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Ministry of Agriculture and Natural Resources

ΤΜΗΜΑ ΑΝΑΠΤΥΞΕΩΣ ΥΔΑΤΩΝ  
WATER DEVELOPMENT DEPARTMENT



## ΑΡΔΕΥΤΙΚΟ ΕΡΓΟ ΧΡΥΣΟΧΟΥΣ

Khrysokhou Irrigation Project

**ΑΡΔΕΥΤΙΚΟ ΕΡΓΟ ΧΡΥΣΟΧΟΥΣ**

**KHRYSOKHOU IRRIGATION PROJECT**

Prepared by the Project Management of  
Khrysokhou Irrigation Project

Water Development Department  
Nicosia — September 1987

Τμήμα Αναπτύξεως Υδάτων  
Λευκωσία — Σεπτέμβρης 1987

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#### Front cover photos

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3. Irrigation network pipes
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General D/S view

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Khrysokhou Irrigation Project  
General layout plan

Εκδόθηκε από το Τμήμα Αναπτυξεως Υδάτων - Υπουργείο Γεωργίας και Φυσικών Πόρων με την ευκαιρία των εγκαινίων του Έργου από την ΑΕ τον Πρόεδρο της Κυπριακής Δημοκρατίας κ. Σπύρο Κυπριανού στις 19.9.1987.

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## I. INTRODUCTION

### I.1 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 ha net presently under implementation and the uplands of the Yioulou - 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 scheduled to be 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<sup>2</sup> 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. The total cost of the dam is estimated at £9.2 million.

#### 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 will be 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<sup>3</sup>/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 is expected in January 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  
 Instrumentation ..... 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
	<hr/>
	£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.

<b>Construction period</b>	Phase I .....	Jan. 1984-Jan. 1988
	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

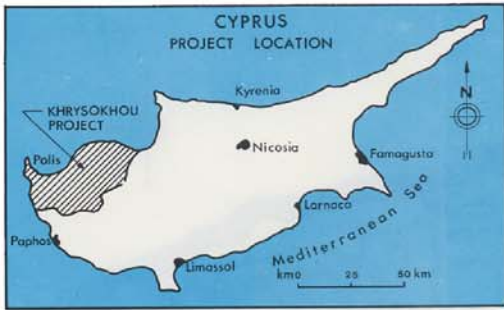
Land consolidation .....	400 ha
Farm road construction .....	90 km
Country families benefited .....	1500

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

## EVRETOU DAM DATA

<b>Type</b> .....	Rockfill
<b>Constructed</b> .....	1984—1986
<b>Catchment area</b> .....	91 km <sup>2</sup>
<b>Reservoir</b>	
Area .....	1.2 km <sup>2</sup>
Capacity .....	25 MCM
<b>Embankment</b>	
Height .....	71 m
Length .....	255 m
Volume .....	1.91 MCM
<b>Spillway discharge</b> .....	360 m <sup>3</sup> /s
<b>Outlet tunnel (3.6 m dia)</b> .....	227 m long
<b>Bottom outlet (1.2 m dia) discharge</b> .....	15 m <sup>3</sup> /s
<b>Irrigation outlet (0.9 m dia) discharge</b> .....	1.6—9 m <sup>3</sup> /s
<b>Diaphragm wall foundation</b>	
Length .....	97 m
Maximum depth .....	37 m
Thickness .....	0.80 m
Volume of concrete .....	1680 m <sup>3</sup>
<b>Alluvial grouting</b>	
Total drilling .....	14 220 m
Cement, bentonite grout .....	940 tons
Chemical grout .....	625 tons
<b>Rock grouting</b>	
Total drilling .....	64 150 m
Cement and bentonite grout .....	7 820 tons

<b>PLANNING</b> .....	Water Development Department
<b>DESIGN</b> .....	Sir William Halcrow and Partners
<b>CONSTRUCTION</b> .....	Shephard Hill-Zachariades, (J.V.)
<b>OPERATION AND MAINTENANCE</b> .....	Water Development Department



- Dam reservoir
- Intake
- Main conveyer
- Irrigation area