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KINGDOM OF GREECE

MINISTRY OF PUBLIC WORKS

SERVICE OF HYDRAULIC WORKS

REPORT

on the

MEGDOVA RIVER PROJECT

October 1952

Knappen Tippetts Abbett Engineering Company

New York Athens

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REPORT ON THE MEGDOVA RIVER PROJECT

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ABBREVIATIONS

The following abbreviations have been used in this report:

°C	degrees Centigrade
cc	cubic centimeters
cm	centimeters
cm^2	square centimeters
Dr	drachmae
EC	electric conductivity
El	Elevation
gm	grams
gr	grain
ha	hectares (1 ha = 10 str = 2.47 acres)
hr	hours
kg	kilograms
km	kilometers
km^2	square kilometers
kva	kilovolt amperes
kw	kilowatts
kwh	kilowatt hours
l/sec	liters per second
m	meters
m^2	square meters
m^3	cubic meters
$10^6 m^3$	millions of cubic meters
mm	millimeters
m.e.	milliequivalents
m^3/sec	cubic meters per second
str	stremmas (1 str = 0.1 = 0.25 acres)
T	tons (metric)

CHAPTER I

INTRODUCTION

1. Foreword

Since the end of World War II and despite the civil disturbances of the years 1944-1949, the people of Greece have made remarkable progress in reconstruction of their destroyed facilities. First emphasis was placed on the restoration of vital transportation, that is, railroads, highways, and ports. Second priority was given to the development of land and water resources in continuation of a reclamation program on which an impressive start had already been made prior to the war.

Greece is located in one of the most strategic areas of the world so that a desproportionate part of the national income has had to be spent on defense. In spite of the great sacrifices which this continual vigilance has entailed, many measures have been undertaken by the authorities to advance the welfare and culture of the people and they are persevering in their work of rehabilitation, reconstruction and development in the numerous fields which were neglected owing to war conditions.

The almost continuous state of war between the years 1939 and 1949 caused severe food shortages and losses of well-established markets for agricultural products such as tobacco, raisins and citrus, the export of which was formerly one of the main-stays of the economy of Greece. The severe dislocations caused by these conditions have required extensive economic assistance in the form of food imports mostly from the United States.

The imports during the past two years are an indication of the magnitude of this assistance. During the fiscal year ending June 1951, the aid extended to Greece by the United States for imports of food amounted to $89,000,000, while for fiscal year 1952, it amounted to $69,000,000. Imports of food on approximately the same scale will have to continue as long as agricultural production in the country is insufficient to meet the needs for a modest diet. As the only method by which these imports can be reduced is through an increase in agricultural production, land reclamation has been one of the primary features of the reconstruction program of the Kingdom of Greece.

A second primary need of the nation is electric power for domestic, municipal and industrial purposes. The present per capita consumption of electricity in Greece is far below that used in most other small countries. Construction of a series of hydro-electric and thermal-electric power plants as proposed by the Public Power Corporation will help offset the present acute power shortage; however, it is expected that within a few years the growth of demand for electric energy will far exceed the capacity of the plants now being constructed, and additional generating facilities will be urgently needed. The Megdova project is a miltipurpose development which could help satisfy the over-growing need for both electric power and irrigated land.

The Megdova River basin and the Karditsa plain are located in Central Greece about 110 km west of the port town of Volos. The recommended plan contained in this Preliminary Report contemplates the transbasin diversion of water from the Megdova River to the Karditsa plain for irrigation and for the development of hydro-electric power. The average annual value of agricultural production in the selected irrigation area can be increased immediately from a present value of 31.4 billion Dr to 71 billion Dr through increased yields resulting from irrigation. The value of farm products can be further increased over a period of years through improved farming practices and better cropping patterns to 114 billion Dr. In addition, an estimated 203,000,000 kwh of primary electric power and 26,000,000 kwh of secondary power having a combined value of 64,000 billion Dr could be produced annually. The estimated project investment cost allocated to irrigation is 70,300 million Dr, and the project investment cost allocated to power is 196,800 million Dr, making a total project investment cost of 267,100 million Dr including interest during construction.

2. Authority, Scope and Purpose

In May 1952 the Greek Government, represented by the Ministers of Coordination, Finance and Public Works, retained the Knappen Tippetts Abbett Engineering Company of New York to prepare a preliminary report on the development of the Megdova River for irrigation of the Karditsa plain, and for the generation of hydro-electric energy. The proposal of the company for preparation of the report was considered satisfactory by the Council of Public Works by virtue of order No. 427 dated March 8, 1952, following which the present agreement was entered into.

From April 1952 to September 1952 basic data needed to supplement the information furnished by the Service of Hydraulic Works of the Ministry of Public Works were collected in the field by a group composed of an agronomist, an irrigation engineer, a geologist, a soils engineer, a hydrologist, an agricultural economist and assistants. Surveys and subsurface investigations were made where needed to supplement existing maps and to obtain information on the foundations for structures.

In the office the field data collected were analyzed and formed the basis for comparative studies of various plans for the utilization of the agricultural and hydroelectric power resources of the Megdova River basin and the Karditsa plain. These studies led to the selection of a practicable and economical plan of development to meet the needs of the region and of the country.

The recommended plan for development of the Megdova River presented in this preliminary report, includes estimates of project costs and earnings, a construction program, an administrative and financial program, and an analysis of the effect of the development on the local, regional and national economies.

3. Previous Reports

Two reports on the development of the Megdova River are available; the first report was written in 1929 by Louis Senn; in 1932 another report was prepared by M. Syrakos, Ministry of Agriculture.

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The Senn paper is titled "Rapport Concernant l'Utilisation des Eaux de la Riviere Megdova en Vue de l'Arrosage de la Plaine de Karditsa et de Creation de Forces Motrices Hydrauliques". This short report is of a reconnaissance nature. On the basis of average annual precipitation it was estimated that a continuous discharge of $3\frac{1}{2}$ m^3/sec could be developed by a reservoir of 110,000,000 m^3 capacity. The water would be diverted to the Karditsa plain by means of a 6.4-km tunnel which would terminate in penstocks having a gross head of about 610 meters. About 100,000 str of land in the Karditsa plain would be irrigated.

The Syrakos (Ministry) report is titled "Irrigation of the Karditsa Area from a Storage Reservoir on Megdova River". This paper enlarges on the Senn Report and proposes a shorter diversion tunnel route. It is estimated that the average annual yield of the Megdova and Karitsiotis Rivers is about 140 million m^3, of which 100 million m^3, or an average of 3.2 m^3/sec, would be available for irrigation and power each year. The irrigation of about 100,000 str annually is contemplated. The Ministry report proposes the construction of a concrete gravity dam at the Kakavakia dam site (Plate II-1). The dam, 70 meters high, would back up water so that it could be diverted through a tunnel about 2 km long with a maximum discharge capacity of 7 m^3/sec. The inlet portal would be located in a tributary arm of the eastern Megdova gorge, and the tunnel would extend to an outlet portal situated in the Karabalis gorge below Kastania whence water would flow down the Karabalis torrent to the Karditsa plain. It was suggested that the water could be used for generation of hydroelectric power if 3 or 4 km of canal were constructed from the tunnel outlet to a mountain saddle near Kastania where, utilizing a power drop of 350 m, 24,000 HP plant could be installed to generate electricity during the six summer months. Other power drops could be obtained further donwstream by rediverting the water at strategic places to gain the necessary fall.

In addition, three reports dealing with flood control and drainage in the Karditsa plain and adjacent areas have been submitted to the Greek Ministry of Public Works.

The first known as the Nobile Report, was prepared by an Italian engineer in 1913. This report recommended control of flooding from the Peneos River by means of levees, and protection of the plains from tributary streams by means of intercepting canals and channel improvements.

The second report, prepared in 1921 by Sir John Jackson, recommends the control of flooding from tributary streams by construction of reservoirs on their headwaters; the water thus impounded would be used for irrigation and development of hydroelectric energy. Flooding of the Peneos River would be controlled by levees and channel improvements.

The third report, prepared by Sir Murdoch Macdonald in 1931, conforms in general with the Nobile report and goes into more detail on the location and scope of the proposed channel improvements, and collector and interceptor drains. This report has formed the basis for much of the flood control and drainage work completed to date.

4. Acknowledgements

In the investigation leading to the preparation of this report, many Governmental and private organizations and individuals assisted in furnishing information. In particular it is desired to acknowledge the cooperation of Mr. D. Papanicolaou, Director of the Service of Hydraulic Works, and Messrs D. Arliotis and K. Antonopoulos of the Ministry of Public Works.

Valuable information and aid were also obtained from officials of the Ministries of Public Works and Agriculture and of the Topographic Service of the former Ministry. Dr. D. Katakouzinos, Director of the Central Soils Laboratory of the Ministry of Agriculture cooperated in making laboratory determinations.

Generous cooperation was given by officials and their staffs of the province of Karditsa and the many communities in the Karditsa and Megdova areas. In the field, Messrs C. Tsoutsinos, Director of the Agricultural service in the Karditsa Nomos, A. Vayakos, Director of the Union of Agricultural Cooperatives at Karditsa, G. Lambiris, Director of the Service of Mechanical Cultivation, C. Ayanoglou, Nomos Engineer and A. Halkiopoulos, Technical Director of the Agricultural Bank of Karditsa and B. Plastiras, Director of Karditsa Electric Power Company, were especially helpful. Many other provincials, trade associations and farmers were interviewed during the course of the field investigations and the data, estimates and opinions received from these individuals were valuable and contributed in a large measure to the progress of the studies. Only space limitations prevent a complete listing together with appropriate acknowledgements and expressions of appreciation.

CHAPTER II

GENERAL DESCRIPTION OF THE AREA

Brief general descriptions of the location, physiography, geology, natural resources and economic conditions in the Megdova River basin and the Karditsa plain are presented in this Chapter. More detailed description of these features may be found in Chapters III, IV and V.

The Megdova project, which contemplates the transbasin diversion of the Megdova River, is concerned with two separate areas, the first being the Megdova River basin which is the source of water for irrigation and for hydroelectric power and the second being the Karditsa plain, where the irrigation water and a part of the electric energy will be used.

1. Location

The Megdova River rises in the Agrafa Mountains which form a part of the Pindos mountain range of central Greece. The upper river flows in a southerly direction following the trough of the upland valley called the Nevropolis plain, which is terraced into the easterly slopes of the Agrafa Mountains. About 2 km below the confluence of the Karitsiotis River, the Megdova River enters a gorge which cuts through the Agrafa Mountains. Below the gorge the Megdova River swings westerly to discharge into the Acheloos River which empties into the Ionian Sea. This report contemplates the storage and diversion of the headwaters of the Megdova River. The upper basin with a drainage area of 147 km^2 includes the Nevropolis plain mentioned above. The principal geographic features of the area are shown on Plate II-1.

2. Physiography

Two topographic zones are traversed by the Megdova River in its course through the upper watershed. The headwaters are in rugged mountains covered in winter by deep snow; here the river branches into many short, steep tributaries which are generally incised deeply into the limestone formation comprising the mountainous portion of the watershed. The second zone consists of the Nevropolis plain which is a benchlike trough into which the upper tributaries collect to form the Megdova River. The Nevropolis plain is bordered by the mountains to the west and a rim of low hills (Ithome hills) to the east; its greatest width is about 2 km. The plain slopes gently to the south, becoming gradually narrower until it ends at the deep gorge downstream of the Karitsiotis River confluence.

The land areas suitable for irrigation and improvement are located in the Karditsa plain that begins a few kilometers east of the Nevropolis plain and is about 600 meters lower in elevation than the latter. The Ithome hills, that form the low ridge between Megdova River and the Karditsa plain, mark the easterly divide of the Megdova drainage basin.

The Megdova River basin and the Karditsa plain, and their position in relation to the political subdivisions of central Greece, are shown on Plate II-1.

The Karditsa plain does not have fixed geographical boundaries, but is known locally as that part of the Thessaly plains that surround the town of Karditsa. In this report the Karditsa plain is considered to be the triangular area of about 600,000 str bordered by the Peneos River on the north, the Sofaditis River on the east and the foothills of the Agrafa Mountains on the southwest. The plain consists of a broad expanse of smooth, gently sloping fertile land devoted principally to cultivation of small grain and sesame; limited amounts of field crops such as corn, cotton and tobacco are also cutlivated.

A large part of the area suffers from high groundwater conditions caused by flooding from tributary streams, artesian flow from areas at higher elevations, and ponding of winter rainfall. Many shallow depressions have been formed in the plains during flood seasons by intermittent meandering streams.

3. Geology

A variety of sedimentary rock types ranging in age from the Mesozoic to the Recent are represented in the Megdova basin (see Plate II-2) and the Karditsa plain. The older formations consist of compactly bedded Mesozoic limestones interbedded with thin layers of hornstone and argillaceous shale. Interfolded with and overlying the limestone unconformably is the Eocene flysh consisting of alternate thin layers of argillaceous shales and sandy shales, interbedded with thick layers of compact quartzite sandstone. Overlying the flysh stratigraphically are the Recent sedimentary deposits of clay, silt sand and gravels.

The high mountains comprising the western portion of the drainage basin are predominately limestone while the lower slopes and foothills are predominately flysh. The flat area of the Karditsa plain consists of Recent alluvial deposits of unknown depth.

The formations of the Megdova region have been subjected to tectonic movements which account for the highly folded and faulted character of the rock. The area is actually a southeastern extension of the Alpine mountain system of south-central Europe.

While earthquakes of strong intensity have been recorded, occasional earthquakes of mild to medium intensity have been reported.

4. Groundwater

Prior to the construction of existing levees and drainage canals, most of the Karditsa plain was seriously affected by high groundwater conditions caused by flooding from the Peneos River and other streams. Although these adverse drainage conditions are being corrected in great measure by the flood control and drainage program of the Ministry of Public Works, large parts of the plain are still affected by excessive moisture particularly during the winter and spring.

There are no large springs in the plain, although a few good-yield artesian wells are found, principally between Karditsa and the Peneos River. While groundwater aquifers underline most of

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the plain, many of the deep wells yield water in quantities sufficient only for domestic use. As described in Chapter III, moderate amounts of irrigation water are obtainable in certain parts of the plain by pumping from shallow wells or drains.

5. Natural Resources

Land: The Karditsa plain has a gross area of about 600,000 str devoted in large part to the farming of wheat and small grain. With the exception of about 6,000 str which are irrigated from artesian sources, or by pumping from streams and wells, the plain is dry-farmed. From a regional standpoint, the Karditsa plain may be considered to be a subdivision of the northern section of the extensive and fertile Thessaly plain, which it resembles in climate, topography and agriculture. West of the Karditsa plain, the foothill lands are utilized for dry farming and grazing while the mountainous region receives high precipitation and is suitable for the growing of forest products.

Mineral: The region is generally lacking in mineral resources. There are indications of lignite, manganese, copper, chromite and natural gas; however, the extent and workability of these deposits is not known.

Water: The annual precipitation, varies from about 1,850 mm in the Megdova basin to 750 mm in the Karditsa plain. Groundwater surveys conducted by the Associated Drilling Supply Company of London show that a part of the plain is underlain by deep aquifers with indication of other aquifers at shallower depths. Artesian waters are found in the plains, principally near Lazarina and Megali Poliana. Several small springs are found along the edge of the plain near the foothills. The average flow of the Megdova River is 8.6 m^3/sec; wide variations in monthly discharges occur, the mean monthly flow for August being 1.3 m^3/sec and 13.5 m^3/sec for December. Hydroelectric power is developable by utilizing the 600-m drop in elevation between the Nevropolis plain and the Karditsa plain.

Population: Based on estimates derived from the 1951 census, the combined population of the Karditsa plain is about

70,000 persons of whom 75 percent live in grouped farm [illegible] villages while the remainder of 18,500 live in Karditsa. Practically all of the residents derive their livelihood directly from the soil or from processing and marketing agricultural products. Excluding the residents of Karditsa, part of whom are not engaged in agriculture, there are approximately 9 str of arable land per farm inhabitant in the plain.

The local inhabitants are, in general, cooperative but not overly industrious. The mode of life is simple; many old customs and modes of dress have been retained. The principal food is bread and pulses. The isolation of the area has resulted in generally poor educational facilities and in lack of improvement in housing and sanitary conditions. Being principally grain farmers, the people have considerable spare time for weaving and other small enterprises. Nevertheless, in general, the farmers have sufficient land to support themselves and their families and appear to have a better-than-average standard of living as compared with other rural areas in Greece.

CHAPTER III

CLIMATOLOGY AND HYDROLOGY

CLIMATOLOGIC DATA

1. Climatologic Stations

In Table III-1 are listed stations in the Megdova River basin, Karditsa plain, and surrounding region at which precipitation and temperature are measured. The stations are operated by the Ministries of Public Works, Agriculture and Air. As indicated in the table, the majority of the stations record precipitation only.

2. Records

As can be seen from an examination of Plates III-1 and III-3 and Table III-1, records of temperature and precipitation in and adjacent to the Megdova River basin are inadequate both as to distribution and length of record to define closely the local variations in the climatic features of the basin. Both the precipitation and temperature vary markedly with differences in altitude and exposure. As many of the available records are for stations located in relatively low-lying sheltered valleys, only approximate determinations can be made of areal precipitation and temperature which, however, are generally sufficiently accurate for the purposes of this report.

3. Precipitation

Average annual precipitation: The Pindos mountain region, in which the Megdova River basin is located, receives more precipitation than any other part of Greece. In order to estimate the average annual precipitation on the Megdova River basin, the records of all stations in the region including the entire Acheloos River basin and surrounding area, were studied. Precipitation-altitude relations were plotted as shown on Plate III-2 for water years 1936 through 1939, the period during which the maximum

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TABLE III-1

SUMMARY OF CLIMATIC RECORDS IN AND ADJACENT TO THE MEGDOVA DRAINAGE BASIN

Station	Location			Precipitation		Temperature	
	Lat.	Long.	Station Elev.	Period of Records	Mean Am.* Precip.	Period of Records	Mean Am.** Temper.
			(m)		(mm)		(°C)
Ayios Vlassios	38°49'	21°31'	850	1935-39	1,562		
Agrinion	38°37'	21°24'	96	1904-39, 1947 to date	976		
Analepsis	38°30'	21°44'	800	1950 to date	1,288		
Ano Prostovas	38°38'	21°38'	620	1950 to date	1,124		
Arta	39°09'	21°10'	39	1894-1939	1,144	1896-1929	17.70
Bezoula	39°18'	21°41'	930	1932-47,1950 to date	1,576		
Chelidona	38°49'	21°39'	625	1950 to date	1,796		
Gavalou	38°32'	21'32'	50	1950 to date	2,110		
Gavdiki	39°32'	21°16'	1,100	1932-42	1,465		
Granitsa	39°06'	21°29'	700	1950 to date	1,186		
Crevenition	39°49'	21°01'	980	1936-42,1950 to date	832		
Ioannina	39°40'	20°51'	508	1915 to date	1,218	1915-29,1936-40	14.70
Kalabaka (Meteora)	39°43'	21°36'	548	1950 to date	778		
Kalabaka (town)	39°41'	21°37'	250	1903-12,1929-31,1935-39	1,066		
Karditsa	39°22'	21°55'	110	1903-10,1936-42,1950 to date	618		
Karitsa	39°16'	21°41'	1,130	1950 to date	1,124		
Karpenission	38°55'	21°49'	963	1904-31, 1946 to date	1,191		
Katafyli	39°12'	21°24'	1,050	1951 to date			
Konitsa	40°03'	20°46'	556	1915-30, 1932-39, 1951 to date	1,100	1936-1940	14.3
Lepenou	38°43'	21°17'	180	1950 to date	1,092		
Malakassion	39°47'	21°19'	1,080	1903-12, 1933 to date	1,400		

III-3

TABLE III-1 (Continued)

SUMMARY OF CLIMATIC RECORDS IN AND ADJACENT
TO THE MEGDOVA DRAINAGE BASIN

Station	Location		Precipitation			Temperature	
	Lat.	Long.	Station Elev. (m)	Period of Records	Mean Ann.* Precip. (mm)	Period of Records	Mean Ann.** Temp. (°C)
Metsovon	39°46'	21°13'	1,132	1915-26, 1950 to date	1,897		
Messolonghion	38°21'	21°28'	4	1894-1939, 1950 to date	830	1900-1929	18.60
Nafpaktos	38°44'	21°51'	5	1912-37, 1950 to date	1,052		
Paradision	38°27'	21°42'	100	1950 to date	2,645		
Perdikaki	39°03'	21°23'	800	1950 to date	2,240		
Pertouli	39°32'	21°28'	1,150	1903-7, 1950 to date	1,554		
Platanos	38°36'	21°47'	1,100	1950 to date	1,710		
Psilovrahos	38°52'	21°34'	450	1950 to date	1,915		
Pyli	39°27'	21°37'	180	1932-42	1,057		
Redina	39°04'	21°59'	1,080	1932-45, 1950 to date	725		
Sarghidda	38°46'	21°24'	220	1950 to date	1,920		
Stamna	38°31'	21°16'	170	1950 to date	1,022		
Theotheriana	39°25'	21°13'	1,400	1951 to date			
Trikala	39°33'	21°47'	154	1894-1939	809	1900-1929	16.60
Tymfristos	38°55'	21°55'	780	1930-1942	1,382		
Tyrna	39°30'	21°32'	923	1907-12, 1950 to date	2,306		
Viniani	38°59'	21°41'	620	1950 to date	1,630		

* Precipitation adjusted to the period 1904-1951

** Temperature adjusted to the period 1896-1950

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number of coincident records were available. (By "water year" is meant the year beginning September 1 and ending August 31). From the precipitation-altitude relations with geographical position and exposure taken into account and with adjustment for long-term trends as given in Table III-1, the isohyetal map on Plate III-3 was drawn; these isohyetal lines were then transferred to Plate III-1. From the latter plate, the average annual basin precipitation was determined as follows:

Basin	Drainage Area (km^2)	Average annual basin precipitation (mm)
Karitsiotis River	53	2157
Megdova River above Karitsiotis confluence	94	1764
Megdova River below Karitsiotis confluence	147	1930

These estimates of basin precipitation are believed to be conservative for two reasons: (1) Precipitation-gage observers are not properly instructed regarding measurement of precipitation in the form of snow; inasmuch as a large proportion of the precipitation particularly at the higher altitudes is in this form, much of the snowfall is lost and values that are too low are obtained. (2) Consideration of basin runoff and loss, as discussed later in this chapter, indicate that the above estimate of basin precipitation is low.

Seasonal distribution: The Megdova River basin and the Thessaly plains have a typical Mediterranean climate with a distinct rainy season occurring during the winter. The months of November, December and January have the greatest precipitation at most stations as shown in Table III-2. The summers are dry except for occasional heavy showers accompanying thunderstorms in the higher mountains. These summer showers are local in character and occasionally cause floods on small torrents; however, they rarely cause flooding in the main river channel.

4. Temperature Records

Records of monthly temperature are available for five stations in the Megdova River basin and Karditsa plain as shown in Table III-1. The monthly temperatures at the proposed Nevropolis reservoir were estimated from the temperature-altitude relations shown in Plate III-4. Table III-3 shows the average monthly and annual temperature for Trikala, Arta, Ioannina, Konitsa, Messolonghion and Nevropolis reservoir adjusted to the period 1894 to 1929.

TABLE III-2

MEAN MONTHLY PRECIPITATION

(millimeters)

Station	KARDITSA		TRIKALA		BEZOULA	
Period of records	1902-11, 1935-43 1949-51		1899-1937		1932-1951	
Month	Total	%	Total	%	Total	%
January	92	13	93	12	258	16
February	79	11	78	10	182	11
March	68	10	68	9	119	7
April	46	6	58	8	115	7
May	47	6	57	7	101	6
June	36	5	41	5	60	4
July	12	2	15	2	21	1
August	11	2	16	2	35	2
September	48	7	35	4	67	4
October	85	12	96	13	168	10
November	72	10	106	14	224	14
December	113	16	104	14	288	18
Annual	709	100%	767	100%	1638	100%

5. <u>Evaporation</u>

No evaporation records have been kept for any location in the Megdova River basin or adjacent area; there are ten years of evaporation records, however, for the period 1932 through 1942 at Lake Marathon near Athens. From this record the water-surface evaporation at the Nevropolis reservoir was estimated using the correlation between temperature and evaporation shown in Plate III-5. The estimated monthly and annual evaporation rates at Nevropolis reservoir are given in Table III-4.

TABLE III-3

AVERAGE MONTHLY AND ANNUAL TEMPERATURE IN °C

Month	TRIKALA	ARTA	IOANNINA	KONITSA	MESSOLONGHION	Nevropolis Reservoir
	El 154	El 25	El 470	El 560	El 4	El 750
January	5.8	8.8	5.4	4.8	10.2	4.6
February	7.2	9.8	6.4	6.3	10.4	6.2
March	11.1	12.4	9.5	9.0	13.3	8.1
April	15.5	15.8	13.1	12.4	16.6	11.0
May	20.3	20.2	17.5	16.7	20.4	15.5
June	24.8	24.1	21.3	21.2	24.9	19.8
July	28.0	27.3	24.8	24.9	27.5	23.5
August	27.5	27.3	24.8	24.3	27.5	23.2
September	23.2	23.9	21.0	20.2	24.7	19.0
October	17.4	19.0	15.7	15.5	20.2	15.2
November	11.5	13.8	10.4	10.6	16.4	9.9
December	7.4	10.2	6.6	6.3	11.7	5.9
Annual	16.6	17.7	14.7	14.3	18.6	16.0

TABLE III-4

MONTHLY AND ANNUAL EVAPORATION AT NEVROPOLIS

Month	Evaporation (mm)	Month	Evaporation (mm)
January	21	July	200
February	28	August	140
March	35	September	91
April	47	October	67
May	69	November	43
June	99	December	27
		Annual	811

6. Groundwater

Drainage conditions: Groundwater is high throughout most of the plain due to the lack of channel maintenance and drainage facilities. Prior to the installation of the existing flood control and drainage systems, a large portion of the lower plain near the Peneos River was swampy, rendering it entirely useless for cultivation.

The Knappen Tippetts Abbett Engineering Company measured the depth to water in 67 shallow wells throughout the Karditsa plain between Sofaditis and the Peneos River with results as given in Tables III-5 and 6 and Plate III-5.

TABLE III-5

GROUNDWATER OBSERVATIONS - MAY 1952
KARDITSA PLAIN

No. of wells	Location	Approximate elev. of gr. surface	Depth to water
1	Artesianon	96.00	1.60
2	Artesianon	97.00	1.80
3	Ayios Theodoros	100.00	1.70
4	Ayios Theodoros	105.00	1.50
5	Ayios Theodoros	104.50	2.00
6	Ayiopighi	124.00	2.00
7	Daouti	115.00	4.50
8	Fanari	96.00	2.00
9	Fanari (Komyles)	95.50	2.00
10	Ftelopoula	114.50	2.00-2.40
11	Frango	125.00	2.30-1.60
12	Georghikon	122.00	2.00
13	Georghikon	128.00	1.50
14	Georghikon	125.00	2.00
15	Gorgovites	98.50	2.00
16	Gorgovites	97.00	1.70
17	Kalyvakia	94.00	2.00
18	Kalyvakia	94.00	1.70
19	Kanalia (Lasda)	98.00	1.80
20	Kanalia (Lasda)	105.00	2.80
21	Kanalia (Lasda)	103.50	1.70
22	Karditsa	102.00	1.90
23	Karditsa	105.00	1.60
24	Karditsa	110.00	1.60
25	Karditsa	104.00	1.80
26	Karditsomagoula	95.00	1.50
27	Karditsomagoula	93.00	1.75
28	Karditsomagoula	93.50	1.50
29	Karpohori	110.00	4.70
30	Kasnesi	128.00	1.20
31	Kasnesi-Magoula	118.00	2.00
32	Koumades	104.00	1.55
33	Kourtesi	101.00	1.80
34	Kria Vrissi	141.00	1.70
35	Makrihori	94.00	1.70
36	Makrihori	92.00	1.50
37	Markou	95.00	2.00
38	Markou	95.00	1.70
39	Markou	94.00	1.60
40	Markou	94.00	1.60

TABLE III-5 (Continued)

GROUNDWATER OBSERVATIONS-MAY 1952
KARDITSA PLAIN

No. of wells	Location	Approximate elev. of gr. surface	Depth to water
41	Mataranga	101.00	2.50
42	Mataranga	100.00	1.50
43	Metropolis	147.00	4.00
44	Metropolis	132.00	7.00
45	Mirous	97.00	2.00
46	Mirous	95.00	1.80
47	Mirous	94.00	2.00
48	Mirous	95.50	1.80
49	Palamas	91.00	2.20
50	Palamas	90.00	1.90
51	Palamas	90.00	1.70
52	Paliokl issi	103.00	1.70
53	Palioklissi	99.50	1.90
54	Palioklissi	100.00	1.10
55	Palioklissi	98.00	1.75
56	Palioklissi	104.00	1.20
57	Palioklissi	100.00	2.25
58	Palioklissi	100.00	1.00
59	Pradaska	110.00	1.00
60	Pyrgos Kierion	104.50	3.50
61	Pyrgos Kierion	108.00	3.70
62	Rouso	130.00	3.40
63	Rizovouni	95.00	1.70
64	Sofades	109.00	4.20
65	Sofades	110.00	2.50
66	Xyroneri	138.00	1.30
67	Xyroneri	139.00	2.30

NOTE: For location of wells, see Plate III-5.

TABLE III-6

GROUNDWATER CONDITIONS
KARDITSA PLAIN

Approx. depth below ground surface	Area	Percent of plain area
	(1000 str)	
1.0 - 1.5 m	21	3
1.5 - 2.0 m	237	40
2.0 - 3.0 m	235	39
Over 3 m	107	18
	600	100

Groundwater supplies: Springs in the Karditsa plain yield water suitable for irrigation but only in limited volumes. Most of the springs are located in the southern portion of the plain at the contact between the flysh and limestone of the mountains and the alluvium of the plain.

Very few dug wells exist in the plain but almost every family has a driven well with hand pump for domestic water supply. About 120 driven wells in the area are equipped with 2 to 3 inch pumps and yield 20 to 50 m^3/hr. The total area irrigated by pumping from wells, springs and streams does not exceed 6000 str in the Karditsa plain. A groundwater survey, which included the Karditsa plain, was made in 1950 by the Associated Drilling and Supply Company, Ltd. of London for the Ministry of Agriculture. The results of the survey are described in "Report on the Survey and Exploration of Underground Water Resources in the Western Thessaly Plain Area" (in two Volumes). The report includes the results of exploratory drilling and geophysical investigations. Tabulations and maps of existing wells together with locations, depths, yields, head and other pertinent data are included.

In general, the report concludes that groundwater supplies could be developed by deep wells in certain selected areas in the north part of the Karditsa plain; however, the south and east parts between Karditsa and Palamas do not appear favorable for development. Within the selected areas that could be developed, the yields for a 6 to 8 inch diameter well 150 m deep is estimated at about 35 m^3/hr.

The Ministry of Agriculture has undertaken a well drilling program in the area but accurate records of yields are not yet available.

It is known that limited amounts of water for irrigation will be obtainable at shallow depths from drains, natural streams and shallow wells, and that the yields from these sources will be strengthened by irrigation losses from the selected irrigation area. The actual amount obtainable from low-lift pumping sources can be determined only after the recommended irrigation project together with the current drainage program of the Ministry of Public Works goes into operation and after the ultimate effects of the reclamation works become evident. However, in order to indicate the amount of water which might be available by pumping from drains, shallow wells and local streams, an estimate on the basis of recharge by precipitation was made. This estimate indicates that about 47 million m^3 would be available from shallow wells and drains, and an additional 18 million m^3 of water would be available from recovery of the irrigation losses. This supplemental water could be used to irrigate about 71,000 str out of the total of 530,000 net irrigable str or about 13 percent of the net irrigable area in the Karditsa plain.

7. Physical Characteristics of the Drainage Basin

The drainage basin under consideration is that of the Megdova River below its confluence with the Karitsiotis River, which is its principal tributary.

The drainage areas concerned are as follows:

Karitsiotis River	53 km^2
Megdova River above Karitsiotis confluence	94 km^2
Megdova River below Karitsiotis confluence	147 km^2

The western part of the basin is mountainous and cut by deep ravines having a general easterly alignment. The mountain slopes are steep and barren, and are devoid of all vegetation on the upper part while wooded and covered by fir and oak trees on the lower part. The eastern part of the drainage basin is hilly with gentle slopes intercepted by saddles giving easy access to the Thessaly plain. The Mesenikolas and Tsardaki saddles are the principal means of access between the Karditsa and the Nevropolis plain.

From its source the Megdova River flows in a southerly direction following a tectonic valley, the upper part of which forms the Nevropolis plain. Vava Lake occupies the northeastern portion of the Nevropolis plain. The Karitsiotis River originates near the village of Karvasara and flows into the Megdova River just below the proposed damsite. The principal springs feeding the Megdova River are located near the villages of Fylakti, Bezoula and Kryoneri.

Little erosion has occurred in the upper Megdova basin except in the vicinity of Lake Vava and the village Kryoneri. The main debris carrier is the Karitsiotis River which drains an area of high barren limestone mountains.

STREAMFLOW

8. Measurements and Tests

Records of stream measurements made in the Megdova basin are summarized in Table III-7. Stage-discharge relations for the

TABLE III-7
DISCHARGE MEASUREMENTS

River	Place	No.	Gage Height (m)	Discharge (m3/sec)	Date	Made by
MEGDOVA	Bezoula Springs			0.511	May 9 1952	KTA
MEGDOVA	Nechori Bridge			0.416	May 8 1952	KTA
MEGDOVA	Daly Mill[1/]	1		3.860	May 19 1950	MPW
		2		3.690	May 20 1950	MPW
		3	1.07	2.360	May 25 1950	MPW
		4	1.33	13.119	Mar. 28 1952	MPW
		5	1.08	3.550	Apr. 16 1952	MPW
		6	1.00	1.765	May 7 1952	KTA
		7	0.92	0.861	May 22 1952	KTA
		8	0.99	1.664	June 6 1952	KTA
		9	0.87	0.300	June 21 1952	KTA
KARITSIOTIS	Mandani Bridge[1/]	1	0.67[2/]	1.717	May 21 1950	MPW
		2	0.59	0.884	May 26 1950	MPW
		3	0.99	10.371	Mar. 28 1952	MPW
		4	0.85	2.474	Apr. 16 1952	MPW
		5	0.79	1.184	May 7 1952	KTA
		6	0.72	0.621	May 22 1952	KTA
		7	0.78	1.179	June 6 1952	KTA
		8	0.61	0.240	June 21 1952	KTA

1/ Staff gage read daily by observer. Staff gage records available May 1950 to date

2/ Estimated

Note: KTA = Knappen Tippetts Abbett Engineering Co.
MPW = Ministry of Public Works

two stations are shown on Plates III-8 and III-9. The lower portions of each curve are well defined by the current-meter measurements. An extension of the curve on Plate III-8 was determined from varied-flow computations based on a series of measured cross sections obtained during May and June 1952. As, according to local inhabitants, there has been no change in the channel cross-sections of the Megdova River since May 1950, the computed point on Plate III-8 should be accurate within about 20%. As the higher discharges are of short duration, the resulting error in monthly-average-flow determinations is much less than this percentage. For the Karitsiotis River the stage-discharge relation is doubtful owing to shifting of the stream bed.

9. Water Quality Tests

Samples for analysis of water quality were taken from the Megdova River near the confluence of the Karitsiotis River, the artesian well in the village of Artesianon and a main drain excavated recently near the village of Kalenzi. The samples were analysed in the soils laboratory of the Ministry of Agriculture with results as shown in Table III-8. The diagram for water quality shown on Plate III-7 was used as a guide in establishing the suitability of water for irrigation use. Reference is made to "Diagnosis and Improvement of Saline and Alkaline Soils", U.S. Regional Salinity Laboratory, Riverside, California, July 1947, for the methods of water analysis used and for the meaning of the symbols in Table III-8.

10. Quantity of Runoff

For the period of gage-height records extending from May 1950 to date, the daily average discharge of the Megdova River at Daly Mill was determined as follows: (1) For periods with only minor variations in flow, the average daily discharge was determined by direct reading of the discharge from the stage-discharge curve on Plate III-8. (2) For flood periods, gage-heights were plotted on a time scale and the gage-height hydrograph was sketched through the known points; this gage-height hydrograph was then converted to discharge by use of Plate III-8; the average daily

TABLE III-8

WATER ANALYSES IN KARDITSA PLAIN AREA

Characteristics	Artesian well near Artesianon (depth 200 m) W_1	Megdova River at the damsite	Main Drain near Kalenzi W_2
pH	8.3	7.6	8.1
Ca+Mg m.e./liter	2.44	2.84	3.16
$\left(\frac{Na \times 100}{Ca+Mg+Na}\right)$	64.8	51.3	46.9
Conductivity (EC x 10^6 at 25°C)	850	400	650
Total salts by conductivity gm/liter	0.59	0.28	0.45
Cl gm/liter	0.008	0.005	0.018
Suitability for irrigation	permissible	Excellent to good	Good to permissible

For location of samples W_1 and W_2 see Plate III-6.

discharge was then determined from the discharge hydrograph.

The discharge for each complete month of record, June 1950 to May 1952 inclusive, was computed from the daily average discharges giving mean monthly discharges as summarized in Table III-9.

A correlation curve, Plate III-10, was then plotted of the mean monthly discharges of the Megdova River versus the Acheloos River at Kremasta; records of the latter are available since September 1937. The Megdova River is one of the principal tributaries of the Acheloos River and the basin precipitation and basin characteristics are generally similar. From this correlation the mean monthly discharges for the months September 1937 through May 1950 were determined as tabulated in Table III-9. In order to complete the missing months of June, July and August 1952 when flows were known to be comparatively low, typical recession curves were drawn from which the quantities shown for these months in Table III-9 were estimated. The mean flow of the Megdova River for the period September 1937 through August 1952 is 8.6 m^3/sec as shown in Table III-9. A residual mass curve

TABLE III-9

MEAN MONTHLY AND ANNUAL DISCHARGE
MEGDOVA RIVER AT DALY MILL
(m^3/sec)

Year	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Mean Annual
1937-38	3.2	4.2	11.7	18.4	17.4	12.8	10.7	14.5	12.3	5.0	2.6	1.7	9.5
1938-39	1.7	4.4	6.9	13.8	12.9	7.4	14.3	14.8	10.0	6.0	3.2	1.9	8.1
1939-40	2.8	8.5	8.6	19.0	18.8	17.0	15.8	15.5	15.9	7.6	2.7	1.7	11.2
1940-41	1.4	6.2	6.0	18.7	20.0	20.8	12.4	13.2	8.9	4.0	2.3	1.7	9.6
1941-42	3.2	9.0	14.0	10.9	13.4	13.5	14.8	12.8	6.5	21.6	2.0	1.4	10.3
1942-43	1.3	1.2	3.8	3.0	7.9	5.5	2.6	6.8	5.9	2.5	1.7	1.3	3.6
1943-44	1.3	1.6	15.8	10.2	9.0	11.4	16.0	13.0	8.2	3.2	1.7	1.6	7.8
1944-45	1.6	13.2	16.7	16.6	14.4	17.0	12.8	9.8	9.4	2.6	1.9	1.1	9.7
1945-46	6.5	2.7	13.4	14.4	13.0	10.5	15.4	12.2	9.4	5.6	2.6	1.8	9.0
1946-47	1.7	9.8	19.2	18.3	14.8	25.5	20.2	15.3	7.4	11.4	10.2	1.2	12.9
1947-48	1.2	1.0	8.6	29.6	19.8	12.7	8.7	15.6	12.1	11.4	2.4	0.9	10.3
1948-49	0.7	0.6	0.7	0.7	5.8	6.6	13.3	8.6	8.2	4.7	1.3	1.0	4.3
1949-50	1.7	3.0	14.8	8.2	9.8	13.6	11.9	11.9	5.4	2.1	0.7	0.6	7.0
1950-51	0.7	1.3	7.3	13.7	13.5	14.8	19.4	10.4	5.6	2.5	1.8	1.2	7.7
1951-52	2.3	27.5	15.7	8.2	15.8	10.6	6.7	5.8	1.7	(0.8)	(0.4)	(0.3)	8.0
Mean	2.1	6.3	10.9	13.5	13.8	13.3	13.0	12.0	8.5	6.1	2.5	1.3	8.6

based on the data in Table III-9 is shown in Plate III-13.

In order to determine whether the period September 1937 through August 1952 is representative of long-term trends, the annual precipitation at various stations in the region were plotted on Plate III-11. Using the station at Agrinion as an index, the correlation on Plate III-12 was plotted. From a study of these two plates it was estimated that the long-term mean flow is about 8.0 m^3/sec rather than the 8.6 m^3/sec given in Table III-9. On the other hand, as can be seen from Plate III-11, the period of runoff records does include water year 1949, the driest year of precipitation in Greece and throughout the Middle East.

Basin runoff and mean water loss: The long-term mean average discharge of 8.0 m^3/sec corresponds to a mean annual flow of 252,000,000 m^3 or 1720 mm on the drainage area of 147 km^2. It was stated previously in this chapter that the average annual basin precipitation is 1930 mm, which value is probably low owing to improper measurement of precipitation in the form of snow. This conclusion is also borne out by consideration of the average basin water loss which would be 210 mm per year if the values of 1930 mm and 1720 mm are accepted respectively for the basin precipitation and basin runoff. Based on studies performed by the Knappen Tippetts Abbett Engineering Company in other areas of Greece, the basin loss should be on the order of 400 mm for which the basin precipitation would be about 2100 mm. By comparison, the basin runoff of the Acheloos River at Kremasta is 1770 mm while the basin precipitation, as near as can be determined from the available information, is 1830 mm.

11. Megdova River Basin Floods

Records of floods on the Megdova River are of only minor interest as there is very little actual or potential damage resulting from floods downstream of the proposed Nevropolis dam. On the other hand, for design of the spillway of the dam, records of maximum floods would be of value; such records are not available however, therefore comparison with other drainage basins was made.

Comparison with other basins: Maximum recorded flood discharges in Greece plotted against drainage area (Plate III-14) have an envelope curve with the equation Q=50VA, where Q equals the peak discharge in m^3/sec and A is the drainage area in km^2. This equation is similar in form to Q = 5000 VA, used for the Pacific slope basins in California, where Q equals the peak discharge in cubic feet per second and A is the drainage area in square miles. This equation converted to metric units, with Q in m^3/sec and A in km^2, is Q = 88 VA; the first equation thus gives results equal to 57 percent of the value for California.

Data on maximum recorded floods in Italy were also examined as contained in "Peine dei Corsi d' Aqua Italiani", published by Servizio Idrografico, Ministero dei Labori Publici, Rome 1930; and "Methodes de Determination du Debit de Crue Maximum à Prévoir pour un Barrage", by Armando Piccoli, Commission Internationale des Grands Barrages, Paris 1951. It is considered that Greek rivers have characteristics similar in general to rivers in that portion of Italy lying roughly between latitudes 40° and 44°. Maximum recorded floods in this part of Italy are at or below the envelope curve Q = 50 VA except for several basins that are at relatively high elevations of 850 to 1,000 m in the northeast slopes of the Apennines in the regions of Romagna and Marche; the envelope curve for these high basins is Q = 77 VA. For the Megdeva River basin, whose mean elevation is 1020 m, the maximum probable flood (used for design of the spillway of the proposed dam as described in Chapter IX) is estimated at 90 VA or 1100 m^3/sec.

12. Karditsa Plain Floods

For data on floods in the Karditsa plain, reference is made to Chapters IV and VII.

13. Effect of Megdeva Diversion on Acheloos River Projects

There are two potential projects on the Acheloos River downstream of its confluence with the Megdeva River. One potential project comprises the Kremasta hydroelectric development and the other is the Agrinion-Neohori irrigation plan. The Megdeva diversion will have a negligible effect on these projects for the following reasons:

(a) The diversion of the Megdova River comprises only about 3 percent of the total yield of the Acheloos basin.

(b) An average of 42 m^3/sec will be wasted by flood-water spilling at the Kremasta dam, whereas an average of only 6.8 m^3/sec will be diverted from the Megdova River; most of this diversion would be wasted at the Kremasta spillway during floods.

(c) At the site of the Agrinion-Mechori irrigation projects the minimum daily summer flow of the Acheloos River is about 18 m^3/sec, while the irrigation requirement is about 17 m^3/sec. The minimum daily summer flow for the Megdova River is only about 0.2 m^3 per sec; thus the diversion of the Megdova River during the summer will not affect appreciably the amounts of water available for irrigation downstream.

FUTURE HYDROLOGIC PROGRAM

14. Personnel and Equipment

The collection of the basic data should be entrusted only to trained, reliable persons instructed in detail on how to collect data and on the importance of correct information for the development of the district and the country as a whole. Wherever possible automatic recording instruments should be installed which will provide uninterrupted records between visits of engineers from the Ministry of Public Works. The schedule of the engineers should be arranged so that all stations in the district will be visited every two weeks.

15. Stream Gaging Stations

Recording gages: Because of the relatively small drainage areas of both the Megdova and Karitsiotis Rivers, these streams are subject to rapid rise and fall in water level, and, therefore the present procedure whereby staff gages are read once or at most twice a day is considered inadequate. It is recommended that automatic recording water-level gages be installed near the existing staff gages on the Megdova River at Daly Mill and on the Karitsiotis River at or near Madani Bridge. Owing to the shifting nature of the channel of the Karitsiotis River, the site of the recording gage should be selected with care and at the same time, consideration should be given to construction of a low concrete sill in the form of a flat "V" in order to stabilize the stage-discharge relation so that much more accurate determination of flow of the Karitsiotis River could be made. Reference is made to Water Supply Paper No. 888 of the U.S. Geological Survey entitled "Stream Gaging Procedure" for the arrangement, installation and maintenance of automatic water level recorders, gaging wells and other items of equipment. Particular reference is made to the section on the installation of staffgages both inside and outside of the stilling wells, pages 193 and 227, and the section on clearing the stilling well and intake, page 227. The discharge rating curve should be checked periodically by making current meter measurements at least twice a month during the rainy season and at least once a month during the dry season.

Cableways: To permit current-meter measurements during high-water periods, cableways should be constructed near the site of each recording gage. Water Supply Paper No. 888 also contains technical information on this subject.

16. Precipitation Gages

As discussed above under precipitation there is evidence that precipitation in the form of snow is not being measured properly at existing precipitation stations. It is recommended that observers at these stations be issued instructions regarding snow measurements for which reference is made to U.S. Weather Bureau Circular E "Measurement of Precipitation" (1936) and Circulars B and C "Instructions for Cooperative Observers" (1941). These instructions should be issued to the observers at Bezoula, Karditsa and Karitsa. It would be well to issue the same instructions to observers in the mountainous portions of the Acheloos River basin.

17. Snow Surveys

Snow surveys for determination of the water content of snow-cover on the drainage basin have proved to be valuable aids in reservoir operation and in promoting maximum use of the available water supply. Reference is made to "Snow Surveying", U.S. dept. of Agriculture, Miscellaneous Publication 380 (1940) for description of snow-surveying methods and to an article by H.P. Board-man in Transactions of the American Geophysical Union of October 1947 for a description of use of snow surveys for water-supply forecasts. It is recommended that a program of snow surveys of the Megdova River basin be carried out by the agency operating the Nevropolis reservoir.

18. Evaporation

Evaporation will comprise a sizeable loss from the proposed Nevropolis reservoir and should be determined with greater accuracy than has been possible for this report. It is recommended that an observation station be established in the reservoir area for measurement of (1) evaporation by means of a "land pan",(2) air temperature, (3) hymidity, (4) wind velocity, and (5) barometric pressure. For further details on the method of making these measurements, reference is made to "Evaporation from Lakes and Reservoirs", by A.F. Meyer, Minnesota Resources Commission, St. Paul, Minn., 1942.

19. Temperature Records

It is recommended that recording of daily temperatures be instituted at Karditsa and continued at Trikala.

CHAPTER IV

STATE OF DEVELOPMENT

CIVIC DEVELOPMENT

1. Political Subdivisions

The Megdova basin and the Karditsa plain are located in central Greece in the Nomos (province) of Karditsa. The Nomos is an administrative unit at the head of which is a Nomarch appointed by the Central Government. Each Nomos is divided into Eparchies, which are geographical rather than administrative units. Each Eparchy is further broken down into municipalities: "Demos" for larger towns and "Kinotis" for smaller towns and villages. In both cases a Municipal or Community Board is elected by the local citizens and the board elects a mayor. The mayors of the municipalities are directly responsible to the Nomarchs.

About 35% of the Megdova basin is situated in Evritania Nomos; the remaining 65% of the basin, together with the Karditsa plain, is located within Karditsa Nomos. Nomos boundaries have been indicated on Plate II-1. As the part of Evritania Nomos occupied by the western portion of the Megdova basin is a mountainous sparsely populated and isolated area, it was not included in the project studies except in connection with the hydrologic studies. Karditsa Nomos has an area of approximately 2,500 km^2 and a 1951 population of about 138,000. The Karditsa plain does not have established political or geographic boundaries; for the purpose of this report its limits have been defined in Chapter II as constituting an area of 600,000 str within which the irrigation and agronomic studies have been made.

The responsibilities of the present day local administrative units, the Demos and Kinotis, include levying taxes, allocting expenditures for administrative purposes and financing public services and community improvements. The budget of forty-two Kinotis in the Megdova basin and the Karditsa plain (but not including the municipality of Kard[illegible] drachmae in 1951-52. In addition to monetary taxes, the Kinotis require each citizen to contribute days of their personal labor.

Municipalities will benefit by the recently adopted measure providing for government distribution of the cigarette tax based on population figures determined by the 1951 census. Receipt of such funds will permit the inauguration of many long-delayed local improvement projects.

The existing administrative organization permits home rule only at the municipality level. With advisory aid from the government, the municipalities will prove to be valuable agents in the development of agriculture and in the improvement of living conditions in the villages. All Nomarchs and representatives of the Government ministries at the Nomos seat are political appointees. New administrative forms will be needed to secure local participation in the maintenance and operation of proposed irrigation projects. This subject is treated further in Chapter XII.

2. Towns and Villages

Industrial activity in and near the Karditsa plain is centered in the towns of Karditsa, Larisa, Trikala and Volos and to a lesser extent in the villages of Sofades, Palamas and Farsala.

Karditsa with a population of about 18,500 is the only settlement in the plain which can be characterized as urban. About 65% of city's population is entirely dependent on agriculture while the remainder consists of factory workers, professionals, shop keepers and Government employees; many of the city dwellers also own land and do part-time farming. The urban character of Karditsa, in contrast to the villages and smaller towns in the area, results from the comparatively high living standards of its population. The budget of the municipality of Karditsa amounted to slightly over 2 billion drachmae in 1951-52. Karditsa has its own diesel-electric power plant of about 470 kw; an additional generator of 130 HP is planned for installation in the near future. The power plant furnishes electricity on a

24-hour basis with a short outage each day for inspection and servicing of the units.

Medical service is better in Karditsa than in the other towns of the plain. Besides several doctors, pharmacies and clinics, there is a State hospital and a Municipal hospital. There are 35 doctors and 11 pharmacies in the plain, most of them located in Karditsa. Medical services are generally inadequate to serve the rural areas.

In the Karditsa plain there are 50 rural villages organized into 45 communities, in addition to the municipalities of Karditsa and Sofades, the total population being about 70,000. The locations and approximate size of the villages are shown on Plate IV-1. The population of the villages varies from 350 to 4,300 with 30 of the 51 villages having a population of less than 1000.

3. Population Trends

The fluctuations in population during the past 20 years are given in Table IV-1. The 1951 census compared to that of 1940

TABLE IV-1

FLUCTUATIONS IN POPULATION IN THE KARDITSA PLAIN DURING THE PERIOD 1928-1951

Year	Persons	% of 1928	Families[1/]	% of 1928
1928	52,744	100	9,600	100
1940	61,066	116	11,300	118
1951	69,939	133	13,132	137

1/ Figures for 1928 and 1940 are estimated.

shows an increase in population of 15 percent for the Karditsa plain. This increase indicates that the population of the plain was not affected during the occupation by starvation, enemy action and migration to the same extent as other areas of Greece.

4. Domestic Water Supply and Sanitation

Karditsa is the only settlement in the area provided with a distribution system for domestic water supply. Ample water of good quality, obtained from shallow wells located in former stream beds is available on a 24-hour basis. However, the Karditsa water system is very old and operates under limited pressure. For this reason, running water is generally available only at ground level.

The rural villages obtain their water from artesian wells, drilled or driven tube wells, springs and streams. In most of the villages the water supply is both inadequate and subject to contamination. As one of the villages have standard pressure distribution systems much time and labor is expended in carrying water from wells and springs. Most of the rural homes are small and poorly lighted and sanitary facilities are primitive.

Tuberculosis, dysentery and other intestinal disturbances and occasionally malta fever are the most common diseases found in the area. It is to be noted that most of these diseases are the result of poor sanitation.

5. Living Standards

Living standards within the area are generally low. Basic foods are bread and pulses supplemented by cheese, eggs, some meat and a few vegetables. Clothing is made largely from hand-woven cloth and to a smaller extent from low-grade commercial cotton-cloth. Housing facilities have only slightly improved in recent times and modern household appliances and conveniences are unknown.

6. Education and Training

The existing educational facilities are not adequate to meet the needs of the people. Nevertheless, even these meager facilities could be utilized in carrying forward a reclamation program.

The grade school, comprising six elementary grades, is the main educational institution in the villages. There are 56 grade schools with 90 teachers, serving the 51 villages in the plain. The school buildings are generally inadequate in size; within the plain there is an average of one elementary grade school teacher for 85 students and one high school teacher for 110 students. At least 60 percent of the buildings are in need of remodeling or replacement. Karditsa is the main educational center of the region with 3 high schools and sufficient grade schools to accommodate the population.

One of the deficiencies of the present public school system is that courses in agriculture and home economics are generally not included. Although the work of the Agricultural Services is now being reorganized with the view of providing an efficient extension program for farm men and women of Greece, a great amount of work remains before an effective channel of communication is established between the farm and farm home on one hand and the research centers on the other. This problem is considered further in Chapter V.

INDUSTRIAL DEVELOPMENT

7. Power and Manufacturing

There are at present no hydroelectric power plants in all Thessaly. The Public Power Corporation is planning to bring power into the Karditsa plain in 1953; this power will be generated at the Aliveri electric plant near Chalkis. Further reference to this development is given in Chapter VI.

At the present time only two towns in the Karditsa plain have diesel-electric generating stations. Karditsa has a station delivering power almost continuously; the Sofades plant delivers electricity only at night for lighting purposes. In addition small amounts of power for industrial uses are provided by isolated diesel plants.

The principal industrial plants consist of a modern pneumatic flour mill in Karditsa. This mill which has a capacity of 50 tons of flour per day, produces its own electric power by means of a diesel-electric plant having a rated capacity of 270 kw. In addition there are seventeen other small flour mills, two ice refrigeration plants, nine carding machines, three cotton gins, seven machine shops, seven sawmills and several other smaller enterprises located in the Karditsa plain.

The labor requirements of industry in the Karditsa plain remain insignificant in comparison with the large portion of the

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population in need of employment. [illegible] in home industry, mainly spinning and weaving. The seven carding machines in Karditsa and two in Sofades process wool principally for home use.

8. Mining

As described in Chapter II, there are no mines actively working in the Karditsa Nomos or in the Megdova basin.

9. Agricultural Processing

Industrial processing of agricultural products is limited to milling, ginning, wool carding and extraction of oil from sesame. The balance of the agricultural processing activities in the area is limited to home preparation of farm products for local use.

Dairy products are processed by very primitive methods with very little regard for even rudimentary sanitary requirements. Lack of refrigeration makes necessary the use of excessive salt for the preservation of cheese, thereby adversely affecting the quality of this and similar dairy products. Processed dairy products are produced in sufficient quantities to be shipped out of the area only to a very limited extent.

AGRICULTURAL DEVELOPMENT

10. General

History reveals that the Karditsa plain had a relatively high state of agricultural development in ancient times. Archaeological studies of the Thessaly plain, in which the Karditsa plain is situated, reveal that a developed civilization existed 6000 years before the Christian era. Between 1100 and 800 B.C., the region was invaded by the inhabitants of Epirus, a region in northwestern Greece. These invaders, called Thessalians, gave the area its regional name. Judging from available records the plain has always been devoted to raising grain and livestock. During the Peloponnesian wars (430-400 B.C.) the farmers of the Karditsa area were engaged in active commerce, furnishing grain and horses to the armies of both sides. In 1420, following long domination by the Roman and Byzantine conquerors, Thessaly was occupied by the Turks. It was under Turkish rule, which lasted until 1881, that the culture and customs of the inhabitants were derived. Following the liberation, the lands of the Karditsa plain were generally consolidated into large estates under control of individual landlords. Under this type of farming the lands were well cared for because each landlord had at his disposal a large labor force which could be effectively utilized in maintaining the drainage systems.

In 1922, large areas of the Karditsa plain were expropriated by the Government and redistributed in small parcels to landless farmers. Due to lack of capital, inexperience in maintenance of the drainage works, and other factors, the then-existing drainage works were allowed to deteriorate until large areas of land reverted to semi-swamp. Recently, through the assistance of the Ministries of Public Works and Agriculture and the Mutual Security Administration of the United States of America, a program of levee construction and channel and drainage-canal improvements has been carried forward with excellent results.

The present custom of devoting most of the plain to cultivation of grains and to unimproved pasture lands does not fully utilize the potential capacity of the land to produce crops of high value. The residents of the plain are dependent on agriculture as there are no other significant sources of livelihood in the area. In general, the farmers of the plain have incomes which while little more than required for subsistence, are still sufficient to meet their modest requirements; thus they have not felt a pressing need to change from grain farming to a more intensive type of agriculture. This lack of incentive along with the lack of funds for capital improvements have caused the delay in the development and growth of agriculture through irrigation, drainage and modern farming practices.

11. Land Use and Farm Practices

Although the average farm in the plain contains about 54 str, each farm property is usually divided into small scattered parcels as described in Section 18 below. A large part of the farm work is done by hand, the farm family supplying all the labor. A limited number of modern farm implements and machines are in use; however, most of the farming is performed with obsolete equipment. The principal crops are wheat and small grain, corn and sesame. Livestock subsists on the limited native forage, and no attempt has been made to develop pastures or to plant hay crops. The absence of improved farm practices can be traced to the following causes: (1) lack of economic pressure to change from grain farming to more intensive use of the land; (2) individual land holdings are divided into scattered parcels; (3) the relative isolation of the area until recent times.

The 600,000 str of land comprising the Karditsa plain can be subdivided according to present land use as given in Table IV-2. According to present cropping pattern as given in Table IV-3, of the total of 530,000 str of agricultural land, 380,000 str or 72% is cultivated while the remaining 28% consists of hay-fields, pasture and fallow. About two-thirds of the farm land is used for grain and pasture. Corn and millet is frequently grown on the heavier and wetter lands, but lack of irrigation and drainage greatly reduces the yields. About 22,000 str are affected by floods to the extent that only late spring crops can be raised; however, upon completion of the current flood-control program of the Ministry of Public Works, most of this area will be improved.

Crop rotations consist mainly of alternating sesame, corn or cotton with wheat, or wheat and fallow.

TABLE IV-2

PRESENT LAND USE OF THE KARDITSA PLAIN

	Stremmas	% of total
Agricultural land (including crop land, pastures, and fallow)	530,000	88
Settlements, roads, wasteland	42,000	7
Swamps	21,500	4
Hills	6,500	1
Total	600,000	100

TABLE IV-5

PRESENT CROPPING PATTERN IN THE KARDITSA PLAIN

Crop	Stremmas	% of total
Wheat and small grains	210,000	40
Corn	62,800	12
Sesame	77,000	14
Cotton	12,000	2
Tobacco	3,700	1
Vegetables, potatoes	10,300	2
Pulses and beans	3,200	1
Wine Grapes	1,000	-
Hay, pasture, fallow	150,000	28
Total Agricultural Land	530,000	100

The use of commercial fertilizers is increasing, although at present the use is insufficient to meet the needs of the crops. During the present crop year only about 200,000 kg of nitrogen, 80,000 kg of phosphate and 2,000 kg of potash were used in the plain. The delay in the adoption of fertilizers on a full scale is mainly due to high costs and lack of knowledge of their use.

Preparation of land is chiefly based upon repeated shallow plowing, often resulting in the formation of plow sole. Two-thirds of the plowing is performed by draft animals and one third by tractors. In the Karditsa plain there are about 80 tractors, 80 reaping machines, 40 grain drills, 50 threshing machines, 45 mowing machines and 60 wheat cleaning machines. Transportation is by horse and wagon or by trucks. There are about 8,000 horses and mules, 6,000 oxen and 6,500 donkeys in the plain.

Wheat and corn seed are usually of improved varieties introduced by the Bank of Agriculture and the Agricultural Service. Small grain is broadcast and covered either with harrow or light plowing. Corn is either broadcast or planted in the plow furrow. About one-third of the harvested grain is cut by machinery; the rest is gathered by hand. Threshing is accomplished either by trampling with animals or by threshing machines.

12. Principal Crops

The principal crops grown in the Karditsa plain are shown in Table IV-4 with average yields and values. The following remarks are applicable to the various types of crops.

Wheat and other small grains consitute the most important crop in the plain. About two-fifths of the cropped land is planted in wheat and small grains (barley and oats) and yields about half of the total income from crops.

Sesame: Sesame ranks second in importance and occupies 14% of the farm land. It produces about 10% of the agricultural income.

Corn: Corn occupies 12% of the cropped land. Only a small percentage of the corn acreage is irrigated. Lack of proper irrigation and drainage has resulted in relatively low yields. Corn produces about 10% of the agricultural income.

Cotton and tobacco occupy 2% and 1% respectively of the cropped area. These crops grow well under dry-farming conditions. Yields of cotton could be substantially increased by irrigation. Tobacco culture is limited to certain favorable areas in the foothills. These crops contribute about 6% of the agricultural income of the plain.

Vegetables: Vegetables and watermelons occupy about 2% of the crop-land and yield 5% of the income.

Forage crops: Livestock forage is provided exclusively by natural vegetation on pastures and hayfields, and by crop residues. With improved land and water conditions, legumes and forage crops should form a major part of the crop pattern. Irrigated pastures would reach high feeding capacities and contribute to the active development of livestock industries.

13. Agricultural Income

Farm production costs and net income including livestock in the Karditsa plain are shown in Table IV-5. The gross annual income of the Karditsa plain from crops and livestock, as given in Table IV-5, is 176,000 million Dr. Of this total 106,000 million Dr are used for production expenses including seeds, fertilizers, feed, farm equipment, work animals, motor fuel, land rental fees and interest. The cost of labor is not included as virtually all manpower requirements are met by the members of the farm families.

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TABLE IV-4

PRODUCTION AND VALUE OF AGRICULTURAL CROPS
KARDITSA PLAIN

Crops	Irrigated Area	Irrigated Yield	Non-Irrigated Area	Non-Irrigated Yield	Total area	Price	Total value	Perc. of total area	Perc. of total value	Gross income per str
	(str)	(kg/str)	(str)	(kg/str)	(str)	(Dr/kg)	($Drx10^6$)	(%)	(%)	($Drx10^3$)
Weat and small grain	-	-	210000	160	210000	2000	67200	40	52	320
Corn	2300	160	60500	110	62800	1800	12641	12	10	201
Beans (intercrop)	-	-	(30000)	40	(30000)	4000	(4800)	(6)	4	160
Sesame	-	-	77000	35	77000	5000	13475	14	10	175
Cotton	500	110	11500	80	12000	5000	4875	2	4	406
Tobacco	-	-	3700	70	3700	10000	2590	1	2	700
Vegetables and trucks	2500	1500	7800	1000	10300	600	6930	2	5	672
Grapes	-	-	1000	700	1000	1000	700	-	-	700
Pulses and beans	200	80	3000	60	3200	4000	784	1	-	245
Alfalfa	500	1000	1500	600	2000	600	840	-	1	420
Hay fields	-	-	35000	250	35000	600	5250	7	4	150
Unimproved pastures	-	-	78000	150	78000	600	7020	15	5	90
Fallow	-	-	35000	150	35000	600	3150	6	3	90
Total	6000	-	524000	-	530000	-	130255	100.0	100.0	246

TABLE IV-5

FARM PRODUCTION COSTS AND NET INCOME
KARDITSA PLAIN

(millions of drachmae)

Crops	Production cost per str	Production cost 1/	Gross income	Net income
Wheat and other small grain	0.180	37,800	67,200	29,400
Corn, non-irrigated	0.165	9,980	11,980	2,000
Corn, irrigated	0.200	460	660	200
Pulses and beans	0.200	640	785	145
Beans (intercropped)	0.100	3,000	4,800	1,800
Sesame	0.120	9,240	13,475	4,235
Cotton, non-irrigated	0.155	1,780	4,600	2,820
Cotton, irrigated	0.190	95	275	180
Tobacco	0.320	1,185	2,590	1,405
Vegetables, non-irrigated	0.170	1,325	4,680	3,355
Vegetables, irrigated	0.290	725	2,250	1,525
Grapes	0.285	285	700	415
Alfalfa, non-irrigated	0.140	210	540	330
Alfalfa, irrigated	0.210	105	300	195
Hayfields	0.040	1,400	5,250	3,850
Pasture, unimproved	0.020	1,560	7,020	5,460
Fallow	0.030	1,050	3,150	2,100
Livestock		35,160	45,745	10,585
Total		106,000	176,000	70,000

Note: 1/ Production costs are given in Table V-9 and V-11. Farm labor expenses are not included in the production costs shown above.

The net farm income of 70,000 million Dr is available for the maintenance of farm families. Based on a total of 11,132 farm families in the plain, the average annual net income per family is 6.3 million Dr or the equivalent of $420 at the official rate of exchange of 15,000 Dr to the Dollar. Based on the actual purchasing power of the drachma, a rate of 24,000 Dr to the dollar has been established as explained in Chapter V. With this rate, the average annual net income per family is only $260. Such a family income is capable of sustaining only an extremely low standard of living and provides little opportunity for the farmers to improve their agricultural practices.

14. Forest Products

The mountainous area west of Karditsa in the vicinity of the Nevropolis plain is well suited for forest culture. In the past, the native forests of oak, fir and chestnut furnished the area with considerable lumber and fuel. Uncontrolled cutting has greatly reduced the stand of trees in the area. At present, harvesting of timber is restricted by the government; the cutting of oak and chestnut trees is prohibited while fir trees are cut on a controlled basis. During 1951, about 3,000 m^3 of fir timber was harvested in the region of the Nevropolis plain.

15. Irrigation Facilities and Practices

At present only a very small portion of the Karditsa plain is irrigated. Irrigation with power-driven pumps has been successful, but only a few installations are found in the area. The utilization of pumps on a large scale is handicapped by the fact that each farm is divided in many small, scattered parcels.

Irrigation is accomplished by flooding and diversion from small supply ditches. Furrow irrigation is practiced on limited areas of truck crops. Of the total of 600,000 str in the plain, only about 6,000 str, dispersed throughout the plain, are irrigated.

16. Storage Facilities

There is one commercial refrigerated food storage plant in Karditsa with a capacity of 450 m^3. Four warehouses in Karditsa, Palamas, and Sofades, with a combined capacity of 3,500 T are operated by the Agricultural Bank and the Union of Farm Cooperatives and are used for storing farm supplies, wheat, sesame and cotton. Small private warehouses having a combined capacity of 2,500 T are also rented and used by the Union of Farm Cooperatives.

Dairing has not developed enough to supply sufficient raw milk for modern processing and cheese-making plants. Local processing of individual dairy products requiring a minimum of storage facilities is the usual practice.

17.

As adequate roads are not available to permit ready access to most villages in the plain, it is difficult to move produce to outside markets for general distribution. Farm produce is hauled to villages mainly by horse or buffalo wagons and moved to cities by train and truck. It is expected that local trucking will increase greatly following improvement of rural roads.

The trading centers for the region are the towns of Karditsa, Trikala, Sofades and Palamas. The marketing of principal crops is performed through the Union of Farmers' Cooperatives located in Karditsa.

Grain, sesame and cotton are the principal products marketed. In 1951 about 10,000 T of wheat, 3000 T of barley and oats, 2500 T of sesame, 1500 T of cotton, 1300 T of hay, 700 T of corn and 800 T of pulses were shipped from Karditsa and Sofades to various market centers within the country.

18. Land Ownership and Tenancy.

As described in Section 10 above the lands of the plains were distributed to landless farmers by the Government in 1922. Under the method of distribution followed, the farmers were alloted definite parcels of land; in most cases, however, clear title was not granted so that ownership of much of the land still rests with the Government.

The pattern of land ownership and tenancy is indicated in Table IV-6. The families who do not own land represent the few people who have immigrated into the area plus the normal population increase. Each land ownership is divided into many scattered parcels. Usually each owner has 5 to 10 and sometimes as many as 40 parcels. This interferes with the intensive development of the land, and causes difficulties in the efficient use of machinery. The consolidation of these plots on a rational basis is a prerequisite to the intensive agricultural development of the plain.

19. Land Values

Sales of land in the Karditsa plain have been very limited owing to unsettled conditions and to the fact that a great many of

TABLE IV-6

OWNERSHIP AND SIZE OF FARMS IN KARDITSA PLAIN

Ownership	Number of families	% of families	Area owned 1/	Average size of farm	% of total area
			(str)	(str)	
Up to 50 str	7,220	55	215,000	30	41
From 50 to 100 str	3,680	28	220,000	60	41
Over 100 str	270	2	55,000	200	10
Subtotal	11,170	85	490,000	44	92
Owning no land	1,960	15	-	-	-
Public ownership		-	40,000	-	-
Total land owned and rented	13,130	100	530,000	40	100

Notes: 1/ Although the land is occupied by the farmers in many cases the Government retains a partial interest in the land and 70 to 75 percent of the farmers do not have a clear title.

the farmers to whom land has been distributed do not have clear title. Quotations of land values obtained from local sources were compared to values in other areas and related to capitalized returns. The following land values were established for Karditsa plain:

Non-irrigated crop land not affected by floods, 1,000,000 Dr/str

Non-irrigated crop land subject to floods, 500,000 Dr/str

The total land value is estimated to be about 520 billion Dr. The potential land values to be expected from reclamation are given in Chapter V.

CHAPTER V

AGRONOMY AND AGRICULTURAL ECONOMICS

1. Scope of Agronomic Study

A preliminary field examination of the Megdova project lands was made from June 30 to July 2, 1952. Semi-detailed irrigability-land-classification and use-capability surveys were started July 30 and completed on August 16, 1952. Test pits were dug or bored to a depth of about 1¼ m at intervals of 1 km or where change in topography, vegetation or soil condition indicated a change in soil characteristics. Recently dug stock-watering pits or drainage-ditch banks were studied when practicable. These often exposed profiles to 3-m depths. Soil profiles were examined and guide field tests made of pH, free calcium carbonate, salinity, permeability, texture, structure, related plant indicators and soil type. This information concerning over 200,000 str in the southern part of the plain was recorded on a topographic base map, scale 1:50,000. North of the Meges drain and from below Castro Fanari and the round butte north of Palamas a reconnaissance-type soil survey was made. Major drainage requirements were studied and irrigation water-supply requirements determined. The location and extent of land irrigability classes are described below and shown in Table V-1 and on Plate V-1.

2. Soil Development

The parent geological material from which the Karditsa plain soils are derived consists of the Lower Tertiary sandstone and clay shales of the foothills and the limestones of the higher mountains west of the plain. Soil development has taken place under the influence of a Mediterranean-type climate. The precipitation on the valley floor is about 700 mm and rises to nearly 2,000 mm in the mountains. Natural vegetation is mainly conifer on the high mountains; oak, mostly scrubby regrowth, covers much of the foothills. Soil indicator plants are [illegible] While some of these plants are found on other irrigability land classes, they are most prevalent on the group with which they are listed.

Climatic soil types recognised in the more developed soils include Mediterranean red earth, as in Ithome series, and meadow podzoloic (or ashy bleached soil) of Kierion series. The latter is usually faintly acid to a depth of ¼ to ½ m and contains a few manganese pellets which are largest and most numerous at 30 to 60 cm from the surface.

TABLE V-1

IRRIGABILITY LAND CLASSES 1/
KARDITSA PLAIN

Class	Stremmas	Percentage
Class 1	95,000	15.8
Class 2	410,000	68.3
Class 3	80,600	13.5
Class 4	3,700	0.6
Class 5	3,200	0.5
Class 6	7,500	1.3
Total Land	600,000	100.0

1/ See Section 4 for definition of land classes.

3. Soil Terms

The soil terms used in this report are defined as follows:

A mature soil is a natural active body forming a thin covering on the land surface that supports plants and has characteristic properties that were caused by climate and living matter having acted on the parent material over an extended period of time.

Soil texture refers to the average or effective degree of finess as judged by moistening and kneading soil in the hand until the soil aggregates are broken down and the degree of stickiness determined.

Soil structure refers to the arrangement or natural grouping of soil particles into crumbs, kernels or clods. Platy, blocky or columnar forms may be present in a soil profile as exposed on the side of a freshy dug pit.

A soil province includes groups of soils developed

TABLE V-2

SOIL QUALITY INDICATOR PLANTS

Land Class	Soil series and location	Name: Greek	Name: Common	Name: Scientific
1.	Karditsa Recent alluvial	Itea Platanos Glykoriza	Willow Sycamore Licorice	Salix Sycomorus Glycirrhiza (leguminoza) Glabra L.
2.	Thermon Fans and terraces	Ptelea Dres Gaidourangatho	Elm Oak Blue thistle	Ulmus campestris Quercus (Fagacese) Circium cardus
3.	Kierion and Ithome Old alluvial flats	Gortza Paliouri Almiriki Mentha Agriada Agriotrifili Trifili	Wild pear Thorn Salt cedar Mint Bermuda grass Birdsfoot trefoil Strawberry clover	Pyrus amygdaliformis Paliurus aculcatus Tamarix Mentha lamium Cynodon dachtylon Lotus corniculatus Trifolium fradiferum
4.	Taka Pond clay	Karix Vourla Psathi	Marsh Grass Sedges Tule grass Cattail	Carex Juncus Typha latifolia
5.	Marsh (Gravelly wash)	Gouliara Pikrodaphni	Swamp grass Oleander	Sorghum halepense Nerium oleander L.

A soil group includes several soils within a limited physiographic position.

Soil textural classes: Soils of similar texture may be grouped in a class; e.g., clay loam texture as determined by mechanical analysis or separation of the mineral soil particles into size groups. These class names can be determined by reference to U.S. Department of Agriculture "Manual of Soil Survey", August 1951.

Soil series include soils of similar origin, position, topography, color, drainage, reaction, profile characteristics, fertility and agricultural value.

Soil types: A soil which is a member of a soil series and conforms to one of the above textural groups is designated as a soil type.

Soil type names consist of two parts:

(1) The series name; e.g., Kierion
(2) The texture, e.g., sandy clay loam

These are combined to form the soil type name; e.g. Kierion sandy clay loam.

A soil profile includes all that may be seen in a vertical cut down through the differentiated horizons and into the underlying parent material. Therein is recorded the history of the soil development. The A horizon is the humus enriched, leached surface soil; the B horizon is the zone of accumulation or subsoil; the C horizon is the slightly modified parent material underneath.

4. Irrigability Land Classes

As used in this study, soils are divided into irrigability land classes as follows:

Class 1: Choice, smooth, deep, permeable, neutral soils with good water capacity and fertility; slopes of less than 2%; depths in excess of one meter.

Class 2: Good soils; slightly rolling or hummocky; slopes 2 to 6%; pH less than 8.5; depths in excess of 75 cm; fair usable water capacity and fertility; includes some heavy clay or gravelly areas.

Class 3: Fair land; slopes 6 to 12%; compact gravelly to stony subsoils or mottled clay; groundwater in summer about 1 m below the surface; depths in excess of 50 cm; less than 9.0 pH.

Class 4: Areas of dark brown to black clay that are difficult to cultivate and are subject to cracking or "slaking" upon drying out.

Class 5: Unsuitable due to water logged or saline condition until drained; water-table within 75 cm of the ground surface.

Class 6: Land physically unsuitable for reclamation due to rocky or steep areas, hills or river wash.

Suffixes are used to show the reason for the Class exceptions; the letter "d" indicates poor drainage; "t" topographic defect; "a" indicates alkali or salinity; and "s" indicates soil of defective texture. Ultimate use capacity after drainage is shown in parentheses; example, Class 5(2).

5. Major Soil Series

Six soil series were recognized in the project area including three soil series recognized in reclamation project areas in other parts of Greece, namely, Scala, Ithome and Taka. Of the latter, the first two are of minor extent in the Karditsa plain. The new series, Karditsa, Thermon and Kierion, occupy substantial areas of the plain. A condensed key showing identifying characteristics is presented in Table V-3.

Scala series is distinguished as old non-calcareous residual soil with mottled subsoil on sandstone.

Ithome is old alluvial reddish-brown to rich-brown terrace soil from limestone and mixed rock residues.

Taka is pond bottom or marshy land with drab concretionary sub-soil well supplied with organic matter and total nitrogen when first reclaimed. The deep subsoil frequently contains sedimentary material which may be pale olive-green and highly calcareous.

Karditsa series is recent alluvial calcareous soil, brown or dark brown in color where fertilized with manure and irrigated. This is choice land with a deep permeable profile and suitable for deep-rooted crops or intensive diversified use. Good returns can be realized with double cropping under irrigation.

Thermon series is distinguished as outwash fans and terraces derived mainly from sandstone. The profile is fairly permeable and medium texture. Commonly the top $\frac{1}{4}$ to $\frac{1}{2}$ m of the profile is non-calcareous and rather low in organic matter. Irrigation will permit crop rotations and cover cropping which will improve the humus and nitrogen content of this soil. Thermon soils are capable of fairly intensive use.

Kierion soil series has developed in flats where fine soil particle derived from clay shale have accumulated. It is gray, bleached and somewhat leached at the surface and contains pellets enriched in iron and manganese in the upper subsoil. Fields composed of Kierion soils have been prepared by plowing dead-furrows repeatedly in the same place for surface drainage. Intensity of development of ashy or podzoloic soil has been accelerated by ponded water or high water-table. With water and weed control and use of phosphates, improved pastures with 2 to 3 times the present carrying capacity could be developed.

6. Laboratory Analyses of Soil Samples

Soil profiles were sampled at five locations. An additional sample was collected from the deep subsoil on the salty drain-bank east of Castro. Three water samples were also collected. All samples were submitted to the Central Soils Laboratory of the

TABLE V-3

KEY TO MAJOR SOIL SERIES
KARDITSA PLAIN

	I Recent Alluvials		II Mature Alluvials		III Residuals	
Series	KARDITSA	TAKA	THERMON	KIERION	ITHOME	SKALA
Position	Bankland	Marsh	Fans and terraces	Flats	Old fans terraces	Hill
Distribution	Karditsa and Palamas	N Central	SW to SE	SW and W	Below Castro	SW corner
Vegetation	Sycamore, licorice	Reeds, marsh grass	Elm, oak	Bermuda thistle clovers	Oak, thorn	
Annual precitation mm	700	700	720	700	750	750
Parent material	Limestone & mixed	Sed. org. material limestone & mixed	Sandstone	Clay, shale & mixed	Limestone & mixed	Sandstone
Color:						
Surface	Gr-Br, Dk-Br	Drab	Li Br	Drab	Dull red	Drab yellow
Top subsoil	Prown	Dk Gr-Br	Tan	Gray	Rd-Br	Tan
Deep subsoil	Yel-Br	Yel-drab sed. cracks	Yel-Br	Yel-Br	Yel-Br	Yel-Drab
Special features	mellow	mottled slakes	non calcareous to ½ m	Low pastures furrowed	Compact	Mottled
Drainage	good	poor	fair	poor	fair	fair
pH	7.2	7.2-8.0	6.8-7.0	6.6-7.0	7.4	6.6-6.9
Textural types	SiCL	Si-C; C	SCL-CL	SiC-C	Si-C	SL, SCL

TABLE V-3 (Continued)

KEY TO MAJOR SOIL SERIES
KARDITSA PLAIN

	I Recent Alluvials		II Mature Alluvials		III Residuals	
Net irrigation requirement mm	750	650	700	700	700	700
Irrig. class	1	5(3)	2	3	3	3
Needs	P, Legumes	Dr, P, Legumes	P, Legumes	Dr, P, Legumes	P, Legumes	P, Legumes
Use capability	Intensive	Shallow rooted crops	General	Pasture,& annuals	Tobacco, grapes	Tobacco, melons

NOTES: 1. Li = light; Br = brown; Gr = gray; Yel = yellow; Rd = red; Dk = dark; Pk = pink.
2. Si = silt; S = sand; C = clay; L = loam.
3. Dr = drainage; P = phosphate.

Ministry of Agriculture; the results of soil analyses are shown in Table V-4 while the results of the water analyses were given in Chapter III. The field locations from which the soil samples were collected are shown in Plate V-1.

Usable water capacity is the difference between the capillary moisture that a soil will retain against gravity or "field capacity", and the moisture content below which plant growth can no longer be maintained, called "permanent wilting percentage" or PWP. Field capacity was determined by centrifuging against 1000 times gravity. The moisture retained after centrifuging 30 minutes, expressed as percent dry weight, is called moisture equivalent percentage (ME). If the ME is known, the PWP can be estimated because it is approximately one half the ME. In order to convert usable water capacity from percent to millimeters it has been necessary to determine or estimate the volume weight or apparent specific gravity of each soil horizon as shown in Table V-5.

A good irrigable soil should have a usable water capacity of at least 100 mm per meter of depth. A good productive soil should contain to plow depth the following chemical nutrients per hectare:

Total nitrogen as N, about 0.12 percent or 3,000 kg.

Available phosphate, expressed as P_2O_5, 115 to 180 kg.

Available potash, expressed as K_2O, 600 kg.

The analyses show Sample 1 (Karditsa) to be sandy loam with somewhat defective texture and fair usable water capacity; it is low in organic matter, but good in total nitrogen; the supply of available potash is excellent, while available phosphorus is very good in the upper horizon (0-25 cm) and deficient in the lower. Sample 2 (Taka) is clay with large usable water capacity, good organic matter content and high total nitrogen; available potash is good but the available phosphorus is deficient in the first horizon and high in the lower. Sample 3 (Thermon) is loamy sand with good usable water capacity; organic matter and total nitrogen are low; the supply of available potash is good but that of available phosphorus is very low. Samples 4 and 5 (Kierion) are from

TABLE V-4

PHYSICAL AND CHEMICAL SOIL CHARACTERISTICS

Sample No. / Location	Size (mm)	1 (XXXX, Hole 94) E of Karditsa			2 (XXXXII, Hole 375) 8 km N of Karditsa			3 (XXXVIII, Hole 48) 4 km SW of Karditsa		
Depth cm		0-25	25-50	50-100	0-30	30-50	50-100	0-50	50-100	100-15
Series		KARDITSA			TAKA			THERMON		
Physical Properties										
Coarse sand, %	2-0.2	2.0	1.0	1.0	0.8	0.8	0.5	17.0	15.0	2.0
Fine sand, %	0.2-0.02	72.0	73.0	56.0	34.0	38.0	38.0	67.0	67.0	60.0
Silt, %	0.02-0.002	12.0	10.0	19.0	22.0	28.0	31.0	4.0	6.0	13.0
Clay, %	below 0.002	14.0	16.0	24.0	43.2	33.2	30.2	12.0	12.0	25.0
Total sand, %		74.0	74.0	57.0	34.8	38.8	38.8	84.0	82.0	62.0
Textural class		Sandy loam			Clay			Loamy sand		
Moisture equivalent		14.5	13.6	17.2	23.1	20.5	19.9	10.3	9.8	18.1
Specific gravity		1.14	1.15	1.15	1.44	1.41	1.41	1.30	1.44	1.44
Usable water cap., mm/m		90			148			100		
Chemical Properties										
pH		7.8	7.7	7.5	7.8	7.7	8.2	7.8	7.7	7.5
Organic matter, %		1.64	0.77	-	2.35	1.27	-	0.35	0.45	-
N available, kg/ha		68.0	43.2	43.2	94.5	62.1	57.7	25.4	25.4	50.8
Total N, %		0.126	0.080	0.080	0.175	0.115	0.094	0.047	0.047	0.094
P_2O_5 available, kg/ha/18 cm		360.0	72.0	-	72.0	216.0	-	54.0	25.0	-
K_2O available, kg/ha/18 cm		2700.0	1125.0	-	1350.0	675.0	-	675.0	675.0	-
$CaCO_3$ %		T	0.4	T	16.0	13.1	13.0	0.6	0.5	0.5
Exchangeable Na, m.e./100 gr		2.0	1.2	2.0	3.0	0.6	2.4	0.4	0.8	1.2
Cl, %		0.011	0.17	0.017	0.006	0.006	0.011	0.011	0.011	0.011
Total salts, %, by conductivity		0.11	0.11	0.11	0.18	0.20	0.16	0.14	0.14	0.14
Base exch. cap., m.e./100 gm		15.9	14.4	18.4	30.0	20.7	20.0	20.7	15.2	24.1
Irrigability land class		1s			3ts			2		

TABLE V-4 (Cotninued)

PHYSICAL AND CHEMICAL SOIL CHARACTERISTICS

Sample No. / Location	4 (XXXIX, Hole 93) 4 km SE of Karditsa			5 (XXXXI, Hole 339) 1.5 km SE of Markou		
Depth cm	0-25	25-50	50-100	0-30	30-50	50-100
Series		KIERION			KIERION	
Physical Properties Size (mm)						
Coarse sand, % 2-0.2	3.0	3.0	1.0	0.8	0.8	0.5
Fine sand, % 0.2-0.02	58.0	53.0	48.0	34.0	38.0	38.3
Silt, % 0.02-0.002	19.0	15.0	15.0	22.0	28.0	31.0
Clay, % below 0.002	20.0	29.0	36.0	43.7	33.2	30.2
Total sand, %	61.0	56.0	49.0	34.8	38.8	38.8
Textural class		Sandy clay loam			Clay	
Moisture equivalent	16.6	16.9	18.7	25.1	20.5	18.8
Specific gravity	1.51	1.41	1.31	1.35	1.35	1.35
Usable water cap., mm/m		122			150	
Chemical Properties						
pH	5.9	5.6	6.3	7.4	6.4	7.5
Organic matter, %	1.01	0.28	-	2.45	1.52	-
N available, kg/ha	54.0	35.1	37.8	54.0	54.0	-
Total N, %	0.10	0.064	0.070	0.171	0.115	0.094
P_2O_5 available, kg/ha/18 cm	72.0	54.0	-	54.0	54.0	-
K_2O available, kg/ha/18 cm	2250.0	1125.0	-	900.0	1125.0	-
$CaCO_3$ %	T	T	T	1.17	T	T
Exchangeable Na, m.e./100 gr	1.8	1.6	1.6	2.0	2.4	2.0
Cl, %	0.006	0.011	0.006	0.011	0.011	0.035
Total salts, %, by conductivity	0.11	0.11	0.11	0.18	0.14	0.14
Base exch. cap., m.e./100 gm	12.4	18.4	28.7	28.8	27.4	22.2
Irrigability land class		2s			3ds	

NOTE: T - trace

sandy loam to clay, with good usable water capacity, the organic matter varies from fair to good; available potash is very good, but available phosphorus is very low. Base exchange capacity in all samples is good.

TABLE V-5

USABLE WATER CAPACITY
OF KARDITSA PLAIN SOILS

Soil type and Sample No.	Depth	Moisture equiv.	Usable water	Apparent sp.gr.	Usable Water capacity	
	(cm)	(%)	(%)		(mm)	(mm/m)
Karditsa SL	0-25	14.5	7.25	1.14	20.6	
40, Hole 94 by	25-50	13.6	6.8	1.15	20.0	
Cemetery E Karditsa	50-100	17.2	8.6	1.15*	49.5	90
Thermon LS	0-20	10.9	5.45	1.30	14.1	
38, Hole 48	20-50	9.8	4.9	1.44	21.0	
4 km SW of Karditsa	50-100	18.1	9.05	1.44*	65.0	100
Kierion SL	0-25	16.6	8.3	1.51	31.3	
39, Hole 93	25-50	16.9	8.45	1.41	29.7	
6 km SE of Karditsa	50-100	18.7	9.35	1.31	61.2	122
Kierion C	0-25	25.1	12.55	1.35	38.2	
41, Hole 339	25-55	20.5	10.26	1.35	41.6	
1.5 km SE of Markou	55-100	18.8	9.4	1.35*	69.8	150
Taka C	0-30	23.1	11.5	1.44	49.7	
42, Hole 375	30-50	20.5	10.25	1.41	28.6	
8 km N of Karditsa	50-100	19.9	9.9	1.41*	69.6	148

* Estimated

7. Drainage and Salinity Control

The Karditsa plain area already has a major system of existing dikes and deep drains; however, attention to control of seepage and waste water will be needed to protect perennial plants on land with impeded internal drainage. Excessive irrigation tends to lower soil temperature, exclude air, and create a toxic condition for plant roots and legume bacteria which may encourage the growth of undesirable water-tolerant weeds or may cause moulding of green vegetables.

Extension of lateral drains will be needed to lower the water-table in the northeast and southwest extremities of the project and to clear out salinity in a few low areas where salt cedar is now prevalent.

Good surface drainage should protect clovers from damage due to winter ponding on the slowly permeable Kierion soils. Heavy black clay areas of Class 4 irrigability land north and east of Palamas may best be excluded from the irrigation project so the water can be used on the best irrigable land.

Existing spoil banks should be levelled off for roadways as needed. Bridges are needed for crossing drains at least every 2 km. Other spoil-banks should be smoothed down and planted to Bermuda grass and strawberry clover or other sod-producing plants to afford some pasture and help control weeds along the ditches and levees.

8. <u>Land Use Capacity</u>

The yields from crops now grown in the Karditsa plain reflects the lack of drainage, flood control, irrigation, weed control and outmoded farm practices. Present and prospective crop yields by land irrigability classes are given in Table V-6.

With irrigation, two immediate effects on the present agricultural pattern will be: (1) increased yield of crops now grown and (2) changes in the present cropping pattern. Both these effects can take place with little or no change of the present land-tenure system. The expected crop pattern and yields for a representative "sample area" of 100,000 str (see Section 15) are indicated in Table V-7 under the columns headed B.

Further changes in both cropping patterns and yields are attainable through better farming practices inclucing the use of fertilizers and improved seed but without increasing the present size of the farmed units. The columns headed C in Table V-7 show the pattern and yields which should be attainable 15 years after completion of the works as discussed further in the section on Economic Gains from Irrigation.

The cropping pattern and yields shown under columns D of Table V-7 represent the maximum average capability of the soil attainable with modern farming practices and cooperative use of the land so as to permit farming in sufficiently large tracts.

TABLE V-6

PRESENT AND PROSPECTIVE CROP YIELDS BY LAND IRRIGABILITY CLASSES

Land class	Soil series	Crop	Present yield	Yield with irrigation and improved practices
			(kg/str)	(kg/str)
1	Karditsa	Beans, green	700	2,000
		Melons	700	2,000
		Corn	120	350
		Cotton	80	250
		Alfalfa	700	1,250
2	Thermon	Melons	500	1,500
		Sorgo	150	350
		Corn	100	300
		Cotton	60	150
		Dry beans	50	100
		Sesame seed	35	100
		Winter wheat	200	300
3	Kierion	Winter wheat	120	200
		Sesame	30	75
		Corn	80	250
		Improved pasture sheep/str	1	2.5
4	Taka	Sorgo	270	500
		Corn	100	180
		Improved pasture sheep/str	3/4	2

9. Consumptive Use and Net Crop Requirements

Crops may be classified, according to their consumptive use requirements, into three general classes: (1) high requirement crops including alfalfa and pasture; (2) medium requirement crops including corn, cotton, vegetables, deciduous fruit; and (3) low requirement crops including grapes, beans, sesame and grain. Consumptive-use and net crop requirements for the various crops were determined in accordance with the procedure outlined in the publication by Blaney and Criddle, USDA Department of Agriculture public-

TABLE V-7

CROP PATTERN AND YIELDS-PRESENT AND FUTURE DEVELOPMENT
KARDITSA PLAIN

Sample irrigation area of 100,000 stremmas

Crops	Area in stremmas					Yields in kg/str				
	Present A		Future (irrigated)			Present A		Future (irrigated)		
	Non-irrig.	Irrig.	B	C	D	Non-irrig.	Irrig.	B	C	D
Wheat and other small grain	40,000	-	20,000	10,000	5,000	160	-	200	250	250
Wheat, other grain, double crop	-	-	-	(5,000)	(7,000)	-	-	175	250	250
Corn	11,400	400	25,000	15,000	10,000	110	160	250	350	350
Beans	600	40	2,000	3,000	3,000	60	80	120	150	150
Beans, intercropped	(5,700)	-	-	-	-	40	-	-	-	-
Sesame	14,500	-	5,000	3,000	3,000	35	-	100	125	125
Cotton	2,500	100	25,000	30,000	35,000	80	110	150	200	200
Vegetables and truck	1,500	460	3,000	5,000	5,000	1,000	1,500	1,800	2,000	2,500
Grapes	200	-	500	2,000	2,000	700	-	1,000	1,200	1,500
Fruit, deciduous	-	-	500	3,000	3,000	-	-	600	750	800
Alfalfa and pasture	300	100	15,000	25,000	30,000	600	1,000	1,000	1,150	1,150
Hayfields	6,600	-	-	-		250	-	-	-	-
Vetch cover crop	-	-	(5,000)	(25,000)	(30,000)	-	-	150	200	200
Clover in wheat stubble	-	-	(1,000)	(5,000)	(5,000)	-	-	500	500	500
Fallow or idle	6,600	-	4,000	4,000	4,000	150	-	-	-	-
Sub-Total	84,200	1,100	100,000	100,000	100,000	-	-	-	-	-
Pastures unimproved	14,700	-	-	-	-	150	-	-	-	-
						-	-	-	-	-
Total	98,900	1,100	100,000	100,000	100,000	-	-	-	-	-

Numbers in ( ) are double crops.

ation [illegible] given in Table V-8 the factors considered are: crop, mean monthly temperature and duration of daylight (a function of the geographical latitude). The project irrigation requirements are given in Chapter VII.

10. Preparation of Land and Methods of Irrigation

Wherever, practicable, the initial preparation of land for irrigation should be carried forward on large tracts. There are few buildings or fences in the Karditsa plain to interfere with this work. Preparation of the land in this manner will permit more efficient use of construction equipment and will result in an integrated development of the irrigation facilities. The preparation od the land by groups of farms suggests the desirability of consolidating scattered ownerships so that each farm can be operated as a compact land unit under one irrigation lateral.

Each farm field should be properly graded or leveled to establish a continuous slope as uniform as practicable. Such land preparation is necessary to obtain uniform irrigation, and in general to increase the ease and efficiency of application of water. The land leveling should be consistent with the method of irrigation to be used and the limitation of the soil slopes and profile characteristics. Steeper lands using the furrow or corrugation method of irrigation generally do not require as precise leveling as bottom lands. In shallow soils or soils having layers of gravel at shallow depths, great care should be taken to see that the sterile subsoils are not exposed during the land leveling process. In such instances it is better to modify the type of irrigation to a method that will maintain the shallow topsoil as nearly as possible in its original state. Deeper soils of Class 1 or Class 2 lands can stand more severe leveling; in some instances lands of Class 2 could be changed to Class 1 simply by grading and smoothing. Land leveling can be most efficiently performed with a heavy construction-type tractor and carryall scraper; usually the land is again floated with a drag or land plane the following season after final settlement of filled-in areas has taken place. The hydraulic Fresno-type leveler and the Eversmen-type smoother are also efficient for use in land preparation.

Flood irrigation may take any one of several forms and can be used generally for forage crops, orchards, and field crops where the topography is such that the border, check, basin or contour stripping methods can be applied. Under any

TABLE V-8

CONSUMPTIVE USE OF WATER BY CROPS
KARDITSA PLAIN

(millimeters)

Crops	Growing season	K	Mar. f 110	Apr. f 137	May f 174	June f 195	July f 213	Aug. f 198	Sept. f 157	Oct. f 124	Season total
I High requirement											
Alfalfa & pastures	3/1-10/31	.80	88	110	139	156	171	159	126	99	1048
Clover in wheat	6/1-10/31	.80	-	-	-	156	171	159	126	99	711
II Medium requirement											
Corn	5/1-8/31	.80	-	-	139	156	171	159	-	-	625
Cotton & raw peas	5/1-9/30	.65	-	-	113	127	139	129	102	-	610
Vegetables & orchards	3/1-9/30	.65	-	89	113	127	139	129	102	-	699
III Low requirement											
Grapes	4/1-9/30	.50	-	69	87	98	107	99	79	-	539
Beans & sesame	5/1-8/31	.60	-	-	105	117	128	119	-	-	469
Grain	10/1-4/30	.80	88	110	-	-	-	-	-	99	297
Vetch cover crop	10/1-4/30	.80	88	110	-	-	-	-	-	99	297

NOTES: 1. Consumptive uses in November, December, January, and February are not considered because of adequate rainfall.

2. Consumptive use coefficient K for each crop was taken from U.S. Dept. of Agriculture publication SCS-TP-96.

3. Factor $f = \frac{(t_c + 18)}{2.2} p$, where t_c = mean monthly temperature in degress Centigrade and p = percentage of daylight hours.

4. Consumptive use u = kf.

of these types of irrigation the land surface is covered by a sheet of water sufficient to replenish the water supply in the root zone and to bring the soil up to field capacity. Strip borders should be more generally used on valley-floor lands. Smaller borders are required if spaced 7 to 8 m apart and carried directly down the slope perpendicular to the contours. A nearly level area at the head of the strip and ample size of headgate will facilitate the even distribution of water.

Furrow irrigation is adapted to row crops and orchards. Water is diverted into small furrows and allowed to run until sufficient has percolated and spread into the root zone. Corn and cotton should be irrigated by the furrow method.

Tests of water penetration should be made by probing to determine that irrigation is adequate before turning off the water supply and to avoid over-irrigation. Where the supply of irrigation water is abundant, it is common practice in Greece to over-irrigate. This over-irrigation causes saturation of the soil, reduces yields, and contributes to the formation of swamps. Over-irrigation is sometimes desirable for leaching of saline soils. Areas which are adversely affected by concentrations of sodium or other toxic salts should be treated with calcium sulphate or sulphur and manure and then copiously irrigated to leach away the objectionable salts. Where neutral sulphates or chlorides of calcium, potassium or magnesium are encountered in objectionable quantities, the land can be reclaimed by deep drainage and copious irrigation. After adverse saline conditions have been corrected, further treatment will be unnecessary in consideration of the high winter rainfall.

Permeability of tight soils may be improved by adding organic matter with deep rooted legumes such as alfalfa, and by deeper plowing when soil is at the proper soil moisture content, so that plow-sole can be loosened.

The publication "Theory and Practice of Irrigation" by W.E. Packard, Greek Ministry of Agriculture Extension Bulletin No. 1, January 1949 should prove useful in educating Greek farmers in good irrigation practices.

11. Crop Adjustments with Irrigation

With irrigation, the following desirable agricultural practices can be accomplished: (1) The practice of fallowing may be eliminated; (2) perennial soil building legume crops may be grown in a rotation with grain and row crops; (3) annual legume crops may be used (the latter may include vetch as a winter cover and humus-building crop and cowpeas or kidney beans as an intercrop with cotton or corn); (4) stalks, legume vines or stubble can be plowed under (after pasturing, manure or ammonium sulphate should be added to aid in their transformation into humus).

Soil building legumes now growing in the area to a limited extent include alfalfa, birds-foot trefoil (Lotus corniculatus), strawberry clover (Trifolium fragiferum), broad beans, little kidney beans and vetch. Cow peas (Vigna sinensis) should make a good summer intercrop, ladino clover (Trifolium repens) should be included in irrigated pasture mixtures. Chick peas (Cicer arientinum) are grown in small area now and the cash value per stremma is relatively high. Peanuts can be grown on the free working textural types of Karditsa and Thermon soil series.

Soil saving grasses for inclusion in pastures to provide turfiness and lessen tendency of legumes to cause bloating, include perennial rye grass (Lolium perenne), Harding grass (Phalaris tuberosa), alta (tall) fescue (Fescue elatior) and meadow foxtail grass (Alopecurus pratensis). The latter grass tolerates innundation. Sweet sudan grass (Sorgum sudanense) can be sown after winter grain for late summer forage.

Cultivated field crops of major importance suited to the conditions are cotton, sorgo, early corn and dry beans.

Vegetable crops which thrive in the area include melons, tomatoes, okra, egg plant, green beans, onions, lettuce, peppers, peas and squash.

12. Crop Rotation Systems

The recommended crop rotation for vegetable growers on Class 1 irrigability land is as follows:

Vegetables 4 years, Alfalfa or pasture 4 years.

The recommended crop rotation for the general farm Class 2 and 3 lands is:

a. A three year rotation: Grain-legumes-rowcrop,

b. The previous rotation with alfalfa grown for 4 to 6 years at a time on one-fourth the crop area and then shifted to a different quarter of the area.

c. A four-year rotation: Grain-legumes-rowcrop-row-crop with fertilizer.

On heavy Class 3 or Class 4 land, shallow-rooted legumes and grasses should be periodically plowed up and their residues utilized in the growing of sorgo, cotton or corn.

The above crop rotations conserve water and soil fertility and help to control pests.

13.

The practice of burning or removing stubble and other coarse crop residues should be discontinued. These residues will form needed humus if plowed into the soil. Treatment of these residues with nitrates or manure will help their transformation into humus and eliminate adverse effects on the immediate supply of nitrates in the soil. Production of manure will increase with the expansion of livestock industries which will utilize the improved forage grown by irrigation. Proper use of manure will be essential for attaining high levels of soil fertility.

Use of commercial fertilizers is an essential part of intensive agriculture, particularly under irrigation. However, it will be found profitable to secure the largest part of the nitrogen supply from the legumes included in rotations. Phosphate will be needed in starting perennial legumes. Phosphates are also effectively used to balance or reinforce barnyard manure and help in retention of ammonia.

Weed control is essential in the area. Dodder patches, thistle, velvet weed, bindweed, cocklebur and sourdock are weeds. frequently found in the area. A cooperative water-users association will be needed and the routing of a power-driven weed sprayer should be one of its projects.

14. Pasture Management

Improved pasture management will be important in the extensive areas of Class 3 lands which are best suited to pasture. Irrigated pastures should be started on a fine, firm, moist seed bed. Seed of new legumes should be inoculated. Use of 16 kgs of 42 percent superphosphate per str is desirable. Pastures should be divided into three equal parts to permit rotational grazing, say 10 day on and 20 day off of each lot. Young plants should be allowed to get well rooted before pasturing begins and care should be taken to avoid pasturing too closely. Also it is necessary to avoid pasturing when soil is soft and muddy. Clipping coarse weedy growth once or twice in late season is needed. Thistle or dock may best be pulled out. Harrowing droppings and application of superphosphate or manure in the fall will promote growth. The carrying capacity of a good pasture mixture with irrigation should be $2\frac{1}{2}$ to 3 sheep per str. Pasturing appears to be the best use for the heavy Class 3 soils.

VALUE OF AGRICULTURAL PRODUCTS

Greece, although primarily an agricultural country, is deficient in food production. Imports in the years 1935-38 average $97.2 million and provided about 30% of the calories consumed. In the two-year period from July 1, 1950 to June 30, 1952 Greece's food imports from the United States totaled $158,000,000. Consumption of food in 1935-38 provided 2,500 calories daily per capita as compared to over 3,000 in the United Kingdom and most West European countries.

The increase in agricultural production resulting from the recommended plan of development for the Karditsa plain can be readily absorbed in the domestic and foreign markets.

15. Sample Irrigation Area

Agricultural statistics presented herein have referred to the 600,000 stremmas defined previously as the Karditsa plain. For simplification of the agronomic and economic evaluations, a representative area surrounding the town of Karditsa, herein termed the "Sample Irrigation Area", has been selected. It contains 100,000 stremmas to be irrigated annually. The area finally selected for irrigation contains 114,000 stremmas irrigated annually, and as this area has a soil-type distribution similar to the sample area, it would produce crops and livestock having 1.14 times the value of that produced in the sample area. The sample area is divided according to soil type as follows: 39% Class 1 land, 59% Class 2 land and 2% Class 3 land.

16. Domestic Market for Agricultural Products

The crops that will be grown in the sample irrigation area with irrigation are listed in Table V-7 and V-9. The effects

TABLE V-9

CROP PRODUCTION IN TONS PRESENT AND FUTURE DEVELOPMENT
KARDITSA PLAIN

Sample irrigation area of 100,000 str.

Crops	A - Present			Future		
	Non-irrigated	Irrigated	Total present A	B	C	D
Grain	6,400	-	6,400	4,000	3,750	3,000
Corn	1,250	70	1,320	6,250	5,250	3,500
Beans	265	3	268	240	450	450
Sesame	510	-	510	500	375	375
Cotton	200	10	210	3,750	6,000	7,000
Vegetables and truck	1,500	690	2,190	5,400	10,000	12,500
Grapes	140	-	140	500	2,400	3,000
Alfalfa and pastures	180	100	280	15,000	28,750	34,500
Hay	1,650	-	1,650	-	-	-
Fruit deciduous	-	-	-	300	2,250	2,400
Vetch and grain hay	-	-	-	750	5,000	6,000
Pastures unimproved	2,200	-	2,200	-	-	-
Fallow	1,000	-	1,000	-	-	-
Clover in wheat stubble	-	-	-	500	2,500	2,500

on the domestic market of the increased production of the principal crops are discussed below. Other less-important crops, such as deciduous fruits, grapes, vegetables, and sesame seed will be produced in such small quantities as compared with the existing demand for these products that the domestic market will not be materially affected.

<u>Grain</u>: The most important element in the Greek diet is grain as is the case in all countries with low standards of living. Annual per capita consumption of grain in 1935-38 was about 180 kg in Greece as compared to about 100 kg in the United States; approximately one-third of this amount was imported. Local production has increased since the war but the country still imports about 400,000 T of bread grains yearly. In order to decrease these imports, development will be toward higher yields per stremma, permiting reduction of the total strommas farmed in grains. With improvement of the country's general economy, incomes and standards of living will rise causing an increase in the consumption of higher quality foods and a decrease in the consumption of bread.

In the sample irrigation area it is anticipated that the percentage of land planted to wheat will decline perceptibly in favor of other crops with higher income. Nevertheless, although the area planted with wheat will decrease to one-fourth the area in wheat at present, it is estimated that future tonnage will be reduced to only half of the present tonnage.

<u>Corn</u>: Another important factor in the nutrition of the Greek population is corn. It is estimated that about one half of the 200,000 T of corn raised annually is used for bread. This is about 1/12 of all bread grains or an average consumption of about 13 kg per capita. The use of corn for bread is restricted, however, to rural areas with greater consumption in the mountainous areas. No prepared corn (cereal) is used in Greece. Present annual consumption of corn products in Greece is about 1 kg of syrup and 0.2 kg of starch per capita as compared to 3.5 kg of syrup, 2 kg of corn sugar, and 0.7 kg of corn starch consumed annually in the United States. The attainment in Greece of consumption levels similar to those prevailing in the United States would provide an

ultimate market for an additional 110,000 T or for an expansion of present total production by 50 percent. Such development will reduce the consumption of imported foods such as wheat and sugar.

Corn is now grown on about 11,800 stremmas in the sample irrigation area of the Karditsa plain producing 1,300 T of grain. The improvement of drainage and the expansion of irrigation will increase the yield and encourage the use of improved farm practices. Although rotation needs and competition by other crops will permit only a small increase in the corn acreage, with higher yields production will increase to about 5,000 T.

Beans: The annual consumption of beans in Greece is approximately 11 kg per capita, used mainly as dry beans. Approximately one-third of the total required quantity is imported from other countries. The Karditsa plain is favorable for cultivation of this crop, and if irrigated will give high yields of 150 to 200 kg per stremma. It is estimated that beans will be grown on 3,000 stremmas, producing 450 T.

Meat: Consumption of meat is low in Greece. In 1935-38 the total consumption of all kinds of meat was estimated at 19 kg per capita, 1/7 of which was imported. This compared with 80 kg in the United States and 120 kg in New Zealand. Conditions of dense population in Greece will not favor the establishment of the large-scale beef industry typical of countries with vast land resourses, but the cattle and pork raising activities will expand and will constitute a market for the increased corn and other animal food crops. Present annual consumption of pork in Greece is estimated at 2.2 kg/capita as compared to over 30 kg in the United States. If pork consumption in Greece is raised to only half that in the United States, a production of 100,000 T of pork will be required in addition to 17,000 T presently produced. This would require feed amounting to 400,000 T of grain, mainly corn.

Prewar consumption of beef from local production was estimated at 2 kg per capita and was supplemented by imports of 0.8 additional kg per capita. Present demand in Greece, as indicated by imports, suggests an immediately available market for over 5,000 T of beef. It is estimated that the sample area will add

450 T of beef to the present supply.

Dairy products must make the greatest contribution to the improvement of the Greek diet. Present consumption of milk and milk products is extremely low in Greece as shown by the comparison with other countries in Table V-10.

TABLE V-10

CONSUMPTION OF MILK AND DAIRY PRODUCTS

kg per capita annually (1935-38)

Product	Greece	United States	England
Milk	43	154	94
Cheese	9	3	41
Total milk (milk and dairy products in milk equivalent)	125	500	700
Butter	1	7	11

To double the present consumption of milk and dairy products of 1,000,000 T would require the replacement of about 500,000 native low-producing cows by improved animals.

The production of forage as required for maintaining and improving soil productivity will make possible improved feeding and higher yields of ewes and will also support about 5,000 improved dairy cows thus adding 11,000 T to the present milk production of 1,000 T. The urban center of Karditsa and the farm population provide a market for 2,000 T of fresh milk, while 10,000 T will be processed for cheese and butter. Table V-11 shows the present and future livestock income.

17. Foreign Markets for Agricultural Products

Exports of farm products constitute an important and necessary element of Greek economy as 3/4 of the value of all Greek exports consists of farm products. The improvement of Greek agriculture will reduce imports of food which now absorb two-thirds of the foreign exchange secured from agricultural exports.

The most promising exportable farm product from the Karditsa

TABLE V-11

LIVESTOCK INCOME
KARDITSA PLAIN

(millions of Dr)

Sample irrigation area of 100,000 str 1/

Kind	Head		Gross income 2/		Production cost excluding labor 3/		Net farm income		Cost of labor		Surplus	
	A	C	A	C	A	C	A	C	A	C	A	C
Cattle:												
Cows, dairy	1,320	4,700	1,780	23,580	1,210	17,700	570	5,880	100	3,610	470	2,270
Beef	940	1,890	620	1,450	530	1,130	90	320	40	250	50	70
Buffaloes (milk)	210	-	310	-	260	-	50	-	20	-	30	-
Sheep	16,970	9,430	3,770	3,770	2,730	2,830	1,040	940	520	620	520	320
Goats	190	-	60	-	40	-	20	-	10	-	10	-
Hogs	1,130	1,890	680	1,890	590	1,410	90	480	70	300	20	180
Poultry	18,860	47,000	1,420	5,535	1,160	4,130	260	1,405	170	920	90	485
Total	-	-	8,640	36,225	6,520	27,200	2,120	9,025	930	5,700	1,190	3,325
Selected irrigation area			9,850	41,290	7,430	31,000	2,400	10,290	1,060	6,500	1,360	3,790

1/ Irrigated annually.
2/ Includes the value of the total livestock production (milk, meat, dairy products, eggs, wool and hair).
3/ Includes the value of feeds either raised on farm or purchased, and other costs.

area is cotton. Cotton will be the principal cash crop on the better land and can benefit from the effect of soil-improving rotations. Yields of cotton will be high while, with prevailing rates of wages, production costs will be low. The proximity of countries lacking cotton, as Yugoslavia, Albania and Italy, increase the possibilities for profitable exports of cotton.

In case of depressed world trade and low prices, the industry can depend to some extent on an expanding local market. Present per capita consumption of cotton in Greece is less than 1/4 the consumption in the United States. If a rising economy leads to a 50 percent increase of consumption, an additional production of 12,000 T of lint cotton will be absorbed. It is assumed in this study that irrigation of the sample irrigation area would add to the present Greek production 2,000 T of lint cotton.

The foreign exchange value of crops which would be grown in the sample irrigation area is given later in this chapter.

18. Price of Farm Products

Until recently, Greek currency was very unstable. Pre-war currency lost practically all its value during the occupation. The new drachma issued after the liberation (1944) underwent repeated devaluations; the official rate of exchange of 200 Dr to the U.S. dollar has increased progressively and since September 1949 has been 15,000 Dr to the dollar. As no free market in the drachma exists, it is necessary to establish the true purchasing power of the drachma for use (1) in establishing reliable domestic prices of farm products in relation to long-term world prices, and (2) in determining the true value of agricultural income resulting from the proposed development.

A rate of 24,000 Dr to the dollar was estimated to correspond to the true value of the drachma. With this rate, the prevailing domestic prices for principal commodities are in reasonable agreement with present world prices as can be seen from Table V-12. This table also gives the accepted domestic prices used in determining present and future farm incomes and project benefits.

TABLE V-12

RELATION BETWEEN DOMESTIC AND WORLD PRICES FOR PRINCIPAL FARM PRODUCTS

Product	(1) U.S. price 1951 actual	(2) U.S. price 1935-39 average	(3) U.S. price 1951 adjusted *	(4) Estimated domestic price **	(5) Prevailing domestic price	(6) Accepted domestic price
	($/kg)	($/kg)	($/kg)	(Dr/kg)	(Dr/kg)	(Dr/kg)
Wheat	.079	.031	.090	2,200	2,200	2,100
Corn	.063	.026	.075	1,800	1,900	1,800
Cotton, lint	.900	.218	.630	15,100	15,000	14,000
Potatoes	.041	.026	.075	1,800	1,200	800
Beans, dry	.180	.077	.223	5,400	5,000	4,000
Pears	-	.033	.095	2,300	3,000	2,000
Hay, all kinds	.023	.012	.035	800	700	600

* Column (2) x 2.9. The factor 2.9 is the ratio of 1951 U.S. farm prices to 1935-39 U.S. farm prices as determined by the U.S. Department of Agriculture.

** Column (3) x 24,000.

19. Costs of Production

Present costs of production are adversely affected by low yields, wasteful methods of cultivation and harvesting and use of man-power rather than animals, machinery and efficient farm tools. In addition village economy makes it necessary to travel long distances from dwelling to field and adds to the inefficiency of labor. With the present wage scale in Greece, however, the estimated costs for raising crops in the sample irrigation area are low, as evidenced by the breakdown of costs for representative crops now grown in the sample irrigation area shown in Table V-13.

It is assumed that the proposed development will coincide with a general rise of the economy of the project area causing a higher wage scale. On the other hand improved farm practices will lead to higher efficiency of labor while improved roads will facilitate movement from village to farm. The costs of production for various stages in the development of the sample irrigation area are shown in Table V-14.

TABLE V-13

FARM PRODUCTION COSTS-PRESENT DEVELOPMENT
KARDITSA PLAIN

Sample irrigation area of 100,000 str 1/

Crops	Cost per stremma in 1000 Dr					Total area cost in million Dr	
	Materials equipment and draft	Interest, contin-gencies	Water	Total cost excluding labor	Labor	Total excluding labor	Labor
Wheat and other small grain	120	20	-	140	60	5,600	2,400
Corn, non-irrigated	105	20	-	125	66	1,425	752
Corn, irrigated	110	20	10	140	80	56	32
Beans	125	25	-	150	65	90	41
Beans, intercropped	40	10	-	50	30	285	171
Sesame	80	15	-	95	40	1,380	580
Cotton, non-irrigated	85	20	-	105	110	263	275
Cotton, irrigated	90	20	20	130	130	13	13
Vegetables, non-irrigated	100	20	-	120	125	180	188
Vegetables, irrigated	150	30	50	230	200	106	92
Grapes	85	150	-	235	180	47	36
Alfalfa, non-irrigated	30	60	-	90	60	27	18
Alfalfa, irrigated	40	60	50	150	80	15	8
Hay fields	10	-	-	10	20	66	132
Sub-total	-	-	-	-	-	9,553	4,567
Land retention	-	-	-	-	-	3,427	-
Livestock cost (not including value of feed)	-	-	-	-	-	1,020	933
						14,000	5,500
Selected irrigation area, 114,000 str 1/						16,000	6,300

1/ Irrigated annually.

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TABLE V-14

FARM PRODUCTION COSTS-FUTURE DEVELOPMENT
KARDITSA PLAIN

Sample irrigation area of 100,000 str 1/

Crops	Unit cost per stremma in 1000 Dr												Total area costs in million Dr					
	Material equipment & draft			Interest & conting.			Total unit cost excluding labor 2/			Labor			Total cost excluding labor 2/			Labor		
	B	C	D	B	C	D	B	C	D	B	C	D	B	C	D	B	C	D
Small grain	125	175	185	25	35	40	150	210	225	56	55	55	3,000	2,100	1,125	1,120	550	295
Grain (double cropped)	-	145	150	-	25	30	-	170	180	-	55	55	-	850	1,260	-	275	385
Corn & sorgum	150	240	250	30	45	50	180	285	300	100	120	120	4,500	4,275	3,000	2,500	1,800	1,200
Beans, dry	155	210	215	30	40	40	185	250	255	80	100	100	370	750	765	160	300	300
Sesame	105	150	155	20	30	30	125	180	185	70	90	90	625	540	555	350	270	270
Cotton	130	180	185	25	35	35	155	215	220	180	225	225	3,875	6,450	7,700	4,500	6,750	7,875
Vegetables & melons	185	270	270	35	50	50	220	320	320	200	245	245	660	1,600	1,600	600	1,225	1,225
Grapes	160	280	280	180	300	300	340	580	580	250	320	320	170	1,160	1,160	125	640	640
Fruit	130	225	225	200	325	325	330	550	550	250	275	275	165	1,650	1,650	125	825	825
Alfalfa & pasture	55	115	115	70	90	90	125	205	205	80	90	90	1,875	5,125	6,150	1,200	2,250	2,700
Cover crops	55	80	80	10	15	15	65	95	95	30	40	40	325	2,375	2,850	150	1,000	1,200
Clover in wheat stubble	50	80	80	10	20	20	60	100	100	40	60	60	60	500	500	40	300	300
Sub-total	-	-	-	-	-	-	-	-	-	-	-	-	15,625	27,375	28,315	10,870	16,185	17,215
Land retention	-	-	-	-	-	-	-	-	-	-	-	-	3,427	3,427	3,427	-	-	-
Livestock costs (not including value of feed)	-	-	-	-	-	-	-	-	-	-	-	-	1,448	5,698	6,258	2,130	5,815	6,785
Total	-	-	-	-	-	-	-	-	-	-	-	-	20,500	36,500	38,000	13,000	22,000	24,000
Selected irrigation area, 114,000 str													23,400	41,600	43,300	14,800	25,100	27,400

1/ Irrigated annually.
2/ Cost of water also excluded.

TABLE V-15

GROSS FARM INCOME-PRESENT AND FUTURE DEVELOPMENT
KARDITSA PLAIN

Sample irrigation area of 100,000 str[1/]

Crops	Unit price per ton	Millions of Dr A	B	C	D
Small grain	2.0	12,800	8,000	7,500	6,000
Corn and sorgum	1.8	2,376	11,250	9,450	6,300
Pulses and beans	4.0	1,050	960	1,800	1,800
Sesame	5.0	2,550	2,500	1,875	1,875
Cotton	5.0	1,050	18,750	30,000	35,000
Vegetable and melons	.6	1,314	3,240	6,000	7,500
Grapes	1.0	140	500	2,400	3,000
Deciduous	2.0	-	600	4,500	4,800
Hay	.6	2,078	9,750	21,750	25,800
Sub-total	-	24,358	55,550	85,275	92,075
Livestock	-	8,642	16,450	36,225	39,925
Total		33,000	72,000	121,500	132,000
Less value of feed raised on farms	-	5,500	10,000	21,500	24,000
Gross farm income	-	27,500	62,000	100,000	108,000
Selected irrigation area 114,000 str		31,500	70,700	114,000	123,000

1/ Irrigated annually.

ECONOMIC GAINS FROM IRRIGATION

In this chapter the various economic gains or benefits attainable by construction of the recommended reclamation works are presented. Comparisons of benefits with costs and estimates of project earnings are considered in Chapter XII. The following irrigation benefits are evaluated in the ensuing paragraphs: (1) direct benefit which equals the increase in net farm income; (2) increase in foreign exchange value; (3) enhanced land values; (4) increase in tax revenues; (5) development of new industries. As there is some duplication of values among these five benefits, they are not to be added in determining the total benefits (see Chapter XII).

20. Direct Irrigation Benefit

Table V-16 gives the direct benefits for the sample irrigation area for future conditions B, C, and D which were defined above under Land Use Capacity. The benefit for condition B equals the net surplus for condition B minus the net surplus for present condition A; the benefits for conditions C and D were determined similarly. The steps followed in calculating the net surplus for each condition were: (1) the costs of production were computed as in Tables V-13 and V-14; (2) gross income from crops and livestock were computed as in Table V-15; (3) production cost was substracted from gross income to obtain net income as in Table V-16; (4) cost of labor was substructed from net income to obtain surplus; (5) the direct benefit for stages B, C, and D were determined in Table V-16 as the increased surplus over stage A.

The cost of labor was not included in production costs as there is very little hired labor, practically all labor being performed by the farm families themselves. On the other hand farm labor is deducted from net income in determining surplus, out of which must come the money for project repayment as explained in Chapter XII. The farm-labor rate of 25,000 Dr per day now prevailing in the selected irrigation area was used in computing labor costs for condition A. For condition B, C, and D the rates assumed

TABLE V-16

NET FARM INCOME PRESENT AND FUTURE DEVELOPMENT
KARDITSA PLAIN

(million Dr)

Part A: Sample irrigation area of 100,000 str

Development stage	Gross farm income	Production cost excluding labor	Net farm income	Cost of labor	Surplus	Direct benefit
A	27,500	14,000	13,500	5,500	8,000	-
B	62,000	20,500	41,500	13,000	28,500	20,500
C	100,000	36,500	63,500	22,000	41,500	33,500
D	108,000	38,000	70,000	24,000	46,000	38,000

Part B: Selected irrigation areas of 114,000 str

Development stage	Net farm income	Direct benefit
A	15,390	-
B	47,300	23,400
C	72,390	38,200
D	79,800	43,300

NOTE: Stages of development are as follows:
"A" Present development.
"B" Expected development 3 years after completion of project.
"C" Expected development 15 years after completion of project.
"D" Possible ultimate development.

were 30,000, 40,000 and 40,000 Dr, respectively. A further discussion of the effect of labor rates on surplus and on project repayment capacity is presented in Chapter XII. Water is included as a cost in condition A but not in condition B, C and D for the reason that water will be paid for out of surplus (see Chapter XII). Land retention expense has been estimated for present conditions and included as a production cost under condition A. As almost all land-improvement costs including land-leveling, farm ditches and farm turnouts will be constructed and paid for by the irrigation district (see Chapters X and XI), the land retention expenses under conditions B, C and D have been assumed the same as under condition A for the purpose of determining net farm income and surplus.

21. Increase in Foreign Exchange

The foreign exchange value of the crops to be grown in the selected irrigation area is the value of all products which can be exported or which will reduce imports; Table V-17 summarizes these values.

TABLE V-17

ANNUAL GAINS IN FOREIGN EXCHANGE

Sample irrigation area of 100,000 str

Source	Price	Increase in T		Value in 1000 $	
		Stage C	Stage D	Stage C	Stage D
	($/T)				
Cotton	560 1/	2,000	2,300	1,120	1,290
Corn	35 2/	4,000	2,200	140	77
Beans	160 3/	200	200	32	32
Milk	60 4/	11,500	13,000	690	780
Meat	400 5/	150	200	60	80
Eggs 6/	350 7/	360	360	126	126
Total	-	-	-	2,168	2,385
Selected irrigation area	-	-	-	2,470	2,720

1/ Wholesale price in Charleston, S.C., ave. 1940-49.
2/ Wholesale price, ave. Chicago and Argentina 1939-48.
3/ Wholesale price in New York, ave. 1940-49.
4/ Price paid to farmed (milk for canning), U.S. ave. 1940-49.
5/ Price paid to farmers (hog, dressed weight equivalent), ave. 1940-49.
6/ 1000 doz.
7/ Price paid to farmers in U.S., ave. 1940-49.

22. Enhanced Land Values

The value of the land in the sample irrigation area will increase as a direct result of the proposed development. The other lands in the valley will increase in value to some extent as a result of the increase in the general economy of the region.

Considering only the lands in the sample irrigation area which will be served by the proposed project, it is estimated that the increase in value for different types of land will be as shown in Table V-18. Land values will increase from a present value of 103,450 million Dr to a future value of 240,000 million Dr.

23. Increased Tax Revenues

Under present laws, land is not subject to taxation. This leads to inefficient use of the land as there is neither incentive nor necessity to obtain sufficient returns from cultivation to pay taxes. The future returns from any land tax which may be imposed cannot be estimated but an indication of the relative returns from any tax under present conditions and after development of the recommended projects is given by the increase in land values shown in Table V-18. This question is discussed further in Chapter XII.

TABLE V-18

INCREASE OF LAND VALUES
KARDITSA PLAIN

Sample irrigation area of 100,000 str
(millions of Dr)

Present condition and use of land which will be reclaimed	Area (str)	Value per str Condition A	Value per str Condition C	Total incr. in value Condition C
1. Land naturally drained and not seriously affected by floods; used normally for row crops (cotton, corn) and grains.	78,500	1.0	2.5	117,750
2. Same land used for horticultural crops, alfalfa and cotton with insufficient irrigation.	1,500	1.5	2.5	1,500
3. Low land affected by floods and high-water table used for pastures.	20,000	0.5	2.0	30,000
Total	100,000			149,250

24. Development of New Industries

The industrial expansion, or increased industrial activity which will result from the development of the recommended plan, will be that required to process the agricultural products. The increased quantities of products under the ultimate development are given in Table V-19.

TABLE V-19

QUANTITIES OF PRODUCTS UNDER ULTIMATE DEVELOPMENT
KARDITSA PLAIN

Sample irrigation area of 100,000 str
(metric tons per year)

Cotton, lint	2,300
Cotton, seed	4,000
Sesame	350
Vegetables	12,000
Fruit	2,500
Milk	14,000
Meat	450

These products will require for their processing the following industries:

a. Two or three cotton gins, of an average production capacity of 800 T annually; the cotton raised on this area could provide the basis of a textile industry in Karditsa.

b. Two or three large oil-seed processing plants would also be required for cotton and sesame seed produced in the area.

c. The increase of milk, meat and other livestock products will require large processing installations such as a milk pasteurization plant in the city of Karditsa with an average capacity of 10 T daily; two or three dairies for the production of cheese, butter and other dairy products; a modern slaughter house for dressing and packing meats.

d. The locally consumed farm produce, fruits and vegetables will also create other small industrial activities, especially in the form of small municipal canneries.

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FARMERS' ORGANIZATIONS

25. Farmers' Cooperatives

Farmers' cooperatives are a common element in the organization of Greek villages. Although these organizations have restricted their work in the past to aiding farmers to obtain loans through mutual warranty, they have also laid the foundation for more extensive cooperative action. The village cooperatives in the Karditsa area were seriously affected by the war and will require help for complete recovery. The "Union of Farmers' Cooperatives" in Karditsa, an association of the village cooperatives in Karditsa Nomos, has shown good leadership. The Union has also been active in marketing wheat and other products and in providing tractors and other tillage and harversting equipment.

The basic advantage of cooperative organization lies in the utilization of the initiatives of the farm population. This fact suggests that government policy should be to encourage cooperatives to assume full responsibility for their actions. State aid to cooperatives should be limited to advice and technical information.

Village cooperatives, with a parent organization such as the Karditsa Union, can play an important role in the modernization of processing and trading facilities. Processing facilities have been described above under Development of New Industries. Marketing facilities are discussed in the next section. Private enterprise will no doubt play a part in providing these needed facilities; however, owing to the direct interest of the farmers in their own improvement, the cooperatives are more suited in many cases to undertake these enterprises. State aid, mentioned above, should include advice on efficient business methods.

Although the operation of irrigation works in the area will be the responsibility of the Irrigation District, the Unions of village cooperatives should also be able to help in the extension of the irrigation in the Karditsa plain, by furnishing financial assistance to develop additional water sources, providing pumps and encouraging the use of electricity for small individual installations.

26. Irrigation Districts

The form of quasi-public corporation common in the United States, known as the "irrigation district", is recommended for adoption in the Karditsa plain in order to operate the proposed irrigation and drainage works as described in Chapter XI.

27. Educational Program for Farmers

Training of farmers will be needed on the following subjects: use of commercial fertilizers, use of legumes and grasses for forage production and soil building, use of cover crops, artificial breeding of cattle, improved feeding of livestock, control of diseases of plants and animals, improved methods of food preservation and processing, and methods of application of irrigation water to the land.

The Greek Ministry of Agriculture with M.S.A. aid is now reorganizing and training the government agricultural services with the aim of securing the use of modern concepts and techniques of extension work. Experience now being gained in the extension program will benefit related activities in the Karditsa area. A team of properly trained field workers should be stationed in the area and the services of specialists should be enlisted to bring to field workers and farmers information derived from both local and foreign research and experience. The irrigation district should prove helpful in the promotion of extension work. Moreover, extension services should enlist the active participation of the farm population through special village organizations like the Farm and Home Bureaus and 4-H clubs in the United States.

MARKETING AND STORAGE FACILITIES

Facilities for storage and marketing of farm produce are not adequate, as described in Chapter IV. This is understandable under the prevailing conditions of subsistence farming. Efficient handling of the increased production from commercialized farming will follow land improvement in the area and will require great expansion of these facilities.

28. Storage

A storage space of about 5,000 m^3 will be needed for storing wheat, corn and other small grain.

The cotton crop will require a storage space of about 3,000 m^3 located at the gin. Modern arrangement of buildings for increased efficiency have been demonstrated in the new gins built with the financial and technical aid of the M.S.A. in other parts of Greece.

Dairy products, meat and fruit will require cold storage. As dairy and meat products will be the main commodity needing cold storage while refrigeration will be needed in the processing of milk, initial cold-storage facilities should be established for dairy and meat-packing plants. Additional cold-storage facilities in the form of community or cooperative plants will be needed for the preservation of fruits and vegetables for market.

29. Marketing

In addition to storage, the handling of over 17,000 T of produce will require extensive transportation and trading facilities. Private truck owners in Greece are providing good service within the limits put by road conditions and the frequent State measures tending to eliminate competition. It is expected that private trucking will expand partly as a result of the rural road network which will be provided as part of the project and included as a cost chargeable to the project, as described in Chapter IX. The seaport of Volos, which is located about 100 km east of Karditsa, could easily handle expected future shipments of farm products, mainly to other Greek ports. Trading facilities to the extent needed, can be provided by cooperatives, as described above.

CHAPTER VI

HYDROELECTRIC POWER DEVELOPMENT

1. The Megdova Power Market Area

For the purpose of this report the Megdova Power Market Area is defined to include the Nomoi of Karditsa and Trikala. (See Plate IX-14). As shown in Table VI-4, the population of the Power Market Area according to the census of 1940 was 251,100, of which about 15 percent resided in Karditsa and Trikala, with the balance in small rural villages or cummunities. The 1951 population is estimated to be 265,000 of which about 16 percent reside in the two urban centers of Karditsa and Trikala.

As interconnection with the future transmission system of the Public Power Corporation can easily be made, the national power network of the PPC also constitutes a possible market for Megdova power provided it can be integrated with the output of PPC generating stations either under construction or proposed.

2. Existing Power Facilities

The existing generating plants consist of four municipal stations in the towns of Trikala, Karditsa, Sofades and Kalabaka and a few privately owned small diesel-electric installations for industrial purposes. In addition, approximately 22 factories and 34 small flour mills provide their own power principally through directly connected prime movers. Transmission facilities extend only a short distance from the municipal power plants; no extended power distribution lines are in operation in the area.

Municipal plants: The capacity and output of the municipal plants in 1951 is shown in Table VI-1. The Karditsa municipal diesel-electric plant began operation in 1910. The plant has expanded its generating capacity up to the present installation of four units having a combined capacity of 470 kw. The municipality has placed orders for sufficient units to increase the total capacity to 570 kw. The Trikala municipal plant was installed in

1906. At present it consists of 5 diesel-electric units with a combined generating capacity of 574 kw. The communities listed in the table are in need of additional power facilities. Only the plant in Trikala gives 24-hour service, while the Karditsa station furnishes energy for 23 hrs in the winter and 21½ hrs in the summer. The two smaller plants operated only about 6 hrs per day.

TABLE VI-1

CAPACITY AND OUTPUT OF MUNICIPAL POWER PLANTS IN THE MEGDOVA POWER MARKET AREA

Location	Population 1951	Capacity Installed** (kw)	Peak Loads (kw)	Annual Production (kwh)	Annual Production per Capita
Karditsa	18,452	470	302	517,800	28
Sofades	4,285	81	46	39,140	9
Trikala	26,300*	574	401	923,660	35
Kalabaka	3,910*	52	40	19,300	5

* Estimated
** Capacity of prime mover

3. Present Power Loads

Classification of loads: About 85 percent of the population of the Power Market Area live in small rural communities. Their present demand for electricity is low and will continue to be low until the standard of living is improved. The present power requirements for such areas are supplied by internal combustion engines, animal power or man power.

Existing and potential consumers of electricity in the power market area may be grouped into four classifications:

1. Private Lighting: Domestic uses including lighting, cooking and other services in homes; lighting in shops and other commercial enterprises.

2. Power: All power uses such as in manufacturing plants, irrigation pumping; lighting and power for large enterprises where all electric service is measured by one meter.

3. Public Buildings: All uses in municipal and national government offices and buildings, also uses by the armed forces.

4. Street Lighting: Lighting of streets, parks, and for security purposes.

Private lighting: The principal use of electricity is for illumination. Very little cooking is done by electricity; wood, coal, charcoal and kerosene are used but these fuels are expensive. Most of the stores and markets are inadequately lighted and depend largely on daylight for illumination. However many of the larger hotels, coffee houses and restaurants use electricity freely. Offices are usually wired, but generally only to the extent of providing for a single open bulb fixture dropped from the ceiling. In 1951 the private lighting customers in the Megdova power market area used about 860,000 kwh of electricity delivered to the four towns of Karditsa, Sofades, Trikala and Kalabaka with a combined population of 53,000 people.

Power: As shown in Table VI-2, the present manufacturing and industrial power installation requirement for all types of prime movers is about 1,470 kw of which less than 485 kw are in the form of electrical generating equipment, the rest being direct-connected diesel engines or other types of prime movers.

Aside from manufacturing and industrial activities, there are no other significant requirements falling within the power classification at the present time. Small enterprises, such as garages and machine shops utilize electric-power-driven tools and equipment to a limited extent; small businesses are mostly operated by internal combustion engines, animal power or man power. It is estimated that the total consumption of electricity for power uses during 1951 was about 155,000 kwh.

Public buildings and street lighting: Approximately 15 percent of the electric energy generated by municipal power plants in the Megdova power market area falls within this classification. Most of this electricity is used for illumination of city and government offices and buildings. About 14 percent of the total municipal power production is used for street lighting. In 1951 the energy consumed for both public buildings and street lighting in the towns of Trikala, Karditsa, Sofades and Kalabaka was about 136,000 kwh.

Rate schedule and tax assessments: Under the present system for establishing electric rates in Greece, each municipality adjusts the rates each month in accordance with a power-rate formula based on operating expenses and amount of energy sold.

TABLE VI-2

PRESENT POWER REQUIREMENTS FOR INDUSTRIAL PLANT (1951)
MEGDOVA POWER MARKET AREA

Location	Industry	Number of factories	Power requirement
			(kw)
Trikala	Cotton textile	3	110
	Flour mill	2	147
	Tobacco factory	1	74
	Cold storage and ice Plant	1	59
Karditsa	Flour mill	2	331
	Tile factory	1	51
	Cotton gin	2	74
	Ice plant	1	37
	Cold storage plant	1	74
Sofades	Flour mill	1	74
	Cotton gin	1	37
Kalabaka	Ice plant	1	18
	Small flour mills 1/	34	220
	Miscellaneous small plants 1/	7	20
	Minor enterprises 1/	-	147
		Total	1,473

1/ Distributed throughout the power market area.

Table VI-3, based on records of the Ministry of Industry, gives the base rates not including taxes for the month of September 1951 for the four municipal plants producing electricity in the area.

Taxes on electricity produced for public or private consumption are levied by the National Government and by the municipalities in which the electricity is used. Taxes are usually assessed at a uniform rate per kilowatt-hour regardless of the class of customer. Typical tax assessments added to total monthly electric bills average about 16% National tax and 10% municipal tax.

TABLE VI-3
TYPICAL BASE RATES FOR ELECTRICITY
SEPTEMBER 1951

Location	Karditsa	Trikala	Sofades	Kalabaka
Kwh sold	31,779	57,213	2,755	1,475
Operating cost, million Dr	38.7	36.0	10.6	6.6
Fuel costs, million Dr	27.1	49.1	2.5	1.3
Private lighting, Dr/kwh	2,495	1,869	5,909	6,138
Industrial power, Dr/kwh	2,008	1,515	-	-
Public lighting, Dr/kwh	2,216	1,667	4,906	5,134
Street lighting, Dr/kwh	2,077	1,566	4,405	4,602
Water supply, Dr/kwh	-	1,313	-	-

4. Estimated Future Power Market

Table VI-4 shows the estimated population growth in the Megdova Power Market Area. The projected future growth is based on past trends which indicate an increase of about 6 percent in the population of the area from 1951 to 1960. Under conditions of reclamation and power development the population of the area may increase at a faster rate.

The development of industry in the Karditsa plain and adjoining areas will require substantial increases in the use of electricity. Further increases will parallel improvements in the standard of living and the mechanization of agricultural activities. Some of the major potential increases are discussed in the following paragraphs.

Private lighting: Ironing, cooking and other household uses will become more common as soon as reliable electricity is available at reasonable cost. Eventually washing machines, stoves, refrigerators and fans will come into general use. With the expected increase in business and commercial activities which will result from the recommended irrigation and power development, the demand for lighting in shops and other establishments will also increase rapidly. It is estimated that the demand for private lighting will increase to 5,200,000 kwh per year in the power market area by 1960 and that about 204,000 people will be located within reach of electric service at that time.

TABLE VI-4
MEGDOVA POWER MARKET AREA
POPULATION GROWTH

Location	1928 1/	1940 1/	1951 1/	1960 2/
Karditsa	13,883	14,024	18,452	21,000
Sofades	3,334	4,046	4,285	5,000
Rural areas	96,685	112,796	115,308	129,000
Total Karditsa Nomos	113,902	130,866	138,045	155,000
Trikala	22,117	22,852	26,300 2/	29,500
Kalabaka	2,952	3,690	3,910	4,600
Rural areas	74,504	93,678	96,790	106,900
Total Trikala Nomos	99,573	120,220	127,000	141,000
Total Power Market Area	213,475	251,086	265,045	296,000
Total Greece		7,340,000	8,100,000	8,600,000

1/ From census records
2/ Estimated

Power: There are favorable opportunities for the development of industries such as food processing, fiber and textile plants, and small shop and home enterprises. Increased agricultural production will furnish most of the raw products which will be needed by the future industries. Canning and processing of vegetables, fruit and meat will require substantial amounts of power. Associated industries which will require power are refrigeration storage plants, slaughter houses, tanneries, leather manufacturing plants, flour mills, and pulp mills. Table VI-5 lists the industries that might be developed or expanded in the Megdova Power Market Area and the probable required capacity of each.

It is estimated that the total consumption of these industrial plants, which will have individual demands aggregating 5,146 kw, will use approximately 12,400,000 kwh per year. This energy consumption represents individual plant load factors averaging 28 percent. Should the work day be increased above the average assumed both the kwh required and the industry load factor would be increased, but the system demand and the generating capacity requirements would not be materially affected.

TABLE VI-5

ESTIMATED FUTURE POWER REQUIREMENTS FOR INDUSTRIAL PLANTS (1960)
MEGDOVA POWER MARKET AREA

Industry	Plants	Power Requirement (kw)	Required Energy (1000 kwh)
Cotton textile	6	710	1,260
Cotton gin	7	311	760
Flour mill	5	552	1,310
Small flour mills	34	220	520
Tobacco factory	1	74	180
Cold storage and ice	6	288	850
Tile factory	1	51	120
Milk pasteurization	1	40	80
Dairy	7	230	670
Seed crushing mill	5	100	300
Slaughter house	1	70	150
Paper and pulp	1	2,000	5,000
Miscellaneous small enterprises	-	500	1,200
		5,146	12,400

The diversity of demand between the many and widely varying types of processing and manufacturing plants may be expected to reduce the actual coincident demand of the industrial group to about 3,550 kw.

In addition to the 114,000 str which will be irrigated annually by diversion of the Megdova River, it is estimated that about 200,000 str in the Power Market Area (Trikala and Karditsa Nomos) can be irrigated by pumping from groundwater sources. The irrigation of 200,000 str by pumping would require approximately 162 million m^3 of water. Assuming an average lift of 10 m, the annual energy requirements would be about 8,000,000 kwh at the power plant.

In order to adequately control groundwater levels in low-lying sections of the Power Market Area, it is estimated that at least four drainage pumping stations aggregating about 1800 kw of installed capacity and consuming as much as 3,100,000 kwh of electric energy per year will be required.

Public buildings: Only small amounts of electric energy will be used to serve municipal and national government buildings in the area. It is estimated that not more than 600,000 kwh will be sold for governmental use by 1960.

Street lighting: Since most of the towns of the area are small rural settlements, a relatively limited street lighting load is anticipated. It is estimated that the street lighting requirements for the entire market area will not exceed 1,000,000 kwh by 1960.

Summary of energy requirements: The electricity demand and sales estimated for the Megdova Power Market Area by 1960 is summarized in Table VI-6.

TABLE VI-6

ESTIMATED ENERGY REQUIREMENTS
MEGDOVA POWER MARKET AREA

Class of customer	Power requirement (kw)	Energy Consumed (1,000 kwh)
Private lighting	2,500	5,200
Power	10,000	23,500
Public buildings	250	600
Street lighting	350	1,000
Total (including system losses)	13,100	30,300

5. Value of Power

The value of the power output of a proposed hydroelectric plant may be considered in terms of: (a) the cost of providing equivalent amounts of power by the cheapest alternate means; (b) the price actually paid by consumers at the present; (c) the price which would be paid by consumers after completion of a proposed development; (d) direct benefit to the economy of the power market area and to the country.

(a) The Megdova Power Market ... the Public Power Corporation transmission network which is planned for extension into the area in 1953. The Megdova power plant can be compared to similar hydroelectric plants in Greece which have been investigated and are known to be feasible for providing energy to the Public Power Corporation network and thus to the Power Market Area. The following four power plants were taken for comparison, with costs as estimated in 1949 by Ebasco Services, Inc.

1. The proposed Kremasta hydroelectric plant on the Acheloos River about 55 km southwest of Karditsa; construction cost $61,700,000.

2. The Ladhon hydroelectric plant now being constructed on the Ladhon River in the central Peloponnesus; construction cost $18,300,000.

3. The Agra hydroelectric plant now under construction on the Voda river; construction cost $9,650,000.

4. The Louros hydroelectric plant now being constructed on the Louros River in Epirus; construction cost $3,875,000.

The estimated construction cost allocable to the Megdova hydroelectric plant is $11,400,000. The plant will have an annual output of 203 million kwh of primary energy and 26 million kwh of secondary energy, and a capacity of 84,000 kw. Comparative data on the Megdova and the four hydroelectric projects of the PPC are given in Table VI-7. From this data it is seen that the cost of developing electric energy at the Megdova hydroelectric plant compares very favorably with the cost of energy developed by other projected plants on the Public Power Corporation network.

(b) The price paid for electric energy by consumers at the present time varies widely over the Power Market Area. As indicated in Table VI-3, rates paid by customers in 1951 vary from 6,138 Dr per kwh in Kalabaka to 1,869 Dr per kwh in Trikala. These prices indicate only the maximum value of power since the demand greatly exceeds the supply. Under conditions of plentiful electricity at lower prices, far greater amounts of energy would be purchased by all types of cunsumers. Present prices are necessarily fixed at high levels because of high production and distribution costs and therefore indicate the value of power only for special or luxury uses.

TABLE VI-7

COMPARISON OF MEGDOVA WITH OTHER HYDROELECTRIC POWER PLANTS

Location	Cost	Capacity	Energy in millions of kwh per year			Construction cost per kw of installed capacity	Cost per annual kwh primary output1/	Cost per annual kwh of total output1/
			Primary	Average secondary	Average total			
	U.S $ x 10^6	(kw)				(U.S. $)	(U.S. $)	(U.S. $)
Megdova	11.4 2/	84,000	203	26	229	135.70	.0058	.0051
Kremasta	61.7 3/	180,000	366	576	942	342.80	.0174	.0065
Ladhon	18.3 3/	50,000	155	136	291	366.00	.0122	.0065
Agra	9.65 3/	40,000	48	0	48	240.00	.0207	.0207
Louros	3.88 3/	5,000	28	14	42	775.00	.0143	.0097

1/ At the power plant. Annual cost based on 20-year amortization of construction cost at 4½% interest plus 33% for operation and maintenance.
2/ Estimated construction cost in 1952 as determined in this report.
3/ Estimated construction cost in 1949 as determined by Ebasco Services, Inc.

(c) The estimated charges to be made by the Public Power Corporation for different types of service are given in Table VI-8. The estimated charges are intended to be only approximations and may vary considerably from the actual future rates; however, they are indicative of the significant reduction in cost of power to the consumers which will take place when the PPC facilities are brought into the Power Market Area.

TABLE VI-8

ESTIMATED AVERAGE ELECTRICITY RATES FOR 1953-54[1/]

Class of business	Average rate
	(Dr/kwh)
Private lighting	583
Power	186
Public buildings	266
Street lighting	266

1/ From EBASCO'S report, 1950, based on 4% capital return. Rates include 20% tax on sales to ultimate customers.

(d) The true value of power when considered on the basis of benefit to the economy of the Power Market Area and of the country as a whole can be evaluated on the basis of the cost of providing equivalent lighting and industrial energy without using electricity. For example, a kerosene lamp used for domestic lighting and providing illumination equivalent to that provided by a 7.5 watt electric bulb used for 5 hours consumes about 160 grams of kerosene at a cost of about 142 Dr after deducting taxes. Illumination by kerosene equivalent to that provided by the consumption of one kwh of electricity would therefore cost about 3,800 Dr for fuel. About 10 percent of this value should be credited to household wiring costs and maintenance and about 25 percent should be credited to the distribution system, leaving about 2,470 Dr per kwh as the value of electric power creditable to generation and transmission.

For an alternative comparison of the value of power it is conservative to estimate that, in industrial production, the output of labor with mechanization and power is at least four times the output with manual methods and that the value of the output with manual methods is at least equal to the labor cost. As manual workers are now paid an average wage of 25,000 Dr per day, the increased value of the output with mechanization and power would be 75,000 Dr per day. If each worker requires 8 kwh in order to achieve the increased output, its value would be 9,400 Dr for each kwh consumed. If it is further assumed that 40% of the value of the increased output is creditable to power (and 60% to mechanization) and, of this amount, 75% is creditable to generation and trahsmission (25 % for distribution) the value of the power would be about 2,820 Dr per kwh.

On the basis of the foregoing, it appears that electricity served to the power market area is worth to the consumer at least 2,500 Dr per kwh. However, under the estimated PPC electricity rates tabulation in Table VI-8, the charge will be about 580 Dr per kwh for lighting and 186 Dr for power.

Projected power sources: As a part of a comprehensive program to develop the power resources of Greece, the Public Power Corporation is constructing the Aliveri thermal-electric plant near Chalkis on the Eubecan Gulf, about 200 km southeast of Karditsa. This plant will furnish electricity to central Greece by means of a transmission line extending northerly through Lamia and Volos to Larissa with a spur line running to Trikala (see Plate IX-14). Also it is contemplated that large amounts of power will be transmitted south to the Athens area.

According to the Ebasco report, the Aliveri plant will consist of two 37,500 kw maximum capacity turbines driving two 37,500/42,000 kva generators. Fuel will be obtained from large deposits of lignite located nearby. Under maximum utilization, the Aliveri plant, when operating on the interconnected system of the PPC, could generate about 590,000,000 kwh marketable energy per year. Completion of the steam plant and the transmission lines to the power market area are planned for 1953.

Transmission and distribution facilities: It is anticipated that the Public Power Corporation will have constructed a transmission line from Chalkis and a part of the primary and secondary distribution system serving the power Market Area by the time the

Megdova power plant is placed in operation. According to the Ebasco report, the main transmission system will consist of a single circuit 150-kv line utilizing aluminimum with steel core conductors. Steel or combination concrete and steel towers, will support the power line. Step-down substations will generally be 150-15 kv planned for unattended operation.

For power distribution, the primary voltage lines will be 15,000 volt and the secondary lines will be 220-380 volts. The lines will be carried on wood or concrete poles.

Electricity produced at the Megdova power plant will be transmitted and distributed through the Public Power Corporation system. The only additional construction required will consist of 38 km of 150 kv transmission line which will extend from the Megdova power plant to the projected PPC transmission line near Trikala.

CHAPTER VII

FLOOD CONTROL, DRAINAGE, IRRIGATION AND DOMESTIC WATER SUPPLY REQUIREMENTS

1. Flood Control

The dual problems of flood control and drainage of the Karditsa plain have been studied extensively by others, and are the subject of several reports as described in Chapter I. Based on the aforementioned reports, a comprehensive program of flood control under the direction of the Ministry of Public Works is in progress of the present time. As it is expected that completion of the program will substantially eliminate the flood control problem in the area, no further consideration of this problem has been given except that the recommended irrigation system has been planned so that it will fit in with the existing and projected flood control works.

2. Drainage

Large areas in the Karditsa plain are affected by high groundwater table or by ponding, as shown on Plate III-6. The floodways planned as part of the current flood control program will serve as deep drains or as lateral drainage canal outlets and will drain most of the water-logged areas in the plain. Additional deep drain will be needed to effectively control the water-table after irrigation water is brought into the plain areas. The location of the deep drains for the irrigation system are shown on Plate IX-19 and will be described further in Chapter IX.

Drainage pumping stations will not be needed in the selected irrigation area. However, as pointed out in Chapter VI, the ultimate development of the Karditsa plain will probably require pumping to drain the low-lying area between the Sophadites and Peneos Rivers near their confluence. Provision for these stations is provided in the future power requirements described in Chapter VI.

3. Irrigation

The present limited extent of irrigation in the Karditsa plain was described in Chapter IV under "Land Use and Farm Practices" and "Irrigation Facilities and Practices". The present yields of agricultural products in the Karditsa plain as compared with potential yields attainable with irrigation were given in Chapter V under "Land Use Capacity".

Irrigation water requirements: To determine the water required for irrigation, the weighted irrigation requirements of each crop by months and the average net irrigation requirement in millimeters for a sample irrigation area of 100,000 stremmas were computed.

The consumptive use requirement of each crop was taken from Table V-8 and effective rainfall and soil moisture contribution subtracted from the determination of the net crop requirement. The area in each crop was taken from Table V-7 for cropping pattern C representing the expected use of the land. The weighted monthly amounts in millimeters for each crop were obtained by multiplying the net requirement by the percentage of the land occupied by each crop.

A similar computation of the crop requirements was made for the year of minimum rainfall. The required average depth of irrigation in such years is 12% higher than in normal years and the water available will not be sufficient to meet this demand. It is estimated that such dry years are likely to occur once in every 6 or 7 years and that 94% of the water requirements can be supplied by eliminating cover crops. It is believed that the omission of the cover crops once in every 6 or 7 years will not materially affect the fertility of the soil and will not affect the crop rotations assumed herein. For these reasons the estimates of net irrigation requirement were based on the average year rainfall.

Table VII-1 gives the gross diversion requirement of the project in millimeters of depth per month. Net crop requirement was determined as described above and losses estimated on the basis of 80% farm irrigation efficiency and canal losses and seepage as equal to 30% of gross diversion. Gross diversion requirement was thus estimated to represent an average depth of 921 mm. Peak demand was taken as equal to 120% of the normal requirement in July which is the peak month in the irrigation season.

4. Domestic Water Supply

Although there is need for improvements in domestic water supply systems as described in Chapter IV, the quantities of water involved are too small to justify development in conjunction with irrigation. General measures recommended for raising water supply and sanitary standards are described in Chapter VIII.

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TABLE VII-1

IRRIGATION WATER REQUIREMENTS
KARDITSA PLAIN

(sample irrigation area of 100,000 str)

Requirements		April	May	June	July	Aug.	Sept.	Oct.	Season total
1. Net crop requirements 1/	mm	44	70	97	140	119	33	14	517
2. Losses 2/	mm	34	55	76	109	93	26	11	404
3. Gross diversion reqt. ave. year	mm	78	125	173	249	212	59	25	921
4. Gross diversion reqt.	10^6 m^3	7.8	12.5	17.3	24.9	21.2	5.9	2.5	92.1
5. Gross diversion reqt.	m^3/sec	3.0	4.7	6.8	9.3	7.9	2.3	0.9	5.0
6. Peak demand 3/	m^3/sec				11.2				

1/ Rainfall for average year assumed, except that rainfall in July and August has not been considered effective in reducing consumptive requirements of crops.

2/ Losses based on: 1. Surface runoff waste 5%, lateral losses and field percolation losses 15% of farm deliveries, i.e. average farm irrigation efficiency used is 80%.
2. Canal operarion losses 15% and seepage 15% of gross diversion.

3/ 120% of July diversion demand.

CHAPTER VIII

PLANS FOR DEVELOPMENT

1. Multi-Purpose Utilization of Megdova River Water

If the water diverted from the Nevropolis reservoir were used primarily for the generation of electric energy, only 74,000 str could be irrigated in the Karditsa plain. Conversely, if the water were utilized primarily for irrigation, about 226,000 str could be irrigated but then only seasonal secondary electric energy could be generated.

Plate VIII-1 shows the annual irrigation supply available for various power drafts and reservoir capacities. With the large reservoir area, ample storage capacity is easily obtainable; the practical limit is the availability of water. As a factor of safety, the practical limit-line has been set at 80% of the available mean flow of 8.4 m^3/sec given in Plate III-13, or 6.8 m^3/sec.

From the data in Plate VIII-1 and with total project benefits for various combinations of power draft and corresponding irrigated area estimated according to the procedures described in Chapter VI and XII, it was found that combined project benefits increased continuously with increase in production of primary power; the maximum benefit would be obtained by generating as much primary power as possible, i.e., with a continuous power draft of 6.8 m^3/sec and a corresponding irrigation area of 74,000 str. However, considering that the irrigable area could be increased by 54% with a corresponding decrease of only 12% in primary power production, the latter division of available water was adopted. The firm power draft will thus be 6.0 m^3/sec; 203 million kwh of primary power and 26 million kwh of secondary power will be generated annually while 105 million m^3 of water will be available for irrigation of 114,000 str each year.

The alternative of using all the water for irrigation and generating only secondary power during the irrigation season was investigated and rejected for the following reasons: (1) this plan would require duplicate installations, one for generating power during the summer and a companion installation elsewhere for winter generation; the installation cost would thus be doubled. (2) In discussing this matter, officials of the P.P.C. indicated that a large block of secondary summer power would be of doubtful value to the Greek power network.

2. Irrigation and Drainage Plans Considered

The dependable annual yield of Nevropolis reservoir is estimated to be 214 million m^3 of which 105 million m^3 will be available for irrigation of 114,000 str during the summer. The balance of the water will not be available for irrigation as it will be released to generate winter power and will subsequently be wasted unless an economical site for hold-over storage can be found.

Although the scope of the irrigation development proposed herein comprises only land to be irrigated by Megdova River water released during the summer, it is recognized that additional supplementary water supplies will be available after development of the recommended project and that these supplies could be used to expand the irrigated area beyond the 114,000 str mentioned above. The possible sources of supplemental water are as follows:

(A) Under the proposed development, 109 million m^3 of water released for generation of power during the winter and wasted into the Peneos River could be utilized for irrigation if hold-over by means of: (1) A reservoir located between the power plant and the Karditsa plain; extensive reconnaissance of the area failed to reveal a suitable basin for such a reservoir. (2) A reservoir between the Karditsa plain and Larisa; in this case the water would be used outside the Megdova project area. (3) Water spreading for recharge of the aquifers in the alluvial fans above the Karditsa plain during the winter and subsequent pumping during the summer.

(B) Recovery of irrigation seepage losses through pumping from drains or shallow wells; as described in Chapter III, about 18 million m^3 of water could be covered from this source.

(C) Diversion of Peneos River water into the Megdova project area in exchange for irrigation return flow from the Megdova project area. The summer flow of the Peneos River is now used to irrigate lands downstream from the Karditsa plain; the minimum summer flow of the river is believed to be about equal to the amount of water resulting from irrigation return flow; therefore, water could be diverted upstream on the Peneos and replaced by return flow without diminishing the net amount of water available to downstream irrigators.

(D) Pumping from small streams, drainage canals, shallow wells or artesian wells. The rough estimate outlined in Chapter III indicates that as much as 47 million m^3 of water may be available in the Karditsa plain each year through recharge by precipitation.

(E) Pumping into off-channel storage. It is possible that off-channel reservoirs could be found which could be filled by pumping from streams during the winter period of high runoff. Pumps, using secondary or dump power from the P.P.C. network, would fill the reservoirs during the winter, and the water could be released for irrigation use during the summer.

(F) Pumping from deep aquifers. Certain areas within the Karditsa plain are underlain with aquifers which are estimated to give an average yield of 35 m^3 hour for a 6 to 8-inch well 150 meters deep (see Chapter III). A well yielding 35 m^3 per hour could be used for irrigation supply where water is valuable and no other sources are available, but such supplies are relatively expensive. It is estimated that pumping from an 8-inch well, at a 20-m lift, would result in a capital cost of 750,000 Dr per str and an annual cost of about 117,000 Dr per str. By comparison, the selected irrigation area will have a capital cost for water supply of about 200,000 Dr per str and an annual cost of 69,000 Dr per str.

Although relatively cheap electric power will be available for use in driving deep well pumps in the Karditsa plain, all the available low-lift sources of water should be developed first, prior to initiating production drilling of deep wells.

The farmers of the Karditsa plain are not accustomed to an irrigation type of agriculture and it is anticipated that development may take place in widely separated areas rather than in compact blocks. For this reason, the selected irrigation area provides 126,000 irrigable str out of which only 114,000 str would be irrigated each year. A net irrigated area of 34,000 str in the vicinity of Palamas was considered as a first future extension to the selected irrigation area utilizing the supplemental water supplies described above, with subsequent development taking place between these two irrigated blocks of land (see Plate IX-16); however, in this report, the costs and benefits resulting from the irr[illegible]cluded.

Drainage of the irrigated area will be coincident with and part of the plan of the irrigation system (see Chapter IX).

3. Recommended Plan of Development

The recommended plan is presented as a single-stage development with a 3-year construction period for completion of the irrigation features. The plan of development consists of the following principal features:

1. Constrution of Nevropolis dam and Karitsiotis diversion dam to furnish 210 million m^3 of water annually for power and irrigation uses.

2. Construction of a power plant headworks near the village of Tsardaki by means of which water will be diverted from the Nevropolis reservoir.

3. Construction of a concrete highline conduit for conveyance of water from the headworks to a steel penstock 1.5 km in length.

4. Construction of an 84,000 kw hydroelectric power plant near Blasdo.

5. Construction of an irrigation system near Karditsa where 114,000 str could be irrigated annually. A project drainage system will be constructed in conjunction with the irrigation system.

Detailed descriptions of the recommended works are given in Chapter IX, estimates of costs in Chapter X and an economic analysis in Chapter XII. In Chapter XI, the organization of an irrigation district to carry out the irrigation development and to maintain the works after completion is described.

4. Domestic Water Supply and Sanitation

In addition to the development project for the Karditsa plain described above, measure should be taken by the local inhabitants to improve domestic water supply and sanitation. Domestic water supplies can be protected against contamination by fencing, and by excluding waste discharges through construction of adequate sanitary facilities at locations removed from sources of supply. There is no provision for obtaining water for domestic use in the Karditsa plain as part of the recommended plan of development. Where existing sources are inadequate, the most feasible method of augmenting the supplies is through dug or drilled wells. As income in the area increases as result of the proposed development, the larger villages will be in a position to install water distribution systems while the smaller villages will be able to install supply systems with distribution limited to public hydrants.

CHAPTER IX

DESCRIPTION OF THE RECOMMENDED WORKS

The principal features of the recommended works, as indicated on Plate IX-1, are listed as follows:

(1) Reservoir formed by Nevropolis storage dam on the Megdova River; Karitsiotis diversion dam for diversion of flow from the Karitsiotis River to the reservoir.

(2) The Megdova power plant, comprising the power-plant headworks near the village of Tsardaki, a concrete high-line conduit conveying water from the headworks to a 1.5-km steel penstock, an 84,000-kw hydroelectric plant near Blasdo and a 150-kv transmission line 38 km, long tying in to the projected P.P.C. network at Trikala.

(3) An irrigation and drainage system consisting of a diversion dam and intake at Metropolis and a main canal and laterals covering the irrigated area. The project drainage system ties into the present system leading to the Megas drain and the Voulgara Torrent.

NEVROPOLIS RESERVOIR

Pertinent data on the dam and reservoir are given in Table IX-1. For explanation of the storage allocations, see Chapter VIII.

1. Description of Site

The Nevropolis dam will be located on the Megdova River about 250 m upstream of its confluence with the Karitsiotis River, about 18 km southwest of Karditsa. At this point the river flows in a southerly direction following a rather well defined and slightly meandering course, making a few sharp bends upstream of the damsite (see Plate IX-2). It has incised a shallow channel ranging from a few meters to 30 meters in width and is characterized by an almost complete lack of alluvial deposits in its stream bed except for a few locations where shallow deposits of sand and gravel are formed.

At the damsite, the river bed at El 745 m has a width of

TABLE IX-1

PERTINENT DATA [illegible]
RESERVOIR & POWER PLANT

Discharge characteristics

Drainage area	147 km^2
Mean inflow	8.0 m^3/sec
Mean inflow per year	252 x $10^6 m^3$
Dependable outflow	6.8 m^3/sec

Elevations and storage allocations	El	Storage allocation (10^6 m3)	Total storage (10^6 m3)
Streambed at dam	745.0		0
Dead storage for sediment		75	
Bottom of live storage	776.0		75
Live storage		210	
Top of live storage and spillway crest	790.0		285
Top of dam	793.0		

Height of dam above foundation	48 m
Area of reservoir at spillway crest	20,500 str

Spillway and Outlet Works

Peak inflow, spillway design flood	1100 m^3/sec
Peak outflow, spillway design flood	115 m^3/sec
Maximum reservoir level, spillway design flood	El 791.2
Spillway length	50 m
Reservoir outlet at dam, inlet invert	El 755.0
Capacity during construction with reservoir at El 765	30 m^3/sec
Final capacity with reservoir at El 776	7 m^3/sec

Power Features

High-line conduit	
Diameter	2.5 m
Length	1094 m
Capacity with reservoir at El 776	24 m^3/sec
Penstock	
Diameter	2.0 m
Length	1521 m
Capacity with reservoir at El 776	24 m^3/sec
Turbines	
No. of units	4
Type	Pelton Wheel
Rating	30,000 Hp
Generators	
No. of units	2
Capacity	42,000 kw
Transformer	15/150 kv
Nominal rating @ 80% power factor	52,500 kva

28 m and at the elevation of top of dam El 793 the width between banks is 158 m.

On the right bank, a hill rises approximately 90 m above the stream bed on a general slope of 4:1. The left bank is much higher and steeper, rising several hundred meters on slopes approaching 1.5:1 in some locations. There is enough soil cover to support an abundant growth of trees and shrubs.

2. Geologic Investigations

General description: The dam and reservoir area lie within formations ranging in age from the Mesozoic to recent. All rock types in this area are sedimentary. The older formation (Mesozoic age of the Olenos-Pindos zone) consists of grey to blue compact well-bedded limestone interbedded with brown to pink or grey hornstone and brownish argillaceous shale in thin layers. The flysh formation of Eocene age (Tertiary) is deposited over the limestone formation in an unconformable contact. The flysh consists of alternate beds of argillaceous silty shale and sandstone shale. The silty shale is well bedded in thin beds and contains very fine quartzite sand and a very small percent of mica. The sandstone is a compact rock in thick beds and consists of fine quartzite sand. Overlying the flysh strata are alluvial and recent deposits of clay, silt, sand and gravel.

The limestone and flysh formations in the Megdova region have been subjected to the Alpine tectonic movements. Both formations are folded with a general dip to the NE (upstream). A system of approximately parallel faults with a general direction from SE to NW exists. The strata at the right abutment are approximately horizontal, while at the left bank they dip into the abutment on angles of from 20 to 30 degrees.

Most of the area to be inundated by the reservoir is covered by a thick bed of alluvial sediments or flysh (argillaceous shale). Outcrops of Mesozoic limestone occur at the intersection of the roads Tzardaki-Bezouli and Tzardaki-Neochori, along the southern shore of Vava lake and 1 km southeast of Vava lake. These outcrops are small and in competent geologic opinion, are underlain by watertight rocks. Rock outcrops give no indication

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of pervious zones nor is there any evidence of sinkholes or underground solution channels. The reservoir rims at the highest level are extremely thick and appreciable leakage is unlikely.

Earthquakes of feeble or medium intensity have occurred, but those of a great intensity have not been experienced. The usual design criteria for seismic effects are considered necessary. Geologic plans and sections of the dam and spillway are shown on Plate IX-3.

Subsurface Explorations: The exploratory program at the damsite consisted of three diamond core drill holes to establish local geologic conditions, determine general excavation grades and to prove the ability of the foundation to support the structure. Boring logs and location are given on Plate IX-4.

The saddle to the left of the dam was examined by means of 5 test pits to determine the thickness of overburden to bed rock which was found very near the surface (0.20 to 0.60 m).

The site for the proposed headworks was investigated by means of two diamond core drill holes. Results are given on Plate IX-9.

Damsite: The river bed consists of Eocene flysh rock, with no overburden; the flysh, which extends up the right bank to El 752.0, is well bedded with a strike NW to SE and a dip 40° NE. From El 752 to 769 the flysh is covered by a bed of brown clay. The strata from El 769 to 790 consists of a well-bedded Mesozoic limestone with a strike NW to SE and a dip 50° NE. On the limestone a compact conglomerate is bedded with normal contact. The latter is composed of limestone gravels cemented by grey calcareous argillaceous shale, with joints of secondary calcite and cracks filled with grey argillaceous shale. The conglomerate in turn is covered by Eocene flysh.

The core borings at the damsite indicate a rather complex geology. DH4 in limestone is encountered to El 761.5 and below this conglomerate to El 749.3. This in turn is underlain by flysh. As the flysh belongs to a later geologic age, it is evident that an overthrust exists and that the older rocks are under the younger rocks.

In DH6 at El 741.2, a bed of limestone 8.7 in thickness was encountered with no sign of conglomerate. A bed of sandstone flysh was interbedded with the limestone from El 732.50 to the bottom of the hole at 726.8.

In DH5 only flysh was encountered. It is watertight rock and no leakage of water is expected for a minute amount through cracks in the flysh; however, in view of the rather complex geology at the site it is recommended that further investigations be made before construction drawings are started with at least 3 more borings at the damsite as follows: one on the right bank starting about El 760, at an angle of 70° to the west and about 40 m deep; the second in the center of the channel (El 746) and 50 m deep, and the third on the left bank, El 765, at an angle of 45° to the east. As bedrock is exposed or near the surface at both abutments and the river bed, excavation will consist essentially of stripping and the forming of a shallow cutoff trench in the rock. The excavation will assume an irregular grade following the contour of the rock. It is not likely that extensive foundation treatment will be required; however, pending further field investigations, an allowance for drilling, washing and grouting has been included in the cost estimate in Chapter X.

Spillway: Bedrock is near the surface at this location and no special treatment is required beyond removal of overburden and excavation of rock for the spillway and spillway channel.

Karitsiotis canal and diversion dam: The canal will lie on the north side of the Karitsiotis River at about El 800. It will pass through an area of flysh (argillaceous silty shale and sandstone shale), the beds of which dip steeply NE (30° to 60°) into the slope of the bank so that there is no danger of slide. The rock is watertight and no seepage losses are anticipated.

At the site of the Karitsiotis diversion dam flysh appears on both abutments. The bed of the river is covered by a layer of sands, gravel and bolders about 1 m thick, the Karitsiotis River being the only stream in the area which has a recent sediment bed. The overburden consists largely of limestone, with only a small proportion of flysh sand and gravel. No special foundation problem exists except the provision of a cutoff to bedrock in the river bed. Two diamond core drill holes were drilled at this location. Under a rather thick mantle of alluvium (5 to 10 m of sandy silty clay) the typical flysh strata were found, i.e., alternate thin strata of sandstone and shale. Because of the laminated nature of the flysh through which the tunnel for this structure must be driven, temporary supports and permanent lining will be required; however, as the rock is practically watertight, no special provisions such as grouting will be required.

High-line conduit, penstock and power house: The areal geology and geologic sections for these structures are shown on Plate IX-10. As indicated thereon, flysh is exposed along the alinement of the high-line conduit, and most of the penstock. Alluvium is exposed along the alinement of the lower end of the penstock and the power house. No difficult foundation problems are expected concerning the high-line conduit and the penstock. For final design, borings will be required at the power house to determine foundation conditions more accurately.

Metropolis diversion dam: This dam will be located in the Karditsa plain which was formed by alluvial deposits of great but unknown depths. The deposits consist of clay, silt, sand, sandy clay, silty clay and gravel. No borings were made for this report, as no special foundation treatment is required for structural reasons; however, in connection with seepage losses and apron protection, borings should be made prior to final design.

3. Nevropolis Dam and Spillway

Selection of site: The site selected for the dam is about 250 m upstream from the confluence of the Karitsiotis River with the Megdova at a narrow point where the contours of the sides of the valley are most favorable for forming the abutments for the relatively high dam contemplated. About 800 m from the left abutment there is a saddle which permits the construction of an overflow spillway with a minimum of excavation. A sharp nose on the left abutment is favorable for location of a tunnel for river diversion during construction and later use as a reservoir outlet (see Plate IX-6).

About 2 km below its confluence with the Karitsiotis, the Megdova River enters a gorge which cuts through the Agrafa Mountains. It had previously been proposed that a storage dam be constructed at a narrow point in the gorge near the village of Kokavakia (see Plate II-1); however, a comparative study indicated that a higher and more costly structure would be required to secure equivalent storage.

Type of dam: Several possible types of dam suitable for the location were investigated prior to deciding on the rolled-fill type recommended herein. With the abundance of suitable borrow material for core and shell adjacent to the damsite, the conventional rolled-fill earth embankment with impervious core and pervious shells was found to be the most economical. The recommended design is shown on Plate IX-6.

The following tabulation gives the controlling dimensions of the embankment.

Top of dam	793
Spillway crest	790
Bed of river	745
Width at crest of dam	10 m
Slopes of impervious central core	1:1.3
Slope of pervious shell	
Downstream	1:1.7
Upstream	1:2.2
Minimum water level in reservoir	770.0

An impervious cutoff will be constructed as an extension of the core with a bottom width of 10 m and side slopes of 1:1. The cutoff trench will extent a minimum of 2 m into the rock foundation throughout the length of the axis of the dam, to minimize seepage under the dam.

Design: The stability and factors of safety of the dam were determined, using the dimensions given above and test results for the borrow material selected. The angle of internal friction of the sand, gravel and boulders of which the pervious shells will be constructed was estimated to be 35°. Material for the core will be taken from borrow area "B". The strength characteristics of this material as determined by direct shear tests and as used in the computations were:

	Test	Used in Computations
Angle of internal friction	23°	18°
Value of cohesion	0.95 kg/cm²	0.8 kg/cm²

A horizontal shear analysis of the section was made for two conditions: (1) The upstream slope subject to drawdown to El 770 with submerged weight shell material below and drained material above; downstream shell assumed drained; both shells resist horizontal shear forces from the core which is assumed to be saturated. (2) Sudden drawdown and seepage line parallel to the slope

The factors of safety for the two cases are summarized as follows:

	Safety factor
Case 1 - Horizontal shear analysis	
Upstream	1.89
Downstream	1.95
Case 2 - Sudden drawdown	1.29

The above factors of safety are considered adequate for the conditions existing at the dam. Danger of piping will be eliminated by excavating the cutoff trench into rock.

Seepage: A seepage analysis was made to determine the loss through the embankment. A factor of $K = 1 \times 10^{-4}$ was used for the coefficient of permeability, though this is far greater than the actual value of the core material when properly compacted. The analysis indicates that the total seepage loss through the embankment would not exceed 0.01 m^3/sec. Seepage under the dam (through the foundation) may safely be disregarded, inasmuch as the impervious core will be carried into the flysh which is watertight.

Borrow materials: The two principal materials for construction of the dam are sand, gravel and boulders of pervious nature for the shells, and silty clay and sandy clay of low permeability for the central core. Shell materials in sufficient quantity are found in the Karitsiotis stream bed, extending for a considerable distance upstream of the confluence of Karitsiotis and Megdova Rivers. Four borrow areas for core materials were investigated by means of shallow explorations consisting of auger borings and test pits as shown on Plate IX-6. Of these, borrow area "B" was finally selected as containing the most suitable material in sufficient quantity. Borrow Area "B" is pasture land located about

600 m upstream of the damsite on the left bank. Three test pits of a maximum depth of 1.50 m were excavated and representative and composite samples were taken from each one. The material was found to be sandy clay containing trace to some gravel as shown on the logs in Plate IX-6. While the high clay content provides the required imperviousness, the adequate percentage of granular material increases its strength characteristics. Borrow Area "C" located opposite borrow area "B" on the right bank will be used solely to supplement any deficiencies. This borrow area was investigated by means of auger borings A-3 and A-4, excavated to a maximum depth of 2.5 m. Samples from these borings were classified as silt and sand with trace to some clay. The clay content increases in the vicinity of boring A-4, while in the vicinity of boring A-3 the material is practically entirely cohesionless. Borrow area "A" at the damsite was eliminated as it contained a limited quantity of suitable material. Borrow area "D", in the vicinity of the confluence of Karitsiotis and Megdova Rivers, which is now used productively for the cultivation of corn was discarded because of the shallowness of the deposits of impervious material. Coarse aggregate for concrete can be obtainned from the Karitsiotis stream bed, and sand may be processed from local sources. Rock for riprap and paving can be obtained from the outlet works and spillway excavation. Additional rock can be quarried in the slopes on either side of the Megdova River farther downstream, where numerous excellent outcrops are available at or near the river bed.

<u>Laboratory tests</u>: The laboratory tests performed on the soil samples obtained during the soils investigations for construction material included sieve analyses, Atterberg limits determinations, Proctor compaction tests, specific gravity determinations, consolidation, unconfined compression and direct shear tests. The latter were used for the determination of the value of the cohesion and the angle of internal friction of the soil. All samples obtained were disturbed and the tests performed on them were in the condition of compaction and optimum moisture content, required when rolled in place. A detailed list of the results of the above tests appears on Table IX-2.

TABLE IX-2

SUMMARY OF LABORATORY TEST RESULTS
ON SOIL SAMPLES FOR NEVROPOLIS DAM CONSTRUCTION MATERIALS

Borrow Area	Sample No.	Natural Moisture Content %	Gradation			Atterberg limits			Casagrande Class.	Proctor Compaction		Unconfined Compression		Specific gravity G_s	Direct Shear	
			MC %	S %	G %	LL %	PL %	PI %		Max. dry unit Wt. (T/m3)	Opt. mois. %	Stress kg/cm²	Strain %		Cohesion C (T/m²)	Angle of friction
								(bag samples)								
"A"	A-1		60			49.2	21.1	28.1	SC							
"B"	TP-1		61	22	17	41.6	21.9	19.7	SC.CL							
	TP-2		26	23	51	36.0	20.2	15.8	GC.SC	1.71	17.5	3.60	1.80	2.83	9.5	23°
	TP-3	19.4	55	32	13	48.6	27.2	21.4	SC							
"C"	A-3 & A-4	21.5	57	41	2	-	-	0	SF	1.78	16.5	1.65	8.0	2.74	4.0	27°
"D"	TP-4 & A-5		60	33	7	34.3	18.9	15.4	SC							
	TP-5		28						SF.ML							
	Sample No. depth							(jar samples)								
	A-1/1.90	22.5				42.0	19.9	22.1								
	A-3/1.30	21.6				43.5	21.8	21.7								
	A-4/2.0	21.5				39.0	18.3	20.7								
	TP-3/1.40	19.4														
	TP-5/-	19.4														
	B/0.50	22.9														

Water passages and intakes: The outlet for irrigation and power located at the upper end of the reservoir on the left side about 6½ km NE from the dam, is described below under power-plant headworks.

The narrow channel and relatively steep slopes at the damsite require that river diversion be accomplished by means of a tunnel for which a good location exists in the left abutment nose. The tunnel (invert El 755) will be about 170-m long of conventional horseshoe shape concrete lining 30-cm thick. The dimensions inside the lining will be 2.5 m high by 2.5 wide. During construction, the tunnel will pass 30 m^3/sec with reservoir level at El 765; this is adequate for a flood with a peak inflow of 200 m^3/sec having an estimated frequency of once in two years. Following completion of the embankment, the diversion tunnel will be converted into a permanent outlet by installation of a concrete plug and emergency valve chamber 70 m from the inlet. A 1-m steel pipe in the tunnel will extend from the plug to the outlet portal of the tunnel where control gate will be installed (see Plate IX-6).

Spillway: The spillway design flood as developed in Section III-11 of this report was taken as 1,100 m^3/sec. The spillway capacity of 115 m^3/sec was determined by assuming the reservoir full at the start of the flood and reducing the given inflow by reservoir surcharge storage. The spillway, located in a saddle about 800 m from the left abutment, will be a straight concrete spillway 50 m long, with its crest elevation at El 790 and approach channel bottom at El 783 (see Plate IX-7). The overflow crest will have a conventional shape terminating in an apron and dentated bucket designed to spread and aerate the overflow nappe. The spillway channel is in rock and is therefore unlined. It leads back to the river 900 m below the dam.

Although no flood control storage is provided, the large reservoir area serves effectually to cut down peak discharges; as described above, with a design inflow of 1,100 m^3/sec, the maximum outflow is only 115 m^3/sec.

Preparation of reservoir area: The reservoir area at spillway crest (El 790) of 20,500 str constitutes 82% of the area of the Nevropolis plain. This plain, in conjunction with the adjacent hill and mountain area, supports a population of about 10,000 people who live in the 12 villages situated near the plain. A meagre living is derived by these inhabitants by farming the plain and by pasturing livestock. About 2,500 str in the plain are now irrigated from the Megdova River. Primitive farming methods, lack of adequate irrigation and drainage facilities and the small parcels of land owned by each family, have kept the average annual farm income at the lower-then-subsistence-level of about 3,000,000 Dr per farm family; a limited additional income is derived from sales of wood and from tourist traffic.

Inundation by the reservoir will permanently eliminate production on about 5,100 str of small grain, 4,500 str of corn, 3,200 str of seed potatoes, 1,000 str of alfalfa and 6,700 str of native pasture and range. This represents a loss of agricultural production which has a gross value of 10 billion Dr, and a net value, after deducting farming expenses, of 5 billion Dr. The value of the land varies from about 200,000 Dr per str for pasture to 2,000,000 Dr per str for good quality irrigated land. It is estimated that the inundated lands will have a value of 20,000 million Dr.

Of the 10,000 people now deriving their livelihood from the Nevropolis plain, about 5,000 people will be displaced by the construction of Nevropolis dam and reservoir. Means should be found of resettling all or part of these people. Possible solutions include (a) labor requirements for irrigation of the larger farms in the Karditsa Irrigation District (see Chapter XI) (b) labor requirements of industries using Megdova power, (c) construction labor for the Megdova project followed by tourist trade along Nevropolis reservoir, (d) settlement in new irrigation districts in the Thessaly plains made feasible by cheap electricity from the Megdova hydroelectric plant.

In the preparation of the area prior to flooding the principal work will be the relocation of a portion of the Kastania-Neohori road on the west shore of the reservoir and a small section (2½ km) of the Kastania-Tsardaki road on the east shore. The reservoir area will be cleared of timber and small trees between the limits of high and low water (El 790 to 776). The area is rather sparsely wooded and the salvage value of the timber to the local residents would more than offset the cost of the required clearing. There are no gaps or saddles in the reservoir area that will require the construction of dikes or embankments, nor are there any known areas of sink holes or depressions along the margin of the reservoir that will require special measures to ensure drainage as the result of fluctuations of the reservoir level.

4. Karitsiotis Diversion

Diversion of the Karitsiotis River will be accomplished by means of a diversion dam 2 km upstream of the Megdova River confluence and a canal along the north bank of the Karitsiotis leading into the Nevropolis reservoir. The diversion dam will be a low uncontrolled concrete overflow weir with a gated intake and sluiceway on the left bank (see Plate IX-8). The dam will be 30 m long and 5 m above streambed (crest El 800 m); it will have an ogee profile and a concrete apron downstream terminating in a bucket. The streambed downstream from the bucket, will be protected against erosion by derrick-stone paving. Cutoff walls, at the toe and heel of the dam, will be carried down to bed rock, and as a further precaution to minimize uplift, the downstream apron will be provided with deep holes and will be underlain by a graded gravel filter. Excavation upstream from the dam will be backfilled with impervious material. A sluiceway will be provided with a radial gate 5 m wide and 6.90 m high between two abutments which will act as training walls and will extend about 20 m up and downstream from the gate sill. The left wall will be dropped to form a skimmer weir with its crest at El 799.40; a stilling basin 6 m wide by 20 m long with its floor at 798.0 will lead to intake gates each 1.5 by 1.5 m.

The canal will have a bottom width of 3.0 m and side slopes of 1 to 1, designed to convey a maximum flow of 7 m^3/sec. As stated previously, the canal is cut into flysh and no loss of water is anticipated.

5. Power Plant

Power plant headworks: The intake for power and irrigation water will be located on the east shore of the reservoir, about 6.5 km NE from Nevropolis Dam and adjacent to the village of Tsardaki. As indicated on Plate IX-11, the headworks will consist of an approach channel leading to a tunnel 260-m long which will, in turn, discharge into a concrete high-line conduit. The approach channel will be 1,100 m long with bottom width of 3 m at El 770.5 m and sideslopes of 1½ to 1. The depth of cut will vary unformly from 0 at the entrance of the channel to 20 m at the tunnel portal. The tunnel, of conventional horseshoe section, will be 2.5 m high by 2.5 m wide inside the concrete lining; it will be on a slight grade, the invert elevation at the inlet portal being 770.5 and at the outlet 770.0. A bell-mouthed inlet to minimize head losses and a trash rock structure will be placed at the waterway entrance. Service and emergency slide gates, placed in a chamber about 90 m downstream from the entrance, will be operated from the control house through a shaft extending to about El 795. Access to the control tower will be from the Kastania-Karditsa road which passes adjacent to it. The outlet portal of the tunnel will be directly connected to the concrete highline conduit. The service gate operated from the tower will permit closure of the conduit for inspection and maintenance.

<u>High-line conduit and terminal regulator</u>: The high-line conduit will lead from the exit portal of the tunnel to the steel penstock; it will be a reinforced concrete pressure conduit 2.5-m in internal diameter, 1,100 m long, supported above ground on concrete cradles (see Plate IX-11). Invert elevation at tunnel portal is El 763 (max. static head 27 m) and at penstock entrace El 753 (max. static head 37 m). A terminal regulator will be provided near the end of the high-line conduit, at the penstock inlet; it will consist of an open well having an area of about 80 m^2 and a height of about 40 m; its purpose will be to avoid transmission of water-hammer effects from the penstock to the conduit and to supply sufficient water to the penstock for a brief period in case of sudden increase in demand at the power house. In preparing final designs of the regulator, consideration should be given to use of automatic tainter gates designed to spill water under disturbed conditions caused by rapid shutdown on the turbines in the power

plan

Penstock: The penstock (see Plates IX-12 and 13) will lead from the high-line conduit at El 753 to the power house at El 287; it will be a steel pipe 1,533 m long, 2 m in diameter, with shell varying from ½" to 1-5/8" thick. It will be supported slightly above ground surface on concrete cradles, with anchor blocks at charges of direction or grade. Maximum static head will vary from 37 m at the high-line conduit to 500 m at the power house. The maximum fiber stress under static head will be 15,000 psi. No allowance has been made in the pipe thickness for water-hammer as with the high head on the plant and the time (10 seconds) at which the governor will be set for complete closure, the water-hammer pressure will not exceed 1/3 of the static head and the tension in the pipe perimeter will not exceed 20,000 psi which is well within the elastic limit. The peak flow through the penstock will be 24 m^3/sec for which the maximum velocity will be 7.7 m/sec and the head loss 60 m or about 12% of the gross head-- this is acceptable considering the short time of occurrence. Although Plate IX-12 indicates the penstock as having a uniform diameter, when final designs are made, consideration should be given to increasing the diameter gradually from the bottom to the top in order to reduce friction losses and water-hammer and achieve possible savings in freight charges (pipe sections of various diameters can be "nested" during shipment). As no relief valve is necessary, no waste of water will occur except through the nozzles during the 10 or 12 seconds of closing time.

Power house: The hydroelectric station will be located near the village of Blasdo about 10 km NE from the dam. It will be reached by an access road from the Metropolis-Blasdo Road. The power house will be of the closed type of reinforced concrete construction. The substructure will be of massive concrete construction and will contain the necessary galleries for inspection, oil and water piping, electric conduits, and turbine pits. Switchgear, batteries, shops and washrooms will be housed in the superstructure. The two generators will be placed 4.5 m back from the downstream end of the tailrace portal and 14 m apart. Each generator has tentatively been placed between and directly connected to the horizontal-shaft Pelton wheels. In final design, consideration should be given to the use of one vertical-shaft Pelton wheel for each unit so as to reduce materially the size of the power house. A bridge crane running the length of the power house will be used to erect and dismantle hydraulic and electric machinery. All major equipment will be electrically operated.

The turbines will be of the Pelton type rated at 30,000 Hp at 430 m head. They will be designed and built by recognized manufacturers of proven experience and will be equipped with all accessories necessary to ensure the guaranteed efficiencies and uninterrupted operation.

The generators will be 52,500-kva at 80 percent power factor, 50-cycle, 15,000-volt units with a continuous 15% overload capacity. Each generator will be equipped with a direct-connected exciter and a permanent magnet pilot generator. The 15 kv transmission line from the plant will dead end in the switchyard located about 40 m west of the power house. Here, transformers will step up the voltage to 150 kv. The electrical equipment will be provided with all accessories needed to ensure the guaranteed efficiencies and uninterrupted operation.

Transmission system: From the switchyard at Blasdo, a 150-kv transmission line designed according to accepted modern standards will run about 10 km easterly to Karditsa and thence 28 km north to Trikala where it will tie in to the proposed P.P.C. network. The power market area and proposed transmission line are shown on Plate IX-14.

IRRIGATION AND DRAINAGE SYSTEMS

6. General Plan

The general layout of the proposed irrigation system is shown in Plate IX-16. The Metropolis diversion dam and canal intake will be located in the channel of an existing torrent into which the power-house tailrace empties. The relatively high elevation of the intake works with respect to the area to be served together with the general slope toward the north will permit effective distribution of irrigation water by gravity.

The main canal will take off from the diversion dam in a NE direction for a distance of two kilometers then turn easterly following the down-slope side of the existing drainage canal as far as the east bank of the Kalenzis River, a distance of 8 km. From this point, the canal may be extended later, at such time that more water becomes available, to serve an area on the west bank of the Sofaditis River.

All the principal laterals except two will be supplied from the main canal as indicated in Plate IX-16; the two exceptions are first the lateral running easterly from the dam which will be served from the intake on the right bank, and second the lateral running westerly from the dam which will take off from the main canal and be carried under the stream by a syphon.

The secondary canals will be located so as to form a parallel grid system suitable for mechanical methods of farming. They will be about 2 km apart and have turnouts every 500 m to the tertiaries which will take the irrigation water to the farms. At every 200 m along the tertiaries a turnout will be provided. From these turnouts the farmers will cut ditches to irrigate their lands. The typical layout will be as shown in Plate IX-17, showing irrigation water supplied to the high corners with return water removed from the low corners by drainage ditches.

The main drains west of the Kalentzis River will tie into the existing Megas drain; those east of the Kalentzis will drain into the Voulgara torrent. Secondary drains will parallel the secondary irrigation canals as indicated on Plate IX-18. Drains will be entirely separated from other types of channels, namely the irrigation canals and the waste ditches, the latter serving to intercept farm waste and surface runoff. The drains will be generally 3 m deep and located so as to reach depressions and areas where groundwater is excessively high and so that the distance from any point in the irrigated area to the nearest drain will not exceed 0.5 km. Generally it will be advantageous to locate the drain parallel and on the upslope side of an irrigation canal as shown on Plates IX-17 and IX-18. Spoil material excavated from the drain and from the parallel irrigation canal will be placed between the drain and the canal and will serve to carry a gravel-surfaced roadway. The latter will provide means of maintaining the drain and canal and will be incorporated into a system of rural roads for the area. The road embankment and the low embankment next to the waste ditch will exclude surface water from the drain.

7. Metropolis Diversion Dam

The diversion dam and intake at Metropolis will serve to divert 16 m^3/sec into the main canal and 3 m^3/sec into the east lateral. As shown on Plate IX-17, the structure will consist of an overflow weir across the torrent channel, a gated sluiceway 4-m wide adjacent to the intakes of the right bank, and two intake weirs perpendicular to the sluice gate. The intake weirs which will act as skimmers to keep sediments out of the canals will be surmounted by slide gates. The entire structure will be founded on earth. To prevent seepage, undercutting and loss of water, the area immediately upstream from the dam for a distance of 15 m will be covered by a clay blanket which will be protected by a layer of riprap. Protection against erosion and scour downstream from the dam will be provided by rock paving for a distance of 10 m. Cutoff walls are provided at toe and heel of the spillway and skimmer weirs.

8. Canals

The canals will serve a gross irrigable area of 140,000 str; the net area available for cultivation will be 126,000 str as determined by deducting an allowance of 10% from the gross area to allow for canals, roads and buildings. Of the 126,000 str of net irrigable land, 114,000 str would be irrigated each year because a part of the arable land will continue to be dry-farmed. The main canal capacity is based on a water requirement or duty of 1 m^3/sec for each 8,000 str and the primary lateral capacities are based on a duty of 1 m^3/sec for each 7,000 str. The secondary and tertiary canals will have sufficient capacities near their

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ends to permit diversion of 0.03 m^3/sec at any 3 farm turnouts simultaneously.

For economy in construction, canal cross-sections were selected that compromised between "the most efficient section" and "non-silting" limits. Grades and locations were chosen so as to balance cuts and fills as far as possible. Berms will be provided for access and maintenance as shown on Plate IX-18. The material through which the canals will be excavated is largely recent alluvial soil. In some low-lying areas the soil is clayey, sticky when wet and hard when dry. Outwash fans and terraces have a sandy soil and are rather permeable. The soils in this area are indicated on the soil classification map, Plate V-1.

Side-slopes of 1 vertical to 1 horizontal in cut and 1 to 1.5 in fill were adopted and will be stable for the soil conditions described. It is expected that occasional pockets of pervious material will be encountered. The cost estimates are adequate to allow for sealing such pockets with clay linings. Typical canal cross sections are indicated on Plate IX-18.

9. Irrigation Structures

Structures required in the canals will include syphons, drops, checks, division structures, wasteways, turnouts, drainage crossings, and road crossings. Typical structures are shown in Plates IX-19 and IX-20.

Parshall flume: It is recommended that a Parshall flume be placed at the upper end of each main canal and lateral for the purpose of obtaining a continuous record of the flow in the canals. Standards for the design of Parshall flumes can be obtained by reference to Bulletin 423 of the Colorado Agriculture Experiment Station, "The Parshall Measuring Flumes", 1926. Where a lateral has a capacity of less than 2 m^3/sec, a battery of modules, similar to those described below, is recommended.

Modules: Modules will be installed at the heads of primary, secondary and tertiary laterals as shown on Plate IX-17. Typical modules for secondary and tertiary laterals, sketches for which are shown on Plate IX-20, would have capacities of 300 and 60 l/sec respectively. These devices are recommended for use on this project as having the following advantages:

(1) Single modules are manufactured for various convenient capacities ranging from 5 to 1000 liters per second. Installed singly or in combination ("battery of modules"), virtually any desired capacity can be achieved.

(2) With selected slides in a battery set in an open position, the discharge into a lateral remains practically constant, even though the upstream level varies within certain limits, and is independent of the downstream level.

(3) The slides in the modules are easily operated and can be closed quickly if necessary.

(4) The cost of the modules compares favorably with conventional slide gates which do not have the above advantages.

Automatic checks: As shown on Plate IX-17, automatic checks will be installed at strategic locations in the conveyance system. The purpose of the checks is to maintain water levels within narrow limits at junctions with branch canals or laterals. Sketches of the automatic checks are shown on Plate IX-20. Also known as "constant upstream level gates", these checks consist of float-buoyed sector gates with attached counterweights. If the level upstream of a gate rises because of increased flow in the canal, the float acts to raise the gate permitting more water to pass and causing the water level upstream of the gate to return to its previous height. A lip is provided at the top of the gate so as to prevent floating debris from blocking the gate. The use of these automatic checks has the following advantages:

(1) Constant levels within narrow limits are maintained at the turnouts to branch canals or laterals irrespective of the discharge in the canal in which the automatic check is placed.

(2) Owing to the instantaneous response of the automatic checks to change in water level, overflow wastes from the canals are reduced to a minimum, resulting in considerable savings in water.

(3) Much less supervision of the irrigation system is required as compared with that needed when non-automatic checks are used.

(4) The price of the automatic checks compares favorably with non-automatic checks employing standard slide gates.

Farm turnouts: As shown on Plates IX-17 and IX-20 farm turnouts to the farm ditches will be located along the tertiary laterals. As the weight of a farm turnout will be only about

600 kg, they can be fabricated in a central yard, hauled to the site, and placed by means of a small derrick. The proposed design shown on Plate IX-20 includes a steel plate that slides in a rubber groove set in the concrete, following a similar design that has been used with success in the United States.

Culverts: Design of two typical culverts for carrying roads over irrigation canals are shown on Plate IX-19. A typical small culvert will consist of a precast concrete pipe while a typical large culvert will be cast in place. Elaborate transitions upstream and downstream of the culverts will be unnecessary as velocities in the canals and through the culverts will be low.

Siphons: Inverted siphons of reinforced concrete will be constructed where canals cross rivers and other natural drainage depressions. The elevations of the canals relative to the natural stream channels do not favor the use of flumes, as these would cause retarding effects on flood flows in the natural channels. A typical siphon for a secondary canal is shown on Plate IX-19.

Drops: The slopes of the canals have been selected so that excessive scouring velocities will not occur. Because of this provision, the installation of a drop structure is required when the natural ground slope exceeds the canal slope. Typical drops for secondary canals will be, as shown in Plate IX-19, small concrete structures in which the excess energy of the fall will be dissipated in a hydraulic jump induced by a sill in the lower basin. Riprap protection will be provided upstream and downstream of the drops. The sills may be omitted for small canals. Drops for primary canals will consist of concrete-lined sections and a transverse sill to facilitate hydraulic jump formation and energy dissipation. Such a drop will sometimes be combined with a check, wasteway and silt sluice.

Automatic wasteways: These structures, a sketch of which is shown on Plate IX-19 will be placed in the main canals and laterals at convenient points near natural stream channels. The automatic gates, which will be similar in design to that used in the automatic checks, would normally be closed but will be set so that in case the water level in the main canal should rise by a predetermined amount they will open thus preventing excessive levels in the main canal and overtopping of the canal banks.

Emergency spillways: Emergency spillways will be placed on the main canal at intervals of about 5 km or less depending on the quantity of cross drainage expected to enter the canal. As shown on Plate IX-19 they will consist of stone-paved depressions in the canal banks. In case the canal bank also serves as a roadway, the width of stone paving will be sufficient to accommodate the road. As in the case of the automatic wasteways, the emergency spillways should be located so as to discharge into natural stream channels.

Drainage crossings: A typical drainage crossing by means of a concrete-pipe culvert is shown on Plate IX-20. Erosion protection will consist of riprap at the outlet. Seepage protection will be provided by concrete collars.

CHAPTER X

ESTIMATES OF COST

1. Basis for Estimates of Cost

In this chapter the estimated costs of construction of the works comprising the recommended plant of development and the construction program are discussed.

Detailed estimates of quantities and cost, prepared for the various features of the project, are summarized herein with the principal quantities and estimated costs given for each feature. The estimated costs are in drachmae for local costs and in United States dollars for imported materials, equipment and services. Unit costs of construction were based upon prevailing costs in Greece for works of a similar nature, utilizing modern construction equipment and methods.

The construction program has been based upon the execution of the work by qualified Greek contractors with the exception of the secondary and tertiary irrigation canals. It is recommended that these canals be constructed by the Irrigation District inasmuch as the equipment required for construction will be needed later for maintenance.

The net estimated construction costs have been increased by 27% to provide for overhead, taxes and contractor's fee. The estimated construction costs have been increased by 15% to provide for unforeseen contingencies. The costs of engineering have been estimated at 8% of the total estimated construction costs plus contingencies.

2. Construction Units

The proposed development must be constructed in the most economical manner in the shortest possible time so as to insure the completion of the various features in the order required for the initiation of operations. For this reason the work has been divided into construction units each of which would be covered by a single contract as follows:

Construction Unit 1:	Nevropolis dam.
Construction Unit 2:	Karitsiotis diversion dam and canal.
Construction Unit 3:	Power plant headworks.
Construction Unit 4:	Power plant including highline conduit penstock, power house and equipment.
Construction Unit 5:	Transmission line, 150 kv, 38 km long.
Construction Unit 6:	Irrigation and drainage system.
Construction Unit 7:	Land preparation.
Construction Unit 8:	Roads.

3. Construction Program

Construction of Nevropolis dam, the power plant headworks, and the penstock and power house would begin in the spring of year minus 3. In year minus 2, construction of the concrete highline conduit and the irrigation system would be initiated; work on the headworks, penstock and power house would be continued; and Nevropolis dam would be completed. The year minus 1 would mark the construction of Karitsiotis diversion dam and canal together with completion of the entire power plant and transmission line; construction of the irrigation system would continue. In year 0, the spring of the fourth year of construction, the power plant and 45,000 str under the irrigation system would go into operation; construction of the remainder of the irrigation system would continue until the fall of the year plus 3; and the full 114,000 str would be under irrigation in the year plus 4.

4. Cost Estimates

The estimates of principal quantities and costs determined as described previously in this chapter are given below in Tables X-1 and X-2.

TABLE X-1

PRINCIPAL CONSTRUCTION QUANTITIES
MEGDOVA PROJECT

1. NEVROPOLIS DAM

Stripping	28,000 m^3
Structural excavation, earth	21,000 m^3
Diversion tunnel excavation, rock	900 m^3
Embankment, pervious	370,000 m^3
Embankment, impervious	111,000 m^3
Gravel filter	11,000 m^3

TABLE X-1 (Continued)

PRINCIPAL CONSTRUCTION QUANTITIES
MEGDOVA PROJECT

Concrete	5,500 m^3
Bituminous surface course	1,700 m^2
Gate valves, 1 m	2 each
Steel pipe, welded, 1 m diameter	115 m
Road Relocation	Job

2. KARITSIOTIS DIVERSION DAM AND CANAL

Excavation, flysh	95,000 m^3
Backfill	9,000 m^3
Gravel bedding and filter	800 m^3
Rock paving	800 m^3
Concrete	4,000 m^3
Gates, slide, 1.5m x 1.5m	3
Gate, radial, 5m x 7m	1

3. POWER PLANT HEADWORKS

Excavation, flysh and earth	436,000 m^3
Excavation for tunnel, flysh	2,600 m^3
Backfill	500 m^3
Rock paving	100 m^3
Concrete lining, tunnel	1,000 m^3
Control tower	Job

4. POWER PLANT

Highline Conduit

Excavation	16,500 m^3
Concrete	3,020 m^3
Reinforcing steel	440 T
Terminal regulator	Job

Penstock

Excavation, flysh	2,600 m^3
Backfill	600 m^3
Anchor blocks, concrete	3,600 m^3
Penstock, steel, 2 m diameter	2,240 T

Powerhouse

Structure	Job
Pelton wheels, 30,000 Hp ea.	4
Generators, 42,000 kw	2
Switchyard and substation	1
Traveling crane	1
Workshop	Job

5. TRANSMISSION LINE - 150 kv — 38 km

TABLE X-1 (Continued)

PRINCIPAL CONSTRUCTION QUANTITIES
MEGDOVA PROJECT

6. IRRIGATION	
Metropolis Diversion Dam	
Excavation earth	5,600 m^3
Backfill	1,200 m^3
Gravel bedding and filter	500 m^3
Rock paving	200 m^3
Concrete	1,200 m^3
Gates, slide, 2m x 3m	4
Gates, slide, 4m x 1.5m	1
Irrigation and Drainage System	
Excavation, irrigation canals	425,000 m^3
Structures:	
Modules	1,694
Checks	1,588
Drops	12
Emergency spillways	24
Wasteways	23
Siphons	7
Parshall flumes	10
Division boxes	3,150
Culverts and bridges	16
Excavation, drainage ditches	950,000 m^3
7. LAND PREPARATION	126,000 str
8. ROADS, SURFACING	330,000 m^2

COST ESTIMATE[1]
MEGDOVA PROJECT
(millions of drachmae)

Item	Domestic Currency	Foreign Exchange Equivalent[2]	Total
Nevropolis dam and reservoir[3]	42,440	2,050	44,490
Karitsiotis diversion weir and canal	4,390	740	5,130
Power plant headworks	12,420	420	12,840
Power plant	21,350	92,050	113,400
Transmission line	5,940	8,400	14,340
Irrigation and drainage system	24,410	5,530	29,940
Land preparation	9,255	135	9,390
Roads	2,825	45	2,870
Total	123,030	109,370	232,400

Notes: 1/ The above costs do not include interest during construction. Interest during construction at 4½% has been included in the financing program described in Chapter XII. Above costs do not include allowance for purchase of land or easements except as noted in 3/

2/ Costs of imported materials and equipment were estimated in U.S. dollars and converted to foreign exchange equivalent at the rate of 15,000 Dr to the dollar.

3/ Cost includes an allowance for purchase of 20,500 str of reservoir land.

CHAPTER XI

ADMINISTRATION, OPERATION AND MAINTENANCE

1. Coordinated Operation of the Megdova Hydroelectric Plant

Effective utilization of the power resources of Greece can best be attained through interconnection of all the major generating stations into a single power pool so that the combined generating resources of the interconnected network can be used to carry the total load served. In order to effect the maximum utilization of the Megdova power plant, and at the same time gain the economic advantage of using the facilities, equipment, and organization which would be available from other units of the power network, it is recommended that the administration, operation and maintenance of the Megdova hydroelectric plant be placed under tha authority of the Public Power Corporation of Greece.

Cost of operation and maintenance: The charges for electric energy delivered to the consumer will include costs of generation and transmission incurred by the recommended development plus additional costs attributable to the use of the P.P.C. transmission and distribution facilities. Table XI-1 gives the estimated costs for operation and maintenance allocated to the Megdova power plant and transmission line to Trikala; charges beyond Trikala incurred in transmitting Megdova energy are not included in this report.

TABLE XI-1

ESTIMATED ANNUAL COSTS OF
OPERATION AND MAINTENANCE
MEGDOVA POWER PLANT
(millions of drachmae)

Description	Cost
Salaries and wages	1,275
Materials and supplies	145
Depreciation, equipment and plant	1,170
Rent, light, heat, miscellaneous	20
Total	2,610

2. Karditsa Irrigation District

It is recommended that an irrigation district be organized to carry out the project for the development of the Karditsa plain. This type of organization has proved successful in the United States for projects of similar size and scope.

The Karditsa Irrigation District would be created by means of a special statute to be enacted by the Parliament of the Kingdom of Greece. Consent of a majority of the citizens residing in the Karditsa plain would be required. The exact geographical limits of the Karditsa Irrigation District would be defined by the statute.

The irrigation district would be managed and operated by an executive board as described below. Supervision by the National Government would be provided to the extent of seeing that laws are enforced and that satisfactory standards are followed in administration, design, construction, operation and maintenance. The district would have the authority to issue bonds for the construction of the works, the bonds to be repaid from the proceeds of assessments levied upon the land. It is contemplated that the bonds would be purchased by the National Government and by quasi-public social security agencies such as "IKA". The district would have taxing power in that it would have the authority to make landvalue appraisals and to collect charges with which to repay the bonds.

The district would also levy charges as described below; the revenues from this source would be used to pay current operating and maintenance charges.

3. Organization of the Irrigation District

Although the Karditsa Irrigation District would be a legal entity separate from and independent of the Megdova power development, the operations of the power authority and the irrigation district would be closely associated, inasmuch as both developments will use water from the Nevropolis reservoir. For this reason the maximum degree of mutual cooperation and coordinated operation of the two activities should be maintained. A suggested plan of organization for the irrigation district is shown in

Table XI-2.

TABLE XI-2

PROPOSED ORGANIZATION
KARDITSA IRRIGATION DISTRICT

Executive Board

5 Members

Chief Engineer

Secretary

Operation & Maintenance	Equipment Pool & Repair Shop	Receipts & Disbursements
1 Supervisor	1 Supervisor	1 Supervisor & chief collector
2 Assessors	2 Mechanics	2 Clerks
3 Foremen	3 Equipment operators	1 Paymaster
2 Clerks	3 Laborers	
5 Drivers		
30 Laborers		

Executive board: It is recommended that the 5-man executive board be selected as follows:

1 member appointed by the Government

4 members elected by majority vote of adult citizens residing in the district, whether landowners or not.

The members of the board should serve without salary but should be entitled to expenses. The appointments, being of considerable honor, should be reserved for distinguished and public-spirited members of the community.

The chief engineer as the chief executive should be selected by the Board and should be subject to dismissal only by it. He should be an experienced engineer with executive ability as he will be responsible for the efficient administration and operation of the irrigation district.

Staff: The supervisor of the Operation and Maintenance Section will represent the chief engineer in all matters dealing with project drainage and irrigation and will be responsible for the issuance of water, the preparation of records of water use and the maintenance and operation of all irrigation and drainage works. It will also be his duty to call and attend meetings of cultivators in order to estimate the needs for irrigation water. The assessors will survey the holdings of the cultivators, issue water and prepare records of land use. The clerks will handle typing, timekeeping, and storekeeping. The foreman, the laborers and drivers will handle routine operating and maintenance duties.

The Equipment Pool and Repair Shop will be responsible for the operation and maintenance of equipment listed in Table XI-3, and will also perform repairs on mechanical equipment in the distribution systems when requested by the Operation and Maintenance Section and approved by the chief engineer.

The Receipts and Disbursements Section will be responsible for billing and collecting fees and charges, preparing payrolls and making routine purchases.

4. Operation of the Irrigation District

Initial tasks: It is recommended that surveys be made of individual land holdings, prior to beginning the reclamation work, to determine for each holding the total area of cultivable land which is suitable for drainage and irrigation. As discussed in Chapter V under Land Use Capacity, farming in large tracts is necessary for attainment of maximum yields. It should be the policy of the district to promote farming in much larger tracts than is customary at present; the size tract devoted to a particular crop can be enlarged by cooperative use of adjacent parcels in varied ownership or by redistribution and consolidation of scattered parcels belonging to the same owner. Land preparation which will be a project cost as stated in Chapter IX, should be carried out under direct supervision of the district following the property surveys and following also, if possible, the property redistribution.

Revenue collection: Fees collected by the district from cultivators will be based on land values and on quantities of water delivered as described in Chapter XII. The part of the fee based on land values will be due whether or not individual land owner irrigates his land. The part based on water use will pay for current operation and maintenance costs; as it will be proportional to water consumed, it will tend to prevent excess use of water which often causes waterlogging of the land and higher costs for maintaining canals and structures.

TABLE XI-3

ESTIMATED OPERATING AND MAINTENANCE EQUIPMENT REQUIREMENTS SELECTED IRRIGATION AREA

I t e m	Quantity
Management and Administration Use	
Station wagon	1
Operation and Maintenance Section	
Pick-up trucks	5
Dump trucks	3
Road grader, motor driven	1
Tractor 120 Hp with caryall and bulldozer attachment	1
Dragline, 3/4 cu.yd. with back-hoe and shovel attachment	1
Concrete mixer, ½ cu.yd.	2
Sump pumps	2
Land leveller	1
Small tools and spare parts	Lot
Equipment Pool and Repair Shop	
Forge and anvil	1
Battery charger	1
Air compressor	1
Grease pit and equipment	1
Block and tackle, 2T	1
Small tools	Lot

At the beginning of each cultivation season, meetings of cultivators would be called by the operations supervisors to determine the anticipated seasonal irrigation requirements. As water is issued, the assessors would record for each land holding the crops irrigated and the corresponding areas. At the end of the irrigation season, data for billing purposes would be forwarded by the assessors, through proper administrative channels, to the Receipts and Disbursements Section where bills would be prepared and mailed to the cultivators. The cultivators would be required to pay the assessed fees within a reasonable specified period of time. Payments may be remitted by mail or delivered in person to the collectors during specified collection periods. A schedule of penalties and discounts should be used to encourage prompt payment of bills.

5. Personnel

The success of an organization such as proposed herein is dependent, among other things, upon its ability to attract and hold high-grade employees. In the employee relationships of the organization, there should be ample provision for eliminating unsatisfactory employees and for promoting employees on a merit basis. It is also essential that the ordinary rules for government employees be not applicable to a program of this type. It may be desirable also to distribute a percentage of the net annual profits to the employees as a bonus. This would have the effect of making all the employees desire to see the organization operate at a profit. Salaries should be fixed by the Executive Board and the policy should be such as to permit the payment of relatively high salaries to those in responsible positions in the organization. Accordingly, allowances have been made in the estimates of administration cost contained herein to pay relatively high salaries to key personnel at the outset and to permit salary increases in subsequent years when salary ranges will undoubtedly be considerably greater than at present as a result of the anticipated development of Greece as a whole. The salaries and wages of the permanent employees of the district are included in Table XI-4 in which annual costs of operation and maintenance are given.

6. Maintenance

The maintenance of the irrigation and drainage systems, will be performed by the regular personnel of the Operation and Maintenance Section and of the Equipment Pool and Repair Shop. Irrigation and drainage systems will be maintained down to the farm ditches, which will be the responsibility of the individual cultivator. The supervisor of the Operation and Maintenance section shall require the individual cultivators to maintain their

TABLE XI-4

ESTIMATED ANNUAL COSTS OF
OPERATION AND MAINTENANCE
SELECTED IRRIGATION AREA

(millions of drachmae)

Description	Cost
Salaries and wages	1,605
Materials and supplies	360
Depreciation, equipment and plant	260
Rent, lights, heat, miscellaneous	35
Total	2,260

ditches and shall be empowered to affect necessary maintenance, if required to protect adjacent lands or to insure the proper functioning of the project, and to charge the cost of such maintenance to the cultivator. The estimated annual cost of operation and maintenance is given in Table XI-4.

CHAPTER XII

JUSTIFICATION AND FINANCING OF THE PROPOSED DEVELOPMENT

1. Allocation of Construction Cost

The allocation of construction cost between power and irrigation features is given in Table XII-1. Where construction features have a common use for both power and irrigation, as in the case of Nevropolis and Karitsiotis dams and the power plant headworks, the cost between power and irrigation was assigned on a 70% and 30% proportion respectively. These percentages were estimated on the basis of the proportion of water used for power and for irrigation; where water is used for both purposes, half was assigned to power and half to irrigation. The estimated total construction cost of the plan of development as given in Table XII-1 is 232,400 million Dr of which 74%, or 171,460 million Dr is allocated to the power features.

TABLE XII-1

ALLOCATION OF CONSTRUCTION COST

(millions of drachmae)

Item	Power	Irrigation	Total
1. Nevropolis dam	31,140	13,350	44,490
2. Karitsiotis diversion dam and canal	3,590	1,540	5,130
3. Power plant headworks	8,990	3,850	12,840
4. Power plant	113,400	-	113,400
5. Transmission line	14,340	-	14,340
6. Irrigation and drainage system	-	29,940	29,940
7. Land preparation	-	9,390	9,390
8. Roads	-	2,870	2,870
Total	171,460	60,940	232,400

2. Annual Power Benefits and Costs

The determination of the direct benefits attributable to the generation and sale of electrical energy at some future time cannot be accurately estimated. In Chapter VI it was demonstrated that the worth of electric power to the consumer could be as much as 2,500 Dr per kwh; however, this figure is intended only to indicate the order of magnitude of power benefits which should be realized.

Chapter VI also included a comparison between the cost of the Megdova power plant and other projected P.P.C. power plants per installed kw and per kwh of primary and secondary energy. Ebasco Services, Inc. indicated in their 1950 report entitled "Electric Power Program" that these power plants are economically feasible. As the Megdova power plant can be constructed for less cost per kw of installed capacity than the P.P.C. plants, and as the cost per kwh is also less, it is concluded that the Megdova hydroelectric plant also is economically feasible.

Under the plan of financing proposed herein, repayments would be made in 20 equal annual payments beginning in the seventh year after project inauguration (Year plus 3) at which time the total allocated power investment at an assumed interest rate of 4½ percent including capital for operation and maintenance of the development until repayment begins, would be 196,800 million Dr. The annual cost of operation and maintenance of the power features, including a reserve for replacement, as given in Chapter XI, is 2,610 million Dr. The annual cost of amortization with interest at the assumed rate of 4½ percent over the 20-year period is 15,120 million Dr (see Table XII-7). The annual cost during the 20-year repayment period for the annual production of 229 million kwh of primary and secondary power is 2,610 plus 15,120 or 17,730 million Dr. This amounts to a unit average cost of 78 Dr per kwh.

IRRIGATION PROJECT JUSTIFICATION

3. Annual Irrigation Benefits and Costs

The direct benefits resulting from the Karditsa irrigation development were discussed in Chapter V. In Table V-16 the direct benefits for the selected net irrigation area of 126,000 str during different stages of development were given as the differences between the surplus under present conditions and those to be obtained in the future as a result of irrigation and drainage. Farm families, which perform all labor under present conditions and will also meet practically all labor requirements in the future, will enjoy an additional benefit termed the "labor benefit". Both the direct benefit and the labor benefit are given in Table XII-2. The latter is discussed further below under Total Benefits.

TABLE XII-2

IRRIGATION PROJECT JUSTIFICATION

(millions of drachmae)

Item	Condition B	Condition C	Condition D
Investment	70,300	70,300	70,300
Annual charges			
Interest and amortization	5,410	5,410	
Operation and maintenance	2,260	2,260	2,260
Total	7,670	7,670	2,260
Annual benefits			
Direct benefits	23,400	38,200	43,300
Labor benefits	8,500	18,800	21,100
Ratio of direct benefits to charges	3:1	5:1	19:1

NOTE: Repayment will be completed in the Year plus 21. The useful life of the development with the annual expenditures for operation and maintenance shown, will be much longer than this.

The allocated construction cost of the irrigation plan as given in Table XII-1 is 60,940 million Dr. Under the plan of financing proposed herein, repayment of capital investment would be made in 20 equal annual payments beginning in the Year plus 2 at which time the total investment at an assumed interest rate of 4½ percent, including capital for operation and maintenance of the development until repayment begins, would be 70,300 million Dr. The annual cost of operation and maintenance of the improvements, including a reserve for replacements, as given in Chapter XI is 2,260 million Dr. The annual cost of interest and amortization at the assumed rate of 4½% over the 20-year period is 5,410 million Dr. Comparison of annual costs and benefits are given in Table XII-2.

4. Improvement in the Standard of Living

As described in Chapter V, the development will result in increased returns to labor, Labor costs under the various stages of development were given in Table V-16; the increases over present conditions (Condition A) may be called the "Labor Benefits" and are given in Table XII-2. In Chapter V, the daily labor rates assumed in determining labor costs were stated to be as follows:

Condition A	25,000 Dr
Condition B	30,000 Dr
Condition C	40,000 Dr
Condition D	40,000 Dr

The above rates for future conditions C and D are thus 60% higher than those prevailing at present. In case the development of Greece as a whole procedes faster than can be foreseen at present, it is likely that the future labor rates will be higher than those indicated above. The labor benefits in that case would be greater, but, on the other hand, the repayment capacity of the project would be less as discussed below in the section on Repayment Capacity. As practically all of the work on the farm is preformed by the farmer and his family, most of the labor benefits represent a better standard of living for the farm family. A large part of the surplus (see Table V-16) except the portion deducted for taxes (see Section 7 below) will also be available in the form of increased income to the farmer. The improvement in the standard of living of the farm families in the selected irrigation area will be reflected throughout the region through increased retail trade and a general increase in economic activity.

5.

The present and estimated future values of the lands in the sample irrigation area were given in Table V-18. The increase in agricultural wealth will create a demand for labor and a market for the products raised on the dry farms and range lands adjacent to the plains. Furthermore a coordinated utilization of the dry farm and range lands in conjunction with the irrigated lands of the plains will result in greater potential productivity of the lands adjacent to the development area, thereby increasing the value of these contiguous areas. These increases may be as much as 15% of the value in the case of dry-farmed lands and 5% in the case of dry pasture lands.

6. Increased Industrial Activity

The expansion of industrial activity resulting from the proposed development will, as described in Chapter V, provide more employment for non-farm labor and seasonal employment for farm labor. The salaries, wages and profits to be expected from the processing of the increased agricultural production are indirect benefits which are attributable to the recommended development program.

7. Increased Tax Returns

The reasons justifying imposition of a tax on land were discussed in Chapter V. As described below under Repayment Capacity, a tax on either land or income was assumed equal to 15% of the surplus available after payment of subsistence living allowance and project charges. Excise and other taxes now collected by the National Government will also increase in direct proportion to the increase in commercial transactions and in the economy of the region.

8. Foreign Exchange Earnings

The foreign exchange value of the produce of the development area was given in Table V-17. As Greece must import food (see Chapter V) and as there are foreign markets for the exportable products of the Karditsa plain, these values represent a net increase in foreign exchange.

9. Total Benefits

The direct irrigation benefits have been given in Table XII-2. The development will also produce the indirect benefits or "civil benefits" described above. The values of the following civil benefits, which stem directly from increased farm income, are already included in the direct benefits:

Increased land values
Increased tax returns
Foreign exchange earnings

Labor benefits and benefits due to increased industrial activity are indirect benefits which will be in addition to the direct benefits. As stated earlier, the labor benefits will amount to at least 30% of the total benefits. The monetary value of the indirect benefits cannot be determined accurately. It is believed, however, that the value of the indirect benefits will be at least equal to half of the direct benefits and that the ratio of total annual benefits to costs will be at least 50% greater than the ratios shown in Table XII-2.

IRRIGATION PROJECT REPAYMENT CAPACITY

10. Funds for Project Repayment

The capacity of a farm family to pay project charges cannot exceed its income less taxes and subsistence expense. It has been estimated that the minimum subsistence expense of a farm family in the Karditsa plain now amounts to about 7.0 million Dr per year (6.3 million Dr farm income plus 7.0 million Dr from small home industries) but that this should be raised to about 10 million Dr per year. It is assumed that future taxes amounting to 15% will be imposed on all income in excess of subsistence and that the farm-family payment capacity (farm-family income less subsistence less taxes) must be at least twice the project charges paid by the family. Based on the data in Chapter V, it has been determined that the minimum size of farm required to achieve this payment capacity is 24 str. In Table IV-6 it was shown that about

41% of the families in the plain have farms averaging 30 str in size; of this 41%, about two-thirds have farms smaller than 24 str and there is therefore, not enough assurance that they would be able to pay project charges. If the Government will distribute lands which it owns so that there will be no farms smaller than 24 str, the repayment capacity of the project as a whole would be 29.3 billion Dr (see Table XII-3) or about 4 times the project charges. If on the other hand the distribution of farm sizes remains about as at present, the repayment capacity would be only 21.0 billion Dr.

Minimum size of farm: As stated above, the minimum area required for a farm family to earn subsistence, pay taxes and have left over sufficient margin to ensure project payment has been estimated to be 24 str. About 27% of the land-owning families in the area now have, however, less than this amount so that means should be found to increase the area owned by this 27% in order better to ensure project repayment. It is likely that because of the base charges recommended below in Section 15, many of the larger land owners will elect to rent or sell part of their land to the smaller landowners; the Government could encourage this tendency by granting long-term low-interest loans for land purchase. In addition, the Government should distribute public land so as to encourage farm units at least 24 str in size.

11. Effects of Increased Labor Rates

In the preceeding section the future income of the 450 landless families in the area, whose income is derived only from wages, was shown to be 10 million Dr per family per year. The present labor rates now prevailing in the Karditsa plain as determined by long-standing economic conditions in Greece is only 25,000 Dr per day. In determining project benefits, it was assumed the labor rate would increase to 40,000 Dr per day (see Sections 3 ans 4 above). With this rate, a landless family would have to work 250 man-days to earn the subsistence allowance of 10 million Dr which appears reasonable. It could be argued that the assumed increase of the labor rate from 25,000 Dr per day to 40,000 Dr

TABLE XII-3

REPAYMENT CAPACITY

Selected Irrigation Area - 126,000 str 1/

(millions of drachmae)

2600 landowning families 2/

PART I - Computation of tax

(1)	Net farm income	72,390 3/
(2)	Subsistence allowance	26,000
(3)	Project annual charges	7,670
(4)	Surplus income (1) minus (2) minus (3)	28,720
(5)	Tax, 15% of (4)	5,800

PART II - Computation of Repayment Capacity

(1)	Present net farm income, per str	135,000 Dr 4/
(2)	Increase in labor income, condition C minus condition A, per str	165,000 Dr 4/
(3)	Total	300,000 Dr

(4) To reach subsistence level from increased labor income, a family must own 10,000,000/300,000 or 33 str

					Over	Total
(5)	Range in size, str	24-27	27-30	30-33	33	
(6)	Average size, str	25.5	28.5	31.5	68	44
(7)	Present net income per farm, (6) x 0.135	3.4	3.8	4.2	9.2	6.0
(8)	Increased labor income per farm, (6) x 0.165	4.2	4.7	5.2	11.2	(7.2)
(9)	Total, (7) and (8)	7.6	8.5	9.4	20.4	(13.2)
(10)	Deficiency below subsistence	2.4	1.5	0.6	0	-
(11)	Number of farms 6/	1100	250	160	1090	2600
(12)	Total deficiency, (10) x (11)	2640	370	100	0	3100
(13)	Direct benefit					38,200 5/
(14)	Deduction, (12) + taxes	3,100 + 5,800				8,900
(15)	Repayment capacity, (13) - (14)					29,300

1/ 114,000 str irrigated annually
2/ From Table IV-6 there are by proportion about 2,600 land-owning families in the selected irrigation area
3/ Table V-16
4/ Table V-16
5/ Tables XII-2 and V-16
6/ Public land distributed so that no farms are smaller than 24 str

per day is insufficient in view of the plans now being projected for industrialization and land reclamation in Greece which, if successful, would increase the demand and price for labor. Such an increase would not, however, seriously impair the ability of the project to repay the necessary investment considering that: (1) If the cost of labor (most of which would be paid to the farmer himself) were increased 50%, the repayment capacity would be reduced to about 22,720 million Dr which is still enough to pay project charges. (2) Greece is primarily an agricultural country with only 4% of the working population engaged in industry; therefore the spread of industrialization to the point where it will compete for labor with agriculture to an appreciable degree is in the distant future. (3) If a large-scale industrialization program were to be put into effect, the prices of farm products would undoubtedly rise thus increasing the net farm income; (4) there is a possibility of getting interest-free financing as described in the following paragraph.

12. Effect of Free Interest

Under the Reclamation Law in the United States, irrigation projects have been financed with public interest-free money. If it were decided to subsidize reclamation in Greece in like manner, as a matter of national policy, the annual charges of the project would be materially reduced. Without interest the charges would be as follows:

1.	Investment (equals cost of construction)	60,940 million Dr
2.	Amortization (one twentieth of Item 1)	3,050 million Dr
3.	Operation and maintenance	2,260 million Dr
4.	Total annual charges	5,310 million Dr

In lieu of lowering the annual charges from 7,670 million Dr (Table XII-2) to 5,310 million Dr, the amortization period could be shortened from 20 years to 11 years if interest-free money is provided.

In the financing schedule given in the next section, it is assumed that interest at 4½% will be paid. It is shown that financing and its repayment based on charges assessed against the cultivators is entirely feasible with this assumption. On the other hand if it is decided to subsidize reclamation by granting interest-free money, the assessments could be greatly reduced as described above.

FINANCING THE PROPOSED DEVELOPMENT

13. Financing Schedule

The financing of the recommended plan of development should be the responsibility of the National Government as, under existing national and international conditions, this is the only feasible method of securing the necessary funds.

It is proposed that the National Government, through the Ministry of Public Works, design and construct the recommended development plan and turn the completed projects over to the operating authorities.

A proposed financing schedule, based on the estimated construction costs and construction program given in Chapter X is presented in Table XII-4 for power, and in Table XII-5 for irrigation.

14. Charges for Electricity

The charges for electricity are based on wholesale price delivered to the P.P.C. power network at Trikala. A charge sufficient to retire the bonded indebtedness of the power plant and to carry on annual operation and maintenance of the power features is estimated at 85 Dr per kwh. This charge is used in the prospective financial statement in Table XII-7.

15. Charges for Irrigation and Drainage

The charges for the irrigation system must be sufficient to yield the revenue required to retire the bonded indebtedness of the Irrigation District. The charges for irrigation water must be sufficient to provide the funds required annually for operation and maintenance of the project and to establish a fund for replace-

TABLE XII-4

PROPOSED FINANCING SCHEDULE
MEGDOVA POWER DEVELOPMENT

Year	Item	Amount
-3	1. Engineering: Field work & design	6,350
	2. Construction: 60% of Nevropolis dam 30% of power plant head works, 30% of penstock, 20% of power house & equipment	40,730
	3. Total engineering and construction	47,080
	4. Interest on item 3 1/	2,120
	5. Total investment for year minus 3	49,200
-2	6. Engineering: Field work & design	3,170
	7. Construction: 40% of Nevropolis dam, 50% of power plant head works, 70% of high-line conduit, 30% of penstock; 40% of power house	58,220
	8. Total engineering and construction	61,390
	9. Interest on items 5 & 8 1/	4,980
	10. Total investment for year minus 2	66,370
-1	11. Engineering: Field work & design	3,170
	12. Construction: 20% of power plant and head works, 30% of the highline conduit; 40% of penstock, 40% of power house, 100% of Metropolis and Karitsiotis diversion dams, telephone and system water supply, housing and sanitary system	59,820
	13. Total engineering and construction	62,990
	14. Interest on items 5, 10 & 13	8,030
	15. Total investment on year minus 1	71,020
0	16. O & M & RR	1,730
	17. Interest on items 5, 10, 15 & 16	8,480
	18. Total investment for year 0	10,210
	Grand Total Investment	196,800

NOTE: 1/ Interest rate 4½%.

TABLE XII-5

PROPOSED FINANCING SCHEDULE
KARDITSA PLAIN IRRIGATION

Selected Irrigation Area, 114,000 str

Year	Item	Amount
-3	1. Engineering: Field work & design	350
	2. Construction: 60% of Nevropolis dam, 30% of head works	8,480
	3. Total engineering and construction	8,830
	4. Interest on Item 3 1/	400
	5. Total investment for year minus 3	9,230
-2	6. Engineering: Field work & design	530
	7. Construction: 40% of Nevropolis dam, 50% f headworks, 50% of main irrigation canal; irrigation & drainage system, land preparation & roads for 25,000 str area	14,980
	8. Total engineering and construction	15,510
	9. Interest on items 5 & 8 1/	1,110
	10. Total investment for year minus 2	16,620
-1	11. Engineering: Field work & design	2,200
	12. Construction: 100% Karitsiotis dam, 20% of head works, 100% of reregulation reservoir, 100% of Metropolis diversion dam, 30% of main irrigation canal, irrigation & drainage system, land preparation & roads in 25,000 str area, 80% maintenance equipment	12,090
	13. Total engineering and construction	14,290
	14. Interest on items 5, 10 & 13	1,810
	15. Total investment for year minus 1	16,100
0	16. Engineering: Field work & design	1,320
	17. Construction: 20% of main irrigation canal, irrigation & drainage system land preparation and roads in 25,000 str area, 20% of maintenance equipment	7,620
	18. Total engineering and construction	8,940
	19. Operation and maintenance	1,350
	20. Interest on items 5, 10, 15, 18 & 19	2,350
	21. Total investment for year 0	12,640
	22. Construction: Irrigation & drainage system, land preparation & roads in 25,000 str area	6,680
	23. Interest on items 5, 10, 15, 21 & 22	2,750
	24. Funds borrowed for construction in year +2 4,010 x 0.9569	3,830
	25. Funds borrowed for construction in year +3 2,670 x 0.9157	2,450
	26. Total investment for year +1	15,710
	Grand Total Investment	70,300

NOTE: 1/ Interest rate 4½%.

ment of equipment and structures. At the same time, the charges must be low enough to make irrigation of high-yield crops and the practice of crop rotations attractive to the cultivator. Based on estimates presented in the section on Annual Benefits and Costs, the average annual costs and charges during Condition C of the development are given in Table XII-6.

TABLE XII-6

IRRIGATION ANNUAL COSTS AND CHARGES

(drachmae per stremma)

Annual cost			Annual charges		
Amortization	Operation & maintenance	Total	Base charge 1/	Water charge 2/	Total
47,000	20,000	67,000	48,000	21,000	69,000

1/ Average annual assessment, based on the value of the land, will pay fixed charges and will be levied against each land owner in the district irrespective of whether water is used.

2/ Charge will be directly proportional to the water delivered and will pay for operation and maintenance.

16. Project Net Revenue and Debt Service

The estimated revenues, costs of operation and maintenance reserve requirements and debt service are shown in Table XII-7 for power and Table XII-8 for irrigation. Repayment of Government loans would be completed in 20 years; the useful life of the project will be much greater than the period set up herein for project repayment.

TABLE XII-7

PROSPECTIVE FINANCIAL STATEMENT
MEGDOVA POWER DEVELOPMENT

(millions of drachmae)

Year	Investment	Power sales kwh x 10^6	Income 85 Dr per kwh	Expenses 1/	Net operating revenue	Amortization with interest at 4½ %	Net surplus	Accumulated surplus
-3	49,200	-	-	-	-	-	-	-
-2	66,370	-	-	-	-	-	-	-
-1	71,020	-	-	-	-	-	-	-
0	10,210	40	3,400	- 2/	3,400	-	3,400	3,400
1		100	8,500	1,730	6,770	8,470 3/	-1,700	1,700
2		200	17,000	2,610	14,390	8,470 3/	5,920	7,620
3		213 4/	18,100	2,610	15,490	15,120	370	7,990
22		213	18,100	2,610	15,490	15,120	370	15,020

NOTES: 1/ Operation, maintenance and reserve for replacement
2/ Included in investment during this year
3/ Interest only
4/ 203 million kwh primary, 26 million kwh secondary which is considered to have revenue equivalent to 10 million kwh of primary power

TABLE XII-8

PROSPECTIVE FINANCIAL STATEMENT
KARDITSA IRRIGATION DISTRICT

Selected Irrigation Area, 114,000 str

(millions of drachmae)

Year	Investment	Area	Income 69,000 Dr per str	Expenses 1/	Net operating revenue	Amortization with interest at 4½ %	Net surplus	Accumulated surplus
-3	9,230	-	-	-	-	-	-	-
-2	16,620	-	-	-	-	-	-	-
-1	16,100	-	-	-	-	-	-	-
0	12,640	45,000	3,100	- 2/	3,100	-	3,100	3,100
1	15,710	70,000	4,830	1,790	3,040	-	3,040	6,140
2		90,000	6,120	2,260	3,950	5,410	-1,460	4,680
3		100,000	6,900		4,640	5,410	- 770	3,910
4		114,000 3/	7,870		5,610		200	4,110
21		114,000	7,870	2,260	5,610	5,410	200	7,510

NOTES:
1/ Operation, maintenance and reserve for replacement
2/ Included in investment during this year
3/ 126,000 str net irrigable, 114,000 str irrigated annually

CHAPTER XIII

CONCLUSIONS AND RECOMMENDATIONS

IT IS CONCLUDED THAT:

1. The water and soil resources of the Megdova basin and the Karditsa plain are in need of development in the interest of improving the industrial economy and the agricultural production of the immediate area and the country as a whole.

2. Regulation of the flow of the Megdova River by means of the Nevropolis dam and reservoir can justify an installation of 84,000 kw dependable capacity at 28.5 percent load factor so as to produce annually 203,000,000 kwh of dependable energy and 26,000,000 kwh of secondary energy.

3. The Megdova hydroelectric plant can be constructed and operated for the following approximate costs in millions of Dr:

Capital cost	196,800
Annual cost of operation, maintenance and reserves for replacement	2,610
Annual cost of amortization with $4\frac{1}{2}$ percent interest during a 20-year repayment period	15,120
Total annual cost	17,730

4. Primary energy from the Megdova power plant delivered at Trikala (on the Public Power Corporation transmission system), will cost only 87 Dr per kwh; the following comparison shows Megdova power to be relatively cheap:

	Megdova	Kremasta	Ladhon	Agra	Louros
P.P.C. project status	-	Projected	Under const.	Under const.	Under const.
Installed capacity, kw	84,000	180,000	50,000	40,000	5,000
Estimated const. cost, million U.S. $	11.4	61.7	18.3	9.65	3.88

	Megdova	Kremasta	Ladhon	Agra	Louros
Year const, cost estimate was made	1952	1949	1949	1949	1949
Primary energy in million kwh per year	203	366	155	48	28
Cost per kwh of primary energy (20-year amortization, 4½% interest), Dr	87	261	183	310	214

5. As a second step, an additional power drop of about 150 m could be developed below the proposed Megdova power plant; further mapping is needed to study this possibility (see Recommendation 2).

6. A part of the water released from the Nevropolis reservoir for power generation can directly irrigate annually 114,000 stremmas of fertile land in the Karditsa plain.

7. The Karditsa irrigation system can be constructed and operated for the following approximate costs in million of Dr:

Capital cost	70,300
Annual cost of operation, maintenance and reserves for replacement	2,260
Annual cost of amortization with 4½ percent interest during a 20-year repayment period	5,410
Total annual cost	7,670

8. The present distribution of farm ownership is such that about 27% of the farm families in the selected irrigation area in the Karditsa plain own less than 24 str, which is the minimum needed to provide sufficient income to pay for farm-family subsistence and project charges; the remaining 73%, however, will receive income of 21,000 million Dr in excess of subsistence and taxes, or about 2.7 times the project charges. If public lands are distributed in a way so as to increase the minimum size of farm unit to at least 24 str, the project repayment capacity would be increased to about 29,000 million Dr, or almost four times the project charges.

9. The main features of the Megdova project as listed

below can be completed in three construction seasons:

a. Nevropolis dam and reservoir
b. Karitsiotis diversion dam
c. Power plant headworks and highline conduit
d. Penstock, power plant and transmission line
e. Metropolis diversion dam
f. Irrigation system for 50,000 str

Construction of the remainder of the 126,000 str irrigation system (114,000 str irrigated each year) would begin in the spring of the fourth construction season and could be completed by the fall of the seventh construction season. Generation of electric energy and irrigation would begin in the spring following the third construction season.

10. The Megdova project is entirely feasible from an engineering viewpoint and is immediately justified as a financial venture and as an economic undertaking.

IT IS RECOMMENDED THAT:

1. Preparation of construction designs, plans, specifications and contract documents for the execution of the following principal construction features be started at once in order that construction may be initiated as soon as financing is arranged:

a. Nevropolis dam and reservoir
b. Karitsiotis diversion dam
c. Power plant headworks and highline conduit
d. Penstock, power plant and transmission line
e. Metropolis diversion dam
f. Irrigation system for 126,000 str

2. To aid in preparation of the final design of the penstock and study possible development of an additional power drop (see Conclusion 5), aero-topographic maps on a scale of 1:10,000 with 10-m contour interval covering the Nevropolis reservoir, the Karditsa plain and the intervening terrain be prepared at once.

3. The cost of the Megdova hydroelectric project be financed by a loan bearing 4.5% interest in the amount of 196,800

million Dr, repayment to extend over a 20-year period; the cost of the Karditsa irrigation system be financed by a loan bearing 4.5% interest in the amount of 70,300 million Dr, repayment to extend over a 20-year period.

4. The Megdova hydroelectric station and the Nevropolis dam and reservoir be turned over to the Public Power Corporation for operation and administration based on an agreement between the Public Power Corporation and Karditsa Irrigation District whereby the district shall be granted a firm allocation of water for irrigation.

5. An Irrigation District for the Karditsa plain be established as soon as financing is assured; the district should be directed by an executive board composed of 4 members elected by the residents of the district and a 5th member representing the National Government. Further participation by the National Government should be limited to technical guidance.

6. The initial task of the Karditsa Irrigation District be the conducting of surveys of idividual land holdings with the view toward (a) redistribution to eliminate scattered ownership of separated parcels and to compensate for rights-of-way taken for canals and roads and (b) promotion of cooperative use of the land to permit farming in sufficiently large tracts to realize thr maximum productivity of the soil.

7. The Government sell public land within the Irrigation District in a manner so that the minimum size of farm unit shall be 24 str; long-term low-interest loans should be provided to small land owners to enable them to purchase public land or land now belonging to large landowners.

8. Maintenance of the completed works by the District be carried out with vigor and dispatch.

9. Repayment of the loan of 70,300 million Dr be undertaken by the Karditsa Irrigation District from revenue obtained from assessments on the lands benefitted and from the sale of water on a quantity basis.

10. Means be found of resettling all or part of the 10,000 persons now dwelling in or near the Nevropolis plain, many

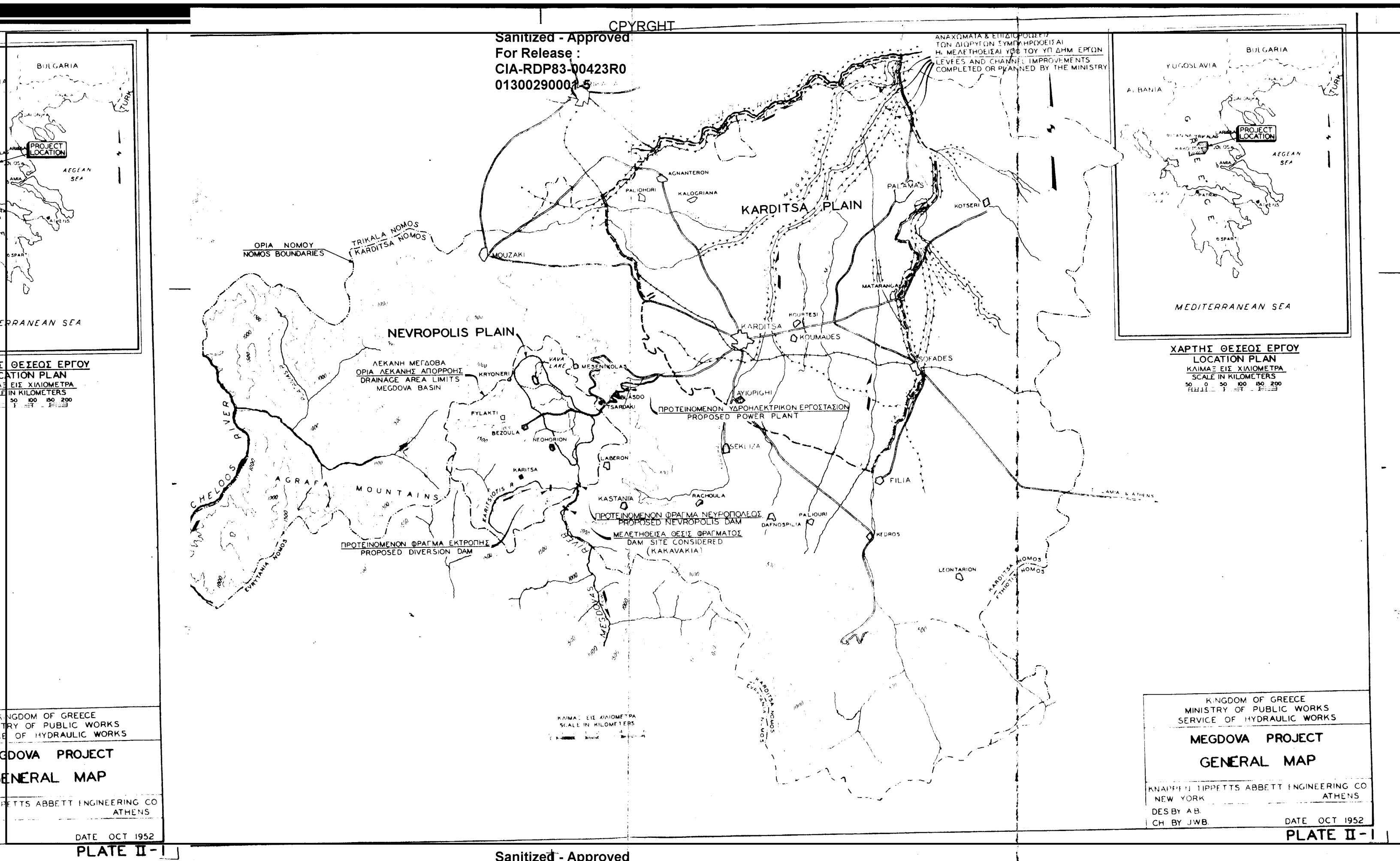
of whom will have to move prior to creation of the Nevropolis reservoir; possible solutions include (a) labor requirements for irrigation of the larger farms in the Karditsa Irrigation District, (b) labor requirements of industries using Megdova power, (c) construction labor for Megdova project followed by tourist trade along Nevropolis reservoir, (d) settlement in new irrigation districts in the Thessaly plains made feasible by cheap electricity from the Megdova hydroelectric plant.

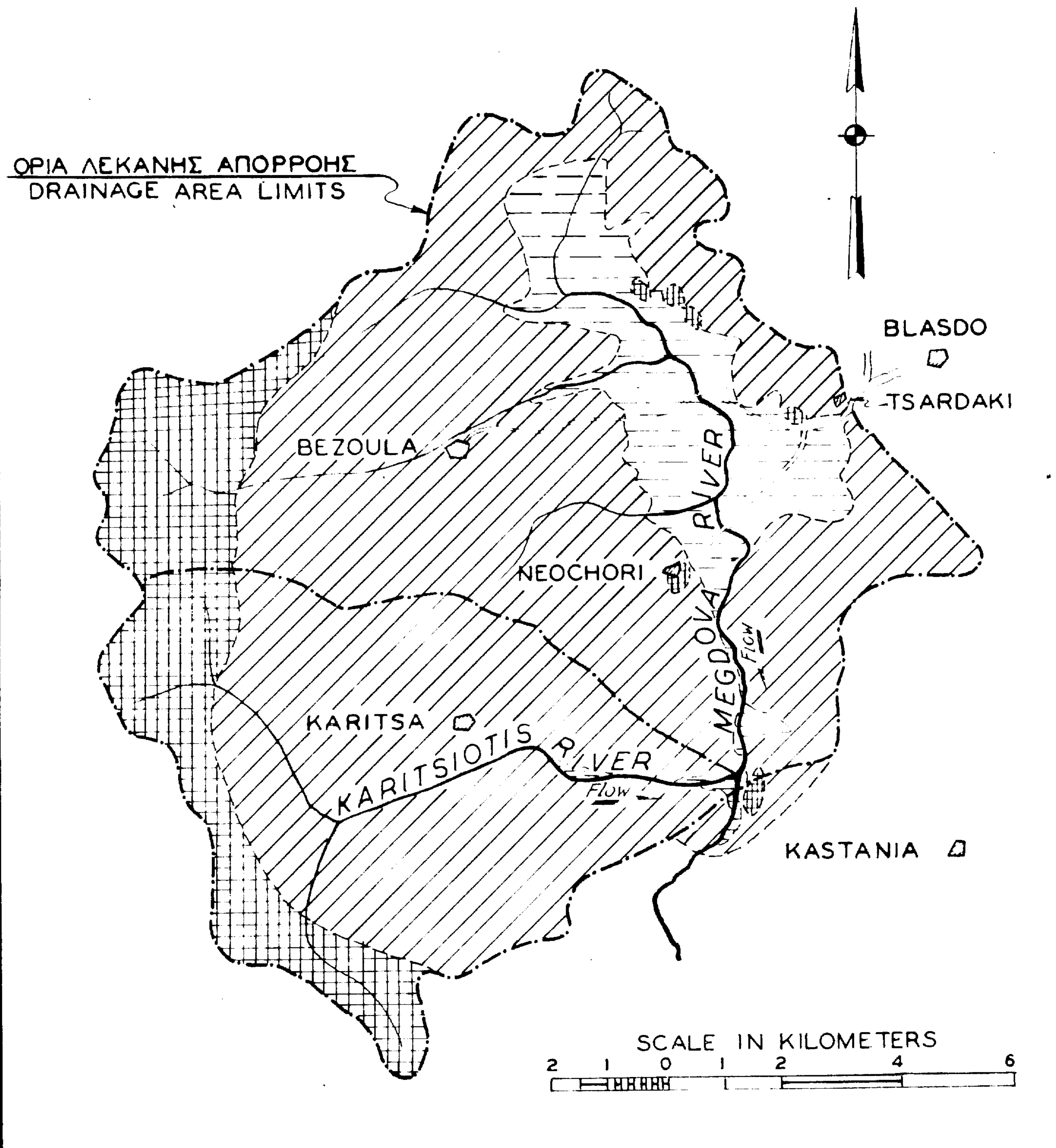
11. Guidance by the National Government be extended to farmers, village cooperatives and unions of cooperatives on the following subjects: crop rotation, use of fertilizers, live-stock management, land and animal diseases, food processing, irrigation methods and domestic water supply and sanitation.

12. Production drilling of deep wells in the Karditsa plain be postponed until all economic sources of surface water and shallow groundwater in and surrounding the plain have been fully utilized through storage or by pumping utilizing electricity from the Megdova power plant. In the region contiguous to the Karditsa plain, surface and shallow groundwater supply sources should be studied for possible development for irrigation utlizing Megdova power.

13. A study be made of the area downstream of the Karditsa plain relative to the effective utilization of water released from the Megdova power plant during the winter, and return flow resulting from irrigation of the Karditsa plain during the summer.

14. The hydrologic program initiated as part of the investigations leading to the preparation of this report be continued and that further improvements in the program of obtaining precipitation and stream-flow measurements be made as described in Chapter III.


KARDITSA PLAIN
NEVROPOLIS PLAIN
ΟΡΙΑ ΝΟΜΟΥ
NOMOS BOUNDARIES
TRIKALA NOMOS
KARDITSA NOMOS
ΛΕΚΑΝΗ ΜΕΓΔΟΒΑ
ΟΡΙΑ ΛΕΚΑΝΗΣ ΑΠΟΡΡΟΗΣ
DRAINAGE AREA LIMITS
MEGDOVA BASIN
ΠΡΟΤΕΙΝΟΜΕΝΟΝ ΥΔΡΟΗΛΕΚΤΡΙΚΟΝ ΕΡΓΟΣΤΑΣΙΟΝ
PROPOSED POWER PLANT
ΠΡΟΤΕΙΝΟΜΕΝΟΝ ΦΡΑΓΜΑ ΝΕΥΡΟΠΟΛΕΩΣ
PROPOSED NEVROPOLIS DAM
ΜΕΛΕΤΗΘΕΙΣΑ ΘΕΣΙΣ ΦΡΑΓΜΑΤΟΣ
DAM SITE CONSIDERED
(KAKAVAKIA)
ΠΡΟΤΕΙΝΟΜΕΝΟΝ ΦΡΑΓΜΑ ΕΚΤΡΟΠΗΣ
PROPOSED DIVERSION DAM
LEVEES AND CHANNEL IMPROVEMENTS
COMPLETED OR PLANNED BY THE MINISTRY
AGRAFA MOUNTAINS
ACHELOOS RIVER
MEGDOVA RIVER
KARDITSA
MOUZAKI
PALAMAS
SOFADES
FILIA
KEDROS
LEONTARION
KOUMADES
MATARANGA
AGNANTERON
KALOGRIANA
PALIOHORI
KOTSERI
MESENIKOLAS
KRYONERI
TSARDAKI
PYLAKTI
BEZOULA
NEOHORION
KARITSA
LABERON
KASTANIA
RACHOULA
DAFNOSPILIA
PALIOURI
SEKLIZA
AYIOPIGHI
VAVA LAKE
EVRYTANIA NOMOS
MEDITERRANEAN SEA
AEGEAN SEA
BULGARIA
YUGOSLAVIA
ALBANIA
TURKEY
PROJECT LOCATION
ΧΑΡΤΗΣ ΘΕΣΕΩΣ ΕΡΓΟΥ
LOCATION PLAN
ΚΛΙΜΑΞ ΕΙΣ ΧΙΛΙΟΜΕΤΡΑ
SCALE IN KILOMETERS
50 0 50 100 150 200
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
GENERAL MAP
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS
DES BY A.B.
CH BY J.W.B.
DATE OCT 1952
PLATE II-1



ΑΛΛΟΥΒΙΑ
ALLUVIUM

ΦΛΥΣΧΗΣ (ΑΝΩ ΚΡΗΤΙΔΙΚΗΣ)
FLYSCH (UPPER CRETACEOUS)

ΑΣΒΕΣΤΟΛΙΘΟΙ (ΜΕΣΟΖΩΙΚΟΙ)
LIMESTONE (MESOZOIC)

KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT
BASIN GEOLOGY

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK ATHENS

DES. BY: F.G.
CH. BY: J.W.B. DATE: OCT. 1952

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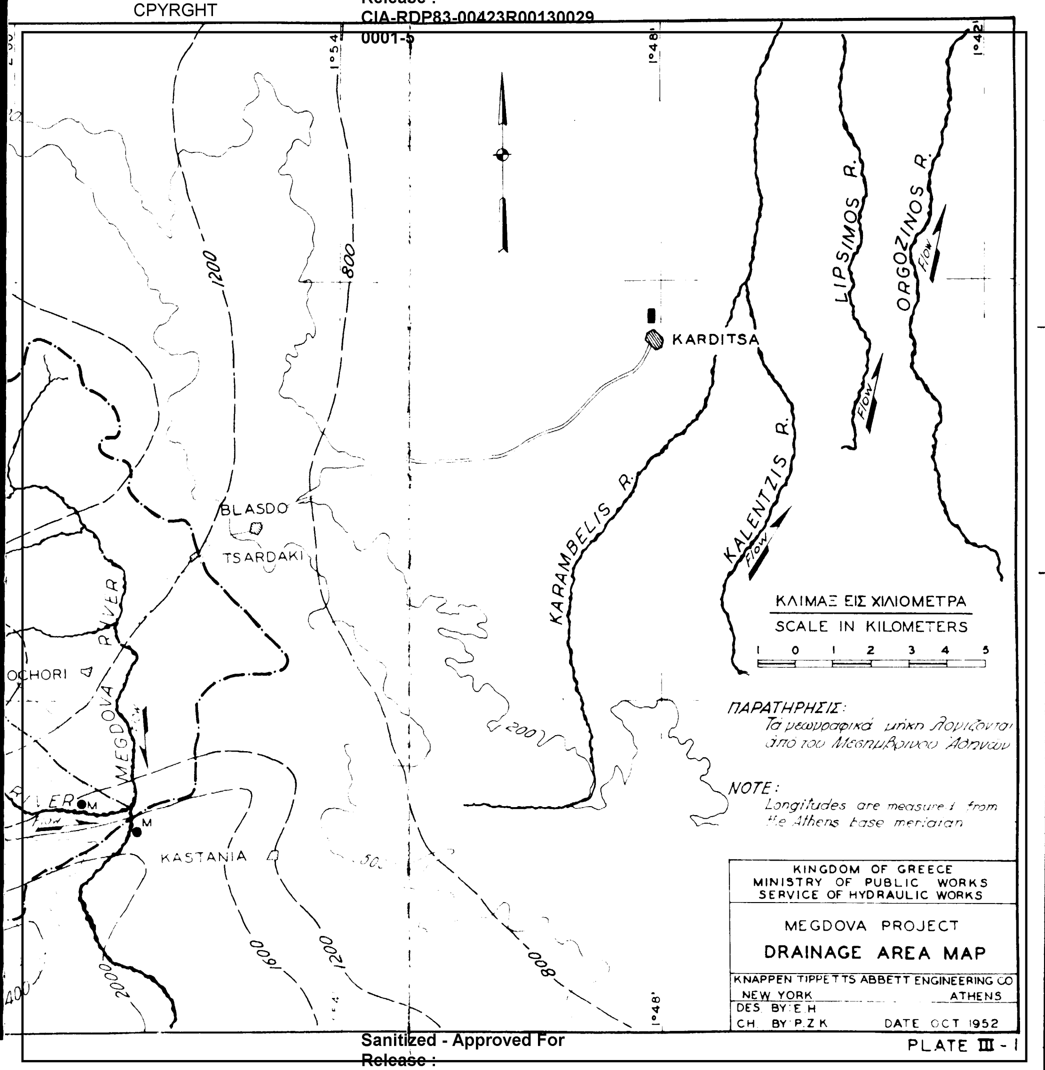
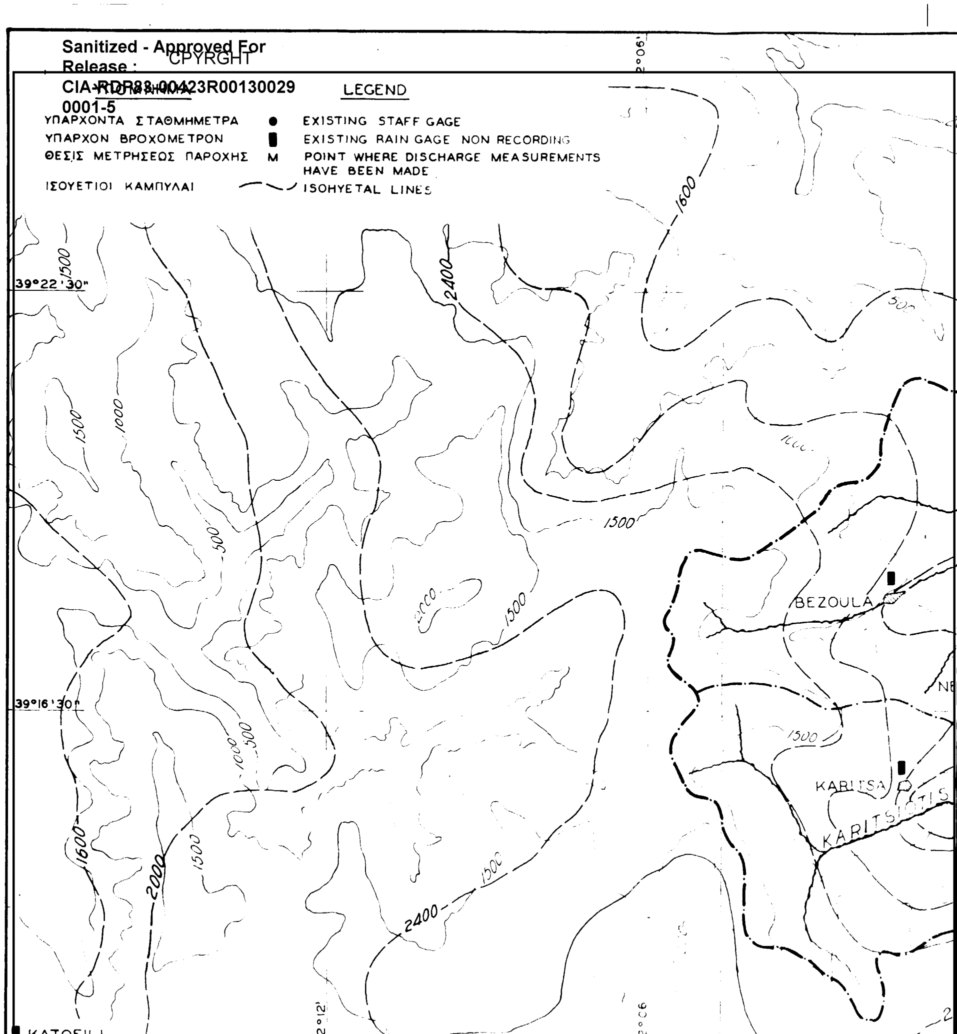
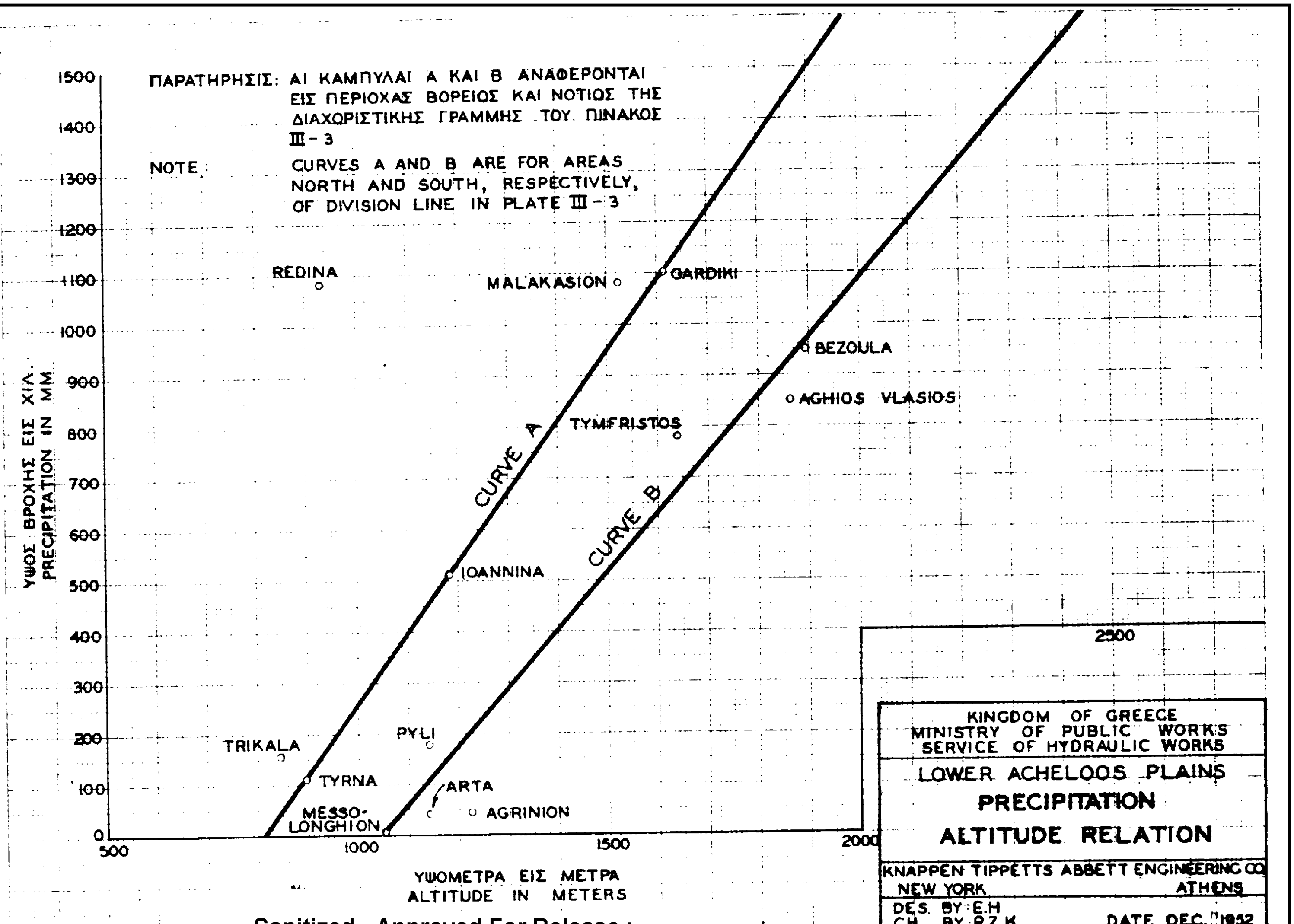
PLATE II-2


KARDITSA
BLASDO
TSARDAKI
OCHORI
KASTANIA
MEGDOVA RIVER
KARAMBELIS R.
KALENTZIS R.
LIPSIMOS R.
ORGOZINOS R.
Flow
1200
800
1600
2000
1°54'
1°48'
1°42'
ΚΛΙΜΑΞ ΕΙΣ ΧΙΛΙΟΜΕΤΡΑ
SCALE IN KILOMETERS
1 0 1 2 3 4 5
ΠΑΡΑΤΗΡΗΣΙΣ:
NOTE:
Longitudes are measured from the Athens base meridian
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
DRAINAGE AREA MAP
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK ATHENS
DES. BY: E.H.
CH. BY: P.Z.K.
DATE OCT 1952
PLATE III - 1


LEGEND
ΥΠΑΡΧΟΝΤΑ ΣΤΑΘΜΗΜΕΤΡΑ ● EXISTING STAFF GAGE
ΥΠΑΡΧΟΝ ΒΡΟΧΟΜΕΤΡΟΝ ▮ EXISTING RAIN GAGE NON RECORDING
ΘΕΣΙΣ ΜΕΤΡΗΣΕΩΣ ΠΑΡΟΧΗΣ M POINT WHERE DISCHARGE MEASUREMENTS HAVE BEEN MADE
ΙΣΟΥΕΤΙΟΙ ΚΑΜΠΥΛΑΙ ISOHYETAL LINES
39°22'30"
39°16'30"
1600
2400
1500
1000
500
2000
BEZOULA
KARITSA
KATOFILI
2°12'
2°06'



KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

LOWER ACHELOOS PLAINS

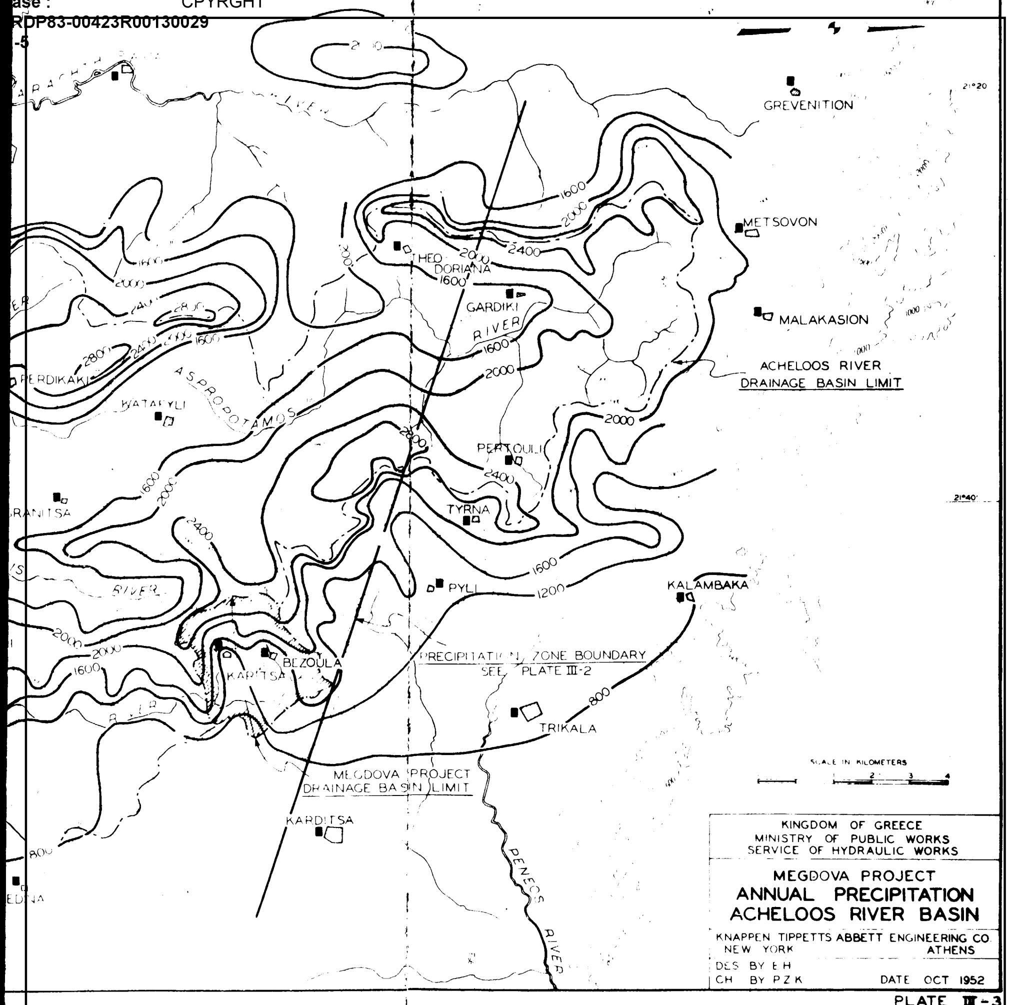
PRECIPITATION

ALTITUDE RELATION

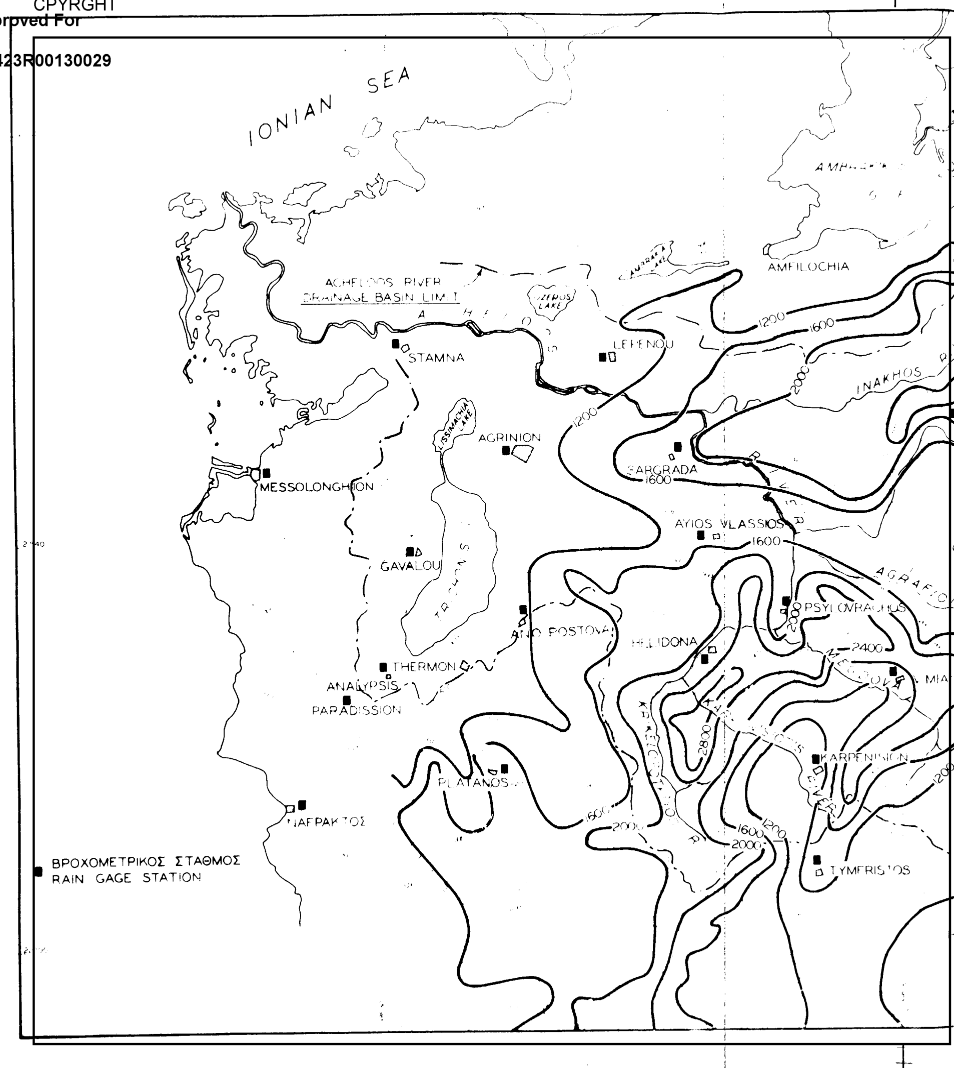
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK ATHENS

DES. BY E.H
CH. BY P.Z.K
DATE DEC. 1952

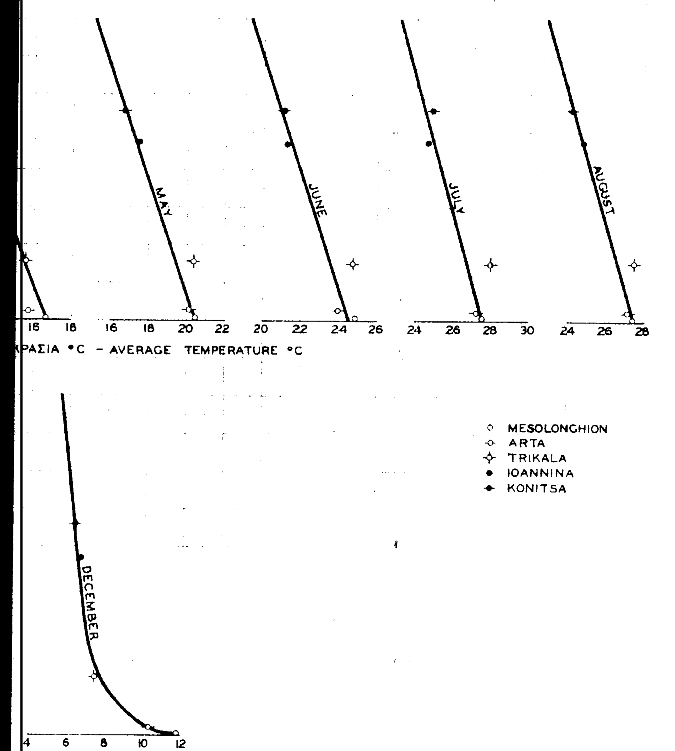
PLATE III - 2



GREVENITION
METSOVON
MALAKASION
ACHELOOS RIVER
DRAINAGE BASIN LIMIT
THEO DORIANA
GARDIKI
RIVER
PERDIKAKI
ASPROPOTAMOS
PERTOULI
TYRNA
PYLI
KALAMBAKA
BEZOULA
KARITSA
PRECIPITATION ZONE BOUNDARY
SEE PLATE III-2
TRIKALA
MEGDOVA PROJECT
DRAINAGE BASIN LIMIT
KARDITSA
PENEOS
RIVER
1600
2000
2400
2800
1200
800
SCALE IN KILOMETERS
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
ANNUAL PRECIPITATION
ACHELOOS RIVER BASIN
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS
DES BY E H
CH BY P Z K
DATE OCT 1952
PLATE III-3


IONIAN SEA
ACHELOOS RIVER
DRAINAGE BASIN LIMIT
AMFILOCHIA
LEPENOU
STAMNA
AGRINION
INAKHOS
SARGRADA
MESSOLONGHION
AYIOS VLASSIOS
GAVALOU
AGRAFIOTIS
PSYLOVRACHOS
ANO POSTOVA
HELIDONA
THERMON
ANALYPSIS
PARADISSION
KARPENISION
PLATANOS
ΝΑΥΠΑΚΤΟΣ
TYMFRISTOS
1200
1600
2000
2400
2800
ΒΡΟΧΟΜΕΤΡΙΚΟΣ ΣΤΑΘΜΟΣ
RAIN GAGE STATION

[redacted]



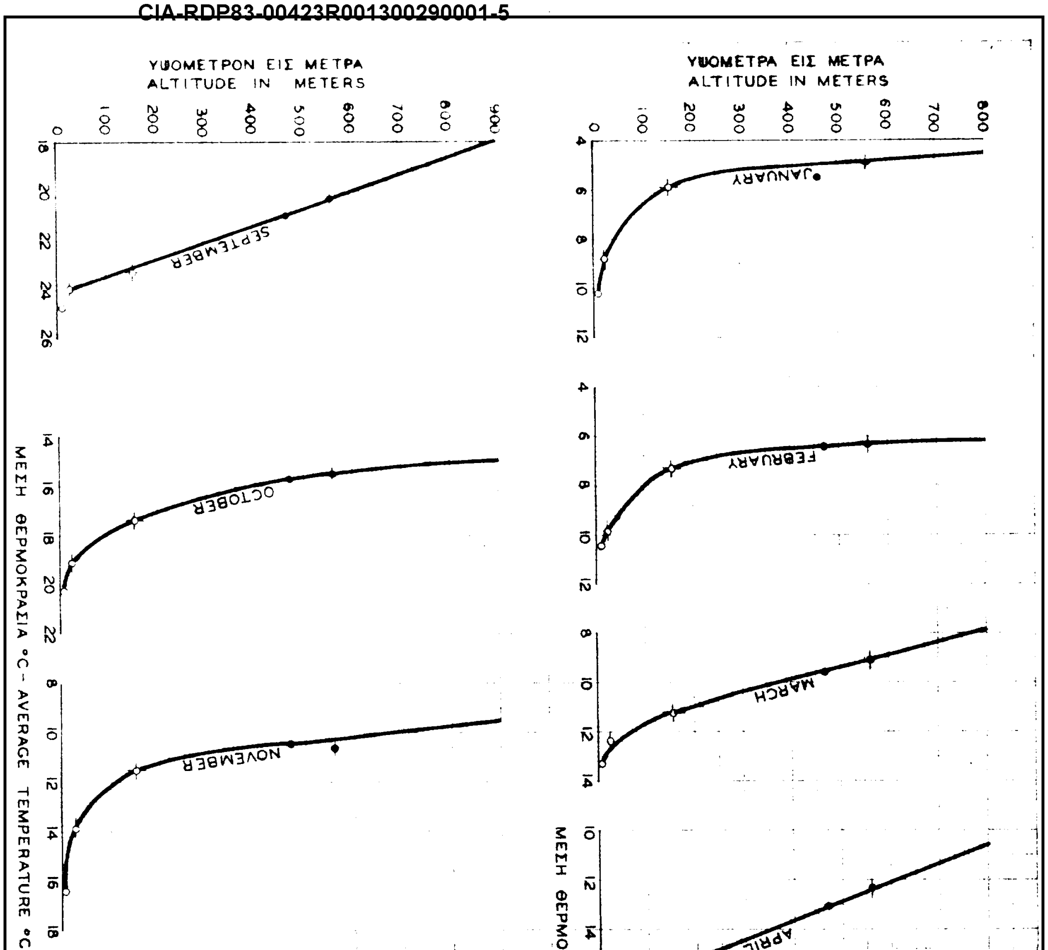
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

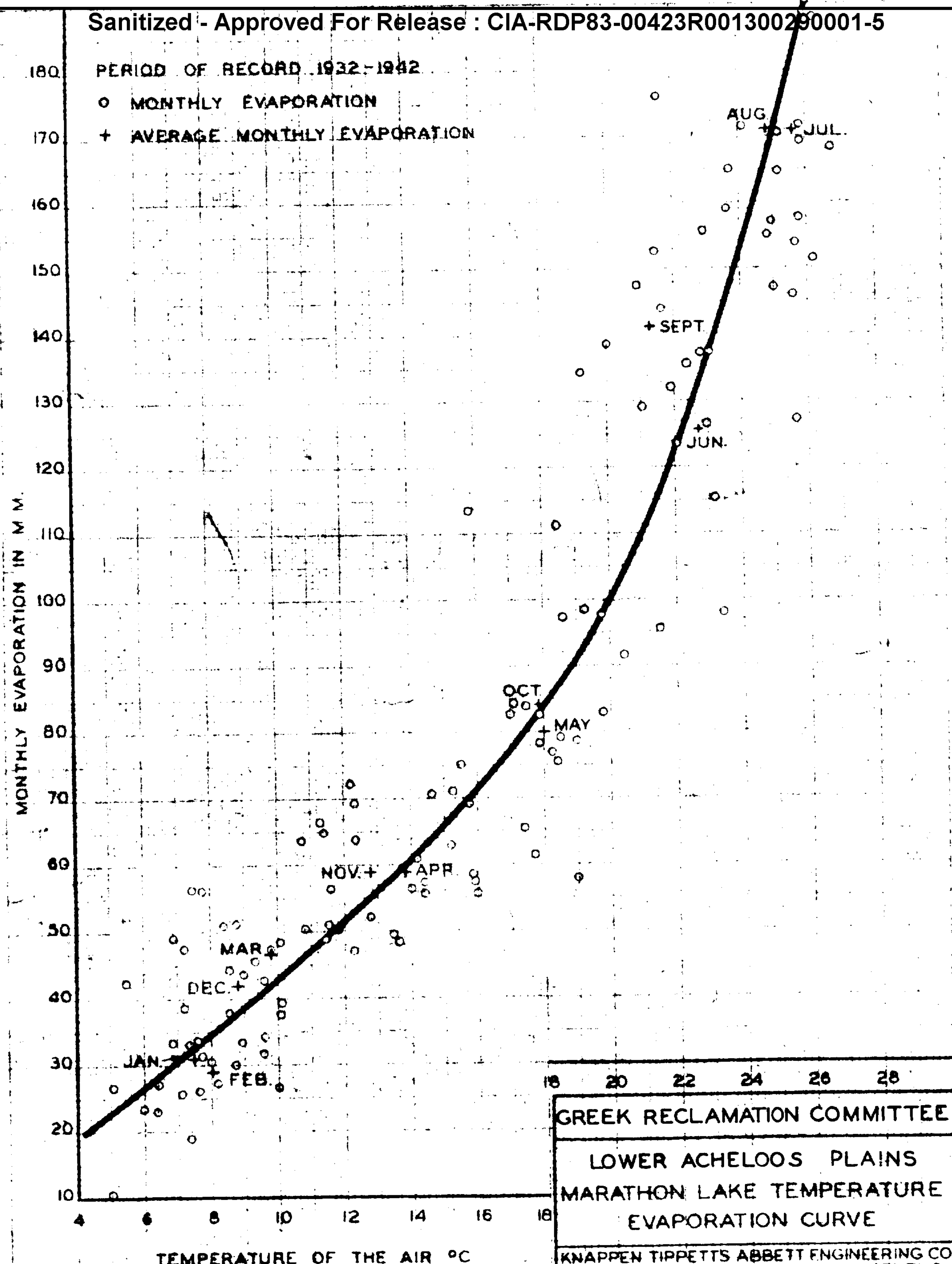
MEGDOVA PROJECT

TEMPERATURE-ALTITUDE RELATIONS

KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS
DES. BY: E.H.
CH. BY: P.Z.K. DATE: OCTOBER 1952

PLATE III-4


ΥΨΟΜΕΤΡΟΝ ΕΙΣ ΜΕΤΡΑ
ALTITUDE IN METERS
ΥΨΟΜΕΤΡΑ ΕΙΣ ΜΕΤΡΑ
ALTITUDE IN METERS
JANUARY
FEBRUARY
MARCH
APRIL
SEPTEMBER
OCTOBER
NOVEMBER
ΜΕΣΗ ΘΕΡΜΟΚΡΑΣΙΑ °C - AVERAGE TEMPERATURE °C



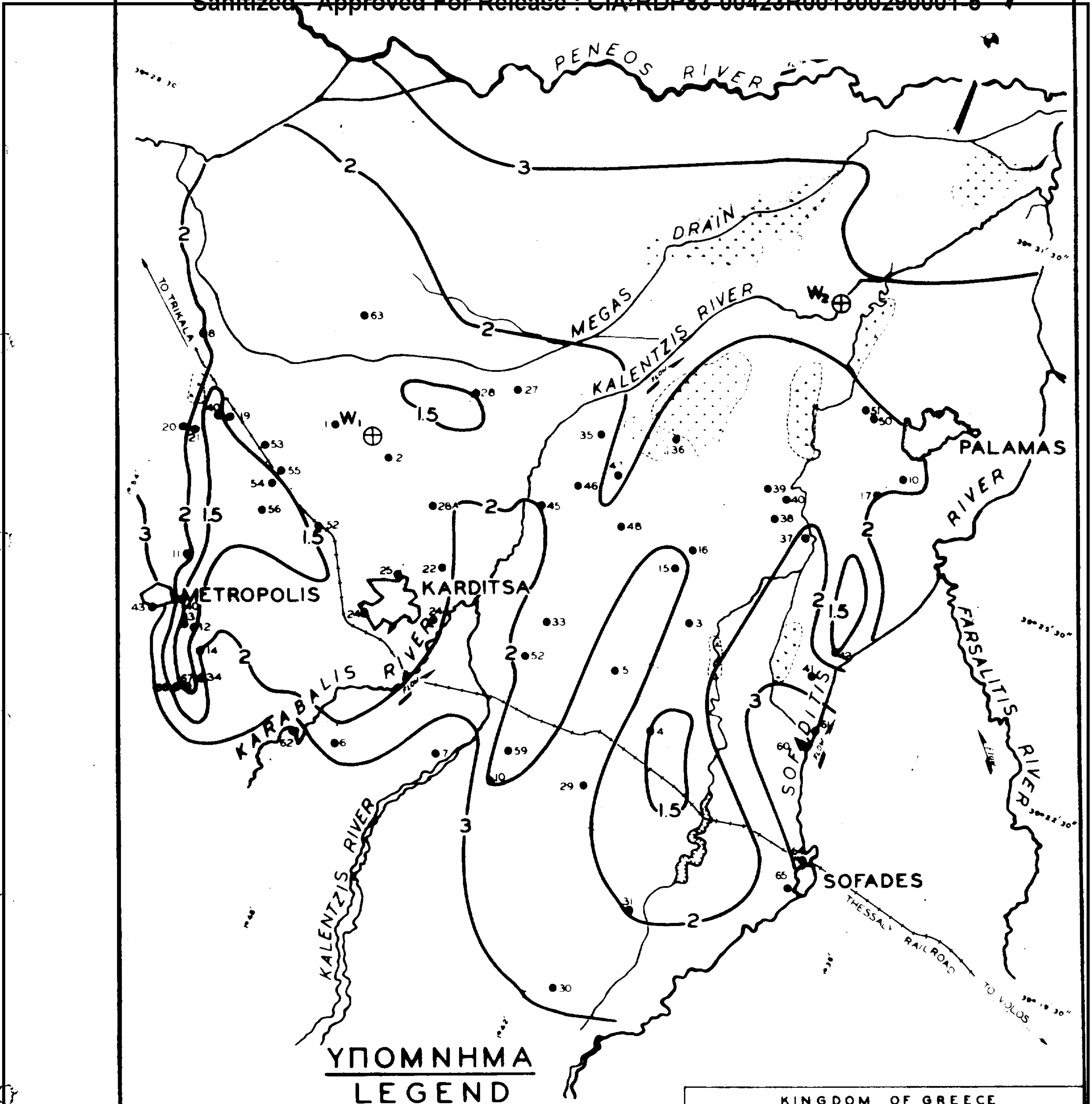
GREEK RECLAMATION COMMITTEE

LOWER ACHELOOS PLAINS
MARATHON LAKE TEMPERATURE
EVAPORATION CURVE

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK ATHENS

DES. BY: E. H.
CH. BY: D.S.B.
DATE: DEC. 1952

PLATE III - 5



ΥΠΟΜΝΗΜΑ
LEGEND

- • 25 — ΥΠΑΡΧΟΝΤΑ ΦΡΕΑΤΑ ΒΛ. ΠΙΝ. III-5 / EXISTING WELLS SEE TABLE III-5
- —2— ΣΤΑΘΜΗ ΥΠΟΓΕΙΩΝ ΥΔΑΤΩΝ-Μ / DEPTH TO WATER TABLE-M
- ΗΜΙΕΛΩΔΕΣ / SEMI-SWAMP
- W ⊕ ΘΕΣΙΣ ΔΕΙΓΜΑΤΟΛΗΨΙΑΣ ΥΔΑΤΟΣ / WATER SAMPLE LOCATION

KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT

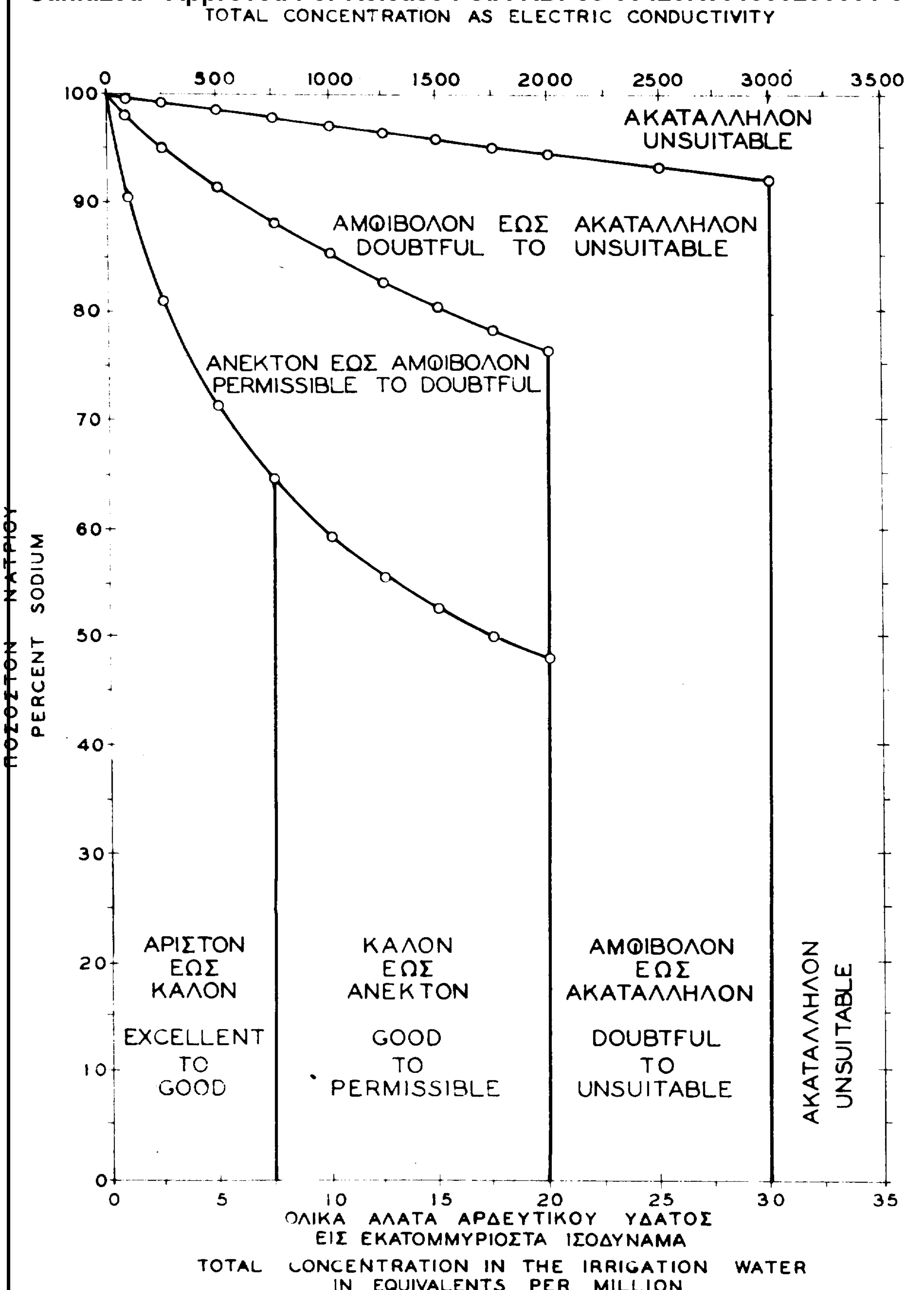
WATER TABLE MAP

MAY 1952

KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS

DES. BY E B
CH. BY P Z K
DATE OCT. 1952

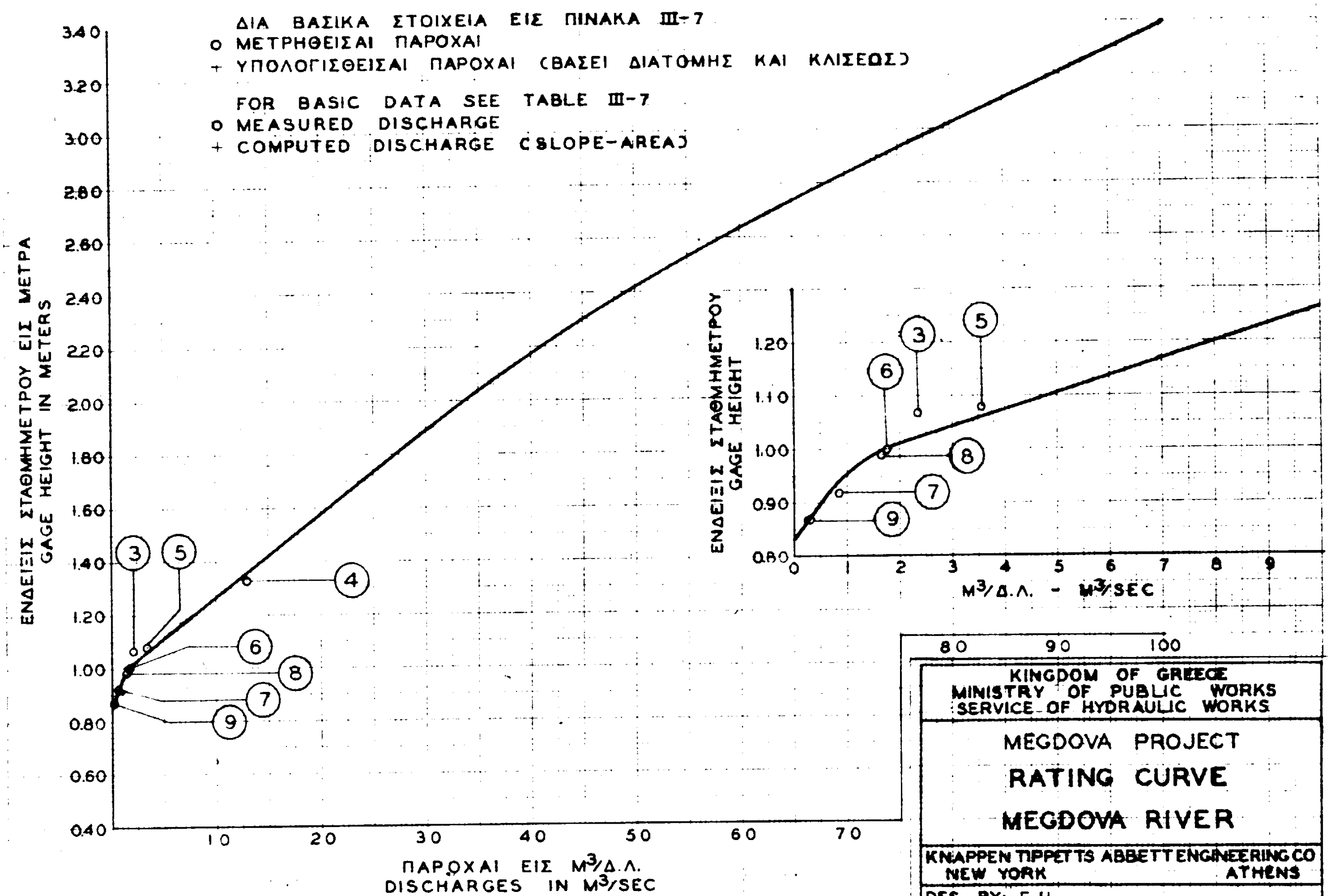
PLATE III-6



ΔΙΑΓΡΑΜΜΑ ΚΑΘΟΡΙΣΜΟΥ ΤΗΣ ΠΟΙΟΤΗΤΟΣ ΤΟΥ ΑΡΔΕΥΤΙΚΟΥ ΥΔΑΤΟΣ
(ΚΑΤΑ WILCOX)

DIAGRAM FOR DETERMINING QUALITY OF IRRIGATION WATER
(AFTER WILCOX)

PLATE III -7



KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT

RATING CURVE

MEGDOVA RIVER

KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS

DES. BY: E.H.
CH. BY: P.Z.K. DATE OCTOBER 1952

PLATE III-8

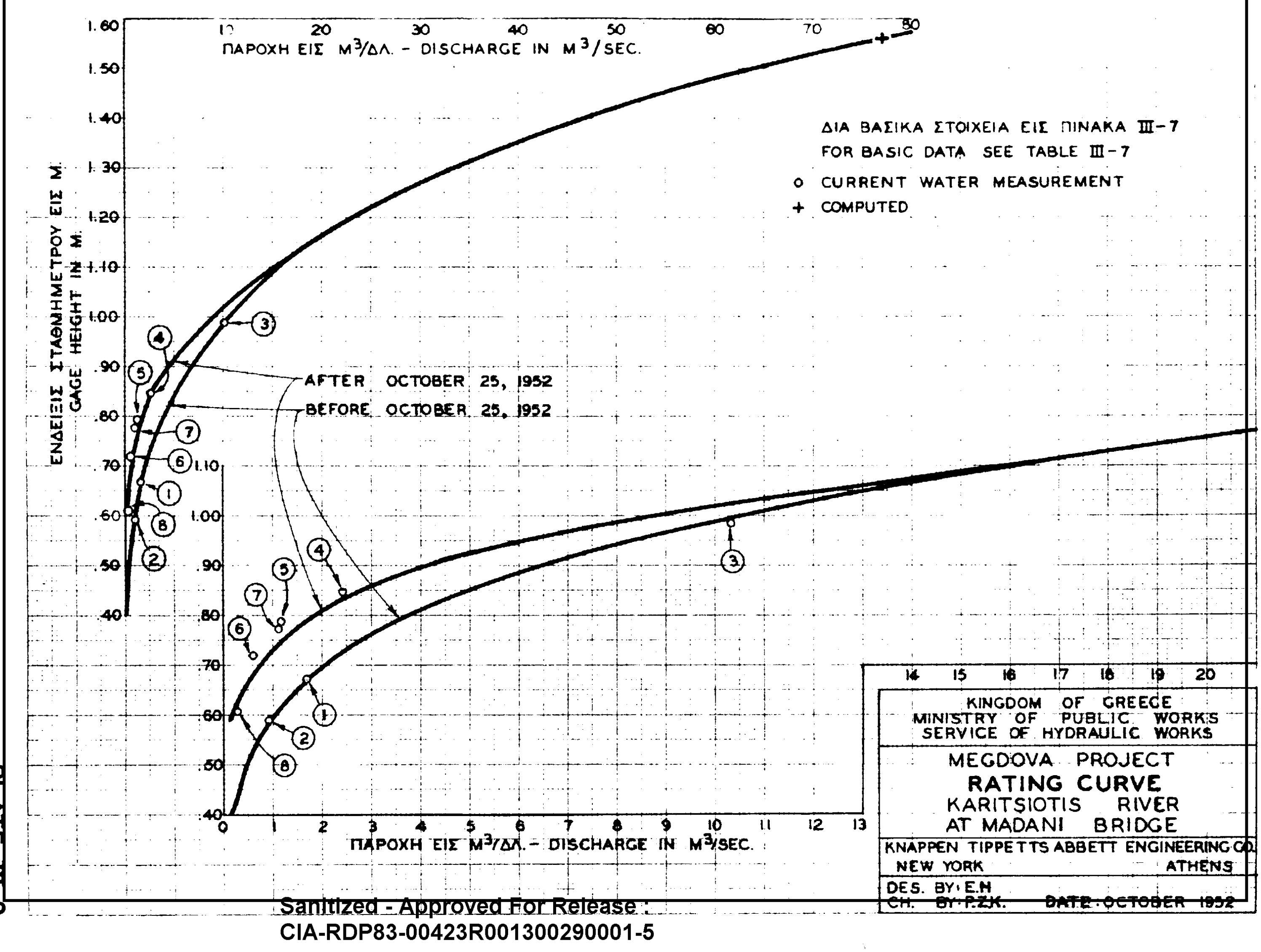
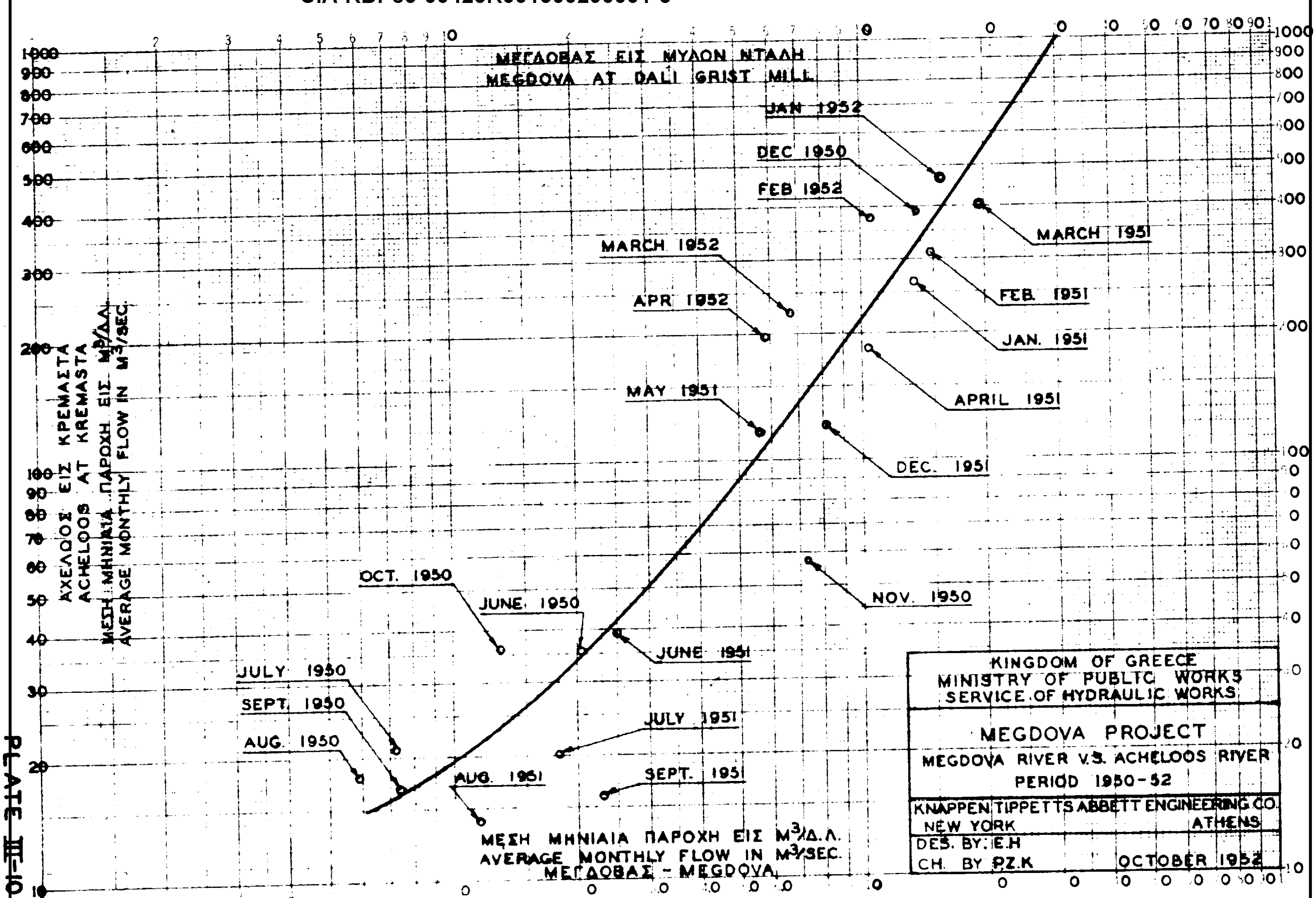
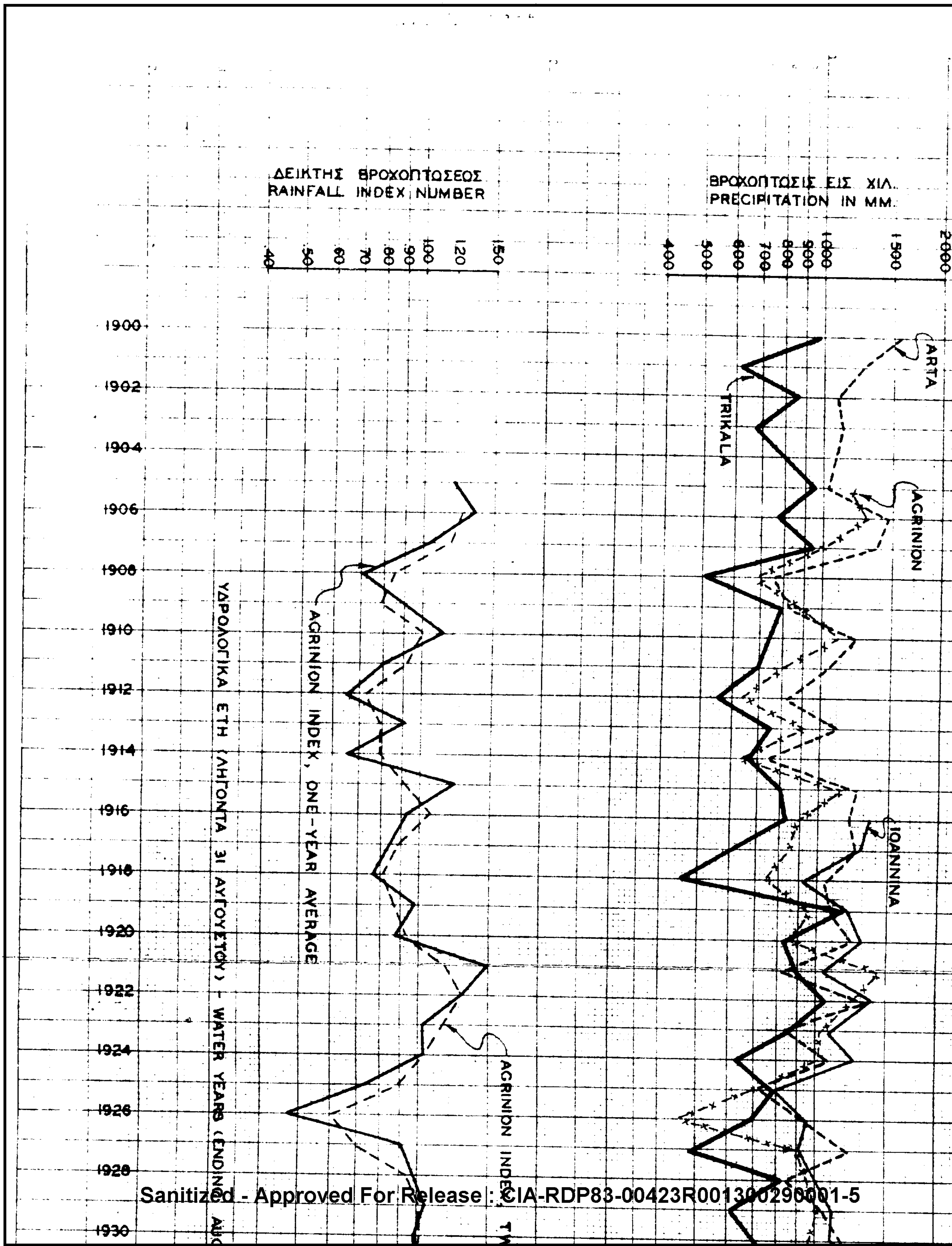
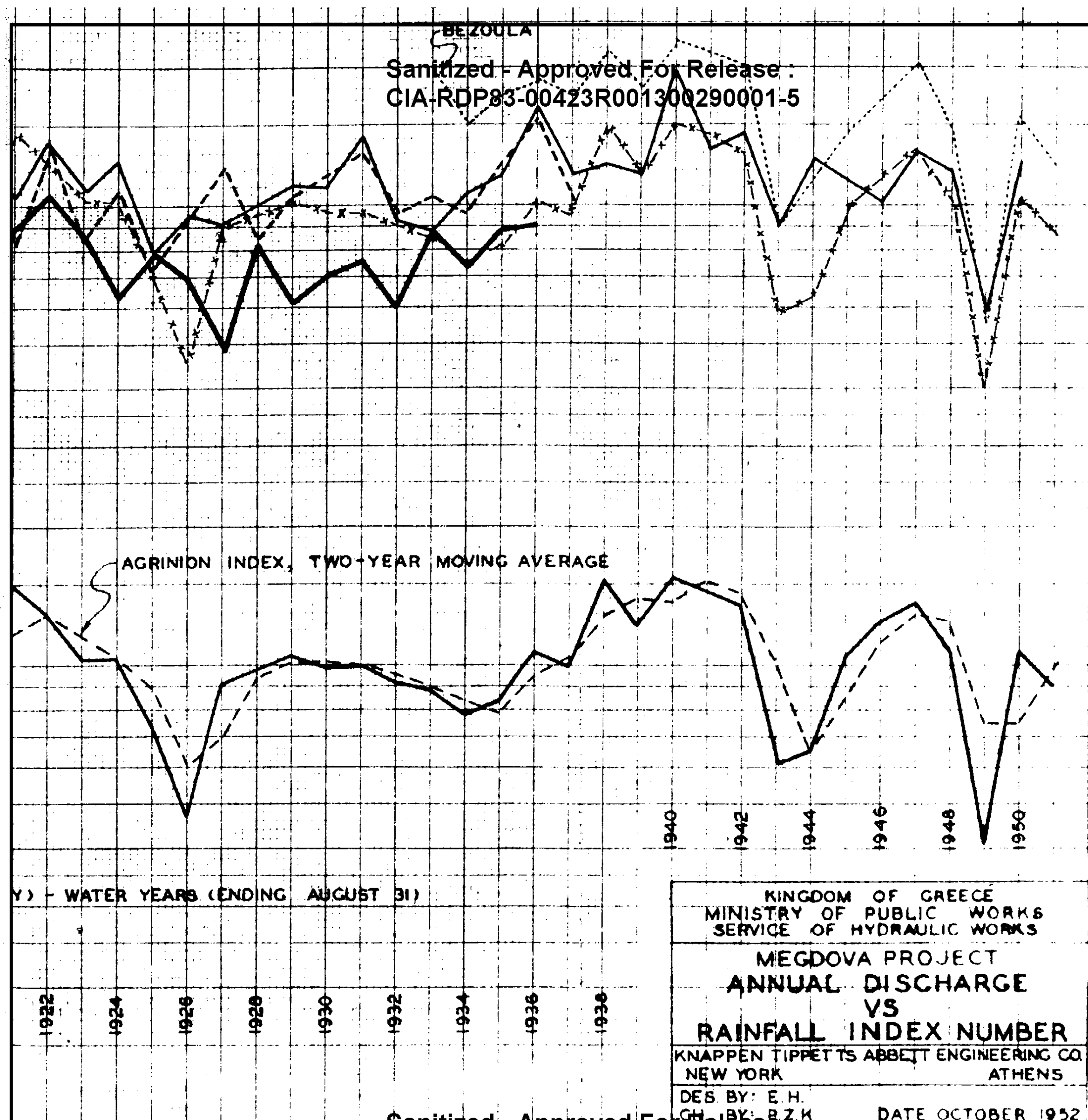

ΠΑΡΟΧΗ ΕΙΣ M³/ΔΛ. - DISCHARGE IN M³/SEC.
ΕΝΔΕΙΞΙΣ ΣΤΑΘΜΗΜΕΤΡΟΥ ΕΙΣ Μ.
GAGE HEIGHT IN M.
ΔΙΑ ΒΑΣΙΚΑ ΣΤΟΙΧΕΙΑ ΕΙΣ ΠΙΝΑΚΑ III-7
FOR BASIC DATA SEE TABLE III-7
o CURRENT WATER MEASUREMENT
+ COMPUTED
AFTER OCTOBER 25, 1952
BEFORE OCTOBER 25, 1952
ΠΑΡΟΧΗ ΕΙΣ M³/ΔΛ. - DISCHARGE IN M³/SEC.
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
RATING CURVE
KARITSIOTIS RIVER
AT MADANI BRIDGE
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK ATHENS
DES. BY: E.H
CH. BY: P.Z.K.
DATE: OCTOBER 1952

PLATE III-9


ΜΕΓΔΟΒΑΣ ΕΙΣ ΜΥΛΟΝ ΝΤΑΛΗ
MEGDOVA AT DALI GRIST MILL
ΑΧΕΛΩΟΣ ΕΙΣ ΚΡΕΜΑΣΤΑ
ACHELOOS AT KREMASTA
ΜΕΣΗ ΜΗΝΙΑΙΑ ΠΑΡΟΧΗ ΕΙΣ Μ³/Δ.Λ.
AVERAGE MONTHLY FLOW IN M³/SEC.
JAN 1952
DEC 1950
FEB 1952
MARCH 1951
MARCH 1952
FEB. 1951
APR 1952
JAN. 1951
APRIL 1951
MAY 1951
DEC. 1951
NOV. 1950
OCT. 1950
JUNE 1950
JUNE 1951
JULY 1950
SEPT. 1950
AUG. 1950
JULY 1951
AUG. 1951
SEPT. 1951
ΜΕΣΗ ΜΗΝΙΑΙΑ ΠΑΡΟΧΗ ΕΙΣ Μ³/Δ.Λ.
AVERAGE MONTHLY FLOW IN M³/SEC.
ΜΕΓΔΟΒΑΣ - MEGDOVA
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
MEGDOVA RIVER V.S. ACHELOOS RIVER
PERIOD 1950-52
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
ATHENS
DES. BY: E.H
CH. BY P.Z.K
OCTOBER 1952
PLATE III-10



ΔΕΙΚΤΗΣ ΒΡΟΧΟΠΤΩΣΕΟΣ
RAINFALL INDEX NUMBER
40 50 60 70 80 90 100 120 150
ΒΡΟΧΟΠΤΩΣΙΣ ΕΙΣ ΧΙΛ.
PRECIPITATION IN MM.
400 500 600 700 800 900 1000 1500 2000
1900
1902
1904
1906
1908
1910
1912
1914
1916
1918
1920
1922
1924
1926
1928
1930
ARTA
TRIKALA
AGRINION
IOANNINA
AGRINION INDEX, ONE-YEAR AVERAGE
ΥΔΡΟΛΟΓΙΚΑ ΕΤΗ (ΛΗΓΟΝΤΑ 31 ΑΥΓΟΥΣΤΟΥ) - WATER YEARS (ENDING AUG
AGRINION INDE



KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT

ANNUAL DISCHARGE VS RAINFALL INDEX NUMBER

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK ATHENS

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DATE OCTOBER 1952

PLATE III - 11

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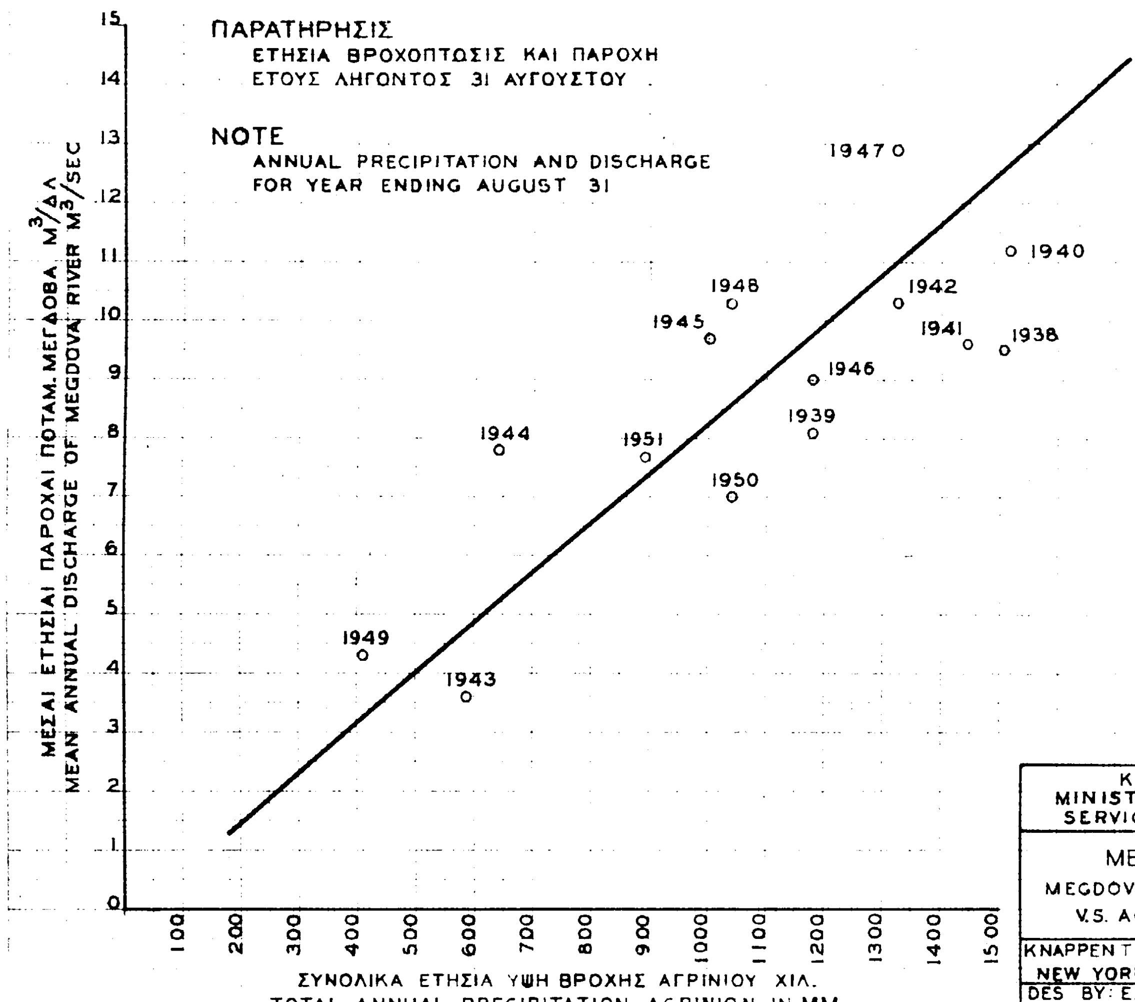


KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

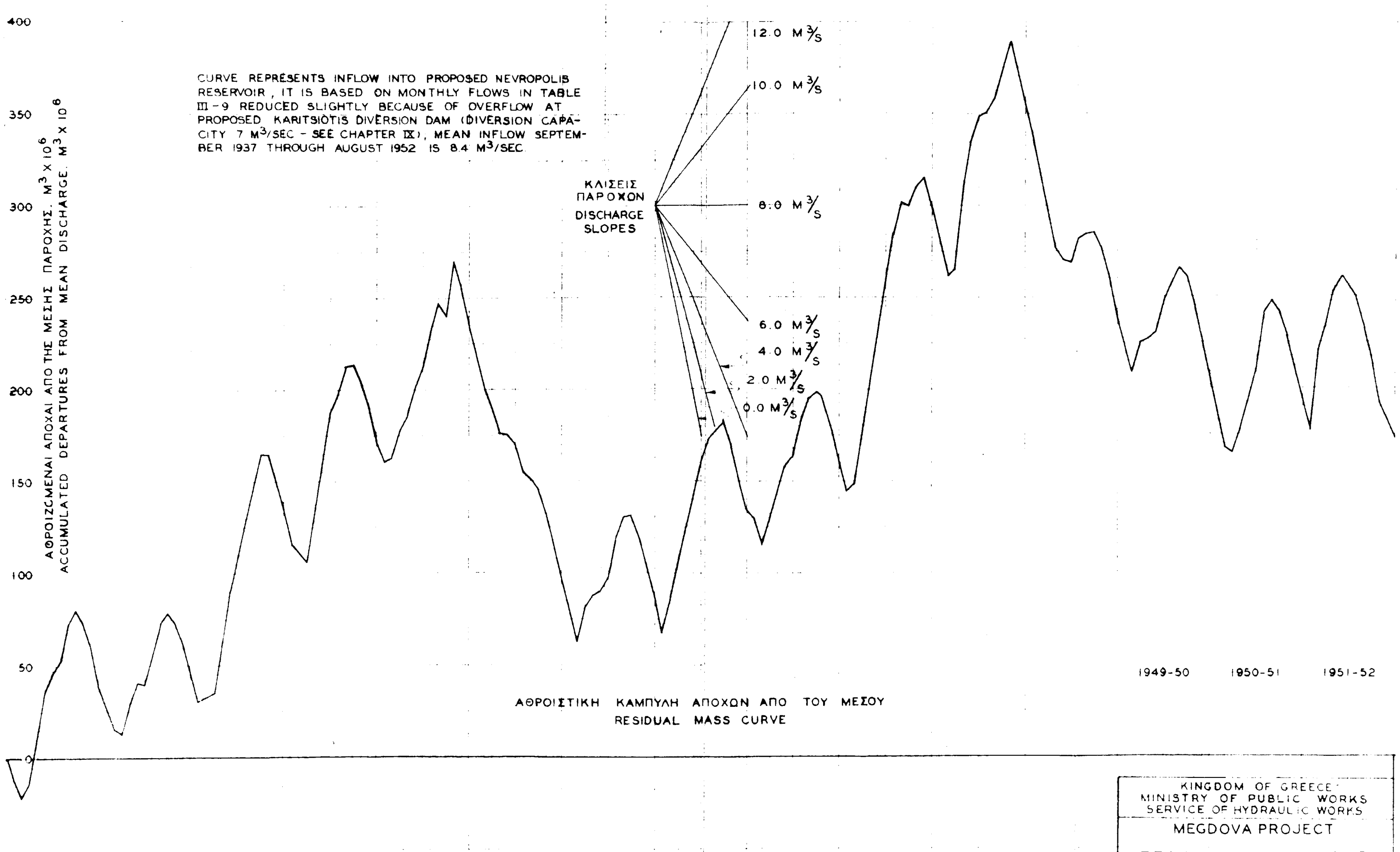
MEGDOVA PROJECT

MEGDOVA MEAN ANNUAL RUNOFF
V.S. AGRINION PRECIPITATION

KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS
DES BY: E.H
CH BY: P.Z.K DATE OCTOBER 1952

PLATE III-12

[redacted]



KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

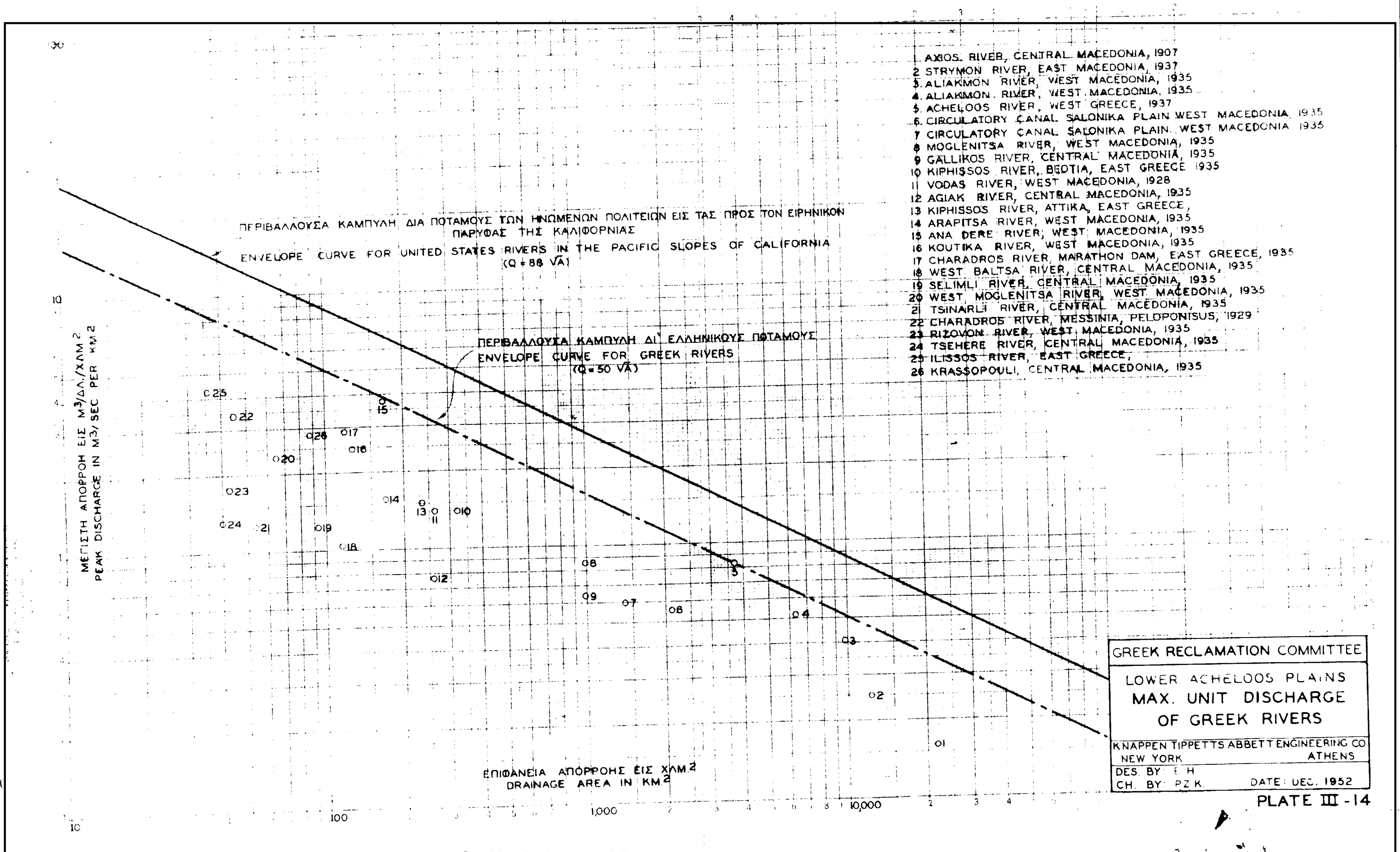
MEGDOVA PROJECT

RESIDUAL MASS CURVE

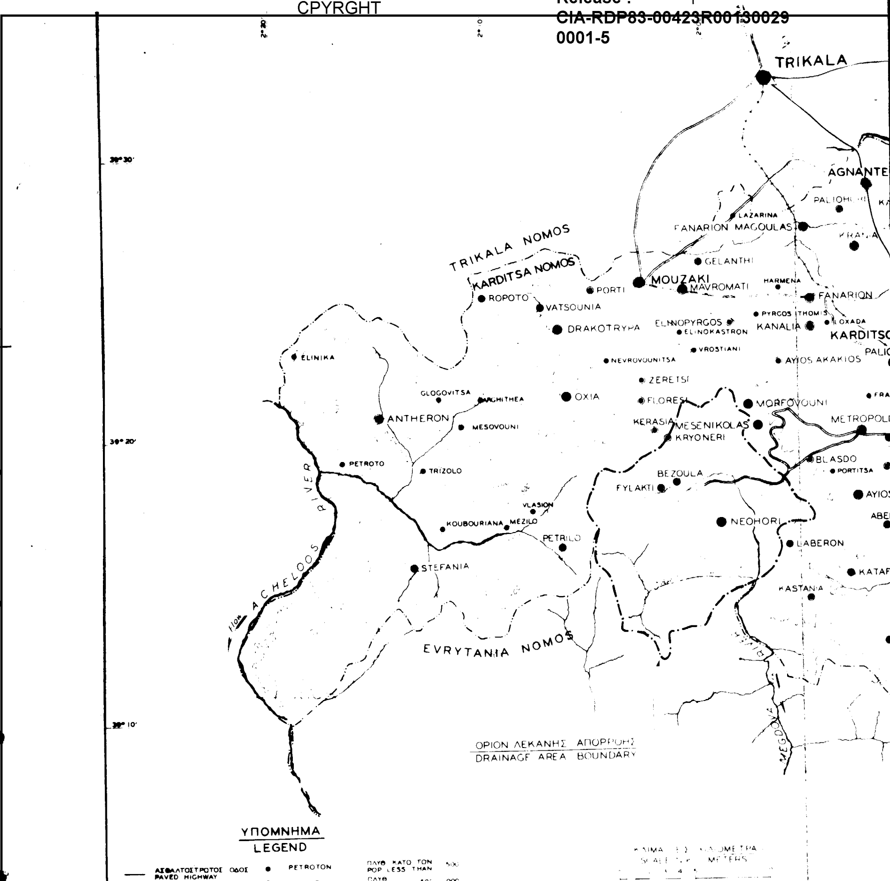
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK ATHENS
DES. BY: E.H.
CH. BY: P.Z.K. DATE: OCTOBER 1952

PLATE III - 13

CPYRGHT



Sanitized - Approved For Release :


TRIKALA
AGNANTERO
PALIOHORI
LAZARINA
FANARION MAGOULAS
TRIKALA NOMOS
KARDITSA NOMOS
GELANTHI
MOUZAKI
MAVROMATI
HARMENA
FANARION
PORTI
ROPOTO
VATSOUNIA
ELINOPYRGOS
ELINOKASTRON
PYRGOS ITHOMIS
LOXADA
KANALIA
KARDITSA
DRAKOTRYPA
VROSTIANI
NEVROVOUNITSA
AYIOS AKAKIOS
ELINIKA
ZERETSI
GLOGOVITSA
ARCHITHEA
OXIA
FLORESI
MORFOVOUNI
ANTHERON
MESOVOUNI
KERASIA
MESENIKOLAS
KRYONERI
METROPOLIS
PETROTO
TRIZOLO
BLASDO
PORTITSA
BEZOULA
FYLAKTI
VLASION
KOUBOURIANA
MEZILO
NEOHORI
PETRILO
LABERON
STEFANIA
KASTANIA
ACHELOOS RIVER
EVRYTANIA NOMOS
39° 30'
39° 20'
39° 10'
ΟΡΙΟΝ ΛΕΚΑΝΗΣ ΑΠΟΡΡΟΗΣ
DRAINAGE AREA BOUNDARY
ΥΠΟΜΝΗΜΑ
LEGEND
ΑΣΦΑΛΤΟΣΤΡΩΤΟΣ ΟΔΟΣ PAVED HIGHWAY
ΣΚΥΡΟΣΤΡΩΤΟΣ ΟΔΟΣ HARD ROAD
ΧΩΜΑΤΟΔΡΟΜΟΣ DIRT ROAD
ΗΜΙΟΝΙΚΗ ΟΔΟΣ TRAIL
PETROTON
LOUTRON
KRANIA
SOFADES
TRIKALA

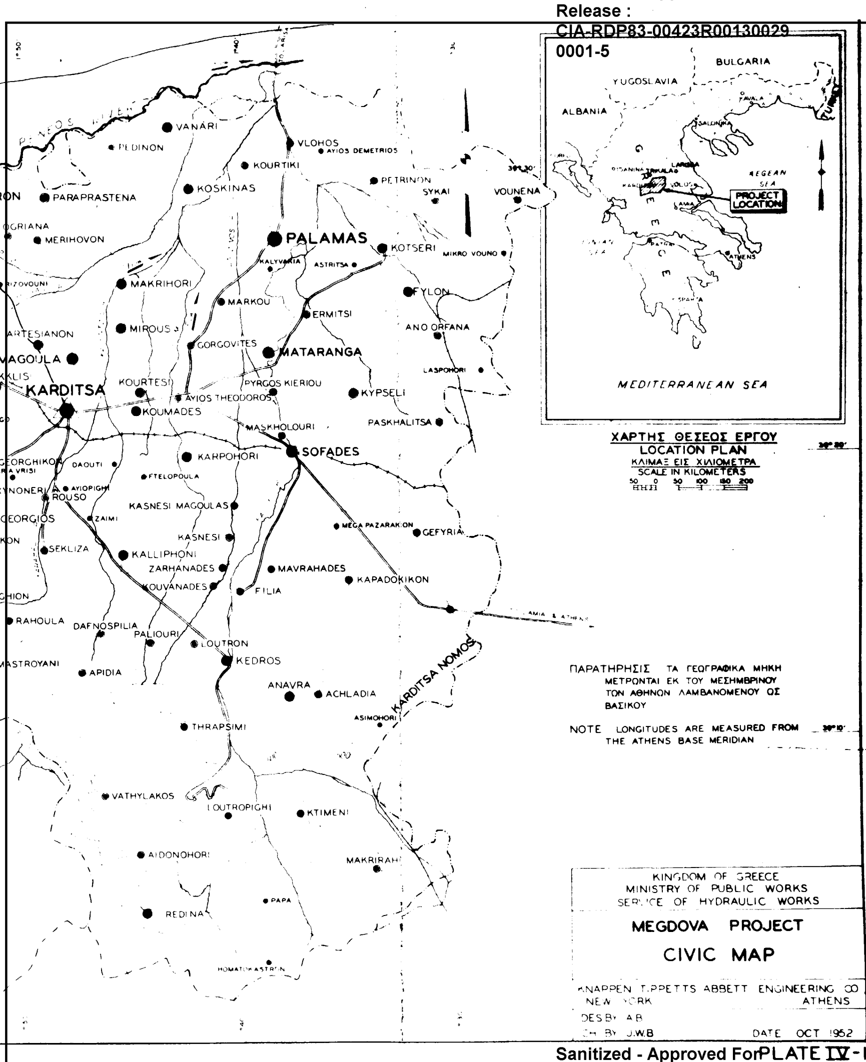
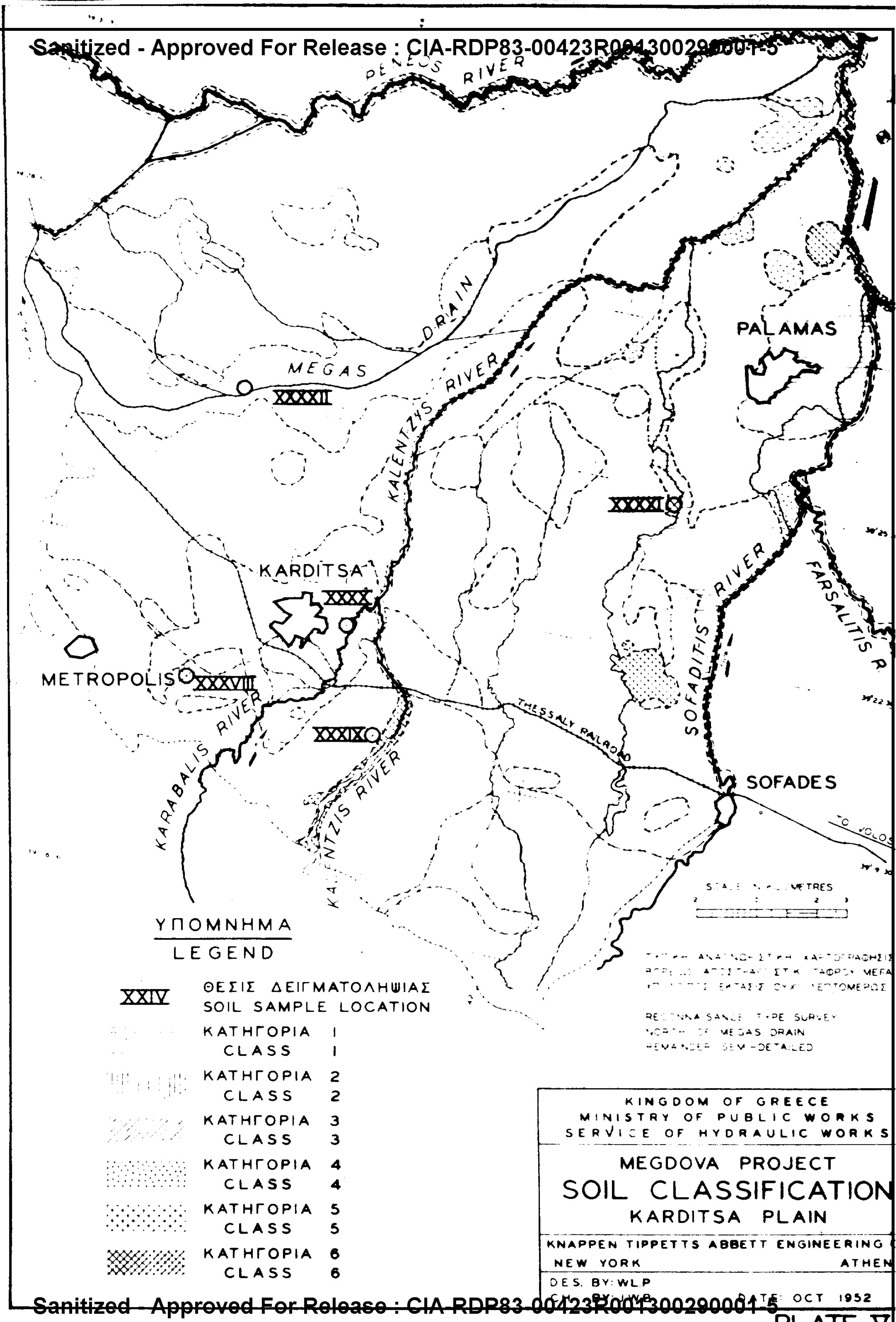
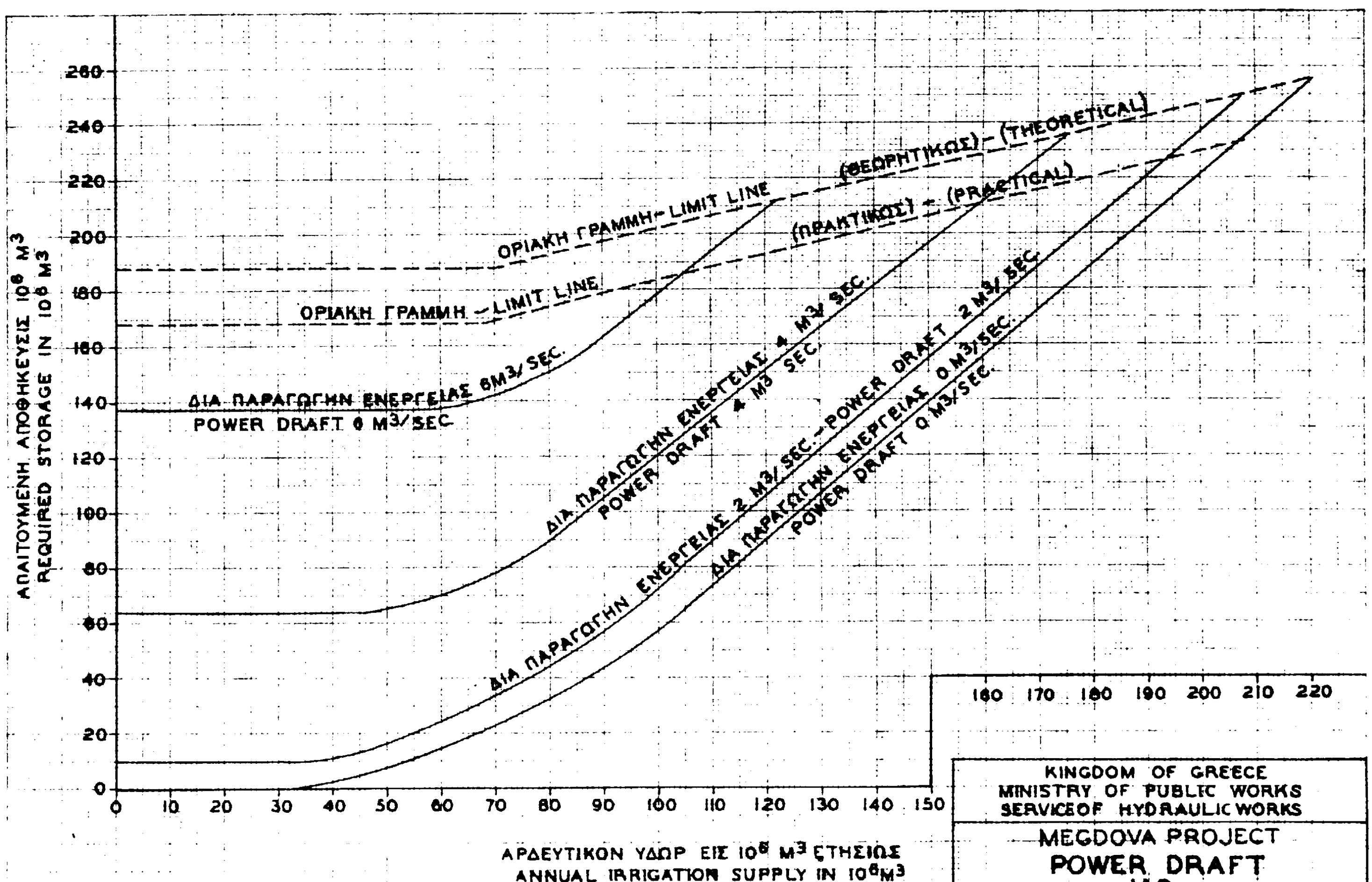

PENEOS RIVER
VANARI
PEDINON
VLOHOS
AYIOS DEMETRIOS
KOURTIKI
KOSKINAS
PARAPRASTENA
PETRINON
SYKAI
VOUNENA
MERIHOVON
PALAMAS
KOTSERI
MIKRO VOUNO
KALYVAKIA
ASTRITSA
MAKRIHORI
MARKOU
FYLON
ERMITSI
ANO ORFANA
ARTESIANON
MIROUS
GORGOVITES
MATARANGA
LASPOHORI
MAGOULA
KOURTESI
PYRGOS KIERIOU
KYPSELI
KARDITSA
AYIOS THEODOROS
KOUMADES
MASKHOLOURI
PASKHALITSA
DAOUTI
KARPOHORI
SOFADES
FTELOPOULA
ROUSO
KASNESI MAGOULAS
ZAIMI
MEGA PAZARAKION
GEFYRIA
KASNESI
SEKLIZA
KALLIPHONI
ZARHANADES
MAVRAHADES
KAPADOKIKON
OUVANADES
FILIA
RAHOULA
DAFNOSPILIA
PALIOURI
LOUTRON
KEDROS
APIDIA
KARDITSA NOMOS
ANAVRA
ACHLADIA
ASIMOHORI
THRAPSIMI
VATHYLAKOS
LOUTROPIGHI
KTIMENI
AIDONOHORI
MAKRIRAHI
PAPA
REDINA
HOMATOKASTRON
YUGOSLAVIA
BULGARIA
ALBANIA
TURKEY
AEGEAN SEA
PROJECT LOCATION
ATHENS
MEDITERRANEAN SEA
ΧΑΡΤΗΣ ΘΕΣΕΩΣ ΕΡΓΟΥ
LOCATION PLAN
ΚΛΙΜΑΞ ΕΙΣ ΧΙΛΙΟΜΕΤΡΑ
SCALE IN KILOMETERS
50 0 50 100 150 200
ΠΑΡΑΤΗΡΗΣΙΣ ΤΑ ΓΕΩΓΡΑΦΙΚΑ ΜΗΚΗ ΜΕΤΡΟΥΝΤΑΙ ΕΚ ΤΟΥ ΜΕΣΗΜΒΡΙΝΟΥ ΤΩΝ ΑΘΗΝΩΝ ΛΑΜΒΑΝΟΜΕΝΟΥ ΩΣ ΒΑΣΙΚΟΥ
NOTE LONGITUDES ARE MEASURED FROM THE ATHENS BASE MERIDIAN
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
CIVIC MAP
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS
DES BY A.B.
CH BY J.W.B
DATE OCT 1952

PLATE IV-1


PENEUS RIVER
DRAIN
MEGAS
XXXXII
KALENTZ'S RIVER
PALAMAS
XXXXI
KARDITSA
XXXX
METROPOLIS
XXXVIII
KARABALIS RIVER
XXXIX
THESSALY RAILROAD
SOFADITIS RIVER
FARSALITIS R
SOFADES
TO VOLOS
KALENTZIS RIVER
ΥΠΟΜΝΗΜΑ
LEGEND
XXIV ΘΕΣΙΣ ΔΕΙΓΜΑΤΟΛΗΨΙΑΣ
SOIL SAMPLE LOCATION
ΚΑΤΗΓΟΡΙΑ 1
CLASS 1
ΚΑΤΗΓΟΡΙΑ 2
CLASS 2
ΚΑΤΗΓΟΡΙΑ 3
CLASS 3
ΚΑΤΗΓΟΡΙΑ 4
CLASS 4
ΚΑΤΗΓΟΡΙΑ 5
CLASS 5
ΚΑΤΗΓΟΡΙΑ 6
CLASS 6
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
SOIL CLASSIFICATION
KARDITSA PLAIN
KNAPPEN TIPPETTS ABBETT ENGINEERING
NEW YORK
ATHEN
DES. BY: WLP
DATE: OCT 1952
PLATE V



KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT

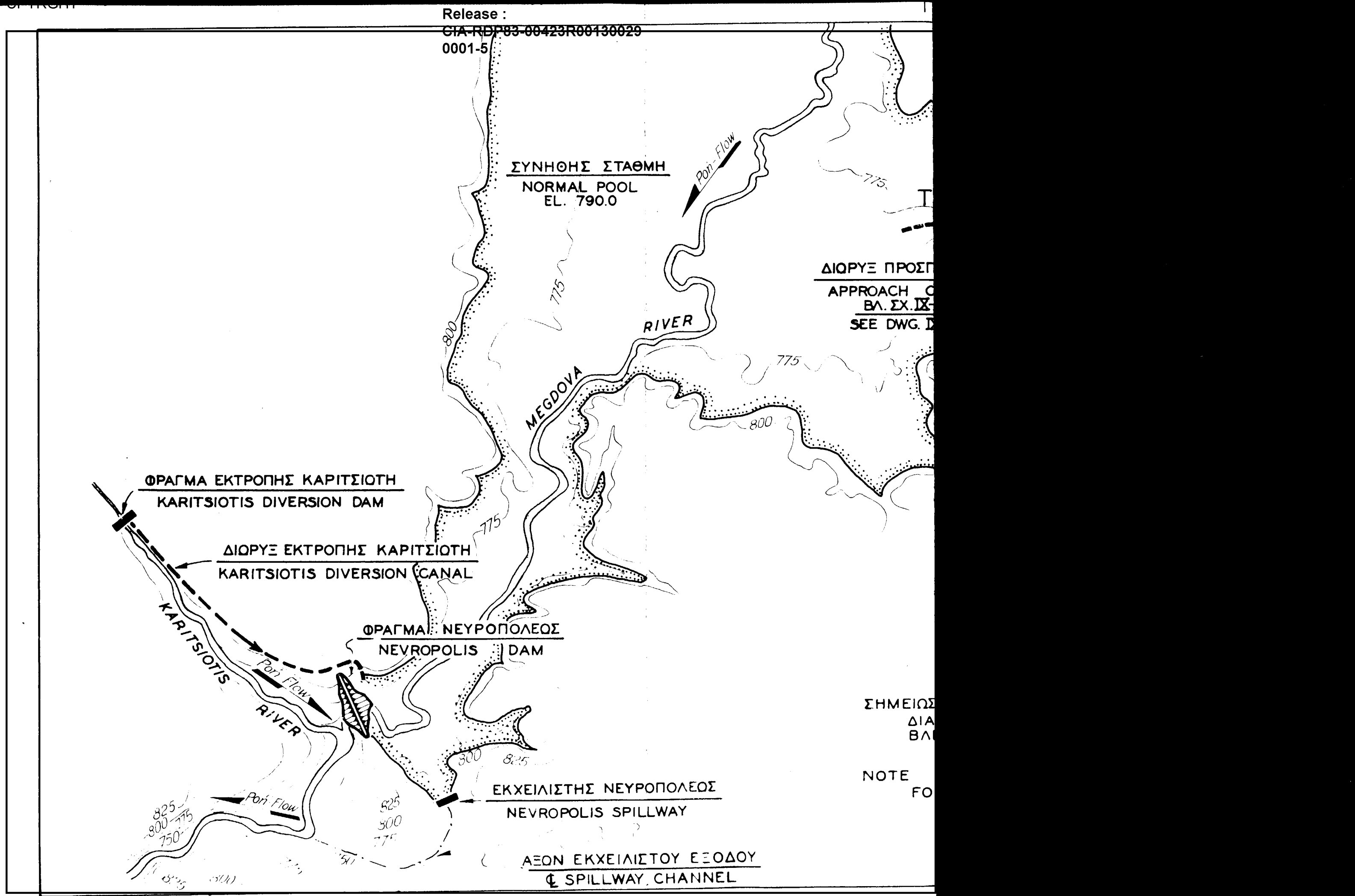
POWER DRAFT VS IRRIGATION DRAFT

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK ATHENS

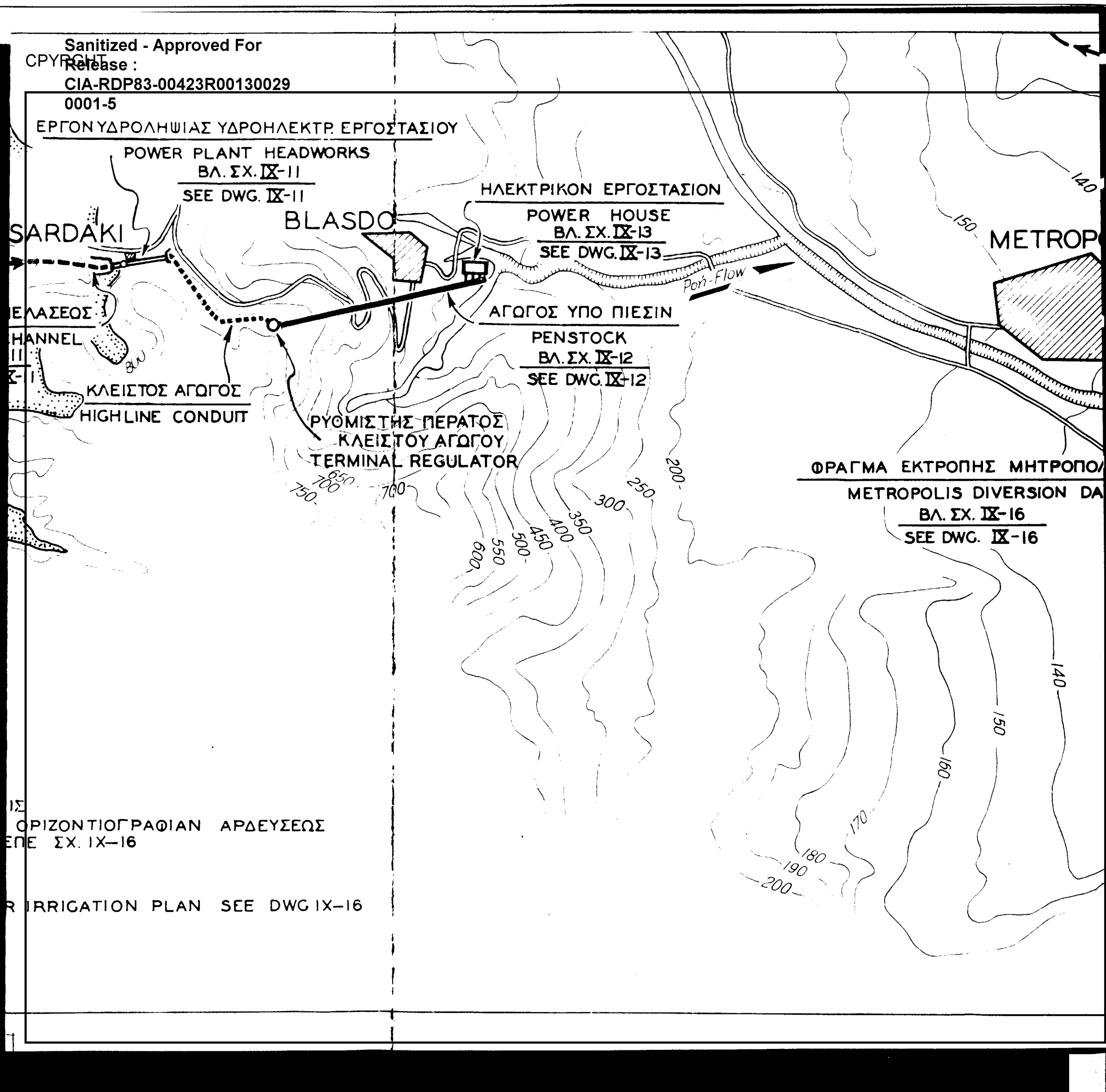
DES. BY: P.Z.K.
CH. BY: E.H.
DATE: OCT. 1952

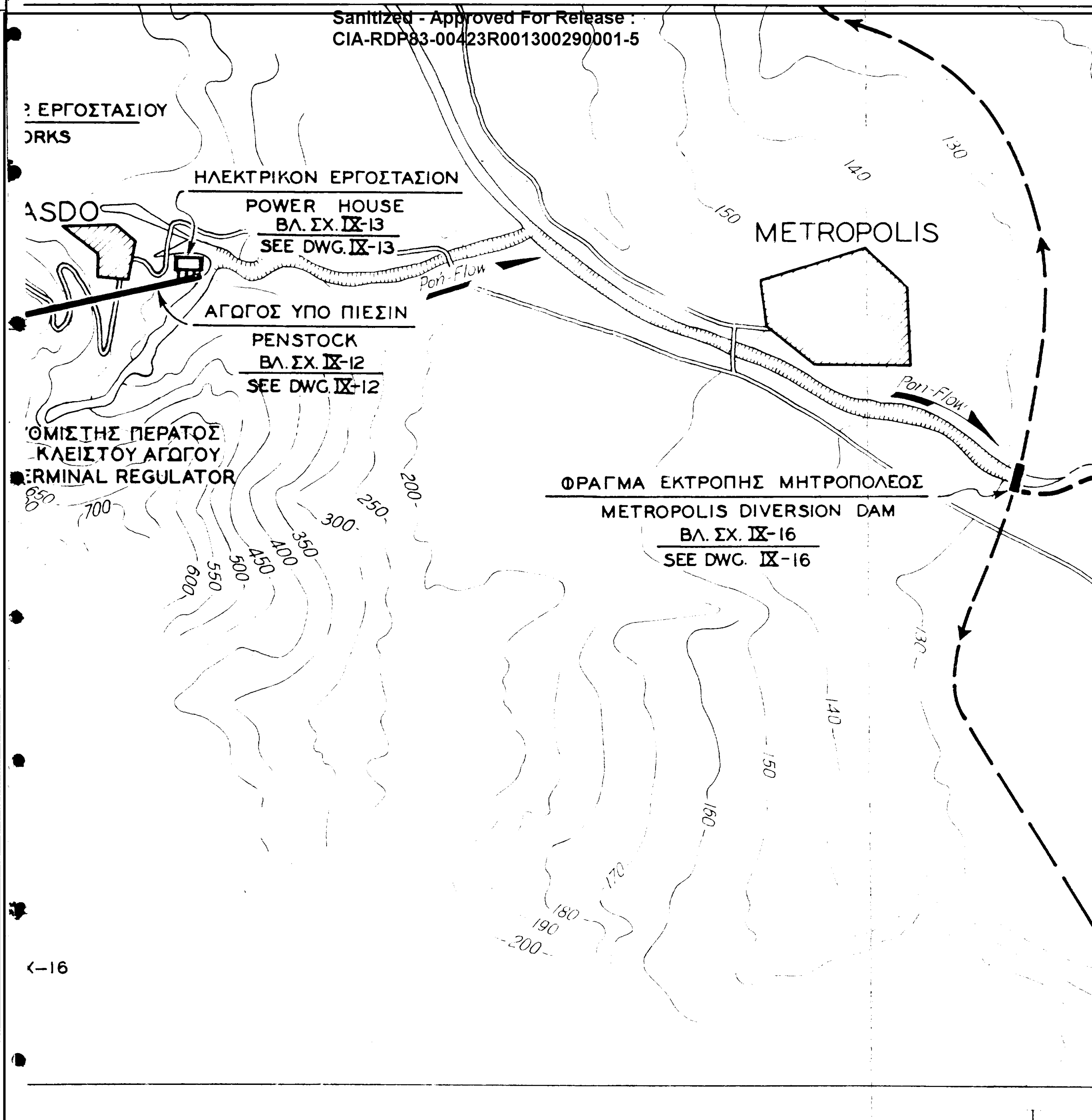
PLATE VIII

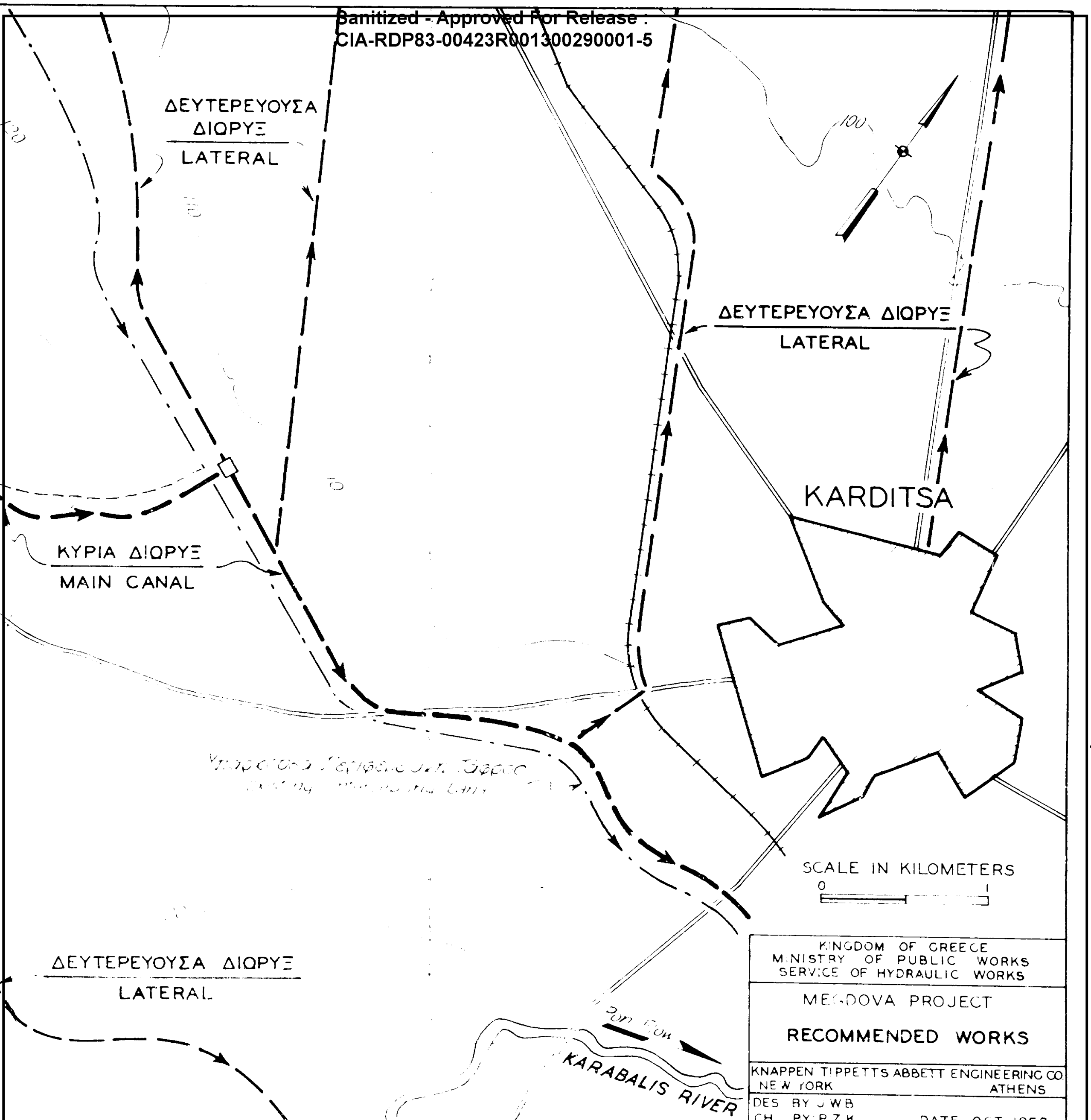
Sanitized - Approved For Release : CIA-RDP83-00423R001300290001-5


ΣΥΝΗΘΗΣ ΣΤΑΘΜΗ
NORMAL POOL
EL. 790.0
Pori Flow
MEGDOVA RIVER
ΦΡΑΓΜΑ ΕΚΤΡΟΠΗΣ ΚΑΡΙΤΣΙΩΤΗ
KARITSIOTIS DIVERSION DAM
ΔΙΩΡΥΞ ΕΚΤΡΟΠΗΣ ΚΑΡΙΤΣΙΩΤΗ
KARITSIOTIS DIVERSION CANAL
KARITSIOTIS RIVER
ΦΡΑΓΜΑ ΝΕΥΡΟΠΟΛΕΩΣ
NEVROPOLIS DAM
ΕΚΧΕΙΛΙΣΤΗΣ ΝΕΥΡΟΠΟΛΕΩΣ
NEVROPOLIS SPILLWAY
ΑΞΩΝ ΕΚΧΕΙΛΙΣΤΟΥ ΕΞΟΔΟΥ
℄ SPILLWAY CHANNEL
775
800
825
750
NOTE

[redacted]


ΕΡΓΟΝ ΥΔΡΟΛΗΨΙΑΣ ΥΔΡΟΗΛΕΚΤΡ. ΕΡΓΟΣΤΑΣΙΟΥ
POWER PLANT HEADWORKS
ΒΛ. ΣΧ. IX-11
SEE DWG. IX-11
SARDAKI
BLASDO
ΗΛΕΚΤΡΙΚΟΝ ΕΡΓΟΣΤΑΣΙΟΝ
POWER HOUSE
ΒΛ. ΣΧ. IX-13
SEE DWG. IX-13
METROP
Pon-Flow
ΑΓΩΓΟΣ ΥΠΟ ΠΙΕΣΙΝ
PENSTOCK
ΒΛ. ΣΧ. IX-12
SEE DWG. IX-12
ΕΛΑΣΕΩΣ
HANNEL
ΚΛΕΙΣΤΟΣ ΑΓΩΓΟΣ
HIGHLINE CONDUIT
ΡΥΘΜΙΣΤΗΣ ΠΕΡΑΤΟΣ ΚΛΕΙΣΤΟΥ ΑΓΩΓΟΥ
TERMINAL REGULATOR
ΦΡΑΓΜΑ ΕΚΤΡΟΠΗΣ ΜΗΤΡΟΠΟ
METROPOLIS DIVERSION DA
ΒΛ. ΣΧ. IX-16
SEE DWG. IX-16
ΟΡΙΖΟΝΤΙΟΓΡΑΦΙΑΝ ΑΡΔΕΥΣΕΩΣ
ΣΧ. IX-16
IRRIGATION PLAN SEE DWG IX-16
140
150
160
170
180
190
200
250
300
350
400
450
500
550
600
650
700
750


? ΕΡΓΟΣΤΑΣΙΟΥ
)RKS
ΗΛΕΚΤΡΙΚΟΝ ΕΡΓΟΣΤΑΣΙΟΝ
POWER HOUSE
ΒΛ. ΣΧ. IX-13
SEE DWG. IX-13
ΑΓΩΓΟΣ ΥΠΟ ΠΙΕΣΙΝ
PENSTOCK
ΒΛ. ΣΧ. IX-12
SEE DWG. IX-12
'ΟΜΙΣΤΗΣ ΠΕΡΑΤΟΣ
ΚΛΕΙΣΤΟΥ ΑΓΩΓΟΥ
ERMINAL REGULATOR
METROPOLIS
Pori-Flow
ΦΡΑΓΜΑ ΕΚΤΡΟΠΗΣ ΜΗΤΡΟΠΟΛΕΩΣ
METROPOLIS DIVERSION DAM
ΒΛ. ΣΧ. IX-16
SEE DWG. IX-16
<—16



KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT

RECOMMENDED WORKS

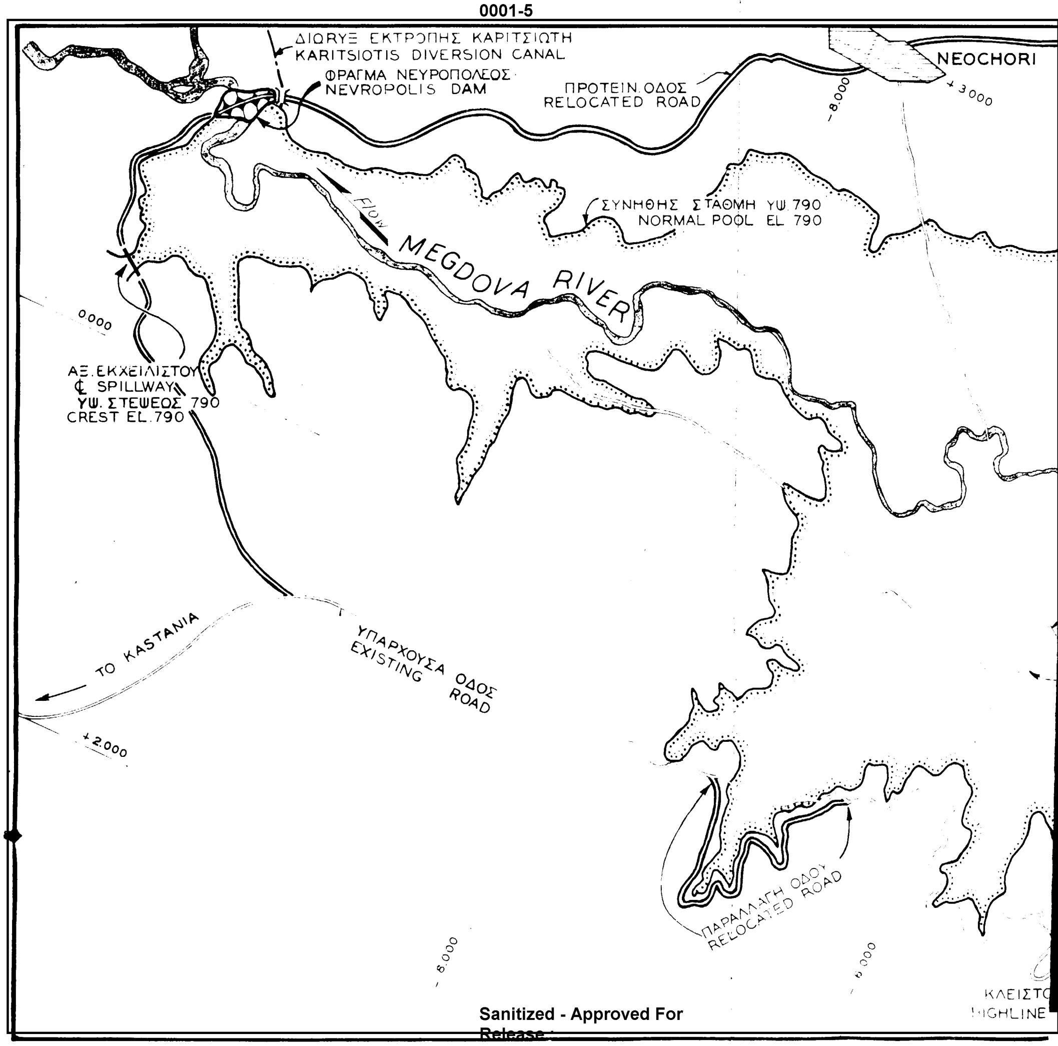
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK — ATHENS

DES BY J W B
CH BY P Z K — DATE OCT. 1952

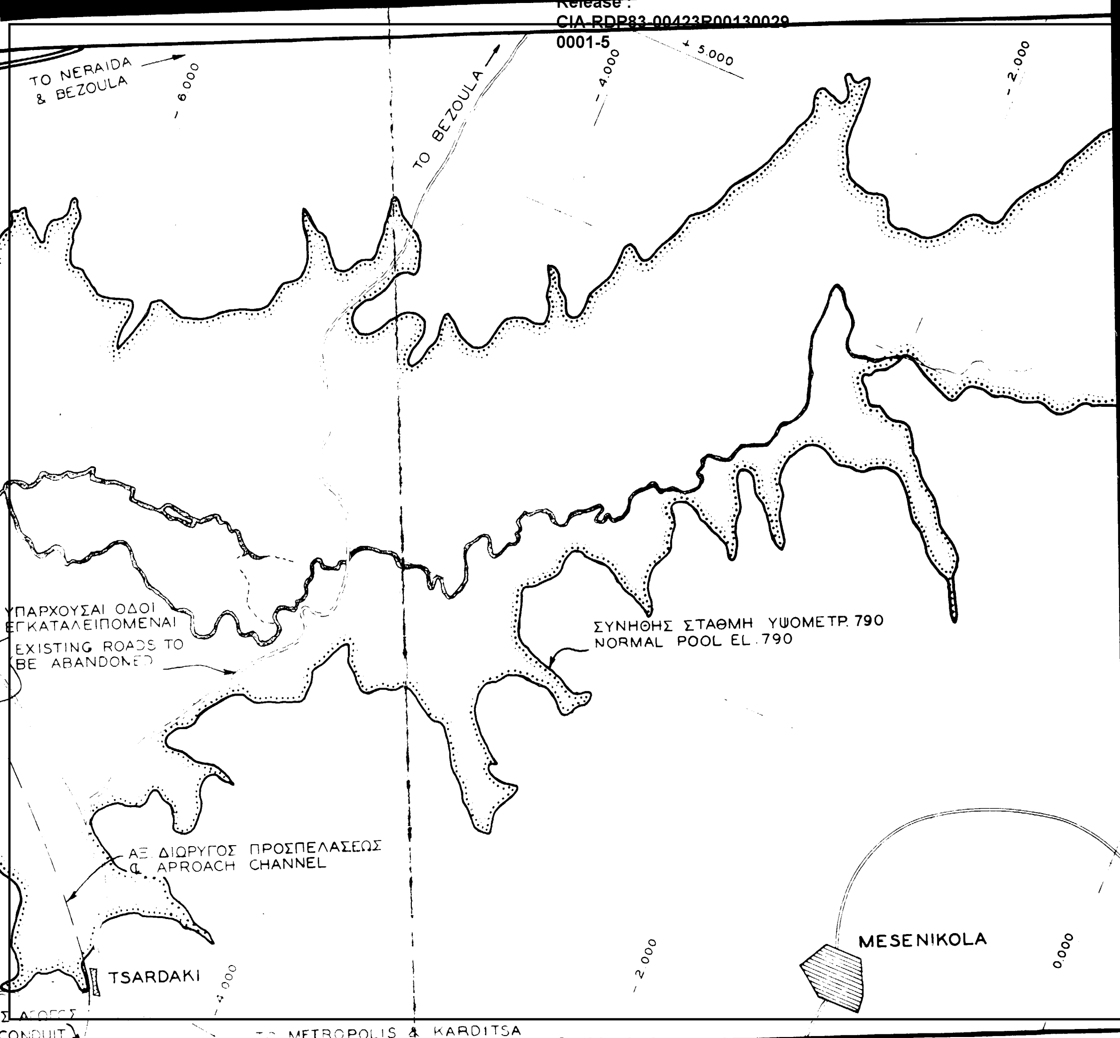
PLATE IX-1

[redacted]

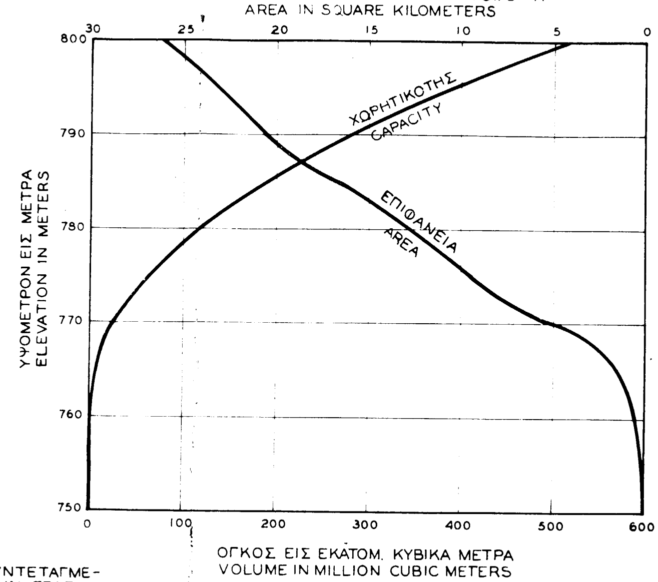
0001-5



[redacted]


TO NERAIDA & BEZOULA
- 6.000
TO BEZOULA
- 4.000
+ 5.000
- 2.000
ΥΠΑΡΧΟΥΣΑΙ ΟΔΟΙ
ΕΓΚΑΤΑΛΕΙΠΟΜΕΝΑΙ
EXISTING ROA_S TO
BE ABANDONE_
ΣΥΝΗΘΗΣ ΣΤΑΘΜΗ ΥΨΟΜΕΤΡ. 790
NORMAL POOL EL. 790
ΑΞ ΔΙΩΡΥΓΟΣ ΠΡΟΣΠΕΛΑΣΕΩΣ
℄ APROACH CHANNEL
TSARDAKI
- 2.000
MESENIKOLA
0.000
CONDUIT
METROPOLIS & KARDITSA

ΕΠΙΦΑΝΕΙΑ ΕΙΣ ΤΕΤΡΑΓΩΝΙΚΑ ΧΙΛΙΟΜΕΤΡΑ
AREA IN SQUARE KILOMETERS



ΟΓΚΟΣ ΕΙΣ ΕΚΑΤΟΜ. ΚΥΒΙΚΑ ΜΕΤΡΑ
VOLUME IN MILLION CUBIC METERS

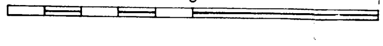
ΚΑΜΠΥΛΑΙ ΕΠΙΦΑΝΕΙΑΣ ΚΑΙ ΧΩΡΗΤΙΚΟΤΗΤΟΣ
AREA AND CAPACITY CURVES

ΗΡΗΣΙΣ

Ο ΠΑΡΟΝ ΣΥΣΤΗΜΑ ΣΥΝΤΕΤΑΓΜΕ-
ΩΝ ΥΙΟΘΕΤΗΘΗ ΑΠΟ ΤΗΝ ΓΕΩΓΡΑ-
ΙΚΗΝ ΥΠΗΡΕΣΙΑΝ ΤΟΥ ΕΛΛ. ΣΤΡΑΤΟΥ.

HE COORDINATE SYSTEM SHOWN
VAS ADOPTED BY THE GEOGRAPHIC
ERVICE OF THE GREEK ARMY

ΚΛΙΜΑΞ ΕΙΣ ΧΙΛΙΟΜΕΤΡΑ
SCALE IN KILOMETERS



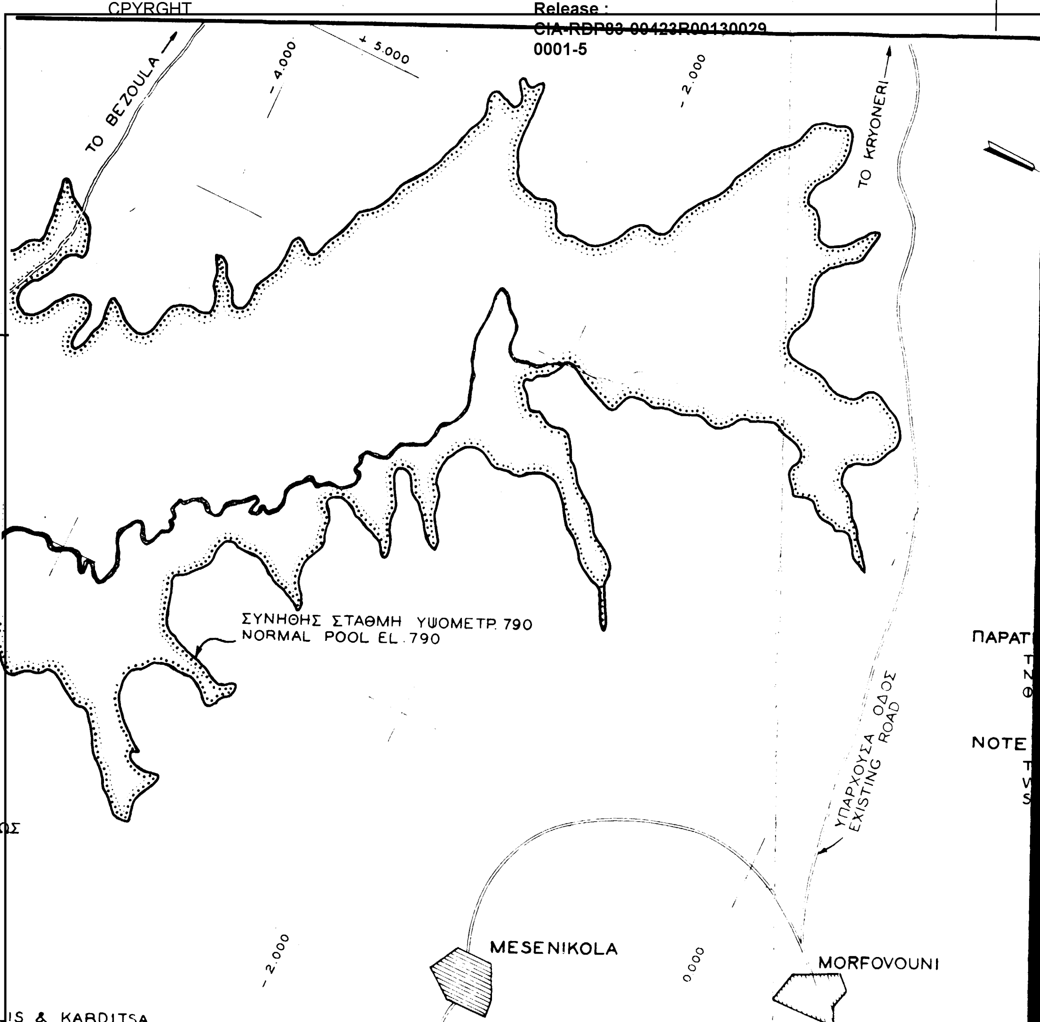
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT
NEVROPOLIS RESERVOIR
AND CAPACITY CURVES

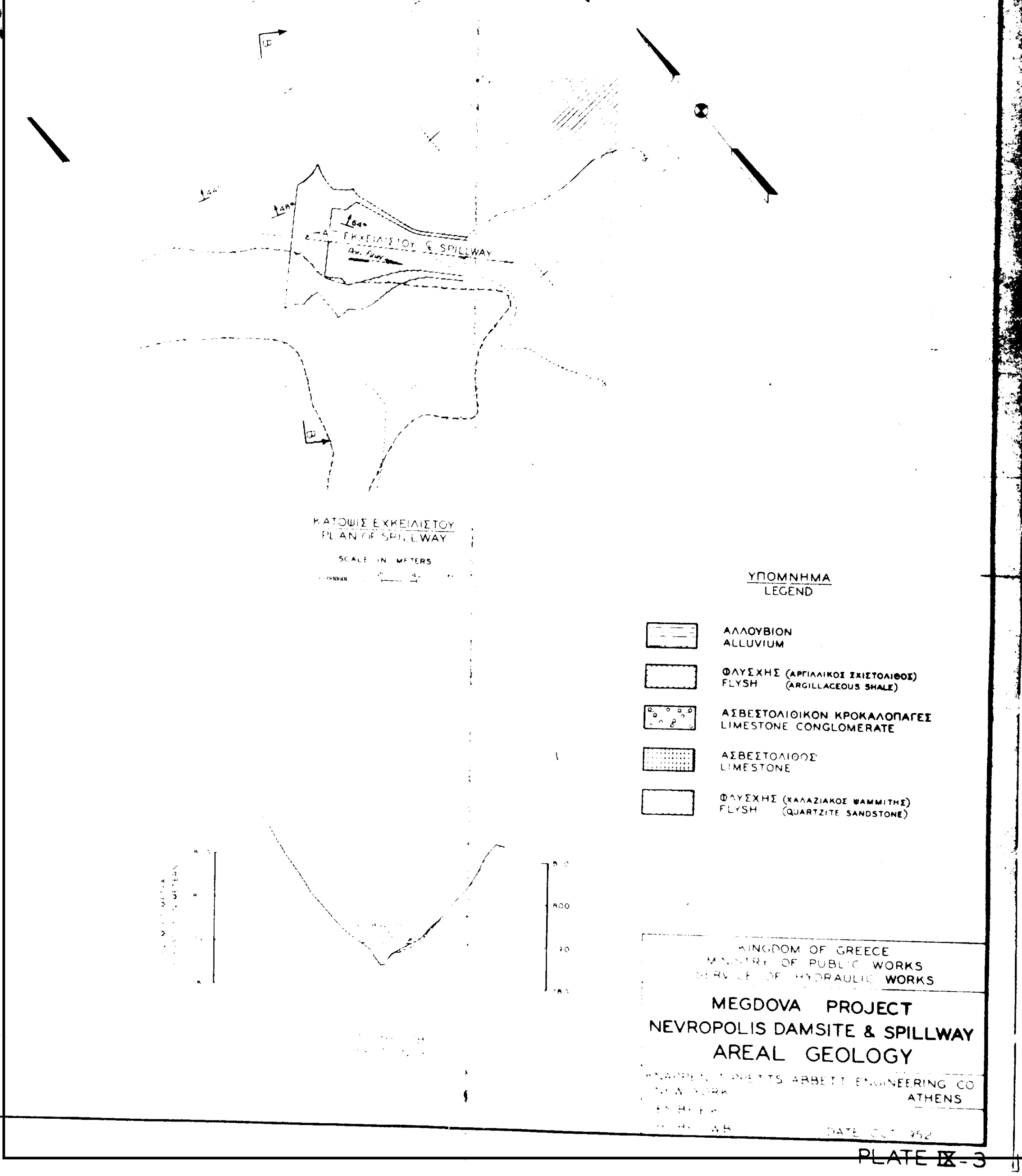
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS

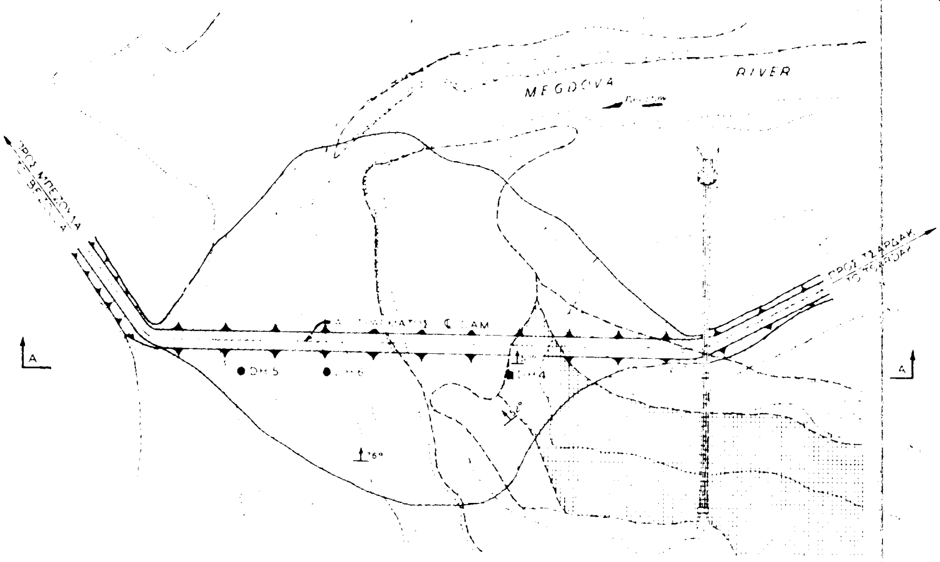
DES. BY: E. H.
CH. BY: P.Z.K.
DATE OCT. 1952

PLATE IX-2


TO BEZOULA
- 4.000
+ 5.000
- 2.000
TO KRYONERI
ΣΥΝΗΘΗΣ ΣΤΑΘΜΗ ΥΨΟΜΕΤΡ. 790
NORMAL POOL EL. 790
ΥΠΑΡΧΟΥΣΑ ΟΔΟΣ
EXISTING ROAD
ΠΑΡΑΤ
NOTE
- 2.000
MESENIKOLA
0.000
MORFOVOUNI
LIS & KARDITSA

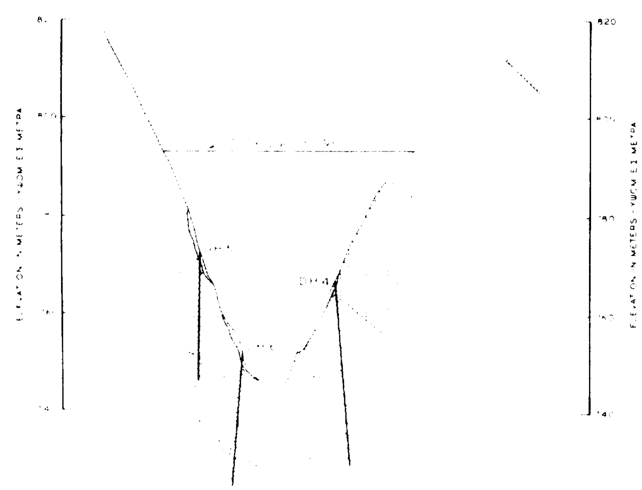
[redacted]

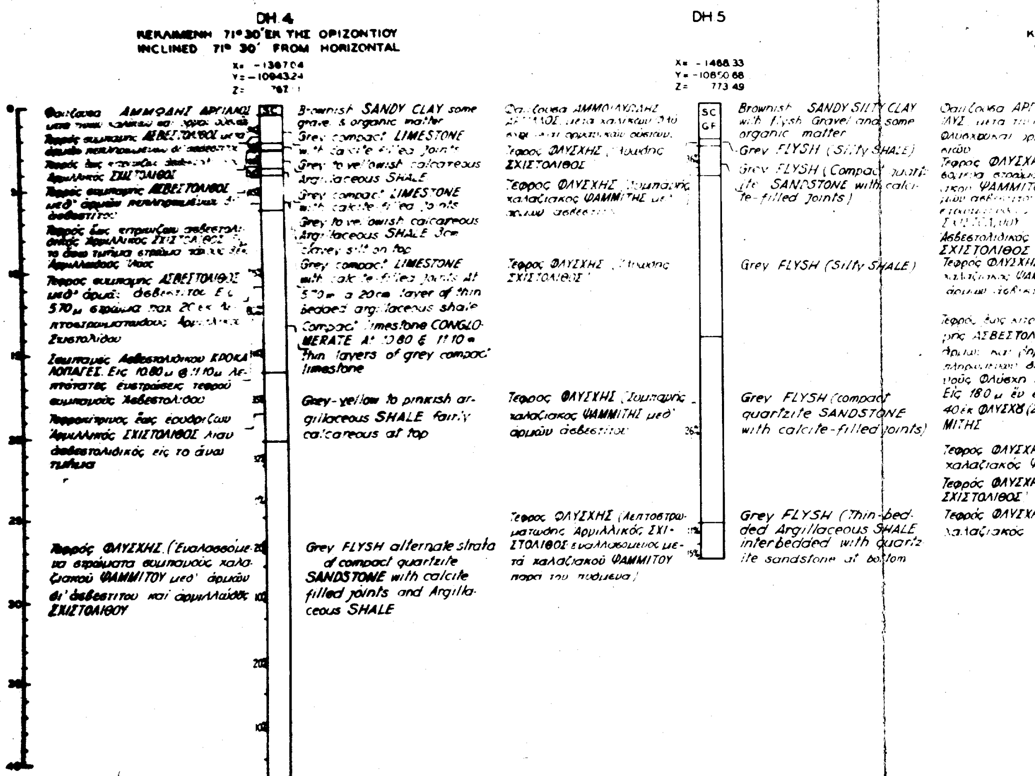

ΚΑΤΟΨΙΣ ΕΧΚΕΙΛΙΣΤΟΥ
PLAN OF SPILLWAY
SCALE IN METERS
ΥΠΟΜΝΗΜΑ
LEGEND
ΑΛΛΟΥΒΙΟΝ
ALLUVIUM
ΦΛΥΣΧΗΣ (ΑΡΓΙΛΛΙΚΟΣ ΣΧΙΣΤΟΛΙΘΟΣ)
FLYSH (ARGILLACEOUS SHALE)
ΑΣΒΕΣΤΟΛΙΘΙΚΟΝ ΚΡΟΚΑΛΟΠΑΓΕΣ
LIMESTONE CONGLOMERATE
ΑΣΒΕΣΤΟΛΙΘΟΣ
LIMESTONE
ΦΛΥΣΧΗΣ (ΧΑΛΑΖΙΑΚΟΣ ΨΑΜΜΙΤΗΣ)
FLYSH (QUARTZITE SANDSTONE)
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
NEVROPOLIS DAMSITE & SPILLWAY
AREAL GEOLOGY
ATHENS
PLATE IX-3



ΚΑΤΟΨΙΣ ΦΡΑΓΜΑΤΟΣ
PLAN OF DAM

SCALE IN METERS





ΠΑΡΑΤΗΡΗΣΕΙΣ

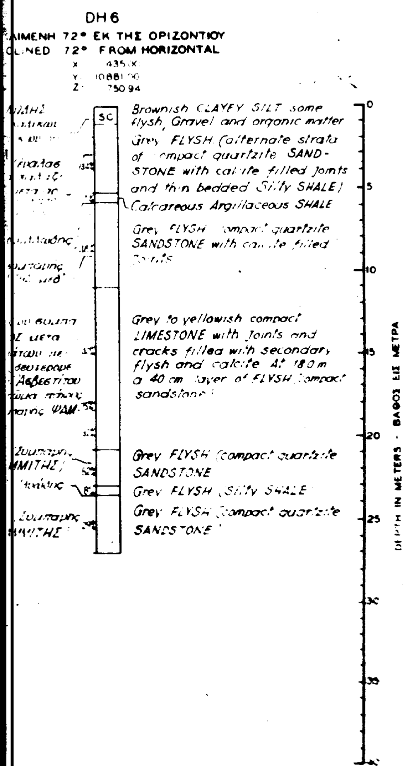
Τα σύμβολα εντός τών στηλών τών γεωτρήσεων αναφέρονται εις αντιστοίχους κατατάξεως εδάφους κατά το σύστημα Casagrande.
Οι μεταξύ τών παυλών αριθμοί οί ευρισκόμενοι παραπλεύρως τής στήλης τών γεωτρήσεων εκπεφρασμένοι εις % δεικνύουν ποσοστόν ανασυρθέντος καρότου διά τό δεικνυόμενον βάθος.
Χ και Υ αναφέρονται εις σύστημα συντεταγμένων υιοθετηθέν υπό τής Γεωγρ. Υπηρεσίας Στρατού.
Ζ αναφέρεται εις το υψόμετρον άνωθεν τής μέσης επιφανείας τής θαλάσσης.

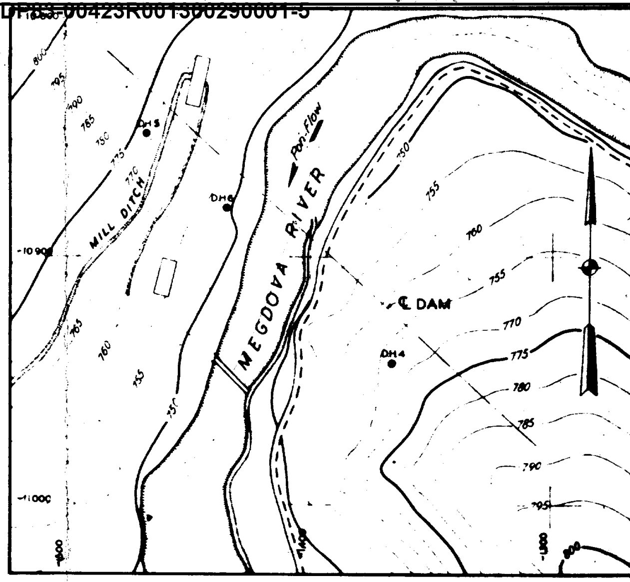
NOTES

Symbols within log column refer to abbreviations of soil classifications of the Casagrande system
Numerals between dashes alongside log column expressed in % indicate core recovery for the depth as marked
X and Y refer to coordinate system adopted from Greek Army
Z refers to elevation above mean sea level

ΥΠΟΜΝΗΜΑ

G Χάλικες
S Άμμος
M Ιλύς
C Άργιλλος
F Λεπτόκοκκοι
W Καλής
P Κακής
L
H





ΚΑΤΟΨΙΣ ΜΕΤΑ ΘΕΣΕΩΝ ΓΕΩΤΡΗΣΕΩΝ

BORING LOCATION PLAN

SCALE IN METERS

20 10 0 10 20 40 60

Low Compressibility
High Compressibility
Classification Symbols
according to Casagrande

KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT

NEVROPOLIS DAM

FOUNDATION EXPLORATIONS

KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS

DES. BY: E. K.
CH. BY: J.W.B. DATE: OCT. 1952

PLATE IX-4

TP-1 — SC / CL — Brown to dark brown, well compacted sandy silty CLAY some fine Gravel mostly from Argillaceous shale.

TP-2 — Brown Clayey TOPSOIL roots etc. — GC — Medium to fine GRAVEL and brown sandy silty CLAY. — GC — Med-fine GRAVEL and brown SANDY CLAY, well compacted

TP-3 — SC — Brown Clayey TOPSOIL — Brown to dark brown, compact sandy CLAY with some small pieces from decomposed Argillaceous Shale, trace of fine Gravel

TP-4 — SC / CL — Brown ... sandy CLAY ... — Sandstone shale limestone BOULDERS

TP-5 — SF — Brown silty SAND some clay, fairly compact — GF — GRAVEL and sandy silty Clay

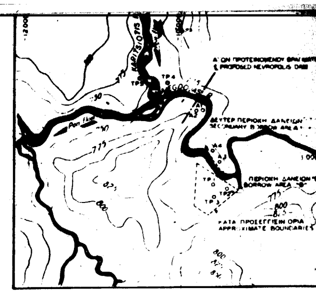
A-1 — CL — Brown lean silty CLAY and m-f sand some organic matter, roots. — CL / SL — Brown lean silty CLAY some med-fine sand — CL — Brown, lean, silty CLAY with some fine Gravel-size admixtures of argillaceous shale — ML / SF — Brown SANDY SILT some clay.

A-2 — ML / SC — Brown Sandy SILT some clay — Brown ... silty SAND & sedimentary sandstone

A-3 — SF — Brown silty SAND & TOPSOIL some clay — ML — Brown SANDY SILT trace of clay — SW — Brown coarse to fine SAND & SILT.

A-4 — SF — Brown SILTY SAND and TOPSOIL some clay — SF — Brown & greyish clayey silty SAND

DEPTH IN METERS - ΒΑΘΟΣ ΕΙΣ ΜΕΤΡΑ



ΚΑΤΟΨΙΣ ΘΕΣΕΩΝ ΓΕΩΤΡΗΣΕΩΝ
BORING LOCATION PLAN

ΚΛΙΜΑΞ ΕΙΣ ΜΕΤΡΑ
SCALE IN METERS
200 0 100 200 400 800

ΠΑΡΑΤΗΡΗΣΕΙΣ

NOTES

ΥΠΟΜΝΗΜΑ — LEGEND
G
S
M
C
F
W
P
L
H

KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT
NEVROPOLIS DAM
BORROW MATERIAL EXPLORATIONS

KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS
DES BY GG
CH. BY JWB DATE OCT 1952

PLATE IX-5

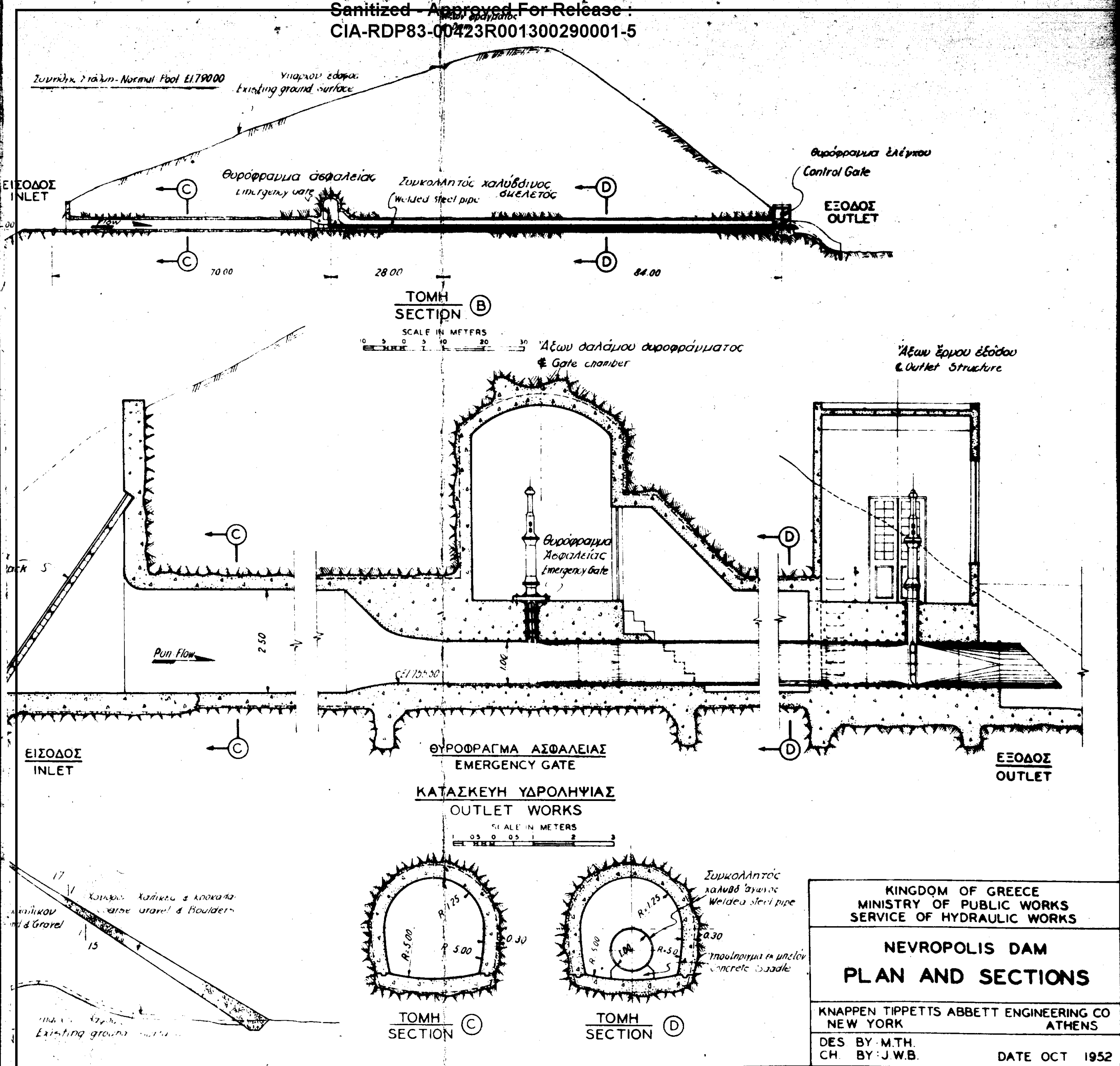
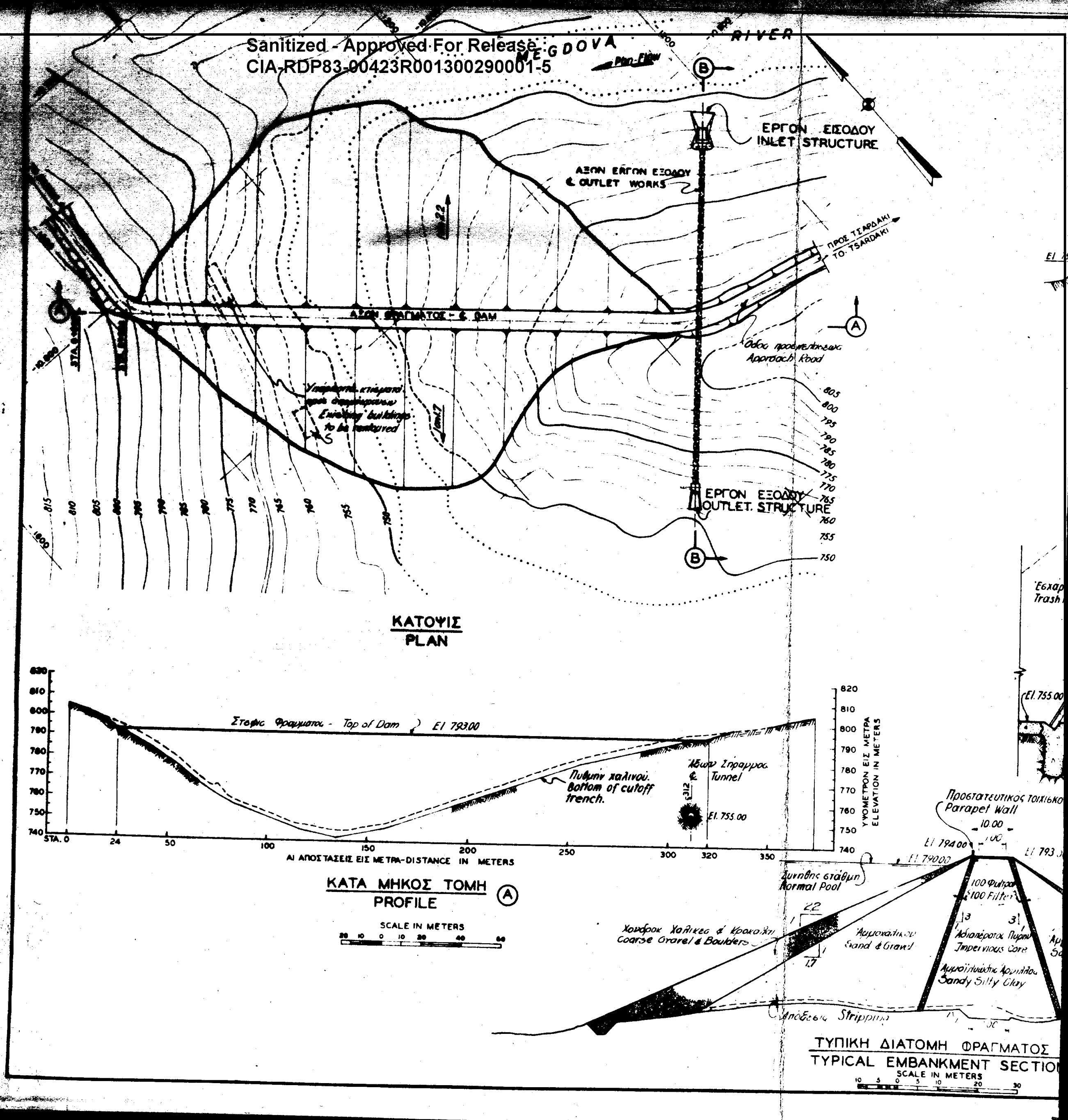
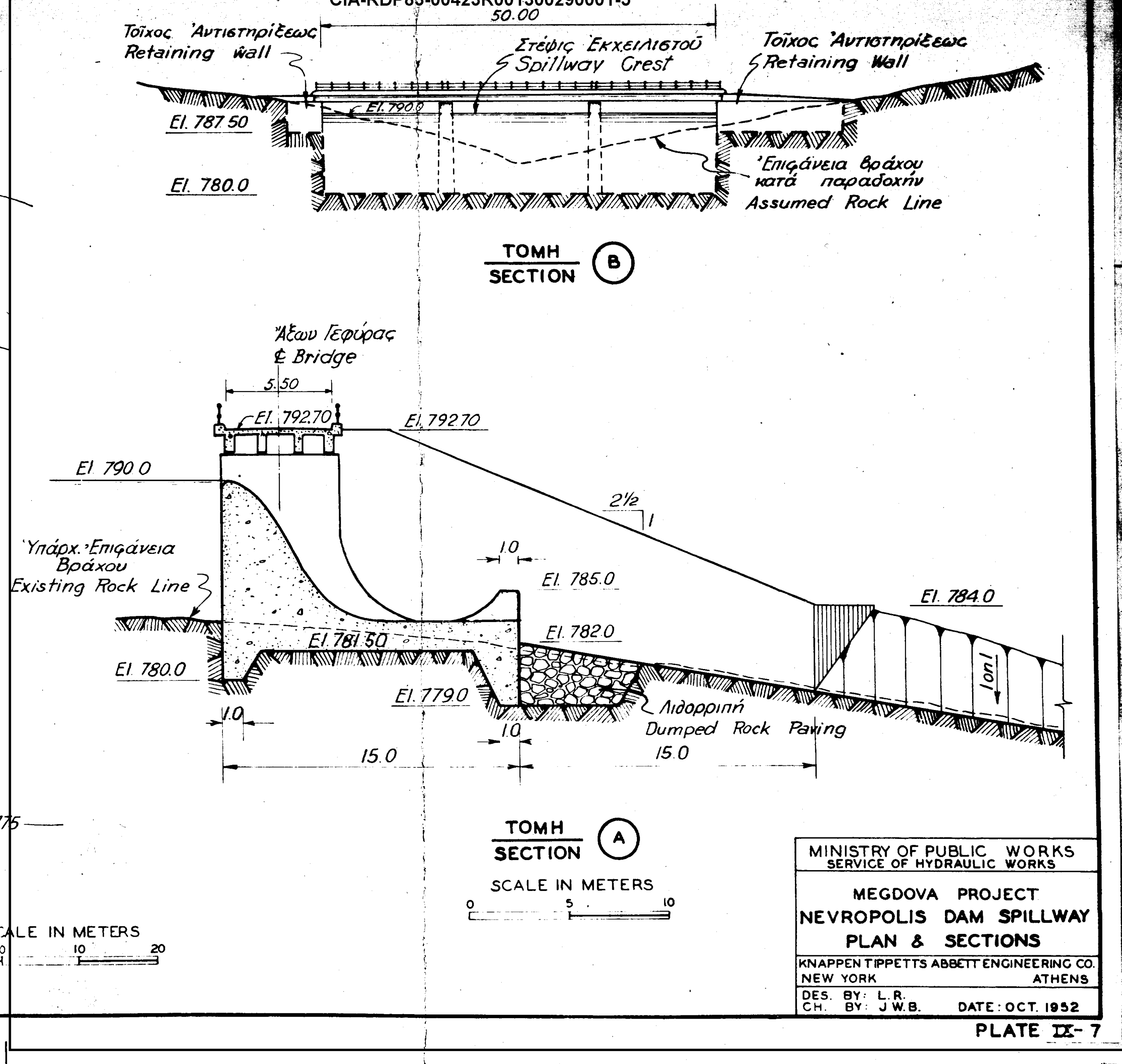
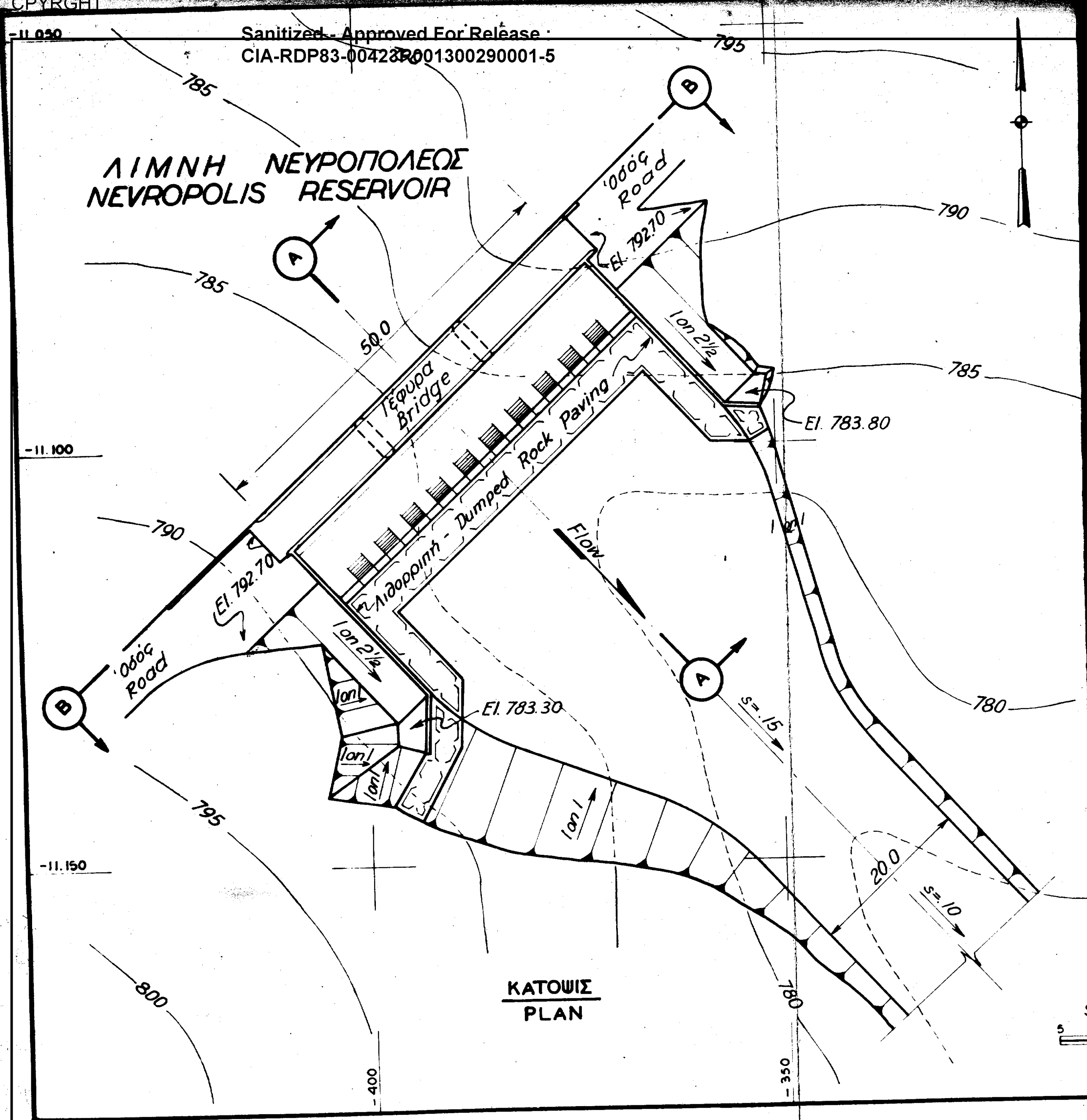

Existing ground surface
Control Gate
ΕΙΣΟΔΟΣ
INLET
Emergency gate
Welded steel pipe
ΕΞΟΔΟΣ
OUTLET
70.00
28.00
84.00
ΤΟΜΗ
SECTION B
SCALE IN METERS
Gate chamber
Outlet Structure
Emergency Gate
ΕΙΣΟΔΟΣ
INLET
ΘΥΡΟΦΡΑΓΜΑ ΑΣΦΑΛΕΙΑΣ
EMERGENCY GATE
ΕΞΟΔΟΣ
OUTLET
ΚΑΤΑΣΚΕΥΗ ΥΔΡΟΛΗΨΙΑΣ
OUTLET WORKS
SCALE IN METERS
Welded steel pipe
Concrete saddle
ΤΟΜΗ
SECTION C
ΤΟΜΗ
SECTION D
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
NEVROPOLIS DAM
PLAN AND SECTIONS
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS
DES BY M.TH.
CH. BY J.W.B.
DATE OCT 1952

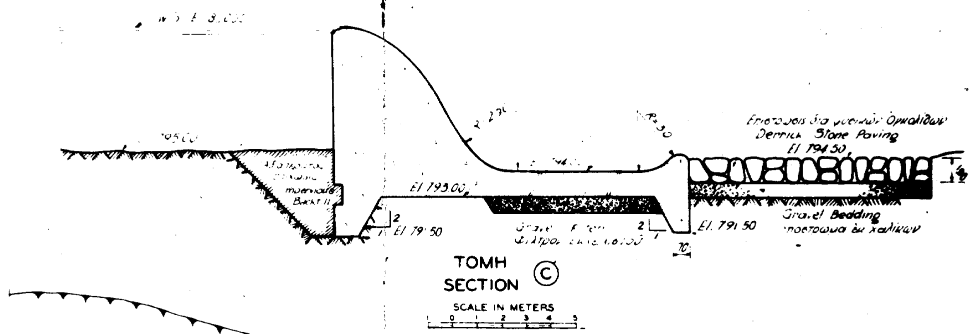
PLATE IX - 6


MEGDOVA RIVER
ΕΡΓΟΝ ΕΙΣΟΔΟΥ
INLET STRUCTURE
ΑΞΩΝ ΕΡΓΟΝ ΕΞΟΔΟΥ
℄ OUTLET WORKS
ΠΡΟΣ ΤΣΑΡΔΑΚΙ
TO TSARDAKI
ΑΞΩΝ ΦΡΑΓΜΑΤΟΣ - ℄ DAM
Οδός προσπελάσεως
Approach Road
Existing buildings to be removed
ΕΡΓΟΝ ΕΞΟΔΟΥ
OUTLET STRUCTURE
ΚΑΤΟΨΙΣ
PLAN
Στέψις Φράγματος - Top of Dam
El 793.00
Πυθμήν χαλινού.
Bottom of cutoff trench.
Άξων Σήραγγος
℄ Tunnel
El. 755.00
ΥΨΟΜΕΤΡΟΝ ΕΙΣ ΜΕΤΡΑ
ELEVATION IN METERS
ΑΙ ΑΠΟΣΤΑΣΕΙΣ ΕΙΣ ΜΕΤΡΑ - DISTANCE IN METERS
ΚΑΤΑ ΜΗΚΟΣ ΤΟΜΗ
PROFILE
SCALE IN METERS
Προστατευτικός τοιχίσκος
Parapet Wall
10.00
El 794.00
El 790.00
Συνήθης στάθμη
Normal Pool
Χονδρόκ Χάλικες & Κροκάλαι
Coarse Gravel & Boulders
Αμμοχάλικον
Sand & Gravel
100 Φίλτρον
100 Filter
Αδιαπέρατος Πυρήν
Impervious Core
Αμμοϊλυώδης Άργιλλος
Sandy Silty Clay
Απόξεσις Stripping
ΤΥΠΙΚΗ ΔΙΑΤΟΜΗ ΦΡΑΓΜΑΤΟΣ
TYPICAL EMBANKMENT SECTION
SCALE IN METERS

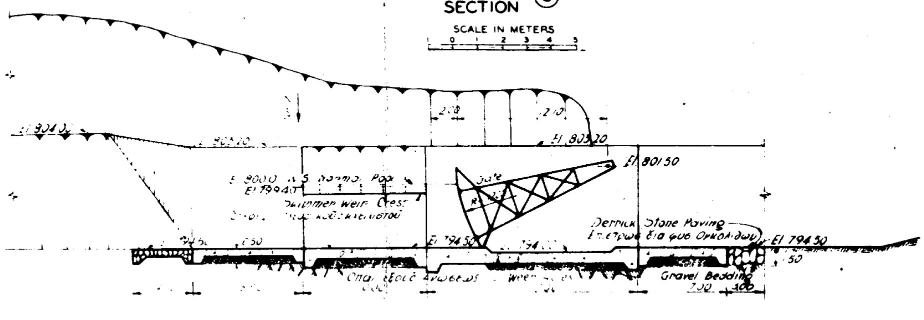

50.00
Τοίχος Αντιστηρίξεως
Retaining Wall
Στέψις Εκχειλιστού
Spillway Crest
Τοίχος Αντιστηρίξεως
Retaining Wall
El. 790.0
El. 787.50
El. 780.0
Επιφάνεια βράχου κατά παραδοχήν
Assumed Rock Line
TOMH
SECTION
B
Άξων Γεφύρας
℄ Bridge
5.50
El. 792.70
El. 792.70
El. 790.0
2½
1
Υπάρχ. Επιφάνεια Βράχου
Existing Rock Line
1.0
El. 785.0
El. 784.0
El. 782.0
El. 781.50
El. 780.0
El. 779.0
1.0
1.0
Λιθορριπή
Dumped Rock Paving
15.0
15.0
1 on 1
TOMH
SECTION
A
SCALE IN METERS
0
5
10
SCALE IN METERS
0
10
20
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
NEVROPOLIS DAM SPILLWAY
PLAN & SECTIONS
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK ATHENS
DES. BY: L.R.
CH. BY: J.W.B.
DATE: OCT. 1952
PLATE IX-7



KATOΨIΣ
PLAN



TOMH
SECTION (C)



TOMH
SECTION (B)

TOMH
SECTION (D)

KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

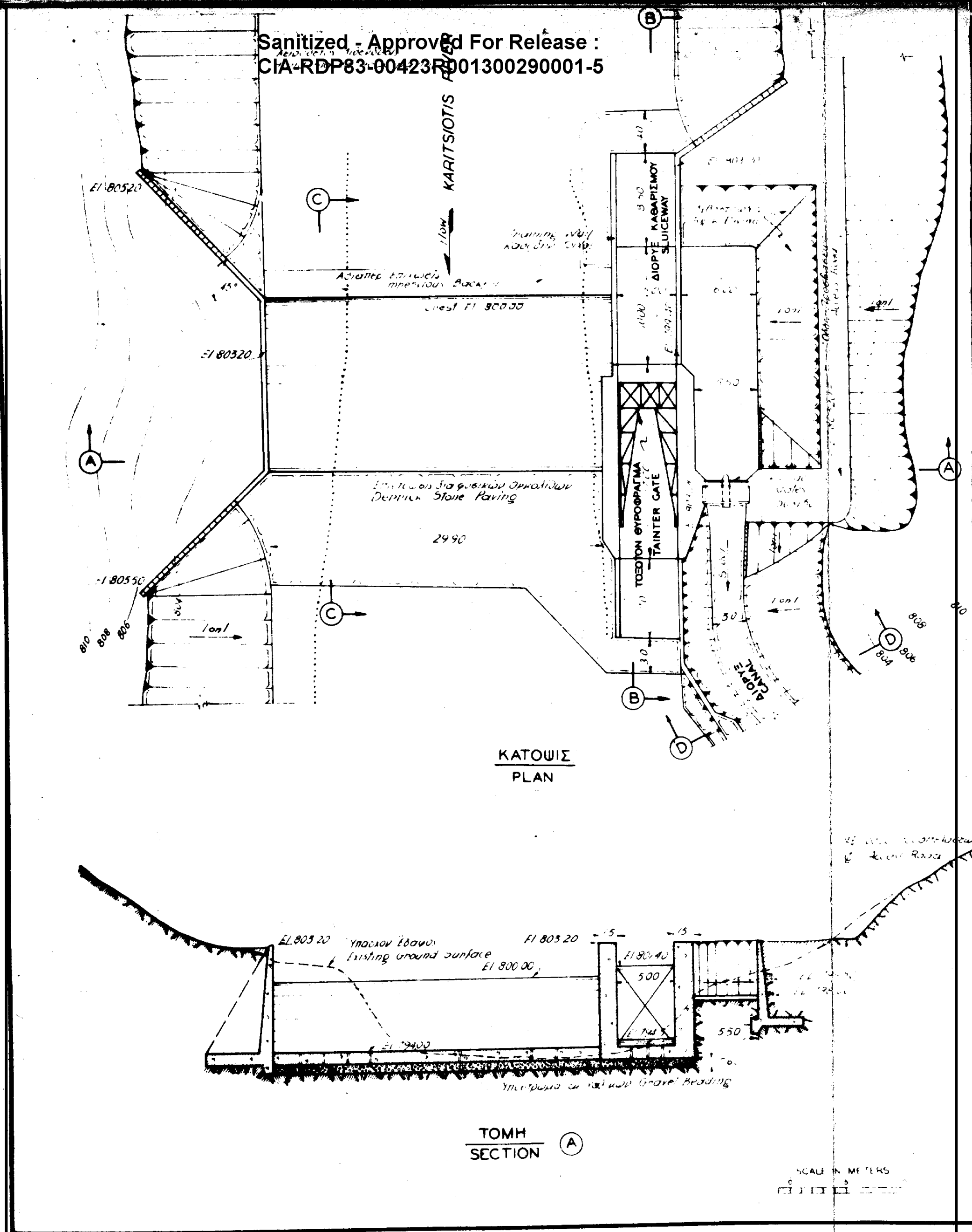
MEGDOVA PROJECT

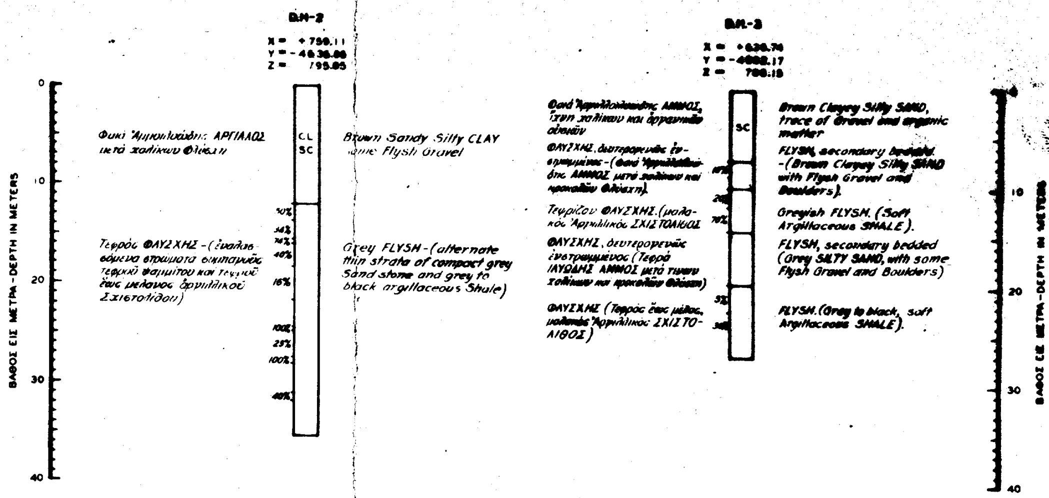
KARITSIOTIS DIVERSION DAM
PLAN, PROFILE & SECTION

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK ATHENS

DES BY PC
CH BY JWB DATE OCT 1952

PLATE IX-8


KARITSIOTIS
Flow
Crest El 800.00
El 805.20
El 803.20
El 805.50
Dennick Stone Paving
29.90
ΤΟΞΟΤΟΝ ΘΥΡΟΦΡΑΓΜΑ
TAINTER GATE
ΔΙΟΡΥΞ ΚΑΘΑΡΙΣΜΟΥ
SLUICEWAY
ΔΙΟΡΥΞ
CANAL
ΚΑΤΟΨΙΣ
PLAN
El 803.20
Υπαρχον Εδαφος
Existing ground surface
El 800.00
El 803.20
El 794.00
5.50
5.00
Gravel Bedding
ΤΟΜΗ
SECTION
A
SCALE IN METERS



ΠΑΡΑΤΗΡΗΣΕΙΣ

Τα σύμβολα εντός των στηλών των γεωτρήσεων αναφέρονται εις συντμήσεις κατατάξεως εδαφών κατά το σύστημα Κασαγκράντε

Οι μεταξύ των παυλών αριθμοί οι ευρισκόμενοι παραπλεύρως της στήλης των γεωτρήσεων εκπεφρασμένοι εις % δεικνύουν ποσοστόν ανασυρθέντος καρότου διά το δεικνυόμενον βάθος.

Χ και Υ αναφέρονται εις σύστημα συντεταγμένων υιοθετηθέν εκ της Γεωγραφικής Υπηρεσίας Στρατού

Ζ αναφέρεται εις το υψόμετρον άνωθεν της μέσης επιφανείας της θαλάσσης.

NOTES

Symbols within log column refer to abbreviations of soil classifications of the Casagrande system

Numerals between dashes alongside log column expressed in % indicate core recovery for the depth as marked

X and Y refer to coordinate system adopted from Greek Army.

Z refers to elevation above mean sea level.

ΥΠΟΜΝΗΜΑ	LEGEND
G = [illegible]	Gravel
S = Άμμος	Sand
M = [illegible]	Silt
C = Άργιλλος	Clay
F = Λεπτόκοκκα ... (πλαστικού ή μη)	Fines (Plastic or not)
W = Καλής κοκκομετρικής διαβαθμίσεως	Well Graded
P = Κακής »	Poorly Graded
L = Ολίγου συμπιεστού	Low Compressibility
H = Λίαν »	High Compressibility
Σύμβολα ταξινομήσεως κατά το σύστημα Casagrande	Classification Symbols according to Casagrande

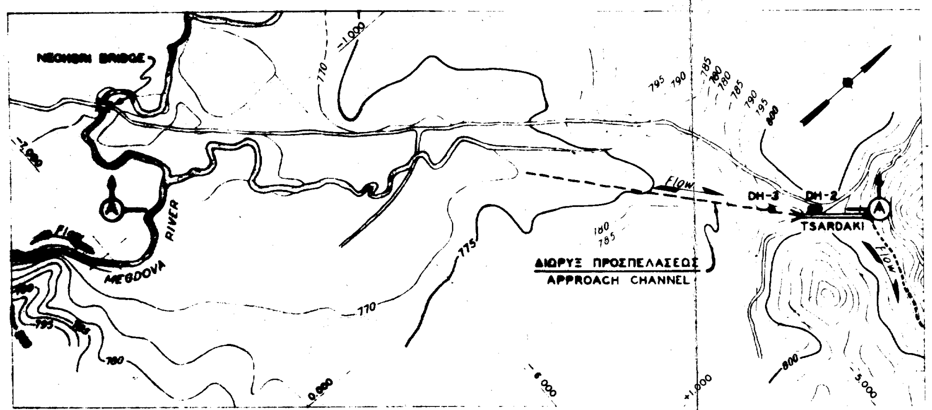
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT
POWER PLANT HEADWORKS
FOUNDATION EXPLORATION
& GEOLOGIC SECTION

KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS

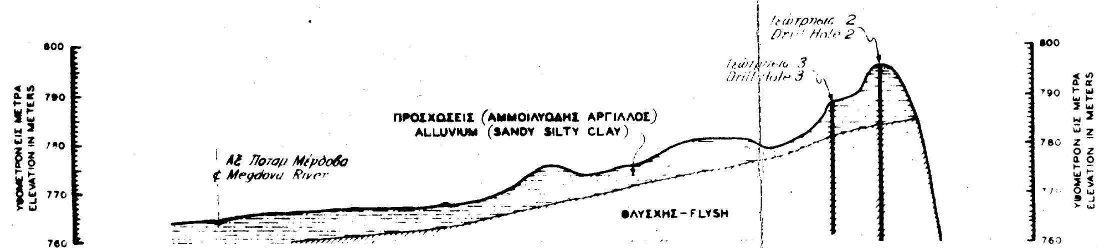
DES BY E. K.
CH BY J. W. B.
DATE OCT 1952

PLATE IX-9

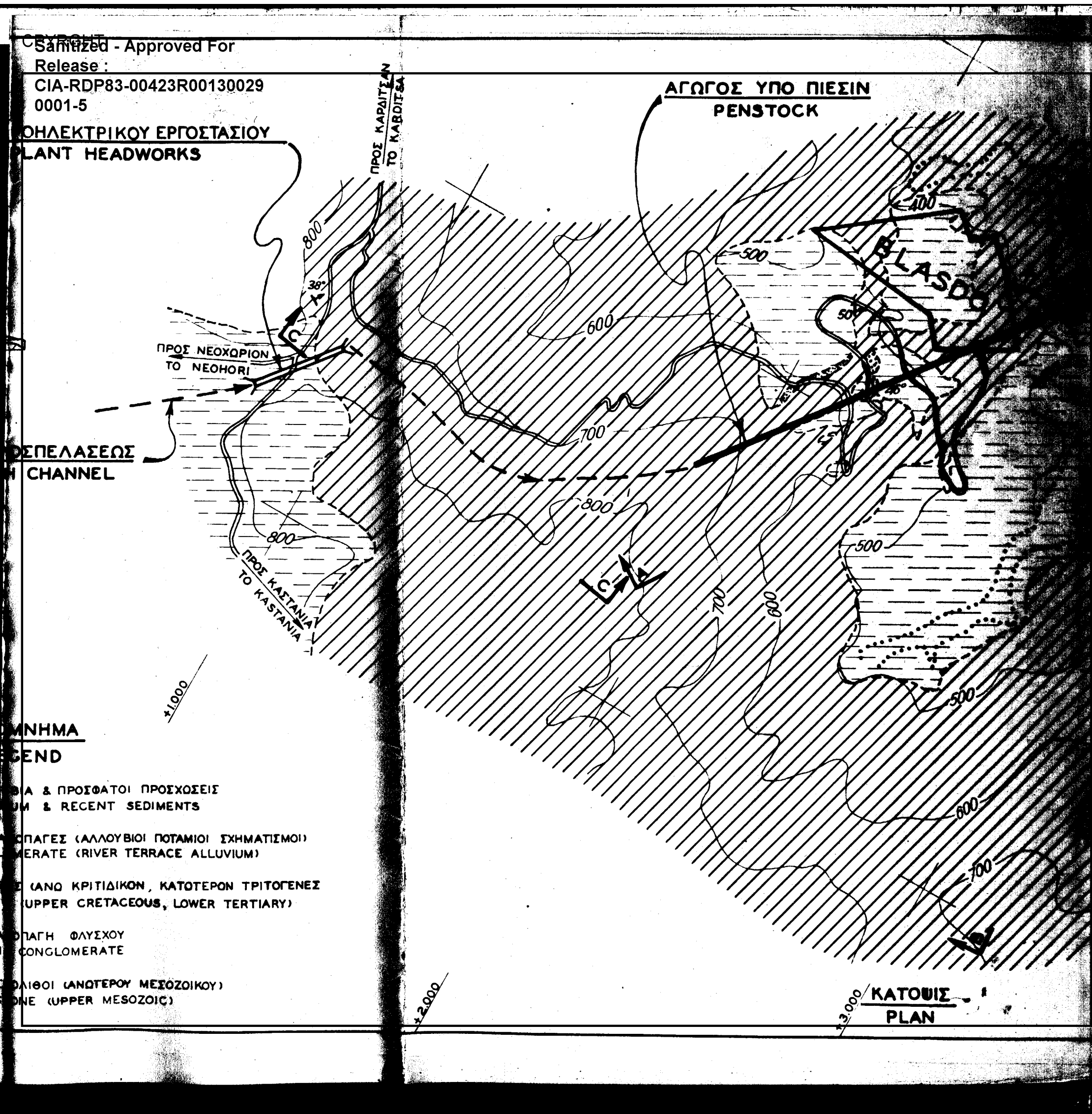


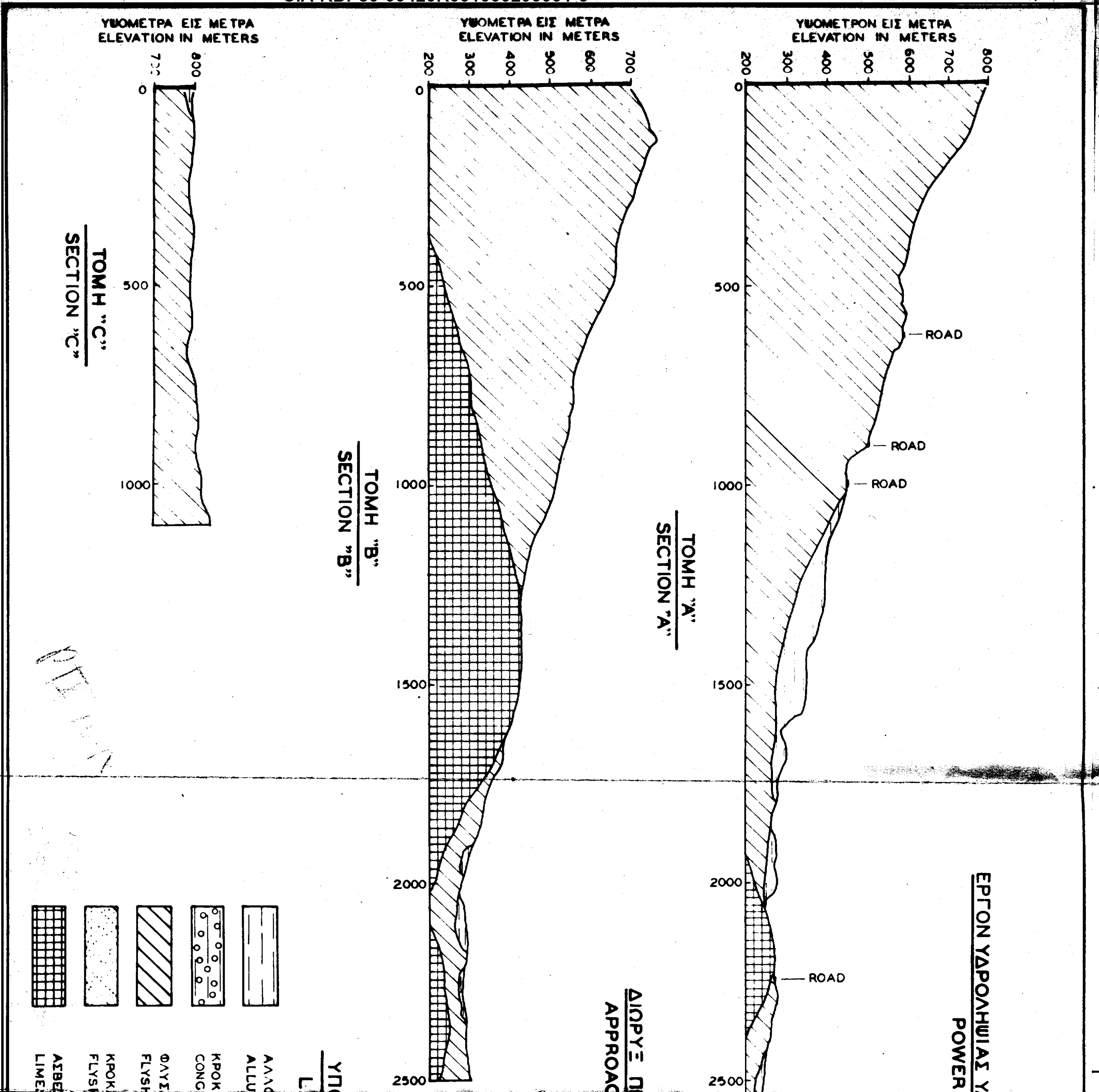
ΚΑΤΟΨΙΣ ΜΕΤΑ ΘΕΣΕΩΝ ΓΕΩΤΡΗΣΕΩΝ
BORING LOCATION PLAN

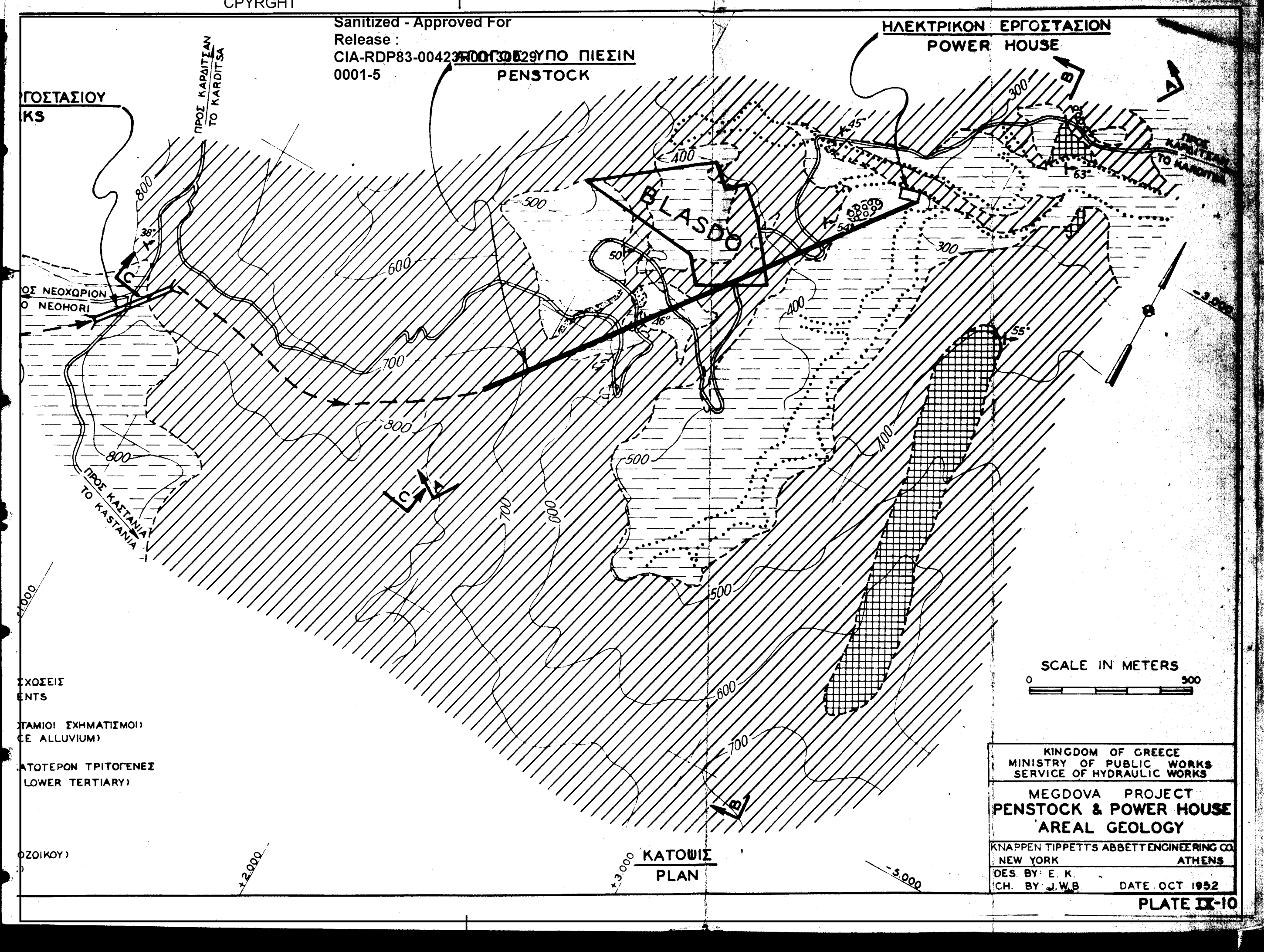
SCALE IN METERS
200 100 0 100 200 400 600

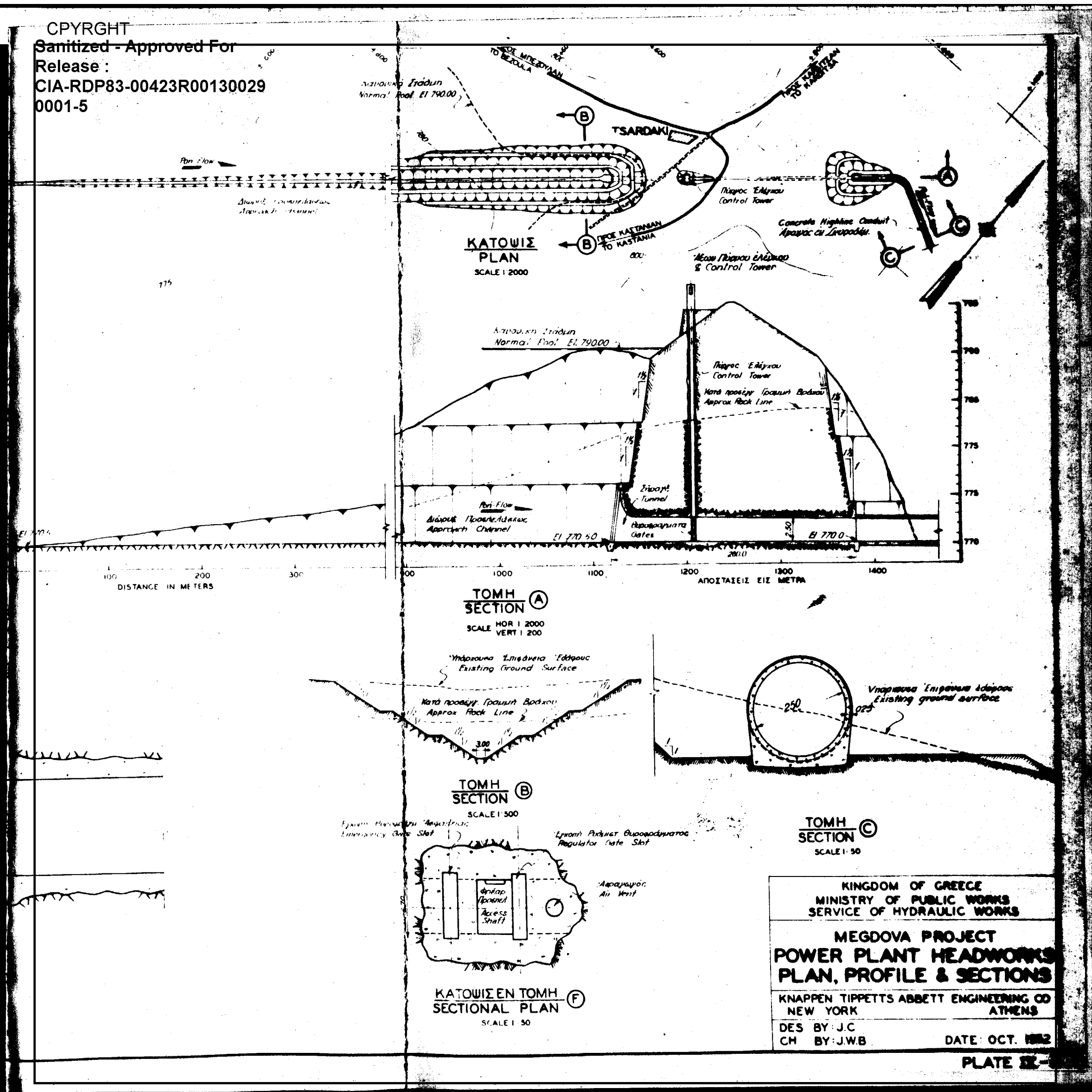


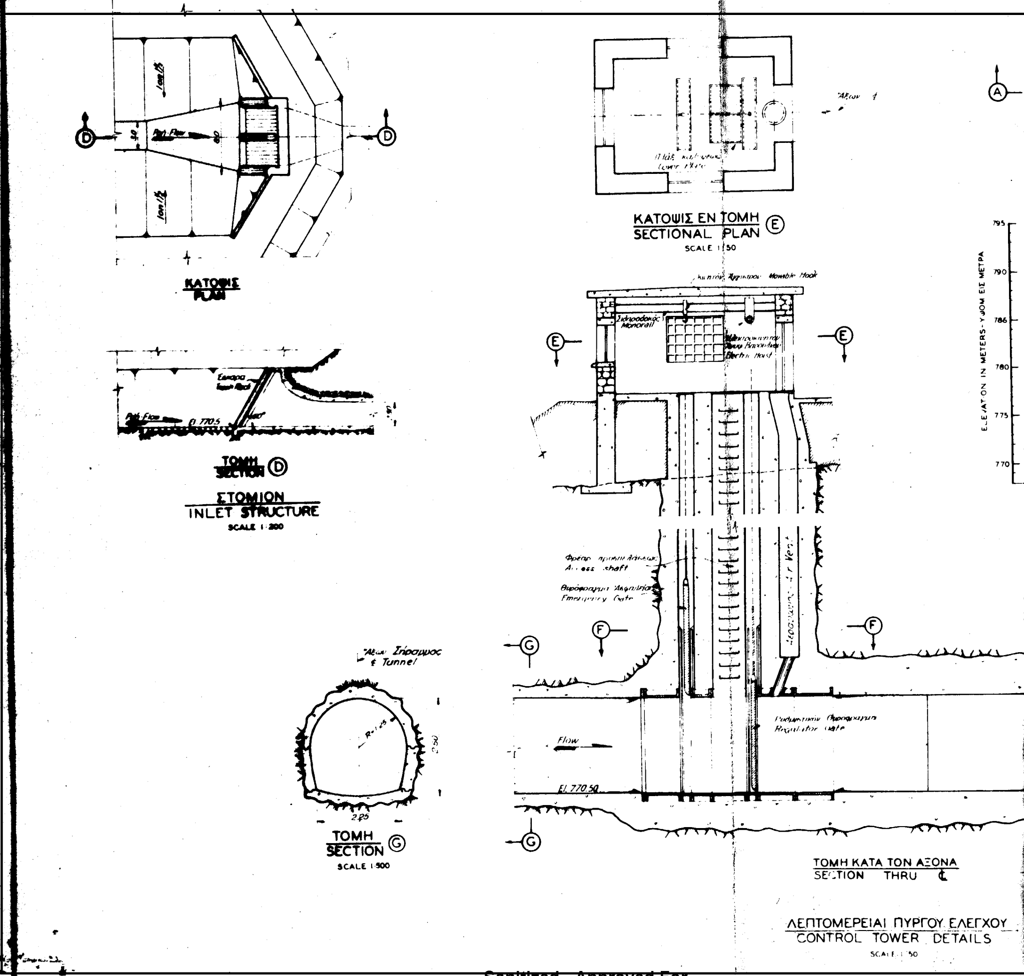
ΓΕΩΛΟΓΙΚΗ ΤΟΜΗ
GEOLOGIC SECTION (A)

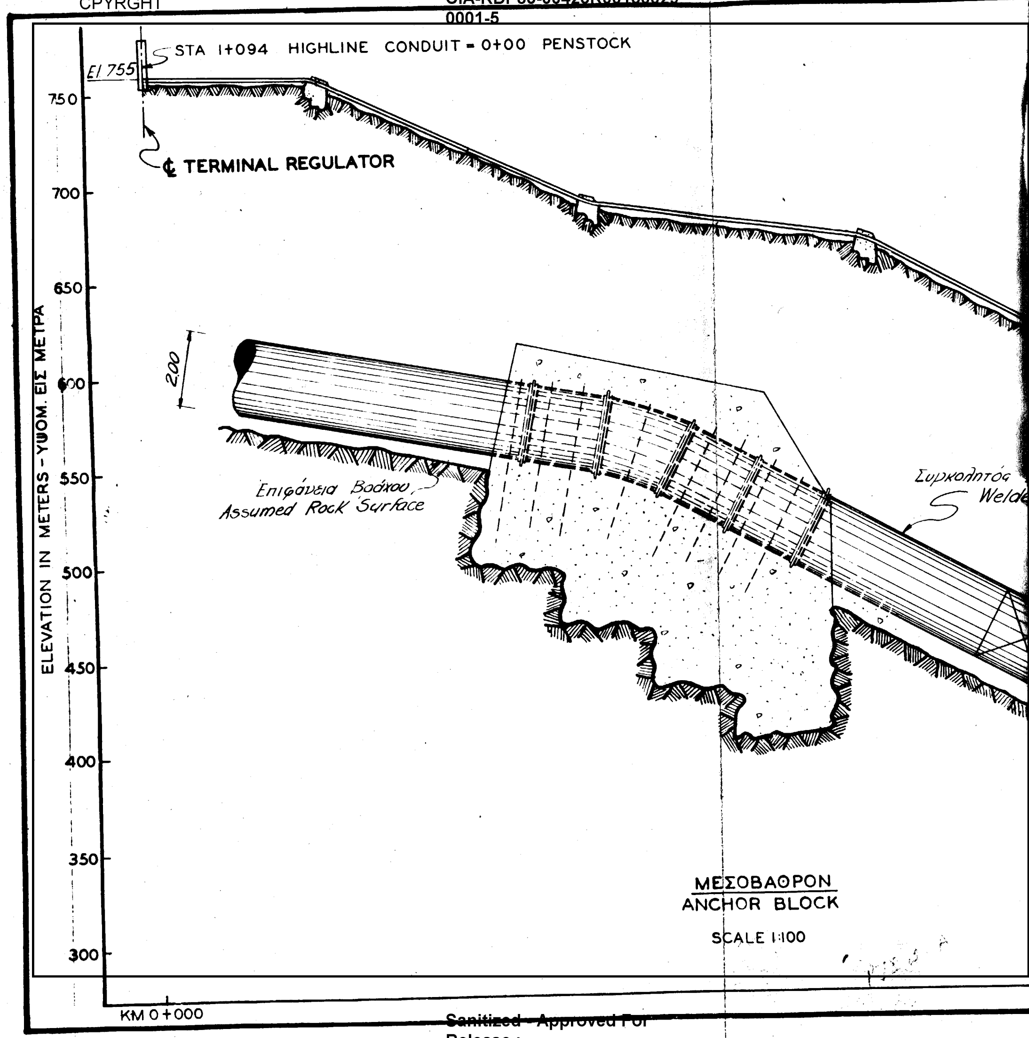

ΑΓΩΓΟΣ ΥΠΟ ΠΙΕΣΙΝ
PENSTOCK
ΟΗΛΕΚΤΡΙΚΟΥ ΕΡΓΟΣΤΑΣΙΟΥ
LANT HEADWORKS
ΠΡΟΣ ΚΑΡΔΙΤΣΑΝ
TO KARDITSA
ΠΡΟΣ ΝΕΟΧΩΡΙΟΝ
TO NEOHORI
ΣΠΕΛΑΣΕΩΣ
CHANNEL
ΠΡΟΣ ΚΑΣΤΑΝΙΑ
TO KASTANIA
800
700
600
500
400
+1,000
+2,000
+3,000
ΜΝΗΜΑ
END
Α & ΠΡΟΣΦΑΤΟΙ ΠΡΟΣΧΩΣΕΙΣ
M & RECENT SEDIMENTS
ΠΑΓΕΣ (ΑΛΛΟΥΒΙΟΙ ΠΟΤΑΜΙΟΙ ΣΧΗΜΑΤΙΣΜΟΙ)
ERATE (RIVER TERRACE ALLUVIUM)
(ΑΝΩ ΚΡΙΤΙΔΙΚΟΝ, ΚΑΤΩΤΕΡΟΝ ΤΡΙΤΟΓΕΝΕΣ
(UPPER CRETACEOUS, LOWER TERTIARY)
ΠΑΓΗ ΦΛΥΣΧΟΥ
CONGLOMERATE
ΛΙΘΟΙ (ΑΝΩΤΕΡΟΥ ΜΕΣΟΖΟΙΚΟΥ)
NE (UPPER MESOZOIC)
ΚΑΤΟΨΙΣ
PLAN

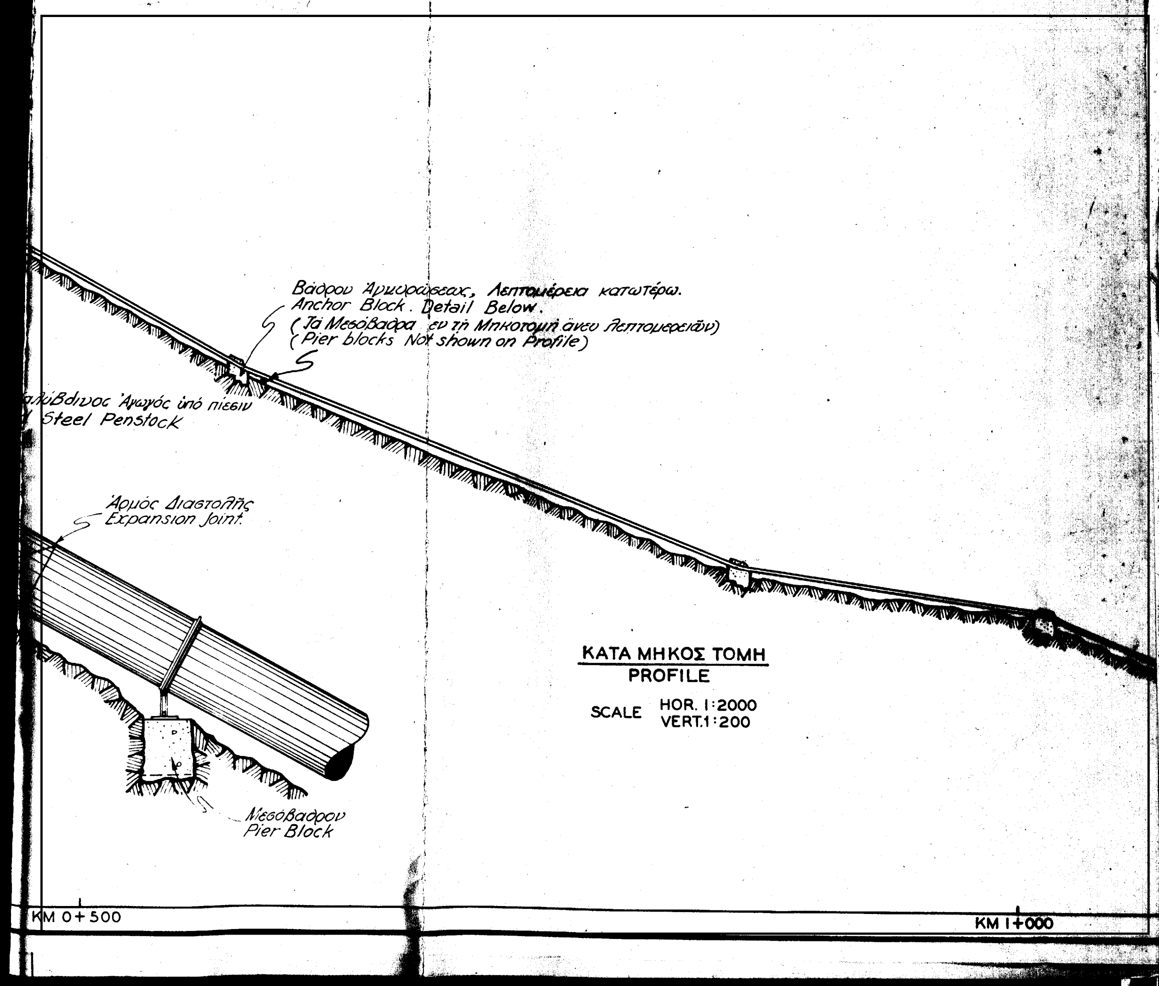

ΥΨΟΜΕΤΡΑ ΕΙΣ ΜΕΤΡΑ
ELEVATION IN METERS
ΤΟΜΗ "C"
SECTION "C"
ΥΨΟΜΕΤΡΑ ΕΙΣ ΜΕΤΡΑ
ELEVATION IN METERS
ΤΟΜΗ "B"
SECTION "B"
ΥΨΟΜΕΤΡΟΝ ΕΙΣ ΜΕΤΡΑ
ELEVATION IN METERS
ΤΟΜΗ "A"
SECTION "A"
ROAD
ROAD
ROAD
ROAD
POWER


ΗΛΕΚΤΡΙΚΟΝ ΕΡΓΟΣΤΑΣΙΟΝ
POWER HOUSE
ΥΠΟ ΠΙΕΣΙΝ
PENSTOCK
ΡΓΟΣΤΑΣΙΟΥ
KS
ΠΡΟΣ ΚΑΡΔΙΤΣΑΝ
ΤΟ KARDITSA
ΟΣ ΝΕΟΧΩΡΙΟΝ
Ο NEOHORI
ΠΡΟΣ ΚΑΣΤΑΝΙΑ
ΤΟ KASTANIA
BLASDO
SCALE IN METERS
0
500
ΧΩΣΕΙΣ
ENTS
ΤΑΜΙΟΙ ΣΧΗΜΑΤΙΣΜΟΙ
CE ALLUVIUM)
ΑΤΩΤΕΡΟΝ ΤΡΙΤΟΓΕΝΕΣ
LOWER TERTIARY)
ΟΖΟΙΚΟΥ)
ΚΑΤΟΨΙΣ
PLAN
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
PENSTOCK & POWER HOUSE
AREAL GEOLOGY
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
ATHENS
DES. BY: E. K.
CH. BY: J.W.B.
DATE OCT 1952
PLATE IX-10


TSARDAKI
Pen Flow
Πύργος Ελέγχου
Control Tower
Concrete Highline Conduit
ΚΑΤΟΨΙΣ
PLAN
SCALE 1:2000
Normal Pool El 790.00
Πύργος Ελέγχου
Control Tower
Approx Rock Line
Tunnel
Pen Flow
Approach Channel
Gates
El 770.50
El 770.0
DISTANCE IN METERS
ΑΠΟΣΤΑΣΕΙΣ ΕΙΣ ΜΕΤΡΑ
ΤΟΜΗ
SECTION Ⓐ
SCALE HOR 1:2000 VERT 1:200
Existing Ground Surface
Κατά προσέγγ. Γραμμή Βράχου
Approx Rock Line
ΤΟΜΗ
SECTION Ⓑ
SCALE 1:500
Existing ground surface
ΤΟΜΗ
SECTION Ⓒ
SCALE 1:50
Regulator Gate Slot
Air Vent
Access Shaft
ΚΑΤΟΨΙΣ ΕΝ ΤΟΜΗ
SECTIONAL PLAN Ⓕ
SCALE 1:50
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
POWER PLANT HEADWORKS
PLAN, PROFILE & SECTIONS
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK
ATHENS
DES BY J.C
CH BY J.W.B
DATE OCT. 1952
PLATE

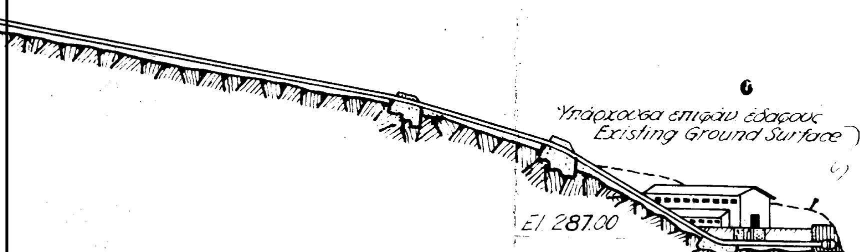

ΚΑΤΟΨΙΣ
PLAN
ΤΟΜΗ
SECTION D
ΣΤΟΜΙΟΝ
INLET STRUCTURE
SCALE 1:200
ΚΑΤΟΨΙΣ ΕΝ ΤΟΜΗ
SECTIONAL PLAN E
SCALE 1:50
Monorail
Access shaft
Emergency Gate
Regulator Gate
Flow
El. 770.50
Tunnel
2.85
ΤΟΜΗ
SECTION G
SCALE 1:500
795
790
786
780
775
770
ELEVATION IN METERS - ΥΨΟΜ ΕΙΣ ΜΕΤΡΑ
ΤΟΜΗ ΚΑΤΑ ΤΟΝ ΑΞΟΝΑ
SECTION THRU ℄
ΛΕΠΤΟΜΕΡΕΙΑΙ ΠΥΡΓΟΥ ΕΛΕΓΧΟΥ
CONTROL TOWER DETAILS
SCALE 1:50


STA 1+094 HIGHLINE CONDUIT = 0+00 PENSTOCK
El 755
℄ TERMINAL REGULATOR
ELEVATION IN METERS - ΥΨΟΜ. ΕΙΣ ΜΕΤΡΑ
750
700
650
600
550
500
450
400
350
300
2.00
Επιφάνεια Βράχου,
Assumed Rock Surface
ΜΕΣΟΒΑΘΡΟΝ
ANCHOR BLOCK
SCALE 1:100
KM 0+000



ΚΑΤΑ ΜΗΚΟΣ ΤΟΜΗ
PROFILE

SCALE HOR. 1:2000
VERT. 1:200



KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT

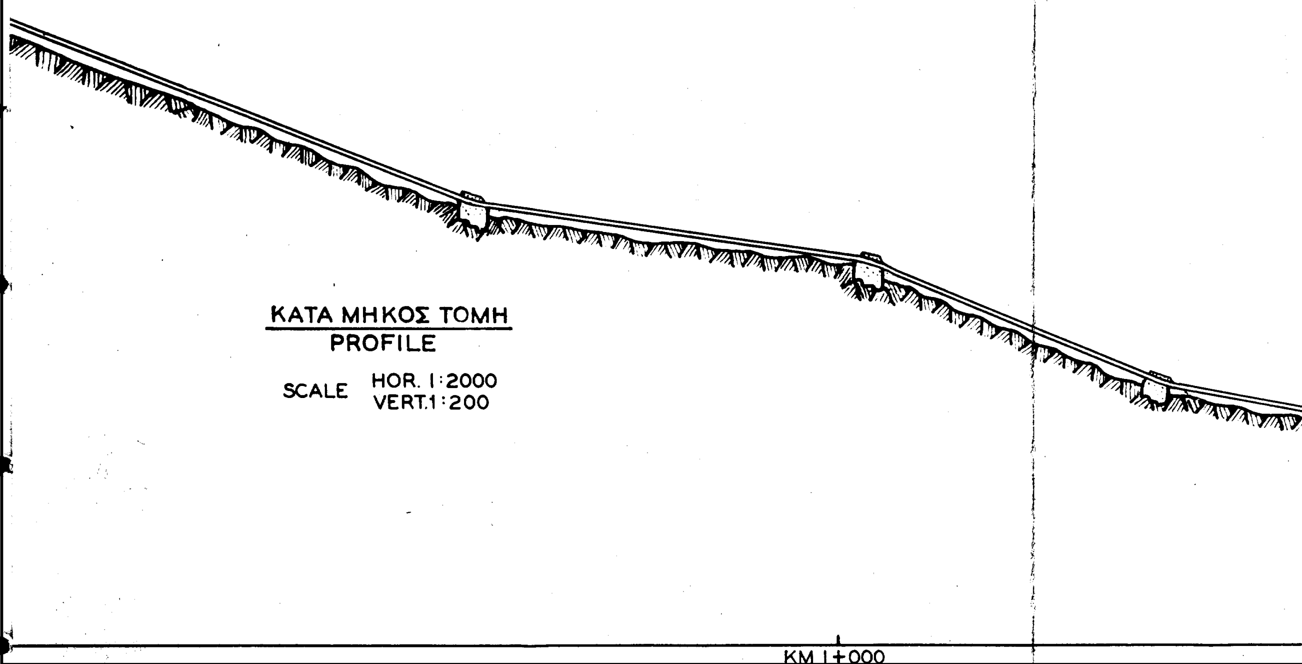
PENSTOCK PROFILE & DETAILS

KNAPPEN TIPPETTS ABBETT ENGINERRING CO
NEW YORK ATHENS

DES BY: M. T.
CH. BY: J.W.B. DATE: OCT. 1952

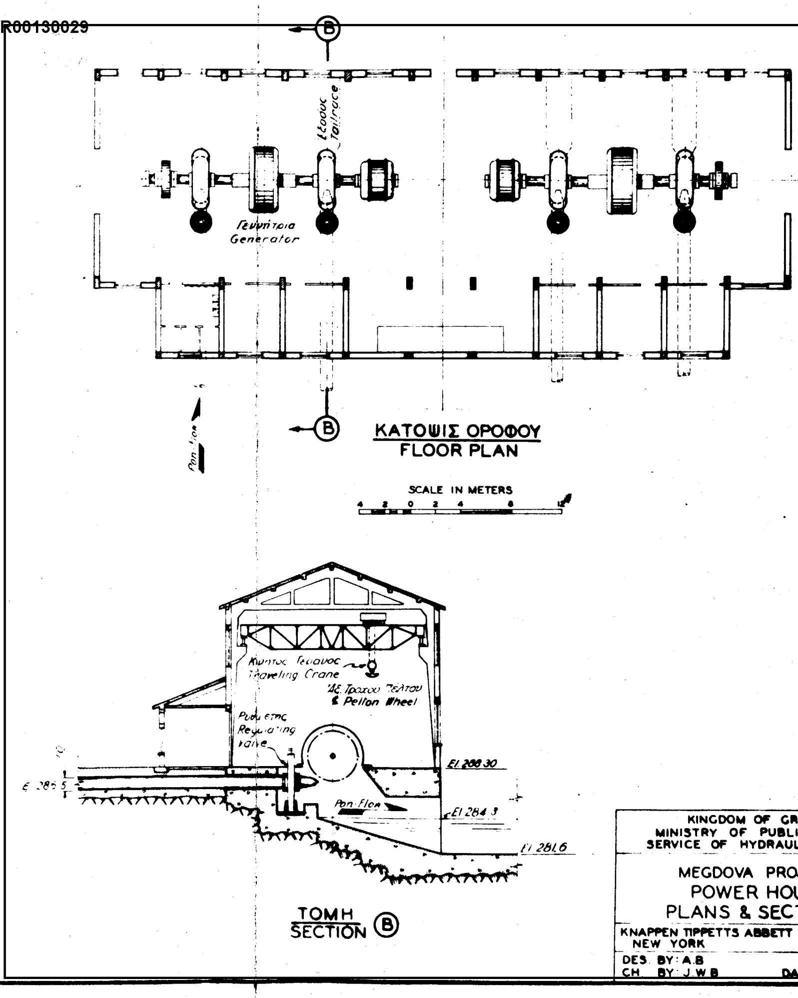
PLATE IX-12 6

...ωρώσεως, Λεπτομέρεια κατωτέρω.
...ck. Detail Below.
...ρα εν τη Μηκοτομή άνευ λεπτομερειών)
...s Not shown on Profile)



KATA ΜΗΚΟΣ ΤΟΜΗ
PROFILE

SCALE HOR. 1:2000 VERT. 1:200

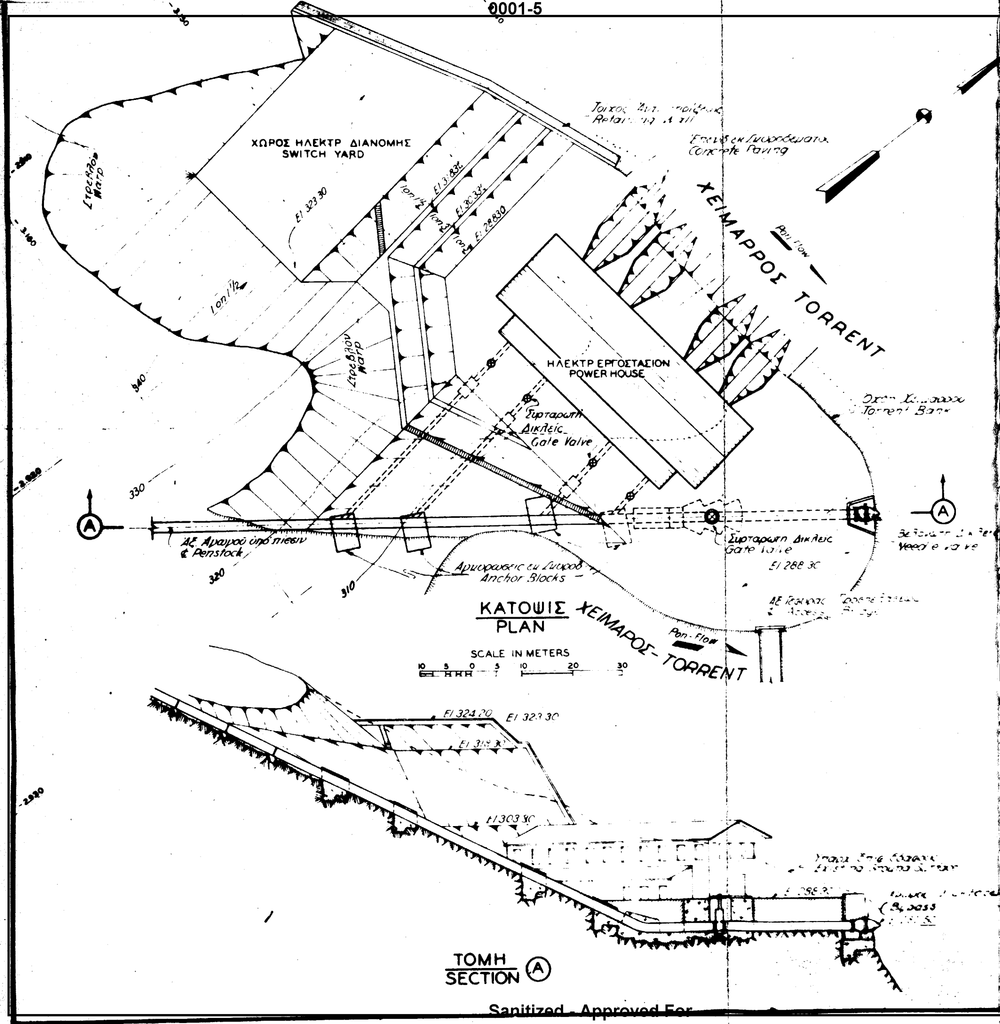


KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT
POWER HOUSE
PLANS & SECTIONS

KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS

DES. BY: A.B
CH. BY: J.W.B DATE: OCT. 1952

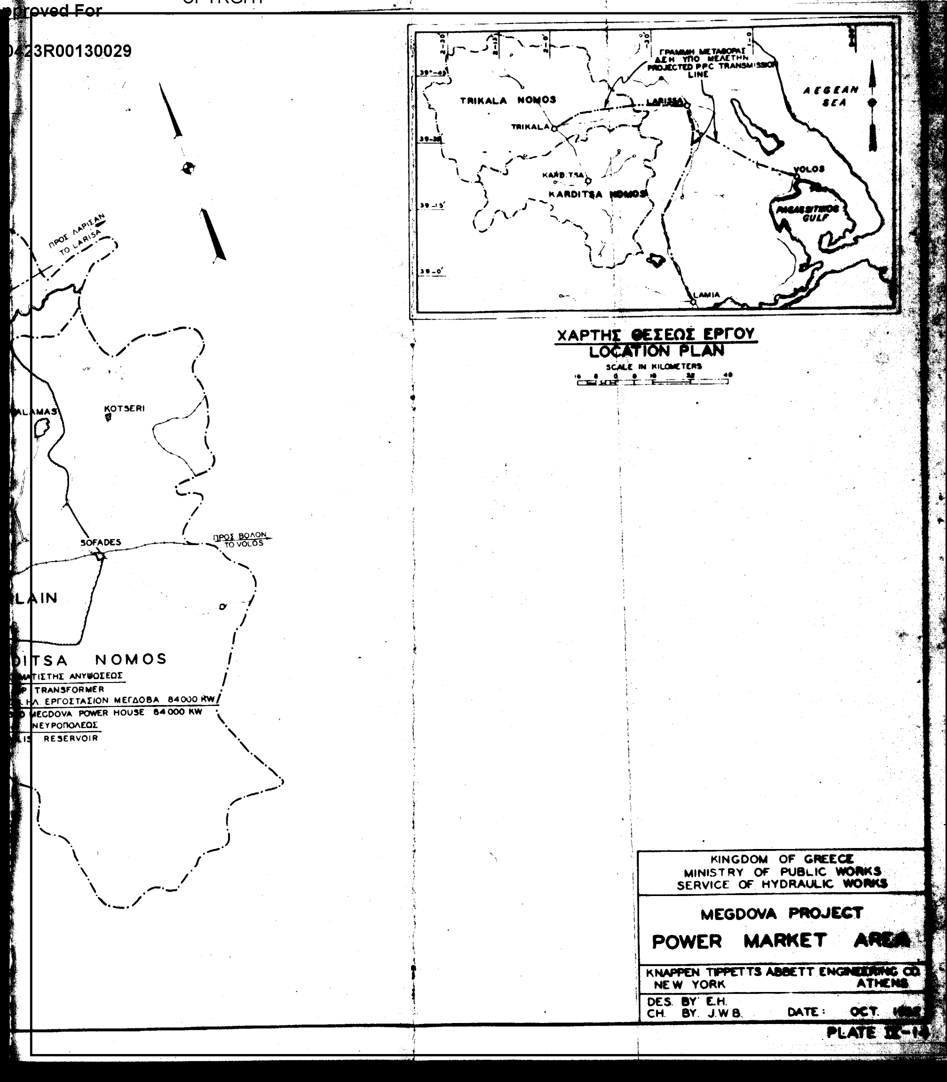


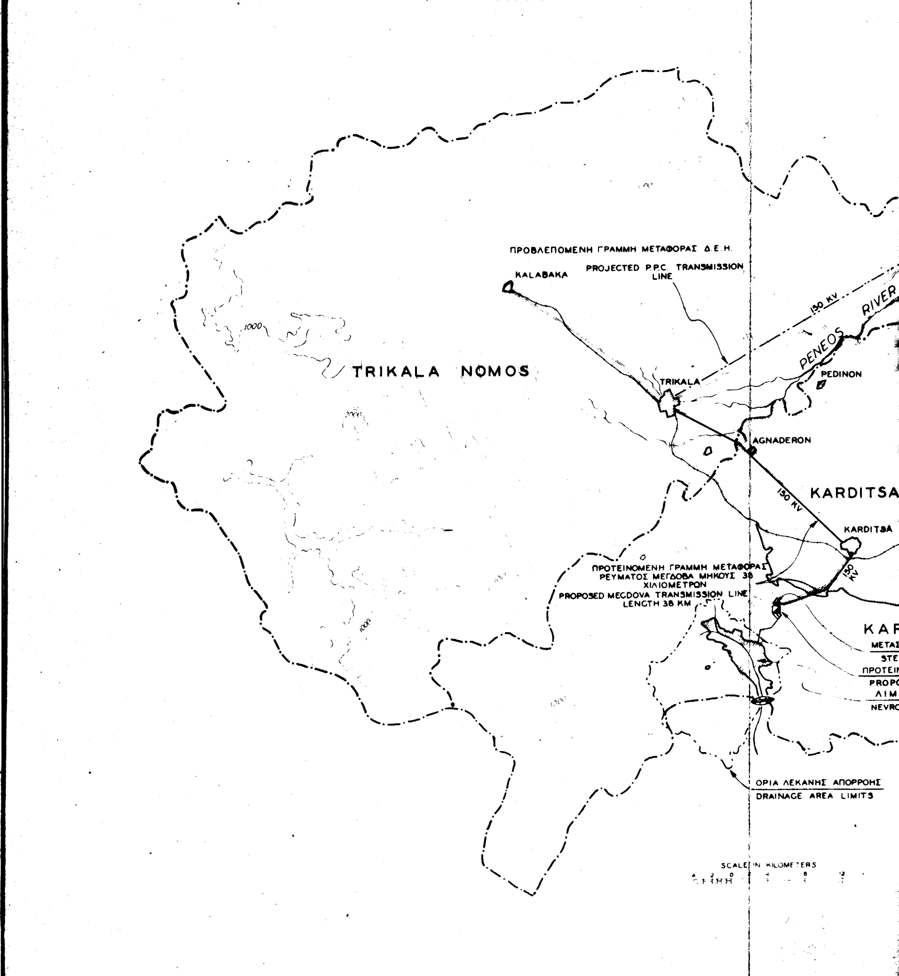
ΚΑΤΟΨΙΣ
PLAN

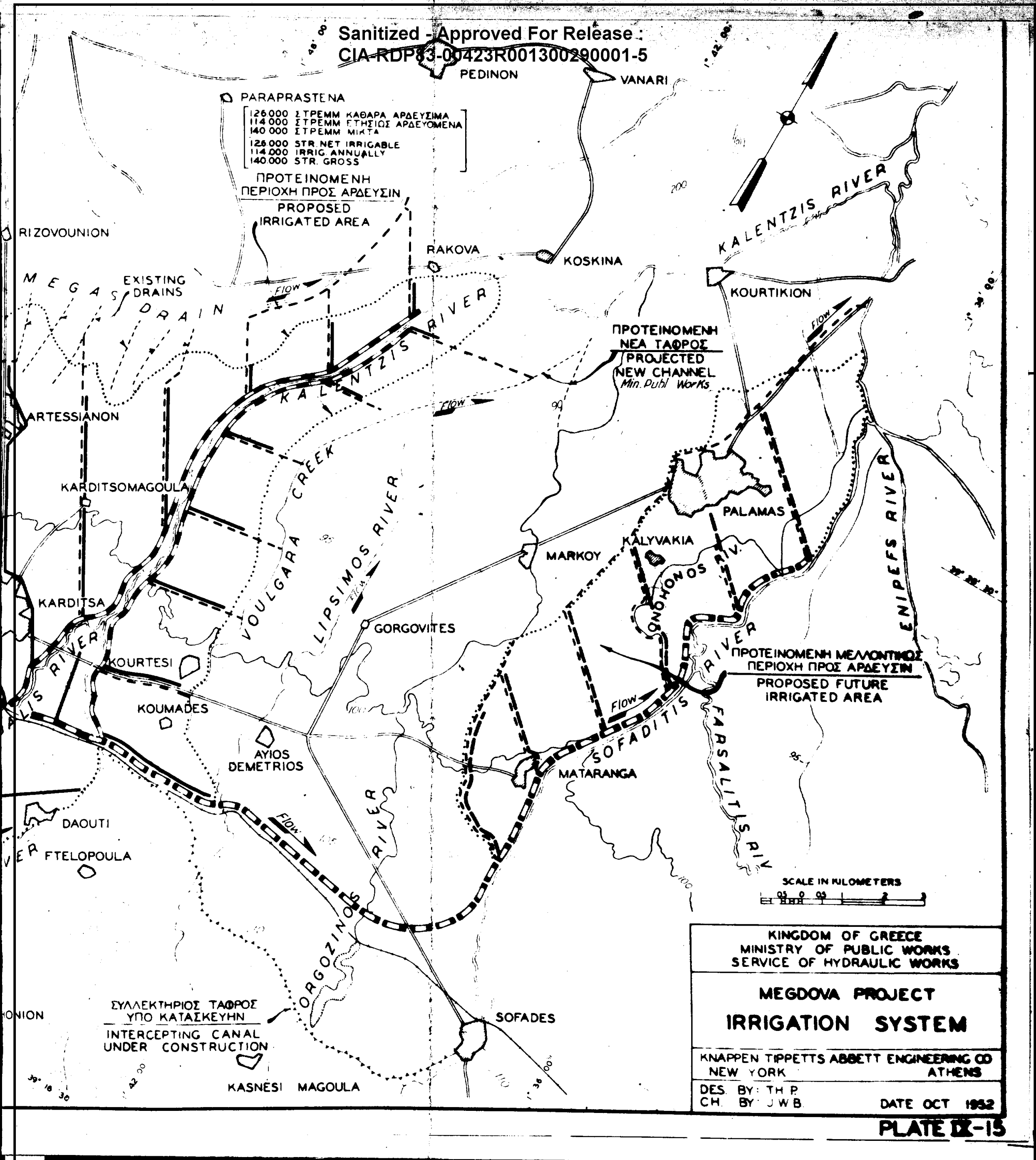
SCALE IN METERS

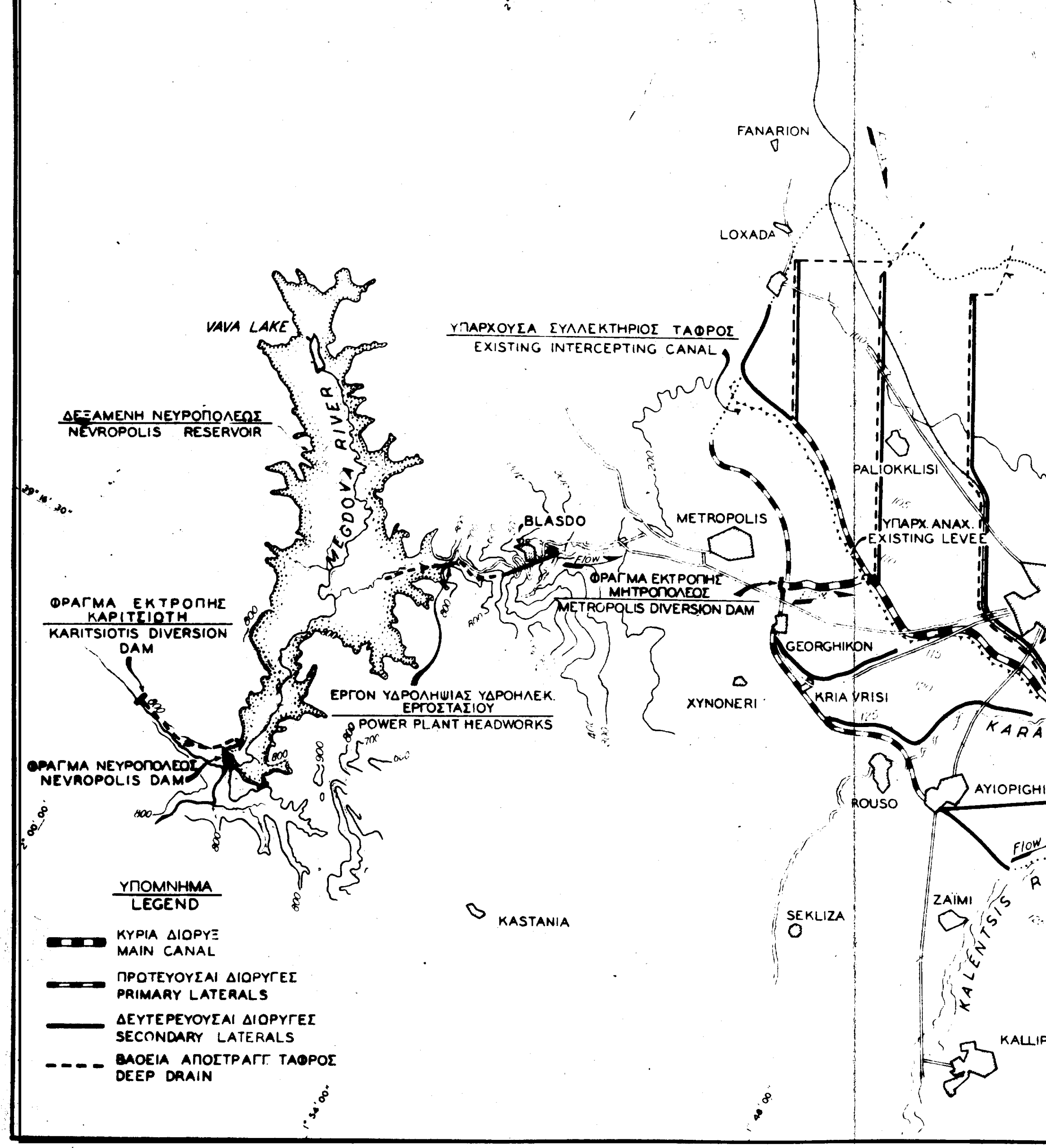
ΤΟΜΗ
SECTION (A)

[redacted]

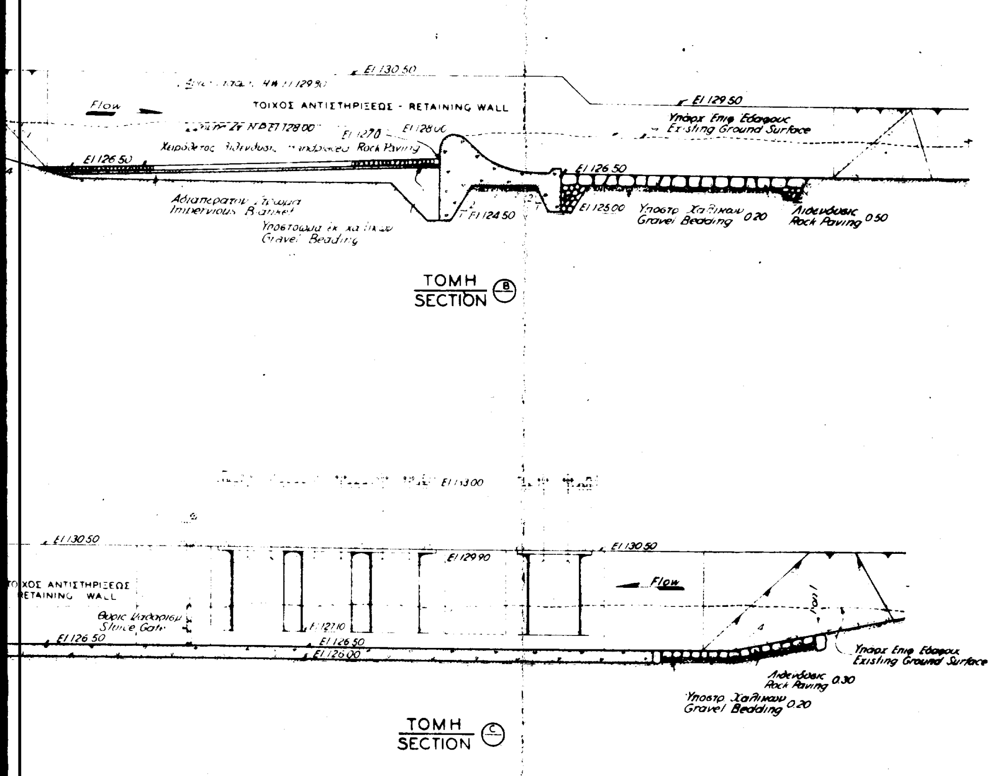

ΠΡΟΣ ΛΑΡΙΣΑΝ
TO LARISA
KOTSERI
SOFADES
ΠΡΟΣ ΒΟΛΟΝ
TO VOLOS
NOMOS
TRANSFORMER
ΕΡΓΟΣΤΑΣΙΟΝ ΜΕΓΔΟΒΑ 84000 KW
MEGDOVA POWER HOUSE 84000 KW
RESERVOIR
TRIKALA NOMOS
TRIKALA
LARISSA
KARDITSA
KARDITSA NOMOS
ΓΡΑΜΜΗ ΜΕΤΑΦΟΡΑΣ ΔΕΗ ΥΠΟ ΜΕΛΕΤΗΝ
PROJECTED PPC TRANSMISSION LINE
AEGEAN SEA
VOLOS
PAGASITIKOS GULF
LAMIA
ΧΑΡΤΗΣ ΘΕΣΕΩΣ ΕΡΓΟΥ
LOCATION PLAN
SCALE IN KILOMETERS
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
POWER MARKET AREA
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
ATHENS
DES. BY E.H.
CH. BY J.W.B.
DATE: OCT.
PLATE

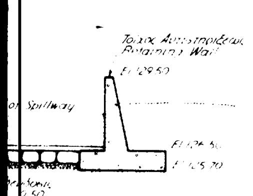

ΠΡΟΒΛΕΠΟΜΕΝΗ ΓΡΑΜΜΗ ΜΕΤΑΦΟΡΑΣ Δ.Ε.Η.
PROJECTED P.P.C. TRANSMISSION LINE
KALABAKA
TRIKALA NOMOS
150 KV
PENEOS RIVER
TRIKALA
PEDINON
AGNADERON
KARDITSA
150 KV
KARDITSA
ΠΡΟΤΕΙΝΟΜΕΝΗ ΓΡΑΜΜΗ ΜΕΤΑΦΟΡΑΣ
ΡΕΥΜΑΤΟΣ ΜΕΓΔΟΒΑ ΜΗΚΟΥΣ 38
ΧΙΛΙΟΜΕΤΡΩΝ
PROPOSED MEGDOVA TRANSMISSION LINE
LENGTH 38 KM
1000
ΟΡΙΑ ΛΕΚΑΝΗΣ ΑΠΟΡΡΟΗΣ
DRAINAGE AREA LIMITS
SCALE IN KILOMETERS


PEDINON
VANARI
PARAPRASTENA
126.000 ΣΤΡΕΜΜ ΚΑΘΑΡΑ ΑΡΔΕΥΣΙΜΑ
114.000 ΣΤΡΕΜΜ ΕΤΗΣΙΩΣ ΑΡΔΕΥΟΜΕΝΑ
140.000 ΣΤΡΕΜΜ ΜΙΚΤΑ
126.000 STR. NET IRRIGABLE
114.000 IRRIG. ANNUALLY
140.000 STR. GROSS
ΠΡΟΤΕΙΝΟΜΕΝΗ
ΠΕΡΙΟΧΗ ΠΡΟΣ ΑΡΔΕΥΣΙΝ
PROPOSED
IRRIGATED AREA
KALENTZIS RIVER
RIZOVOUNION
RAKOVA
KOSKINA
KOURTIKION
MEGAS DRAIN
EXISTING DRAINS
Flow
ΠΡΟΤΕΙΝΟΜΕΝΗ
ΝΕΑ ΤΑΦΡΟΣ
PROJECTED
NEW CHANNEL
Min. Publ. Works.
KALENTZIS RIVER
ARTESSIANON
KARDITSOMAGOULA
VOULGARA CREEK
LIPSIMOS RIVER
PALAMAS
KALYVAKIA
MARKOY
ONOHONOS RIV.
ENIPEFS RIVER
KARDITSA
GORGOVITES
KOURTESI
ΠΡΟΤΕΙΝΟΜΕΝΗ ΜΕΛΛΟΝΤΙΚΩΣ
ΠΕΡΙΟΧΗ ΠΡΟΣ ΑΡΔΕΥΣΙΝ
PROPOSED FUTURE
IRRIGATED AREA
KOUMADES
AYIOS
DEMETRIOS
SOFADITIS RIVER
FARSALITIS RIV.
MATARANGA
DAOUTI
FTELOPOULA
ORGOZINOS RIVER
SCALE IN KILOMETERS
ΣΥΛΛΕΚΤΗΡΙΟΣ ΤΑΦΡΟΣ
ΥΠΟ ΚΑΤΑΣΚΕΥΗΝ
INTERCEPTING CANAL
UNDER CONSTRUCTION
SOFADES
KASNESI MAGOULA
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS
MEGDOVA PROJECT
IRRIGATION SYSTEM
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS
DES. BY: TH. P.
CH. BY: J.W.B.
DATE OCT 1952
PLATE IX-15


FANARION
LOXADA
VAVA LAKE
ΥΠΑΡΧΟΥΣΑ ΣΥΛΛΕΚΤΗΡΙΟΣ ΤΑΦΡΟΣ
EXISTING INTERCEPTING CANAL
ΔΕΞΑΜΕΝΗ ΝΕΥΡΟΠΟΛΕΩΣ
NEVROPOLIS RESERVOIR
MEGDOVA RIVER
PALIOKKLISI
BLASDO
METROPOLIS
ΥΠΑΡΧ. ΑΝΑΧ.
EXISTING LEVEE
FLOW
ΦΡΑΓΜΑ ΕΚΤΡΟΠΗΣ ΜΗΤΡΟΠΟΛΕΩΣ
METROPOLIS DIVERSION DAM
ΦΡΑΓΜΑ ΕΚΤΡΟΠΗΣ ΚΑΡΙΤΣΙΩΤΗ
KARITSIOTIS DIVERSION DAM
GEORGHIKON
ΕΡΓΟΝ ΥΔΡΟΛΗΨΙΑΣ ΥΔΡΟΗΛΕΚ. ΕΡΓΟΣΤΑΣΙΟΥ
POWER PLANT HEADWORKS
XYNONERI
KRIA VRISI
ΦΡΑΓΜΑ ΝΕΥΡΟΠΟΛΕΩΣ
NEVROPOLIS DAM
ROUSO
AYIOPIGHI
FLOW
ΥΠΟΜΝΗΜΑ
LEGEND
KASTANIA
SEKLIZA
ZAIMI
KALENTSIS
ΚΥΡΙΑ ΔΙΟΡΥΞ
MAIN CANAL
ΠΡΩΤΕΥΟΥΣΑΙ ΔΙΟΡΥΓΕΣ
PRIMARY LATERALS
ΔΕΥΤΕΡΕΥΟΥΣΑΙ ΔΙΟΡΥΓΕΣ
SECONDARY LATERALS
ΒΑΘΕΙΑ ΑΠΟΣΤΡΑΓΓ. ΤΑΦΡΟΣ
DEEP DRAIN

CPYRGHT





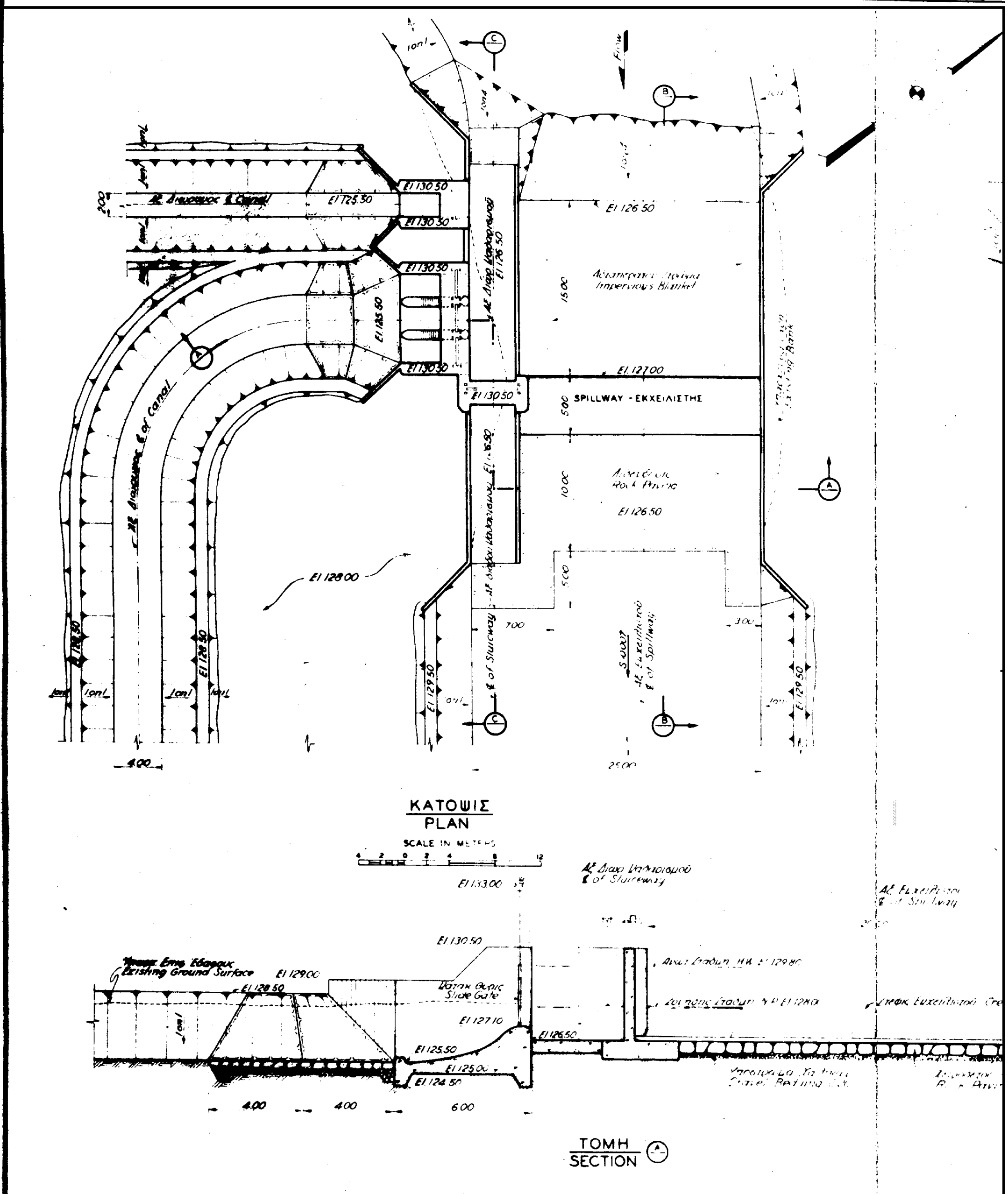
KINGDOM OF GREECE
MINISTRY OF PUBLIC WORKS
SERVICE OF HYDRAULIC WORKS

MEGDOVA PROJECT
METROPOLIS DIVERSION DAM
PLAN & SECTIONS

KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS

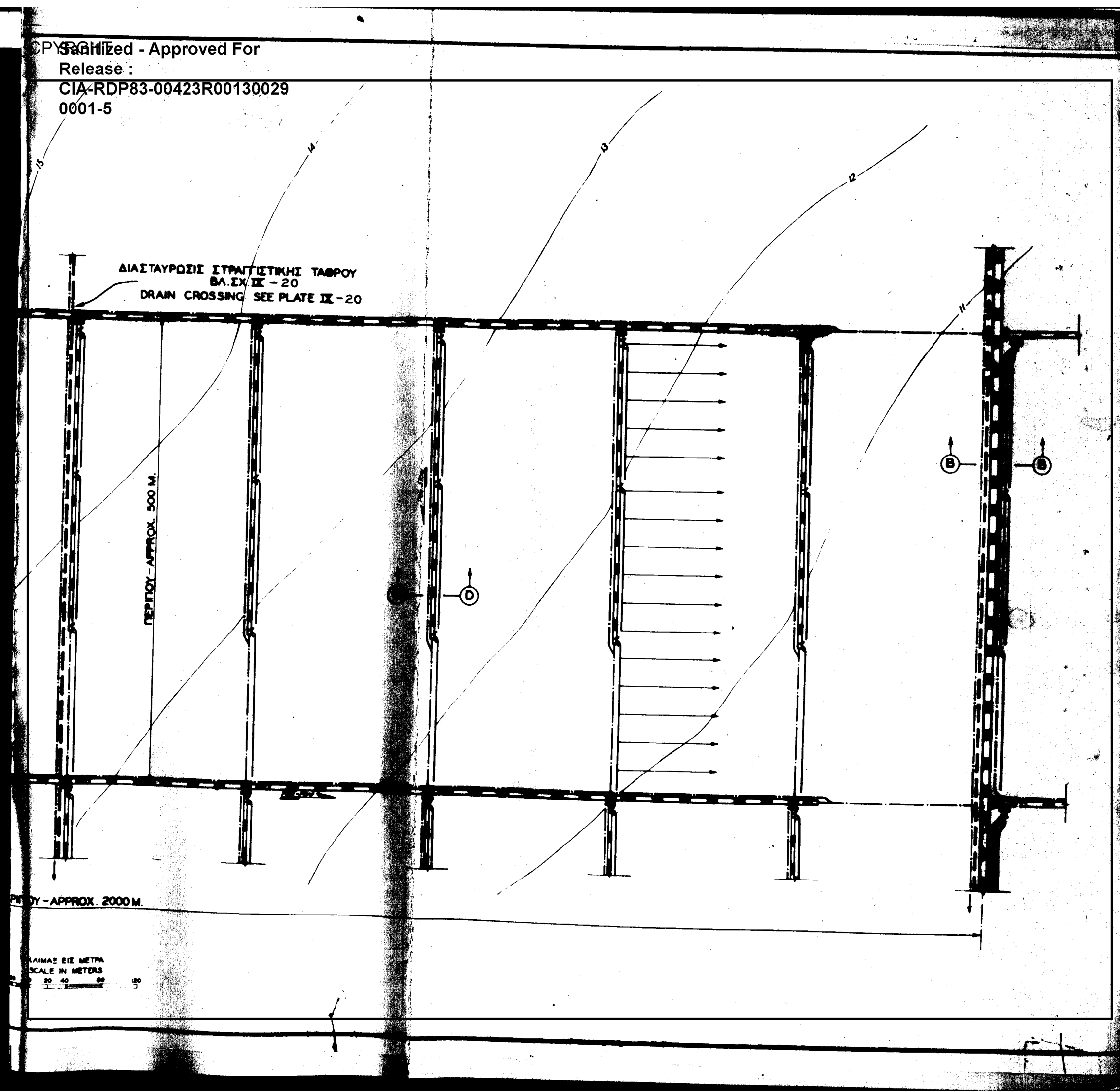
DES. BY P.C.
CH. BY J.W.B.
DATE: OCT. 1952

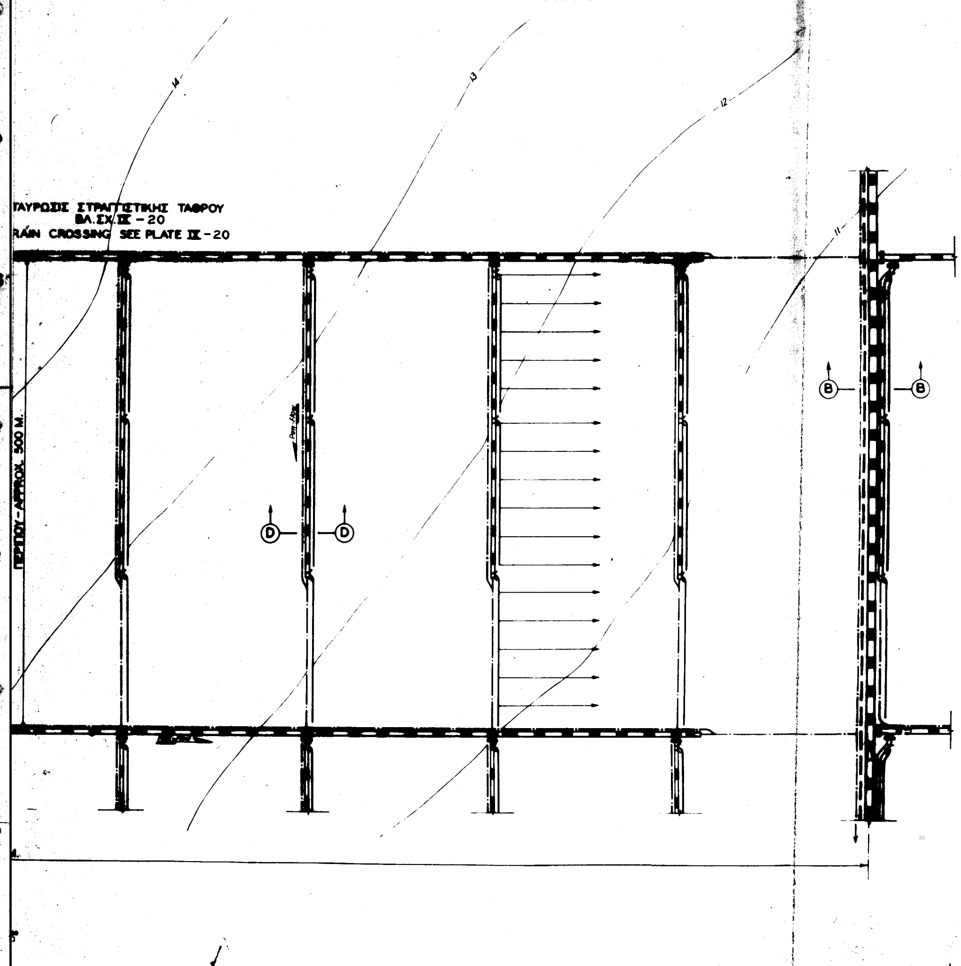
PLATE [illegible]



Flow
El 130.50
El 125.50
El 126.50
Αδιαπέρατος Τάπητας
Impervious Blanket
15.00
El 127.00
SPILLWAY - ΕΚΧΕΙΛΙΣΤΗΣ
5.00
10.00
Rock Paving
El 126.50
El 128.00
El 129.50
El 128.50
of Sluiceway
of Spillway
of Canal
4.00
7.00
3.00
25.00
2.00
ΚΑΤΟΨΙΣ
PLAN
SCALE IN METERS
of Sluiceway
El 133.00
El 130.50
Existing Ground Surface
El 129.00
El 128.50
Slide Gate
El 127.10
El 126.50
El 125.50
El 125.00
El 124.50
4.00
4.00
6.00
ΤΟΜΗ
SECTION

[redacted]


15
14
13
12
11
ΔΙΑΣΤΑΥΡΩΣΙΣ ΣΤΡΑΓΓΙΣΤΙΚΗΣ ΤΑΦΡΟΥ
ΒΛ.ΣΧ. IX - 20
DRAIN CROSSING SEE PLATE IX - 20
ΠΕΡΙΠΟΥ - APPROX. 500 M.
D
B
B
ΠΟΥ - APPROX. 2000 M.
ΚΛΙΜΑΞ ΕΙΣ ΜΕΤΡΑ
SCALE IN METERS



ΥΠΟΜΝΗΜΑ
LEGEND

ΚΥΡΙΑ ΔΙΩΡΥΞ
MAIN CANAL

ΠΡΩΤΕΥΟΥΣΑ ΔΙΩΡΥΞ
PRIMARY LATERAL

ΔΕΥΤΕΡΕΥΟΥΣΑ ΔΙΩΡΥΞ
SECONDARY LATERAL

ΤΡΙΤΕΥΟΥΣΑ ΔΙΩΡΥΞ
TERTIARY LATERAL

ΑΡΔΕΥΤΙΚΟΣ ΧΑΝΔΑΞ
FARM DITCH

ΣΤΡΑΓΓΙΣΤΙΚΗ ΤΑΦΡΟΣ
DEEP DRAIN

ΤΑΦΡΟΣ ΑΠΟΧΕΤΕΥΣΕΩΣ ΕΠΙΦΑΝΕΙΑΚΩΝ ΥΔΑΤΩΝ
WASTE DITCH

ΜΕΤΡΗΤΗΣ
MODULE

ΑΥΤΟΜΑΤΟΣ ΡΥΘΜΙΣΤΗΣ
AUTOMATIC CHECK

ΑΓΡΟΤΙΚΗ ΠΑΡΟΧΕΤΕΥΣΙΣ
FARM TURNOUT

ΔΙΑΣΤΑΥΡΩΣΙΣ ΣΤΡΑΓΓΙΣΤΙΚΗΣ ΤΑΦΡΟΥ
DRAIN CROSSING

NOTE:

ΔΙΑ ΚΑΤΑ ΠΛΑΤΟΣ ΤΟΜΑΣ ΒΛ. ΣΧ. IX-18
FOR CROSS SECTIONS SEE PLATE IX-18

ΑΙ ΥΨΟΜΕΤΡΙΚΑΙ ΚΑΜΠΥΛΑΙ ΣΗΜΕΙΟΥΝΤΑΙ ΜΟΝΟΝ ΔΙΑ ΝΑ ΔΕΙΞΟΥΝ ΤΗΝ ΚΛΙΣΙΝ ΤΟΥ ΕΔΑΦΟΥΣ
CONTOURS ARE SHOWN ONLY TO INDICATE GROUND SLOPE

GREEK RECLAMATION COMMITTEE

LOWER ACHELOOS PLAINS

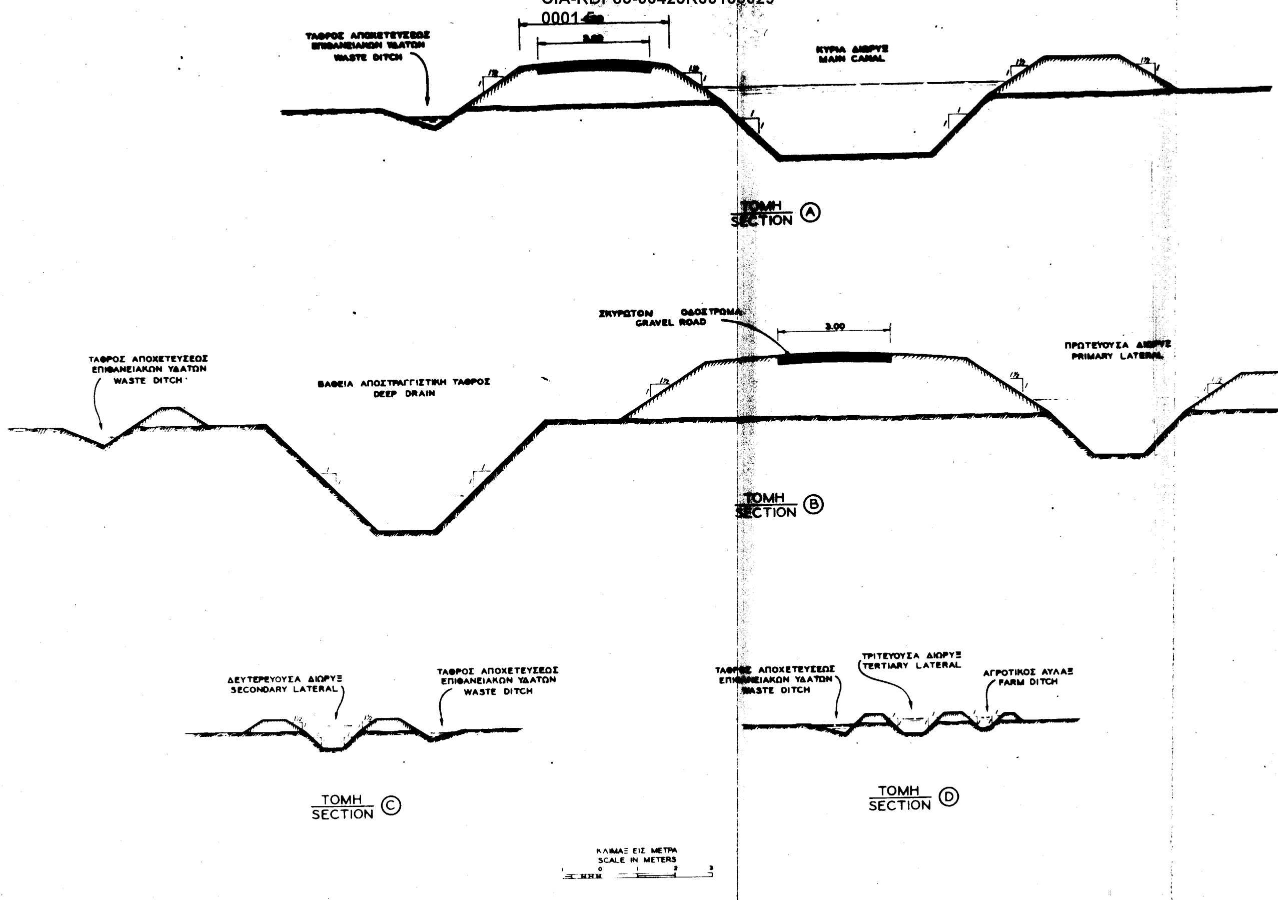
DISTRIBUTION SYSTEM

TYPICAL LAYOUT

KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS

DES. BY: P.Z.K.
CH. BY: J.B.B.
DATE: DEC. 1952

PLATE IX-17B



GREEK RECLAMATION COMMITTEE

LOWER ACHELOOS PLAINS

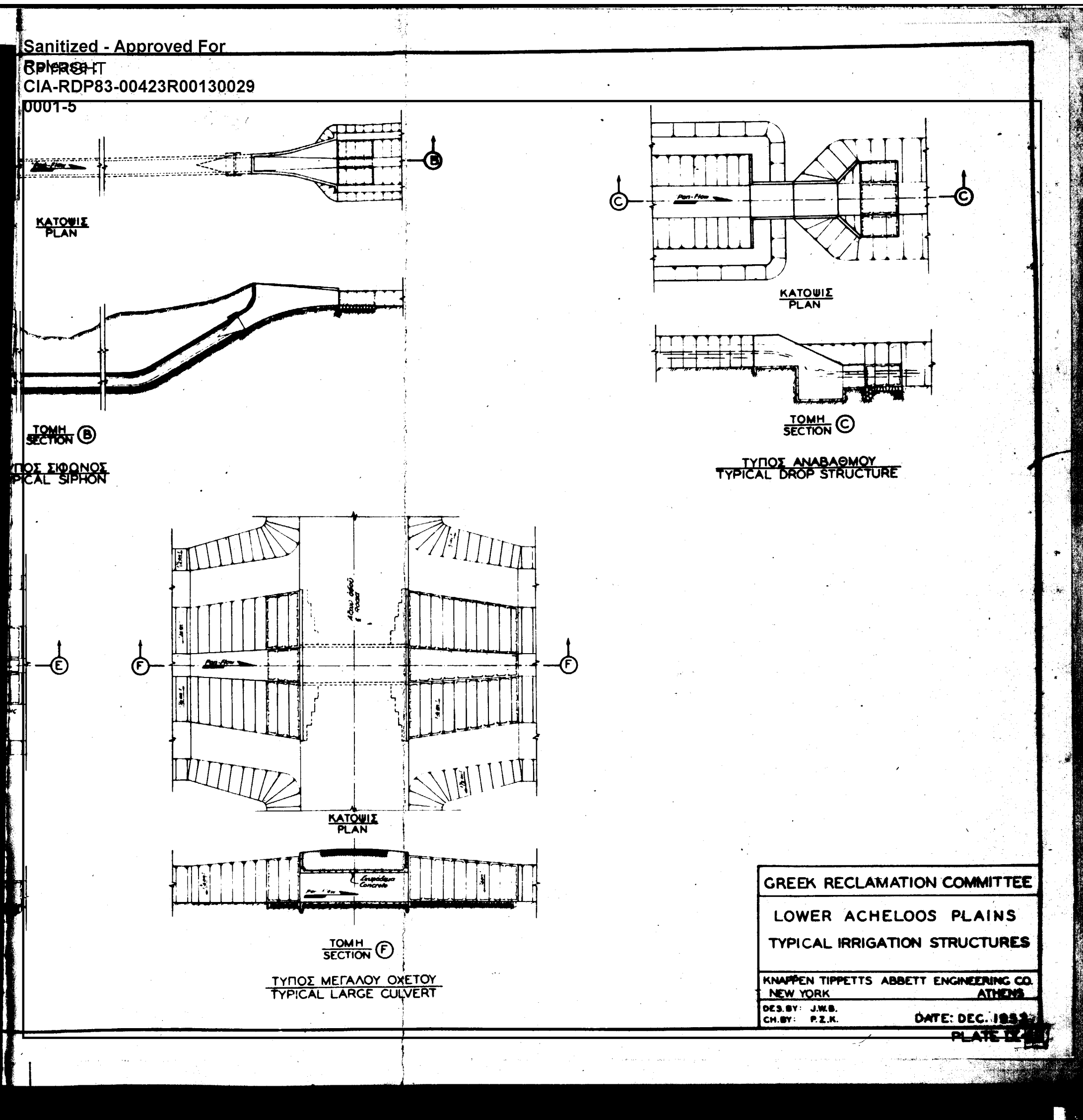
TYPICAL CROSS-SECTIONS

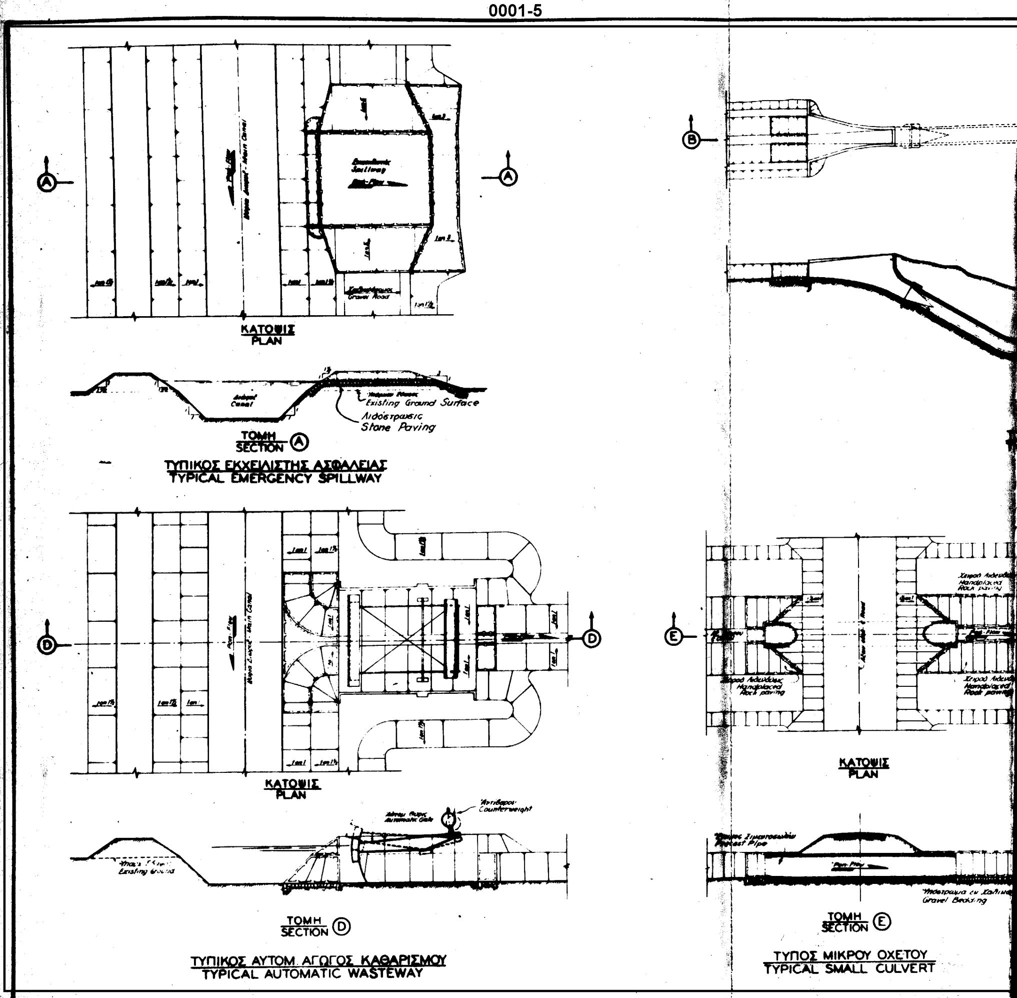
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK — ATHENS

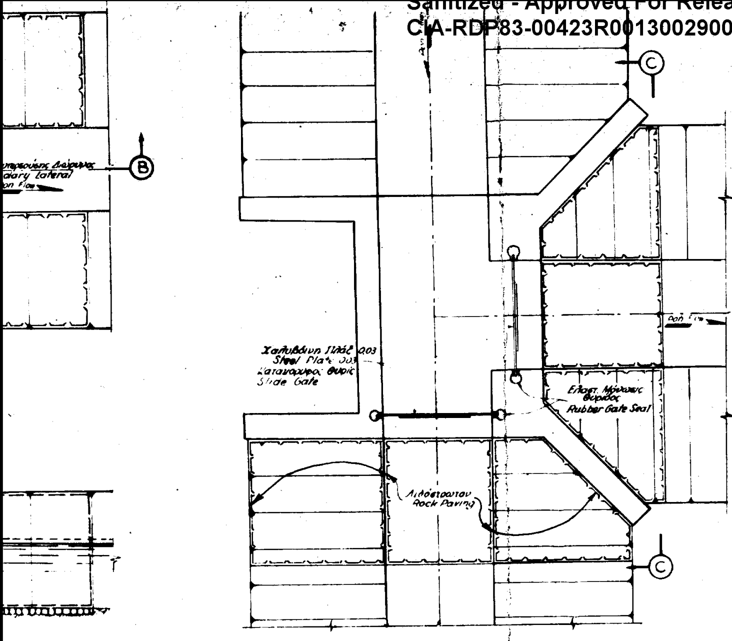
DES. BY P.Z.A.
CH. BY J.W.S.

DATE: DEC. 1952

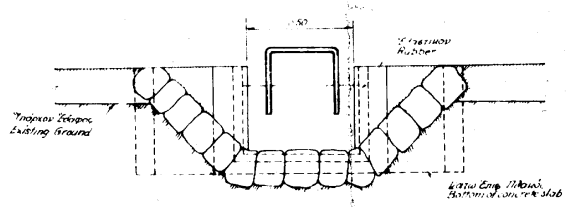
PLATE IX-18


ΚΑΤΟΨΙΣ
PLAN
ΤΟΜΗ
SECTION B
ΥΠΟΣ ΣΙΦΩΝΟΣ
PICAL SIPHON
ΚΑΤΟΨΙΣ
PLAN
ΤΟΜΗ
SECTION C
ΤΥΠΟΣ ΑΝΑΒΑΘΜΟΥ
TYPICAL DROP STRUCTURE
ΚΑΤΟΨΙΣ
PLAN
ΤΟΜΗ
SECTION F
ΤΥΠΟΣ ΜΕΓΑΛΟΥ ΟΧΕΤΟΥ
TYPICAL LARGE CULVERT
GREEK RECLAMATION COMMITTEE
LOWER ACHELOOS PLAINS
TYPICAL IRRIGATION STRUCTURES
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
ATHENS
DES. BY: J.W.B.
CH. BY: P.Z.K.
DATE: DEC. 195
PLATE


ΚΑΤΟΨΙΣ
PLAN
Existing Ground Surface
Λιθόστρωσις
Stone Paving
ΤΟΜΗ
SECTION Ⓐ
ΤΥΠΙΚΟΣ ΕΚΧΕΙΛΙΣΤΗΣ ΑΣΦΑΛΕΙΑΣ
TYPICAL EMERGENCY SPILLWAY
ΚΑΤΟΨΙΣ
PLAN
Αντίβαρον
Counterweight
ΤΟΜΗ
SECTION Ⓓ
ΤΥΠΙΚΟΣ ΑΥΤΟΜ ΑΓΩΓΟΣ ΚΑΘΑΡΙΣΜΟΥ
TYPICAL AUTOMATIC WASTEWAY
ΚΑΤΟΨΙΣ
PLAN
ΤΟΜΗ
SECTION Ⓔ
ΤΥΠΟΣ ΜΙΚΡΟΥ ΟΧΕΤΟΥ
TYPICAL SMALL CULVERT

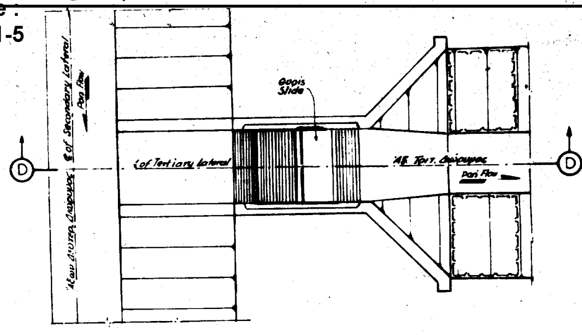


ΚΑΤΟΨΙΣ
PLAN

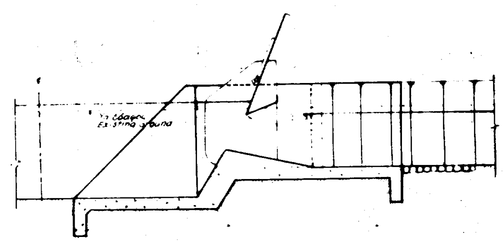


ΤΟΜΗ
SECTION (C)

ΤΥΠΟΣ ΑΓΡΟΤΙΚΗΣ ΠΑΡΟΧΕΤΕΥΣΕΩΣ
TYPICAL FARM TURNOUT BOX



ΚΑΤΟΨΙΣ
PLAN



ΤΟΜΗ
SECTION (D)

ΤΥΠΟΣ ΜΕΤΡΗΤΟΥ ΤΡΙΤΕΟΥΣΗΣ ΔΙΩΡΥΓΟΣ
TYPICAL MODULE FOR TERTIARY LATERAL
60 ΛΙΤΡΑΙ ΚΑΤΑ ΔΕΥΤΕΡΟΛΕΠΤΟΝ
60 LITERS PER SECOND

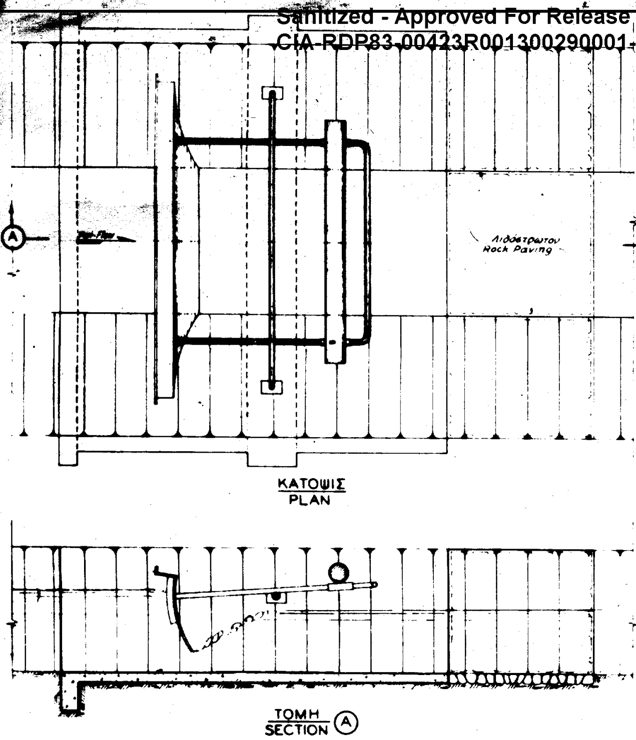
GREEK RECLAMATION COMMITTEE

LOWER ACHELOOS PLAINS
TYPICAL IRRIGATION STRUCTURES

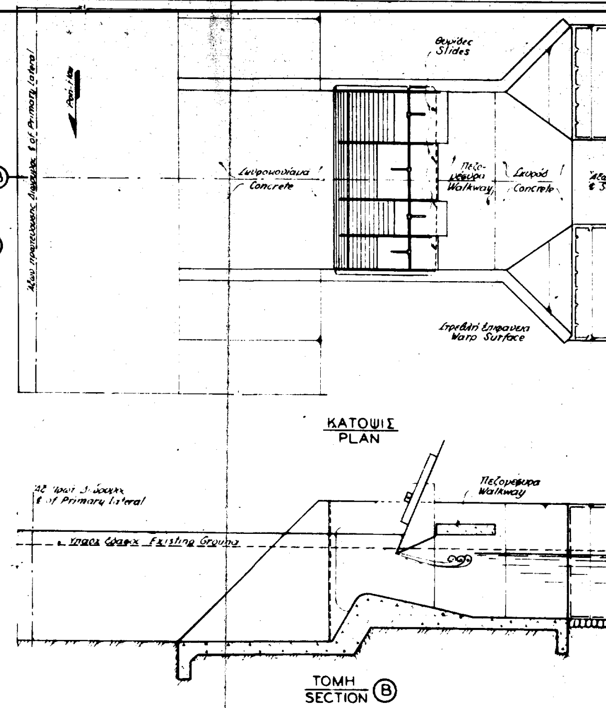
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK ATHENS

DES. BY: J.W.B.
CH. BY: P.Z.K.
DATE: DEC. 1952

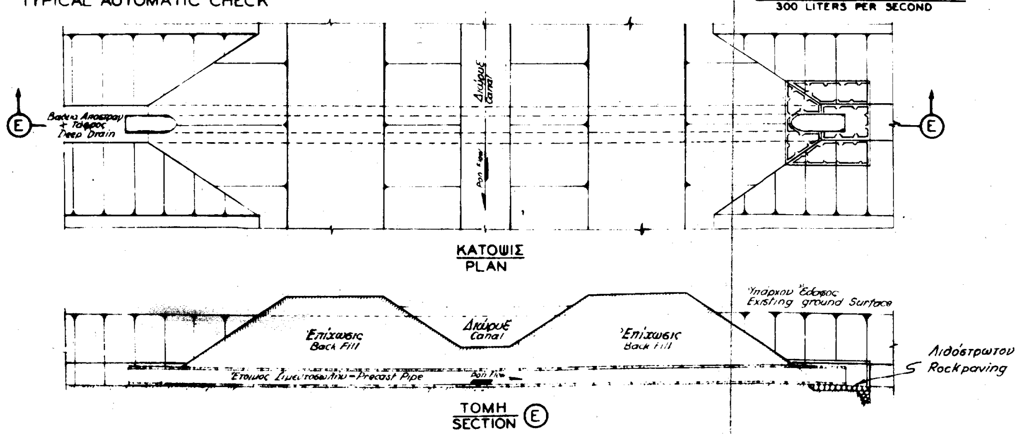
PLATE IX-20



ΤΥΠΟΣ ΑΥΤΟΜΑΤΟΥ ΡΥΘΜΙΣΤΟΥ
TYPICAL AUTOMATIC CHECK



ΤΥΠΟΣ ΜΕΤΡΗΤΟΥ ΔΕΥΤΕΡΕΟΥΣΗΣ ΔΙΩΡΥΓΟΣ
TYPICAL MODULE FOR SECONDARY LATERAL
300 ΛΙΤΡΑΙ ΚΑΤΑ ΔΕΥΤΕΡΟΛΕΠΤΟΝ
300 LITERS PER SECOND



ΤΥΠΟΣ ΔΙΑΣΤΑΥΡ. ΔΙΩΡΥΓΟΣ & ΑΠΟΣΤΡΑΓΓ. ΤΑΦΡΟΥ
TYPICAL DRAIN CROSSING

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