2. SUMMARY OF FINDINGS

This section of the report presents the findings of the environmental impact study. There follows a presentation of the impacts and proposed mitigation methods for the impacts on the man-made, biological and physical environment. The final section of this chapter sets out the conclusions and recommendations of the Planning Consultants regarding the possibility and method of implementing the Project, taking into account environmental criteria.

2.1. MAN-MADE ENVIRONMENT

2.1.1 Impact on urban planning zones

During construction, the building of new roadways and the compulsory purchases which it entails will have a direct impact on urban planning zones. The affected zones are laid out in Table 2.1.

TABLE 2.1 : Extent of coverage in the area surveyed

Section	Urban Planning Zones	Extent covered in metres*
A	Κα8	625
	Βα4-ΒΕ3	450
	Κα5	500
	Τ3β	500
B	Γα2	1000
	Κα8	375
	Γα5	1425
	Βδ5	875
	Βα4	375
	Ββ2 Κα5	875 625
	Αα4	250
C	Εβ6 Εβ	100 100
	Κα7	800
	Κα5	800

* the extent of coverage in each urban planning zone is the covered length on either side of the roadway

A detailed description of the urban planning zones and their characteristics is given in Annexe D.

2.1.2 Impact on Land Values

Privately owned land will be affected in the section of the Project where a new roadway will be built (section B). This negative impact will be dealt with by paying owners the necessary compensation. This will be carried out within the framework of the relevant legislation.

At the same time, however, plans for the roadway are expected to cause initial mobility in the market and may, in the short term, have a positive effect on prices in residential areas in the region as a whole.

2.1.3 Impact on irrigated and agricultural land

According the regional plan of Limassol, part of section B consists of areas of intensive agriculture. Furthermore, there is an irrigation network in the area, part of the Germasogeia-Polemidia Irrigation Scheme, which will be affected and will therefore have to be replaced.

The bore-holes located along the planned road (Map 5 – ANNEXE B) are at a safe distance and are thus not affected by the construction works.

2.1.4 Impact from Noise Generation

2.1.4.1 Impact during Construction

Noise levels at the construction site are estimated to be 84dB at a distance of 10m from the source. At 30m this level drops to 74dB, at 75m to 66.5dB, at 100m to 64dB, at 200m to 58dB and at 250m to 56dB.

Bearing in mind that the nearest individual residences and organised residential areas are 1m away from the proposed road, it is evident that there will be a significant environmental impact.

Table 2.2, which follows, summarizes the expected noise levels resulting from the construction works at the frontages of the houses nearest the Works, at distances of 1 to 40 metres between the machinery and the houses. At the frontages of residences located more than 40 metres away from the proposed roadway, according to our estimates the noise level will not surpass the 72dB level which has been set as a criterion for this study.

Table 2.2 : Expected noise levels caused by the construction works at the facades of buildings neighbouring the works

Description	Noise Level (dB)
Machinery to receptor distance up to 5 metres	93
Machinery to receptor distance up to 10 metres	84
Machinery to receptor distance up to 20 metres	79
Machinery to receptor distance up to 30 metres	74
Machinery to receptor distance up to 40 metres	72

It is anticipated that a school will be built at the 12.4 kilometre mark, 10 metres from the proposed roadway. As previously mentioned, schools belong to the “sensitive” category of receptors to which special criteria for acceptable noise levels are applied. This study has adopted criteria of 57 dB during the day and 47 dB at night. Based on the previous predictions, at the construction stage the noise level in the school grounds will reach 84 dB, which is greater than the adopted criterion.

Mitigation Measures

For the protection of the individuals concerned from increased noise levels, ear defenders (protective covers) must be used. Also, silencers could be installed on the machinery so as to reduce noise emissions.

Additionally, some of the recommendations referred to in British Standard BS5228:84 could be implemented in order to create an environment in which construction site noise can be controlled. Some of those points are:

- Good relations between those carrying out the work and those who live near the site, explaining the duration of the Project and how and when various stages of the Project will be carried out, and keeping to the works schedule. This entails taking complaints seriously, and taking measures if necessary. If the contractor follows a policy which shows understanding towards those with a complaint, then they will be more tolerant.
- Noise levels at sensitive sites (schools, homes) should be monitored with sound level meters to pre-empt complaints.
- The contractor should train its workers to follow 'good engineering practice'.

I. Avoid making unnecessary noise
II. Avoid locating machinery inappropriately (in relation to the neighbours)

III. Noise barriers should be used around noisy machinery
IV. Silencers, where they exist, should be used
V. Faulty equipment etc. should be reported

Further to the above, in the case of residences located very close to the road and where there will be severe opposition from the residents, the contractor should employ noise barriers (even if only of limited height) around the noisiest machinery, which will mitigate the impact. Furthermore, the prescribed "quiet hours" must be observed at sites which border the residences.

Comment [Dave Bind1]: In Cyprus and Greece, 'quiet hours' are when noisy activities in residential areas are not permitted during the lunchtime siesta period, nor during the evening and at night.

Finally, however, it should be stressed that the impact from noise will have a limited duration and will only last through the working day (from 07:00 to 17:00 at most).

2.1.4.2 Noise from heavy plant machinery carrying raw materials and excavated materials

The construction works will also have an impact on the road network and districts surrounding the works. Based on the estimated long-distance movement of raw materials and excavation waste lorries along a specified route (via Omonias Ave.) and on the total number of journeys expected during the construction period, at an average speed of 30km/h, maximum peak hourly workload equivalent to twenty journeys of 15km, we have arrived at a combined traffic level for the three peak hours on Omonias Ave. as shown in Table 2.3, which follows:

Table 2.3 : Increased (peak hour) noise levels on Omonias Ave. caused by the link road construction works

Distance (metres)	1st Peak Hour (07:15 -08:15)		2nd Peak Hour (13:00-14:00)		3rd Peak Hour (16:30-17:30)	
	Current situation	Construction works	Current situation	Construction works	Current situation	Construction works
1	76.0	76.6	77.7	78.1	74.8	75.5
5	71.0	71.6	72.7	73.1	69.8	70.5
10	67.9	68.5	69.6	70	66 7	67.4
20	63.3	63.9	65.1	65.4	62.1	62.8
30	60.9	61.5	62.6	63	59.7	60.4
40	59.3	59.9	61.0	61.4	58.1	58.8
50	58.1	58.7	59.8	60.2	56.9	57.6
70	56.3	56.9	58.1	58.4	55.1	55.8
100	54.5	55.1	56.2	56.6	53.3	54.0
150	52.3	52.9	54.0	54.4	51.1	51.8
200	50.6	51.2	52.4	52.7	49.4	50.1
250	49.3	49.9	51.1	51.4	48.1	48.8
300	46.1	48.7	49.9	50.2	46.9	47.6
350	47.1	47.7	48.9	49.2	45.9	46 6

These estimates show that the increased noise levels on Omonias Ave. caused by the movement of heavy vehicles transporting raw materials will not be significant, since noise levels on Omonias Ave. are already high due to the transportation of goods to and from Limassol Port.

2.1.4.3 Impact during operation

In assessing the environmental impacts expected from the operation of the highway, the 1 hour LAeq parameter was used, with relevant estimates for 2007, 2012, 2017, 2022 and 2027.

Those estimates result in the following findings:

For all receptors located more than 10 metres away, the anticipated noise level will be less than the 65 dB limit along the entire length of the road and throughout the time-scale of the study, i.e. from 2007 to 2027. For distances below 10 metres (there are dwellings less than 10 metres away) the anticipated noise level reaches 70 dB which, when noise-reduction is taken into account, is close to the 65 dB limit. Despite that, given the uncertainty regarding estimated future traffic volumes and the fact that the road will be used by heavy lorries, details of appropriate measures to limit the impact are given in Chapter 9.

The construction of the road, aside from the aforementioned negative impacts on the areas which line its route, will have a positive impact on the nearby road network because it will reduce its traffic noticeably. The most significant positive impact is expected to be on Omonias Ave., with the easing of heavy vehicle congestion to and from Limassol Port. Based on current details of peak-hour traffic volumes and the number of lorries travelling to and from Limassol Port during those hours, the change in noise levels on Omonias Ave. has been estimated as follows in Table 2.4:

Table 2.4 Estimation of Noise Levels on Omonias Ave. after completion of the project

Distance (metres)	**1st Peak Hour (07:15-08:15)**		**2nd Peak Hour (13:00-14:00)**		**3rd Peak Hour (16:30-17:30)**	
	Current situation	During construction	Current situation	During construction	Current situation	During construction
5	71.0	66.4	72.7	68.7	69.8	67.4
10	67.9	63.3	69.6	65.6	66.7	64.3
20	63.3	58.7	65.1	61.1	62.1	59.8
30	60.9	56.3	62.6	58.6	59.7	57.3
40	59.3	54.7	61.0	57.0	58.1	55.7
50	58.1	53.5	59.8	55.8	56.9	54.5
100	54.5	51.7	56.2	54.1	53.3	52.8
200	50.6	49.9	52.4	52.2	49.4	50.9
250	49.3	47.7	51.1	50.0	48.1	48.7
300	48.1	46.0	49.9	48.4	46.9	47.1
350	47.1	44.7	48.9	47.0	45.9	45.8

Evaluating the nuisance level in the residential areas neighbouring the road, the following conclusions have been reached:

- The construction of the link road will improve traffic conditions on the neighbouring road network (chiefly on Omonias Ave.) significantly reducing current noise levels (Table 2.4). In any case, Omonias Ave. experiences high noise levels at peak hours.
- As far as the basic LAeq noise level at 10 metres from the boundary is concerned, it is estimated that the 65 dB limit will not be surpassed in any of the three sections throughout the time-scale of the study (2007-2027)
- There are a number of residences along the length of the roadway at various distances from its axis. Furthermore, construction of a school near the northern part of the road is planned (position SCH, map 5b, ANNEXE B). The anticipated noise level in those locations (Map 5, ANNEXE B) is given in Table 2.5, which follows:

Table 2.5 : Assessment of Noise Levels in Residentially Developed areas near the Works

Site	Description	2007	2012	2017	2022	2027
a	Homes/ 20 metres	65.2	66	66.7	67.3	67.9
b	Home / 20 metres	65.2	66	66.7	67.3	67.9
c	Homes /10 -20 metres	65.2	66	667	67.3	67.9
d	Homes / 50 metres	54.1	54.8	55.7	56.3	57
e	Homes /100 metres	49.5	50.3	51.1	51.8	52.5
f	Homes / 80 metres	50	50.8	51.7	52.3	53
g	Homes/10-15 metres	62.9	63.7	64.6	65.2	65.9
h	Home / 30 metres	56.3	57.1	58.2	58.6	59.3
i	Home / 80 metres	50	50.8	51.7	52.3	53
j	Homes /10 metres	62.9	63 7	64.6	65.2	65.9
k	Homes / 5 metres	66	66.8	67.7	68.3	69
l	Homes / 50 metres	51.1	51.5	52.4	53	53.6
m	Home / 5 metres	64	64.4	65.2	65.9	66.5
SCH	10 metres	62.9	63.7	64 6	65.2	65 9

In all cases, at some stage the noise level will be greater than the 65 dB limit (prevention of stress, headaches and increased blood pressure etc.). Despite the fact that these values will actually be lower thanks to the drastic reduction in noise levels through the use of sound-absorbing materials between the source and the receptor (soil, vegetation, parapet walls etc.), measures to reduce the noise to acceptable levels must be planned for. Relevant references and recommendations are given in Chapter 9.

Based on the previous results, it is clear that the noise created when the new road is operating will have a significant environmental impact on the few areas of residential development in the study area. Despite this, by taking appropriate management measures the impact can be dealt with to a satisfactory degree.

In contrast, the construction and operation of the project will reduce noise levels in the neighbouring road network and residential urban fabric which already exists, which constitutes a positive environmental impact. Noise levels are already high in these areas and residential development has already taken shape in such a way that any proposed interventions for reducing impact from noise will be difficult to implement.

Mitigation Measures

Measures which could be taken to reduce noise-pollution include:

- **The use of suitable planting (artificial planting)**

The use of suitable planting can significantly reduce noise-pollution. The noise level reduction depends on the planting (type and arrangement) and its distance from the highway. The relative noise reduction achieved using this method can be as much as 10 dB(A) (Plan 9.1 and 9.2)

- **The use of a low-noise (porous) road surface**

The type of road surface has a significant effect on noise levels which, of course, also depends on other factors such as speed, wetness/dryness of the surface, the frequency of the sound source etc. Porous road surfaces reduce noise by 3 – 7 dB(A) depending on void content. Use of a road surface of this type presupposes that its specifications meet the requirements of the Public Works Department.

- **Construction of noise barriers**

These constitute the normal noise reduction measure. Their cross section and the material they are made from affects the degree of noise reduction which is achieved.

Adopting a 3.0 metre high noise barrier at a distance of 5 metres from the median line of the nearest lane as a solution, noise levels at the aforementioned "problematic" sites are altered as follows in Table 2.6.

Table 2.6. Noise levels dB(A) with and without noise barriers

SITE	DESCRIPTION	2007		2012		2017		2022		2027	
		WITH	W/OUT	WITH	W/OUT	WITH	W/OUT	WITH	W/OUT	WITH	W/OUT
a	Homes / 20 m	**54.7**	65.2	**55.5**	66	**56.8**	66.7	**57.8**	67.3	**57.4**	67.9
b	Home / 20 m	**54.7**	65.2	**55.5**	66	**56.8**	66.7	**57.8**	67.3	**58.4**	67.9
c	Homes / 20m	**54.7**	65.2	**55.5**	66	**56.8**	66.7	**57.8**	67.3	**58.4**	67.9
g	Homes / 15 m	**53.9**	62.9	**54.7**	63.7	**55.6**	64.6	**56.2**	65.2	**56.9**	65.9
h	Home / 30 metres	**47.3**	56.3	**48.1**	57.1	**49.2**	58.2	**49.6**	58.6	**50.3**	59.3
j	Homes / 10 m	**53.9**	62.9	**54.7**	63.7	**55.6**	64.6	**56.2**	65.2	**56.9**	65.9
k	Homes / 5 m	**53.5**	66	**54.3**	66.8	**55.2**	67.7	**55.8**	68.3	**56.5**	69
m	Home / 5 m	**51.5**	64	**51.9**	64.4	**52.7**	65.2	**53.4**	65.9	**54**	66.5
SCH	10 m	**53.9**	62.9	**54.7**	63.7	**55.6**	64.6	**56.2**	65.2	**56.9**	65.9

The achieved levels fulfil the adopted 65 dB criterion. Any slight deviations from this limit are not considered significant, taking into account the influence that the existing vegetation and the technical details of the road have on the level of noise-reduction, which has not been taken into account in the calculations.

The selected noise barriers, apart from having the technical properties which they need in order to achieve the necessary noise reduction, must also satisfy fundamental aesthetic principles, something which is very often not taken into account at the selection stage.

Some principles for the selection of the form of noise barrier are:

- The noise barriers should help the drivers determine their course
- The designs used must be in keeping with their surroundings for reasons of history, culture, or the natural environment.
- The selected noise barriers should highlight and safeguard the environment.

Additionally, in particular for the school which is to be built at the 12.4 km mark, measures to reduce the impact of noise should be adopted, the main ones being:

- Use of double-glazing on windows and doors
- Locating the building (classrooms) as far as possible away from the road axis (locating the school-yard near the road)

2.1.5 Impact on archaeological remains

Based on information received from the Department of Antiquities the are no archaeological remains at all in the area, therefore there is not expected to be any impact. However, should anything be discovered in the course of the construction work, then the matter will be handled by the Director of the Department of Antiquities.

2.1.6 Impact on access

Access problems are expected during the construction works, mainly at the points where the proposed roadway intersects the main arterial roads (Franklin Roosevelt and the Paphos Road) but also some approaches to the Ypsonas Industrial Area.

Specifically, problems are expected at the following points:

- 8.8 km mark Junction construction (port perimeter road with the proposed roadway)
- 9.5 km mark The proposed roadway intersects A. Tasou Ave.
- 10.0 km mark Junction at the intersection with Franklin Roosevelt Ave.
- 10.7 km mark The proposed roadway intersects a rural lane
- 11.1 km mark Junction. The proposed roadway intersects the approach to the Industrial Area.
- 12.8 km mark Junction. The proposed roadway intersects Paphos Road.

In order to help local residents and people travelling through the area, provisions will have to be made for the construction of auxiliary roads for the duration of the construction works

It is important to stress that these impacts are temporary since the inconvenience will come to an end with the completion of the construction works.

2.1.7 Impact on traffic

An increase in local traffic is anticipated during construction of the proposed road. A significant increase is expected on Omonias Ave. which runs alongside and which, according to the traffic study which has been conducted, will bear the full weight of the changes in traffic patterns during the construction stage.

The impact on traffic due to the construction works comes from two distinct sources:

From the movement of heavy vehicles transporting materials to the construction site and from construction equipment.

- From the diversion of the current traffic load on sections of the existing perpendicular/vertical road onto the neighbouring road network, and especially onto Omonias Ave..

It should be taken into account that the local road network serves the port of Limassol and, therefore, it already bears the weight of heavy lorries transporting goods to and from the port.

A significant increase in heavy vehicle traffic will be observed at peak hours. This increase, although very small (~1.5%) compared to the total traffic (vehicles of all types), is expected to affect smooth traffic circulation since the construction site vehicles will be slow because they will be carrying construction materials.

Road safety

The anticipated number of accidents on the road in question depends on both the level of traffic and the design of the road itself and of its links to the neighbouring road network.

International experience has shown that urban roads with a central reservation and controlled approach roads represent a definite improvement to the road network and have a positive effect on the reduction of accidents. A relevant study conducted overseas found that the construction of a central reservation between opposing streams of traffic reduces both the number and the severity of accidents. Experience in Greece shows that when an arterial road has a 3 metre central reservation, the reduction in the number of cars which cross the reservation is of the order of 40%. Comparable results are expected for the project being studied. Modern road lighting will be installed along the entire length of the proposed road, which will contribute to road safety conditions.

Furthermore, a similar improvement in safety conditions is expected to be observed on the existing road network as a result of the anticipated reduction in traffic volumes, especially that of heavy lorries. Based on the results of the traffic study's forecasts, at peak periods about 65% of the heavy vehicles which now use Omonias Ave. will use the new road, while at other times that figure will be about 50%. It is estimated that this decrease will bring about a reduction in accidents of 25%. (Source: **"Feasibility Study for the Construction of Link Road Between Limassol Port and Limassol-Paphos M/Way"**).

2.1.8 Impact on infrastructure projects

Some infrastructure projects are expected to be affected during the course of construction works.

Those projects are as follows:

Electricity Authority of Cyprus (E.A.C.)

- Intersection of existing high- and low-voltage underground cables at the 8.8 km mark, 10.0 km mark, 12.6 km mark and the 12.8 km mark.
- Existing high- and low-voltage above-ground lines at the 10.45 km mark, 10.9 km mark, and the 11.9 km mark.
- Existing 132kV cables at the 12.8 ken mark.

The precise locations and routes of the cables and lines are shown in Map 5 – ANNEXE B

Information regarding the management plan which will be developed by the E.A.C. Is not available at this stage of the study, because the Department for Public Works has not made construction plans available to the E.A.C..

Cyprus Telecommunications Authority (CYTA)

The existing underground network could be affected at the following points:

- Underground cable along the length of Franklin Roosevelt Ave. at the 10.0 km mark
- Underground cable along the length of Paphos Road at the 12.8 km mark

At the current stage of the study it is not possible to determine how much the CYTA network will be affected due to a lack of construction plans.

Sewerage Board of Limassol- Amathus (SBLA)

- Make provisions for laying stormwater and wastewater pipelines in accordance with the SBLA's Master Plan.
- Extension of the wastewater network to integrate it into the project's area of study

Water Development Department (WDD)

- The bore-holes mentioned in paragraph 4.1.6 and in Table D3 of Annexe D are not affected.
- Replacement of the irrigation network of the Germasogeia-Polemidia Irrigation Scheme wherever it may be affected.

The precise points at which replacements will be carried out will be determined by the WDD when they have the construction plans.

Water Board of Limassol (WBL)

- The existing network mentioned in paragraph 4.1.6 will be replaced with a new one wherever it is affected because relocating it is not cost-effective.
- Laying pipes along two pavements.

At this stage in the study it is not possible to indicate the precise points at which replacements will be made, as this must be preceded by a study by the WBL after they get the construction plans from the Department for Public Works.

Industrial Waste Processing Unit (IWPU)

- Part of the IWPU drainage basin is covered by the proposed road (Photograph 8 – Annexe C)
- The IWPU's processed waste will be piped into the SBLA's network.

2.1.9 Impact on the biological environment

Impact on ecosystems

The project is not expected to cause a significant negative impact on the area's ecosystems since the natural areas affected are very limited. Essentially the project will result in the covering or degradation of areas which are already man-made or disturbed and are of no special ecological value.

Impact on flora

No particular negative impact on flora is expected, either. The impact will be on populations of several species (which abound on disturbed ground or in man-made areas) which will be destroyed. It should be remembered that one of these species is endemic to Cyprus and that two are, according to books on the subject, quite rare. However, the severity of this impact is mitigated by the fact that these species are common in several areas of Cyprus, in much greater numbers and in much more natural conditions. Thus, if the work is carried out, despite the fact populations of several plants will be reduced, there is not expected to be any threat to the presence of any species in Cyprus.

Impact on fauna

It is expected that most animal species will move to similar neighbouring habitats when the road is being opened up, whilst the reptiles and amphibians in the area will be directly affected during the construction works. Also, there is expected to be a direct effect on birds which – according to a survey that was carried out – nest in the area under study, chiefly in the citrus orchards.

Mitigation Measures

During construction of the new road, particular care must be taken so that the aquatic habitat of the Limassol Salt Lake, located at the southern end of the road, is not disturbed in any way. When the road has been completed, trees should be planted on both sides of the road so as to prevent birds from being hit by on-coming vehicles. Relevant recommendations are set out in Chapter 9.

The trees should reach a height of at least 4m so that birds are forced to fly above the level of the traffic.

It is recommended that local species of plants should be used for landscaping bare areas created during the works. As well as the fact that these plants are better suited to this particular environment and their water requirements are low to negligible, planting them will also contribute to maintaining the natural character of the area. It is recommended that those in charge of the project should get in contact with the Forestry Department to investigate which local species could be obtained from the Forestry Nurseries and utilized in landscaping the area. The plants shown in Table 9.2 could cover a broad range of requirements in terms of appearance and cover. Most of these plants can be supplied by the Forestry Department.

Avoid using acacia (Acacia saligna) which has been utilized in the past along the sides of motorways and which has shown itself to be one of the most "aggressive" naturalized species in Cyprus. It appears that the acacia can spread easily into wild areas from areas where it has been planted, taking over and completely spoiling the character of natural ecosystems (Christodoulou 2003).

2.2 IMPACT ON THE PHYSICAL ENVIRONMENT

2.2.1 Impact on air quality

2.2.1.1 During construction

The impact on air quality during construction of the project is caused by emission of dust during earth-moving work, emissions from material production plant equipment (asphalt plant) if they are not permanent installations far from the work site, and emissions from the vehicles used during construction. The main characteristic of this impact is its temporary nature. The impact will only be felt during the construction phase and the consequences are reversible.

Earth-moving work

Emissions released as a result of the earth-moving work are related to ground-clearance, excavation, tunnelling, cut and fill work, piling up and using the aggregates (soil, sand etc.) needed during construction of the project, and the movement of construction equipment around the construction site and on dirt auxiliary roads and temporary access roads which will be made and used solely for the purposes of the project.

Dust emissions vary greatly from day to day and depend on the expanse on which the work is taking place, the pace of the construction work, the type of work and the prevailing weather conditions.

The estimated amount of dust emitted by the construction works is:

e_1=108 tonnes / month (or 145 kg/hour of continuous activity)

The corresponding emissions from the piling up and storage of materials (soil, sand etc.) at the construction site amounts to:

e_2= 100 Kg/day

Mitigation measures

Measures which can be taken to reduce the emission of dust into the atmosphere include:

- The passage of lorries, especially through residential areas, should happen with the lorries covered.
- The site where excavated materials are stored should be far from inhabited areas
- Areas where rubble and excavated materials are to be collected should be damped down so as to avoid releasing dust into the atmosphere as far as possible.

Emissions from construction vehicles

Emissions from construction vehicles stem from the release of dust as they move around the construction site and the dirt auxiliary roads, and from gaseous pollutants from their motors (diesel engines).

Based on the composition of the construction site as shown in **Table 6.3**, the amount released because of the movement of construction vehicles around the site and on the auxiliary and adjacent dirt roads is estimated to be:

e_3=24 kg/kilometre/day

The expected emissions of gaseous pollutants are very low and, consequently, the impact on the area's air quality will also be very low.

2.2.1.2 During operation

The assessment of air quality during the operational phase of the project is based exclusively on the influence of road traffic. The emissions concerned are CO, NOx, HC, PM and SO_2

The assessment of the air quality in the vicinity of the project was carried out using the USA Environmental Protection Agency's HIWAY2 mathematical model.

Expected concentrations in the air in the vicinity of the project are well below the air quality limits set by Cypriot Legislation.

Taking into account that the calculation of the concentrations was carried out for the most adverse weather conditions (a very stable atmospheric state, mixing layer height 100m) during which the pollutants remain trapped near the ground, it is evident that a deterioration of air quality is not expected and, therefore, based on the results of the HIWAY2 mathematical model, the operation of the link road will not have any significant impact on the area's air quality.

Table 2.7 Estimated maximum concentrations (μg/m^3)

YEAR	POLLUTANT	CONCENTRATION	QUALITY LIMIT[1]
2007	NO_X	139.3	400
	HC	15.4	___
	CO	225.2	30000
	SO_2	13	250
2027	NO_X	169.6	400
	HC	26.6	__
	CO	450.45	30000
	SO_2	20.8	250

2.2.2 Impact on Hydrology and Hydrogeology

2.2.2.1 During construction

Hydrogeology

The impact on water resources in the vicinity of the works is expected to be caused chiefly by liquid and solid waste.

The liquid waste created during construction is expected to be:

- Wastewater from the temporary sanitary facilities provided for the workers at the construction sites.
- Surface run-off which may wash away pollutants such as engine oils, hydrocarbons, dust and other chemical substances caused by the construction equipment, the excavated materials, and the road construction materials.
- Surface run-off (caused by rain) washes away material found on the ground between the 10.8 and 11.8 km marks, where there used to be extensive and uncontrolled dumping of rubbish and of household and industrial waste of unknown qualities and level of pollution.
- Wastewater from draining the improvised tank (11.1 km mark) where effluent from the industrial waste processing unit on the nearby industrial estate is stored.
- Brackish groundwater; the water table is near the surface, and it is likely that it will have to be

pumped out in order to build foundations.

The types of solid waste during the construction stage can be divided into:

- Excavated materials
- Plastic and other items discarded by the workers
- Surplus construction materials such as concrete, iron and asphalt.

Measures to protect groundwater include:

- Cleaning up engine oil and other toxic substances
- Avoiding the use of chemicals to suppress the dust caused by the movement of vehicles on dirt roads.
- Drafting an Emergency Action Plan for dealing with accidents involving vehicles carrying toxic substances.
- Protecting any bore-holes which may be covered by the road to prevent pollutants from entering the groundwater directly, duly informing the relevant Department.
- Locating sanitary facilities suitably

- Before commencing any embankment or excavation work, topsoil should be removed and stored for re-use during re-vegetation work. There are red-brown soils along the entire route of the project; however, in the section between the 10.9 and 11.8 km marks (Vounari tou Zakakiou / Zakaki Hill), the havara (limestone) and sandstone quarries, and other areas where there has been human interference, these soils are limited. South of the 10.0 km mark (the junction with Franklin Roosevelt Ave.) salt concentrations in the soil should be checked before it is reused, since the groundwater in the area is brackish because of seawater intrusion and because the water table is very close to the surface.
- The soil should, preferably, be kept near the sites of the excavation and embankment works, to be used in re-vegetation work.
- Avoid making lots of site access roads.
- Avoid discarding engine oils and other pollutants in areas bordering the works.
- Avoid spraying the dirt roads with chemical substances to suppress dust.
- Avoid, or significantly limit, putting rubble and construction materials on areas with good topsoil.

Hydrology

In summary, the impact of the construction work on the hydrology of the area is likely to be:

- Temporary and reversible disruption of the natural drainage network because of excavation/embankment work.
- Pollution of surface and ground water by pollutants brought to the surface by excavation and other earth-moving work.
- Pollution of surface and ground water by used engine-oils, fuel and other chemical substances which may be used during construction.
- The creation of stagnant water.
- The section of the road between the 10.8 and 11.8 km marks is characterised by abandoned lime sandstone pits and a variety of waste that has been dumped in them. This waste is of industrial origin, waste materials, rubble from demolished buildings, household liquid and solid waste, effluent, and waste from the neighbouring industrial units' biological wastewater processing plant (stored in a provisional tank). Also, west of the 11.6 km mark, just 80 metres away, there is the “Askarel” landfill site as well as scrap-iron yards.

The whole area neighbouring the section between the 10.8 and 11.8 km marks should be suspected of being severely polluted.

Given the situation it is vital that, in this area, the following measures be taken to avoid spreading the pollution with a negative impact on hydrology, soil and the air.

- Before work commences, representative samples of the soil, rubble and effluent from the waste tank should be taken. The aim is to conduct the required chemical analysis to determine the present scale of pollution, and to create a database (background values) for future monitoring.
- Based on the results of the above-mentioned analysis, the way that the rubbish and wastewater will be disposed of will be determined in line with current legislation.
- A study should be carried out into the landscaping that is needed in the wider area between the 10.8 and 11.8 km marks, in order to design and bring about a controlled way to remove stormwater in a way which avoids transporting pollutants out of the area (to the south and north).
- A study should be carried out into the need to construct concrete-lined stormwater channels so that there is no outflow of water from polluted land, especially towards the south where any pollutants could end up in the Akrotiri aquifer and in Akrotiri lake.

Particular attention is recommended in the 11.7 to 11.8 km area which neighbours the Askarel landfill site, and we emphasize that every effort should be made to avoid disturbing it.

For the remainder of the road's route, the following should be implemented:

- Replacement of the area's natural drainage system wherever it is disrupted by the excavation and embankment works.
- Careful siting of unwanted excavated material so that it doesn't cut off or disrupt major watercourses.
- Where major watercourses intersect with embankments, drainage pipes must be designed appropriately taking into account not just the amount of surface flow, but also other facts such as the disruption to the hydrological system from changes in the direction of natural flows, changes to the network's gradient caused by the construction work, and increased erosion and sediment load in the surrounding area.
- Avoid constructing embankments across major natural drainage routes.
- Correct design of artificial drainage systems so as to reduce changes to surface flows to a minimum, and so that they are adapted to suit the wider natural drainage system.
- Protect areas which receive water from the artificial drainage from erosion and sedimentation, by:
  - having an increased number of drainage pipes with an increased drainage capacity
  - careful siting of pipe outlets to avoid creating waterfalls
  - protecting surfaces which receive water with a layer of concrete or stones
  - using sediment collection pools before the water is channelled into the natural drainage system.
- Avoid polluting surface water with oil or other pollutants by clearing them up carefully, and by implementing measures to protect against any possible spillage of the pollutants at the work sites.

2.2.2.2 During operation

When the project is operational, some waste will be created as a result of vehicle movement, road maintenance work, and the effects of the weather on the slopes of the embankments and cuttings. The impact on geology is expected to be insignificant; the impact on the soil, however, is expected to be somewhat more significant because these pollutants will be carried via the road drainage system or in the air.

The impact will mainly consist of the following:

- Fall of debris from the slopes, and the need to clear it up
- Disruption of the natural drainage system with consequent increased erosion and the deposition of some of the eroded material onto the area's soil, leading to a deterioration in the quality thereof.
- A build-up in the soil bordering the road of various pollutants from vehicles (lead, organic compounds, zinc, cadmium, toxic substances) and from clearing the road shoulders (insecticides, pesticides)

Impact on Hydrology and Hydrogeology

When the project is operational, some pollutants will start to build up as a result of vehicle movement, road maintenance work, and the effects of the weather on the slopes of the embankments and cuttings. These pollutants may be transported via the roads drainage system either into the surface water at Akrotiri lake and into the sea, or into the groundwater of the aquifers in the area. They include, mainly:

- Lead, mainly from petrol. With the use of unleaded petrol, lead concentrations will drop significantly.
- Organic compounds such as oil products, lubricants and asphalt which can release polyaromatic hydrocarbons.
- Zinc and cadmium from galvanized parts of cars
- Various toxic substances which may be being transported by vehicles involved in accidents
- Insecticides / pesticides which may be used for clearing the road shoulders.
- Material eroded from the slopes of the embankments and cuttings. The existence of pollutants such as PCBs, engine oils and heavy metals in the soil in the central section of the works makes this an even more negative factor.

Concentrations of most of the aforementioned pollutants are not expected to be at levels which would constitute a risk to the quality of surface and ground water. The impact is expected to be more acute, although short-term and localized, during rainstorms, periods of drought or after an accident involving a vehicle transporting hazardous substances (a possibility which, though highly unlikely, is nevertheless real).

2.2.3 Impact on the soil

2.2.3.1 During construction

Impact on the soil

Impact on the soil during the construction work will mostly be due to loss of soil because it has been moved or covered by other materials, as well as pollution from liquid and solid waste.

Soil loss

- Soil loss along the entire length of the road because of excavation and embankment work. This loss is not reversible, nor can it be avoided.
- Soil loss from the construction of auxiliary access roads.
- Deterioration of soil quality because of vehicle movement. This impact is reversible.
- Soil loss where materials for the embankments are quarried, and where unsuitable materials are placed.

Liquid Waste

Some of the liquid waste – whether spilled directly (such as engine oil) or carried away by surface water – ends up in the soil, causing its quality to deteriorate. The concentration of pollutants is greatest at the edge of the road and on the soil surface; it decreases significantly with depth.

Solid Waste

Solid waste is, for the most part, rubble from excavation work which is not suitable for use in embankments;

and it is likely to be put in a temporary location before it is disposed of permanently. One such material is marl which will come from the excavation between the 11.54 and 11.72 km marks.

Solid waste could also come from road construction materials, some of which may be washed away by surface water or remain in the soil after use. Mixing solid waste with the soil spoils its natural state and usually leads to a deterioration in its quality.

2.2.3.2 During operation

When the project is operational, some waste will begin to be produced as a result of vehicle movement, road maintenance work, and the effects of the weather on the slopes of the embankments and cuttings. The impact on geology is expected to be insignificant; the impact on the soil, however, is expected to be somewhat more significant because these pollutants will be carried via the road drainage system or in the air.

This impact consists mainly of the following:

- Fall of debris from the slopes, and the need to clear it up
- Disruption of the natural drainage system with consequent increased erosion and the deposition of some of the eroded material onto the area's soil, thus making its quality deteriorate.
- A build-up in the soil bordering the road of various pollutants from vehicles (lead, organic compounds, zinc, cadmium, toxic substances) and from clearing the road shoulders (insecticides, herbicides).

Mitigation measures

The proposed measures to mitigate the impact include:

- Before commencing any embankment or excavation work, topsoil should be removed and stored for re-use during re-vegetation work. There is soil along the entire route, the depth and consistency of which varies from place to place, depending on the nature of the underlying bedrock.
- The soil should, preferably, be kept near the sites of the excavation and embankment works, to be used in re-vegetation work.
- Avoid making lots of site access roads.
- Avoid discarding engine oils and other pollutants in areas bordering the works.
- Avoid spraying the dirt roads with chemical substances to suppress dust.
- Avoid, or significantly limit, putting rubble and construction materials on areas with good topsoil.

2.2.4 Impact on topography and geomorphology

2.2.4.1 Topography

The relief in the vicinity of the project is gentle and is characterized by extensive level surfaces with a slight gradient towards the south-southeast, that is to say towards Akrotiri Bay. These surfaces constitute part of the marine shelf of the coastal region of Limassol which has emerged from the sea in the recent geological past, and which the elements have not changed from its initial form in any notable way.

The only interruption to the view is provided by the low hill, elongated in a north-south direction, called Vounari tou Zakakiou (Zakaki Hill) which occupies the central section of the project (10.9 to 10.8 km mark). The top of the hill is almost flat (trapezoidal) and appears to be part of an older marine shelf. This hill is the most significant land-form in the area.

The excavations and embankments along the road are of limited length and depth/height and, although they are permanent and irreversible, they are not considered to spoil the natural topographical features – and, by extension, the nature of the landscape – to any significant degree.

The excavation between the 11.54 and 11.72 km marks, with a maximum depth of 2.5 metres, is not expected to have any other impacts (such as landslides or areas of increased erosion) because of its relatively shallow depth and also because of the nature of the rocks.

The temporary location of rubble in some places is not expected to have any impacts, such as erosion and sediment deposition, because of the gentle gradient of the ground.

There are absolutely no important landforms which could be affected in the area.

In conclusion, the impacts on the topography during the construction phase are limited, and basically include:

- A slight incompatibility of the slopes of the cuttings and embankments with the topography
- Disruption to some topographical features from the temporary siting of rubble and other material.

Mitigation measures

The main measures to avoid or minimize impact on the topography are:

- Distribution of the excavated materials which are unsuitable for making embankments but which are suitable for other uses. This can minimize the problems caused by the disposal of large quantities of unsuitable materials. There are materials belonging to this category along the length of the section between the 11.54 and 11.72 km marks (Pliocene marls estimated at 15000m^3). The said materials may be placed in temporary sites or transported directly away from the site of excavation.
- Creation of an artificial drainage system adapted to the main natural drainage routes. Channelling large quantities of water though small-diameter sewers should be avoided, and the formation of stagnant water should be prevented.
- Construction of sediment traps to avoid conveying large quantities of sediment into the natural drainage system.
- Immediate planting of slopes and piled earth with shrubs and trees, as soon as waste disposal and landscaping is complete.

2.2.4.2 Borrow pits

It is estimated that the majority of the volume of materials (calculated to be in the order of 400,000m^3) required for embankments on this section of the road will need to brought in from outside, since the volume from excavation work will be very limited and most of that material will be unsuitable for reuse in embankments.

Supply from borrow sources is expected to come from either the Perekklisia quarries where diabase is mined, or from the Polemidia quarries where sandstone rocks are mined from the Pachna Formation.

In summary, the impact from the use of borrow pits located outside the area of the section in question are expected to be:

- Loss of vegetation and soil at the excavation sites
- Changes to the topography
- Disruption of the natural drainage system with an increase in erosion and sedimentation.
- Air pollution from the creation of dust and exhaust gases, both at the quarrying sites and from the movement of vehicles transporting the materials via rural or main roads.
- Nuisance from the quarrying work and the cargo vehicles
- Degradation of the landscape's aesthetic value

Mitigation measures

A. Measures during the quarrying process

Measures which should be taken during the quarrying works include the following:

- Correct planning of the development of the quarry sites so as to avoid unnecessary movement of materials, and sensible use of the embankment materials in the previously defined area.
- Quarry sites should be surveyed in advance to determine their size, the amount they will be able to quarry and the quality of the material.
- An artificial drainage system should be put in place so as to avoid increased erosion and transportation of sediment load into environmentally sensitive areas. The system should make provisions for collecting water around the perimeter to prevent large quantities from entering the quarried area, drainage via a suitable number of sewers, and avoiding channelling disproportionately large quantities through sewers with a limited drainage capacity.
- Systematic spraying of the dirt access roads to the quarry to avoid dust problems in agricultural and residential areas.
- Storage of topsoil for subsequent use in site restoration work.

B. Measures for restoration of the quarry sites

These measures include the following:

- Putting unusable material that was excavated during construction into the hollow left by the quarrying work, whenever practical (proximity of the quarry sites to the Project's excavation sites). By successively quarrying material for the embankments and filling the void with rubble from the site excavations, the quantity of unusable materials that will have to be disposed of in landfill sites will be dramatically reduced.
- Landscaping of the quarry sites in a way which is in keeping with the natural surroundings. The restoration should be carried out in a way that doesn't leave exposed faces higher than 4 meters or slopes with an overall gradient greater than 40 degrees.
- Initially using species of plants which grow quickly and have low water requirements when replanting the re-landscaped slopes and bare surfaces.

At a later stage, once the slopes have been stabilized and protected from erosion, saplings of species that grow in the area of the quarry may be planted.

2.2.4.3 Removal of rubble

The geological and geotechnical studies have assessed a large proportion of the excavated material to be unsuitable for use in the embankments.

Specifically, the red-brown topsoil whose depth (in the 8.7 to 10.8 km mark section) varies from 0.5-3.0 metres is unsuitable for embankments; it is, however, suitable for use as soil for plants and could be stored temporarily and used in the final landscaping of the project. Topsoil of similar quality is found in the 10.8 to 12.9 km section of the road, but it is of limited depth (of the order of 20 centimetres).

The volume of excavated material from the 10.8 to 11.8 km section could be considered to be suitable for embankments in part (the calcareous sandstone, wherever it is encountered) whilst the marl is unusable due to its clay-like properties. It should, however, be noted that because of the extent and variety of spoil dumped along this section of road by earlier quarries, and other pollutants deposited in the form of liquid waste, all layers of the section (rubble, sandstone and marl) are suspect and potentially dangerous due to human activity.

Removal of the red-brown topsoil, even for temporary storage, will have the following possible impacts on the environment:

- Change of the topography and geometry where it is placed
- Some disturbance of the natural drainage system

- Loss of vegetation and soil in the storage areas
- Creation of stagnant water
- Creation of dust and exhaust emissions from the movement of vehicles to the dumping sites
- Deterioration of the aesthetic value of the dumping grounds

It should be noted and stressed that, if quantities of excavated material from the 10.8 – 11.8 km section (which are considered to be partially or completely polluted because of earlier waste-dumping in the area) are dumped, the impacts on the environment will be worse than those referred to above for the red-brown soils. Any uncontrolled dumping of already polluted soils would give rise to serious risks and severe repercussions on the dumping sites.

Mitigation measures

The main measures which could be implemented to minimize the environmental impact on the areas where unusable materials are dumped are the following:

- The piles of unusable material should be arranged in such a way that they are no more than 4 metres high and 8 metres wide, and the slopes are no more than 40 degrees.
- The slopes created should not cut perpendicularly across existing features such as watercourses, ridges and watersheds. The landscaping should follow and be in line with the layout of the landscape.
- Avoid dumping the material in areas which have steep gradients.
- Construct an artificial drainage system adapted to the main natural drainage courses, to avoid channelling large volumes of water through small-diameter sewers and to prevent the formation of stagnant water.
- Construction of sediment collection tanks to avoid conveying large quantities of sediment into the natural drainage system.
- Immediate replanting of the slopes and bare surfaces of the heaps.

Stabilizing the slopes quickly will prevent the phenomenon of “pirate” drainage which would eventually destabilize the heaps and cause large quantities of the material to move to lower levels.

A measure which should be studied seriously is the utilization of the materials which are unsuitable for use in the embankments, but suitable for other uses. This could minimize the problems created by the dumping of large quantities of unsuitable materials. As mentioned/recommended elsewhere, some or all of the excavated material could be used for landscaping the area of abandoned quarries in the area neighbouring the 10.8 to 11.8 km section, within the framework of a properly studied Landscape Plan for the wider area.

2.2.4.4 Surplus Construction Materials

An exact calculation of the amount of spoil resulting from unused construction materials is difficult, as it depends on the execution plan for each individual construction process, the method employed by each group in carrying out the work, and unforeseeable factors which cannot be precisely defined at this stage. Based on experience from similar projects, it is estimated that the unused materials will not exceed 2-3% of the total volume of concrete and reinforcements.

The Contractor must dispose of this spoil in accordance with the guidelines and rules of the relevant laws regarding the disposal of construction and other materials. The Contractor could, as long as it is within the framework of the legislation and has the approval of the Chief Engineer, propose controlled ways to dispose of this material in the area of abandoned quarries in the area neighbouring the 10.8 to 11.8 km section, as part of a landscaping design for the wider area.

2.2.4.5 Important Landforms

There are no important landforms in the area of the project, and no measures need to be taken.

2.2.5 Impact on the natural landscape - aesthetics

The technical characteristics of this urban road are favourable to a reduced impact on aesthetics, on the one hand because the longest unbroken stretch of traffic flow does not exceed 700 metres (11.8 to 11.1 km marks) and, on the other hand, because its course does not feature any sharp bends.

Mitigation Measures

Essential elements for dealing with the impact on the landscape are the road's alignment with the area's landscape features and the correct use of planting.

Having trees or shrubs by roads not only helps the aesthetic and structural (slope-erosion) performance of the road, but also has a positive effect on noise reduction.

The measures which follow can be divided into two categories:

- measures which have already been taken into account during the planning stage of the project
- measures which should be taken during the construction and operational stages of the project

In detail, the following measures are proposed:

- The project should be in keeping with existing vegetation (wherever possible), a matter not only of aesthetics and environmental sensitivity but also of improved road safety, either because it helps to visually guide the driver, or because it breaks the monotony which can slow reaction times.
- Where aggregates are taken from the immediate vicinity of the road the landscape should be restored, both for aesthetic reasons and to prevent soil erosion. The same should be done for the slopes, for exactly the same reasons. Making sure that they are long-lasting should involve a combination of construction design and planting. The plants should be those best suited to the particular environment, and their planting should contribute to maintaining the area's natural appearance. Where the shrubs are considered insufficient (mainly because of their small size) it is recommended that they be supplemented with plants which grow wild in Cyprus, particularly ones which grow in environments as similar as possible to the area under study.
- During construction of the embankments, the surrounding vegetation should be protected since it enhances the aesthetics of the area.
- During road widening, it is not necessary to destroy the trees on both sides of the road (if there are any) since one side can be kept and the other side can be planted later.
- During the operational phase of the project, the vegetation acts as a glare-reducer, a wind-break, and a means of visually guiding traffic which is much better than road markings and signs in poor-visibility conditions (mist, darkness, cambers with a change of direction) which not only improves traffic safety but also helps to integrate the road into the landscape better. Care should be taken to plant the outside of bends with sparse vegetation so as to delineate the edges of the road surface sufficiently and allow an unrestricted view of the landscape from time to time. An exception is when the inner side of the bend is already enhanced by impressive vegetation, in which case the outer side should also be planted with large trees for reasons of visual balance.
- The central reservations should be planted with evergreen pollution-resistant shrubs because, apart from enhancing the aesthetics of the project and helping it to fit in with the natural landscape, they improve traffic safety by protecting drivers from being dazzled by vehicle headlights.
- Retaining walls and other man-made structures should be hidden by planting because this enhances the environment, gives road-users a pleasant journey, and hides construction imperfections.

The aforementioned measures to restore the landscape also contribute to reducing the visual intrusiveness of the lights of the vehicles using the road.

Wherever possible, the restoration of the landscape using plants should begin as soon as possible so that, after the completion of the works, the trees or shrubs have already grown sufficiently that they reduce visual nuisance.
In the area neighbouring the section between the 10.8 and 11.8 km marks there are abandoned quarries, part

of which has been filled with rubble, and other materials of unknown quality and type, which constitute a serious environmental problem. Our recommendation is that the study into the road be extended to include the area of the old quarries, even though they lie outside its route; and that the earth-moving works during construction be exploited as an opportunity to landscape the wider area and improve the environment. Any such intervention in the area of the old quarries must pay serious attention to the existence of chemicals and other pollutants which have been dumped there in the past, as well as to the existence of the "Askarel" controlled landfill site, which should not be disturbed.

2.2.6 Impact on geology

There are no features of geological or palaeontological value in the area of the project which will require preservation. Consequently there is not expected to be any negative impact during construction.

The foundation conditions, as already mentioned in the chapter on "Geotechnical conditions" , are for the most part good, except for the southernmost section of the road in the area of the new port where there are soft lacustrine deposits which are judged to be unsuitable as foundations.

2.3 QUANTIFICATION OF THE IMPACTS

The methodology which this study will follow in order to quantify the impacts of the construction and operation of the project is a Multiple Criteria Decision Analysis. Henceforth it will be referred to as "Road Development Project Evaluation Model". The model consists of five steps:

1. **Aim,** defining the basic aim or purpose
2. **Quantification of criteria,** mathematical description (ranking with the help of coefficients) of each criterion.
3. **Criterion weighting,** determining their relative importance in achieving the basic aim
4. **Quantification of scenarios,** calculating the total score (according to a cumulative function) of each scenario.
5. **Ranking scenarios,** comparative evaluation and ranking of the scenarios.

A brief explanation of each of the five steps will follow.

The advantages of the method can be summarized as:

- The method takes into account a large number of criteria as well as interactions between criteria with the help of a decision making tree (Step 2).
- It allows the detailed and most rational determination of the weightings with N*(N-1)/2 table comparing all the criteria to each other (Step 3)
- It allows a scenario to be graded even when the details are not precise, but given with some degree of uncertainty with a confidence interval (Step 4)
- **The final ranking of the scenarios is more reliable since scenarios which are not significantly different from one another are placed in the same category (Step 5).**

2.3.1 Aim

The general aim of this study is to evaluate the environmental impacts of the construction works for the link road from Limassol Port to the Limassol-Paphos motorway. The mathematical coefficients determined for each criterion and the final ranking provide a method of measuring the degree to which the natural and man-made environment cope with whatever impacts may result from the interventions related to the works.

2.3.2 Quantification of criteria

The first step in developing the model is the determination of the impacts of the work for each criterion. This is done for each criterion by describing the impacts and determining the corresponding grade on a scale of 1-5 where:

- very little impact, grade 1
- slight negative impact, grade 2
- moderate negative impact, grade 3
- high negative impact, grade 4
- very high negative impact, grade 5
- if the works do not comply with an area's “protected” status, the impact is given a grade of 100 to show mathematically that implementing the proposed option is not possible.

This is usually done either using the mathematical ratio of a physical quantity to the corresponding impacts, or using a table which shows the impacts as a step function on the scale of 0-5. In some cases a criterion can be further analysed in other sub-criteria with the help of an impact tree. Each sub-criterion is dealt with in the above way, that is to say as a separate criterion. This aspect of the model makes it possible to examine the interactions between the criteria, where one criterion is shown as a sub-criterion of another.

2.3.3 Weighting the criteria

In many decision making problems, it can be seen that the criteria do not contribute equally to achieving the basic aim, or that in the decision maker's opinion the criteria have varying degrees of importance. The relative importance of the criteria is determined by a separate analysis of tables, and is applied as a weight vector at the grading stage. The said criteria are compared to each other one by one, and the weight vector is obtained from the maximum eigenvector on the comparison table.

2.3.4 Grading the scenarios

The coefficients of the criteria are combined using a cumulative function, which involves each criterion's grade weighted using the weight vector. Also, to make the grading more understandable without sacrificing the reliability of the method, the criteria are subdivided into three categories or groups of criteria which have fixed weighting coefficients. These weighting coefficients express the relative importance of each criterion in relation all the others, both on a local and a broader level. These coefficients were obtained by grading each criterion individually on the scale of 0-5 as a percentage of the total score. During this stage of the grading it is possible to determine the impact of each criterion as an approximation using a confidence interval. Thus, if a criterion can be graded exactly it is given a number on the scale of 0-5 .e.g. 3, while if there is some uncertainty about the available data the criterion can be graded as a probable range of grades e.g. 1-2.

2.3.5 Ranking scenarios

For the ranking process, each scenario gets a final score as obtained from the cumulative function Σ, and finally the various scenarios are placed in order relative to one another, first, second, third and so on, in order of their scores. That is to say that the scenario with the lowest score is placed first (as the most desirable, with the smallest environmental impact overall), the next highest score is placed second, and so on. Since, during step 4, a criterion's coefficient may turn out to be an interval of scores, this interval must be used for the comparison. A scenario X is considered to be better than scenario Y if the lower limit X1 in the interval (X1, X2) is greater than or equal to the upper limit Y2 in the interval (Y1, Y2). In this way, if two scenarios are not substantially different from one another, they are placed in the same category, something which would not happen if whole numbers had been used in the comparison instead of confidence intervals.

2.3.6 Quantification of the impacts

Next is an overall evaluation of the state of the environment WITH and WITHOUT the project being studied, so as to establish the expected negative and/or positive impacts quantitatively and qualitatively. The results are presented in tables 2.8-2.9 which follow, which were arrived at based on the previously described methodology.

In those tables:

- The horizontal rows of each table record the various activities which affect the environment (e.g. vehicular traffic, operation of site machinery etc.)
- The vertical columns of each table record the various criteria (as laid out in Table 2.7)
- The data in each table shows the evaluation of the impacts of each activity corresponding to the column, to the criterion corresponding to the row, with:
  - an evaluation of the size of the impact at the top left-hand side, graded from 0 (positive impact) to 5 (very big impact)
  - an evaluation of the extent of influence of the impacts at the bottom right-hand side, ranked from I (only local), II (wider area of the project) and III (wider area at town level).

Table 2.7 Multiple criteria analysis criteria groups

Multiple criteria analysis criteria groups		
Environmental – Ecological Environment	**Land use – Social Environment**	**Protected Areas – Cultural Environment**
1. Morphological and topological characteristics	8. Land use	14. Aesthetics
2. Geological, tectonic and soil characteristics	9. Access	15. Cultural heritage
3. Hydrology / Hydrogeology	10. Transport / traffic	
4. Air	11. Infrastructure work	
5. Flora – Fauna	12. Socio-economic environment	
6. Noise	13. Health and safety	
7. Energy		

For the selected coefficients, it should be made clear that – because of the nature of primary road projects, the importance of the project at a local and supra-local level, and also the special nature of the works to cut new sections of road – when investigating the situation WITH the works, both at the construction stage and the operational stage, the views of the affected parties (Municipalities, Communities) were taken into account.

Finally, it should be noted that the evaluation of the operational phase refers overall to the direct influence of the works and to the indirect impacts at town level, for the studied period mentioned earlier up until 2027.

Based on the above, the choice of weighting coefficients for all the environmental data in the evaluation tables is grouped and analysed below.

Coefficient 1 (Very low weighting)

- **Criterion/Criteria**

➔ Cultural Heritage: No antiquities have been found along the length of the works

Coefficient 2 (low weighting)

- **Criterion/Criteria**

➔ Infrastructure works: When the project is carried out, new infrastructure will be created such as CYTA (telephone) and EAC (electricity) networks, as well as irrigation networks, consequently the impact of these projects is considered to be positive.

Coefficient 3 (medium weighting)

- **Criterion/Criteria**

➔ Morphological and topological characteristics: The area's relief is not particularly extreme, however the changes that will be brought about by the small sections of cuttings and/or the embankments will be permanent and irreversible.

➔ Hydrology – Hydrogeology: There are important aquifers in the area. The quality of their water could be affected negatively both during construction (poor management of liquid waste) and during operation (from liquid waste spillage due to an accident).

➔ Geological, tectonic and soil characteristics: As a result of the project covering the ground, the characteristics of the sub-soil and groundwater are expected to deteriorate. After removal of the topsoil, the subsoil will be levelled and covered with impermeable materials which do not allow water to enter. The result will be a small change in the natural hydrology and the interruption of groundwater replenishment.

➔ Access: A consequence of the construction works will be the temporary or even permanent blocking of access roads; however, new access roads will be available when the project is operational.

Coefficient 4 (heavy weighting)

- **Criterion/Criteria:**

➔ Flora – Fauna: The impacts on plant-life are significant, and the interference is considered especially damaging in areas which already have mature vegetation containing many endemic plants, and in cultivated areas. The impacts on animal life are focused around the fact that some aquatic habitats will be destroyed.

➔ Natural landscape – Aesthetics: this criterion (during both construction and operation) is the environmental factor which is most significant in terms of community sensitivity. This fact is given further weight by the average link-road user's great desire for an aesthetically improved and enhanced landscape.

➔ Socio-economic environment: The evaluation of the impacts of the proposed project, based on the current socio-economic characteristics which prevail in the various areas the route passes through, is particularly significant in determining the project's acceptance level among the residents of the immediate area. For this reason, the main types of area the route passes through and their characteristics were assessed as indicators of the existing structure and functioning of these areas, as were the opinions of the Municipalities and Communities in each area.

Coefficient 5 (very heavy weighting)

- **Environmental elements**

➔ Air: This criterion (during both construction and operation) is the environmental element with the greatest significance in the immediate and wider zones of influence, given the scale of:
  - the negative impacts of creating a new road on air quality (e.g. dusts, fumes, particulate pollutants etc.),
  - the expected positive impacts at the town level during operation, but also the expected negative impacts in the immediate vicinity (local increase in pollutants etc.)

➔ Land use: This criterion (during both construction and operation) is an environmental element of very high significance in the project's immediate zone of influence given the scale of the impacts of a major transport system of this sort, primarily on land use and consequently on cultural and socio-economic structure and development. Significant impacts will arise particularly in section B, where the main land use is agricultural production.

➔ Noise: This criterion is an environmental element of very high significance in the project's immediate zone of influence both in terms of airborne noise (from the operation of works sites) which is characterised by its limited duration but possible nuisance at night, and also in terms of noise during operation which is expected to affect certain land use (isolated houses along the road).

➔ Transport / traffic: The impact on traffic in the immediate and wider area is the most significant parameter in evaluating the project, and determines the need to carry it out.

➔ Accidents – Safety: This criterion is an environmental element of very high significance because the movement of commercial lorries in conjunction with busy roads increases the likelihood of serious accidents.

➔ Energy: This criterion is an environmental element of very high significance because vehicular traffic on the road network is directly linked to fuel consumption, which accounts for 45% of liquid fuel consumption at the national level.

Following are the results of implementing the methodology to evaluate the environmental impacts in the immediate and wider area throughout the time period:

- **WITHOUT** the project – Table 2.8
- **WITH** the project – Table 2.9

Based on the analysis of tables 2.8 and 2.9 which follows, in can be concluded that the expected weighted impact of the scenarios WITH and WITHOUT the Project can be evaluated as follows:

- Scenario WITHOUT the Project: Impact level 313

- Scenario WITH the Project: Impact level 296

The above evaluations for the scenario WITH the Project take into account the implementation of the management plan which is analysed later in Chapter 9.

The above assessments of the impacts are especially interesting given that:

- The total weighted impact for the scenario WITHOUT the project is greater than the corresponding one WITH the project, as the scenarios are expected to develop up to the year 2027.

The preceding environmental assessment for the Project is not in itself sufficient for taking a decision to implement the Project, as its economic benefits to the wider society have not been taken into account. If this factor is also taken into account (see techno-economic study) the project is expected to have even more positive impacts.