set)	650 KW
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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

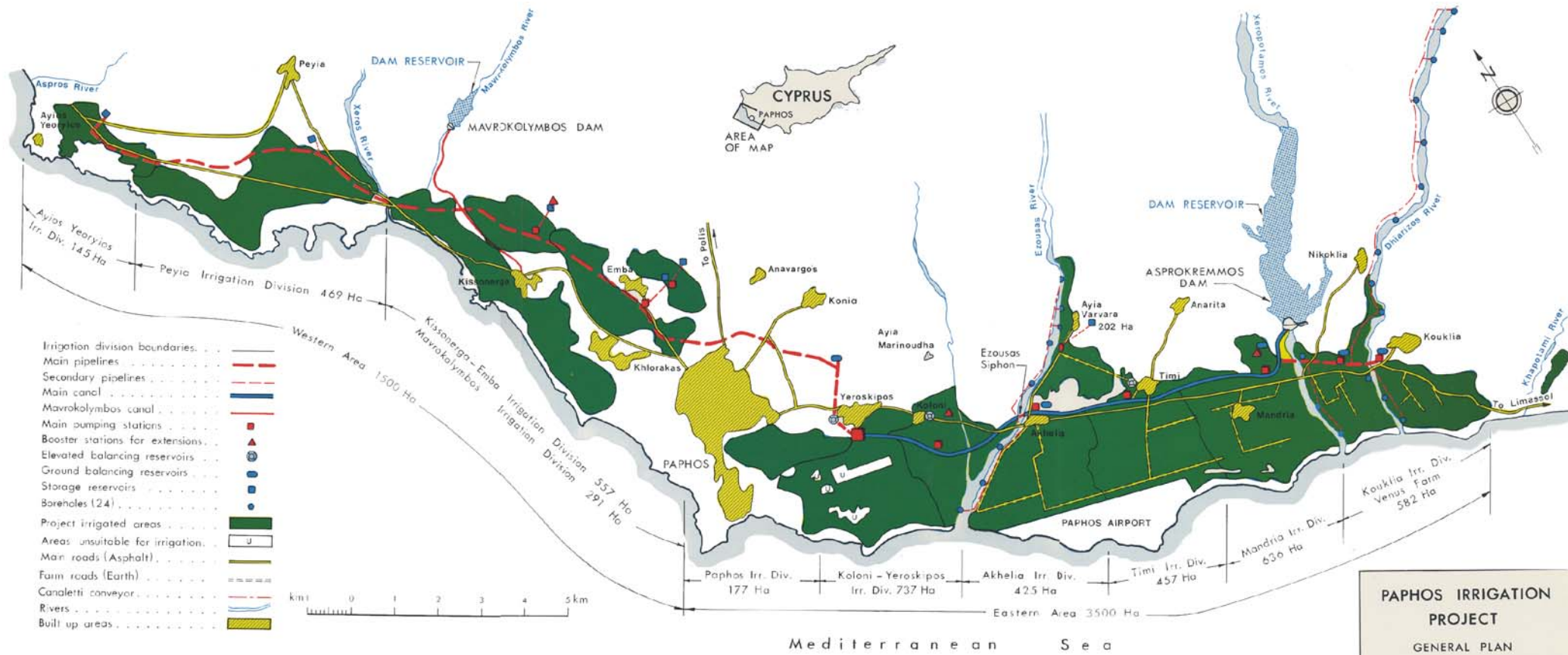
Commencement May 1978
Completion Dec 1982

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

References: Appraisal Report of the World Bank.

Design Report of Asprokremmos Dam by Sir M. MacDonald and Partners, U.K.

Review and Comment on the Feasibility Study of P.I.P. by SOGREAH, France.



PAPHOS IRRIGATION PROJECT
GENERAL PLAN

