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EXECUTIVE SUMMARY

As a future member of the European Union, Cyprus must fulfill the EU pre-accession requirements concerning the protection of the environment and therefore meet the obligations and requirements of Council Directive 91/271/EEC on urban wastewater treatment. The Directive concerns the collection, treatment and discharge of wastewater from sufficiently populated areas.

As a part of the "Implementation Programme of the Council Directive 91/271/EEC" and in the context of the Council Directive 91/271/EEC, a project was launched by the Water Development Department of the Ministry of Agriculture, Natural Resources and the Environment to upgrade the sewage systems of communities with equivalent population of more than 2000 which are not already equipped with a centralised collection and treatment system. The project includes 28 communities, which have been divided into 4 groups according to their district areas. This study is concerned with the Larnaca Communities of Group B, which includes the villages of Aradippou, Kiti, Perivolia, Dromolaxia, Meneou, Livadia and Athienou.

PROJECT DESCRIPTION

The project includes the design of the collection, conveyance and centralized treatment of the urban sewage effluents from the Larnaca communities. During the feasibility stage a number of alternative schemes were evaluated based on technical, financial and environmental criteria and a final scheme was selected as the preferred alternative. This included for the construction of a sewage treatment plant to the northeast of Aradippou, next to the animal husbandry zone, for the connection of the communities of Aradippou and Livadia; and the connection of the villages of Kiti, Dromolaxia, Meneou and Perivolia to the existing Larnaca STP, which will be extended to accommodate for the additional flows.

Athienou has been addressed separately due to its distance from the other communities and will be serviced by its own STP. Two of the three alternative locations originally selected have been examined in detail in the EIA for the construction of the Athienou STP, one to the southeast and the second to the north of the village, both next to the border with the occupied areas. Both sites were examined because, although the site to the southeast of the village is the preferable in environmental terms, the site to the north of the community is preferable from the technical and economic perspectives, while even though the environmental impacts that will arise from construction of the plant are higher as compared to the first alternative they are not as significant as to deter development at this site. From the detailed evaluation, and taking into account technical and economic considerations, it has been concluded that the preferred location for the construction of the STP is the site to the north of Athienou.

Regarding the treatment process, the activated sludge process combined with tertiary treatment has been suggested. This is proven and reliable process, which is currently in operation in three of the main treatment plants in Cyprus. Strict effluent quality standards will be applied for the design of the plant, which are a combination of the Cyprus and EU Standards for the quality of treated sewage waters. The main objective is the reuse of the treated water for irrigation. One of the advantages of the selected site is the possibility to store the treated effluent in the Achna Dam, particularly during the winter months. If this is not possible, the study has examined the possibility of constructing an additional long term storage reservoir near the plant.

The main objective for the sludge that will be produced from the process is agricultural reuse, as fertilizer. Selection of the treatment process will be based on this assumption.

EVALUATION OF IMPACTS AND MITIGATION MEASURES

Following a description of the baseline environment of the area, the environmental impacts that could result from the project have been identified and mitigation measures have been proposed to eliminate or minimize such impacts. Impacts have been examined in relation to project location and design, the project construction and operation phases, and the reuse of the treated effluent for irrigation.

A summary of the impacts that have been identified is outlined in the table below.

SUMMARY OF ENVIRONMENTAL IMPACTS

	Expected Impacts
IMPACTS DUE TO PROJECT LOCATION	**Permanent land acquisition** Permanent acquisition of land for construction of the STP, the storage reservoir and the pumping stations
	Impacts on surface water hydrology Positive impacts – additional surface water body
	Impacts on ecological values No impacts in the case of the Aradippou and Athienou STPs. Possible disturbance of wildlife in the case of the Larnaca STP, particularly birds, during construction, due to proximity of site to the Salt Lakes. Also, possible disturbance of wildlife during operation as a result of noise. Positive impacts through the creation of a new wetland habitat through the construction of the long term storage reservoirs.
IMPACTS DUE TO PROJECT DESIGN	**No significant impacts are anticipated** - Treatment process is reliable and proven and effluent will meet the set performance standards. - Emergency storage will safeguard against problems in treatment process. - Sludge treatment to be chosen will be effective in achieving required standards.
IMPACTS DUE TO CONSTRUCTION	**Temporary land acquisition** Temporary acquisition of land for workers' facilities, construction storage sites, pipe laying. This will result in possible loss of natural vegetation, grazing or agricultural land.
	Vegetation clearing Clearing of vegetation for construction of the STPs, the storage reservoirs, the pumping stations and the conveyance system.
	Soil impacts - Soil erosion: resulting from uncovered and unconsolidated materials during construction - Soil disaggregation - Soil compaction
	Dust, fumes and noise - Dust: from stockpiles and vehicle movement, particularly in dry weather and strong winds. - Noise: from construction operations, machinery and vehicle movements. - Fumes: from vehicle movements and machinery.
	On-site safety Risk of accidents on construction sites.

	Expected Impacts
	Waste management Construction waste, domestic solid waste
	Pollution Air water and soil pollution resulting from heavy operating machinery and vehicles, and from the storage of potential pollutants, such as petrol, motor oils and concrete.
	Traffic. Off-site public safety and inconvenience As a result of increased vehicle movement and road excavations.
IMPACTS RELATED TO OPERATION	**Landscape impacts** Minimum impacts
	Noise impacts At STP sites and pumping stations. Impact at STP sites limited as they are at a considerable distance from residential areas, however pumping stations are within urban areas.
	Odour impacts At STP sites and pumping stations. Impact at STP sites limited as they are at a considerable distance from residential areas, however pumping stations are within urban areas
	Impact on underground resources Positive impact: reduction in groundwater pumping, and reduction in nitrates released in the environment
	Impact of sludge production and reuse
	Risk of system overload Minimum risk: emergency storage available, design includes seasonal variations
	Risk of insufficient treatment of effluent
	Reuse of Treated Effluent in Irrigation Possible impacts on agricultural production, soils and groundwater bodies, impacts in plants and animals
	Urban reuse of the treated effluent Possibility of inappropriate use of treated water
	Groundwater recharge Possibility of aquifer contamination

ENVIRONMENTAL MANAGEMENT PROGRAMME

An Environmental Management Programme has been prepared outlining a set of mitigation measures and monitoring programmes, in relation to the project construction and operation, with the purpose of avoiding and controlling any adverse environmental impacts that might arise. As a result many of the impacts that have been identified will be effectively mitigated limiting the projects resulting effect on the environment.

1. INTRODUCTION

As a future member of the European Union, Cyprus must fulfill the EU pre-accession requirements concerning the protection of the environment and therefore meet the obligations and requirements of Council Directive 91/271/EEC on the collection, treatment and discharge of wastewater from sufficiently populated areas

The Water Development Department of the Ministry of Agriculture, Natural Resources and the Environment has elaborated an "Implementation Programme of the Council Directive 91/271/EEC" (a full compliance programme including projects' timetables and costs). The programme covers 32 communities of more than 2,000 p.e., 4 greater urban areas (Nicosia, Larnaca, Limassol and Paphos) and 2 major summer resorts. It covers development in collection networks and treatment plants including technical studies, designs, tendering, construction and supervision. The financial needs of the Programme will be met through commercial loans guaranteed by the Government which subsidizes part of the cost. The implementation of the Programme will assure conformity with the Directive's requirements in the year 2012. This implementation Programme has been submitted to the European Commission and derogation for Cyprus has been granted up to 2012.

As a part of the Programme, and in the context of the Council Directive 91/271/EEC, a project was launched by the Water Development Department of the Ministry of Agriculture, Natural Resources and Environment to upgrade the sewage systems of communities with equivalent population of more than 2000 which are not already equipped with a centralised collection and treatment system.

The number of these communities is 28. They have been split in 4 groups. These groups which are related to district areas are as follows:

- **Group A: Nicosia district**: Peristerona, Astromeritis, Palaiometocho, Kokkinotrimithia, Akaki and Lympia
- **Group B: Larnaca district**: Aradippou, Kiti, Perivolia, Dromolaxia/Meneou, Livadia and Athienou
- **Group C: Famagusta district**: Xylotymvou, Achna, Ormideia, Avgorou, Xylofagou, Agios Georgios Acheritou, Liopetri, Frenaros, Sotira and Deryneia
- **Group D: Limassol and Paphos districts**: Ypsonas, Kolossi, Episkopi, Trachoni, Erimi and Polis

1.1. CONTRACT FOR ENGINEERING SERVICES

A contract for engineering services EuropeAid/113561/D/SV/CY was signed with the consortium SOGREAH, France and A.F.Modinos & S.A. Vrahimis, Cyprus.

The specific objective of engineering assignment is to provide technical and detailed studies for collection networks and appropriate treatment for the sewage system upgrading of the above mentioned communities.

The engineering services are composed of the following stages:

- ⇨ Inception stage,
- ⇨ Technical studies (feasibility studies, financial studies, EIA)
- ⇨ Detailed studies.

1.2. PURPOSE OF STUDY

The purpose of the Environmental Impact Assessment Study for the Larnaca Group is to evaluate the environmental impacts that will result from the proposed project and to propose mitigation measures and monitoring requirements through the Environmental Management Programme that has been drafted.

2. INSTITUTIONAL FRAMEWORK FOR EIA

2.1. ENVIRONMENTAL ORGANISATION IN CYPRUS

2.1.1. CENTRAL GOVERNMENT LEVEL

In Cyprus, environmental policy is coordinated through the **Minister of Agriculture, Natural Resources and Environment (MANRE)**, although responsibilities for town and country planning issues rest with the **Minister of the Interior** and for air pollution control/air quality with the **Minister of Labour and Social Security**.

The **Council for the Protection of the Environment** which is an advisory body, chaired by MANRE, advises the Council of Ministers on issues, legislation and policy relating to the environment and sustainable development.

The **Environment Committee**, chaired by the Permanent Secretary of MANRE and constituted of representatives from all the ministries and government services involved in environmental issues, deals with the formulation and determination of the environmental policy objectives and assists in their co-ordination and implementation.

There are also two **Technical Committees** concerned by environmental issues, one responsible for evaluating the Environmental Impact Assessment (EIA) studies and the other for reviewing the Licensing of Discharges and the Registration of Processes under the laws for the Protection of Water and the Protection of Air. The Environment Committee and the Technical Committees are the main formal bodies through which the Government agencies communicate with each other, and through which inter-departmental issues are addressed.

The key Ministries and Agencies involved in Environmental Management in Cyprus are the following:

The **Ministry of Agriculture, Natural Resources and Environment (MANRE)** has prime responsibility for many different aspects of the environment. These responsibilities are distributed among the Environment Service and seven separate Departments.

The **Environment Service** is the coordinating agency for Government programs for the protection of the environment. It heads the Technical Committee on the Environmental Impact Assessment (TCEIA) of projects, advises on environmental policy and is mandated to ensure the implementation of the environmental policy. Among its responsibilities, the ES is in charge of the co-ordination of the adoption of the EU environmental acquis in co-operation with the Planning Bureau of the Ministry of Finance. The **ES** is also in charge of the TCEIA (which responsibility is to review EIA studies for environmental clearance), and is responsible for the enforcement of the Law on the Control of Water Pollution, for the promotion of environmental awareness and training, and for the provision of support to the Environment Committee and the Council for the Environment. The **ES** acts as the National Focal Point for a wide range of international agreements, conventions and organisations related to biodiversity and environmental protection.

The **Water Development Department (WDD)** is the largest single department of MANRE, reflecting the critical importance of water resources in Cyprus. It is responsible for most aspects of the implementation of water policy and the management of water resources (supply and use). This includes hydrological and hydrogeological water resources, the planning, design, construction and operation of water supply infrastructure, sewerage and wastewater treatment (outside the major urban areas) and the monitoring of water resources quality and quantity.

The **Department of Agriculture (DoA)** is the second largest department of MANRE, after WDD. Aside from responsibilities in the general agricultural development sector, the DoA is

particularly responsible for those components as wastewater reuse and utilisation of STP sludge for agricultural production.

The **Department of Forests (DoF)** of MANRE is responsible for the management and exploitation of state forests (which account for 19% of the area of Cyprus), including environmental aspects, and can declare nature reserves and national forest parks within those forests.

The **Ministry of Interior (MoI)** is responsible for town and country planning, including related environmental issues. The Department of Town Planning and Housing (DTPH) of the MoI is not only responsible for policy and legislation in this area but also acts as planning authority outside the four major conurbations of Nicosia, Larnaca, Limassol, and Paphos. It is responsible for imposing environmental conditions (based on recommendations of the ES and the EIA Technical Committee) through the planning permit, and participates in the EIA Technical Committee.

The **Ministry of Health (MoH)** also has an important role in relation to the environment in general and health impacts in particular. The State General Laboratory (SGL) of the MoH is the main government laboratory in Cyprus.

The **Public Health Service (PHS)** of the MoH has a large inspectorate responsible primarily for the monitoring of drinking water quality but also other environment-related aspects of public health. This includes the monitoring of groundwater quality (where this is used for drinking water), public health aspects of waste management (including, with ES and WDD, landfill site inspection), seawater quality (bathing beaches) and swimming pools.

2.1.2. LOCAL LEVEL

A total of **24 Municipalities** cover the major conurbations and larger towns in Cyprus, with a further 9 in the area occupied by Turkey. Population sizes range from almost 90,000 (Limassol) to less than 1,000 (Lefkara), although the average is around 16,500. Nicosia is covered by seven different Municipalities representing a total population of some 170,000. The Municipalities are represented by the Union of Cyprus Municipalities.

Under the Municipalities Law, the Municipalities are nominally responsible for water supply, sewerage and wastewater treatment, rainwater drainage, street cleaning, refuse collection and disposal and the protection of the natural environment.

The major Municipalities (greater Nicosia, Limassol, Larnaca and Paphos) are also Town Planning Authorities, responsible for issuing permits for the construction and operation of new developments in their areas. The major Municipalities discharge their responsibilities for wastewater collection, treatment and disposal through Municipal Sewage Boards (MSBs), which are established as separate entities but linked to the Municipalities. The Municipalities also work together where appropriate (particularly in Nicosia) on joint projects, for example sewage treatment works and waste disposal sites.

In addition to these Municipalities, there are **352 Communities** in the rural areas of Cyprus. These cover only about 40% of the population but 80% of the land area. The average population served by a Community is only around 750 and many are much smaller than this. They are represented by the Union of Cyprus Communities, and have a more limited role in relation to environmental issues. Like the Municipalities, the Communities also work together where appropriate.

In practice, neither the Municipalities nor the Communities have the financial resources or the staff to discharge their environmental responsibilities effectively. It follows that responsibility for infrastructure investment required by the local authorities generally falls to central government, as for example the Water Development Department of MANRE.

2.1.3. NON GOVERNMENTAL ORGANISATIONS

There are more than 30 purely environmental or environmentally-concerned NGOs in Cyprus, and their involvement in environmental policy formulation is actively encouraged. Under law 57(1) on

EIA, the Federation of Environmental and Ecological Organizations participates as a member in the TCEIA.

Several NGOs are members of the Council for the Environment and of steering committees for protected areas. They are also invited to express their views during hearings at the Parliamentary Environment Committee. The awareness-raising activities of NGOs are supported by financial assistance from Government for specific actions.

2.2. CYPRUS NATIONAL LAW 57(I)/2001 ON EIA

2.2.1. OBLIGATION FOR EIA STUDY

According to Cyprus Law 57(1) of 2001, STPs with a capacity above 2,000 equivalent-population are subject to full EIA study. This level is extremely low when compared to the same requirement of EU Directive 97/11/EC which is 150,000 equivalent-population, but understandable when considering the limited size and population of Cyprus.

The Law, however, does not mention any environmental requirements specific to the construction of sewer networks.

What will be considered for the present EIA study is:

- Full EIA will be carried out for all the STPs proposed, as all the projects will serve more than 2,000 people each.
- For groups of villages to be connected to an existing STP, Preliminary Environmental Impact Assessment (PEIR) will be carried out, complemented by an Environmental Management Plan (EMP) focusing on mitigation and monitoring measures during the construction stage.

In the Proposal of the Consultant, it was anticipated to carry out one EIA study for each group (cluster) of villages, or 4 EIAs. It is obvious that the splitting of some initial groups into two different systems will complicate the task. According to the Environment Service of MANRE, in such situation, one EIA report may still be maintained, considering that a two facilities scheme is the preferred alternative. We may presently stick to this suggestion, but final presentation of documents (common or separate reports) will be decided later according to needs.

2.2.2. CYPRUS NATIONAL LAW 57(I)/2002 ON EIA

A significant part of the harmonization procedure of Cyprus with the EU 'acquis' has been the adoption of the Law for the Assessment of the Environmental Impacts from Certain Projects (No. 57(I)/2001, Gazette No. 3488 of April 12th, 2001), which is now fully implemented, with responsibilities resting primarily with the Environmental Service. The Law deals with the environmental impacts from projects and activities, and aims at minimizing these impacts taking into consideration the environmental parameters before the issuing of a permit for the execution of the project.

The Law is based on the EU Directive 85/337/EEC, as amended by Directive 97/11/EEC. It has replaced the system of assessing the impacts to the environment that was applied based on a Council of Ministers Decision (No. 35/700, dated 20/6/1991).

According to this Law, the granting of a permit or approval for a project, including public projects, that may have significant environmental impacts, should be done only after assessing its potential impacts on the environment. This applies for every project that falls in the project categories of Annex I or II of the Law. The projects which are included under Annex I are those that could potentially result in significant adverse impacts on the environment and must go through a full assessment of their impacts. Annex II projects do not necessarily and in all occasions have significant environmental impacts, and for this they are subject to a Preliminary Environmental Impact Report (PEIR). Following evaluation of the PEIR, it is decided whether a full environmental assessment is required. Therefore, when an application is submitted for a planning permit or project approval, an EIA must be submitted for Annex I projects, or a PEIR for Annex II projects. With

regards to sewage treatment plants, those with a capacity above 2 000 population-equivalent are included in Annex I and are thus subject to a full EIA. (Articles 9 and 10, Law 57(I)/2001).

The EIA must contain the information specified in Annex III of the Law. It must identify, describe and evaluate the direct and indirect impacts likely to result from the project on a number of factors, including human beings; flora and fauna; the natural, as well as the historic and traditional man-made landscape; water, air and climate, and soils; material assets; and the architectural, cultural and archaeological heritage. (Article 12, Law 57(I)/2001)

Following the submission of the EIA, the developer (public or private authority) must publicize a Notification in two local daily newspapers announcing the submission of the EIA, the project and the area where it will be executed and the place where the study can be inspected. Any person can submit opinions or representations regarding the scope of the EIA or the possible environmental impacts of the project to the Environmental Authority (which is the Director of the Environment Service) within 30 days from the publication of the notification. (Article 20, Law 57(I)/2001)

The EIA is evaluated by the Environmental Authority who is advised by a permanent Committee (Committee for the Assessment of Environmental Impacts). This comprises representatives of all key Ministries and Departments related to the environment, as well as representatives of civil society. The Committee must take into consideration any justified opinions or representations made by any persons, organisation or authorities. It then makes recommendations to the Environmental Authority which delivers a justified opinion to the planning authority proposing measures to be imposed with the permit or even that the project is not executed. (Article 13, Law 57(I)/2001). In issuing the permit, the opinion of the environmental authority must be taken into account as a fundamental factor in the decision-making. (Article 4, Law 57(I)/2001)

2.3. OTHER NATIONAL LAWS

The use of sewage sludge in agriculture is not yet practiced except on an experimental basis. The disposal of sewage sludge is covered by the Water Pollution Control Law. Limit values for heavy metals are set in permits for land-spreading operations. A study financed by the European Investment Bank has been prepared, considering the options available (including for agricultural purposes) for the re-use of such sludge from the various treatment plants. The study indicates that the sludge produced could find use in agriculture and as an alternative low cost fuel in cement factories. A Code of Good Agricultural Practice (Use of Sewage Sludge in Agriculture), used as a guide for the discharge consent terms, has been completed and adopted in the beginning of 2002, under the Water Pollution Control Law.

The Quality of Water Intended for Human Consumption Law was enacted in May 2001 (Law No.87 (I) 2001), which fully covers requirements to safeguard drinking water quality

2.4. EU ENVIRONMENTAL DIRECTIVES

2.4.1. EU DIRECTIVE 97/11/EC ON EIA

EIA is a procedure required under the terms of European Union Directive 85/337/EEC amended by **EU Directive 97/11/EC** on assessment of the effects of certain public and private projects on the environment. Article 2 of the Directives requires that *"Member States shall adopt all measures necessary to ensure that, before consent is given, projects likely to have significant effects on the environment by virtue, inter alia, of their nature, size or location are made subject to a requirement for development consent and an assessment with regard to their effects."* Article 8 then requires that *"The results of consultations and information gathered pursuant to* [the EIA procedure] *must be taken into consideration in the development consent procedure"*.

These requirements are elaborated further in the Directive and in the EIA system introduced in Cyprus (Law 57(1) of 2001).

The environmental information that developers are required to provide under the EIA procedure is defined in Article 5(3) and Annex IV of Directive 97/11/EC. Article 5(3) requires that the information must include "*at least*

- *A description of the project comprising information on the site, design and size,*
- *A description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects,*
- *The data required to identify and assess the main effects which the project is likely to have on the environment,*
- *An outline of the main alternatives studied by the developer and an indication of the main reasons for his choice, taking into account the environmental effects,*
- *A non technical summary of the information mentioned in the previous indents*".
- Article 5(1) provides that the developers must supply the information in Annex IV "*in an appropriate form (…) in so much as:*
- *The Member State considers that the information is relevant to a given stage of the consent procedure and to the specific characteristics of a particular project or type of project and of the environmental features likely to be affected;*
- *The Member State considers that a developer may reasonably be required to compile this information having regard to current knowledge and methods of assessment*."

In most Member States, as in Cyprus, the information is provided in the form of an Environmental Impact Statement or EIS.

2.4.2. OTHER EU DIRECTIVES

Council Directive 91/271/EEC of 21May 1991 on urban wastewater treatment;

Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture;

Birds Directive 79/409/EEC: This Directive was implemented in April 1981 and imposes strict legal obligations on European Union Member States to maintain populations of naturally occurring wild birds at levels corresponding to ecological requirements, to regulate trade in birds, to limit hunting to species able to sustain exploitation, and to prohibit certain methods of capture and killing. Article 1 applies to the conservation of birds and also to their eggs, nests and habitats. Article 4 requires Member States to take special measures to conserve the habitat of certain listed threatened species through the designation of **Special Protection Areas** (SPAs).

Habitats Directive 92/43/EEC (Directive on the Conservation of Natural and Semi-natural Habitats and of Wild Fauna and Flora) aims to conserve fauna, flora and natural habitats of EU importance. The fundamental purpose of this directive is to establish a network of protected areas throughout the Community designed to maintain both the distribution and the abundance of threatened species and habitats, both terrestrial and marine. The network of **Special Areas of Conservation** (SAC) is called **Natura 2000**, and will include SPAs of the Birds Directive. Criteria for selection include priority habitats and species, as identified in its Annexes.

Under the Habitats Directive, **Natura 2000** is defined in Article 3(1) as a coherent European ecological network of special areas of conservation. This network, composed of sites hosting the natural habitat types listed in Annex I and habitats of species listed in Annex II, would enable the natural habitat types and the species' habitats concerned to be maintained or, where appropriate, restored at a favourable conservation status in their natural range.

Based on the Bird and Habitat Directives, the network sets the minimum standard for biodiversity conservation in the Member States, encompassing a wide range of issues and containing a number of concrete obligations. This concept is strengthened by the Maastricht Treaty, according to which all

Community policies and instruments must comply with the Community's environmental statutes, including the Habitats and Birds Directives.

In Cyprus, 38 sites Natura 2000 have already been proposed.

2.5. INTERNATIONAL AGREEMENTS AND CONVENTIONS

Several international conventions for the protection of the environment have also been ratified such as the Convention for the Conservation of the European Wildlife and Natural Habitats, the Convention on Biological Diversity, the Convention on the International Trade of Endangered Species (C.I.T.E.S.), the Convention for the Protection of the Mediterranean Sea Against Pollution and its four Protocols (MARPOL), the Global Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal, the Vienna Convention and the Montreal Protocol on the Protection of the Ozone Layer, the Climate Change Convention, the Convention for Migratory Species, the Convention on EIA in a Transboundary Context, the Convention to Combat Desertification, and the Convention on Wetlands of International Importance (RAMSAR).

3. PROJECT DESCRIPTION

3.1. PROJECT JUSTIFICATION

As a future member of the European Union, Cyprus must fulfill the EU pre-accession requirements concerning the protection of the environment and therefore must meet the obligations and requirements of Council Directive 91/271/EEC on urban wastewater treatment. The Directive 91/271/EEC on urban wastewater treatment concerns the collection, treatment and discharge of wastewater, including biodegradable industrial wastewater discharges, from sufficiently populated areas. It sets deadlines until 31 December 2005, to provide for collection systems and at least for secondary treatment for communities of different levels of populations, ranging from 2 000 population equivalent (p.e.) to more than 100 000 p.e. More advanced tertiary treatment is required for sensitive areas, including communities of less than 2 000 p.e. It also requires prior regulations and authorizations for all discharges of wastewater into the environment, for industrial discharges into urban wastewater systems and for the disposal of sewage sludge.

The current project involves the design of sewerage systems for the Larnaca (Group B) Area, which includes the communities of Aradippou, Kiti, Perivolia, Dromolaxia – Meneou, Livadia and Athienou. The sewage systems will consist of the collection and conveyance systems, and the central sewage treatment plants. For this purpose, during the feasibility stage a number of alternative schemes were evaluated based on technical, financial and environmental criteria and a final scheme was selected as the preferred alternative. This includes for the construction of a sewage treatment plant to the northeast of Aradippou, next to the Aradippou animal husbandry zone, for the connection of the communities of Aradippou and Livadia; and the connection of the villages of Kiti, Dromolaxia – Meneou, and Perivolia to the existing Larnaca STP which will be extended to accommodate for the additional flows.

Athienou has been addressed separately due to its distance from the other communities and will be serviced by its own STP. Two of the three alternative locations originally selected have been examined in detail for the construction of the Athienou STP, one to the southeast and the second to the north of the village, both next to the border with the occupied areas. Both sites were examined because, although the site to the southeast of the village is the preferable in environmental terms, the site to the north of the community is preferable from the technical and economic perspectives, while even though the environmental impacts that will arise from construction of the plant are higher as compared to the first alternative they are not as significant as to deter development at this site.

3.2. PROJECT LOCATION

The proposed location for the sewage treatment plant which will service the communities of Aradippou and Livadia is to the northeast of the village of Aradippou. The STP will be constructed at two separate sites. Site A will accommodate for the construction of the treatment plant and the emergency storage reservoir, while Site B will accommodate for the construction of the long term storage reservoir. Site A is at a distance of approximately 3 km from the boundary of the Aradippou residential zone and 2.8 km from the boundary of the Livadia residential zone, while Site B is at a distance of approximately 2 km and 2.3 km respectively. Both sites are within the Da3 buffer zone assigned to isolate animal husbandry and industrial zones from neighbouring areas. The location of the two sites is given in Drawing EIA-B-1.

Drawing EIA-B-2 gives the location of the existing Larnaca STP, to which the communities of Kiti, Dromolaxia – Meneou and Perivolia will be connected, following the expansion of the plant. Drawing EIA-B-4 gives the suggested sewer routes and the locations of the pumping stations, however, these are only preliminary and subject to detailed design.

Being remote from the other communities, Athienou will be serviced by a separate STP. Two alternative sites have been examined, one to the southeast of the village, approximately 1.5 km from the nearest houses, and the second to the north of the village, at approximately 1.0 km. Both locations are within the community's agricultural zones. The locations of the two sites are given in Drawing EIA-B-3.

3.3. PROJECT CHARACTERISTICS

3.3.1. SERVICED AREA

Table 3.1 lists the Larnaca Area Communities that are included in Group B.

TABLE 3.1: LARNACA AREA (GROUP C) COMMUNITIES

COMMUNITY NUMBER	COMMUNITIES
b1	Athienou
b2	Aradippou
b3	Livadia
b4	Dromolaxia – Meneou
b5	Kiti
b6	Perivolia

The water demand analysis is summarised in the table below.

TABLE 3.2: WATER DEMAND

COMMUNITIES	AVERAGE WATER DEMAND IN 2005 (INTO BRACKET AVERAGE WATER DEMAND INCLUDING ADDITIONAL SUMMER CONSUMPTION) M^3/DAY	AVERAGE WATER DEMAND IN 2030 (INTO BRACKET AVERAGE WATER DEMAND INCLUDING ADDITIONAL SUMMER CONSUMPTION) M^3/DAY
Athienou	620 (620)	860 (860)
Aradippou	1660 (1660)	2770 (2770)
Livadia	700 (700)	1130 (1130)
Dromolaxia – Meneou	880 (1170)	1380 (2280)
Kiti	450 (590)	750 (1110)
Perivolia	260 (1150)	480 (2580)

Domestic and non domestic consumption for the villages was calculated on the bases of the predicted future number of inhabitants and the specific water consumption which varies between 134 l/cap/day in year 2005 up to 141 l/cap/day in year 2030. For some of the communities with developing tourist activities, there will be a distinct seasonal variation of water consumption. For hydraulic design purposes it was taken into account by adding the water demand of the summer houses and where applicable hotels. The specific consumption of water for summer houses used for the study is 150 l/cap/day, while for the hotels 350 l/bed/day.

3.3.2. SEWAGE TREATMENT PLANT

3.3.2.1. EXPECTED CAPACITY

Wastewater production was derived from the data on water demand taking into account

- The return rate from the water supply to the sewers
- The corresponding flow from the summer houses
- A peak day factor
- A peak hour factor

Concerning the return of water to the wastewater system, studies made for the Greater Nicosia Sanitary System indicate that approximately 85% of domestic consumption could enter into the sewerage system, assuming a connection existed. Such a figure is in the range of those encountered elsewhere and was used in this study.

Infiltration resulting from the presence of ground water can be introduced in the waste water production. Groundwater infiltration occurs in gravity pipes where water leaks into the system through joints, cracks and other defects. With proper design, pipe material choice and construction the infiltration is minimized. Furthermore, infiltration is likely to occur in winter months when water consumption is low. For the purpose of this study the infiltration was taken into account as provision. According to the obtained data groundwater levels in the study area are generally lower that invert levels of the collection system except for parts of the Livadia and Perivolia. The flow from the infiltration is calculated using the value of 30m3/day/km which is the value commonly used in Europe and USA. According to the geological investigations it was estimated that approximately 30 % of the collection systems in Livadia and Perivolia will be bellow the ground water elevation. Furthermore it was estimated that in year 2005 only 25 % of the collection system will be in operation, while in year 2015, 75 % will be constructed. On the basis of these assumptions the additional flow due to the infiltration was estimated.

The average dry weather flow (ADWF) was calculated as a sum of domestic, non domestic and additional summer houses and hotel flow. In addition infiltration is added as a provision. Peak factors in sewerage systems correlate to a certain extent to those in water supply. In the GNSS project the peak water consumption was 1.4 times the average water consumption. This factor has been used to derive a Maximum Dry Weather flow (MDWF). The factor is not applied to the infiltration flow. The estimated wastewater production is given in Table 3.3 for the years 2005, 2015 and 2030.

Dry weather flow varies during the day with a major peak typically occurring in the early morning. It depends on the number of the inhabitants as well as on the size of the catchment area. As the catchment areas expand, the peak value decreases due to the superposition of different dry weather flow hydrographs and flow attenuation in the network.

The peak factor for the maximum hour varies for different consumers (domestic and industrial). On average the Peak hour factor is approximately 2.00, while for industries it rises to 3.8, relative to average day flow.

TABLE 3.3: WASTEWATER FLOW

COMMUNITIES	2005 ANNUAL PRODUCTION IN m^3/year	2005 MAXIMUM DRY WEATHER FLOW IN m^3/day	2015 ANNUAL PRODUCTION IN m^3/year	2015 MAXIMUM DRY WEATHER FLOW IN m^3/day	2030 ANNUAL PRODUCTION IN m^3/year	2030 MAXIMUM DRY WEATHER FLOW IN m^3/day
Athienou	224 840	733	255 500	833	313 170	1 021
Aradippou	605 535	1 974	737 300	2 404	1 008 860	3 289
Livadia	255 865	908	308 060	1 227	413 180	1 644
Dromolaxia – Meneou	348 440	1 396	431 216	1 895	584 419	2 709
Kiti	177 630	702	221 175	928	305 365	1 325
Perivolia	175 955	1 412	243 320	2 083	363 470	3 219
TOTAL	**1 788 265**	**7 125**	**2 196 571**	**9 370**	**2 988 464**	**13 208**

TABLE 3.4: SEWAGE TREATMENT PLANTS

Location		Nominal Capacity (m^3/d)
STP NAME	URBAN/RURAL/GOVERNMENT	
Aradippou	R	4 933
Larnaca STP	R	7 254
Athienou	R	1 021
TOTAL		**13 208**

The area requirements for the STP have been estimated to be 1.6 m^2/m^3/day, assuming a unit wastewater flow of 145 l/cap/day, or 0.3 m^2/population equivalent.
The land requirements for the sewage treatment plants will be as follows:

STP NAME	AREA REQUIREMENTS FOR SEWAGE TREATMENT PLANT	AREA REQUIREMENTS INCLUDING NEEDS FOR SLUDGE STORAGE, PARKING SPACE, OFFICES, BUFFER ZONE, ETC
Aradippou STP	7 893 m^2	8 000 m^2
Larnaca STP	11 606 m^2	11 700 m^2
Athienou STP	1 634 m^2	1 700 m^2

Infiltration was assumed to take place at a rate of 30m^3/day/km of pipe. The assumption was made that the groundwater level is going to be high such that (or precipitation taking place is to be such that the storm water) will infiltrate in the conveyance system for 30 days per year. Infiltration can be minimized with the addition of silica fume in the concrete making the manholes and it is also recommended that the conveyance system pipes be made of HDPE with welded connections at crucial points.

3.3.2.2. ESTIMATED POLLUTANT LOAD

There is no data available on the quality of the wastewater for the villages and it is difficult to characterize wastewater from a few spot analyses. Therefore, the wastewater pollution loadings have been estimated using per capita loading rates in accordance with the EU Directive 91/271/EEC. The following unit loading rates have been used:

TABLE 3.5: PROPOSED WASTEWATER POLLUTION UNIT LOADING RATES

BOD g/cap/d	COD g/cap/d	SS g/cap/d	TKN g/cap/d	P g/cap/d	Total coli MPN/cap/d	Faecal coli MPN/cap/d
60	135	75	12	4	10^8	10^7

The resulting average and peak pollutant loads presently and at medium and long term are given in Table 3.6 for BOD which is the basic design parameter for the sewage treatment plants.

TABLE 3.6: WASTEWATER POLLUTANT LOAD ESTIMATES (BOD)

COMMUNITY	2005 ANNUAL LOAD kg BOD/yr	2005 PEAK DAILY LOAD kg BOD/day	2015 ANNUAL LOAD kg BOD/yr	2015 PEAK DAILY LOAD kg BOD/day	2030 ANNUAL LOAD kg BOD/yr	2030 PEAK DAILY LOAD kg BOD/day
Athienou	134 992	440	150 725	491	179 094	584
Aradippou	363 409	1 185	434 793	1 418	577 001	1 881
Livadia	153 578	545	181 624	723	236 466	941
Dromolaxia – Meneou	229 862	921	285 982	1 257	381 817	1 770
Kiti	119 019	470	151 768	637	209 256	908

COMMUNITY	2005 ANNUAL LOAD kg BOD/yr	2005 PEAK DAILY LOAD kg BOD/day	2015 ANNUAL LOAD kg BOD/yr	2015 PEAK DAILY LOAD kg BOD/day	2030 ANNUAL LOAD kg BOD/yr	2030 PEAK DAILY LOAD kg BOD/day
Perivolia	187 596	1 505	265 596	2 274	406 370	3 599
TOTAL	**1 188 455**	**5 067**	**1 470 489**	**6 800**	**1 990 004**	**9 683**

3.3.2.3. EXPECTED QUALITY OF THE TREATED EFFLUENT

A combination of the standards specified by both the EU Directive 91/271/EEC and the Cyprus Codes of Practice for the disposal or reuse of treated effluents (Law 106(I)/2002 on the Control of Water and Soil Pollution) will be used (Appendix 1), and the most stringent values will be applied for the design of the wastewater treatment plant. Removal of nitrogen will be governed by the EU standards, whereas the limits for BOD, Suspended Solids (SS) and micro-organisms will follow the Cyprus Standards.

According to the EU Directive, the effluent discharged to sensitive areas should have concentrations of Nitrogen and Phosphorus not exceeding 15 mg/l (N) and 2 mg/l (P) respectively. However, the Government of Cyprus has requested deviation from the EU Directive in the case of phosphorus removal when the treated effluent will be used for irrigation purposes. In light of this it has been suggested that the treatment plant should be designed in a way as to ensure that the nitrogen concentration of the treated effluent does not exceed 15 mg/l, while with regards to phosphorus removal, only provision for future installation shall be provided for in the plant. Nevertheless, for the reuse of the treated effluent for irrigation purposes, the removal of phosphorus is also recommended here. Table 3.7 outlines the proposed limit values for the treated effluent as compared with the EU and Cyprus Standards.

TABLE 3.7: SUGGESTED DISCHARGE STANDARDS FOR THE DESIGN OF THE STP

PARAMETER	EU STANDARDS	CYPRUS REGULATION 517/2002 (FOR IRRIGATION OF ALL CROPS	PROPOSED LIMIT VALUES
BOD_5	25 mg/l	10 mg/l	10 mg/l
COD	90 mg/l	< 125 mg/l	< 125 mg/l
SS	35 mg/l	10 mg/l	10 mg/l
Total N	15 mg/l	–	15 mg/l
Faecal coliforms	–	5 units/100 ml (in 80% of samples) 15 units/100 ml (maximum)	5 units/100 ml (in 80% of samples) 15 units/100 ml (maximum)
Intestinal worms	–	Nil	Nil
Total P	2 mg/l	–	2 mg/l

3.3.2.4. TYPE OF PROCESS

ACTIVATED SLUDGE PROCESS

The activated-sludge process is one of the most common treatment processes and is currently in operation in three of the main treatment plants in Cyprus (Paralimni, Limassol and Larnaca). The process can be designed in many modified forms, including: selection of the reactor type, oxygen requirements and transfer, and types of settling tanks, but fundamentally the theoretical aspects of the process are similar:

- Wastewater is introduced into a reactor (aeration basin) where an aerobic bacterial culture is maintained in suspension. The reactor contents are referred to as the “mixed liquor”. In the

reactor, the bacterial culture carries out the conversion of the organic matter into biological solids (biological cells).

- The aerobic environment in the reactor is achieved by the use of diffused or mechanical aeration, which also serves to maintain the mixed liquor in a completely mixed regime.
- After a specific period of time, the mixture of biological solids is passed into a settling tank, where some of the settled sludge is recycled to maintain the desired concentration of organisms in the reactor and the remainder is removed from the system.
- The level at which the biological mass in the reactor should be kept (mean cell - residence time) depends on the desired treatment efficiency and other considerations, including the nature of the wastewater, and the local environmental conditions.

Different parameters can be used for the design of the activated-sludge process:

- The food to micro-organism ratio or mass loading defined as the mass of BOD applied per day to the treatment system divided by the mass of mixed liquor suspended solids (MLSS) in the aeration tank.
- The mean cell-residence time or sludge age that is the ratio of the mass of MSS in the aeration tank to the mass of sludge removed per day from the system.
- The volume loading defined as the mass of BOD applied per day to the treatment system divided by the aeration tank volume.

The activated sludge process was initially designed for removal of dissolved organic pollution (expressed as BOD, COD and SS), where removal rates up to 90%-95% can be expected depending on the design parameters. In the later years, the removal of nitrogen by biological nitrification and denitrification has been largely developed, requiring an increase of the sludge age in the tank and specific mixing, aeration and recycling arrangements. It has also been shown that biological phosphorus reduction can be achieved if an anaerobic tank is added at the inlet of the biological reactor and this development is now gaining more and more interest.

Aeration equipment for injecting oxygen into the MLSS can consist of mechanical aerators or diffused air systems that blow air into the MLSS.

Final settling tanks are used to separate the biological solids produced in activated sludge from the treated wastewater. Settling tanks are mainly designed on the basis of an overflow rate. Overflow rates may range from 0.5 to 0.7 m/h at peak flows.

It should be pointed out that an activated-sludge process does not provide any significant reduction in coliform counts (only a factor 10 to 100). Where coliform reduction is required, as the case is here, a tertiary treatment should be added to the treatment train, most often consisting in sand filtration and disinfection by chlorine or UV radiation.

Provided with tertiary treatment, the activated sludge process would meet the set performance requirements. However, due to the space requirements, the process could be difficult to locate where little land is available and leads to high costs if the plant should be covered and odour treated.

3.3.2.5. SLUDGE TREATMENT

The expected sludge production for the years 2005, 2015 and 2030 is outlined in Table 3.8.

TABLE 3.8: EXPECTED SLUDGE PRODUCTION

COMMUNITY	ANNUAL DRY SOLIDS PRODUCTION, KG DS/YEAR		
	2005	2015	2030
Athienou	134 992	150 725	179 094
Aradippou	363 409	434 793	577 001
Livadia	153 578	181 624	236 466
Dromolaxia – Meneou	229 862	285 982	381 817

COMMUNITY	ANNUAL DRY SOLIDS PRODUCTION, KG DS/YEAR		
	2005	2015	2030
Kiti	119 019	151 768	209 256
Perivolia	187 596	265 596	406 370
Total	**1 188 455**	**1 470 489**	**1 990 004**
TOTAL SLUDGE VOLUME AT 30% DS CONTENT	**3 961 m^3/year**	**4 901 m^3/year**	**6 633 m^3/year**

The experience from other wastewater treatment plants in Cyprus shows that sludge can easily be reused in agriculture and, due to the low rate of industrial wastewater of the total, that the sludge meets EU requirements for agricultural use without problems. It is therefore anticipated that the sludge from the treatment plant will be used as soil amendment in agriculture in accordance with the Code of Practice for the Use of Sludge for Agricultural Purposes (Law 106(I)/2002) and the standards imposed by it. The process selection for the sludge treatment will be based on this assumption.

Nevertheless, a significant percentage of the sludge produced will be disposed in landfills despite objectives for reuse, particularly during the first years of operation of the STP. Disposal must take place in an official controlled landfill site appropriate for the disposal of such wastes, which will incur additional costs for the transport of sludge.

Three different steps in the sludge treatment can normally be distinguished: thickening, stabilization and dewatering. Sometimes, thickening and dewatering can be combined or stabilization be omitted. An additional drying stage could also sometimes be required.

SLUDGE THICKENING

The excess sludge which is withdrawn from the secondary clarifier has a dry solids (DS) content of around 8 g/l and, in consequence, a water content of 99.2%. The sludge at this stage is thus very liquid, "dirty water". The purpose of sludge thickening is to concentrate the solids to a solids content of around 30 g/l or 3%. The sludge is after thickening still a liquid but with the volume reduced to around ¼ of the initial volume. Sludge thickening is generally carried out either by gravity thickeners, air flotation or drainage screens.

Gravity thickener is the most common type of sludge thickening device. It gives excellent results on primary sludge and acceptable results on digested secondary sludge. The principle and the operation are simple and robust. Gravity thickeners cannot be used if biological phosphorus removal is used, since anaerobic conditions will appear in the thickener with subsequent phosphorus release as a result.

Dissolved air flotation is used when the sludge is light and difficult to settle, typically for unstabilised activated sludge or sludge from biofilters. It is also a preferred option when biological phosphorus removal is used. The process is however more complicated to operate and more costly in operation and maintenance.

Drainage screens are mainly used in small treatment facilities and can be an interesting and space saving option.

SLUDGE STABILIZATION

The purpose of the sludge stabilization is to reduce the content of organic matter in the sludge and thereby reduce the potential for further fermentation or putrefaction and, in the same time, eliminate offensive odours. The stabilization will also reduce pathogens in the sludge to some extent. The processes used are:

- anaerobic digestion
- aerobic digestion

- lime stabilization
- thermal treatment

Anaerobic digestion by methane fermentation is a powerful means of removing substantial quantities of organic matter. The process most generally used is mesophilic digestion at 35°C. For normal wastewater treatment sludge, a reduction of 45 to 50% of the organic matter content can be expected. The digestion is producing biogas, mainly consisting of methane and carbon dioxide. A part of the produced biogas is used for the heating of the digester and the surplus can be used for heating other facilities or for producing electricity for the aerators of the plant.

Aerobic stabilization is usually employed in open-air units provided with air diffusers or surface aerators. The aerobic stabilization is rather energy consuming and is therefore rarely used as a specific unit. However, in an extended aeration activated sludge process, sludge is partly aerobically stabilised within the treatment process.

The advantages and disadvantages of aerobic and anaerobic stabilization are compared in the following table (from Degrémont Water Treatment Handbook):

TABLE 3.9: ADVANTAGES AND DISADVANTAGES OF AEROBIC AND ANAEROBIC STABILISATION

	Aerobic Stabilization	Anaerobic Stabilization
Products	CO_2 H_2O NO_3^-	CH_4 CO_2 H_2O NH_4^+
Energy released in liquid medium per g of organic matter removed	20 kJ	0.8 kJ
Energy generated in gas form per g of organic matter removed	0	20.9 kJ
Rate of breakdown	+	-
Final reduction of organic matter	-	+
BOD_5 of filtered supernatant	30-50 mg/l	200-400 mg/l
Resistance to inhibitors	+	-
Long-term storability	-	+
Sludge filterability	-	+

The fermenting capacity of sludge can be temporarily reduced by adding chemical agents in bacteriostatic dosages. Lime is the most widely used reagent because it is cheap, offers the right alkalinity and enhances the physical structure of the sludge. Lime can be added to the liquid sludge or to the dewatered sludge. The advantage of lime treatment is the absence of heavy investments in civil works and equipment, but this saving should be seen in the light of the relatively high operating costs.

Thermal treatment is principally used for the conditioning of the sludge by release of bound water in the cells and for deactivation of pathogenic agents.

As a matter of fact, in many cases it is a combination of these processes that are used. In an extended aeration process, sludge is first partly stabilised in the aeration tank, thus aerobic digestion, before undergoing anaerobic digestion. The digested sludge is then often treated with lime in order to improve the physical properties and to ensure that the sludge could be stored for long periods without any renewed fermentation.

SLUDGE DEWATERING

The purpose of the dewatering process is to further reduce the moisture content in the sludge, thereby also reducing the volume. Typically, dewatered sludge has a dry matter content between 20% and 40% depending on the process, which means a tenfold reduction of the volume. The

degree of dewatering depends on the type of equipment being used and it should be selected depending on the final destination of the sludge. Where sludge should be transported over long distances, additional drying up to 60% or even 90% DS could be considered in order to reduce the transportation costs.

Some kind of chemical conditioning is most often required to improve the dewatering characteristics of the sludge. Various types of chemicals are used: metal salts such as ferric chloride and aluminium sulphate, polymers (very commonly used) and lime. The most commonly used dewatering devices and their performances are given in the following table:

TABLE 3.10: DEWATERING DEVICES AND THEIR PERFORMANCES

Device	Performance for stabilised biological sludge	Energy consumption
Centrifuge	20% - 30%	55-70 kWh/ton dry matter
Belt filter	18% - 26%	40 kWh/ton dry matter
Plate filter press	30% - 40%	30-40 kWh/ton dry matter

Dewatering of sludge on drying beds is a very inexpensive solution, but is limited to small treatment plants due to the large surface areas required. About 0.25 m² of land per population equivalent is required, which would double the required surface for an activated sludge plant.

3.3.2.6. ODOUR CONTROL

Generally, three types of odour removal systems are used in applications related to wastewater conveyance and treatment:

- Chemical scrubbers
- biological filters
- activated carbon filters

Chemical scrubbers, including three (or two) scrubber towers and using acid, alkaline and oxidising agents are able to remove satisfactorily all odorous compounds in the air. The system requires daily verification but not any complicated operation procedures. The chemicals used need to be renewed at intervals.

Biological filters are now being developed more and more for odour treatment. Until recently, the biological filter consisted of an organic filter media, normally made up by peat and ligneous fibres which needed to be replaced every five years. However, mineral filter media are now being developed that do not need replacement. Sprinkling with fertiliser is required at intervals to maintain the biological activity on the filter. The biological filters are being more and more efficient with the recent development and can now remove most odorous components, but with reduced efficiency on nitrogen components.

Activated carbon filters can be used to adsorb some odorous compounds. The type of odorous compounds to be removed depends on the treatment of the activated carbon. Hydrogen sulphide (H_2S) can be well removed, but nitrogen compounds are difficult to remove by this system. The activated carbon filter media gets saturated and needs to be replaced from time to time. The design life depends on the applied load, but does generally not exceed six months.

Chemical scrubbers is the system used in a large majority of odour removal systems for wastewater treatment plants and pumping stations in France because of the high efficiency and the relatively low operation costs. Biological filters tend also to be used more frequently.

The use of activated carbon filters is limited to very small installations with low air flows and with a temporary operation, e.g. for odour control of a storm water holding tank, where the air treatment is only operated 10 to 20 days per year.

In normal cases, odour treatment is applied to the facilities that generate the most odours, i.e. pre-treatment and sludge treatment. In some particularly sensitive cases, where the treatment plant is close to housing areas, the whole plant could be covered and the air treated.

3.3.3. EMERGENCY STORAGE

An emergency storage reservoir will be constructed for each of the three sewage treatment plants, to provide for effluent storage in case of problems in the treatment process. The reservoirs will provide emergency storage for 7 days.
The depth of the reservoirs will be 5 m, with a resulting area requirement of 1.4 m^2/m^3/day.

TABLE 3.11: EMERGENCY STORAGE

Location		Volume Required (m^3)
STP NAME	URBAN/RURAL/GOVERNMENT	
Aradippou STP	R	34 531
Larnaca STP	R	50 771
Athienou STP	R	7 147

The land requirements for the emergency storage reservoirs will be as follows:

STP NAME	AREA REQUIREMENTS FOR THE EMERGENCY STORAGE RESERVOIR
Aradippou STP	6 910 m^2
Larnaca STP	10 160 m^2
Athienou STP	1 430 m^2

3.3.4. LONG TERM STORAGE

Provisions must be made for the long term storage of the treated effluents, which will be a necessity, particularly during the winter months when the demand for irrigation will be low. Each reservoir will provide storage for 120 days, and, having a depth of 5 m, the resulting area requirement will be 24m^2/m^3/day.

TABLE 3.12: LONG TERM STORAGE RESERVOIR

Location		Volume Required (m^3)
STP NAME	URBAN/RURAL/GOVERNMENT	
Aradippou STP	R	591 960
Larnaca STP	R	870 480
Athienou STP	R	122 520

The land requirements for each long term storage reservoir are as follows:

STP NAME	AREA REQUIREMENTS FOR THE LONG TERM STORAGE RESERVOIR
Aradippou STP	118 400 m^2
Larnaca STP	174 100 m^2
Athienou STP	24 510 m^2

3.3.5. SEWERS AND PUMPING STATIONS

3.3.5.1. SEWERAGE COLLECTION SYSTEMS

The sewerage collection networks for each community will be completed in two Phases. Phase A covers the areas to be presently connected to the network, while Phase B includes the areas to be connected in the future and its boundaries are in most cases the same as the water supply boundaries.
For the gravity pipes in the collection system the PVC pipes will be used while for the force mains the PEHD are predicted. For the detailed design of the collection system the following criteria will be used:

In the Nicosia sewerage scheme the minimum diameter adopted is 200 mm which is also the case in mainland Europe. It is proposed in this study to use 160 mm as a minimum diameter for the collection system while it is 110 mm for the house connections. The minimum depth from cover to the top of the pipe should be 1.6 m. This takes into account that house connections have a minimum depth to cover between 1.2 and 1.0m and generally a minimum slope of 1%.

The estimated total length of the sewerage collection networks is given in Table 3.13.

TABLE 3.13: ESTIMATED LENGTH OF THE COLLECTION NETWORK

VILLAGE	LENGTH (m)	MIN GROUND ELEVATION (masl)	MAX GROUND ELEVATION (masl)
Athienou	33 505.00	134.00	179.00
Aradippou	63 629.00	17.00	71.00
Livadia	32 289.00	4.00	30.00
Dromolaxia – Meneou	44 098.00	13.00	37.00
Kiti	42 091.00	12.00	31.00
Perivolia	16 812.00	2.00	13.00
TOTAL	**232 424.00**		

3.3.5.2. CONVEYANCE SYSTEM AND PUMPING FACILITIES

The conveyance system and the pumping facilities consist of the pipelines and pumping stations which are needed to transfer the wastewater flow from each community to the centralized treatment system. Pipelines are divided in two categories depending on the way the water is forced to flow. If the water flows by gravity, the pipelines are gravity sewers. If the flow is pushed by pumps, the pipelines are forcemains.

In forcemains the wastewater is in a closed environment without the presence of air. Formation of sulphides, which causes creation of unpleasant odours, is possible in case of long transfer of water without aeration which lasts a few hours – approximately 6 hours. With appropriate standard design, no problem of creation of sulphides, and therefore unpleasant odours, is anticipated for lengths of forcemain below 10 km, which corresponds to a transfer time of approximately 3 hours.

The proposed scheme is with two sewage treatment plants, one near Aradippou and Livadia, and the second at the existing Larnaca STP. The layout of the scheme and the corresponding flows are presented in Drawing EIA-B-4.

All communities located west of Larnaca will be connected to the existing Larnaca STP. Connection of the communities will be mainly by gravity, with the exception of Perivolia. Waste water from Dromolaxia and Kiti will be transferred by gravity with a short forcemain. Aradippou and Livadia will be connected to the Aradippou STP, located to the northeast of Aradippou. Connection from Aradippou will be a forcemain, while the wastewater from Livadia will be partly conveyed with gravity pipe and partly with the forcemain towards the STP.

The main components of the conveyance system are:

- The total length of the gravity pipes is 10.3 km with the diameter ranging between 250 mm to 600 mm.
- The total length of the forcemains is 10.6 km with the diameter being from 200 mm to 250 mm.
- Four pumping stations have been estimated, with the discharge capacity varying from 19.0 l/s to 46.7 l/s and installed power from 5.0 kW to 13.0 kW.

The locations of the pumping station are as follows:

TABLE 3.14 : POSITION OF PUMPING STATIONS

PUMPING STATION	POSITION
S.P.S. 1	Aradippou (in the outskirts of the residential area)
S.P.S. 2	Livadia (outside the residential area, to the northeast of the village)
S.P.S. 3	Perivolia (outside the residential area, to the southeast of the village)
S.P.S. 4	Meneou (outside residential area, to the southeast of the village)

The area required for each pumping station will be 500 m^2 (0.05 ha), with a total area of 2 000 m^2 (0.2 ha).
Details regarding the pumping stations are provided in Appendix 3.

3.4. IMPLEMENTATION SCHEDULE

The project schedule is outlined in the Project Implementation Programme (Appendix 4).

3.5. PROJECT COST

TABLE 3.15: SUMMARY OF TOTAL COSTS FOR THE ARADIPPOU AND LARNACA STP SYSTEMS

	COST (CYP)
CAPITAL COSTS	
Total Capital Costs	**14 715 482**
Conveyance System (pipelines and pumping stations)	2 910 065
STP and Emergency Storage	11 805 417
Long Term Storage	0
OPERATIONAL COSTS	
Total Operational Costs	**1 146 628**
Conveyance System (pipelines and pumping stations)	57 580
STP and Emergency Storage	1 089 048
NPV ON A 40 YEARS PERIOD	
Capital Cost	14 715 482
Annual Operating Cost at Design Flow	1 146 628
Net Present Value	**29 082 443**

TABLE 3.16: SUMMARY OF TOTAL COSTS FOR THE ATHIENOU SYSTEM

	COST (CYP)
CAPITAL COSTS	
Total Capital Costs	**1 807 432**
Conveyance System (pipelines and pumping stations)	0
STP and Emergency Storage	1 784 970
Long Term Storage	0
OPERATIONAL COSTS	
Total Operational Costs	**166 074**
Conveyance System (pipelines and pumping stations)	0
STP and Emergency Storage	166 074
NPV ON A 40 YEARS PERIOD	
Capital Cost	1 807 432
Annual Operating Cost at Design Flow	166 074
Net Present Value	**3 902 177**

3.5. EXISTING LARNACA STP

The existing Larnaca sewage treatment plant is designed based on the activated sludge process, combined with tertiary treatment. The treatment of sludge then follows three stages: thickening, with the use of a gravity thickener; stabilization with the use of anaerobic digestion; and finally drying with the use of drying beds.

The design parameters for the plant are as follows:

Design capacity ▪ Average flow ▪ Maximum flow	12 000 m^3/day ▪ 600 m^3/day ▪ 280 l/s
Annual average daily flow design capacity	8 500 m^3/day
Maximum daily flow design capacity	25 920 m^3/day
Annual average actual wastewater flow treated*	4 309 m^3/day
Maximum actual daily wastewater flow treated*	9 450 m^3/day
** With 34% of hotels to be connected A.N. and 14 613 homes to be connected in P. & A.N.*	
Project maximum flow when full connection in 5 years	13 327 m^3/day

4. LARNACA AREA: DESCRIPTION OF THE ENVIRONMENTAL BASELINE

4.1. PHYSICAL ENVIRONMENT

4.1.1. TOPOGRAPHY, GEOLOGY AND SOILS

The location of the Aradippou STP is indicated on a topographic map in Drawing EIA-B-5, and the location of the existing Larnaca STP in Drawing EIA-B-6. Drawings EIA-B-8 and EIA-B-9 provide geological maps of the two locations.

4.1.1.1. GENERAL GEOLOGICAL ENVIRONMENT

DROMOLAXIA – MENEOU – KITI – PERIVOLIA AREA

This area forms part of a flat coastal plain in the south of Cyprus, whose ground surface dips gently towards the sea. Elevations vary from 0 – 50 m a.s.l. In this area an extensive aquifer, called the Kiti aquifer has developed. It is considered as the most important aquifer in the Larnaca area, although overexploitation in the last few decades has led to its near depletion and to an increase of groundwater salinity in wide areas due to sea-water intrusion. Problems of increasing salinity have been experienced to distances of up to 3.5 km from the sea shore.

The coastal plain deposits consist principally of sands and silts with lenses of gravel, clayey silt and clay belonging to the Athalassa Formation (Upper Pliocene – Lower Pleistocene age). Their thickness ranges from 5 m to 30 m in the south. They are covered by a top soil up to 0.5 m thick consisting of brownish sandy silt. The basement on which the coastal deposits rest consists of impermeable marls of the Pakhna Formation and in other areas of the Nicosia Formation.

Alluvial deposits consisting of sands and silts with gravels and boulders have formed along the Tremithos river valley. The thickness of these deposits reaches a maximum of 45 m in a buried channel to the southwest of Kiti. These deposits appear to constitute a preferential course of groundwater flow towards the sea.

The hydraulic conductivity of the aquifer has been estimated by hydrogeologists in the range of 1 – 8 m/day (1.2×10^{-5} – 9.3×10^{-5} m/s). The higher values correspond to the Tremithos alluvial aquifer.

In the area of Cape Kiti and Kiti Tower to the north contorted chalks of the Lefkara Formation are observed on the sea cliff of the 12 m raised beach. The chalks are capped by a 2 m layer of raised beach deposits represented by cemented gravel and sand.

Water levels for March – April 2003 still show sea-water intrusion into the area, from the south and the east. A depression still exists, in spite of reduced pumping which extends inland for 2.0 – 2.5 km. The deepest depression of -4 m is observed west of Perivolia, but on the main this is confined down to -2 m. Water levels rise above 0 m at Kiti and Meneou and increases to more than 40 m to the west of Dromolaxia.

ARADIPPOU AREA

The Aradippou area forms part of the wider Larnaca coastal plain. It is a flat lying area which slopes gently to the southeast and is only interrupted in the north by a shallow river valley.

The area is covered mainly with marine terrace deposits consisting of silts, clayey silts, silty clays, clays and marls, with lenses of gravels with boulders. In the north and northwest alluvial deposits are encountered which include, apart from silts and marls, gravels of sedimentary origin. A top soil of light brown silt and sand, 0.1 – 0.3 m thick has developed on top of the marine terrace and alluvial deposits. All the formations appear to be fairly soft and only rare occurrences of hard kafkalla and havara have been reported. The thickness of the terrace and alluvial deposits reaches a maximum of about 30 m. These deposits rest on Pliocene marls which in turn rest on gypsum. The depth to the gypsum is about 25 m to the southwest of Aradippou increasing to 100 m to the north east.

LIVADIA AREA

The Livadia area forms part of the wider Larnaca coastal plain. Its south eastern part drops down to elevations of about 3 m and forms part of the recent marine deposits. The ground rises to the north and northwest to elevations over 20 m where it becomes more hilly with flat-topped hills. These hills are covered with marine terrace deposits while the lower ground is covered with alluvial deposits.

The main lithological types of the terrace and alluvial deposits down to a depth of 20 m are silts, sands, gravels and marls. They are loose to weakly cemented deposits but cementation may become moderate to strong at places. Hard havarized gravels have been reported in the south and east. Havara has been reported near the oil refinery. Hard calcarenite and strongly cemented silt were also encountered in certain boreholes. The basement on which the marine terrace and alluvial deposits rest is formed of yellow to grey marls which extend to depths of at least 100 m.

4.1.1.2. SOIL CHARACTERISTICS AND PRESENT SANITARY SITUATION IN THE REGION

Table 4.1 gives the soil characteristics for each of the concerned communities and the present sanitary conditions. The current sewerage system consists of septic tanks and absorption pits, however, the soil conditions in most of the communities are not favourable for such a sanitation system. As a result, most communities face serious absorption problems and construction of a sewage treatment plant is viewed as a necessity.

TABLE 4.1 : SOIL CHARACTERISTICS AND PRESENT SANITARY CONDITIONS IN THE LARNACA COMMUNITIES

Communities	Soil characteristics	Present sanitation situation
ARADIPPOU	Top soil of light brown silt and sand 0.1-0.3m thick rests on a succession of marine terrace and alluvial deposits of maximum thickness of about 30 m consisting of loose to weakly cemented silt, sandy silt, clayey silt, sand and marl with thin lenses of gravels with boulders. This succession lies on top of Pliocene marls which in turn rest on gypsum at about 25 m in the southwest of Aradippou increasing to nearly 100 m in the northeast. The permeabilities of the terrace and alluvial deposits are low to intermediate.	In the area located south from the Larnaca – Limassol highway there are absorption problems
LIVADIA	There is a loose light brown silty top soil over most of the area up to 0.5 m thick. Fill material occurs at places. The above rests on an alternating succession of marine and alluvial silts, sands and gravels with boulders, mostly loose or weakly cemented but more strongly cemented at places down to a depth of about 20 m. Succession rests on marls extending in depth to at least 100 m. Permeabilities of succession low to intermediate. Water levels shallow in the south and east.	
DROMOLAXIA – MENEOU	Brownish top soil of sandy silt 0.5-1.0m thick lies on top of marine terrace deposits of silts, sands, marls and gradations of these with occasional gravel lenses of a maximum thickness of about 20 m. Cementation weak and permeabilities low to intermediate. Terrace deposits lie on thick Pliocene marls.	There are no severe problems with the absorption

Communities	Soil characteristics	Present sanitation situation
KITI	Top soil of silty sand 0.1-0.3 m thick lies on a succession of marine and alluvial deposits up to 25 m thick consisting of silts, sands and clays with layers of gravels. Permeabilities low to intermediate and water levels generally deeper than 4 m. Groundwater salinity high. Deposits loose to weakly cemented, mainly rest on thick layers of marl.	
PERIVOLIA	Thin light brown top soil up to 0.3 m thick of soft silt with sand and some clay followed below by a sequence of soft to weakly cemented silts with sand and clay and occasional thin gravel layers up to 1 m thick. At some places the gravels are moderately to strongly cemented. Above sequence of marine deposits rests on Pliocene – Pakhna marls of large thickness. Permeabilities low to intermediate. Shallow water levels encountered in the coastal area.	

4.1.2. CLIMATE

In terms of climate, the year in Cyprus can be divided in two seasons: the winter period, between October to March, and the summer period, between April to September. During the winter period there are significant fluctuations in the climatic conditions, with large variations in temperature and pressure, and frequent alterations in wind directions and speed. In contrast, during the summer period climatic conditions are largely stable.

4.1.2.1. TEMPERATURE

Mean annual temperatures in the Larnaca region are approximately 19^{o}C – 20^{o}C. Mean monthly temperatures are within the range of approximately 11^{o}C in January/February and 28^{o}C in July/August. The mean monthly temperatures for the period 1961 – 1990 were between 12^{o}C in January and 27.6^{o}C in August, with a mean annual temperature of 19.6^{o}C.

Average temperatures for the periods 1981 – 1990, 1991 – 2000 and 1961 – 1990 are as follows:

1981 – 1990	Mean annual temperature	19.1^{o}C
	Mean monthly temperature range	10.6^{o}C (Jan) – 27.4^{o}C (Jul)
1991 – 2000	Mean annual temperature	19.8^{o}C
	Mean monthly temperature range	10.9^{o}C (Feb) – 28.0^{o}C (Aug)
1981 – 2000	Mean annual temperature	19.5^{o}C
	Mean monthly temperature range	10.8^{o}C (Jan) – 27.7^{o}C (Jul)
1961 – 1990	Mean annual temperature	19.6^{o}C
	Mean monthly temperature range	12^{o}C (Jan) – 27.6^{o}C (Jul)

4.1.2.2. PRECIPITATION

The mean annual precipitation in the Larnaca region for the period 1991 – 2000 was 339.1 mm, with normal precipitation (1961 – 1990) being 343.5 mm. The average monthly precipitation ranged between 0.4 mm in August to 86.4 mm in December, while the normal average monthly precipitation is in the range of 0 mm for July and 86.0 mm for December.

Average precipitation values for the Larnaca region are as follows:

Mean monthly precipitation range (1991-2000)	0.4 mm (Aug) – 86.4 mm (Dec)
Normal monthly precipitation range (1961-1990)	0 mm (Jul) - 86.0 mm (Dec)
Mean annual precipitation	339.1 mm
Normal annual precipitation	343.5 mm

The average annual number of rain days (≥ 0.2 mm of rain) for the period 1961 – 1990 was 51, and the average number of wet days (≥ 1.0 mm of rain) was 40.

4.1.2.3. EVAPORATION

The mean daily evaporation for the period 1991 – 2000 was between 2.5 mm in December and 9.8 mm in July, with the average being 6.1 mm.

Average values for the Larnaca region during the period 1991 – 2000 are as follows:

Mean daily evaporation	2.5 mm (Dec) – 9.8 mm (Jul)
Annual mean daily evaporation	6.1 mm

4.1.2.4. RELATIVE HUMIDITY (RH)

The mean annual RH at 08:00 hrs LST for the period 1981 – 1990 was 69% and, for the period 1991 – 2000, 67%. Monthly averages were between 60%, in May, and 83%, in January, during 1981 – 1990, and 59% in September/October to 79% in December for 1991 – 2000. The mean annual RH at 13:00 hrs LST for the period 1981 – 1990 was 55%, with monthly means ranging between 51% in September/October and 59% in January/February. For the period 1991 – 2000, the annual mean was 53%, and the monthly averages ranged between 49% in September/October to 58% in December. For the period 1961 – 1990 data is only available for the RH at 08:00 hrs LST. The annual mean was 67.6%, with monthly averages in the range of 52% for October to 77% for January/December.

Average values for Relative Humidity in the Larnaca area are as follows:

1981 – 1990	Mean monthly RH at 08:00 hrs LST	60.0% (May) – 83.0% (Jan)
	Mean annual RH at 08:00 hrs LST	69.0%
	Mean monthly RH at 13:00 hrs LST	51.0% (Sep/Oct) – 59.0%(Jan/Feb)
	Mean annual RH at 13:00 hrs LST	55.0%
1991 – 2000	Mean monthly RH at 08:00 hrs LST	59.0% (Sep/Oct) – 79.0 % (Dec)
	Mean annual RH at 08:00 hrs LST	67.0%
	Mean monthly RH at 13:00 hrs LST	49.0% (Sep/Oct) – 58.0% (Dec)
	Mean annual RH at 13:00 hrs LST	53.0%
1981 – 2000	Mean monthly RH at 08:00 hrs LST	60.0% (May/Sep) – 80.5% (Jan)
	Mean annual RH at 08:00 hrs LST	68.0%
	Mean monthly RH at 13:00 hrs LST	50.0% (Sep/Oct) – 57.5% (Dec/Jan)
	Mean annual RH at 13:00 hrs LST	54.0%
1961 – 1990	Mean monthly RH at 08:00 hrs LST	52.0% (Oct) – 77.0% (Jan)
	Mean annual RH at 08:00 hrs LST	67.6%

4.1.2.5. WIND SPEED

- *ANEMOGRAPH, HEIGHT: 2m*
  The average annual wind speed for the Larnaca region, during the period 1982 – 1992, was 2.5 m/s, with monthly averages being in the range of 2.2 m/s between, October to January, to 2.9 m/s during the months of June and July.
- *ELECTRIC ANEMOGRAPH, HEIGHT 10M*
  The mean annual wind speed, measured at a height of 10m, for the period 1982 – 1992 was 4.0 m/s, with monthly averages being between 3.6 m/s for October and 4.4 m/s for July.

4.1.2.6. WIND DIRECTION

From September to April the prevailing winds have a northwest direction, with angles between 300^{o} to 330^{o}. South to southwest winds also have a relatively high percentage of occurrence, except during the months of November and December. From May to August the prevailing winds have a southwest direction, with angles of 210^{o}. There is also a strong occurrence of south winds, with angles of 180^{o}; as well as a high percentage of northwest winds, except in August.

Climatic data for the region are given analytically in Appendix 5.

4.1.3. SURFACE WATER RESOURCES

4.1.3.1. NATURAL STREAMS AND SURFACE WATER BODIES

ARADIPPOU STP

There are two small streams next to the sewage treatment plant site, however, since they are permanently dry, the treated effluent cannot be discharged in these streams.

EXISTING LARNACA STP

The existing Larnaca sewage treatment plant is at a distance of approximately 500 m from the salt lake that lies to the southeast of the airport, while the storage reservoir is next to the lake, about 230 m from the plant. The plant is also at a distance of approximately 530 m from the coastline which lies to the east of the site. An additional long term storage reservoir will be constructed on the site as the discharge of the treated effluent in the sea should be avoided due to the presence in the area of the water desalination plant.

4.1.3.1. EXISTING RESERVOIRS

ARADIPPOU STP

There is no existing reservoir near the Aradippou STP site, therefore, a long term storage reservoir will be constructed at Site A (as indicated in map EIA-B-1) for the storage of the treated effluent, particularly during the winter months when the demand of water for irrigation will be low.

EXISTING LARNACA STP

Following the expansion of the STP under Phase 2 of the Larnaca system, the storage of the treated effluent from the villages to be connected under the scheme cannot be accommodated by the existing reservoir. An additional long term storage reservoir will be constructed on the site as the

discharge of the treated effluent in the sea should be avoided due to the presence in the area of the water desalination plant.

4.1.4. GROUND WATER RESOURCES

In the Aradippou and Livadia area the groundwater level lies at a depth of approximately 2 – 4 m in the south and east. In the north and west, however, it appears to deepen.

In the case of the villages to be connected to the Larnaca STP, the Kiti aquifer, which covers an area of 38 km^2 is considered to be the most important aquifer in the Larnaca District and most of the irrigation water is supplied by this aquifer. However, over-development and over-pumping has caused reduction in water levels, and an associated seawater intrusion in its coastal zone. Salinity problems are experienced for distances of up to 3.5 km from the coastline or the Salt Lakes that border the aquifer to the east. The most productive parts of the aquifer are in the areas of Kiti, Perivolia and Meneou, where the aquifer thickness ranges between 20 and 45 m, however sea intrusion has led to abandonment in the early 1980s. Moreover, over-pumping has led to the depletion of the less productive sections of the aquifer. Currently it is estimated that a total of approximately 2 Mm^3/year are being extracted. This is coupled by the low rainfall patterns of the last decade that has resulted in a reduction in the direct natural recharge of the aquifer.

4.2. ECOLOGICAL ENVIRONMENT

4.2.1. VEGETATION

ARADIPPOU STP SITE

The proposed location for the Aradippou sewage treatment plant is next to the animal husbandry area and within the Da3 buffer zone which has been created to protect the areas neighbouring this. Site B, where the long term storage will be constructed, consists largely of barren land, with very sparse vegetation. There are only a few cultivated plots further downstream from the site, mainly for fodder used for grazing. Site A, where the treatment plant and emergency storage reservoir will be constructed, is similarly within the Da3 buffer zone and consists mostly of barren land, with only a few plots cultivated with fodder for grazing.

EXISTING LARNACA STP

The vegetation cover on the fringes of the salt lakes and the surrounding areas is very rich and diverse, consisting of many species of trees, plants and flowers. There is extensive halophytic vegetation, and species like the Salocornia fructicosa, Suaeda spp., Salicornia europa, and the Juncos spp are common. Other plants include the Acacia cyanophylla, Anemone Koronaria, Anchusa andulata, Ophrys fusca, Orchid coriophora, Pinus hapepensis, Limonium virgatum, Thymus capitatus, etc.

4.2.2. WILDLIFE

ARADIPPOU STP SITE

The area of the proposed location for the Aradippou sewage treatment consists largely of barren land and due to the nature of the region any occurrences of wildlife fauna, including bird species, will be restricted.

EXISTING LARNACA STP

The Larnaca Salt Lakes constitute one of the most significant wetland habitats of the island and attract a wide and diverse number of bird species, including migratory, resident and endemic species. Particularly due to its location, the long term storage reservoir of the existing sewage treatment plant, which is adjacent to one of the salt lakes, it provides an additional habitat most of these species. Table 4.2 provides a list of bird species that have been reported both at the Larnaca Salt Lakes and the reservoir, while Table 4.3 gives some of the resident species in the area.

TABLE 4.2: LIST OF MIGRATORY BIRD SPECIES REPORTED AT THE LARNACA SALT LAKES AND THE SEWAGE WORKS

	Common Name	Scientific Name	Status
1.	Common Sandpiper	*Actitis hypoleucos*	Passage Migrant
2.	Skylark	*Alanda arvensis*	Passage Migrant, Winter Visitor
3.	Northern Pintail	*Anas acuta*	Passage Migrant
4.	Northern Shoveler	*Anas clupeata*	Passage Migrant, Winter Visitor
5.	Common Teal	*Anas crecca*	Passage Migrant, Winter Visitor
6.	Eurasian Wigeon	*Anas penelope*	Passage Migrant, Winter Visitor
7.	Mallard	*Anas platyrhynchos*	Passage Migrant, Winter Visitor
8.	Garganey	*Anas querquedula*	Passage Migrant
9.	Gadwall	*Anas strepera*	Passage Migrant, Winter Visitor
10.	White-fronted Goose	*Anser albifrons*	Rare in Cyprus, Winter Visitor
11.	Greylag Goose	*Anser anser*	Passage Migrant, Winter Visitor
12.	Red-throated Pipit	*Anthus cervicus*	Passage Migrant
13.	Meadow Pipit	*Anthus pratensis*	Passage Migrant, Winter Visitor
14.	Tree Pipit	*Anthus trivialis*	Passage Migrant
15.	Common Swift	*Apus apus*	Summer visitor
16.	Alpine Swift	*Apus melba*	Summer Visitor
17.	Pallid Swift	*Apus pallidus*	Summer Visitor
18.	Grey Heron	*Ardea cinerea*	Passage Migrant, Winter Visitor
19.	Purple Heron	*Ardea purpurea*	Passage Migrant
20.	Squacco Herron	*Ardeola ralloides*	Passage Migrant
21.	Pochard	*Aythya farina*	Passage Migrant
22.	Tufted Duck	*Aythya fuligula*	Passage Migrant
23.	Ferruginous Duck	*Aythya nyroca*	Winter Visitor
24.	Stone Curlew	*Burhinus oedicnemus*	Passage Migrant, Breeds
25.	Common Buzzard	*Buteo buteo*	Passage Migrant
26.	Short-toed Lark	*Calandrella brachydactyla*	Passage Migrant
27.	Lesser short-toed Lark	*Calandrella rufesceus*	Rare in Cyprus, Passage Migrant
28.	Sanderling	*Calidris alba*	Passage Migrant
29.	Dunlin	*Calidris alpine*	Passage Migrant
30.	Little Stint	*Calidris minuta*	Passage Migrant

	Common Name	Scientific Name	Status
31.	Little Ringed Plover	*Charadrius dubius*	Passage Migrant
32.	Ringed Plover	*Charadrius hiaticula*	Passage Migrant
33.	Greater Sand Plover	*Charadrius leschenaultii*	Rare in region, Passage Migrant, Winter visitor
34.	White-winged Black Tern	*Chlidonias leucopterus*	Passage Migrant
35.	Marsh Harrier	*Circus aeroginosus*	Passage Migrant
36.	Common Quail	*Coturnix coturni*	Passage Migrant
37.	Common Quail	*Coturnix coturnix*	Passage Migrant
38.	House Martin	*Delichon urbica*	Passage Migrant
39.	Little Egret	*Egretta garzetta*	Passage Migrant
40.	Cretzschmar's Bunting	*Emberizia caesia*	Passage Migrant
41.	Pied Flycatcher	*Ficedula hypoleuca*	Passage Migrant
42.	Common Coot	*Fulica atra*	Passage Migrant, Winter bird
43.	Gull-billed Tern	*Gelocheliton nilotica*	Passage Migrant
44.	Black-winged Stilt	*Himantopus himantopus*	Passage Migrant, Summer Visitor,
45.	Red-rumped Swallow	*Hirundo danrica*	Summer visitor
46.	Barn Swallow	*Hirundo rustica*	Passage Migrant
47.	Barn Swallow	*Hirundo rustica*	Summer visitor, Passage Migrant
48.	Little Bittern	*Ixobrychus minutus*	Passage Migrant
49.	Red-backed Shrike	*Lanius collurio*	Passage Migrant
50.	Armenian Gull	*Larus armenicus*	Passage Migrant, Winter Visitor
51.	Audouin's Gull	*Larus audouinii*	Passage Migrant, Winter Visitor
52.	Caspian Gull	*Larus cachinnans*	Passage Migrant, Winter Visitor
53.	Lesser Black-bagged Gull	*Larus fuscus*	Passage Migrant
54.	Slender-billed Gull	*Larus genei*	Passage Migrant, Winter Visitor
55.	Heuglin's Gull	*Larus heuglini*	Passage Migrant, Winter Visitor
56.	Great Black-headed Gull	*Larus ichthyaetus*	Rare in Cyprus, Passage Migrant, Winter Visitor
57.	Mediterranean Gull	*Larus melanocephalus*	Passage Migrant, Winter Visitor
58.	Yellow-legged Gull	*Larus michahellis*	Passage Migrant, Winter Visitor
59.	Little Gull	*Larus minutus*	Passage Migrant, Winter Visitor
60.	Black-headed Gull	*Larus ridibundus*	Passage Migrant, Winter Visitor
61.	Broad-billed Sandpiper	*Limicola falcinellus*	Passage Migrant
62.	Bar-tailed Godwit	*Limosa lapponica*	Passage Migrant
63.	Black-tailed Godwit	*Limosa limosa*	Passage Migrant
64.	Nightingale	*Luscinia megarhynchos*	Passage Migrant
65.	Pied (White) Wagtail	*Motacilla alba*	Passage Migrant, Breeds (irregularly)
66.	Blue-headed Wagtail	*Motacilla flava*	Passage Migrant

	Common Name	Scientific Name	Status
67.	Red-crested Pochard	*Netta ruffian*	Passage Migrant
68.	Curlew	*Numenius arquata*	Passage Migrant
69.	Whimbrel	*Numenius phaeopus*	Passage Migrant
70.	Black-crowned Night Heron	*Nycticorax nycticorax*	Passage Migrant
71.	Cyprus Pied Wheatear	*Oenanthe cypriana*	Summer visitor
72.	Black-eared Wheatear	*Oenanthe hispanica melanoleuca*	Passage Migrant
73.	Isabelline Wheatear	*Oenanthe isabellina*	Passage Migrant
74.	Northern Wheatear	*Oenanthe oenanthe*	Passage Migrant
75.	Golden Oriole	*Oriolus oriolus*	Passage Migrant
76.	White-headed Duck	*Oxyura leucocephala*	Passage Migrant
77.	Great Cormorant	*Phalacrocorax carbo sinensis*	Passage Migrant, Winter Visitor
78.	Ruff	*Philomachus pugnax*	Passage Migrant
79.	Greater Flamingo	*Phoenicopterus roseus*	Passage Migrant
80.	Common Redstart	*Phoenicurus phoenicurus*	Passage Migrant
81.	Chiffchaff	*Phylloscopus collybita*	Passage Migrant
82.	Eurasian Spoonbill	*Platalea Leucorodia*	Passage Migrant
83.	Glossy Ibis	*Plegadis falcinellus*	Passage Migrant
84.	Grey Plover	*Pluvialis squatavola*	Passage Migrant
85.	Great Crested Grebe	*Podiceps cristatus*	Passage Migrant, Winter Visitor
86.	Black-necked Grebe	*Podiceps nigricollis*	Passage Migrant
87.	Little Crake	*Porzana parva*	Passage Migrant
88.	Pied Avocet	*Recurvirostra avosetta*	Passage Migrant
89.	Collared Dove	*Streptopelia decaocto*	Passage Migrant
90.	Turtle Dove	*Streptopelia turtur*	Passage Migrant
91.	Blackcap	*Sylvia atricapilla*	Passage Migrant
92.	Spectacled Warbler	*Sylvia conspicillata*	Summer visitor, Breeds
93.	Lesser Whitethroat	*Sylvia curruca*	Passage Migrant
94.	Cyprus Warbler	*Sylvia melanothorax*	Summer visitor
95.	Ruppell's Warbler	*Sylvia rueppellii*	Passage Migrant
96.	Little Grebe	*Tachibabtus ruficollis*	Passage Migrant, Winter Visitor
97.	Ruddy Shelduck	*Tadorna ferruginea*	Rare in Cyprus, Passage Migrant
98.	Common Shelduck	*Tadorna tadorna*	Passage Migrant, Winter Visitor
99.	Spotted Redshank	*Tringa erythropus*	Passage Migrant
100.	Wood Sandpiper	*Tringa glareola*	Passage Migrant
101.	Greenshank	*Tringa nebularia*	Passage Migrant
102.	Greenshank	*Tringa nebularia*	Passage Migrant
103.	Green Sandpiper	*Tringa ochropus*	Passage Migrant

	Common Name	Scientific Name	Status
104.	Marsh Sandpiper	*Tringa stagnatilis*	Passage Migrant
105.	Common Redshank	*Tringa tetanus*	Passage Migrant
106.	Mistle Thrush	*Turdus viscivorus*	Passage Migrant
107.	Hoopoe	*Upupa epops*	Passage Migrant
108.	Spur-winged Plover	*Vanellus spinosus*	Passage Migrant
109.	Northern Lapwing	*Vanellus vanellus*	Passage Migrant

TABLE 4.3: LIST OF RESIDENT BIRD SPECIES REPORTED AT THE LARNACA SALT LAKES AND THE SEWAGE WORKS

	Common Name	Scientific Name	Status
1.	Linnet	*Carduelis cannabina*	Resident
2.	Greenfinch	*Carduelis chloris*	Resident
3.	Cetti's Warbler	*Cettia cetti*	Resident
4.	Kentish Plover	*Charadrius alexandrinus*	Resident
5.	Fan-tailed Warbler	*Cisticola juncidis*	Resident
6.	Woodpigeon	*Columba palumbus*	Resident
7.	Hooded Crow	*Corvus cornix*	Resident
8.	Corn Bunting	*Emberiza calandra*	Resident
9.	Common Kestrel	*Falco tinnunculus*	Resident
10.	Crested Lark	*Galerida cristata*	Resident
11.	Moorhen	*Gallinule chloropus*	Resident
12.	Calandra Lark	*Melanocorypha calandra*	Resident
13.	House Sparrow	*Passer domesticus*	Resident
14.	Spanish Sparrow	*Passer hispanioleusis (transcaspicus)*	Resident
15.	Magpie	*Pica pica*	Resident
16.	Collared Dove	*Streptopelia decaocto*	Resident

4.2.3. PROTECTED OR RESTRICTED AREAS

Drawings EIA-B-17 and EIA-B-18 provide maps of the protected areas near the STP sites.

4.2.3.1. ARADIPPOU STP SITE

The proposed location for the Aradippou STP is within a Da3 Protection Zone which is a buffer zone for animal husbandry and industrial zones for the protection of the neighbouring areas. The construction provisions applicable for this zone are outlined in Section 4.3.2.

4.2.3.2. EXISTING LARNACA STP

The existing Larnaca STP is within a designated Da2 Protection Zone, as a result of its proximity to the Larnaca Salt Lakes. Areas designated as Protection Zones include sites of natural beauty,

forests, parks, public recreation areas, archaeological sites and buffer zones. Protection zones are classified as Da2, Da3 and Da5, with the associated construction provisions being more restrictive for Da2 areas. The 1% land coverage that is permitted in Da2 zones, significantly increases the land requirements for construction, thus effectively diverting development away from such sites.

The Larnaca Salt Lakes are of a significant ecological value, being one of the most important wetland habitats on the island. This includes the lakes to the northwest and south-southeast of the airport, as well as the lake fringes.

In 1997 the Council of Ministers approved the Programme for the Protection and Management of the Larnaca Salt Lakes, aimed at the protection and conservation of the lake habitats, and the protection and conservation of the area from any kind of pollution or environmental degradation. The Larnaca District Plan endorses the proposals of the Programme, which must be taken into account by the Planning Authority and other bodies in connection to any development plans examined for the area.

The lake to the northwest of the airport is a designated Ramsar site, having being recognised as a wetland of international importance, significant for the conservation of biodiversity. Furthermore, it has been proposed that the lakes be included in the Natura 2000 network.

According to the District Plan, there will be no development of the area to the south of the airport (to the southwest of the existing STP) as a result of its designation as a Natura 2000 site and its status as part of the sensitive lake ecosystem, as well as due to its proximity to the airport, the STP and the desalination plant.

The actual area of the STP, to the southeast of the airport, has been designated as a Da2 Protection Zone, and in accordance with the District Plan, it must be protected from any unwanted development, so as to preserve the ecological balance of the area.

4.2.3.2. GAME RESERVES

The area of the Larnaca Salt Lakes is a Permanent Game Reserve.

Two categories of game reserves, where no hunting is permitted, are used to ensure the effective protection of habitats. Certain habitats, including all wetlands, like the Achna Dam, and significant migration corridors, have been designated as Permanent Game Reserves. Additionally, some reserves are specifically designated for the conservation of certain species.

The second category of reserves is the Game Reserve Areas which act as reservoirs allowing wild-bred fauna to disperse into neighbouring areas thus ensuring the sustainability of the species stock. During the hunting of migratory species additional areas are designated for the protection of corridors and passage migrants.

4.3. SOCIAL AND CULTURAL ENVIRONMENT

4.3.1. ADMINISTRATIVE BOUNDARIES

The Aradippou STP site is located within the administrative area of Aradippou, next to the community's boundary with the Kellia administrative area, to the east. The Aradippou community covers a total area of approximately 55.4 square kilometers. The administrative boundaries and the location of the STP site are given in Drawing EIA-B-14.

The existing Larnaca STP is within the Larnaca administrative area, to the south east corner of the municipality. The total area of the Larnaca Municipality is approximately 29.1 square kilometers. Drawing EIA-B-15 shows the administrative boundaries of the area and the location of the STP site.

4.3.2. URBAN PLANNING ZONING

The proposed area for the Aradippou STP is located next to the Gg2 Animal Husbandry Zone, which is a zone for heavy animal husbandry with an increased degree of nuisance. The following provisions apply for constructions within this zone:

Maximum Construction Coefficient	0.50 : 1
Maximum Number of Floors	2
Maximum Height	7.00 m
Maximum Percentage of Coverage	–

The area where the Aradippou treatment plant and storage reservoirs will be constructed (Sites A and B) is within the Da3 Zone, which is a buffer zone for animal husbandry and industrial areas. The construction provisions for this zone are as follows:

Maximum Construction Coefficient	0.05 : 1
Maximum Number of Floors	1
Maximum Height	5.00 m
Maximum Percentage of Coverage	0.05 : 1

The planning zones for the Aradippou and Livadia communities are given in Drawing EIA-B-17.

The existing Larnaca STP is within a Da2 Protection Zone. According to the Larnaca District Plan such zones must be protected for any unwanted development so as to preserve their ecological balance. The strict provisions which apply for developments within Da2 zones serve to discourage construction in such areas:

Maximum Construction Coefficient	0.01 : 1
Maximum Number of Floors	1
Maximum Height	5.00 m
Maximum Percentage of Coverage	0.01 : 1

Drawing EIA-B-18 provides the planning zones for the area.

4.3.3. LOCAL FACILITIES

ARADIPPOU STP

Access is provided by a single lane track road (all weather, loose surface) which leads up to the STP site. There are no asphalted roads in the surrounding area and close to the site. The nearest electricity transmission line (66 kV) is at a distance of approximately 800 m from Site B, where the long term storage reservoir will be constructed, and about 1.4 km from Site A, where the treatment plant and emergency storage reservoir will be located. Next to the STP area, to the north of Site B and to the west of Site A, and at a distance of about 50 m, there is a farm. A number of other piggeries and farms are scattered in the area surrounding the site from the southwest to the north, with the closest one being at a distance of approximately 250 m from the STP location. Downstream from the STP area, to the south, where the long term storage reservoir will be located (Site B) there are no constructions.

EXISTING LARNACA STP

A single lane road provides access to the existing sewage treatment plant from the south. There is no access to the area from the north side due to the presence of the airport.

The desalination plant is next to the STP site, to the north, while the Larnaca airport is at a distance of approximately 600 m to the west.

4.3.4. LAND OWNERSHIP

ARADIPPOU STP

The land requirements for the Aradippou sewage treatment plant are as follows:

STP	8 000 m^2
Emergency storage reservoir	6 910 m^2
Long term storage reservoir	118 400 m^2

The total area of land that will be taken up for the construction of the STP is approximately 133 400 m^2 (13.4 ha), including the land that will be taken up for the construction of roads, parking places, planting around the treatment plant and storage reservoirs, etc. Drawing EIA-B-19 provides a cadastral map of the proposed STP location, indicating the plots which will be acquired for the STP in Sites A and B. These are only a rough indication, as the actual layout of the plant and the plots that will be taken up will be finalized following the more detailed design of the plant. Nevertheless, all the plots indicated are private land, while there is no government land in the immediate vicinity of the proposed location.

EXISTING LARNACA STP

The land requirements that will arise from the expansion of the existing STP, so as to accommodate the additional capacity from the villages of Perivolia, Kiti and Dromolaxia – Meneou, are as follows:

STP	11 700 m^2
Emergency storage reservoir	10 160 m^2
Long term storage reservoir	174 100 m^2

These result in a total area of approximately 196 000 m^2 (19.6 ha), including the land that will be taken up for the construction of roads, parking places, planting around the treatment plant and storage reservoirs, etc . It has been estimated that the land available on the STP site is adequate to satisfy the requirements for this expansion. All the land that will be taken up is government land.

PUMPING STATIONS

The exact locations for the pumping stations will be determined during the detailed design of the sewage system, therefore it cannot be assessed at this stage which plots will be acquired and whether the land will be governmental or privately owned.

4.3.5. LAND USE

ARADIPPOU STP

The area proposed for the construction of the Aradippou sewage treatment plant is within the Da3 buffer zone that has been designated for the protection of areas neighbouring the Animal Husbandry Zone. The areas where the treatment plant and the emergency and long term storage reservoirs will be constructed are largely barren land, with only a few agricultural plots cultivated with fodder for grazing.

The land next to the proposed STP location, to the north and west of Site A and B respectively, is within the community's Animal Husbandry Zone, Gg2, which is a zone designated for heavy animal

husbandry practices with an increased degree of nuisance, including the breeding of pigs. The region is widely known as the Aradippou piggeries areas, and a number of pig farms are located in the areas surrounding the STP, from the west to the north of the site, together with the lagoons that have been created for the disposal and treatment of effluents from piggeries.

EXISTING LARNACA STP

The land requirements that will arise from the further extension of the existing STP to accommodate the additional capacity from the villages that will be connected according to the scheme will largely be satisfied by the land available on the STP site.

PUMPING STATIONS

The pumping stations will be located within the urban areas.

4.3.6. BUILT UP PROPERTIES

ARADIPPOU STP

There are no build up properties on the plots of land that will be used for the construction of the Aradippou sewage treatment plant, including the land that will be taken up by the emergency and long term storage reservoirs. No property is expected to be affected as a result.

EXISTING LARNACA STP

The existing Larnaca STP will be extended to accommodate for the additional villages that will be connected according the proposed scheme. It is expected that the land requirements for such an extension can be satisfied by the land available at the existing site. As there are no other built up structures within the STP site, or the surrounding area (with the exception of the desalination plant to the north, which will not be affected by the expansion of the STP), the extension of the STP will not lead to the destruction of any property.

4.3.7. SOCIO-ECONOMIC PROFILE

4.3.7.1. POPULATION PROFILE

A summary of the population figures for the communities, according to the 2001 Census of Population, is given in Table 4.4.

TABLE 4.4 : POPULATION FIGURES

Community	Housing units			Households		Institutions		Total Population
	TOTAL	USED AS USUAL RESIDENCE	VACANT OR TEMPORARY RESIDENCE	NUMBER	POPULATION	NUMBER	POPULATION	
Aradippou	3 347	3 036	311	3 041	11 425	1	23	11 448
Livadia	1 801	1 454	347	1 454	4 854	1	29	4 883
Dromolaxia	1 563	1 462	101	1 462	4 994			4 994
Meneou	696	348	348	348	1 196			1 196
Kiti	1 113	947	166	947	3 140			3 140
Perivolia	1 821	570	1 251	570	1 801			1 801

4.3.7.2. POPULATION PROJECTIONS

TABLE 4.5 : POPULATION PROJECTIONS

VILLAGE	2001	2005	2010	2015	2020	2025	2030
Aradippou	11 500	12 383	13 583	14 900	16 343	17 927	19 665
Livadia	4 883	5 232	5 705	6 220	6 781	7 393	8 060
Dromolaxia	4 994	5 267	5 629	6 016	6 430	6 872	7 344
Kiti	3 140	3 376	3 695	4 045	4 427	4 847	5 305
Perivolia	1 800	1 967	2 196	2 452	2 738	3 056	3 412
Meneou	1 196	1 320	1 493	1 690	1 912	2 163	2 450
TOTAL	**31 913**	**34 148**	**37 170**	**40 475**	**44 081**	**48 024**	**52 336**

TABLE 4.6 : POPULATION – PERMANENT AND SEASONAL

Village	2005			2015			2030		
	PERMANENT	SUMMER	TOTAL	PERMANENT	SUMMER	TOTAL	PERMANENT	SUMMER	TOTAL
ARADIPPOU	12 383	0	12 383	14 900	0	14 900	19 665	0	19 665
LIVADIA	5 232	0	5 232	6 220	0	6 220	8 060	0	8 060
DROMOLAXIA	5 267	0	5 267	6 016	0	6 016	7 344	0	7 344
KITI	3 376	910	4 286	4 045	1 540	5 585	5 305	2 450	7 755
PERIVOLIA	1 967	5 950	7 917	2 452	8 750	11 202	3 412	14 000	17 412
MENEOU	1 320	1 670	2 990	1 690	2 768	4 458	2 450	4 313	6 763
TOTAL	**34 148**	**8 530**	**42 678**	**40 475**	**13 058**	**53 533**	**52 336**	**20 763**	**73 099**

4.3.7.2. MAIN FEATURES OF THE AREA

All the settlements included in the Larnaca District Group, except Athienou, are within the peri-urban zone of Larnaca Town. Although the villages under study share rather common characteristic of the location characteristic of being closely clustered around Larnaca, they are differentiated according to their sources of growth and their likely future growth potential. One group (Aradippou, Livadia and Dromolaxia) is subject to urbanization, and another group (Kiti and Perivolia) due to their coastal location grow in response to tourism-related development (mainly holiday houses for weekend and summer residence). The difference in their growth experience reflects the relative strength of the influence of urbanization and tourism development. The first group benefits from easy access to urban employment, and the second group from holiday housing development and from the consequent growth in local services, such as restaurants and shops.

Aradippou Municipality and Livadia are adjacent settlements and lie north-west and north of Larnaca town, while Dromolaxia lies south west of Larnaca town. All three communities fall within the Larnaca Local Plan Area. Kiti and Perivolia are rural coastal communities and lie south of Larnaca town and south-west of Dromolaxia, almost adjacent to Larnaca International Airport and the southern section of the Larnaca Salt Lake.

In terms of their character as settlements, Aradippou, Perivolia and Dromolaxia are effectively suburbs of Larnaca growing mainly through urbanization. Kiti and Perivolia are coastal villages growing mainly through tourism-related development.

DROMOLAXIA – MENEOU, KITI AND PERIVOLIA

The villages of Dromolaxia-Meneou, Kiti and Perivolia lie South-West of Larnaca in a vast plain descending slightly to the sea with a slope of about 2 to 3 meters per kilometer. The area is drained

on the West side by the Tremithos River reaching the sea 2 kilometers west of Perivolia. The area is mainly occupied by cultures in fields.

ARADIPPOU AND LIVADIA

The communities of Aradippou and Livadia lies North of Larnaca in a hill area. Both villages are located in the urban attraction zone of Larnaca. A continuous urbanized area is observed between these towns and Larnaca, particularly for Livadia. The area presents a significant slope (around 10 meters per kilometers) descending South-Eastwards to the sea. A large storm drain originated at a point between Aradippou and Livadia collects the surface waters and discharges them to the sea 3 km north of the Larnaca town center.

4.3.7.3. AGRICULTURE IN THE LARNACA REGION

The only data available regarding the agricultural land in the project region comes from the 1994 Census of Agriculture. Therefore, this section outlines information regarding only the total cultivated areas according to crop types. More detailed data from the Census, including the areas reported as irrigated on non-irrigated agricultural land, are provided in Appendix 7.

The agricultural land of the Larnaca district is characterized by two broad agricultural zones. The Larnaca Coastal Region is part of the coastal zone and includes the villages of Kiti, Perivolia, Dromolaxia and Meneou. Aradippou and Livadia are included in the Larnaca Mixed Farming Region which is within the dry-land zone.

General information on the agricultural land of the Larnaca Coastal Region:

Number of holdings	1 493
Number of plots	5 765
Area of cultivated land (donums)	57 073
Area of irrigable land (donums)	17 758
Total area (donums)	63 395

General information on the agricultural land of the Larnaca Mixed Farming Region:

Number of holdings	3 494
Number of plots	15 706
Area of cultivated land (donums)	122 580
Area of irrigable land (donums)	12 189
Total area (donums)	142 177

LARNACA COASTAL REGION

TABLE 4.7: LAND USE IN THE LARNACA COASTAL REGION (1994)

	Total Area (donums)	Percentage of Total Agricultural Land (%)
Temporary crops	51 614	81.4 %
Permanent crops	4 504	7.1 %
Fallow land	954	1.5 %
Grazing land	96	0.2 %
Forest land	53	0.1 %
Uncultivated land	3 507	5.5 %
Scrub land	2 665	4.2 %
TOTAL	63 395	100.0 %

TABLE 4.8: AREA OF TEMPORARY CROPS IN THE LARNACA COASTAL REGION (1994)

Temporary Crops	Total Area (donums)	Percentage of Total Area of Temporary Crops (%)
Cereals	41 595	78.4 %
Pulses	306	0.6 %
Industrial crops	21	0.04 %
Aromatic plants	1	0.002 %
Fodder crops for grain	47	0.09 %
Green fodder for grazing	2 873	5.4 %
Green fodder for hay	3 040	5.7 %
Vegetables	5 186	9.8 %
TOTAL	**53 069**	**100.0 %**

TABLE 4.9: AREA OF PERMANENT CROPS IN THE LARNACA COASTAL REGION (1994)

Crops	Total Area (donums)	Percentage of Total Area of Permanent Crops (%)
Table grapes	106	2.3%
Wine grapes	522	11.4%
Citrus	2 087	45.4%
Dry nuts	214	4.7 %
Fruits	286	6.2 %
Olives	1 048	22.8 %
Carobs	335	7.3 %
TOTAL	**4 598**	**100.0 %**

LARNACA MIXED FARMING REGION

TABLE 4.10: LAND USE IN THE LARNACA MIXED FARMING REGION (1994)

	Total Area (donums)	Percentage of Total Agricultural Area (%)
Temporary crops	113 853	80.1 %
Permanent crops	6 621	4.7 %
Fallow land	2 104	1.5 %
Grazing land	175	0.1 %
Forest land	2 078	1.5 %
Uncultivated land	12 663	8.9 %
Scrub land	4 679	3.3 %
TOTAL	**142 173**	**100.0 %**

TABLE 4.11: AREA OF TEMPORARY CROPS IN THE LARNACA MIXED FARMING REGION (1994)

Temporary Crops	Total Area (donums)	Percentage of Area f Total Area of Temporary Crops (%)
Cereals	93 417	81.5 %
Pulses	178	0.2 %
Industrial crops	80	0.1 %
Aromatic plants	0	0.0 %
Fodder crops for grain	23	0.02 %
Green fodder for grazing	8 784	7.7 %
Green fodder for hay	10 796	9.4 %
Vegetables	1 306	1.1 %
TOTAL	**114 584**	**100.0 %**

TABLE 4.12: AREA OF PERMANENT CROPS IN THE LARNACA MIXED FARMING REGION (1994)

Crops	Total Area (donums)	Percentage of Total Area of Permanent Crops (%)
Table grapes	110	1.7 %
Wine grapes	255	3.9 %
Citrus	1 499	22.7 %
Dry nuts	409	6.2 %
Fruits	876	13.2 %
Olives	2 775	42.0 %
Carobs	691	10.5 %
TOTAL	**6 615**	**100.0 %**

AGRICULTURAL LAND BY VILLAGE

TABLE 4.13: AGRICULTURAL LAND BY VILLAGE (1994)

Village	Total Area (donums)
Aradippou	13 748
Livadia	3 492
SUB TOTAL	*17 240*
Kiti	7 352
Perivolia	3 655
Dromolaxia	8 538
Meneou	2 194
SUB TOTAL	21 739
TOTAL	**38 979**

TABLE 4.14: AGRICULTURAL LAND USE BY VILLAGE (1994)

Village	Temporary Crops (donums)		Permanent Crops (donums)		Fallow Land (donums)		Uncultivated Forest and Scrub Land (donums)	
	DONUMS	%	DONUMS	%	DONUMS	%	DONUMS	%
Aradippou	12 411	90.3 %	408	3.0 %	98	0.7 %	832	6.1 %
Livadia	2 970	85.0 %	140	4.0 %	24	0.7 %	359	10.3 %
SUB TOTAL	*15 381*	*89.2 %*	*548*	*3.2 %*	*122*	*0.7 %*	*1 191*	*6.9 %*
Kiti	6 912	94.0 %	122	1.7 %	52	0.7 %	268	3.6 %
Perivolia	3 213	87.9 %	88	2.4 %	64	1.8 %	290	7.9 %
Dromolaxia	8 327	97.6 %	54	0.6 %	96	1.1 %	59	0.7 %
Meneou	1 635	74.5 %	505	23.0 %	6	0.3 %	48	2.2 %
SUB TOTAL	*20 087*	*92.4 %*	*769*	*3.5 %*	*218*	*1.0 %*	*665*	*3.1 %*
TOTAL	**35 468**	**91.0 %**	**1 317**	**3.4 %**	**340**	**0.9 %**	**1 856**	**4.8 %**

TABLE 4.15: AREA OF TEMPORARY CROPS BY VILLAGE (1994)

Village	Cereals (%)	Pulses (%)	Industrial (%)	Fodders] (%)	Potatoes (%)	Vegetables (%)
Aradippou	77.7 %	0.02 %	0.0 %	22.2 %	0.0 %	0.1 %
Livadia	77.1 %	0.1 %	0.0 %	21.4 %	0.0 %	1.4 %
Sub Total	*77.6 %*	*0.05 %*	*0.0 %*	*22.1 %*	*0.0 %*	*0.4 %*
Kiti	72.9 %	1.1 %	0.9 %	5.2 %	7.3 %	12.6 %
Perivolia	73.5 %	0.5 %	0.0 %	1.5 %	6.3 %	18.3 %
Dromolaxia	77.1 %	0.1 %	0.0 %	18.8 %	0.6 %	3.4 %
Meneou	83.4 %	0.0 %	0.0 %	12.3 %	0.9 %	3.4 %
Sub Total	*75.5 %*	*0.5 %*	*0.3 %*	*10.7 %*	*3.9 %*	*9.1 %*
TOTAL	**76.4 %**	**0.3 %**	**0.2 %**	**15.6 %**	**2.2 %**	**5.3 %**

MAIN CROP CULTIVATED **SECOND MOST WIDELY CULTIVATED CROP**

Most of the agricultural land in the project region is cultivated with temporary crops, and mainly cereals. In terms of treated effluent reuse, all temporary crops, with the exception of vegetables, and all permanent crops can be irrigated. The suggested effluent standards allow for the irrigation of all crops, except leafy vegetables. It is, however, recommended that the irrigation of vegetables is altogether avoided, particularly in the case of those vegetables eaten raw, so as to avoid any risk of health hazards that could arise from the misuse of the treated effluent.

Table 4.16 provides information on the total area of agricultural land that is irrigated with water supplied from the Southern Conveyor, in the communities to be serviced by the Aradippou and Larnaca STPs.

TABLE 4.16: SOUTHERN CONVEYOR PROJECT – IRRIGATED AREAS (2000, WDD)

Community	Irrigated Area		Total Irrigated Area in Project Regions	
	HECTARES	DONUMS	HECTARES	DONUMS
Aradippou	250	1 869	250	1 869
Kiti	523	3 910	719	5 376
Dromolaxia	111	830		
Meneou	85	636		

Assuming the total agricultural area has not changed significantly since the 1994 Census of Agriculture, and taking the total agricultural in the Aradippou and Livadia communities to be approximately 17 240 donums (Table 4.13), then about 11 % of the total land in the region is connected to the current irrigation network, with water being supplied from the Kouris Dam, as part of the Southern Conveyor Project. For the communities of Kiti, Perivolia, Dromolaxia and Meneou, which will be connected to the existing Larnaca STP, taking the total agricultural area to be 21 739 donums (1994 Census, Table 4.13), then approximately 25 % of the total agricultural land is connected to the irrigation network. The treated effluent from the Aradippou and the existing Larnaca STPs can be used for the irrigation of the areas outside the irrigation schemes.

UNIT CROP IRRIGATION WATER DEMAND IN THE AREAS OF LIVADIA AND LARNACA

TABLE 4.17: UNIT CROP IRRIGATION WATER DEMAND (m^3/DECAR/YEAR, 2001)

Crops	livadia	larnaca
PERMANENT CROPS		
Citrus	700	800
Deciduous	700	850
Olives	400	500
Table grapes	224	335
Fodders	1100	1300
Almonds	450	600
ANNUAL CROPS		
Tomatoes GH[1]	800	1000
Cucumbers GH	800	1000
Beans GH	550	750
Peppers GH	800	1000
Melons GH	550	750
Strawberries GH	650	850
Flowers GH	900	1100
Potatoes	250	450
Tomatoes OF[2]	550	750
Cucumber OF	550	750
Beans OF	550	750
Squash	300	500
Onions	400	600

Crops	livadia	larnaca
Peppers OF	550	750
Groundnuts	500	700
Cabbage	400	600
Parsley	700	900
Carnation	850	1050
Artichoke	650	850
Kolokasse	1960	2220
Spices	300	500
Carrots	400	560
Beets	200	400
Watermelon	400	600
Broad beans	50	250
1. Greenhouse, 2. Open Field		

4.3.7.4. LIVESTOCK PRODUCTION

TABLE 4.18: LIVESTOCK NUMBERS BY VILLAGE (1994)

Village	Sheep	Goats	Cattle	Pigs	Chicken
Aradippou	8 704	3 917	6 066	52 057	162 691
Livadia	1 880	457	351	5 287	20 324
Sub Total	*10 584*	*4 374*	*6 417*	*57 344*	*183 015*
Kiti	1 866	751	1 454	0	70 446
Perivolia	919	221	0	0	237
Dromolaxia	6 498	1 755	2 830	798	9 303
Meneou	0	20	300	0	24 209
Sub Total	*9 283*	*2 747*	*4 584*	*798*	*104 195*
TOTAL	**19 867**	**7 121**	**11 001**	**58 142**	**287 210**

4.3.7.5. EMPLOYMENT

TABLE 4.19: EMPLOYMENT IN THE BROAD AGRICULTURAL SECTOR IN THE LARNACA DISTRICT (1994)

	Holders of Agricultural land and Family Members			Employees			Total		
	MALES	FEMALES	TOTAL	MALES	FEMALES	TOTAL	MALES	FEMALES	TOTAL
Crop production	1 377	655	2 032	331	424	755	1 708	1 079	2 787
Livestock production	1 066	501	1 567	261	80	341	1 327	581	1 908
Forestry	8	6	14	9	2	11	17	8	25
Fishing	177	0	177	249	3	252	426	3	429
TOTAL	**2 628**	**1 162**	**3 790**	**850**	**509**	**1 359**	**3 478**	**1 671**	**5 149**

TABLE 4.20: EMPLOYMENT IN CROP AND LIVESTOCK IN THE LARNACA DISTRICT (1994)

	Holders of Agricultural land and Family Members			Employees			Total		
	MALES	FEMALES	TOTAL	MALES	FEMALES	TOTAL	MALES	FEMALES	TOTAL
Coastal Region	708	395	1 103	170	180	350	878	575	1 453
Mixed Farming Region	1 054	385	1439	317	78	395	1 371	463	1 834
TOTAL	**1 762**	**780**	**2 542**	**487**	**258**	**745**	**2 249**	**1 038**	**3 287**

TABLE 4.21: EMPLOYMENT ON THE FARM (1994) (FULL-TIME EQUIVALENT NUMBER OF PERSONS)

	Holders of Agricultural Land and Family Members	Employees (permanent and casual)	Total
ARADIPPOU			
Males	171	55	226
Females	37	10	47
TOTAL	**208**	**65**	**273**
LIVADIA			
Males	39	14	53
Females	10	2	12
TOTAL	**49**	**16**	**65**
KITI			
Males	82	28	110
Females	48	44	92
TOTAL	**130**	**72**	**202**
PERIVOLIA			
Males	39	4	43
Females	17	25	42
TOTAL	**56**	**29**	**85**
DROMOLAXIA			
Males	116	11	127
Females	48	8	56
TOTAL	**164**	**19**	**183**
MENEOU			
Males	16	10	26
Females	9	26	35
TOTAL	**25**	**36**	**61**

4.3.8. CULTURAL AND ARCHAEOLOGICAL VALUES

There are no archaeological or historic sites near the sites of the Aradippou or the existing Larnaca sewage treatment plants. Although, Perivolia village has a number of historic monuments, including the Kiti Tower, and the area southeast of the main salt lake on the other side of the airport is an archaeological site, these are at some distance from the existing STP.

5. ATHIENOU: DESCRIPTION OF THE ENVIRONMENTAL BASELINE

5.1. INTRODUCTION

Two of the three alternative sites which were originally been identified for the construction of the sewage treatment plant, and specifically Alternatives 4(a) and 4(c), to the southeast and north of the Athienou village respectively, have been examined in detail. The reason being that, although from an environmental perspective site 4(a) scores higher, from a techno-economic perspective site 4(c) is preferable, while at the same time, even though in comparison the environmental impacts that have been associated with construction of the STP at this location are higher, their significance and magnitude has not been assessed to be such as to warrant elimination of this alternative following the initial evaluation. Therefore, a more detailed assessment of the resulting environmental impacts was warranted to enable and justify a decision over which site is to be chosen for the construction of the Athienou STP.

5.2. PHYSICAL ENVIRONMENT

5.2.1. TOPOGRAPHY, GEOLOGY AND SOILS

The locations of the two alternative sites for the Athienou STP are indicated in Drawing EIA-B-3. Drawing EIA-B-7 gives a topographic map of site 4(a) and Drawing EIA-B-10 gives a geological map of the area.

5.1.1.1. GENERAL GEOLOGICAL ENVIRONMENT IN THE ATHIENOU AREA

The Athienou region is a flat lying area covered with a thin succession of superficial deposits, probably of lacustrine origin, consisting of silt, sandy silt, clayey silt, silty sand and clay with lenses of gravels with boulders. The thickness of this succession exceeds 4 m but does not seem to be much thicker than this. It rests on a layer of Pliocene marls which pass below into gypsum at a depth of about 35 m. In the extreme south of the area the superficial cover rests on Pakhna marls with sandstone or gypsum. The permeabilities of the superficial cover are low to intermediate while the Pliocene marls are impermeable.

5.1.1.2. SOIL CHARACTERISTICS AND PRESENT SANITARY SITUATION IN THE ATHIENOU AREA

Table 5.1 gives the soil characteristics for the Athienou community and the present sanitary conditions. The current sewerage system consists of septic tanks and absorption pits, however, the soil conditions are not favourable for such a sanitation system, leading to serious absorption problems. Therefore, construction of a sewage treatment plant is viewed as a necessity.

TABLE 5.1 : SOIL CHARACTERISTICS AND PRESENT SANITARY CONDITIONS IN THE FAMAGUSTA COMMUNITIES

Soil characteristics
Top soil of light brown silt with sand 0.1-0.3 m thick rests on an alternating sequence of weakly cemented silt, sandy silt, clayey silt, sand, silty sand and clay with lenses of gravels and boulders at least 4 m thick (superficial cover). Thin havara and havarized silt of medium hardness found below soil in southern part of area. Superficial cover rests on a layer of impervious Pliocene marls followed below by gypsum at about 35 m depth. In the south of the area superficial cover rests directly on Pakhna marls with sandstone or gypsum. Permeability of superficial cover low to intermediate. Water table 3.7- 3.9 m depth in NW and NE of area but deeper elsewhere.

5.1.2. CLIMATE

In terms of climate, the year in Cyprus can be divided in two seasons: the winter period, between October to March, and the summer period, between April to September. During the winter period there are significant fluctuations in the climatic conditions, with large variations in temperature and pressure, and frequent alterations in wind directions and speed. In contrast, during the summer period climatic conditions are largely stable.

5.1.2.1. TEMPERATURE

Mean annual temperatures in the Athienou region are approximately 19°C – 20°C. Mean monthly temperatures are within the range of approximately 10°C for January and 28°C for July/August.

Average temperatures for the periods 1981 – 1990 and 1991 – 2000 are as follows:

1981 – 1990	Mean monthly temperature range	9.6°C (Jan) – 28.4°C (Jul)
	Mean annual temperature	19.2°C
1991 – 2000	Mean monthly temperature range	10.0°C (Jan) – 29.5°C (Aug)
	Mean annual temperature	19.8°C
1981 – 2000	Mean monthly temperature range	9.8°C (Jan) – 28.9°C (Aug)
	Mean annual temperature	19.5°C

5.1.2.2. PRECIPITATION

The mean annual precipitation in the Athienou region for the period 1991 – 2000 was 347.4 mm, with normal precipitation (1961 – 1990) being 309.8 mm. The average monthly precipitation ranged between 1.6 mm for August to 79.4 mm for December, while the normal average monthly precipitation is in the range of 2.5 mm for August to 59.8 mm for December.

Average precipitation values for the Athienou region are as follows:

Mean monthly precipitation range (1991-2000)	1.6 mm (Aug) – 79.4 mm (Dec)
Normal monthly precipitation range (1961-1990)	2.5 mm (Aug) – 59.8 mm (Dec)
Mean annual precipitation	347.4 mm
Normal annual precipitation	309.8 mm

5.1.2.3. RELATIVE HUMIDITY (RH)

The mean annual RH at 08:00 hrs LST during the period 1981 – 1990 was 65.0%, and 66.0% for 1991 – 2000. Monthly averages were between 47.0% for May/June and 84.0% for January/February during 1981 – 1990, and in the range of 48.0% for June and 86.0% for December for the period 1991 – 2000. No data is available for the RH at 13:00 hrs LST.

Average values for the Athienou area are as follows:

1981 – 1990	Mean monthly RH at 08:00 hrs LST	47.0% (Jun) – 84.0% (Jan)
	Mean annual RH at 08:00 hrs LST	65.0%
1991 – 2000	Mean monthly RH at 08:00 hrs LST	48.0% (Jun) – 86.0% (Dec)
	Mean annual RH at 08:00 hrs LST	66.0%
1981 – 2000	Mean monthly RH at 08:00 hrs LST	47.5% (Jun) – 84.5% (Dec)
	Mean annual RH at 08:00 hrs LST	65.5%

Climatic data for Athienou are given analytically in Appendix 5. No data is available regarding wind speed and direction in the Athienou area, therefore conditions will be assumed to be similar to those in the Larnaca region. Some differences are expected in the wind speeds between the two regions

as Larnaca is a coastal area, however wind directions will be similar, since the prevailing winds are the same for the Achna area, which is also further inland.

5.1.3. SURFACE WATER RESOURCES

5.1.3.1. NATURAL STREAM AND SURFACE WATER BODIES

In the case of alternative 4(a) there is a small stream at a distance of approximately 1.1. km from the site, to the northwest. There are no other streams in close proximity to the site. For alternative 4(c) there are no streams near the site. Nevertheless, since the streams in the region are predominantly dry rivers throughout the year, no emergency discharge of the treated effluent would be permitted in any case.

5.1.3.2. EXISTING RESERVOIR

As there are no existing reservoirs near the vicinity of the two alternative sites selected, a long term storage reservoir will need to be constructed for the storage of the treated effluent, particularly during the winter months when the demand for irrigation water will be low.

5.1.4. GROUND WATER RESOURCES

The water table in the Athienou region lies at 3.7 – 3.9 m depth in the northwest and northeast, however elsewhere in the area it is deeper than 4 m.

5.2. ECOLOGICAL ENVIRONMENT

5.2.1. VEGETATION

- ALTERNATIVE SITE 4(A): The area of the site is mainly used as agricultural land for the cultivation of crops, including cereals and fodder. There are no permanent crops in the area, such as olive or fruit trees.

- ALTERNATIVE SITE 4(C): The area of site 4(c) is predominantly agricultural land. The location selected for the construction of the STP consists of a large expanse cultivated with temporary crops, such as cereal and fodder. This is surrounded by olive plantations, some of which will be destroyed for the construction of the STP.

5.2.2. WILDLIFE

The two alternative locations selected consist mainly of agricultural land. Due to the agricultural nature of the region the presence of any wildlife fauna species will be rare and any occurrences will be only on passage.

5.2.3. PROTECTED OR RESTRICTED AREAS

Both alternative locations selected for the Athienou STP are within agricultural zones and there are no protected areas in close proximity to the sites. However, as Athienou is within the buffer zone, and since both sites are near the border of the buffer zone with the occupied areas, approval must be obtained from the United Nations for construction of the STP.

5.3. SOCIAL AND CULTURAL ENVIRONMENT

5.3.1. ADMINISTRATIVE BOUNDARIES

The two alternative sites identified for the Athienou STP are located within the Athienou administrative area, site 4(a) to the southeast and site 4(c) to the north of the villages. The Athienou community, although retaining its administrative powers under the Cyprus government, is entirely within the buffer zone, while a significant part of its land, from the northwest to the east of the community, is under Turkish occupation. The total administrative area of Athienou, including the occupied areas is approximately 64.4 square kilometers. Both sites are next to the border with the occupied areas.

The administrative boundaries and the location of the STP site are shown in Drawing EIA-B-16.

5.3.2. URBAN PLANNING ZONING

Both sites proposed are within a G2 Agricultural Zone. The following provisions apply for constructions within this zone:

Maximum Construction Coefficient	0.15 : 1
Maximum Number of Floors	2
Maximum Height	8.30 m
Maximum Percentage of Coverage	0.10 : 1

5.3.3. LOCAL FACILITIES

- ALTERNATIVE SITE 4(A): Site 4(a) is next to a single lane track road, on the other side of which lie the occupied areas. The nearest electricity transmission line (66 kV) is at a distance of approximately 400 m from the site.

- ALTERNATIVE SITE 4(C): A single lane track road provides access to the site which is bordered to the north by the occupied areas. The nearest electricity transmission line (66kV) is at a distance of approximately 1.8 km from the site.

5.3.4. LAND OWNERSHIP

The land requirements for the Athienou sewage treatment plant are as follows:

STP	1 700 m^2
Emergency storage reservoir	1 430 m^2
Long term storage reservoir	24 510 m^2

The total area of land that will be taken up for the construction of the STP is approximately 27 700 m^2 (2.8 ha), including the land that will be required for the construction of roads, parking places, etc, and for the planting of trees. Drawing EIA-B-20 provides a cadastral map of the site 4(a), indicating the plots which will be acquired for the STP. These are only a rough indication, as the actual layout of the plant and the plots that will be taken up will be finalized following the more detailed design of the plant. In both cases though, the land that will potentially be acquired is private land, while there is no government land in the immediate vicinity of the proposed sites.

5.3.5. LAND USE

Both the alternative sites proposed are located on land that is predominantly used for agricultural purposes, in the case of site 4(a) for the cultivation of temporary crops, such as cereal and fodder, whereas in the case of site 4(b) mainly for the cultivation of olive trees, in addition to temporary crops. As regards to land use, alternative 4(c) is within an area of higher agricultural quality.

5.3.6. BUILT UP PROPERTIES

In the case of either alternative, there are no build up properties in the plots of land that will be used for the construction of the Athienou sewage treatment plant, including the land that will be taken up by the emergency and long term storage reservoirs.

5.3.7. SOCIO-ECONOMIC PROFILE

5.3.7.1. POPULATION PROFILE

A summary of the population figures for the Athienou community, according to the 2001 Census of Population, is given in Table 5.2.

TABLE 5.2 : POPULATION FIGURES

Community	Housing units			Households		Institutions		Total Population
	TOTAL	USED AS USUAL RESIDENCE	VACANT OR TEMPORARY RESIDENCE	NUMBER	POPULATION	NUMBER	POPULATION	
Athienou	1 411	1 272	139	1 275	4 242	1	19	4 261

5.3.7.2. POPULATION PROJECTIONS

TABLE 5.3 : POPULATION PROJECTIONS FOR ATHIENOU

VILLAGE	2001	2005	2010	2015	2020	2025	2030
Athienou	4 400	4 603	4 869	5 152	5 450	5 766	6 100

TABLE 5.4 : PROJECTED NUMBER OF HOUSES FOR ATHIENOU

		Population
2005	Permanent	4 603
	Summer	0
	TOTAL	*4 603*
2015	Permanent	5 152
	Summer	0
	TOTAL	*5 152*
2030	Permanent	6 100
	Summer	0
	TOTAL	*6 100*

5.3.7.3. DESCRIPTION OF THE COMMUNITY

MAIN FEATURES OF THE AREA

Athienou lies away from the above 5 communities 15 km North of Larnaca. It is located 10 km away from Lympia (group A). Athienou lies within a limestone hills area in which the bedrock lies at a shallow depth. The ground level at town center is approximately 160 meters asl. Athienou is located in the upper catchment of the Yialias River reaching the central plain of the island.

5.3.7.4. SOCIO-ECONOMIC INDICATORS

Details on the agricultural land of the Larnaca District are given in Section 4.3.7.3. Athienou is included in the Mixed Farming Region of Larnaca, within the dryland agro-geographic zone.

AGRICULTURAL LAND IN THE ATHIENOU COMMUNITY

Information on the agricultural land of Athienou, regarding area, extent of irrigated land and land use, according to the 1994 Census of Agriculture is outlined in Appendix 7. The tables below provide information regarding total agriculture area and land use.

TABLE 5.5: AGRICULTURAL LAND IN ATHIENOU (1994)

Village	Total Area (donums)
Athienou	15 719

TABLE 5.6: AGRICULTURAL LAND USE IN ATHIENOU (1994)

Village	Donums	% of Total Agricultural Land
Temporary Crops	15 001	95.4 %
Permanent Crops	337	2.1 %
Fallow Land	25	0.2 %
Uncultivated Forest and Scrub Land	357	2.3 %
TOTAL	**15 720**	**100.0 %**

TABLE 5.7: AREA OF TEMPORARY CROPS IN ATHIENOU (1994)

Village	Cereals (donums)	Pulses (donums)	Industrial (donums)	Fodders (donums)	Potatoes (donums)	Vegetables (donums)
Athienou	80.7 %	0.0 %	0.0 %	19.3 %	0.0 %	0.03 %

Most of the agricultural land in Athienou is cultivated with temporary crops, mainly cereals. In terms of treated effluent reuse, all temporary crops, with the exception of vegetables, and all permanent crops can be irrigated. The suggested effluent standards allow for the irrigation of all crops, except leafy vegetables. It is, however, recommended that the irrigation of vegetables is altogether avoided, particularly in the case of those vegetables eaten raw, so as to avoid any risk of health hazards that could arise from the misuse of the treated effluent.

The table below gives the agricultural area in Athienou which is irrigated with water supplied from the Southern Conveyor.

TABLE 5.8: SOUTHERN CONVEYOR PROJECT – IRRIGATED AREA IN ATHIENOU

	Irrigated Agricultural area
Hectares	451
Donums	3 372

Assuming the total agricultural area has not changed significantly since the 1994 Census of Agriculture, and taking the total agricultural land in Athienou to be approximately 15 720 donums, then about 12 % of the total land in the community is connected to the current irrigation network, with water being supplied from the Kouris River, as part of the Southern Conveyor Project. The treated effluent from the Athienou STP can be used for the irrigation of those areas outside the irrigation scheme.

LIVESTOCK PRODUCTION

TABLE 5.9: LIVESTOCK NUMBERS IN ATHIENOU (1994)

Village	Sheep	Goats	Cattle	Pigs	Chicken
Athienou	4 674	1 538	6 867	9 232	112 229

EMPLOYMENT

TABLE 5.10: EMPLOYMENT IN CROP AND LIVESTOCK IN ATHIENOU (1994) (FULL-TIME EQUIVALENT NUMBER OF PERSONS)

	Holders of Agricultural Land and Family Members	Employees (permanent and casual)	Total
Males	128	56	184
Females	13	8	21
TOTAL	**141**	**64**	**205**

5.3.8. CULTURAL AND ARCHAEOLOGICAL VALUES

There are no archaeological or historic sites near the proposed site for the Athienou STP.

6. IMPACT ANALYSIS

6.1. METHODOLOGY

A screening of the impacts that could potentially result from the development was carried out in relation to project location and design, and the construction and operation phases. Table 6.1 outlines the probable impacts that have been identified.

6.2. IMPACT SCREENING

TABLE 6.1 : SCREENING TABLE

	Expected Impacts
IMPACTS DUE TO PROJECT LOCATION	**Permanent land acquisition** Permanent acquisition of land for construction of the STP, the storage reservoir and the pumping stations
	Impacts on surface water hydrology Positive impacts – additional surface water body
	Impacts on ecological values No impacts in the case of the Aradippou and Athienou STPs. Possible disturbance of wildlife in the case of the Larnaca STP, particularly birds, during construction, due to proximity of site to the Salt Lakes. Also, possible disturbance of wildlife during operation as a result of noise. Positive impacts through the creation of a new wetland habitat through the construction of the long term storage reservoirs.
IMPACTS DUE TO PROJECT DESIGN	**No significant impacts are anticipated** - Treatment process is reliable and proven and effluent will meet the set performance standards. - Emergency storage will safeguard against problems in treatment process. - Sludge treatment to be chosen will be effective in achieving required standards.
IMPACTS DUE TO CONSTRUCTION	**Temporary land acquisition** Temporary acquisition of land for workers' facilities, construction storage sites, pipe laying. This will result in possible loss of natural vegetation, grazing or agricultural land.
	Vegetation clearing Clearing of vegetation for construction of the STPs, the storage reservoirs, the pumping stations and the conveyance system.
	Soil impacts - Soil erosion: resulting from uncovered and unconsolidated materials during construction - Soil disaggregation - Soil compaction

	Expected Impacts
	Dust, fumes and noise Dust: from stockpiles and vehicle movement, particularly in dry weather and strong winds. Noise: from construction operations, machinery and vehicle movements. Fumes: from vehicle movements and machinery.
	On-site safety Risk of accidents on construction sites.
	Waste management Construction waste, domestic solid waste
	Pollution Air water and soil pollution resulting from heavy operating machinery and vehicles, and from the storage of potential pollutants, such as petrol, motor oils and concrete.
	Traffic. Off-site public safety and inconvenience As a result of increased vehicle movement and road excavations.
IMPACTS RELATED TO OPERATION	**Landscape impacts** Minimum impacts
	Noise impacts At STP sites and pumping stations. Impact at STP sites limited as they are at a considerable distance from residential areas, however pumping stations are within urban areas.
	Odour impacts At STP sites and pumping stations. Impact at STP sites limited as they are at a considerable distance from residential areas, however pumping stations are within urban areas
	Impact on underground resources Positive impact: reduction in groundwater pumping, and reduction in nitrates released in the environment
	Impact of sludge production and reuse
	Risk of system overload Minimum risk: emergency storage available, design includes seasonal variations
	Risk of insufficient treatment of effluent
	Reuse of Treated Effluent in Irrigation Possible impacts on agricultural production, soils and groundwater bodies, impacts in plants and animals
	Urban reuse of the treated effluent Possibility of inappropriate use of treated water
	Groundwater recharge Possibility of aquifer contamination

6.3. ASSESSMENT OF POTENTIAL IMPACTS AND MITIGATION MEASURES

6.3.1. IMPACTS DUE TO PROJECT LOCATION

6.3.1.1. PERMANENT LAND ACQUISITION

PROCESS FOR THE ACQUISITION OF LAND

Subject to the provisions of Article 23 of the Constitution and of the Compulsory Acquisition of Property Law 15/62, any property may be acquired compulsorily for a purpose which is to the public benefit.

When immovable property needs to be acquired compulsorily the acquiring authority:

1. Shall publish a notice of the intended acquisition in the Official Gazette of the Republic.
2. Shall serve a copy of the notice of the intended acquisition to any interested person.
3. Shall invite any interested person to submit to the acquiring authority any objections within 30 days from the date of service of the notice.
4. Will proceed to the examination of any objections to the acquisition made. The acquisition must be confirmed with the publication of an order of acquisition within 12 months from the date of publication of the notice. If an order is not publish the procedure is deemed to have been abandoned.
5. Shall, within fourteen months from the date of publication of the notice, send a written offer relating to the compensation payable for the property to be acquired.

Upon receipt of the offer, any interested person may:

1. Accept the compensation for full and final settlement of any claims relating to the acquisition of the property.
2. Accept the amount offered reserving the right to apply to Court for the fixing of the final amount of compensation.
3. Refuse or ignore the offer, in which case either the acquiring authority or the interested person may apply to the Court for the determination of the final compensation.

Where the whole property is subject to compulsory acquisition, the amount of the compensation shall be assessed with reference to the market value of the property as at the date of publication of the notice of acquisition. Where only part of the property is acquired the compensation is also assessed with reference to the market value of that part of the property as at the date of publication of the notice. In these cases, the Law provided the set-off of betterment and compensation for injurious affection/severance, trade disturbance, reinstatement and any other damages or losses sustained by the owner. Finally, it provides that an interest of 9% should be added to the amount of compensation starting from the date of publication of the notice to the date of payment.

The exchange of state land with property or part of a property which has been acquired compulsorily is also possible where:

1. The compensation for the acquisition of the property has been finally determined.
2. Such acquisition deprives the applicant of the whole or part of his property which was used either:
    - i) As a dwelling-house or was intended for the construction of a dwelling-house for use by the applicant or his family,
    - ii) For the carry-on of any business, trade, profession or vocation,
    - iii) The applicant's financial situation is considered to be poor, and
    - iv) The state land that is to be exchanged:
        - (a) Is situated in the same district and preferably in the same area as the acquired property.
        - (b) Is suitable for the purposes for which the property was also used.
        - (c) Is of an almost equal value with the compensation finally determined.

PERMANENT LAND ACQUISITION FOR CONSTRUCTION OF THE STPS

The following tables outline the land requirements for the Aradippou and the Athienou sewage treatment plants, the extension of the existing Larnaca STP, and the pumping stations for the sewage collection and conveyance system. The figures given account for the additional land that will be required for sludge storage, for parking space, for offices and for the vegetated buffer zone around the facilities.

TABLE 6.2 : LAND REQUIREMENTS FOR THE ARADIPPOU STP

STP		8 000 m^2 (≈ 0.8 ha)
Emergency storage		6 910 m^2 (≈ 6.9 ha)
Long term storage		118 400 m^2 (≈ 11.9 ha)
Pumping stations	Each	500 m^2
	Total area	1 000 m^2
Total		134 400 m^2 (≈ 13.4 ha)

TABLE 6.3 : LAND REQUIREMENTS FOR THE ATHIENOU STP

STP	1 700 m^2 (≈ 0.2 ha)
Emergency storage	1 430 m^2 (≈ 0.15 ha)
Long term storage	24 510 m^2 (≈ 2.5 ha)
Total	27 700 m^2 (≈ 2.8 ha)

TABLE 6.4 : LAND REQUIREMENTS FOR EXTENSION OF THE EXISTING LARNACA STP

STP		11 700 m^2 (≈ 1.2 ha)
Emergency storage		10 160 m^2 (≈ 1.0 ha)
Long term storage		174 100 m^2 (≈ 17.4 ha)
Pumping stations	Each	500 m^2
	Total area	1 000 m^2
Total		197 000 m^2 (≈ 19.7 ha)

❑ ARADIPPOU STP

In the case of the Aradippou STP, the land that will be taken up is within the Da3 Protection Zone, which constitutes a buffer zone for the protection of the areas neighbouring the animal husbandry zone that lies next to the proposed location. The area consists predominantly of barren land, with only a few cultivated plots with fodder used for grazing. Due to the nature of the area no land use impacts are expected to arise as a result of the acquisition of land for the construction of the STP.

The treatment plant, together with the emergency storage reservoir, will be constructed at Site A, as indicated in Drawings EIA-B-1 and EIA-B-5, resulting in the permanent acquisition of approximately 14 910 m^2 (≈ 1.5 ha). The long term storage reservoir will be located at Site B, covering a total area of about 118 400 m^2 (≈ 11.9 ha). The total area that will be acquired for the construction of the Aradippou STP will be approximately 134 400 m^2 (13.4 ha), which includes the areas that will be required for sludge storage, offices, parking lots and the buffer zone, most of which is privately owned land. As a result, compensation must be paid to the owners of each plot of land that will be acquired in accordance with the relevant law provisions.

Since the land is largely barren and not used for the cultivation of crops, the acquisition of this land will potentially not lead to any loss of income, while there will be no destruction of permanent crops or agricultural yields from temporary cultivations that could warrant additional compensation.

- EXISTING LARNACA STP

In the case of the extension of the existing Larnaca sewage treatment plant, the land requirements will be accommodated by the land available on the site, which is government land. Therefore, the construction of the STP will not result in any permanent acquisition of privately owned land.

- PUMPING STATIONS

The actual location of the pumping stations will be determined following the detailed design of the sewage collection system. Construction of the four pumping stations will result in the permanent acquisition of 2 000 m^2 (0.2 ha) of urban land. For those pumping stations that will be located within private land, compensation must be paid to the owners for the land or any loss of income that might result from any potential disruption in business.

- ATHIENOU STP

The construction of the Athienou STP, including the treatment plant, the emergency and long term storage reservoirs, and the additional requirements for sludge storage, offices, parking lots and the buffer zone, will result in the permanent acquisition of approximately 27 700 m^2 ($\approx$ 2.8 ha), which for either of two alternative sites will be privately owned land. Therefore, compensation must be paid to the owners for each plot of land acquired.

In the case of site 4(a) (southeast of Athienou), the land that will be taken up is agricultural land used for the cultivation of temporary crops, such as cereal and fodder. Compensation must be paid to the land owners for any loss of income that will potentially result form the destruction of crop yield.

For alternative 4(c) (north of Athienou), the land that will be taken up is also agricultural land, however, in addition to the destruction of temporary crops, the construction of the STP will result in the destruction of some olive plantations. Therefore, compensation must be paid for all permanent crops that will be destroyed, as well as for any loss of income that will be incurred.

In terms of land use, the area of site 4(c) is of better agricultural quality and is cultivated with olive plantations, thus the land use impacts that will arise will be higher in comparison.

6.3.1.2. IMPACT ON ECOLOGICAL VALUES

ARADIPPOU AND ATHIENOU STP

Due to the nature of the proposed locations, no adverse ecological impacts are expected in the case of the Aradippou and the Athienou sewage treatment plants. The Aradippou STP site is within the Da3 buffer zone which consists mostly of barren land, while being next to the animal husbandry zone, in a region characterized predominantly by barren rocky land, already significantly degraded by the presence of farms, piggeries and the installations for the treatment of animal wastes, and which is of a relatively low ecological value. Instead, the creation of the long term storage reservoir will have a beneficial effect as it could potentially attract bird species, creating a wetland habitat in the region.

Although not similarly degraded, the both areas proposed for the Athienou STP are agricultural land, bordered on the one side by occupied areas, and which are of no significant ecological value. As is the case for Aradippou, the construction of the STP will have a beneficial impact on the ecology of the region through the creation of a reservoir that will provide a wetland habitat, particularly for bird species.

EXISTING LARNACA STP

Although the additional capacity of the villages of Perivolia, Kiti, Dromolaxia and Meneou will be accommodated through the extension of the existing Larnaca sewage treatment plant, thus minimizing the scale of the impacts that would arise from the construction of a separate STP; the

location of the existing plant near the ecologically sensitive area of the Larnaca Salt Lakes will enhances the significance of any impacts that might arise and the need for careful implementation of mitigation measures.

The land requirements for the expansion of the STP will be accommodated by the land available on the STP site, thus minimizing the possibility of destruction of any part of the lake habitat. The potential for any adverse ecological impacts arises mainly from the construction and operational phases of the STP, rather than from the direct destruction of habitat.

During the construction phase there could be some short term impacts on the ecology of the area, and in particular bird species, as a result of machinery operation and vehicle movement, where construction activity and noise may lead to a reduction in sensitive fauna species, or a disruption of migratory and breeding patterns. Such impacts, however, will only be temporary, while the adoption of the proposed mitigation measures in connection to construction activities will reduce any adverse short term effects.

During the operation of the STP no significant adverse impacts are expected. Noise from the site could potentially disturb the wildlife in the area, however, the use of low noise processes and the adoption of all necessary mitigation measures, regarding the design and operation of the plant, will eliminate the risk of such impacts occurring. Generally the potential for adverse effects during the operational phase of the plant is minimum. The scheme involves the expansion of the existing plant, which has been operating in the area without imposing negatively on the ecology of the region. Instead, the STP has had in effect a beneficial impact, as it has provided the area an additional wetland habitat which currently attracts a number of bird species, the majority of those also found near the Salt Lakes. Similarly, the creation of another long term reservoir, or the expansion of the existing one will exert a beneficial effect by increasing the area of this artificial wetland habitat and enhancing its biodiversity.

PUMPING STATIONS

Ecological impacts as a result of the location of the pumping stations could potentially arise only in the case of the Meneou Station, which is in close proximity to the salt lake that lies to the south-southwest of the airport. Impacts might arise as a result of construction activity, noise and vehicle movement; or noise during the operation of the station. As this is an ecologically sensitive area, care must be taken to ensure the adoption of the proposed mitigation measures in relation to construction activities, as well as the use of low noise equipment and the adoption of all the necessary design and operational parameters that will eliminate impacts during operation.

The other three pumping stations will not be located within ecologically sensitive areas, therefore no significant impacts are expected to result.

6.3.2. IMPACTS RELATED TO PROJECT DESIGN

No significant impacts are anticipated in relation to the design of the STPs and the conveyance systems. The activated sludge process that has been proposed for the treatment of sewage, in the case of the Aradippou and the Athienou STPs, and which is in use at the existing Larnaca STP, is a proven and reliable process, and, as it will be provided with tertiary treatment, the treated effluent will meet the set performance standards.

With the activated sludge process there will be stable performances despite variations in the hydraulic road. The process will ensure the removal of dissolved organic pollution (BOD, COD and SS), while the tertiary treatment will reduce the coliform counts, in accordance with the specified standards. Additionally, the process will be configured to achieve nitrogen reduction, thus reducing the nutrient levels of the receiving waters and soil, while provisions will also be made for the future removal of phosphorus. Therefore, in terms of performance, the process will ensure the adequate treatment of wastewaters, thus minimizing the risk of any impacts arising as a result of insufficient treatment of the effluents.

The design of the sewage treatment plants includes the construction of an emergency storage reservoir for each plant to address the possibility of emergency problems in the treatment process. This will provide storage for 7 days, thus reducing the risk of any impacts resulting from emergency conditions.

The treatment of the sludge is covered in Sections 3.3.2. and 6.3.4.4. The process selection for the sludge treatment though will be based on the assumption that the treated sludge will be reused in agriculture as fertilizer in accordance with the specified standards. In the case of the existing Larnaca STP the sludge treatment stages ensure that the treated sludge is of a quality that can be safely used in agriculture, provided the Code of Practice for the Use of Sewage Sludge for Agriculture is adopted.

The design of the conveyance systems will ensure that there will be no problem of creation of sulphides along the forcemains.

6.3.3. IMPACTS RELATED TO PROJECT CONSTRUCTION

6.3.3.1. TEMPORARY LAND ACQUISITION

During the construction phase land will be required for the construction facilities, which include worker camps, workshops, and storage and disposal areas. This could potentially lead to the temporary take up of additional land. Where it is necessary to acquire additional land, measures should be taken up to ensure that such sites are limited to the minimum possible area required. Following the construction stage all land which was acquired temporarily must be rehabilitated.

6.3.3.2. VEGETATION CLEARING

In the case of the Aradippou sewage treatment plant, the extent of the vegetation clearing on the sites will be limited, as most of the area is barren land, therefore no significant impacts are anticipated as a result of construction.

For the Athienou STP, the land at both alternative locations under consideration is agricultural land, therefore the crop cultivations on the site selected will be destroyed as a result of the construction of the plant and the emergency and long term storage reservoirs. In the case of alternative 4(a) the agricultural land in the area is cultivated with temporary crops, such as cereal and fodder. There are no permanent cultivations on the site, thus reducing the extent and the significance of the impact. On the other hand, construction of the STP at site 4(c) will result not only in the destruction of temporary, but also permanent crops, as there are olive plantations in the area. Therefore, the resulting impacts will be higher in comparison. In case alternative 4(c) is selected the design and layout of the STP must ensure that the destruction of the surrounding olive plantations is minimized to the highest extent possible.

The impacts arising from vegetation clearing during construction will be more pronounced in the case of the extension of the existing Larnaca STP due to its location within a protection zone. The construction stage will potentially result in the destruction of natural vegetation on the site of the existing plant and efforts must be made to minimize the extent of the vegetation expanses that will be cleared and or, where this is not possible, to lower the impacts through the implementation of mitigation measures aimed at the restoration of any vegetation that inevitably must be cleared. Such measures include the careful removal of vegetation allowing for its replanting in adjacent areas and the restoration of any vegetation lost following the construction phase.

During the construction of the conveyance systems, it is possible that vegetation, including cultivations, trees and natural vegetation, along the pipe routes will need to be cleared. In most cases this will only be temporary, and the vegetation can be restored following the construction phase. In the case of the pumping stations, the extent of vegetation destruction that will result from construction will be limited as most of the pumping stations will be within the urban areas. The only exception is the Meneou Station, which is near the sensitive salt lake area to the south of the airport.

For this, similar measures must be taken as in the case of the existing STP, so as to reduce the extent of the impacts and to preserve the existing vegetation of the area.

Where crop cultivations are destroyed, from construction of the Athienou STP or any of the pumping stations, compensation must be paid to the owner for any loss of income that might result from the destruction of crop yields and trees.

6.3.3.3. EROSION OF UNCONSOLIDATED MATERIALS

Impacts on the soil of the STP sites and along the conveyance routes could arise during the construction phase if appropriate measures are not implemented. Such impacts mainly include the erosion, disaggregation and compaction of the soil. Generally, during the construction phase, the topsoil must be effectively preserved for eventual use.

SOIL EROSION

This concerns mainly earthworks and spoiled areas and is usually caused by rainfall or wind. To prevent soil erosion it must be ensured that the earth piles are correctly shaped (e.g. with gentle gradients) and protected against erosion by protective walls. The creation of large expanses of bare soil must be avoided and the removal of vegetation must be reduced to the minimum possible. Additionally, the construction of the pipe network should be done by segmentation in order to minimize the spoil production.

SOIL DISAGGREGATION

This is the mixing up of soils and arises particularly when soil is removed from one location to another. Soil disaggregation can be prevented by removing the soil in order of horizons and keeping each horizon in a separate pile.

SOIL COMPACTION

This is an inevitable impact during the construction stage, resulting from the movement of vehicles over soil, as well as the storage of soil heaps or other materials. A number of mitigation measures can be taken to reduce soil compaction, including the use of only a single or a few tracks by vehicles; the use of wider tires which will spread the weight of vehicles; or by tilling the area once compaction has occurred.

6.3.3.4. DUST, FUMES AND NOISE

IMPACTS ON AIR QUALITY DURING CONSTRUCTION

During the construction phase of the sewage treatment plants and the collection and conveyance systems, the main sources of air pollution will be the machines and vehicles through the burning of fuel, as well as the generation of dust from vehicle movement and construction activities. To minimize the impacts, the construction field and any access roads which are not asphalted must be watered to reduce the amount of dust produced, while the regular maintenance of machinery and vehicles should be ensured. Provided that dust control and site management measures are adopted, the impacts will be localized, temporary and are not expected to be significant.

NOISE IMPACTS DURING CONSTRUCTION

During the construction phase the levels of noise to be generally anticipated are in the range 92 – 95 dB (A) at 5m. More specifically, it will vary between the different stages of the construction process, including:

- Site clearance
- Foundation work
- Building construction
- Road construction

The main sources of noise will be the operation of construction machines, the vehicles transporting materials and personnel, and the vibration caused by activities such as blasting.

TABLE 6.5: TYPICAL MAXIMUM NOISE LEVELS PERMITTED FROM CONSTRUCTION PLANT

Construction Equipment and Vehicles	DB(A)
Lorries	85
Bulldozer	120
Diesel mechanical shovel	110
Diesel earth excavator	105
Concrete breaker	110
Diesel winch	105
Dumper trucks	100
Diesel ground compactor	110
Concrete mixer	115
Concrete pump	115
Tractor	120
Soil grader	120
Pneumatic drill	125
Fixed compressor	115
Loader	115
Electric motor (300HP)	105
Electric pump (300HP)	120
Car	75
Bus	85

TABLE 6.6: NOISE VALUE OF THE MAIN MACHINERY USED AT VARYING DISTANCES

	Equipment	15 M	30 M	50 M	100 M	200 M
1.	Excavator	78	72	67	61	53
2.	Bulldozer	78	72	67	61	53
3.	Drilling machine	89	83	78	72	66
4.	Air compressor	75	69	64	58	52
5.	Vibrator	76	70	65	59	53
6.	Mixer	75	69	64	58	52
7.	Truck	76	70	65	59	53
8.	Truck	77	70	65	59	53

Noise impacts during the construction phase will arise mainly from the construction of the collection systems, as works will take place within the residential areas, and partly from construction of the conveyance systems. In the case of the STPs, there will be no noise impacts on the resident population as all three sites are at a sufficient distance from housing areas, although in the case of the existing Larnaca STP there could be some impacts on the people using the area for recreation purposes, particularly near the adjacent salt lake.

Although during the construction phase noise control measures can be incorporated in the contract with the constructors, such measures are rather restricted. Construction takes place in the open with the use of heavy machinery and only limited control measures are feasible, such as the use of low noise compressors, engines and equipment. Furthermore, any construction during the night hours, when background noise levels are low, should be strictly controlled to minimise impacts.

Mitigation measures to be adopted include:

- ⇨ the use of low noise compressors, engines and equipment
- ⇨ a specification on the hours when construction will commence, while construction during the night hours when background noise levels are low should be strictly controlled to minimize impacts.

To ensure the effective adoption of mitigation measures these will be incorporated in the environmental specifications of the constructor as part of the contract.

6.3.3.5. ON-SITE SAFETY

Health and safety measures must be implemented on the construction sites by the contractor to ensure the avoidance of accidents in relation to the work force and the environment. The construction equipment and machinery, and all vehicles must undergo regular maintenance, while measures to ensure traffic security must be adopted and applied at all times. Regarding the work force, personal protective equipment must be provided and used at all times, medical assistance should be readily available, and preparedness procedures in case of accidents or emergency situations must be established.

6.3.3.6. WASTE MANAGEMENT

Waste is expected to arise as a result of construction activities, including construction waste and domestic solid waste from the workers' facilities. Domestic waste should be collected and transported to the appropriate official landfill site. In the case of construction waste, where these cannot be reused elsewhere, they should also be disposed at an official landfill site. Measures must also be taken for the handling of effluents from workers' sanitary facilities to prevent any risk of effluent runoffs.

6.3.3.7. POLLUTION

During the construction phase there is the possibility of soil or water pollution as a result of effluents from camps, oils from engines, effluents from concrete production, or from other building materials used. Such effluents pose a risk for soil pollution and, potentially, aquifer pollution if the aquifer is near the surface. The risk for surface water pollution is lower, unless there is water runoff leading to the transport of pollutants into surface water bodies. Where the release of effluents is considered to pose a serious threat of soil pollution or when there is a possibility for runoff, procedures must be taken for the containment of pollutants.

Pollution, and particularly soil pollution, may also be the result of accidental spillages on construction sites, particularly in the case of storage tanks or on-site pumps. Measures must be taken to minimize the impacts of any accidental spillages, including the containment of such tanks on concrete floors with walls to prevent the release of effluents on the soil in case of a spillage.

6.3.3.8. OFF-SITE PUBLIC SAFETY AND INCONVENIENCE

During the construction of the sewage treatment plants there will be increased vehicle movement to and from the sites for the transportation of materials, equipment and personnel. This could potentially lead to driver delays along these roads, as well as increased risk of road traffic accidents.

The impacts during the construction of the collection and conveyance systems, however, will be more significant. The proposed collection and conveyance systems will, in most cases, be constructed along main roads, often within the community residential areas, which will cause

inconveniences for the resident population. The opening of trenches and the partial or total closing of roads during the excavation and pipe-laying stages will lead to traffic congestions, especially along the main roads, and increase the risk of car accidents.

Mitigation measures are rather restricted. In the case of increased vehicle movements, these should be restricted to avoid hours of peak traffic. Good site management during the construction stage and the adoption and adherence to road safety measures will, to some extent, minimize these impacts.

6.3.4. IMPACTS RELATED TO PROJECT OPERATION

6.3.4.1. LANDSCAPE IMPACTS

The proposed location for the Aradippou sewage treatment plant is next to a zone of heavy animal husbandry practices, which by nature holds little value in terms of landscape. The area, which consists predominantly of barren rocky land, has been already degraded, in terms of landscape by the presence of animal husbandry facilities and animal waste treatment lagoons. As a result of this landscape character of the area, construction of the plant will not result in any adverse landscape impacts. Furthermore, as the area is remote, being at a considerable distance from main roads and residential areas, and thus not visible from such areas, visual impacts will also be limited.

Landscape and visual impacts in the case of the expansion of the existing Larnaca sewage treatment plant will be limited. Although the salt lake region holds a significant ecological and landscape value, the scheme involves the extension of the plant which is already present in the area, and which is sited in a remote location, not visible from the surrounding areas due to the presence of the airport which isolates the site from the main salt lake. Furthermore, the landscape at the particular location is already imposed on by the presence of the airport, the existing waste treatment facilities and the desalination plant, therefore the proposed scheme will not result in any additional significant adverse visual impacts.

For the Athienou sewage treatment plant, location 4(a) is within an agricultural area of little landscape value, bordered on the side of the road by occupied areas which consist largely of barren, derelict land. The site is remote and isolated from views from main roads, residential or recreational areas. As a result, the presence of the sewage treatment plant will not result in any significant landscape or visual impacts. Landscape and visual impacts will be somewhat more pronounced in the case of 4(c) because the area is flat and visible from the side of the village. Nevertheless, the impacts will not be significant as the site is at some distance from the village, bordered by the occupied areas, and to some extent it will be hidden from views by the plantations present in the surrounding areas.

6.3.4.2. QUALITY OF LIFE IMPACT

No significant noise or odour impacts are expected on the resident populations as a result of the operation of the Sewage Treatment Plants.

The STP sites are all at a sufficient distance from residential areas ensuring that there will be no risk of noise or odour impacts. The Aradippou location is at a distance of approximately 2.0 km for Site B and 2.8 km for Site A from the boundaries of the Livadia residential zone, while the existing Larnaca STP site is about 2.5 km from the residential zone of Meneou and 2.3 km from that in Dromolaxia. Additionally, in the case of the Aradippou STP, the proposed site is located within an area already degraded in terms of odours by the presence of animal husbandry farms and lagoons for the treatment of animal waste, and, particularly with the adoption of all necessary mitigation measures, operation of the plant will not give rise to any significant impacts. For the Athienou STP, site 4(a) is at a distance of approximately 1.5 km from the nearest houses and site 4(c) about 1.0 km, therefore no odour or noise impacts are anticipated on the resident population, although site 4(c) is close in comparison thus slightly increasing the risk.

In terms of wind direction, between the months of September to April the prevailing winds in the Larnaca area have a northwest direction, with angles between 300^{o} to 330^{o}, while south to southwest winds also have a strong percentage of occurrences. For the months between May and August, southwest winds are prevailing, with angles of 210^{o}, together with the frequent occurrence of south and northwest winds. For the Aradippou STP, the northwest winds between September and April will be in the direction of the Livadia village, which is, however, at a distance of approximately 2 and 2.8 km from two sites, therefore there will be no noise or odour impacts on the resident population. In the case of the existing Larnaca STP the south winds will be directed towards the Larnaca residential area, but as the site is at a distance of about 3.5 km from the edge of the residential area, there will be no adverse effects on residents with regards to noise or odour. Lastly, for the Athienou STP the prevailing winds are not in the direction of the village for either of the two alternative locations.

Additional to the sufficient distance of the sites from the communities, with regards to odours, the plant design will ensure the effective control of odours as it will incorporate an odour removal system. Moreover, noise impacts are also addressed by the Environmental Management Programme through the introduction of a noise monitoring programme and mitigation measures to ensure the avoidance of any impacts that could arise.

In conclusion, the plant design and the Environmental Management Programme, in conjunction with the distance of the STP site from residential areas ensure that there will be no adverse impacts on the quality of life for the concerned communities.

NOISE IMPACTS DURING OPERATION OF THE STPS

Noise levels in the range 65 – 70 dB (A) may be expected near equipment such as pumps, ventilators and air compressors. However, as mentioned above, the distance of the site from residential areas is itself a mitigation measure against impacts on the resident population. Other measures include:

- Use of low noise equipment
- The application of noise control equipment at various stages of the treatment process
- Enclosing the sources of noise
- Use of noise screens, including tree plantings

A monitoring programme for the control of noise is addressed in the Environmental Management Programme.

NOISE AT PUMPING STATIONS

The careful design of pumping stations will ensure the minimization of any noise produced during operation. As pumping stations work intermittently, operation will be more frequent during peak hours which are not usually during the night time, therefore any impacts are inherently minimized. The use of low noise equipment and the design of buildings to incorporate specific acoustic features, together with their sitting at appropriate locations as far away from residential areas as possible and again the use of natural barriers will ensure the mitigation of any such impacts.

ODOUR IMPACTS DURING OPERATION OF THE STPS AND CONVEYANCE SYSTEMS

During the operation of the STPs and the conveyance systems, odours can potentially arise from a number of sources, including screenings and grit removal facilities, primary settling tanks, organically overloaded biological treatment processes, sludge thickening tanks, sludge conditioning and dewatering facilities, or sludge digesting and composting operations. However, the risk of odour impacts can be effectively mitigated through:

- The application and adherence to proper process procedures
- The covering of process areas and the provision for adequate air filtration

- The regular monitoring of processes and the conducting of all appropriate chemical and biochemical analyses
- The regular maintenance of the plant and pumping stations.

The introduction of odour control systems in the STP design and the distance of the site from residential areas, as mentioned above, in conjunction with these measures will effectively mitigate odour impacts.

Regarding the formation of sulphides in the case of the forcemains along the conveyance system, with appropriate design no impacts are expected for lengths of forcemain below 10m, which corresponds to a transfer time of approximately 3 hours.

6.3.4.3. IMPACT ON UNDERGROUND RESOURCES

The project is anticipated to have a significantly positive impact on underground water resources. The volumes of treated water that will be produced from the three sewage treatment plants in 2005, 2015 and 2030 are as follows:

	WASTEWATER FLOW (m^3/ year)
ARADIPPOU STP	
2005	861 400
2015	1 045 360
2030	1 422 040
LARNACA STP (VALUES ONLY FOR THE VILLAGES INCLUDED IN THE SCHEME)	
2005	702 025
2015	894 711
2030	1 253 254
ATHIENOU STP	
2005	224 840
2015	255 500
2030	313 170

This water will potentially be used for irrigation purposes, thus providing an additional permanent water resource for the region. This will result in a reduction in the amount of water pumped from the groundwater bodies, therefore reducing the risk of aquifer depletion. This is of particular importance in the area of the existing Larnaca STP, where the problems of salinity of the Kiti aquifer have resulted as a result of over-pumping and groundwater depletion.

An additional advantage is that the project will result in a reduction of nitrates which are currently released into the soil from the existing sanitary system (septic tanks) in the project area.

6.3.4.4. IMPACT OF SLUDGE PRODUCTION

The expected quantities of sludge to be produced are given in the following Table.

	Total Sludge Quantity at 30% DS Content		
	2005	2015	2030
Aradippou STP	1 723 m^3/yr	2 055 m^3/yr	2 711 m^3/yr
Larnaca STP	1 788 m^3/yr	2 344 m^3/yr	3 325 m^3/yr
Athienou STP	450 m^3/yr	502 m^3/yr	597 m^3/yr

Table 6.7 gives the average sludge composition in Cyprus. Detailed information regarding sludge quality and constituents are outlined in Appendix 8.

TABLE 6.7: AVERAGE SLUDGE COMPOSITION IN CYPRUS

	CYPRUS
Date	1995 – 1999
Dry Matter (%)	22 – 73
Organic Matter (% DM)	67 – 72
N % DM	3.75 – 4.53
P % DM	1.97 – 2.27
K % DM	0.25 – 0.26
mg/kg DM	
Cd	1.85 – 3.5
Cr	22 – 133
Cu	129 – 202
Hg	0.4
Ni	30 – 32
Pb	44 – 70
Zn	659 – 1173
nb/g wm	
Enteric virus	4.3×10^4/100g
Viable Helminth eggs	0

DISPOSAL AND REUSE OF SLUDGE

Particularly during the first years of operation of the STPs, the main disposal route for the sewage sludge will be landfill, which will accommodate a significant percentage of the quantities produced annually. Regarding landfill disposal, two options are available:

- ⇩ Either the sludge will be transported for disposal to the nearest official controlled landfill site that is appropriately designed to receive such waste, or,
- ⇩ A site will be identified within the region to be serviced by the STPs for the creation of a new controlled landfill, designed to accommodate such waste as sewage sludge, in addition to the solid waste from the villages.

For this purpose, a feasibility study must be conducted to:

- ⇨ Assess the costs of the two options, i.e. the costs for the transport of sludge to the existing landfill site as compared to the costs for the creation of a new site(s) near the STPs.
- ⇨ Identify possible locations for a new landfill site/sites
- ⇨ Evaluate the costs and benefits of each option in economic, technical and environmental terms.

However, the volume of sludge that is disposed in landfill must be reduced, primarily through the reuse of sludge for agricultural purposes. Based on this objective, the quality of the treated sludge must be according to the set standards, while provisions must be made for the storage and drying of the sludge at the STP sites. A minimum storage period of two months is recommended, in addition to the treatment process, to further reduce the pathogens present in sludge to appropriate levels. Such reuse will recycle the constituents of sludge which are important nutrients in crop production, while at the same time reducing the need for fertilisers, and the quantities of sludge that are disposed in landfills. For the efficient use of sludge in agriculture, a regional management plan must be drafted which will increase the percentage of sludge that is recycled and ensure safe reuse practices.

SEWAGE SLUDGE: REUSE MANAGEMENT PLAN

The drafting of a regional management plan is proposed to ensure the availability and efficiency of long term disposal and, more importantly, recycling possibilities for sludge.

Although landfills are currently the main disposal route for sludge, and will continue to be the base option for a significant percentage of the total sludge quantities that will be produced, EU policy is in favour of developing the use of sludge in agriculture, as it is considered to be the best option from both the economic and environmental perspectives.

To increase the percentage of sludge used in agriculture and ensure the sustainability and acceptance of this route, together with the adoption and adherence to appropriate management practices, the development of a regional reuse plan is recommended. This plan will seek to increase the extent and possibility for sludge recycling and secure that the reuse of sludge shall be carried out in such a way as to minimise any risk of negative effects to:

- Human, animal and plant health
- The quality of groundwater and surface water
- The long term quality of the soil

The reuse plan must be based on the following criteria:

- SLUDGE QUALITY: sludge quality must be according to the set standards regarding heavy metal concentrations, as well as N and P concentrations.

- APPLICATION RATES: they must be determined based on the N and P requirements of the specific crops, the N and P levels in the sludge, the metal concentrations in the sludge and the application rates specified in the set standards, and the quality of the soil.

- CROP SELECTION: based on crop nutrient requirements and crop tolerance to certain sludge constituents.

- APPLICATION METHODS: depending of the physical characteristics of the sludge and soil, and the types of crops.

- SCHEDULING OF APPLICATION: the timing of land applications must be scheduled around the tillage, planting and harvesting operations for the crops grown, also taking into account climate and soil properties.

- SITE IDENTIFICATION: possible sites where sludge can be used (also securing acceptance by farmers).

- MEASURES TO ENCOURAGE USE OF SLUDGE AND REDUCE CONSTRAINTS: including

  - Technical options:
    - Implement regular monitoring of sludge quality
    - Guarantee quality of sludge recycling practices

  - Economic and regulatory options:
    - Establish clear provisions on producer responsibility ensuring that sludge producers are responsible for the quality of the sludge supplied and shall guarantee its suitability for use.
    - Measures to ensure that sludge suppliers accept liability for any economic or damage associated with the use of sludge
    - Establishment of guarantee funds or insurance systems in case of accidents.
    - Arrange voluntary agreements between farmers and food suppliers to ensure no discriminative measures are taken against products grown with the use of sludge.

MITIGATION MEASURES FOR THE APPROPRIATE USE OF SLUDGE IN AGRICULTURE

Misuse of the agricultural value of sludge **Leaching of nitrates to groundwater**
⇩ Better knowledge of sludge content in terms of compounds of agricultural value
❑ Adequate sampling procedures (frequency, number of samples, etc.)
❑ Adequate analysis protocols
⇩ Improve use of sludge agricultural value
❑ Determination of the sludge agricultural value (N, P, K, content)
❑ Planning and application adapted according to: ⇨ Plant needs ⇨ Other fertiliser sources ⇨ N remaining in the soil ⇨ Nutrient bioavailability ⇨ Adequate spreading periods according to agricultural and environmental constraints
❑ Regular soil analyses to establish increase in nutrient content
❑ Information from farmers about quantities spread
SOIL CONTAMINATION BY HEAVY METALS AND ORGANIC POLLUTANTS
⇩ Determination of background levels in soil
⇩ Determination of pollutant content in sludge
⇩ Safe storage of sludge
❑ Safe storage to reduce leaching
❑ Sufficient storage capacity
❑ Reduction of storage duration in the field
WATER CONTAMINATION BY HEAVY METALS AND ORGANIC CONTAMINANTS
⇩ Forbid sludge spreading in sensitive areas, especially:
❑ On sloping land ❑ Near surface water ❑ On wet areas ❑ Within water resource protection areas ❑ On sandy soils ❑ On frozen grounds ❑ In areas where the water table is near the surface
⇩ Encourage fast ploughing down in order to reduce the risk of runoff and the use of close-to-ground techniques in order to reduce the formation of aerosols
⇩ Safe storage of sludge
CROP CONTAMINATION BY HEAVY METALS AND ORGANIC POLLUTANTS
⇩ Reduce transfer in the food chain
❑ Encourage sludge spreading before non-food crops
⇩ Limit plant uptake
❑ Adapt sludge spreading to soil types (mainly according to pH and CEC)
❑ Take into consideration heavy metal bioavailability in soil
❑ Define a crop/sludge type matrix with specific recommendations
❑ Prohibit sludge spreading on plant/crops which are known to accumulate heavy metals
⇩ Limit deposition on plant
❑ Limit use of sludge on vegetable and certain fruit productions
⇩ Analyses of the metal level in crops and foodstuff

ANIMAL CONTAMINATION BY HEAVY METALS AND ORGANIC POLLUTANTS
⇩ Limit pollutant transfer to animals
❑ Tighten limits concerning quantity and quality of sludge which may be applied
❑ Grazing land: ⇨ Introduce a time period before harvesting ⇨ Favour sludge ploughing down
❑ Grassland: ⇨ Allow spreading before sowing and after each cut
⇩ Control of the metal levels in foodstuffs
❑ Analysis of the pollutant levels in animal products (especially in offal and milk)
HUMAN CONTAMINATION
⇩ Limit pollutant transfer in the food chain (see above)
⇩ Protection of operating equipment
❑ Ensure safe manipulation of sludge
❑ Material cleaning and maintenance
❑ Protective clothes
CONTAMINATION BY PATHOGENS
⇩ Animal contamination
❑ Grazing land: introduce a time period before grazing
❑ Grassland: allow spreading before sowing and after each cut
❑ Encourage fast ploughing down of sludge
⇩ Human contamination
❑ Prohibition of sludge spreading on products which are to be consumed raw
❑ Safe transportation of sludge
❑ Prohibition of sludge spreading in the vicinity of houses and near bathing water and drinking water supply areas

Sludge must be used according to the following table.

TABLE 6.8: SAFE-SLUDGE MATRIX

	Advanced Treatments	Conventional Treatments
Pastureland	Yes	Yes, deep injection and 6-week no-grazing
Forage crops	Yes	Yes, 6-week no-harvest
Arable land	Yes	Yes, deep injection or immediate ploughing down
Fruit and vegetable crops in contact with the ground	Yes	No. no harvest for 12 moths following application
Fruit and vegetable crops in contact with the ground – eaten raw	Yes	No. no harvest for 30 moths following application
Fruit trees, vineyards, tree plantations and reforestation	Yes	Yes, deep injection and 10-month no-access to the public

SUGGESTED LIMIT STANDARDS FOR SLUDGE QUALITY

A set of limit values are suggested for the concentrations of heavy metals in the sludge, the soils on which sludge will be applied and for the heavy metal application rates. These are lower than the

standards set by the Regulations on the Use of Sludge in Agriculture (517/2002) and the Code of Practice for the Use of Sludge for Agricultural Purposes.

TABLE 6.9: PROPOSED HEAVY METAL CONCENTRATION LIMIT VALUES IN THE SOIL

PARAMETER	LIMIT VALUES (mg/kg DS)			
	REGULATION 517/2002 6<pH<7	PROPOSED LIMIT VALUES		
		5 ≤ pH < 6	6 ≤ pH < 7	pH ≥ 7
Cadmium (Cd)	1 – 3	0.5	1	1.5
Copper (Cu)	50 – 140	20	50	100
Nickel (Ni)	30 – 75	15	50	70
Lead (Pb)	50 – 300	70	70	100
Zinc (Zn)	150 – 300	60	150	200
Mercury (Hg)	1 – 1.5	0.1	0.5	1
Chromium (Cr III)	–	30	60	100

TABLE 6.10: PROPOSED HEAVY METAL CONCENTRATION LIMIT VALUES IN THE SLUDGE USED IN AGRICULTURE

PARAMETER	LIMIT VALUES (mg/kg DS)		LIMIT VALUES (mg/kg P)
	REGULATION 517/2002	PROPOSED LIMIT VALUES	PROPOSED LIMIT VALUES
Cadmium (Cd)	20 – 40	10	250
Copper (Cu)	1 000 – 1 750	1 000	25 000
Nickel (Ni)	300 – 400	300	7 500
Lead (Pb)	750 – 1 200	750	18 750
Zinc (Zn)	2 500 – 4 000	2 500	62 500
Mercury (Hg)	16 – 25	10	250
Chromium (Cr III)	–	1 000	25 000

TABLE 6.11: PROPOSED LIMIT VALUES FOR AMOUNTS OF HEAVY METALS WHICH MAY BE ADDED ANNUALLY TO SOIL, BASED ON A TEN YEAR AVERAGE

PARAMETER	LIMIT VALUES (kg/ha/year)	
	REGULATION 517/2002	PROPOSED LIMIT VALUES
Cadmium (Cd)	0.15	0.03
Copper (Cu)	12	3
Nickel (Ni)	3	0.9
Lead (Pb)	15	2.25
Zinc (Zn)	30	7.5
Mercury (Hg)	0.1	0.03
Chromium (Cr III)	–	3

MONITORING PROGRAMME

In addition to the mitigation measures and the sludge management plan, a monitoring programme is required regarding sludge and soil quality, and application rates and practices, to ensure that

implementation of the mitigation measures and good practice guidelines, as well as the adherence to the set standards. This is outlined in the Environmental Management Programme.

6.3.4.5. RISK OF SYSTEM OVERLOAD

The risk of system overload is minimum. The design parameters for the sewage treatment plants will be based on the population projections for the year 2030, while by accounting for the summer tourism requirements for each of the communities the risk of seasonal overload is not anticipated. Any accidental overload from equipment failure will be mitigated though the construction of the emergency storage reservoir.

6.3.4.6. RISK OF INSUFFICIENT TREATMENT OF EFFLUENT

A combination of the standards specified by both the EU Directive 91/271/EEC and the Cyprus Standards for the reuse of the treated effluent for irrigation purposes will be used for the design of the sewage treatment plants, and the most stringent values will be applied. Thus removal of nitrogen and phosphorus will be governed by the EU standards, whereas the limits for BOD, Suspended Solids and micro-organisms will follow the Cyprus standards. This will ensure the sufficient treatment of the effluent. However, regular monitoring of the quality of the treated effluent is required to ensure that the process is carried out according to design parameters and any emergency situations are detected.

6.3.5. DISPOSAL OF THE TREATED EFFLUENT

6.3.5.1. TREATED EFFLUENT QUANTITIES

The maximum expected quantities of treated effluent for the years 2005, 2015 and 2030 have been estimated as follows:

2005	1 788 265 m^3
2015	2 196 571 m^3
2030	2 988 464 m^3

6.3.5.2. REUSE OF TREATED EFFLUENT IN AGRICULTURE

The low rainfall patterns in Cyprus have often resulted in long periods of drought and, as a result, water shortages with their associated impacts on the agricultural sector. During the years between 1997 and 2000, for instance, the supplies of irrigation water were severely limited due to the low rainfall, with the available water in dams having reached critical levels. Irrigation water was rationalized and the amount allocated to farmers ranged between 30 – 70 % of the normal demand. Priority was given only to permanent crops, at the expense of annual cultivations. To overcome shortages groundwater supplies were excessively pumped to meet demand, while, at the same time, the agricultural sector had suffered severe losses. Taking the situation in Cyprus with regard to such shortages, the reuse of the treated effluent for irrigation purposes is recommended, since it will provide an additional water resource. Additionally, since the regulations regarding the disposal of treated effluents in water bodies in essence prohibit discharges in dry river courses, as the quantity of the effluent must not exceed 10% of the river flow, and while government policy discourages disposal in the sea, then agricultural reuse is the only viable option.

According to the 1994 Census of Agriculture, in the Larnaca Coastal Region 47.6% of the water demand for the irrigated areas is satisfied by boreholes and wells, while for the Mixed Farming Region the percentage rises to 74.4%. Although groundwater is still the main source for the irrigation demands of the areas outside the Government Irrigation Schemes, the resource has been mismanaged over the past decades and, on many occasions, nearly depleted through over

pumping. One example of this is the case of the Kiti aquifer, where over-development and over-pumping since the late seventies have led to depletion and, in turn, seawater intrusion in its coastal zone. This has resulted in the abandonment of its more productive parts in the areas of Perivolia, Kiti and Meneou, and the consequent overexploitation of the remaining less productive parts of the aquifer. This is despite the fact that groundwater plays a key role in supplementing and balancing the water shortages during drought years, even for areas within the Irrigation Schemes, and should thus be conserved to secure adequate water supply during periods of shortage. Reuse of the treated effluent for irrigation purposes will not only provide an additional water resource, it will also significantly reduce pumping and, in turn, the depletion of groundwater bodies.

In consideration of the above, it is recommended that the treated effluent be used for irrigation purposes, either directly or indirectly though aquifer recharge.

6.3.5.3. TREATED EFFLUENT QUALITY

The suggested limit standards regarding the quality of the treated effluent are a combination of EU and Cyprus Standards. As a result the discharge limits will be those imposed by the Code of Practice for the use of Treated Sewage Effluents in Irrigation, for the irrigation of all crops; while also addressing the removal of nitrogen and phosphorus as indicated by the EU Standards. This will ensure that no adverse impacts arise from the reuse of the treated effluent.

TABLE 6.12: SUGGESTED LIMIT STANDARDS FOR TREATED EFFLUENT QUALITY

Parameter	Limit Value
BOD_5	10 mg/l
COD	< 125 mg/l
Suspended Solids	10 mg/l
Total N	15 mg/l
Faecal Coliforms	5 units/100 ml (in 80% of the samples) 15 units/100 ml (maximum)
Intestinal Worms	Nil
Total P	2 mg/l

6.3.5.4. LAND REQUIREMENTS FOR REUSE OF THE TREATED EFFLUENT

Taking an average water demand of 800 m^3/donum/year, the land requirements for the reuse of the treated effluent for the two regions, for the years 2005, 2015 and 2030, are as follows:

YEAR	FLOW (m^3)	LAND REQUIRED (DONUMS)
ARADIPPOU STP		
2005	861 400	1 077
2015	1 045 360	1 307
2030	1 422 040	1 778
EXISTING LARNACA STP (FLOWS FROM THE VILLAGES OF GROUP B)		
2005	702 025	878
2015	895 711	1 120
2030	1 253 254	1 567

In the case of Athienou, the land requirements, based on an average water demand of 800 m^3/donum/year, are as follows:

YEAR	FLOW ($m^{3)}$	LAND REQUIRED (DONUMS)
ATHIENOU STP		
2005	224 840	281
2015	255 500	319
2030	313 170	391

Table 6.13 provides estimates of the amount of agricultural land in each village that is either irrigated using boreholes or is not irrigated cultivated land. The treated effluents can be used for the irrigation of these cultivated areas.

TABLE 6.13: AREAS IRRIGATED BY BOREHOLES AND NOT-IRRIGATED AREAS

	Area (donums)
ARADIPPOU STP	
Aradippou	
Area irrigated by boreholes	765
Not irrigated cultivated land	11 888
Livadia	
Area irrigated by boreholes	427
Not irrigated cultivated land	2 559
Total Area Irrigated by Boreholes	*1 192*
Total Not Irrigated Cultivated Land	*14 447*
LARNACA STP	
Kiti	
Area irrigated by boreholes	1 349
Not irrigated cultivated land	4 251
Perivolia	
Area irrigated by boreholes	559
Not irrigated cultivated land	2 190
Dromolaxia	
Area irrigated by boreholes	613
Not irrigated cultivated land	7 191
Meneou	
Area irrigated by boreholes	446
Not irrigated cultivated land	1 208
Total Area Irrigated by Boreholes	*2 967*
Total Not Irrigated Cultivated Land	*14 840*
ATHIENOU STP	
Athienou	
Area irrigated by boreholes	161
Not irrigated cultivated land	15 145

Although the actual area which will be required for reuse of the treated effluent will depend on the crops to be irrigated, taking the average water demand to be 800 m^3/donum/year, the treated effluent from the three sewage plants can be reused for the irrigation of agricultural land within the project villages, since the land which is currently irrigated by boreholes or which is not irrigated cultivated land is sufficient to satisfy requirements until the year 2030.

6.3.5.5. EFFLUENT REUSE FOR IRRIGATION: REGIONAL MANAGEMENT PLAN

To ensure the efficiency and sustainable reuse of the treated effluent for irrigation the drafting of a Regional Management Plan is recommended, aimed at optimising crop yields and quality, maintaining soil productivity and safeguarding the environment.

COMPOSITION OF THE TREATED EFFLUENT

One of the key considerations in drafting an agricultural reuse management plan is the composition of the treated effluent in nutrients and other constituents. A number of constituents in treated effluents are of concern in connection with its reuse for agricultural irrigation, including salinity, sodium, trace elements, chlorine and nutrients. Treated water tends to have higher concentrations of these constituents than groundwater or surface water and a reuse scheme must take into account the sensitivity of the crops to be irrigated in relation to these constituents.

- SALINITY

Salinity is one of the most important agricultural water parameters affecting plant growth, and crop yield and quality, while the tolerance of plants to salinity varies widely. Generally, crops must be chosen carefully to ensure that they can tolerate the salinity of the treated effluent that will be used for irrigation, while the soil must be properly drained and adequately leached to prevent salt build-up.

Salinity has an influence on the soil's osmotic potential and specific ion toxicity, and may result in degradation of the soil physical conditions. These could result in reduced plant growth rates or reduced yields. Table 6.14 gives the relative salt tolerance of certain agricultural crops. To avoid any adverse effects, the salinity of the treated effluents must be monitored regularly and the crops to be irrigated must be carefully selected in accordance with their sensitivity.

TABLE 6.14: RELATIVE SALT TOLERANCE OF AGRICULTURAL CROPS

TOLERANT	
FIBRE, SEED AND SUGAR CROPS	
Barley	*Hordeum vulgare*
Cotton	*Gossypium hirsutum*
Jojoba	*Simmondsia chinensis*
Sugarbeet	*Beta vulgaris*
GRASSES AND FORAGE CROPS	
Alkali grass	*Puccinellia airoides*
Alkali sacaton	*Sporobolus airoides*
Bermuda grass	*Cynodon dactylon*
Kallar grass	*Diplachne fusca*
Saltgrass, desert	*Distichlis stricta*
Wheatgrass, fairway crested	*Agropyron cristatum*
Wheatgrass, tall	*Agropyron elongatum*
Wildrye, Altai	*Elymus angustus*
Wildrye, Russian	*Elymus junceus*
VEGETABLE CROPS	
Asparagus	*Asparagus officinalis*
FRUIT AND NUT CROPS	
Date palm	*Phoenix dactylifera*

MODERATELY TOLERANT	
FIBRE, SEED AND SUGAR CROPS	
Cowpea	*Vigna unguiculata*
Oats	*Avena sativa*
Rye	*Secale cereale*
Safflower	*Carthamus tinctorius*
Sorghum	*Sorghum bicolor*
Soybean	*Glycine max*
Triticale	*X Triticosecale*
Wheat	*Triticum aestivum*
Wheat, Durum	*Triticum turgidum*
GRASSES AND FORAGE CROPS	
Barley (forage)	*Hordeum vulgare*
Brome, mountain	*Bromus marginatus*
Canary grass, reed	*Phalaris, arundinacea*
Clover, Hubam	*Melilotus alba*
Clover, sweet	*Melilotus*
Fescue, meadow	*Festuca pratensis*
Fescue, tall	*Festuca elatior*
Harding grass	*Phalaris tuberosa*
Panic grass, blue	*Panicum antidotale*
Rape	*Brassica napus*
Rescue grass	*Bromus unioloides*
Rhodes grass	*Chloris gayana*
GRASSES AND FORAGE CROPS	
Ryegrass, Italian	*Lolium italicum multiflorum*
Ryegrass, perennial	*Lolium perenne*
Sudan grass	*Sorghum sudanense*
Trefoil, narrowleaf birdsfoot	*Lotus corniculatus tenuifolium*
Trefoil, broadleaf	*L. corniculatus arvenis*
Wheat (forage)	*Triticum aestivum*
Wheatgrass, standard crested	*Agropyron sibiricum*
Wheatgrass, intermediate	*Agropyron intermedium*
Wheatgrass, slender	*Agropyron trachycaulum*
Wheatgrass, western	*Agropyron smithii*
Wildrye, beardless	*Elymus triticoides*
Wildrye, Canadian	*Elymus canadensis*
VEGETABLE CROPS	
Artichoke	*Helianthus tuberosus*
Beet, red	*Beta vulgaris*
Squash, zucchini	*Cucurbita pepo melopepo*
FRUIT AND NUT CROPS	
Fig	*Ficus carica*

Jujube	*Ziziphys jujuba*
Olive	*Olea europaea*
Papaya	*Carica papaya*
Pineapple	*Ananas comosus*
Pomegranate	*Punica granatum*
MODERATELY SENSITIVE	
FIBRE, SEED AND SUGAR CROPS	
Broadbean	*Vicia faba*
Castorbean	*Ricinus communis*
Maize	*Zea mays*
Flax	*Linum usitatissimum*
Millet, foxtail	*Setaria italica*
Groundnut/peanut	*Arachis hypogaea*
Rice, paddy	*Oryza sativa*
Sugarcane	*Saccarum officinarum*
Sunflower	*Helianthus annuus palustris*
GRASSES AND FORAGE CROPS	
Alfalfa	*Medicago sativa*
Bentgrass	*Agrostisstoloniferapalustris*
Bluestem, Angleton	*Dichanthium aristatum*
Brome, smooth	*Bromus inermis*
Buffelgrass	*Cenchrus ciliaris*
Burnet	*Poterium sanguisorba*
Clover, alsike	*Trifolium hydridum*
GRASSES AND FORAGE CROPS	
Clover, Berseem	*Trifolium alexandrinum*
Clover, ladino	*Trifolium repens*
Clover, red	*Trifolium pratense*
Clover, strawberry	*Trifolium fragiferum*
Clover, white Dutch	*Trifolium repens*
Corn (forage) (maize)	*Zea mays*
Cowpea (forage)	*Vigna unguiculata*
Dallis grass	*Paspalum dilatatum*
Foxtail, meadow	*Alopecurus pratensis*
Grama, vlue	*Bouteloua gracilis*
Lovegrass	*Eragrostis sp.*
Milkvetch, Cicer	*Astragalus deer*
Oatgrass, tall	*Arrhenatherum, Danthonia*
Oats (forage)	*Avena saliva*
Orchard grass	*Dactylis glomerata*
Rye (forage)	*Secale cereale*
Sesbania	*Sesbania exaltata*
Siratro	*Macroptilium atropurpureum*

Sphaerophysa	*Spaerophysa salsula*
Timothy	*Phleum pratense*
Vetch, common	*Vicia angustifolia*
VEGETABLE CROPS	
Broccoli	*Brassica oleracea botrytis*
Brussel sprouts	*B. oleracea gemmifera*
Cabbage	*B. oleracea capitata*
Cauliflower	*B. oleracea botrytis*
Celery	*Apium graveolens*
Corn, sweet	*Zea mays*
Cucumber	*Cucumis sativus*
Eggplant	*Solanum melongena esculentum*
Kale	*Brassica oleracea acephala*
Kohlrabi	*B. oleracea gongylode*
Lettuce	*Latuca sativa*
Muskmelon	*Cucumis melon*
Pepper	*Capsicum annum*
Potato	*Solanum tuberosum*
Pumpkin	*Cucurbita peop pepo*
Radish	*Raphanus sativus*
Spinach	*Spinacia oleracea*
Squash, scallop	*C. pepo melopepo*
Sweet potato	*Ipomoea batatas*
Tomato	*Lycopersicon lycopersicum*
Turnip	*Brassica rapa*
Watermelon	*Citrullus lanatus*
FRUIT AND NUT CROPS	
Grape	*Vitis sp.*
SENSITIVE	
FIBRE, SEED AND SUGAR CROPS	
Bean	*Phaseolus vulgaris*
Guayule	*Parthenium argentatum*
Sesame	*Sesamum indicum*
Vegetable Crops	
Bean	*Phaseolus vulgaris*
Carrot	*Daucus carota*
Okra	*Abelmoschus esculentus*
Onion	*Allium cepa*
Parsnip	*Pastinaca sativa*
FRUIT AND NUT CROPS	
Almond	*Prunus dulcis*
Apple	*Malus sylvestris*
Apricot	*Prunus armeniaca*

Avocado	*Persea americana*
Blackberry	*Rubus sp.*
Boysenberry	*Rubus ursinus*
Cherimoya	*Annona cherimola*
Cherry, sweet	*Prunus avium*
Cherry, sand	*Prunus besseyi*
Currant	*Ribes sp.*
Gooseberry	*Ribes sp.*
Grapefruit	*Citrus paradisi*
Lemon	*Citrus limon*
Lime	*Citrus aurantifolia*
Loquat	*Eriobotrya japonica*
Mango	*Mangifera indica*
Orange	*Citrus sinensis*
Passion fruit	*Passiflora edulis*
Peach	*Prunus persica*
Pear	*Pyrus communis*
Persimmon	*Diospyros virginiana*
Plum: Prune	*Prunus domestica*
Pummelo	*Citrus maxima*
Raspberry	*Rubus idaeus*
Rose apple	*Syzgium jambos*
Sapote, white	*Casimiroa edulis*
Strawberry	*Fragaria sp.*
Tangerine	*Citrus reticulata*

The concentration of specific ions in the treated water may cause trace elements to accumulate in the soil and plants, while long term build-up may potentially result in animal and human health impacts or phytotoxicity in plants. Of particular concern are sodium, chloride and boron ions, as they may be present in treated wastewaters in concentrations such as to cause toxicity. Toxicity normally results in impaired growth, reduced yields and changes the morphology of the plant.

- SODIUM

Then present in exchangeable form, sodium salts may cause adverse physico-chemical changes in the soil, particularly soil structure, lowering the permeability and affecting the tilth of the soil. Although sodium does not impair the uptake of water by the plants, it impairs the infiltration of water into the soil, thus affecting the growth of plants through the unavailability of soil water.

Cadmium and magnesium act as stabilising ions in contrast to the destabilising effect of sodium, regarding soil structure. However, treated water may be high in sodium relative to calcium and may cause soil permeability problems if not properly managed. Regular monitoring is required to ensure that adverse effects are avoided.

TABLE 6.15: RELATIVE TOLERANCE OF SELECTED CROPS TO EXCHANGEABLE SODIUM

SENSITIVE	SEMI-TOLERANT	TOLERANT
Avocado	Carrot	Alfalfa

SENSITIVE	SEMI-TOLERANT	TOLERANT
(Persea americana)	*(Daucus carota)*	*(Medicago sativa)*
Deciduous Fruits	Clover, Ladino	Barley
Nuts	*(Trifolium repens)*	*(Hordeum vulgare)*
Bean, green	Dallisgrass	Beet, garden
(Phaseolus vulgaris)	*(Paspalum dilatatum)*	*(Beta vulgaris)*
Cotton (at germination)	Fescue, tall	Beet, sugar
(Gossypium hirsutum)	*(Festuca arundinacea)*	*(Beta vulgaris)*
Maize	Lettuce	Bermuda grass
(Zea mays)	*(Lactuca sativa)*	*(Cynodon dactylon)*
Peas	Bajara	Cotton
(Pisum sativum)	*(Pennisetum typhoides)*	*(Gossypium hirsutum)*
Grapefruit	Sugarcane	Paragrass
(Citrus paradisi)	*(Saccharum officinarum)*	*(Brachiaria mutica)*
Orange	Berseem	Rhodes grass
(Citrus sinensis)	*(Trifolium alexandrinum)*	*(Chloris gayana)*
Peach	Benji	Wheatgrass, crested
(Prunus persica)	*(Mililotus parviflora)*	*(Agropyron cristatum)*
Tangerine	Raya	Wheatgrass, fairway
(Citrus reticulata)	*(Brassica juncea)*	*(agropyron cristatum)*
Mung	Oat	Wheatgrass, tall
(Phaseolus aurus)	*(Avena sativa)*	*(Agropyron elongatum)*
Mash	Onion	Karnal grass
(Phaseolus mungo)	*(Allium cepa)*	*(Diplachna fusca)*
Lentil	Radish	
(Lens culinaris)	*(Raphanus sativus)*	
Groundnut (peanut)	Rice	
(Arachis hypogaea)	*(Oryza sativus)*	
Gram	Rye	
(Cicer arietinum)	*(Secale cereale)*	
Cowpeas	Ryegrass, Italian	
(Vigna sinensis)	*(Lolium multiflorum)*	
	Sorghum	
	(Sorghum vulgare)	
	Spinach	
	(Spinacia oleracea)	
	Tomato	
	(Lycopersicon esculentum)	
	Vetch	
	(Vicia sativa)	
	Wheat	
	(Triticum vulgare)	

❑ TRACE ELEMENTS AND HEAVY METALS

Trace elements are present in treated effluents normally in concentrations less than a few mg/L. Although some are essential for plants and animals, at elevated concentrations they become toxic. Trace elements include aluminium (Al), beryllium (Be), cobalt (Co), fluoride (F), iron (Fe), lithium (Li), manganese (Mn), molybdenum (Mo), selenium (Se), tin (Su), titanium (Ti), Tungsten (W) and Vanadium (V).

Heavy metals are a group of trace elements that have been shown to create health impacts when taken up by plants. These include arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg) and zinc (Zn). Of particular concern are cadmium, copper and molybdenum as they can be toxic to animals at concentrations too low to affect plants.

❑ CHLORINE

Free chlorine residual at concentrations less than 1 mg/L usually poses no problems to plants. However, some sensitive crops may be damaged at levels as low as 0.05 mg/L, while some woody crops may accumulate chlorine in the tissue to toxic levels. Chlorine at concentrations greater than 5 mg/L causes sever damage to most plants.

TABLE 6.16: CHLORIDE TOLERANCE OF SOME FRUIT CROP CULTIVARS AND ROOTSTOCKS

CROP	ROOTSTOCK OR CULTIVAR	MAXIMUM PERMISSIBLE Cl^- WITHOUT LEAF INJURY[1]	
		ROOT ZONE (Cl_e) (me/l)	IRRIGATION WATER (Cl_w)[2 3] (me/l)
	ROOTSTOCKS		
Avocado *(Persea americana)*	West Indian	7.5	5.0
	Guatemalan	6.0	4.0
	Mexican	5.0	3.3
Citrus *(Citrus spp.)*	Sunki Mandarin	25.0	16.6
	Grapefruit		
	Cleopatra mandarin		
	Rangpur lime		
	Sampson tangelo	15.0	10.0
	Rough lemon		
	Sour orange		
	Ponkan mandarin		
	Citrumelo 4475	10.0	6.7
	Trifoliate orange		
	Cuban shaddock		
	Calamondin		
	Sweet orange		
	Savage citrange		
	Rusk citrange		
	Troyer citrange		
Grape*(Vitis spp.)*	Salt Creek, 1613-3	40.0	27.0
	Dog Ridge	30.0	20.0
Stone Fruits *(Prunus spp.)*	Marianna	25.0	17.0
	Lovell, Shalil	10.0	6.7
	Yunnan	7.5	5.0

CROP	ROOTSTOCK OR CULTIVAR	MAXIMUM PERMISSIBLE Cl^- WITHOUT LEAF INJURY[1]	
		ROOT ZONE (Cl_e) (me/l)	IRRIGATION WATER (Cl_w)[2 3] (me/l)
	CULTIVARS		
Berries *(Rubus spp.)*	Boysenberry	10.0	6.7
	Olallie clackberry	10.0	6.7
	Indian SUmmer	5.0	3.3
	Raspberry		
Grape*(Vitis spp.)*	Thompson seedless	20.0	13.3
	Perlette	20.0	13.3
	Cardinal	10.0	6.7
	Black Rose	10.0	6.7
Strawberry *(Fragaria spp.)*	Lassen	7.5	5.0
	Shasta	5.0	3.3

[1] For some crops, the concentration given may exceed the overall salinity tolerance of that crop and cause some reduction in yield in addition to that caused by chloride ion toxicities.
[2] Values given are for the maximum concentration in the irrigation water. The values were derived from saturation extract data (EC_e) assuming a 15-20 percent leaching fraction and $EC_d = 1.5\ EC_w$.
[3] The maximum permissible values apply only to surface irrigated crops. Sprinkler irrigation may cause excessive leaf bum at values far below these.

TABLE 6.17: RELATIVE BORON TOLERANCE OF AGRICULTURAL CROPS[1]

VERY SENSITIVE (<0.5 mg/l)	
Lemon	*Citrus limon*
Blackberry	*Rubus spp.*
SENSITIVE (0.5-0.75 mg/l)	
Avocado	*Persea americana*
Grapefruit	*Citrus X paradisi*
Orange	*Citrus sinensis*
Apricot	*Prunus armeniaca*
Peach	*Prunus persica*
Cherry	*Prunus avium*
Plum	*Prunus domestica*
Persimmon	*Diospyros kaki*
Fig, kadota	*Ficus carica*
Grape	*Vitis vinifera*
Walnut	*Juglans regia*
Pecan	*Carya illinoiensis*
Cowpea	*Vigna unguiculata*
Onion	*Allium cepa*
SENSITIVE (0.75-1.0 mg/l)	
Garlic	*Allium sativum*
Sweet potato	*Ipomoea batatas*
Wheat	*Triticum eastivum*
Barley	*Hordeum vulgare*
Sunflower	*Helianthus annuus*

Bean, mung	*Vigna radiata*
Sesame	*Sesamum indicum*
Lupine	*Lupinus hartwegii*
Strawberry	*Fragaria spp.*
Artichoke, Jerusalem	*Helianthus tuberosus*
Bean, kidney	*Phaseolus vulgaris*
Bean, lima	*Phaseolus lunatus*
Groundnut/Peanut	*Arachis hypogaea*
MODERATELY SENSITIVE (1.0-2.0 mg/l)	
Pepper, red	*Capsicum annuum*
Pea	*Pisum sativa*
Carrot	*Daucus carota*
Radish	*Raphanus sativus*
Potato	*Solanum tuberosum*
Cucumber	*Cucumis sativus*
MODERATELY TOLERANT (2.0-4.0 mg/l)	
Lettuce	*Lactuca sativa*
Cabbage	*B. oleracea capitata*
Celery	*Apium graveolens*
Turnip	*Brassica rapa*
Bluegrass, Kentucky	*Poa pratensis*
Oats	*Avena sativa*
Maize	*Zea mays*
Artichoke	*Cynara scolymus*
Tobacco	*Nicotiana tabacum*
Mustard	*Brassica juncea*
Clover, sweet	*Melilotus indica*
Squash	*Cucurbita pepo*
Muskmelon	*Cucumis melo*
TOLERANT (4.0-6.0 mg/l)	
Sorghum	*Sorghum bicolor*
Tomato	*L. lycopersicum*
Alfalfa	*Medicago sativa*
Vetch, purple	*Vicia benghalensis*
Parsley	*Petroselinum crispum*
Beet, red	*Beta vulgaris*
Sugarbeet	*Beta vulgaris*
VERY TOLERANT (6.0-15.0 mg/l)	
Cotton	*Gossypium hirsutum*
Asparagus	*Asparagus officinalis*

[1] Maximum concentrations tolerated in soil water without yield or vegetative growth reductions. Boron tolerances vary depending upon climate, soil conditions and crop varieties. Maximum concentrations in the irrigation water are approximately equal to these values or slightly less.

❑ NUTRIENTS

Treated sewage effluents contain nutrients important for crop growth. The most beneficial nutrient is nitrogen, however, the concentrations in treated water are not sufficient enough to produce satisfactory crop yields and supplementary fertiliser is necessary. Similarly, the concentrations of phosphorus are usually too low to meet plant requirements, yet over time it can build-up in the soil and reduce the need for phosphorus supplementation.

REUSE MANAGEMENT PLAN

In consideration of the above, the reuse management plan must be based on a combination of criteria.

❑ SITE SELECTION

The objective is the identification of suitable sites for reuse, in case reuse will be in areas outside the Irrigation Scheme, where the long term application of the treated effluent will be feasible without adverse environmental or health impacts.

❑ CROP WATER REQUIREMENTS

Assessment of the specific crop water demands to estimate the required amounts of water to be applied and the resulting total land requirements for reuse. Information on crop water demand and indicative land requirements for the irrigation of specific crops are given in Appendix 9.

❑ CROP SELECTION

An evaluation must be made of viable combinations of the cropping options possible on the land available, taking into consideration crop sensitivity to specific effluent constituents, as outlined above, in conjunction with a selection of types of crops to be irrigated to eliminate the risk of adverse health impacts. Based on the suggested treated effluent quality standards, the irrigation of all crops is possible, with the exception of leaved vegetables, bulbs and corms eaten uncooked (Code of Practice).

❑ IRRIGATION METHODS

Appropriate irrigation methods must be identified, based on the types of crops to be irrigated and the site specific characteristics, such as soil type and structure.

Crop Type	Irrigation Methods
Vines	⇩ Drip irrigation ⇩ Mini sprinklers and sprinklers ⇩ *Movable irrigation systems are not allowed*
Fruit trees	⇩ Drip irrigation ⇩ Hose basin irrigation ⇩ Bubblers irrigation ⇩ Mini sprinklers
Vegetables	⇩ Subsurface irrigation ⇩ Drip irrigation
Vegetables eaten cooked	⇩ Sprinklers ⇩ Subsurface irrigation ⇩ Drip irrigation

Crop Type	Irrigation Methods
Industrial and fodder crops	⇩ Subsurface irrigation ⇩ Bubblers ⇩ Drip irrigation ⇩ Pop-up sprinklers ⇩ Surface irrigation methods ⇩ Low capacity sprinklers ⇩ Spray or sprinkler irrigation with a buffer zone of about 300 m

❑ IRRIGATION SCHEDULING

This encompasses timing and quantity determination on two levels:
- ⇩ Timing of application prior to harvesting
- ⇩ Ensuring that the loading rates of water, nutrients and salts are balanced with a site's ability to safely convert, absorb, use or store the nutrients and salts over the long term.

❑ NUTRIENT LOADING RATES

The nutrient balance must be determined to ensure that nutrients are applied at an optimal rate and load for each specific crop.
- ⇩ Nitrogen: The nitrogen loading rate must be balanced annually with the crop requirements to prevent excessive nitrogen leaching to groundwater.
- ⇩ Phosphorus: The loading rates must be determined to prevent phosphorus leaching to groundwater or accumulation in the surface layers of soils.

❑ SALT LOADING RATES

A salt balance must be undertaken so as to limit its potential to contaminate groundwater and affect soil productivity.

Overall, the performance objectives of the Reuse Management Plan will include:
- ⇨ The optimisation of water and nutrient uptake by plants
- ⇨ The prevention of adverse changes to soil structure, chemistry and therefore productivity
- ⇨ The prevention of adverse environmental and health impacts.

6.3.5.6. MITIGATION MEASURES FOR THE REUSE OF THE TREATED EFFLUENT IN AGRICULTURE

Mitigation Measures for the Reuse of the Treated Effluent in Irrigation
❑ Impacts on soil productivity; groundwater contamination; health impacts; impacts on crop growth and quality
⇨ Drafting of Reuse Management Plan, incorporating:
⇩ Appropriate site identification (for reuse in areas outside the Irrigation Scheme) ⇩ Crop water requirements ⇩ Crop selection ⇩ Irrigation methods and scheduling ⇩ Evaluation of nutrient and salt loading rates
❑ Nitrogen leaching to groundwater, accumulation in soil
⇨ Balance nitrogen loading rates with crop requirements
❑ Phosphorus leaching to groundwater, accumulation in soil
⇨ Balance phosphorus loading rates with crop requirements
❑ Adverse impacts on soil productivity and risk of groundwater contamination

⇨ Determine salt loading rates
⇨ Ensure irrigation practices do not result in off-site run-off, appropriate leaching and drainage provisions
❑ Adverse impacts on crop yields and quality
⇨ Crop selection based on crop sensitivity to treated effluent constituents
❑ Adverse impacts on health
⇨ Timing of irrigation prior to harvesting
⇨ Correct irrigation practices
⇨ Minimise site access during irrigation periods
⇨ Use of signs specifying that treated effluent is used
⇨ Establishment of buffer zones around irrigated areas where necessary
❑ Quality considerations
⇨ Implements treated effluent quality monitoring programme to ensure compliance with the set standards
⇨ Implement soil quality monitoring programme
⇨ Monitoring of irrigation methods and practices

6.3.5.7. URBAN REUSE OF THE TREATED SEWAGE EFFLUENTS

The treated sewage effluents can be reused for the irrigation of public parks and recreation centres, hotel gardens, athletic fields, highway medians and shoulders, landscaped areas surrounding public buildings and facilities, or commercial office and industrial developments, golf courses, decorative water features (e.g. fountains), sanitary facilities in commercial buildings, dust control and concrete production in construction activities, etc.

In the case of urban reuse of the treated effluent system reliability must be ensured regarding the quality of the treated effluent, so as to avoid any adverse public health impacts. Additionally, a number of safeguards must be adopted, including:

- ❑ Assurance that the treated water delivered meets the quality requirements for the intended uses
- ❑ Prevention of improper operation of the system through regular monitoring and maintenance
- ❑ Prevention of improper use of the water through a clear labeling of any pipes conveying treated effluent and of areas irrigated with such water
- ❑ Prevention of cross connections with drinking water supply lines.

Such reuse is currently the practice in the case of the existing Larnaca STP. The treated effluents are being used for the irrigation of the Larnaca Municipality gardens, hotel gardens and athletic courses, while part of the effluent is used for the irrigation of industrial crops.

6.3.5.8. GROUNDWATER RECHARGE

The treated sewage effluents can alternatively be used indirectly for agricultural purposes through the recharge of groundwater aquifers. Apart from providing an additional supply of water in aquifers that are currently over-pumped and in danger of depletion, recharge can offer a number of additional advantages:

- ❑ The establishment of salt water intrusion barriers in coastal aquifers: As in the case of the Kiti aquifer, over-pumping of groundwater in coastal areas often results in seawater intrusion into the aquifers. A battery of injection and extraction wells using treated water can be established, which will create a hydraulic barrier to maintain intrusion control.

- ❑ Provision of further treatment of effluents: Infiltration and percolation of the treated water takes advantage of the sub-soil's natural ability for biodegradation and filtration, thus providing

additional in situ treatment of the wastewater and additional treatment reliability to the overall system.

- Provision of storage for the treated effluent: Groundwater aquifers provide a natural mechanism for storage and subsurface transmission of the treated wastewater. Groundwater recharge eliminates the need for additional storage facilities. Aquifers also serve as a natural distribution system and may reduce the need for surface conveyance systems.

- Groundwater recharge helps provide a loss of identity between the treated effluents and groundwater. This has a positive psychological impact where reuse is considered, particularly for irrigation purposes, and is an important factor in making reclaimed water acceptable for a variety of uses.

INFILTRATION BASINS

Surface spreading is a direct method of recharge, whereby the water moves from the land surface to the aquifer by infiltration and percolation through the soil matrix.

Infiltration basins are the most widely used method of groundwater recharge, affording high loading rates, and relatively low maintenance and land requirements. Rapid infiltration basins require highly permeable soil to achieve high hydraulic loading rates. For additional treatment, the soil must be fine enough to provide sufficient soil surfaces for biochemical and microbiological reactions.

DIRECT INJECTION

This involves the pumping of the treated effluent directly into the groundwater zone. This is used where groundwater is deep or where the hydrogeological conditions are not conducive to surface spreading, including unsuitable soils of low permeability, unfavourable topography for construction of basins, or scarcity of land.

Direct injection requires water of higher quality that surface spreading because of the absence of the soil matrix treatment.

Groundwater recharge may increase the risk of aquifer contamination, particularly in the case of direct injection, therefore a monitoring programme is required regarding the quality of the treated effluents to be recharged, as well as the quality of the groundwater, to ensure that any impacts are avoided.

Although groundwater recharge is currently not a common practice yet in Cyprus, in the case of the Limassol sewage treatment plant part of the treated wastewater that is not used for direct irrigation is expected to be used for the recharge of the Akrotiri aquifer, and subsequently for irrigation purposes. Additional water quality standards have been set for the effluent that will be recharged, particularly regarding nitrogen removal.

7. PROJECT ALTERNATIVES

7.1. ALTERNATIVE SEWAGE TREATMENT PROCESSES

In order to achieve the suggested discharge standards, the requirements for the treatment process are high. The discharge standards are stringent and therefore the treatment process needs to be highly performing on a wide range of parameters. In addition to these requirements purely related to process performances, further requirements related to the protection of the area, the architectural insertion and the limited space available should be met depending on the location of the site.

A number of processes have been examined including:

- Activated sludge (Section 3.3.2.4.)
- Trickling filters
- Bio aerated filters
- Membrane bio reactors
- Stabilization ponds
- Anaerobic reactors

7.1.1. TRICKLING FILTERS

The tricking filter consists of a bed of a highly permeable medium to which micro-organisms are attached and through which wastewater is percolated or trickled. The filter medium consisted in the past of carefully graded rock. Rock has been replaced by synthetic medium (plastic essentially) in the recent trickling filters. Plastic medium offers better specific surface area (surface area per unit of volume of the medium) and air circulation than the rock medium. Another advantage of the plastic medium is the best resistance to plugging due to its important void space and the lower mass to unit volume enabling lower surface area than for the rock medium. In terms of efficiency, operation and maintenance, the plastic medium has the best advantages and has to be recommended, although rock medium has the advantage of low cost.

In comparison with activated-sludge process, trickling filters have the following disadvantages:

- important transportation costs of the specific medium filter, that has to be imported,
- necessity of a primary sedimentation, in order to avoid nozzle plugging of the rotary distributor that causes reduced performance,
- problems of odours and flies especially during the summer,
- the flow of air in a trickling filter is governed by the temperature difference and wind forces. During the summer, when the temperature is hot and wind is weak, airflow could be decreased and problems of odours and flies increased.

The trickling filters are particularly adapted where the incoming wastewater is concentrated and where the discharge requirements are not to strict. But for our case, several additional steps of treatment would be required to treat nitrogen, to further reduce BOD and SS and to reduce the coliform count.

The trickling filter process it is therefore not recommended for the treatment plants in this project.

7.1.2. BIO AERATED FILTERS

The bio aerated filter technology is an attached growth process, i.e. the purifying biomass is attached on a substrate (the contrary is the suspended growth process, e.g. activated sludge, where the biomass is kept in suspension in the biological reactor). In a biofilter, the substrate consists in

grains with size in the range 1 to 4 mm with a high specific favourable to bacterial development. This material combines the functions of biological reactor and solid-liquid separation and therefore, no additional sedimentation tank is required.

The result of progress made during the last decade is that today, bio filtration has become a particularly advantageous treatment process. In municipal wastewater treatment, it makes it possible to carry out secondary biological treatment (removal of BOD and nitrogen) and retention of the SS at the same time.

The biofiltration process uses biomass of greater concentration and, above all, of greater activity than activated sludge and have the following advantages:

- savings in land space, particularly due to elimination of the secondary clarifier stage. This compactness makes it easier to cover units, control harmful effects (odours and sound) and produce aesthetic units,
- no risk of leaching since the biomass is attached to a support such that flow variations can be readily handled,
- quick restarting, even after stopping for several months, and therefore suitable to seasonal variations in load,
- modular construction and easy automation.

The filtration could be either upflow or downflow depending on the supplier. The biofiltration is normally used after primary settling or flotation (these steps can be preceded by flocculation).

The process provides a high degree of treatment of BOD and SS and can also perform nitrification-denitrification to desired level. However, as most intense biological processes, the faecal coliform reduction is low and the process needs to be completed by tertiary disinfection to provide a quality required for reuse.

7.1.3. MEMBRANE BIO REACTORS

The development of submerged membrane bioreactor technology started in the 1980s and there are today several thousands of facilities implemented around the world. The membrane bioreactor technology combines a biological treatment of pollutants (BOD, N, P) with a membrane separation of the biomass and the treated water. The biological treatment used is an activated sludge process with high sludge concentration. The solid-liquid separation is carried out by microfiltration (MF) membranes, which most often are submerged directly in the aeration tank. Depending on suppliers, either flat sheet membranes, hollow fibre membranes or tubular membranes are used.

The most visible advantage with a membrane bioreactor, compared with an activated sludge plant, is the reduced footprint. This is due to, on one hand, that there is no more need for sedimentation tanks. The biological reactor is also operated at much higher MLVSS concentrations (in the range of 12 to 15 g/l) and the reactor can therefore be smaller.

The process is therefore very well adapted where the site is small and the plant needs to be covered in order to reduce odour and noise problems.

Due to the high sludge age, the production of sludge is reduced. Some sources indicate a reduction of up to 40% compared with an activated sludge process. The high sludge age also favours biological nitrification.

The microfiltration membranes have a pore size in the range of 0.1 to 0.4 microns, which retains suspended solids and some bacteria but not macro-molecules and virus. However, experience show that the membranes are rapidly covered by a layer of cellular material which enhances the filtration performances.

The replacement of membranes is an important item in the operating cost budget. Nevertheless, membranes are today guaranteed by the suppliers for at least 5 years operation and could in many cases operate for more than 10 years.

The capital cost for a membrane bioreactor plant is higher than a conventional activated sludge plant, when only BOD and SS reduction to "normal' level (25-30 mg/l) is imposed. But when reuse of

the treated effluent is planned and treatment requirements are tougher, including coliform reduction, then the membrane bioreactor becomes competitive.

7.1.4. STABILIZATION PONDS

Aerobic stabilization lagoons are large, shallow earthen basins of wastewater where the treatment is provided by natural processes involving the use of both algae and bacteria. Natural aeration processes are used to supply some or all of the oxygen needed by the bacteria to metabolize organic matter and reduce the BOD.

Stabilization lagoons have become very popular in small communities, because they are simple and economical to operate, requiring minimal operation and maintenance, namely one sludge removal of the primary lagoon once every two to three years and one sludge removal of the secondary lagoon once every five years.

Aerobic lagoons are designed with a maximum depth of 1.5 m. A large surface area is then required to maximize the natural aeration capacity of the system. The rate of surface area may range from 6 to 10 m²/inhabitant, depending on the variation of water temperature. This area requirement includes only the lagoons themselves, with no allowance for access roads or other facilities. With a maximum depth of 1.5 m, the retention time is about 60 days, which is the minimum required to achieve a significant reduction in coliform counts (reduction of about 10^4).

The process would be expected to meet the discharge requirements regarding coliforms and, with addition of tertiary sand filters, the requirements for SS and possibly BOD. The standards for nitrogen would probably not be met. However, the most significant disadvantage is the large size of the plants, and stabilization ponds are therefore not retained in this case.

7.1.5. ANAEROBIC REACTORS

Anaerobic reactors, of UASB type, represent a simple and reliable solution with low operating costs. This technology, which has been much developed during the latest decade, is much used for industrial pre-treatment, for initial reduction of the organic pollution of strong wastewater. However, its use for treatment of urban wastewater is not very widespread, in particular not for large size plants. The current discharge standards for BOD (10 mg/l) are largely below the expected performance limits of the process (50 mg/l at the best). This process is therefore not further considered.

7.1.6. COMPARISON OF PROCESSES

A number of these processes have been eliminated at an early stage as they cannot meet the requirements and the remaining processes have been compared in more detail. Table 7.1 summarises the advantages and disadvantages of these processes.

TABLE 7.1: COMPARISON OF TREATMENT PROCESSES

PROCESS	ADVANTAGES	DISADVANTAGES
Activated sludge	❑ Proven and reliable process. ❑ Stable performances at variations in hydraulic load. ❑ Moderate cost for the base process.	❑ Additional tertiary treatment required to meet treatment requirements. ❑ High sludge production. ❑ Relatively high land requirements. ❑ Large basins, difficult to cover. ❑ Long start-up of the biological process, can not treat peak loads.

PROCESS	ADVANTAGES	DISADVANTAGES
Bio aerated filters	❑ Compact process, easy to cover. ❑ Modular design makes easy to adapt the process to incoming loads and flows. ❑ Quick restarting, therefore suitable to seasonal variations in load. ❑ Modular construction and easy automation.	❑ Additional tertiary treatment required to meet treatment requirements. ❑ High sludge production. ❑ Higher investment costs than for activated sludge (~30%)
Membrane bioreactors	❑ Very high treatment performances, also on faecal coliforms. ❑ No chlorination or UV disinfection required. ❑ Low sludge production. ❑ Compact process, easy to cover. ❑ Modular construction and easy automation.	❑ Some uncertainty regarding the membrane life length and related replacement cost. ❑ Higher investment costs.

The three processes can provide treatment to the level required for discharge and reuse according to current regulations. However, for the purpose of the study, the activated sludge process with tertiary treatment will be retained as base solution for sewage treatment.

7.2. SCREENING OF OPTIONS AND ALTERNATIVES

7.2.1. ALTERNATIVE SCHEMES

7.2.1.1. INITIAL SCREENING OF ALTERNATIVE SCHEMES

Four alternative schemes were initially examined, based on a different number of STPs, locations and conveyance routes. These are outlined in Table 7.2.

TABLE 7.2: LARNACA AREA (GROUP B) SCHEMES

Scheme	Location of STPs	Comments
B1a	One single STP – Existing Larnaca STP	Aradippou and Livadia are connected and the waste water is conveyed through Larnaca towards existing STP. Dromolaxia-Meneou, Kiti and Perivolia are connected and water is transferred from south to existing Larnaca STP.
B2a	Two STPs – one near Perivolia and one near Aradippou	The waste water from Aradippou and Livadia is conveyed towards STP which is located north of the highway in the piggery farms area. Dromolaxia-Meneou, Kiti and Perivolia are connected and water is transferred to the STP located on the coast near Perivolia.
B2b	Two STPs – one existing Larnaca STP and one near Aradippou	The waste water from Aradippou and Livadia is conveyed towards STP which is located north of the highway in the piggery farms area. Dromolaxia-Meneou, Kiti and Perivolia are connected and water is transferred from south to existing Larnaca STP.

Scheme	Location of STPs	Comments
B5	Five STP – in each community	Each community has its own STP

Schematic presentations of the schemes are included in Appendix 10.

Due to the geographic location and altitude, the Athienou community will be served by a separate sewage treatment plant, and thus it has not been included in the schemes.

Following the initial screening of the schemes, the site near the coastline of Perivolia was eliminated due to the nature of the area, in terms of tourist development and the presence of historic sites in the vicinity. Scheme B2a was therefore cancelled.

TABLE 7.3: INITIAL SCREENING OF LARNACA AREA (GROUP B) SCHEMES

Scheme	Location of STPs	Comments
B1a	One single STP – existing Larnaca	Economical evaluation of the scheme was carried out.
B2a	Two STPs: 1 STP near Perivolia 1 STP near Aradippou	Scheme was cancelled as there is no possibility to locate the STP near Perivolia
B2b	Two STPs: 1 existing Larnaca STP 1 STP near Aradippou	Economical evaluation of the scheme was carried out.
B5	One STP for each village	Economical evaluation of the scheme was carried out.

7.2.1.2. BRIEF DESCRIPTION OF THE COMPONENTS OF ALTERNATIVE SCHEMES

SCHEME B1A

Scheme B1a is a scheme with one single Sewerage treatment plant for all the communities except Athienou, existing STP Larnaca.

All communities are connected to the STP Larnaca. Connection of the communities on the western side of Larnaca town is mainly by gravity with the exemption of Perivolia. Waste water from Dromolaxia and Kiti is transferred by gravity with a short forcemain. Pipes from Aradippou and Livadia are connected in Larnaca and the water is pumped on the short distance and then conveyed by gravity towards STP Larnaca.

It has to be stressed that the sizing of the Aradippou and Livadia branch for the purpose of economical comparison of the schemes, was carried out only for the estimated flows from these communities. In reality these pipes will be part of Larnaca sewerage network (Planned Phase B of Larnaca). For their actual sizes additional information on wastewater production in Larnaca is essential.

The main components of the system are:

- Total length of gravity pipes is 21.1 km with the diameter from 250mm to 700 mm.
- Length of forcemains is 8.7km with the diameter from 250mm to 300mm
- Three pumping station are estimated with the discharge capacity varying from 37.3 l/s to 57.0 l/s and installed power from 5 kW to 22 kW.

- Location of STP is on the location of existing Larnaca STP, with the nominal capacity of 12 200 m3/d. Required area for STP and emergency storage is 5.4 ha.

SCHEME B2B

Scheme B2b is a scheme with two Sewerage treatment plants, one existing STP in Larnaca and the near Aradippou and Livadia.

All communities located western of Larnaca are connected to the STP Larnaca. Connection of the communities is mainly by gravity with the exemption of Perivolia. Waste water from Dromolaxia and Kiti is transferred by gravity with a short forcemain.

Aradippou and Livadia are connected to the STP Aradippou located on the north of communities. Connection from Aradippou is a forcemain while the wastewater from Livadia is partly conveyed with gravity pipe and partly with the forcemain towards STP.

The main components of the system are:
- Total length of gravity pipes is 10.3 km with the diameter from 250mm to 600 mm.
- Length of forcemains is 10.6 km with the diameter from 200mm to 250mm
- Four pumping station are estimated with the discharge capacity varying from 19.0 l/s to 46.7 l/s and installed power from 5 kW to 13.0 kW.
- STP Larnaca on the location of existing treatment plant is with the nominal capacity of 7 250 m3/d.Required area for STP and emergency storage is 3.2 ha. Location of the second STP is in the piggery area of Aradippou north from the highway. The nominal capacity is 4 930 m3/d, while the required area for STP and emergency storage is 2.0ha.

SCHEME B5

Scheme CB5 is a scheme with the Sewerage treatment plant for each community.

There are five sewerage treatment plants. (STP in Athienou is not included in the comparison of the schemes) The connection of each municipality and the treatment plant is assumed to be part of the collection system.

Location of STPs is predicted to be at the lowest area of the community. The nominal capacity of the treatment plants are following:

	CAPACITY
Aradippou	3 289 m^3/d
Livadia	1 644 m^3/d
Dromolaxia – Meneou	2 709 m^3/d
Kiti	1 325 m^3/d
Perivolia	3 219 m^3/d

7.2.2. ALTERNATIVE SITES

A number of alternative sites have been investigated, including the site between Aradippou and Livadia for schemes B2a, and B2b; the area near the coastline of Perivolia for scheme B2a; the site of the existing Larnaca sewage treatment plant for schemes B1a and B2b; and two sites for the Athienou sewage treatment plant. The results of the preliminary environmental evaluation and comparison of these alternative sites are given Appendix 11.

7.2.2.1. ALTERNATIVE 1: BETWEEN ARADIPPOU AND LIVADIA

Schemes B2a and B2b include the construction of one STP to service the communities of Aradippou and Livadia. The site that has been selected is between the two communities and within the

Aradippou animal husbandry area. It is at a distance of approximately 3.5 km from the centre of Aradippou and 2.5 km from the nearest houses.

The main advantage of locating the STP at the site is the nature of the surrounding area which has been developed mainly for animal husbandry and mostly piggeries. The area is largely barren land with only some agricultural plots scattered around for the cultivation of animal-feed crops. The environment has already been degraded, both in terms of landscape value and odours, as a result of the presence of animal farms, as well as the lagoons for the discharge and treatment of animal effluents from the farms. Therefore, sitting the treatment plant in this area will result in no landscape or visual impacts, since the area is of a very low landscape value. Moreover, due to the heavy odours from the surrounding farms and the animal wastes, and together with the distance of the site from the housing areas no additional odour or noise impacts will result on the resident population.

Regarding land-use, the impacts will again not be significant since the site is within the animal husbandry area, while, due to the large extent of this area, the land take-up for the construction of the STP will not adversely affect or restrict the future development of the zone.

One disadvantage of this site is that there will be a need for the construction of a long-term storage reservoir for the treated water, since there is no other disposal option for the excess water during the winter period when the demand for irrigation will be lower. This will increase the land requirements of the plant.

However, no other significant environmental impacts are expected, such as ecological impacts, since the area is not considered an environmentally sensitive area.

7.2.2.2. ALTERNATIVE 2: PERIVOLIA (NEAR THE COASTLINE)

The second STP included in Scheme B2a would service the communities of Perivolia, Kiti, Dromolaxia and Meneou, with the STP being sited to the southeast of the village of Perivolia, near the coastline. The main advantage of this would be the possibility of discharging the treated effluent in the sea, which would reduce the land area requirements of the plant as there would be no need for the construction of long-term storage facilities. This would in turn significantly reduce the land-use impacts of the STP.

However, due to the location of the proposed STP site and the nature of the surrounding areas, construction of the plant in the vicinity of the Perivolia coastline would result in a number of significant adverse environmental impacts. The coastline area, which is in very close proximity (approximately 0.5 km from the nearest resorts) to the proposed site, is a tourist area which has developed relatively rapidly over the past decade. A number of holiday resorts, tourist villages, hotels and recreation facilities are currently located in the area. Furthermore, it is anticipated that the tourist development will continue inland, towards the side of the village. Additionally, there are a number of designated archaeological and historic sites in the area. Construction of the STP at this site will result in odour and noise impacts, particularly as the tourist area will expand inland in the future and closer to the site; landscape and visual impacts, whose significance will be enhance by the nature of the area in terms of topography (flat area) and built-up environment; and, more significantly land-use impacts as land will be taken up from tourist development. Lastly, the possibility of discharging the treated effluent in the sea in an area where this is used for recreation would need to be examined, while the land availability is restricted to readily allow the construction of a long-term storage reservoir.

As a result of the nature and significance of these impacts the site has been eliminated.

7.2.2.3. ALTERNATIVE 3: EXISTING LARNACA STP

The Larnaca STP is located in an uninhabited area between the airport and the sea. Currently the plant is at full load due to the BOD concentrations of the received wastewater, which are higher than the design parameters of the plant.

An extension to double the capacity of the STP is planned before 2012 (Phase 2). The land available on the site will accommodate the requirements of such an extension. It is anticipated that part of this extended capacity, between 3000 and 4000 m^3/d, could potentially be allocated for the connection of some additional villages to the Larnaca sewage network. According to the relevant scheme B2b, the villages of Dromolaxia-Meneou, Kiti and Perivolia will be connected to the existing Larnaca STP. The required capacity for servicing these villages is 5 000 m^3/d, which would require additional extension of the STP. The land available on the STP site is adequate to satisfy the land requirements for this Scheme.

In the case of Scheme B1a, where all Group B villages (except Athienou) will be connected to the existing Larnaca STP, the total capacity would be 12 200 m^3/d, which would necessitate a tripling in the size of the STP. For such an extension, although the land available at the site is enough to satisfy the requirements for the treatment of effluents it is constricted in accommodating the land requirements for the long-term storage reservoir.

7.2.2.4. ALTERNATIVE 4: ATHIENOU SITE

ALTERNATIVE 4(A)

The first alternative site selected for the STP which will service the community of Athienou is to the southeast of the village and at a distance of approximately 2 km from the centre of the village and 1.5 km from the nearest houses. The site is next to the border of the buffer zone with the occupied areas, while the area consists mainly of agricultural land.

Due to the distance of the site from the housing areas no odour or noise impacts are expected on the resident population. Due to the undeveloped nature of the location there will be some landscape impacts, however any visual impacts will be limited as the site is isolated and not clearly visible from the surrounding areas, while also being next to the border of the buffer zone.

The main disadvantage of sitting the plant at this location will be the need for the construction of a long-term storage reservoir, as there are no other disposal options for the excess treated effluent during the winter months. This will increase the land requirements for the STP. On the other hand, the geomorphology of the area is suitable for the easy construction of the reservoir as the natural cavity can be used. No other significant environmental impacts are anticipated as the area is not an environmentally sensitive area.

ALTERNATIVE 4(B)

The second alternative site for the Athienou STP is the south-southeast of the village at a distance of approximately 4 km from the village centre and 2.5 km from the nearest houses. The area is mostly agricultural land with some barren plots, and is near the Athienou animal husbandry zone.

Similarly, the main disadvantage of the site is the need for the construction of a long-term storage reservoir for the treated effluent, which will increase the land requirements for the plant. Furthermore, the construction of a reservoir at such a location will be difficult as the area is hilly, with large variations in elevations.

The site is at a considerable distance from the village housing areas, therefore no odour or noise impacts are expected on the resident population. However, due to the undeveloped nature of the area and the geology of the area, the landscape impacts from the construction of the plant can potentially be significant. Additionally, there will be significant visual impacts as the site is relatively close to and clearly visible from the main road connecting Athienou to Larnaca.

ALTERNATIVE 4(C)

The third alternative site for the Athienou STP is to the north of the village at a distance of approximately 1 km from the nearest houses. The area is agricultural land. The selected location consists of a large expanse cultivated with temporary crops. This is surrounded by olive plantations.

Due to the distance of the site from the housing areas no significant odour or noise impacts are expected on the resident population. As the area is flat and visible from the village side there will be some landscape and visual impacts, although these will be reduced as the STP will be shielded, to some extent, by the surrounding tree plantations.

Again the main disadvantage is the need for the construction of a long term storage reservoir. Additionally, as the site is flat there are no suitable geological formations for the easy construction of the reservoir.

The locations of the proposed sites are shown on the drawings EIA-B-21 and EIA-B-22.

7.3. EVALUATION OF FINAL ALTERNATIVES

Based on the probable impacts that might result from the proposed development, as identified in the impact scoping stage, the alternative sites and schemes, including the 'no action' alternative, have been evaluated in terms of their expected impact on the environment.

A number of criteria have been used to determine the extent of each of the impacts, including the expected severity of the impact, its duration and the expected probability of occurrence. The added score based on these parameters was then calculated by the extent of mitigation following the implementation of measures, to obtain the final impact score. For each of the environmental impacts assessed a weight was assigned according to their significance in relation to the environment, the extent to which the impact would immediately affect the concerned population, the sensitivity of the environmental receptor, and the cumulative impact potential of the impact. The final impact scores were then multiplied with the respective weights for each environmental aspect to provide the weighted impact scores for each alternative. The evaluation was carried out for each of the final alternative sites examined, and then for each of the alternative schemes.

The box below outlines the evaluation criteria used for the assessment of the weighted impact scores of the alternatives examined. Tables give the assessment results for the alternative site and alternative scheme evaluation respectively. A summary of the impacts and scores for each of the sites is outlined in Tables 7.4 – 7.6.

LARNACA COMMUNITIES

In the evaluation of the alternative sites for the sewage treatment plants, the site which has been selected near Aradippou has the highest score, followed by the site of the existing Larnaca plant. The site near the Perivolia coastal area needs to be excluded due to its proximity to the residential and tourist areas, as well as the environmental problems that are expected to arise from the construction of the plant at this location.

In the evaluation of the alternative schemes, the proposed scheme, which includes the construction of a sewage treatment plant at the Aradippou site, for the connection of the communities of Aradippou and Livadia, as well as the connection of Dromolaxia-Meneou, Kiti and Perivolia to the existing Larnaca plant, has the highest score, since the impacts which are expected to arise as a result are minimized in comparison. Scheme B1a, according to which all communities would be connected to the existing Larnaca sewage treatment plant, must be excluded due to the restricted land that is available at the site, while from an environmental perspective the extension that would be required would exert significant additional pressures in an environmentally sensitive region. Scheme B2a must also be excluded since it includes the construction of the treatment plant at the site in Perivolia.

The evaluation of the alternative sites and schemes indicates that the proposed scheme is the preferred alternative, while at the same time it justifies the development of the project since the impacts that would arise through the continuation of the current situation are significantly greater.

ATHIENOU SEWAGE TREATMENT PLANT

For Athienou, the alternative 4(a) is the preferred site from an environmental perspective as it scores more favourably in the evaluation. The second alternative site, to the SSE of the village, must be eliminated due to the nature of the area as far the geomorphology, the landscape and its land uses, as well as its surface drainage systems, land availability constraints, and its proximity to the main road.

Regarding the final choice between alternatives 4(a) and 4(c), the analysis and evaluation of the impacts associated with each option indicate that location 4(a), to the southeast of Athienou, is more favourable as the resulting environmental impacts will be lower in comparison. Site 4(c) is in an area of significant agricultural value and which offers the possibility for future agricultural and housing development in the case of a solution of the Cyprus problem. The impacts on the land use and value of the area, as well as the other possible environmental impacts that are expected to arise, will be significantly greater in comparison. Based on this, and in connection with the opinions of the community, which has finally selected and approved site 4(a), the construction of the sewage treatment plant at this location, to the southeast of the village is recommended.

IMPACT EXTENT

SEVERITY		DURATION		POSSIBILITY OF OCCURRENCE		TOTAL SCORE
Major Negative	-15	*Negative Impacts*		*Negative Impacts*		Severity + Duration + Possibility of Occurrence
Moderate Negative	-10	Permanent	-10	High Probability	-10	
Minor Negative	-5	Short Term	-5	Low Probability	-5	
No Impact	0	No Impact	0	No Impact	0	
Minor Positive	5	*Positive Impacts*		*Positive Impacts*		
Moderate Positive	10	Permanent	10	High Probability	10	
Major Positive	15	Short Term	5	Low Probability	5	

IMPACT SCORE

IMPACT EXTENT		IMPACT MITIGATION		IMPACT SCORE
Negative Impacts		*Negative Impacts*		Impact Extent x Impact Mitigation
	-35	Not Possible to Mitigate Impacts	2	
	-30	Impact Reduced	1	
	-25	Impact Prevented	0	
	-20	Impact Prevented and Positive Impacts Derived	-(2)	
	-15			
No Impact	0	No Impact	0	
Positive Impacts		*Positive Impact*	2	
	15			
	20			
	25			
	30			
	35			

WEIGHTS	
	WEIGHT
IMPACTS RELATED TO PROJECT LOCATION	
Land Availability	5
Permanent land acquisition	3
Impact on surface water hydrology	2
Impacts on geology and soils.	2
Impact on ecological values	3
Impact on land use and land cover	2
IMPACTS RELATED TO PROJECT DESIGN	4
IMPACTS RELATED TO PROJECT CONSTRUCTION	
Temporary land acquisition	1
Vegetation clearing	2
Ecological impacts	2
Soil impacts	4
Air pollution (dust, fumes)	3
Noise impacts	3
On-site safety	2
Waste management	1
Pollution	4
Off-site public safety	2
Traffic	2
IMPACTS RELATED TO PROJECT OPERATION	
Landscape impacts	3
Noise and odours	5
Impact on soils	5
Impact on underground resources	5
Impact of sludge production	4
Risk of system overload	2
Risk of insufficient treatment of effluent	5
Impacts of Treated Effluent Reuse	
Use for agricultural irrigation	4
Urban reuse	4
Groundwater recharge	5
TOTAL SCORE	**84**

TABLE 7.4 : EVALUATION OF ALTERNATIVE SITES

Alternative 1: Aradippou STP Site

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Permanent land acquisition	-15	-10	-10	-35	2	-70	3	-210
Impact on surface water hydrology	0	0	0	0	0	0	2	0
Impacts on geology and soils.	-5	-10	-10	-25	1	-25	2	-50
Impact on ecological values	10	10	10	30	2	60	3	180
Impact on land use and land cover	-5	-10	-10	-25	2	-50	2	-100
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-5	-5	-5	-15	1	-15	2	-30
Ecological impacts	0	0	0	0	0	0	2	0
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-5	-10	-5	-20	0	0	3	0
Noise and odours	-5	-10	-5	-20	0	0	5	0
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-155**	**-110**	**-115**	**-380**	**17**	**-100**	**84**	**275**

TABLE 7.4: EVALUATION OF ALTERNATIVE SITES (CONT.)

Alternative 3: Existing Larnaca STP Site

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Permanent land acquisition	-5	-10	-10	-25	2	-50	3	-150
Impact on surface water hydrology	0	0	0	0	0	0	2	0
Impacts on geology and soils.	-10	-10	-10	-30	2	-60	2	-120
Impact on ecological values	10	10	10	30	2	60	3	180
Impact on land use and land cover	-5	-10	-10	-25	2	-50	2	-100
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-5	-5	-5	-15	1	-15	2	-30
Ecological impacts	-5	-5	-5	-15	1	-15	2	-30
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-5	-10	-10	-25	1	-25	3	-75
Noise and odours	-5	-10	-5	-20	0	0	5	0
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-155**	**-115**	**-125**	**-395**	**20**	**-155**	**84**	**160**

TABLE 7.4: EVALUATION OF ALTERNATIVE SITES (CONT.)

Alternative 2: Perivolia Site

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Permanent land acquisition	-15	-10	-10	-35	2	-70	3	-210
Impact on surface water hydrology	0	0	0	0	0	0	2	0
Impacts on geology and soils.	-10	-10	-10	-30	2	-60	2	-120
Impact on ecological values	10	10	10	30	2	60	3	180
Impact on land use and land cover	-15	-10	-10	-35	2	-70	2	-140
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-5	-5	-5	-15	1	-15	2	-30
Ecological impacts	0	0	0	0	0	0	2	0
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-15	-10	-5	-30	2	-60	3	-180
Noise and odours	-15	-10	-5	-30	1	-30	5	-150
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-190**	**-110**	**-115**	**-415**	**21**	**-245**	**84**	**-165**

TABLE 7.4: EVALUATION OF ALTERNATIVE SITES (CONT.)

Athienou – Alternative 4(a): SE of Athienou

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Permanent land acquisition	-15	-10	-10	-35	2	-70	3	-210
Impact on surface water hydrology	0	0	0	0	0	0	2	0
Impacts on geology and soils.	-5	-10	-10	-25	1	-25	2	-50
Impact on ecological values	10	10	10	30	2	60	3	180
Impact on land use and land cover	-10	-10	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-5	-5	-5	-15	1	-15	2	-30
Ecological impacts	0	0	0	0	0	0	2	0
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-5	-10	-5	-20	1	-20	3	-60
Noise and odours	-5	-10	-5	-20	0	0	5	0
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-160**	**-110**	**-115**	**-385**	**18**	**-130**	**84**	**195**

TABLE 7.4: EVALUATION OF ALTERNATIVE SITES (CONT.)

Athienou – Alternative 4(b): SSE of Athienou

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Permanent land acquisition	-15	-10	-10	-35	2	-70	3	-210
Impact on surface water hydrology	-10	-10	-5	-25	1	-25	2	-50
Impacts on geology and soils.	-10	-10	-10	-30	2	-60	2	-120
Impact on ecological values	-5	-10	-5	-20	1	-20	3	-60
Impact on land use and land cover	-10	-10	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-5	-5	-5	-15	1	-15	2	-30
Ecological impacts	-10	-5	-5	-20	1	-20	2	-40
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-10	-10	-10	-30	2	-60	3	-180
Noise and odours	-5	-10	-5	-20	1	-20	5	-100
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-205**	**-145**	**-145**	**-495**	**22**	**-350**	**84**	**-425**

TABLE 7.4: EVALUATION OF ALTERNATIVE SITES (CONT.)

Athienou – Alternative 4(c): N of Athienou

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Permanent land acquisition	-15	-10	-10	-35	2	-70	3	-210
Impact on surface water hydrology	0	0	0	0	0	0	2	0
Impacts on geology and soils.	-5	-10	-10	-25	1	-25	2	-50
Impact on ecological values	10	10	10	30	2	60	3	180
Impact on land use and land cover	-15	-10	-10	-35	2	-70	2	-140
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-10	-5	-5	-20	1	-15	2	-30
Ecological impacts	0	0	0	0	0	0	2	0
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-10	-10	-5	-25	1	-25	3	-75
Noise and odours	-5	-10	-5	-20	0	0	5	0
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-175**	**-110**	**-115**	**-400**	**18**	**-150**	**84**	**160**

TABLE 7.5 : EVALUATION OF ALTERNATIVE SCHEMES

Scheme B2b

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Land Availability	15	0	0	15	2	30	5	150
Permanent land acquisition	-10	-10	-10	-30	2	-60	3	-180
Impact on surface water hydrology	0	0	0	0	0	0	2	0
Impacts on geology and soils.	-5	-10	-10	-25	1	-25	2	-50
Impact on ecological values	10	10	10	30	2	60	3	180
Impact on land use and land cover	-5	-10	-10	-25	2	-50	2	-100
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-5	-5	-5	-15	1	-15	2	-30
Ecological impacts	-5	-5	-5	-15	1	-15	2	-30
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-5	-10	-5	-20	0	0	3	0
Noise and odours	-5	-10	-5	-20	0	0	5	0
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-140**	**-115**	**-120**	**-375**	**20**	**-75**	**89**	**425**

TABLE 7.5: EVALUATION OF ALTERNATIVE SCHEMES (CONT.)

Scheme B1a

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Land Availability	-10	0	0	-10	2	-20	5	-100
Permanent land acquisition	-5	-10	-10	-25	2	-50	3	-150
Impact on surface water hydrology	0	0	0	0	0	0	2	0
Impacts on geology and soils.	-10	-10	-10	-30	2	-60	2	-120
Impact on ecological values	10	10	10	30	2	60	3	180
Impact on land use and land cover	-5	-10	-10	-25	2	-50	2	-100
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-5	-5	-5	-15	1	-15	2	-30
Ecological impacts	-5	-5	-5	-15	1	-15	2	-30
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-5	-10	-10	-25	1	-25	3	-75
Noise and odours	-5	-10	-5	-20	0	0	5	0
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-165**	**-115**	**-125**	**-405**	**22**	**-175**	**89**	**60**

TABLE 7.5: EVALUATION OF ALTERNATIVE SCHEMES (CONT.)

Scheme B2a

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Land Availability	-10	0	0	-10	2	-20	5	-100
Permanent land acquisition	-15	-10	-10	-35	2	-70	3	-210
Impact on surface water hydrology	0	0	0	0	0	0	2	0
Impacts on geology and soils.	-10	-10	-10	-30	2	-60	2	-120
Impact on ecological values	10	10	10	30	2	60	3	180
Impact on land use and land cover	-15	-10	-10	-35	2	-70	2	-140
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-5	-5	-5	-15	1	-15	2	-30
Ecological impacts	-5	-5	-5	-15	1	-15	2	-30
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-15	-10	-5	-30	2	-60	3	-180
Noise and odours	-15	-10	-5	-30	1	-30	5	-150
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-205**	**-115**	**-120**	**-440**	**24**	**-280**	**89**	**-295**

TABLE 7.5: EVALUATION OF ALTERNATIVE SCHEMES (CONT.)

Athienou – Alternative 4(a): SE of Athienou

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Land Availability	15	0	0	15	2	30	5	150
Permanent land acquisition	-15	-10	-10	-35	2	-70	3	-210
Impact on surface water hydrology	0	0	0	0	0	0	2	0
Impacts on geology and soils.	-5	-10	-10	-25	1	-25	2	-50
Impact on ecological values	10	10	10	30	2	60	3	180
Impact on land use and land cover	-10	-10	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-5	-5	-5	-15	1	-15	2	-30
Ecological impacts	0	0	0	0	0	0	2	0
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-5	-10	-5	-20	1	-20	3	-60
Noise and odours	-5	-10	-5	-20	0	0	5	0
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-145**	**-110**	**-115**	**-370**	**20**	**-100**	**89**	**345**

TABLE 7.5: EVALUATION OF ALTERNATIVE SCHEMES (CONT.)

Athienou – Alternative 4(b): SSE of Athienou

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Land Availability	-5	0	0	-5	2	-10	5	-50
Permanent land acquisition	-15	-10	-10	-35	2	-70	3	-210
Impact on surface water hydrology	-10	-10	-5	-25	1	-25	2	-50
Impacts on geology and soils.	-10	-10	-10	-30	2	-60	2	-120
Impact on ecological values	-5	-10	-5	-20	1	-20	3	-60
Impact on land use and land cover	-10	-10	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-5	-5	-5	-15	1	-15	2	-30
Ecological impacts	-10	-5	-5	-20	1	-20	2	-40
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-10	-10	-10	-30	2	-60	3	-180
Noise and odours	-5	-10	-5	-20	1	-20	5	-100
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-210**	**-145**	**-145**	**-500**	**24**	**-360**	**89**	**-475**

TABLE 7.5: EVALUATION OF ALTERNATIVE SCHEMES (CONT.)

Athienou – Alternative 4(c): N of Athienou

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Land Availability	15	0	0	15	2	30	5	150
Permanent land acquisition	-15	-10	-10	-35	2	-70	3	-210
Impact on surface water hydrology	0	0	0	0	0	0	2	0
Impacts on geology and soils.	-5	-10	-10	-25	1	-25	2	-50
Impact on ecological values	10	10	10	30	2	60	3	180
Impact on land use and land cover	-15	-10	-10	-35	2	-70	2	-140
IMPACTS RELATED TO PROJECT DESIGN	0	0	0	0	0	0	4	0
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	-5	-5	-5	-15	1	-15	1	-15
Vegetation clearing	-10	-5	-5	-20	1	-15	2	-30
Ecological impacts	0	0	0	0	0	0	2	0
Soil impacts	-15	-10	-10	-35	1	-35	4	-140
Air pollution (dust, fumes)	-10	-5	-10	-25	1	-25	3	-75
Noise impacts	-15	-5	-10	-30	1	-30	3	-90
On-site safety	-5	-5	-5	-15	0	0	2	0
Waste management	-5	-5	-10	-20	1	-20	1	-20
Pollution	-10	-5	-5	-20	1	-20	4	-80
Off-site public safety	-10	-5	-5	-20	1	-20	2	-40
Traffic	-15	-5	-10	-30	2	-60	2	-120
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	-10	-10	-5	-25	1	-25	3	-75
Noise and odours	-5	-10	-5	-20	0	0	5	0
Impact on soils	15	10	10	35	2	70	5	350
Impact on underground resources	15	10	10	35	2	70	5	350
Impact of sludge production	-5	-10	-5	-20	1	-20	4	-80
Risk of system overload	-10	-5	-5	-20	0	0	2	0
Risk of insufficient treatment of effluent	-15	-5	-5	-25	1	-25	5	-125
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	-10	-5	-5	-20	-2	40	4	160
Urban reuse	-10	-5	-5	-20	-2	40	4	160
Groundwater recharge	-15	-5	-5	-25	-2	50	5	250
TOTAL SCORE	**-160**	**-110**	**-115**	**-385**	**20**	**-120**	**89**	**310**

TABLE 7.5: EVALUATION OF ALTERNATIVE SCHEMES (CONT.)

No Action Alternative

	SEVERITY	DURATION	POSSIBILITY	TOTAL	MITIGATION	SCORE	WEIGHT	TOTAL SCORE
IMPACTS RELATED TO PROJECT LOCATION								
Land Availability	0	0	0	0	0	0	0	0
Permanent land acquisition	0	0	0	0	0	0	3	0
Impact on surface water hydrology	-15	-10	-5	-30	2	-60	2	-120
Impacts on geology and soils.	-15	-10	-10	-35	2	-70	2	-140
Impact on ecological values	-15	-10	-5	-30	2	-60	3	-180
Impact on land use and land cover	0	0	0	0	0	0	2	0
IMPACTS RELATED TO PROJECT DESIGN	-15	-10	-10	-35	2	-70	4	-280
IMPACTS RELATED TO PROJECT CONSTRUCTION								
Temporary land acquisition	0	0	0	0	0	0	1	0
Vegetation clearing	0	0	0	0	0	0	2	0
Ecological impacts	0	0	0	0	0	0	2	0
Soil impacts	0	0	0	0	0	0	4	0
Air pollution (dust, fumes)	0	0	0	0	0	0	3	0
Noise impacts	0	0	0	0	0	0	3	0
On-site safety	0	0	0	0	0	0	2	0
Waste management	0	0	0	0	0	0	1	0
Pollution	0	0	0	0	0	0	4	0
Off-site public safety	0	0	0	0	0	0	2	0
Traffic	0	0	0	0	0	0	2	0
IMPACTS RELATED TO PROJECT OPERATION								
Landscape impacts	0	0	0	0	0	0	3	0
Noise and odours	-5	-5	-5	-15	2	-30	5	-150
Impact on soils	-15	-10	-10	-35	2	-70	5	-350
Impact on underground resources	-15	-10	-10	-35	2	-70	5	-350
Impact of sludge production	0	0	0	0	0	0	4	0
Risk of system overload	-15	-5	-5	-25	2	-50	2	-100
Risk of insufficient treatment of effluent	-15	-10	-10	-35	2	-70	5	-350
IMPACTS OF TREATED EFFLUENT REUSE								
Use for agricultural irrigation	0	0	0	0	0	0	4	0
Urban reuse	0	0	0	0	0	0	4	0
Groundwater recharge	0	0	0	0	0	0	5	0
TOTAL SCORE	**-125**	**-80**	**-70**	**-275**	**18**	**-550**	**84**	**-2020**

8. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

8.1. PURPOSE AND OBJECTIVES OF THE EMP

A key objective of the Impact Assessment process is to identify the potential impacts on the environment of the activities anticipated and to develop a set of mitigation measures technically appropriate, financially acceptable and practically feasible. These mitigation measures are usually identified during the EIA stage and then set out in a practical and co-ordinated way in the EMP.

The role of the EMP is to outline the mitigation, monitoring and institutional measures to be taken during project implementation and operation to avoid or control adverse environmental impacts, and the actions needed to implement these measures. The EMP provides the crucial link between alternative mitigation measures evaluated and described in the EIA and ensuring that such measures are effectively implemented.

For each proposed measure, the EMP defines the technical content, the estimated cost, the schedule of implementation, the role and responsibilities of Government Agencies, the source of funding and the way to monitor the results.

8.2. SUMMARY OF IMPACTS AND MITIGATION MEASURES

TABLE 8.1: ANTICIPATED IMPACTS AND PROPOSED MITIGATION MEASURES

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
IMPACTS RELATED TO PROJECT LOCATION	
ARADIPPOU SEWAGE TREATMENT PLANT	
Permanent land acquisition Permanent acquisition of private land for construction of the STP, the storage reservoir and the pumping stations	↳ Compensation for loss of land, agricultural trees and possible loss of income.
Impacts on ecological values No adverse ecological impacts expected. Positive impacts from the creation of a wetland habitat (storage reservoir) in an otherwise degraded region.	No mitigation measures required.
LARNACA STP	
Permanent land acquisition Acquisition of additional government land for extension of the STP and construction of additional long term reservoir. Acquisition of private land for construction of pumping stations.	↳ No compensation required in the case of the STP, since land acquired is government land. ↳ Compensation for loss of land, crops and any possible loss of income for land acquired for pumping stations.
Impacts on ecological values Possible disturbance of wildlife, particularly birds, during construction and operation of the STP, due to proximity to salt lakes.	↳ Use of low noise equipment during operation and construction. Impacts during construction are only temporary, therefore no additional measures are required other

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
The scheme involves only extension of the existing Larnaca STP, therefore no significant destruction of habitat.	than those proposed for the construction phase.
ATHIENOU STP	
Permanent land acquisition Permanent acquisition of private land for construction of the STP and the storage reservoirs.	↳ Compensation for loss of land, agricultural trees and possible loss of income.
Impacts on ecological values No adverse ecological impacts expected. Positive impacts from the creation of a wetland habitat (storage reservoir) in an otherwise not ecologically significant area.	No mitigation measures required.
IMPACTS RELATED TO PROJECT DESIGN	
No significant impacts are anticipated ↱ Treatment process is reliable and proven and effluent will meet the set performance standards. ↱ Emergency storage will safeguard against problems in treatment process. ↱ Sludge treatment to be chosen will be effective in achieving required standards.	
IMPACTS RELATED TO PROJECT CONSTRUCTION	
Temporary land acquisition Temporary acquisition of land for workers' facilities, construction storage sites, pipe laying. This will result in possible loss of natural vegetation, grazing or agricultural land.	↳ Compensation for the temporary use of land, loss of production, or inconvenience created. ↳ Design to minimise construction land requirements. ↳ Special obligation on contractor to minimise impacts on temporarily acquired agricultural land so that it can be put back to production quickly. Measures include the preservation of soil through profiling of the top and sub soil to the original level. Building material must be fenced and the land should be cleared after construction. ↳ Full rehabilitation of sites to be required form contractor.
Vegetation clearing Clearing of vegetation for construction of the STP, the storage reservoirs, the pumping stations and the conveyance system.	↳ Compensation for the destruction of agriculture, particularly trees (permanent crops). ↳ Prior to construction a rapid survey of affected trees and vegetation should be carried out to clearly indicate the number of trees to be cleared. ↳ An equivalent number of trees and vegetation to be planted by contractor.
Soil Impacts ↱ Soil erosion: resulting from uncovered and unconsolidated materials during construction	↳ Strict clauses regarding earthworks management during construction to be imposed to the contractor. ↳ Careful design of construction operations, including the selection of haulage routes into the site and the location of stockpiles. ↳ Pipe construction should be divided into sub-sections, after excavating one section,

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
	backfilling it and clearing the area. Timely carry away discarded soil. The temporary deposits should be kept within barriers to prevent erosion. Avoid large scale excavations during rainfall or strong winds. Remove as little vegetation as possible during construction and revegetate bare areas as soon as possible after construction. Avoid creating large expanses of bare soil. If such expanses are created, then windbreaks may be required.
Soil disaggregation	Take the soil out in horizons and keep each horizon in a separate pile.
Soil compaction	Use wide tyres to spread the weight of vehicles. Use a single or as few tracks as possible to bring vehicles to construction sites. Till the area after compaction has taken place.
Dust, fumes and noise	
Dust: from stockpiles and vehicle movement, particularly in dry weather and strong winds.	Frequent spraying of stockpiles and haulage roads with water. Regular sweeping of access roads. Covering of vehicles carrying materials. Early planting of peripheral tree screens where they will be part of the development. A system of monitoring site accesses and stockpiles should be implemented.
Noise: from construction operations, machinery and vehicle movements, particularly in the case of the Larnaca STP which is near the Salt Lakes.	Use equipment with low noise outputs. Where it is necessary for construction sites to operate at night, causing an impact on residents, it is required that noise reduction measures are taken so that reasonable noise levels are maintained. Blasting and other operations with significant noise outputs should be restricted to certain hours of the day, while being prohibited at night. A plan for the management of construction activities, so as to minimise noise impacts and ensure compliance with noise control measures to be imposed on contractor. Construction operations must be carefully planned to minimise construction time.
Fumes: from vehicle movements and machinery.	Plan routes to minimise vehicle movements as far as possible.
On-site safety	Strict clauses imposed on contractor for the implementation of on-site health and safety measures and standards. Regular maintenance of construction equipment, machinery and vehicles must be ensured.

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
	➢ Measures to ensure traffic security to be adopted. ➢ Preparedness procedures in case of accidents and emergency situations to be established.
Waste management Construction waste, domestic solid waste	➢ Contractors must make arrangements for the collection and transportation of domestic waste to official landfill sites. ➢ The contractor must prepare a plan for the collection and appropriate disposal of construction waste and transportation plans must be made. ➢ Transportation at peak hours must be avoided. ➢ Spoil and wastes should be transported along specified routes and disposed of at designated sites. ➢ Inspection should be carried out to ensure that the plans are properly implemented.
Pollution Air water and soil pollution resulting from heavy operating machinery and vehicles, and from the storage of potential pollutants, such as petrol, motor oils and concrete.	➢ Strict clauses regarding the operation and maintenance of construction equipment to be imposed on contractor. ➢ Regular monitoring of water and air quality near construction sites must be carried out. ➢ Procedures must be taken for the containment of pollutants at storage sites. ➢ Measures must be taken to avoid impacts from any accidental spillages, including the containment of storage tanks on concrete floors will walls to prevent the release of effluents on the soil. ➢ Preparation and implementation of a management plan for the collection, storage and disposal of used oils and other pollutants.
Traffic As a result of increased vehicle movement and road excavations.	➢ The construction of the conveyance system should be phased and excavation, pipe laying and trench refilling should be completed as quickly as possible. ➢ For busy roads, construction at peak hours should be avoided. ➢ Spoil soils on roads under construction should be kept to a minimum so as not to affect local traffic. ➢ Specific routing must be prepared for vehicles.
IMPACTS RELATED TO PROJECT OPERATION	
Landscape impacts Minimum impacts	Planting on and off site, and retention of existing vegetation where possible
Noise impacts At STP sites and pumping stations. Impact at STP sites limited as they are at as sufficient distance from residential areas, however pumping stations are within urban areas. In the case of the Larnaca STP there could be possible disturbances to the wildlife of the region, although current operation of the plant has not resulted in such impacts.	➢ Enclose sources to insulate noise and incorporate specific acoustic features in the design of buildings. ➢ Use low noise equipment. ➢ Application of noise control equipment where necessary. ➢ Use of noise screens, including tree plantings. ➢ The noisiest sources should be monitored four times a year and noise measurements should be carried out near the plant and pumping stations two times a year during the day and night.
Odour impacts	➢ Application and adherence to proper process procedures. ➢ Covering of process areas and provisions for

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
	adequate air filtration. ↬ Regular monitoring of processes and conducting all appropriate chemical and biochemical analyses. ↬ Regular maintenance of the plant and pumping stations. ↬ Use of odour control systems in the STP design. ↬ Appropriate design of conveyance system to avoid formation of sulphides.
Impact on underground resources Positive impact: reduction in groundwater pumping, and reduction in nitrates released in the environment	No measures required.
Impact of sludge production and reuse	↬ Choice of treatment process to meet standards for reuse in agriculture. ↬ Correct soil application methods according to the Code for the Use of Sewage Sludge in Agriculture. ↬ Monitoring of sludge and soil quality in accordance with the Code.
Risk of system overload Minimum risk: emergency storage available, design includes seasonal variations	No measures required.
Risk of insufficient treatment of effluent	↬ Design for maximum flow ↬ Emergency storage reservoir
Reuse of Treated Effluent in Irrigation	↬ Regular monitoring of effluent quality according to the Code of Practice for the Use of Treated Effluent for Irrigation. ↬ Choice of irrigation methods according to the Code. ↬ Crop selection to avoid adverse impacts on crop yields.
Urban reuse of the treated effluent	↬ Regular monitoring of effluent quality. ↬ Labeling of pipes and use of signs in areas irrigated with treated effluent.
Groundwater recharge	↬ Monitoring of effluent and groundwater quality to avoid risk of aquifer pollution.

Mitigation Measures for the Reuse of Sludge
Misuse of the agricultural value of sludge *Leaching of nitrates to groundwater*
⇩ Better knowledge of sludge content in terms of compounds of agricultural value
❑ Adequate sampling procedures (frequency, number of samples, etc.)
❑ Adequate analysis protocols
⇩ Improve use of sludge agricultural value
❑ Determination of the sludge agricultural value (N, P, K, content)
❑ Planning and application adapted according to: ⇨ Plant needs ⇨ Other fertiliser sources ⇨ N remaining in the soil ⇨ Nutrient bioavailability ⇨ Adequate spreading periods according to agricultural and environmental constraints
❑ Regular soil analyses to establish increase in nutrient content

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
❑ Information from farmers about quantities spread	
Soil contamination by heavy metals and organic pollutants	
⇩ Determination of background levels in soil	
⇩ Determination of pollutant content in sludge	
⇩ Safe storage of sludge	
❑ Safe storage to reduce leaching	
❑ Sufficient storage capacity	
❑ Reduction of storage duration in the field	
Water contamination by heavy metals and organic contaminants	
⇩ Forbid sludge spreading in sensitive areas, especially:	
❑ On sloping land ❑ Near surface water ❑ On wet areas ❑ Within water resource protection areas ❑ On sandy soils ❑ On frozen grounds ❑ In areas where the water table is near the surface	
⇩ Encourage fast ploughing down in order to reduce the risk of runoff and the use of close-to-ground techniques in order to reduce the formation of aerosols	
⇩ Safe storage of sludge	
Crop contamination by heavy metals and organic pollutants	
⇩ Reduce transfer in the food chain	
❑ Encourage sludge spreading before non-food crops	
⇩ Limit plant uptake	
❑ Adapt sludge spreading to soil types (mainly according to pH and CEC)	
❑ Take into consideration heavy metal bioavailability in soil	
❑ Define a crop/sludge type matrix with specific recommendations	
❑ Prohibit sludge spreading on plant/crops which are known to accumulate heavy metals	
⇩ Limit deposition on plant	
❑ Limit use of sludge on vegetable and certain fruit productions	
⇩ Analyses of the metal level in crops and foodstuff	
Animal contamination by heavy metals and organic pollutants	
⇩ Limit pollutant transfer to animals	
❑ Tighten limits concerning quantity and quality of sludge which may be applied	
❑ Grazing land: ⇨ Introduce a time period before harvesting ⇨ Favour sludge ploughing down	
❑ Grassland: ⇨ Allow spreading before sowing and after each cut	
⇩ Control of the metal levels in foodstuffs	
❑ Analysis of the pollutant levels in animal products (especially in offal and milk)	
Human contamination	
⇩ Limit pollutant transfer in the food chain (see above)	
⇩ Protection of operating equipment	
❑ Ensure safe manipulation of sludge	

ANTICIPATED IMPACTS	PROPOSED MITIGATION MEASURES
❑ Material cleaning and maintenance	
❑ Protective clothes	
Contamination by pathogens	
⇩ Animal contamination	
❑ Grazing land: introduce a time period before grazing	
❑ Grassland: allow spreading before sowing and after each cut	
❑ Encourage fast ploughing down of sludge	
⇩ Human contamination	
❑ Prohibition of sludge spreading on products which are to be consumed raw	
❑ Safe transportation of sludge	
❑ Prohibition of sludge spreading in the vicinity of houses and near bathing water and drinking water supply areas	
MITIGATION MEASURES FOR THE REUSE OF THE TREATED EFFLUENT IN IRRIGATION	
Impacts on soil productivity; groundwater contamination; health impacts; impacts on crop growth and quality	
⇩ Drafting of Reuse Management Plan, incorporating:	
❑ Appropriate site identification (for reuse in areas outside the Irrigation Scheme) ❑ Crop water requirements ❑ Crop selection ❑ Irrigation methods and scheduling ❑ Evaluation of nutrient and salt loading rates	
Nitrogen leaching to groundwater, accumulation in soil	
⇩ Balance nitrogen loading rates with crop requirements	
Phosphorus leaching to groundwater, accumulation in soil	
⇩ Balance phosphorus loading rates with crop requirements	
Adverse impacts on soil productivity and risk of groundwater contamination	
⇩ Determine salt loading rates	
⇩ Ensure irrigation practices do not result in off-site run-off, appropriate leaching and drainage provisions	
Adverse impacts on crop yields and quality	
⇩ Crop selection based on crop sensitivity to treated effluent constituents	
Adverse impacts on health	
⇩ Timing of irrigation prior to harvesting	
⇩ Correct irrigation practices	
⇩ Minimise site access during irrigation periods	
⇩ Use of signs specifying that treated effluent is used	
⇩ Establishment of buffer zones around irrigated areas where necessary	
Quality considerations	
⇩ Implements treated effluent quality monitoring programme to ensure compliance with the set standards	
⇩ Implement soil quality monitoring programme	
⇩ Monitoring of irrigation methods and practices	

8.3. MITIGATION MEASURES

8.3.1. CONTRACTUAL BACKGROUND FOR ENVIRONMENTAL MANAGEMENT

8.3.1.1. CONTRACTUAL DISPOSITIONS

From experience, it has been observed that obtaining any specific task from a contractor requires first that the task is specified in the contract documents and then, that a specific payment is allocated to that task. This is the basis for any construction contract which relies on detailed technical specifications and their related bills of quantities.

To be effective, the environmental and social obligations of a contractor must be comprehensively specified and individually payable through the contract documents. Both actions work together because the payment system will influence the way specifications are displayed and prepared.

In case of a project, the Environmental Impact Assessment report is generally mentioned in the Assurances in a way that all mitigation measures recommended have to be implemented.

Thus, the preparation of detailed environmental and social specifications for the Contractor is proposed prior to the bidding process, with the objective to have eventually a legal document which establishes clearly the obligations of the contractor, the quantities of work involved and the related cost of measures.

8.3.1.2. PREPARATION OF TECHNICAL ENVIRONMENTAL SPECIFICATIONS

The environmental and social specifications for the Contractor will be organised into 4 sections:

- SECTION A : Environment Protection Management
- SECTION B : Labour Camps and Worker Health Management
- SECTION C : Safety Management
- SECTION D : Social Management

Each section will address the 2 following aspects:

Sub-Section 1: description of the Contractor's obligations with regards to those aspects covered by the section.

Sub-Section 2: description of indicators that will be monitored for payment

DESCRIPTION OF CONTRACTOR OBLIGATIONS

- SECTION A : ENVIRONMENT PROTECTION MANAGEMENT

  The Section A will specify the Contractor obligations with regards to the preparation of a Construction Site Environmental Management Program (CSEMP) aiming at protecting the work sites and their surroundings against potentially adverse impacts. The Contractor's CSEMP will include the facilities and procedures for the management of solid wastes, the soil conservation measures and proposed rehabilitation works once the construction ends, the measures aiming at protecting the local fauna and flora, the preventive measures against water pollution and the monitoring program (air, water). For each aspect, the environmental specifications will provide the contractor with standards or quality objectives to be achieved.

- SECTION B : LABOUR CAMPS AND WORKER HEALTH MANAGEMENT

  The Section B will address the minimum standards to be implemented in the labour camps and facilities regarding issues as accommodation, food supply and canteen, waste management,

water supply, treatment of sewage and sanitary conditions on site. The following topics will be addressed:

- Maximisation of employment of locally based labour who will be transported to the sites by bus;
- Mechanisms to ensure contractors provide their work force and camps with adequate quantities and standards of the following :
  - Water supply
  - Sanitation and solid waste disposal
  - Health checks
  - Security and lighting
  - Disease pathogen and vector control
  - Fire extinguishers and fire drills
  - Training for specific tasks, particularly safety training
  - Catering and canteen services
  - Personal Protective Equipment (PPE)
  - Transport to public transport facilities
- Actual volumes, quantities and standards for the above mentioned items.

SECTION C : SAFETY MANAGEMENT

For safety issues, Environmental Specifications will have to address two distinct aspects:

- The **On-site Safety**, PPE, and Medical issues, and
- The **Off site Safety**, Medical and Road traffic issues

The *On-site Safety, PPE, and Medical Aspects* will address all the measures the Contractor needs to implement to ensure a safety standard close to international standards, and appropriate medical evacuation of the workforce.

For most *Off-site Safety accident and Medical issues*, the Environmental Specifications will fix the objectives. In its offer, the Contractor will detail which measures he intends to apply for achieving these objectives. Major issues to be covered under this headline include:

- Road signs
- Road accidents
- Speed limits through populated areas and speed control bumps (near schools, at the entrance of villages)
- Project traffic regulations including: night-stop regulations, truck cleaning, washing and cargo transfers, use of headlights, carriage of unofficial persons and goods, educating project drivers in safety matters, regular inspections of vehicle condition, compulsory first aid kits, fire extinguishers, use of vehicle log books, seat belts, etc.
- First aid and emergency medical facilities,
- Third party, livestock and property accident insurance cover,
- Hazardous cargo movement and accident procedures,
- Exceptional load movement procedures,
- Accident reporting procedures,
- Off-site damage / injury claim procedures,
- Village liaison and discussion arrangements,
- Repairs of local roads and bridges damaged by project traffic,
- Load shedding and spillage accidents.

SECTION D : SOCIAL MANAGEMENT

The Section D will fix the minimum conditions to be applied by the Contractor while managing all social aspects related to construction activities. Most of them will focus on how to reduce nuisance to villagers.

Meetings must be arranged between the contractors and the village authority of all villages likely to experience nuisance events.

As a result of the meetings, the contractors will prepare a nuisance control program which will be posted in public places in affected villages. This program includes measures to deal with at least the following issues:

Traffic density:	Possible by-pass route, Speed bumps near villages, Crossing places, Prohibition of night traffic
Noise:	Regulations about traffic and working hours in/near residential areas, Regulations about use of klaxons in villages.
Fumes, dust	Regulations on refuelling, fly ash or cement transfer in or near residential areas, Road watering, Effective covering of truck loads such as sand or gravel.
Traffic obstruction:	Temporary parking, regulations for keeping open roads even during upgrading works or during movements of exceptional loads.
Social relation:	Monthly meeting between contractor and representative of potentially affected village to be organised for solving conflict issues.

Public information can be carried out among concerned villages to use the monthly meeting with contractor to ensure the nuisance reduction program continues to serve their interests.

DESCRIPTION OF MONITORING INDICATORS

For the four specification sections, the indicators that will be monitored during the site inspections must be specified.

MEASURABLE ITEMS

Most of the contractor environmental and social obligations are actually measurable. For these ones, indicators to be monitored will be quantities and the Contractor will be paid only if these quantities are observed on the sites.

For example in section B "Labour Camps and Worker Health Management", the following obligations and indicators could be considered with regards to Restrooms:

⇩ Description of the Contractor's obligations

"The Contractor shall provide washrooms and other facilities, as necessary, to satisfy the needs and customs of its workforce. Washrooms shall be located and sized based upon the size of the workforce and shall include adequate lighting and appropriate number of facilities. Separate facilities shall be provided for men and women. Washrooms shall be constructed in well-ventilate areas, and supplied with an adequate amount of hot and cold water (potable) and other ancillaries"

⇩ Description of indicators

"As a minimum, the following shall be provided:

- Toilets: 1 unit per 15 persons. Each unit being supplied with toilet paper and holders, waste receptacle, and deodorant ;
- urinals: 1 unit per 25 men ;
- shower stalls: 1 per 10 persons ;
- Washbasins and mirrors: 1 per 5 persons.

NON-MEASURABLE ITEMS

Some environmental and social obligations remain difficult to quantify. A typical example is the protection of areas adjacent to construction areas: It is not realistic to specify a penalty for a number of trees cut at a wrong place, or for any cubic meter of material cast aside the road.

But for these non-measurable items, it is important to specify the methods anticipated to reduce adverse impacts and also to specify clearly which condition would constitute a non-payment situation.

PAYMENT PROCEDURES FOR ENVIRONMENTAL AND SOCIAL OBLIGATIONS

An adapted payment procedure is the most efficient tool to oblige a Contractor to fulfil its obligations. The payment procedures should provide the executive agency with the maximum guarantee that money is to be paid only when the work is totally and satisfactorily completed. Also, the payment procedure should act as an incentive for the Contractor, exacerbating its willingness to fulfil its environmental and social obligations with the best results. In such case, the budget considered for the services should be significantly higher than what should be the expenses to implement the measures.

These issues will be discussed when preparing the environmental specifications for the contractor, and they will consider the most appropriate and acceptable solutions for the remuneration of Contractor Environmental and Social Obligations.

8.3.2. COMPENSATION FOR LAND ACQUISITION AND RESETTLEMENT

Compensation must be paid for all permanent land acquisitions as well as temporary acquisitions.

8.3.3. COMPENSATION FOR THE LOSS OF TREES

The executing authority will carefully confirm the number of trees affected by the Project and discuss with the Contractor to identify any possibility to minimise the loss during the construction.

The Contractor will make provisions for the planting of an equivalent number of trees lost because of construction activities. These trees will be planted in an area to be determined with the relevant authority and resident representatives.

The cost for purchase of plants, their transport to the project site, their planting and 2 years of follow up will be included in the environmental budget of the contractor.

8.3.4. DECOMMISSIONING: RECLAMATION OF TEMPORARY USED SITES

Decommissioning refers to the dismantling, decontamination and removal of process equipment and facility structures, at the end of the construction stage, and to recontouring the land and planting vegetation to prevent soil erosion as appropriate. Assuming there is no other use for field facilities, all structures and related infrastructure facilities are to be dismantled by the contractor.

All the sites used temporary by the contractor installations will be fully rehabilitated at the end of the construction stage and shall be returned to their initial use. This concerns areas for borrowing earth, for temporary access roads, for workers camps and facilities, for material storage and for machinery parking and maintenance.

- SITE RECLAMATION: Construction related sites to be decommissioned and reclaimed will be re-contoured and restored so that the pre-disturbance vegetation can re-establish itself in a short period of time. Reclamation will be limited to disturbed areas of the site. To facilitate re-vegetation, mitigation measures that may apply include fertilising and seeding, mulching and surface texturing. Close attention will be paid to areas where erosion potential is high. Large plots of land such as storage yards, borrow areas, and main camp sites will be re-vegetated and maintained until plant growth is established.

- GRADING AND SURFACE RECLAMATION: Disturbed areas where temporary construction facilities existed will be returned to natural contours where possible. Areas of high erosion will be identified in the field and treated with special design measures that may include anti erosion mats or mulching. Compaction of the sub-soil will be relieved by scarification in areas of disturbance. The topsoil stored during the initial phase of construction will be returned to the site, evenly spread and lightly packed to prevent depressions and water pockets. In areas where topsoil was not stripped, the surface will be ripped or scarified to relieve compaction. Grading and surface reclamation activities will not take place when the topsoil is muddy or the subsoil wet.

- REVEGETATION: If seeding and planting are needed, native seed mixtures or plant seedlings used will be compatible with local soil conditions and climatic zones. Seed will be applied uniformly in a manner appropriate for the type of seed used and will be placed in a firm, moist seedbed at a suitable depth. Seedlings will be planted at a density and in a manner conducive to successful growth. In disturbed temporary construction site areas with little topsoil or naturally sparse vegetation, fertilisation and mulching may be included in the site reclamation works. Seeded or planted sites failing to show successful growth after one growing season will be assessed to determine cause for failure, and corrections will be made as appropriate.

- TEMPORARY STORAGE OF REMOVED TOPSOIL: will be done at appropriate sites in a manner that maintains its fertility (i.e. storage of removed topsoil for less than 6 months, protection of topsoil stockpiles from surface drainage).

8.4. MONITORING PROGRAMS

Environmental monitoring programs are designed to provide the necessary feedback about the actual impacts of the projects during its construction and operation stage. Monitoring helps judge the success of mitigation measures in protecting the environment. Monitoring is also used to ensure compliance of activities with existing standards, as for example, effluent quality discharged in a water body.

If efficiently backed-up by authorities to ensure corrective action when the results of monitoring show it necessary, a monitoring program is a proven way to ensure effective implementation of mitigation measures.

8.4.1. WATER QUALITY MONITORING DURING CONSTRUCTION

8.4.1.1. OBJECTIVES OF MONITORING

The objectives of water quality monitoring are:

- To ensure a strict control of pollution from construction activities and to check the efficiency of water quality protection measures set up by the civil work contractor;
- To ensure that construction activities do not alter significantly the river or reservoir or aquifer water quality.

To satisfy these objectives, two monitoring systems must be organised: one, focussing on construction sites and on the release of pollutants, the other on the condition of the receiving water bodies.

The first monitoring system is called a *Compliance Monitoring*, which will compare discharges from the site activities with existing standards. Implicit in this system is the assumption that if a characteristic being monitored is within acceptable limits, then the effects will also be within acceptable limits.

The second system is called an *Effect Monitoring*, as it tries to link specific human activities to any changes in the environmental characteristics of the receiving water body. This monitoring is the most widely used in EIA, but unfortunately, too frequently with very limited results.

8.4.1.2. LOCATION OF SAMPLING SITES

For the construction sites monitoring (compliance monitoring), sampling sites will be distributed in points where the control of effluents from construction activities can be easily implemented: surface drainage channels from construction sites, from concrete preparation plant, from worker camps sewage facilities, from disposal areas for earth-fill or for solid waste, from machinery reparation yards and from petrol products storage areas.

For the follow up of water body quality, the selection of sampling stations located upstream and downstream the anticipated influence zone will be considered.

All the sites for monitoring will have to be determined at the early stage of project implementation, when the Contractor has already submitted the location for camps, storage and major earthworks.

8.4.1.3. SAMPLING AND ANALYSIS

PARAMETERS TO BE MEASURED

The selection of parameters to be measured depends on the potential pollution expected, the type of water body and water use concerned, and the sensitivity of the biological environment.

Two types of indicators should be considered:

- ⇨ Those related to the follow up of potential pollution sources resulting from construction activities, and
- ⇨ Those related to larger characterisation of the receiving (or threatened) water body in relation to its quality and sensitivity for the biodiversity.

The most frequently observed pollution types from construction works are mainly suspended solids due to earthworks, acidification due to concrete related activities, and hydrocarbons from engine leakage and maintenance. Potential pollution from workers camps is mainly of bacteriological nature and related to sanitation systems. The parameters to be followed must be the best indicators of activities anticipated in the sites, which may clearly establish the presence or not of a nuisance directly induced by the activities.

The other group of parameters concerns those providing more general information on the condition of the receiving water body, either a river or a reservoir. Sampling stations have to be located at a greater distance from the construction sites, to ensure that they reflect the wider influence (if any) of the construction activities on the receiving water body and on the biodiversity it supports. In this case, sampling is performed simultaneously upstream the activity area and downstream.

Therefore, the recommended parameters to be monitored are:

GROUP 1: INDICATORS OF POLLUTION:

- ❑ At any discharge point from the construction sites: Temperature, pH, electrical conductivity, Dissolved Oxygen (DO).
- ❑ At the treated effluent discharge point from the labour camps: faecal coliforms, total coliforms, Ammonia, Biochemical Oxygen Demand in 5 days (BOD_5).
- ❑ At the outlet of concrete production effluent (if any): Total Suspended Solids (TSS) pH
- ❑ At the outlet/drains draining construction activities and mechanical maintenance areas: pH, Turbidity or (TSS), Lead, Hydrocarbons (HPA), oils.

GROUP 2: INDICATORS OF WATER BODY QUALITY:

- ❑ Temperature, pH, electrical conductivity, TSS, TDS, Chemical Oxygen Demand (COD), Ammonia, Total Nitrogen, Total Phosphorus.

TYPE OF SAMPLING AND FREQUENCY OF COLLECTION

- ⇩ Sampling for Group 1 indicators should be performed on a weekly basis[1]. The Contractor will be requested to carry out the sampling and the analysis, the implementing Agency being mainly in charge of random control sampling.
- ⇩ Sampling for Group 2 indicators should be performed on a monthly basis

Samples should be kept in the dark and maintained as cool as possible within a chilled insulated container and returned to the laboratory promptly after collection. Samples should be analysed as soon as possible and preferably within 8h of collection. Samples storage is recommended not to exceed 24h at 5°C.

Temperature, turbidity, TSS, pH and Dissolved Oxygen could be measured directly on site in using a multi-parameter probe, with regular laboratory calibration.

BOD_5, Lead, Hydrocarbons (HPA) and bacteriology must be measured in a Water Quality Laboratory.

REPORTING AND DATA INTERPRETATION

All results (site and laboratory) will be recorded in a logbook and computerised so as to ensure proper data record and an easy data interpretation with graphs.

8.4.1.4. ORGANIZATION

The Contractor will be requested to follow up on a *weekly basis* the pollution load from its installations, in imposed sampling sites and in accordance with sampling procedures determined. Samples have to be delivered to an agreed laboratory for analysis.

It is advisable to carry out on a random basis control sampling to ensure the results provided by the Contractor are true and correct. A minimum control sampling of once per month is recommended. For the monitoring of the larger receiving water bodies, sampling and analysis will be carried out once a month during the construction period by the relevant authorities.

8.4.1.5. REPORTING

Weekly results from compliance monitoring compiled by the Contractor will be immediately submitted to the relevant authority. Monthly report with results and interpretative analysis will be submitted monthly together with other monitoring material by. The monthly report will also include results from random control analysis and of water bodies monitoring.

8.4.1.6. SCHEDULE OF ACTIVITIES

TABLE 8.2: SCHEDULE OF ACTIVITIES FOR WATER QUALITY MONITORING

PERIOD	ACTIVITIES	COMMENTS
PRE-CONSTRUCTION	Prepare Contractor specifications for water quality compliance monitoring	Defines number of sites, location, parameters to analyse, frequency of sampling, procedures for sampling, laboratory designated for analysis, reporting of results.
	Identify suitable sites on receiving water body and carry out preliminary sampling & analysis	Sites must be selected for easy access and representativeness of conditions prevailing in the area. If possible should rely on existing stations used for long term monitoring of the whole river system.

[1] *Weekly basis the first few months of construction, then twice a month if results appear satisfactory.*

CONSTRUCTION	Sampling in selected sites on weekly basis, deliver samples to laboratory and provide weekly report on results	Weekly report submitted to relevant authority.
	Carry out monthly random sampling to control accuracy of contractor's monitoring	Results to be submitted to relevant authority for further action if required.
	Prepare formal notice to Contractor if results do not comply with standards	Follow up for effective implementation of corrective action by Contractor, if required.
	Carry out monthly sampling of receiving water body	Results to be submitted to the relevant authority for further action if required.
	Monthly report of water quality results to be prepared	Report with conclusions to be submitted to relevant authority.
	Quarterly report on water quality monitoring	Report with conclusions to be submitted to relevant authority.
OPERATION	Carry out monthly sampling of receiving water body	Regular monitoring of the receiving water quality of storage of the treated effluent in the Achna Dam or in case of groundwater recharge

8.4.2. WATER QUALITY MONITORING DURING OPERATION

During the operation of the STP, if the treated effluent is stored in the Achna Dam or if it is used for groundwater recharge purposes, regular monitoring of the quality of the receiving waters is required.

The following parameters must be examined:

- Temperature, pH
- Electrical conductivity
- Suspended Solids
- BOD_5, COD
- Coliforms, intestinal worms
- Total N
- Total P

Monitoring must be carried out on a weekly basis

8.4.3. AIR AND NOISE MONITORING

8.4.3.1. OBJECTIVE OF MONITORING

Air quality is anticipated to be locally and temporally altered by the construction activities in 3 fields: Generation of exhaust fumes from trucks and heavy machinery, production of noise and emission of dust because of earthworks.

PRODUCTION OF FUMES AND GASES

Direct monitoring of possible sources of pollution is strongly recommended. Direct control of exhaust systems on trucks may limit the production of exhaust gas resulting from the use of old or badly maintained trucks. The strict enforcement of speed limitation in urbanised areas will also reduce the production of exhaust gas. General control of air quality will not provide usable information, as few dozens of trucks or bulldozers will not alter significantly the air quality of widely opened and windy areas.

PRODUCTION OF NOISE

Noise must be monitored at workers camps level, on the construction sites (within the worker safety component) and in the nearby villages or residential areas. Monitoring of noise does not just concern measuring a point, but also collecting any claims of nearby population or of workers suffering from noise. Request or suggestion boxes have to be opened in various places where people may express their inconvenience regarding noise, and from where the breaking of the rules by the Contractor can be proved and discussed. Strict rules have to be established regarding the use of noisy equipment near residences, including the traffic of trucks.

During the operation of the STP noise levels must be regularly monitored near plant equipment, such as pumps, ventilators and air conditioners; near pumping stations; and in the nearby villages or residential areas; or recreation areas

PRODUCTION OF DUST

Dust will be produced in several places where construction and pipe laying will commence, particularly during the summer when the dry climate will increase the risk of soil erosion from winds. Dust will also be produced by the trucks along the earth roads and with a particular adverse influence when crossing residential areas. For the well being of the workforce and of the surrounding population, dust emission has to be minimised in the most critical areas. For that purpose, regular watering of such areas is necessary. Strict clauses will be established regarding the obligation of the Contractor to water soil regularly along the roads crossing villages, inside camps and construction sites and on the disposal areas for earth fill.

8.4.3.2. LOCATION OF MEASURE SITES

Specific sites for regular measurement of air quality are not anticipated. If disputes arise between the Contractor and workers or resident population on a specific air quality issue, appropriate analysis in appropriate locations will be conducted in order to assess the magnitude of the inconvenience and its level compared to existing standards. This will probably mainly concern noise and dust emissions. Selective measurements of exhaust gas may also be carried out in case doubtful equipment is used.

However, before construction starts, it is advisable to carry out a campaign of measures in the project area, in villages crossed by the access road in order to establish a broad baseline of local conditions which may eventually referred to in case of dispute or claim. Parameters to be checked are Total Suspended Particulate (TSP), No_x, SO_2 and noise level at various times of the day.

8.4.3.3. ORGANIZATION

The concerned authorities will carry out on a random basis control measures of noise, dust or exhaust gases to ensure that the Contractor is operating within the Standards or to oblige it to appropriate measures in case standards are not respected.

8.4.3.4. SCHEDULE OF ACTIVITIES

TABLE 8.3: SCHEDULE OF ACTIVITIES FOR AIR QUALITY MONITORING

PERIOD	ACTIVITIES	COMMENTS
PRE-CONSTRUCTION	Prepare Contractor specifications for air quality compliance to existing standards	Includes also specifications for maintenance of engines, watering of roads and stock piles, noise limitation, and traffic in urbanised areas
	Identify suitable sites in project area and carry out preliminary sampling & analysis	Sites must be selected for easy access and representativeness of conditions prevailing in the area.

PERIOD	ACTIVITIES	COMMENTS
CONSTRUCTION	Carry out public information about obligations of contractor regarding fumes, dust & noise Inform villagers on grievance procedure.	Open grievance boxes in villages concerned. Link with specifications on traffic control imposed to Contractor
	Review monthly grievance, and if justified meet with concerned villagers/head of village to identify corrective measure	Impose measures on contractor if required. Request analysis to be carried out if justified
	Carry out random sampling to control respect by Contractor of standards and specifications	Results to be submitted to relevant authority for further action if required
	Prepare formal notice to Contractor if results do not comply with standards or obligations	Follow up for effective implementation of corrective action by Contractor, if required
	Monthly report of air related activities to be prepared	Report with conclusions to be submitted to relevant authority
	Quarterly report on air quality activities	Report with conclusions to be submitted to relevant authority
OPERATION	No activity anticipated	

8.4.4. SLUDGE CONTROL MONITORING

A sludge control monitoring programme must be implemented incorporating:

- ⇩ Monitoring of sludge quality
- ⇩ Monitoring of soil quality
- ⇩ Monitoring of sludge application rates
- ⇩ Monitoring of application methods and practices

The Code of Practice for the Use of Sludge for Agricultural Purposes (Appendix 1) and the Regulations on the Use of Sludge for Agriculture (517/2002) set out the minimum monitoring requirements and limit values. A more detailed monitoring programme, incorporating these requirements, is recommended to ensure the safe reuse of sewage sludge in agriculture.

8.4.4.1. MONITORING OF SLUDGE QUALITY

The following parameters must be analysed in order to characterise and monitor the composition of sludge in terms of heavy metal and nutrient content:

- ❑ Dry matter and organic matter
- ❑ pH
- ❑ Primary nutrients: Nitrogen (as Total N and NH_4^-N), Phosphorus (P) and Potassium (K)
- ❑ Secondary nutrients: Calcium (Ca), Magnesium (Mg), Sulphur (S)
- ❑ Micro-nutrients: Boron (B), Cobalt (Co), Iron (Fe), Manganese (Mn), Molybdenum (Mo)
- ❑ Heavy metals: Cadmium (Cd), Nickel (Ni), Lead (Pb), Zinc (Zn), Mercury (Hg) and Chromium (Cr III).

Values for the maximum permissible heavy metal content in the sludge according to the Regulations and the proposed limit values are outlined in Appendix 1.

According to the Regulations and the Code of Practice, the sludge must be analysed every 6 months. In cases where change is observed in the quality of the sewage, the frequency of the

analyses will need to be adjusted accordingly. If the analyses results do not differ significantly during the period of one year the sludge can be analysed every 12 months.

However, to ensure the safe use of sludge in agriculture, the following analysis frequency is recommended as a minimum, depending on the sludge quantity produced.

TABLE 8.4: PROPOSED ANALYSIS FREQUENCY FOR SLUDGE

Quantity of Sludge Produced per Year and per Plant (tonnes of DS)	Minimum Number of Analyses per Year		
	AGRONOMIC PARAMETERS	HEAVY METALS	MICRO-ORGANISMS
< 250	2	2	2
250 – 1 000	4	4	4
1 000 – 2 500	8	4	8
2 500 – 4 000	12	8	12
> 4 000	12	12	12

The analyses must be carried out at regular intervals during the year.

Sludge will be assumed to conform to the recommended limit values for heavy metals, or to a maximum to the set regulation standards, if for each concentration limit considered, the 90-percentile of the samples within a twelve-month period are at or below the threshold value and if the 10-percentile of the samples exceed only one threshold value and by less than 50%.

TABLE 8.5: PROPOSED HEAVY METAL CONCENTRATION LIMIT VALUES IN THE SLUDGE USED IN AGRICULTURE

PARAMETER	LIMIT VALUES (mg/kg DS)		LIMIT VALUES (mg/kg P)
	REGULATION 517/2002	PROPOSED LIMIT VALUES	PROPOSED LIMIT VALUES
Cadmium (Cd)	20 – 40	10	250
Copper (Cu)	1 000 – 1 750	1 000	25 000
Nickel (Ni)	300 – 400	300	7 500
Lead (Pb)	750 – 1 200	750	18 750
Zinc (Zn)	2 500 – 4 000	2 500	62 500
Mercury (Hg)	16 – 25	10	250
Chromium (Cr III)	–	1 000	25 000

SAMPLING

The samples must be representative of the final sludge to be applied on land, and sampling must be carried out after the treatment of sludge and before its delivery to the user. To achieve this, samples must be representative of the entire amount of sludge being sampled, collected after the last treatment process, and taken from the same location each time monitoring is performed.

Ideally, sampling locations must be as close as possible to the stage before final application. It is therefore recommended that samples are taken at the storage site prior to track loading for transport to the application sites.

Sample collection and sampling procedures must be clearly defined and followed consistently to minimise process errors. For this a sampling procedure must be drafted, which will include:

- Specification of the personnel responsible for the sampling

- Identification of the appropriate sampling equipment
- Description of sample mixing procedures
- Specification of the size and type of sample containers
- Specification of sample preservation procedures and holding times
- Specification of equipment cleaning procedures to ensure that cross contamination of samples does not occur
- Description of procedures to ensure that the integrity of samples is maintained during transport and analyses.

8.4.4.2. MONITORING OF SOIL QUALITY

The frequency of the analyses will depend on the initial condition of the soil and its heavy metal content, which must be verified before the application of sludge begins, together with the heavy metal content of the sludge and the frequency of the sludge deposition.

Analyses must be carried out for the following parameters (according to Regulations):
- pH
- Cadmium, copper, nickel, lead, zinc, mercury and chromium.

In addition, further analyses are recommended to determine the soil characteristics and chemical parameters in order to assess the sludge application rates depending on crop requirements in nutrients. Monitoring of the following parameters is suggested:

MONITORING PRIOR TO SLUDGE APPLICATION

- Surface layer:
  - Particle size distribution
  - Electrical conductivity
  - Cation exchange capacity (CEC)
  - Lime requirement (acid soils)
  - Plant available P and K
  - Soil N parameters:
    - NO_3^-N
    - NH_4^-N
    - Organic matter
    - Organic N
    - O:N ratio
    - Soil microbial biomass C and N
    - N mineralization potential
- Subsurface layers:
  - Particle size distribution
  - Electrical conductivity
  - Cation exchange capacity (CEC)

MONITORING FOLLOWING SLUDGE APPLICATION

- Surface layer:
  - Electrical conductivity
  - Lime requirements (acid soils)
  - Plant available P and K
  - Soil N parameters
    - Organic matter
    - Organic N
- Subsurface layers:
  - Electrical conductivity

The concentrations of heavy metals in the soil must be according to the proposed standards, or to a maximum according to the set regulation standards.

TABLE 8.6: PROPOSED HEAVY METAL CONCENTRATION LIMIT VALUES IN THE SOIL

PARAMETER	LIMIT VALUES (mg/kg DS)			
	REGULATION 517/2002 6<pH<7	PROPOSED LIMIT VALUES		
		5 ≤ pH < 6	6 ≤ pH < 7	pH ≥ 7
Cadmium (Cd)	1 – 3	0.5	1	1.5
Copper (Cu)	50 – 140	20	50	100
Nickel (Ni)	30 – 75	15	50	70
Lead (Pb)	50 – 300	70	70	100
Zinc (Zn)	150 – 300	60	150	200
Mercury (Hg)	1 – 1.5	0.1	0.5	1
Chromium (Cr III)	–	30	60	100

Sampling must be carried out up to a depth of 0.25 m below the soil surface. Where this is difficult, sampling can be carried out for depths up to 0.10 m. A representative sample is that which is prepared by the mixture of 5 samples from different points per hectare. For smaller areas, mixtures must contain samples that have been taken proportionally at 1 sample per hectare.

8.4.4.3. MONITORING OF APPLICATION RATES

The sludge application rates must be in accordance with the recommended limit values for the heavy metal concentrations that can be added annually to soils.

TABLE 8.7: PROPOSED LIMIT VALUES FOR AMOUNTS OF HEAVY METALS WHICH MAY BE ADDED ANNUALLY TO SOIL, BASED ON A TEN YEAR AVERAGE

PARAMETER	LIMIT VALUES (kg/ha/year)	
	REGULATION 517/2002	PROPOSED LIMIT VALUES
Cadmium (Cd)	0.15	0.03
Copper (Cu)	12	3
Nickel (Ni)	3	0.9
Lead (Pb)	15	2.25
Zinc (Zn)	30	7.5
Mercury (Hg)	0.1	0.03
Chromium (Cr III)	–	3

8.4.4.4. MONITORING OF APPLICATION METHODS AND PRACTICES

Regular monitoring is required to ensure that the sludge application practices followed are in accordance to the specifications of the Sludge Management Plan and the Regulations for the Use of Sludge in Agriculture, regarding:

- Crop selection
- Application methods
- Scheduling of application and harvesting

Harvesting following sludge application must follow the following guidelines:

TABLE 8.8: SLUDGE APPLICATION AND HARVESTING GUIDELINES

	ADVANCED TREATMENTS	CONVENTIONAL TREATMENTS
Pastureland	Yes	Yes, deep injection and 6-week no-grazing
Forage crops	Yes	Yes, 6-week no-harvest
Arable land	Yes	Yes, deep injection or immediate ploughing down
Fruit and vegetable crops in contact with the ground	Yes	No. no harvest for 12 moths following application
Fruit and vegetable crops in contact with the ground – eaten raw	Yes	No. no harvest for 30 moths following application
Fruit trees, vineyards, tree plantations and reforestation	Yes	Yes, deep injection and 10-month no-access to the public

8.4.4.5. INFORMATION REQUIREMENTS AND RECORD KEEPING

Records must be kept on the following information requirements:

- The quantity of sludge produced and the quantities supplied for use in agriculture
- The composition and properties of the sludge in relation to the agronomic parameters suggested above
- Results of the analyses of the sludge in relation to the heavy metal content
- Names and addresses of the receivers of sludge
- Location of the plots of land on which the sludge will be applied, their area and the quantities of sludge received for use
- Type of land use, i.e. crops grown
- Results of the analyses of the soil
- Monitoring results in relation to the application rates and practices

8.4.5. MONITORING PROGRAMME FOR THE REUSE OF THE TREATED EFFLUENT

8.4.5.1. MONITORING OF TREATED EFFLUENT QUALITY

The quality of the treated effluent must be regularly monitored to ensure compliance with the set standards. Monitoring must be carried out for the following parameters:

PARAMETER	SUGGESTED FREQUENCY
pH	Weekly
BOD_5	Weekly
COD	Weekly
SS	Daily
Coliform, intestinal worms	Daily
Turbidity	Continuous
Cl_2 residual	Periodic monitoring
Nitrogen, phosphorus	Periodic monitoring
Total Dissolved Solids (TDS)	Periodic monitoring
Heavy Metals	Periodic monitoring

Concentration limits must be according to the suggested design standards for the quality of the treated effluent.

TABLE 8.9: SUGGESTED DISCHARGE STANDARDS FOR THE TREATED EFFLUENT QUALITY

Parameter	Limit Values
BOD_5	10 mg/l
COD	< 125 mg/l
SS	10 mg/l
Total N	15 mg/l
Faecal coliforms	5 units/100 ml (in 80% of the samples) 15 units/100 ml (maximum)
Intestinal worms	Nil
Total P	2 mg/l
Free Chlorine	> 0.5 mg/l and < 2 mg/l

These values must not be exceeded in 80 % of the samples per month (minimum number of samples: 5).

TABLE 8.10: HEAVY METAL CONCENTRATION LIMITS

Metal	Maximum Concentration Limit (mg/l)
Aluminium	5.0
Arsenic	0.1
Beryllium	0.1
Boron	0.75
Cadmium	0.01
Chromium	0.1
Cobalt	0.05
Copper	0.2
Iron	5.0
Lead	5.0
Lithium	2.5
Manganese	0.2
Molybdenum	0.01
Nickel	0.2
Selenium	0.02
Vanadium	0.1
Zinc	2.0
Mercury	0.005

These values must not be exceeded for 75 % of the samples yearly. For the total concentration of metals the following relationship must be valid:

$C_{M1}/L_{M1} + C_{M2}/L_{M2} + \text{--------} + C_{Mi}/L_{Mi} \leq 1,$
where, C_{Mi} is the metal concentration and L_{Mi} the permissible metal concentration limit.

SAMPLING LOCATION

The most representative sample of the treated effluent is from a point where the effluent is thoroughly mixed and close to the outlet from the treatment plant.

8.4.5.2. MONITORING OF SOIL QUALITY

Soil quality must be monitored to ensure that there are no adverse impacts on soil quality and productivity as a result of irrigation with treated effluents.

The soil should be analysed at least every 2 to 3 years, including the initial baseline monitoring for the following parameters:

- ⇨ pH
- ⇨ Electrical conductivity
- ⇨ Exchangeable cations
- ⇨ Total N, P and K
- ⇨ Total cation concentration
- ⇨ Sodium absorption ratio
- ⇨ Heavy metal concentrations

SAMPLING LOCATIONS

The number and location of sampling sites will depend on the distribution of soil types in the area to be irrigated. If there is little variation, 3 to 5 sites may be sufficient for 5 to 10 hectares. More sites will be required for more complex land systems.

8.4.5.3. MONITORING OF IRRIGATION PRACTICES

Monitoring of the irrigation practices followed is recommended to ensure that the appropriate methods are implemented in accordance with the Reuse Management Plan and the Code of Practice.

The irrigation methods applied must be as follows:

TABLE 8.11: MONITORING OF IRRIGATION METHODS

Crop Type	Irrigation Methods
Vines	⇩ Drip irrigation ⇩ Mini sprinklers and sprinklers ⇩ *Movable irrigation systems are not allowed*
Fruit trees	⇩ Drip irrigation ⇩ Hose basin irrigation ⇩ Bubblers irrigation ⇩ Mini sprinklers
Vegetables	⇩ Subsurface irrigation ⇩ Drip irrigation
Vegetables eaten cooked	⇩ Sprinklers ⇩ Subsurface irrigation ⇩ Drip irrigation
Industrial and fodder crops	⇩ Subsurface irrigation ⇩ Bubblers ⇩ Drip irrigation ⇩ Pop-up sprinklers ⇩ Surface irrigation methods ⇩ Low capacity sprinklers ⇩ Spray or sprinkler irrigation with a buffer zone of about 300 m

The timing of irrigation prior to harvesting must also be monitored. As a minimum, the following conditions are suggested for application and harvesting:

- Fodder crops: Irrigation is recommended to stop at least one week before harvesting
- Vines: No crops must be collected from the ground
- Fruit trees: In case where crops are wetted, irrigation must stop one week before harvesting

8.4.5.4. INFORMATION REQUIREMENTS AND RECORD KEEPING

Records must be kept on the following information requirements:

- The quantity of the treated effluent supplied for irrigation
- The plots of land irrigated with the treated effluent
- Type of crops irrigated
- Results of the analyses of the treated effluent
- Monitoring results for soil quality and irrigation management.

8.4.6. MONITORING OF CONSTRUCTION ACTIVITIES

8.4.6.1. IMPORTANCE OF MONITORING CONSTRUCTION ACTIVITIES

Past experience has shown that many construction contractors do not fully understand their obligations with respect to environmental mitigation measures. Most of the time, they do not make adequate provision for the work to be done during bid preparation and they find themselves without sufficient funds to fully implement the mitigation measures. This is unfortunately frequent for the works which come at the end of a project construction and which often concern the rehabilitation of construction or disposal sites.

It is thus of utmost importance that the construction contract includes provisions to ensure:

- The contractor understands clearly environmental mitigation measures and its obligations,
- The mitigation measures are specified in sufficient detail that the contractor can make reasonable estimates of actual costs in its tender document,
- The project management has the legal and financial power to enforce the application of mitigation measures through the contractor.
- The project management has the capability to monitor the contractor's performance in this regard.

Practically this means that to be effective, the EMP must rely on 1) clear contractual dispositions, 2) clear technical environmental specifications and 3) a capable body empowered with legal and technical authority to monitor contractor environmental activities.

Contractual dispositions and technical environmental specifications are major mitigation measures proposed and discussed in the following section.

8.4.6.2. CONTENT AND IMPLEMENTATION OF THE MONITORING

The environmental monitoring of construction activities is at the heart of the effective implementation of the EMP. The objective is to carry a regular and comprehensive review of the actual status of the environmental obligations of the Contractor. This monitoring aims at ensuring compliance of Contractor activities with its contractual commitments and the environmental regulations and standards. It is carried out all along the project construction on a monthly basis

In accordance with the Environmental specifications, monitoring will be carried out for all aspects relevant to the 4 sections of the specifications: Environmental Protection Measures Section, Labour

camps and Worker Health Management Section, Safety Management Section and Social Management Section.

For each section, a *Standard Review Sheet (SRS)* will be prepared at the early beginning of the project. The SRS system should allow 1) a rapid review of the status of all components, 2) an easy way for ranking the level of satisfaction for each group of components, and 3) a formal way to check if requirements expressed to the Contractor the previous month have been given due attention and satisfaction. The results on the review being the approval or not of payments for the concerned issues. For information purpose, some examples of SRS are provided in Appendix 2.

Prior to the start of construction, responsibilities must be assigned by the relevant authorities for the preparation of the environmental specifications for the contractor and organisation of programmes and reviews.

8.4.6.3. SCHEDULE OF ACTIVITIES

TABLE 8.12: SCHEDULE OF ACTIVITIES FOR CONSTRUCTION ACTIVITIES MONITORING

Period	Activities	Comments
PRE-CONSTRUCTION	Recruit personnel	
	Organise training of personnel	Training on EIA standards and formats, training on monitoring construction activities
	Prepare Technical Environmental Specifications for construction activities	To be included in the bidding documentation
	Prepare Standard Review Sheets and working Program	
	Participate to Tender evaluation and contract negotiation with contractor	Review all aspects related to social and environmental matters
CONSTRUCTION	Review with contractor location of borrow areas, disposal sites, camps, temporary access roads	Determine clearly land allocated and ensure compensation is fair and received by affected people.
	Review weekly standard of camps and facilities, of request made to contractor, of implementation of mitigation measures	Impose measures on contractor if required.
	Carry out control analysis if justified	
	Co-ordination of responsible bodies	Co-ordination of all monitoring programs at sub-project level
	Prepare formal notice to Contractor if results do not comply with standards or obligations	All orders or advises to Contractor to be forwarded through the responsible authority. Follow up for effective implementation of corrective action by Contractor, if required.
	Monthly Review	
	Monthly report on monitoring of construction activities	Report based on monthly review plus weekly reports from
	Quarterly report on monitoring of construction activities	Report with conclusions to be submitted to authority
OPERATION	Follow up of sites rehabilitation the first 2-3 years after completion of construction	Reporting of problems to relevant authority

8.5. ENVIRONMENTAL MANAGEMENT ORGANIZATION

The Water Development Department (WDD) will be responsible for the implementation of the mitigation measures required during the construction stage. Responsibility for the operation of the STP and monitoring programmes will be with the Sewage Board that will direct the STP with the assistance of the WDD.

8.6. COST ESTIMATE FOR THE EMP

ITEM	ANNUAL BUDGET (CYP)	5 YEAR BUDGET (CYP)	RESPONSIBILITY EXECUTION
INVESTMENTS	(Year 1 only)		
Creation of Internet Site	15,000	15,000	WDD/Consultant
Technical Assistance to WDD	20,000	20,000	WDD/Consultant
Communication campaign	15,000	15,000	WDD/Consultant
Land Acquisition & Compensation (1)	1,820,000	1,820,000	WDD
SUB-TOTAL	*1,870,000*	*1,870,000*	
OPERATION EXPENSES			
Environmental Manager (WDD)	20,000	100,000	WDD
Environmental Supervisor (CSE)	18,000	90,000	CSE
Budget for Ad Hoc expertise	10,000	50,000	WDD/Consultant
Budget for Construction EMP(2)	120,000	600,000	Contractor
Construction Monitoring			
Water Quality	2,400	12,000	WDD/Consultant
Air Quality & Noise	2,000	10,000	WDD/Consultant
Operation Monitoring			
Water Quality	1,000	-	ES
Air Quality & Noise	1,000	-	ES
Sludge Quality	1,000		WDD/SB
Treated Effluent Quality	1,000		WDD/SB
SUB-TOTAL	*176400*	*862,000*	
TOTAL COST	*2,046,400*	*2,732,000*	

9. PUBLIC CONSULTATION

Consultations were carried out with the relevant authorities, including:

- ⇨ Water Development Department
- ⇨ The Environment Service
- ⇨ The Town and Country Planning Department

Consultations took place at the feasibility stage, when the STP site was to be selected, which included site visits. The recommendations made by the authorities were taken into consideration in the final decision over the proposed site. These recommendations are included in Appendix 13.

Consultations with the local authorities were also carried out. The local authorities were consulted during the initial stage of site selection. Following the preliminary evaluation of the sites, and submission of the feasibility study two presentations were made to the representatives of the community councils, one for the villages of the proposed Larnaca scheme, namely Aradippou, Livadia, Dromolaxia, Kiti, Perivolia and Meneou; and the other for the village of Athienou which will have its own separate STP. Representatives of the Larnaca Sewerage Board also participated in the first presentation, since four of the villages will be connected to the existing Larnaca STP . The feasibility study was presented to members of the local councils, including the proposed schemes and alternative sites for the sewage treatment plants. The views of the communities were included in the evaluation of the alternative sites, whereby in the case of Athienou, alternative site 4(c) was included in the assessment as requested by the council, and for Aradippou Site B was included for construction of the STP and the emergency storage reservoir.

APPENDIX 14

SITE PICTURES

APPENDIX 10

ALTERNATIVE PROJECT SCHEMES

APPENDIX 11

ENVIRONMENTAL SCREENING OF ALTERNATIVES

APPENDIX 13

CONSULTATION LETTERS

APPENDIX 1

STANDARDS IN CYPRUS AND EU

STANDARDS FOR DISCHARGE OR REUSE OF TREATED EFFLUENT, LAW 106(I)/2002 ON THE CONTROL OF WATER AND SOIL POLLUTION

CODE OF PRACTICE FOR THE USE OF TREATED WASTEWATER IN IRRIGATION

A Sewage Effluent Technical Committee Cyprus has developed draft regulation concerning the reuse of wastewater effluents in the irrigation of crops for human consumption, of fodder crops, industrial crops and amenity areas. These regulations are presented in Table A1.1.

TABLE A1.1: CYPRUS STANDARDS FOR URBAN TREATED EFFLUENT USED FOR IRRIGATION

IRRIGATION OF	BOD_5 (mg/l)	SS (mg/l)	FAECAL COLIFORMS / 100 ml	INTESTINAL WORMS/L	TREATMENT REQUIRED
All crops	(A) 10*	10*	5* 15**	Nil	Secondary and Tertiary and disinfection
Amenity areas of unlimited access and vegetables eaten cooked	10* 15*	10* 15**	50* 100**	Nil	Secondary and Tertiary and disinfection
Crops for human consumption Amenity areas of limited access	20* 30*	30* 45**	200* 1000**	Ni	Secondary and storage > 7 days and disinfection or Tertiary and disinfection
Fodder crops	– 20* 30*	– 30* 45**	200* 1000** 1000* 5000*	Nil Nil	Stabilisation – maturation ponds total retention time > 30 days or Secondary and storage > 30 days
	–	–	5000**	Nil	Stabilisation – maturation ponds total retention time > 30 days or Secondary and storage > 30 days
Industrial crops	50* 70*	–	3000* 10000**	-	Secondary and disinfection
	–	–	3000** 10000*	-	Stabilisation – maturation ponds total retention time > 30 days or Secondary and storage > 30 days

A: Mechanised methods of treatment (activated sludge, etc.)

B: Stabilisation ponds

*: These values must not be exceeded in 80 % of samples per month

**: Maximum value allowed

COD < 125 mg/l

For the purpose of this project, the category corresponding to unrestricted irrigation (all crops) has been assumed. The WDD would thus have the flexibility to reuse the wastewater for any purpose. Furthermore, it is understood that most of the treated wastewater reuse currently practiced in Cyprus

is for irrigation of hotel lawns and gardens and golf courses, for which a high quality effluent is required.

TABLE A1.2: CONTROL OF METALS
METAL CONCENTRATION LIMITS FOR THE TREATED WATER FOR PURPOSES OF CONTINUOUS IRRIGATION

METAL	CONCENTRATION, mg/l
Aluminium	5.0
Arsenic	0.1
Beryllium	0.1
Boron	0.75
Cadmium	0.01
Chromium	0.1
Cobalt	0.05
Copper	0.2
Iron	5.0
Lead	5.0
Lithium	2.5
Manganese	0.2
Molybdenum	0.01
Nickel	0.2
Selenium	0.02
Vanadium	0.1
Zinc	2.0
Mercury	0.005

For the total concentration of metals, the following relationship must be valid:

$$\frac{C_{M1}}{L_{M1}} + \frac{C_{M2}}{L_{M2}} + \text{- - - -} + \frac{C_{Mi}}{L_{Mi}} \leq 1$$

Where, C_{Mi} = the metal concentration and
L_{Mi} = the permissible metal concentration limit

The values must not be exceeded for 75% of the samples yearly.

The sewage treatment and disinfection must be kept and maintained continuously in satisfactory and effective operation so long as treated sewage effluent are intended for irrigation, and according to the license that will be issued under the existing legislation.

Skilled operators should be employed to attend the treatment plant, following formal approval by the appropriate authority that the persons are competent to perform the required duties, necessary to ensure that the above conditions are satisfied.

The treatment and disinfection plant must be attended every day according to the programme issued by the Authority and records to be kept of all operations performed according to the instructions of the appropriate Authority. A copy must be kept for easy access within the treatment facilities.

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

No cross connections with any pipeline or works conveying potable water, is allowed. All pipelines conveying sewage effluent must be satisfactorily marked with red tape so as to distinguish them

from domestic water supply. In unavoidable cases where sewage/effluent and domestic water pipes must be laid close to each other the sewage pipes should be buried at least 0.5 m below the domestic water pipes.

Irrigation methods allowed and conditions of application differ between plantations as follows:

- *Park lawns and ornamental in amenity areas of unlimited access*
  - Subsurface irrigation methods
  - Drip irrigation
  - Pop-up, low pressure and high precipitation rate, low angle sprinklers (less than 11 degrees). Sprinkling preferably to be practiced at night and when people are not around.

- *Park lawns and ornamental in areas of limited access, industrial and fodder crops*
  - Subsurface irrigation
  - Bubblers
  - Drip irrigation
  - Pop-up sprinklers
  - Surface irrigation methods
  - Low capacity sprinklers
  - Spray or sprinkler irrigation is allowed with a buffer zone of about 300 m

  For fodder crops, irrigation is recommended to stop at least one week before harvesting and no milking animals should be allowed to graze on pastures irrigated with sewage. Veterinary Services should be informed.

- *Vines*
  - Drip irrigation
  - Minisprinklers and sprinklers (in case where crops get wetted, irrigation should stop two weeks before harvesting)
  - Movable irrigation systems are not allowed
  - No crops should be selected from the ground

- Fruit trees
  - Drip irrigation
  - Hose basin irrigation
  - Bubblers irrigation
  - Mini sprinklers

  No fruits to be collected from the ground except for nut trees. In case where crops are wetted, irrigation should stop one week before harvesting.

- *Vegetables*
  - Subsurface irrigation
  - Drip irrigation

  Crops must not come in contact with the ground or the effluents (only vegetables which are supported).

  Other irrigation methods could also be considered.

- *Vegetable eaten cooked*
  - Sprinklers
  - Subsurface irrigation
  - Drip irrigation

Other irrigation methods may be allowed after the approval of the appropriate Authority. Restrictions may be posed to any method of irrigation by the appropriate authority in order to protect public health or environment.

The following tertiary treatment methods are acceptable:

- Coagulation plus flocculation followed by Rapid Sand Filtration

- Slow Sand Filters
- Any other method, which may secure the total removal of helminth ova and reduce faecal coliforms to acceptable levels. Must be approved by the appropriate authority.

Appropriate disinfection methods must be applied when sewage effluent are to be used for irrigation. In the case of chlorination the total level of free chlorine in the effluent at the outlet of the chlorination tank, after an hour of contact time should be at least 0.5 mg/l and not greater than 2 mg/l.

Suitable facilities for monitoring the essential quality parameters should be kept on the site of treatment.

CODE OF PRACTICE FOR THE DISPOSAL OF TREATED SEWAGE WATER IN SURFACE WATERS

The disposal of treated water in the water bodies mentioned below only if any other method of disposal is practically impossible or excessively costly and provided it does not create any dangers to public health and following an environmental study.

The recycled water must have the quality specified in the specifications for the purposes of irrigation of all cultivations. (BAO_5 < 10mg/l, SS < 10mg/l, Faecal Coliform < 5/100ml, eggs of intestinal parasites = none.)

Also there will be toxicity tests and control according to Appendix E1 and control for the concentration of heavy metals according to Appendix A1.

In case of disposal of recycled water in sensitive water bodies it is imposed that (total) nitrogen concentrations in the recycled water must not exceed 10mg/l.

For the disposal of recycled water from treatment plants with equivalent population above 100 000 the phosphorus concentration in the recycled water must not exceed 1mg/l, while from plants with equivalent population between 10 000 – 100 000 the concentration must not exceed 2mg/l. Alternatively a minimum reduction (phosphorus) of 80% must be achieved during treatment.

The disposals must stop in cases where eutrophication appears.

IN RIVERS/STREAMS ACCORDING TO THE FOLLOWING CONDITIONS:

- Disposal is not allowed in rivers/streams that are directly related to water supply sources.
- In cases of disposal in rivers/streams that are indirectly related to sources of water supply there must be no possibility of contamination/pollution.
- In no case must the disposal rate for the recycled water exceed 10% of the river/stream flow at the moment of disposal. The percentage will be smaller if other disposals are being carried out, depending on distances and the natural purification capacity of the water.

DAMS/BARRAGES ACCORDING TO THE FOLLOWING CONDITIONS:

- Under no circumstances will the direct disposal of recycled water of any degree of treatment be allowed in dams/barrages where the water is used for water supply purposes. However, such a disposal can be examined in the case of rivers/streams which end up in sources of water supply if the disposal is carried out at a distance of at least 10km from them.
- In dams/barrages that are used only for irrigation purposes. The total daily volume of disposals of recycled water must not exceed 5% of the stored volume during the time of disposal. Also, denitrification must be carried out (total nitrogen < 15mg/l) and the phosphorus must be observed.

- In rivers/streams, dams/barrages where there are fish or where there is aquaculture the disposals must be such so as to ensure the water quality as it is defined by the EU directive 78/659/EEC.

IN NATURAL LAKES/WETLANDS ACCORDING TO THE FOLLOWING CONDITIONS:

- The disposal in rivers and wetlands is not permitted.

Relaxations of these terms may be granted if with the relaxations public health is not endangered and under the condition that the environmental impact assessment will indicate that any negative environmental impacts will be marginal.

CODE OF PRACTICE FOR THE USE OF SLUDGE FROM THE TREATMENT OF SEWAGE FOR AGRICULTURAL PURPOSES

- The installations for the treatment of sludge that is expected to be used or made available according to the license or licenses issued from the Competent Authority must continuously operate to a satisfactory level.

- The storage area for the treated sludge must be such so as not to create any danger to public health or environmental problems including the danger of underground or surface water resources.

- The quality of the sludge must be monitored according to the programme approved by the Competent Authority.

- The sludge treatment installations must be supervised and kept at a satisfactory level of operation by suitably qualified staff approved by the Competent Authority.

- The following sludge treatment methods are acceptable:
  - Anaerobic digestion
  - Mesofile
  - Regular
  - Aerobic digestion
  - Heat treatment
  - Deposition in shallow reservoirs for a period of two years
  - Sludge stabilization and use of lime (CaO)
  - Sludge stabilization after a complete biological cleaning or extended aeration
  - Drying in specially designed areas
  - Storage of sludge for a year
  - Any other method which will be approved by the Competent Authority and through which the quality standards for the use of sludge can be ensured.

- The rate and quantity of sludge deposition on the soil for agricultural purposes will depend on the quality of the sludge, the type of soil and cultivation and the time period for the deposition.

- The use of sludge is not recommended for the following cases:
  - In areas where it is possible to cause impacts on, or the degradation of, the quality of surface waters (dams, water sources, rivers, etc.).
  - In areas where it is possible to cause impacts on, the degradation of, the quality of underground water bodies (e.g. underground water beds).

  - The use of sludge is forbidden in the following cases:
  - In places of pasture or in the cases where stock-breeding plants are cultivated and will be harvested in less than three weeks from the time of the sludge deposition.

- On soil where the cultivation of fruits and vegetables is in process with the exception of fruit-bearing trees.
- On soil where there is intention to cultivate fruit and vegetables which will be in direct contact with the soil and are usually eaten raw unless the sludge is deposited at least 12 months prior harvesting the cultivations.
- On grass, unless the sludge is deposited at least 12 months before its use.

- For monitoring the use of sludge for agricultural purposes the following programme of analysis is defined:

  - ANALYSES OF SLUDGE: The sludge must be analyzed every 6 months. In cases where change is observed in the quality of the sewage the frequency of the analyses will need to be adjusted accordingly. If the analyses results do not differ significantly during the period of one whole year, the sludge can be analyzed at least every 12 months.

    Analyses must be carried out for the following parameters:
    - Dry matter, organic matter
    - pH
    - nitrogen, phosphorus
    - cadmium, copper, nickel, lead, zinc, mercury and chromium (Table A1.3)

  - SOIL ANALYSIS: the frequency of the analyses will depend on the initial condition of the soil and its heavy metal content which will be verified before the use of sludge begins, as well as the quality and heavy metal content of the sludge and the frequency of sludge deposition and other relevant influencing factors.

    The analyses frequency will be decided taking into consideration the metal concentration in the soil before the use of the sludge, the quantity and composition of the sludge to be used, as well as other relevant influencing factors.

    Analyses must be carried out for the following parameters:
    - pH
    - cadmium, copper, nickel, lead, zinc, mercury and chromium (Table A1.4)

    The maximum permissible heavy metal content of the soil is shown in Table 2 and the maximum permissible quantity that can be deposited every year on agricultural land is shown in Table A1.5.

- The following sampling methods are acceptable:
  - FOR THE SOIL: Sampling must be carried out up to a depth of 0.25 m bellow the soil surface. Where this is difficult, sampling can be carried out for depths up to 0.10 m. A representative sample is that which is prepared by the mixture of 5 samples from different points per hectare. For smaller areas mixtures will contain samples that have been taken proportionally at 1 sample per hectare.
  - FOR THE SLUDGE: The samples must be representative and sampling must be carried out after the treatment of the sludge and before its delivery to the user.

- Methods of analysis: The analyses for the heavy metals must be carried out after digestion with the use of strong oxidizing acids. The method of reference is that of atomic absorption (AAS) and the detection level for each metal must not be greater than 10% of the corresponding level value.

- For the purposes of correct management, analyses of the sludge and soil are considered useful for the following elements:
  - Nitrogen (N)
  - Phosphorus (P)
  - Potassium (K)
  - Sodium (Na)
  - Calcium (Ca)
  - Manganese (Mg)

- ⇨ Iron (Fe)
- ⇨ Boron (B)

TABLE A1.3: MAXIMUM PERMISSIBLE HEAVY METAL CONTENT IN THE SLUDGE (MG/KG OF DRY MATTER)

PARAMETERS	MAXIMUM VALUE (MG/KG)
Cadmium (Cd)	40
Copper (Cu)	1750
Nickel (Ni)	400
Lead (Pb)	1200
Zinc (Zn)	4000
Mercury (Hg)	25
Chromium (Cr III)	1000

TABLE A1.4: MAXIMUM PERMISSIBLE HEAVY METAL CONTENT IN THE SOIL (MG/KG OF DRY MATTER)

PARAMETERS	MAXIMUM VALUE (MG/KG)
Cadmium (Cd)	3
Copper (Cu)	140
Nickel (Ni)	75
Lead (Pb)	300
Zinc (Zn)	300
Mercury (Hg)	1.5
Chromium (Cr III)	150

TABLE A1.5: MAXIMUM PERMISSIBLE QUANTITY OF HEAVY METALS THAT CAN BE ADDED EVERY YEAR ON AGRICULTURAL LAND, BASED ON A TEN YEAR AVERAGE (KG/HA/YR)

PARAMETERS	MAXIMUM VALUE (MG/KG)
Cadmium (Cd)	0.15
Copper (Cu)	12
Nickel (Ni)	3
Lead (Pb)	15
Zinc (Zn)	30
Mercury (Hg)	0.1
Chromium (Cr III)	-

TABLE A1.6: TOXICITY CONTROL, TESTS AND TOXICITY LIMITS FOR THE DISPOSAL OF TREATED SEWAGE WATER IN WATER BODIES

TESTS	DISPOSAL IN STREAMS[1]	DISPOSAL IN DAMS AND LAKES[1]
Acute Toxicity Microtox: organism Photobacterium phosphorium (Vibrio fischeri) Algaltox 72 hours: organism Selenastrum capricornutum Daphtox: organism Daphnia magna Straus	Applicable	Applicable

Gene Toxicity 1 Mutatox with and without activation with hepatic enzymes S9: organism Photobacterium phosphorium (Vibrio fischeri) Acceptable Limits The results and the limits are expressed in Toxic Units TU*	Not requested In accordance with the term that the maximum daily disposal < or equal to 10% of the running water and provided that the streams are not directly related to irrigation the 75% of the samples will have to be consistent with the following limits fro acute toxicity: Microtox: TU50 ≤ 1 or/and TU20 ≤ 1.5 Daphnia: TU50 ≤ 1 Algae: TU50 ≤ 1	Applicable In accordance with the term that the maximum daily disposal < or equal to 3% of the stored water and provided that the water will not be used for irrigation the 75% pf samples will have to be consistent with the following limits for acute toxicity: Microtox: TU50 ≤ 1 or/and TU20 ≤ 1.5 Daphnia: TU50 ≤ 1 Algae: TU50 ≤ 1 Mutatox: The treated waste must not be positive in the direct or following the activation with S9 Mutatox test

1. The acute toxicity control is carried out 4 times a year and the control at least once a year. If it is confirmed that the waste because of its quality and in conjunction with the quality or dilution does not have a reasonable potential a) to be toxic and b) its specific use to contribute directly or indirectly to the degradation of the receivers and the environment, then the control for toxicity could be restricted appropriately.
2. TU50, TU20: toxic units for 50% and 20% influence of the organism under trial or the equivalent biological action.

DISCHARGE STANDARDS ACCORDING TO THE EU DIRECTIVE 91/271/EEC

The EU Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment sets the following standards for wastewater that shall be discharged to the receiving waters:

TABLE A1.7: DISCHARGE STANDARDS ACCORDING TO THE EU DIRECTIVE

PARAMETER	VALUE
BOD_5	25 mg/l
COD	90 mg/l
SS	35 mg/l

For discharge to sensitive water bodies, the following additional limits shall apply:

TABLE A1.8: ADDITIONAL DISCHARGE STANDARDS ACCORDING TO THE EU DIRECTIVE FOR DISCHARGE TO SENSIBLE WATER BODIES

PARAMETER	VALUE
Total-N	15 mg/l N (10,000 to 100,000 PE) 10 mg/l N (> 100,000 PE)
Total-P	2 mg/l (10,000 to 100,000 PE) 1 mg/l (> 100000 PE)

In the case that the treated wastewater could not be reused, a possibility for discharge should be provided. The discharge point would in most cases be into a small, non permanent, water course in the vicinity of the treatment plant. Since these water courses most often are dry, they should be considered as sensible areas according to the EU directive and the additional standards in should apply.

APPENDIX 4

PROJECT IMPLEMENTATION PROGRAMME

APPENDIX 8

SLUDGE COMPOSITION AND QUALITY

Sewage sludge contains several plant macronutrients, principally nitrogen (N) and phosphorus (P), and, in most cases, varying amounts of micronutrients, such as boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn), making its use relevant as an organic fertiliser. However, since at high concentrations several of these components, and in particular the heavy metals and organic chemicals, as well as the pathogens present in sludge could be toxic, the use of sludge in agriculture should be carried out following the procedures set out in the Code of Practice for the Use of Sludge for Agricultural Purposes, and regularly monitored, including the monitoring of sludge and soil quality, to ensure that no adverse impacts result from improper practices and insufficient sludge treatment.

The composition of the untreated sludge will depend on the sewage treatment process. Typical compositions are given in Tables A8.1 and A8.2.

TABLE A8.1: IMPACT OF TREATMENT ON THE SEWAGE SLUDGE COMPOSITION AND PROPERTIES

		A	B1	B2	C	D
Dry matter (DM)	**g/L**	12	9	7	10	30
Volatile matter (VM)	**%DM**	65	67	77	72	50
pH		6	7	7	6,5	7
C	**% VM**	51,5	52,5	53	51	49
H	**% VM**	7	6	6,7	7,4	7,7
O	**% VM**	35,5	33	33	33	35
N	**% VM**	4,5	7,5	6,3	7,1	6,2
S	**% VM**	1,5	1	1	1,5	2,1
C/N	**-**	11,4	7	8,7	7,2	7,9
P	**% DM**	2	2	2	2	2
Cl	**% DM**	0,8	0,8	0,8	0,8	0,8
K	**% DM**	0,3	0,3	0,3	0,3	0,3
Al	**% DM**	0,2	0,2	0,2	0,2	0,2
Ca	**% DM**	10	10	10	10	10
Fe	**% DM**	2	2	2	2	2
Mg	**% DM**	0,6	0,6	0,6	0,6	0,6
Fat	**% DM**	18	8	10	14	10
Protein	**% DM**	24	36	34	30	18
Fibres	**% DM**	16	7	10	13	10
Calorific value	**kWh/t DM**	4 200	4 100	4 800	4 600	3 000

A	Primary sludge
B1	Biological sludge (low load)
B2	Biological sludge from clarified water (low and middle load)
C	Mixed sludge (A and B2 types)
D	Digested sludge

TABLE A8.2: PHYSICOCHEMICAL CHARACTERISTICS OF SEWAGE SLUDGES

PARAMETER		ANAEROBIC SLUDGE		AEROBIC SLUDGE	
		MEAN	STD	MEAN	STD
Dry matter	%	20.29	8.18	22.12	12.39
Humidity	%	79.71	8.18	77.15	12.73
Ash	%	40.22	11.97	45.22	8.41
Organic matter	%	59.85	11.97	55.05	8.11
Organic C	%	30.4	7.56	26.57	3.92
Total N	%	4.08	1.58	3.21	1.13
Total P	%	0.9	0.51	2.08	1.39
Total K	%	0.39	0.21	0.37	0.12
pH		7.42	0.41	7.1	0.66
Cd	mg/kg	2.52	2.07	3.86	5.06
Total Cr	mg/kg	414.57	355.27	113.58	76.27

PARAMETER		ANAEROBIC SLUDGE		AEROBIC SLUDGE	
		MEAN	STD	MEAN	STD
Hg	mg/kg	21.69	29.98	0.98	0.5
Ni	mg/kg	164.04	248.18	76.02	50
Pb	mg/kg	196.53	80.44	221.11	114.68
Cu	mg/kg	414.18	350.49	367.09	201.23
Zn	mg/kg	1619.92	887.04	1228.48	576.77
As	mg/kg	2.82	2.15	6.51	10.19
Se	mg/kg			0.92	0.7
B	mg/kg			51.48	51.05

The average sludge composition in Cyprus is given below.

TABLE A8.3: AVERAGE SLUDGE COMPOSITION IN CYPRUS

	CYPRUS
Date	1995 – 1999
Dry Matter (%)	22 – 73
Organic Matter (% DM)	67 – 72
N % DM	3.75 – 4.53
P % DM	1.97 – 2.27
K % DM	0.25 – 0.26
mg/kg DM	
Cd	1.85 – 3.5
Cr	22 – 133
Cu	129 – 202
Hg	0.4
Ni	30 – 32
Pb	44 – 70
Zn	659 – 1173
nb/g wm	
Enteric virus	4.3×10^4/100g
Viable Helminth eggs	0

The sludge characteristics for the Limassol Sewage Treatment Plant are given below.

TABLE A8.4: LIMASSOL SEWAGE TREATMENT PLANT: SLUDGE CHARACTERISTICS

PARAMETER	
Nitrogen %	1.4
Phosphorus %	0.2
Potassium %	2.5
O.M. %	72
Sodium %	0.14
Boron (B), mg/l	31
Zinc (Zn), mg/l	605
Copper (Cu), mg/l	128
Cadmium (Cd), mg/l	3
Nickel (Ni), mg/l	17
Lead (Pb), mg/l	28
Chromium (Cr III), mg/l	22

SEWAGE SLUDGE COMPONENTS

❑ pH

The pH of sewage sludge can affect crop production at land application sites by altering the pH of the soil and influencing the uptake of metals by soil and plants. Low pH sludge (< 6.5) promotes leaching of heavy metals, while high pH sludge (> 11) kills many bacteria and, in conjunction with soils of neutral or high pH, can prohibit movement of heavy metals through the soils.

❑ ORGANIC MATTER

The relatively high level of organic matter in sewage sludge allows it to be used for soil improvement, including the improvement of the physical properties of soil, such as structure; the retention capacity of minerals and water; the soil bearing strength; and the reduction of the potential for surface runoff and water erosion.

The table below compares the content of organic matter of different types of sludge and other wastes that have been used as fertilisers.

TABLE A8.5: CONTENT OF ORGANIC MATTER IN SLUDGE AFTER DIFFERENT TREATMENTS AND IN OTHER URBAN WASTE AND ANIMAL MANURE

	Organic Matter Content (% of DM)
URBAN SLUDGE	
Aerobic digestion	60 – 70
Anaerobic digestion	40 – 50
Thermal treatment	< 40
Lime treatment	< 40
Composting	50 – 85
URBAN COMPOST	40 – 60
ANIMAL MANURE	45 – 85

❑ NUTRIENTS

Nutrients present in sewage sludge, such as nitrogen (N), phosphorus (P) and potassium (K), are essential for plant growth. Nutrient levels are key determinants of sludge application rates, as excessive levels due to high application rates may result in groundwater or surface water pollution. The proportion of phosphorus and nitrogen in sewage sludge is given in Table A8.6.

TABLE A8.6: CONTENT OF NITROGEN AND PHOSPHORUS IN SLUDGE AFTER DIFFERENT TREATMENTS AND IN OTHER URBAN WASTE AND ANIMAL MANURE

	Total N % OF DM	$N - NH_4$ % OF N TOTAL	P % OF DM
URBAN SLUDGE			0.9 – 5.2
Liquid	1 – 7	2 – 70	
Semi-solid	2 – 5	< 10	
Solid	1 – 3.5	< 10	
Composted	1.5 – 3	10 – 20	0.2 – 1.5
URBAN COMPOST	0.96		0.39
LITTER	2.2 – 4.4	10	0.61 – 1.61
MANURE	4 – 7	50 – 70	0.91 – 3.3

⇩ Nitrogen

Nitrogen is mostly found under organic form in sludge, and to a lesser extent under ammoniac form. As plants can assimilate only mineral nitrogen, the agricultural value of the sludge is also determined by the aptitude of its organic N to be mineralised. Loss of nitrogen may also result from volatilisation of the ammoniac, or if nitrates are leached. This may represent a risk of groundwater pollution and can occur when the amount of sludge applied is in the excess of the plant needs in nutrients or because of the fast degradation of sludge-borne organic matter which could give rise to a peak of nutrient in the soil. Table A8.8 gives the nitrogen availability of different sludge types.

TABLE A8.7: INFLUENCE OF TREATMENT ON THE NITROGEN CONTENT OF SOME SEWAGE SLUDGE

	Total N (% of DM)	$N\text{-}NH_4^+$ (% of total N)
LIQUID SLUDGE		
Aerobic digestion, gravity thickening	5 – 7	5 – 10
Aerobic digestion, mechanical thickening	4 – 7	2 – 8
Anaerobic digestion	1 – 7	20 – 70
Lagooning	1 – 2	N/A
SEMI-SOLID SLUDGE		
Aerobic digestion, mechanical dewatering	3 – 5.5	< 5
Anaerobic digestion, mechanical dewatering	1.5 – 3	< 5
Lime treatment	3.4 – 5	< 10
SOLID SLUDGE		
Aerobic digestion, lime treatment	2.5	< 10
Composted	1.5 – 3	10 – 20
Aerobic, dewatered on drying beds	2 – 3.5	< 10
Anaerobic, dewatered on drying beds	1.5 – 2.5	< 10
DRIED SLUDGE	3.5 – 6	10 – 15

TABLE A8.8: NITROGEN AVAILABILITY ACCORDING TO LABORATORY TESTS

SLUDGE TYPE	AVAILABILITY (%)
Aerobic digested sludge	24 – 61 %
Anaerobic digested sludge	4 – 48 %
Digested composted sludge	7 %
Composted raw sludge	4 %
Thermally dried sludge	7 – 34 %

⇩ Phosphorus

Phosphorus is used by the plants for growth, cell wall rigidity and the development of root systems. Sludge-borne phosphorus is of particular value as phosphorus is a limited natural resource. Phosphorus in sludge is mostly present under mineral form.

TABLE A8.9: INFLUENCE OF TREATMENT ON THE PHOSPHORUS CONTENT OF SEWAGE SLUDGE

	P_2O_5 (% of DM)	P (% of DM)
Liquid sludge: aerobic digestion	4.9 – 6.9	2.1 – 3
Aerobic digestion	2.5 – 12.65	1.1 – 5.5
Primary sludge, lime treated	2.5 – 12	1.1 – 5.2

⇩ Other Compounds

Other compounds present in sludge, such as potassium, sulphur, magnesium and sodium, may also be of interest in crop production, however, they are present in sludge under various forms and their efficiency will depend on their availability.

❑ HEAVY METALS

Sewage sludge may contain varying amounts of heavy metals, some of which are nutrients needed for plant growth. However, at high concentrations they may be toxic to plants, animals and humans, affecting plant health and growth, soil properties and microorganisms, livestock and human health, and accumulate in the environment. The average content of 7 heavy metals in the member states is given below.

TABLE A8.10: AVERAGE CONTENT IN SEWAGE SLUDGE OF 7 HEAVY METALS IN THE MEMBER STATES

	Directive 86/278/EEC MG/KG DM	Range in the Member States MG/KG DM
Cd	20 – 40	0.4 – 3.8
Cr	1 000 – 1 750	16 – 275
Cu	1 000 – 1 750	39 – 641
Hg	16 – 25	0.3 – 3
Ni	300 – 400	9 – 90
Pb	750 – 1 200	13 – 221
Zn	2 500 – 4 000	142 – 2 000

❑ ORGANIC POLLUTANTS

A wide variety of organic chemicals with diverse physical and chemical properties may be present in sewage sludge. However, most sludge contains low levels of these chemicals and does not pose a significant risk on humans or the environment.

❑ PATHOGENS

Stabilisation greatly reduces the number of pathogens in sewage sludge, including bacteria, parasites, protozoa and viruses, together with odour potential. However, even stabilised sludge will usually contain some pathogens. Following land application, generally none of these microorganisms will leach through the soil system to pollute the receiving groundwaters. Where surface runoff occurs though, buffers should be used to filter out pathogens and prevent entry into the receiving water bodies.

APPENDIX 15

REFERENCES

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5. Census of Agriculture 1994, Department of Statistics and Research, Ministry of Finance
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7. The Assessment of Water Demand of Cyprus, Ministry of Agriculture, Natural Resources and the Environment, FAO, 2001

APPENDIX 12

DRAWINGS

APPENDIX 16

OPINION OF THE PUBLIC AUTHORITY

APPENDIX 2

WATER PRODUCTION

APPENDIX 3

PUMPING STATIONS

TABLE A3.1: PUMPING STATIONS

LOCATION		HEAD (m)	FLOW (l/s)	INSTALLED POWER (kW)	ANNUAL ENERGY CONSUMPTION (kWh)
	URBAN/RURAL/GOV				
PS Meneou	U	7.0	46.7	4.9	30 682
PS Perivolia	U	23.0	37.3	12.9	80 520
PS Aradippou	U	16.0	38.0	9.1	57 065
PS Livadia	U	40.0	19.0	11.4	71 331

TABLE A3.2: GRAVITY CONVEYORS

LOCATION		PIPE	QUANTITY (m)
	URBAN/RURAL/GOV	DIAMETER (mm)	
Kiti – Meneou	U	250	2 300
Dromolaxia – Meneou	U	350	1 060
Meneou – PS Meneou	U	400	1 900
Conn. B – STP Larnaca	U	600	4 350
Livadia – PS Livadia	U	250	700
		TOTAL	10 310

TABLE A3.3: PUMPING MAINS

LOCATION		PIPE	QUANTITY
	URBAN/RURAL/GOV	DIAMETER (MM)	
PS Meneou – conn.B	U	250	900
PS Perivolia – conn. B	U	250	4 500
PS Aradippou – STP Aradippou	U	250	2 600
PS Livadia – STP Aradippou	U	250	2 600
		TOTAL	10 600

APPENDIX 5

CLIMATIC DATA

CLIMATIC DATA: LARNACA AREA

TABLE A5.1: MEAN TEMPERATURES FOR THE LARNACA REGION, 1961 – 1990

Month	Maximum (°C)	Minimum (°C)	Average (°C)
January	16.4	7.6	12.0
February	16.8	7.6	12.2
March	18.9	9.1	14.0
April	22.6	12.0	17.3
May	26.1	15.5	20.8
June	30.3	19.5	24.9
July	32.7	22.2	27.5
August	32.9	22.2	27.6
September	30.8	20.1	25.5
October	27.2	16.9	22.1
November	22.5	12.8	17.7
December	18.2	9.3	13.8
ANNUALLY	**24.6**	**14.6**	**19.6**

TABLE A5.2: AVERAGE NUMBER OF RAIN DAYS (RD) AND WET DAYS (WD), 1961 – 1990: LARNACA AIRPORT STATION

	Rain Days, MM (≥ 0.2 MM of rain)	Wet Days, MM (≥ 1.0 MM of rain)
January	10	8
February	9	7
March	7	6
April	4	3
May	2	2
June	<1	<1
July	0	0
August	<1	<1
September	1	<1
October	3	2
November	5	4
December	10	8
TOTAL	**51**	**40**

TABLE A5.3: MEAN RELATIVE HUMIDITY (RH) AT 08:00HRS LST, 1961 – 1990 : LARNACA AREA

Month	Mean RH at 08:00 hrs LST (%)
January	77
February	76
March	71

Month	Mean RH at 08:00 hrs LST (%)
April	65
May	64
June	66
July	67
August	64
September	61
October	52
November	71
December	77

TABLE A5.4: CLIMATOLOGICAL DATA 1981 – 1990: LARNACA AIRPORT STATION

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE													
Mean Monthly Maximum Temperature (C)	18.9	20.0	22.7	28.7	33.4	35.0	36.4	36.2	34.8	30.8	26.0	21.6	28.7
Mean Monthly Minimum Temperature (C)	2.2	2.5	2.9	7.3	10.1	14.9	18.4	18.1	16.1	11.4	6.5	3.5	9.5
Mean Monthly Temperature (C)	10.6	11.3	12.8	18.0	21.8	25.0	27.4	27.2	25.5	21.1	16.3	12.6	19.1
Mean Daily Temperature	11.9	11.7	13.3	17.2	20.4	24.0	26.6	26.9	24.9	21.3	16.6	13.4	19.0
Extreme Monthly Maximum Temperature	19.9	21.1	24.9	31.9	37.7	37.8	39.7	38.0	37.0	33.6	29.1	23.7	–
Extreme Monthly Minimum Temperature	-0.6	-0.9	-1.0	4.9	8.5	12.8	16.3	16.8	13.2	8.0	1.9	1.5	–
PRECIPITATION													
Actual Precipitation (mm) (1961-1990)	68.0	58.0	39.0	18.0	9.0	2.0	0.0	1.0	2.0	19.0	42.0	86.0	344.0
RELATIVE HUMIDITY (RH)													
Mean RH at 08:00 hrs LST (%)	83.0	80.0	76.0	64.0	60.0	62.0	65.0	63.0	61.0	63.0	74.0	80.0	69.0
Mean RH at 13:00 hrs LST (%)	59.0	59.0	57.0	54.0	55.0	55.0	56.0	52.0	51.0	51.0	54.0	57.0	55.0

TABLE A5.5: CLIMATOLOGICAL DATA 1991 – 2000: LARNACA AIRPORT STATION

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE													
Mean Monthly Maximum Temperature (C)	19.6	20.1	23.7	29.6	33.6	35.4	36.6	36.4	35.6	32.5	27.3	21.5	29.3
Mean Monthly Minimum Temperature (C)	2.6	1.7	3.9	6.5	11.2	16.0	19.2	19.5	16.2	12.8	7.2	5.0	10.2
Mean Monthly Temperature (C)	11.1	10.9	13.8	18.1	22.4	25.7	27.9	28.0	25.9	22.7	17.3	13.3	19.8
Mean Daily Temperature	12.0	11.7	13.5	17.0	21.1	25.0	27.3	27.6	25.4	22.6	17.5	13.7	19.5

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Extreme Monthly Maximum Temperature (C)	21.0	22.4	30.3	32.2	38.3	38.9	41.1	40.9	39.7	34.8	29.7	24.9	–
Extreme Monthly Minimum Temperature (C)	0.4	-1.3	2.4	2.0	8.9	12.5	16.9	17.5	12.4	10.4	2.6	0.6	–
PRECIPITATION													
Mean Monthly Precipitation (mm)	62.4	35.1	37.4	16.6	10.4	3.2	0.6	0.4	4.0	16.1	66.4	86.4	339.1
Actual Precipitation (mm)(1961-1990)	68.0	58.0	39.0	18.0	9.5	1.7	0.0	0.6	1.7	19.0	42.0	86.0	343.5
RELATIVE HUMIDITY (RH)													
Mean RH at 08:00 hrs LST (%)	78.0	76.0	71.0	63.0	60.0	63.0	65.0	66.0	59.0	59.0	70.0	79.0	67.0
Mean RH at 13:00 hrs LST (%)	56.0	53.0	52.0	53.0	52.0	52.0	53.0	53.0	49.0	49.0	51.0	58.0	53.0
EVAPORATION													
Mean Daily Evaporation (mm)	2.6	3.2	4.4	6.0	7.7	9.4	9.8	9.5	8.3	6.1	3.9	2.5	6.1
WINDRUN													
Mean Daily Windrun at 2m (km)	187.0	204.0	219.0	233.0	237.0	253.0	274.0	258.0	221.0	182.0	184.0	172.0	219.0

TABLE A5.6: MONTHLY AND ANNUAL PRECIPITATION (mm), 1961 – 1990

Village	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annually
Aradippou	63.0	59.0	40.0	18.0	14.0	4.0	0.0	1.0	4.0	22.0	39.0	81.0	345.0
Larnaca airport	68.0	58.0	39.0	18.0	9.0	2.0	0.0	1.0	2.0	19.0	42.0	86.0	344.0
Larnaca marina	64.0	54.0	38.0	19.0	13.0	2.0	0.0	1.0	3.0	20.0	42.0	84.0	340.0
Kiti	74.0	63.0	38.0	15.0	8.0	2.0	0.0	1.0	1.0	18.0	39.0	89.0	348.0
Athienou	56.0	50.0	37.0	19.0	18.0	8.0	3.0	3.0	5.0	22.0	28.0	60.0	309.0
Avdellero	55.0	53.0	38.0	20.0	15.0	10.0	1.0	1.0	5.0	24.0	37.0	65.0	324.0

TABLE A5.7: MAXIMUM MONTHLY PRECIPITATION, 1992 – 2000 (mm)

	January	February	March	April	May	June	July	August	September	October	November	December
Aradippou	140.5	60.1	54.0	55.1	31.6	12.0	5.2	18.8	34.7	44.1	200.6	312.9
Larnaca airport	132.6	66.7	75.1	42.5	46.3	22.4	5.7	4.4	14.2	43.7	223.7	368.2
Larnaca marina	128.8	70.9	64.1	47.3	46.8	24.5	2.2	9.9	12.9	60.6	224.9	398.1
Kiti	144.7	90.7	77.8	69.2	50.8	10.1	13.2	0.0	10.9	50.2	248.0	313.6
Athienou	135.2	57.5	57.0	43.4	80.4	102.0	40.5	13.7	44.0	63.0	193.3	205.7
Avdellero	130.9	71.4	72.1	46.0	21.1	16.4	25.4	41.6	27.7	58.1	177.5	256.2

TABLE A5.8: AVERAGE MONTHLY WIND SPEED, M/S (1982 – 1992)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annually
ANEMOGRAPH, HEIGHT 2M	2.2	2.4	2.5	2.6	2.7	2.9	2.9	2.8	2.4	2.2	2.2	2.2	2.5
ELECTRIC ANEMOGRAPH, HEIGHT 10M	4.1	4.3	4.1	4.1	4.1	4.1	4.4	4.1	3.7	3.6	3.8	3.8	4.0

TABLE A5.9: PERCENTAGE OF OCCURRENCE OF THE MEAN HOURLY WIND SPEED, 1982 – 1992: LARNACA AIRPORT STATION

WIND DIRECTION	FREQUENCY	WIND SPEED (m/s)													
	%	<1	2	3	4	5	6	7	8	9	11	13	15	17	>17
0	5.6	0.07	0.71	0.92	1.12	0.90	0.72	0.49	0.29	0.15	0.17	0.05	0.01	0.00	0.00
30	5.0	0.08	0.36	0.57	0.82	0.76	0.69	0.66	0.45	0.28	0.25	0.08	0.03	0.00	0.00
60	3.6	0.07	0.34	0.72	0.78	0.56	0.45	0.30	0.17	0.08	0.09	0.03	0.01	0.00	0.00
90	3.4	0.08	0.54	0.99	0.88	0.45	0.21	0.14	0.07	0.03	0.01	0.00	0.00	0.00	0.00
120	3.2	0.07	0.32	0.73	0.99	0.55	0.27	0.14	0.09	0.03	0.02	0.01	0.00	0.00	0.00
150	4.5	0.08	0.36	0.62	1.18	1.08	0.65	0.33	0.14	0.03	0.02	0.00	0.00	0.00	0.00
180	9.6	0.08	0.70	0.86	1.22	1.55	1.93	1.45	0.72	0.36	0.47	0.17	0.06	0.01	0.01
210	18.5	0.07	1.39	1.87	2.11	1.74	2.09	2.20	2.11	1.59	2.02	0.83	0.39	0.09	0.02
240	6.5	0.08	1.63	1.35	1.16	0.61	0.52	0.38	0.30	0.16	0.21	0.07	0.04	0.01	0.00

WIND DIRECTION	FREQUENCY	WIND SPEED (m/s)													
270	4.8	0.08	2.04	1.32	0.78	0.30	0.12	0.07	0.05	0.02	0.02	0.00	0.00	0.00	0.00
300	20.0	0.08	5.20	7.46	4.88	1.16	0.46	0.32	0.16	0.12	0.12	0.06	0.00	0.00	0.00
330	15.2	0.08	3.19	4.56	3.80	1.57	0.91	0.49	0.29	0.15	0.12	0.05	0.02	0.00	0.00
TOTAL		**0.91**	**16.77**	**21.98**	**19.71**	**11.21**	**9.01**	**6.97**	**4.84**	**3.01**	**3.51**	**1.35**	**0.54**	**0.11**	**0.03**

TABLE A5.10: PERCENTAGE OF OCCURRENCE OF THE MEAN HOURLY WIND SPEED PER MONTH, 1982 – 1992: LARNACA AIRPORT STATION

WIND DIRECTION	WIND SPEED (m/s)													
	<1	2	3	4	5	6	7	8	9	11	13	15	17	>17
0	0.22	12.20	23.95	24.39	11.44	8.00	6.29	4.60	2.85	3.23	1.68	0.74	0.16	0.12
30	0.40	12.62	22.63	21.96	11.59	7.86	6.27	5.44	3.87	4.41	1.79	0.87	0.08	0.07
60	0.44	12.92	21.74	22.71	12.97	9.43	6.44	5.46	3.33	3.53	0.70	0.54	0.08	0.00
90	0.72	17.04	21.52	19.21	12.45	9.05	6.47	4.95	2.61	3.40	1.44	0.82	0.35	0.08
120	0.87	19.91	18.77	17.81	10.41	9.57	7.31	4.74	3.31	4.66	2.13	0.61	0.06	0.00
150	1.41	23.15	16.22	13.70	9.96	10.81	8.75	5.92	3.68	4.25	1.47	0.47	0.10	0.07
180	1.52	20.25	16.85	12.63	10.12	9.76	8.62	6.63	4.82	5.49	1.97	1.13	0.16	0.00
210	2.13	22.29	17.05	12.95	9.47	10.04	9.12	6.66	3.75	4.44	1.40	0.41	0.14	0.00
240	1.36	22.23	22.00	16.54	11.33	9.89	7.06	4.00	2.07	2.65	0.66	0.14	0.03	0.00
270	0.94	16.03	26.37	23.33	12.26	8.37	5.67	2.90	1.56	1.81	0.54	0.17	0.02	0.00
300	0.38	9.75	28.10	26.99	12.22	8.16	5.63	3.49	2.19	2.07	0.73	0.25	0.03	0.00
330	0.32	12.95	28.81	24.38	10.47	7.45	5.79	3.36	2.10	2.38	1.38	0.49	0.09	0.07

TABLE A5.11: MEAN HOURLY WIND SPEED, 1982 – 1992: LARNACA AIRPORT STATION

HOUR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
01.00	3.6	3.4	3.2	2.7	2.3	2.0	2.2	2.0	2.2	2.7	3.2	3.3
02.00	3.6	3.5	3.2	2.8	2.4	2.1	2.2	2.0	2.2	2.7	3.2	3.3
03.00	3.6	3.6	3.2	2.8	2.4	2.1	2.1	2.0	2.2	2.7	3.2	3.4
04.00	3.7	3.6	3.2	2.8	2.4	2.0	2.1	2.0	2.2	2.8	3.3	3.4
05.00	3.7	3.6	3.2	2.8	2.4	1.9	2.0	1.9	2.2	2.8	3.3	3.3
06.00	3.6	3.5	3.3	2.6	2.3	1.8	2.0	1.9	2.2	2.8	3.2	3.3
07.00	3.6	3.6	3.2	2.7	2.6	2.1	2.3	1.9	2.1	2.7	3.3	3.3
08.00	3.6	3.6	3.3	3.2	3.3	2.9	3.1	2.5	2.4	2.7	3.2	3.2
09.00	3.7	3.7	3.9	4.0	4.0	3.6	3.9	3.3	3.1	3.4	3.5	3.3
10.00	4.1	4.5	4.6	4.6	4.8	4.6	4.8	4.1	3.8	4.0	4.2	3.8
11.00	4.7	5.2	5.1	5.3	5.6	5.5	5.7	5.1	4.6	4.4	4.5	4.4
12.00	5.1	5.6	5.6	5.9	6.4	6.2	6.6	6.1	5.4	4.9	4.7	4.7
13.00	5.4	5.7	5.9	6.4	6.8	6.8	7.3	6.8	6.0	5.4	5.1	5.0
14.00	5.5	6.0	6.1	6.6	7.0	7.4	7.8	7.4	6.4	5.7	5.3	5.0
15.00	5.5	6.1	6.1	6.6	7.1	7.5	8.1	7.8	6.7	5.8	5.3	5.1
16.00	5.4	6.9	5.8	6.5	6.9	7.5	8.1	7.8	6.7	5.5	5.1	4.8
17.00	4.9	5.5	5.4	5.8	6.4	7.2	7.9	7.6	6.3	4.8	4.4	4.3
18.00	4.3	4.7	4.5	5.0	5.7	6.5	7.2	6.9	5.2	3.7	3.9	3.9
19.00	3.8	4.0	3.7	4.0	4.5	5.4	6.0	4.6	3.8	2.8	3.4	3.7
20.00	3.8	3.6	3.2	3.3	3.5	4.0	4.6	4.1	2.9	2.6	3.2	3.4
21.00	3.6	3.5	3.2	3.1	2.9	3.1	3.4	3.1	2.4	2.6	3.2	3.4
22.00	3.5	3.4	3.2	2.8	2.6	2.6	2.7	2.6	2.3	2.6	3.2	3.4
23.00	3.5	3.4	3.2	2.7	2.5	2.3	2.3	2.3	2.2	2.6	3.2	3.4
24.00	3.5	3.5	3.2	2.8	2.5	2.2	2.2	2.1	2.1	2.6	3.2	3.3
MEAN MONTHLY WIND SPEED	**4.1**	**4.3**	**4.1**	**4.1**	**4.1**	**4.1**	**4.4**	**4.1**	**3.7**	**3.6**	**3.8**	**3.8**

TABLE A5.12: WIND DIRECTION, 1982 – 1992: LARNACA AIRPORT STATION

WIND DIRECTION	0	30	60	90	120	150	180	210	240	270	300	330
MONTH	PERCENTAGE OF OCCURRENCE											
January	10.8	7.9	4.8	2.2	1.6	2.0	4.9	10.7	6.7	4.1	24.8	20.1
February	8.5	9.2	4.4	3.0	2.1	2.6	3.9	11.7	7.9	5.2	22.7	18.7
March	7.0	7.9	4.2	2.5	3.1	3.1	6.0	13.6	7.6	4.8	21.5	17.9
April	5.8	5.2	4.2	5.0	4.0	4.5	8.8	18.4	6.7	4.8	17.9	14.8
May	4.4	3.9	3.5	4.4	4.6	6.1	12.5	23.9	6.4	4.5	13.6	12.3
June	3.4	2.5	2.3	3.1	4.1	8.0	17.4	27.7	6.9	5.0	10.7	8.9
July	2.5	1.7	1.6	2.8	3.9	6.3	17.1	35.3	6.1	4.7	9.4	8.6
August	2.3	1.8	1.7	3.0	3.5	6.5	16.1	30.2	6.2	5.7	13.2	9.7
September	2.8	1.7	2.3	3.1	3.7	6.1	12.3	20.0	6.3	6.9	21.3	13.5
October	4.8	4.4	3.5	3.6	3.4	4.3	7.3	11.9	5.5	4.3	29.0	18.0
November	8.1	7.6	6.0	3.5	2.5	2.0	4.8	8.3	5.5	3.7	28.8	19.2
December	8.3	7.2	5.3	3.1	2.1	1.8	4.0	9.3	6.1	4.4	27.4	21.0
AVERAGE	**5.7**	**5.1**	**3.7**	**3.3**	**3.2**	**4.4**	**9.6**	**18.4**	**6.5**	**4.8**	**20.0**	**15.2**

TABLE A5.13: WIND DIRECTION, 1982 – 1992: LARNACA AIRPORT STATION

Month	Direction	Degrees	Percentage of Time	Total Percentage
JANUARY	NW	300 °	24.8 %	44.9 %
		330 °	20.1 %	
	N	0 °	10.8 %	10.8 %
	SW	210 °	10.7 %	10.7 %
			Total Percentage for all directions	66.4 %
FEBRUARY	NW	300 °	22.7 %	41.4 %
		330 °	18.7 %	
	SW	210 °	11.7 %	11.7 %
			Total Percentage for all directions	53.1 %
MARCH	NW	300 °	21.5 %	39.4 %
		330 °	17.9 %	
	SW	210 °	13.6 %	13.6 %
			Total Percentage for all directions	53.0 %
APRIL	NW	300 °	17.9 %	32.7 %
		330 °	14.8 %	
	SW	210 °	18.4 %	18.4 %
			Total Percentage for all directions	51.1 %
MAY	NW	300 °	13.6 %	25.9 %
		330 °	12.3 %	
	S	180 °	12.5 %	36.4 %
	SW	210 °	23.9 %	
			Total Percentage for all directions	*62.3 %*
JUNE	NW	300 °	10.7 %	10.7 %
	S	180 °	17.4 %	45.1 %
	SW	210 °	27.7 %	
			Total Percentage for all directions	*55.8 %*
JULY	S	300 °	17.1 %	52.4 %
	SW	210 °	35.3 %	
			Total Percentage for all directions	*52.4 %*
AUGUST	NW	300 °	13.2 %	13.2 %
	S	180 °	16.1 %	46.3 %
	SW	210 °	30.2 %	
			Total Percentage for all directions	*59.5 %*
SEPTEMBER	NW	300 °	21.3 %	34.8 %
		330 °	13.5 %	
	S	180 °	12.3 %	32.3 %
	SW	210 °	20.0 %	
			Total Percentage for all directions	*67.1 %*
OCTOBER	NW	300 °	29.0 %	47.0 %
		330 °	18.0 %	
	SW	210 °	11.9 %	11.9 %
			Total Percentage for all directions	*58.9 %*
NOVEMBER	NW	300 °	28.8 %	48.0 %
		330 °	19.2 %	
			Total Percentage for all directions	*48.0 %*
DECEMBER	NW	300 °	27.4 %	48.4 %
		330 °	21.0 %	
			Total Percentage for all directions	*48.4 %*

CLIMATIC DATA: ATHIENOU

TABLE A5.14: CLIMATOLOGICAL DATA 1981 – 1990: ATHIENOU STATION

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE													
Mean Monthly Maximum Temperature (C)	18.7	20.8	23.6	31.3	36.3	37.4	39.2	38.8	37.5	33.0	26.3	21.5	30.3
Mean Monthly Minimum Temperature (C)	0.5	0.2	0.8	5.2	8.2	14.0	17.5	17.8	15.4	10.0	4.5	2.0	8.0
Mean Monthly Temperature (C)	9.6	10.5	12.2	18.3	22.3	25.7	28.4	28.3	26.5	21.5	15.4	11.8	19.2
Mean Daily Temperature (C)	10.2	10.3	12.3	17.0	21.2	25.3	28.3	28.2	25.8	21.1	15.5	12.0	18.9
Extreme Monthly Maximum Temperature (C)	20.7	24.0	26.2	35.0	40.0	39.5	41.0	41.0	40.0	36.0	30.0	24.0	–
Extreme Monthly Minimum Temperature (C)	-2.0	-3.5	-3.0	3.3	5.5	11.2	14.9	16.5	13.7	5.5	-1.5	0.4	–
PRECIPITATION													
Normal Precipitation (mm) (1961-1990)	56.0	50.0	37.0	19.0	18.0	8.0	3.0	3.0	5.0	22.0	28.0	60.0	309.0
RELATIVE HUMIDITY (RH)													
Mean RH at 08:00 hrs LST (%)	84.0	83.0	78.0	62.0	50.0	47.0	51.0	53.0	57.0	58.0	78.0	83.0	65.0

TABLE A5.15: CLIMATOLOGICAL DATA 1991 – 2000: ATHIENOU STATION

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE													
Mean Monthly Maximum Temperature (C)	19.6	20.2	24.9	31.3	36.6	39.1	39.8	40.1	37.6	34.5	27.6	21.2	31.0
Mean Monthly Minimum Temperature (C)	0.4	0.0	2.0	4.6	9.6	15.0	17.8	18.8	15.1	10.9	5.1	2.6	8.5
Mean Monthly Temperature (C)	10.0	10.1	13.5	18.0	23.1	27.1	28.8	29.5	26.4	22.7	16.4	11.9	19.8
Mean Daily Temperature (C)	10.4	10.3	12.6	16.8	21.8	26.3	29.0	28.9	26.0	22.3	16.2	12.2	19.4
Extreme Monthly Maximum Temperature (C)	21.5	22.5	29.5	35.0	41.0	40.7	43.5	43.0	41.0	36.4	30.5	23.5	–

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Extreme Monthly Minimum Temperature (C)	-2.0	-3.9	0.0	0.9	7.5	12.0	11.0	16.5	13.1	9.3	1.0	-0.2	–
PRECIPITATION													
Mean Monthly Precipitation (mm)	47.7	33.5	31.4	17.7	23.0	19.8	4.5	1.6	7.8	21.6	59.4	79.4	347.4
Normal Precipitation (mm) (1961-1990)	55.8	50.1	37.2	19.2	18.2	8.2	3.4	2.5	4.9	22.2	28.3	59.8	309.8
RELATIVE HUMIDITY (RH)													
Mean RH at 08:00 hrs LST (%)	84.0	82.0	76.0	60.0	52.0	48.0	50.0	57.0	57.0	65.0	76.0	86.0	66.0

APPENDIX 6

DESCRIPTION OF COMMUNITIES

ARADIPPOU

GENERAL DESCRIPTION

Aradippou is located at the western edge of Larnaca town, about 2-3 km. from the Larnaca seafront and the central business area. Part of the area is included in the Larnaca Local Plan.

POPULATION TRENDS

The population of Aradippou has grown from 7,226 in 1992 to 11,448 in 2001, corresponding to an absolute growth of 58.4% (or 4.7% average per annum). This rate of growth is higher than that of the Larnaca Urban Area itself and that of the average urban rate of all Cyprus

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce vastly different estimates of future population with the current population growth trend showing that the existing housing expansion zone will be developed fully in the next 10 years (2010). Given that the Local Plan and the housing zone has a 5 year time horizon (2002-2007), if current population trends continue appropriate adjustments will be made to the housing development zone. A third scenario is examined, considered more realistic, based on a declining growth rate for the period up to the year 2030.

TABLE A6.1: POPULATION FORECAST FOR ARADIPPOU

Scenarios	Population (households)			
	2001	2010	2020	2030
Average 4.7% p.a. population growth scenario	3,041	4,810	7,600	12,000
Housing land stock scenario (Population growth corresponding to the estimated housing development capacity of the vacant land stock in the housing zone apportioned evenly over the 30-year period).	3,041	3,471	3,900	4,340
Probable scenario (declining growth rate) Based on the assumption that the population growth rate will gradually move towards the average urban rate of 1.5%-1.8% per annum, that is 2.0% up to the year 2010 and 1.65% thereafter.		2.0%	1.65%	1.65%
Declining growth rate scenario	3,041	3,700	4,400	5,200

JUSTIFICATION OF THE PROBABLE GROWTH SCENARIO

The main source of population growth in Aradippou is urbanization fuelled by employment growth serving Larnaca and all other urban areas due to Aradippou's strategic location on the national road network (Airport, Limassol, Nicosia and Paralimni-Famagusta). But, the current growth rate cannot be sustained because the period 1992-2001 was the main expansion of Aradippou and such growth reflects a major population boom which will level off within the normal urban growth prevailing in Cyprus.

Also:

- Rapid retail trade and industrial development growth will continue justifying a continuation of growth at a declining rate.

- There is no potential for tourism in Aradippou, although its proximity to Larnaca also justifies employment increase.
- There is also significant agricultural development (animal husbandry, pig farms) which is another factor that will keep population growth at about average urban growth.
- Policy changes associated with membership to the European Union (purchase of houses by other European nationals), or the solution of the Cyprus problem (refugee houses vacated and recycled in the housing market) are unlikely to affect local growth in any major way.

It is therefore reasonable to assume that Aradippou will follow the pattern of the other peri-urban growth villages / areas whose previous high growth rate has settled at a lower level (Engomi, Strovolos, Latsia, Lakatamia, etc). As a conclusion, a population of approximately 20000 inhabitants is projected at the horizon of 2030.

DENSIFICATION OF THE POPULATION

The spatial development pattern of Aradippou is typical of most villages. It has an old village core with old houses and shops, around which new shops and offices are concentrated, and a spread out new housing development area. About 40% of the housing area is predominantly empty with scattered houses and partly developed road network. There are also scattered houses outside the designed housing development zone (about 25).

Housing development is at present controlled by the Larnaca Local Plan (currently revised and finalized but not yet published). It is expected that the area of the designated housing zone will expand east towards Larnaca (not yet confirmed). From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the expected level of development as its population capacity in term of the land stock it includes is far greater that the realistic housing needs for the foreseeable future. The housing development zone estimated at about 650 ha corresponds to a population capacity of about 27,000 – 34,000 people, while the presently vacant land stock (about 40% of the area) could accommodate an additional estimated amount of 1,300 housing units. The densification of the population in the residential area is estimated to be approximately 30 inhabitants/ha.

SUMMARY OF INFORMATION FOR THE ARADIPPOU COMMUNITY

TABLE A6.2: INFORMATION SUMMARY FOR ARADIPPOU

Aradippou				
		2005	2015	2030
Population and houses				
	Permanent population	12 383	14 900	19 665
	Number of summer houses	0	0	0
Water consumption				
	Domestic consumption (m^3/day)	1 238	1 516	2 063
	Non domestic consumption (m^3/day)	421	504	701
	Total domestic and non domestic (m3/day)	1 659	2 020	2 764
	Additional summer consumption (m^3/year - 90 days)	0	0	0
	Additional summer consumption (m^3/day)	0	0	0
	Average day summer (ADD) (m^3/day)	1 659	2 020	2 764
	Maximum day summer (MDD) (m^3/day)	2 323	2 828	3 870
Waste water production				
	Return factor	0.85	0.85	0.85
	Infiltration (m^3/day)	0.00	0.00	0.00
m^3/day	Average Dry Weather flow (ADWF)	1 410	1 717	2 349
	Maximum Dry Weather Flow (MDWF)	1 974	2 404	3 289

Aradippou				
		2005	2015	2030
	Peak Hourly flow (PHF)	4 230	5 151	7 048
l/s	Average Dry Weather flow (ADWF)	16.32	19.87	27.19
	Maximum Dry Weather Flow (MDWF)	22.85	27.82	38.07
	Peak Hourly flow (PHF)	48.96	59.62	81.58

LIVADIA

GENERAL DESCRIPTION

Livadia is located at the edge of Larnaca town and Aradippou, about 5 km from the Larnaca seafront and central business area. Part of the area is within the Larnaca Local Plan.

POPULATION TRENDS

The population of Livadia has grown from 3,936 in 1992 to 4,883 in 2001, corresponding to an absolute growth of 24.0% (or 2.2% average per annum). This rate of growth is higher than that of the Larnaca Urban Area itself and that of the average urban rate of all Cyprus, but half of Aradippou.

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce vastly different estimates of future population with the current population growth trend showing that the existing housing expansion zone will be developed fully in the next 10 years (2010). Given that the Local Plan and the housing zone has a 5 year time horizon (2002-2007), if current population trends continue appropriate adjustments will be made to the housing development zone. A third scenario is examined, considered more realistic, based on a declining growth rate for the period up to the year 2030.

TABLE A6.3: POPULATION FORECAST FOR LIVADIA

Scenarios	Population (households)			
	2001	2010	2020	2030
Average 2.2% p.a. population growth scenario	1,454	1,800	2,230	2,760
Housing land stock scenario (Population growth corresponding to the estimated housing development capacity of the vacant land stock in the housing zone apportioned evenly over the 30-year period).	1,454	1,620	1,800	2,000
Probable scenario (declining growth rate) Based on the assumption that the population growth rate will gradually move towards the average urban rate of 1.5% per annum, that is 2.0% up to the year 2010 and 1.5% thereafter.		2.0%	1.5%	1.5%
Declining growth rate scenario	1,454	1,780	2,060	2,400

JUSTIFICATION FOR PROBABLE GROWTH SCENARIO

The main source of population growth in Livadia (like Aradippou) is urbanization fuelled by employment growth serving Larnaca and all other urban areas due to location on the national road network (Airport, Limassol, Nicosia and Paralimni-Famagusta). But, the current growth rate cannot be sustained because the period 1992-2001 was the main expansion of Livadia and Aradippou and such growth reflects a major population boom which will level off within the normal urban growth prevailing in Cyprus.

Also:

- Rapid retail trade and industrial development growth in near-by Aradippou will continue justifying a continuation of growth at a declining rate.
- There is no potential for tourism in Livadia, although its proximity to Larnaca also justifies employment increase.
- There is also some agricultural development (animal husbandry) which is another factor that will keep population growth at about average urban growth.
- Policy changes associated with membership to the European Union (purchase of houses by other European nationals), or the solution of the Cyprus problem (refugee houses vacated and recycled in the housing market) are unlikely to affect local growth in any major way.

It is therefore reasonable to assume that Livadia will follow the pattern of the other peri-urban growth areas whose previous high growth rate has settled at a lower level. As a conclusion, a population of approximately 8000 inhabitants is projected at the horizon of 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Livadia is typical of most villages. It has an old village core with old houses and shops, around which new shops and offices are concentrated, and a spread out new housing development area. About 30% of the housing area is predominantly empty with scattered houses and partly developed road network. There are also scattered houses outside the designed housing development zone (about 20).

Housing development is at present controlled by the Larnaca Local Plan (currently revised and finalized but not yet published). It is expected that the area of the designated housing zone will expand east towards Aradippou (not yet confirmed). From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the expected level of development as its population capacity in term of the land stock it includes is far greater that the realistic housing needs for the foreseeable future. The housing development zone estimated at about 220 ha corresponds to a population capacity of about 12,000 people, while the presently vacant land stock (about 30% of the area) could accommodate an additional estimated amount of 500 housing units. The densification of the population in the residential area is estimated to be approximately 35 inhabitants/ha.

SUMMARY OF INFORMATION FOR THE LIVADIA COMMUNITY

TABLE A6.4: INFORMATION SUMMARY FOR LIVADIA

Livadia				
		2005	2015	2030
Population and houses				
	Permanent population	5 232	6 220	8 060
	Number of summer houses	0	0	0
Water consumption				
	Domestic consumption (m^3/day)	523	633	845
	Non domestic consumption (m^3/day)	178	211	287

Livadia				
		2005	2015	2030
	Total domestic and non domestic (m3/day)	701	844	1132
	Additional summer consumption (m^3/year - 90 days)	0	0	0
	Additional summer consumption (m^3/day)	0	0	0
	Average day summer (ADD) (m^3/day)	701	844	1132
	Maximum day summer (MDD) (m^3/day)	981	1 182	1 585
Waste water production				
	Return factor	0.85	0.85	0.85
	Infiltration (m^3/day)	74.25	222.75	297.00
m^3/day	Average Dry Weather flow (ADWF)	670	940	1259
	Maximum Dry Weather Flow (MDWF)	908	1227	1644
	Peak Hourly flow (PHF)	1 862	2 375	3 184
l/s	Average Dry Weather flow (ADWF)	7.76	10.88	14.57
	Maximum Dry Weather Flow (MDWF)	10.51	14.20	19.03
	Peak Hourly flow (PHF)	21.55	27.49	36.85

DROMOLAXIA

GENERAL DESCRIPTION

Dromolaxia is located at the south western edge of Larnaca town (near the International Airport), about 5 km. from the Larnaca seafront and the central business area. Part of the area of the Larnaca Local Plan. It has direct access to the Nicosia-Aradippou-Airport and the Larnaca-Airport-Limassol national roads.

POPULATION TRENDS

The population of Dromolaxia has grown from 4,423 in 1992 to 4,994 in 2001, corresponding to an absolute growth of nearly 13.0% (or 1.2% average per annum). This rate of growth is lower than that of the Larnaca Urban Area itself and that of the average urban rate of all Cyprus, approximating the rural average rate.

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce different estimates of future population with the current population growth trend showing that the existing housing expansion zone will be more than sufficient to accommodate future population growth according to the current rate of 1.2% p.a. average. A third middle scenario is examined, considered more realistic, based on a marginally increased growth rate for the period up to the year 2030.

TABLE A6.5: POPULATION FORECAST FOR DROMOLAXIA

Scenarios	Population (households)			
	2001	2010	2020	2030
Average 1.2% p.a. population growth scenario	1,462	1,650	1,870	2,110

Scenarios	Population (households)			
	2001	2010	2020	2030
Housing land stock scenario (Population growth corresponding to the estimated housing development capacity of the vacant land stock in the housing zone apportioned evenly over the 30-year period. This implies an average annual growth rate of 1.4% - 1.5% which is rather unlikely but not completely unrealistic.)	1,462	1,730	2,000	2,260
Probable scenario (middle growth rate of 1.35%) Based on the assumption that the population growth rate will gradually increase to just below the urban rate of 1.5% per annum, that is 1.35%.				
Middle growth rate scenario	1,462	1,660	1,890	2,150

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The main source of population growth in Dromolaxia is urbanization fuelled by its semi-urban location, access to the national road network (Airport, Limassol, Nicosia and Paralimni - Famagusta), and also close to the Airport and the costal area of Kiti - Perivolia. The current growth rate is thus likely to increase marginally due to all these factors.

Also:

- Rapid retail trade and industrial development growth in near-by Aradippou may justify the assumption of higher growth rate.
- The community is close to tourism zones (Kiti & Perivolia), also justifying higher than the present growth rate.
- There is also some agricultural development (animal husbandry) which is an additional growth factor.
- Policy changes associated with membership to the European Union (purchase of houses by other European nationals, or the solution of the Cyprus problem (refugee houses vacated and recycled in the housing market) are unlikely to affect local growth in any major way.

It is therefore reasonable to assume that Dromolaxia will follow a moderate growth pattern as a semi-urban community. As a conclusion, a population of approximately 7 300 inhabitants is projected at the horizon of 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Dromolaxia is typical of most villages. It has an old village core with old houses and shops, around which new shops and offices are concentrated, and a spread out new housing development area. About 40% of the housing area is predominantly empty with scattered houses and partly developed road network. There are also scattered houses outside the designed housing development zone (about 25).

Housing development is at present controlled by the Larnaca Local Plan (currently revised and finalized but not yet published). It is expected that the area of the designated housing zone will not expand (not yet confirmed). From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the expected level of development as its population capacity in term of the land stock it includes is far greater that the realistic housing needs for the foreseeable future. The housing development zone estimated at about 375 ha corresponds to a population capacity of about 17,000 people, while the presently vacant land stock (about 40% of the area) could accommodate an additional estimated amount of about 800 housing units. The densification of the population in the residential area is estimated to be approximately 20 inhabitants/ha.

SUMMARY OF INFORMATION FOR THE DROMOLAXIA COMMUNITY

TABLE A6.6: INFORMATION SUMMARY FOR DROMOLAXIA

Dromolaxia				
		2005	2015	2030
Population and houses				
	Permanent population	5267	6016	7344
	Number of summer houses	0	0	0
Water consumption				
	Domestic consumption (m^3/day)	527	612	770
	Non domestic consumption (m^3/day)	179	205	262
	Total domestic and non domestic (m3/day)	706	817	1032
	Additional summer consumption (m^3/year - 90 days)	0	0	0
	Additional summer consumption (m^3/day)	0	0	0
	Average day summer (ADD) (m^3/day)	706	817	1032
	Maximum day summer (MDD) (m^3/day)	988	1144	1445
Waste water production				
	Return factor	0.85	0.85	0.85
	Infiltration (m^3/day)	0.00	0.00	0.00
m^3/day	Average Dry Weather flow (ADWF)	600	694	877
	Maximum Dry Weather Flow (MDWF)	840	972	1228
	Peak Hourly flow (PHF)	1800	2083	2632
l/s	Average Dry Weather flow (ADWF)	6.95	8.04	10.15
	Maximum Dry Weather Flow (MDWF)	9.72	11.25	14.21
	Peak Hourly flow (PHF)	20.84	24.11	30.46

MENEOU

GENERAL DESCRIPTION

Meneou is coastal village located at the south western edge of Larnaca town (near the International Airport), about 7 km. from the Larnaca seafront and the central business area. Inside the area of the Larnaca Local Plan. It has direct access to the Nicosia-Aradippou-Airport and the Larnaca-Airport-Limassol national roads.

POPULATION TRENDS

The population of Meneou has grown from 952 in 1992 to 1,169 in 2001, corresponding to an absolute growth of nearly 26% (or 2.3% average per annum). This rate of growth is higher than the all Cyprus urban rate and higher than that of Larnaca Town itself.

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce different estimates of future population with the current population growth trend showing lower population level compared to the land capacity scenario, even without further future land increase. A middle

scenario is considered more realistic envisaging a higher future growth than the current population growth rate.

TABLE A6.7: POPULATION FORECAST FOR MENEOU

Scenarios	Population (households)			
	2001	**2010**	**2020**	**2030**
Local Population				
Average 2.3% p.a. population growth scenario	348	435	544	680
Housing land stock scenario (Population growth corresponding to the estimated housing development capacity of the vacant land stock in the housing zone apportioned evenly over the 30-year period. This implies an average annual growth rate of 3.4% which is rather unlikely.	348	785	1,000	950
Probable scenario - middle scenario (increased growth of maximum 2.5% average p.a. in the next 30 years).	348	445	570	730
Holiday housing development scenarios Continuation of the present trend scenario (Holiday houses increasing at the rate of about 20 units per year, or 200 every 10 years - from 163 to 348 since 1992).	348	548	748	948
Tourist zone land stock capacity scenario (land capacity for about 656 additional houses, or about 22 units average per year).	348	568	788	1008
Due to the high demand for holiday houses in the area the (higher land stock scenario is adopted as realistic.	348	568	788	1008
Taking into account the possibility of some hotel development (on up to 20% of the tourist zone), the estimated No. of holiday houses and hotel beds is as follows:				
Holiday houses on 80% of the land (525 units)	348	523	700	875
Hotel beds on 20% of the land (1250 beds)	0	420	830	1250

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The main source of population growth in Meneou (like Perivolia and Kiti) is holiday housing development due to its coastal location and its proximity to Nicosia, Larnaca and Limassol. Current population growth will most probably remain constant, or increase marginally, because of the important geographical advantages of the community and the strong demand for holiday houses along the coastal zone around Cape Kiti.

Also:

- The development of holiday houses will continue most probably at the current rate as it is already quite high. The higher land capacity development scenario is adopted as a likely future perspective.
- The community is close to Larnaca, Nicosia and Limassol and it is realistic to assume a high demand for holiday houses.
- There is also agricultural development in the wider area and an expanding local market for fruits and vegetables.

- Policy changes associated with membership to the European Union (such as purchase of houses by other European nationals, is likely to be a factor in maintaining population growth and housing development.
- Hotel development is considered rather unlikely as the trend for high size and quality holiday houses is strongly established. Nevertheless, for purposes of water consumption estimates, it is assumed that if 20% of the tourism zone land is developed for hotel accommodation the maximum number of beds will be 1,250

As a conclusion, a population of approximately 2 450 inhabitants is projected at the horizon of 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Meneou (like Pervolia and Kiti) is typical of most villages. It has an old village core with old houses and shops, around which new shops, restaurants and some offices are concentrated, and a spread out new housing development area. About 40% of the housing area is predominantly empty with scattered houses and partly developed road network. There are also some scattered houses in the 'countryside zone' outside the designed housing development zone. There are also about 348 holiday houses in the coastal tourist zones of about 75 Ha.

Building development is controlled by the Larnaca Local Plan. The village land use zones have been recently revised in 2003. From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the development expected for the next 5-10 years as its population capacity is much larger than the local housing needs realistically expected for that time period. The housing development zone of about 150 Ha corresponds to a population capacity of about 6,200 people, while the presently vacant land stock (about 40% of the area) could accommodate an additional estimated amount of about 600 housing units at a low density. The densification of the population in the residential area is estimated to be approximately 15 inhabitants/ha.

SUMMARY OF INFORMATION FOR THE MENEOU COMMUNITY

TABLE A6.8: INFORMATION SUMMARY FOR MENEOU

Meneou				
		2005	2015	2030
Population and houses				
	Permanent population	1320	1690	2450
	Number of summer houses	420	605	875
	Number of hotel beds	200	650	1250
Water consumption				
	Domestic consumption (m^3/day)	132	172	260
	Non domestic consumption (m^3/day)	45	58	88
	Total domestic and non domestic (m3/day)	177	230	348
	Additional summer consumption (m^3/year - 90 days)	26145	49061	80719
	Additional summer consumption (m^3/day)	291	545	897
	Average day summer (ADD) (m^3/day)	468	775	1245
	Maximum day summer (MDD) (m^3/day)	655	1085	1743
Waste water production				
	Return factor	0.85	0.85	0.85
	Infiltration (m^3/day)	0.00	0.00	0.00
m^3/day	Average Dry Weather flow (ADWF)	397	659	1058
	Maximum Dry Weather Flow (MDWF)	556	922	1481

Meneou				
		2005	2015	2030
	Peak Hourly flow (PHF)	1192	1977	3174
l/s	Average Dry Weather flow (ADWF)	4.60	7.63	12.25
	Maximum Dry Weather Flow (MDWF)	6.44	10.68	17.15
	Peak Hourly flow (PHF)	13.80	22.88	36.74

KITI

GENERAL DESCRIPTION

Kiti is coastal village located at the south western edge of Larnaca town (near the International Airport), about 7 km. from the Larnaca seafront and the central business area. Outside the area of the Larnaca Local Plan. It has direct access to the Nicosia-Aradippou-Airport and the Larnaca-Airport-Limassol national roads.

POPULATION TRENDS

The population of Kiti has grown from 2,622 in 1992 to 3,140 in 2001, corresponding to an absolute growth of nearly 20% (or 1.8% average per annum). This rate of growth is equal to the all Cyprus urban rate and higher than that of Larnaca Town itself.

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce similar estimates of future population with the current population growth trend showing that the existing housing expansion zone (without further future increase) will be sufficient to accommodate future population growth according to the current rate of 1.8% p.a. average. In this case, the current population growth is considered as a realistic scenario.

TABLE A6.9: POPULATION FORECAST FOR KITI

Scenarios	Population (households)			
	2001	2010	2020	2030
Local Population				
Average 1.8% p.a. population growth scenario	950	1,135	1,356	1,600
Housing land stock scenario (Population growth corresponding to the estimated housing development capacity of the vacant land stock in the housing zone apportioned evenly over the 30-year period. This implies an average annual growth rate of 1.8% which corresponds to the current growth rate.	950	1,166	1,380	1,600
Probable scenario (continuation of current trend)	950	1,150	1,360	1,600
Holiday housing Holiday houses increased from 95 to 166 since 1992 (about 7 units average per year). Tourist zone land stock scenario (land capacity for about 800 additional houses, or 27-28 per year average)	166 166	236 440	306 715	376 1,000

Scenarios	Population (households)			
	2001	2010	2020	2030
Middle scenario (about 18 additional houses per year average)	166	350	530	700

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The main source of population growth in Kiti is holiday housing development due to its coastal location and its proximity to Nicosia, Larnaca and Limassol. Current population growth will most probably be maintained because of the important locational advantages of the community.

Also:

- The development of holiday houses will continue at an increasing rate (between the past rate (1992-2001) and the land capacity rate, approximately 18 units per year average).
- The community is close to Larnaca, Nicosia and Limassol and it is realistic to assume increase of holiday houses.
- There is also agricultural development in the wider area and an expanding local market for fruits and vegetables.
- Policy changes associated with membership to the European Union (such as purchase of houses by other European nationals), is likely to boost up local growth in the future.

As a conclusion, a population of approximately 5 300 inhabitants is projected at the horizon of 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Kiti is typical of most villages. It has an old village core with old houses and shops, around which new shops, restaurants and some offices are concentrated, and a spread out new housing development area. About 50% of the housing area is predominantly empty with scattered houses and partly developed road network. There are also some scattered houses outside the designed housing development zone (about 20). There are also about 166 holiday houses in the coastal tourist zones.

Housing development is at present controlled by the Countryside Policy. The village zones have been recently revised in 2002. From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the expected level of development as its population capacity in term of the land stock it includes is far greater that the realistic housing needs for the foreseeable future. The housing development zone of 315 ha corresponds to a population capacity of about 13,000 people, while the presently vacant land stock (about 50% of the area) could accommodate an additional estimated amount of about 650 housing units at a low density. The densification of the population in the residential area is estimated to be approximately 15 inhabitants/ha.

SUMMARY OF INFORMATION FOR KITI COMMUNITY

TABLE A6.10: INFORMATION SUMMARY FOR KITI

Kiti				
		2005	2015	2030
Population and houses				
	Permanent population	3376	4045	5305
	Number of summer houses	260	440	700
Water consumption				
	Domestic consumption (m^3/day)	338	412	557

Kiti				
		2005	2015	2030
	Non domestic consumption (m^3/day)	115	137	189
	Total domestic and non domestic (m3/day)	**453**	**549**	**746**
	Additional summer consumption (m^3/year - 90 days)	12285	20790	33075
	Additional summer consumption (m^3/day)	137	231	368
	Average day summer (ADD) (m^3/day)	**590**	**780**	**1114**
	Maximum day summer (MDD) (m^3/day)	825	1092	1559
Waste water production				
	Return factor	0.85	0.85	0.85
	Infiltration (m^3/day)	0.00	0.00	0.00
m^3/day	Average Dry Weather flow (ADWF)	501	663	946
	Maximum Dry Weather Flow (MDWF)	702	928	1325
	Peak Hourly flow (PHF)	1503	1989	2839
l/s	Average Dry Weather flow (ADWF)	5.80	7.67	10.95
	Maximum Dry Weather Flow (MDWF)	8.12	10.74	15.34
	Peak Hourly flow (PHF)	17.40	23.02	32.86

PERIVOLIA

GENERAL DESCRIPTION

Perivolia is coastal village located at the south western edge of Larnaca town (near the International Airport), about 7 km. from the Larnaca seafront and the central business area. Outside the area of the Larnaca Local Plan. It has direct access to the Nicosia-Aradippou-Airport and the Larnaca-Airport-Limassol national roads.

POPULATION TRENDS

The population of Perivolia has grown from 1,508 in 1992 to 1,801 in 2001, corresponding to an absolute growth of nearly 20% (or 1.8% average per annum). This rate of growth is equal to the all Cyprus urban rate and higher than that of Larnaca Town itself.

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce different estimates of future population with the current population growth trend showing lower population level compared to the land capacity scenario, even without further future land increase. A middle scenario is considered more realistic envisaging a higher future growth than the current population growth rate.

TABLE A6.11: POPULATION FORECAST FOR PERIVOLIA

Scenarios	Population (households)			
	2001	2010	2020	2030
Local Population				
Average 1.8% p.a. population growth scenario	570	680	800	960

Scenarios	Population (households)			
	2001	2010	2020	2030
Housing land stock scenario (Population growth corresponding to the estimated housing development capacity of the vacant land stock in the housing zone apportioned evenly over the 30-year period. This implies an average annual growth rate of 2.5% which is rather unlikely.	570	785	1,000	1,220
Probable scenario - middle scenario (increased growth of up to 2.0% p.a. average in the next 10 years and 2.2% average p.a. for the rest of the period).	570	700	870	1,080
Holiday housing Holiday houses increased from 570 to 1,251 since 1992 (about 68 units average per year).	1,251	1,930	2,610	3,290
Tourist zone land stock scenario (land capacity for about additional houses, or 90 per year average)	1,251	2,150	3,050	4,000
Middle scenario (about 80 additional houses per year average).	1,251	2,050	2,850	3,750

JUSTIFICATION OF THE PROBABLE SCENARIO

The main source of population growth in Perivolia (and Kiti) is holiday housing development due to its coastal location and its proximity to Larnaca, Nicosia and Limassol. Current population growth will most probably increase because of the important advantages due to the location of the community and the strong demand for holiday houses along the coastal zone around Cape Kiti.

Also:

- The development of holiday houses will continue at an increasing rate (between the past rate (1992-2001) and the land capacity rate, approximately 80 units per year average).
- The community is close to Larnaca, Nicosia and Limassol and it is realistic to assume increase of holiday houses.
- There is also agricultural development in the wider area and an expanding local market for fruits and vegetables.
- Policy changes associated with membership to the European Union (such as purchase of houses by other European nationals), is likely to boost up local growth in the future.

As a conclusion, a population of approximately 3 400 inhabitants is projected at the horizon of 2030.

DENSIFICATION OF POPULATION

The spatial development pattern of Perivolia (and Kiti) is typical of most villages. It has an old village core with old houses and shops, around which new shops, restaurants and some offices are concentrated, and a spread out new housing development area. About 60% of the housing area is predominantly empty with scattered houses and partly developed road network. There are also some scattered houses outside the designed housing development zone (about 15). There are also about 1,251 holiday houses in the coastal tourist zones of about 236 ha.

Housing development is at present controlled by the Countryside Policy. The village zones have been recently revised in 2002. From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the expected level of development as its population capacity in term of the land stock it includes is far greater that the realistic housing needs for the foreseeable future. The housing development zone of

200 ha corresponds to a population capacity of about 8,300 people, while the presently vacant land stock (about 60% of the area) could accommodate an additional estimated amount of about 650 housing units at a low density. The densification of the population in the residential area is estimated to be approximately 20 inhabitants/ha.

SUMMARY OF INFORMATION FOR THE PERIVOLIA COMMUNITY

TABLE A6.12: INFORMATION SUMMARY FOR PERIVOLIA

Perivolia				
		2005	2015	2030
Population and houses				
	Permanent population	1967	2452	3412
	Number of summer houses	1700	2500	4000
Water consumption				
	Domestic consumption (m^3/day)	197	249	358
	Non domestic consumption (m^3/day)	65	94	120
	Total domestic and non domestic (m3/day)	262	343	478
	Additional summer consumption (m^3/year - 90 days)	80325	118125	189000
	Additional summer consumption (m^3/day)	893	1313	2100
	Average day summer (ADD) (m^3/day)	1155	1656	2578
	Maximum day summer (MDD) (m^3/day)	1616	2318	3609
Waste water production				
	Return factor	0.85	0.85	0.85
	Infiltration (m^3/day)	37.80	113.40	151.20
m^3/day	Average Dry Weather flow (ADWF)	1019	1521	2343
	Maximum Dry Weather Flow (MDWF)	1412	2083	3219
	Peak Hourly flow (PHF)	2982	4335	6725
l/s	Average Dry Weather flow (ADWF)	11.80	17.60	27.11
	Maximum Dry Weather Flow (MDWF)	16.34	24.11	37.26
	Peak Hourly flow (PHF)	34.51	50.17	77.84

ATHIENOU

GENERAL DESCRIPTION

Athienou is located mid way on the old Nicosia – Larnaca road. This road is inaccessible as it is and blocked by the occupied area. Road access is now through the main Nicosia - Larnaca highway. The village is about 20 km from Nicosia and 15 from Larnaca. Athienou is a rural Municipality covered by its own Local Plan.

POPULATION TRENDS

The population of Athienou has grown from 3,865 in 1992 to 4,261 in 2001, corresponding to an absolute growth of 10.2% (or 0.9% average per annum). This rate of growth is below that of the rural average for Cyprus due to the village's reduced accessibility relative to its location at mid distance between Nicosia and Larnaca.

There appear to exist two main possible projections of future population growth with several intermediate ones. One projection based on the recent and current population growth (period 1992-2001) applied for the year 2030, and one based on the population capacity of the designated housing development zone area. These are shown below. The two scenarios produce roughly different estimates of future population, with the present housing expansion zone more or less accommodating future housing needs for the next 30 years even without significant increase of the housing zone area. However, a third scenario must be considered with the Solution of the Cyprus Problem which will justify increased population growth due to Athienou's location close to Nicosia and Larnaca. This third scenario is considered more realistic, based on an increased growth rate for the period up to the year 2030.

TABLE A6.13: POPULATION FORECAST FOR ATHIENOU

Scenarios	Population (households)			
	2001	2010	2020	2030
Average 0.9% p.a. population growth scenario	1,272	1,400	1,550	1,710
Housing land stock scenario (Population growth corresponding to the estimated housing development capacity of the vacant land stock in the housing zone apportioned evenly over the 30-year period).	1,272	1,450	1,650	1,770
Probable scenario (Solution of the Cyprus Problem) Based on the assumption that the population growth rate will gradually move towards the average urban rate of 1.5% per annum (2004-2030).	1,272	1,435	1,670	2,000

JUSTIFICATION FOR THE PROBABLE GROWTH SCENARIO

The main source of future population growth in Athienou will be urbanization fuelled by its location close to Nicosia and Larnaca. (also close to the Airport, Limassol, Nicosia and Paralimni-Famagusta).

Also:

- Urbanization will stimulate some retail trade, small scale manufacturing development in addition to agriculture which will justify continuation of urban-like growth rate.
- There is no potential for tourism in Athienou to imply higher growth rate.
- There is potential for agricultural development (cereals and some animal husbandry), being additional factor keeping population growth at about the average urban growth rate.
- Policy changes associated with membership to the European Union (purchase of houses by other European nationals) is unlikely to affect population growth further.

As a conclusion, a population of approximately 6 100 inhabitants is projected at the horizon 2030.

DENSIFICATION OF THE POPULATION

The spatial development pattern of Athienou is typical of most villages. It has an old village core with old houses and shops, around which new shops and offices are concentrated, and a spread out new housing development area. Its spatial sprawl however is limited due to the village's location on the 'buffer zone' About 35% of the housing area is predominantly empty with scattered houses and partly developed road network. There are also scattered houses outside the designed housing development zone (about 20).

Housing development is at present controlled by the Athienou Local Plan. From the point of view of future infrastructure planning (such as water supply and sewerage), the area of the housing development zones is a misleading indication of the expected level of development as its population

capacity in term of the land stock it includes is greater that the realistic housing needs for the foreseeable future of 5-10 years ahead. The housing development zone estimated at about 250 ha corresponds to a population capacity of about 12,000 people, while the presently vacant land stock (about 36% of the area) could accommodate an additional estimated amount of about 500 housing units.

The densification of the population in the residential area is estimated to be approximately 25 inhabitants/ha.

SUMMARY OF INFORMATION FOR THE ATHIENOU COMMUNITY

Table gives a summary of the information for the Athienou Community.

TABLE A6.14: SUMMARY OF INFORMATION FOR ATHIENOU

Athienou				
		2005	2015	2030
Population and houses				
	Permanent population	1 603	5 152	6 100
	Number of summer houses	0	0	0
Water consumption				
	Domestic consumption (m^3/day)	460	524	640
	Non domestic consumption (m^3/day)	156	176	218
	Total domestic and non domestic (m3/day)	616	700	858
	Additional summer consumption (m^3/year - 90 days)	0	0	0
	Additional summer consumption (m^3/day)	0	0	0
	Average day summer (ADD) (m^3/day)	616	700	858
	Maximum day summer (MDD) (m^3/day)	862	980	1 201
Waste water production				
	Return factor	0.85	0.85	0.85
	Infiltration (m^3/day)	0.00	0.00	0.00
m^3/day	Average Dry Weather flow (ADWF)	524	595	729
	Maximum Dry Weather Flow (MDWF)	733	833	1 021
	Peak Hourly flow (PHF)	1571	1 785	2 188
l/s	Average Dry Weather flow (ADWF)	6.06	6.89	8.44
	Maximum Dry Weather Flow (MDWF)	8.48	9.64	11.82
	Peak Hourly flow (PHF)	18.18	20.66	25.32

APPENDIX 7

AGRICULTURAL LAND IN THE REGION

AGRICULTURAL LAND IN THE LARNACA REGION

The agricultural land of the Larnaca district is characterized by two broad agricultural zones. The Larnaca Coastal Region is part of the coastal zone and includes the villages of Kiti, Perivolia, Dromolaxia and Meneou. Aradippou and Livadia are included in the Larnaca Mixed Farming Region which is within the dryland zone.

LARNACA COASTAL REGION

TABLE A7.1: LAND USE IN THE LARNACA COASTAL REGION (1994)

	Irrigable Area (donums)	Not Irrigable Area (donums)
Temporary crops	12 932	38 682
Permanent crops	3 227	1 277
Fallow land	666	288
Grazing land	–	96
Forest land	–	53
Uncultivated land	932	2 575
Scrub land	–	2 665
Total	17 758	45 637
TOTAL AGRICULTURAL LAND		**63 395**

TABLE A7.2: IRRIGATED LAND BY SOURCE OF WATER IN THE LARNACA COASTAL REGION (1994)

Source of Water	Irrigated Area (donums)	Percentage (%)
Borehole / Well	8 451	47.56%
Dam	9 283	53.28%
River	14	0.08%
Spring	8	0.03%
TOTAL	**17 758**	**100%**

TABLE A7.3: AREA OF TEMPORARY CROPS IN THE LARNACA COASTAL REGION (1994)

Temporary Crops	Irrigated Area (donums)	Not Irrigated Area (donums)
Cereals	238	41 357
Pulses	303	3
Industrial crops	21	–
Aromatic plants	1	–
Fodder crops for grain	–	47
Green fodder for grazing	278	2 595
Green fodder for hay	224	2 816
TOTAL	**1 066**	**46 819**

TABLE A7.4: AREA OF VEGETABLES AND FLOWERS IN THE LARNACA COASTAL REGION (1994)

	Vegetables (donums)	Flowers (donums)
Open field	4 420	0
Greenhouses	400	16
Tunnels	365	–
TOTAL	**5 186**	**16**

TABLE A7.5: AREA AND CROPS PLANTED IN NURSERIES IN THE LARNACA COASTAL REGION (1994)

Plants	Area, M^2
Ornamental plants	19 107
Vegetable plants	13 680
Seedlings	–
Forest plants	–
Mushrooms	–
Other plants	–
TOTAL	**32 787**

TABLE A7.6: AREA OF PERMANENT CROPS IN THE LARNACA COASTAL REGION (1994)

Crops	Irrigated Area (donums)	Not Irrigated Area (donums)
Table grapes	62	44
Wine grapes	107	415
Citrus	2 086	1
Dry nuts	42	172
Fruits	273	13
Olives	528	520
Carobs	5	330
TOTAL	**3 103**	**1 495**

TABLE A7.7: TOTAL NUMBER OF TREES IN THE LARNACA COASTAL REGION (1994)

Trees	Total Number
Citrus	84 940
Dry nuts	3 533
Fruits	12 601
Olives	33 051
Carobs	9 789
TOTAL	**143 914**

LARNACA MIXED FARMING REGION

TABLE A7.8: LAND USE IN THE LARNACA MIXED FARMING REGION (1994)

	Irrigable Area (donums)	Not Irrigable Area (donums)
Temporary crops	6 078	107 775
Permanent crops	3 637	2 984
Fallow land	687	1 417
Grazing land	–	175
Forest land	–	2 078
Uncultivated land	1786	10 877
Scrub land	–	4 679
Total	*12 188*	*129 985*
TOTAL AGRICULTURAL LAND		**142 173**

TABLE A7.9: IRRIGATED LAND BY SOURCE OF WATER IN THE LARNACA MIXED FARMING REGION (1994)

Source of Water	Irrigated Area (donums)	Percentage (%)
Borehole / Well	9 068	74.39 %
Dam	2 600	21.33 %
River	393	3.22 %
Spring	127	1.04 %
TOTAL	**12 189**	**100 %**

TABLE A7.10: AREA OF TEMPORARY CROPS IN THE LARNACA MIXED FARMING REGION (1994)

Temporary Crops	Irrigated Area (donums)	Not Irrigated Area (donums)
Cereals	298	93 119
Pulses	169	9
Industrial crops	80	–
Aromatic plants	–	–
Fodder crops for grain	0	23
Green fodder for grazing	701	8 083
Green fodder for hay	1 191	9 605
TOTAL	**2 439**	**110 839**

TABLE A7.11: AREA OF VEGETABLES AND FLOWERS IN THE LARNACA MIXED FARMING REGION (1994)

	Vegetables (donums)	Flowers (donums)
Open field	1 214	3
Greenhouses	69	3
Tunnels	23	–
TOTAL	**1 306**	**6**

TABLE A7.12: AREA AND CROPS PLANTED IN NURSERIES IN THE LARNACA MIXED FARMING REGION (1994)

Plants	Area, M^2
Ornamental plants	4 091
Vegetable plants	–
Seedlings	844
Forest plants	32
Mushrooms	–
Other plants	–
TOTAL	**4 967**

TABLE A7.13: AREA OF PERMANENT CROPS IN THE LARNACA MIXED FARMING REGION (1994)

Crops	Irrigated Area (donums)	Not Irrigated Area (donums)
Table grapes	35	75
Wine grapes	104	151
Citrus	1 475	24
Dry nuts	205	204
Fruits	817	59
Olives	955	1 820
Carobs	23	668
TOTAL	**3 614**	**3 001**

TABLE A7.14: TOTAL NUMBER OF TREES IN THE LARNACA MIXED FARMING REGION (1994)

Trees	Total Number
Citrus	59 987
Dry nuts	13 449
Fruits	32 090
Olives	77 827
Carobs	20 554
TOTAL	**203 907**

AGRICULTURAL LAND BY VILLAGE

TABLE A7.15: AGRICULTURAL LAND BY VILLAGE (1994)

Village	Total Area (donums)		
	Irrigated	Not Irrigated	Total
Aradippou	1 028	12 720	13 748
Livadia	574	2 918	3 492
Sub Total	*1 602*	*15 638*	*17 240*
Kiti	2 833	4 519	7 352

Village	Total Area (donums)		
	Irrigated	Not Irrigated	Total
Perivolia	1 175	2 480	3 655
Dromolaxia	1 288	7 250	8 538
Meneou	938	1 256	2 194
Sub Total	*6 234*	*15 505*	21 739
TOTAL	**7 836**	**31 143**	**38 979**

TABLE A7.16: AGRICULTURAL LAND USE BY VILLAGE (1994)

Village	Temporary Crops (donums)	Permanent Crops (donums)	Fallow Land (donums)	Uncultivated Forest and Scrub Land (donums)
Aradippou	12 411	408	98	832
Livadia	2 970	140	24	359
Sub Total	*15 381*	*548*	*122*	*1 191*
Kiti	6 912	122	52	268
Perivolia	3 213	88	64	290
Dromolaxia	8 327	54	96	59
Meneou	1 635	505	6	48
Sub Total	*20 087*	*769*	*218*	*665*
TOTAL	**35 468**	**1 317**	**340**	**1 856**

TABLE A7.17: AREA OF TEMPORARY CROPS BY VILLAGE (1994)

Village	Cereals (donums)	Pulses (donums)	Industrial (donums)	Fodders (donums)	Potatoes (donums)	Vegetables (donums)
Aradippou	9 745	3	–	2 788	–	13
Livadia	2 315	4	–	641	–	42
Sub Total	*12 060*	*7*	*0*	*3 429*	*0*	*55*
Kiti	5 188	76	64	372	519	897
Perivolia	2 569	18	–	51	219	638
Dromolaxia	6 551	5	–	1 599	54	290
Meneou	1 373	–	–	203	15	56
Sub Total	*15 681*	*99*	*64*	*2 225*	*807*	*1 881*
TOTAL	**27 741**	**106**	**64**	**5 654**	**807**	**1 936**

TABLE A7.18: PERMANENT CROPS BY VILLAGE (1994) (NUMBER OF TREES)

Village	Vines	Citrus	Fruits	Nuts	Olives	Carobs
Aradippou	2	777	2 797	1 090	6 622	519
Livadia	7	611	955	109	1 975	162

Sub Total	*9*	*1 388*	*3 752*	*1 199*	*8 597*	*681*
Kiti	3	1 571	1 489	438	869	2
Perivolia	–	2 649	244	11	233	–
Dromolaxia	–	770	1 180	148	1 298	59
Meneou	–	15 064	159	16	1 395	–
Sub Total	*3*	*20 054*	*3 072*	*613*	*3 795*	*61*
TOTAL	**12**	**21 442**	**6 824**	**1 812**	**12 392**	**742**

THE KITI – PERIVOLIA IRRIGATION PROJECT

Part of the project region is covered by the Kiti – Perivolia Government Irrigation Project. For the irrigated areas outside the Project, water demand is satisfied, to a large extent, by groundwater. Detailed information on the area of irrigated land and water demand for areas within the Project, as well as on the irrigated areas which are outside it is provided in the following tables.

TABLE A7.19: IRRIGATED AREAS FOR MAJOR WATERSHEDS (EXCL. GOVERNMENT WATER SCHEME AREAS, 2001)

Crop	Aradippou River		Larnaca Salt Lake Area	
	IRRIGATED AREA (DECARS)	IRRIGATION WATER DEMAND (1000 m^3)	IRRIGATED AREA (DECARS)	IRRIGATION WATER DEMAND (1000 m^3)
Citrus	–	–	–	–
Deciduous	14	10	–	–
Olives	5	2	–	–
Vines	–	–	–	–
Bananas	–	–	–	–
Fodders	812	893	47	52
Potatoes	–	–	37	16
Greenhouses	–	–	–	–
Vegetables	–	–	5	3
TOTAL	**831**	**905**	**89**	**71**

TABLE A7.20: UNIT CROP IRRIGATION WATER DEMAND (m^3/DECAR/YEAR, 2001)

Crops	livadia	larnaca
PERMANENT CROPS		
Citrus	700	800
Deciduous	700	850
Olives	400	500
Table grapes	224	335
Bananas	0	0
Fodders	1100	1300
Almonds	450	600
ANNUAL CROPS		
Tomatoes GH[1]	800	1000

Crops	livadia	larnaca
Cucumbers GH	800	1000
Beans GH	550	750
Peppers GH	800	1000
Melons GH	550	750
Strawberries GH	650	850
Flowers GH	900	1100
Potatoes	250	450
Tomatoes OF[2]	550	750
Cucumber OF	550	750
Beans OF	550	750
Squash	300	500
Onions	400	600
Peppers OF	550	750
Groundnuts	500	700
Cabbage	400	600
Parsley	700	900
Carnation	850	1050
Artichoke	650	850
Kolokasse	1960	2220
Tobacco	0	0
Spices	300	500
Carrots	400	560
Beets	200	400
Watermelon	400	600
Broad beans	50	250
2. Greenhouse, 2. Open Field		

TABLE A7.21: PLANTED AREAS AND ANNUAL IRRIGATION WATER DEMAND (EXCL. GOVERNMENT IRRIGATION SCHEMES)

	Aradippou			livadia			larnaca		
	Planted Area (decars)	Water Demand (m^3)	Unit Crop Water Demand (m^3/decar/ year)	Planted Area (decars)	Water Demand (m^3)	Unit Crop Water Demand (m^3/decar/ year)	Planted Area (decars)	Water Demand (m^3)	Unit Crop Water Demand (m^3/decar/ year)
Citrus									
Deciduous	14	10 016	715						
Olives	1	240	240	4	1 720	430			
Grapes									
Bananas									
Fodders	671	738 166	1 100	141	155 100	1 100			
Greenhouses									
Potatoes							37	16 425	444
Vegetables									
TOTAL	**686**	**748 422**	**1 091**	**145**	**156 820**	**1 082**	**37**	**16 425**	**444**

TABLE A7.22: KITI – PERIVOLIA IRRIGATION PROJECT: AREAS AND WATER DEMAND

	Perivolia (decars)	Kiti (decars)	Meneou (decars)	Dromolaxia (decars)	Unit Water Demand (M^3/decar/Year)
Permanent Crops					
Citrus	–	21	712	7	800
Deciduous		23			843
Olives	81	185	116	64	474
Grapes					0
Bananas					0
Sub Total	*81*	*229*	*828*	*71*	648
Annual Crops					
Fodders	180	240		343	1 300
Potatoes	39	467	3	84	450
Greenhouse	17	53		16	1 003
Open Field Vegetables	1 100	1 080	280	590	750
Sub Total	*1 336*	*1 840*	*283*	*1 033*	814
TOTAL	**1 417**	**2 069**	**1 111**	**1 104**	**776**

AGRICULTURAL LAND IN ATHIENOU

TABLE A7.23: AGRICULTURAL LAND IN ATHIENOU (1994)

Village	Total Area (donums)		
	IRRIGATED	NOT IRRIGATED	TOTAL
Athienou	217	15 502	15 719

TABLE A7.24: AGRICULTURAL LAND USE IN ATHIENOU (1994)

Village	Temporary Crops (donums)	Permanent Crops (donums)	Fallow Land (donums)	Uncultivated Forest and Scrub Land (donums)
Athienou	15 001	337	25	357

TABLE A7.25: AREA OF TEMPORARY CROPS IN ATHIENOU (1994)

Village	Cereals (donums)	Pulses (donums)	Industrial (donums)	Fodders (donums)	Potatoes (donums)	Vegetables (donums)
Athienou	12 104	–	–	2 894	–	4

TABLE A7.26: PERMANENT CROPS IN ATHIENOU (1994) (NUMBER OF TREES)

Village	Vines	Citrus	Fruits	Nuts	Olives	Carobs
Athienou	–	81	1 471	2 094	5 359	729

APPENDIX 9

IRRIGATION LAND REQUIREMENTS

Table A9.1 gives the unit water demand for the village of Livadia and for the municipality of Larnaca. As data is not available for the other regions, water demand for Livadia will be taken to be representative of the Aradippou STP region, while the water demand for Larnaca will be taken to be applicable for region of the existing STP and the villages of the scheme that will be connected to it.

TABLE A9.1: UNIT WATER DEMAND

Crops	Livadia M^3/DONUM/YEAR	Larnaca M^3/DONUM/YEAR
PERMANENT CROPS		
Citrus	936	1070
Deciduous	936	1137
Olives	535	669
Table grapes	300	448
Bananas	0	0
Fodders	1472	1739
Almonds	602	803
ANNUAL CROPS		
Tomatoes GH[1]	1070	1338
Cucumbers GH	1070	1338
Beans GH	736	1003
Peppers GH	1070	1338
Melons GH	736	1003
Strawberries GH	870	1137
Flowers GH	1204	1472
Potatoes	334	602
Tomatoes OF[2]	736	1003
Cucumber OF	736	1003
Beans OF	736	1003
Squash	401	669
Onions	535	803
Peppers OF	736	1003
Groundnuts	669	936
Cabbage	535	803
Parsley	936	1204
Carnation	1137	1405
Artichoke	870	1137
Kolokasse	2622	2970
Tobacco	0	0
Spices	401	669
Carrots	535	749
Beets	268	535
Watermelon	535	803
Broad beans	67	334

The expected wastewater flows for the Aradippou STP, and for the existing Larnaca STP (arising only from the villages of Perivolia, Kiti, Dromolaxia and Meneou), for the years 2005, 2015 and 2030 have been used to calculate the cultivated area that would be required for each crop for each of the two regions, so as to provide an indication as to the land requirements for the agricultural reuse of the treated effluent in relation to crop selection.

TABLE A9.2: LAND REQUIREMENTS FOR REUSE OF THE TREATED EFFLUENT, 2005 (DONUMS)

Crops	Livadia	Larnaca
PERMANENT CROPS		
Citrus	920	656
Deciduous	920	617
Olives	1610	1050
Table grapes	2875	1566
Bananas	0	0
Fodders	585	404
Almonds	1431	875
ANNUAL CROPS		
Tomatoes GH[1]	805	525
Cucumbers GH	805	525
Beans GH	1171	700
Peppers GH	805	525
Melons GH	1171	700
Strawberries GH	991	617
Flowers GH	715	477
Potatoes	2576	1166
Tomatoes OF[2]	1171	700
Cucumber OF	1171	700
Beans OF	1171	700
Squash	2146	1050
Onions	1610	875
Peppers OF	1171	700
Groundnuts	1288	750
Cabbage	1610	875
Parsley	920	583
Carnation	758	500
Artichoke	991	617
Kolokasse	329	236
Tobacco	0	0
Spices	2146	1050
Carrots	1610	937
Beets	3219	1312
Watermelon	1610	875
Broad beans	12878	2099

TABLE A9.3: LAND REQUIREMENTS FOR REUSE OF THE TREATED EFFLUENT, 2015 (DONUMS)

Crops	Livadia	Larnaca
PERMANENT CROPS		
Citrus	1116	837
Deciduous	1116	788
Olives	1954	1339
Table grapes	3488	1999
Bananas	0	0
Fodders	710	515
Almonds	1736	1116
ANNUAL CROPS		
Tomatoes GH[1]	977	670
Cucumbers GH	977	670
Beans GH	1421	893
Peppers GH	977	670
Melons GH	1421	893
Strawberries GH	1202	788
Flowers GH	868	609
Potatoes	3126	1488
Tomatoes OF[2]	1421	893
Cucumber OF	1421	893
Beans OF	1421	893
Squash	2605	1339
Onions	1954	1116
Peppers OF	1421	893
Groundnuts	1563	956
Cabbage	1954	1116
Parsley	1116	744
Carnation	919	638
Artichoke	1202	788
Kolokasse	399	302
Tobacco	0	0
Spices	2605	1339
Carrots	1954	1196
Beets	3907	1674
Watermelon	1954	1116
Broad beans	15628	2678

TABLE A9.4: LAND REQUIREMENTS FOR REUSE OF THE TREATED EFFLUENT, 2030 (DONUMS)

Crops	Livadia	Larnaca
PERMANENT CROPS		
Citrus	1519	1171
Deciduous	1519	1102
Olives	2657	1874
Table grapes	4745	2796
Bananas	0	0
Fodders	966	721
Almonds	2362	1561
ANNUAL CROPS		
Tomatoes GH[1]	1329	937
Cucumbers GH	1329	937
Beans GH	1933	1249
Peppers GH	1329	937
Melons GH	1933	1249
Strawberries GH	1635	1102
Flowers GH	1181	852
Potatoes	4252	2082
Tomatoes OF[2]	1933	1249
Cucumber OF	1933	1249
Beans OF	1933	1249
Squash	3543	1874
Onions	2657	1561
Peppers OF	1933	1249
Groundnuts	2126	1338
Cabbage	2657	1561
Parsley	1519	1041
Carnation	1251	892
Artichoke	1635	1102
Kolokasse	542	422
Tobacco	0	0
Spices	3543	1874
Carrots	2657	1673
Beets	5315	2342
Watermelon	2657	1561
Broad beans	21259	3747