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CONSULTANCY SERVICES FOR ENVIRONMENTAL IMPACT STUDY

PAFOS SEWERAGE AND DRAINAGE PROJECT

Prepared for

THE SEWAGE BOARD OF PAFOS

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ENVIRONMENTAL IMPACT ASSESSMENT

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EXECUTIVE SUMMARY

Continued growth in tourism and related development in the town of Pafos and associated Greater Urban Area have led to the need for improved sewerage and drainage infrastructure in the region.

In 1990, the Municipality produced an Urban Master Plan proposing such improvements, followed by a more detailed Master Plan and Feasibility Study in 1992. In 1993 a Feasibility Study and Preliminary Design Report for the sewerage and drainage scheme of Pafos town and environs was undertaken by Louis Berger International Inc.

To address the social and environmental concerns associated with the proposed sewerage and drainage scheme, the Sewage Board of Pafos has commissioned an Environmental Impact Assessment (EIA) to address these issues and to form part of the documentation required for World Bank and other funding institutions.

The objectives of the EIA study are:

- to prevent any detrimental environmental consequences and propose mitigating measures to ameliorate identified impacts

- to maximise the expected environmental benefits and to avoid costs and delays

- to encourage inter-agency and non-governmental co-ordination and strengthen environmental capability within Cyprus.

DESCRIPTION OF PROPOSED PROJECT

The proposed sewerage and drainage scheme is based on the design presented by Louis Berger International Inc.

The main elements of the scheme are:

- sewage treatment works: to be developed in two stages - year 2000 (stage 1) and year 2010 (stage 2)

- sanitary sewerage scheme: to be developed in two stages (as above)

- surface water drainage scheme - to be developed in three stages - Stage 1, Priority Zone; Stage 2, Urbanised Area currently under development; and Stage 3, Remainder of Area.

The sewage treatment works will consist of, *inter alia:* reception and preliminary treatment, screening, comminutor and grit removal plant, primary clarifiers, sludge thickeners, activated sludge aeration tanks, settlement tanks, aerobic digesters, filter belt press.

The proposed foul sewerage network consists of:

- sewer mains (branches)
- main gravity collector
- secondary sewers (laterals)
- four pumping stations - with emergency marine outfalls
- force mains.

Within Stage 1 of the surface water drainage scheme a set of thirteen high priority primary and secondary drains have been identified. The system has principally been designed to connect primary and secondary level drainage although tertiary and quaternary level systems have been considered.

DESCRIPTION OF EXISTING ENVIRONMENT

Existing Sewage Treatment

Septage from Pafos is currently treated in one of two ways:

- private residences equipped with septic tanks which are cleaned out periodically and septage tankered to waste stabilisation ponds near Agia Marinouda

- hotels with individual waste treatment plants which are managed by the hotels themselves

Associated environmental problems include complaints from residents of Agia Marinouda regarding septage tankers travelling through the village and problems due to odour from the stabilisation ponds and the municipal refuse site. There are also odour problems associated with malfunctioning hotel treatment plants.

Physical Environment

The study area topography varies considerably. To the north of Pafos are rounded ridges topped by small flat plateaux gaining height further inland with steep sided valleys and occasional cliffs. To the south of the town the relief is less pronounced and is bisected by river valleys. The coastal plain, which is narrow in the town and to the north, broadens significantly to the south of Pafos.

The underlying geology can be divided into upland and coastal regions. Recent deposits are present in the base of the river valleys and form wide fan deposits in the coastal zone.

The hydrology of the area is complex, comprising coastal plain aquifers and river gravel aquifers. Abstracted water is principally used for irrigation. Rivers in the study area are numerous, bisecting urban areas and forming natural drainage channels for storm water. Man-made drainage channels are infrequent.

The climate is typically Mediterranean with hot, dry summers; damp, mild winters and very short autumn and spring periods. There are distinct changes in the daytime wind direction in the Pafos region. The prevailing daytime wind blows from the west and veers to a north-easterly direction at night.

Marine Conditions

The coastline near Pafos includes attractive sandy beaches and occasional rocky outcrops, providing a significant tourist attraction to the area. Marine biota have recently been studied near Pafos Airport indicating low species diversity and population densities. Biota include seagrass, a protected species within the Mediterranean. Marine fishing is particularly popular around the Moulia Rocks.

Biotic Environment

The limestone and sandstone upland areas have thin soils which support typical and man-modified maqui and garigue vegetation. The coastal plain is heavily cultivated with pockets on natural flora. River flood channels provide habitat corridors and enhance visual amenity within the urban areas and agricultural coastal plain.

Socio-Cultural Environment

Population in urban and suburban areas has increased rapidly in recent years, particularly in Pafos itself. The service sector (principally the tourism industry) is the dominant (87%) employer for urban residents.

The Louis Berger Report significantly underestimates the current provision of tourism beds and the forecast for the year 2000 is almost certainly too low. It follows, therefore, that the "no project" option becomes less sustainable if there is a more rapid increase in tourism beds than was estimated in the Feasibility Study. If the engineering of the Project takes account of this, there should be no significant environmental impacts resulting from the underestimation.

It is generally considered that government-owned land should be selected for public utilities and other public projects. However, this view was not allowed to become the predominant factor in site selection and did not restrict or predetermine choices.

ENVIRONMENTAL IMPACTS AND MITIGATION

The proposed sewerage and drainage scheme will result in the following benefits:

- The recovery of approximately 7650 Ml pa of high quality treated wastewater (Stage2).
- Potential enhancement of the local environment, by use of recovered water for irrigation of recreational areas.
- Increased availability of water for irrigation of crops.
- Termination of polluting discharges from the existing treatment lagoons into the surface water system.

- Protection of groundwater sources from organic and bacterial contamination.

- Enabling growth in tourism to occur whilst avoiding further impact from an increased load on existing facilities.

- Reduced noise and traffic disturbance from septage tankering.

- Alleviation of odour problems from existing septic tanks.

- General improvement in sanitary conditions.

- The production of sewage sludge as a valuable fertiliser and soil conditioner.

- A reduction in tanker discharges to unauthorised sites.

- Improved compliance with EU environmental directives.

Negative impacts have been sub-divided into those which are short-term and those which are long-term. These are summarised in Tables 1 and 2.

ANALYSIS OF ALTERNATIVES

Alternatives for the following issues are examined including:

- Overall scheme alternatives.

- Area Alternatives - A comparative assessment is made of five selected areas and one area is selected east of the lower Ezousa River. Table 3 shows the Area selection Assessment.

- Site Location for Sewage Treatment Works - Within the preferred Area of Search, sites are identified and evaluated based on a wide range of criteria, and a recommendation made.

- Sewage Treatment Process - Alternative schemes are presented in the Louis Berger Report in little or no detail. Consideration of alternatives is recommended prior to detailed design.

- Sludge and Wastewater Disposal - Options are not discussed in detail in the Louis Berger Report and disposal to land is considered to be the preferred option. However, there is public resistance to this disposal option.

- Stormwater Drainage Scheme - Natural channels should be encouraged wherever possible. The Louis Berger Report provides an appropriate prioritisation scheme. Wherever possible, drainage systems should be provided with any new developments.

MONITORING AND ENVIRONMENTAL MANAGEMENT

Short and long-term monitoring programmes have been outlined to assess the impacts of the development and success of mitigation. In addition, elements for a successful Environmental Management System have been detailed including specific management plans.

RECOMMENDATIONS

The proposed Pafos sewerage and drainage scheme is considered beneficial and desirable. Several assumptions within the Louis Berger Report are considered to be questionable, and additional or more detailed analysis is considered necessary in some cases.

An analysis of alternative sites for the location for the Sewage Treatment Works has been undertaken and a recommended site identified.

The mitigation and monitoring plans and Environmental Management System will help to ensure that negative impacts are alleviated and that environmental issues are effectively addressed throughout the life of the scheme.

Table 1: Potential Short Term Negative Impacts Associated with Sewerage and Drainage Scheme System Construction and Start-up, and Mitigation Options

Potential Negative Impact	Mitigation
Noise	Avoid construction at night. Minimise noise disturbance in the centre of town by trenching this area in winter.
Dust	Minimise dust in town centre by trenching in winter. Workers to wear face masks if dust a problem. If high winds blow dust to airport, work should halt.
Waste Disposal: Oil spills and leaks	Proper maintenance and operation of equipment. Clean spills and dispose of clean-up materials in landfill.
Disposal of fill	Engineering designs to minimise fill produced. Use excess in landscaping or landfill.
Disposal of rubbish, concrete	Collect in skip/truck and landfill.
Traffic: Delays to traffic	Develop detour routes with local police. Publicise work schedule and detours. No construction in commercial or tourist areas in summer months.
Traffic disturbance	Restrict times of day lorries move to and from site (specify in contract). Provide and enforce use of wheel cleaners for lorries leaving STW site. Restrict routes available for lorry movements.
Pedestrian traffic disturbance	Provide walkways for access. Minimise length of open trench in urban areas.
Reduction of recreational or tourist activity	No construction in tourist areas in summer months.
Financial detriment and disturbance to shop keepers	No construction in commercial area in summer months. Inform shop keepers of work schedule at least a month in advance.
Atmospheric pollution from construction machinery	Proper maintenance of construction vehicles. Minimise unnecessary construction traffic.
Disruption to existing services	Correct operation of back-hoe. Co-ordinate work/repairs with existing services.
Accidental destruction of archaeological sites	Inform Director of Antiquities of trenching operations. Cease work if archaeological remains found. Maintain contact with the Archaeological Museum in Pafos.
Sedimentation	Ensure run-off, if any is directed to bare ground or drainage ditches in town; away from halophytic community at STW site.
Odours: During construction	Minimise by removing contaminated groundwater as soon as possible and by drainage septic tanks immediately.
During filling of aeration tanks	Careful planning during start-up procedure.
Exposure of contaminated septate or septate contaminated ground during trenching	Tanker contaminated septate to disposal in landfill.. Do not allow disposal in the marine environment.
Disturbance to existing building foundations	Appropriate engineering design and construction provisions.
Loss of marine habitat and organisms in construction of outfalls	Conduct offshore survey of sensitive habitats, breeding grounds, rich biotic communities and route outfalls accordingly.
Water quality decline during construction of outfalls	Conduct water movement and quality surveys.

Table 2: Potential Long Term Negative Impacts Associated with the Sewage Treatment Works and Storm Drainage System

Potential Negative Impacts	Mitigation
Sewage Treatment Works Site and Operations	
Vegetation irreversibly lost from Sewage Treatment Works site	This is an unavoidable, permanent loss of Government-owned, leased agricultural land, amounting to 4ha (depending on design).
Unplanned developed induced by sewage works	Review or enforce existing land use controls and regulations.
Aesthetics of sewage treatment works	Colour building elements to be unobtrusive. Landscape and plant the site.
Odour	Re-evaluate the sewage treatment process design, as elaborated in the text.
Noise	Proper equipment selection. Proper operation and management of sewage treatment works. Minimise with tree planting and landscaping.
Effect on Land Values	Unavoidable in part, but should only significantly affect development (ie non-agricultural) land. Avoid allocation of affected land for development purposes and ensure implementation of measures above to minimise impact.
Social attitudes of farmers to re-use of effluent	Make provisions for aquifer recharge. Educate farmers on merits and problems of effluent re-use. Run test plots at Acheleia Experimental Farm. Encourage effluent re-use by a favourable pricing structure.
Social attitudes of farmers to re-use of sludge	Make necessary arrangements for land-filling sludge. Educate farmers of merits and problems of sludge fertilisation. Run test plots at Acheleia Experimental Farm.
Marine outfall interference with fishing	Bury outfall
Emergency discharge of sewage resulting in seagrass death, visible water pollution, potential onshore pollution	Conduct surveys of seagrass beds, water surface movements and build outfall accordingly.
Sewerage System	
Disturbance associated with maintenance of pumps and pipes in town	Locate pumps inside streets. Co-ordinate with other service repairs.
Road or infrastructure settlement	Appropriate engineering design and construction provisions.
Increased tanker traffic movement to Sewage Treatment Works	Unavoidable but will cease once Stage 2B is complete. Expected to be a minor increase to existing traffic flow.
Loss of sewage tanker business and associated employment	Provide advice/help on re-employment.
Loss of irrigation water for hotel grounds from existing package treatment plants.	Examine alternatives with hoteliers, including pricing structure
Siting of pumping station in Archaeological area	Relocate to Intersection of Poseidonos Avenue and Alkininis Street.
Surface water Drainage System	
Rubbish accumulation along stormwater (stream) channels	Screen storm water prior to sediment/oil and grease traps. Encourage proper rubbish disposal by residents and tourists.
Storm water ditch failure leading to flooding/erosion	Enforce maintenance programme. Keep ditches clear of vegetation and rubbish.
Malfunction of pumping stations	Provide an alarm system with attendant procedures for response.

Table 3: Areas of Search: Comparative Assessment.

	Area of Search					
	A	B	C	D	E1	E2
LANDSCAPE						
- Visibility from existing roads	-	-	+	-	+	-
- Visibility from proposed roads	+	--	-	-	-	+
- Landscape impact	--	-	+	+	--	+
- Screening potential	--	-	++	+	--	+
ECOLOGY						
- Proximity to important habitats	--	-	-	+	-	-
- Proximity to important species	-	-	0	+	-	0
NUISANCE/AMENITY						
- Proximity to settlements	0	-	-	+	-	0
- Meteorological influences	-	-	0	-	-	-
- Nuisance effects from access	-	-	+	0	0	0
ARCHAEOLOGY						
- Effects on known antiquities	0	0	0	0	0	0
LAND USE						
- Agricultural land quality	++	++	-	-	+	--
- Compatibility with land uses	-	++	0	0	0	0
- Blighting of potential development	-	++	-	0	0	0
- Tourism effects	-	+	-	-	-	+
- Accessibility	-	0	+	+	0	0
LAND OWNERSHIP						
- Predominant ownership pattern	0	-	+	++	0	-
PLANT OUTPUTS						
- Potential for local sludge re-use	-	-	++	++	-	-
- Potential for local effluent re-use	-	+	+	+	0	-
COST IMPLICATIONS						
- Distance to plant	--	+	++	0	--	--
- Elevation (pumping)	--	-	++	++	-	++
- Topography	--	-	++	++	-	++

++ Significant Advantage
+ Slight Advantage
0 Neutral
- Slight Disadvantage
-- Significant Disadvantage

1. INTRODUCTION

1.1. Background

In recent years the town of Pafos and associated Greater Urban Area (Figure 1-1) have seen a rapid growth in tourism. This, together with increasing public environmental sensitivity regarding the effects of such growth and development in the Pafos area (Figure 1-1), are reflected in the Urban Master Plan issued by the Municipality in 1990. This document established guidelines for the pattern of development in the area through until the year 2000. It has now been updated and re-stated in the current approved Pafos Local Plan (1994).

A key aspect of the Plan was the need for improvement of the infrastructure to accommodate the increasing number of tourists visiting the area each year. At present sewage is dealt with independently by individual houses or hotels and stormwater drainage is extremely limited. These factors have resulted in a host of related problems including flooding, poor sanitary conditions, contamination of surface water and groundwater and odour problems. Accordingly, one of the improvements identified in the plan was the need for a Sanitary Sewerage and Stormwater Drainage System for the Pafos area.

In 1992, a Master Plan and Feasibility Study was prepared, examining sewerage and drainage requirements for the area through to the year 2010. Following on from this, in 1993, a Feasibility Study and Preliminary Design Report for the Sewerage and Drainage Scheme of Pafos Town and Environs was undertaken by Louis Berger International Inc. (1993). This will subsequently be referred to as the "Louis Berger Report".

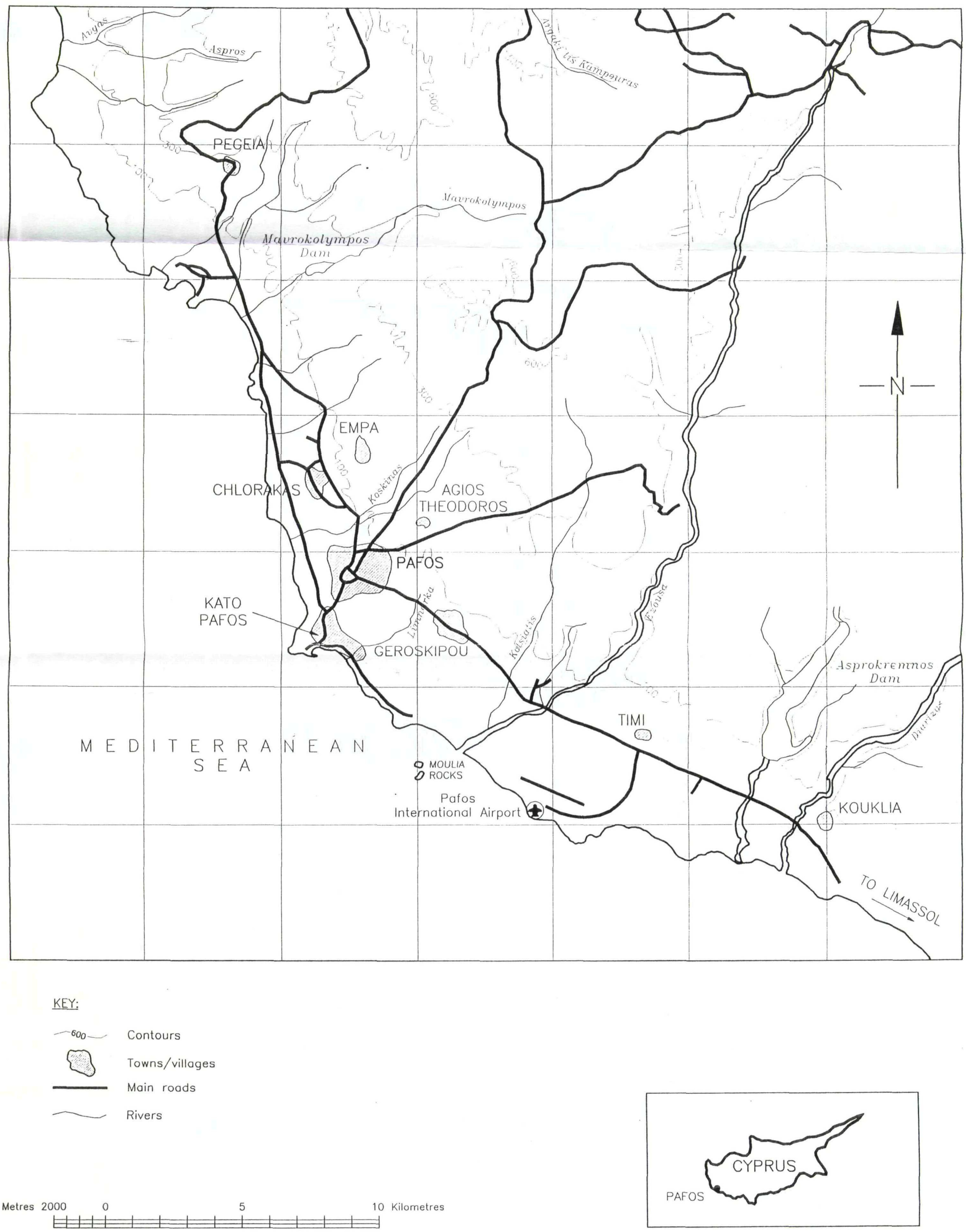
As part of the documentation of a project suitable for World Bank or other funding agencies, an Environmental Impact Assessment (EIA) was required in line with the World Bank Operational Directive 4.01. The EIA is required under Cypriot law and must comply with EU Directive 85/337/EEC. In order to address the social and environmental concerns associated with the proposed project, the Sewage Board of Pafos commissioned Howard Humphreys and Partners Ltd (Brown and Root Environmental) in conjunction with John Theophilou Consulting Engineers Ltd, Nicosia, to undertake the EIA according to the Terms of Reference and letter of 5th April 1995 given in Appendix A. A list of the individuals who prepared the EIA is given in Appendix B.

1.2. Objectives

The main objective of the EA is to ensure that the Pafos Sewerage and Drainage Project will be environmentally sustainable through the identification of potential environmental problems and the timely incorporation of their mitigation into project design. By alerting project designers, implementing agencies, and Government staff to issues early on in the project cycle, the EIA will:

- prevent any detrimental environmental consequences
- propose mitigating measures
- maximise the expected environmental benefits
- help avoid costs and delays in implementation due to unanticipated environmental problems.

The EIA will also provide a formal mechanism for inter-agency co-ordination and for addressing the concerns of affected groups and local non-governmental organisations (NGOs), and will assist in building environmental capability in the country.



MAP TITLE : PROJECT AREA BASE MAP	JOB NAME : PAFOS SEWERAGE AND DRAINAGE SCHEME – EIA FOR SEWAGE BOARD OF PAFOS
FIGURE No. : 1–1	JOB No. : WSBE53

2. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

In Cyprus there are many laws which contain provisions for the preservation or protection of the natural environment. It is the policy of the Government of the Republic to consolidate and amend these laws and regulations in accordance with European Union Directives.

An outline of the existing laws pertinent to the proposed project are cited below:

2.1. Groundwater Protection

Underground waters may be polluted from two possible sources: from salt water seeping in when aquifers are depleted by over-pumping and from the seepage or leaching of pollutants deposited in or on the ground. The statutory provisions providing protection are as follows:

- Wells Law, Cap 355 (as amended)
- Water Supply (Special Measures) Law No. 32 of 1964 (as amended)
- Water (Development and Distribution) Law. Cap 348
- Streets and Buildings Regulation Law. Cap 96 (as amended)
- Government Waterworks Law. Cap 341 (as amended by Law 1 of 1977)
- Control of Water Pollution Law No. 69/1991 (as amended 1992)

2.2. Surface Water Protection

The relevant laws are:

- Public Rivers Protection Law. Cap 82
- Fisheries Regulations
- Mines and Quarries Law. Cap 270 (as amended)
- Government Waterworks Law. Cap 341 (as amended by Law 1 of 1977)
- Control of Water Pollution Law No. 69/1991 (as amended, 1992)

The purpose of the Control of Water Pollution Law No. 69/1991 - is the protection of surface waters, ground waters and coastal waters of Cyprus from human activities and the control of industrial liquid wastes. For the enforcement of this law, Inspectors are appointed with power to enter any industrial premises on which there is reasonable cause to believe any activity is being conducted which leads to the breach of any of the provisions of the Law. Among other powers, the Inspectors can carry out tests and measurements as well as inspect records containing information relevant to their investigation.

2.3. Coastal Waters Protection

The relevant laws are:

- Fisheries Regulations
- The Fisheries (Amendment) Regulations of 1981
- Cyprus Ports Organisation Law No. 38 of 1973
- Cyprus Ports Organisation (Operation of Port Precincts) Regulations of 1976
- Petroleum Law. Cap 272 (as amended)
- Petroleum (Production) Law of 1974

- The Foreshore Protection Law. Cap 59 and Laws 22/61, 17/64 and 8/72
- Control of Water Pollution Law No. 69/1991

2.4. Nature Conservation

There is substantial legislation in Cyprus on the conservation of nature. The relevant laws are:

- Game and Wild Birds Law No, 39 of 1974
- Forest Law No. 14 of 1967
- Forest Regulations of 1967
- Mines and Quarries Regulations of 1958
- Tree Planting (Village Areas) Law. Cap 100
- Public Health (Marsh Areas) Law. Cap 258
- Soil Conservation Law. Cap 94
- Fisheries Regulations
- Sponge Fishery Law. Cap 146 (as amended)

2.5. Noise

There are various forms of noise nuisance in Cyprus, in particular from discotheques and civil engineering works. There is also the problem of traffic noise. The following provisions govern noise nuisances:

- Civil Wrongs Law. Cap 148 (Section 46)
- Criminal Code Cap. 154 (Sections 186, 191 and 193)
- Motor Vehicles and Road Traffic Law No. 86 of 1972
- Motor Vehicles Regulations
- Protection of Common Peace Law. No. 27 of 1974
- Bulb Horns and Whistles Prohibition Law. Cap 331
- Bells Regulation Law. Cap 33
- Aerodromes Law. Cap 300

2.6. Odours

There are some provisions in Cyprus legislation which directly or indirectly serve to prevent or reduce the emission of unpleasant odours. These are:

- Civil Wrongs Law. Cap 148 (Section 46)
- Criminal Code. Cap 154 (Sections 186 and 183)
- Village (Administration and Improvement) Law. Cap 243

2.7. Atmospheric Pollution

There is provision in Cyprus legislation which directly serves to eliminate, reduce and control the pollution of the atmosphere from industrial sources. The relevant law is :

- Control of Atmospheric Pollution Law No. 70/1991 (as amended 1992)

The purpose of the above law is the elimination or reduction and control of pollution of the atmosphere from industrial sources.

The enforcement of the Control of Atmospheric Pollution Law is carried out by Inspectors appointed by the Minister of Labour and Social Insurance. Inspectors can enter any premises when they have reasonable cause to believe any activity is being conducted which leads to a breach of any of the provisions of the above Law. They can also inspect, examine, carry out measurements and require the production for inspection of any records relevant for the purpose of their investigation.

2.8. Solid Wastes

There is considerable legislation in Cyprus on the collection and disposal of solid wastes.

- Municipal Corporation Law. Cap 240
- Village (Administration and Improvement) Law. Cap 243
- Public Health Villages Law. Cap 259
- Forest Law No. 14 of 1967
- Public Roads (Protection) Law. Cap 83
- Public Rivers (Protection) Law. Cap 82
- Mines and Quarries Regulations.

Draft legislation on the control of soil pollution from special wastes as well as the control of dangerous substances has been prepared and is expected to be drafted soon into law.

2.9. International Conventions

The following international conventions and protocols in the field of the environment which have been ratified by the Government of the Republic of Cyprus are:

- Convention on the International Trade in Endangered Species of Wild Fauna and Flora. 3 March 1973. (Ratification Law No. 20/1974 - 21.6.74)

- Convention Concerning Protection of the World and Cultural Heritage. 23 November 1972. (Ratification Law No. 23/1975 - 16.5.1975)

- Convention for the Protection of the Mediterranean Sea Against Pollution. 16 February 1976. (Ratification Law No. 51/1979 - 8.6.1979)

- Protocol for the Protection of the Mediterranean Sea against Pollution from Land Based Sources. (Ratification Law No. 366/87 - 27.11.1987)

- Protocol Concerning Mediterranean Specially Protected Areas. (Ratification Law No. 24/1988 - 18.3.1988)

- Convention on the Conservation of European Wild Life and Natural Habitats, 21 September 1979 (Ratification Law No. 24/1988 - 18.3.1988)

- Convention on Long-range Transboundary Air Pollution, Geneva - 13 November 1979

- Protocol to the 1979 Convention on Long-range Transboundary Air Pollution on Long-term Financing of the Co-operative Programme of Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), Geneva - 28 September 1984.

- Convention on the High Seas (Ratification Law No. 35/1988)

- United Nations Convention of the Law of the Sea (Ratification Law No. 203/1988) as amended

The Government of the Republic is also considering signing the Convention on the Conservation of Migratory Species of Wild Animals and is prepared to ratify the RAMSAR and Biodiversity Conventions.

2.10. Use of Treated Sewage Effluent and Sludge

A national committee has been established to prepare quality standards on the use of treated effluent and sludge from domestic sewage for agricultural purposes. The quality standards for treated effluent and sludge for irrigation have already been prepared by the committee. A standard for groundwater recharge is under preparation.

The Provisional Code of Practice for Treated Domestic Sewage Effluent used for Irrigation makes the following points:

1. The sewage treatment and disinfection plant must be kept and maintained continuously in satisfactorily and effective operation so long as treated sewage effluents are, or are expected to be used for irrigation, or disposed according to the permit/s issued.

2. Skilled operators must be employed to attend the treatment and disinfection plant, following formal approval by the appropriate authority that the person/s is/are competent to perform the required duties necessary to ensure that conditions of (1) are satisfied.

3. The treatment and disinfection plant must be attended according to a schedule approved by the appropriate authority and records kept of all analyses and operations performed. A copy of these records must be kept at a convenient place for inspection at any time.

4. All outlets, taps and valves in the irrigation system shall be of type that can be secured to prevent their use by unauthorised persons. All such outlets must be red coloured and clearly labelled so as to warn the public that the water is unsafe for drinking.

5. All efforts should be made to ensure that no cross-connections occur with any pipeline or works conveying potable water. All pipelines conveying sewage effluent must be satisfactorily marked with red tape, so as to be distinguished from domestic water supply. In unavoidable cases, where sewage/effluent and domestic water supply pipelines must be laid close to each other, the sewage or effluent pipes should be buried at least 0.5m below the domestic water pipes.

6. Irrigation methods allowed and conditions of applications differ between various plantations as follows:

Park lawns and ornamentals in amenity areas of unlimited access:

- subsurface irrigation methods
- drip irrigation
- pop-up low angle (equal or less than 7°)
- low pressure and high precipitation rate sprinklers (more than 20mm/hr)

Sprinkling should be practised at night and when people are not around

Park lawns and ornamentals in amenity areas of limited access, and industrial and fodder crops:

- subsurface irrigation methods
- drip irrigation
- surface irrigation methods
- minisprinklers
- sprinkler irrigation is allowed if there is a buffer zone of 300 metres.

For fodder crops, irrigation should stop at least one week before harvesting and no milking animals should be allowed to graze on pastures irrigated with sewage effluents. All cases of fodder irrigated with treated effluent should be reported to the veterinary services also.

Vines:

- drip irrigation
- mini sprinklers (irrigation should stop before harvesting)

Portable irrigation networks are not allowed and no fruit to be collected from the ground.

Trees with fruits eaten raw without peeling:

- drip irrigation
- hose basin irrigation
- bubblers irrigation

No fruit to be collected from the ground.

Trees with fruit eaten after peeling, nuts and the similar:

- drip irrigation
- minisprinklers (irrigation should stop one week before harvesting)

No fruit to be collected from ground, nut collection allowed.

Other irrigation methods may be allowed after formal approval by appropriate authority, which shall take into consideration the public health, agricultural and environmental aspects. Restricting measures could also be enforced for any irrigation method by the appropriate authority if with such measures health, environmental or others hazards are avoided.

7. The following tertiary treatment methods are acceptable:

- coagulation plus flocculation followed by rapid filtration
- slow sand filtration
- any other method which shall secure the total removal of helminth ova and faecal coliforms down to acceptable level. It must also be approved by the appropriate authority.

8. Appropriate disinfection methods should be applied when required by the irrigation standards. In the case of chlorination, the residual free and total level of chlorine in the effluent should be equal or more than 0.5 ppm and 2 ppm respectively at the point of use.

9. Suitable apparatus for the monitoring of all essential parameters as required by the appropriate authority should be kept on site at all times.

The Provisional Code of Practice for Treated Domestic Sewage Sludge for Agricultural Use makes the following points:

1. The sludge treatment and disinfection plant must be kept and maintained continuously in satisfactory and effective operation so long as the treated sewage sludge is, or is expected, to be used for agricultural purposes or disposed of according to the permits issued.

2. The storage of the treated sludge must not cause environmental problems including risks to public health and pollution of surface and groundwaters.

3. The quality of the treated sludge must be monitored in accordance with a schedule approved by the appropriate authority.

4. Skilled operators must be employed to attend the treatment and disinfection plant, following formal approval by the appropriate authority that the person/s is/are competent to perform the required duties, necessary to ensure that conditions of (1) are satisfied.

5. The following domestic sewage sludge treatment methods are acceptable:

- Anaerobic digestion
- Aerobic digestion

- Thermal treatment
- Storage in shallow lagoons for a period of two years
- Sludge stabilisation and use of lime (CaO)
- Sludge stabilisation after complete biological treatment or extended aeration
- Drying in specially built spaces (sludge drying beds)
- Storage for a year of the treated sludge
- Any other method which will be formally approved by the appropriate authority and which method produces a sludge in accordance with the standards for the quality of sludge used for agricultural purposes.

6. The use of the sludge as a soil conditioner is allowed for the following crops:

- Crops for human consumption, eaten cooked
- Crops for human consumption, canned
- Forest plantations
- Tree plantations
- Grass for golf courses, 18 months before planting
- Flower beds in parks

7. For the use of sludge for agricultural purposes the following measures must be taken:

- There must be control of circulation within the land on which sludge has been used for a period of at least 12 months after placing.
- Grazing of animals on land on which sludge has been placed is not allowed for a period of at least 5 weeks after placing the sludge.
- Cultivation of plants yielding fruit to be eaten raw and having no direct contact with the sludge is not allowed for a period of 18 months from the day of placing the sludge.
- Collections of any produce, grown on soils conditioned with sludge is not allowed within a period of 3 months from placing the sludge.
- The amount of sludge to be placed on a soil shall be determined by the appropriate authority after evaluation of the test results for the quantities of heavy metals found in the sludge and in the soil on which the sludge is intended

to be used, in accordance with Tables 2-1 and 2-2 of the Standards for Quality of Sludge for Agricultural Use.

8. For the control of the sludge used for agricultural purposes the following programme of analyses is defined:

Analyses of Sludge: The sludge must be analysed every six months. In cases where variations are observed in the quality of the sewage, the frequency must be adjusted accordingly. These analyses must be for the elements cited in Tables 2-1 and 2-2.

Analyses of Soil: The frequency of the analyses will depend on the initial composition of the soil and its content in heavy metals which must be determined before using the sludge and also on the content in heavy metals of the sludge to be used and the frequency of its placing.

9. The following methods of sampling are acceptable:

For the Sludge: Sampling of the sludge must be carried out after its treatment and before its delivery to the user and it must be representative of the produced sludge.

For the Soil: Sampling to be done down to a depth of about 20cm below the surface of the soil. Where this is difficult, sampling may be carried out down to 10cm from the surface. Representative sample is that which is being prepared by mixing 5 samples per hectare x 10^{-1}.

10. In order to provide correct management, analyses for N, P, K, Ca, Mg, Fe, B in the soil and the sludge are considered to be useful.

PROVISIONAL QUALITY STANDARDS FOR THE USE OF TREATED DOMESTIC SEWAGE SLUDGE FOR AGRICULTURAL PURPOSES

Table 2.1 Maximum permissible content of heavy metals in the sludge (milligrams per kilogram of dry sludge)

Parameters	Maximum Value (mg/kg)
Cadmium (Cd)	40
Copper (Cu)	1750
Nickel (Ni)	400
Lead (Pb)	1200
Zinc (Mg)	4000
Mercury (Hg)	25
Chromium (Cr)	1000

Table 2.2 Maximum permissible content of heavy metals on the soil (milligrams per kilogram of dry soil)

Parameters	Maximum Value (mg/kg)
Cadmium (Cd)	3
Copper (Cu)	140
Nickel (Ni)	75
Lead (Pb)	300
Zinc (Mg)	300
Mercury (Hg)	1.5
Chromium (Cr)	150

3. DESCRIPTION OF PROPOSED PROJECT

The following description of the proposed sewerage and drainage scheme is based upon the preliminary design presented in the Louis Berger Report.

3.1. Sewage Treatment Works

The sewage treatment works will be developed in two stages, designed respectively for the years 2000 (Stage 1) and 2010 (Stage 2).

Sewage will be chlorinated in the force (rising) main upstream of the treatment works, to reduce the potential odour nuisance from subsequent exposure to air.

At the treatment works, all preliminary treatment units will be covered to further reduce odour nuisance. These units include:

- a coarse screen of 7.16 to 10.16cm bar spacing, followed by
- fine screens of 1.58cm bar spacing
- a comminutor, and
- a grit removal plant.

The coarse screen will be manually cleaned. The fine screens, which are expected to collect a larger quantity of debris, will be mechanically cleaned under automatic control. The screenings removed from this process will be compressed and delivered into a receiver via a chute. The receiver typically used for this purpose is a skip, which leads conveniently to final disposal by landfill.

The comminutor will break up any remaining large particulates and rags, and will disperse them into the main flow.

The grit removal system will be of a design which creates a "cyclone " effect, encouraging grit to settle to the floor of the chamber. Lighter organic particles will be held in suspension by injection of air. The settled grit removed will be automatically washed and dewatered, and ejected into containers for disposal. The typical disposal route would be to landfill. One grit removal tank will be installed at each stage of development, the dimensions of each will be 9.1m x 9.1m x 6.5m sidewall depth.

Sewage will be led from preliminary treatment to primary clarifiers, two of which will be constructed at each stage. The clarifiers will be open structures, 15.5m diameter x 3.5m sidewall depth. They will operate on a continuous flow system. Sludge from the central hoppers, and scum removed automatically from the tank surfaces, will be pumped to the sludge thickeners.

Settled sewage will be passed to activated sludge aeration tanks, of which four will be constructed in each stage. The tanks will be open structures, each 22.8m x 22.8m x 4.5m depth. Surface aerators of the rotating cone pattern will provide process oxygen and keep the contents of the tanks in suspension. It is in this section of the plant that the greatest part of the polluting load contained in the crude sewage will be removed. The process will rely upon the assimilation of organic nutrients by a naturally-established population of bacteria and protozoa. As the process continues, the quantity of such organisms held in the aeration tanks will steadily increase, and this tendency will need to be offset by the daily removal of a quantity of "surplus activated sludge". This is a waste by-product of the process, and in the recommended scheme will be fed to the sludge thickeners.

The wastewater from the continuously-fed aeration process will be led to circular final settlement tanks, two of which will be constructed at each stage. The dimensions of the final settlement tanks will be 17.4m diameter x 3.65m sidewall depth. Their function will be to separate activated sludge from the treated wastewater. The activated sludge will be removed from a submerged central hopper and returned to the aeration tanks. The virtually clear wastewater will be conducted over peripheral weirs to chlorination, followed optionally by tertiary treatment.

Tertiary treatment will not be installed as a part of Stage 1 or 2. A suitable process has, however, been outlined. Its principle would be chemically-aided coagulation, settlement and sand filtration.

Waste sludges from primary and secondary stages will be received into a sludge thickener for initial dewatering. Only one thickener, 12.2m diameter x 3m depth, will be constructed, as a part of Stage 1. The thickener will be equipped with a slowly-rotating "picket fence" device, to aid disengagement of gases and increase settlement velocity. The tank will operate permanently filled, with supernatant liquor being removed from a peripheral weir and returned to the works inlet for full treatment. The thickened sludge will be removed from a central bottom draw-off and fed to aerobic digesters.

Four digestion cells will be constructed at each stage. Each cell will be 18.2m x 18.2m x 4.5m depth. The cells will be open structures, and will be equipped with mechanical surface aerators of the cone type. The purpose of aerobic digestion will be to reduce the odour and the quantity of the sludge, and the concentrations of pathogens.

Final dewatering will take place on a filter belt press, one of which will be constructed at each stage. The process depends upon increasing compression of the liquid sludge between belts and rollers. The final product is a semi-solid cake typically of around 70% moisture content.

The sewage treatment works will include an administration and laboratory building.

3.2. Sanitary Sewerage Scheme

The areas served by the sanitary sewerage scheme are shown in Figure 3-1.

In parallel with the sewage treatment works, the sewerage scheme is to be developed in two stages for implementation in years 2000 and 2010 respectively. The priority area, to be developed in Stage 1, is indicated in Figure 3-2.

The flow contributions identified for both stages are almost entirely from resident and tourist populations, the level of industrial development being very low.

The proposed foul sewerage network consists (quoting the Louis Berger Report) of the following elements:

- a series of sewer mains (branches) running along the natural ground slope from inland to the sea front
- a gravity main collector running along the sea front
- secondary sewers (laterals) of a few hundred metres carrying sewage from the side streets to the sewer mains
- four pumping stations, two to be constructed in Stage 1 and two in Stage 2, and
- force (rising) mains carrying sewage from pumping stations to downstream portions of the gravity collector main or to the sewage treatment plant.

The pumping stations will be equipped with emergency marine outfalls which are expected to operate rarely, if ever. During the detailed design stage the potential requirement for chlorination or other odour suppression techniques associated with rising mains will be studied.

3.3. Surface Water Drainage Scheme

The drainage scheme proposed in the Louis Berger Report was designed to accommodate surface run-off calculated according to the Rational Method. The Rational Method includes parameters to account for soil infiltration, surface roughness, area drained, rainfall intensity, etc., and is an accepted methodology for engineering design. The majority of the drainage network was calculated to cater for a storm return period of 5 years.

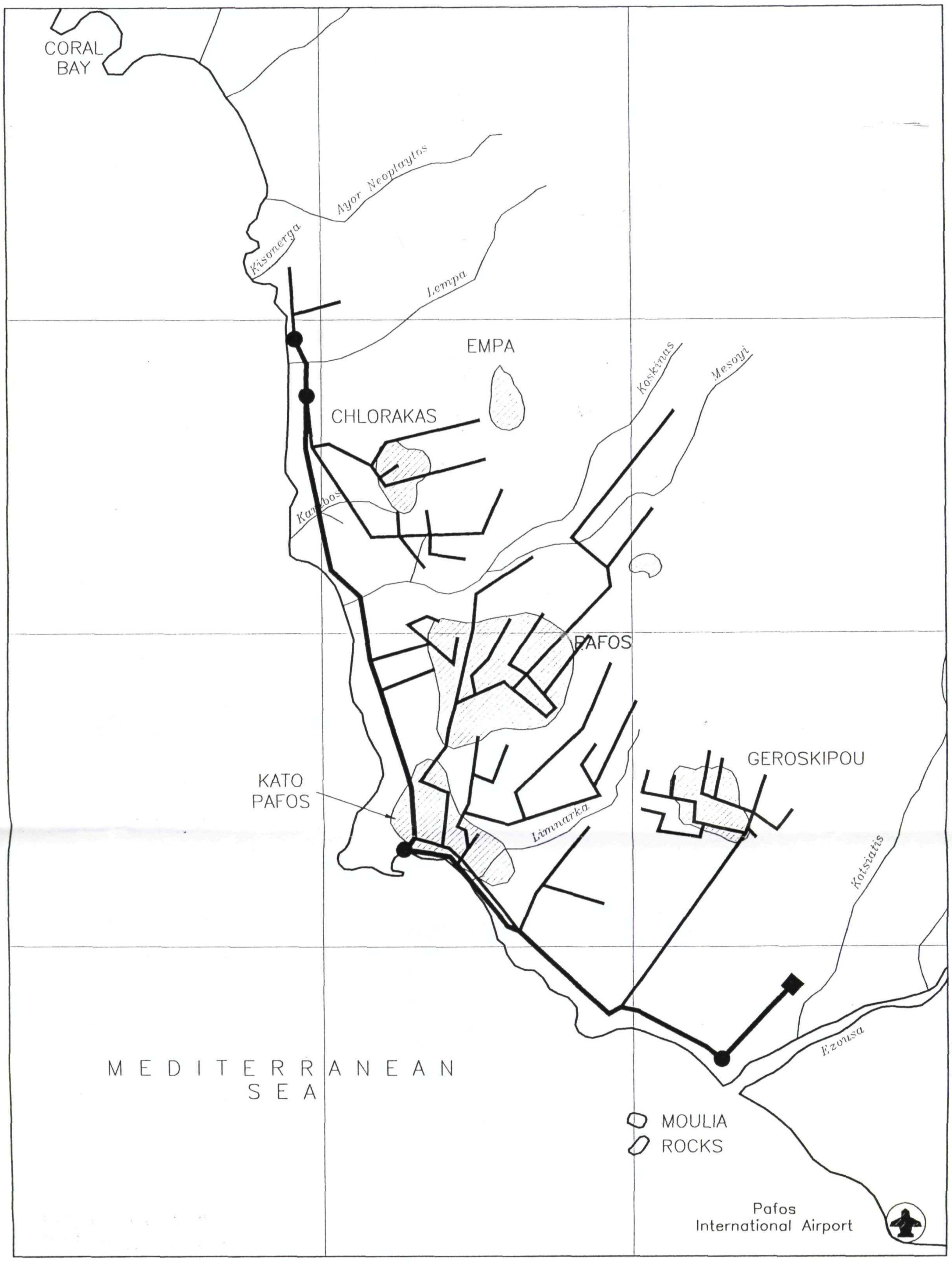
The system was designed to provide primary and secondary level drainage, although a tertiary (street drains 300-500mm diameter) and quaternary (street gutters) level drainage systems were included in the cost analysis. Primary and secondary drains comprise 10-20% of the total system, 893km length. Tertiary drains comprise 30-40% of the total system, or 1,775km length, while quaternary drains comprise 40-50% of the total system, or 2,117km length.

It is difficult to state definitively the recommendations within the Louis Berger Report as to the treatment of existing river channels, which currently function as stormwater conduits. In a number of places it is implied that the valleys will be concreted with "a drainage channel or conduit" (page C2, last paragraph; page C9, third paragraph), while other sections imply the channels are to remain earthen, although excavated (page C12, and thereafter).

The surface water drainage system will be developed in three stages:

Stage 1:	Priority Zone as indicated in Figure 3-3
Stage 2:	Urbanised areas currently under development
Stage 3:	Remainder of the Study Area.

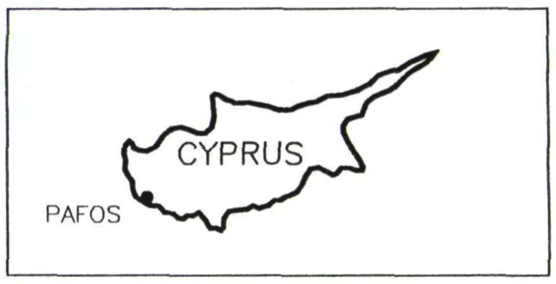
Within Stage 1, a set of thirteen high priority primary and secondary drains have been identified. These serve areas prone to flooding, and include drains which can be laid alongside the sewerage network to offset costs.



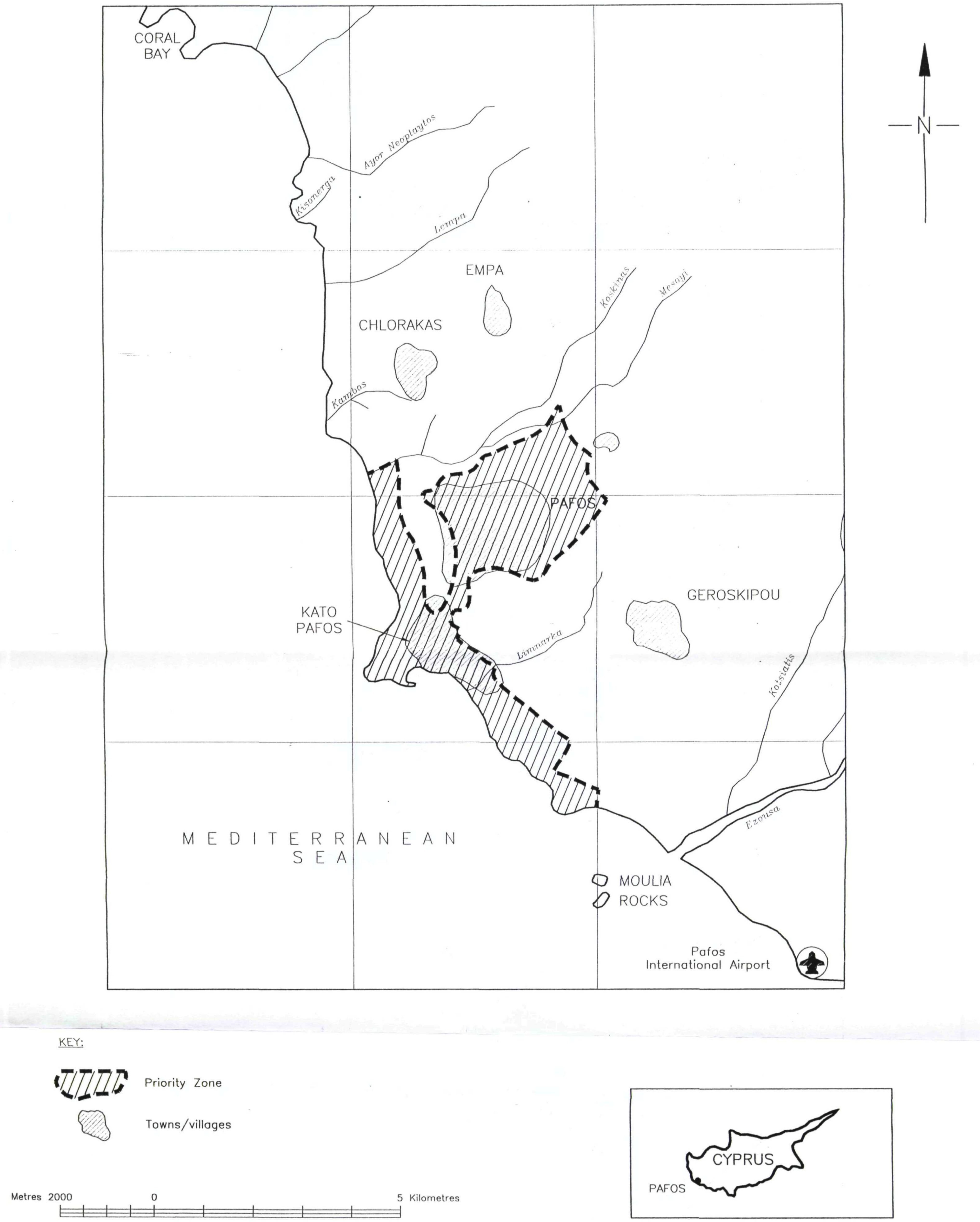
KEY:

- Pumping Station
- Sewage Treatment Works
- Trunk Sewer
- Sewer Network
- Towns/villages

Metres 2000 0 5 Kilometres



MAP TITLE ;	JOB NAME ;
SANITARY SEWERAGE SYSTEM FROM LOUIS BERGER REPORT (1993)	PAFOS SEWERAGE AND DRAINAGE SCHEME – EIA FOR SEWAGE BOARD OF PAFOS
FIGURE No. ; 3–1	JOB No. : WSBE53



MAP TITLE ;

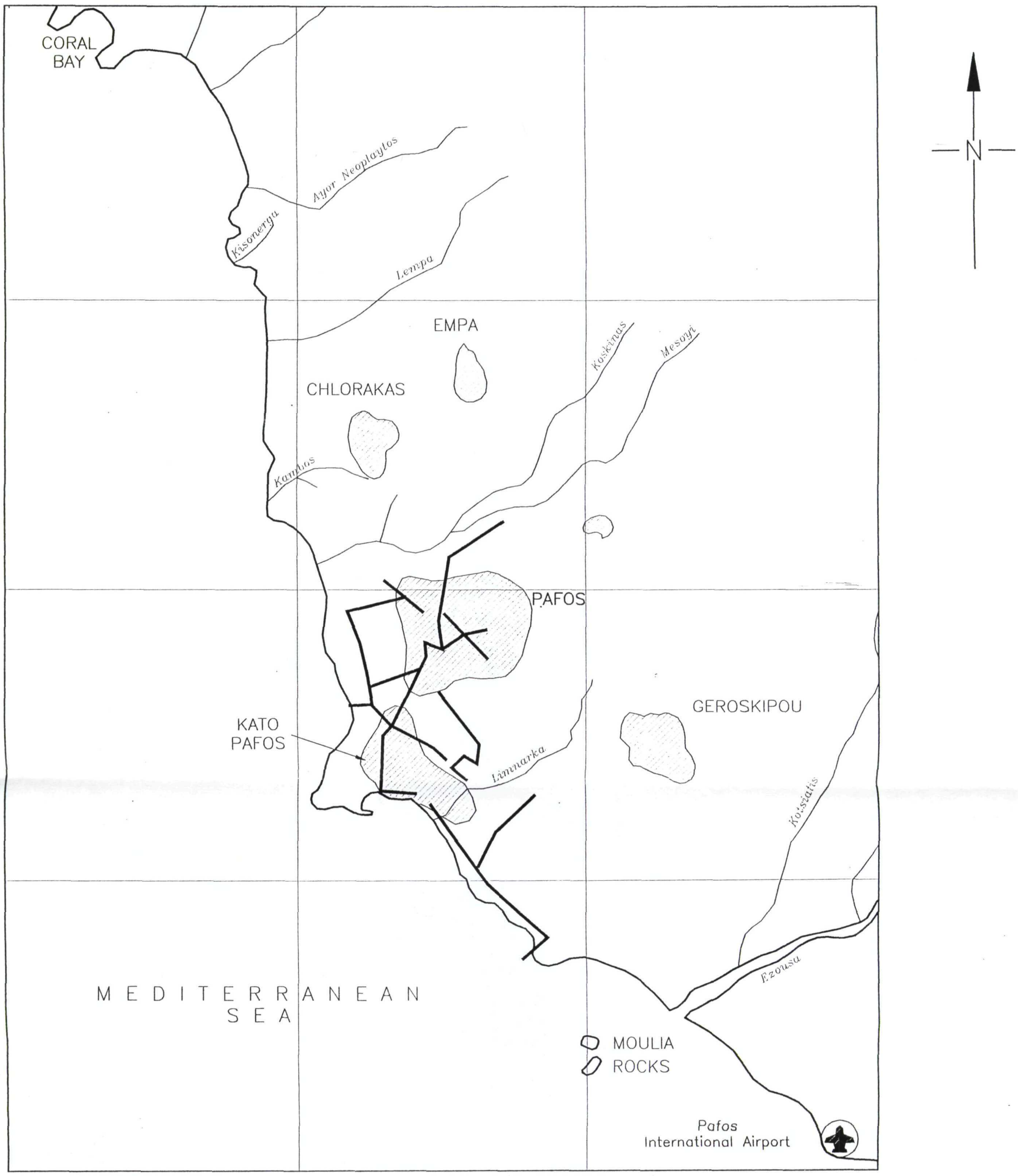
LOUIS BERGER PRIORITY ZONE

JOB NAME ;

PAFOS SEWERAGE AND DRAINAGE SCHEME – EIA FOR SEWAGE BOARD OF PAFOS

FIGURE No. ; 3–2

JOB No. : WSBE53

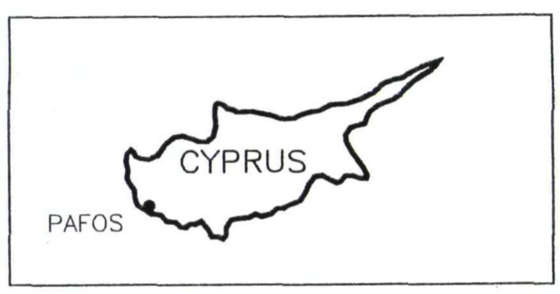


KEY:

Sewer Network

Towns/villages

Metres 2000 0 5 Kilometres



MAP TITLE ;

PRIORITY STORMWATER DRAINAGE SYSTEM
FROM LOUIS BERGER REPORT (1993)

JOB NAME ;

PAFOS SEWERAGE AND DRAINAGE SCHEME – EIA
FOR SEWAGE BOARD OF PAFOS

FIGURE No. ; 3–3

JOB No. : WSBE53

4. DESCRIPTION OF EXISTING ENVIRONMENT

Within this Section, the present situation regarding sewage treatment in the region is discussed together with details of the natural and socio-cultural environment.

4.1. *Existing Sewage Treatment*

Septage from Pafos is currently treated in one of two ways:

- Private residences are equipped with septic tanks, which are cleaned out periodically. Septage is tankered to the waste stabilisation ponds near Agia Marinouda.

- Hotels have individual waste treatment plants within their properties, which are managed by the hotels.

Septage is tankered to the waste stabilisation ponds about 1km to the east of the village of Agia Marinouda. Tankers pass through the village, almost completely blocking the narrow village roads, and trickling septage as they pass through. Currently about 50 tankers a day transport sewage (equivalent to 500 tonnes sewage a day, or 500m^3) to the stabilisation ponds.

The sewage effluent is discharged into one of two receiving ponds, the second receiving pond being cleaned of sediment when not in use. The effluent runs to a third, large pond kept clear of emergent vegetation, then on to a smaller fourth and subsequently a fifth pond, both of which have emergent vegetation. A visual inspection during the site visit indicated that the colour of the effluent remains about the same between the fourth and fifth ponds.

Some liquid wastes and sludge from a slaughter house is discharged into a separate receiving pond, which is small, and heavily stained with blood. The effluent runs to a long ditch, and then into the fifth stabilisation pond described above. The colour did not appreciably diminish in the course of the treatment, and the colour of the final (fifth) pond was apparently due to the slaughter house effluent.

It appeared that the waste stabilisation ponds were overloaded, in that the retention times were insufficient to clear the colour from the effluent, although quantitative data on the chemical characteristics were not obtained.

The effluent is discharged to a small surface drainage ditch which joins the Kotsiatis Stream and then the Ezousa River. Water discoloration was visible at the confluence of the Kotsiatis and the Ezousa. In the summer months, effluent form the waste stabilisation ponds percolates the gravel beds to the groundwater.

There is reported to be a problem with rats at the waste stabilisation ponds. However, the ponds are well-managed, and had only slight odour problems. The municipal rubbish dump is immediately adjacent to the waste stabilisation ponds. This is more likely to attract vermin, such as rats, and certainly odour was emitted from the rubbish dump. In addition, fires are common, and the black smoke wafting to Agia Marinouda generates complaints. The municipal waste dump is unlined, but leachate runs into the waste stabilisation ponds for treatment.

Due to complaints about the waste stabilisation ponds and the municipal dump from the village of Agia Marinouda, the decision was recently made by the government to re-locate the facilities. A number of probable sites are currently being studied. In the next few years, the waste stabilisation ponds are planned to be replaced by the sewage treatment plant.

Treatment within Pafos is undertaken by hotels, which operate their own treatment plants, buried underground, and which use the effluent to irrigate their grounds. It is reported that some treatment plants are poorly maintained (about four function improperly at any one time), resulting in overflow to the ocean, and the effluent generates considerable odour when used for irrigation.

Land zoning includes specifications for sewage treatment that must be adhered to in new constructions:

- 0-100m from the coast - tertiary treatment and irrigation on grounds
- 100-300m from the coast - secondary treatment and borehole recharge
- over 300m from the coast - septic tanks which are regularly emptied.

A summary of the environmental problems associated with the existing sewage treatment includes:

- complaints from the residents of Agia Marinouda about septage tankers travelling through the village

- mal-functioning hotel treatment plants, which detract from the attractiveness of Pafos to tourists.

4.2. Physical Environment

4.2.1. Introduction

Within this Section, information is provided regarding the topography, geology, hydrogeology and hydrology of the study area.

4.2.2. Topography

The study area has been broadly divided into three regions to facilitate topographical discussion. The first region is located in the vicinity of Mavrokolympos dam, about 9km north of the city of Pafos, near the Coral Bay. It occupies an area of nearly 12km^2. The second region is essentially the coastal plain which extends from the village Geroskipos to Kouklia village in the city of Pafos and includes the area of Anatolikon. Its total area is nearly 54km^2. The third region is north of the limestone cliff which forms the inland (northern) border of the coastal plain.

The information presented below is based on the Louis Berger Report, and interpretation of aerial photos and field observations.

The first region rises gently from 100m to nearly 400m above sea level. Rounded ridges, topped by small, flat plateaux, run back to the interior, gaining elevation as they progress inland. Abrupt changes in topography, such as cliffs, are not a common feature, although there are steep-sided valleys, and the landscape is topographically interesting. The area is well drained, with run-off directed to the Mavrokolympos Dam, and Nature Reserves are established to the east of the reservoir.

The second region is within the coastal plain slopes gently down towards the sea. It is flat, with no topographic barriers, rising from sea level to about 30m above sea level. Its northern boundary is marked by an almost continuous escarpment (old marine cliff) which roughly follows the 60m contour. The continuity of the escarpment is cut by the rivers in the region. The rivers in the coastal plain form wide valleys 500 - 1000m wide. There are three major rivers draining the area, namely the Ezousa, Xeropotamos and Dhiarizos. The river valley flood plains are wide, bordered by vertical banks about 1-2m high. The three valleys are almost parallel and have a NNE-SSW direction.

The third region is above the coastal plain and is a hilly area with an overall gradient sloping gently towards the sea. The hills rise to elevations of about 200m above sea level, with rounded and flat crests. The area is bisected by river valleys of different sizes, which are incised with steep-sided valleys. Although the area has few significant topographic features, such as cliffs, the overall impression is one of interest and complexity.

4.2.3. Geology

Geological description of the study areas is principally based upon technical information from the Geological Survey Department of Cyprus - Geological Bulletin and Map. In addition, information has been gained from geotechnical data contained in the Louis Berger Report and limited field investigation. In general, discussion of the geology of the study areas can be divided into upland and coastal regions.

The Upland Region

This region is composed of sedimentary and igneous rocks of the Mamonia Group together with the Lefkara and Pukhna Formations. The sedimentary rocks of the Mamonia Group (Triassic Age) are primarily composed of interbedded sandstones and limestones of variable thickness. Characteristically, rocks of this nature are fairly permeable in nature. Also within the group are igneous strata comprising pillow lavas and serpentinites which are characteristically highly resistant to weathering and which are generally impermeable.

The more recent strata of the Lefkara and Pakhna Formations (Upper Mastrichtian to Eocene and Middle Miocene Ages respectively) comprise alternating bands of marls and chalks which generally constitute more permeable strata when compared to that of the Mamonia Group. However, within the Pakhna Formation there are some well cemented calcarenite beds which tend to be fairly impermeable and resistant to weathering often forming more resistant hill cappings.

The Coastal Region

The geology of this region is composed of sedimentary and recent deposits which form the coastal plain and river valleys. The sedimentary rocks of the Athalassa Formation are well developed in the coastal regions, comprising alternating bands of calcarenite and marl. Recent deposits (Pleistocene Age), constitute clayey alluvium and river gravel deposits. The river gravels form a heterogeneous collection of gravels and coarse sands which vary locally in thickness (20m to 40m) being derived from sedimentary and igneous strata with those of sedimentary origin (chalks) being the most common. The gravels present in the base of the valleys and in the coastal zone form wide (0.5km to 1km) fan deposits as in the Ezousa River.

4.2.4. Hydrogeology

The hydrogeology of the study area is complex as it comprises a number of different aquifers. The Mamonia Group of rocks are generally considered as an aquiclude, while the Lefkara and Pakhna Formations show aquiferous characteristics, but with limited extent and importance. The Athalassa Formation of the coastal zone and the river deposits form a continuous coastal plain aquifer.

The Coastal Plain Aquifer

The coastal plain is a phreatic aquifer which extends from Kissonerga village in the west to the Khapotami River in the east.

The aquifer width ranges from 0.5km to 3.0km with an average saturated thickness of approximately 5m. The base of the aquifer is generally above sea level dipping towards the sea. The gradient of the water table is about 1.5% - 1.8% depending on the season. The water table is above sea level in the entire area.

The aquifer is highly permeable with transmissivities ranging from 100 to 1000m/day. The chloride content of the aquifer is about 300ppm. There are numerous boreholes drilled in the aquifer used entirely for irrigation purposes. The coastal plain aquifer is laterally connected with the three River Gravel Aquifers and (see below) are in hydraulic continuity.

Locally the Coastal Plain Aquifer consists of the Calcarenite aquifer which is present from Kato Pafos to Acheleia and a short, narrow aquifer to the north of the study area which has little potential for recharge. The Kato Pafos to Acheleia aquifer exhibits high nitrate levels (50mg/l) due to fertiliser use in the area. This aquifer has a low permeability and difficult recharge conditions. The Pafos aquifer is approximately 100-200m deep with abstracted water being used for irrigation purposes.

The River Gravel Aquifers

These occur along the river valleys and are fills of areas eroded by the streamflow. The base of the aquifer is formed by the marls of the Pakhna Formation. The thickness of the gravels in all three major rivers in the area is approximately the same and ranges between 20m and 25m. The aquifer is 500 to 100m wide with a large number of boreholes present for water supply and irrigation purposes. The gravel aquifers are under water table conditions and they are in hydraulic continuity with the Coastal Plain Aquifer. They have high to very high transmissivites reaching values as high as 1,600m^2/day. The groundwater gradient is as high as 1.8% to 2% depending on the season.

Locally the Ezousa Aquifer is of importance for irrigation purposes with an existing abstraction rate of 3-4 million m^3 per annum and a potential yield of 5-8 million m^3 per annum. Sulphate levels within this river gravel aquifer are high, rendering the abstracted water unsuitable for potable supply.

The reservoir of the Asprokremnos Dam recharges an associated aquifer (via boreholes) which occurs at a depth of 100m to 250m.

Chemistry of Groundwater

The phreatic Coastal Plain Aquifer has good quality water. It is low in chlorides (up to 300ppm) but relatively high in Calcium Carbonate. Sea intrusion has not been detected and water is good for irrigation purposes. No domestic water supply boreholes are located in this aquifer and the pH values vary between 7 - 8. The River Gravel Aquifers have also good to very good quality water. The chloride content ranges between 50-80 ppm. The situation becomes better when this part of the aquifer is artificially recharged with fresh water from Asprokremnos Dam. The Ezousa river gravels yield water with high, to very high sulphate contents of 350 - 800ppm.

4.2.5. Hydrology

River Ezousa

The Ezousa River channel is hydrologically represented by the flows of the Ezousa stream as measured at Acheleia river gauging station. Basic statistics from this gauging station (Table 4-1) indicate that the highest instant flows occur in December, January, February and March. Flow values as high as 125m^3/sec were estimated for December 1968. High flows of 30-70m^3/sec are not uncommon for the Ezousa river.

The months of July to October are considered dry and for the most of the time the streamflow is zero. However, summer thunderstorms in the area result in flooding which is occasionally severe.

Table 4-1 Monthly and Yearly Flows and Averages (Ezousa River - Acheleia Gauging Station)

	Monthly River Flow (m^3 x 1000)											
Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Annual
65-66	420	4	1150	5500	1250	1050	200	74	3	0	0	2	9653
66-67	60	540	4500	6700	10700	24000	6700	3500	300	14	0	0	57004
67-68	22	400	880	10000	5000	3100	500	115	0	0	0	0	20017
68-69	170	2600	18100	20400	5200	13600	2700	1150	100	3	0	0	64023
69-70	0	180	420	640	450	960	145	130	9	0	0	0	2934
70-71	0	66	165	145	1500	190	1800	7	0	0	0	0	3873
71-72	0	0	48	86	0	7	0	78	0	0	0	0	214
72-73	1	0	0	6	10	0	1	180	0	0	0	0	198
73-74	4	1	0	230	0	52	0	0	0	0	0	0	287
74-75	0	37	1000	2300	12200	3800	230	790	11	0	0	0	29360
75-76	0	0	400	2200	920	1090	330	115	5	0	0	0	5020
76-77	19	290	850	2200	110	1000	630	17	0	11	0	0	5157
77-78	0	0	1300	2300	10600	4500	2700	620	15	0	0	0	29035
78-79	0	0	400	1650	1400	220	26	0	0	0	0	0	3696
79-80	0	0	1300	5900	6600	9300	3200	570	22	0	0	0	26692
80-81	0	0	0	8600	12500	5300	7800	1000	200	61	0	0	30461
81-82	0	130	1200	1300	2100	3900	1100	79	3	0	0	00	9812
82-83	0	0	3	690	3100	5600	1000	210	5	0	0	0	10608
83-84	9	77	400	1250	2900	1450	1650	240	0	0	0	0	7976
84-85	0	130	94	3500	5300	1650	350	0	0	0	0	0	11024
85-86	1	0	36	1500	1400	96	0	0	0	0	0	0	3033
86-87	0	0	115	1800	980	11100	1660	360	0	0	0	0	16005
87-88	0	0	520	2100	5800	18000	3600	1050	21	0	0	0	31091
88-89	0	0	4300	10300	2900	1200	98	12	0	0	0	0	18410
89-90	0	0	0	0	1650	410	13	0	0	0	0	0	2073
90-91	0	0	0	0	0	0	0	0	0	0	0	0	0 *
91-92	0	0	5000	2200	4400	1850	220	2	0	0	0	0	13672
92-93	0	0	1300	1100	1200	2900	105	34	0	0	0	0	6639

* No average is calculated because of a major change in hydrological regime.

Source - Department of Water Development (1994)

The Ezousa River drains areas covered by gypsum deposits which enrich the flowing water with sulphates. During the winter period the sulphate content is low due to mixing with good quality run-off water from the upper reaches of the watershed. During the early summer period when the streamflows are very low the sulphate content increases values as high as 800-1000ppm sulphate are not uncommon.

Suspended sediments are also very high, especially during the early streamflow periods, i.e., October to November. Actual values are difficult to assess because continuous systematic measurements are not available.

Drainage Channels

Storm water drainage channels developed to collect rainfall and surface run-off from roofs, gardens and particularly streets and parking lots are present in the urban areas of the study area. The drainage channel network has developed in a haphazard manner, comprising existing river channels, old (pre-1960) and modern underground drains and open concrete culverts. The river channels are important components of the system: the channels are large enough to contain the annual storm run-off, they provide a rough, vegetated channel which slow the water flow enhancing ground water percolation, and additionally provide important ecological habitat. The following is a brief synopsis of the natural surface water drainage channels (shown on Figure 3-3):

Lempa Stream runs from Tala through Kisonerga to Lempa on the coast. The catchment is undeveloped, with high soil percolation likely. The upper reaches, above Kisonerga, are well vegetated with high plant and bird species diversity. Lower down, waste white goods (large appliances) have been dumped which could damage culverts in flood conditions.

Koskinas and *Mesoyi Streams* originate in the mountains, near the villages of Trimithousa and Mesogi, and run through Chlorakas to the sea. They receive mountain road run-off, and are prone to heavy flows and flash floods. The river valleys are wide, with incised channels and the channel vegetation tends to be grassy, with few trees. Small industrial developments have resulted in partial blockage of the river channels and the river eroding new channels. Flood waters carry a high sediment load and wastes, dumped within the channel, which block under-road culverts.

Limnarka River has a wide channel with gently sloping sides. It is grassy, with few trees, and provides an attractive open space near Kato Pafos. It is likely to have the capacity to contain flood run-off.

The importance of the river channels is recognised in the Pafos Local Plan, which prohibits development directly within the channels, and minimises development immediately adjacent to the rivers. However, a number of recently constructed properties have been built over natural drainage channels, thereby exacerbating the flooding problem during periods of intense rainfall.

The surface water drainage network is currently incomplete, in that significant areas of Pafos flood during heavy rains. The street pattern and gradients are such that storm water run-off is directed to the Old Market of Pafos, and houses and shops in the area are occasionally flooded.

A second area of flooding is in the Kato Pafos area, where again the gradients and an underground parking facility minimise storm water run-off to the sea. A historical monument (Panagia Theoskepasti Church), hotels and office blocks are threatened with flooding in addition to local shops and houses. In the heavy rains of November 1994, an emergency drainage channel was built to direct the water to the sea, and this channel now forms part of the storm water drainage network. It is likely that flooding problems in this area have been alleviated.

4.2.6. Soils

The superficial soil cover comprises recent alluvium and terrace soils and red ferrogenous soils. They cover the river valleys, the coastal plain and the older terraces. Soils are relatively thin on the old terraces and attain thicknesses of up to two metres in the coastal plain river valleys.

4.2.7. Seismic Risk

The regional tectonics of Cyprus are governed by the subduction zone resulting from the collision of the African and Eurasian Plates which zone runs roughly parallel to the south of the south-western, southern and south-eastern coastlines of Cyprus. There is a multitude of seismic epicentres crowding this zone.

The seismic zoning of Cyprus is characterised by increasing seismic intensities from the Troodos Mountains to the south-west, south, south-east and east (Figure 4-2). The zone of highest maximum observed intensities (intensities between 8 and 10 of the Medvedev-Sponheuer, Karnik or M.S.K. scale) runs along the southern coast of Cyprus, from Pafos to Famagusta, including the whole of the study area. Several tens of earthquakes, ranging in magnitude from 4 to 6.5 with epicentres within distances of less than 50km for the limits of the study area have been recorded.

Cyprus has experienced destructive earthquakes in both historical and recent times. Pafos in particular, has experienced the destructive effects of earthquakes twice in the last 50 years. In 1953 an earthquake caused the destruction of a number of villages in the District of Pafos and the collapse of several buildings in the town of Pafos. Recently, on 23 February 1995 an earthquake of magnitude 5.4 on the Richter scale caused the destruction of a number of houses in the villages of Arodes, Miliou, Peristerona, Argaka, Latsi, Akourdalia, Polis Chrosohou and other neighbouring villages and the loss of two human lives at the village of Miliou (all located to the north of the study area). The epicentre of this earthquake was located in the Chrysochou Bay, about 35km north of the town of Pafos. The Government has embarked on a programme of assessing the material damages which are estimated at four million pounds. Complete reconstruction is required for the totally collapsed or severely damaged houses.

From 1 July 1993, proposed civil engineering structures must be designed in accordance with the Seismic Code for Reinforced Concrete Structures in Cyprus. This code sets down minimum design requirements to be met when dealing with seismic situations. It also sets down the Design Criteria and defines the Seismic Action to be considered in the design. The code provides a Seismic Risk Map (Figure 4-3).

A detailed seismic study was carried out for the design of Evretou dam (to the north of the study area) incorporating an analysis of over 3000 earthquakes between 1900 and 1987. This study could be used as the basis for the structural design of the Sewage Treatment Plant although, obviously, the necessary adjustments will be made for the location and geology of the site.

Particular attention must be given to the structural design of the sewers. The material selected for construction of the sewers and the joints between sewers and between sewers and manholes must be capable of sustaining earth tremors. Designers should endeavour to produce a design capable of accommodating earthquake action with least disruption to the sewerage system.

4.2.8. Climate and Meteorology

The climate is typically Mediterranean with hot, dry summers, damp, mild winters and very short autumn and spring periods.

Details from four monitoring stations are presented:

- Pafos Airport (Station Number 82)
- Acheleia (Station Number 81)
- Mavrokolympos Dam (Station Number 38)
- Asprokremnos Dam (Station Number 94)

Table 4-2 presents monthly and annual precipitation (mm) and Table 4-3 presents recorded mean hourly wind speeds and directions. Figure 4-1 shows wind-roses indicating prevailing wind directions in Cyprus.

Table 4-2: Monthly and Annual Precipitation (mm) (1961 - 1990)

Station Number and Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
82 Pafos Airport	94	69	49	24	10	1	0	0	2	31	52	98	430
81 Acheleia	96	70	49	25	11	1	0	0	2	36	52	101	443
38 Mavrokolympos Dam	99	77	54	23	10	0	1	1	2	30	60	101	458
94 Asprokremnos Dam	95	70	51	24	11	1	0	0	2	34	53	100	441

Table 4-3: Mean Monthly Wind Direction and Speed at 10m Measured at Pafos Airport (1983-1993)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Mean Daily Wind[1]	03/8	03/9	04/8	27/8	27/7	27/7	27/6	28/6	28/6	04/7	03/8	03/8
Highest Mean Hourly Wind[1]	24/29	28/34	09/30	09/26	14/26	30/20	30/21	30/19	28/20	08/25	26/32	33/30
Highest Gust[1]	25/64	19/53	10/49	06/41	16/45	30/31	28/29	29/27	28/29	03/44	15/49	25/50

[1]Note: Direction in tens of degrees, speeds in knots.

The average annual precipitation (1961-1990) for Acheleia is 443mm, the majority of this falling during the winter months (Nov, Dec, Jan & Feb). The summer months (June to Sept) are characterised by low to zero precipitation. Winter rain tends to be of a torrential nature, with flash storms comprising the vast majority of the rainfall (Table 4-2).

There are distinct changes in the daytime wind direction in the Pafos region which are typical of a Mediterranean coastal area. The prevailing daytime wind blows from the west; this veers to a north-easterly direction at night. In the early mornings, there is a light to gentle (5-10 knots) north-easterly wind. By 1000 in the winter and as early as 0600 in the summer, this becomes a gentle westerly sea breeze. By 1700 hours in the winter and 1900 hours in the summer, the direction reverts to a north-easterly. The average annual windspeed at Pafos Airport is 7.3 knots (1983-1993). The highest mean hourly windspeed recorded at this station was 34 knots from the west-northwest in February. The highest gust recorded at Pafos airport was 64 knots in January from the west-southwest. Table 4-4 presents daily wind direction and speed variations at Pafos airport and Acheleia.

The odour assessment (Appendix E) used worst case meteorological conditions to assess dispersion. The conditions include the windspeed, atmospheric stability category and mixing height which are likely to generate the highest ground level concentration from the modelled releases. These meteorological parameters are interrelated. A windspeed of 1m/s (1.94 knots) was selected by the model. The higher average windspeeds reported for Pafos Airport (Table 4-3) are likely to generate better dispersion conditions and therefore lower ground level concentrations.

Table 4-4: Daily Wind Variations

Mean Hourly Wind at 10 Metres - Pafos Airport (1989-1985)												
Hour Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
0600	050/ 9.0	050/ 9.9	050/ 8.1	050/ 6.9	050/ 5.6	320/ 5.0	320/ 4.7	050/ 4.5	050/ 5.4	050/ 7.3	050/ 7.5	050/ 7.7
1200	270/ 9.5	270/ 11.5	270/ 10.4	270/ 10.4	270/ 8.7	270/ 8.4	270/ 8.3	270/ 8.1	270/ 9.3	270/ 8.3	270/ 8.6	270/ 8.7
2000	050/ 8.7	050/ 9.3	050/ 8.0	320/ 7.4	320/ 6.3	320/ 6.4	320/ 5.5	320/ 6.2	320/ 5.0	050/ 6.3	050/ 6.4	050/ 6.5
Mean Hourly wind at 7 metres - Acheleia (1982 - 1985)												
Hour Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
0600	050/ 8.4	050/ 8.0	050/ 7.0	050/ 5.6	050/ 4.7	050/ 4.3	050/ 4.1	050/ 4.3	050/ 5.8	050/ 7.6	050/ 8.0	050/ 8.5
1200	270/ 6.6	270/ 8.0	270/ 7.2	270/ 8.0.	270/ 8.0	270/ 8.4	270/ 8.2	270/ 8.2	270/ 8.0	270/ 7.0	270/ 6.6	270/ 6.4
2000	050/ 6.6	050/ 6.4	050/ 5.2	320/ 3.9	320/ 3.5	320/ 3.3	320/ 3.1	320/ 2.9	320/ 2.9	050/ 4.3	050/ 5.8	050/ 6.8

Note: Wind direction is presented as degrees from which the wind is blowing, windspeed is in knots.

The mean daily summer temperatures range between 22°C to 26°C, with extreme maximum monthly temperatures as high as 42°C (July 1978, Acheleia). Throughout the winter mean daily temperatures fall to around 13°C, however, during extreme periods the temperature falls to below freezing (Table 4-5).

Table 4-5 Temperature and Relative Humidity for the Pafos Airport and Acheleia Monitoring Stations.

Pafos Airport (1984 - 1990)													
Temperature in °C; Relative Humidity (RH) in %													
Months	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
Mean Daily Max. Temperature	16.7	16.9	18.0	21.4	24.4	27.0	29.4	30.1	28.9	25.6	21.6	18.4	23.2
Mean Daily Min. Temperature	8.1	7.9	8.3	11.0	14.5	17.5	20.2	20.4	18.6	15.5	12.2	9.4	13.6
Mean Daily Temperature	12.4	12.4	13.1	16.2	19.4	22.2	24.8	25.3	23.8	20.5	16.9	13.9	18.4
Mean No. of Days With Air Frost	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Mean R.H. 0800 hrs	75	74	70	64	66	72	71	68	60	58	67	71	68
Mean R.H. 1300 hrs	62	61	64	65	65	70	70	68	64	58	58	58	64
Acheleia (1976 - 1990)													
Temperature in °C; Relative Humidity (RH) in %													
Months	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
Mean Daily Max. Temperature	16.6	16.9	18.6	22.5	26.1	29.3	31.5	31.5	29.9	26.7	22.4	18.5	24.2
Mean Daily Min. Temperature	8.6	8.5	9.5	12.3	15.3	18.6	21.1	21.3	19.7	16.7	13.0	10.1	14.5
Mean Daily Temperature	12.6	12.7	14.1	17.4	20.7	23.9	26.3	26.4	24.8	21.7	17.7	14.3	19.4
Mean No. of Days With Air Frost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean R.H. 0800 hrs	74	71	71	63	61	64	65	65	61	57	64	71	66
Mean R.H. 1300 hrs	63	62	63	57	55	56	58	60	58	54	55	61	58

Evaporation within the region greatly exceeds rainfall, which is important in the context of water reuse for irrigation. The relationship between rainfall and evaporation largely determines the rate at which effluent can be used for irrigation and influences the design of storage facilities. Table 4-6 presents the monthly and annual Class A pan evaporation (mm) recorded at Pafos Airport, Acheleia and Asprokremnos Dam.

Table 4-6: Monthly and Annual Class A Pan Evaporation (mm) 1976 - 1990)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Yr
Pafos Airport	87	94	126	156	200	216	222	222	182	147	106	96	1875
Acheleia	73	71	99	140	189	221	236	220	185	144	102	77	1757
Asprokremnos Dam	82	81	107	175	209	263	282	268	236	184	126	96	2108

4.3. Marine Conditions

The coastline near Pafos includes attractive sandy beaches and occasional rocky outcrops, providing a significant tourist attraction to the area. In addition, the rich marine resources support an active fishing industry.

The waves approach from the east-south-east and from the west-north-west (120-300°), with a wave fetch of 300km and 1,000km respectively. The most severe storm conditions are from the west and north-west. The tidal range is about 0.3m (mean spring tide) and 0.1m (mean neap tide) (Delft Hydraulics, 1989).

The areas under consideration are described in greater detail below.

The marine environment beyond Coral Bay, one of the most popular tourist beaches along the coastline has a heavy demand for coastal recreational activities, and similarly for on-land coastal development. The bay adjacent and to the south of Coral Bay has limited tourist potential, as the strong currents result in dangerous swimming conditions.

The marine environment north west of the Airport has an attractive sandy shoreline. The beaches are predominately used for recreation by locals. The off-shore bathymetry is quite complex due to rocky outcrops, the highest of which emerge above the water level and are named Moulia Rocks (see Figure 1-1). The water depth at 3km from the headland to Moulia Rocks is about 18m, although in the Ezousa River, the water depth is about 25m one kilometre from shore.

The coastal environment adjacent to Pafos International Airport is heavily modified by the Pafos airport. The airport boundary fence restricts human access to a narrow coastal strip, which includes a shingle beach and encroaching coastal vegetation. The shore gradient is steep, and the water depth is about 25m one kilometre from shore.

The marine environment south east of the Airport to the Diarizos estuary is relatively undeveloped and the shingle bench, which contains a rich halophytic plant community, is bounded by almost flat and highly productive agricultural land. The shore gradient is somewhat more gentle, with a water depth of 25m achieved 1.5km from shore.

The water quality in the Pafos region (expected to apply to all Areas of Search under consideration) is high. Microbial contamination is very low, and turbidity is likewise low. Oxygen saturation is 100%. The nutrient status is unknown, but it is likely to be slightly elevated above natural levels due to septage leachate and fertiliser run-off, although there was no evidence of marine eutrophication during the site visit (March). Water quality and water current measurements have not been taken in Pafos or in the area of Moulia Rocks.

The marine biota were studied for the proposed marina EIA near the airport (UNEP 1990). The species diversity was low (18 species), and the population densities were very low (generally only one representative of each species found per sample). The fauna included sea urchins, worms, and crustacea. The sea-weeds included sea-grass, which is a protected species within the Mediterranean, and also serves as a critical feeding and rearing ground for many marine creatures, including commercially important species. The sea-grass beds are particularly rich at and around Moulia Rocks.

The abrupt cliff drop offshore results in deepwater upwelling and increased productivity. Fishermen particularly fish the rocky outcrops of Moulia Rocks off the Ezousa estuary, which are both productive and sheltered in rough weather. The wide open bays and exposed headlands along the coastline are not regularly used for commercial fishing.

A commercial fish farm for fattening sea bass and sea bream for export was recently moved to Moulia Rocks. The fish farm is an important, large scale commercial venture. As the fish farm interferes with the fishing vessels going to Moulia Rocks, it is due to be relocated to opposite the airport.

4.4. Biotic Environment

4.4.1. Introduction

The information presented below is based upon site visits and published data, particularly the Environmental Study on the impact of proposed waterworks in the Ezousa Watersheds (Balasha Jalon Consultants, 1992).

The limited time available did not allow detailed investigation and sampling of flora, in particular, to be carried out.

The description of flora makes use of the areas identified in the Site Selection exercise in Chapter 6 (see para 6.2 and Figure 6-1 below).

4.4.2. Flora

The sites A and B are located in the Mamonia Formation. Site A is located in the surroundings of Mavrokolympos dam while site B is just east of Agia Marinouda Village. The rest of the sites, i.e. C, D, E1 and E2, are located on the coastal zone on sedimentary rocks of the Plio-Pleistocene age and on younger marine terrace and deltaic deposits.

The composition of the Mamonia rocks is such that allows the existence of rich flora habitats. Vegetation on site A includes many drought-resistant wild flowers, short grasses and scattered trees. For this particular area, soil analysis and systematic sampling of the flora is required to enable more definite conclusions.

The flora present on the area of site B is considered to be very interesting. The many types of rocks present in this area form different types of soil, which in turn enhance the growth of a high variety and density of plant communities. The area is unique and merits a more detailed survey of rocks, soil type and plant species. (Balasha Jalon Consultants, 1992, p. 8-11).

The other high areas of Anatolikon, and Kouklia to the south support a richer grassy community. These areas are not intensively cultivated; tall grass meadows with a high density of wild flowers predominate. Small fields are cultivated with crops such as wheat, and carob orchards are also present. The limestone pavement to the north of these areas has thin soil supporting plants tolerant of nutrient impoverishment and drought conditions. many of these flora are rare or endemic (Balasha Jalon, 1992), and comprise in some cases important plant communities.

The coastal plain is heavily cultivated, with irrigation as part of the Southwest Irrigation Project being regularly undertaken. The pockets of native flora along tracks, within abandoned or uncultivated fields and along the river and drainage channels are floristically rich, and had lush growth at the time of the field survey. The sedimentary and marine terrace sediments have thin redzina soils which support maqui and garique vegetation with scattered trees. Communities of *Ceratonia sillqua*, *Pistacla lenticus* and *Crataegus azarolus* are common. Shrubs, sub-shrubs and grasses like *Hyparrenia hizta* are also present.

The areas covered with deltaic and river sediments contain thick layers of gravels, sands and silt which form rich soils. This, together with the presence of plentiful water in the area, supports the growth of thick vegetation. The main plant communities in these areas, and in particular in area C, are *Phragmites austalis* and *Sachharum ravennea*, *Arundo* and *Vitex anguseastus*. For a more detailed list of plants present in the coastal zone, see Balsha Jalon Consultants, 1992 p. 8.12.

Natural vegetation along the beach margin was typical halophylic communities of low species diversity.

4.4.3. Fauna

Birds

The whole of the study area is disturbed to a greater or lesser extent. The upland areas are more remote and human presence is at a low level, although probably on a daily basis. The coastal areas are heavily modified by man, and traffic (vehicles and aeroplanes) are continuously present. Animal and bird species present in the areas under study are likely to be relatively common and adjusted to semi-natural habitat with human presence.

The drainage channels, both the natural river channels and the non-concreted drainage channels running through urban areas, are likely to support a higher diversity of birds, reptiles and small mammals than the surrounding urbanised landscape, and are the most important habitat type within the study area.

4.4.4. Significance of Area and Ecology

The study area is typical of the cultivated coastal zones and the Mamonia and chalky hilly lands to the south-western flanks of the Troodos range. The community types are not unique or endangered. The flora and fauna expected in these habitats are common in Cyprus, although the hilly areas are expected to support a greater species diversity and possibly species of ecological significance.

The Ezousa River channel supports natural flora within the agricultural coastal plain, and probably acts as an important habitat for small animals and birds, and is a travel route for other species.

Within the urban context, the existing drainage channels form important, un-developed habitat "islands". They are likely to provide nesting and feeding sites as well as travel routes for many types of animals and birds.

4.5. Socio-Cultural Environment

4.5.1. Introduction

This section deals in turn with the demographic profile of the study area, housing, economic and employment aspects (focusing on the tourism industry), land use and planning policy. The relevance of these socio-economic characteristics stems not only from the need to match the capacity of the sewage collection and surface water systems to future patterns of demand, but also from the need to ensure that future socio-economic and land use changes are taken into account in the siting of the Sewage Treatment Works (STW).

4.5.2. Demographic Profile

The main source of demographic data is the Census of Population 1992, the reference date for which was 1 October 1992. Comparative data for the illustration of trends are drawn mainly from the 1982 Census. Most data relate to the Pafos Urban Area which is defined in the 1992 Census and comprises the Municipality of Pafos and the settlements of Geroskipou (now also a municipality), Agia Marinouda, Koloni, Anatolikon, Acheleia, Konia, Chlorakas, Empa, Lempa, Kisonerga, Maa, Tala, Trimithousa, Mesogi and Mesa Chorio. Five of these settlements were not included in the Urban Area in the 1982 Census, so appropriate adjustments have been made to the 1982 figures to ensure consistency.

The population of Pafos Urban Area in October 1992 was 32,575, an increase of 10,369 (or 46.7%) on the 1982 adjusted figure of 22,206. In contrast, the Pafos Rural Area's population fell from 23,439 in 1982 to 19,997 in 1992, a decline of 3,442 (or 14.6%) over the 10 year period.

The increasing concentration of population in urban and suburban areas is a trend common to all five districts in the Government controlled area. However, it is more pronounced in Pafos District than in any other part of Cyprus. Using 1992 boundaries, the population of Pafos District was 48.6% urban and 51.4% rural in 1982, whereas it was 62.0% urban and 38.0% rural in 1992.

The age structure of the population in the rural areas of Pafos district is typical of an area experiencing population decline due to net out-migration. In 1992, 23.4% of the rural population were aged 65 or over compared with 8.1% of the urban population; whereas only 19.3% of the rural population were under 14 compared with 28.2% of the urban population.

These and other key factors of the area's demographic profile are presented in Table 4-7.

Table 4.7: Demographic Profile

	Pafos District			Cyprus (Govt. Controlled Area)		
	Urban	Rural	Total	Urban	Rural	Total
1992 Total Population	32,575	19,997	52,572	407,324	194,701	602,025
1982 Total Population	22,206	23,439	45,645	325,645	186,712	512,098
Growth 1982-92	10,369	-3,442	6,927	81,938	7,989	89,927
% Growth 1982-92	46.7%	-14.6%	15.2%	25.2%	4.3%	17.6%
1992 Residence (%)	62.0%	38.0%	100%	67.7%	32.3%	100%
1982 Residence (%)	48.6%	51.4%	100%	63.5%	36.5%	100%
Age Structure (1992)						
0-14	9.5%	6.5%	8.4%	8.3%	8.6%	8.4%
5-19	25.3%	18.7%	22.8%	23.6%	24.4%	23.8%
20-44	40.1%	27.7%	35.5%	38.6%	34.2%	37.2%
45-64	16.7%	23.7%	19.4%	19.8%	18.8%	19.5%
65+	8.1%	23.4%	13.9%	9.6%	13.8%	11.0%
Sex Structure (1992)						
Male	51.0%	49.6%	50.4%	49.5%	50.2%	49.8%
Female	49.0%	50.4%	49.6%	50.5%	49.8%	50.2%

Sources: 1982 and 1992 Censuses of Population
Note: 1982 data for the Pafos District have been adjusted to ensure consistency following re-definition of the Urban Area in 1992.

4.5.3. Population Projections

The Department of Statistics and Research in the Ministry of Finance has produced population projections for the period 1998-2028 for the Pafos District. These are shown in the left hand column of Table 4-8 below.

In order to produce a realistic estimate of the urban area's population (and hence an estimate for STW and sewerage design), the following assumptions have been made:

- that the proportion of the district's population living in the urban area will reach the 1992 national average of 67.7% by 2003
- that the population will thereafter increase by 0.5% per annum up to 2013 when it will reach 72.7%

- that the proportion will then remain stable at this figure until the end of the projection period.

Table 4-8: Population Projections - 1998-2028

Year	Pafos Region[1]	Urban Area[2]	Rural Area[2]
1998	57,637	37,377	20,260
2003	60,012	40,628	19,384
2008	62,318	43,747	18,571
2013	64,690	47,030	17,660
2018	67,033	48,733	18,300
2023	69,128	50,256	18,872
2028	70,971	51,596	19,375

1 Dep. of Statistics and Research, Ministry of Finance
2 Consultant's Estimates

The official projections for Pafos District as a whole suggest that the total population growth of 13,334 between 1998 and 2028 will largely be a result of natural change rather than net in-migration. The annual growth of 475 between 1998 and 2003 is projected to comprise a natural increase of 379 and net in-migration of 96. At the end of the projection period (2023-2028), annual growth is projected to reduce to 368, comprising a natural increase of 330 and net in-migration of 38.

4.5.4. Population Distribution

Table 4-9 presents the distribution of population within the Pafos Town Region (the Municipality and Greater Urban Area), and in a few selected settlements outside the Urban Area which may be affected by alternative siting proposals for the sewage treatment plant. The table contains data for both 1982 and 1992, allowing assessment to be made of changes in the intercensal period.

In 1992, 59.7% of the population of the Town Region lived in Pafos Municipality, compared with 15.8% in the Greater Urban Area SE of Pafos and 24.5% in the Greater Urban Area north of Pafos. In the south-east area, the population is heavily concentrated in the Municipality of Geroskipou, whilst to the north the population is more evenly distributed among several suburban or semi-rural settlements (Figure 4-5).

Table 4.9: Population Distribution - 1982 and 1992

	1982	1992	Change
PAFOS TOWN REGION	22,206 [1]	32,575	10,369
Pafos Municipality	**13,506**	**19,452**	**5,946**
- Moutallos	2,411	2,190	-211
- Agios Pavlos	3,176	5,037	1,861
- Agios Thedoros	6,556	9,467	2,911
- Kato Pafos	981	1,966	985
- Anavargos	382	792	410
Gtr. Urban Area SE of Pafos	**3,361**	**5,142**	**1,781**
- Geroskipou	2,634	4,156	1,522
- Konia	416	588	172
- Agia Marinouda	65	93	28
- Koloni	144	200	56
- Acheleia	92	74	-18
- Part of Airport (Timi)	10 [2]	16	6 [2]
Gtr. Urban Area N of Pafos	**5,309**	**7,981**	**2,672**
- Chlorakas	1,470	2,032	562
- Lempa	38	194	156
- Empa	1,175	2,069	894
- Trimithousa	369	393	24
- Mesa Chorio	225	276	51
- Mesogi	752	1,061	309
- Tall	426	730	304
- Kisonerga	809	1,092	283
- Maa (Coral Bay)	70 [2]	122	52 [2]
- Part of Koili	5 [2]	12	7 [2]
Selected Rural Area Settlements SE of Pafos			
- Agia Varvara	51	51	0
- Anarita	329	327	-2
- Kouklia	683	672	-11
- Mandria	488	417	-71
- Nikojleia	92	74	-18
- Timi	622	840	218
- Marathounta	234	226	-8
- Armou	265	275	10
- Akoursos	44	48	4
- Kathikas	515	386	-129
- Pegeia	1,195	1,551	356

Source: Censuses of Population 1982 and 1992
Notes: 1: Figure adjusted to 1992 Town Region area.
2: Estimated (due to boundary changes in intercensal period)

Between 1982 and 1992, Pafos Municipality increased its resident population by 44.0%. This compares with a growth of 53.0% in the Greater Urban Area south-east of Pafos (most of which was in Geroskipou), and 50.3% in the Greater Urban Area north of Pafos where the growth was more evenly distributed.

Outside the Greater Urban Area, a number of settlements to the south-east and east experienced small population declines between 1982 and 1992, the exception being Timi. To the north, population growth focused on Pegeia.

4.5.5. Housing Data

The housing stock in the Pafos Town Region is shown in Table 4-10.

Table 4-10: Housing Stock in Pafos Town Region, 1992

	Total Living Quarters	Used as Usual Residence	Vacant or Temporary Residences
Pafos Municipality	8,548	5,948	2,600
Greater Urban Area SE of Pafos	1,739	1,495	244
Greater Urban Area N of Pafos	3,571	2,440	1,131
Total	13,858	9,883	3,975

Source: Census of Population 1992

Over the Town Region as a whole, 28.7% of the housing stock consists of dwellings which are not occupied as normal residences. This is largely due to the number of holiday houses and second homes in the Pafos area.

The figures in Table 4-10 conceal very considerable local variations. In Kato Pafos, for example, 65.3% of the housing stock of 2,089 consisted of vacant or temporary residences. In Geroskipou, by way of contrast, only 11.7% of the housing stock of 1356 was vacant or in temporary occupation.

The extent of recent development in the Greater Pafos Area is indicated in Table 4-11 below showing the year of construction of conventional dwellings. Across the Town Region as a whole, 63.4% of the 1992 conventional housing stock had been built within the previous 12 years.

Table 4-11: Conventional Dwellings by Year of Construction

		Year of Construction						
	Total	**Before 1950**	**1950-1959**	**1960-1969**	**1970-1979**	**1980-1989**	**1990-1992**	**Not Stated**
Pafos Municipality	8,490	496	489	649	1,201	4,316	1,287	52
Gtr Urban Area SE of Pafos	1,725	193	65	162	272	753	247	33
Gtr Urban Area N of Pafos	3,530	384	145	207	567	1,481	633	113
Total	13,475	1,073	699	1,018	2,040	6,550	2,167	198

Source: Census of Population 1992

These figures also indicated that, at the time of the 1992 Census, house building was proceeding at a rate of approximately 700 per year in the Greater Urban Area as a whole. Of this total, about 430 were in the Municipality, 80 in the Greater Urban Area south-east of Pafos and 210 in the Greater Urban Area north of Pafos.

Although no official statistics are available for the period 1992-1995, the views of planning and other officials in Pafos are that house building has slowed somewhat since the late 1980s and early 1990s.

In terms of tenure, the majority of households in the Town Region are owner-occupiers (59.4%). Rented accommodation is occupied by 24.7% of households, with other tenures making up the remaining 15.9%.

A wide range of social indicators relating to housing conditions illustrate improving living standards of the decade 1982-1992. In the Pafos Town Region, average household size fell from 3.55 to 3.29, rooms per dwelling increased from 4.8 to 5.1 and average number of persons per room fell from 0.75 to 0.65.

4.5.6. Employment Structure

Table 4-12 presents unpublished data from the 1992 Census on employment by branch of economic activity. The urban/rural division is by place of residence rather than by place of employment.

Agriculture provides 32.0% of jobs for rural residents and is the largest source of employment, ahead of construction (17.5%) and hotels/restaurants (16.0%).

Table 4-12: Employment Structure in Pafos District by Place of Residence, 1992

	Urban	Rural	Total
Agriculture/Hunting/Forestry	509	2,445	2,954
Fishing	41	29	70
Other Primary Sector	7	25	32
Manufacturing	1,258	491	1,749
Electricity, Gas, Water	78	32	110
Construction	1,762	1,337	3,099
Wholesale/Retail	2,063	550	2,613
Hotels/Restaurants	3,227	1,226	4,453
Transport/Storage	725	399	1,124
Public Administration/Education	1,965	521	2,486
Other Service Sector	2,334	575	2,909
Not stated	34	18	52
TOTAL	14,003	7,648	21,651

The service sector is overwhelmingly dominant for urban residents, providing 87% of all jobs compared with 9.0% for manufacturing industry. A substantial proportion of service sector jobs are directly or indirectly related to the tourism industry, with 23% of jobs in the hotels/restaurants sector.

4.5.7. Development of the Tourism Industry

Between 1988 and 1994, the number of tourist beds in accommodation of all types in Pafos rose from 7,617 to 18,029. Figures for three years in this period are provided in Table 4-13. Growth has been concentrated in three star to five star hotels (which have increased in number from 14 in 1988 to 35 in 1994) and in hotel apartments (22 in 1988 and 42 in 1994).

It is worth noting that the figures contained in the Louis Berger Report significantly underestimate the current provision of tourism beds and therefore provide an estimate for the year 2000 (the sanitary sewerage system stage 1 design year) which is almost certainly too low. The actual number of beds in 1984 (18,029) is only a few hundred short of the 2000 forecast figures of 18,929 suggesting that an upward revision of the Stage 1 Design Year forecast may be required.

The December 1994 figures for beds under construction in Pafos do, however, indicate a slow-down in the very rapid growth of previous years. At that time, only 319 beds were under construction in Pafos - a very much lower figure than at previous year ends since 1988.

Table 4-13: Tourism Accommodation in Pafos, 1988, 1991 and 1994

		No of Beds		
		1988	**1991**	**1994**
Hotels	5*	-	859	2,685
	4*	1,454	2,610	3,944
	3*	1,907	2,937	4,147
	2*	334	333	333
	1*	239	271	459
Total Hotels:		3,934	7,010	11,568
Hotel Apartments:				
	A	818	1,242	2,008
	B	459	627	805
	C	428	520	702
Total Hotel Apartments:		1,705	2,389	3,515
Tourist Villages		-	-	222
Villas		318	318	382
Tourist Apartments		1,386	1,959	1,908
Furnished Apartments		140	475	362
Hotels without *		96	34	34
Guest Houses		38	38	38
Total Beds:		7,617	12,223	18,029

Source: Cyprus Tourism Organisation

The Cyprus Tourism Organisation also produces figures for overnight stays by visitors. In all types of accommodation, the number of overnight stays in Pafos rose from 1,543,775 in 1988 to 4,392,739 in 1994. Figures for 1993 show that, for hotel and hotel apartment guests, overnight stays peaked in August (349,089) and were at their lowest in January (90,142). This variation is also reflected in the 1993 room capacity occupancy rates which ranged from 82% in August to 33% in December. Seasonal peaks and troughs in occupancy rates are somewhat less pronounced than in other parts of Cyprus, illustrating the greater popularity of Pafos as a winter holiday destination.

4.5.8. Land Use and Planning

Current Land Use

The extension of the built-up areas within the Pafos Town Region has occurred around the original nucleus of Pafos Town and later nuclei such as Geroskipou, Kato Pafos, Chlorakas and Empa. From these nuclei ribbons of mixed commercial and residential uses (known as activity axles) extend along the main roads to the suburban centres. This form of ribbon development links Pafos Town with Kato Pafos, Geroskipou/Koloni, Mesogi and Chlorakas, with other "axles" extending shorter distances into the suburbs to the north and east of Pafos Town. Ribbons of development also extend from the Pafos-Kato Pafos road (Apostolou Pavlou) northwards along the Tafon ton Vasileon, and south-eastwards from Kato Pafos along the coastal road (Poseidonos).

Between these "axles", the density of development within the designated built-up area is generally extremely low, with substantial areas remaining undeveloped. Development of these areas is governed by the personal decisions and commercial judgements of many small landowners, especially in the extensive residential zones. Small landowners traditionally regard land as a security and an investment or they may retain it to house family members in the future. In land use terms, the consequence is that much of the "built up area" is, in fact, undeveloped, and remains either unused or in small-scale agricultural use.

These areas of low-density development merge into the agricultural land on the fringes of the Town Area. Agricultural land uses in these outer areas divide sharply between the flat irrigated land in the alluvial soils of the coastal plain and the uplands to the east.

Between the Mavrokolympos Dam and River to the north of Pafos and the Asprokremnos Dam and Xeropotamos River to the south-east, there is a total of 3,280ha. of irrigated agricultural land. Some 2,432ha. of this total lies to the south-east of Pafos. High value food crops such as potatoes as well as citrus and grapes are grown in the irrigated coastal plains. A typical feature of the landscape of this area, especially the land either side of the Ezousa River and around Pafos Airport, is the shelter belts of cypress and other conifer species around the citrus and grape plantations.

The upland agricultural areas above the limits of pumping for irrigation are strikingly different in character from the irrigated coastal plain. These areas east of the coastal plain are characterised by extensive areas of natural or semi-natural vegetation used for grazing and by much more limited cultivated areas, mainly used for wheat or tree crops.

Industrial land uses make up only a very small proportion of the Pafos Town Area. The main industrial zone is situated west of the Ezousa River at Anatolikon, with other zones located at Mesogi and north of Geroskipou.

The other principal land use is tourism, occupying much of Kato Pafos and extending, in a south-easterly direction, to the public beach operated by Geroskipou Municipality. Whilst Kato Pafos itself is almost continuously developed, the southern part of this zone is more intermittently developed on the seaward side of the coastal road and virtually undeveloped on the landward side. This pattern is repeated in the coastal area north of Kato Pafos, with virtually continuous development along the Tafon ton Vasileon as far as the municipal boundary and, further north, sporadic development as far as Coral Bay.

Pafos Local Plan

Future land use in the Pafos Town Region is controlled by the approved Pafos Local Plan published in June 1994. In addition to the zoning and density maps, this document includes a written statement setting out land use policy upon which development control decisions are based.

The reluctance of private landowners to release land for development means that the area of land zoned for development in the Local Plan is very much larger than can be justified by any projections of population or economic growth. It is also anticipated that, when the Local Plan is next reviewed (by the end of 1995), amendments to the Plan will be made which will zone additional areas for development by including them in the defined built-up area. Officials expect that the additional land for development will be primarily to the north and east of Pafos, partly because this area above the coastal plain is seen as being more attractive for housing development and partly because of a desire to ensure that high quality irrigated land on the coastal plain retains its agricultural zoning.

The Local Plan provides strict controls on the density of new development; with comprehensive restrictions on numbers of storeys, building heights, plot ratios and plot coverage. These controls all help to reinforce the low density of development across the Town Region.

Controls on tourism development are based not only on the Local Plan but also on the requirement for all such developments to obtain consent from the Cyprus Tourism Organisation (CTO). Currently the policy is to restrict the provision of additional hotel beds and to focus on up-market accommodation such as 5-star, 4-star or occasionally 3-star hotels. Additional apartment blocks will not be permitted. Tourist villages are favoured, with vernacular architecture and extensive areas of open space.

Much of the coastal zone is already dedicated to tourism development, the main exception being the Archaeological Area at Kato Pafos and the area occupied by the Tombs of the Kings. Within this area any type of development which disturbs the soil is, with very few exceptions, impossible.

Pressure for coastal tourism development further south, between the Municipal beach and the Ezousa River, is expected to be considerable, in spite of the planning restrictions. Pressures stem from:

- the wish by Geroskipou Municipality and Koloni Village, which extend to the coast in this area, to see additional tourism development here
- the inflation in land values resulting from a tourism land use zoning
- the proposal to construct a marina in this area, which is supported by CTO.

Land Values

The zoning of land for development has major financial consequences for landowners, especially at times of urban expansion. Given the role of land as an investment in Cyprus, its value and future development potential are jealously guarded. Developments which may adversely affect land values, especially those which may reduce the likelihood of land being zoned for development in the future, are vigorously opposed.

The compulsory acquisition of land by public authorities is widely resented. It is generally considered that government-owned land should be selected for public utilities and other public projects if it is available. Within the Pafos area, the largest block of government-owned land is in the area of Acheleia and Pafos Airport, east of the Ezousa River. The agricultural land in this area either forms part of Acheleia Experimental Farm or is leased to local farmers.

The value of land in the Pafos area, according to estimates from the District Land Office, generally falls within the following ranges:

- Non-irrigated agricultural land — £CY 25,000/ha
- Irrigated agricultural land — £CY 50,000/ha
- Residential land — £CY 100-150,000/ha
- Tourism land (non-coastal) — £CY 250-500,000/ha
- Tourism land (coastal) — £CY1,000,000/ha

The Marina Proposal

One of the key development projects, impacting on future tourism land uses on the waterfront and on possible sites for the sewage treatment works, is the proposed Pafos marina.

A pre-feasibility study has identified four potential sites for the Pafos marina. A preferred site was identified immediately to the west of the Ezousa River mouth, and rough layouts and approximate costs were provided. The site selection is subject to review in an environmental impact assessment which will focus on coastal processes, coastal and marine ecology, airport-related issues and possible conflicts in land use terms with a sewage treatment plant located in this area. It is anticipated that the selected site will, however, remain in the area between the Geroskipou Municipal Beach and the Ezousa River mouth.

The marina will have full facilities, up to 900-1000 berths, dry docking and a land facility. It is seen by the CTO as the main pleasure harbour in western Cyprus with commercial potential to attract shops, offices, restaurants, etc.

Golf Courses

The CTO favours the development of three or four golf courses in the Pafos area, and sees the potential for effluent water to be used for irrigation. The Tsada golf course is the only one currently operating, and this relies on borehole water which may not be an adequate source in the long term. Another application with good prospects is proposed for a site north of Geroskipou (close to Anatolikon), two have been proposed in the Kouklia area, and three north of Pafos. Applicants are expected to submit environmental studies with their applications for permission.

4.5.9. Infrastructure

Roads

The urban area is serviced by an adequate network of paved roads. The major routes are typically 6-7 metre single carriageways, though a number of routes in the main tourist areas are wider carriageways which allow single or double on-street parking. In the rural areas, virtually all major and minor roads are sealed, though in the hillier areas several of the minor roads are of only single-track width.

Congestion in the urban area is predominately a seasonal problem, with the main congested areas being in the narrow streets of the old town, the Pafos-Kato Pafos road and the seafront in Kato Pafos.

The principal new road proposal in the Pafos area is the new Limassol to Pafos road which is proposed to run through the higher ground north-west (and roughly parallel to) the existing Limassol road. This road project should enable a greater volume of traffic to by-pass the town centre.

Other relevant proposals include a road running parallel to the Kotsiatis River which would also link with a proposal to construct a new route to the airport across the lower Ezousa river. This proposal would greatly reduce the road distance between the airport and Kato Pafos, but it is not a firm proposal at this stage. The road would be extremely close to the western end of the airport runway and to the beach.

Water Supply

Two water supply schemes serve the study area:

- The Municipal Water System which serves the Municipality and Anavargos. This system is supplied from drilled wells above the Asprokremnos Dam and additional wells below the dam. A 300mm conveyor feeds the Vasiliko tanks from which central Pafos is supplied. From there water is pumped to tanks which supply the upper part of the town and Anavargos.

- The Lower Village Water Scheme which is also supplied by wells above and below the Asprokremmos Dam. This scheme supplies the villages within the town region through an extensive network of tanks and distribution mains.

4.5.10. Archaeology

The Pafos region is exceptionally rich in archaeological sites and of very considerable importance from a historical and cultural point of view. Palepaphos (near Kouklia village) was founded in the 12th Century BC and became a site of major importance through the classical period largely through the sanctuary dedicated to the worship of the Goddess Aphrodite.

The sanctuary and gardens extended as far as modern Geroskipou, so it is likely that undiscovered remains exist in this area.

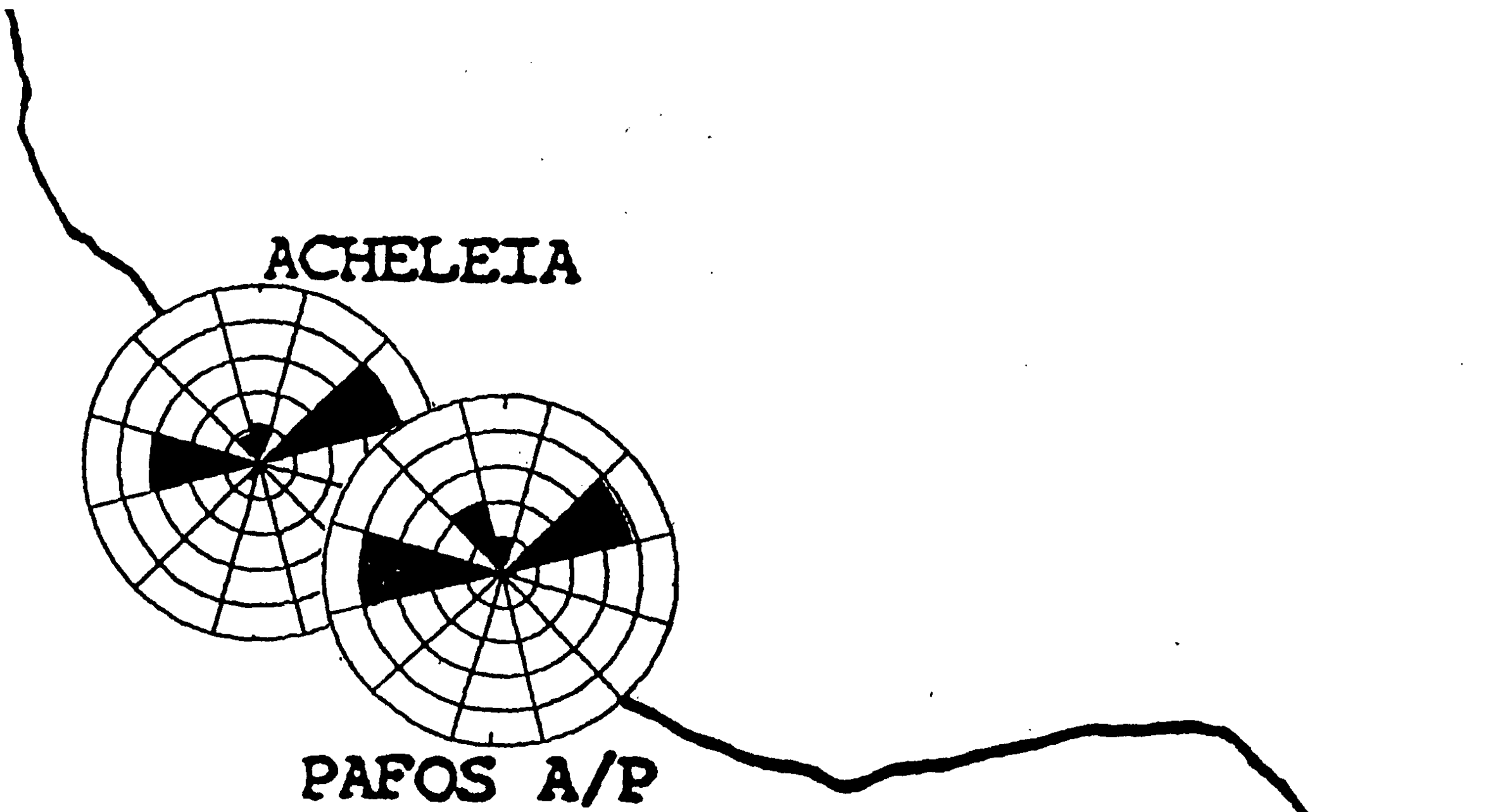
Around the 4th Century BC, the principal settlement moved to its present site. The antiquities in the present town, especially the mosaics, are so important that they are included in the official UNESCO World Cultural Heritage List.

The principal laws protecting archaeological sites in Cyprus are the 1959 Antiquities Law, and later laws of 1964, 1973 and 1974. The system operates as follows:

- if a major site is discovered in the course of development work, site works can be permanently stopped and the land acquired by the Department of Antiquities

- if the site or find is less important, the Department must be informed and an opportunity provided for site investigations to be conducted.

The main designated Archaeological Areas in Kato Pafos enjoy a very high level of protection. A substantial area west of the Pafos-Kato Pafos road, a smaller area to the east of the road, and the area of the Tombs of the Kings are all owned by the Department of Antiquities. It is highly unlikely that consent would be given for any works affecting the ground surface in this area. The car park behind the harbour in Kato Pafos is included in this protected area, though the north-east corner of the car park was proposed in the Feasibility Study as the site for a pumping station.



Note: Each circle corresponds to a 10% increase in the frequency of the wind direction. The outer circle corresponds to 50% of the observations.

Figure 4-1: **Prevailing Wind Directions**

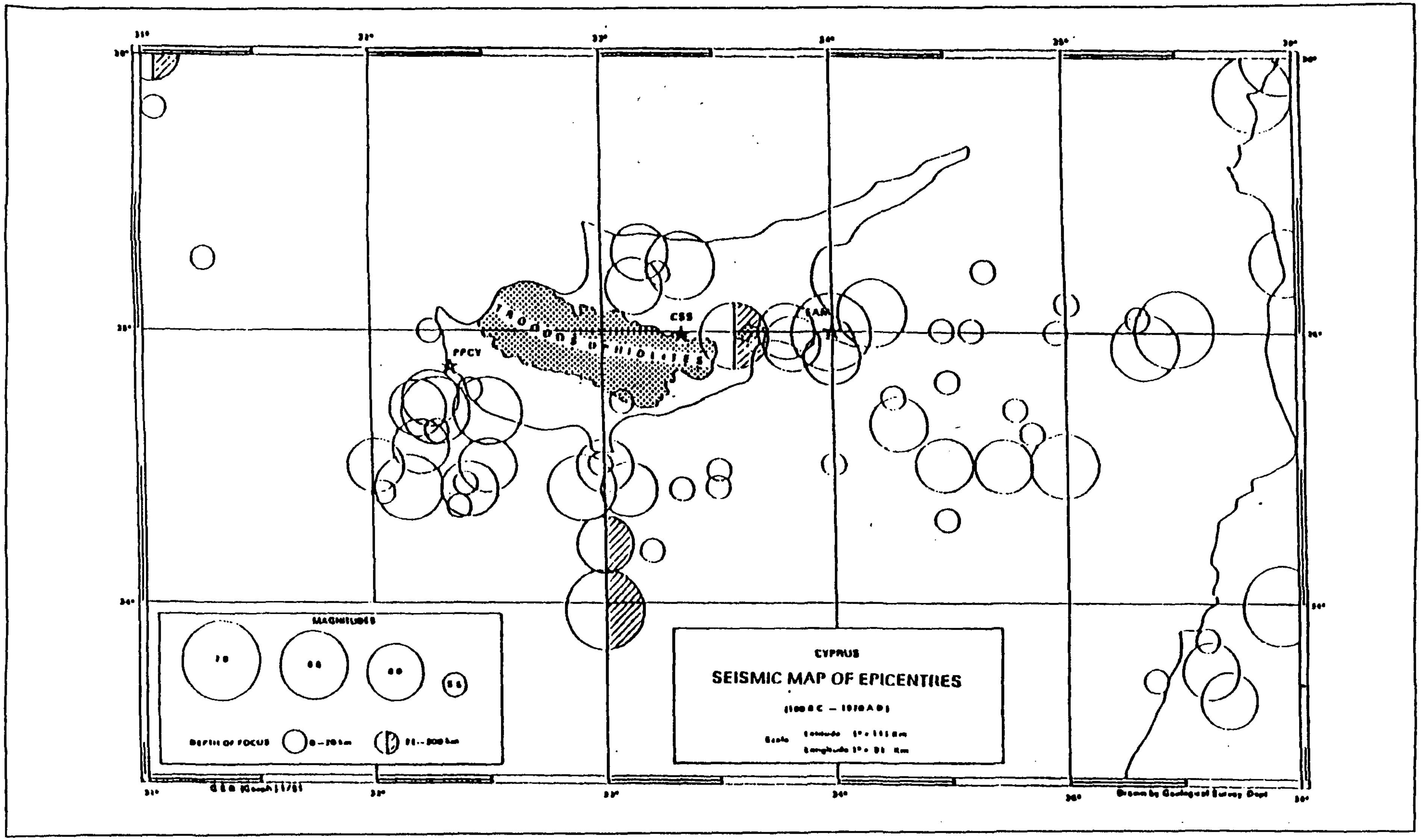


Figure 4-2: **Seismic Map of Epicentres**

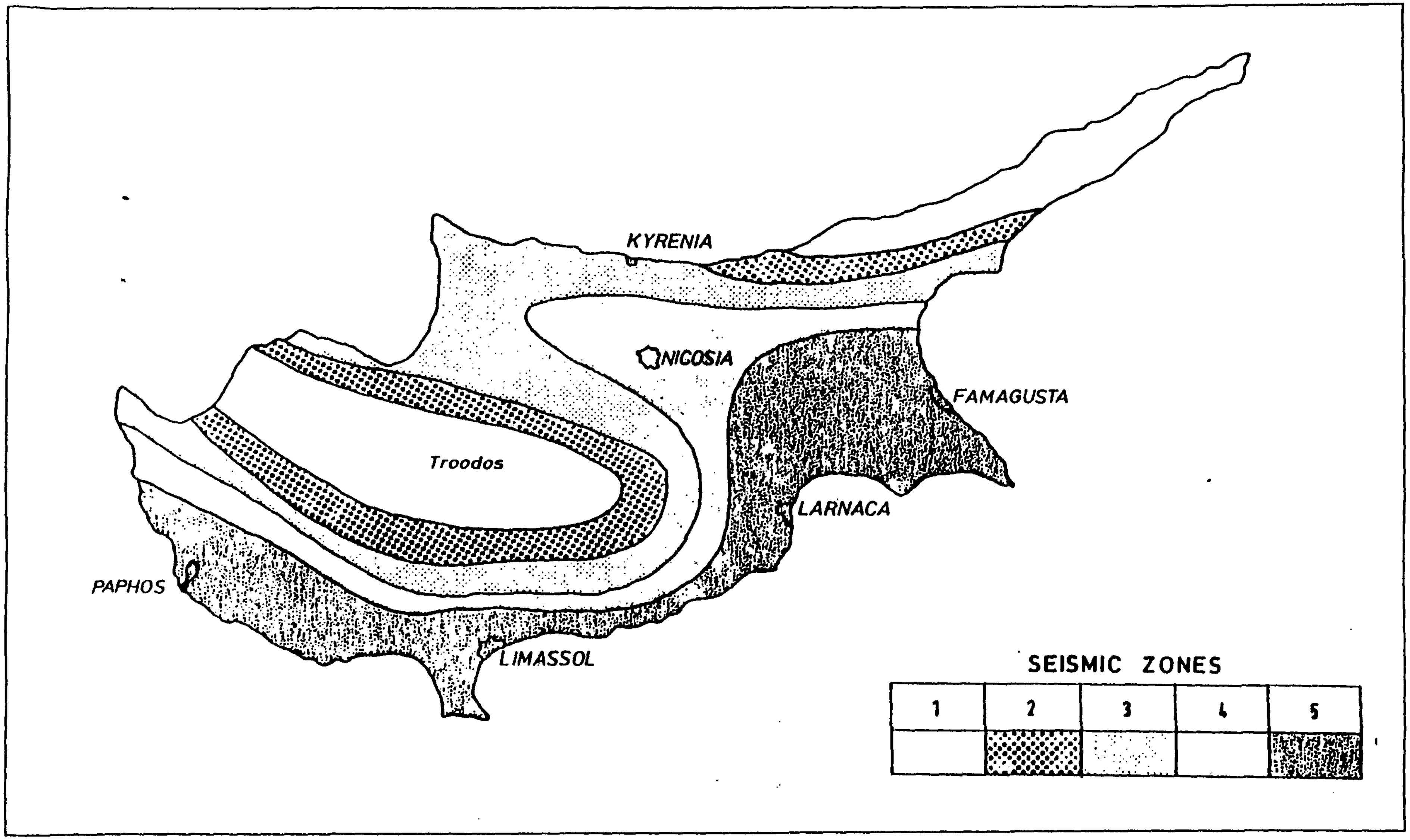


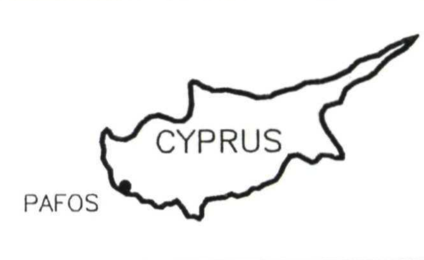
Figure 4-3: **Seismic Code for Reinforced Concrete Structures in Cyprus**

KEY:

- 600 Contours
- Towns/villages
- Main roads
- Rivers

NOTE: Figure given for Pafos includes: Moutallos, Agios Pavlos, Agios Theodoros, Kato Pafos and Anavargos

Metres 2000 0 5 10 Kilometres



MAP TITLE :	JOB NAME :
POPULATION DISTRIBUTION 1992	PAFOS SEWERAGE AND DRAINAGE SCHEME – EIA FOR SEWAGE BOARD OF PAFOS
FIGURE No. : 4–4	JOB No. : WSBE53

5. SIGNIFICANT ENVIRONMENTAL IMPACTS

5.1. Construction Phase

This section reviews the alternatives addressed in the Louis Berger Report and Howard Humphreys/Brown & Root Environmental's assessment of the positive and negative environmental impacts associated with their proposed alternatives.

At the date of this report, the construction programme has not been determined. The Louis Berger Report assumes a four-year construction period, starting in 1994, with commissioning in 1998. This is clearly to be postponed by a period of at least two years.

The impacts from construction of the Sewage Treatment Works will be limited largely to closely neighbouring communities and areas on the main route for transportation of building supplies. The types of impact will include:

- noise from construction plant
- noise and disruption from vehicles delivering construction supplies
- noise and disruption from vehicles used by construction staff and other visitors to site
- dust
- waste disposal, and
- impacts on flora and fauna.

During the commissioning phase for the Sewage Treatment Works a further impact may arise from operation of the process under abnormal conditions. In this period, the volumetric and organic loadings will be substantially lower than design values, and the control and operation of severely underloaded plants can be difficult. This arises particularly because of the absence of sufficient organic matter and other nutrients to develop and sustain the normal bacterial population in the secondary treatment process. Although this period should be brief (pending completion of the foul drainage scheme), it may be accompanied by a tendency to produce more than the expected level of odour, accompanied by a poor quality final effluent.

To some extent this problem can be controlled by tankering of septage direct to the sewage treatment works, and by ensuring via the construction programme that a substantial flow is diverted over the shortest possible period of time.

The sewerage construction phase (both surface water and foul) will have more significant negative impacts, including the following in addition to those listed above:

- excavation noise
- road traffic restrictions in streets undergoing works
- pedestrian traffic restrictions
- financial detriment to businesses, especially shops, to which access is temporarily restricted
- atmospheric pollution from construction machinery
- accidental disturbance to other underground services
- accidental destruction of archaeological sites
- odours,and
- impacts on flora and fauna.

Disturbance to the antiquities area and to the main tourist shopping area of Pafos, the waterfront, will be considerable when the main trunk sewer is laid along Poseidano Avenue.

5.2. Sewage Treatment Works Site Selection

Appendix C should be read in advance of the following discussions.

The Louis Berger Report considered four potential sites for the location of the Sewage Treatment Works (STW):

Site A: On the eastern bank of Ezousa River on the coast.

Site B: On the western bank of the Ezousa River at its confluence with the Kotsiatis River.

Site C: On the western bank of the Ezousa River, just north of the Pafos-Limassol highway.

Site D: In the bed of Ayia Stephanos stream, 1.3km southwest of Kisonerga and 1.2km northwest of Lempa.

The selection criteria to judge the preferred site included:

- proximity to towns and villages
- direction of prevailing winds
- accessibility
- area available for STW and future expansion
- land use and zoning requirements
- topography to minimise pumping, and
- access to a stream which could be impounded as a wastewater storage lagoon in the future.

The four potential sites were not subjected to a uniform and consistent assessment: Site A was rejected due to its proximity to the coast and airport; Site C was rejected due to its elevation; and Site D was rejected due to its proximity to villages. The Louis Berger analysis of STW site selection is given in Table 5.1

Table 5.1: Comparison of Alternatives for the Proposed Sewerage and Drainage Scheme Presented in The Louis Berger Report

Alternative	Advantages	Disadvantages	Status
Sewage Treatment Works Site Location			
Site A	low elevation low cost	close to sea development potential close to airport	reject
Site B	low elevation low cost prevailing winds favourable good access effluent disposal by recharge	low political acceptance privately owned land	adequate
Site C	good access compatible land use	high elevation potentially visible from roads	reject
Site D		high pumping costs close to villages prevailing winds unfavourable	reject
Sewage Treatment Process Operation			
Chlorination of crude sewage		odour potential production of chlorinated organics	re-assess
Enclosure of primary treatment plant		equipment failure potential human safety	re-assess
Aerated grit removal		odour generation	re-assess
Primary settlement tanks		odour generation possible attraction of birds	re-assess
Primary sludge generation		processing costs odour generation	re-assess
Sewerage System Operation			
Pumping stations	below ground no visual intrusion emergency overflow standby pumps	maintenance one pumping station in antiquities area	re-assess
Sewerage network	below ground no visual intrusion	main sewers along primary tourist areas	re-assess
Drainage System Operation			
Priority stormwater drainage system	drains seriously flooded area cost-reduction if drains laid with sewerage network	system does not incorporate existing drainage channels	accept
Extended stormwater drainage system		drains areas not currently flooded	re-assess
Drainage channel type	not clearly defined	not clearly defined	re-assess

Site B was selected as the preferred STW site. Its advantages are given in the Feasibility Study Report as follows:

- The site is not in the vicinity of the villages or Geroskipou, Koloni and Acheleia. In fact, the villagers of Geroskipou and Koloni consider the site to be too close to their village boundaries.

- The prevailing winds are from west to east, directing odours from the villages. Although this interpretation of the prevailing winds is not correct (see Section 4.2.8) both the onshore (west to east) and offshore winds (east to west) will direct odours away from existing villages and the airport.

- The site is accessible along existing dirt tracks which can be upgraded, and is close to the Pafos-Limassol highway.

- The land is agriculturally zoned. In fact, although the land is agriculturally zoned, it is in private ownership; and the siting of a STW on private land is considered a major disadvantage.

- The site is flat, minimising construction and operational costs.

- It is adjacent to the Kotsiatis River which could be used for treated effluent storage. However, the flooding of the river channel is considered a significant negative impact given the corridor of native vegetation it provides through the coastal plain.

- The treated effluent can be used to recharge the Ezousa river bed aquifer.

Additional advantages to Site B, not listed in the report, include:

- Screening potential which is within the existing landscape character.

- The ecology of the area, excluding the Ezousa River channel, has been heavily modified by agricultural practices, and is of low value.

- The proximity of the Acheleia Experimental Farm is a significant advantage, in that it may use treated effluent and sludge in the short-term while other markets are being developed.

5.3. Sewage Treatment Process Operation

Appendix D should be read in advance of the following discussion.

The proposed scheme is represented in Figure 5.1, reproduced from the Feasibility Study Report. Sewage is chlorinated in the rising main, and enters the treatment works via screening and grit removal stages. The sewage is then passed through a comminutor to primary settlement tanks, before receiving secondary treatment in a conventional activated sludge plant with mechanical aerators. After secondary settlement, the effluent is chlorinated, treated with coagulants, resettled and sand filtered.

In sewage treatment operations such as the above, the potential for a significant degree of environmental impact inevitably exists. Good practices in design and operation will limit this impact to an acceptable level. It is at the design stage that many of the potential impacts can be foreseen and minimised. It will become clear from later discussions that in the current proposals for the Pafos scheme some substantial negative impacts are incurred unnecessarily. The following sections summarise the positive and negative impacts of the proposed scheme.

5.3.1. Positive Environmental Impacts

- The recovery of approximately 7650 Ml pa of high quality treated wastewater (Stage 2).
- Potential enhancement of the local environment, by use of recovered water for irrigation of recreational areas.
- Increased availability of water for irrigation of crops.
- Termination of polluting discharges from the existing treatment lagoons into the surface water system.
- Protection of groundwater sources from organic and bacterial contamination.
- Enablement of growth in tourism whilst avoiding further impact from an increased load on existing facilities.
- Reduced noise and traffic disturbance from septage tankering.
- Alleviation of odour problems from existing septic tanks.
- General improvement in sanitary conditions.
- The production of sewage sludge as a valuable fertiliser and soil conditioner.
- A reduction in tanker discharges to unauthorised sites.
- Improved compliance with EU environmental directives.

5.3.2. Negative Environmental Impacts

- The proposal for chlorination of crude sewage in the rising main before reception at the treatment works, should be regarded as unacceptable for environmental reasons. The argument is summarised in Appendix D, and includes concerns about the production of a range of chlorinated organic substances whose environmental significance is often unknown.
- Chlorine itself represents a potential health hazard particularly in the event of an unintentional release of the gas. The storage of chlorine or hypochlorite would require further consideration on the same grounds.
- It is recognised in the report that despite efforts at avoiding septicity in the incoming crude sewage, a risk from odour at the inlet works will persist. This leads to the enclosure of all preliminary treatment plant, and consequently a hazardous and corrosive environment within the enclosures. Gases will need to be extracted and scrubbed, and the potential failure of this system presents a further environmental hazard. Man-entry to attend enclosed equipment will present serious personal hazards

which will need to be monitored by detection systems. A later discussion (Chapter 7) will show that a major part of this hazardous area could be avoided.

- Experience has shown that the use of comminutors (Louis Berger Report, page 35) can lead to the development of "ropes" of rags which are a hazard to subsequent stages of treatment and hence to the environment.

- The type of grit removal plant selected (an aerated plant) can be a source of odour nuisance, by effectively 'air stripping' any dissolved odour compounds. Non-aerated systems are available and would be preferred. A later discussion (Chapter 7) will also indicate a potential means of avoiding the grit removal stage.

- As discussed in Appendix D, primary settlement is also an important source of odour nuisance. This applies particularly during long periods of retention which can arise overnight and which will also occur during the early stages after commissioning, when design flow has not been achieved. Primary settlement in open tanks also attracts gulls in coastal locations, although usually only in small numbers (CAA, 1995). A later discussion will show how the use of primary settlement tanks could be avoided.

- Primary settlement tanks, as included in the recommended scheme, tend to be an attraction for birds. This is a potential disadvantage, which may become relevant if the treatment site ultimately selected is close to Pafos Airport. The presence of primary settlement tanks may slightly increase the risk from bird strikes but see discussion in Chapter 6.

- Experience shows that the plant areas in which primary sludge (from settlement of crude sewage) is handled are an important potential source of odour. The selected process produces primary sludge and hence incurs this hazard. A later discussion (Chapter 7) will show how the production of primary sludge could be avoided.

- The main treatment process proposed is conventional activated sludge. Although widely proven, this process is more sensitive to disruption than the alternative of extended aeration activated sludge. The selected process therefore does not minimise the potential impact from the secondary treatment stage.

- At Stage 1, the proposed design includes only one sludge belt press. In the event of this press failing, there is no emergency storage capacity for liquid sludge. If repairs are delayed, and no alternative sludge outlet exists, a backlog of sludge will develop in the aeration plant. The consequences will rapidly become severe, with anaerobic conditions leading to the onset of an odour nuisance.

- In general the sludge treatment and disposal system does not appear to have received detailed consideration. A reliable and robust operation in this area is vital to the success and environmental acceptability of the scheme. In particular, the final disposal route has not been addressed. It is recognised that this may be a result of local uncertainties, but it is vital to the success of the project that this be considered in more detail at the current stage. If this area is not given due attention, the result may ultimately be operational pressure on the treatment plant which leads to public nuisance from odour.

- Although the decommissioning of the existing sewage disposal site has overwhelming advantages, monitoring will be required in the early months and years to ensure that the site does not become a nuisance because of odour, flies or rodents. Health and safety issues associated with public access will also need to be considered.

In addition to the specific impacts discussed above, several more general impacts should be highlighted. These may arise from:

- mechanical and process noise
- visual appearance of the plant
- insects
- rodents
- vehicles used in the transport of sludge
- direct effects of final disposal of sludge and
- plastics and other intractable materials in the final discharge

These sources of impact are discussed in some detail in Appendix D. Given due attention during the design stage, and due operational care, none of these impacts should be significant, except possibly vehicle disturbance during the transportation of sludge. The sludge yield is estimated in the Louis Berger Report as 8.1 tonnes per day, expressed as cake at around 65% moisture. If daily transport can be arranged the local impact will be minor. However, the use of a seasonal sludge application programme would lead to brief but intensive periods of transportation. The impact could be reduced by arranging long-term storage close to the site(s) of application.

The above point reinforces the earlier comments about lack of detailed study of the sludge disposal scheme.

In summary, the proposed design includes several major sources of environmental impact which are incurred unnecessarily. It also fails to present a detailed and practical scheme for sludge treatment and disposal. Other sources of impact are those which apply to sewage treatment schemes generally and which should be addressed by careful design and operation.

5.4. Sewerage System Operation

The proposed foul sewerage network consists (Louis Berger Report) of the following elements:

- A series of sewer mains (branches) running along the natural ground slope from inland to the sea front.

- A main gravity collector running along the sea front, the main tourist area in Pafos.

- Secondary sewers (laterals) of a few hundred metres carrying sewage from side streets to the sewer mains.

- Four pumping stations, two to be constructed in Stage 1 and two in Stage 2.

- Force (rising) mains carrying sewage from pumping stations to downstream portions of the gravity collector main or to the Sewage Treatment Plant.

The Louis Berger Report gives ample reference to the potential problem of sulphide generation in sewers. Its conclusion is that the impact should be insignificant in the gravity sewers, but that the force (rising) mains will probably suffer from sulphide generation. There is some discussion on sulphide suppression techniques (Appendix D).

The Louis Berger Report also discusses the visual impact of pumping stations, and takes the view that submersible stations with all structures below ground level will be the most effective approach.

Reliability will be achieved by installing three pumps in each station, along with a standby generator. Each pumping station will have an emergency overflow to a marine outfall.

Thus, the report covers the most important impacts arising from foul sewage pumping stations. The following potential impacts are not referred to, and need to be addressed:

- The visual impact of screenings discharged from pumping station emergency outfalls, on occasions which should be rare.
- Noise from standby generators
- The consequences of delays in receiving or responding to information, in the event of pumping station failures or sewer blockages.

5.5. Drainage System Operation

The scale of the proposed drainage system appears excessive, although it is made clear that no engineering analysis of the scheme is undertaken in this report. It is simply observed that many of the Stage 2A and Stage 2B channels are draining areas that are only partially developed, and currently there is a high proportion of open space that could act as soakaways. Unnecessary or premature building of stormwater drainage channels would be both costly and have construction-related negative impacts (see Section 5.1) while giving little appreciable benefit.

The proposed scheme makes use of natural channels wherever possible. However, there is no commitment to retain the natural stream bed and vegetation. The culverting of natural channels would be a significant and permanent negative impact, depleting natural habitat and visual amenity within an urban environment.

In the proposed surface water drainage system, no pumping stations are involved. The environmental impacts arising from its operation should be minimal. The report refers to the need to protect public safety, which includes the fencing off of dangerous locations and the prevention of entry into culverts.

The report does not consider any potential benefit from the surface water system in terms of amenity use. Such local benefits could be explored at the detailed design stage.

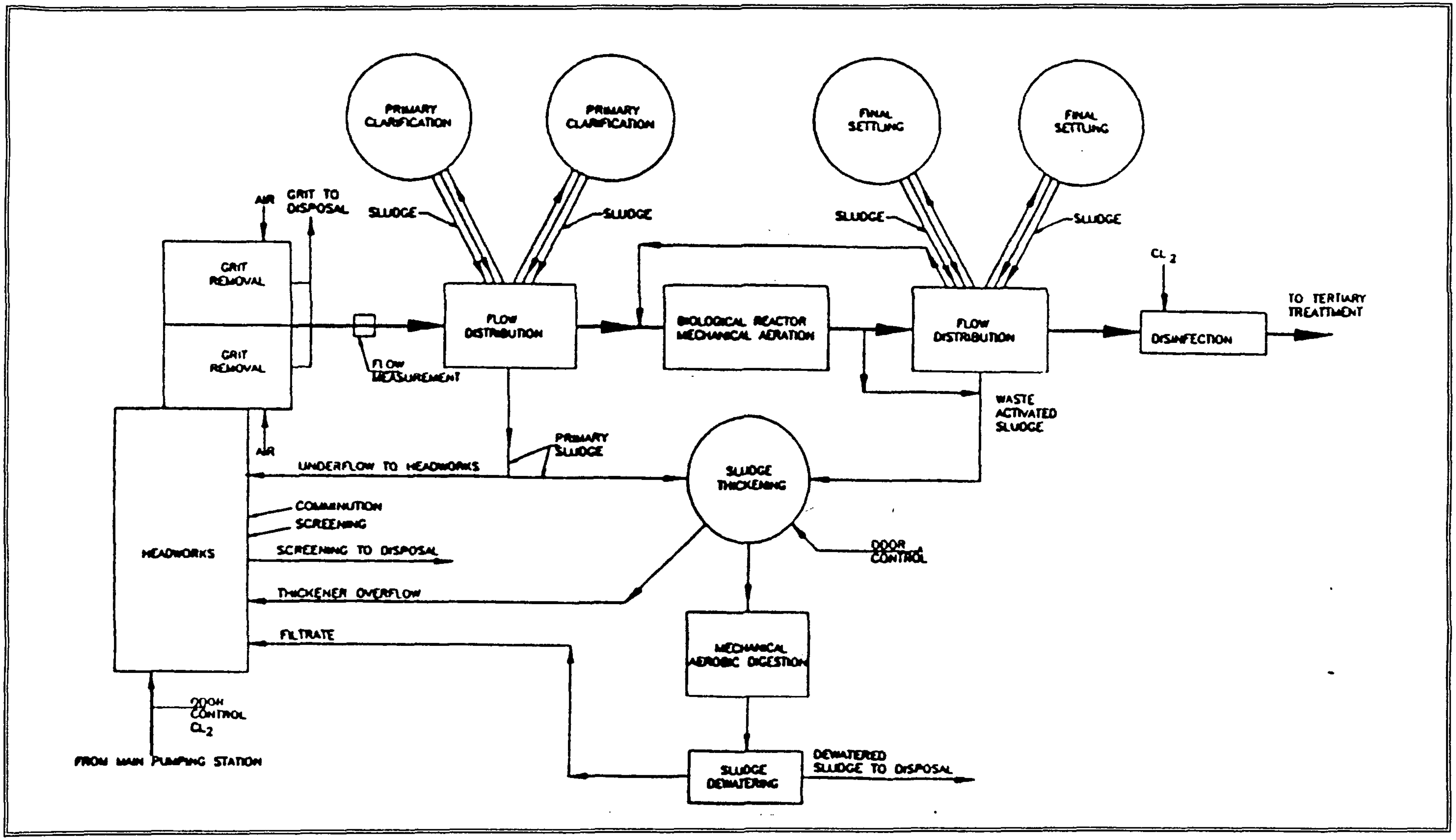


Figure 5-1: Secondary Treatment Plant Flow Sheet

6. ANALYSIS OF ALTERNATIVES

6.1. Overall Scheme Alternatives

This Section discusses the alternatives for the overall scheme, including:

- not implementing a foul sewerage system (No Action)
- sewerage system only
- sewage treatment works only
- giving only partial treatment to sewage.

6.1.1. No Action

The No Action alternative involves the continued use of the waste stabilisation ponds near Agia Marinouda. The ponds are to be relocated following complaints from the villagers about septate tankers passing through the village, and also due to the new road connecting Limassol to Pafos which will be constructed almost directly over the waste stabilisation ponds. New sites for the waste stabilisation ponds are under study.

Section 5.3.1 lists the joint positive impacts of the sewerage and sewage treatment schemes. If both schemes were rejected, then the loss of these benefits would be compounded by a new group of environmental impacts, including the following:

- A steady increase in septage tanker movements as Pafos and its tourist industry expands.

- A proportionate increase in usage of the Agia Marinouda site, and its replacement leading to greater emissions to watercourses and possibly to the atmosphere.

- Continued discharge of waste stabilisation pond effluent to the surface water channels, and the loss of at least part of this water to the sea.

- Increasing nuisance from ageing septage systems in urban areas.

- Continued nuisance from poorly maintained tertiary treatment plants.

- Possible future emergence of groundwater or marine contamination from septic tank leakage.

6.1.2. Sewerage System Only

It is difficult to envisage a scheme in which the sanitary sewerage system would be developed but would not be supported by a sewage treatment works. The disadvantages would be severe. The combined sewage discharge would not be acceptable for agricultural or amenity use, and hence its asset value would be lost. A discharge route would be required for a large daily volume of an offensive and polluting wastewater. Routing via the existing Agia Marinouda disposal site would be damaging because the increased volumes involved (due to lack of percolation from septic tank systems) would inundate the lagoons.

The disposal of untreated sewage through a marine outfall is recognised as being a primary factor in polluting the marine environment. There are particular and overriding concerns if the outfall is located near a tourist beach. Sewage is typically lighter than sea water and the plume floats to the water surface where it forms a visible, coloured plume. The surface water movements are not known or measured, but it is likely that the on-shore winds will blow surface waters on-shore. The ecological effects are less severe if there is a low level of industrial waste or if there is an operating pre-treatment programme, as the sewage is predominantly organic with a low level of persistent metals or organics. There will be an oxygen sag in the vicinity of the discharge, which can be minimised by the use of a diffuser head. Of overriding importance is the fact that the discharge of untreated sewage into the Mediterranean is prohibited, and Cypriot law requires the re-use of sewage wherever possible. Therefore, discharge to the marine environment is unacceptable for legal, aesthetic and environmental reasons

The development of a sanitary sewerage system without a supporting sewage treatment works cannot therefore be considered a viable option.

6.1.3. Sewage Treatment Works Only

It is possible to envisage a scheme in which no foul sewerage system is constructed, but a sewage treatment works receiving tankered septage is constructed. This would have much in common with the scheme currently under development for Vathia Gonia, near Nicosia. Against the economic advantages the following disadvantages would be incurred:

- A steady increase in septage tanker movements as Pafos and its tourist industry expand.
- Increasing nuisance from ageing septage systems
- A major reduction in the volume of high quality recovered wastewater, and a consequent loss of asset value.
- Continued nuisance from poorly maintained tertiary treatment plants, if hotel sewage is not tankered to the STW.
- Possible future emergence of groundwater or marine contamination from septic tank leakage.

In addition, if the surface water drainage system were pursued in the absence of a foul system, the economic advantage of selecting common routes would be lost. At some future date, it is likely that a foul drainage scheme would become necessary and the full disadvantage in economic and disruptive consequences would then be incurred. Delay would also make it necessary to disturb a larger area of Pafos, including newly constructed areas. For these reasons, delays to either one or both of the sewerage schemes should not be considered acceptable.

6.1.4. Partial Sewage Treatment

Finally, the option of a sewage treatment scheme offering partial treatment only should be considered. The proposed scheme consists of the following principal stages:

- Primary (sedimentation)
- Secondary (activated sludge)
- Disinfection
- Tertiary (sand filtration)

The respective capital and operating costs are not presented in the Report, but the omission of the tertiary treatment stage would give only a minor saving, of the order of 10% of total project costs. For this saving, restrictions on the use of the discharge would be incurred. A detailed study of cost benefits for the tertiary treatment stage, taking into account the actual areas of use available, would be justified.

Savings incurred by omitting the disinfection stage would be much smaller and would have a major impact on the handling of the treated wastewater and on the acceptable disposal routes. Disposal to irrigation would be unacceptable under the Provisional Quality Standards for Treated Domestic Sewage Effluent Used for Irrigation in Cyprus, which demand that disinfection be carried out. Omitting disinfection is therefore unlikely to be cost effective option.

Although major cost savings could be achieved by giving primary treatment only, the resulting discharge would be highly polluting (biochemical oxygen demand of around 200 mg/l), and odorous. Its use would be highly restricted and a major disposal problem could arise. Primary treatment alone should not be considered a realistic option.

6.1.5. Conclusions

To summarise the above discussion, the advantage lies strongly with the acceptance of all three parts of the package offered in the Feasibility Study Report:

- Foul drainage system
- Sewage treatment works and
- Surface water drainage system

This does not imply acceptance of their details.

6.2. Sewage Treatment Works - Site Selection

The sewage treatment works site selection is discussed in full in Appendix C. In summary, the selection methodology had two main components.

- *Area Analysis*

  The identification of Areas of Search, their evaluation against a range of criteria and the choice of a preferred area.

- *Site Analysis*

  The identification of sites within the preferred Area of Search, their evaluation against a range of criteria and the choice of the preferred site for the STW.

6.2.1. Area Analysis

Five Areas of Search were selected (shown on Figure 6-1):

- Areas A to the northeast of Pafos near Mavrokolympos Dam

- Areas B between the Ezousa and Kotsiatis Rivers north of the Pafos-Limassol highway near the industrial complex at Anatolikon.

- Areas C on the coastal plain southwest of the Pafos-Limassol highway, including the lower Ezousa River.

- Area D on the coastal plain including Pafos airport and surrounding agricultural land.

- Area E to the south of Pafos extending from the coastal plain below Mandria and Kouklia to the lower slopes of Asprokremnos Dam. Area E was divided into two sections, E1 including the uplands, and E2 on the coastal plain.

Twenty-three evaluation criteria were selected, which are grouped as follows:

- *Landscape:* including visibility from existing and proposed roads, landscape impact and screening potential.

- *Ecology:* proximity to important habitats and important species.

- *Nuisance/Amenity:* odour is the key issue, but noise and dust are also of some importance. The criteria evaluated are proximity to settlements, meteorological influences and nuisance effects from the access. The latter aspect is important for consideration of construction effects and the delivery of sewage by truck to the STW when only Phase 1 of the network has been constructed.

- *Archaeology:* effects on known antiquities.

- *Land Use:* the evaluation criteria selected are agricultural land quality, compatibility with existing land uses, blighting of the anticipated development potential of adjoining land, effects on the operation of the tourism industry, and the accessibility of the area from the road network.

- *Land Ownership:* private or government ownership, and known obstacles to acquisition of private land.

- *Plant Outputs:* potential for the re-use of sludge and effluent.

- *Cost implications:* three locational factors relevant to cost were assessed - the remoteness of the plant from the major areas of sewage collection, the elevation of the plant (affecting pumping costs), and the effects on construction cost of topography and ground conditions.

Table 6-1 sets out a comparative assessment of the Areas of Search of the evaluation criteria, above.

Table 6-1: Areas of Search: Comparative Assessment.

	Area of Search					
	A	B	C	D	E1	E2
LANDSCAPE						
- Visibility from existing roads	-	-	+	-	+	-
- Visibility from proposed roads	+	--	-	-	-	+
- Landscape impact	--	-	+	+	--	+
- Screening potential	--	-	++	+	--	+
ECOLOGY						
- Proximity to important habitats	--	-	-	+	-	-
- Proximity to important species	-	-	0	+	-	0
NUISANCE/AMENITY						
- Proximity to settlements	0	-	-	+	-	0
- Meteorological influences	-	-	0	-	-	-
- Nuisance effects from access	-	-	+	0	0	0
ARCHAEOLOGY						
- Effects on known antiquities	0	0	0	0	0	0
LAND USE						
- Agricultural land quality	++	++	-	-	+	--
- Compatibility with land uses	-	++	0	0	0	0
- Blighting of potential development	-	++	-	0	0	0
- Tourism effects	-	+	-	-	-	+
- Accessibility	-	0	+	+	0	0
LAND OWNERSHIP						
- Predominant ownership pattern	0	-	+	++	0	-
PLANT OUTPUTS						
- Potential for local sludge re-use	-	-	++	++	-	-
- Potential for local effluent re-use	-	+	+	+	0	-
COST IMPLICATIONS						
- Distance to plant	--	+	++	0	--	--
- Elevation (pumping)	--	-	++	++	-	++
- Topography	--	-	++	++	-	++

++ Significant Advantage
+ Slight Advantage
0 Neutral
- Slight Disadvantage
-- Significant Disadvantage

As Table 6-1 and the discussion in Appendix C show, each area has favourable and unfavourable characteristics. Overall, however, Areas of Search C and D had the greatest number of advantages, and the least disadvantages. It was considered that since Area C was slightly further from villages and town, and would interfere less with the expansion plans for Pafos Airport, this was the preferred area within which to site the Sewage Treatment Works.

6.2.2. Site Analysis

A more detailed site selection exercise was conducted within Area of Study C, the lower Ezousa River area. Key constraints were developed, which included:

- Distance from settlements. All land within 1km of the village zoned land was excluded.

- Distance from proposed marina site. Again, land within 1km of the marina was excluded.

- Distance from main roads. The wish of the Cyprus Tourism Organisation to minimise the visibility of the STW from main roads was taken into account by excluding land within 500m of such roads.

- Pafos Airport expansion. Although the airport expansion has not been formalised, an approximate area was safeguarded to allow for this development to take place.

- Ezousa River flood channel. The Ezousa flood channel was excluded from consideration due to its local ecological value and the openness of its aspect in visual terms.

Modern sewage treatment plants, unlike their predecessors, are relatively minor bird attractants (CAA, 1995), and the proximity of the Pafos Airport to the sites does not represent incompatible land uses. Large water supply reservoirs and municipal refuse tips are acknowledged as potential hazards.

The above constraints are presented on Figure 6-2. The site recommended amounts up to approximately 9 hectares and lies on the east bank of the Ezousa River. It lies approximately 1,000 metres from the nearest zoned development land in Acheleia and 1,400 metres from the nearest zoned development land in Koloni. It is nearly 3,000m from the larger settlement of Geroskipou.

The land is screened from the single track access road and from the Ezousa River channel by a shelter belt of cypress and other coniferous trees. The screening which this affords can, if necessary, be strengthened and reinforced by additional planting. The land is cultivated and irrigated and slopes at a shallow gradient towards the Ezousa River channel. Impacts associated with this site are the loss of about 4ha of agricultural land and potentially the generation of pressure for development between Kato Pafos and the proposed site.

A key advantage of this site is that the land is owned by the Government and, on all sides, it borders other land which is also Government-owned. It is part of a larger area of land to the west of the Acheleia Experimental Farm which is leased to local farmers. The Government-run Acheleia Experimental Farm may demonstrate the local usage of treated effluent and sludge while additional disposal routes are developed.

6.3. Sewerage System

The No Action alternative to the proposed sewerage system has been addressed in Section 6.1. The alternative to the schemes discussed below are in concept only as no engineering analysis has been conducted on the technical feasibility of the suggested modifications.

6.3.1. Location of Main Gravity Collector

The proposed route of the main sewer along the harbour and sea front will cause severe disturbance to tourist activity and commercial trade. Maintenance of the sewers and pumps will cause periodic disturbance over the long-term.

It is possible that trenching and laying of sewers will weaken building foundations and expose septate-contaminated soil or ground water. Improper reinstatement may result in road or surface failure.

6.3.2. Location of Pumping Stations

The pumping stations are designed to be underground, and to operate with minimal noise disturbance. However, the construction of the Kato Pafos pumping station (PSB) within the UNESCO World Heritage Site is difficult from a political perspective, and is likely to expose antiquities, the excavation of which could delay the construction schedule. The alternative location given in the Louis Berger Report, at the intersection of Poseidonos Avenue and Alkininis Street is preferred on environmental grounds.

6.3.3. Conclusions

Although it is stated in the Louis Berger Report that alternative schemes were analysed, they are not presented in the report. It is not known if the ideas presented above were considered and if they are technically feasible. We recommend that alternatives to significant construction along the sea front be considered as a precursor to the detailed design study, for example an offshore route from Pafos to a landfill across the bay.

6.4. Sewage Treatment Process

For each stage of the treatment process, a wide range of alternatives could have been considered. Many of these are not referred to or discussed in the Feasibility Study Report, having correctly been discounted at an early stage.

<u>Preliminary Treatment</u>

The Report does not discuss or justify the selection of preliminary treatment plant. The following plant requirements are identified:

- coarse manually raked bar screens
- mechanically cleaned bar screens
- comminution
- grit removal plant

The use of a comminutor is questioned in 5.3.2 above because of the possible formation of "ropes" of rags which interfere with subsequent treatments. The need for comminution after the two sets of screens proposed is doubtful. The use of an aerated grit removal plant is also questionable, in view of its ability to strip dissolved odour compounds into the atmosphere. A "detritor" type grit removal plant would be preferred.

Secondary Treatment

The Feasibility Study Report identifies the following options:

- trickling filters (biological filters)
- extended aeration
- conventional activated sludge
- activated biofiltration

Trickling filters are correctly discounted (Louis Berger Report, Section 3.7.1) although for reasons other than the environmental considerations which would also have justified this decision. Activated biofiltration is discounted because of cost: taking account also of the increased complexity of this process, this is a reasonable decision.

However, the report gives only the briefest consideration (Section 3.7.1) to the extended aeration option, and fails to acknowledge several of its important advantages. As a result, the selection stage may be seriously flawed.

The advantages of extended aeration are as follows:

- possible elimination of the grit removal stage
- elimination of crude sewage screening
- production of a less offensive by-product, in smaller quantity, after screening at a later stage
- reduced exposure of crude sewage to atmosphere at the preliminary stage
- elimination of primary settlement, including the resulting exposure of sewage to the atmosphere
- elimination of primary sludge and its handling
- greater tolerance to disruption, and more rapid recovery from process disturbances

The disadvantages of extended aeration generally lie in higher capital and operating costs, and increased land requirements. Despite these disadvantages, the benefits have often been accepted as overwhelming and many extended aeration plants have been constructed throughout the world. The view of this report is that the Feasibility Study Report is deficient in not giving a full analysis of alternatives and should be amended in this area. Extended aeration appears to be an attractive option in the situation of Pafos, and should be fully considered.

Sludge Treatment

Alternative sludge treatment schemes considered are:

- anaerobic digestion
- aerobic digestion
- wet air oxidation

Wet air oxidation, a high temperature process, has in the past been a source of extreme odour nuisance. Although modified technologies are now being applied, this process carries a higher risk than the remaining alternatives and is correctly discounted.

The two digestion processes are both likely to achieve a strong measure of success. Anaerobic digestion is not generally subject to the degree of odour nuisance described in the report, but because of its more critical control requirements, its rejection in favour, of aerobic digestion is reasonable.

For the treated sludge to be acceptable for use by farmers solids must be screened out prior to land application. However, typically such a screening process results in odour. Screening is only not required of land filling is the final disposal route.

Sludge Drying

Alternative sludge drying processes considered are:

- belt pressing and
- atmospheric drying beds

Drying beds are correctly discounted because of their reputation for odour nuisance and occasionally fly nuisance. Belt pressing is an effective method which is often preferred to the traditional method of plate pressing. Centrifuges are correctly not considered because of the higher moisture content of the sludge cake produced. The selection of belt pressing is an environmentally and operationally acceptable conclusion.

The Report does not consider contingencies such as failures of sludge processing plant, and this important deficiency should be addressed.

Disinfection

The disinfection processes reviewed were chlorination and UV irradiation. Despite recognising its disadvantages in producing traces of organochlorines, the report recommends chlorination. There is a strongly expanding interest in UV disinfection which would justify a re-examination of this conclusion.

Tertiary Treatment

The selection of sand filtration for tertiary treatment coincides with practice in many other comparable schemes, and with the Cyprus Provisional Code of Practice for Treated Domestic Sewage used for Irrigation. Its use is therefore acceptable.

Marine Outfalls

A marine outfall was included in the Louis Berger Report costing estimates, but is not described in the text. It would operate as an emergency outfall in case of plant failure, rather than for routine discharge of treated effluent. The construction of a marine outfall has considerable negative impacts on both the marine water quality (sediment suspension, release of contaminated material, release of anaerobic sediments) and the benthos (loss of habitat, death of organisms). The offshore marine environment off the Ezousa River is poorly studied, but is known to include seagrass beds near Moulia Rocks, which are very sensitive to disturbance and to changes in water quality.

Once constructed, an unburied marine outfall could represent a hazard to fishing using trawl nets. Line fishing is likely to be slightly stimulated by the outfall as the pipe forms a substrate which encourages marine growth. The use of a marine outfall for emergency discharges of sewage could significantly and permanently impact the seagrass beds.

Alternatives to the marine outfall were not considered, but could include emergency overflow lagoon. This would take a considerable area of land, and will represent a major source of odour and pest attraction.

6.5. Sludge Disposal

The Louis Berger Report does not discuss in detail the alternative routes for sludge disposal. These are summarised and commented upon in Table 6-2.

Disposal of sewage sludge to agriculture is widely practised for its economic, environmental and agricultural benefits. Environmental protection schemes are fully developed in many parts of the world (e.g. European Directive 86/278/EEC) The Cyprus Provisional Code of Practice for Treated Domestic Sewage Sludge for Agricultural Use also applies. Sewage sludge contains valuable amounts of nitrogen, phosphorus and trace minerals. Its suspended organic content also improves the structure and water retention of soils. There is a strong preference for digested sludge over crude sludge, because:

- the nitrogen is present in a more readily available form in digested sludge
- pathogens are significantly reduced in number during digestion
- digestion destroys most of the fat content of crude sludge
- digested sludge is less odorous than crude sludge

The recommendations of the Louis Berger Report take advantage of these benefits.

Provided sufficient agricultural land is available close enough to the treatment site to avoid excessive transport costs, this should be the preferred route for disposal. The land requirement will depend upon the crops under cultivation and the characteristics of the sludge. Typically, either metal concentrations or nitrogen dose become a limiting factor. In the case of Pafos, which is a largely non-industrial area, it should be expected that the nitrogen requirements of specific crops will control the maximum rates of application. Preliminary estimates suggest that an area of around 100ha of arable land would serve long-term requirements. This estimate will need to be refined as more data become available on the sludge composition and types of crop involved. The spraying of sludge on aerodrome grass is not recommended, as the increased soil water content and organic matter raise soil invertebrate populations which in turn attracts large numbers of gulls CAA, 1995).

Table 6.2: Comparison of Alternatives for Treated Sludge Disposal

Alternative	Advantages	Disadvantages	Status
Agricultural use in liquid form	full asset value of sludge recovered	high number of vehicle movements politically difficult odour potential receiver crops limited land required-1,000ha good record keeping required	accept
Agricultural use in cake form	full asset value of sludge recovered moderate number of vehicle movements limited odour potential	land required 700ha good record keeping required politically difficult	accept
Incineration	low land area	expensive complex to maintain loss of asset value of sludge potential to pollute atmosphere	reject
Controlled tipping	politically acceptable	loss of asset value of sludge steady consumption of land environmental problem for future generations	questionable
Discharge to sea	low operating cost low land area	politically unacceptable marine pollution high construction cost aesthetically unacceptable	reject

6.6. Wastewater Disposal

Wastewater Disposal

The Louis Berger Report identifies and briefly discusses several options for final disposal of treated wastewater. These are summarised, along with their respective advantages and disadvantages, in Table 6.3.

This Report takes the view that, in the context of the value placed upon water resources in Cyprus, there should be a strong preference for effluent reuse. A specific method of reuse is not recommended, and this aspect should form the subject of a separate study.

During the field study conducted for this report, a considerable amount of discussion took place with individuals directly concerned with the future of water resources.

Table 6.3: Comparison of Alternatives for Treated Effluent Disposal

Alternative	Advantages	Disadvantages	Status
Marine discharge	low operation cost low land area	economic loss of water asset high construction cost very low political acceptability	reject
Evaporation	low operation cost	economic loss of water asset high land area low political acceptability	reject
Groundwater recharge	high water re-use Ezousa aquifer potentially needs recharging low development cost low operation cost low land area	concern about pathogens potential to clog soil/aquifer pores	accept
Agricultural use	high water re-use full economic budget of water	unsuitable for crops to be eaten raw some crop restrictions good record keeping required	accept
Golf courses and parks	high water re-use enhances other assets positive habitat creation positive encouragement of tourism	transportation costs and infrastructure	accept
Spraying on forests, hilly areas	high water re-use	economic value of water not fully realised capacity for soils to absorb verification of water needed	questionable

A view which frequently arose was that there is some resistance, largely for aesthetic reasons, to the reuse of sewage effluent for agriculture. For operators of spray irrigation devices this reluctance is reinforced by the problem of becoming personally contaminated with water while moving spraying equipment. Thus only users of drip irrigation are likely to accept recovered wastewater. One small landowner considered that only large owners were likely to accept recovered wastewater.

Currently, not all of the land designated for agricultural use has yet become cultivated. Because the home market for farm produce is saturated, an expansion in exports is needed and this is the main restraint which prevents more land being placed under cultivation. Despite this aspect, there is currently considerable pressure from farmers to be selected for irrigation by the four new dams under construction. Demand will exceed the new supplies by 100%. This lends some justification to the view that the recovered effluent will be a valued resource.

It is also noted that many orchards are currently being irrigated with only 50% of their true water requirement, and are only barely surviving.

Aquifer recharge is considered an important possibility. The Esouza Aquifer is used only for irrigation, due to high sulphate levels. Existing boreholes currently extract 3-4000 Ml pa, but the rate slows during the summer months. Since recharge may be further slowed by the planned construction of the Esouza Dam, recovered wastewater could become valuable in this area.

It is important that the correct influences be applied to encourage the use of recovered wastewater. Amongst these should be economic advantage. The tariff for existing water resources is:

- for agricultural use 6.5 Cyprus cents(c)/m^3
- for private gardening 15 Cyprus cents(c)/m^3

It has been suggested that to encourage its use, recovered wastewater should be charged at 2c/m^3. This suggests a total asset value of CY £153,000 pa (Stage 2). The value could increase markedly if public acceptance makes it possible to equalise the price with that of other water resources.

The proximity of the Government-run Acheleia Experimental Farm gives a potential means of demonstrating in practice the value of both recovered wastewater and sewage sludge. Non-use at the Experimental Farm would be discouraging to other potential users.

The issue of future demands on water resources is a complex one which would justify a separate study.

6.7. Stormwater Drainage Scheme

The No Action alternative to the proposed stormwater drainage scheme is discussed in Section 6.1. Alternatives to the proposed scheme include:

- partial stormwater drainage scheme
- surface channels and ditches
- underground pipes
- a combination of surface channels and underground pipes.

6.7.1. Partial Stormwater Drainage Scheme

Areas of Pafos suffer serious flooding on a regular basis (Figure 6-3), and a stormwater drainage system is undeniably essential in these areas. Other parts of the Louis Berger Report study area, serviced with drains in the proposed scheme, have minimal problems with flooding with the existing level of urbanisation. Restricting the stormwater drainage system to areas with demonstrated needs will have the following benefits:

- reduction in disturbance to access and traffic
- reduction in dust
- reduction in sedimentation potential
- reduction in cost.

The major disadvantage is that the non-serviced areas may flood, resulting in public anger. Reductions in the proposed scheme must be verified as a precursor to the detailed design study.

6.7.2. Surface Channels and Ditches

Surface channels deal comparatively well with extreme rainfall since a small increase in flow depth relative to channel capacity represents a large increase in both water discharge and storage. Disadvantages are that insects can breed in open, wet channels; rubbish and sand accumulate requiring regular cleaning; run off from roads can carry significant contaminant loading, and children may play in the channels.

Channels may be either grass or concrete lined. Concrete channels are easy to maintain and the lack of vegetation minimises insect and rat breeding areas. Disadvantages are that they are expensive to build; are visually unattractive, and provide no infiltration capacity.

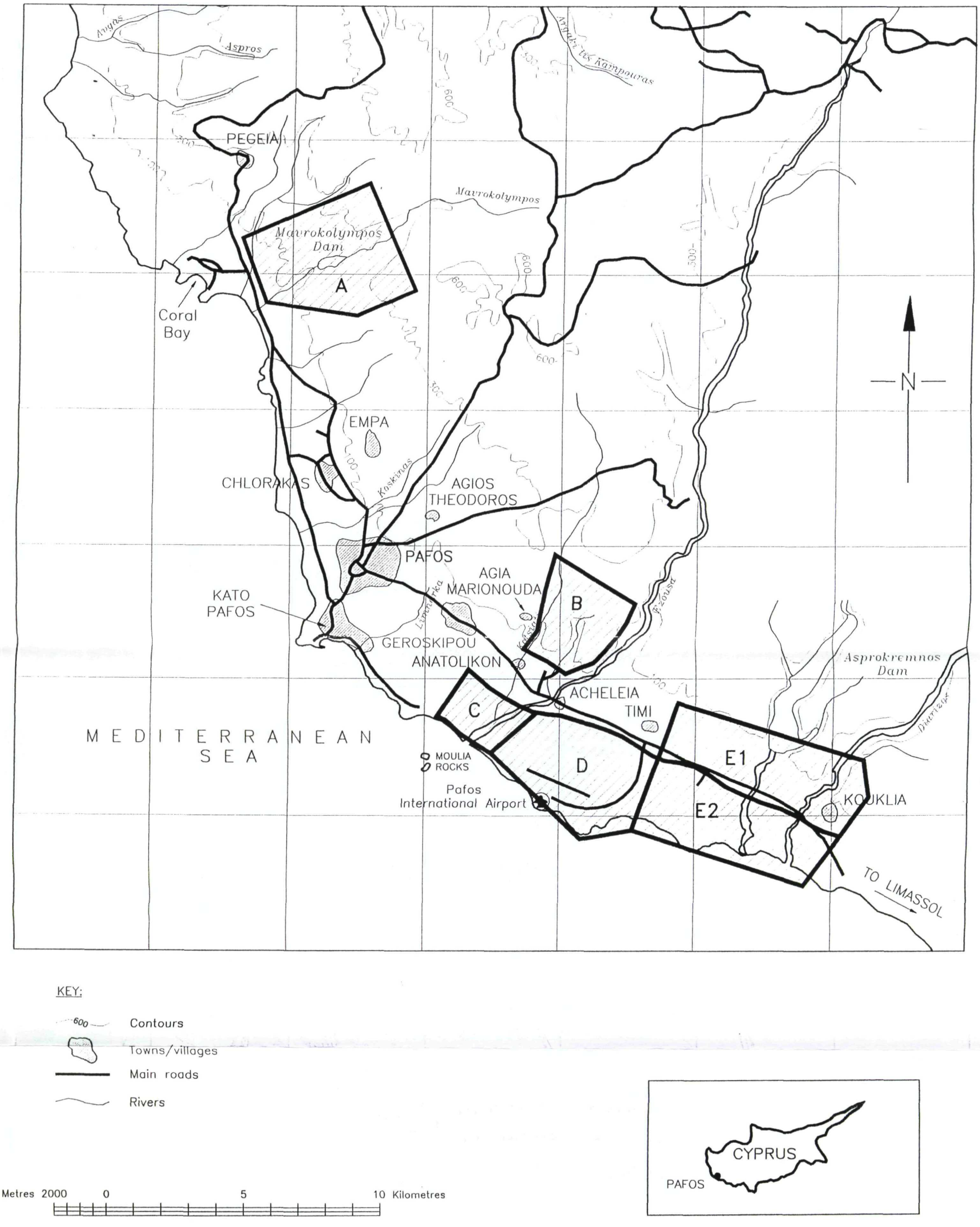
Grass lined channels are less costly to build and require some routine maintenance to keep vegetation under control. They are visually attractive and promote water infiltration. Disadvantages are that insects and rats may breed in the vegetation, and the channels may be eroded in heavy flows.

6.7.3. Underground Pipes

Underground piped systems are expensive to construct and maintain, particularly as they are susceptible to failure due to blockage, collapse or extreme rainfall. Additional disadvantages are that unpleasant odours can be produced; rats may breed in the pipes, and when placed in areas of high water tables, there can be excessive infiltration into the system. There is no potential for infiltration to the ground, and all run off and contaminants are discharged. The overriding advantage is that land can be developed over buried pipes, offering much greater flexibility particularly where road widening or realignment is envisaged.

6.7.4. Combined Surface Channels and Underground Pipes

The preferred alternative is to use a mixture of surface channels and underground pipes. In this way the easy maintenance and lower costs of the former can be exploited where possible, and underground pipes can be used where future development is envisaged.



MAP TITLE :

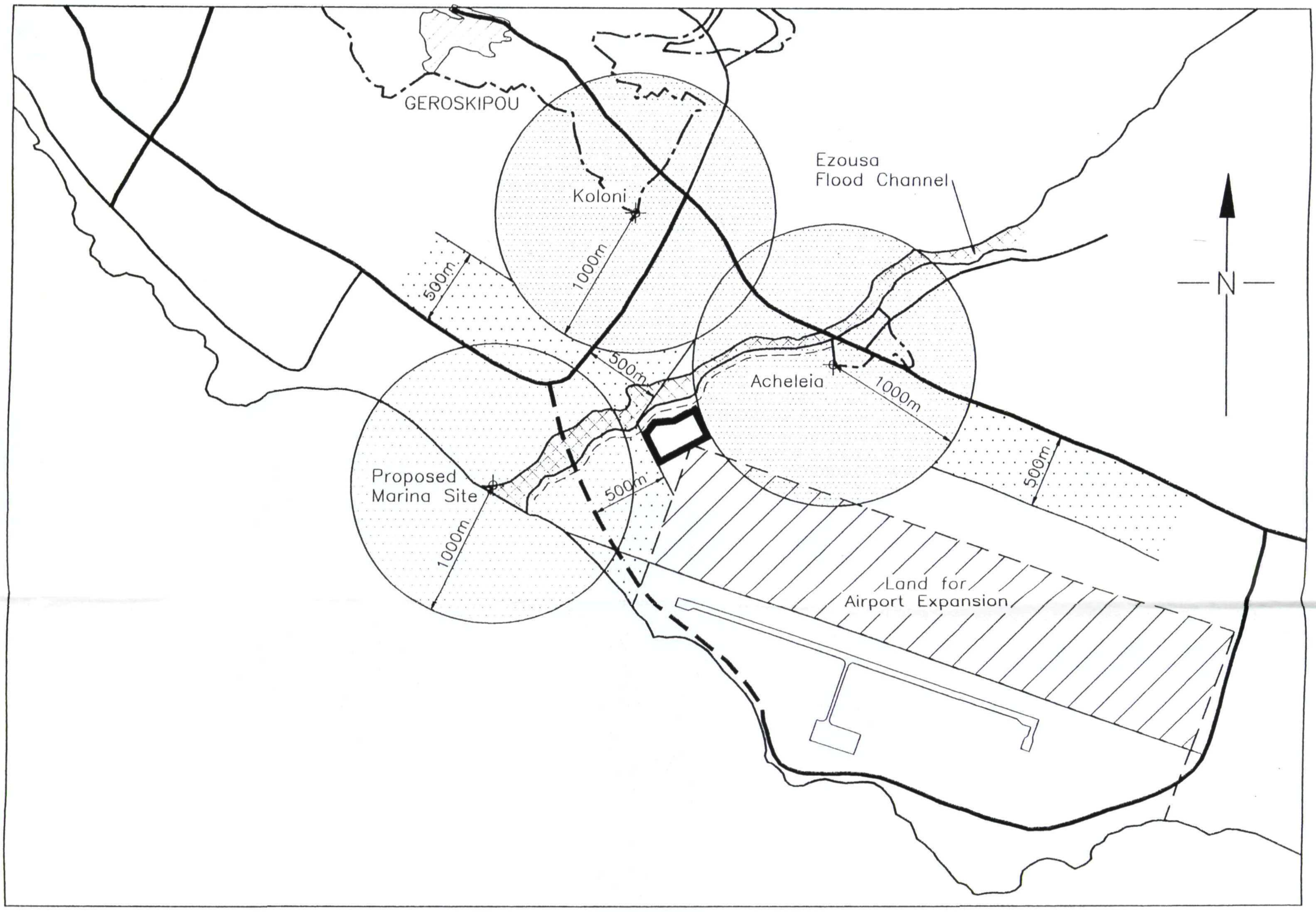
AREAS OF SEARCH FOR SEWAGE TREATMENT WORKS

JOB NAME :

PAFOS SEWERAGE AND DRAINAGE SCHEME – EIA FOR SEWAGE BOARD OF PAFOS

FIGURE No. : 6–1

JOB No. : WSBE53



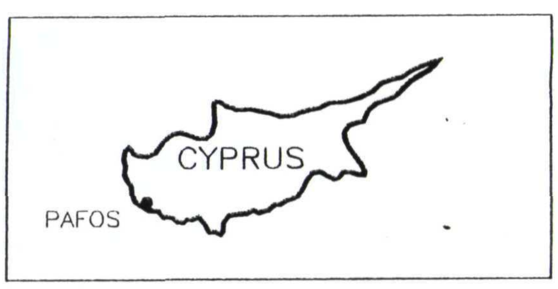
KEY:

SELECTED SITE FOR S.T.W.

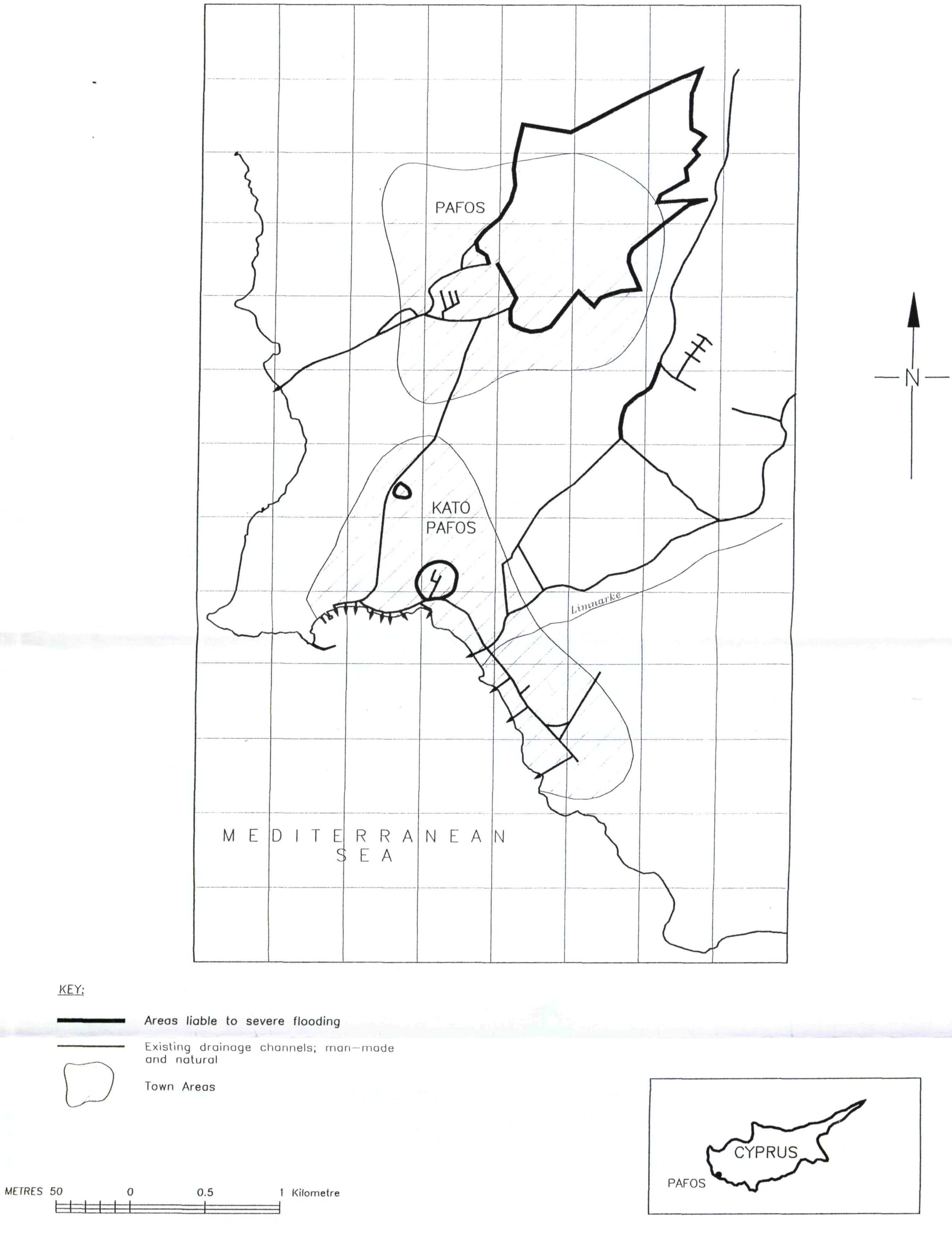
------ Surfaced single-track road East of River Ezousa

—·— Zoned Built-Up Area (Approved Pafos Local Plan)

0 500 1000 1500 2000 Metres



MAP TITLE : SEWAGE TREATMENT WORKS SITE SELECTION	JOB NAME : PAFOS SEWERAGE AND DRAINAGE SCHEME – EIA FOR SEWAGE BOARD OF PAFOS
FIGURE No. : 6–2	JOB No. : WSBE53



MAP TITLE :

EXISTING STORMWATER DRAINAGE AND PROBLEM AREAS IN PAFOS

JOB NAME :

PAFOS SEWERAGE AND DRAINAGE SCHEME – EIA FOR SEWAGE BOARD OF PAFOS

FIGURE No. : 6–3

JOB No. : WSBE53

7. MITIGATION ACTION PLAN AND MONITORING PLAN

Many of the negative impacts identified in Chapter 5, concerning the proposed Louis Berger scheme, are overcome if the alternatives presented in Chapter 6 are adopted. In particular, the siting of the Sewage Treatment Works (STW) should be reviewed. A re-appraisal of the proposed sewage treatment process, and of the sewerage and drainage networks would address additional negative impacts; this re-appraisal must be conducted by engineers, and it is suggested that this work is conducted as the first stage of the detailed design.

7.1. Mitigation Action Plan

The mitigation actions recommended below address the negative impacts identified in Section 6, and concentrate on:

- construction and commissioning
- sewage treatment
- sewerage and drainage systems

7.1.1. Construction and Commissioning

The short-term negative impacts, and their mitigation, are summarised in Table 7-1. Major points are elaborated below:

- The local impacts arising from sewer construction should be carefully examined, and a work plan developed for least impact. The schedule and nature of the disruption should be discussed with persons most directly affected.

- The construction programmes for foul sewerage and sewage treatment works should be considered in relation to each other, so that the commissioning details for the treatment works can be determined and if necessary planned for minimum impact.

- During the construction stage a large proportion of the area of the STW site will be excavated, or used to establish temporary offices, stores, machinery depots, etc. Also construction traffic and operations will cause permanent damage to the topsoil and flora of the site. After completion of the works the site should be reinstated, where possible, to its original character by the following methods:

    - formation of contoured ground levels and slopes using excess spoil and fill from construction operations

    - the borders and peripheral areas of the site should be planted with indigenous screens of shrubs and trees, such as thickening and extending the existing row of cypress trees

In addition, the existing disposal site should be monitored after decommissioning to ensure that odour, fly or rodent nuisance does not develop. Matters of health and safety linked with public access to the site should be considered. Ultimately a plan for rehabilitation will be required.

Table 7.1: Potential Short Term Negative Impacts Associated with Sewerage and Drainage Scheme System Construction and Start-up, and Mitigation Options

Potential Negative Impact	Mitigation
Noise	Avoid construction at night. Minimise noise disturbance in the centre of town by trenching this area in winter.
Dust	Minimise dust in town centre by trenching in winter. Workers to wear face masks if dust a problem. If high winds blow dust to airport, work should halt.
Waste Disposal: Oil spills and leaks	Proper maintenance and operation of equipment. Clean spills and dispose of clean-up materials in landfill.
Disposal of fill	Engineering designs to minimise fill produced. Use excess in landscaping or landfill.
Disposal of rubbish, concrete	Collect in skip/truck and landfill.
Traffic: Delays to traffic	Develop detour routes with local police. Publicise work schedule and detours. No construction in commercial or tourist areas in summer months.
Traffic disturbance	Restrict times of day lorries move to and from site (specify in contract). Provide and enforce use of wheel cleaners for lorries leaving STW site. Restrict routes available for lorry movements.
Pedestrian traffic disturbance	Provide walkways for access. Minimise length of open trench in urban areas.
Reduction of recreational or tourist activity	No construction in tourist areas in summer months.
Financial detriment and disturbance to shop keepers	No construction in commercial area in summer months. Inform shop keepers of work schedule at least a month in advance.
Atmospheric pollution from construction machinery	Proper maintenance of construction vehicles. Minimise unnecessary construction traffic.
Disruption to existing services	Correct operation of back-hoe. Co-ordinate work/repairs with existing services.
Accidental destruction of archaeological sites	Inform Director of Antiquities of trenching operations. Cease work if archaeological remains found. Maintain contact with the Archaeological Museum in Pafos.
Sedimentation	Ensure run-off, if any is directed to bare ground or drainage ditches in town; away from halophytic community at STW site.
Odours: During construction	Minimise by removing contaminated groundwater as soon as possible and by drainage septic tanks immediately.
During filling of aeration tanks	Careful planning during start-up procedure.
Exposure of contaminated septate or septate contaminated ground during trenching	Dispose of wastes appropriately. Do not allow disposal in the marine environment.
Disturbance to existing building foundations	Appropriate engineering design and construction provisions.
Loss of marine habitat and organisms in construction of outfalls	Conduct offshore survey of sensitive habitats, breeding grounds, rich biotic communities and route outfalls accordingly.
Water quality decline during construction of outfalls	Conduct water movement and quality surveys.

7.1.2. Sewage Treatment Works - Site and Operations

The mitigating actions listed below and in Table 7-2 should be carried out with particular reference to the environmental sensitivity of the Pafos area and other local factors including climate:

- Construction of a Sewage Treatment Works at the selected site will result in the permanent loss of high quality agricultural land. The loss is partially off-set by the production of treated effluent which will be available for irrigation of currently non-irrigated, private agricultural land. Furthermore, the proposed site is Government-owned land, not private agricultural holdings. Loss of vegetation will be an impact regardless of the method of disposal (creation of waste stabilisation ponds also involves a sterilisation of land) or of the site selected.

- The availability of sewage treatment along the coastal area between Kato Pafos and the Ezousa River is likely to increase pressure for development, regardless of current land use zoning. This pressure will be greater if the planned marina is built. These pressures could be resisted by strict adherence to the established zoning, which classifies this section of land as irrigated agricultural land.

- The primary recommendation in respect of the sewage treatment process, is that the selection of the secondary treatment process should be reviewed. There is a considerable body of experience in the industry which suggests that, in the environmentally sensitive area of Pafos, extended aeration activated sludge would be a more suitable choice than the conventional activated sludge scheme selected. The costs and benefits of an extended aeration scheme should be fully evaluated. It should be recognised that the best environmental advantage may not coincide with the lowest cost.

- The proposal for chlorination of crude sewage should be abandoned in favour of an alternative technique. Chlorination of final effluent is more acceptable but should also be reviewed in the light of expanding use of UV disinfection.

- Landscaping and visual screening of the proposed site should be considered.

- Equipment selection should be carried out with reference to any potential noise impact.

- The route for effluent disposal should be considered in more detail, as a part of a more general study of the future demand on water resources.

- The need for an emergency marine outfall should be reviewed.

- The sludge treatment and disposal scheme should be examined in more detail, particularly in respect of the following:

    - operational robustness and practicality
    - provision of standby mechanical plant
    - emergency storage for liquid sludge
    - storage (surface area and locations) for sludge cake

- handling techniques
- final disposal route

Table 7-2: Potential Long Term Negative Impacts Associated with the Sewage Treatment Works and Storm Drainage System

Potential Negative Impacts	Mitigation
Sewage Treatment Works Site and Operations	
Vegetation irreversibly lost from Sewage Treatment Works site	This is an unavoidable, permanent loss of Government-owned, leased agricultural land, amounting to 4ha (depending on design).
Unplanned developed induced by sewage works	Enforce existing land use controls and regulations.
Aesthetics of sewage treatment works	Colour building elements to be unobtrusive. Landscape and plant the site.
Odour	Re-evaluate the sewage treatment process design, as elaborated in the text.
Noise	Proper equipment selection. Proper operation and management of sewage treatment works. Minimise with tree planting and landscaping.
Social attitudes of farmers to re-use of effluent	Make provisions for aquifer recharge. Educate farmers on merits and problems of effluent re-use. Run test plots at Acheleia Experimental Farm. Encourage effluent re-use by a favourable pricing structure.
Social attitudes of farmers to re-use of sludge	Make necessary arrangements for land-filling sludge. Educate farmers of merits and problems of sludge fertilisation. Run test plots at Acheleia Experimental Farm.
Marine outfall interference with fishing	Bury outfall
Emergency discharge of sewage resulting in seagrass death, visible water pollution, potential onshore pollution	Conduct surveys of seagrass beds, water surface movements and build outfall accordingly.
Sewerage System	
Disturbance associated with maintenance of pumps and pipes in town	Locate pumps inside streets. Co-ordinate with other service repairs.
Road or infrastructure settlement	Appropriate engineering design and construction provisions.
Increased tanker traffic movement to Sewage Treatment Works	Unavoidable but will cease once Stage 2B is complete. Expected to be a minor increase to existing traffic flow.
Loss of sewage tanker business and associated employment	Provide advice/help on re-employment.
Loss of irrigation water for hotel grounds from existing package treatment plants.	Examine alternatives with hoteliers, including pricing structure
Siting of pumping station in Archaeological area	Relocate to Intersection of Poseidonos Avenue and Alkininis Street.
Surface water Drainage System	
Rubbish accumulation at stormwater discharge	Screen storm water prior to sediment/oil and grease traps. Encourage proper rubbish disposal by residents and tourists.
Storm water ditch failure leading to flooding/erosion	Enforce maintenance programme. Keep ditches clear of vegetation and rubbish.
Malfunction of pumping stations	Provide an alarm system with attendant procedures for response.

- seasonal effects on access to disposal areas
- transportation routes and traffic impact

The airport should not be fertilised with sludge to avoid bird attraction.

- After the initial design stage, a Hazop study should be used to identify any areas of weakness in the design which may have environmental significance. This will include an examination of:

  - control system reliability
  - provision of standby plant
  - provision of spares
  - monitoring systems
  - alarm systems
  - training requirements
  - operational skills required
  - health and safety issues

  A final Hazop review at a more advanced design stage will monitor the completion of the required actions.

7.1.3. Sewerage and Surface Drainage Systems

- Provision of alarm systems in pumping stations should be considered, along with procedures for attending to alarms received in and out of working hours.

- Provision of hand-raked screens on the emergency outfalls from sewage pumping stations should be considered. These should be provided with a bypass weir.

- As building developments are planned and approved, the necessary surface water drainage channels should be incorporated into the building scheme. The city engineering department or the Sewage Board of Pafos should have oversight of the various components to ensure the system develops as an integrated unit.

- In the short term (Stage 2A), a proportion of the sewage is likely to be tankered to the Sewage Treatment Works. This will increase the tanker traffic along the main access route of Pafos, and through the towns of Geroskipou, Koloni and Acheleia. Disturbance should be minimised by ensuring the tankers are well maintained and do not drip sewage. In the longer term, as the sewerage system is completed (Stage 2B) all sewage will be pumped to the Sewage Treatment Works, removing the need for tankerage, but resulting in unemployment for the drivers. Re-deployment to treated sludge transport could be considered.

7.2. Monitoring Plan

Monitoring will need to be conducted during the construction phase of the project (Short Term Monitoring) and as part of the routine operation of the Sewage Treatment Works (Long Term Monitoring). Monitoring procedures should be established early on in the project planning and be agreed upon by all parties concerned.

7.2.1. Short Term Monitoring

Short term monitoring requirements for the proposed scheme involve the construction of the treatment plant, the sewerage system and the drainage system. The main areas of concern are:

- dust, noise and odours
- archaeological features
- traffic

Dust, Noise and Odours

The control of dust, noise and odours will be the prime responsibility of the Contractors Site Engineer, with expertise provided by the Public Health Officers and the Sewage Board of Pafos Project Manager. It is expected that the Site Engineer will meet and discuss matters with the Public Health Officers and the Project Manager so that potential nuisances may be identified and avoided. Documentation of meetings will record the duties of the site staff.

The recording and reporting of complaints from the public by site staff and Public Health Officers will be useful to identify appropriate changes in site practices aimed at reducing nuisances. The submission of summary reports to the Municipal and District authorities outlining complaints and actions taken to reduce nuisances would be advisable.

Archaeological Features

There is a possibility that archaeological features will be unearthed during excavations. Notice of planned excavations should be presented to the Director of Antiquities and an archaeologist may be required to be present during certain work. Any finds should be notified to the Director of Antiquities and work should cease within that specified area while the site is inspected by an archaeologist. This provision should be put in any works contract or sub-contract.

Traffic

Traffic diversions should be agreed with the police and traders in advance. Close liaison with the residents of Pafos, particularly in the tourist areas, the villages and local land users should be recorded and used to identify appropriate changes in site practices aimed at reducing nuisances.

7.2.2. Long Term Monitoring

The long term monitoring of the sewerage and drainage operations will include:

- sewerage network and pumps
- influent quality
- Sewage Treatment Works
- pest populations
- odours
- irrigation water
- irrigated soils

- sludge produced
- sludge application sites
- stormwater drainage channels
- management reviews

Sewerage Network and Pumps

It is important that the sewerage network and pumping stations be supported by adequate maintenance facilities. The functions performed will include:

- cleaning of sewer blockages
- routine sewer cleaning, in locations shown by experience to require this on a regular basis
- mechanical and electrical maintenance to pumping stations
- routine cleaning and maintenance of pumping stations

The four proposed pumping stations on the foul sewerage system are strategic points which should be monitored for failures. Because ultimately their failure would lead to an overflow of untreated sewage to the marine environment, a system will be required for receiving, evaluating and responding to alarms both during and outside normal working hours.

To some extent, the general public will be a contributor to the monitoring of the sewerage system. The public will need to be aware of a contact number in case of emergencies (e.g., sewer blockages), and of the level of service which they should expect.

Other monitoring will include the routine recording of pumping station and sewer maintenance, in order that "breakdown maintenance" can be replaced in due course by "preventative maintenance". In this way the level of service offered by the system will be optimised.

Influent Quality

The requirements for monitoring of influent quality will be dependent upon:

- The presence of significant amounts of harmful constituents in the sewage, e.g., sulphide, contaminants of industrial origin, e.g. metals.

- The routine requirements of process monitoring and control. Should industrial effluent be received at the sewage treatment works, the effluent should be sampled at source and, if necessary, monitored at the Sewage Treatment Works.

Sewage Treatment Works

Monitoring requirements associated with the safe operation of the works should be developed in conjunction with the design and site engineers. The Sewage Treatment Works should be equipped with a chemical laboratory for routine checks and control of the effluent and sludge applied to land.

Pest Populations

Pest populations can be minimised by good housekeeping and by ensuring pest breeding grounds are kept to a minimum. The preliminary design does not include a tertiary treatment lagoon, which will minimise mosquito breeding habitats. Rats can apparently be controlled by "tame" snakes (as at Vathia Gonia Waste Stabilisation Ponds).

It should be noted that the existing waste stabilisation ponds near Agia Marinouda are very well-run, and do not appear to have attracted high populations of pests.

Specific advice and experience could be gained from other sites where sewage treatment plants are operated in Cyprus (e.g., Limassol - Amathus Reuse Scheme).

Odours

Odours are not expected to be a problem provided odour controls are in place and the treatment works are well-maintained. Strict supervision of operational maintenance will be required to ensure that the works are adequately cleaned and run efficiently. Liaison may be required with Public Health Officers, should complaints occur.

One source of possible odour is hydrogen sulphide gas. Hydrogen sulphide monitors are relatively easy to install and maintain, although they are expensive. Hydrogen sulphide should not be released from a well-operated and well-maintained treatment works and general monitoring should not be required unless complaints are received. The protection of staff by atmospheric monitors in specific local areas (usually enclosed environments) should be considered. This may be achieved by the use of portable monitors.

Marine Outfall

These are serious impacts associated with the construction of the marine outfall, and with its use to discharge raw sewage in case of an emergency. In the case of emergency discharge, the most severe impact is the death of seagrass beds around Moulia Rocks. Seagrass beds are vital habitats for the young of commercially important marine species, and also form feeding grounds for adults. The outfall must be built beyond the seagrass beds, to a depth and distance where contamination is unlikely to occur. This distance is likely to be over 1.5km form shore, but will need to be verified by survey.

The occasional discharge of raw sewage into the marine environment represents a localised organic enrichment and is likely to stimulate biotic activity. The sewage will be eaten or dispersed within a few days, depending on water movements at the point of discharge. If a diffuser head is used, dispersion is much more rapid and typically falls to 10ppm within 100m of the discharge. A survey should be conducted to ensure water movements do not carry the discharged sewage to shore.

Irrigation Water

Irrigation waters will need to be analysed to ensure adequate quality in relation to Cyprus legislation on the quality of water for irrigation (Table 7-3). The chemical laboratory on site will conduct this routine testing.

Irrigated Soils

Soil quality in irrigated areas will require sampling both prior to irrigation and to monitor potential changes. Sampling and analyses will need to address levels of chloride, nitrates, metals, and effects on permeability and drainage.

Sampling on a quarterly basis should be sufficient to highlight problems in the soils. Where problems have been identified, appropriate investigations should be made to determine specific causes, effects and measures.

Table 7-3: Provisional Quality Standards for Treated Domestic Sewage Effluent used for Irrigation in Cyprus

Irrigation Of:	BOD mg/l	SS mg/l	Faecal Coliforms 100 ml	Intestinal Worms/1	Treatment required
Fruit trees amenity area of unlimited access	10* 15*	10* 15*	50* 100*	NIL	secondary + tertiary + disinfection
Amenity areas of limited access	20* 30*	30* 45*	200* 300**	-	secondary + storage for 1 week or tertiary + disinfection
Nuts and other similar trees	20* 30**	30* 45**	200* 300**	-	secondary + disinfection
Fodder crops	20* 30**	30* 45**	1 000* 5 000**	NIL	secondary + storage for 1 week or tertiary + disinfection
Industrial crops	50* 70**	-	1 000* 10 000**	- -	secondary + disinfection

* These values should not be exceeded in 80% of samples analysed in a month.

** Maximum value allowed.

NOTE:

1. Irrigation of vegetables is not allowed.
2. Irrigation of ornamentals for trade purposes is not allowed.
3. No substances accumulating in the eatable parts of crops and proved to be toxic to humans or animals are allowed in effluent.

Source: Ministry of Agriculture, Natural Resources and Environment.

Sludge Produced

Sludges should be regularly analysed for those parameters which are considered potentially harmful. A total of thirteen parameters have been listed in the Code of Practice for Sewage Sludges in the UK (DOE, 1989). The parameters are concerned with the fertiliser value of the sludge: dry matter; organic toxicity; zinc; copper; nickel; cadmium; lead; mercury; chromium; molybdenum; selenium; arsenic and fluoride. In addition, analysis for total nitrogen and total phosphorous should be conducted.

Sampling should be undertaken at least every month and every time that sludge quality is deemed to have significantly changed.

Sludge Application Sites

Soils to which sludges are applied need to be monitored for quality and accumulation of metals. It is recommended that the EU Directive 86/278/EEC criteria are used for this purpose (Table 7-4). It is anticipated that the Department of Agriculture, Cyprus will assume responsibility. The recording of fields to which sludge is applied and dosages applied will need to be enforced.

Sampling of soils for those parameters which may be prejudicial to the growth of crops should be undertaken prior to the deposit of sludge.

The sites for application should continue to be assessed for general acceptability for sludge application. Factors that must be included are acceptable access, odour control and farm storage. Potential for surface run-off and groundwater pollution will also need to be assessed.

Stormwater Drainage Channels

Periodic checks of the entire drainage system should be audited, with a thorough review before the winter rains. Trash, and in particular large items and appliances that may block or break culverts should be removed. In natural channels, excess vegetation should be removed to allow rapid run-off of storm water, although sufficient vegetation should be left to protect the earthen banks from erosion, to slow flow allowing percolation and to provide visual and ecological value to the urban environment.

Management Reviews

At the end of the first year of operation, and periodically thereafter, the aims and results of monitoring should be reviewed by those responsible for management of the sewerage and drainage scheme. Increases or decreases in monitoring could be identified as well as changes in objectives for monitoring.

Compliance with relevant standards for influents, irrigation waters and sludges should be reviewed. If compliances are inadequate, appropriate operational charges would need to be identified to improve performance.

Table 7-4: EU Limit Values for Heavy Metal Concentrations In Sludge For Use In Agriculture

Parameters	Limit values (mg/kg of dry matter)
Cadmium	20 to 40
Copper	1000 to 1750
Nickel	300 to 400
Lead	750 to 1200
Zinc	2500 to 4000
Mercury	16 to 25
Chromium (1)	-

(1) It is not possible at this stage to fix limit values for chromium. The Council will fix these limit values later on the basis of proposals to be submitted by the Commission within one year following notification of this Directive.

Source: EU Directive 86/278/EEC

8. ENVIRONMENTAL MANAGEMENT AND TRAINING

Sound environmental management of the Pafos Sewerage and Drainage Scheme Project would benefit the Sewage Board of Pafos by:

1. minimising environmental risk
2. ensuring legislative compliance
3. decreasing programme delays, and
4. reducing adverse third party comment.
5. promote disposal routes for effluent and sludges

Incorporation of the findings of this Environmental Assessment, particularly the recommended mitigation options (Chapter 7), into a Project Environmental Management Plan would help to ensure that these elements (1 to 4 above) are achieved.

8.1. Environmental Management Programme

An Environmental Management Programme sets out the policy and principles to which the project would conform, and will define the means by which these are implemented. The programme would form the key reference document for ensuring that environmental issues were addressed throughout the life of the Project (from construction to operation) and which will be fully communicated to all project staff. It is recommended that the following key elements are included in such a programme:

- Environmental Policy (Employers and Contractors)

  The environmental policy, normally one page or less, states in general terms the Sewage Board's commitment to safeguarding the environment, employee safety and public health.

- Organisation and Responsibility

  Project environmental organisation and responsibilities, including appointment of a dedicated Project Manager sensitive to technical, environmental and social issues.

- Environmental Resources

  As the sewerage and drainage project progresses, additional environmental issues may need to be addressed. It is expected that the Project Manager would deal with routine environmental and social issues, particularly as many of the potential impacts to the natural and socio-economic environments have been identified in this Environmental Impact Assessment. One additional recommended study is a survey of existing drainage channels; which could include advertising for information, in the newspapers for example, from the general public. The new stormwater drainage system should incorporate existing channels wherever possible.

  The allocation of time to environmental issues should include liaison with the relevant regulatory and statutory bodies; and submitting sufficient information to obtain appropriate consents, licences and authorisations. A register could be developed of key legislative, regulatory and other policy requirements and codes applicable to the environmental aspects of the project's activities. The register would be regularly updated to take into account any relevant changes in legislation and would also include future pending requirements likely to impact on the project.

- Objectives and Targets

  Where significant environmental effects have been identified, objectives and targets could be established and a programme implemented to ensure the objectives and targets were adequately supported. The programme would delegate responsibilities, set timescales, state how objectives and targets to be achieved and how progress could be monitored.

- Development of Project Environmental Procedures/Plans

  In order to manage significant environmental effects, Project Environmental Procedures/Plans could be developed which are likely to include the following:

  - Noise and Nuisance
    - measures to be taken to minimise noise and nuisance
    - monitoring requirements
    - hours of working/minimising night time working
    - mitigation methods
    - control of dust, drips from tankers

  - Safety of the Public
    - public access
    - fencing of sites
    - site security

More detailed project specific plans could include:

- Waste Management Plan

  Procedures could be developed as part of the environmental management programme to ensure compliance with statutory and good practice requirements relating to the production handling, transport, storage, treatment and disposal of waste (both tankered raw sewage during Stage 1, and treated sludge). Wastes to be generated during the course of the project (including construction wastes) would be identified during the initial phase of the project and procedures implemented to ensure the appropriate handling of these wastes.

- Environmental Contingency Plans

  A contingency plan would detail procedures to be taken in the event of an environmental pollution incident including whom to contact, location of spill response equipment and actions to be taken. In addition, staff could be trained in preventative and precautionary procedures, and chemical, oil and fuel handling procedures would be developed to ensure that the opportunities for pollution incidents are minimised.

- Traffic Management Policy

  This will aim to reduce nuisance caused by increased traffic from construction vehicles etc. Establishment of designated routes for heavy plant and machinery and limits on traffic through local villages will help to reduce the Project impact.

- Review of Environmental Performance

  Periodic reviews should be held by the Sewage Board of Pafos to ensure that the specified project policy, objectives and programme are met. Recommendations and corrective actions could then be developed and implemented. Audit reports, for example, typically document observations and present recommendations for improvement or corrective action together with an implementation schedule for the proposed actions.

8.2. Communication and Training

Given the sensitivity of the general public to the Sewage Treatment Works, procedures could be developed to catalogue and respond to external communications and complaints relating to the environment. The procedure would address communications with regulatory bodies, members of the public and other interested bodies. In addition, communication and training programmes are important for all levels of project personnel to ensure an understanding of environmental policies and procedures and to raise awareness of the importance of environmental project issues.

8.3. Institutional Capability

Cyprus is developing its capacity for sewage treatment as a priority in its infrastructure development. Legislation is already in place to cover the treatment of sewage, and the use made of the products, wastewater effluent and sludge (Section 2.10). The reuse of treated effluent is considered an urgent need in the country which receives inadequate rainfall for its agricultural potential.

Studies have been conducted, at a national level, on the reuse of treated effluent for irrigation purposes: the Agricultural Research Institute has successfully conducted research over the last 10 years, while additional studies have been undertaken by private consultancies and the Department of Water Development. Despite this long-term research and evidence internationally that treated effluent is a useful water supplement, local farmers remain very suspicious of treated effluent and its reuse on their land. An information campaign, targeted at the local level, should be conducted, supplemented by trial plots operated by local branches of the Agricultural Research Institute or the Department of Water Resources. An obvious area would be the experimental farm, adjacent to the recommended Sewage treatment Works site. Trials should be widely advertised, with guided tours for local farmers, and the results publicised locally.

The mitigation measures outlined in this report (Chapter 7.0) should be incorporated in the contract documents for both detailed design and construction. Regular audits should be conducted in the field by the Sewage Board of Pafos representative (for example the Project

Manager) to ensure compliance. Penalties for non-compliance, for example improper waste disposal, should be outlined in the contract documents.

During the operation of the Sewage Treatment Works, the policies and procedures developed as suggested above (Section 8.1) should be followed. Reports to the national agency, the Ministry of Agriculture, Natural Resources and Environment, should be made on a regular basis to allow for country-wide synthesis of data.

9. INTER-AGENCY AND PUBLIC INVOLVEMENT

During the preparation of this Environmental Impact Assessment, a wide range of government agencies, NGOs and affected groups were consulted to obtain information relevant to the project and to solicit the opinions and views of the organisations representatives.

Table 9-1 provides a record of meetings with individuals and subject areas discussed:

Table 9-1: Record of Communications

Name	Organisation	Role	Subject(s) discussed
Mr Loizoides	Dept. of Fisheries, Ministry of Agriculture, Natural Resources and Environment, Nicosia	Senior Officer	Conversation about marine, marine water quality
Ms Stephanou	Dept. of Fisheries, Nicosia	Senior Officer	Conversation about marine fish farm, fishing interests, marine water-based activities
Ms Athanosiadou Hadjichristoforou	Dept. of Fisheries, Nicosia	Senior Officer Head of Environmental Section	Conversation about marine currents Conversation about marine biology
Mr N Georgiades	Ministry of Agriculture, Natural Resources and the Environment, Nicosia	Director of Environmental Services	EIA in Cyprus. General discussion regarding project and re-use of sludge in agriculture
Mr Sergides Ms Christofidou	Dept. of Town Planning, Pafos	- -	Conversation about land use planning
Mr Spanos	Water Development Dept., Pafos	-	Conversation about irrigation scheme reuse of treated water, areas available for irrigation, aquifers, water quality
Ms I Chappa	Dept. of Statistics and Research, Ministry of Finance, Nicosia.	Senior Statistics Officer	Discussion on Census data and population trends
Mr A Agathangelou	Dept. of Statistics and Research, Ministry of Finance, Nicosia	Statistics Officer	Conversation about data availability on employment and establishments.
Ms P Katsouris	Cyprus Tourism Organisation, Nicosia	Chief Tourist Officer	Discussion on tourism policy and marina proposal.
Ms Myrianthous	Cyprus Tourism Organisation, Nicosia	Statistics Officer	Provision of tourism statistics
Mr L Hadjioannou	Natural Resources and Environment, Nicosia	Meteorological Officer	Provision of detailed meteorological data
Ms X Loizidou	Ministry of Communications and Works, Nicosia	Civil Engineer	Discussion on coastal processes
Mr M Meletiou	Cyprus Ports Authority, Nicosia	Head of Civil Engineering and Architecture	Conversation about hydrology and hydraulics in the port area
Mr M Kiriakides	Town Planning Dept., Nicosia	Planning Officer	Discussion on planning policy and new road proposals.
Mr M Stylianou	Dept. of Water Development, Nicosia	Senior Engineer	Conversation about options for re-use of effluent
Mr I Ionas	Dept. of Antiquities, Pafos	-	Discussion about the archaeological constraints on the scheme
Mr C Giorgallides	Pafos District, Pafos	District Officer	Discussed views and concerns of local communities on the siting of the STW
Mr Christodoulou Mr Dimosthenous Mr Neophytos	-	Mayor of Geroskipou Chairman of Koloni Chairman of Acheleia	Meeting to discuss concerns of communities SE of Pafos regarding the siting of the STW
Mr A Eoanides Mr K Aristotelous	Dept. of Lands and Surveys, Pafos	District Lands Officer Assistant District Lands Officer	Discussion on land ownership and land values

A joint meeting was also held with environmental pressure groups in Pafos (Friends of the Earth, the Environment Association and Pafos 2000) at which key environmental concerns were outlined. A meeting was also held with hoteliers and local civil engineers. Finally, the consultants met on several occasions with Mr Savvas Savva and Mr Eftychios Malikides to discuss progress and to obtain a wide range of data and local knowledge.

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