Larnaca Sewerage & Drainage Board

Environmental Impact Assessment

Phase B of Larnaca Sewerage System

Final Report

April 2006

ΑΤΛΑΝΤΙΣ
ΣΥΜΒΟΥΛΕΥΤΙΚΗ

MWH

CONTENTS

EXECUTIVE SUMMARY

i. INTRODUCTION

According to the Law 57(I)/2001 on the Assessment of Impacts from projects, that was recently replaced by Law 140(I)2005, the Larnaca Sewerage and Drainage Board (LSDB) undertook the Environmental Impact Assessment (EIA) of Phase B of the Larnaca Sewerage System. The project was assigned to the consortium of companies, Atlantis Consulting and MWH&I.

ii. PROJECT DESCRIPTION

The project concerns the construction of a sewerage collection system and pumping stations, in the areas that lie between the limits of phase A works and LSDB boundary for Phase B works. The project concerns also the expansion of the sewerage treatment station, the tertiary treatment of liquid waste and the treatment and disposal of the sludge.

Within the scope of the EIA various alternative solutions were evaluated in order to select the optimum available alternatives. The preferred solution includes the selection of locations for the sites of pumping stations and the technologies of expansion of the existing Phase A sewerage treatment station, with the option of anaerobic sludge treatment.

The total lengths of the phase B sewers are listed in the following table:

Area	Sewer	Length
Area B-II	Main Sewers	10.0 km
	Pressure Mains	6.9 km
	Secondary Sewers	156 km
Area B-III	Main Sewers	1.4 km
	Pressure Mains	0.9 km
	Secondary Sewers	42 km

According to the MWH&I feasiblilty study, one (1) pumping station is proposed for area B-I, seven (7) pumping stations for area B-II and two (2) pumping stations for area B-III of phase B of the sewerage system of Larnaca. All pumping stations will be equipped with odor reduction filters.

The sewage of Phase B will be transferred to the existing sewerage treatment station that will be expanded.

The proposed treatment method is a combination of the aerobic decomposition of the liquid waste and anaerobic sludge digestion. The proposed treatment intends in the use of the treated water for irrigation and of the sludge as fertilizer in agriculture.

It is noted that the storage and distribution of the treated water is outside the scope of this study.

iii. Impact Assessment and minimization measures

During the construction period the impacts that have been identified are mainly due to the negative impact in the quality of life of the neighbors that will inevitably arise from the discomfort and vexation the construction works will cause. In addition, the impacts to the environment from works that are going to take place in the salt lake areas were evaluated. For the operation phase the impacts from the operation of the station and the use of the treated sludge as a fertilizer were evaluated.

The main impacts from the project and the suggested measures for minimization are briefly presented in the table that follows:

Impact	Minimization measures
Negative impact in the quality of life from the discomfort and vexation during the construction period.	The impact mitigation measures for the organization and management of the construction works are the following: • The contractor shall provide timely and precise warnings to the affected population regarding the scheduling and nature of works. • For minimizing the duration of inconvenience in each

Impact	Minimization measures
	area of the project, it is proposed that storage sites for construction materials are selected every 500 meters were this is feasible. The site will only be used during works in the vicinity. • Where traffic detours are possible, the roads along which construction is taking place should be completely closed off. • In the area of the works there shall not be any temporary storage of soil since this practice is creating problems from additional dust and material escaping in the roads and nearby private properties. • Drainage pumps and generators constitute a major noise source. It is proposed that this equipment is insulated with noise insulating encapsulations. • The contractor shall designate appropriate borrow and waste disposal areas.
Impacts on habitats during construction works at the locations near the salt lakes.	The following measures are proposed in order to reduce the interferences: • Restrict the building sites and storage locations outside the limits of the salt lake's habitat. • Isolation and covering of construction materials to avoid erosion, leakages and landscape deterioration. • Immediate removal of excavation materials so that the probability of wash outs towards the salt lake's habitat and sedimentation or other negative impacts on the habitat's physiology or productivity of the plants is eliminated.
Intervention on landscape and aesthetics.	For the proposed pumping stations the following guidelines are suggested: • The appearance of the pumping station buildings

Impact	Minimization measures
	should be upgraded with the adoption of a modern frugal design and the use of high quality aesthetic building materials. In the main urban areas fair-face type concrete and painted metal should be used for doors and ventilations. For further improvement of the concrete's appearance, decorative patterns can be applied, such as the creation of voids, a practice usually accompanied by filling the voids with lead. In the salt lake surroundings, Tochni stone or similar material and painted metal can be used. For further improvement of the walls appearance decorative patterns of drawings can be applied. • Areas that are not planted should be covered with paving. • The fencing is proposed to be comprised by a low wall (up to 1m) and then complemented with metal bars. • The planting should be used for beautification and not for concealment of the stations. For this reason, sparse planting of trees which will be supplemented with low vegetation is suggested.

Additional measures

Consumption of energy	Production of electric energy from biogas is proposed as a means to: • Recover the energy use of the pumping stations and treatment plant • Savings in fuels and thus reduction of the production

	of CO_2 and other atmospheric pollutants that correspond to the production of electric energy. • Anaerobic digestion of sludge is considered as the most optimal method that can be used in the sewage treatment station of Larnaca. The further evaluation of the construction and operation costs is recommended.
Water conservation	Measures for optimizing the use of treated water: • Early arrangements should be made in order to find the additional tertiary treated water users. • The additional storage reservoirs required should not be installed in the salt lakes area.
Treated Sludge Production	The selection and monitoring of plantations where treated sludge is applied, should be made in co-operation with the Department of Agriculture.
The interruption of sewage disposal in septic tanks has important positive impacts in the water and soil quality of Larnaca.	No measures necessary.
Odors	The decreased flow duration in sewers and especially the long ones should be reduced. The impact minimization measures suggested are the following: • The regions upstream of the pumping stations should be connected in such priorities so that pumping stations with long gravity sewers will not operate for long periods with low flows. • Two pumping pipelines should be used (one pipe should be used the first years of operation and as the flows increase the second pipe should be used) for assuring suitable flow velocities. • Reduce the pressure main lengths and use longer

	gravity mains where feasible. Continue the operation of the biological filter in the sewage inlet chamber at the sewage treatment station for odor removal. Installation of activated filters in all Phase B pumping stations.

Chapter

1

1. Introduction

This report constitutes the Final Report of the Environmental Impact Assessment (EIA), in which the results of this study are presented.

The main objective of the EIA is the configuration of the most preferrable solution. The environmental consultants consider as preferable the solution that fulfills the goals of the project with the least environmental and social cost. For selecting the preferable solution, the study team examined the study area in-depth and located the environmental issues that concern the project area.

In the Final Report the following have been accomplished:

- Description of the study area. Among other actions, the study team evaluated all existing information and paid visits to the study area, aiming at the better possible evaluation of the environmental parameters of the study area.
- Description and analysis of the project.
- Correlation of the project with the environmental parameters of the installation area so that environmental issues that result from the project are identified.

The results of this study are presented in the chapters that follow.

Chapter 2

2. Legislation

The construction of the pumping stations, the extensions of the pipelines and all the works that will take place for the completion of the Phase B of the Larnaca Sewerage system, according to the Larnaca Local Plan-Policy Measures (chapter 28) constitute 'municipal service' developments.

More specifically and according to the above policy, the construction of this kind of developments should be definitely regulated and designed for specific development areas and zones such as housing, industrial, tourist, commercial, foder and other zones.

For the quicker and more efficient implementation of the goals of the local plan it is important and necessary that the design and programming of the network of the public services is done on an integrated basis. The town planning authority is responsible for taking all the necessary measures for the minimization of all the negative environmental impacts that a proposed development project (pumping stations, sewage pipes) is likely to cause on the urban and the natural environment. According to the regulations of the development plans special care should be taken to the following:

- To the underground construction of the proposed development projects. The underground constructions should be encouraged in the cases of pedestrian roads, historical/ traditional urban or rural areas with the main aim the enhancement of the aesthetic value of the environment.
- To the correct spatial, landscape and architectural design of the proposed development (mainly pumping stations) for the reduction of the visual pollution of the environment.
- Development should be permitted provided that the following are adhered:
    - In the cases where the development is designed to take place in a housing zone, the plot ratio should not be higher than 70% of what is permitted in that development zone.

- The proposed development should have a minimum distance of 6m from the plot's boundaries.
- The authorities should take special measures for vegetation planting surrounding the development to make sure that the aesthetic value of the area is not reduced.
- The development project should be of high architectural value

For the construction of the pumping stations within the boundaries of the Larnaca municipality the responsible authority for issuing a permit, is the town planning authority of the Larnaca municipality, but in the cases where pumping stations will be located outside the city boundaries the Larnaca District Officer of the town planning and housing authority is responsible for the permits.

In the framework of the harmonization procedure with the environmental legislation of the European Union, the legislation for the evaluation of environmental impacts from various development projects has been prepared. More specifically, the relevant law is the 57 (I)/ 2001 and according to the regulations of these and the Article 9 of Annex I all the works concerning the extension of sewerage systems fall within the category of projects for which a full environmental impact study is needed.

As such, the parameters that will be examined and hence the impacts on the environment evaluated are those of nature and natural ecosystems, the atmosphere, the geomorphology, aquatic systems and water resources, land and soil, noise levels during the construction phase and during the operational procedures. Furthermore, a comparative environmental impact assessment will be undertaken for all the alternative solutions discussed for the location of the pumping stations.

Moreover, the Cyprus National Environmental Policy promotes Sustainable Development and as such we are obliged at the National level to encourage the extensions of existing sewerage systems for the sustainable management of waste in the context of the local and European legislation.

The directives concerning sewerage systems of 1971 to 2005, of 1991 to 1994 and all the new versions that have followed (260/92, 247/94, 288/95, 296/98, 217/00, 306/01, 818/04) have regulations regarding the location and construction of sewerage systems, their management and control and finally their treatment and disposal. As such, all the appropriate measures should be taken during the design and construction of the system and also during the operational procedures so that all the relevant regulations and obligations are strictly applied.

Concerning the areas where the effluent discharge from the water treatment procedures will be disposed special care should be taken to the areas with blue flag beaches and beaches with

facilities for swimmers. The relevant directive safeguarding the swimmers' health and an approved water quality is the directive 76/160/EEC Bathing Water Quality which is also included in the local legislation N. 106 (I)/2002 regarding the control of water pollution. This directive deals mainly with the levels of the physicochemical and microbiological parameters that we are obliged to reach and also with the continuous monitoring of water quality.

Furthermore, the content and the way that the treated sludge is used, as a product of the biological treatment of urban waste should follow the rules and obligations of the code of good agricultural practice (article 407/2002) and also the Nitrates Directive (91/676/EEC).

The main aim of the code of good agricultural practice is to guide all the people dealing with agricultural activities in order to avoid or reduce environmental pollution and also to set environmentally accepted conditions for the use of recycled water for irrigation purposes and for the use of biologically treated sludge in agricultural activities.

The regulations dealing with the control of water pollution are also very important 772/2003 according to the articles 5(2), 7(4) and 34(2). These regulations have to do with the collection, treatment and disposal of urban waste and the waste from industrial developments and are very important for environmental protection and the impacts of uncontrol water and solid waste disposal.

It is very important that all the appropriate measures are taken during the construction and the operational procedures of the extensions of the sewerage system so that all the environmental impacts are minimized.

The directive 91/676/EEC secures the reduction of pollution from nitrates from agricultural activities and also the prevention from further pollution.

Finally, according to the regulation 91/271/EEC Urban Waste Water Treatment special care should be taken to the quality and the quantity of the urban wastes that are produced and are pumped from the pumping stations so that the leaks towards sensitive natural ecosystems are minimized and that the pollution of water resources is prevented.

Legislative framework for safety at work

Safety at work is a very important parameter for the creation of a sustainable working environment, the protection of workers and the various environmental parameters. The application of all the relevant regulations is based on national standards for health and safety and for the correct operation of the production processes.

The following regulations and directives give a general picture of the Cyprus reality.

Law 89 (I)/96 for health and safety at work

This law comprises mostly of codes of practice for the protection of the workers at work and all the relevant obligations and responsibilities for the provision of information, training and safety conditions within the working environment.

D.I. 212/2000 Health and Safety at work, 1996

The relevant article indicates the security signs and warnings that could be used for the protection of the working environment.

D.I. 268/2001 Regulations for health and safety at work (chemical parameters)

All the aspects concerning venturousness from chemical substances in the working environment are evaluated and some basic protection and safety measures are indicated

D.I. 172/2002 Health and safety at work (minimum requirements for temporary and portable worksites)

This regulation refers to the responsibilities of the coordinator during the elaboration of the design and feasibility project of the proposed development and to the responsibilities of the coordinator for the construction of the project.

D.I. 444/2001 Minimum requirements for health and safety (The use of equipment at work)

In this regulation are included the minimum requirements for the safe use of equipment at work and all the measures that should be taken for their appropriate design and working efficiency.

D.I. 230/2002 Health and Safety at work (Protection from noise)

According to the regulation the accepted level of daily exposure to noise is 85 dB(A). If noise levels reach higher levels then it is very important that the employer informs and trains his/her staff about the risks that underpin the working environment and hence the hearing capacity of the workers

D.I. 315/2003 Basic Requirements

It describes the basic requirements the Individual Protection Equipment has to comply with so that it can be distributed in the market. The requirements of the compliance label "CE" are defined. These represent the confirmation of the manufacturer or his authorized representative that the equipment manufactured complies with all relevant legislation and has undergone all relevant procedures for certificate valuation according to legislation.

D.I. 166/81 Atmosphere and dangerous substances control in industrial plants

This regulation sets the maximum accepted concentration of chemical substances in the atmosphere which can also be inhaled form human beings without causing severe damage in the physiology of their system.

L 25/89 Industrial plants

This law refers to the protection of machinery and other material and also to the construction and maintenance of all kinds of machinery devices or security devices targeted for use in industrial diggings

D.I. 134/97 Committees of safety and health in the working environment

This regulation refers to the selection of the members of the committee and to the exact way of working and decision-making processes. All the responsibilities of the members of the committee are also defined.

D.I. 173/2002 Management of health and safety issues at work

This regulation refers to the commitment of the employer to prepare a report on the assessment of risks and dangers at work and to undertake all the appropriate measures for their reduction.

Chapter

3

3. Description of the study area

3.1. Overview

The province of Larnaca is located in the south-eastern coastal area of Cyprus. It borders with the Nicosia province in the north west, Famagusta in the north- east and in the south-west with the Limassol province. In the south it is washed by the Gulf of Larnaca.

The province of Larnaca is subdivided in the following regions:

A) Larnaca plain

B) Kokkinochoria

C) Mountain area east and south east of the Troodos ophiolite cluster

D) Troodos Ophiolite cluster

E) Mesaoria

3.2. Natural Environment

3.2.1 Climate

The climate of the Larnaca province does not deviate from the more general framework of the Mediterranean climate that characterizes all of Cyprus, with microclimatic fluctuations depending on the relief and the distance from the sea. In the province of Larnaca a dense network of meteorological and precipitation stations exist.

Current Activity

The general winds that prevail in Cyprus are south-western to eastern in the winter, western to north-eastern in the spring, western to northern in the summertime and western to north-eastern in the autumn. However this general wind directions are modified in the various regions of the island by local winds, onshore and offshore breezes, that are caused by the temperature difference of land and sea. These local winds are observed mainly in the

coastal areas, but become perceptible up to 35 kilometres inland. The province of Larnaca is also influenced by onshore and offshore breezes. The table 3.1 that follows gives the mean monthly wind speed at a height of 10 metres and 2 metres above ground, as it was determined by the Meteorological Service with climatic data of the time period 1991-2000 from the meteorological station of the Larnaca airport.

Table 3.1 Mean monthly wind speed at 10m and 2m height above ground.

Month	Mean Monthly Wind speed (m/s)	
	Level 10m	Level 2m
January	4.1	2.2
February	4.3	2.4
March	4.1	2.5
April	4.1	2.6
May	4.1	2.7
June	4.1	2.9
July	4.4	2.9
August	4.1	2.8
September	3.7	2.4
October	3.6	2.2
November	3.8	2.2
December	3.8	2.2
Annual	4	2.5

Precipitation

The mean annual rainfall in the province varies between 300 and 800 millimeters. The effect of the topography in the distribution of rainfall is important. Generally the higher regions accept also highest rainfall. The rainfall is mainly distributed during the months of December and January and to a lesser degree in the months February-March and October-November. The remainder months, the rainfall is very low, almost non-existent. Table 3.2 that follows gives the maximum, mean and minimum monthly rainfall according to the meteorological data of 1991-2000, of the meteorological station of the Larnaca airport.

Table 3.2. Monthly rainfall at Larnaca Airport Meteorological station

Month	Rainfall (millimeters)

	Maximum	Mean	Minimum
January	132.6	62.4	4.1
February	66.7	35.1	7.8
March	75.1	37.4	13.1
April	42.5	16.6	4.4
May	46.3	10.4	0
June	22.4	3.2	0
July	5.7	0.6	0
August	4.4	0.4	0
September	14.2	4	0
October	43.7	16.1	0.9
November	223.7	66.5	5.2
December	368.2	86.4	8.6
Annual	-	339.1	-

Temperature

The province of Larnaca, as well as the rest of Cyprus is characterized by hot summers and soft winters. However, this general state is differentiated by place to place by two factors: the topography and the sea breeze effect. The mean daily maximum temperature is 24.7 °C and the mean daily minimum temperature is 14.4 °C in the city of Larnaca, according to the climatic data of the meteorological station of the city airport (See Table 3.3).

Table 3.3 Monthly and Annual Temperature of the study area

Month	Temperature (°C)			
	Mean Daily Maximum	Daily Maximum	Mean Daily Minimum	Daily Minimum
January	16.6	21	7.4	0.4
February	16.7	22.4	6.7	-1.3
March	18.8	30.3	8.3	2.4
April	22.4	32.2	11.5	2
May	26.4	38.3	15.8	8.9
June	30.3	38.9	19.7	12.5
July	32.4	41.1	22.1	16.9
August	32.7	40.9	22.5	17.5
September	30.9	39.7	19.8	12.4
October	28.1	34.8	17.1	10.4

Month	Temperature (°C)			
	Mean Daily Maximum	Daily Maximum	Mean Daily Minimum	Daily Minimum
November	22.6	29.7	12.5	2.6
December	18.3	24.9	9.1	0.6
Annual	24.7	-	14.4	-

Relative Humidity

The relative humidity is influenced by the altitude and the distance from the coast. The daily fluctuations of relative humidity in the coastal areas in the summer is smaller than in the central plain due to the sea breeze. Also the fluctuations are small in the mountainous areas in the winter due to the low temperatures that prevail. The mean relative humidity at 08:00 and 13:00 hours is presented in Table 3.4.

Table 3.4 Mean Relative Humitity at 08:00 and 13:00 hours

Month	Mean Relative Humitity (%)	
	08:00 M.L.T	13:00 M.L.T
January	78	56
February	76	53
March	71	52
April	63	53
May	60	52
June	63	52
July	65	53
August	66	54
September	59	49
October	60	49
November	70	51
December	79	57
Annual	67	53

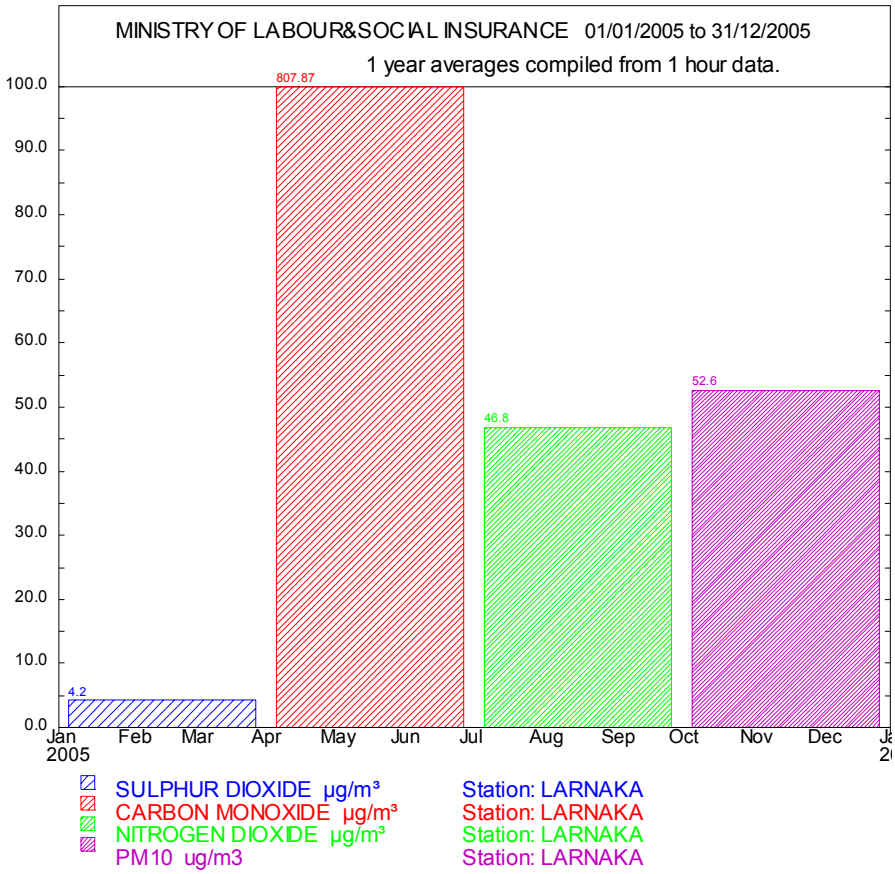
3.2.2 Quality of the atmosphere

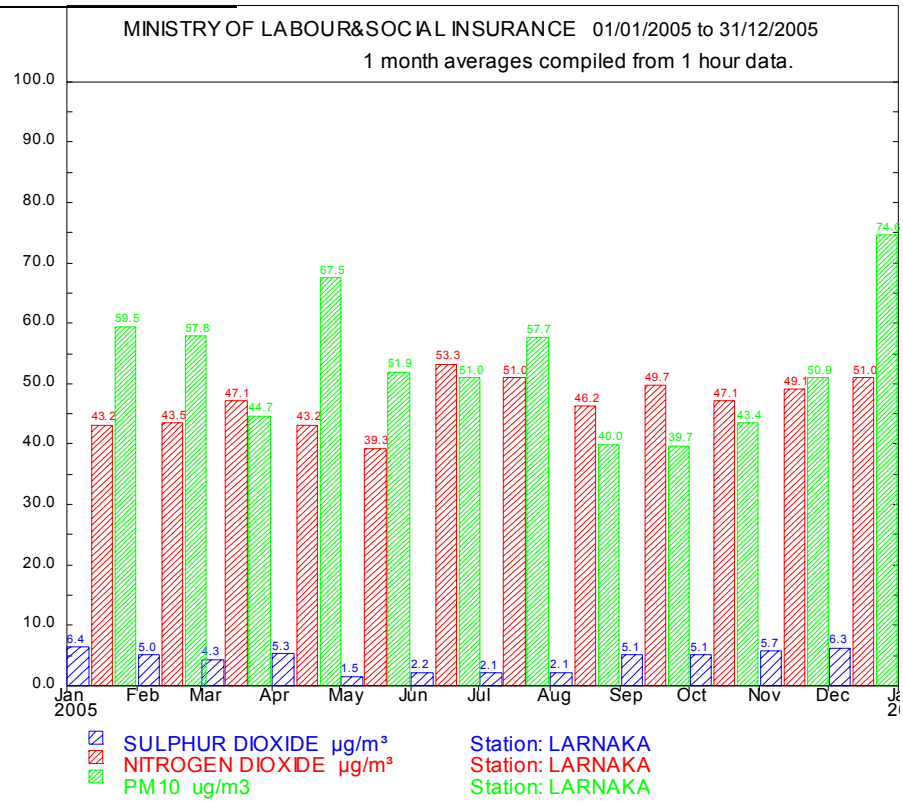
Overall quality of the armosphere

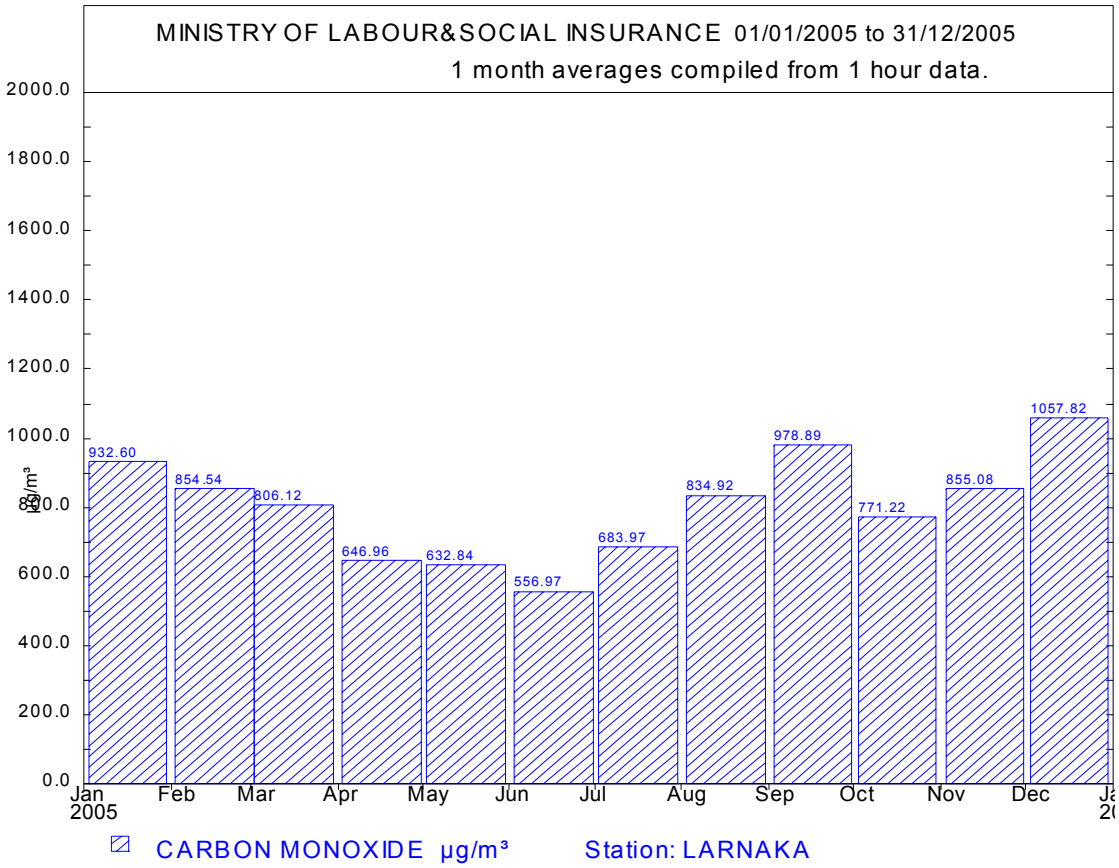
Because the proposed work does not concern particularly the impacts in the quality of the atmosphere, the evaluation of Larnaca's atmospheric quality was limited in a rough evaluation according to data obtained from the Department of Labour Inspection.

Generally for the main urban pollutants NO2, CO, PM10, SO2, the concentrations of pollutants remain within permissible limits. In particular with the import of unleaded gasoline and Eurodiezel, the SO2 and Lead have ceased to constitute issues of concern. Exception remains the breathable suspended particles where their concentration is expected to exceed the allowed limits. It is noted that the pollutants of interest for the project are the breathable suspended particles at the construction phase and the odours at the operation phase. Substances concerning odours are not measured on a regular basis. It can be assumed that under normal conditions, such substances do not exist in the atmosphere.

The montly and annual mean values of pollutants as reported by the Department of Labour Inspection are presented below.




MINISTRY OF LABOUR&SOCIAL INSURANCE 01/01/2005 to 31/12/2005
1 month averages compiled from 1 hour data.
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Jan 2005
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
6.4
43.2
59.5
5.0
43.6
57.8
4.3
47.1
44.7
5.3
43.2
67.5
1.5
39.3
51.9
2.2
53.3
51.0
2.1
51.0
57.7
2.1
46.2
40.0
5.1
49.7
39.7
5.1
47.1
43.4
5.7
49.
50.9
6.3
51.0
74.6
SULPHUR DIOXIDE µg/m³ Station: LARNAKA
NITROGEN DIOXIDE µg/m³ Station: LARNAKA
PM10 ug/m3 Station: LARNAKA


MINISTRY OF LABOUR&SOCIAL INSURANCE 01/01/2005 to 31/12/2005
1 month averages compiled from 1 hour data.
2000.0
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
µg/m³
Jan 2005
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
932.60
854.54
806.12
646.96
632.84
556.97
683.97
834.92
978.89
771.22
855.08
1057.82
CARBON MONOXIDE µg/m³ Station: LARNAKA

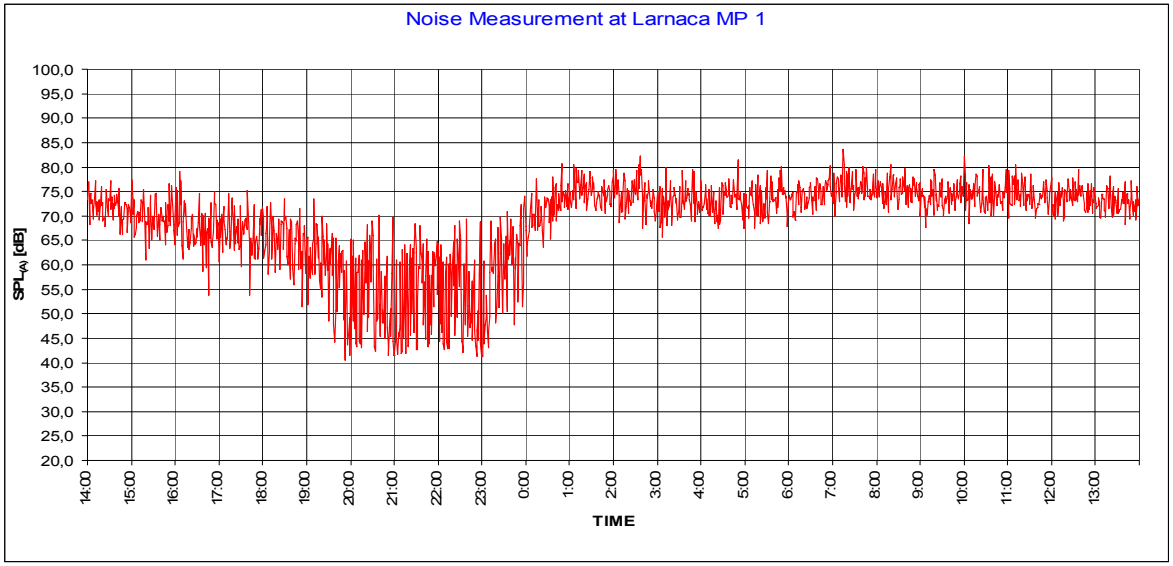
3.2.3 Acoustic environment

The acoustic environment in the study area is mainly influenced by the local traffic. In the pumping stations and the sewerage treatment station sites no other important sources of noise have been identified. It should be reported though that the airport constitutes an important source of noise for the neighbouring regions and particularly for the study area south of the airport.

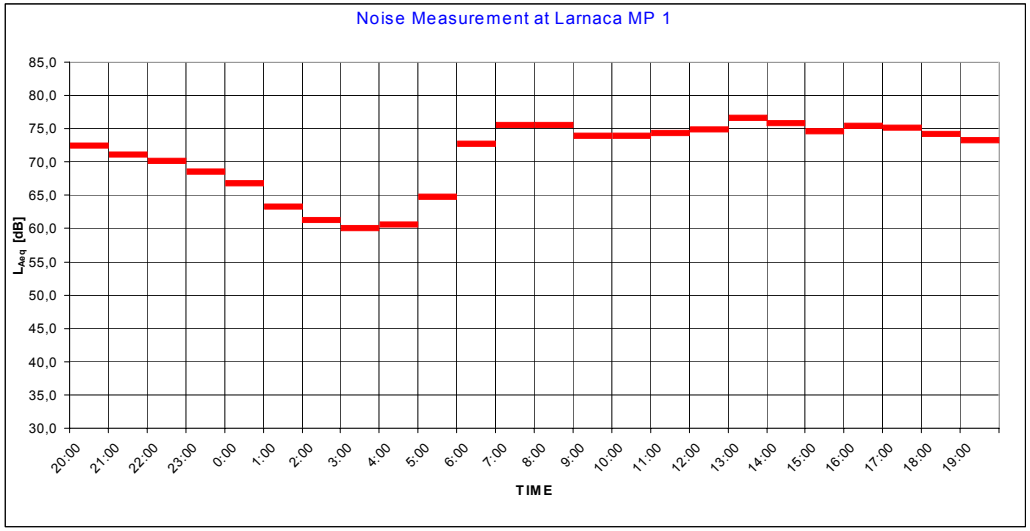
In the wider region of the project were carried out totally eight 24-hours measurements, in a previous study, in the framework of the program LIFE Third countries 2003 - 2005. The work was carried out by the Environment Service in collaboration with Atlantis Consulting and two other partners.

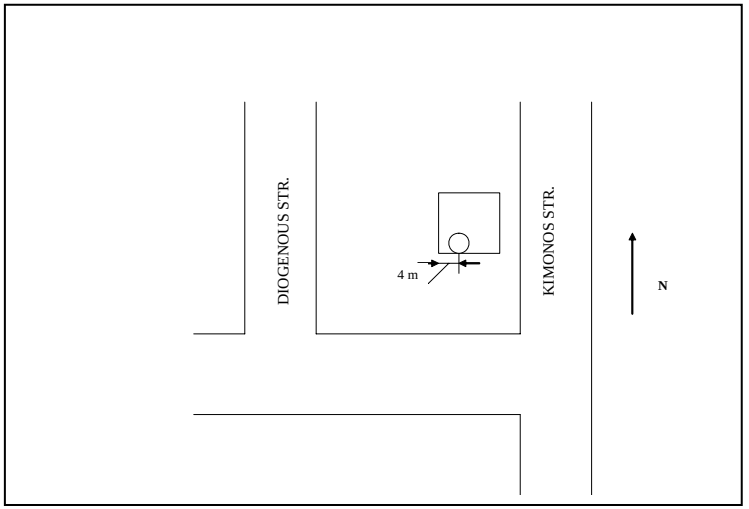
From the results of the above mentioned measurements the consultants proceeded in the evaluation of the acoustic environment in the study area. General perception of the consultants is that the noise in the largest part of the study area is determined mainly by the traffic conditions. Therefore, the main road arteries where the noise can exceed the 75 LAeq during the day (Lday) and reach the 70 - 75 LAeq at the 24-hour duration (Lden) are more charged. The less charged regions, e.g. the residential areas of the pumping stations PSBII-3 and PSBII-4 in the saltlake boundaries, present noise levels of Lden and Lday of the order 50 - 52 dBA.

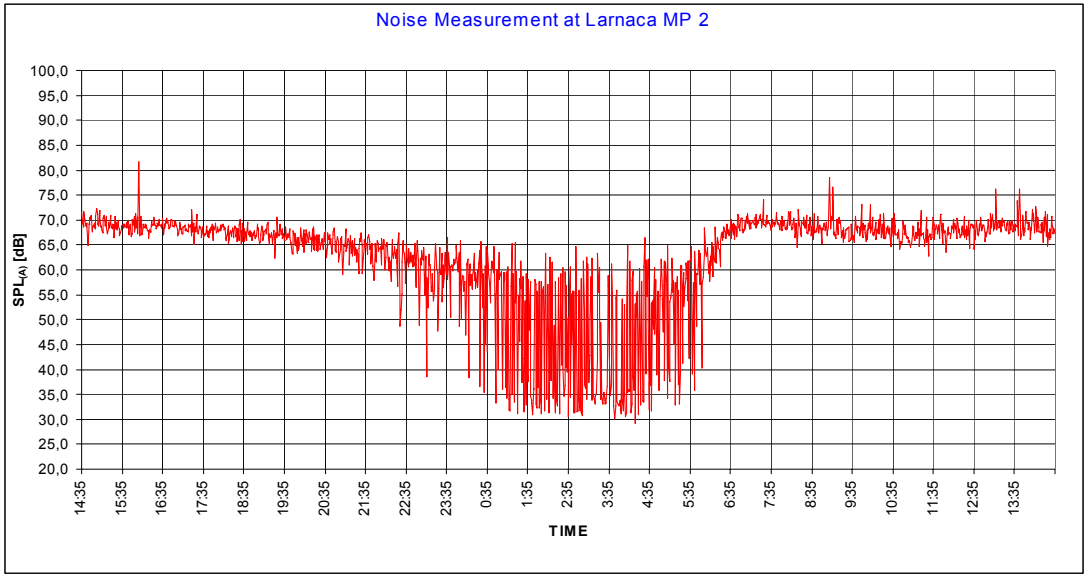
The analytic results are presented in the acoustic environment reports that follow.

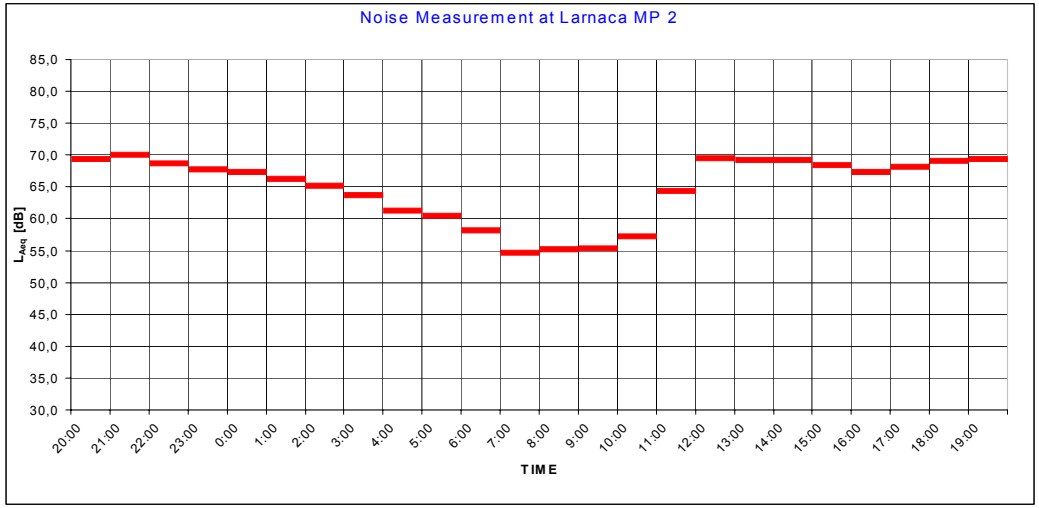


Laeq		**73,1**
Lday(6:00-20:00)		**74,8**
Levening(20:00-22:00)		**71,9**
Lnight(22:00-6:00)		**65,9**
Lden		**75,4**
L_{den}=	**75,4**	**dB**
L_{day}=	**74,8**	**dB**
$L_{evening}$=	**71,9**	**dB**
L_{night}=	**65,9**	**dB**
L_{Aeq}=	**73,1**	**dB**
L_{Amin}=	**40,4**	**dB**
L_{Amax}=	**83,6**	**dB**
$L_{A,1}$=	**80,0**	**dB**
$L_{A,95}$=	**47,2**	**dB**





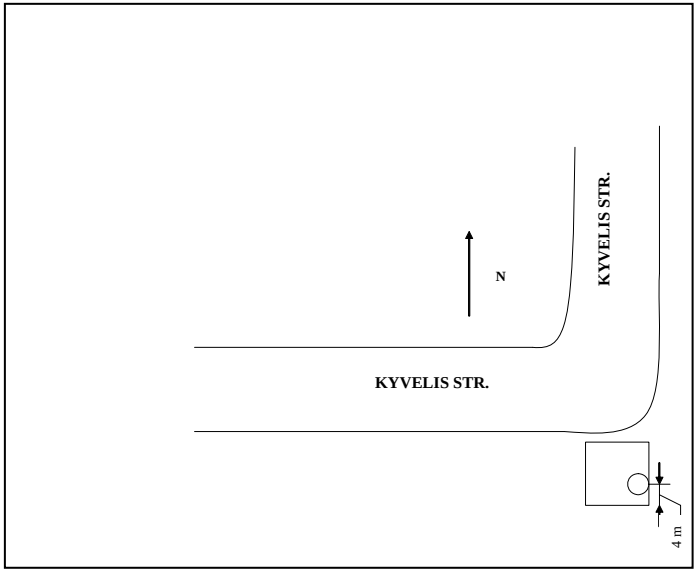


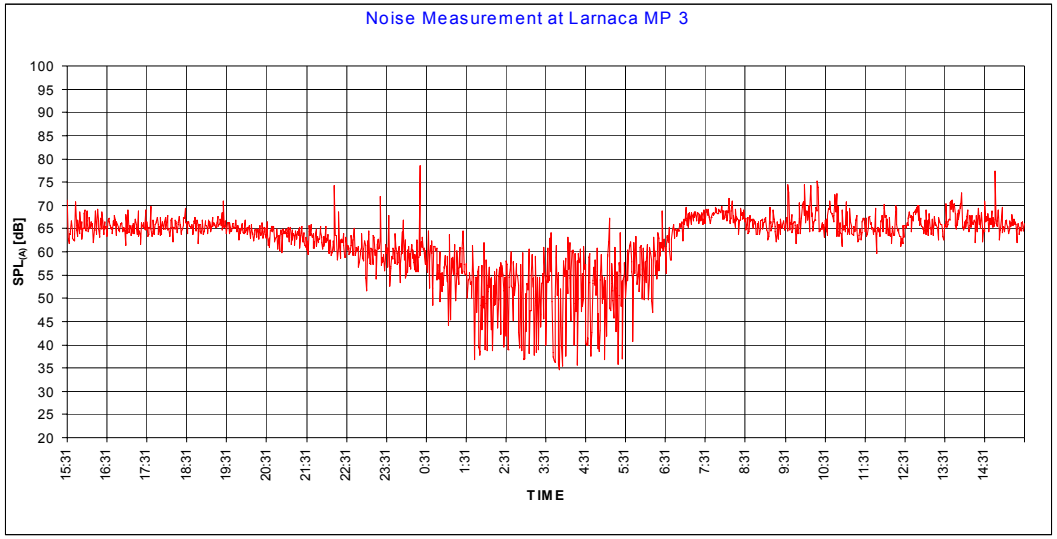


Laeq

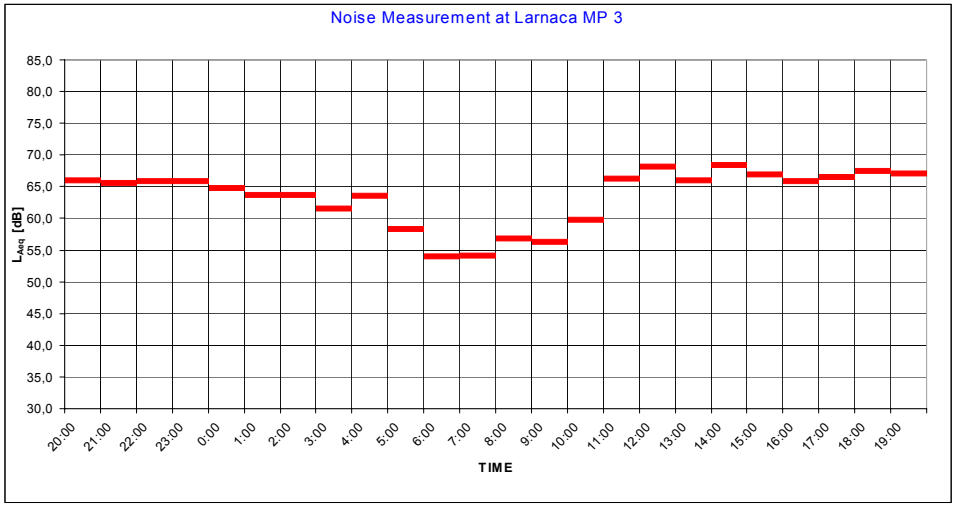
Lday(6:00-20:00)
Levening(20:00-22:00)
Lnight(22:00-6:00)
Lden

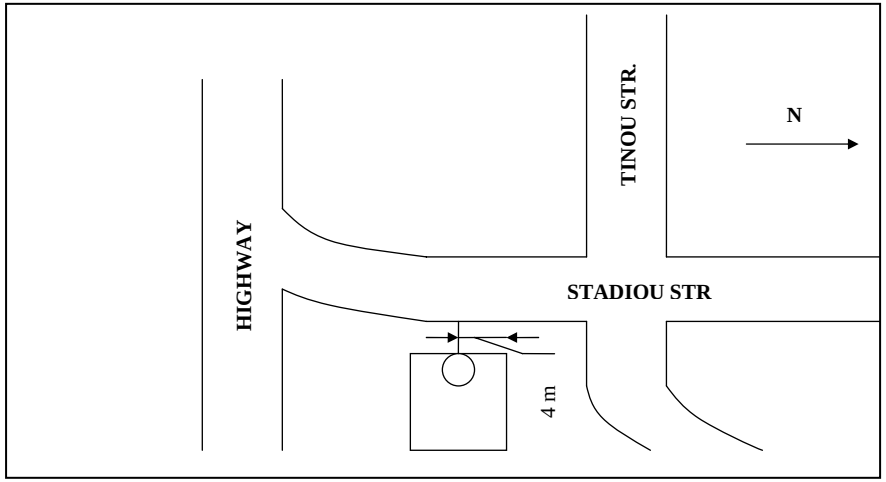
L_{den}=	72,6
L_{day}=	66,8
$L_{evening}$=	69,7
L_{night}=	65,9
L_{Aeq}=	66,9
L_{Amin}=	29,1
L_{Amax}=	81,8
$L_{A,1}$=	72,0
$L_{A,95}$=	34,3

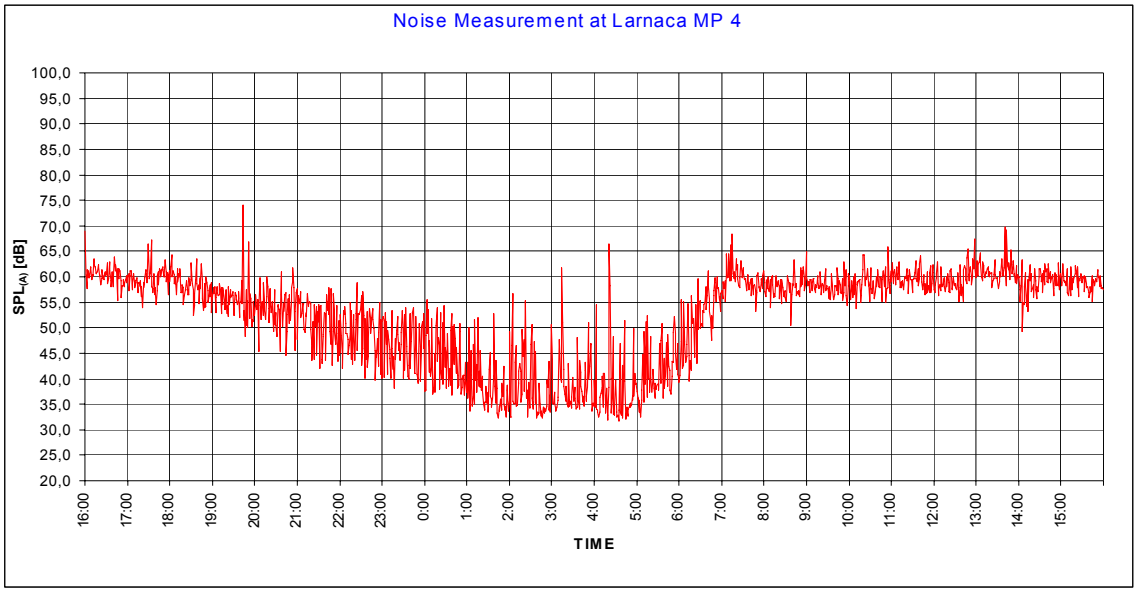




Laeq		**65,0**
Lday(6:00-20:00)		**65,4**
Levening(20:00-22:00)		**65,8**
Lnight(22:00-6:00)		**63,9**
Lden		**70,5**
L_{den}=	**70,5**	**dB**
L_{day}=	**65,4**	**dB**
$L_{evening}$=	**65,8**	**dB**
L_{night}=	**63,9**	**dB**
L_{Aeq}=	**65,0**	**dB**
L_{Amin}=	**34,6**	**dB**
L_{Amax}=	**78,6**	**dB**
$L_{A,1}$=	**71,2**	**dB**
$L_{A,95}$=	**47,4**	**dB**

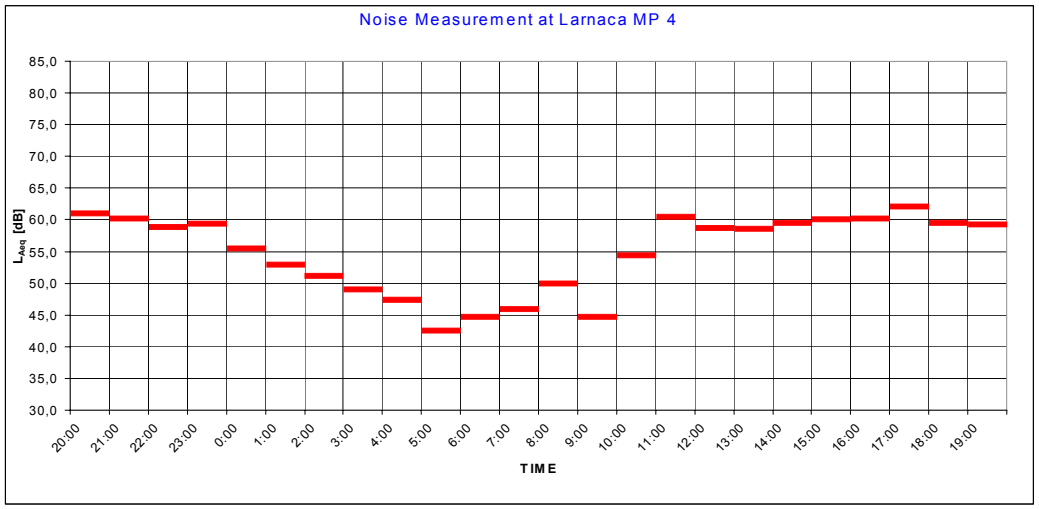


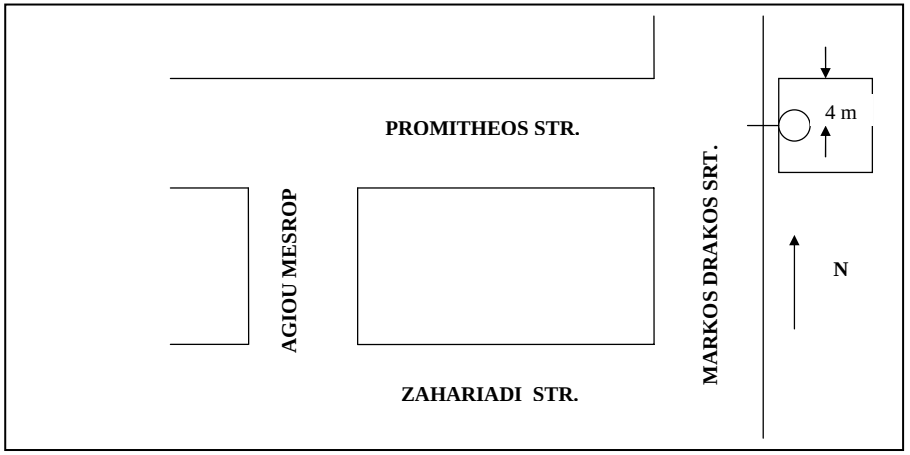


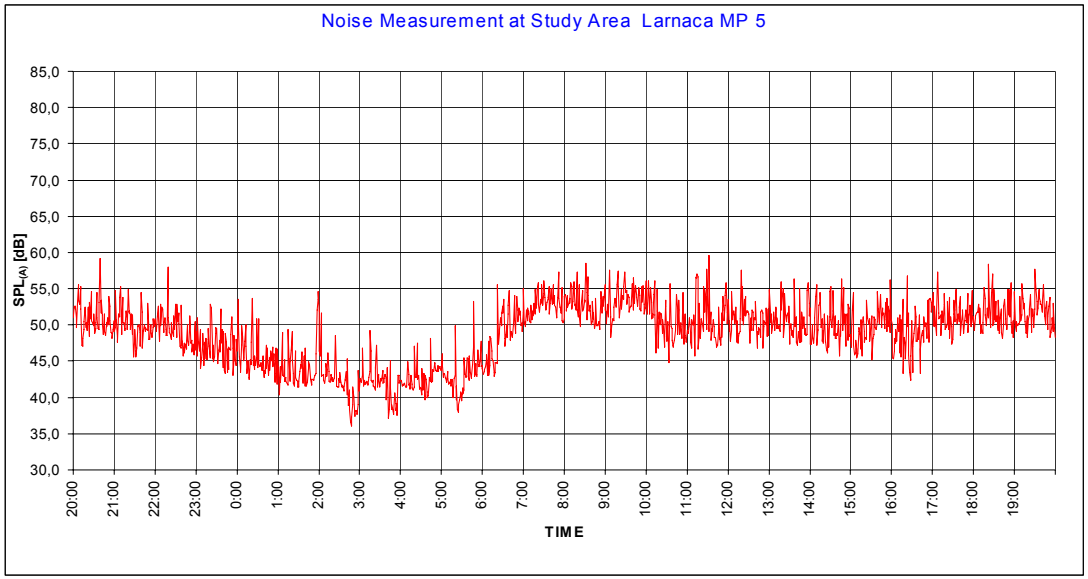


Laeq	**57,7**
Lday(6:00-20:00)	**58,2**
Levening(20:00-22:00)	**60,6**
Lnight(22:00-6:00)	**54,9**
Lden	**62,4**

L_{den}=	**62,4**	**dB**
L_{day}=	**58,2**	**dB**
$L_{evening}$=	**60,6**	**dB**
L_{night}=	**54,9**	**dB**
L_{Aeq}=	**57,7**	**dB**
L_{Amin}=	**31,8**	**dB**
L_{Amax}=	**74,1**	**dB**
$L_{A,1}$=	**64,8**	**dB**
$L_{A,95}$=	**34,6**	**dB**

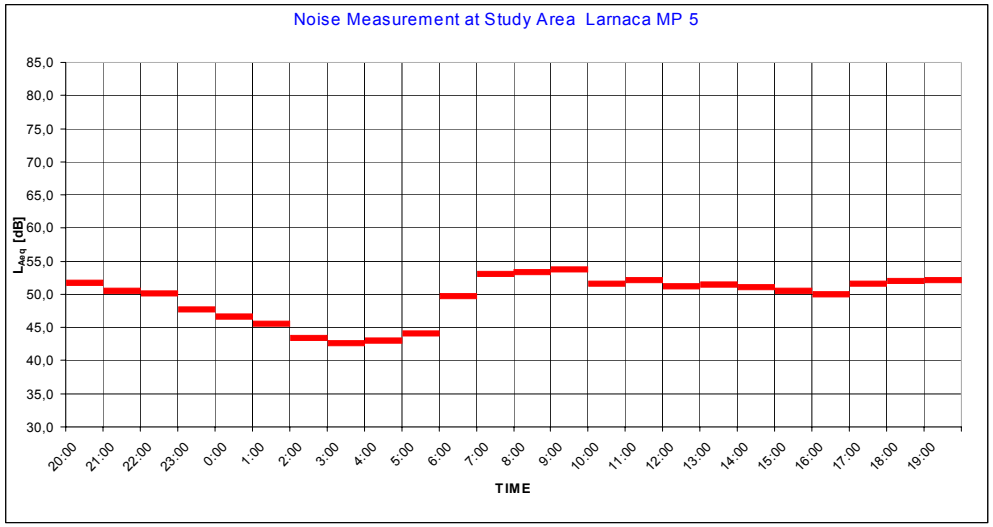


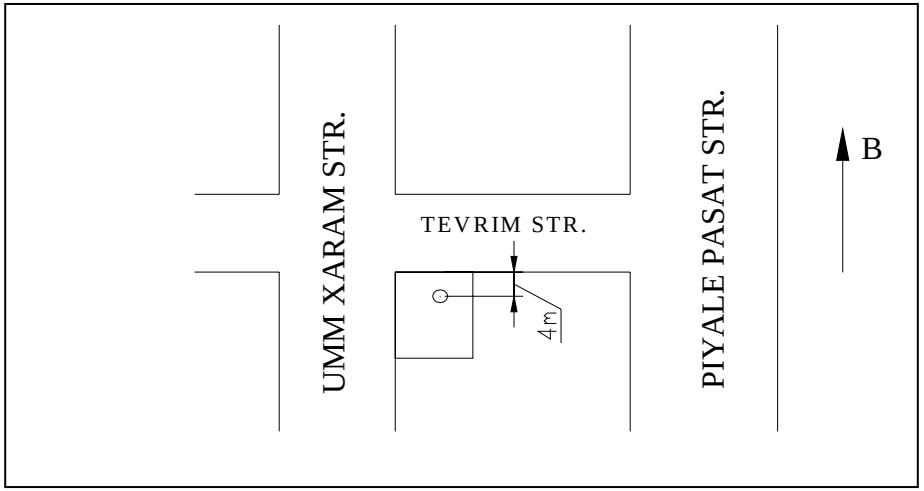


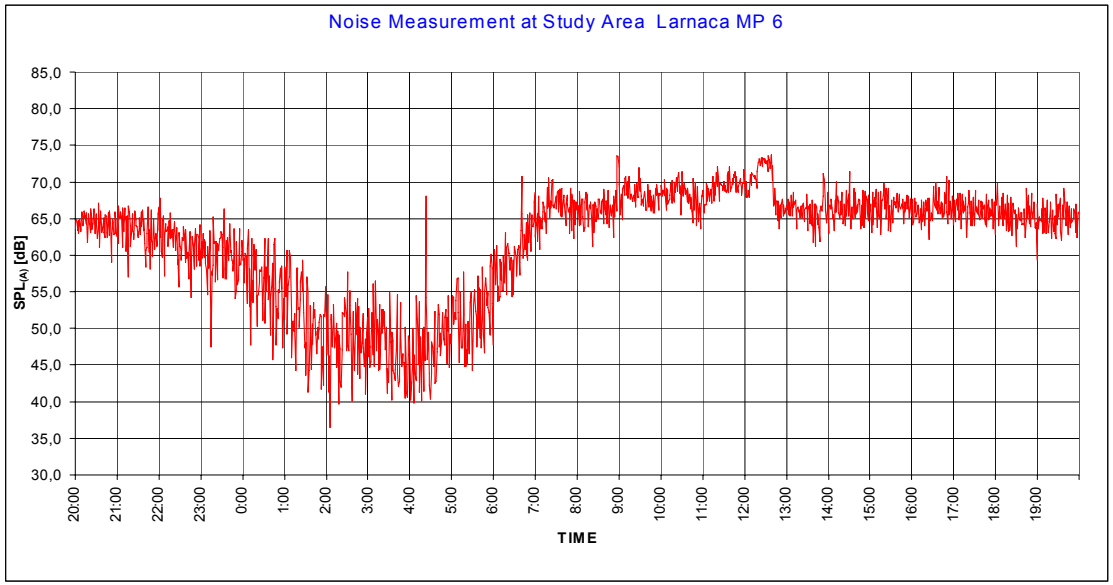


Laeq	**50,6**
Lday(6:00-20:00)	**51,8**
Levening(20:00-22:00)	**51,2**
Lnight(22:00-6:00)	**46,1**
Lden	**54,2**

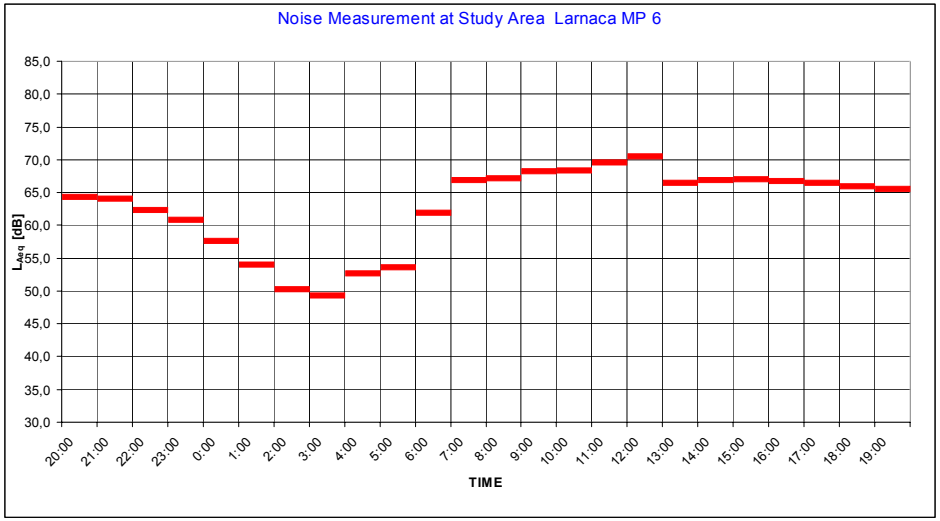
L_{den}=	**54,2**	**dB**
L_{day}=	**51,8**	**dB**
$L_{evening}$=	**51,2**	**dB**
L_{night}=	**46,1**	**dB**
L_{Aeq}=	**50,6**	**dB**
L_{Amin}=	**0,0**	**dB**
L_{Amax}=	**0,0**	**dB**
$L_{A,1}$=	**57,1**	**dB**
$L_{A,95}$=	**41,5**	**dB**

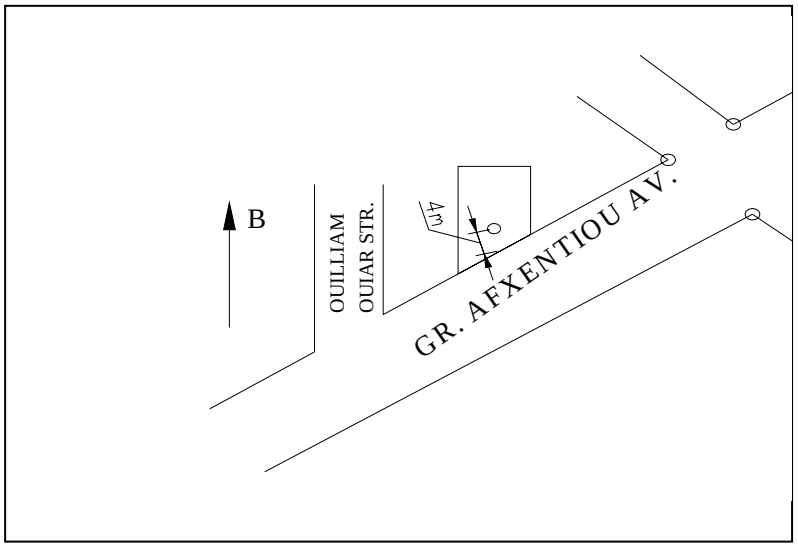


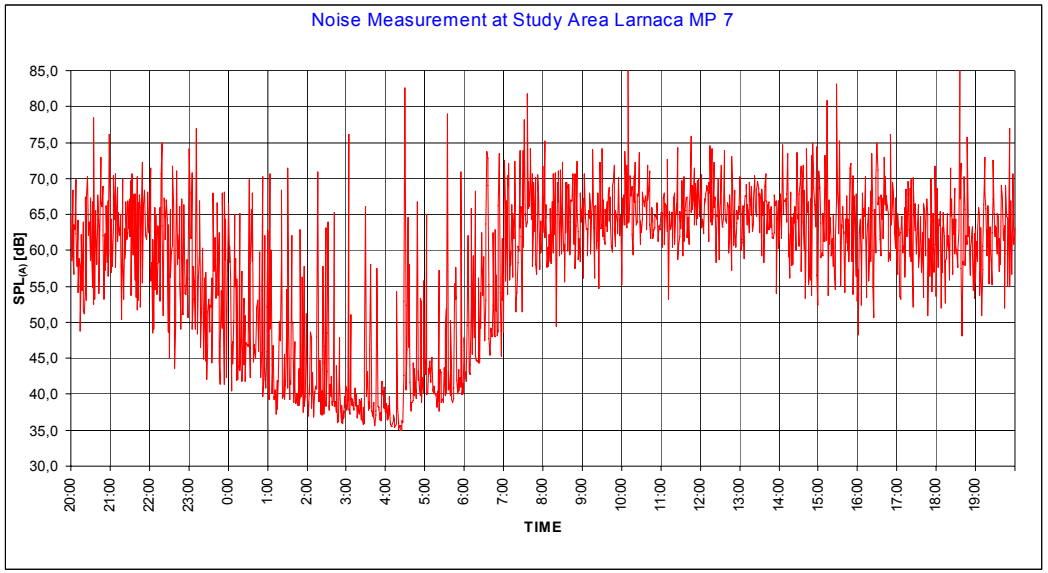




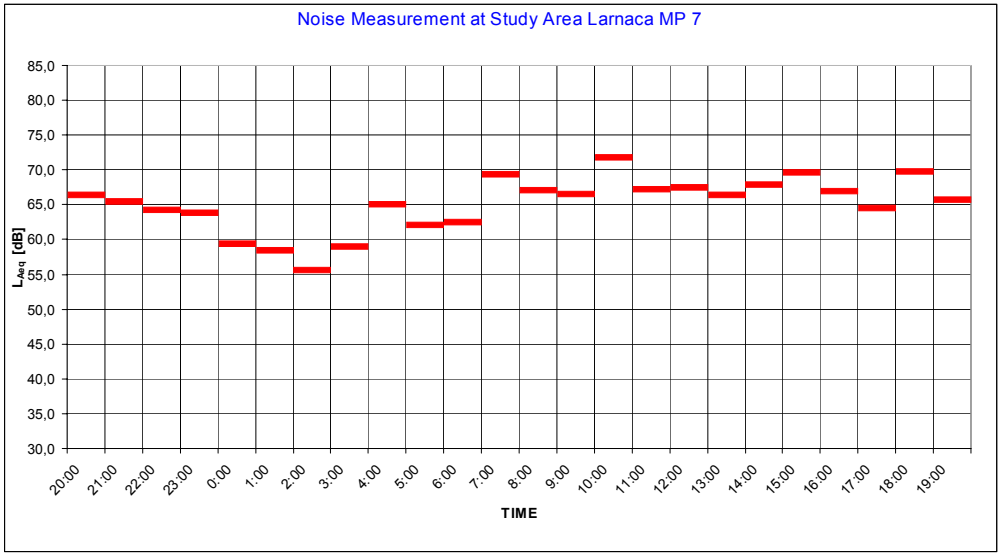
Laeq		**65,6**
Lday(6:00-20:00)		**67,4**
Levening(20:00-22:00)		**64,2**
Lnight(22:00-6:00)		**57,3**
Lden		**67,6**
L_{den}=	**67,6**	**dB**
L_{day}=	**67,4**	**dB**
$L_{evening}$=	**64,2**	**dB**
L_{night}=	**57,3**	**dB**
L_{Aeq}=	**65,6**	**dB**
L_{Amin}=	**0,0**	**dB**
L_{Amax}=	**0,0**	**dB**
$L_{A,1}$=	**72,6**	**dB**
$L_{A,95}$=	**45,6**	**dB**

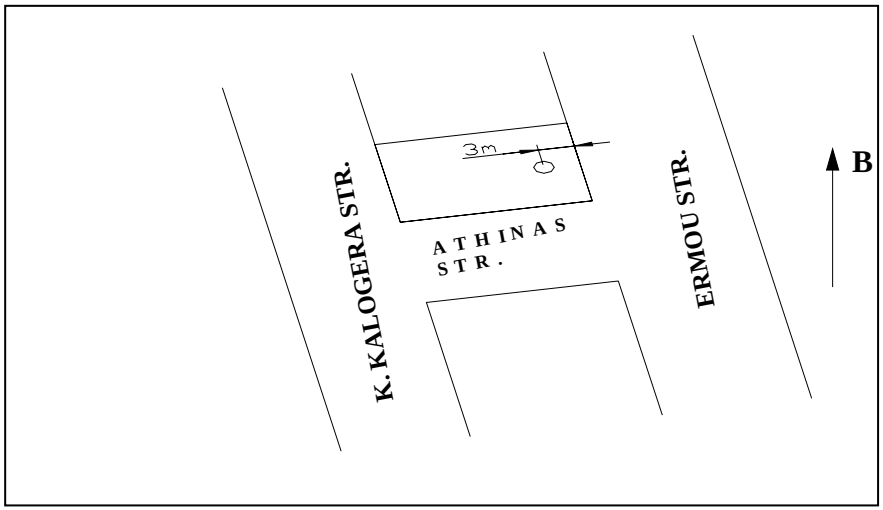


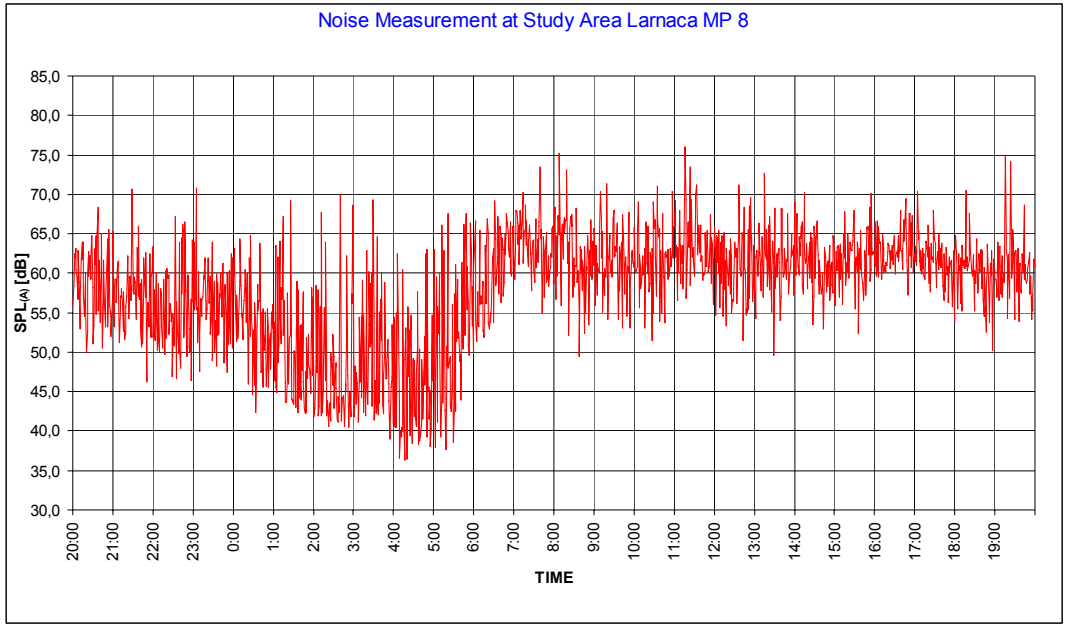




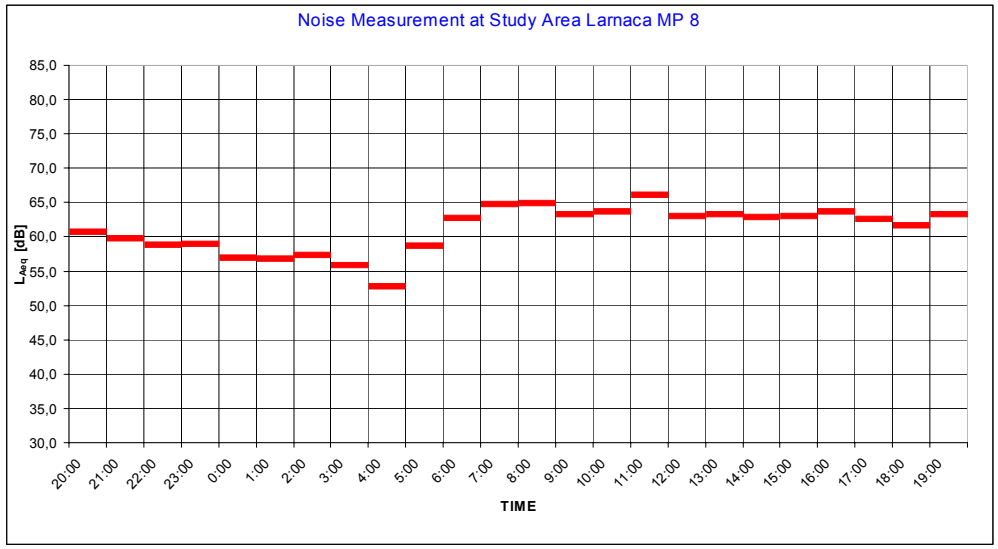
Laeq			**66,5**
Lday(6:00-20:00)			**67,9**
Levening(20:00-22:00)			**66,0**
Lnight(22:00-6:00)			**62,0**
Lden			**70,0**
L_{den}=		**70,0**	**dB**
L_{day}=		**67,9**	**dB**
$L_{evening}$=		**66,0**	**dB**
L_{night}=		**62,0**	**dB**
L_{Aeq}=		**66,5**	**dB**
L_{Amin}=	**e=33.1**		**dB**
L_{Amax}=	**e=96.4**		**dB**
$L_{A,1}$=		**75,9**	**dB**
$L_{A,95}$=		**38,2**	**dB**

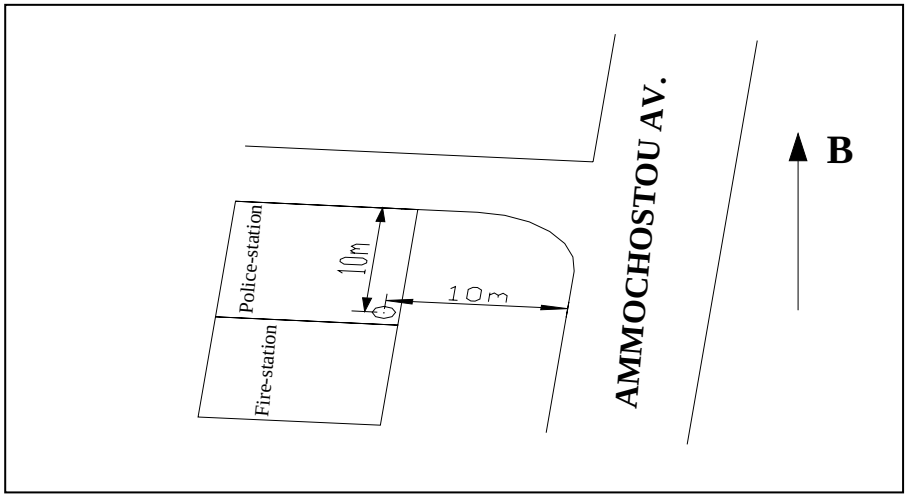






Laeq			**62,1**
Lday(6:00-20:00)			**63,6**
Levening(20:00-22:00)			**60,3**
Lnight(22:00-6:00)			**57,4**
Lden			**65,4**
L_{den}=		**65,4**	**dB**
L_{day}=		**63,6**	**dB**
$L_{evening}$=		**60,3**	**dB**
L_{night}=		**57,4**	**dB**
L_{Aeq}=		**62,1**	**dB**
L_{Amin}=	**e=34.5**		**dB**
L_{Amax}=	**e=94.8**		**dB**
$L_{A,1}$=		**70,6**	**dB**
$L_{A,95}$=		**43,1**	**dB**





3.2.4 Biology

The Larnaca district supports a very rich flora which also includes a big variety of endemic species and priority species. The vegetation is rich on hilly and upland areas which support the largest area of national forests of the district. The main National forests are the following: Aetomouti, Stavrovouni, Ormidia, Xylotympou and Xylophagou. The lower forests of Ormidia, Xylotympou and Xylophagou have gone extinct due to the continuous and uncontrolled felling and the transformation of the ecosystem in agricultural areas. The salt lakes represent a biotope of high ecological significance and part of them is falling within the boundaries of the study area for the Larnaca Sewerage extensions (see map 3.1).

Larnaca salt lakes ecological characteristics

The site Alykes Larnacas includes two salt lakes and the adjacent wetland and is situated to the south of Larnaca and to the east of Meneou and Dromolaxia villages. The international airport, the Larnaca Wastewater Treatment Plant and a Desalination plant are located within it and are seriously threatening the ecological quality of this unique ecosystem. The site covers an area of about 1761 ha of which 670 ha is water (when fully flooded) and nearly 300 ha are natural halophytic scrubland (maps 3.2 and 3.3).
The salt lakes (habitat type 1150) are recharged by rainfall, surface runoff and possibly by seawater intrusion. Sea water seepage is possible due to the partly leaky character of the sifty sand lenses embedded in this impervious complex. They have a seasonally variable water depth (max 1m) and accordingly variable salinity concentrations (20ppt-350ppt). Salinity and its fluctuation is one of the major factors concerning the function of the ecological system of the lakes. Three species are regularly present in these lakes and they are important for the ecosystem function due to their role in the foodweb: Dunaliella salina (a unicellular algae), Artemia salina and Branchianella spinosa. Dunaliella salina is the base of the food chain. The brine shrimp Artemia Salina, serves as the main food supply of the greater Flamingo (Phoenicopterus ruber). In the water there is also the plant Zannichellia palustris a submerged perennial or ephemeral herb, typical to fresh and brackish water.
Halophilous scrub (1420) is the main vegetation in the wetland and includes various communities characterized by *Arthrocnemum macrostachyum, Halocnemum strobilaceum, Sacrocornia fruticosa, Suaeda vera* and rarely *Suaeda aegyptiaca*. Halophilous and halonitrophilous pioneer therophytic communities (1310) occur in mosaics with the scrub or the margins of the scrub towards the lakes. They are composed of *Halopeplis amplexicaulis, Salicornia europaea, Shoenopus divaricatus, Mesebryanthemum nodiflorum, Limonium avei*. At few places, at the margins of the lakes there are some

small salt meadows communities (1410) with Juncus rigidus, Juncus heldreichianus, Juncus subulatus, Plantago maritime ssp.crassifolia, Juncus hybridus, Juncus acutus and Arthrocnemum macrostachyum.

At the northern part of the site small reed beds (CY02) develop with Bolboschoenus maritimus and/or Phragmites australis and Carex spp. At the western edge of the site there is a variably inundated grazed area with grassland mainly composed of therophytes (6220). Plantago lagopus, Hordeum murinum are dominant with frequent participation of Bromus intermedius, Bromus sterilis, Bromus diadrus, Lolium rigidum and also of species as Polygonum aviculare, Polygonum equisetiforme, Phalaris minor. Human influence is evident in the communities composition which includes segetals and ruderals such as Centaurea hyalolepis, Beta vulgaris, Capsella bursa pastoris, Prosopis farcta, Notobasis syriaca, Calendula arvensis, Sonchus oleraceus.
The sandy beach has been intersected all along by a road and the coastal communities are restricted to a narrow zone and rather degraded. There is a drift line zone with Cacile maritime (1210) and then primary dune communities (2110) with Elymus farctus and/or Zygophyllum album as sand-fixing species. At the margins with the salt lake Parapholis incurve, Limonium virgatum, Inula crithmoides and Arthrocnemum macrostachyum participate to the sand dune vegetation.
On the west there are some phrygana formations (5420) with Sarcopoterium spinosum, Thymus capitatus, Helichrysum italicum, Asparagus stipularis, Rhamnus oleoides.

Quality and Importance

Alykes Larnacas consist one of the largest wetland systems of Cyprus but also one of the most severely stressed by human activities. The two ''Alykes'' (salt lakes) of Larnaca are the second in size and importance in Cyprus after the salt lake of Akrotiri at Limassol.
The following elements indicate the ecological quality and importance of the site:

1) The variety of extended and representative halophilous wetland habitat types. These habitats occur at few sites in Cyprus.
2) The avifauna of the site with more that 100 bird species (31 of them listed on Annex I 79/409/EEC or new additions to the Annex) is important at national as well as international level, especially for migratory and for water birds. For this reason the site was recently designated a Ramsar area. The salt lakes consist one of the few locations in Cyprus where migrating birds can be seen when stopping over in order to feed and rest. The most famous is *Phoinicopterus ruber* (which stays there from November till the end of March, although a rich local and migrating avifauna can be

also seen during the winter. *Phoenicopterus ruber* has a large population in the site. The site is very important for migrating *Charadrius alexandrinus* and *Himantopus himantopus*, *Philomachus pugnax*, *Tringa stagnatilis* and *Tringa nebularia*. Other important migratory birds are Herons, Slender-billed gulls, Larks, Pipits, Wheatears and Warblers.

3) The rest of the vertebrate fauna of the site includes 19 species of amphibians and reptiles while the invertebrate fauna includes 63 important insects, 35 of them endemic and 8 endemic land snails.
4) A very small population of Ophrys kotchyi (an accepted new addition to Annex II 92/43/EEC) grows in the site.

Site designation

In 1997, the ministerial council approved a plan for the protection and management of the Salt lakes system. The main goals of this plan were the protection and management of the salt lakes ecosystem, the protection of the surrounding areas from all the kinds and sources of pollution and environmental degradation and finally the sustainable use of the whole area for environmental education and awareness campaigns.

The Larnaca local plans designed from the departments of town-planning and housing and implemented in cooperation with the rest of the governmental organizations and departments has adopted the above plan for the protection and management of the Salt lakes, and has a leading and regulating role for all the decisions made from the town planning authority and other public organizations regarding development or other impacts on the Salt lake systems and the surrounding area.

The salt lakes of Larnaka (668 ha) are designated as a Barcelona Convention Special Protected Area (UNEP Directory)

Also the area of the two salt lakes has recently been proposed and accepted as a Ramsar site named ‘’Larnaca Salt Lake’’ and it represents the 1801st aquatic biotope of international importance. Furthermore the whole lake system is included in the ‘Natura 2000’ network of the European Union in the framework of the habitats directive.

The design and construction of development projects as in the case of the construction of pumping stations and the proposed extensions of the pumps and the biological station of the Larnaca sewerage system within the lake boundaries or at the lake boundaries should definitely be combined with a detailed Environmental Impact Study according to the regulations of the relevant legislation concerning the environmental impacts from various development projects (57/I/2001).

Larnaka salt lakes have also been characterized as an Important Bird Area (Birdlife International) and the whole site is proposed as a Special Protection Area (SPA, Dir 79/409/EEC).
Furthermore, the site is designated as a permanent game reserve area.

Vulnerability, Threats

The ecosystems of the site are in danger because of the already existing International airport and the plans for its expansion, the construction of a desalination plant, road construction, tourism activities, hunting, grazing and expansion of cultivation and habitation.
The airport, the Larnaca sewerage treatment plant, tourist development and a network of paved and unpaved roads have already claimed a substantial part of the wetland habitats.
Grazing, cultivation and the passage of vehicles through the marshes are undermining the habitat's quality. Hunting is not allowed since the site is a designated permanent game reserve area.
The area is under constant pressure for further development such as the expansion of the airport. Moreover, a large section of the site is already a designated tourist zone in which development is expected to start. In addition to diminishing the habitat size, the area's development also involves the danger of disrupting the water cycle. Lastly, the lakes are recipients of polluted surface rainwater runoff from the city of Larnaka.

Description of the Oroklini lake area

The area of the Oroklini lake (Map 3.3) constitutes one great ecological importance system, that is not protected by any conservation action and is severely charged due to excavations in the area, soil and waste disposal and influx of fertilisers from nearby cultivations.This is also apparent from the Spirogyra algae growth in the system, serious indication of degradation and eutrophism. Totally in the area of the lake, 69 taxa have been registered, of which two are endemic and one rare ((Suaeda aegyptiaca) with only one reference from Larnaca Saltlake (Meikle 1985).

In the area that is flooded by rain water, there are groups of alophytes, mainly Arthrochemum macrostachyum and water loving plants such as *Juncus maritimus* and rare *Typha domongensis*.

Around the flooded by rain water area, predominates in good condition, alophytes of habitat type 1420, Mediterranean and thermo-Atlantic halopilous scrubs-Arthrocnemetalia fruticosae, with typical species the *Arthrocnemum macrostachyum* και *Suaeda vera.*

In between scrubs, exists habitat type 1310, Salicornia and other annuals colonizing mud and sand. The characteristic types are Salicornia europea, Shenopus divaricatus, Frankenia pulverulenda and Cressa cretica (Christodoulou 2002).
In the lake boundaries where the soil has been disturbed and especially in the northeastern part, there exist the *Chenopodium murale, Eballium elaterium, Lavatera cretica, Oxalis pescaprae, Salsola kali, Sisymbrium iriol* etc.

3.2.4 Antiquities

The town of Larnaca, is built on the ruins of the ancient Kition, and all of its province, have an important number of stationary and mobile antiquities, that are timed from the beginnings of the 7th millenia b.c. until the ends of the 19th century a.c and shine plenty of light in the most ancient periods of the ancient Cypriot civilization. The stationary antiquities include a lot of impressive public and private buildings and a lot of sculpted and built monumental tombs, that belong to important prehistorical and historical archaelogical towns, settlements and cemeteries, great byzantine churches and monasteries, medieval castles and various other buildings of traditional cypriot character.

Stationary antiquities that were declared Ancient Monuments and that concern the wider study region are the famous “Kamares” by Larissis road and parts of the grounds and remnants of the aqueduct. In addition, the ancient remnants of Chrysopolitissis parish are remarkable.

These domains are presented in the Land Use map 3.3 (Archaelogical areas).

The monuments and antiquities constitute an essential element of our cultural inheritance and are determined by the Antiquities Law. Based on this and according to the relevant provisions and policies of the Larnaca Local Plan, in case of a planning permit request for any development in a plot that is specified as an Ancient Monument, or in the wider region of an ancient monument, the Town Planning Authority will ensure that the development respects the environment and the archaelogical character of the area, with the least possible interference to the wider area of the ancient monument.

3.2.5 Geology

The study area was divided into three sub areas, based on the soil and bedrock type.

Area 1

The most recent deposit is alluvium, which appears to the east, across the coast. Silty, occasionally organic and gravely sand, consisted by different type of excavation matter, is the main contents of the alluvium. The upper tidal flat of the coast is composed by sand with high percentage of organic matter (oceanic seaweeds). The deposit at the area of pumping station PSB III-2 (K2) is the most resent (referenced map 3.4, 3.5 και 3.6 in Annexes 2 και 3).

The subsoil is terrace to the west part of the study area. The deposit is consisted of sandy gravel of Pleistocene, with varied thickness (between 1.6 m at the pumping station PSBI (V1) and 8 m at the pumping station PSBII-1 (A1) and PSBIII-1 (H2)) and calcareous silt, which are divided into layers of different percent of sand - gravel - calcareous silt. The subsoil thickness near the pumping station PSBIII-2 (K2) is approximately 4 m (referenced maps 3.4, 3.5 and 3.6 in Annexes 2 and 3).

The bedrock of the area 1 is firm, joined, sandy marl, named Athalassa Formation of Pliocene, which appears to north. The deposit thickness is 900 m in total (referenced maps 3.4, 3.5 και 3.6 in Annexes 2 and 3).

Area 2

The subsoil at the pumping stations PSBII-5 (Z1, (Z2)) and PSBII-6 (X1) is the resent terraces, and the bedrock is the Athalassa Formation (referenced map 3.6 in Annexes 2 and 3).

At the pumping station PSBII-2 (Q1), the thickness of the deposit is approximately 1 m, however, the thickness, at the pumping station PSBII-7 (Y1), is unknown. There is also at the surface a layer with matter, deposited for the embankment. There are no available data for the subsoil at the area B IV (referenced map 3.6 in Annexes 2 and 3).

Area 3

The areas near the pumping stations PSBII-3 (J1) and PSBII-4 (W1) are within lagoon depositions with sand, silt and clay and with great percentage of organic matter. The underling formation is the Athalassa Formation (referenced map 3.6 in Annexes 2 and 3).

3.2.7 Hydrology - Hydrogeology

Groundwater

Area 1

The alluvium border on marine water and, because of the high permmability, the underground water level is in small depth from the sea level. Specifically the level of underground water in the area near the pumping stations PSBI (V1) and PSBII-1 (A1) is about 0.5 metres under the ground surface. The level of underground water in the area near the pumping station PSBIII-1 (I2) and PSBIII-2 (K2) is approximately 6 and 3 metres under the sea level (referenced maps 3.4, 3.5 and 3.6 in Annexes 2 and 3).

Area 2

The marine terraces include underground water in small depth from the ground surface. The level of groundwater is roughly 5 metres under the ground surface, at the area near the pumping stations PSBII-2 (Q1) and PSBII-7 (Y1). On the other hand, the level of groundwater, at the area near the pumping station PSBII-5 (Z1 (Z2)), is 3 metres under the ground surface. Regarding the area at the pumping station PSBII-6 (X1) and the area B IV, data for the precise depth of the groundwater level are not available. However, the groundwater level is respectively estimated between 1 and 9 metres under the ground surface (referenced map 3.6 in Annexes 2 and 3).

Area 3

Regarding the area at the pumping stations PSBII-3 (X1) and PSBII-4 (W1), data for the precise depth of the groundwater level are not available. It is estimated, though, that the depth of the groundwater level is respectively between 1 and 2 metres under ground surface (referenced map 3.6 in Annexes 2 and 3).

Groundwater quality

The groundwater at the study area is not considered suitable for water supply and irrigation. Because of sea intrusion and aquifer overpumping, the groundwater has an increased salinity, with a value greater than 4.5 mS/ cm. Salinity, at the area of pumping stations PSBII-5 (Z1 (Z2)) and PSBII-6 (X1) and at the area B IV, is between 2.3 and 4.5 mS/cm. Also the groundwater within the study area has high sodium, chlorides and sulphates concentration.

Surface water drainage

Depending on the ground dip, the rainfall runoff varies in places within the study area. The direction of surface water flow appears in map 3.7 (referenced in Annex 2).

PSBI/II-1/III-1+2

At the area near the pumping stations PSBIII-1 (H2) and PSBIII-2 (K2), the surface water flow will run off into sea, via coastal areas SWF1 and SWF2. While the rainfall water at the area of the pumping stations PSBI (V1) and PSBII-1 (A1) will be flowing into pumping stations operation area.

PSB/II -2 (Q1)

There is a valley within the study area, as the directions of the surface water flows converge because of the topography. The rainfall water will flow into the sea, at the area SWF4, to the south.

PSB/II -3 (J1)

The rainfall water run off to the south-west and flows into the saltmarsh of the saltlake.

PSB/II -4 (W1)

The surface rainfall water of drainage basins, which appeared to the north, is assembled at the area of the pumping station. The surface water flows finally to the saltmarsh of the saltlake.

PSB/II -5 (Z1 (Z2))

The rainfall water in the study area runs off to the south-west and it finally flows into the Valley of Kalo Chorio River. Then the river flows at lower attribute leading to the saltmarsh of the saltlake.

PSB/II -6 (X1)

The drainage basins, which appear to the south, incline to the south, resulting in surface water accumulation, especially in the area of the pumping station.

PSB/II -7 (Y1)

The west drainage basins incline to the east. Therefore the surface water flows into the sea, via the coastal area SWF5.

PSBIV

The rainfall water in the area flow to the south-east, because of the ground dip, and finally ends up into the sea, via the costal area SWF5.

3.2.8 Seismic Characteristics

The study area is within the seismic area III, in which have been observed the highest in intensity and number earthquakes. The reason is the "Cypriot Arc", which is to the south of the island and constitutes the tectonic limit between the African and Eurasian Lithospheric Plates.

The factor A has been recorded in the region of Larnaca, in order to determine the ground acceleration in a seismic vibration. The higher the factor is, the more unstable is the geological formation and the more hazardous is the region in ground movements. Based on the microseismic and geotechnical data, two faults interrupt the geological formation.

The area at the pumping stations PSBII-1 (A1), PSBII-3 (J1) and PSBIII -1 (H2) appear to have the higher factor A value, between 2.5 and 5 units. While the area at the pumping stations PSBI (V1), PSBII-2 (Q1), PSBII-4 (W1), PSBII-5 (Z1(Z2)), PSBII-6 (X1), PSBII-7 (Y1), PSBIII-2 (K2) and PSBIV have lower or equal factor A value from 2.5 units.

3.2.9 Suitability of Excavation Materials for Embankments Construction

Alluvium (Area 1) appears to have various issues and therefore they might not be suitable for embankments at the construction of the current work. Concrete issues that are present are the followings:

- Because of their weak mechanic behaviour and their rapid, horizontal and vertical, variance, major settlements are observed in foundations, specifically in the presence of organic matter.
- Liquidation of formation, after a powerful seismic vibration, and consequently reduction of cohesion that may lead to damage of the technical works.
- Chemical erosion, because of the chemical substances that are often contained within the alluvium aquifer, may create resistibility issues to the concrete.

Marine terraces formation of the Areas 2 and 3 are considered more suitable materials for embankment construction, because of grand resistance. Therefore the excavation wastes, that will be created at the earthworks for the current work, it can be used for embankment construction.

3.3 Manmade environment

3.3.1 Data on population, tourism and employment

Data on existing population and households

The data on population and households for Larnaca District were taken from the Republic's Statistical Service. Tables 3.5 και 3.6 show the population for all Larnaca District, Larnaca Town Region and surrounding villages for years 1992 and 2001 respectively.

Table 3.5 Population and Households according to Geographical Region, 1992

District. Town, Village & Quarter	Households		Services		Total
	Number	Population	Number	Population	Population
Larnaca District	29997	99765	19	477	100242
Larnaca Town Region	18495	60164	12	393	60557
Larnaca Town (Larnaca Municipality)	13846	43233	10	353	43586
Skala	2071	5554	1	48	5602
Chrysopolitissa	2367	7015	2	47	7062
Sotira	2663	8778	3	123	8901
Arch. Makarios III	334	1085	0	0	1085
Tsakilero	712	1834	0	0	1834
Kokkines	516	1565	1	42	1607
Agios Nicolas	4025	13699	3	93	13792
Agioi Anargyroi I	453	1527	0	0	1527
Agioi Anargyroi II	440	1442	0	0	1442
Kamares	245	734	0	0	734
Larnaca Greater Urban Area	4639	16931	2	40	16971
Aradippou Municipality	1878	7183	2	40	7223
Levadia	1116	3936	0	0	3936
Dromolaxia	1229	4422	0	0	4422

District. Town, Village & Quarter	Households		Services		Total Population
	Number	Population	Number	Population	
Meneou	249	951	0	0	951
Voroklini Coastal Zone	110	294	0	0	294
Pyla Coastal Zone	49	145	0	0	145
Pyla Area	4302	15001	2	25	15026
Aradippou Region	8802	23724	2	25	23749

Table 3.6 Population and Households according to Geographical Region, 2001

District, Town Village and Quarter	Households		Services		Total Population
	Number	Population	Number	Population	
Larnaca District	36302	114745	28	523	115268
Larnaca Town (Larnaca Municipality)	15948	46324	16	342	46666
Skalal	2353	5559	3	86	5645
Chrysopolitissa	2732	7307	3	43	7350
Sotira	3514	11356	5	80	11436
Arch. Makakrios III	320	918	0	0	918
Tsakilero	576	1473	0	0	1473
Kokkines	399	1063	1	31	1094
Agios Nicolaos	4641	14656	4	102	14758
Agioi Anargyroi I	458	1297	0	0	1297
Agioi Anargyroi II	461	1303	0	0	1303
Kamares	225	559	0	0	559
Zenon	269	833	0	0	833
Areas surrounding Larnaca					
Aradippou Municipality	3041	11425	1	23	11448
Livadia	1454	4854	1	29	4883
Oroklini	1156	3310	0	0	3310
Of which Coastal Zone					836
Pyla	466	1379	0	0	1379
Of which Coastal Zone					479
Dromolaxia	1462	4994	0	0	4994

District, Town Village and Quarter	Households		Services		Total Population
Meneou	348	1196	0	0	1196
Kiti	947	3140	0	0	3140
Pervolia	570	1801	0	0	1801
Aradippou Region	8814	28732	3	29	28761

According to data from the Larnaca Town Planning Department, the population in the area covered by the Larnaca Local Plan for year 2002, was 71,108 residents. These data are in agreement with the projections of the Revised Local Plan of 1996, regarding the total population and its distribution in the study area.

Housing Units

Table 3.7 gives the number of housing units by quarter in Larnaca Municipality and surrounding areas in 2001.

Table 3.7. Number of Housing Units in each Quarter

Community	HOUSING UNITS		
	Total	Used as usual residence	Vacant or temporary residence
Larnaca Municipality			
Skala	4278	2350	1928
Chrysopolitissa	3742	2726	1016
Sotira	4163	3512	651
Arch. Makarios III	340	319	21
Tsakilero	793	576	217
Kokkines	412	399	13
Agios Nicolaos	5443	4637	806
Agioi Anargyroi I	487	458	29
Agioi Anargyroi II	496	460	36
Kamares	247	225	22
Zenon	310	269	41
Total Larnaca Municipality	**20711**	**15931**	**4780**
Area Surrounding Larnaca			

Community	HOUSING UNITS		
	Total	Used as usual residence	Vacant or temporary residence
Aradippou Municipality	3347	3036	311
Livadia	1801	1454	347
Dromolaxia	1563	1462	101
Meneou	696	348	348
Oroklini	2388	1154	1234
Pyla	1163	466	697
Kiti	1113	947	166
Pervolia	1821	570	1251

From the above data it is clear that the number of housing units is substantially greater than the number of households. This fact has implications when interpreting water supply data in per capita terms.

Population Trends and Growth Rates

The population of Cyprus trend is towards stabilization, with natural growth rates decreasing from almost 10% in 1990 to 3,8% in 2002. This natural growth is counteracted to some extent by migration.
The Statistical Service data in Figure 3.1 show exactly this trend in Larnaca's urban areas (Larnaca municipality, Aradippou, Livadia, Dromolaxia, Meneou, Pyla and coastal zone of Oroklini) during the period 1992-2002.

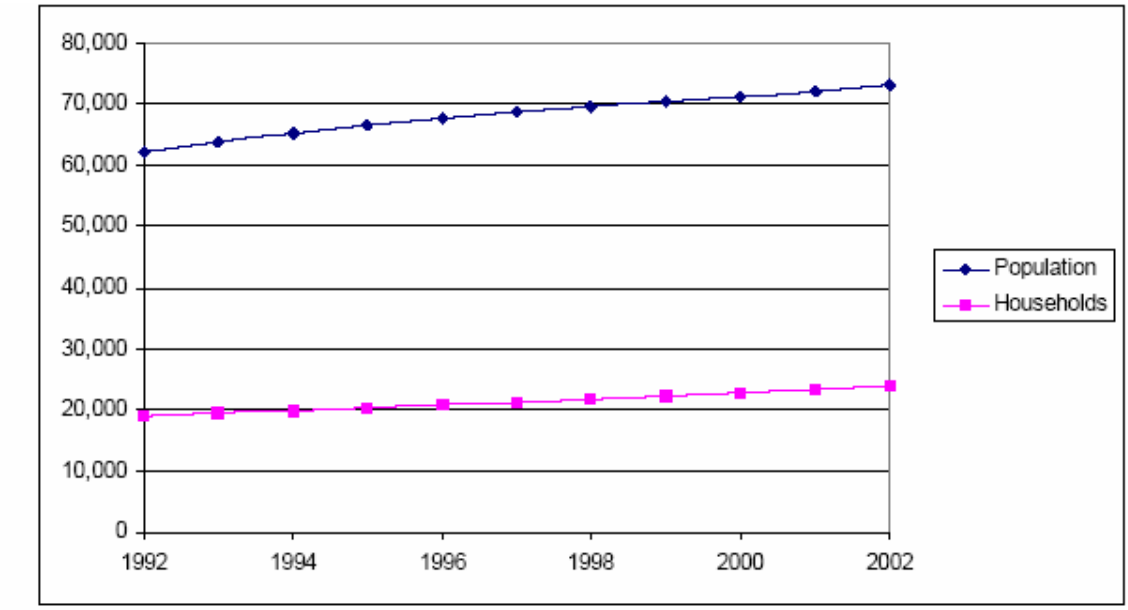


Figure 3.1 Population growth in urban areas of Larnaca 1992-2002

The distribution and population growth from 1996 to 2002 in the area covered by the Local Plan is shown in Table 3.8 and leads to the following conclusions:

i. The permanent population of the Municipality and the communities in the area increased in the 1992-2002 decade.
ii. The population of Aradippou had the highest growth rate compared to the Larnaca's municipality and other communities' population.
iii. A big part of the urban population continues to live in the central towards west urban areas.
iv. The increase of population in the peri-urban communities is a sign of the population movement, of the area covered by the local plan, towards these communities.

Table 3.8 Local plan of population distribution 1992-2002

Local Authorities	Population 1992	Population 2002	1992-2002 Change	Population Percentage 1992	Population Percentage 2002
Larnaca Municipality	43586	47009	7.9%	72%	66.1%
Aradippou Municipality	7223	11918	65%	11.9%	16.8%
Dromolaxia	4422	5058	14,4%	7.3%	7.1%

Local Authorities	Population 1992	Population 2002	1992-2002 Change	Population Percentage 1992	Population Percentage 2002
Community Council					
Meneou Community Council	951	1224	28.7%	1.6%	1.7%
LivadiaCommunity Council	3936	4989	26.8%	6.5%	7%
Oroklini Community Council	294	618	110.2%	0.5%	0.9%
Pyla Community Council	145	292	101.4%	0.2%	0.4%
Total	60557	71108	17.4%	100%	100%

Tourist and other visitors – Annual data

During 2001 a total of 2.6 million visitors visited the island but during 2003 an important reduction was observed. The 90% of these visitors were tourists while the information presented in Table 3.9 shows that 9% or 200,000 people stayed in Larnaca.

Table 3.9 Visitor data for Cyprus and for Larnaca

	1999	2000	2001	2002	2003
Tourist Arrival	2,434,300	2,686,200	2,696,700	2,418,238	2,303,247
% change	+9.5%	+10.3%	+0.4%	-10.3%	-4.8%
% staying in Larnaca	No data	No data	9.4 %	8.6 %	9 %

Seasonal variations

In Figure 3.2 the fluctuation in visitor numbers during the year is illustrated. In particular, the total arrivals in Cyprus and the number of those staying in Larnaca is shown. The figures correspond to total arrivals for each month, while the average stay is 7-10 days.

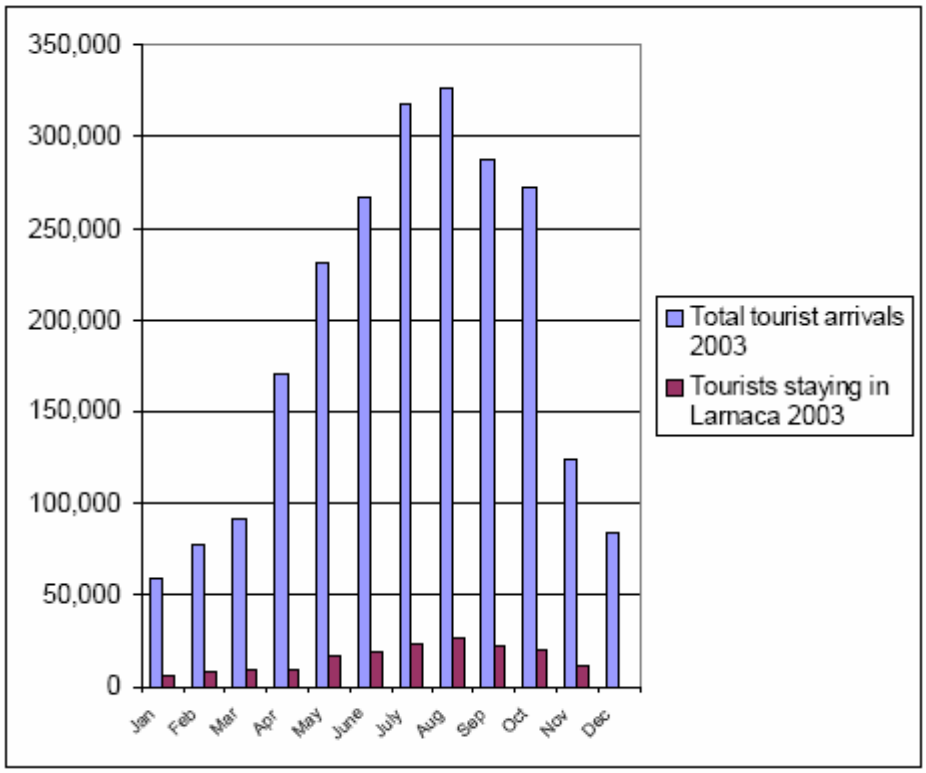


Figure 3.2 Monthly tourist arrivals, 2003.

Figure 3.3 shows the use of beds for year 2000 as it is estimated by the water demand table (water demand 2000).

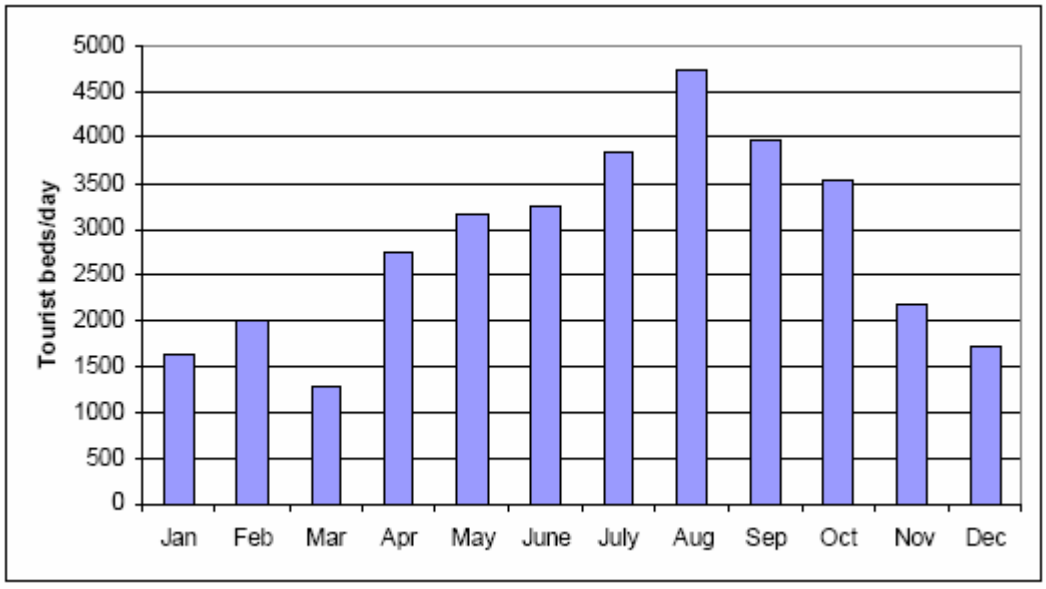


Figure 3.3 Tourist beds per day for year 2000.

Employment

In some cities the analysis of the employment distribution is useful and important because some parts of the cities take a lot of people during working hours. As a result different sewage flows are developed at work areas and different at residences.

For the case of the Larnaca Sewage study it is not considered necessary to adopt such an approach, because the key development parameters for this study are:

- the distribution of the residential population
- the location of specific industrial areas
- the flow that the sewage treatment works receives separately from the airport
- the locations and sizes of hotels

Therefore, specific employment flow factors and employment distributions have not been attempted to be defined.

Socio-economic information

Table 3.10 shows the mean annual income by Source and by Urban and Rural Areas.

Πίνακας 3.10 Mean Annual Income by Source and by Urban and Rural Areas (CY £)

Source of Income	Total	Urban	Rural
Net Income	**10,743**	**11,478**	**9,590**
I. Primary Income	**9,761**	**10,211**	**9,056**
1. Net income from Employment	5940	6342	5309
2. Net Income from Non-Salaried Activity	1977	1851	2174
-Self-employed other than earners	1335	1562	979
- Self-employed earners	563	236	1075
- Benefits in Kind	79	53	121
3. Net Property Income	216	284	109
4. Net Income from Rents	1629	1734	1463
II. Secondary Income	**982**	**1,267**	**574**

Source of Income	Total	Urban	Rural
1. Net income from Pensions	796	894	643
2. Unemployment Allowance	34	45	16
3. Other Benefits	338	329	151
4. Current transfers received/ paid out	-106	0	-476

3.3.2 Water resources, supply and demand

This section gives a short description of the current situation on water resources, supply and demand. According to "Water policy Issues in Cyprus" the water scarcity has "acted as a limiting constraint for the development of agriculture and for other economic activities such as tourism" that are water intensive.

Water Sources

Springs

Larnaca's water supply comes from ground waters, surface waters and desalination.

The ground water is considered a reliable source for water but unfortunately all aquifers in Cyprus have been exploited over their safe yield. The over pumping has caused sea intrusion in most of the coastal aquifers.

In addition, the depletion of aquifers and the simultaneous increase in water demand necessitated the need for establishing, developing and promoting programs for the development of surface waters. Cyprus today has one of the highest numbers of large dams per square kilometer in Europe.

The last years only a few permits for drilling private domestic boreholes have been granted which do not cover the total water demand and for this reason the desalination technology has been introduced.

The various sources of Larnaca Water Supply as given by the Water Supply Board for year 2003, are presented in Table 3.11.

Table 3.11 Larnaca Water Supply Sources, 2003

Months	Borehole Control Meter	Chirokitia Pipe	Tersephanou Pipe	Desalination	Total	m3/ day	Seasonal Factor
January	113770	0	8890	336120	458780	14799	0,94
February	118210	0	0	270840	389050	13895	0,91
March	164780	0	5300	242310	412390	13303	0,87
April	166290	180	17840	224470	408780	13626	0,89
May	171110	0	114300	201920	487330	15720	1,03
June	166080	0	193100	125420	484600	16153	1,06
July	167440	0	315860	52040	535340	17269	1,13
August	166450	180	291820	84870	543320	17526	1,15
September	155900	100	207180	144420	507600	16920	1,11
October	155920	0	133950	184360	474230	15298	1,00
November	147190	90	16580	266680	430540	14351	0,94
December	145890	0	2580	276790	425260	13718	0,90
Total	1839030	550	1307400	2410240	5557220	15225	1,00

Current water demand and supply

Annual Water Supply 2000-2003

According to information obtained from the Larnaca Water Board there was a steep rise in the total water supplied between the years 2000 and 2001. This was due to the water cut measures taken in 2000, a measure taken for confronting the droughts in that year. During the years 2001-2003 the quantities of water supplied were kept in quite stable levels (Tables 3.12 and 3.13).

Table 3.12 Total water supplied to the 14 zones in 2000-2003.

	2000	2001	2002	2003
Total Water, m^3	3,617,000	5,564,010	5,722,660	5,641,170
m^3/ day	9,910	15,244	15,679	15,455

Table 3.13 Water supplied to each zone in 2002.

Zone	1	2	3	4	5	6	7
Location	Larnaca Western Suburbs				North West Larnaca		South East Larnaca
Total m^3	42,840	588,960	426,910	504,040	572,420	360,490	981,770
m^3/ day	117	1,614	1,170	1,381	1,568	988	2,690
Number of water meters 2003	121	1155	3025	2642	4401	3610	3991
Sewerage Zone	B	B	B	B	A	A	A

Zone	8	9	10	11	12	13	14
Location	Town Centre	North East Larnaca		Tourist Area	Industrial Area	Outside municipality	Airport
Total m^3	657,440	529,980	200,340	713,040	91,230	12,230	40,970
m^3/ day	1,801	1,452	549	1,954	250	34	112
Number of water meters 2003	3,018	2,665	899	2,724	83	14	1
Sewerage Zone	A	A	A	A	B	B	A

As a conclusion, the population growth trend towards the urban areas of Larnaca and the high number of housing units compared to households are creating pressures and force the need for extending the current sewerage system. The increased tourist activity in the area and the fluctuations of this activity as illustrated in the relevant figures and statistics for seasonal variations, the population distribution, the industrial area locations, the fluctuations in sewage generation from the airport according to tourist activity and the distribution and hotel sizes as well as the water shortage define the need for a sewage system and consequently the degree and nature of the extensions that need to take place.

Industrial activities

The Larnaca district met a remarkable industrial development, particularly after the Turkish invasion of 1974. To this development contributed the rapid population and tourist growth that increased considerably the need for industrial products as well as the availability of local workforce.

In addition, the airport and port of Larnaca contributed an important role in the whole industrial development of the district. The industrial areas and zones established and operating are the following:

Aradippou Industrial Area, Aradippou Industrial Zone, Industrial Zone of Larnaca's refinery-port, Aradippou-Dromolaxia Industrial Zone, Light Industrial Area "Pampoulas" in the town of Larnaca and Free Industrial Zone.

Transport

The transport network of Larnaca's province consists of a) asphalted roads of two or more lanes, b) one lane asphalted roads, c) gravel covered roads and d) earth roads that present problems mainly during the winter months.

The rapid growth rate observed in the after 1974 period and the great influx of refugees have rendered the transport network insufficient. The improvements conducted compared to the growth rates were not sufficient and this resulted in the expansion of traffic problems. The main activities in Larnaca that cause traffic are located in or around the town center. This creates a radial road network with all main roads ending in the town center. The traffic problems are more intense in the town center where the roads are narrow and are intensified by the lack of parking places and the illegal parking that results in the reduction of the traffic circulation.

Larnaca airport

The international airport of Larnaca was built after the shut down of the Nicosia airport in 1974 and played an important role in the economic development of the town. Beyond the positive contributions of the aiport, there was a negative side also, such as the inhibition of the town development towards the southwest as well as all the negative impacts to the adjacent ecosystems with major impacts in the flora and the bird populations because of the chemical and noise pollution. The General Development Plan of the International Airport has been completed and approved and the project implementation has been initiated.

Larnaca marina

Larnaca marina is located next to the Finikoudes area and started its operation in 1976. This marina is the main marina of Cyprus and has a capacity of 210 small boats of all types. The development of the marina was considered essential in order to promote the nautical tourism and according to a study conducted by the Cyprus Tourism Organisation the Larnaca marina is planned to have a capacity of 1000 boats.

3.3.3 Description of pumping stations' and treatment works' area

The extension works (Phase B) of the sewerage system will cover four main areas that are distributed in all the extent of Larnaca's municipality.

BI

This area surrounds the airport and is composed of mainly by agricultural land and two low density housing development zones that constitute a combination of summer and permanent residences. In the area there is a biological station within the residential zones, that constitutes a source of nuisance and aesthetic pollution for the residents. The water of the biological station is used for irrigation. In case the water is not suitable for irrigation, this ends in the Orfani saltlake (map 3.1).

Saltlake Glossa is in the west, a system of great ecological value but markedly polluted and charged with rubbles, excavations, vehicle passage, waste disposal as well as illegal disposals from the private biological station of the local residences. In addition, the perimeter of the saltlake according to the urban zones consititutes a aprotection area.

Close to this area and south of the airport there is the sewerage treatemnt station.

BII

This area consists of 900 hectares with a prevailing residential land use and covers the western part of Larnaca city between the boundaries of phase A works and LSDB limits for phase B works (see maps 3.8-3.14).

BIII

This area is located north of Larnaca, covers an area of 170 hectares and has predominantly a summer/tourism land use. The area comprises the near coastal areas between the coastal area served by phase A in the east and the villages Pyla, Oroklini and Livadia in the west. The Oroklini lake comprises a system of great ecological value regarding the flora but mainly avian fauna. The existing interventions within the lacustrine system and the depletion of its ecological value render imperative the need for the safequarding and the sustainable management of this system. Consequently special attention should be

given in the selection of the pumping station sites as well as the form and the methods used for reconstructing the area and landscaping of the pumping stations (flora species etc.).

BIV

This area is located within the Aradippou industrial zone and covers an area of approximately 30 hectares (see map 3.8).

3.3.4 Urban Zones

Larnaca town center

The potential location of pumping station PSBII-1 (A1) is located within a Turkish Cypriot plot on Schubert road (2 alternative sites, photo 3.1 and 3.2). Within the study location that is approximately 200 m from the coastal zone and close to the Castle hotel there is phase A pumping station PS B2 (photo 3.3).

The under study plot (103) lies within a Ka3 zone with prevailing residential land use (plot ratio 1.40 : 1, maximum cover rate 0.50 :1) (see urban zone map 3.9, land use map 3.10, plot map 3.8.1).

Photo 3.1 PSBII-1 (Site 1)

Photo 3.2 PSBII-1 (Site 2)

Photo 3.3 Existing Phase A pumping station

For the under study pumping station PSBII-2 (Q1) there are three alternative locations. Site 1 is on an empty plot on Griva Digeni Avenue that currently is being used as a parking area and is surrounded by commercial buildings and residential complexes. This plot lies within a zone (Πα2) that is characterised as a core region (continuous buildings layout). Site 2 is located within the government nursery (photo 3.4) and is characterized as zone Δα2 (protection zone- plot ratio 0.01 :1, maximum coverage ratio 0.01:1). Near the road are the offices of the Forest Department of the Ministry of Agriculture, behind which there is a large parking area. Further south, Site 3 is located. This plot (500) lies within a zone with prevailing residential land use (Κα3) (see urban zone map 3.9, Land use map 3.3 and plot map 3.9.1).

Photo 3.4 PSBII-2 (Site 2)

The pumping station PSBII-5 (Z1(Z2) site is located in the abandoned biological station plot. The site is across the Zinon refugee housing estates (see photo 3.5, plot map 3.12.1) within a Κα5 zone in a government plot with a prevailing residential land use (plot ratio 1 : 1, maximum coverage ratio 0.5 : 1).

Photo 3.5 PSBII-5 (Zenon Refugee Housing Estates)

For pumping station PSBII-6 (X1) two alternative sites exist (Photo 3.6). Site 1, plot 2356 is in a Δα2 zone (protection zone- plot ratio 0.01:1, maximum coverage ratio 0.01:1). Site 2 is located in a Γα4 agricultural zone (maximum plot ratio 0.10 : 1, maximum coverage ratio 0.10 : 1) near the aqueduct ruins.

Photo 3.6 PSBII-6

Finally the proposed site for pumping station PSBII-7 (Y1) is located in the empty plot 694, located in a Κα4 zone, close to Chrysopolitissis church, in a residentially developed area. (Photo 3.7, plot map 3.14.1).

Photo 3.7 PSBII-7

Saltlakes' Boundaries

The sites for pumping stations PSBII-3 (J1) και PSBII-4 (W1) are located at the Great saltlake's boundaries (see Urban Zone Map 3.2, Land Use Map 3.3). The boundaries of the saltlakes system (including the saltlakes located southeast of the Larnaca airport) are classified as a Δα2 zone in the Urban Zone Plan number 10 and as a Protection Zone in the Land Use Plan number 9. This zoning provides the area with a strict protection status against any type of development or interference that is not in agreement with the relevant Declaration of Policy and does not comply with the demands of the prevailing zone (residential, industrial or other) that the development in question can be allowed.

The plot ratio of the developments in protected areas (Saltlake boundaries) is defined in the local Plan as 0.01 : 1, for both the private as well as the government plots, independent from the General Provision Policies.

For pumping station PSBII-3 (J1) three alternative sites are available. Site 1 (plot 148) is in a Κα8 zone with a prevailing residential land use. Site 2 (plot 624) as well as site 3 (plot 540) is in a Κα8 zone with a prevailing residential land use. The area is characterized by low density residential development with an amazing saltlake view with the corresponding flora as well as the recently constructed European Nature Path E4, that passes by the facade of alternative Site 2 (photo 3.8 and 3.9, plot map 3.10.1).

Photo 3.8 PSBII-3 (Site 1)

Photo 3.9 PSBII-3 (Site 2)

For pumping station PSBII-4 (W1), three alternative sites are available, located south of Faneromeni avenue and east of the round about. Site 1 is a big government plot within a Κα8 zone with prevailing residential land use. Site 2 is a private plot (698) within a Κα8 zone, while Site 3 is on a government land in the boundaries with the saltlake and within a protection zone Δα2 (Photos 3.10 and 3.11, plot map 3.11.1).

Photo 3.10 PSBII-4 (Site 3)

Photo 3.11 PSBII-4 (Site 2)

Area South of the Airport

In the saltlake area south of the airport there is located the existing sewerage treatment station that is proposed to extent it to take phase B flows, and also the proposed pumping station location for PSBI-1 (V1) (Map 3.1, Photo 3.12). The area is included in the NATURA 2000 network. According to the Urban Zones and Land Use maps of the Local Plan of Larnaca, the proposed pumping station site is in a Δα protection zone. The area is also included in the area grid of RAMSAR, IBA etc.

Photo 3.12 PSBI-1 Site of existing private biological station

Oroklini area

The area adjacent to the northern coastal strip still to be covered by sewerage networks is divided in two sub-catchments. This area is not zoned for development. Two pumping stations, PSBIII-1(H2) and PSBIII-2(K2), will be needed for this area. PSBIII-2(K2) will be located close to the Oroklini lake (see Urban Zone and Land Use maps) that even it is an important biotope, it is not classified as a protection area. The area that is preliminary proposed for the pumping station is in a Kα10α zone (a zone with a prevailing residential land use).

Aradippou area

This area comprises the fourth area (Area B-IV) of phase B of the Sewerage System of Larnaca, from which wastewater from the Larnaca Industrial Area would be collected by gravity and directed to the upstream end of the main sewer on Griva Digeni Avenue that will serve area B-II. No pumping station will be installed in this area.

Table 3.14 that follows gives a summary of the pumping station proposed sites, alternative sites and the Urban Zones they fall in.

Table 3.14 Urban Zones

Pumping Station	Site	Plot No.	Sheet/Plan	Private or Government Land	Urban Zone	Land use	District
PSBI-1(V1)	1	-	LX.17.W2	Government	Δα	Protection Zone	Larnaca Skala
PSBII-1(A1)	1	103	LX.1.W1&W2	TurkishCypriot	Κα3	Zone with prevailing residential land use	Larnaca Skala
	2[1]	103	LX.1.W1&W2	TurkishCypriot	Κα3	΄΄	Larnaca Skala
PSBII-2(Q1)	1	598	XL.64.2.II	Private	Πα2	Core Building Layout	Larnaca Chrysopolitissa
	2[1]	9	XL.64.2.IV	Government	Δα2	Protection Zone	Larnaca Agios Nicolaos

Pumping Station	Site	Plot No.	Sheet/Plan	Private or Government Land	Urban Zone	Land use	District
	3	588	XL.64.2.II	Private	Κα3	Zone with prevailing residential land use	Larnaca Chrysopolitissa
PSBII-3(J1)	1	148	XL.64.W2	Ιδιωτικό Private	Κα8	,,	Larnaca Agios Nicolaos
	2[1]	624	XL.64.W2	Κρατικό Government	Κα8	,,	Larnaca Agios Nicolaos
	3	540	XL.64.W2	Private	Κα8	,,	Larnaca Agios Nicolaos
PSBII-4(W1)	1	1	XL.64.W2	Government	Κα8	,,	Larnaca Agios Nicolaos
	2	2698	XL.64.W2	Private	Κα8	,,	Larnaca Agios Nicolaos
	3[1]	2	XL.64.W2	Government	Δα2	Protection Zone	Larnaca Ayiios Nicolaos
PSBII5(Z1(Z2)	1	871	XL.63.E1	Government	Κα5	Zone with prevailing residential land use	Larnaca Ayios Nicolaos
PSBII-6(X1)	1	2356	L.7.W1	Government	Δα2	Protection Zone	Larnaca
	2[1]	-	L.7.W1	Government	Γα4	Agricultural Zone	Larnaca Dromolaxia
PSBII-7(Y1)	1	694	XL.56.6.III	Private	Κα4	Housing Zone	Larnaca Chrysopolitissa
PSBIII-1(H2)	[2]		XLI.17				Larnaca
PSBIII-2(K2)	[2]		XLI.17				Larnaca

[1] Proposed site.

[2] Site will be decided at the detailed design stage.

3.3.5 Topography- Geomorphology

PSB I (V1)

The study area is within the coastal zone of Larnaka city at about 2 metres above sea level and in distance of 75 metres from the coast. The topography of the area is smooth, dipping to the direction of the sea. In distance 1 kilometre to the west, the lake Soros is located (referenced map 3.5 in Annex 2).

PSBII-1 (A1)

The pumping station area appears to have a smooth relief, dipping to the direction of the sea and is locate at about 3 metres above sea level. A small mountain appears to the south-west and in distance of 170 metres, at about 6 metres above the sea level. The area is located in distance of 250 metres from the coast and 500 metres by the main saltmarsh (referenced map 3.6 in the Annex 2).

PSBII-2 (Q1)

At 7 metres above sea level is the higher elevation point of valley, dipping to the north-south, of the pumping station area. The main saltmarsh is at 750 metres from the area. The pumping station area is over-populated, therefore no more observations were recorded (referenced map 3.6 in the Annex 2).

PSBII-3 (J1)

A few metres from the main saltmarsh, the pumping station area is located at 7 metres above sea level. The relief is smooth, dipping to the direction of the saltmarsh (referenced map 3.6 in the Annex 2).

PSBII-4 (W1)

The study area is situated at 100 metres from the main saltmarsh. The area 1, which is at a hill, is located 15 metres above sea level and the areas 2 and 3 are about 12 metres above sea level. The smooth relief of areas 2 and 3 is dipping to the saltmarsh direction (referenced map 3.6 in the Annex 2).

PSBII-5 (Z1(Z2))

The study area of the pumping station is at about 10 metres above sea level. The smooth relief is dipping to the main saltmarsh, which is roughly 400 metres from the pumping station area (referenced map 3.6 in the Annex 2).

PSBII-6 (X1)

At about 10 metres from sea level, the pumping station is located in the valley margin, bending to the main saltmarsh direction. The pumping station area is situated at about 650 metres from the lake. To the

east there is a possible fault with a strike from north-east to south-west (referenced map 3.6 in the Annex 2).

PSBII-7 (Y1)

The pumping station is located at about 5 metres above sea level. Water stagnant was observed to the area because of rain water gathering. The area is over-populated, therefore no more observations were recorded (referenced map 3.6 in the Annex 2).

PSBIII-1 (H2)

The pumping station area is located at the coastal zone of city Larnaka, at about 500 metres from the coast and 3 metres above sea level. The relief is generally smouth, with minor dip to the sea direction, while there are hills to the north-east and south-west, witch are at about 5 metres above sea level (referenced map 3.4 in the Annex 2).

The lagoon at the area has surface salt depositions at the lake floor. The lake is about 2 metres above sea level.

PSBIII-2 (K2)

The pumping station area is about 5 metres above sea level. The area is located 375 metres from the coast, within the coastal zone. The area is in a hill, in which there is a valley with a channel for irrigation to the west(referenced map 3.4 in the Annex 2).

PSBIV

The area is about 45 metres above sea level. There is a valley to the west, witch is dipping to the south-east, while the area to the north-west, at about 900 metres, appears to have fissures and holes within the ground (referenced map 3.6 in the Annex 2).

Chapter

4

4. Description of proposed sewerage works

4.1 Brief description of Phase A Sewerage System

4.1.1 Introduction

Phase A of Larnaca sewerage system, including the wastewater treatment plant, was constructed under four different contracts. The grid of Phase A includes 100 kilometer sewers and 17 pumping stations and serves approximately 26,000 people (end of year 2005). There is also another pumping station serving the Larnaca airport.

Phase A of the sewerage system serves the tourist areas in the coast area north of Larnaca and extends southwards up to the Larnaca airport. The Phase A area is a low lying area approximately 2 meters above sea level. The areas that are served by phase A of the Larnaca Sewerafe system can be seen on map 4.1.

The sewerage treatment works is located in an area, that was granted by the Government to the Larnaca Sewerage and Drainage Board.

The main sewers run from north to south and range in diameter from 200mm to 800mm. Also the pressure mains vary in diameter from 100mm to 500mm. The branch sewers connect to the main sewers from east and west, have a diameter of 150mm and slopes of 0,4% to 0,5%.

The lengths of the sewers with diameter >150mm that were constructed under contracts 2, 3 and 4 are listed in table 4.1. Also, approximately 80 kilometers of 150mm diameter pipe were contructed during Phase A.

Table 4.1 Length (m) of sewers with diameter >150mm constructed under contracts 2, 3, και 4

	Sewers Diameter (mm)									
	200	250	300	350	400	500	600	700	800	**Total**
Contract 2	438	62	455	472		82		583	1275	**3367**
Contract 3	2129	2664	343		431	1004	1276			**7847**
Contract 4	1830	645	1018		2186	1246				**6925**
Total	4397	3371	1816	472	2617	2332	1276	583	1275	**18139**

4.1.2 Existing Sewage Treatment Facilities

The existing sewage treatment facilities (photo 4.1) are located south of the Larnaca airport, near the saltlakes and next to the desalination plant (map 4.1).

Photo 4.1 Sewerage Treatment Facilities

The sewage treatment is performed using aerobic decomposition of the liquid waste and sludge.
The process diagram of the sewage treatment is presented in Figure 4.1. The sewage is transferred to the treatment works with a 500mm pressure main and reaches the inlet chamber were it is mixed with return sludge and liquors. In order to avoid odour build up at the inlet chamber the building is ventilated.

The air in the inlet chamber passes through a biofilter that is build on a concrete base next to the inlet chamber (figure 4.1). The mixture of sewage and activated sludge passes through a mechanical screen, stage at which big pieces of various materials that may be present in the incoming sewage are removed and then pass through the grit chamber.
After the inlet chamber the sewage is directed in two parallel oxidation ditches. Sludge is settled and collected in the two parallel final settlement tanks.
The liquid from the final settlement tanks is directed in the secondary treated tank and then pumped to the two secondary treated storage lagoons.

During the tertiary treatment stage, liquid from the storage lagoons is transferred with pumps to four sandfilters and then chlorinated. Finally the treated water is pumped to the irrigation system.

The water from backwashing of the filters is directed to the waste lagoon of the sewerage treatment works.

Figure 4.1

The final treated water is pumped to the irrigation system according to demand. At the treatment works there is an emergency lagoon were sewage can be diverted in case of an emergency. The lagoon's capacity is a 24 hour peak summer flow.

The surplus sludge produced is transferred to the sludge thickening tank and then to two aerobic digestion tanks. Then the sludge is directed to the belt press and from there to the drying beds.

The sludge produced contains compounds of agricultural value (organic matter, nitrogen, phosphorus and potassium and in lower concentrations calcium, sulphur and magnesium) and pollutants such as heavy metals and pathogens. The quality characteristics of the produced sludge depends on the initial quality of the sewage and also the technical characteristics of the wastewater and sludge treatments.

Table 4.2 tabulates the monthly sludge production (humidity 80%) for year 2004.

Table 4.2: Monthly sludge production for year 2004

Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Quantity(m3)	250	390	480	370	680	835	440	440	570	140	330	465

A portion of the produced sludge (4977 m3) for year 2004 was spread as fertiliser on 160 hectares of a wheat field located in the Archangelos area of Avdellero village.

The quality of Phase A produced sludge for years 2004-2005 are presented in table 4.3.

Table 4.3: Sludge quality 2004-2005

Parameter		Limits	30/6/04	30/6/05
pH	---	6.0-7.0	7.0	6,55
Dry Solids	%		15,5	15,2
Organic matter	% of DS		74,9	71,3
TKN	% of DS		6,8	5,53
Total Phosphorus	% of DS		3,6	2,85
Cadmium	mg/l	40	---	0,97
Copper	mg/l	1750	146,3	163
Nickel	mg/l	400	---	25,4
Lead	mg/l	1200	---	38,3
Zinc	mg/l	4000	174,3	626
Mercury	mg/l	25	---	3,97
Chromium	mg/l	1000	16,1	35,9

Table 4.3 presents Phase A sludge quality. The heavy metals concentration comply with the limits set in the Disposal Permit the Sewerage and Drainage Board obtained for the disposal of the Sludge, according to the Control of Water pollution Law (Agricultural use of Sludge) regulation 517/2002.

At the sewage treatment station there is a lab analyzing samples from various process stages: inlet, the two oxygenation tanks, the two settlement tanks (samples are taken from 1 meter depth), return activated sludge, sludge thickening tank, aerobic digwestion tanks and tertiary treated water.

For year 2005, the sewage treatment station laboratory reported the following values for the tertiary treated water (Table 4.4)

The quality of the tertiary treated water, overall complies with the 2002 law, (L.106(I)/2002, Reg.269/2005), concerning water pollution, except conductivity and boron.

Table 4.4

Mean Daily Values (Sewerage Treatment Works Laboratory Results)

Treated Water Quality for 2005

Routine	Temperature		20.71
	pH		7.59
	Conductivity mS/cm	<2,0	4.94
	BOD_5 (mg/l)	<10	3.12
	COD (mg/l)		27.15
	Suspended Solids (mg/l)	< 10	7.29
	Nitrate (mg/l)		20.27
	Nitrite $NO2^-$ (mg/l)		1.55
	Nitrogen as NH_3 (mg/l)		0.36
	Nitrogen Total	<15	2.21
	Phosphorus		5.04
	Total Chlorine (mg/l)	2	1.89
	Free Chlorine (mg/l)		1.45
	Chlorides mg/l		1177.25
	Boron mg/l	0.75	0.99
	Iron Fe	5	0.14
	Mercury Hg	0.005	0.01
	Cadmium Cd	0.01	0.01
	Copper Cu	0.2	0.15
	Cobalt Co	0.05	0.05
	Nickel Ni	0.2	0.13
	Lead Pb	5	2.50
	Zinc Zn	2	1.05
	Chromium Cr III	0.1	0.10
	Manganese Mn	0.2	0.05
Toxicological	Phelols	-	0.01
Remarks			

4.1.3 Phase A pumping stations

The topography of Larnaca necessitates a number of sewage pumping stations to transport sewage to the sewage treatment works. The Phase A works divided the drainage area into 17 catchments. Each catchment is drained by gravity to a pumping station. The Larnaca airport operates one additional pumping station which transfers wastewater from the airport to the sewage's main pipeline.

Phase A pumping stations layout is presented in figure 4.2.

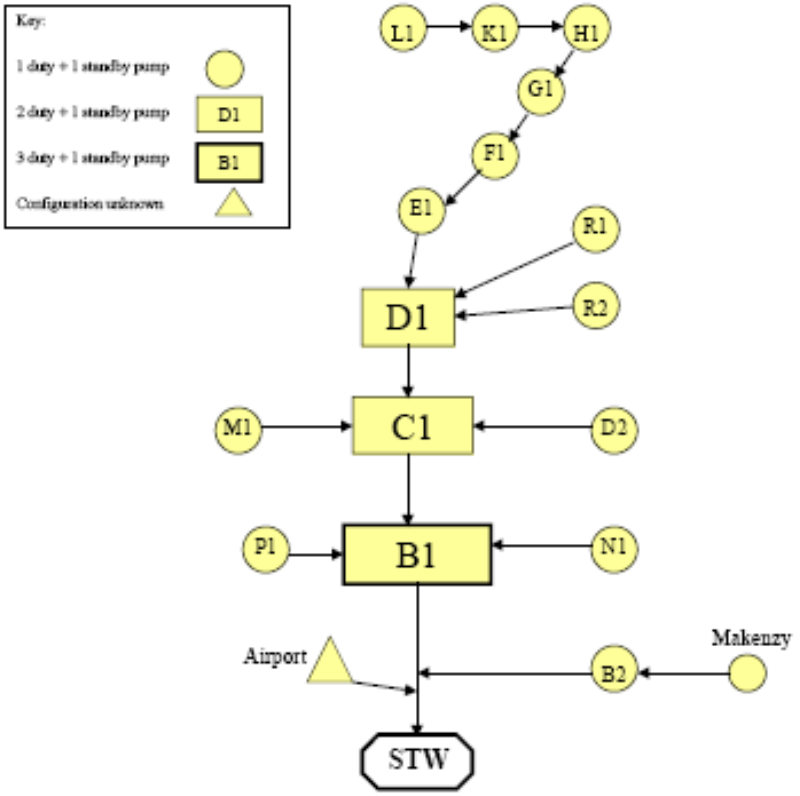


Figure 4.2: Pumping station diagram

The small lateral pumping stations were constructed to lift sewage from some of the long lateral sewers.

All pumping stations were constructed using C30/20 reinforced concrete, they all utilize submersible pumps and operate automatically.

No provision was made for emergency overflows from the pumping stations because any emergency discharges would reach the sea. One of the primary goals of the project was to avoid any sewage entering the sea. For this reason all pumping stations are equipped with:

- standby pumps
- standby generator
- Ultra sonic and float level switch
- automatic alarm systems that give warnings locally and in the control room of the sewage treatment works.

The smaller pumping stations have one pump on duty and one pump on standby. During normal operation the pumps work alternate to ensure that the standby pump is regularly tested.
Any deviations from normal operation give an alarm to the control room of the sewage treatment works.

The larger pumping stations have two or more duty pumps and a standby and are programmed to operate similarly to the smaller pumping station.

Typical pumping station designs are presented in Annex 4.

A new telemetry system that was installed in September 2005, detects pumping station problems, so that all necessary actions can be taken promptly without any interruption in the sewerage flow. The telemetry system notifies the duty engineer through SMS, for any problems in the operation of the pumping stations.

In case of power supply failure all pumping stations are equipped with generators and automatic switching and change over equipment. This equipment in case of power failure, isolates the pumps from the town power supply, starts the standby generators and connects the pumps to the generator. The pumping system then continues to run on automatic control as normal but powered by the local generator.

LSDB is responsible for the maintenance of all pumping stations exept the one that serves the Larnaca airport. The main sewerage pumping characteristics are shown in table 4.5.
In addition there is a small pumping station that serves the Army Officer's summer houses area to the south of the sewage treatment works. This pumping station has 1 duty + 1 standby pump with a nominal

capacity of 4 l/s. The pumping station is designed to cater for flows from 300 people (average) or 600 people (peak).

Table 4.5 : Sewage pumping stations characteristics

Main Pumping Stations in Chain	Lateral Pumping Stations Connected	Lateral Pumping Stations	Pump Capacity (l/sec)	Against Head(m)	No of Duty Pumps	Standby Pumps	No of Persons in Each Catchment Area	Sump Full Capacity(m^3)	Sump Water Capacity (m^3)
L1	**Nil**		28	12.5	1	1	751	24.54	11.39
K1	**Nil**		47	10	1	1	4718	24.54	12.71
H1	**Nil**		77	9.5	1	1	5948	48.1	22.99
G1	**Nil**		90	8.6	1	1	432	48.1	26.94
F1	**Nil**		90	8.6	1	1	2444	52.92	28.38
E1	**Nil**		102	9.94	1	1	6227	48.1	21.65
D1	**2 (R1, R2)**		108	5.80	2	1	8927	169.44	51.07
		R1	15	7.50	1	1	2610	24.54	7.36
		R2	15	7.50	1	1	1350	24.54	7.36
C1	**2 (M1, D2)**		145	5.60	2	1	5602	91.8	38.76
		M1	75	11.00	1	1	4612	29.45	13.76
		D2	28.5	5.30	1	1	2274	52.92	30
B1	**2 (N1, P1)**		165	33.00	3	1	*	127.4	61.07
		N1	80	10.50	1	1	3141	29.45	15.18
		P1	10	5.30	1	1	1699	19.63	8.18
		B2	90	10.00	1	1	3141	29.45	13.76
		R4 (Makenzy)	8	4.75	1	1	*	22.50	15.75

4.2 Phase B of Larnaca Sewerage System

4.2.1 Introduction

The proposed sewerage system covers all areas of the Larnaca municipality between the limits of Phase A works and LSDB boundary for Phase B works. It also includes a small area to the west of LSDB (west of Zinon and Makarios III). This area is already served by a sewerage system, with a temporary pressure main discharging to PS B1. In future, flows from this area can discharge to the Phase B system, and it may be possible to use the pressure main for other purposes.

Phase B of the Larnaca Sewerage System will cover the following four principal areas:

- Area B-I: This area surrounds the airport and comprises agricultural land and two low density housing development zones. The area to be served by sewerage networks consists of the two small housing development zones.
- Area B-II: This area, with predominantly residential land use, covers the western part of the town of larnaca between the limits of phase A works and LSDB boundary for Phase B. The approximate size of the area is 900 hectares.
- Area B-III: This area, which has a predominantly summer/ tourism land use, is located north of Larnaca and comprises the near coastal areas between the coastal area served by Phase A in the east and Pyla, Oroklini and Livadia in the west. The size of this area is approximately 170 hectares.
- Area B-IV: This area comprises the Aradippou industrial zone (approximately 30 hectares).

The proposed pipeline routes and diameter as well as pumping station locations for the Phase B of sewerage system were proposed by MWH&I in August 2004 (Feasibilty Study of Phase B of the Larnaca Sewerage System) that from herein under will be referred to as “MWH&I study”. The works for Phase B are presented in map 3.1.

4.2.2 Sub-catchments

For design purposes the Phase B area is divided in four catchments ***B-I, B-II, B-III*** and ***B-IV*** *(map 4.2).* These areas have been divided in subcatchments (maps 3.4-3.7).

Area B-I

The B-I area is located between the village Pervolia and the sewage treatment station. Flows from this area are extremely low but the surrounding area is under development while the area is located close to the sea, factors that suggest the need for establishing a sewerage system. Other areas under development in area B-I are located within the Meneou village boundaries, an area that is not included in the Phase B of the sewage treatment.

A private pumping station and a 90mm polyethylene pressure main were built to serve the KAYY military resort. This pressure main sewer crosses the Ramsar protected area.

A previous study (Sogreah, 2003) assessed whether it will be preferable to built a separate sewage treatment station that will serve the four villages that are located further west near the coast at Pervolia. From this study it was concluded that it will be more econical and also better for other reasons to pump flows to an expanded sewage treatment station.

Area B-II

The proposed sewage treatment system covers the western part of the town and is located between the boundaries of Phase A and the limits of the sewage system for Phase B. It will also accept flows from a small existing sewerage system serving the residential area west of Zinon and Makarios III.

This area was divided in 35 sub-catchments. The main sewer will follow the Griva Digeni Avenue, Leonida Kioupi then Artemidos Avenue and will collect sewage from the sub-catchments that will be served by 7 pumping stations. The 7 pumping stations are described in detail in the following paragraphs.

Area B-III

This area is located in the northern part of Larnaca, is very small and contains sporadic residential development. For this area it is recommended to connect to the existing pumping stations of Phase A. The advantages will be:

- The additional flow directed to the Phase A grid will improve the system performance.
- Connecting to the B-II network would be costly, since it will require the construction of a long pressure main that will transfer small volumes of flow and hence will be prone to septicity.

Area B-IV

Sewage from the industrial area near Aradippou will be collected by gravity and directed to the main pipeline of area B-II, on Griva Digeni Avenue.

4.3 Suggested Structure of Phase B of Larnaca Sewerage System

For the Phase B of the sewerage system, the following works are recommended:

- Construction of 7 pumping stations
- Construction of sewage collection pipelines
- Expand the sewage treatment station

4.3.1 Pumping Stations

According to the MWH&I study, 7 pumping stations are recommended. Most of the Phase B pumping stations will be circular with one (1) duty pump and one (1) standby pump. The main pumping stations will be rectangular with two (2) duty pumps and one (1) standby pump. All pumping stations will be equipped with odour reduction equipment.

The submersible pumps that were used successfully in Phase A, are also recommended by MWH&I to be used for Phase B. The pumping stations pipings will be made of GRP (Glassfibre reinforced Plastic) or HDPE (High Density PolyEthylene).

The locations of the proposed pumping stations are presented in figure 4.3.

The locations of the pumping stations are briefly described below. It is noted that no designs for the pumping stations have been prepared. Typical pumping stations are presented in Annex 4.

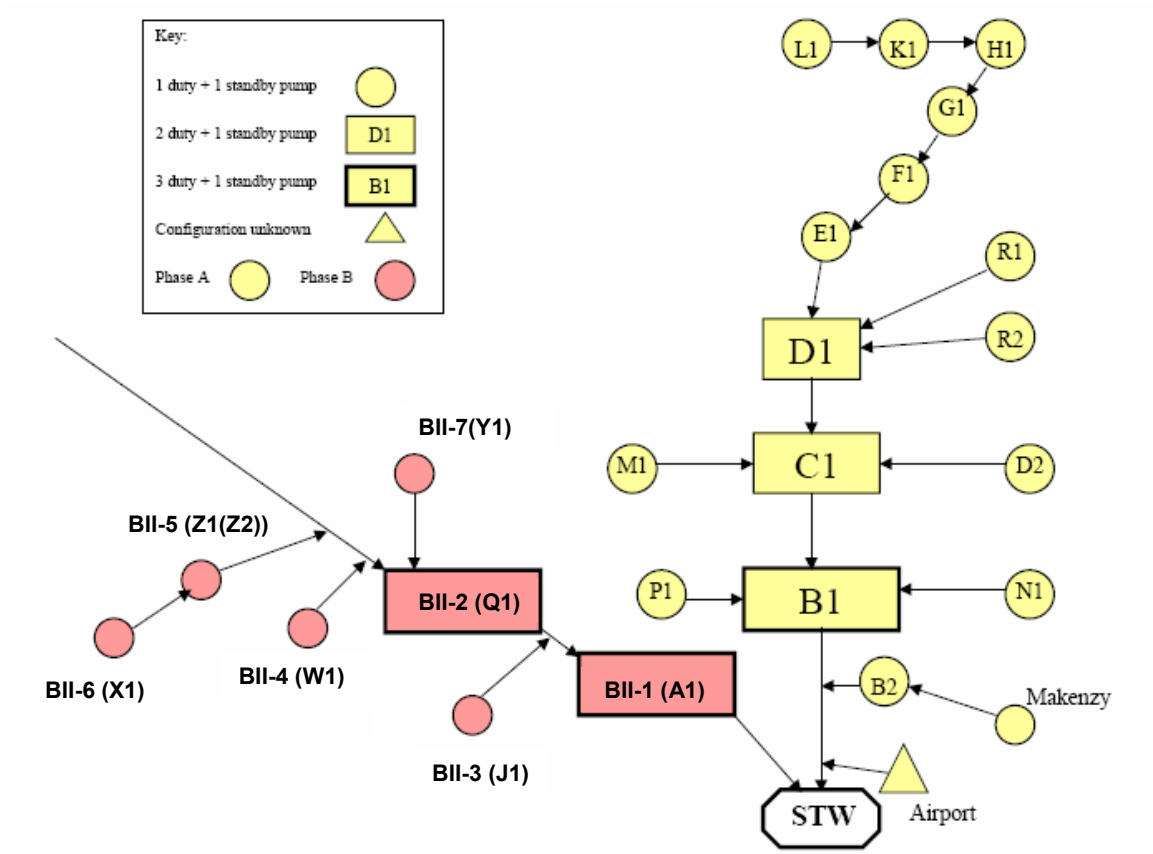


Figure 4.3: Diagram of Phase B proposed pumping stations

Pumping Station PSBII-1 (A1)

The main pumping station for area B-II (PSBII-1) is recommended to be erected on the emply plot (number 103) behind the existing pumping station PS B2 (map 3.8).

For the installation of the pumping station, that will occupy an area 25mx20m, two locations were considered. The preferred location is Site 2, which is immediately behind PS B2. The reason for selecting site 2 mostly lies on the reduction of the aesthetic interference from the road. Also, the empty Turkish Cypriot land next to the site can be used for the storage of the pipelines and other construction materials during construction. The existing entrance to PS B2 will be used as common entrance for PSBII-1 (A1) also and the rear fence of PS B2 would be removed to create one common area for the two pumping stations.

Photo 4.2: Existing pumping station B2

Pumping Station PSBII-2 (Q1)

The pumping station PS BII-2 is located in the area of Griva Digeni Avenue (map 3.9). The area is densely developed with mainly commercial buildings.

As can be seen on the map, three alternative locations were identified. Site 1 is in the borders with the Avenue (plot 598). Site 2 is located south of the Avenue. This site is within the Forest Department's "government nursery" (plot 9). Site 3 is located north of the Avenue (plot 588). This site though is surrounded by buildings on three sides. The most preferable location is Site 2 (photo 4.3).

The pumping station will collect wastewater on the sewer along Griva Digeni Avenue and then transfer it to pumping station PSBII-1(A1). The wastewater will be transferred by pressure from Leonida Kioupi Avenue to Artemidos Avenue and then by gravity.

Photo 4.3: Recommended location for PS BII-2

Pumping Station PSBII-3 (J1)

The pumping station PSBII-3 can be located in one of the empty plots (540, 624, 148) south of Alkamenous street (Photo 4.4, 4.5) (Map 3.10). It will serve a small area south of Faneromenis Avenue. The pumping station will be located in the borders of a residential area with Larnaca's Saltlake protected zone. In the south of this location there is a large undeveloped area that is expected to be developed in the future. The area is characterized by low density housing and the view of open space and the saltlake in the west. The preferable location is Site 2 (plot 624) .

Photo 4.4: Saltlake view west of the proposed pumping station

Photo 4.5: Proposed location for pumping station PS BII-3

Pumping station PSBII-4 (W1)

The area is located south of the roundabout on Faneromenis Avenue on the borders with the Saltlake's protected zone (Map 3.11). This pumping station will serve an area north of Faneromenis Avenue and a small developed area between Faneromenis Avenue and the Saltlake. The alternative locations are located on empty plots south of Faneromenis Avenue (Photo 4.6). Site 3 and Site 1 are on public land zoned as green area. Site 2 (plot 2698) is private plot for sale.

Photo 4.6
Roundabout view from the proposed pumping station site

Site 1 is rejected because it creates the need for an additional pumping station in order to collect flows from the lower areas near the saltlake.
Site 2 is currently for sale. Site 3 is located east of site 2 and is the most preferred location. The saltlake is south of the proposed pumping station (photo 4.7).

Photo 4.7: PSBII-4 proposed location

Pumping Station PSBII-5 (Z1(Z2))

This pumping station will be located across the Refugee Housing Estate Zenon (Map 3.12), will receive the wastewater of pumping station PSBII-6 and will also serve many catchments around Zenon and Kamares Housing estates. The wastewater will be transferred from pumping station PSBII-5 to the proposed main sewer of Phase B on Griva Digeni Avenue initially by pressure and then gravity. At the proposed location there is also an abandoned biological treatment station and one pumping station in operation.

The existing pumping station in this area serves the housing estates of Zenon and Kamares and pumps flows through a temporary pressure main adjacent to the Salt Lake boundary to the Phase A network.

Photo 4.8: Abadoned biological treatment station in the Zenon and Kamares area

Currently some houses in the Kamares area discharge sewage into the river and subsequently into the Salt Lake. The LSDB is planning to divert these flows to the same pumping station.
The options for this area are listed below:

1. construction of a new pumping station PSBII-5 and continuous use of the existing pumping station but with revised regulations for pumping to the Phase B sewage system.
2. construction of pumping station PSBII-5 to accept flows from all Zenon/Kamares/ Makarios III area including the sub-catchment that is temporarily served by the existing pumping station.

Pumping Station PSBII-6(X1)

The pumping station PSBII-6 will collect flows from the housing estate Makarios III and two subcatchments in the west (Map 3.13). Roads and residences have already been constructed in the relatively low-lying area in the south. The proposed pumping station is located on agricultural land south of the residential zone boundaries.

About 200m from the proposed location there is a well preserved section of the ancient aqueduct (photo 4.9a,b).

In the MWH&I study it is recommended to utilize the agricultural site than the residential plot (number 2356) for the following reasons:

- The pumping station is recommended to be located outside the residential zone in order to eliminate any odour problems.
- If the pumping station is located in the agricultural land the aesthetic effect can be avoided more easy than in the residential zone.
- If the pumping station is located in the residential zone the nearby plots will be considered inferior therefore affecting their value.

The proposed location was selected so that it will cause the least visual effect to the ancient aqueduct's visitors.

The sewage from this pumping station is transferred to PSBII-5 initially with a pressure pipe that follows Kastalias street until the intersection with Agios Polykarpos Street and then by gravity.

Photo 4.9 Area of Pumping Station PSBII-6

Pumping Station PSBII – 7(Y1)

This pumping station will be located on plot 694 (Map 3.14), tangential to Terrasanta Avenue, north of Archiepiskopos Kyprianos Avenue and will serve the other subcatchments in area B-II

The purpose of this pumping station is the connection of subcatchments A,B and C and the transfer of wastewater to pumping station PSBII-2.

Photo 4.10 Proposed site of pumping station PSBII-7

Pumping Station PSBI – 1 (V1)

This pumping station is located south of the sewage treatment station in the north of Pervolia village (Map 3.1). Both proposed sites are located east of the coast road. One alternative is the site were the existing private biological station is located (photo 4.11).

Photo 4.11 Pumping Station PSBI-1

4.3.2 Phase B Sewerage Network

The sewerage piping system proposed for the sewerage collection network is presented on Map 4.2. The total lengths of phase B pipings are described in Table 4.6.

Table 4.6: Lengths of Phase B Pipings

Area	Pipings	Length
B-II	Main Pipings	10,0 km
	Pressure mains	6,9 km
	Secondary pipings	156,0 km.
B-III	Main Pipings	1,4 km
	Pressure mains	0,9 km
	Secondary pipings	42 km

MWH&I reccommends that the pressure mains for pumpings stations PSBII-1 (A1) and PSBII-2 (Q1) have a diameter of 400mm, for pumping stations PSBII-3 (J1) and PSBII-4 (W1) 150 mm, for PSBII-5 (Z1(Z2)) 225 mm, PSBII-6 (X1) 150 mm and for PSBII-7 (Y1) 180 mm. For the upstream part of phase B, the 150mm diameter pipes are hydraulically suitable if they are installed with the correct slopes. The LSDB though suggests that the smallest diameter pipe for phase B is 200mm because of the problems that were observed in telescoping of the 150mm pipes of phase A.

The sewage collection network will have to cross other utility networks that are already installed. The most important obstruction is the crossing of the water grid. The major sewerage watermains obstructions are presented in Map 4.3.

For the construction of pressure mains glass reinforced plastic (GRP) and high density polyethylene (HDPE) will be used. For the smaller gravity sewers, unplasticised polyvinyl chloride (uPVC) will be used as in phase A. For larger diameter gravity sewers glass reinforced plastic or high density polyethylene will be used.

4.3.3 Sewerage Treatment Station

The sewage of phase B of the LSDB will be transferred to the existing sewage treatment station that will be expanded. The MWH&I proposed works considered the following:

- The size of the required tanks and their placement at the existing treatment station is the basis for any extension so that the extension works will not incorporate similar type systems of different sizes.
- Weaknesses on the existing design should be improved. This suggests that the oil and grease is removed befor the biological treatment, either using primary treatment or specialized grease removal equipment.
- Phase B design goal is the maximum depletion of septicity problems. The septicity that was observed in phase A will be decreased as the flows and velocities in the sewers increase. Eventhough, the odours due to septicity of the incoming wastewater is possible to exist and therefore odour control systems should be designed and installed.
- Denitrification will ne needed so that the treated wastewater fulfills the concentration limits in nitrates and total nitrogen. This will improve the efficiency of the final tanks. The design should secure that there is enough carbon for the denitrification preferably without the addition of chemicals such as methanol.

For the sludge disposal the following factors were evaluated:

- The available options for sludge disposal stress the need for a stabilizing procedure that will minimize the quanity of sludge and improve its stability
- Change of the sludge stabilization process to anaerobic digestion will improve the stabilization, decrease the quantity of sludge for disposal and also produce electric energy.
- The Sewerage Sludge Directive 86/278/EEC and Landfill of Waste Directive 99/31/EEC have passed to the Cyprus legislation with regulation P.I. 517/2002 of the Water Pollution Control Law 106(I)/2002 and Law 215(I)/2002 regarding Control and management of solid and hazardous waste. The Control and Management of Solid and Hazardous Waste law imit the available options for sustainable stabilization of sludge. In the 3rd draft working document on sludge- EU directive 86/278/EEC it is declared that the sludge is necessary to be treated so that the chances of transmitting pathogens to

the environment is minimized. According to this document the sludge will have to be treated with one of the following processes:

Advanced Treatment (hygienisation):

- Thermal drying ensuring that the temperature of the sludge particles is higher than 80°C with a reduction of water content to less than 10% and maintaining a water activity above 0.90 in the first hour of treatment.
- Thermophilic aerobic stabilisation at a temperature of at least 55°C for 20 hours as a batch, without admixture or withdrawal during the treatment.
- Thermophilic anaerobic digestion at a temperature of at least 53°C for 20 hours as a batch, without admixture or wirhdrawal during the treatment.
- Thermal treatment of liquid sludge for a minimum of 30 minutes at 70ºC followed by mesophilic anaerobic digestion at a temperature of 35°C with a mean retention period of 12 days.
- Conditioning with lime reaching a pH of 12 or more and maintaining a temperature of at least 55°C for 2 hours.
- Conditioning with lime reaching and maintaining a pH of 12 or more for three months.

The process shall be initially validated through a 6 Log_{10} reduction of a test organism such as *Salmonella Senftenberg W775*

The treated sludge shall not contain *salmonella spp* in 50 g (wet weight) and the treatment shall achieve at least a 6 Log_{10} reduction in *Escherichia Coli* to less than $5 \cdot 10^2$ CFU/g.

Conventional treatments:

- Thermophilic aerobic stabilization at a temperature of at least 55°C with a mean retention period of 20 days.
- Thermophilic anaerobic digestion at a temperature of at least 53°C with a mean retention period of 20 days.
- Conditioning with lime ensuring a homogeneous mixture of lime and sludge. The mixture shall reach a pH of more than 12 directly after liming and keep a pH of at least 12 for 24 hours.

- Mesophilic anaerobic digestion at a temperature of 35°C with a mean retention period of 15 days.
- Extended aeration at ambient temperature as a batch, without admixture or withdrawal during the treatment period*.
- Simultaneous aerobic stabilization at ambient temperature*.
- Storage in liquid form at ambient temperature as a batch, without admixture or withdrawal during the storage period*.

The sludge treatment shall at least achieve a 2 Log_{10} reduction in *Escherichia Coli*. The relevant process parameters shall be monitored at least daily, and preferably continuously if practicable. Records shall be kept and made available upon request to the competent authority for inspection purposes.

MWH&I compared various treatment methods in order to make the best method selection for phase B sewerage system. Two issues that played an important role in the final selection of treatment methods were the need for an efficient and effective nitrogen removal and the selection of a suitable sludge digestion process. The sewage treatment method selection was based on the following:

- The method would make maximum use of the existing sewage treatment station facilities,
- will cause the least possible interruption at the existing treatment works,
- will be easy to operate and
- will have the lowest construction and operational cost.

*The minimum time length of the treatment shall be laid down by the competent authority taking into consideration the prevailing climatic conditions in the area where the treatment plant is located.

The possible alternative processes that were considered in the MWH&I study included:

- Sewage treatment with primary settling followed by anaerobic digestion of the sludge
- Sewage treatment without primary settling followed by anaerobic digestion of the sludge
- Sewage treatment without primary settling followed by aerobic digestion of the sludge (Fill and draw batch aerobic digester tanks, 15 days retention time)
- Sewage treatment without primary settling followed by aerobic digestion (continuous feed aerobic digester tanks)

It should be noted that in the Annex 1 of the 3rd Draft Working Document on Sludge of EU Directive 86/278, it is stated that the sludge is necessary to be treated in such way that the possibility of transmitting pathogens to the environment is reduced. This document is not finalized so it is not part of any legislation yet but it constitutes a guide on acceptable technologies while at the same time shows the direction in which the European union is taking regarding the acceptable treatment methods.

The energy consumption per cubic meter of sewage treatment at the current station for aerobic digestion is relatively high. For the year 2005, the energy consumption was 1.24 kWh/ m^3 (this value includes the energy consumed for pumping the treated water to the irrigation system).

A combination of primary settling followed by aerobic treatment of wastewater and anaerobic digestion of sludge will lead to reduction of the produced sludge for disposal by 25%, better stabilization of sludge with less pathogens, 5-10% more dry matter in the produced sludge, savings in energy consumption for aeration and capacity to produce energy from biogas (15 kWh/ PE/ y).

A disadvantage of this method is the higher initial cost of investment required for this more complex process and the risk of odour creation. It is also possible to have increased operation costs.

The anaerobic digestion of primary sludge is easier than the digestion of biological sludge therefore implementation of primary settling is possible.

The final decision in selecting anaerobic or aerobic digestion is based on the cost that includes:

- Production of organic loads and the quantity of biogas that can be produced
- Cost of facilities contruction

- Operation cost and management
- Annual energy consumption (aerobic treatment)
- Annual energy production (anaerobic digestion)

After an analysis of the advantages and disadvantages of the four treatment processes described above and the cost analysis of each process, the MWH&I study recommends the following two processes:

1. Combination of primary settling followed by aerobic treatment of the liquid waste and anaerobic digestion of sludge (for 2040 flows).
2. Aerobic treatment of the liquid waste and anaerobic digestion of sludge.

For option 1, the primary settling can be implemented after the year 2012. The structure for both options will be similar except the size of the tanks. The main works required for option 1 of phase B are the following:

Phase B Works (for 2020 flows)- to be constructed before 2012

- Inlet chamber modifications in order to accommodate the second pressure main and screening
- Use of the existing detritor unit
- New aerated grit and grease removal chambers (4 lines, covered) with associated blower station and deodorization facilities
- New anoxic zones comprising a distribution chamber and three tanks approximately 30mx24m and with a water depth of 5.5m split into lanes by internal guide walls
- One additional oxidation ditch of the same design as the existing units
- One additional final sedimentation tank of the same design as the exising units and a new distribution chamber
- Additional associated recycle, RAS,SAS and deodorization facilities
- Transform one of the existing aerobic digester tanks to SAS buffer tank
- Transform one of the existing aerobic digester tanks to thickened sludge buffer tank
- Transform the existing sludge thickener tank to digested sludge buffer tank
- New mechanical sludge thickening facilities
- New anaerobic digestion facilites: options vary from a single methanogenic digester tank of about 13.7m diameter (27.5 m high) to two tanks of about 10.8 m diameter (21.5 m hogh);

- New heating and heat recovery facilities
- One new digester's operation building
- One new biogas holding tank and flare
- Additional dewatering facilities and an extension to the existing sludge dewatering building
- New power production facilities from biogas and a biogas motor/generator building
- New disinfection facilities
- Miscellaneous extensions: service building, washout facilities, envlosed storage areas, sheltered parking

The layout of the proposed process is presented in Figure 4.4 (liquid treatment layout) and Figure 4.5 (sludge treatment layout). A layout of option 1, for the wastewater and sludge treatment process is presented in figure 4.6.

The wastewater treatment layout for 2040 flows (containing primary settling) is presented in figure 4.7.

Option 2 does not incorporate primary settling and requires the construction of the following treatment/disposal options for the wastewater and sludge:

- Amended inlet to accommodate additional pressure main and screening
- Existing detritor unit
- New aerated grit and grease removal chambers (4 lines, covered) with the associated blower station and deodorization facilities
- New anoxic zones comprising a distribution chamber and three tanks approximately 30m x 31m and with a water depth of 5.5 m split into lanes by internal guide walls
- One additional oxidation ditch of the same design as the existing units
- One additional final sedimentation tank of the same design as the existing units and a new distribution chamber
- Additional associatd recycle, RAS,SAS and deodorization facilities
- Transform one of the existing aerobic digester tanks to SAS buffer tank
- Transform one of the existing aerobic digester tanks to thickened sludge buffer tank
- Transform the existing sludge thickener tank to digested sludge buffer tank
- New mechanical sludge thickening facilities

- New anaerobic digestion facilities: options vary from a single methanogenic digester tank of about 14.4 m diameter (29.0 m high) to two tanks of about 11.5 m diameter (23 m high)
- New heating and heat recovery facilities
- One new digester's operation building
- One new biogas holding tank and flare
- Additional dewatering facilities and an extension to the existing sludge dewatering building
- New power production facilities from biogas and a biogas motor/ generator building
- New disinfection facilities
- Miscellaneous extensions: service building, washout facilities, enclosed storage areas, sheltered parking

The process options are shown in figures 4.8 and 4.9. The process diagram for the wastewater and sludge treatment is shown on figure 4.10.

Σχέδιο 4.4

ΣΧΈΔΙΟ 4.5

Σχεδιο 4.6

Σχεδιο 4.7

Σχεδιο 4.8

Σχεδιο 4.9

Σχεδιο 4.10

4.4 Construction Works

4.4.1 Regulations at Worksites

In order to satisfy the contractor's needs and safety requirements, the worksites will have to be configured accordingly. This configuration will include the following:

- Removal of useless or other materials present at the site
- Configuration of space for the storage of materials
- Fencing of worksites and placement of visible and obvious labels (according to the "Minimum Requirements for Safety and Health Signs at Work Regulations of 2001")
- Near the workers' working areas sufficient number of lavatories, suitable locker rooms as well as sufficient quantity of potable water will be placed
- Depending on the characteristics, dimensions of the worksite and the area use, as well as the maximum number of individuals that can be present there, sufficient number of suitable firefighting means will be provided.

All the worksites, the surrounding areas, the perimeters of worksites as well as the roads and danger exits will have visible, obvious signs (according to the "Minimum Requirements for Safety and Health Signs at Work Regulations of 2001) and fencing so that they are visible and easily recognized.

4.4.2 Construction of the sewage collection network

During the construction works, the affected roads will either be diverted completely or be temporarily transformed to one way roads (in the case that only one lane will be needed).

For the construction of the sewerage network the following works will be needed:

- removal of asphaltic paving and pavements
- excavation of ditches and removal of excavation material

- Because in a big part of phase B works, the height of the aquifer is close to the surface, a major part of the works will be the draining of the channels. Drainage will be continuous for all the 24-hour period. The water pumped will be channelled to rain water sewers.
- Arrangement for utilities where these are obstructed (5.2.3).
- The possible temporary storage of excavation material if it is intended to be used for embankment
- Transport and storage of pipes in temporary storage sites in the region of works, materials of paving and embankment.
- Installation of pipelines
- Embankment of ditches
- Placing of asphaltic paving and construction of pavements.

4.4.3 Liquid and Solid Waste Generation

During the construction phase, the main sources of waste include:

- the materials removed from worksites/ construction sites
- materials of excavation
- materials of demolition
- Packaging of equipment and structural materials
- Small quantities of household waste that are produced by the workers
- Small quantities of oils and fuels from the equipment and vehicles

The characteristic types of waste that are connected with these activities include:

- Inactive materials, concrete, asphaltic paving, vegetation
- Plastic, timber paper and aluminium, metal equipment
- Structural materials
- Oils

4.4.4 Littering of regions liquidation materials

Most of the pipelines will be placed under existing roads and pavements and consequently minimum waste will be generated from the vegetation removal, which will be limited in the areas of some of the pumping stations.

4.4.5 Materials of Excavation

Since most of the pipelines will be placed under the existing roads and pavements, the excavation materials produced, will be generatd from the excavation of ditches for the placement of pipelines and the excavations for the construction of the pumping stations. These materials will mainly include earth, asphalt and concrete. The expected quantities of excavated materials and materials of embankment for the construction of pipelines are presented in table 4.7.

Table 4.7 Expected quantities of excavation and embankment materials for the construction of pipelines

Area	Pipeline	Length	Excavated volume (m^3)	Embankment volume (m^3)	Required Volume (m^3)
B-II	Main pipelines	10,0 km	45,000	31,500	13,500
	Pressure mains	6,9 km	31,050	21,735	9,315
	Secondary pipelines	156,0 km	312,000	218,400	93,600
B-III	Main pipelines	1,4 km	6,300	4,410	1,890
	Pressure mains	0,9 km	4,050	2,835	1,215
	Secondary pipelines	42 km	84,000	58,800	25,200
	Total	217,2 km	482,400	337,680	144,720

The volume of excavation materials that will be produced by the construction of the pumping stations will be insignificant compared to the excavation volume that will be produced by the excavation of ditches for the placement of pipelines. It is calculated that roughly 50m3- 100m3 will be produced by the excavations for the pumping stations. The final volume of excavations will depend mainly from the depth and the reservoir size of each pumping station, parameters that will be determined in the detailed design stage. The preliminary estimated depths and reservoir sizes for the pumping stations of the B-II area are listed in Table 4.8.

Table 4.8 Prelimiary estimated depths and reservoir sizes for B-II pumping stations

Area	Pumping Station	Reservoir Depth	Reservoir Size
B-II	PSBII-1 (A1)	5,7	4,0 x 5.1
	PSBII-2 (Q1)	5,9	4,0 x 5,1
	PSBII-3 (J1)	4,5	2.5 diam.

Area	Pumping Station	Reservoir Depth	Reservoir Size
	PSBII-4 (W1)	4,5	2.5 diam.
	PSBII-5 (Z1(Z2))	5,5	2.5 diam.
	PSBII-6 (X1)	4,5	2.5 diam.
	PSBII-7 (Y1)	5,0	2.5 diam.

The volume of excavated materials that will be produced by the extension of the sewage treatment station has not been estimated. It is noted that the material near the sea coast and pumping stations PSB-III-1, PSBIII-2, PSBII-1 (A1) and PSBI-1 (V1) is not appropriate for embankment and it should be rejected. This volume is estimated not to exceed 5,000m3.

4.4.6 Demolition Materials

The demolition materials will be produced mainly by the demolition of the abandoned biological station that is located in the area of the proposed pumping station PSBII-5 (Z1Z2)). These materials will include mainly inactive structural materials as concrete and iron.

4.4.7 Other Solid and Liquid Wastes

Other solid and liquid wastes result from daily works and they mainly concern littering of packaging of structural materials, bad quality or surplus construction materials (mainly cement and asphalt pavings) and household wastes produced by the workers. The liquid wastes are generated by the household sewages from the hygiene places of the workers.

Under the contractor's responsibility and accordingly to the "Buildings and Works of Engineering Construction (Safety, Health and Welfare) Regulations of 1973, suitable hygiene places will be installed, such as mobile toilets, the number of which will be according to table 4.9 and the removal of liquid wastes will be under the contractor's responsibility.

Number of male workers	Minimum number of hygiene places
	Toilets
Up to 15	1

Number of male workers	Minimum number of hygiene places
	Toilets
Up to 25	2
Up to 50	3
Up to 75	4
Every additional 35	1

The contractor has also the responsibility for receiving and managing all the materials that concern construction materials.

4.4.8 Deposition of quarry and other inactive materials

It is estimated that a total of 145,000m3 of inactive material will have to be collected and rejected in designated areas. In the study region there are no available areas for the rejection of these materials. Probable locations in the wider region include the quarries in Dromolaxia or Klavdia villages. Suitable locations will be indicated by the contractor and will be approved by the responsible authority of Larnaca Municipality.

4.4.9 Areas of temporary storage of construction materials

During construction works the contractor needs to ensure areas for the temporary storage of materials. These plots must have ample space that will enable them to be used for storage but also allow for the implementation of all precautionary measures. They will also need to provide easy access to the working sites so that no repercussions result in the traffic in the region during transportation of materials.

4.5 Timetable of Phase B of Larnaca Sewage System

Based on the European Directivive 91/271/EEC, all Phase B works need to be completed before the end of year 2012. In map 4.2 and also in the table 4.9 that follows, the various stages for implementing Phase B works are presented.

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Πίνακας 4,9

Chapter

5

5. Identification and Assessment of Environmental Impacts

5.1. Synopsis of Environmental Issues

In this chapter the environmental issues that result from the construction and operation of Phase B of the Sewage System of Larnaca are described. Then the predicted impacts of the contruction and operation phase are presented analytically. Finally, where it is considered essential for the comprehension of text, an explanation of the scientific background is included in the appendices.

During the construction period the impacts identified are mainly due to the negative impact in the quality of life of residents in nearby houses that will inevitably result from the discomfort and vexation the preparatory works will create. Additionally, the probable impacts to the environment from the work near the Salt lakes area is evaluated. Finally, in this chapter, the impacts from using of the land for the project's works, eventhough that this results exclusively from the planning and arrangement and not the construction works, are included.

It is estimated that certain temporary negative impacts to the environment and the quality of life of the project area residents will be present even by taking suitable protective action. At the same time, it is noted that no permanent or irreversible impacts will be created at the stage of construction.

The main environmental issues that have been evaluated are summarised below:

- Removal, degradation or influence of regions with ecological, cultural archaeological or functional value.

- Safety. The worksites generally can contain accident hazards particularly to third persons. This issue is considered particularly important because the works will be carried out in residentially developed areas and for a big part in busy regions.
- Interruption or hindrance of road access to built-up and commercial areas.
- impacts on commercial activities
- Quality of atmosphere/ dust
- Noise pollution
- Water and soil pollution
- Temporary acquisition of open areas for the temporary storage of materials. These plots will be used for the temporary storage of structural materials. Beyond these issues that concern all work sites, an additional issue is regarding the interruption of activities which most probable take place in these plots.
- Impacts on the public infrastructure and other growths

At the operation phase, a series of issues concerning the urban and natural environment and the use of natural resources have been evaluated. At the same time, the gains resulting from the operation of the project have been located and evaluated. Particularly the improvement of ground water quality from the interruption of seweage diposal in septic tanks, stop tanker vexation and overflows of septic tanks are some advantages. Another advantage is the recycling of important quantities of water resulting in savings of this important natural resource.

The main issues identified are summarised in the following list:

- Degradation or influence of land with ecological, cultural archaeological or functional value.
- Impacts on the economic or residential growth.
- Impacts on the aesthetics and character of the affected regions.
- Consumption of natural resources (water, electricity, fuels).
- Waters and soil quality.
- Noise pollution.
- Quality of atmosphere/ odours.

5.2. Impacts During the Construction Phase

5.2.1 Removal, degradation or influence of regions with ecological, cultural/archaeological or functional value

Within the area of the Larnaca salt lakes many projects and developments have taken place from which many have caused serious negative impacts in the landscape combined with detrimental effects on the populations of the flora and fauna species and hence the levels of the biodiversity. It is also estimated that many of these impacts may have caused major changes to the processes of antagonism (within species, between species), symbiosis and the rest of the species interactions that are observed in nature with immediate consequences to the ecological balance and hence the long-term stability of the system. Furthermore, in these cases of the disruption of habitats, major changes follow in the evolutionary and speciation processes that take place in a habitat and which certainly take long timescales and provided that the system is stable in terms of its abiotic and biotic characteristics. These impacts contribute to the processes of shrinkage and/or disappearance of habitats of major importance for the survival of some rare and or vulnerable habitats and species of the Cyprus flora.

We assume that a further shrinkage of the available habitat for the plant and animal species of the habitat from the proposed works will contribute significantly negatively to the quality of the habitats within the Natura boundaries.

The proposed works that are expected to affect directly or indirectly sites of major ecological value are the following:

- Biological station for the treatment of waste.
- PSBII-3 (J1)
- PSBII-4 (W1)
- PSBII-6 (X1)

The main plant and animal species populations that could possibly be affected from the expansion of the Larnaka sewerage system are situated on the boundaries of the salt lake and mainly in the areas of the pumping stations PSBII-3, PSBII-4 and the biological station.

For the construction works of the above installations the following impacts have been studied which are expected to have negative effects to the avifauna and the flora of the area.

These are:

i) The disappearance of the habitats
ii) Habitat fragmentation phenomena or disruption of wildlife corridors
iii) Impacts of noise on the avifauna of the area.

In general, the construction works are situated in urban areas which do not possess major ecological interest. The exceptions to these rae the biological station the construction of the pipes and the pumping stations PSBI-1, PSBII-1, PSBII-3 and PSBII-4.
The works will include the construction of the pumping stations, the pipes and the expansion of the biological station. For the pumping stations specifically the works will include excavations and the installation of groundwater pumps and other electromagnetic systems.
In the following paragraphs we provide our estimations for each one of the possible impacts.

I. Habitat destruction

The works for the pumping stations are in general of a small size. Furthermore, they are situated on the boundaries of the salt lakes but they do not enter the system and also they do not possess important flora and fauna species within or around the area where their construction is planned.
Despite of this fact, we have to mention here that negative impacts will be possessed in the case at which there will be permanent or transient accumulations of dust and/or other materials or there will be movement of cars.
Furthermore, the network for the collection of wastes is situated in existing roads so there is no possibility of destruction or disappearance of habitats.

II. Impacts of the disruption of the coherence of habitats of plant and animal species and of the wildlife corridors

The pumping stations consist of small buildings that do not exist the 3m in height and at the same time they are situated in areas where development takes place. As such we do not expect to have disruption of wildlife corridors and serious or dramatic habitat modifications.

III. Impacts from probable sewage leakages

During the construction phase no sewage leakages are expected towards the saltlakes or other areas.

IV. Noise impacts

Regarding the effects of noise on animal species, according to scientific studies (Radle *et al*), this may cause impacts in the physiology and the behavior of animal species, while in the long term basis can be destructive for the energy budgets for the reproduction of some species and their reproductive success.

From the under study project it is not expected to have noise on a long term basis that will cause this type of effects on animal species. The noise produced is expected to be produced at the construction phase, during the transportation and operation of machineries as well as the dewatering stage which is necessary to operate all 24 hours of the day. In addition, the area is affected by the noise of the nearby airport, a fact that will probably reduce the reaction of the animal species to the added noise from the construction works.

The consultants estimate that the impacts from the construction works will be confined to the temporary leave of animal species, especially birds that visit the treated water reservoirs.

Areas of cultural/ archaelogical and functional value

During the selection of the pumping station sites, serious efforts were exerted for avoiding areas with cultural and archaelogical value. For this reason, no serious impacts on the aesthetics of the archaelogical sites of the town of Larnaca are expected. In addition, if all necessary actions are taken for the architectural design and landscaping of the pumping stations, so that they can be placed harmonically among the character of each site, then there is no reason to worry for any changes in the aesthetics, the quality of the archaelogical sites or the possibility of successfully accessing them.

From the installation and operation of the worksites, temporary but important impacts are expected in accessing the affected areas with negative impacts in the functionality of the road network and pedestrian passage. The cutoff of roads constitutes the most common nuisance and neighbours' reaction near construction works. A part of the works will take place in main commercial roads while another part will affect the coastal tourist areas. Impacts will occur in all of the project's area. The following impacts are selectively chosen:

- There will be difficulties in road and pedestrian access of visitors to the coast from pumping station PSBII-1(A1) up to the Makenzy coast. Choosing of the alternative sewer route Y from this pumping station (map 3.8) will eliminate this impact from the Castle hotel area.

- There will be difficulties in road and pedestrian access of the visitors in the area north of the pumping station PSBI-1(V1).
- Accessing the Saltlake's trail path area near the pumping station PSBII-4 (W1) can be achieved from Faneromenis Avenue. The works will possibly impede the access of the pedestrians, tourists or other visitors towards the trail path but also influence the functionality of the area as a recreation area.

There will be difficulties in accessing the areas that were identified as sensitive to safety issues (see section 5.2.2).

5.2.2 Safety

In general the worksites contain accident hazards for personnel but also other people. This issue is considered particularly important because the project will be carried out in built-up, developed areas and for a major part in busy regions. Dangers include:

- Dangers to road traffic by the creation of unfavourable conditions of driving (excavations, structural materials and equipment in the road arteries, temporary fencings etc). These dangers are decreased drastically with the following measures:
  - **i** Suitable and sufficient labelling and lighting
  - **ii** Complete cutting off of particularly dangerous accesses
  - **iii** Effective detours of traffic
  - **iv** Avoid placing materials and equipment in or near road arteries
  - **v** Avoid the escape of materials and other materials in the roads

- Dangers to pedestrians

More sensitive to this type of accidents are the busy regions, particularly in the evening hours, and the regions in which children gather. In the project area where the main sections of the sewage network will be constructed the following sensitive points have been located:

i. Pattichio
ii. Cineplex
iii. Municipal Library
iv. Old stadium 'ΓΣΖ' and gym
v. Dianellios Technical School

vi. Hotels and restaurants in the Makenzy area
vii. School off Kastalias road
viii. Technical School of Saint Lazarus

5.2.3 Repercussions in the infrastructure and other growths

The installation of the sewage collection network constitutes a necessary work for the urban region of Larnaca, which will upgrade the infrastructure of the city. Nevertheless the construction works will affect existing infrastructures and installations. The impacts on the existing infrastructure will include:

- Excavation of streets and temporary diversion of roads
- Probability for interventions in fencings and pavements of private properties
- Sporadic damage in pavements, fencings and private properties from vibrations and small accidents
- Probable displacement of telecommunication cables[2]
- Probable displacement of watermains[2]

5.2.4 Quality of atmosphere/ dust

The quality of atmosphere will be influenced by the creation of dust, the impacts of which are limited to vexation. At the same time, the long-lasting exposure in high concentrations of breathable particulate matter (PM10) creates problems in the health, which include:

- Increase the probability for asthma outbreaks
- Excerbation of respiratory problems
- Allergies

Because the increased dust will be limited in the construction period, the impacts from the project are limited in vexation and excerbation of problems in individuals that already have respiratory problems. The evaluation of vexation that will be caused by the dust at the constructional phase will be based on the following parameters:

- Concentration of dust
- Duration of dust production
- How much the people is informed about the duration of the works

The region of Larnaca is generally characterized from medium speed winds and minimal periods of very low winds or no winds at all, (V<2ms-1), a fact that creates good conditions of atmospheric dissemination. The dense growth in some regions however, e.g. in the central regions of Larnaca constitutes suspensive factor in the dissemination of atmospheric pollutants. Consequently it is expected that the dust that will be created at these points will create high mean concentrations of dust. It is considered certain that during the construction works in dry periods, the concentration of dust will exceed the acceptable levels in the most regions of work. It is noted however that the importance of this impact is decreased by the fact that this impact is temporary. Specifically, the atmospheric quality during the construction works will be influenced by the following sources of dust:

- Excavation Works
- Deposition and transport of inactive excavation materials
- Borrow land of inactive materials of embankment
- Increased deposition of earth on asphalt roads from vehicles transferring materials and rubble

At the pumping station and sewer construction areas, where the sensitive to dust developments exist, the main source of dust is contributed by the excavation works.

5.2.5 Noise pollution

Noise Criteria

The maximum levels of noise emission from new installations are determined by the noise criteria for the environment that the various Authorities (local and government) determine for different regions. In Cyprus there are no legislative providences on noise specifically. The 49/2002 European Union Directive, harmonises the checked parameters and their method of evaluation but does not propose common limits regarding environmental noise for the member states.

According to various study results, responsible international organisations (eg WHO) have drawn up a line for suggested maximium noise limits in which satisfactory protection of health and quality of life is offered. The main suggestion with a direct relation to the present study includes:

- Protection of sleep for which maximum levels lie between 35 - 45 dB during evening hours

- Protection of quality of life from interventions in communication, the reduction of concentration and productivity and creation of vexation for which values of up to 55 dB are suggested, and
- Protection of health from psychological intensity, headaches, increase of pressure etc, that are caused in values above 65 dB.

The Cyprus Legislation does not yet define acceptable noise levels that affect built-up or other regions. For this reason, preliminary suggestions from the Environment Service were used for determination of the noise criteria. According to the preliminary suggestionsons the limits of environmental noise are expected to vary in the following values:

Expected noise limits for Cyprus

Land use / Parameter	Residential	Other Urban
Lden	55	65
Lnight	45	55

It is noted that at the present stage no guidelines exist for worksites allowed noise levels aiming at the protection of the environment. For this reason, applied practices mainly from United Kingdom were used. The directives that are generally used define that the contractor of the project has the obligation to ensure that the highest noise levels 1m from residence windows in the area of the works, will not exceed for various hours and days the predetermined levels. For this project the following values are considered as acceptable levels of noise:

Table 5.1: Maximum Noise Levels from construction works

Period	Maximum Level in façade LAeq (1hour)	Maximum instantaneous level dB(A)
Monday-Friday 07.30-18.30 except holidays	75	80
Monday-Friday 18.30-22.00 except holidays	65	70

Period	Maximum Level in façade LAeq (1hour)	Maximum instantaneous level dB(A)
Daily 22.00-07.30	45	50[1]
Saturday 07.30-1300	65	70
Saturday 13.00-22.00 Sunday & holidays 07.30-22.00	55	60

For the purposes of this study, the maximum acceptable noise level from construction works during the day (7.00 - 18.30) is considered the level of 75 dB LAeq, 1m from windows that are likely to be affected by the construction works and the level of LAnight 45 dB during the night hours.
The above criteria are in effect unless a government or other responsible department define different criteria and periods.

Estimated noise levels

The noise from the construction works was estimated according to the Bristish Standard BS 5228:84 "Noise Control on Construction and Open Sites". This Standard provides guidelines for the factors that should be taken into consideration in order to evaluate the impacts of noise from construction work. It presents levels of noise emissions from various construction equipment and then suggests maximum noise level goals within the limits of constructional work in order to be able to control the noise emissions. The suggestions take into consideration the existing levels of environmental noise in the area, the type of affected areas, the work hours, the duration of works, the type of instruments and the type of constructional works that will take place.

The noise from the construction works closer to the residences, has been calculated according to the methods that are given in BS 5228:84. Because the precise type of equipment that will be used for the construction works is not known at this stage, the highest noise levels for the hypothetical equipment that will be used in the project were taken out of this Standard. The noisiest equipment that will be used for the construction works are the transportation and excavation vehicles,

[1] Μοναδική δραστηριότητα κατά τη νυχτερινή περίοδο αποτελεί η αποστράγγιση η οποία δημιουργεί σταθερά επίπεδα θορύβου.

compressors and equipment working with air, cement mixers and cranes. The study also considered that no construction works will take place after 16:00 hours.

Examining the worst noise emission conditions from the construction works, the noise levels of the equipment are estimated to be in the order of 92 dB LAeq (9 hour), in a 10 m distance from the equipment. For the study, it is estimated that during the day, it will be used a machine plus a drainage pump with noise levels that will reach a total noise level of 92 dB (A). The remainder equipment in the worksite will be found either further away or will be less noisy, and consequently their effect will be negligible. The exception will occur at the extension of the sewage treatment station, where the highest level will exceed the 95 dBA, taking into consideration the probability that more than one heavy vehicles simultaneously.

Table 5.2 gives a summary of the way the noise levels from the construction works were calculated, in a distance between equipment and residences of 10, 20 and 80 metres and with 92dBA noise at the source.

Table 5.2: Expected noise levels from construction works in the facade of nearby developments in distance between source and receptor of 80, 20 and 10 metres[2]

Description	Distance 80m.	Distance 20m.	Distance 10m.
$L_{Aeq(9\ hour)}$, BS 5228, total noise from works in 10 m distance in dB	92	92	92
Reduction/increase of noise due to distance in dB	-18	-6	-0
Noise reduction from obstructions (eg buildings) in dB	0 -15	0 -15	0
Noise increase from façade reflections in dB	0	0	0
Final noise level in façade in dB $L_{Aeq(9\ hour)}$	61 - 46	86 – 74	92

[2] Τα επίπεδα θορύβου κατά τη διάρκεια της νύχτας αξιολογούνται σε 5-7 περίπου dB χαμηλότερα από τα παραπάνω αφού ο εξοπλισμός αποστράγγισης δημιουργεί θόρυβο της τάξης των 85-87 dB(A).

During the night equivalent levels are expected to be 5-10 dB lower, taking into consideration that only the drainage pumps will be operating.

Appraisal of noise complaints

The appraisal of noise complaints was performed using the methodology described in Annex 5.

It is estimated that in most work areas the nearby developments are found in a distance of 10 - 30 metres from the construction works. Consequently, according to the above mentioned method the levels of mean hourly noise will vary from 84 - 70 dB on the receptors.

According to the methodology for complaint appraisal it is appreciated that in the central areas with high road traffic the impacts will be reduced since in such conditions the environmental noise reaches high levels and as a consequence the additional burden from the works is of the order of 5 dB (A).
In the purely residential areas, because of the low level of background that exists, an ` important ' increase of noise and consequently negative effect will be created, which justifies reactions and complaints.

During the night, the background noise is estimated as 47 up to 34 dB (A) in the urban centre and in the purely residential areas respectively, while the nightly noise (LAnight) is estimated from 66 up to 46 dB in the urban centre and the purely residential areas respectively.

According to the above, it is expected that during the drainage phase, the noise in the facades of the nearest residences will vary from LAeq 70 - 85 dB (Constant level).

Consequently, an additional value of 20 or even 30, LAeq 70 - 85 dB that constitutes an ` important ' burden to the acoustic environment of the nearest residences of all the study area with the exception of the area of sewerage treatment station. More serious burden and consequently harmful effect will naturally be created in the residential areas.
Finally it is noted that the noise from vehicle transportations is considered insignificant since the access roads that will be used are very busy and therefore any additional burdens are minimised.

5.2.6 Water and Soil Pollution

At the construction phase no major danger for leakage of pollutants was identified. There exists however the danger of escape of structural materials and rubbles from the areas of temporary deposition of materials (see paragraph 5.2.7) and areas of permanent rubble disposal. Also exists the danger of escape of earth from the areas where the works will be carried out.

In case of material and rubble leakage in the project area it is expected that no important repercussions in the quality of waters and soil will exist. Nevertheless, it will increase the discomfort that will be created to the neighbours with the hindrance of road traffic and pedestrian walking conditions, the devalorisation of aesthetics and the quality of urban areas, the transport of earth and other materials in the the nearby properties and the increase of dust.

Particularly sensitive are considered the coastal areas which cross the sewage collection network from pumping station PSBII-1 up until the airport. Besides, the central roads like Makarios Avenue, Faneromeni Avenue, Griva Digeni Avenue, Artemidos Avenue etc are also considered important due to the dense commercial or tourist activity they host. In these regions the additional discomfort is expected to constitute an additional factor of visitors avoiding the region and consequently to accentuate the reduction in tourist and commercial activities.

In the regions of ecological interest, the chance of sedimentation in the nearby areas is expected to have temporary repercussions in the flora of the region. Such danger has been located at pumping stations PSBII-3 (J1) and PSBII-4 (W1), that are found near the Larnaca saltlakes and at the sewage treatment station which is found in the protected area of the Saltlakes. It is noted that in the pumping stations there is no danger for serious or permanent devalorisation of the environment since the size of the works is not such that can cause serious sedimentation in the nearby area. This is concluded based on the assumption that the contractor will not use neighbouring to the pumping station areas for the deposition of materials or rubbles or the circulation/ parking of vehicles. Because around the pumping stations exists sufficient suitable area for use by the contractor there is not serious danger of extending the works in unsuitable for this purpose areas.

In the sewerage treatment works exists enough area for the development of the construction works. Perhaps an exception constitutes the development of works in the north-western part of the plot where it probably needs to use an area beyond the limits of the plot for accessing the works. In particular if the temporary storage of rubble in the area is not permitted, it is estimated that the potential interventions in areas beyond the project's plot will be limited in a bandwidth of the order of 5 metres in the northern border of the projects's plot. It is also believed that no problems of leakage of important quantities of materials to the neighbouring Saltlake will exist.

5.2.7 Temporary use of open areas for the storage of materials.

Site visits were realised in the areas where the pumping stations will be erected in order to find the plots that will be used for the temporary storage of construction materials. Beyond the issues that concern all the worksites an additional issue that results is the exemption of any other activities the plots may be used for.

In the site visits the following resulted:

- PSBI-1 (V1): The works that will be carried out in this pumping station's area as well as the installation of the pipeline from the Makenzi coast up to the treatment station is surrounded by the saltlakes and the coast. For this reason it is recommended to use the same area for the storage of materials that will be used for the extension works of the treatment station
- PSBII-1 (A1): In the area behind plot No 103 (Map 3.8) that the pumping station PSBII-1 will be erected there is enough space for the temporary storage of construction materials
- PSBII-2 (Q1): Plot 598 (Map 3.9) that is found opposite the entrance of the sub-prefect's residence and had been proposed as a candidate area for the erection of pumping station PSBII-2 is empty in its facade. Further in to this plot, the former ice making machine is found that now however it has been abandoned. For storage purposes the back of this plot could be used. Alternatively, in the point where the two parallel roads Adamantiou Korae and William Weir are connected to the perpendicular Franklin Rousevelt road there is an empty plot (No 39).
- PSBII-3 (J1): There is plenty of space in plot no. 148, (Map 3.10), which the pumping station will be erected.

- PSBII-4 (W1): Plot 1 (Map 3.11) has abundant place for storage. It is marked however that the region is found in the saltlake boundaries and the space that will be used for the temporary storage of the construction materials should be delimited strictly and be limited as close as possible to the Site 3 area where the pumping station will be erected.
- PSBII-5 (Z1(Z2)): The pumping station will be erected in the area of the abandoned biological station, plot 871 (Map 3.12) where after the biological station is demolished there will be enough available space. Alternatively there are a lot of available empty plots in the region.
- PSBII-6 (X1): A lot of emply plots exist in the region, among which are the plots 1054 and 1055 (Map 3.13) that border with the proposed pumping station site.
- PSBII-7 (Y1): There is plenty of space in plot 694 (Map 3.14) where the pumping station will be erected.

5.3 Impacts during operation

The major impacts or dangers that are expected to result during operation of the sewage system are described below.

5.3.1 Devalorisation or influence of regions with ecological value

The dangers for negative repercussions in the populations of flora and fauna and the ecotopes is located in the potential leakages of sewage or processed water in the Saltlakes system. The dangers from such a possibility are analyzed below.

- Overflow of pumping stations

The pumping stations have multiple systems for handling of emergency situations thus minimizing the probability of sewage leakages and decreasing the duration of such leakages. Nevertheless it is considered advisable to report the expected repecursions in case of such leakages.

In case of sewage leakages from the pumping stations and the pipelines near the saltlakes, there is a danger of influencing the ecosystems of the saltlakes. Here it should be taken into consideration that the salt lakes are considered “closed hydrological systems” and consequently have a great capacity of accumulating pollutants compared to sweet water lakes and rivers. According to scientific reports (Bradley and Dunn 1989) the concentration of sulfur (S) that is included in the sewage can influence, in case of a leakage, the distribution of plant species in the affected biotope,

the physiology, the reproduction and their growth rate. As a result serious changes are expected in the composition of the populations of the salt lake and the distribution and the cover ratio from flora species that may be important for Nitrogen metabolism.

Probable increased levels of nitrogen and sulfur within the salt lake from probable sewage leakages can bring changes in the efficiency of the photosynthetic mechanism of the flora species and consequently the productivity, the intake ability and the water balances (Naidoo 1987).
The flora in or at the boundaries of the salt lakes provides increased surface for settling of bacteria capable of absorbing nitrogen and also increase the frequency of daily changes in the water chemistry and the nitrogen concentration.

Consequently, the conservation and the sustainable management of the system is of great importance for the regulation of the ammonia concentration and especially in the cases of the system enrichment from sewage leakages.

The vegetation of the halophytes of the salt lakes is characterized from a rich variety of unique ecological adaptations that allow them to survive in the cases of high aridity and high salt concentrations and also for the regulation of ion concentrations. As such they could be used for phytoremediation purposes thanks to their ability to absorb ions. These species fall within the following genuses: *Chenopodium, Salicornia, Salsola, Suaeda, Tamarix, Artiplex*

- Leakages from treated water reservoirs

  In case of treated water leakage from the reservoirs, changes in the natural rythms of ecological succession and eutrophication phenomena will probably result. In these cases, beyond the blue-green algae growths, the reduction of oxygen levels and of the system's ecological quality there exists the danger of growth of species types such as Phragmites australis and Arundo donax which could displace the native alophytic vegetation as well as endemic populations and rare orchids which have been located in specific biotope areas (Hadjichristoforou M.- personal communication). The algae can produce toxins that are poisonous to the wild life of the system (mainly species of fauna) but also degrade the quality of the waters of the system.

  The average concentrations of N and P in the treated water that is stored in the reservoirs of the station is 25 mg/L and 3 mg/L respectively. Eventhough the concentrations of N and P in the

saltlake system are still not known, the above mentioned concentrations are high enough to create conditions of eutrophication.

The turbidity and the water temperature can also change as a result of sewage entering the system and increase in concentration of solid particles with direct repercussions in the amount of light that will reach in the Saltlakes and consequently in the organisms whose survival depends also from satisfactory levels of solar radiation (photosynthetic organisms, Dunaliella salina).

Concluding, the danger for the repercussions from sewage leakages to occur is extremely remote, taken in consideration the essential measures taken for the avoidance of pumping stations' sewage overflows.

A more serious danger that concerns the operation of the Sewage System is located in the probability of leakages of the reservoirs with possible changes in salinity of the nearby areas, of the pH and generally the characteristics of the dwelling. The repercussions in such a case (sewage outflows) have been discussed above extensively and concern eutrophication issues, change of physiological course of succession, water turbidity, food chain etc. These repercussions is possible to cause changes in the composition of plant communities and devalorisation of the alophyte population and encouragement of growth of other species (eg Phragmites australis) with direct repercussions in the physiognomy and the ecology of the system.

It is noted that the existing treatment station and its proposed extensions are located in a protection area (see maps 3.3 and 3.1) and for this reason particular attention should be paid.

5.3.2 Impacts in economic or residential development

Taking measures for the architectural design, landscaping and odor reduction is expected to have positive results in the public's perception regarding the presence of pumping stations close to residences or other developments. Nevertheless however, it is not possible to shape the public's perception to the extend that all negative perceptions against this type of developments is completely eliminated.

The plots proposed for the pumping stations do not border with any commercial activities and as a result, the probability of influencing commercial activities is avoided. The pumping station PSBII-1 (A1) is located in an area with tourist growth. The presence of the pumping station may be a suspensive factor in the development of the neighbouring plot. It should however be taken into consideration that in the same plot (103), already exists a pumping station and that any probable repercussions that will be developed will be independent from the proposed pumping station construction.

5.3.3 Impacts on the aesthetics and landscape of the affected areas

The impacts on the aesthetics and landscape are analyzed based on the following parameters:

1. Incompatibility of character or size of installation with the area in which it will be installed
2. Interruption or alteration of view
3. Important alterations in the topographic bas-relief

The pumping stations constitute industrial type constructions that as an activity is not consistent with residential development, open areas or areas of recreation. In addition, it is reported that the up to now practice of dissimulation with vegetation in the perimeter of the pumping stations, constitutes a partial solution of the problem that in certain sensitive regions is likely not to be sufficient. At the same time, it is considered that the wire fencing that is used in the existing pumping stations is not compatible with the quality of architecture and aesthetics that is progressively developed both in residential as well as other developments.

In the regions located within urban areas, the presence of pumping stations does not constitute an important optical intervention since both the scale as well as the location of the works is not such that would interrupt or change considerably the optical fields.

Nevertheless, with the existing practice of architectural design, fencing and landscaping, it is considered that the pumping stations create an image that is at a disadvantage compared to the existing quality of materials and architectural design that exists and that is improving in the

residential and commercial developments. Consequently the presence of pumping stations recommends degradation of the regions in which they are installed.

Exception in this case constitutes the pumping station PSBII-5 (Z1(Z2)). In the proposed site exists an abandoned biological station which downgrades considerably the region by the bad image that it creates but also because it is a source of odors at periods that the reservoir collects rain waters which remain stagnant for a long time. The demolition of the biological station that will take place prior to the construction of the pumping station constitutes an important improvement for the region.

From the works in and at the boundaries of the Saltlakes impacts in the aesthetics are mainly created from:

- Sewerage treatment station
- Pumping station PSBII-2 (Q1)
- Pumping station PSBII-3 (J1)
- Pumping station PSB-II-4 (W1
- Pumping station PSBII-6 (X1)

Sewerage treatment station

In the sewerage treatment station additional process units will be installed for the treatment of sewage which will be compatible with the size and type of materials with the existing installations and will have less height from the existing buildings. In the proposed works however, is also included the installation of a biogas production unit which will have a height up to 29 metres. Additionally this unit also needs a flare system for the combustion of byproduct gases which will have a height of over 30 meters.

These works will inevitable have an important intervention in the optical field. They will be particularly visible from the airport region and the tourist regions south of the treatment works.

Pumping station PSBII-2 (Q1)

In the proposed pumping station area there were three alternative sites available (map 3.9). Site 1 is surrounded by dense growth in three of its sides and is estimated that it will present increased

impacts both at the construction as well as the operation phase. Site 2 is located inside the Government Nursery of the Forest Department. In this case the site has an advantage because it is located in a relatively remote area and in greater distance than the surrounding developments. Site 3 is located on a plot off of Griva Digeni Avenue, that is no longer available. \

Pumping station PSBII-3 (J1)

The pumping station area is characterized by low density residential development, the open space view of the saltlakes and the European trail path.

It is estimated that the installation of the pumping station will degrade the aesthetics of the area. In case the pumping station is constructed in Site 2 or Site 3 it will obstruct the view to the trail path and the saltlakes.

Pumping station PSBII-4 (W1)

This pumping station's area also is characterized by low density residential development, the open space view of the saltlakes and the trail path. It is noted however that the pumping station will be located in an area with dense vegetation and hence will not be particularly visible from the trail path or the Faneromeni Avenue. North of the proposed pumping station there is a hill of over 5 meters, the obstruction of the optical field is markedly reduced in this area. Despite all this, the character and the aesthetics of the pumping station will affect the neighbouring area. It should also be noted that the pumping station will be close to the saltlake's trail path that hosts a lot of visitors daily.

Pumping station PSBII-6 (X1)

This pumping station is also located at the saltlake boundaries in the area of the Makarios III Refugee Housing Estates. The proposed pumping station site is located in agricultural land located behind behind a hill that will render the pumping station invisible from the residential areas. In a 200m distance from the proposed location there is a section of the ancient aqueduct. The pumping station is not expected to cause any adverse impact on the enjoyment of the view of the ancient site.

5.3.4 Natural Resources Consumption (water, energy)

Water resources

The importance of water is continuously increasing. The overpumping of underground waters in Cyprus led to the aquifers water level reduction and sea water intrusion with a resulting increase in salinity. In the city of Larnaca the mean annual rainfall is only 340 mm and there is an enormous need for water, not only for residential and agricultural use but also for landscaping and the creation of a better quality of environment and life for the local community as well as tourists.

The lack of water has been a negative factor for the agricultural and tourism development that both require large quantities of water. The water supply in Larnaca comes from various sources such as the desalination, surface and underground waters. The underground waters supplied water in the past on a regular basis but all the aquifers of Cyprus have been exploited beyond their safe yield resulting in sea intrusion in the coastal aquifers. The drilling permits for for private use have been limited.

The depletion of the aquifers and the increase in the demand rendered essential the development of a management program for surface waters. Cyprus now has one of the highest number of large dams per km2 in Europe.

The exploitation of underground and surface waters is very close to their limits and for this reason non conventional sources such as desalinations have been installed. The first large scale desalination plant with 40.000 m3/ day production was installed in Dhekelia 1997, and a second one with 52,000 m3/ day was installed next to the sewage treatment station in 2000. Data from the Water Supply Board on water supplied from various sources for year 2003 are given in table 3.8.

The Water Supply Board used the parameters presented in the following table for estimating the water demand for 2005.

Table 5.3: Parameters used for estimating water demand for 2005

Parameters	2005
Population	50,042
Tourist beds/ day (peak August)	5,225
Tourist beds/ day (average)	3,125
Domestic demand, L/hour/day	250
Tourist demand, L/bed/ day	500
Commercial and Industrial demand, m3/ day	1,709
Miscellaneous demand, m3/ day	91.9
Net demand, m3/ year	5,794,841
Losses	20%
Gross demand, m3/ year	6,808,938

The search for additional water resources led to the use of the tertiary treated sewerage as an additional resource. Treated water from the sewerage treatment plant is used for irrigation and landscaping of Larnaca. Generally all the treated water produced is being used. For the year 2005, 1,841,900 m3 were given to the irrigation system of Larnaca.

With the completion of Phase B works for the Sewage System, (year 2020 flows), 17,000 m3/ day will flow to the treatment station, while for year 2040, 24,000 m3/ day will flow to the treatment station. The sewage after treatment will be used for irrigation, landscaping, recharging of aquifers, industrial use etc. Here it should also be noted that the increased salinity of the treated water observed in phase A is expected to decrease with the operation of phase B, since no seawater is expected to enter the sewage network of phase B and blending of phase A sewage with phase B will lead to better quality water.

Energy

The sewage treatment station consumes large quantities of electricity particularly at the oxygenation stage. The existing sewage treatment station had an energy consumption of 3,305,845 kWh for 2003, 3,177,675 kWh in year 2004 and 3,308,386 kWh for the year 2005. The corresponding years, the sewage flows to the treatment station reached 2.144.554 m^3, 2.868.157 m^3 and 2.666.662 m^3 respectively.

Secondary treatment consumes roughly 45% of the total energy consumption, while 15% of the energy is consumed in the tertiary treatment. The remainder 40% of the energy is consumed by the irrigation pumping system.

According to the above data, the total consumption of energy per m^3 varies as follows: 1.54 kWh/m^3 in 2003, 1.11 kWh/m^3 in 2004 and 1.24 kWh/m^3 in 2005. According to data on consumption percentage distribution in the secondary treatment it is concluded that the energy that was consumed for secondary treatment was 0,693 kWh/m^3 in 2003, 0.50 kWh/m^3 in 2004 and 0.56 kWh/m^3 in 2005. Table 5.4 presents the pollutant emissions that correspond to this electric energy consumption.

The calculation of the emissions corresponding to the energy produced at the power station that the sewage treatment consumed for year 2005 is presented below. These emissions concern the power station that supplies with electricity the sewage treatment station.

Table 5.4 Fuel consumption and atmospheric pollutant emissions during 2005.

Parameter	Quantity
Mazout consumption	3,66 kg / kWh X 3.308.386 kWh/year = 12,109 tonnes / year
CO2 emissions	0.86 kg / kWh X 3.308.386 kWh/year = 2,845 tonnes / year
SO2 emissions	2.9*10-3 kg / X 3.308.386 kWh/year = 9.6 tonnes / year
NOx emissions	2.6*10-3 kg / kWh X 3.308.386 kWh/year = 8.6 tonnes / year
Particulate matter emissions	0.055 kg / kWh X 3.308.386 kWh/year = 182 tonnes / year

The MWH&I study proposes the use of anaerobic treatment and the energy production from biogas. During the process of electricity production from biogas the atmosphere is not charged with pollutants, as it happens with the combustion of conventional fuels for the same purpose.

Consequently, the process of producing electric energy from biogas and from renewable sources reduces the emissions of carbon dioxide CO2, nitrogen oxides NOx, sulfur dioxide SO2 and dust. The total annual gain, from the reduction of atmospheric emissions, from the operation of the biogas plant appears in the table that follows. In parallel with the energy production at the sewage treatment station, the raw materials that are used for the production of electric energy with the conventional method, eg crude oil will be saved.

The estimated annual production of electric energy from the operation of the biogas plant is 1.150 GWh. In Tables 5.5 and 5.6 the savings in fuels and atmospheric pollutant emissions that correspond to the production of this electric energy are presented.

Table 5.5 Energy produced from biogas according to year 2020 flows (source MWH&I)

	No of units
Expected biogas production (Nm3/ day)	1300
Daily methane production (Nm3/ day)	910
Power production (kW)	375
Yearly power production (GWh/ year)	3.285
Yearly heat production- 65% of power (GWh/ year)	2.135
Yearly electricity production- 35% of power (GWh/ year)	1.150

Table 5.6 Gains in fuel consumption and atmospheric pollutant emissions from the production of electricity from biogas.

Parameter	Quantity
Mazout consumption	3,66 kg / kWh X 1,150,000 kWh/year = 4,209 tonnes / year
CO2 emissions	0.86 kg / kWh X 1,150,000 kWh/year = 989 tonnes / year

Parameter	Quantity
SO2 emissions	2.9*10-3 kg / kWh X 1,150,000 kWh/year = 3.3 tonnes / year
NOx emissions	2.6*10-3 kg / kWh X 1,150,000 kWh/year = 3 tonnes / year
Particulate matter emissions	0.055 kg / kWh X 1,150,000 kWh/year = 63 tonnes / year

During operation of phase B of the Sewerage System (year 2020 flows), 17,000 m^3 of sewage will enter the sewage plant for treatment. A preliminary evaluation of the various treatment methods, based on MWH&I data, is presented in Table 5.7:

Table 5.7

	Aerobic Digestion (Continuous Feed Reactor)	Aerobic Digestion (Fill and Draw Batch Reactor)	Anaerobic Digestion with Primary Sedimentation	Anaerobic Digestion without Primary Digestion
Energy consumption (kWh)	2,203,263	3,115,579	1,535,453	1,788,874

From the preliminary energy consumption calculations, presented in Table 5.7, it is seen that the energy consumption reduction achieved by the anaerobic sludge digestion with primary sedimentation compared to the aerobic digestion (batch reactor) is 1,580,126 kWh and is recommended that the construction and operation cost of the anaerobic sludge treatment method is further studied.

Table 5.8 shows the additional gain in fuel consumption and atmospheric pollutant emissions by using the anaerobic sludge treatment.

Table 5.8

Parameter	Quantity
Mazout consumption	3,66 kg / kWh X 1,580,126 kWh/year = 5783 tonnes / year
CO2 emissions	0.86 kg / kWh X 1,580,126 kWh/year = 1359 tonnes / year
SO2 emissions	2.9*10-3 kg / kWh X 1,580,126 kWh/year = 4.6 tonnes / year
NOx emissions	2.6*10-3 kg / kWh X 1,580,126 kWh/year = 4.1 tonnes / year
Particulate matter emissions	0.055 kg / kWh X 1,580,126 kWh/year = 86.9 tonnes / year

5.3.5 Water and Soil Quality

Impacts from sewage treatment

The interruption of sewage disposal in septic tanks has important positive repercussions in the quality of waters and soil of Larnaca.

The gains in the quality of waters are much more than any local pollution that can be caused at the length of the sewage collection network. Nevertheless it should be reported that the sewage system will create certain dangers for pollution in the sewerage works axis. Pollution from leakages during normal operation of the sewerage system can be caused by problems in the pipings construction and from damages in the piping network. Generally in Phase A it has been confirmed that there is a waterproofing problem in a lot of points of the network. However, leakage of sewages has not been observed because the high level of the aquifer does not allow the flow of sewages out but on the contrary causes the water flow into the network. In the network of Phase B it is estimated that the piping problems will be solved and consequently a lot less problems of import of water in the network will exist. At the same time the probability of soil pollution from leakages is minimized.

The second case of pollution concerns emergency incidents of pumping station overflows.

It is noted that the case of pumping station overflows is considered an extreme scenario given the telemetry systems and the automations installed and the backup pumps and generators that exist. The estimation of the dangers presented below is performed for the evaluation of a worse case scenario.

In such a remote case, the maximum sewage quantity that will likely leak to the environment was estimated, based on the following scenario for pumping station PSBII-1 (A1). It is noted that this pumping station will collect all of phase B sewage flows. For further reducing the probability of overflows from damage in the pumping station PSBII-1 (A1) or phase A pumping station B2, the reservoir of the pumping station PSBII-1 (A1) can be linked with the reservoir of the existing pumping station B2.

The calculations presented below were based on the following assumptions:

- The maximum duration of malfunction is 1 hour
- The sewage flow at the time of the incident is taken as the 1/16 of the total daily sewage inlet.
- The sewage system is independent from the storm water system and the probability of rain water input to the sewage system has not been accounted for.

According to the above assumptions the sewage flow to the pumping station is as follows:

17.000 m3/day * 1 day/ 16 hours of sewage flow to PSBII-1(A1) = 1063 m3/ hour

The capacity of the gravity sewer that transfers the sewages to the pumping station is calculated based on the following assumptions:

L = Length of pipeline = 3000 m
D = Diameter of pipeline = 600 mm
V = capacity of pipeline = $\pi * (0,3)^2 * 3000 = 848\ m^3$

In case of damage in pumping station PSBII-1 (A1), and taken into consideration that the gravity sewer will be 35% full, then the gravity sewer will be full in approximately 31 minutes and moreover 512 m^3 of sewages will reach the pumping station PSBII-1 (A1). Keeping in mind that there is a provision for a reservoir of 114 m^3 capacity and that there is no provision for an overflow reservoir, then roughly 398 m3 of sewages will overflow from the reservoir of this pumping station.

Impacts from sludge treatment

After an approval obtained by the environment service, the sludge that is produced at the sewage treatment station can be used in agricultural land. This practice is followed at present and will be continued in the future.

According to data provided by the sewage treatment station supervisor, the sewage treatment station produced 5010 m^3 of sludge with roughly 80% humidity, and allocated 4928 m^3 of sludge with 60% humidity in fields in the region Archangelos of Avdellero village for the year 2005 (Table 5.9). The difference in the quantities is due to the fact that the sludge remains in the station for 3 months before is given out, thus quantities from the previous year exist.

The up to now analysis of the fields did not show any signs of heavy metal charging of the soil (Table 5.10). Taking into consideration this, it is believed that the continuation of this practice for Phase B of the sewage system, will not create any problems.

Solid waste from the treatment station screens (90 m^3) and grits (20m^3) were disposed at the landfill of the Larnaca Municipality.

Generally the Sewerage Board of Larnaca follows the terms of the waste disposal permit in very good co-operation with the operators of the Environmment Service and the Agriculture Department.

Table 5.9 Sludge monthly production for year 2005

Month	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC
Quantity (m3)	635	445	360	260	420	545	860	540	305	155	275	310

Table 5.10 Soil quality before and after 6 and 12 months of sludge use

Parameter		Before sludge deposition	12/01/05	02/08/05
pH	---	7,76	8,05	7,85
Άζωτο	%	0,14	0,30	0,13
Φωσφόρος	%	0,15	0,11	0,83
Κάδμιο	mg/l	1,88	0,10	1,25
Χαλκός	mg/l	44,2	34,90	31,80
Νικέλιο	mg/l	24,4	45,70	41,00
Μόλυβδος	mg/l	2,2	1,72	11,50
Ψευδάργυρος	mg/l	31	25,40	27,90
Υδράργυρος	mg/l	<0,5	0,59	<0,1
Χρώμιο	mg/l	13	8,6	5,9

5.3.6 Noise pollution

During operation no sources of noise that would constitute a danger for impacts to the acoustic environment were located. Along the sewerage network, no equipment exists that would create noise. At the same time, all the pumps in the pumping station are submersed and as a result the noise that create is not detactable at the perimeter of the pumping station plots. The only source of environmental noise constitutes the backup generator (when it functions) that is installed in the control building.

According to the specifications of the Larnaca Sewerage Board, the generators used should not produce noise over 70 dB (A) in a 1m distance. In case where their installation creates more noise from vibrations then it can reach the 80 dB (A) noise levels in a 1m distance. Because the generators are enclosed in the control building, the noise created in the perimeter of each pumping station is not expected to exceed the 50 dB (A).

As it has already been mentioned, these are backup generators and they are placed in operation only in case of electricity failures. The electricity supply is exceptionally reliable the last years and

failures rarely exist. Consequently, it is expected that the generators will rarely operate for periods that will not exceed three hours. In addition, these generators are placed in test operation once a month for a period of 10 minutes, during working hours.

The sewerage treatment station does not constitute a significant source of environmental noise.

5.3.7 Quality of atmosphere/ odours

The main gases that are produced in the sewerage systems include hydrogen sulfide, ammonia, methane and carbon dioxide. The formation and concentration of these gases is differentiated with the time they remain in the system, composition of the sewage, temperature and pH. A summary of the dangers or impacts these gases create is given in Annex 6.

In certain pumping stations of phase A network, odour problems had been observed during the first years of operation. This problem was due to the fact that the sewer upstream these pumping stations had a small slope, was very long and had small diameter. Under these conditions the sewage gets in an anaerobic state, especially at high temperatures during summer. Also, the gravity sewers have small slopes resulting in small speeds in the pipeline and small dissolved oxygen make up in the sewages. Because the speeds in the pressure mains are very small, the forces that are exerted on the walls of the pipelines are respectively small and thus a mucous membrane is created around the pipeline walls. The mucuous membrane that is created on the pipeline surface uses the oxygen from the sulfates that are present in the sewage thus creating septic conditions.
The Sewerage Board wanting to completely eliminate the problem of odour creation, installed in two of the pumping stations of phase A, C1 and B1, forced ventilation filters. In the remainder 15 pumping stations of Phase A they have installed self breathing activated carbon filters.
In Phase B the measures for odour reduction will be taken from the beginning so that the creation of odour problems is avoided. If properly designed and operated, the measures proposed are generally very effective. These measures, as they are proposed by MWH&I include:

- Connect the regions upstream the pumping stations with such priorities so that the pumping stations with long gravity sewers will not operate for a long time with small flows.

- Use twin pumping pipes (one pipe should be used at the first years of operation and as the flows increase then start using the second pipe) this action will provide adequate sewage speeds.
- The length of the pressure mains should be reduced and longer gravity sewers should be used where possible.

For the pumping stations with high septicity tendency the following are additionally proposed:

- Install a dosing system for the addition of ferric chloride or similar chemical as a temporary solution until all the system connections are completed.
- Importing of air or oxygen in the sewages in order to maintain a dissolved oxygen concentration of 1mg/L – this solution is not proposed for small pumping stations
- Protection of the downstream gravity sewers, including the pump reservoirs, by selecting to use durable materials that are not corrosive.
- Use activated carbon filters.

The increase in sewage flows, which involves the reduction of time the sewages stay in the network, will contribute to the reduction of the concentration of odourous gases, while the additional control measures aim at solving odour problems when these arise. According to the above no significant odour problems are expected. It always remains however the danger of casual problems in cases of disfunction of the odour reduction system or in exceptional cases where the flows will happen to be much smaller than the expected.

Odour problems can also arise at the wastewater and sludge treatment processes at the sewage treatment station. It is noted that in the existing sewage treatment station a biofilter has been installed at the entrance of the station and the odours at the station's inlet have been reduced effectively. It is estimated that with the biofilter use a satisfactory odour control will exist at the station inlet for phase B also.

Finally, taking into consideration that the anaerobic sludge digestion method will be used, it is estimated that with this method no major odour problems will develop during the transport of the processed sludge.

Dangers and health impacts

The main dangers to health from exposure to sewerage gases are:

1. Hydrogen sulfide poisoning, suffocation due to oxygen displacement or oxygen consumption.
2. Decreased perception and fatigue due to decreased levels of oxygen (from CO2 and CH4).
3. Biological pollution.
4. Fire hazard and explosion from methane, hydrogen sulfide and other flammable gases.

The above dangers are limited to the working areas and consequently concern the safety and hygiene of workers. It is noted that no such concentrations will develop in the environment that would recommend any dangers to the neighbours of the Sewerage System Installations.

Chapter

6

6. Environmental Impact Minimisation Measures

6.1. Introduction

The minimisation measures aim at the reduction or elimination of negative impacts as well as the maximisation of likely positive impacts from the work. This "optimisation" of the environmental record of work is supported mainly in the equitable arrangement and planning of work and consequently choosing suitable technologies and sizes. The right design of the works contributes in the prevention of unnecessary interventions and impacts in sensitive regions, in the reduction of consumption of resources and in the easier integration of work in the region that will be constructed.

Having ensured the correct design of the project, individual protective measures and improvement of the environment can be developed where this is judged necessary or deliberate either during the construction or the operation phase.

A big part of the optimisation work for the project was performed at the feasibility study (MWH&I, 2004) which dealt with sizing issues, technological choices and positioning of the project. Below are described the minimisation measures as they were shaped taking into consideration the proposals of study MWH&I and additional proposals that resulted from the present study.

6.2. Positioning of the sewerage treatment works and the pumping stations

The selection of the position of the sewerage treatment works and pumping stations was studied by MWH&I, taking into consideration mainly technical but also environmental criteria. In the environmental study the sewerage treatment works location was considered given. At the feasibility study the following alternative locations were studied and rejected:

- Region west of Larnaca (choice 1-west of Kamares, choice 2-south of Makarios III housing estate,
- Industrial region near the Kalo Chorio round about)
- Construction of new system that will be directed from south and east to north-west in order to be linked with the future sewerage treatment station of Aradippou.

According to the conclusions of MWH&I, the advantages from the extension are much more than those of constructing a new plant. The conclusions were summarised as follows:

- In the existing station there is enough available space for the phase B works extension.
- It is located far from residential regions or other growths
- There are cost savings when sewages from the two phases are processed in the same treatment station
- The general direction of flow is from higher regions in the northwest towards the coastal lower regions
- All the premises lie within the administrative boundaries of the Sewerage Board of Larnaca.

Negative of this choice was considered 1) the fact that it is found within the saltlakes and 2) that a long pipeline is required for the sewage transfer to the existing station.

According to the Environmental Impact Assessment (Chapter 5), placing of the treatment plant in the saltlake area creates certain dangers for the environment of the area. It is marked that beyond the impacts in the biological environment also exists the impact on landscape. Given the existing interventions in the area of the treatment works, the proposed extension of the airport and the continued growth in the tourist regions south of the treatment works, the south-eastern extents of the saltlakes have already been influenced to a large extent.

Nevertheless the proposed biogas unit, is an installation of bigger scale from the surrounding growths due to its great height and the optical intervention that will create will be serious.

Taking into consideration, that the treatment plant is already in place and working, it is considered that the additional dangers in the ecosystem of the Saltlakes and the optical intervention by the proposed extension are not such that would suggest the construction of a new plant in another location.

It should however be stressed that for the above conclusion the consultants took into serious consideration that no additional space will be occupied for the extension works. Undoubtetly, with the presence of the extension works there exists the danger to start thinking that the south-east extent of the saltlakes will be henceforth enough overloaded to justify the installation of also new work of infrastructure, something which should be avoided.

For the arrangement of the pumping stations the consultants had the choice to select exact locations in some of the pumping stations. The advantages of the proposed places are included in Chapter 5. The suggestions of the consultants for each pumping station site are presented below.

Pumping station PSBII - 1 (A1)

There are no substantial differences between the two alternative sites. The alternative site 2 is suggested (map 3.8) because it will create less intervention in the front view of the plot that borders on the road. In addition, it is proposed to adopt route Y for the first 300 metres of the piping in order to reduce the intervention in the coastal road.

Pumping station PSBII - 2 (Q1)

For this pumping station, the proposed site is site 2 (map 3.9), within the nursery of the Forest Department. In this site the pumping station will occupy planted space, which however is not used as open space of green. Selecting this option, the impacts in the nearby developments are avoided in the biggest possible degree.

Pumping station PSBII - 3 (J1)

The alternative site 2 (map 3.10) is proposed. With this choice the distance from the saltlakes path is increased and at the same time the pumping station optical intervention to the saltlake is reduced. In addition, more land can be used for the embellishment and landscaping of the site.

Pumping station PSBII - 4 (W1)

For this pumping station the Site 3 (map 3.11) is proposed. Site 1 has been excluded because it is located in a higher altitude than some of the residences, a fact that creates additional pumping requirements. Simultaneously, it will degrade the open view to the saltlakes from the developments north of the Faneromeni Avenue. The remainder two sites do not present any differentiations. Site 2 is located in a private plot and is visible from the residences opposite to this site. Site 3 is proposed, because even though is located in a protected area, it is located in a distance from the saltlakes and in this area dense vegetation prevails a fact that will render the pumping station not visible by the pedestrians.

Pumping station PSBII - 5 (Z1(Z2))

The pumping station is located in the area of the abandoned biological station (map 3.12). It Is estimated that the installation of the pumping station will improve the areasince it it will be accompanied by the demolition of the biological station that creates an ugly picture but also causes odor problems.

Pumping station PSBII - 6 (X1)

The site of the southest alternative is proposed for this pumping station because it is found on agricultural land (map 3.13). A hillock between the residences and this site decreases the optical intervention of the pumping station. The second site is found in a protection area.

Pumping station PSBII - 7 (Y1)

Site 1 is proposed. Site 2 has been excluded because it is located in a main street opposite Dianellio Technical School. Site 1 is found in a plot at the end of Terra Santa road in a one way road with very little traffic.

Pumping station PSBI -1 (V1)

There is no essential differentiation between the two alternative sites.

6.3. Wastewater and sludge treatment methods

The MWH&I study proposes as a treatment method the combination of primary sedimentation, following the aerobic treatment of the liquid waste and the anaerobic digestion of the sludge. Description of this treatment and its advantages is given in Chapter 4.

According to the European practice for acceptable sludge treatment methods and in combination with the economic and technical parameter analysis performed by MWH&I, the anaerobic sludge digestion is considered as the best method that can be used at the sewerage treatment station of Larnaca. Beyond the possibility of sludge use in agriculture the advantages of this method (combination of primary settlement, aerobic treatment of wastewater and anaerobic digestion of the sludge) is the reduction of the final sludge volume and the possibility of electric energy production from the biogas produced. The reservoirs for Phase B of the sewerage system were designed based on the estimated capacity of the project for the year 2040.

The main advantage of the biogas method for sludge treatment is the possibility of producing electricity from renewable sources of energy. According to the preliminary design of MWH&I the expected biogas production for year 2020 will be between 1296-2160 Nm3/ day. Beyond the fuel savings and the reduction of emissions to the atmosphere, the biogas installation will also contribute in meeting the Cyprus Republic goal for energy production from renewable sources, as this arises from Directive 2001/77/EK..

However, as it already has been reported, an important disadvantage of this method is the fact that the anaerobic digestion reservoir will have almost 30 metres height.

The Sewerage Board will have to preset the maximum permissible height so that the design engineers of the anaerobic reservoirs do not exceed this limit. For achieving this maximum permissible limit a partial immersion of the installations will have to be performed. For an estimate of the degree of immersion the following parameters should be considered:

- Maximum possible reduction of the optical intervention of the installations. The consultants appreciate that for a satisfactory reduction of such impacts the height of the installation should not exceed 15 metres. To reach this conclusion, they took into consideration the existing installations and the fact that at this height a satisfactory dissimulation can be achieved with the use of tall vegetation. Simultaneously however the consultants recognize that the technical problems and the additional investments that will result from a 15 meter immersion are rendering the realization of such measure not feasible

- The maximum height of the installations will have to be limited to the maximum limit the civil aviation will set. For this part of the study the civil aviation's evaluation of safety issues in air traffic is still pending. The opinion of the Civil Aviation is expected.

The immersion presupposes among other things the following important construction infrastructure:

- Excavation works for the construction of the under ground part and the continuous draining at the construction phase
- Proofing of the installation's under ground department
- Construction of retaining walls and base which will be able to bear the boyant forces caused by the marine water pressures.

Finally, because of the continuously increasing quality requirements imposed by the European union the consultants examined the possibility of use of membranes (membrane bioreactor - MBR) as a treatment method. The need for high quality levels in the treated water in combination with the need for increased levels of reliability can constitute a suitable for this case solution. In addition, the method has low space requirements and consequently there is the facility to install it in the existing area of the sewerage treatment works.

The method combines the treatment of activated sludge with a membrane separation process. The reactor functions similarly with the traditional sludge treatment. However, there are no final settling tanks. In replacement, the sludge passes from low pressure membranes that separate the sludge from water.

The membrane method can produce high quality treated water with high BOD rejection, nitrification and denitrification, TOC removal and total SS reduction. Because the separation is performed by the membrane and not the settling tank this method is operating at high suspended solids concentration MLSS.

For the safety of the membranes, 3 mm sieves can be used at the pretreatment stage. The membranes can function also without primary settling. This method has been installed in cases where:

- There is a need for high quality treated water
- High quality treated water is produced without the need for using tertiary filters
- 5-log reduction of coliforms

- There is not enough space available for the treatment station

A preliminary design for phase B was based on the following:

POPULATION	80,000
BOD/ head	90 g/ day
Peak Flow	24,000 m3/ day
NH3-N	47 mg/l
SS	400 mg/l

In case of extending the existing treatment, in combination with the method of membranes MBR, the existing oxygenation tanks will remain, while the final settlement tanks will be converted to anoxic zones and the membranes will be placed in a specially constructed membrane reservoir.

Aeration volume required
Volume of existing reservoirs = 2 * 3643 = 7286 m3
BOD load = 7200 kg/day

Based on the assumption that 10 kg/m3 MLSS enter in the membrane reservoir,
then the proportion F/M = 7200 /(7286 * 10) = 0.099 per day

Anoxic zone volume required
Volume of settling tanks = 2 * ((322*π)/4)*2,5 = 4020 m3

Total volume of reservoirs (aeration and settling) = 11,306 m3

If the final settling tanks are converted to anoxic zones, then
the proportion of anoxic zone = 4020/11306 = 36% which is an acceptable proportion.

The requirements in oxygen assuming 80% denitrification and a peak factor 1.3 have real requirements in oxygen (AOR) 17,000 kg/day.

This quantity of oxygen cannot be produced only from `ro'tors', because six ro'tors would be required for each reservoir (12 totally) which are too many for the available surface of the reservoirs. It is suggested that the two existing ro'tors in each reservoir remain and the quantity of oxygen that remains to be provided using fine bubble diffused aeration.

The quality of produced water with the method of membranes MBR is so high that could be immediately directed to the irrigation system. Consequently the use of sand filters will be limited only to the cases where there is big demand for processed water and more water will be needed to be pumped from the storage reservoirs.
There is plenty of space in the existing station for the construction of the membrane reservoir. At the detailed design stage the hydraulic characteristics of the system can be determined.

6.3.1 Treated Sludge Management

When the sludge will be used in agriculture the plant requirements in N and P should be checked, as well as their limits at the other components of the sludge, such as heavy metals. Consequently a careful selection of plants should be conducted together with the Department of Agriculture.

However, the sludge disposal is prohibited in cases where the concentration in one or more heavy metals

Table 6.1 Limit values of heavy metals concentration in soil

(mg/kg dry matter of representative soil sample with pH 6 to 7)

Parameters	Limit Values
Cadmium	**1-3**
Copper	**50-140**
Nickel	**30-75**
Lead	**50-300**
Zinc	**150-300**
Mercury	**1-1,5**
Chromium	**-----**

The determination of the maximum quantities of sludge, expressed in tons of dry matter that can be disposed in soil per surface area per year, compying with the concentration limit values for heavy metals in sludge are determined in regulation 517/2002 (see table 6.2).

Table 6.2 Limit values for heavy metals concentration for sludge used in agriculture (mg/kg dry matter)

Parameters	Limit values
Cadmium	20-40
Copper	1000-1750
Nickel	300-400
Lead	750-1200
Zinc	2500-4000
Mercury	16-25
Chromium	-----

The compliance with the limit values of heavy metal quantities that are added to the soil per surface area per year should be complied according to the values listed in Regulation 517/2002 (see Table 6.3).

Table 6.3 Limit values for heavy metals concentrations that can be disposed in cultivated fields per year according to an average of 10 years (kg/ha/year)

Parameters	Limit values
Cadmium	0,15
Copper	12
Nickel	3
Lead	15
Zinc	30
Mercury	0,1
Chromium	-----

According to the current practice the following will continue to be followed:

- Before disposing the sludge to the fields as fertilizer, operators from the Environment Service together with operators from the Department of Agriculture and the Sewerage Board of Larnaca, visit the fields in order to give their approval.
- The sludge is transferred in closed trucks in order not to drip water during the transfer in the roads and is also covered with plastic on top.
- The outside of the trucks are washed and cleaned before they leave the factory. The sludge is spread in the fields with a special sludge distributor of the Department of Agriculture and as soon

as the sludge is spread the tractor ploughs immediately the field in order to mix the sludge with earth.

- After the end of the works the jetting vehicle of the Larnaca Sewerage Board goes to the field and washes and disinfects all the instruments that took part in the works.

6.3.2 Treated Water Management

The management of the treated water is under the jurisdiction of the Water Development Department and does not concern the present study. It is considered deliberate to report certain measures which also concern the Sewerage Board.

According to the ' Control of Pollution of Waters Law 2002 (L..106 (I)/2002) the maximum permissible limits in the qualitative characteristics of the treated sewages for disposal in dams and ponds are presented in Table 6.4.

Table 6.4 Maximum permissible limits in the quality characteristics of the treated water for rejection in dams and ponds

Parameter	Units	Limits
BOD 5	mg/l	10
Suspended Solids (SS)	mg/l	10
Conductivity	μS/cm	2000
Total Nitrogen	mg/l	15
Fats and grease	mg/l	5
Faecal Coliforms	/100 ml	5
Residual Chlorine	mg/l	2
Aluminum	mg/l	5
Arsenic	mg/l	0,1
Berillium	mg/l	0,1
Boron	mg/l	0,75
Cobalt	mg/l	0,05
Copper	mg/l	0,2
Iron	mg/l	5

Parameter	Units	Limits
Lead	mg/l	5
Lithium	mg/l	2,5
Manganese	mg/l	0,2
Molybdenum	mg/l	0,01
Nickel	mg/l	0,2
Selenium	mg/l	0,02
Vanadium	mg/l	0,1
Zinc	mg/l	2
Mercury	mg/l	0,005
Chromium (III)	mg/l	0,1
Cadmium	mg/l	0,01

Optimisation measures for the management of the processed water are:

- Early arrangements should be made in order to find additional users for the phase B treated water. It is noted that the salinity of Phase B is expected to drop.
- The additional storage reservoirs that will be required should be constructed in an area except the saltlake area. The Water Development Department is already conducting studies for selecting the right position for the storage reservoirs.

6.4. Habitat protection measures

As it was mentioned before, the excavation works and construction of the pumping stations at the areas that are close to the saltlake's boundaries (PSBII-3 (J1), PSBII-4 (W1)) will probably cause small scale interventions in this appreciable dwellings.

For the reduction of these type of interventions the following are proposed:

- the worksites and the storage of material areas should be outside the limits of the saltlake's biotope

- fencing and configuration of worksites and material storage areas, for avoiding leakages and easy removal of resulting rubble so that the probability of leaching to the ecosystem of the Saltlake and potential sedimentation or other negative impact on the physiology or the productivity of plants of system is avoided.

For the installation of the pipelines in the area the possibility of utilisation of methods of underground installation (no-dig technology) has been studied. Even if this method will eliminate the impacts to the ecosystem, it is considered that the impacts from the construction are not such that will necessitate this additional investment cost which is preliminarily estimated in 500 Cyprus pounds per metre.

For the protection of the saltlakes at the construction phase the contractor should organise the worksites and roads of truck circulation so that the minimal possible intervention is ensured. Areas of storage of materials or equipment inside the limits of the biotope of the saltlake will not be permitted. Proposed worksites and storage sites are presented in Section 5.2.7. In addition all rubble and other useless materials should be removed immediately without any temporary storage in the works area. With the end of the works the affected area should be restored. For this reason the Fisheries and Forest Department should be asked to get involved.

The storage reservoirs are not part of the present study and consequently no measures for reducing the dangers from potential underground leakages have been evaluated. Nevertheless it should be reported that for securing the prevention of leakages of the processed water during operation, it would be important that all essential arrangements are conducted for the disposal of water.

6.5. Mitigation measures for the negative impacts on the landscape

The project area has been separated in two landscape categories based on the existing growth and the characteristics of the bas-relief and the natural landscape that surrounds the pumping stations and the treatment works.

In the central regions of Larnaca it exists or it is forecasted to exist in the near future important residential and commercial growth which determines the character of the landscape. In this category it is included the bigger part of the Phase B area. On the contrary in the regions surrounding the Saltlakes the aesthetics is determined by the open optical fields and the view of Saltlakes and least by the urban

growth. In this category they are included the treatment works and the pumping stations PSBII-3 (J1), PSBII-4 (W1) and PSBII-6 (X1).

For the proposed pumping stations it is suggested that the guiding lines below are followed:

- The appearance of the building should be upgraded with the adoption of modern frugal line and high aesthetic structural materials. In the central urban regions concrete of type fairface can be used and painted metal for the doors and ventilations. For further improvement of the concrete appearance decorative patterns can be used, as the creation of voids in the concrete which are filled with color. In the remainder regions, the To'hni Stone can be used and painted metal. For further improvement of the walls' appearance decorative patterns or drawings can be used.
- All the extents that will not be planted it is proposed to be covered with pavings.
- The fencing is proposed to be made of a low wall (up to 1m) and then metal bars.
- The planting should be used for the beautification and not the dissimulation of space. For this goal it is proposed the thin planting of trees which will be supplemented with low vegetation.

For the beautification of the pumping stations that are found in the saltlake boundaries and the sewage treatment station plants listed in the left column of the following table are proposed. For the beautification of the city pumping stations the plants proposed are listed on the right column of the table. Alternatively, citrus fruits and other plants can be used, that characterize the wider region of Larnaca.

Pumping stations at the saltlake boundaries	Pumping stations in the city of Larnaca
Pistacia lentiscus	*Deliciosa*
Pistacia terebinthus	*Citrus paradise*
Juniperous phoenicea	*Ceratonia siliqua*
Quercus spp	*Cercis siliquastrum*
Rosmarinus officinalis	*Olea Europaea*
Nerium oleander	*Cupressus sempervirens*
	Pistacia atlantica

It is noted that the above constitute a preliminary proposal of governing lines which aims mainly to promote the possibility of improvement of the pumping stations appearance. For optimisation of the design the design engineers of the detailed design of phase B should assign the design of the pumping station and landscaping of the treatment works area to an architect. For the factory it is considered that they cannot be proposed measures that would decrease considerably the impacts in the nearby area. The high vegetation however can decrease the sense of volume the station occupies and improve the station's view from the nearby regions. Taking into consideration the rows of Pine and cypress trees that are present in the Meneou region, it is proposed that this type of trees are planted in the perimeter of the factory.

6.6. Odours

According to the proposed project design a series of measures for odour prevention in the collection grid are suggested (Chapter 5). These measures are considered satisfactory for odour control. It should be noted here that one of the measures is planning of the connection works so that the period at which decreased flows exist in the pipelines, and in particular the long pipelines is reduced. Consequently the Board is supposed to plan in advance so that the contractor commits himself for the preparation and execution of a suitable work program.

There is a biological filter installed at the sewage inlet of the treatment works which has constituted a satisfactory odour solution at the treatment works entrance. The same practice is expected to be continued in Phase B. There is a short description of the method below.

The filter is a cylindrical tank installed on a cement base next to the inlet chamber. Air and odours are transferred to the biofilter's base and after it passes through a peat layer is released to the atmosphere. A water drainage pipe removes the additional water from the biofilter's peat media, and moreover the 100mm U-turn, prevents unrefined air to be released outside. After the peat layer is sprayed with water remains wet because of the high humidity of the air that passes through the biofilter.
In spite of this an irrigation system above the peat layer is installed in order to provide additional humidity since it is very important that the peat is maintained under humid conditions in order to ensure the microbial operation and biofilter effectiveness. Moreover, water is added in the peat for pH control. The

irrigation system is placed in operation periodically using a solenoid valve at water entrance which is checked electronically with a timer.

The following components are added to the peat according to the manufacturer's instructions:

- Microbial inoculum: A suspension of microbial inoculum that contains specific chemical decomposers is added to the filter bed. The microbial inoculum will shorten the adaptation period after start up and will increase the biofilter performance.
- Neutralising materials: The oxidation of reduced sulfur compounds results in the formation of sulfuric acid. If this accumulates in the filter bed, the pH of the materials will decrease to a level which is unsuitable for microbial activity. The acid is neutralized by calcium carbonate. Calcium carbonate in the form of flour and chippings is added to the biofilter materials during instatllation for the purpose of maintaining a constant pH during operation of the biofilter.
- Nutrients: Supplementary nutrients Nitrogen, Phosphorus and Potassium are added to the biofilter materials during the bed filling stage, to enhance the growth of microorganisms.

6.7. Mitigation measures during construction

6.7.1 Worksite organization and construction activities

For reducing the impacts to the environment and the neighbours, the following measures of organization and worksite management as well as construction acitivities management are proposed:

- The contractor shall inform in time the influenced residents for the works schedule, potential nuisances, diversions and cutting off of streets. It is proposed that one person will be in charge for the briefing of the people in influenced areas and the handling of complaints or suggestions.
- The places of temporary storage of materials should be proposed by the contractor and be approved by the Sewerage Board. For reducing the duration of nuisances in each region of work it is proposed that places for the storage of materials exist in every 500m where this is possible. These places will be suitably shaped, litted up and signaled and will be restored with the end of works in the region they serve. In paragraph 5.2.7 empty plots that have been located by the consultants are indicated.
- As a general principle it is proposed that where alternative detours exist the roads are completely closed during the works since this way the works can be accelerated. These decisions however depend exclusively in the jurisdiction of the police

- At the works area there shouldn't be any temporary deposition of rubble since this practice creates problems from the increased dust, the escape of materials in roads and private plots and the potential omission of restoring of areas after the end of the works. Exception constitute the excavation materials that will be used later for embankments
- The drainage pumps create noise pollution. For the reduction of noise it is proposed the installation of noise insulating materials. A potential solution constitute the manufacturing of metal encapsulators.
- The contractor should propose suitable area for the rubble deposition. In the study area no suitable areas have been located.

According to Regulation D.I. 134/97, there should be a safety committee according to the following table.

Table 6.6 Number of safety representatives needed according to employee number.

Number of Employees	Number of Safety Representatives
5-9	1
10-19	2
20-49	3
Every 50 additional	1

For the employees' safety and health, the employer is obliged according to the Department of Labor Inspection Guide to estimate the dangers in the work areas, as it is reported in Regulation D.I. 173/2002. For the reduction of dangers, there are prevention measures reported in the legislation on the following sources of danger:

1. Work Equipment (D.I. 444/2001)
2. Noise (D.I. 230/2002)
3. Control of Atmosphere and Dangerous Substances in Factories (D.I. 166/81)
4. Machines in Factories (L.25/89)

The dangerous parts of any machinery, that are used or constitute part of equipment in a factory, should be protected except, in the case they are not safe for the employees.

For the obliteration of danger, there are protection measures according to the existing legislation:

1. Work equipment (D.I. 444/2001)

Bumpers and protection systems of work equipment can eliminate the danger. Also the lifting equipment should be provided with the suitable means and systems.

2. Means of Individual Protection (D.I. 315/2003)

The means of individual protection that are used by the employees should fill the basic requirements of health and safety, as:

- Design principles (ergonomy, levels and orders of protection)
- Absence of danger (suitable materials of manufacture, satisfactory state of the surface of each part of the MIP that come in contact with the user, maximum allowed restrictions for the user)
- Comfort and performance (adaptation of the MIP according to the user's morphology, light and durable manufacture, compatibility of various orders MIP that are designed for simultaneous use)
- Information provided by the manufacturer
- The manufacturer should comply with the above requirements and ensure an EC declaration of conformity and certificate of testing of EC type.

3. Machines in Factories (L.25/89)

Safety equipment, which impedes the exposition of danger in that part of the machine which is in motion, or stops immediately the machine in case of danger, is allowed to be used by law.

Beyond the above mentioned protection measures of health and safety, there are some individual necessities for the working places at worksites, that should be filled according to legislation (D.I. 172/2002). The minimum general requirements in this case are:

- The materials, and generally any element that can put in danger the safety and health of people, it should be stabilised accordingly and in a secure way
- Roads and exits of danger should remain unblocked and lead shortly to a safety area.
- Depending on the worksite characteristics, there should be sufficient firefighting means and if needed fire detectors and fire alarm systems

- The clean air supply should be forecasted in sufficient quantities
- People should not be exposed to damaging noise levels at work and in exterior damaging effects
- The sash doors should have a safety system that will prevent their derailment and fall
- The roads should be constructed for easy use, with complete safety
- The surface area of the working place should be calculated in such a way that sufficient freedom in personnel movements exists, taking care the existing equipment and material.
- The area and the raw materials as well as the information of the local first aid have to be pointed out
- Provided that the employees are obliged to wear special clothes of work, suitable locker rooms should be available
- The employees should have neat the work places, dedicated areas provided with enough number of lavatories and toilets or even showers, provided that it is imposed by the type of work or for reasons of hygiene
- Employees should have access to rest areas or lodgings
- The area and perimeter of the worksite should have obvious labelling and fencing. According to Regulation D.I. 173/2002, the employer is obliged to take all the essential measures for first aid and fire safety, as well as for working accidents and dangerous incidents and to inform the employees. Some of these measures are reported below.

6.8. Measures for handling dangerous incidents

- Sewerage diversion at the sewerage treatment works

For handling the need for diverting sewage there is an emergency reservoir at the treatment station for accepting temporary diversions. The reservoir can accept one day's peak summer flows.

- Measures in case of pumping station damages

For preventing sewage leakages in case of pump failures the following have already been implemented:

- All the pumping stations will be equipped with 1-2 backup pumps
- A telemetry system already exists for giving early warning signals in cases of damage and/ or failure. There is available personnel for the immediate response in case of damage
- The pumping stations will have a backup generator for cases of electricity failures.

- Double system of initializing pump operation (1 ultra sonic and 1 float switch)
- Fire detectors and automatic firefighting system.

It has been observed in Phase A that all damages can be restored within one hour. For the collection of the sewages in such a case, it is proposed to design an overflow reservoir at each pumping station or to be considered at the wet well design.

- Measures in case of fire

In case of fire, the treatment works has worked out an action plan. The plan prescribes a concentration area and also distributes responsibilities to personnel, that are summarized below:

- Team A, which is in charge for firefighting, with the use of fire extinguishers, which their use is supposed to be known by all personnel
- Team B, which undertakes the following:
    1. Notifies the fire brigade.
    2. Shuts down the computers.
    3. If needed, calls an ambulance.
    4. It confirms that the building is empty and that all workers are found in the concentration area, except of Team A.
    5. Removes oxygen/acetylene outside the laboratory.
    6. It isolates the gas bottle in the kitchen
- Support Team, which offers help in the above teams and what other needed, as individuals are substituted in the teams. Also they confirm the visitor's safety and that they are also found in the concentration area
- Stretcher bearers team, which is gathered in the concentration area with the drugstore and a car, in order to provide first aids and, in case of serious wound, they notify the first aids of the general hospital.

For the above teams there are individuals in charge of each team, while for team A also exists a team assistant. The persons in charge of each team should verify the safety of employees. In case of danger, the general coordinator should be informed.

- Measures in case of chlorine leakage

In case of chlorine leakage, the employees are grouped in teams and each team should know the individuals in their team and have the following responsibilities:

- Team A, which is trained on isolating the chlorine leakage using suitable equipment
- Team B, which is in charge:
  1. Notify the ambulance and if needed the ambulance.
  2. A person of the team stays at the entrance of the treatment works in order to inform the fire brigade upon its arrival.
  3. Ensure the personnel, except team A, is gathered in the concentration area and guides them in to a safe from chlorine gas, depending on the direction of wind.
- Stretcher bearers team, with responsibilities similar as in the case of fire.

Each team has a responsible person in charge, who should make sure that all employees are safe. Also there is a person assigned for the coordination of the teams.

Κεφάλαιο

7

7. Monitoring System

7.1 Operation

- Water and Soil Quality Around the Seweage Treatment Station

According to article 8 of the water framework directive, 2000/60/EC, for monitoring of the surface, ground waters and protected regions, the member states ensure the preparation of programs for monitoring of the water's state, so that a cohesive and complete picture of the water's state exist. For the protected areas, the programs are supplemented with the specifications that are contained in the community legislation with which the individual protected regions (treaty Ramsar) have been selected.

The above-mentioned monitoring should comply with the requirements of annex V. The Water Development Department and the Fisheries Department are the main responsible departments for the monitoring of the saltlakes.

Moreover, the water and soil quality close to the sewerage treatment station should be monitored regularly so that any leakages from the sewage treatment station or the secondary treated storage reservoirs are detected. The proposed action is to take soil samples from three locations and in the case of the area west of the reservoirs that borders with the saltlakes, to take water samples also, every 3 months. The three locations near the sewage treatment station are:

1. the area west of the sewage treatment station
2. the area south east of the storage reservoirs of the secondary treated water
3. the area west of the storage reservoirs of the secondary treated water (saltlake)

In the indicative list of the main pollutants in Annex VIII of the Water Framework Directive, are included substances that contribute in the eutrophication (mainly nitrates and phosphates) and substances that influence unfavourably the oxygen balance of oxygen (and can be measured using parameters as BOD, COD etc)

The parameters proposed to be checked are pH, conductivity, nitrogen, phosphorus, BOD5 and total coliforms.

- Odors

For minimizing the danger of odor releases, activated carbon filters have been installed in all phase A pumping stations, with very good results. The same filters will also be installed in all phase B pumping stations. The life of the activated carbon depends on the concentration of odorous compounds. The activated carbon's state can be checked by taking samples from two points located at the side of the filter.
At the treatment station a biofilter has been installed next to the phase A inlet chamber which also functions with very good results and it is proposed that the biofilter operation is continued for phase B of the sewerage system. The operation of the biofilter is checked by checking the biofilter's pH.

- Sludge quality prior its use for agricultural purposes.

The sludge should be analyzed every 6 months. In case there is a change in the quality of urban sewages the frequency of analyses should be adapted accordingly. If the results of analyses are almost the same for one year, the sludge can be analyzed every 12 months. The analyses performed should check the following parameters:

  - Dry matter
  - pH
  - Nitrogen, phosphorus
  - Cadmium, coper, nickel, lead, zinc, mercury, chromium

- Water quality before sent to irrigation

The quality limits of tertiary treated water that will be used in agriculture as defined by the Water Development Department are presented in table 6.5.

Table 6.5 Quality Limits as defined by the Water Development Department

Parameter	Unit	Limits
BOD 5	mg/l	<10
COD	mg/l	<25
Suspended Solids	mg/l	<10
Nitrogen in NH3	mg/l	<3
Nitrate	mg/l	<3
Conductivity	mS/cm	<2,0
pH		7.0-8.0
Total Chlorine	mg/l	<1.5
Free Chlorine	mg/l	0.5-1.5
Sodium	mg/l	<150
Chlorides	mg/l	<800
Boron	mg/l	0.75
Nitrogen Total	mg/l	<5
Phosporus	mg/l	<3
Micobiological		
Total Coliforms	Counts/100ml	<500
Faecal Coliforms	Counts/100ml	<100
Heavy Metals		
Cadmium	mg/l	0.01
Copper	mg/l	0.2
Nickel	mg/l	0.2
Lead	mg/l	5.0
Zinc	mg/l	2.0
Mercury	mg/l	0.005
Chromium	mg/l	0.1

In table 7.1 the heavy metals concentration limits for tertiary treated water intended for use in agriculture are:

Table 7.1

Limits of Heavy Metals Concentration in Recycled Water Used for Irrigation

Metal	Concentration (mg/l)
Aluminum	5,0
Arsenic	0,1
Beryllium	0,1
Bromine	0,75
Cadmium	0,01
Chromium (III)	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

To calculate the total concentration of heavy metals use the following formula:

$C_{M1} / L_{M1} + C_{M2} / L_{M2} + \ldots\ldots\ldots + C_{ML} / L_{ML} \leq 1$

Where C_M = heavy metal concentration

L_M = admissible limit of heavy metal concentration

The values should not be exceeded for 75% of the measurements performed per year.

In Table 7.2, the limits and tests for toxicity levels of the tertiary treated water intended for irrigation are presented:

Table 7.2

Limits and Tests for Toxicity Levels in Recycled Water Intended for Irrigation Use.

TEST	IRRIGATION[3]
Acute Toxicity 1. Microtox: Photobacterium phosphoreum organism (Vibrio fischeri). 2. Algatox 72 hours: Selenastru capricornulum organism. 3. Daphtox: Daphnia magna Straus organism	Applicable only for 1, 2, 3
Mutatox GENOTOXICITY with or without S9 hepatic enzyme activation. Photobacterium phosphoreum Organism (Vibrio fischeri). **Accepted Limits** The results and limits are given in toxic units TU[4]	Applicable only for 1, 2, 3. 75% of samples should have the following acute toxicity limits: Microtox Daphnia & Algae TU50<1 Mulatox The processed waste should not be positive on direct activation or after S9 Mulatox test.

7.2 Construction

It is suggested that during construction the following items should be checked under the contractors responsibility.

- Implementation of worksite management measures

[3] Acute toxicity control is performed twice per year while the genotoxicity control once per year. If the wastewater is not a) toxic and b) its use does not affect the environment, then the toxicity control can be limited accordingly.

[4] *TU50, TU20: means toxic units with 50% and 20% influence upon the tested organism or biological activity.*

The contractor should assign a responsible individual for the conformity of works follow-up with the measures for environmental protection and the organisation of worksite that is proposed in Capital 6.

- Public reactions

It is proposed to have a responsible individual for briefing of public with regard to the constructional activities and the recept of complaints or other comments. For any comments the responsible engineer of the Sewerages Board should be informed.

- Dust

The dust should be recorded periodically, particularly if complaints exist. The measurements will concern inhalable dust and should be based on the existing legislation. In case of increased levels of dust and complaints for dust, actions for reducing the impacts should be taken, such as as watering of the ground

- Noise

The noise should be recorded at regular intervals outside the residences nearest to the works. The measurements will be 24-hours and will concern the Laden, LAnight values. The measurements will be performed according to the provisions of the law. In case of increased levels of noise, measures of noise reduction should be adopted, particularly for the drainage pumps.

Annex 1: New pumping station Nomenclature

MWH&I nomenclature	LSDB nomenclature
PS BI – 1	V_1
PS BII – 1	A_1
PS BII – 2	Q_1
PS BII – 3	J_1
PS BII – 4	W_1
PS BII – 5	$Z_1(Z_2)$
PS BII – 6	X_1
PS BII – 7	Y_1

Annex 2: Maps

3.1 Phase B areas

3.2 Urban Zones map (1: 25000)

3.3 Land Use map (1: 25000)

3.4 Geological map for area BIII

3.5 Geological map for area BI

3.6 Geological map for areas BII and BIV

3.7 Sewerage Piping System

3.8 Cadastral map PSBII-1

3.9 Cadastral map PSBII-2

3.10 Cadastral map PSBII-3

3.11 Cadastral map PSBII-4

3.12 Cadastral map PSBII-5

3.13 Cadastral map PSBII-6

3.14 Cadastral map PSBII-7

4.1 Phase A Sewerage System

4.2 Phase B Sewerage System

4.3 Phase B Sewerage Watermains Obstructions

4.4 Sewerage Piping System Nodes

Annex 3: Borehole logs

Borehole ID on the Geological Maps	Borehole ID at Borehole Logs
BH1	EG 33/90
BH2	EG 38/84
BH3	EG 32/90
BH4	EG 50,61,83,86/96
BH5	EG 17/84
BH6	EG 88,89/96
BH7	EG 72/97
BH8	EG 58,68/96
BH9	EG 15/85
BH10	EG 74/76
BH11	EG 57/76
BH12	EG 23/80
BH13	EB 114
BH14	EG 36/78
BH15	EB 116
BH16	EG 22/85

Annex 4: Typical Pumping Stations

Annex 5: Noise Pollution, Explanatory Notes

***See* BS 5228:84**

Annex 6: Atmospheric Pollution, Explanatory Notes

- **Hydrogen Sulfide**

Hydrogen sulfide is formed by the biochemical reactions in the liquid sewages and is released to the environment. The concentration in the gas phase depends on the concentration of the liquid phase and ambient conditions. At non-toxic levels, hydrogen sulfide has the characteristic odor of rotten eggs. At acute toxic levels, hydrogen sulfide paralyses an individual's ability to detect its odor and looses consciousness. Hydrogen sulfide is also flammable at concentrations which exceed by far the toxic levels (Lower explosive limit 4.35%, Upper explosive limit 46%).

- **Ammonia**

Ammonia has a characteristic, strong odor that renders it detectable before its concentration reaches toxic levels. Exposure to high levels of ammonia can cause eye and mucous membrane irritation. It is very rare to reach toxic levels of ammonia from biochemical reactions in domestic sewages, only.

- **Methane**

Methane in sewage systems is produced from biochemical reactions in organic compounds. Methane does not have a characteristic odor that will render it traceable, is extremely flammable, has a wide explosive range and a low flash point.These characteristics result in a substantial fire and explosion hazard. Usually its concentration is below the lower explosive limit and at that concentration range will only decrease the available oxygen concentration one percent for every five percent methane.

Methane can add to the explosive vapors that may be present from other flammable and explosive chemicals that have been discharged to the system. The presence of elevated of nitrogen and carbon dioxide may alter the flammability limits of methane. Methane also reacts spontaneously with some oxidizers.

- **Carbon Dioxide**

Carbon dioxide is the natural product of respiration, oncluding that from microbial activity, and is harmful due to the consumption and displacement of oxygen that accompanies its generation.

- **NOx (Nitrogen Oxides)**

Nitrogen monoxide and dioxide (NO, NO_2) is formed due to traffic. Their concentration near roads follows the same patterns with the traffic. The NO formed is soon transformed into NO2 (Life cycle ≈ 2 λεπτά). Near the source of NO low ozone levels are reported. As NO is transferred by the wind, it is transformed into NO_2, having retained one molecule of oxygen from the atmospheric oxygen O_2 (O_2 + NO = NO_2 + O-), that is binding with another O_2 molecule forming one molecule of ozone. Consequently, at some distance from the NO source elevated levels of ozone are detected.

- **SO_2 (Sulfur Dioxide)**

Sulfur Dioxide is formed mainly from industries that use carbon fuels. It has a half-life approximately 4 hours and after its release is converted to sulfuric acid that causes the acid rain. The traffic is considered a small source of SO_2, due to the low concentration of S in fuels.

- **CO (Carbon Monoxide)**

Carbon monoxide is formed by incomplete combustions. The larger source of CO are the motor vehicles. Due to the fast conversion of CO to CO_2 , CO has a completely local character. A major source of CO emissions is caused by the traffic on busy roads, especially under conditions of low vehicle speeds or traffic jams.

- **Suspended Particles**

Small size of matter in solid, liquid or mixed form in the atmosphere. Major source of suspended particles is the wind blown dust. Major man-made sources of emission come from excavation works, mineral processing industries, power stations, diesel vehicles as well as the use of earth roads. The suspended particles are measured as total (TSP), inhalable (PM10) and PM2.5. The legislation concerns the PM10 parameter.

Quality Targets for the Atmosphere

The concentration limits for the atmospheric air quality of Cyprus, as set in the Legilsation of Cyprus, as well as the direction followed by the World Health Organisation (W.H.O) are listed in Table 1 that follows.

Table 1: Atmospheric Air Quality Limits

POLLUTANTS		CYPRUS	W.H.O
Nitrogen Dioxide (NO_2)	Annual Mean Value	40	150
	1-h Mean Value	200	400
Ozone (O_3)	8-h Mean Value	110	100-120
	1-h Mean Value	180	150-200
Carbon Monoxide (CO)	8-h Mean Value	10000	10000
Sulfur Dioxide (SO_2)	24-h Mean Value	125	125
	1-h Mean Value	350	350
Inhalable Particulate Matter (PM10)	24-h Mean Value	50	-
Lead (Pb)	Annual Mean Value	0.5	-

Note: All values are in μg/m3 at 293K temperature and 101.3 kPa pressure.