(4) Total Estimated Flood Damages

These are summarised in Table 40.

Table 40 Oued Bou Khamsa - Summary of Estimated Flood Damages in 2020 under
Preasent and Future Land Use Situations

	Present	Future
*Persons affected	9,500	26,700
	(DT 1,000)	
*Damage to Property	150	214
*Loss of Income (Residents)	32	469
*Loss of Income (Employees)	41	82
*Damage (local roads)	704	1,408
*Damage (GP1 / MC33E)	504	504
*Traffic delays (Income losses)		
*GP1	511	6,000
*MC33E	255	3,000
*Increased Vehicle Operating Costs		
*GP1	150	626
*MC33E	75	312
Total	2,422	12,612

8. Oued Ain Zerga

8.1 Introduction

According to the return period of 100-year, the flooded areas under future land use
conditions will be as follows:

Table 41   Impact of Flooding in Ain Zerga

Present Land Use	Zone A	Zone B
Inundated Area	19.4 ha	9.6 ha
Inundation Period	6.2 Hours	6.2 Hours
Future Land Use		
Inundated Area	26.1 ha	12.6 ha
Inundation Period	12.0 Hours	8.0 Hours

8.2 Estimation of Damages

(1) Damage in Residential Areas

Assumptions on the population and number of houses affected are based on the
coefficients used by the ONAS Study for the "South Coast". Theses are:

*15 houses per ha,

*5.8 persons per household.

*Population growth rate of 2.3% p.a.

One third of the houses, however are assumed to be four storey houses, i.e. representing 23.2 persons per house. This represents 173 persons per hectare at present and 320 in the future. On this basis, the population affected will be 6,000 at present land use basis, and 8,350 in the future land use , for Zone A, and 3,000 and 4,000 respectively for Zone B.

On the assumption that 50% of the residential area is constructed area, the total area of buildings affected is estimated to be:

	Present Land Use	Future Land Use
ZONE A	97,000 m2	130,000 m2
ZONE B	48,000 m2	63,000 m2

In applying a construction cost of DT 350/m2, and a typical damage factor of 3% i.e. DT10.5/m2, the total damage costs are estimated to be:

	(DT1,000)	
	Present Land Use	Future Land Use
ZONE A	1,018.5	1,365.0
ZONE B	504.0	661.5

(2) Loss of Income to Residents

Flooding duration of 6.2 hours at present and between 8 and 12 hours in the future, will effectively mean the loss of an entire days wages per person employed. Applying the rate for skilled labour of DT67 per day per day in 2020, the following loss is estimated:

Table 42 Estimated Loss of Earnings by Residents

	(DT)			
	Present Land Use		Future Land Use	
	Employees	Lost Income	Employees	Lost Income
ZONE A	2,064	138,300	2,880	192,960
ZONE B	1,014	67,938	1,380	92,460
Total		206,238		285,480

(3) Transport and Traffic Losses

a) Traffic Flow Data

The GP1 passes through the flooded area. It is estimated that in the event of a 100-year return period flood, approximately 1 km of road will be affected. Traffic will be delayed for a period of 6.2 hours in the present situation, and up to 12 hours in the future land use situation. Flooding impact will be felt in the following areas:

With regard to traffic flows detailed data is not available except for the main arteries. The latest traffic counts are available in the Regional Transport Master Plan for the District of Tunis (Ministry of Interior, 1989). The traffic count on the GP1 at the southern exit to Tunis indicated flows in the region of 40,000 vehicles per day. the structure of traffic was estimated to be 33% for private cars and taxis, 3% for buses, 39% for heavy vehicles and 25% for light vehicles. The rate of occupation for private cars and taxis ranged from 2.1 to 3.8, and for camionettes and lorries between 1.2 and 2. The higher figures are used for the evaluation. For buses data was not readily available and an occupancy factor of 45 is used. It is also assumed that passengers in private cars and taxis will be in the skilled labour bracket, while those in buses, and heavy and light vehicles unskilled. Based on the above assumptions the numbers of passengers affected are shown in Tables 43 and 44.

Table 43   Estimates of Number of Passengers per Day on the GP1 at Present

Category	Vehicles (Number)	Occupancy Rate	Total Pass
Private Cars and Taxis	13,200	3.8	50,160
Buses	1,200	45	54,000
Light Vehicles	10,000	2.0	20,000
Heavy Vehicles	15,600	2.0	31,200
Total	40,000		155,360

Traffic is expected to grow in line with GDP forecasts. In maintaining the present structure the following estimates are made for traffic in the year 2020:

Table 44   Estimates of Number of Passengers per Day on the GP1 under Future Conditions

Category	Vehicles (Number)	Occupancy Rate	Total Pass
Private Cars and Taxis	55,200	3.8	210,000
Buses	5,000	45	225,000
Light Vehicles	42,000	2.0	84,000
Heavy Vehicles	65,000	2.0	130,000
Total	167,000		649,000

b) Estimated Loss of Income due to Traffic Delays

In 2020 under present land use conditions, delays of 6.2 hours are expected, and in future conditions 12 hours. Applying the appropriate value of time, income losses are estimated as follows:

(DT)

	Present Land Use	Future Land Use
Skilled Labour	2,734,200	5,292,000
Unskilled Labour	1,905,260	3,687,600
Total	4,639,500	8,979,600

c) Increased Vehicle Operating Costs - GP1

While it is assumed that the level of flooding will be sufficient to halt traffic completely during the period of inundation (6.2 hours in present situation and 12 hours in the future situation), a further impact will be felt in the increased operating costs experienced by vehicles both as a result of more difficult operating conditions and following the degradation in the road surface. This additional cost should be included in the damage assessment. The different rates are applied to the existing and expected traffic flows on the GP1, of which 1 kilometre is expected to be flooded. The following tables show the costs by category in the present and future situations.

Table 45 Additional Vehicle Operating Costs in the Flooded and Non-flooded Cases - Present Situation

Vehicle Type	Difference (DT per 1,000 vehicle/km)	Daily Traffic	Costs Per Day (DT)
Private Car/Taxi	28.79	13,200	380
Bus	51.60	1,200	62
Light/Medium Goods	86.11	10,000	861
Heavy Goods	236.73	15,600	3,693
Total			4,996

Over a 30 day period costs will be estimated at DT150,000.

Table 46 Additional Vehicle Operating Costs in the Flooded and Non-flooded Cases - Future Situation

Vehicle Type	Difference (DT per 1,000 vehicle/km)	Daily Traffic	Costs Per Day (DT)
Private Car/Taxi	28.79	55,200	1,590
Bus	51.60	5,000	458
Light/Medium Goods	86.11	42,000	3,616
Heavy Goods	236.73	65,000	15,388
Total			21,352

Total VOCs in the future land use situation are estimated at DT640,500.

(d) Damage to major Roads and to Inconvenience to traffic

Assuming 1 km of secondary roads per 10 ha, the total roads likely to suffer from damage are in the region of 4 km in the future. With reconstruction costs estimated at DT80,000 per km damage will be between DT320,000. In addition 0.5 km of the GP1 will need rehabilitation. Assuming costs of DT120,000 per km, costs will be DT60,000. Total road damage costs are estimated at DT380,000.

(4) Total estimated Flood Damages

Tables 47 and 48 summarise the damages expected by flooding in Ain Zerga in 2020 the event of a 100-year return period under present and future land use conditions.

Table 47   Summary of Estimates of Flooded Damage in Ain Zerga - Present Land Use

(DT 1,000)

	Zone A	Zone B	Total
Damage to Property	1 019	504	1,523
Loss of Earnings (Residents)	138	68	216
Damage to local roads			380
Loss of Income (GP1)			4,640
Increased Vehicle Operating Costs			150
Total			6,909

Table 48   Summary of Estimates of Flood Damage in Ain Zerga - Future Land Use
(DT 1,000)

	Zone A	Zone B	Total
Damage to Property	1,365	662	2,027
Loss of Earnings (Residents)	193	93	286
Damage to local roads			380
Loss of Income (Delays)			8,980
Increased Vehicle Operating Costs			640
Damage to GP1			
Total			12,313

9. Oued Hammam

9.1. Introduction

Flooding of the Oued Hammam will result in damage and inconvenience in 4 areas. On a 100-year return period a total of 269.5 ha under present land use conditions and 319.5 ha under future land conditions. The major area to be affected will be Hammam Sousse, and there will also be flooded areas adjoining Akouda, Kalaa Kebira and Kalaa Seghira. The population of these towns in recent years is shown in Table 49.

Table 49 Governorate of Sousse - Estimation of Population by Delegation - 1 Jan.
1992

Delegation	Total	Population Communal	Rural	Rate of Urbanization
Akouda	16,900	13,800	3,100	82%
Hammam Sousse	25,200	25,200	0	100
Kalaa Kebira	43,100	37,700	5,400	87
Kalaa Seghira	16,900	14,900	2,000	87

According to the urban master Plan the following projections are made (Table 50).

Table 50 Population Projection by Town

Town	Population 1989	Population 2006	Growth	Growth Rate (%)
Hammam Sousse	23,491	37,017	13,526	2.71
Akouda	12,975	22,009	9,034	3.16
Kalaa Kebira	35,395	59,840	24,445	3.14
Kalaa Seghira	13,968	23,072	9,104	3.00

In assuming that these towns will continue to grow in the same ratio, but at lower rates, 2.0% for Hammam Sousse, 2.75% for Akouda and Kalaa Kebira and 2.5% p.a. for Kalaa Seghira, the populations of these towns will be as follows in the year 2020:

Hammam Sousse	:	48,800
Akouda	:	32,200
Kalaa Kebira	:	87,500
Kalaa Seghira	:	32,600

9.2 Estimation of Damages

(1) Loss of Income to Residents

The main area where residents will be affected is Hammam Sousse. Assuming that around 50 % of the area is residential, 100 ha is taken as flooded area. Density in Sousse town is estimated at 275 persons per ha. Since some of the areas will have spontaneous housing, it is proposed to use a density of 250 per ha, for the area affected. This represents a population of 2,750. Based on an average of 5 persons per household, some 550 families will be affected.

Assuming two workers per household and incomes of DT67 per day for skilled labour in the year 2020, income losses will be DT221,000 under flooding conditions under present land use (3 days) and DT295,000 under future conditions (4 days lost income).

With regard to the other zones, it is expected that only spontaneous housing on the sides of the oued will be affected. Assuming 10 % of these flooded areas will be residential, some 10 ha will be involved. Densities in these areas will be much lower than for Sousse. Assuming 100 persons per ha, a further 1,000 persons could be affected. Loss of income in these zones will probably be over two days. An allocation of DT25,000 is made for the present land use situation, and DT50,000 for the future situation.

(2) Damage to Buildings

It is estimated that up to 100 ha of residential areas in Hammam Sousse could be affected by the flooding. Assuming a built up ratio of 80%, some 800,000 m2 could be affected. Since the area contains much spontaneous housing, it is assumed that 50 % will consist of lower class housing with a unit cost of DT150/m2, and the remainder medium standard housing at DT250/m2. On this basis, and assuming flood damage at 3% of construction costs, flood damage is estimated at DT4.8 million in the future land use situation. On a pro rata basis, damage in present land use conditions will amount to DT4.0 million.

In addition 80,000m2 of buildings will be affected along the side of the oued representing a cost of DT360,000. Under present land use conditions this will amount to DT300,000.

(3) Transport and Traffic Losses

The flooding will affect the following main roads:

* Zone A :Hammam Sousse
        *Tourist Road
        *GP1
        *Local Roads
*Zone Zone C
        *Akouda - Kalaa Seghira Road
        *Local Roads
*Zone D
        *Akouda :Republique Avenue
        *Kalaa Kebira : Avenue Farhat

(a) Zone A
(i) Loss of Income to Passengers
It is assumed that the roads will be cut off for the duration of the flooding. It is probable that this could be a longer period due to clearing up operations, but for the purposes of the evaluation it is assumes that the roads will be cut off for 47 hours in present

conditions and 59 hours in future conditions. The value of time is estimated at 25% of the hourly wages of skilled and unskilled labour. At current rates the appropriate value is estimated to be DT0.5 per hour for skilled labour and DT0.16 per hour for unskilled labour in present conditions. These are assumed to increase in line with expected GDP growth and to be DT 2.1/hour and DT0.7/hour respectively. With regard to traffic flows data is used provided by the Ministry of Equipment and Housing and is shown in Table 51.

Table 51   Estimates of Number of Passengers per Day on the GP1 at Present

Category	Vehicles (Number)	Occupancy Rate	Total Pass
Private Cars and Taxis	5,600	3.8	21,280
Buses	350	45	15,750
Light Vehicles	4,200	2.0	8,400
Heavy Vehicles	1,500	2.0	3,000
Total	11,650		48,430

Traffic is expected to grow in line with GDP forecasts till the year 2000 (6% p.a.) and to fall due to road saturation to rates of 4% p.a. between 2000 and 2010, and 2% p.a. between 2010 and 2020. In maintaining the present structure the following estimates are made for traffic in the year 2020 (Table 52):

Table 52   Estimates of Number of Passengers per Day on the GP1 under Future Conditions

Category	Vehicles (Number)	Occupancy Rate	Total Pass
Private Cars and Taxis	15,200	3.8	57,800
Buses	950	45	42,800
Light Vehicles	11,400	2.0	22,800
Heavy vehicles	4,200	2.0	8,400
Total	31,754		131,800

Under present land use conditions, delays of 47 hours will be encountered. This represents 3 full working days (24 hours on an 8 hour working day basis), and taking into account increases in salaries in line with GDP, total losses are estimated to be : DT11.6 million for skilled labour, and DT4.9 million for unskilled labour - a total of DT16.5 million. Traffic on the tourist road is assumed to 50 % of the GP1. Total losses on income are there fore estimated to be DT24.75 million under present land use conditions. Under future land use conditions delays of 59 hours will be met. It is assumed that 4 full working days will be lost. Costs will therefore be DT33.0 million.

(ii) Increased Vehicle Operating Costs

While it is assumed that the level of flooding will be sufficient to halt traffic completely during the period of inundation, a further impact will be felt in the increased operating costs experienced by vehicles both as a result of more difficult operating conditions and following the degradation in the road surface. This additional cost should be included in the damage assessment. For the purposes of the evaluation it is assumed that the increased operating costs will only apply to the period of flooding, although in practice these will apply for the duration until the road is repaired. For the purposes of the evaluation it is proposed to take 30 days as the repair period.

It is assumed that 1 km of roads will be affected by the flooding. In applying the rates for operating costs between the assumed conditions of non flooded and flooded roads, according to the World Bank HDM model, the increased vehicle operating costs are shown in the following Tables for existing and future traffic.

Table 53   Additional Vehicle Operating Costs per Day in the Flooded and Non-flooded Cases - Future Situation

Vehicle Type	Difference (DT per 1000 vehicle/km)	Daily Traffic	Costs Per Day (DT)
Private Car / Taxi	28.79	15,200	437
Bus	51.60	950	49
Light/Medium Goods	86.11	11,400	982
Heavy goods	236.73	4,200	994
Total			2,463

In taking account the additional traffic on the tourist road (50% of GP1), the total value of increased VOCs is estimated at DT111,000.

(iii) Damage to roads

Approximately 3 km of the main roads will be damaged. Assuming a rehabilitation cost of DT120,000 per km, the costs of damage are estimated at DT360,000. In addition, secondary roads alongside the Oued will be affected. These are estimated at 10 km on the basis of 1 km of road per hectare. With a rehabilitation cost of DT80,000 per km, the costs are estimated at DT800,000. Total road rehabilitation costs are therefore estimated at DT1.4 million.

(b) ZONE B

This area is mainly agricultural and it is assumed there will be no major traffic flows.

(c) ZONE C

Traffic on the RVE in Zone C was estimated to be 22% of that on the GP1 (Sousse - Kalaa Seghira :3534) in 1987. Applying this ratio to future traffic, and assuming flood duration of 40 hours and 41 hours under present and future land use conditions respectively, loss of income for traffic delays is estimated to be DT3.0 million and DT 3.4 million respectively. With regard to increased VOCs only a few 100 metres of road will be affected. A cost of DT20,000 is allocated for this purpose. DT12,000 is allocated for road damage.

(d) ZONE D

The Oued will cut off the MC 48 in two places. However, traffic delays are only taken into account once. According to the traffic count carried out in 1987 the traffic on the road from Sousse to Kalaa Kebira was 5,655 vehicles per day compared to 15,758 on the main GP1 A factor of 35% is used for this road for traffic. Delays experienced will be 14 hours and 22 hours under present and future land use conditions respectively. On this basis, loss of income is estimated at DT1.675 million and DT2.85 million respectively.

0.5 km of road are expected to be affected, and a value of DT50,000 is taken for increased VOCs. DT60,000 is allocated for damage to roads. Total costs under this category under the present land use situation are therefore estimated to be:

	(DT 1,000) ZONES			
	A	C	D	Total
*Loss of income to Passengers	24,750	3,000	1,675	29,425
*Increased VOCs	110	20	50	180
*Road damage	1,400	120	60	1,580
Total	26,260	3,140	1,785	31,185

Under the future land use situation the damages and costs are estimated as follows:

	(DT 1,000) ZONES			
	A	C	D	Total
*Loss of income to Passengers	33,000	3,400	2,850	39,250
*Increased VOCs	110	20	50	180
*Road damage	1,400	120	60	1,580
Total	34,510	3,540	2,960	41,010

(4) Damage to Industries

Although all the towns affected have some industries located in them, it is probable that under the flooding pattern envisaged only some industries in Hammam Sousse will be affected. The latest Survey carried out by the Industrial Promotion Agency shows that there are 40 enterprises in Hammam Sousse employing 1,153 employees.

Assuming flooding of 47 hours and 59 hours, it is assumed that three days and four days will be lost in present and future land use conditions. This represents an income loss of DT232,000 and DT309,000 respectively. The total investment value of these companies is estimated to be DT 4.6 million. In estimating flood damages as a proxy of 3% of the investment value of these companies total damages are estimated at DT138,000; this figure is increased to DT150,000 to take account of equipment losses. Under present land use situation an amount of DT100,000 has been allocated to cover this category.

(5) Damage to Agricultural land

Agricultural land affected by flooding is mainly in Zone B with some areas in the other zones as well. These areas are estimated at approximately 70 ha on the mapping. Applying a land value of DT15,000 per ha and assumin that losses will amount to 20% of these, total agricultural losses are estimated at DT210,000 in the future land use situation, and on a pro rata basis, DT180,000 in the present land use situation.

(6) Total estimated Flood Damages

The estimate of total damages is shown in Table 54.

Table 54   Oued Hammam - Summary of Estimated Flood Damages under Present and
Future Land Use Situation in 2020

	Present	Future
*Population Affected		
	(DT1,000)	
*Damage to Property (Residents)	4,300	5,160
*Loss of Income (Residents)	246	345
*Damage (Roads)	1,580	1,580
*Traffic Delays (Income Losses)	29,425	39,250
*Increased Vehicle Operating Costs	180	180
*Agricultural areas	180	210
*Damage to Industries	100	150
*Loss of Income (Industries)	232	309
Total	36,243	47,184

10. Oued Blibane

10.1 Introduction

On the basis of a 100-year return period, flooding will occur in three areas, as indicated on the attached map. The areas flooded according to different return periods are indicated in the Tables 55. The evaluation of damages is carried out on the basis of 100-year return period under present and future land use conditions.

Table 55 Oued Blibane - Flood Inundation Area

100-year Return Period	Land Use Conditions (Ha)					
	Present			Future		
	Zones					
	A	B	C	A	B	C
Flooded Area (Hectares)	6.8	12.8	3.4	9.5	17.0	4.6
Flooding Duration (Hours)	18.9	16.5	14.2	27.0	23.5	20.6

The evaluation is presented below according to each zone.

10.2 Zone A

(1) Introduction

This area which is located between the GP1 and the sea can be divided into two land uses. The area between the tourist road and the sea is mainly a tourist area and will continue to remain one. It is estimated at 4.5 ha according to future land use conditions. The area between the two roads (5 ha) consists of spontaneous housing, and is designated in the future as an area for mixed and collective housing. Damage in this area will be as follows:

*Damage to spontaneous housing, requiring relocation of residents into collective housing
*Damage to the two major road arteries - (GP1 and the tourist road)
*Loss of income to drivers and passengers due to traffic delays
*Increased vehicle operating costs
*Inconvenience to adjacent Hotels and Residents

The latter is however unquantifiable in monetary terms but need to be borne in mind.

(2) Damage to Housing

The population affected directly consists largely of spontaneous housing on the side of the oued. In the future this is to be replaced by collective and mixed housing. Damage is assessed on the basis of potential future construction. It is assumed that 50% of the future flooded area could be suiTable for construction, and that actual built up area would be half that. Assuming a total built up area of 250,000 m2 and a construction cost of DT500/m2, it is assumed that rehabilitation costs will be 3% i.e. DT15/m2. Flood damage could therefore amount to DT375,000 in the future land use condition. Under present conditions a pro-rata cost is taken (0.7) and damage is estimated at DT265,000. While possibilities exist for the construction of a hotel within the potentially flooded area, no account is taken in assessing the potential damages.

(3) Transport and Traffic Losses

a) Traffic Flow Data

It is assumed that the roads will be cut off for the duration of the flooding. It is probable that this could be a longer period due to clearing up operations, but for the purposes of the evaluation it is assumes that the roads will be cut off for 9.5 hours in present conditions and 27 hours in future conditions. With regard to traffic flows data is used provided by the Ministry of Equipment and Housing and is shown in Table 56.

Table 56   Estimates of Number of Passengers per Day on the GP1 at Present

Category	Vehicles (Number)	Occupancy Rate	Total Pass
Private Cars and Taxis	5,600	3.8	21,280
Buses	350	45	15,750
Light Vehicles	4,200	2.0	8,400
Heavy Vehicles	1,500	2.0	3,000
Total	11,650		48,430

Traffic is expected to grow in line with GDP forecasts till the year 2000 (6% p.a.) and to fall due to road saturation to rates of 4% p.a. between 2000 and 2010, and 2% p.a. between 2010 and 2020. In maintaining the present structure the following estimates are made for traffic in the year 2020 (Table 57):

Table 57 Estimates of Number of Passengers per Day on the GP1 under Future Conditions

Category	Vehicles (Number)	Occupancy Rate	Total Pass
Private Cars and Taxis	15,200	3.8	57,800
Buses	950	45	42,800
Light Vehicles	11,400	2.0	22,800
Heavy Vehicles	4,200	2.0	8,400
Total	31,754		131,800

b) Loss of Income

In assuming delays of 27 hours, effectively 2 working days (16 hours), and taking into account increases in salaries in line with GDP, total losses are estimated to be :DT1,950,000 for skilled labour, and 830,000 for unskilled labour - a total of DT2.78 million. Traffic on the tourist road is assumed to 50 % of the GP1. Total losses on income are there fore estimated to be DT4.17 million.

c) Increased Vehicle Operating Costs

While it is assumed that the level of flooding will be sufficient to halt traffic completely during the period of inundation, a further impact will be felt in the increased operating costs experienced by vehicles both as a result of more difficult operating conditions and following the degradation in the road surface. This additional cost should be included in the damage assessment. For the purposes of the evaluation it is assumed that the increased operating costs will only apply to the period of flooding, although in practice these will apply for the duration until the road is repaired. It is assumed that 0.5 km of roads will be affected by the flooding. In applying the rates for operating costs between the assumed conditions of non flooded and flooded roads, according to the World Bank HDM model, the increased vehicle operating costs are shown in the following tables for existing and future traffic.

Table 58 Additional Vehicle Operating Costs in the Flooded and Non-flooded Cases - Present Situation

Vehicle Type	Difference (DT per 1,000 vehicle/km)	Daily Traffic	Costs Per Day (DT)
Private Car / Taxi	28.79	5,600	161
Bus	51.60	350	18
Light/Medium Goods	86.11	4,200	361
Heavy Goods	236.73	1,500	355
Total			895

In taking account of the additional traffic, the total additional VOCs for the traffic on the two roads is estimated at DT1,350 per day . assuming a 30 day repair period, VOCs are estimated at DT40,500.

Table 59 Aditional Vehicle Operating Costs in the Flooded and Non-flooded Cases - Future Situation

Vehicle Type	Difference (DT per 1,000 vehicle/km)	Daily Traffic	Costs Per Day (DT)
Private Car / Taxi	28.79	15,200	422
Bus	51.60	950	49
Light/Medium Goods	86.11	11,400	981
Heavy goods	236.73	4,200	994
Total			2,446

In taking account the additional traffic on the tourist road, the total value of increased VOCs is estimated at DT3,669 per day. Over 30 days total VOCs are estimated at DT110,000.

d) Damage to roads

Approximately 0.5 km of the main roads will be damaged. Assuming a rehabilitation cost of DT120,000 per km, the costs of damage are estimated at DT60,000. In addition, secondary roads alongside the Oued will be affected. These are estimated at 3 km. With a rehabilitation cost of DT80,000 per km, the costs are estimated at DT140,000.

(4) Oued Blibane - Summary of Estimated Flood Damages -Zone A

The estimate of total damages in the present and future land use situation are shown in Table 60 based on a 100-year return period.

Table 60 Oued Blibane - Summary of Estimated Flood Damages - Zone A - Present and Future Situation

	(DT)	
	Present	Future
*Damage to Property	265,000	375,000
*Damage to roads	140,000	140,000
*Traffic delays (Income losses)	2,780,000	4,170,000
*Increased Vehicle Operating Costs	40,500	110,000
Total	3,225,500	4,795,000

10.3 Zone B

This zone can be split into two major land uses. The area in the vicinity of the fork is densely populated and is marked with residential zones and industries. The future of this

area is designated for rehabilitation and relocation projects. The rest of the area adjoining the Oued Kharroub is presently used for small and limited agricultural activities. Future use of this area depends on the scenario adopted,. according to one, the area will continue to be agricultural; the other scenario envisages some urban development.

It is probable, however that the flooding will only affect agricultural areas, although there is some spontaneous housing that is likely to be affected in the rainy season. For the purposes of flood damage estimation, it is assumed that around 10 % of the potentially floodable area will be occupied by spontaneous housing. As a proxy to the relocation of this population it is proposed to use the potential flood damage that might occur if buildings were located in this area (1 hectare or 5,000 m2 of built up area). Assuming a cost of DT500/m2, and flood damage of 3%, total flood damage is estimated to be DT65,000.

With regard to the agricultural areas, a crop loss is assumed. As a proxy for the loss of crops, the price of agricultural land is taken to reflect the potential damage; this price varies enormously according to the soil conditions but ids believed to be around DT 15,000 per hectare. it is assumed that flooding will reduce this price by a third, and a value of DT5,000 is assumed to reflect this. Assuming that under present land use conditions, 12.8 ha is flooded, and in future land use conditions, 17 hectares, flood damage could amount to DT64,000 in the former case, and DT85,000 in the latter. Traffic losses on the closure of the GP1 are already included in the flood impact on Zone A. Total flood damage in Zone B is therefore estimated at DT129,000 in the former and DT150,000 in the latter case.

10.4 ZONE C

The area bordering the north fork of the Oued Blibane is at present marked with a medium rate of occupancy (50%) of residential housing and spontaneous settlements. However minimal damage is expected to housing. With regard to agricultural land it is assumed that 3 hectares could be affected by flooding and that the loss of income would amount to DT5,000 per ha or DT15,000 in total. This fork of the oued would also affect traffic on the main road and this as taken into account in the evaluation of Zone A.

10.5 Oued Blibane -Summary of Flood Damage

Table 61 summarises the flood damage for the three Zones.

Table 61   Oued Blibane - Summary of Flood Damage

	Present conditions	Future Conditions
ZONE A	3,225,500	4,795,000
ZONE B	129,000	150,000
ZONE C	15,000	15,000
Total	3,369,500	4,600,000

11. Oued Hallouf

11.1 Introduction

The estimated flooded Area for the Oued Hallouf is 77.3 ha under future flooding conditions, and 60.8 ha under present land use conditions assuming a 100-year return period. Three zones will be flooded with the following major impacts:

Zone A : Flood damage to factories and some residences; Disruption of traffic on a major road and on some secondary roads

Zone B : Flood damage to factories and residences; disruption to 2 secondary roads and several local roads

Zone C : Flood damage to major factories and infrastructure including schools; Disruption of traffic on major axis and on 2 secondary roads and several local roads; flooding of agricultural land.

The evaluation is presented below on a zonal basis.

11.2 ZONE A

(1) Introduction

Under a100-year return period the flooding will be as follows:

10 ha under present land use conditions, and 14.3 ha under future land conditions with durations of 14.1 and 22,8 hours respectively. The major impact of the zone will be on the industrial area located between the Avenue Abdel Hamid and the sea. The flooding will also cut off the town on the direct road to Sousse airport, which will have an impact on the tourist business. The Authorities are considering a project for controlling and rehabilitating the oued at this spot.

(2) Evaluation of Damages

a) Flooding of the Industrial Area

The immediate impact will be loss of revenue for the factories located in the flooded area
. As a proxy it is proposed to use the loss of revenue of employees. It is assumed that 10
factories will be affected by the floods. According the latest data prepared by A P I (
Agence de Promotion de l'Industriel), there were 60 enterprises in Sousse town
employing 2,000 persons - an average of 35. It is therefore assumed that 350 workers
will be directly affected. Applying a daily wage of DT67 for skilled labour in the year
2020. Allowing for time to clear up flood damage in order to make the factories
operational, it is assumed that the factories will be closed for 3 days under present land
use condition (actual flooding time of 14.1 hours) and 5 days under future conditions
(flooding time of 22.8 hours). Total lost income is therefore estimated at DT70,300 and
DT117,000 respectively.

Damage to the factories is based on applying 3% of construction cost (estimated at
DT500/m2). Assuming 5 hectares of industrial area will be affected, and a built-up ratio
of 66% (based on average ratios for industrial estates), total building area is estimated to
be 40,000 m2. Damage to buildings could be estimated at DT400,000. This figure is
increased by 20% to account for damage to equipment. A total of DT500,000 is
therefore proposed for the future land use situation. On a pro-rata basis of different
levels of flooding expected, the present land use conditions are estimated at DT350,000.

b) Damage to Housing

It is assumed that the residential areas in this zone cover 2 hectares. assuming damage to
10,000 m2, and construction costs of DT250/m2 (popular housing), damages are
estimated at DT75 000 for the future land use conditions and DT50,000 for present land
use conditions.

c) Loss of Income to residents

According to the Planning criteria used in Sousse, density varies from 15 to 35 houses
per hectare. Assuming 20 houses, the number of inhabitants affected will be 100 per
hectare or 200 for the area affected by flooding. The population of this area is likely to
be in the unskilled income bracket and daily wages are assumed to be DT22 for unskilled
workers for the year 2020. It is assumed that there will be two earners per household
i.e. 80 employees. It is assumed that 2 days income will be lost in the case of present
land use, and 3 in the second case, resulting in income loss of DT3,500 and DT5,000
respectively.

(3) Damage to Roads and Traffic

i)Traffic Flow Data

A major road and a secondary road will be affected. In view of the lack of sufficient data on traffic counts, it is assumed that the estimates for the main traffic flow will be scaled down for the secondary road by a factor of 0.5. According to traffic estimate in 1987 traffic on the Abdelhamid road was estimated to be 15,758 vehicles per day. In assuming the growth rates of GDP till 2000 and the relevant growth rates for traffic flows, it is estimated at 20,000 in 1993, 30,000 in 2000, 45,000 in 2010 and 54,000 in year 2020.

The structure of traffic for Sousse was estimated as follows in 1987:

Private Cars and Taxis   : 48%
Light Vehicles   : 36%
Heavy Vehicles   : 13%
Buses   : 3%

In applying the following occupancy rates the flow of passengers is estimated as shown in the following table:

Table 62   Oued Hallouf - Estimate of Daily Passenger Flow on the Avenue
            Abdelhamid in 2020

Category	Vehicles	Occupancy rate	Total Passengers
Passengers and taxis	25,900	3.8	98,500
Buses	1,600	45	72,000
Light vehicles	19,500	2.0	39,000
Heavy vehicles	7,000	2.0	14,000
Total	54,000		223,500

ii) Estimated Loss of Income due to Traffic Delays

It is assumed that traffic will be halted for 14.1 hours in the present land use situation and 22.8 hours in the future land use situation. The value of time is estimated at 25% of the hourly wages of skilled and unskilled labour. At current rates the appropriate value is estimated to be DT0.5 per hour for skilled labour and DT0.16 per hour for unskilled labour in present conditions. These are assumed to increase in line with expected GDP growth and to be DT2.1/hour and DT0.7/hour respectively in the year 2020. Passengers in private cars are costed at skilled labour rates and the rest at unskilled. On this basis the loss of income in the year 2020 is estimated at DT2.9 million for skilled labour and DT1.2 million for unskilled, a total of DT4.1 million. for the present land use situation. In the future land use situation, these figures are estimated at DT4.7 million and DT2.0 million respectively, a total of DT6.7 million. Losses on the other main roads are taken

at 25% of this value. Total value of time lost on the major roads is therefore estimated to be DT5.1 million and DT8.4 million respectively.

iii) Increased Vehicle Operating Costs

The flooding is expected to cut the major roads rather than damage large sections of it. Adding together the various points which will be affected, it is assumed that damage will occur to approximately 0.5 km of major roads. Increased VOCs are therefore likely to be minimal and a value of DT5,000 per day is proposed. Over a 30 day period, VOC cost are estimated at DT150,000.

iv) Damage to Roads

Assuming road maintenance and rehabilitation costs of DT120,000 per kilometres for major roads the estimated flood damage is estimated to be DT60,000.

(4) ZONE A-Total Estimated Flood Damages

Total losses due to floods on a 100-year return basis in 2020 under present and future land use situation are shown in the following Table.

Table 63   Oued Hallouf : Zone A - Summary of Estimated Flood Damages - Present and Future Situation

	Present	Future
*Persons affected		10,000
	(DT)	
*Loss of Income (Industrial Area)	70,300	117,000
*Damage to Property(Industry)	350,000	500,000
*Damage to Housing	50,000	75,000
*Loss of Income (Residents)	3,500	5,300
*Road Damage	60,000	60,000
*Traffic delays (Income losses)	5,100,000	8,400,000
*Increased Vehicle Operating Costs	150,000	150,000
Total	5,783,800	9,307,300

11.3   ZONE B

(1) Introduction

Under a 100-year return period, flooding will amount to 18.8 ha under present land use conditions and 22.5 ha under future conditions, with durations of 6.5 and 8,2 hours respectively. 25% of the area is currently under industrial use, and a similar figure is assumed for residential use. Flooding will affect the VE 822 and other minor roads.

With future development it is assumed that industrial and residential use will increase and the in the year 2020, each will occupy 40 % of the land.

(2) Estimation of Damages

a) Flooding of the Industrial Areas

The duration of flooding will resulting the loss of one days income. Applying the same ratios of employment as for Zone A (70 workers per ha) to the flooded areas and using 5 ha under present land use and 9 ha under future, income loss is estimated at DT23,500 under present, and DT42,200 under future land use conditions. Damage to factory buildings and equipment is estimated at DT350,000 and DT630,000 respectively.

b) Damage to Housing

Residential areas will cover 5 ha and 9 ha respectively, and damage is estimated at DT125,000 and DT225,000.

c)Loss of Income to residents

With an assumed density of 100 persons per ha, employees affected, on the basis of 2 per household will be 200 and 360. These are likely to be unskilled and loss of income will be DT4,400 and DT8,000 in the two cases.

d) Transport and Traffic Losses

The VE 822 is a secondary road, and it is assumed that traffic will be 25% of that on the major roads in Zone A. However, compared with Zone A, delays will be significantly lower (Present land use conditions : 6.5 hours for Zone B compared to 14.1 hours in Zone B; future conditions: 8.2 hours as against 22.8 for the Avenue AbdelHamid). Based on this ratio, the loss of income to passengers will be DT470,000 and DT600,000 on present and future land use situations. In addition local traffic will also experience difficulties and 10% is added to these costs (Total costs : DT520,000 and DT660,000 respectively). It is estimated that 0.5 km of roads will be affected, and applying rehabilitation costs of DT80,000 per km, total damage to roads is estimated at DT40,000.

(3) Total estimated Flood Damage - Zone B

Damages are summarised in Table 64 for the two land use situations in the year 2020.

Table 64 Oued Hallouf : Zone B - Summary of Estimated Flood Damages - Present
and Future Land Situation in 2020

	Present		Future
		(DT)	
Loss of Income (Industries)	23,500		42,200
Loss of Income (Residents)	4,400		8,000
Damage to Industries	350,000		630,000
Damage to Housing	125,000		225,000
Traffic Delays (Income losses)	520,000		660,000
Increased VOCs	150,000		150,000
Road Damage	40,000		40,000
Total	1,207,900		1,750,200

11.4 ZONE C

(1) Introduction

The majority of this area is presently used for agricultural purposes. This function will
change radically as heavy urban development is proposed. in future development Plans.
Flooded areas in the present and future land use situations are 32.0 ha and 40.5 ha
respectively with durations of 11.7 and 16.3 hours in the year 2020. The following
assumptions are made between the present and future land use situations for the flooded
areas:

Category	Present Land Use		Future Land Use	
	Ha.	%	Ha.	%
Agriculture	18.0	50	4	10
Residential	8.0	20	32	80
Industry	8.0	20	8	10

(2) Estimation of Damages

a) Flooding of Industrial Areas

Assuming 560 workers with a loss of one day's income losses will be DT37,520 in both
present and future land use conditions. Similarly damage will be the same estimated at
DT560,000.

b) Damage to Housing

On the above land use figures, damage in present situation will be DT200,000 and in the
future land use situation DT750,000.

c) Loss of Income to Residents

Based on a density of 100 persons per ha, the number of residents affected will be 800 and 2,000 respectively; employees affected will be 320 and 800 resulting in a loss of one day's income of DT7000 and DT17,000 respectively.

d) Transport and Traffic Losses

(i) Loss of Income due to Delays

Loss of income resulting from delays on the major roads will be DT3.4 Million and DT4.8 million respectively. These are increased by a factor of 25% to cover local roads. Total losses caused by delays will therefore be DT4.25 million and DT6.0 million.

(ii) Increases in VOCs

These are estimated at DT10,000 per day., or DT300,000 in total.

(iii) Damage to Roads

Approximately 1 km of roads (GP 12 and GP 1) will need to be repaired at a cost of DT120,000.

e) Agricultural Losses

Assuming a cost of DT15,000 per hectare damages will amount to DT270,000 under present land use conditions and DT60,000 under future conditions.

(3)Total estimated Flood Damage - Zone C

These are summarised in Table 65.

Table 65 Oued Hallouf : Zone C - Summary of Estimated Flood Damages - Present and Future Land Situation in 2020

	Present	(DT)	Future
Loss of Income (Industries)	38,000		38,000
Loss of Income (Residents)	7,000		17,600
Damage to Industries	560,000		560,000
Damage to Housing	200,000		750,000
Traffic Delays (Income losses)	4,250,000		6,000,000
Increased VOCs	300,000		300,000
Road Damage	120,000		120,000
Agricultural losses	270,000		60,000
Total	5,745,000		7 845,600

11.5 Total Estimated Flood Damage - Oued Hallouf

This is summarised in Table 66.

Table 66 Oued Hallouf - Summary of Estimated Flood Damages - Present and Future Land Situation in 2020

	Present (DT)	Future
Loss of Income (Industries)	131,800	197,200
Loss of Income (Residents)	14,900	30,900
Damage to Industries	1,260,000	1,690,000
Damage to Housing	375,000	1,050,000
Traffic Delays (Income losses)	9,870,000	15,060,000
Increased VOCs	600,000	600,000
Road Damage	220,000	220,000
Agricultural losses	270,000	60,000
Total	12,741,000	18,908,000

12. Oued Hamdoun

12.1 Introduction

The flooded area is mainly agricultural, except for the coastal area between the main road and Port Sidi Abdel Hamid which is mainly industrial. Little future changes in land use are foreseen and there will be minimal difference in flood damage between present and future land use situations.

12.2 Estimation of Damages

a) Damage to Industrial Areas

Zone A is industrial between the main road and the sea, with an estimated area of 6 ha. Assuming 10 factories with a total employment of 350 and a loss of 2 days income, loss of income is estimated at DT47,000. Damage to Industrial buildings is based on 3% of construction costs of DT500 per m2. These costs are inflated by 20% to account for damage to equipment. Building area affected is estimated at 40,000 m2. Total costs are estimated at DT720,000.

b)Damage in Agricultural Areas

About 139 ha are assumed to be affected by flooding. As a proxy for crop loss an assumed value of DT15,000 per ha is taken. Total losses are estimated at DT2,100,000.

c) Transport and Traffic Losses

(i) Loss of Income due to delays

Given the situation of the oued, it is assumed that the traffic affected will be identical to that of Oued Hallouf. Delays experienced will be 10 hours under present land use conditions and 11 hours under future conditions. On a pro-rata basis with Oued Hallouf, damages are estimated at DT2.9 million and DT3.2 million for present and future land use situations. These costs are inflated by 25% to take account of delays on the road to M'Saken and on several secondary roads. Total costs are estimated at DT3.63 million and DT4.0 million respectively.

(ii) Increased VOCs

On a pro-rata basis with Oued Hallouf and assuming 30 days, VOC increases are estimated at DT300,000.

(iii) Road Damage

0.3 km of major roads and 0.7 km of secondary roads will be affected by the flooding. Assuming rehabilitation costs of DT120,000 and DT80,000 per km, total costs are estimated at DT92,000.

12.3 Total Estimated Flood Damage - Oued Hamdoun

This is summarised in Table 67.

Table 67 Oued Hamdoun - Summary of Estimated Flood Damages - Present and Future Land Situation in 2020

	Present	Future
	(DT)	
Loss of Income (Industries)	47,000	47,000
Damage to Industries	720,000	720,000
Traffic Delays (Income losses)	3,630,000	4,000,000
Increased VOCs	300,000	300,000
Road Damage	92,000	92,000
Agricultural losses	2,000,000	2,000,000
Total	6,789,000	7,259,000

C. ESTIMATION OF FLOOD DAMAGES

II. FEASIBILITY STUDY STAGE

THE STUDY
ON
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C. ESTIMATION OF FLOOD DAMAGES

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II. FEASIBILITY STUDY STAGE

II.1 Oued Ennkhilet

1.1 Introduction

The areas which are subject to flooding by the Oued Ennkhilet can be considered under two broad categories : those where the floods can be solely attributed to overflow from the Oued, and those where the floods are due partly to water flows from the Oued, but also to flows from other sources.

Figure 1.1 shows the delineation of these areas under a 100-yr flood. For the purposes of the evaluation they have been divided into different zones. Zones A and B, which will be flooded directly by the Oued Ennkhilet are estimated at 359 ha. The other areas, (Zones C, D, E and F), where flooding is partly due to the Oued Ennkhilet are estimated at 388 hectares. The total flooded areas are expected to remain the same under present and future conditions, although the land use will change within these areas.

An evaluation has also been made for potential damages under 1-yr and 10-yr floods. The Delegations which are located in the flood prone areas directly attributable to flooding from the Oued Ennkhilet consist of Ariana Superieur (Zone A), and Raoued (Zone B). Other areas are located in Borj Louzir (Zones C and D), and parts of Soukra Chotrana (Zones E and F). Basic Socio-economic Data reflecting the different characteristics of these zones is presented below in the evaluation of the specific zones.

1.2 Methodology

1.2.1 Introduction

An assessment of the direct and indirect costs associated with flooding will depend on the extent, depth and expected duration of the floods. An analysis of flood damage is made on two base cases : Impact under present land use conditions, and impact under future land use conditions. Damage assessment has been made for 1-yr, 10-yr and 100-yr return periods.

Flood damage has been assessed in categories related to residential, industrial,

commercial and, agricultural areas; the analysis also considers the effect of flooding on roads and transport movements. The methodology for each of these categories is discussed below.

1.2.2 Damage and Losses in Residential Areas

(1) Introduction

Some residential areas affected, particularly in the immediate vicinity of the Oued include large areas of spontaneous housing. In Ariana Nord it has been estimated that as much as 65% of the housing in certain parts is spontaneous. According to the Revised Urban Plan for the Commune of Ariana, it was estimated that in 1993 more than 600 ha. were illegally occupied, leading to bad control of development of public areas, and the fragmentation of property. This has also resulted in increased flooding due to drainage problems, and pollution of agricultural areas.

It is clear that damage to spontaneous housing will need to be taken into account, since there appear to be no moves by the Authorities to resettle residents to officially designated areas. Indeed, in many cases, the Authorities have provided drainage and water connections to spontaneous illegal housing, thus accepting that this is a permanent situation. Land use estimates have been made of the potentially flooded areas; housing densities and the number of houses affected are based on site visits.

The main damage categories attributable to the flood, will be physical damage caused to buildings and to household effects, and potential loss of income to residents through disruption, which will result in their absence from work for a period of time.

(2) Damage to Buildings

(a) Methodological Approach
There are a number of approaches which can be adopted to estimate potential flood damage. Such hypothetical damage, particularly in residential areas, could be obtained through a comparison of land values for similar property in flooded and non-flooded areas. In normal circumstances, flooding should have an impact on property prices. However, in Tunis, but particularly in the Ariana area, exposure to flooding does not seem to be a contributory factor in determining land and house prices. The range of land prices quoted in Madina El Fadila/El Gazelle varies from DT25 to DT35 per m2, while the range is even higher in Ennkhilet - from DT10/m2 to DT 25/m2. Thus cases even exist where similar neighboring properties in the same area have a considerable price

differential.

It is evident that factors other than potential flooding have a greater influence in determining prices. It is also frequently the case that spontaneous construction itself causes the flooding. It should be noted that in present circumstances, flooding is regarded by occupiers to be a temporary phenomenon, and therefore to be considered a nuisance.

Another approach to estimation of flood damage - the contingent valuation approach ("assessment of the willingness to accept compensation for the inconveniences caused by flooding") is considered invalid, in view of the infrequency, and little damage actually experienced in recent years. The assessment of flood damage cannot in this case be based on actual experience.

Difficulties are likely to be encountered in arriving at unbiased and undistorted opinions about the "willingness to pay" of the different respondents. Actual market behavior relating to, for example, property values in flooded as against non-flooded areas has been distorted by the pressure on accommodation within most of the urban area, and it would be extremely difficult to assign realistic values to any hypothetical environmental improvements.

A separate approach to evaluation of the likely benefits of the projects is to use the hedonic method as applied to property prices, between flooded areas and similar homogeneous areas. In principle, the difference in values is taken as an indicator of the likely premium paid to avoid the inconveniences and damage caused by flooding. However, an investigation of the municipal rates shows that these reflect neither the true value of properties nor the environment in which they are located, but are set rather on an basis which does not reflect economic factors. Property values are therefore not considered to be a valid basis for estimating flood damage in the Ariana/Chotrana area.

The approach which is adopted here for the estimation of flood damage is based on assigning hypothetical values for repairing and rehabilitating buildings in relation to construction costs for different categories of buildings.

(b) Assumptions
Increasing urbanisation is a phenomenon which is likely to carry on in the potentially floodable areas in the Ariana/Chotrana districts. Land use has been estimated for these areas under present and future conditions. The impact of flooding on buildings will be felt on the deterioration of foundations and rehabilitation required in repairing walls and

plaster work and other physical damage. Since it is impossible to carry out surveys on all individual buildings likely to be flooded, some general criteria is used.

Estimation of typical construction costs is notoriously difficult in view of physical factors relative to specific sites. An analysis of data provided by SNIT (Study of Construction Costs of Buildings in Tunis - Etude des couts de production des logements dans le District de Tunis), indicates that foundation costs vary between 5% and 12% for SNIT buildings, and are generally around 8% in the private sector. The cost of interior decoration and glass used is between 5% to 6%. These costs are generally therefore between 10% and 18%. For the purposes of the analysis, it is assumed that in a 100-year flood, damage could amount to 10% of construction costs.

Construction costs naturally vary considerably depending upon the nature of terrain and type of construction and finish. Housing in the Ariana area can be generally divided into three categories as shown below (Costs have been estimated through discussion with the relevant Departments of MOEH, District of Tunis, as well as the Agence Foncier de l'Habitation).

```
*Popular/social housing (including
  spontaneous housing)        :DT150/m2 to DT200/m2
*Medium standard housing      :DT250/m2 to DT300/m2
*High Class/Villas            :DT350/m2
```

Flood damage is assessed at 10% of these costs.

Housing Density is based on site visits and data from other studies, in particular the Master Drainage Plan of ONAS, the 1984 Population Census, and Specific Reports prepared by the Ariana Governorate and the District of Tunis. In the Chotrana area housing plots vary from 50 m2 to 4 ha For spontaneous and popular housing, average typical constructed areas of 60 m2 are assumed, for medium standard housing coefficients of 100m2 and for high class housing 150 m2.

(3) Losses of Household Articles

The value of typical items of household articles in a middle class house, is estimated at around DT3,500. This includes refrigerators, cookers, furniture, carpets, mattresses, clothes and food items. Experience in other countries indicates that flooding of up to 1 meter results in damage of around 10% to household articles. This climbs significantly to nearly 70% at a height of more than 3 meters.

It is unlikely in view of the nature of the terrain that flood depth in Ariana will exceed 1 meter. It is therefore proposed to use 10% of the value of goods as indicative of the likely flood damage (i.e. DT350 per house).

(4) Losses of Income to Residents

It is assumed that disruption caused by flooding will result in loss of income to residents and households. The number of workers per household will vary according to the active population and the level of unemployment in different areas. Ariana is a mainly commercial and services area with an important Industrial Estate located at Charguia, (but out of the flooded areas). The breakdown of employment in the District was estimated as follows;

<u>Ariana : Breakdown of Employment (%)</u>

Sector	1984	1989
Agriculture	17.9	17.2
Industry	37.1	35.8
Services	45.0	47.0

Source : Commune of Ariana, Revision of the Urban Development Plan, Feb. 1991.

Statistics on active population and employment in the Ariana Governorate indicate that generally employment was around 1.6 workers per household. However, this figure is likely to be misleading, since it does not take into account the informal sector. Accordingly, it is assumed that there will be 2 workers in each household.

Projections of wages have been made till the year 2020 based on increasing incomes in line with expected growth of GDP (6% p.a. till the year 2000, 5.5% between 2000 and 2010 and 5% between 2010 and 2020). On this basis, estimates for skilled labor are DT16 per day at present and DT67 per day in 2020, and for unskilled labor DT5 and DT22 respectively.

1.2.3 Losses to Industry and Commercial Enterprises

In a 100-year flood a considerable number of commercial and industrial enterprises on the RVE 533 will be affected. Losses can be measured in this sector in terms of loss of income for workers, actual damage to the physical assets of a company and disruption to factories resulting in higher costs for the delivery of raw materials and transport of finished products. In order to account for periods of starting up after flood, additional days of inconvenience will be felt beyond the period of flooding.

It is assumed that damage to industrial buildings will be less than to residential buildings, in view of their more basic construction and simpler decoration. Since most of the industry is of a light or commercial nature, actual physical damage will not be significant, and damage is assumed at 5% of construction cost, estimated at DT300/m2 i.e. DT15/m2. In order to estimate the number of workers , data is taken from the Industrial Survey of the Charguia Estate as being typical The average employment per factory unit was 33 (see Table 1.1). The loss of income for workers for the duration of the flooding is based on the estimated wages, as calculated above.

1.2.4   Losses to Agriculture

There has been considerable loss of agricultural land to housing and this can be expected to continue as urban areas expand. In the meantime, flooding will also cause losses to agricultural crops. Major crops grown include vegetables, irrigated cereals, animal foodstuffs and root crops. There is also some arboriculture, olive tees and citrus. Table 1.2 shows estimated areas cultivated and productivity in the plain of Soukra/Chotrana.

Productivity of the land varies enormously as do prices of crops. For olives it is proposed to use a figure of 10 tons per ha (Assuming a density of 200 trees per ha, and an average productivity of 50 kg per tree) which at current prices (DT0.160/kg), puts a value of the crop at around DT1,600 per ha.

With regard to vegetables, a wide range of crops are grown in the area. Productivity varies from 3.8 tons per ha for cereals to 35 tons per ha for root crops (the latter is based on a number of crops per year). Winter crops have a productivity of 9 tons per ha and it is proposed to use this as a basis for calculating damage loss. Assuming a medium price level of DT0.200/kg, losses are estimated at DT1,800 per ha per crop.

In the Ariana area most of the olive trees are cultivated on higher levels which will not be affected by the flooding. It is therefore assumed that the majority of the crops in the flooded areas will be vegetables. For the evaluation, it is assumed that 75% of areas will be devoted to vegetable and the rest to arboriculture. On this basis the typical loss per hectare of agricultural crops is estimated at DT1,750.

1.2.5 Losses to Transport

(1) Road Damage

It is assumed that in both present land use conditions and expected future land use, roads flooded will need rehabilitation. Construction costs for a new two way road are estimated at around DT240,000 (excluding taxes). Rehabilitation costs are estimated at 50% of the construction cost, and are assumed at DT120,000 per km for primary roads and DT80,000 per km for secondary roads, based on a general estimate provided by the Department of Bridges and Roads. The construction costs for basic agricultural roads (pistes) are estimated at DT25,000 per km.

The major road affected will be the RVE 533. Secondary roads will also be affected, particularly in Borj Louzir and Chotrana. Future plans mentioned in the Urban Development Plan include the extension of the X 20 across Soukra and Chotrana. There are also number of agricultural roads in the area.

(2) Traffic Delays and Value of Time

For the purposes of the evaluation, it is assumed that the roads will under 100-yr flood condition be cut off for the duration of the floods. This will entail delays and diversions to other roads, and will result in loss of income. Damages and losses will be less under 1-yr and 10-yr flood conditions.

The number of passengers affected is based on the vehicle occupancy rates from the 1989 Survey of traffic in Tunis, carried out by the Ministry of Transport; traffic projections are based on GDP growth rates.

The value of time of passengers is calculated on forecasts of wages to the year 2020 (see Paragraph 1.2.2). In transport studies generally, the loss of leisure time is calculated at 20% of salary levels, and that of business time at 33% of hourly income. Due to lack of sufficient data in the traffic surveys on purpose of journeys it is proposed to apply an average factor to all journeys. The value of time is therefore taken at 25% of earnings.

At current rates the appropriate value is estimated to be DT0.5 per hour for skilled labor and DT0.16 per hour for unskilled labor at present. These are assumed to increase in line with expected GDP growth and to be DT2.1 per hour and DT0.7 per hour respectively in the year 2020.

It is further assumed that passengers in private cars and taxis will be in the skilled labor bracket and all others (using buses, trucks and passengers on two wheels) will be unskilled.

(3) Increased Vehicle Operating Costs

There are two elements of costs involved here. Additional operating costs due to the diversion, and increased vehicle costs due to travel on damaged roads. While it is assumed that the level of flooding will be sufficient to halt traffic completely during the period of inundation, a further impact will be felt in the increased operating costs experienced by vehicles both as a result of more difficult operating conditions and following the degradation in the road surface. This additional cost should be included in the damage assessment. For the purposes of the evaluation it is assumed that the increased operating costs apply for the duration until the road is repaired.

The costs of increased vehicle operation are based on assumptions from the World Bank HDM III model, assuming different degrees of roughness of surfaces in a "with" and "without" situation.

On the basis of the HDM III model, it is assumed that in the "without project case" the section of road affected by flooding is in poor shape, with visible irregularities and shape defects, (this represents a "roughness " level of 71.5 to 91 m/km). In the "with project case" i.e. without flooding, the state of the road is considered as high quality asphalt road (i.e. with a specification of 21-33 m/km). The difference in vehicle operating costs between these categories of road are shown in Table 1.3.

These rates are applied to the existing and forecast traffic flows. It is assumed that damage to road surfaces will be the same in cases of present and future land use conditions, but duration of flooding will be different.

1.2.6 Other Factors

The major unquantifiable factor here is the impact on health. This is difficult to assess due to lack of sufficient data, and the problem of attributing diseases to local flooding problems, rather than other causes which may lie outside the study area.

Interviews with the Health Authorities indicate that flooding and stagnant water has not hitherto caused the contraction of any serious water-borne diseases among residential populations. This is a potential problem for which concern has been expressed. An

analysis of present flooding shows that overflows from the oued are only one of several causes creating unhealthy environments.

The following are contributory factors for which solutions will need to be found:

-the overloading of networks due to encumbrance from solids - erosion of hills, as well as waste from housing and other works
-the malfunctioning of the secondary networks particularly in housing areas
-increased flows due to high rates of urbanization in previously agricultural areas
-construction of numerous obstacles and the infilling of the Oued, particularly in zones of spontaneous housing
-insufficient maintenance works

A further potential hazard is the disruption likely to be caused to the ONAS treatment plant, although the Plant itself is unlikely to be affected by flooding.

1.2.7 Summary of Coefficients used in Estimating Flood Damage

The various factors and coefficients used for estimating flood damage are summarized as follows; It is difficult to estimate future inflation rates for property and commodities, wages are assumed to rise in line with GDP. For other factors, present rates are maintained . Future damage estimates are therefore conservative, and these items can be subject to sensitivity studies.

Summary of Coefficients Used to Estimate Flood Damage (DT)

Category	Coefficient	
	Present (1993)	Future (2020)
1. Residential Areas		
(i) Damage to Buildings		
*Popular/Spontaneous Housing	15/m2	15/m2
*Medium Standard	25/m2	25/m2
*High Standard	35/m2	35/m2
(ii) Damage to Household Articles		
(per household)	350	350
(iii) Loss of Income to Households (DT per day)		
*Skilled	16	67
*Unskilled	5	22
2 Industrial Sector		
(i) Damage to Buildings	15/m2	15/m2
(ii)Loss of Income to workers	(as per households)	
3 Agricultural Sector (per hectare)		
(i) Value of Olive Crops	1,600	1,600
(ii)Value of vegetable crops	1,800	1,800
(ii)Average loss per ha.	1,750	1,750

4. Transport

(i) Rehabilitation of Roads (per km)
*Primary   120,000   120,000
*Secondary   80,000   80,000
*Agricultural Roads   25,000   25,000
(ii) Traffic Delays/Value of Time (DT per hour)
*Skilled Labor   0.5   2.1
* Unskilled Labor   0.16   0.7
        *Tourists   1.0   4.0
(iii) Additional Vehicle Operating Costs (DT per 1,000 km)
*Private Cars/taxis   28.79   28.79
*Buses   51.60   51.60
*Light/Medium trucks   86.11   86.11
*Heavy trucks   236.73   236.73

1.3 Evaluation of Flood Damage - Directly Flooded Areas

1.3.1 Introduction

As noted above flood prone areas can be considered under two categories. Those where flooding can be attributed 100% to overflows from the Oued Ennkhilet, and those where there are other sources as well (see Figure 1.1). Estimates are made below based on 100-yr, 10-yr, and 1-yr flood conditions.

In this section estimates are made for directly flooded areas. The flooded area can be considered in two parts, the area to the west of the RVE 533 (referred to as Zone A), and the other area to the east (Zone B).

1.3.2 Zone A - Upper Ariana (Ariana Superieur)

(1) Characteristics of the Area

This is largely a residential area, planned for urban expansion. It consists of the El Madina El Fadhila. In addition to the damage caused to residents and property within the area, a large section of the side e of the RVE 533 which borders the zone will be affected by the flooding.

Land use for the affected areas under a 100-yr flood in present and future conditions is estimated as follows;

Oued Ennkhilet -Estimated land use in the flood prone areas - Zone A (ha)

	Present land Use	Future Land Use
Residential	44.0	112.0
Agricultural	65.0	0.0
Commercial	2.0	3.0
Recreational	0.0	0.5
Wetlands	0.0	0.0
Open Space	6.0	1.0
Infrastructure(schools)	0.0	0.5
Total:	117.0	117.0

(2) Loss of Income to Residents

The range of housing consists of spontaneous, and medium to upper standard house; there are also a few apartment blocks, and a popular housing development at the edge of the flood prone area. Data of the last Census can be considered to be outdated in terms of the composition of housing in view of the large urban expansion in the area in recent years. The area of New Ariana had an average density of 4.9 persons per household (3,045 houses, 2,783 households and a resident population of 13,722).

On the basis of densities of 120 persons per ha at present and 140 per ha in the future, population affected is estimated to be 5,280 at present and 15,680 in the future. Assuming 4.9 persons per household, the total number of households affected will be 1,080 and 3,200 respectively. It is further assumed that there will be two workers per household, i.e. 2,160 and 6,400.

An analysis of the housing data forecast for the year 2011 by ONAS, indicates that 75% of the housing will be popular housing, 17 % medium standard, and 8% high standard. These housing ratios are used as proxies for calculating lost income insofar as 75 % of the population will consist of unskilled and the rest of skilled workers.

With a duration of flooding estimated at 12 hours at present and 24 hours in 2020 under future land conditions it is assumed that two full working days will be lost. Total income losses for residents are estimated to be in present land use conditions DT18,000 for skilled and DT5,500 for unskilled labor. Under future land use conditions these figures are DT221,000 for skilled workers, and DT218,000 for unskilled workers. Total loss of income is therefore estimated to be DT23,500 under present land use conditions, and DT439,000 under future land use conditions.

(3) Damage to Residential Buildings

The breakdown by type of building estimated in the ONAS Drainage Master Plan, is used to calculate potential flood damage. These factors are applied to the number of households and the relevant damage factors per m2 are used as shown in Table 1.4.

Total damages to buildings in this zone are therefore estimated to be DT1,641,000 under present land use conditions, and DT17,104,000 under future land use conditions.

(4) Damage to Household Articles

On the basis of losses of DT350 per household damages are estimated at DT378,000 under present land use conditions, and DT1,120,000 under future land use conditions.

(5) Losses in the Industrial and Commercial Sectors

Commercial and some light industrial enterprises located along the RVE 533 will be affected by the flooding. Areas of 2 ha under present land use and 3 ha under future land use will be affected. Assuming that some 50 units will be affected, with average employees of 30, the total number affected will be 1,300. It is assumed that there will be a loss of income over two days under present land use conditions and 3 days under future conditions; it is further assumed that half the employees are skilled. Losses are is estimated at DT127,300 and DT173,500 respectively.

There will also be damages to commercial and industrial buildings. Using a criteria that 80% of these surfaces will be covered by buildings, areas affected will be 16,000 m2 and 24,000 m2 respectively, resulting in damages estimated at DT240,000 and DT340,000.

(6) Losses in the Agricultural Sector

It is estimated that at present 65 ha of agricultural land in Zone A is prone to flooding. Assuming the loss of crop at an average of DT1,750 per ha. total losses at present are estimated to be DT113,750.

(7) Transport and Traffic Losses

(a) Introduction
Flooding from the Oued Ennkhilet will have a number of consequences for different types of traffic.

* The major impact will be on the RVE 533, which is expected to be affected for a period of 12 hours under present land use conditions, and 24 hours under future land use conditions. These conditions will result in diversions and some delays.

* Secondly, there will considerable inconvenience to the populations of Ariana Superieur, Raoued and parts of Borj Louzir and Soukra Chotrana.

* Thirdly, there will be a backup effect on traffic on the GP-8 which will entail considerable delays.

Assumptions are made below in order to estimate these various impacts.

(b) Traffic Flow Data

No detailed traffic counts are available for the sections of road expected to be flooded - the RVE 533 and local roads within the Zones affected. The Transport Study for Greater Tunis carried out in 1989 indicated that traffic on the GP8 in Ariana was estimated to be around 25 000 vehicles per day. In applying the GDP growth rates and the relevant growth rates for traffic flows, it is estimated that traffic will reach 46,800 v.p.d. by 2000, 69,000 v.p.d. by 2010 and 84,500 v.p.d. by the year 2020.

The structure of traffic for the GP 8 is estimated in the traffic Census as follows:

Private cars and Taxis   : 51%
Light vehicles   : 24%
Heavy Vehicles   : 22%
Buses   : 2%
Others (2 wheels)   : 1%

In applying the following occupancy rates the flow of passengers is estimated on the North-South axis to be as shown in Table 1.5 for the year 2020. It is estimated that the total number of passengers will reach around 320,000.

The RVE 533 mainly serves the residential population in the communes of Raouad, Ariana Superieur and Borj Louzir. In order to estimate the traffic movements for these areas, data concerning Ariana town is used from the Master Transport Plan for the District of Tunis. With a population of 55,289 (11,350 households), daily traffic was estimated as follows;

2 wheels   : 2,011
Public Transport   : 29,893
Private cars and taxis   : 62,123
Total: : 94,027

According to the Traffic Census, the average journeys per person per day were estimated

at 1.7 in Ariana. This ratio is applied to the populations in areas affected by the flooding. It is assumed that 50% of the population of Ariana Nord will be affected in terms of traffic movements. i.e. populations of 62,500 at present and 179,000 in the year 2020. Thus passenger movements on the RVE 533 are estimated at 105,400 per day at present, and 304,300 in the future. These estimates are used below to evaluate flood damage on the transport sector.

(c) Estimated Loss of Income due to Traffic Delays

For the GP8, it is assumed that in the event of a 100-year flood, delays to traffic will amount to 1 hour. In applying the relevant rates for the value of time to the above passenger flow, it is estimated that losses under present conditions will amount to DT31,600.

With regard to future land use conditions it is assumed that delays will reach two hours. Using future traffic estimates and incomes, losses will amount to DT905,600.

With regard to present traffic on the RVE 533 (105,400 movements per day) and assuming delays of 2 hours at present, estimated losses for the value of time are DT69,600 for skilled (private cars and taxis), and DT11,500 for unskilled labor (other transport) - a total of DT81,100 under present land use conditions.

Assuming that traffic movements will grow in line with population growth , there will be an estimated 304,000 movements per day of population in the area, of which 200,640 will be in private cars and taxis, and 103,360 in other forms of transport. Assuming 3-hour delays in the future, losses due to traffic delays are estimated at DT1,264,000 for skilled and DT217,000 for unskilled labor - a total of DT1,481,000.

(d) Increased Vehicle Operating Costs

There is not expected to be any major damage to the RVE 533 and therefore it is not expected that there will be any increased VOCs involved. There will however be some damage to local roads resulting in higher operating costs, and a notional amount of DT10,000 is allocated to this aspect, under present conditions. In the future these costs can be expected to increase in line with traffic growth, and are estimated at DT30,000.

(e) Damage to Roads

Local roads will also be affected. In applying a ratio of 1 km of local roads per 10 ha of surface area, around 10 km of these roads will be affected. Assuming a rehabilitation cost of DT80 000 per km the total damage to local roads could be around DT800,000.

(8) Summary of Damages to Zone A

Potential flood damages in this zone under 100-yr flood condition are summarized as follows;

Oued Ennkhilet - Zone A - Estimated Flood Damage (DT1,000)

Category	Land Use Conditions	
	Present	Future
Losses to Residents		
Loss of Income to Residents	23,500	439,000
Damages to Household Articles	378,000	1,120,000
Damage to Residential Buildings	1,614,000	17,104,000
Losses to Industrial Sector		
Loss of Income	127,300	173,500
Damage to Buildings	240,000	360,000
Losses to Agricultural Sector	113,750	Nil
Losses in the Transport Sector		
Delays GP-1	31,600	905,600
Delays -local traffic	81,100	1,481,000
Increased VOCs	10,000	30,000
Road Rehabilitation	800,000	800,000
Total:	3,419,250	22,413,100

1.3.3 Estimation of Damages - ZONE B

(1) Characteristics of the Area

The land use of the flood prone area in 100-yr flood conditions is summarized as follows for present and future land use conditions;

Oued Ennkhilet -Estimated land use in the flood prone areas (ha)

	Present Land Use	Future Land Use
Residential	41.0	127.0
Agricultural	66.0	32.0
Commercial	0.0	0.0
Recreational	0.0	1.2
Wetlands/Inundated areas	7.0	40.0
Open Space	124.0	40.0*
Infrastructure(schools)	4.0	1.8
Total:	242.0	242.0

*Note Assigned for Petroleum Storage

Urbanization will proceed rapidly at the expense of agricultural areas and open areas. One main change of land use will the use of space for petroleum storage.

(2) Loss of Income to Residents

This zone is particularly noted for anarchic/spontaneous housing. Apart from one small area of planned housing, the majority of houses are of anarchic lower quality houses. Density in this area is less than in other parts of Ariana. According to the 1984 Census, this area had a density of 3.99 persons per household as well as fewer houses.

In estimating the population affected by potential flooding, it is proposed to use a density below that of Ariana as estimated by ONAS, i.e. 80 persons per ha. against an average of 120. On this basis, the population affected in Zone B is around 3,300 under present conditions.

Density can be expected to increase in the future and on the basis of 120 persons per ha. Population affected in the future will be around 15,000. Assuming 4.0 persons per household, the total number of households affected will be 825 at present and 3,750 in the future.

On this basis, the number of workers in the area will be 1,650 and 7,500 respectively. It is assumed that half of these workers will be unskilled, given the preponderance of anarchic housing. Duration of flooding in a year flood is estimated at 24 hours under present and 35 hours under future conditions. Two full working days will be lost as a result of the flooding.

Total income losses for residents are estimated to be in present land use conditions DT26,400 for skilled and DT8,250 for unskilled labor. Under future land use conditions these figures are DT502,500 for skilled workers, and DT165,000 for unskilled workers. Total loss of income is therefore estimated to be DT34,650 under present land use conditions, and DT667,500 under future land use conditions.

(3) Damage to Residential Buildings

825 households will be affected by flooding at present, and 3,750 in the future. These will be divided equally between social and medium standard housing, with areas of 60m2 and 100 m2 respectively. Total areas affected will be 66,000 m2 at present and 300,000 m2 in the future, resulting in damages of DT825,000 and DT6,000,000.

(4) Damage to Household Articles

On the basis of losses of DT350 per household damages are estimated at DT288,750

under present land use conditions, and DT1,312,500 under future land use conditions.

(5) Losses in the Industrial and Commercial Sectors

There will be no losses in this area.

(6) Losses in the Agricultural Sector

There are at present 66 ha of agricultural land prone to flooding in Zone B. These will reduce to 32 in the future. Assuming the loss of crop at an average of DT1,750 per ha, total losses at present are estimated to be DT115,500, and in the future at DT56,000.

(7) Transport and Traffic Losses

The losses in this sector to residents in terms of lost income and traffic delays have already been included in the estimates of Zone A. There will be additional damage to local roads. There are around 10 km of roads in Zone B. At rehabilitation costs of DT80,000 per km total cost of rehabilitation is estimated at DT800,000. With the development of the area in the future , 200 km are expected to be developed; assuming 1 km of road per 10 ha it can be expected that there will be 20 km of roads and damage will double to DT1,600,000.

A notional amount of DT10,000 under present conditions and DT20,000 under future conditions is proposed to cover increased vehicle operating costs.

(8) Summary of Damages to Zone B

Potential flood damages in this zone under 100-yr flood conditions are summarized as follows;

<u>Oued Ennkhilet - Zone B - Estimated Flood Damage (DT1,000)</u>

Category	Land Use Conditions	
	Present	Future
<u>Losses to Residents</u>		
Loss of Income to Residents	34,650	667,500
Damages to Household Articles	288,750	1,312,500
Damage to Residential Buildings	825,000	6,000,000
<u>Losses to Industrial Sector</u>	Nil	Nil
<u>Losses to Agricultural Sector</u>	115,500	56,000
<u>Losses in the Transport Sector</u>		
Road Rehabilitation	800,000	1,600,000
Additional VOCs	10,000	20,000
<u>Total:</u>	<u>2,073,900</u>	<u>9,656,000</u>

1.3.4 Estimates of Flood Damage - Directly Flooded Areas

The total Damages estimated for the areas which where flooding is entirely due to overflows from the Oued Ennkhilet are estimates as follows for 100-yr flood conditions.

Zone	Present Land Use Conditions	Future Land Use Conditions
A	3,419,250	22,413,100
B	2,073,900	9,656,000
Total:	5,493,150	32,069,100

1.4 Estimation of Damages - Partly Affected Areas

1.4.1 Introduction

These areas will be affected to different degrees by the flooding of the Oued Ennkhilet, since flows from other areas also contribute to the flooding. it is assumed that those nearer the Oued will be affected to a greater extent than those further away. Figures 1.1 shows the delineation of these areas.

For the purposes of the evaluation the effect of the Oued in terms of flooding impact is estimated at 10 % of estimated flood damage in these areas.

The evaluation is carried out below jointly for Zones C and D together, and E and F since they are of a similar nature.

1.4.2 Assessment of Damages caused by Flooding under Present Land Use Conditions

(1) Characteristics of the Areas Affected

It is estimated that a total of 388 ha will be subject to some degree of flooding from the Oued Ennkhilet under 100-yr flood conditions. Present land use in these areas is summarized as follows;

Oued Ennkhilet -Estimated Present land use areas partially flooded (ha)

Zones	C	D	E	F	Total:
Residential	32.0	46.0	25.0	0.0	103.0
Agricultural	0.0	16.0	75.0	32.0	123.0
Commercial	0.0	0.0	0.0	0.0	0.0
Wetlands	0.0	15.0	0.0	42.0	57.0
Open Space/Recreation	32.0	51.0	0.0	18.0	101.0
Infrastructure(schools)	4.0	0.0	0.0	0.0	4.0
Total:	68.0	128.0	100.0	92.0	388.0

It can be seen from above that 41% of the areas are at present open spaces and wetlands. The major impact of the flooding will be on the population and on agricultural areas.

(2) Estimates of population affected

A total of 103 ha of residential land will be affected. It is evident that areas C and D which are closer to the major roads have a higher density of population than areas E and F. In using the average density estimated for Ariana by ONAS (120 per ha) for the former and 100 persons per ha for the latter, total population affected is estimated to be around 9,500 in areas C and D, and 2,500 in areas E and F. These had high densities according to the 1984 Census (5.25 persons per household in Soukra, 5.45 in Chotrana, and 4.81 in Borj Louzir). Assuming an average of 5 persons per household, the total number of households are estimated at 1,900 and 500 respectively.

(3) Loss of Income to Residents
Under 100-yr flood conditions, duration of flooding is estimated at 24 hours under present and 35 hours under future land use conditions. Assuming a 50:50 breakdown between skilled and unskilled labor, and flood duration over two days, income losses are estimated at DT80,000 for areas C and D, and DT21,000 for areas E and F.

(4) Damage to Residential Buildings

In areas C and D there appears to be less spontaneous housing than in areas E and F. For the former, it is assumed that only 20% of the housing is spontaneous, while in the latter the majority, 80% is assumed. On this basis housing areas affected is estimated to be 152,000 m2 of medium standard housing and 23 000 m2 of lower standard housing in areas C and D, and 24,000 m2 of lower standard and 10,000 m2 of medium standard housing. Applying damage factors of DT25/m2 and DT15/m2 respectively, damage to buildings is estimated at DT4,145,000 in Areas C and D, and DT610,000 in areas E and F.

(5) Damage to Household Articles

On the basis of a loss of DT350 per household damage is estimated at DT665,000 for Zones C and D, and DT350,000 for Zones E and F.

(6) Losses in the Industrial and Commercial Sectors

No losses are expected in these sectors.

(7) Agricultural Areas

On the basis of the loss of one harvest at an average value of DT1,750 per ha losses are estimated at DT28,000 in zones C and D, and DT188,000 for Zones E and F.

(8) Damage to Roads

Local roads will be affected by floods. It is estimated that in areas C and D there are approximately 15 km of roads. At rehabilitation costs of DT80,000 total damages are estimated at DT1,200,000. Areas E and F have sparse population at the moment. Total roads are estimated at 5 km. Damages are estimated at DT400,000

(9) Summary of Flood Damages under Present Land Use Conditions

Total flood Damages in partially affected areas in a 100-yr flood under present conditions are estimated as follows;

	Areas C and D (DT)	Areas E and F (DT)
Loss of Income to residents	80,000	21,000
Damage to Buildings	4,150,000	610,000
Damage to Household Articles	665,000	350,000
Damage in Agricultural areas	28,000	188,000
Damage to Roads	1,200,000	400,000
Total:	6,123,000	1,569,000

Assuming that flooding is partly due to the Oued Ennkhilet, 10 % of the total is allowed, i.e. DT615,000 and DT157,000 - a total of DT772,000.

1.4.3 Assessment of Damages caused by Flooding under Future Land Use Conditions

(1) Characteristics of the Areas Affected

It is estimated that a total of 388 ha. will be subject to some degree of flooding from the Oued Ennkhilet in a 100-yr flood. Future land use in these areas is summarized as follows;

Oued Ennkhilet -Estimated Future land use in the flood prone areas (ha)

Zones	C	D	E	F	Total:
Residential	64.0	57.0	53.0	0.0	174.0
Agricultural	0.0	0.0	0.0	14.0	14.0
Commercial	0.0	0.0	0.0	0.0	0.0
Wetlands	0.0	38.0	40.0	28.0	106.0
Infrastructure(schools)	4.0	9.0	0.0	0.0	13.0
Open space/recreation	0.0	24.0	0.0	*50.0	74.2
Total:	68.0	128.0	100.0	92.0	388.0

*Note : Area reserved for Petroleum Storage

It can be seen from above that residential areas have increased substantially at the expense of agricultural lands, which are expected to be almost non existent. Open and recreational land has also reduced by over 25%

(2) Estimates of Population Affected

The rapid increase in population will result in 174 ha of residential areas in the future -121 ha in zones C and D, and 53 in zones E and F. In using the average density estimated for Ariana by ONAS of 140 per ha in the future, total population affected is estimated to be around 17,000 in areas C and D, and 7,500 in areas E and F. Assuming an average of 5 persons per household, the total number of households are estimated at 3,400 and 1,500 respectively.

(3) Loss of Income to Residents

Assuming a 50:50 breakdown between skilled and unskilled labor, and flood duration over two days, income losses are estimated at DT605,000 for areas C and D, and DT267,000 for areas E and F.

(4) Damage to Residential Buildings

In evaluating damages in the future it is assumed that all houses in areas C and D will be of medium standard   On this basis housing areas affected are estimated to be 340,000 m2. Applying damage factors of DT25/m2 damage to buildings is estimated at DT8,500,000   For areas E and F it is assumed that all new building will be of medium type construction, and the ratio of spontaneous housing to total will drop to 25%. There will therefore be 112,500 m of medium type, and 22,500 m2 of lower standard housing. Damage to buildings is therefore estimated at DT3,150,000.

(5) Damage to Household Articles

On the basis of a loss of DT350 per household damage is estimated at DT1,200,000 for Zones C and D, and DT525,000 for Zones E and F.

(6) Losses in the Industrial and Commercial Sectors

No losses are expected in these sectors.

(7) Agricultural Areas

There will be no agricultural areas in areas C and D, and only 14 ha. in areas E and F. On the basis of the loss of one harvest at an average value of DT1,750 per ha. losses are estimated at DT24,500 for Zones E and F.

(8) Transport and Traffic Losses

Local roads will be affected by floods. In applying a factor of 1 km of local roads for every 5 ha. total roads in areas C and D are expected to be around 25 km. At rehabilitation costs of DT80,000, total damages are estimated at DT2,000,000. In areas E and F there will be 53 ha of constructed areas, and 10 km of local roads. Total damages in this are will be DT800,000.

(9) Summary of Flood Damages under Future Land Use Conditions

Total flood Damages in partially affected areas under future conditions in a 100-yr flood are estimated as follows;

	Areas C and D	Areas E and F
Loss of Income to residents	600,000	267,000
Damage to Buildings	8,500,000	3,150,000
Damage to Household Articles	1,200,000	525,000
Damage in Agricultural areas	Nil	25,000
Damage to Roads	2,000,000	800,000
Total:	12,300,000	4,767,000

10 % of future damages are allocated to flooding from the Oued Ennkhilet - a total of DT1,707,000.

1.5   Estimate of Total Damages

1.5.1   Potential Damages in a 100-yr Return Period Flood

The estimate of total flood damages caused by the Oued Ennkhilet in flood prone areas is estimated as follows;

Areas	Present Land Use (DT)	Future Land Use (DT)
Directly Flooded Areas	5,493,000	32,069,000
Indirectly Flooded Areas	773,000	1,707,000
Total:	6,266,000	33,776,000

1.5.2   Potential damages in a 1-yr and 10-yr Return Period Floods

The overall potential damage likely to be caused in 1-yr and 10-yr return period floods under present and future land use conditions are shown below. These are based on estimates of flood areas and duration of flooding (see Chapter 7, Main Report). Details of flood damage by zone for these return periods are shown in Tables 1.6 to 1.9.

Areas	Present Land Use (DT)		Future Land Use (DT)	
	1-yr	10-yr	1-yr	10-yr
Directly Flooded Areas	921	2,499	4,998	14,712
Indirectly Flooded Areas	133	331	346	885
Total:	1,054	2,830	5,344	15,597

ESTIMATION OF FLOOD DAMAGES

II. FEASIBILITY STUDY STAGE

II.2 Oued Hammam

2.1 Introduction

2.1.1 General Background

The areas affected by flooding in the Oued Hammam lie within the Communes of Hammam Sousse, Akouda, and Kalaa Kebira. The impact of flooding will be felt in residential, agricultural, and industrial and commercial areas. In addition to the specific impact, a general impact will be felt on population residing within the vicinity of the Oued and on transport flows within and between some of these areas.

The assessment of damages is estimated for different sections of the Oued in order to enable separate evaluations to be made for the alternative works proposed and to enable proper phasing so as to optimize expenditure. The evaluation is based on the extent and duration of potential flooding estimated by the Consultants, and on interviews with Officials and local residents concerning their judgements on the impact of previous floods. These are only considered as indications, since the last major floods occurred in 1969. No specific damage assessments of previous floods have been made in the past for Oued Hammam.

2.1.2 Population Affected

The zone of influence of potential flooding will extend beyond the flood-prone areas since it will indirectly affect the populations in the Communes located in the vicinity. All these Communes have high rates of urbanization - Akouda 81.6%, Kalaa Kebira 87.17% and Hammam Sousse effectively 100%. According to the Urban Master Plan for the Sousse-Monastir area, these towns will continue to be important centers of urban expansion in the future. Projections of population are made on the basis of growth rates to the year 2002 from the latest Urban Development Plans for Akouda and Hammam Sousse (Plan d'Amenagement Urbain de la Commune de Hammam Sousse, et Plan d'Amenagement Urbain de la Commune d'Akouda, 1991), and those for Kalaa Kebira based on forecasts of the Urban Master Plan for Sousse-Monastir (Plan de Developpement Urbain pour la Conurbation de Sousse- Monastir, 1993).

The rate of growth for Hammam Sousse is estimated at in the Plan at 5.97%. However, such a rate cannot be expected to be maintained over the long term, since high saturation rates will be reached, and there is limited space for expansion. Accordingly, future growth rates beyond 2002 are reduced to 4% p.a. for Hammam Sousse and 3% for the other two Communes. On these assumptions the population of the three Communes is expected to exceed 200,000 by the year 2020 as shown below;

Governorate Of Sousse - Estimation Of Existing and Future Population By Commune affected by Potential Flooding of the Oued Hammam - 1992

Commune	1992	2002	2020
Hammam Sousse	28,000	50,000	85,000
Akouda	15,400	22,100	37,600
Kalaa Kebira	38,800	52,900	90,000

Source : Governorate of Sousse

2.1.3 Impact on Transport

One of the major consequences will be the disruption to traffic, in terms of delays through the flooding of roads. This will apply both to local and to through traffic. The Oued Hammam is traversed by three important roads - the GP-1, the by-pass to the GP-1, and the RVE 845 (the touristic road). Serious flooding in the past has caused considerable problems through the closure of the GP-1 and the RVE 845, and considerable delays on the GP-1 by-pass, as well as the MC-48 road which runs from Hammam Sousse to Akouda. However the problem has been alleviated to a large extent by the opening in 1993 of the Autoroute which bypasses the town, the result of which has been to divert a significant part of through traffic from the GP-1. Despite this, traffic on these roads still remains considerable and can be expected to increase rapidly as urbanization and tourist development proceeds.

Table 2.1 shows the results of a 1992 traffic census on the GP-1 and GP-1 Bypass. Since the full impact of the Autoroute on this traffic needs to be evaluated some assumptions are made on the traffic diverted from the GP-1 to the Autoroute. Informal assessments by the local Authorities indicate that perhaps 50% of 1992 traffic has been diverted. Table 2.2 shows the present estimated levels of traffic on the GP-1 and the GP-1 By-pass. These are estimated at nearly 6,000 movements per day on the GP-1 bypass, and 9,300 for the GP-1. Table 2.3 shows the results of the traffic census on the MC 48 and RVE 835. Traffic on the RVE 845 is not expected to have been affected by the

Autoroute, while that on the MC 48 could even have increased due to traffic using it to access the Autoroute. Daily flows are estimated at 12,322 for the MC 48, and 13,319 for the RVE 845.

Traffic is expected to grow in line with GDP forecasts to the year 2000 i.e. 6% p.a. However in view of the probable saturation of the roads thereafter, lower growth rates can be expected, and rates of 4% p.a. (between 2000 and 2010) and 2% p.a. (between 2010 and 2020) are used to estimate flows. Estimates of the number of passengers are based on typical occupancy rates in Tunisia (as used in the Transport Master Plan for Tunis) as follows:

Two wheeled traffic   : 1.2 persons
Private cars and taxis   : 3.8 persons
Autobuses   : 45 persons
Light vehicles   : 2 persons
Heavy vehicles   : 2 persons

Tables 2.4 and 2.5 show traffic and passenger estimates for the GP-1 By-pass and for the GP-1 for 1993 and the year 2020. Tables 2.6 and 2.7 show the forecasts for the MC 48 and the RVE 835. These estimates of future traffic flows are used below for the calculations of the benefits for the various sections of the flooded areas of the Oued Hammam.

2.2 Methodology

2.2.1 Introduction

An assessment of the direct and indirect costs associated with flooding will depend on the extent, depth and expected duration of the floods. An analysis of flood damage is made on two base cases : impact under present land use conditions, and impact under future land use conditions. Damage assessment has been made for 1-yr, 10-yr and 100-yr return periods. Flood damage has been assessed in categories related to residential, industrial and commercial and, agricultural areas; the analysis also considers the effect of flooding on roads and transport movements.

2.2.2 Damage and Losses in Residential Areas

(1) Introduction
Some residential areas affected particularly in the immediate vicinity of the oueds include spontaneous housing. It is clear that damage to spontaneous housing will need to be

taken into account, since there appear to be no moves by the Authorities to resettle residents to officially designated areas. Land use estimates have been made of the potentially flooded areas; housing densities and the number of houses affected are based on site visits.

The main damage categories attributable to the flood, will be physical damage caused to buildings and to household effects, and potential loss of income to residents through disruption.

(2) Damage to Buildings
(a) Methodological Approach
In broad terms, indicative flood damage particularly in residential areas is generally obtained through a comparison of land values for similar property in flooded and non flooded zones. In normal circumstances, flooding should have an impact on property prices. However, in the Oued Hammam, exposure to flooding does not seem to be a contributory factor in determining land and house prices. The range of land prices quoted in Sousse and within potentially floodable areas is wide, and cases even exist where similar neighboring properties in the same area have a considerable price differential.

It is evident that factors other than potential flooding have a greater influence in determining prices, such as, proximity to Sousse Center and Tourist areas. It should be noted that in present circumstances, flooding is regarded by occupiers to be a temporary phenomenon. Spontaneous housing is a phenomenon observed along the Oued Hammam, and in some cases these are located in areas which are easily prone to flooding.

Another approach to estimation of flood damage - the contingent valuation approach ("assessment of the willingness to accept compensation for the inconveniences caused by flooding") is considered invalid, in view of the infrequency, and little damage actually experienced since 1969. Difficulties are likely to be encountered in arriving at unbiased and undistorted opinions about the "willingness to pay" of the different respondents. Actual market behavior relating to, for example, property values in flooded as against non-flooded areas has been distorted by the pressure on accommodation within most of the urban area, and it would be extremely difficult to assign realistic values to any hypothetical environmental improvements.

A separate approach to evaluation of the likely benefits of the projects is to use the hedonic method as applied to property prices, between flooded areas and similar homogeneous areas. In principle, the difference in values is taken as an indicator of the

likely premium paid to avoid the inconveniences and damage caused by flooding. However, an investigation of the municipal rates shows that these reflect neither the true value of properties nor the environment in which they are located, but are set rather on an basis which does not reflect economic factors. Property values are therefore not considered to be a valid basis for estimating flood damage in the Oued Hammam. It is therefore proposed to use rehabilitation and building construction costs as a proxy to assess the impact of flooding.

(b) Assumptions

Land use has been estimated for the potentially flooded areas, and an analysis and survey of existing housing and construction within these areas been carried out. Increasing urbanization is a phenomenon which is likely to carry on in the potentially floodable areas. Estimates are therefore made for built-up areas under present and under future land use conditions.

The impact of flooding on buildings will be felt on the deterioration of foundations and rehabilitation required in repairing walls and plaster work and other physical damage. Since it is impossible to carry out surveys on all individual buildings likely to be flooded, some general criteria is used.

Estimation of typical construction costs is notoriously difficult in view of physical factors relative to specific sites. An analysis of data provided by SNIT (Etude des couts de production des logements dans le District de Tunis), indicates that foundation costs for a building vary between 5% and 12% for SNIT buildings, and are generally around 8% in the private sector. The cost of interior decoration and glass used is between 5% to 6%. These costs are generally therefore between 10% and 18%. For the purposes of the analysis, flood damage is estimated at 10% of construction costs.

While these are naturally variable depending upon the nature of terrain and type of construction and finish, two categories of housing are considered. In general, social class housing is estimated to have a unit cost of around DT150/m2 to DT200/m2, and medium standard housing of DT250/m2 to DT300/m2. Costs of spontaneous housing are estimated at the same level as social class housing. Unit cost of DT15/m2 and DT25/m2 are used to calculate flood damage for the two categories.

Housing Density is based on site visits. Where this has not been possible, data from other studies (ONAS) have been used. For spontaneous and popular housing, average typical constructed areas of 60m2 are assumed, and for medium standard housing coefficients of 100m2·

(3) Losses of Household Articles

The value of typical items of household articles in a middle class house, is estimated at around DT3,500. This includes refrigerators, cookers, furniture, carpets, mattresses, clothes and food items. Experience in other countries indicates that flooding of up to 1 meter results in damage of around 10% to household articles. This climbs significantly to nearly 70% at a height of more than 3 meters. Although there are certain areas in Oued Hammam where the height of the water surpassed 1 meter in the great flood of 1969, it is unlikely that this will be exceeded. It is therefore proposed to use 10% of the value of goods as indicative of the likely flood damage (i.e. DT350 per house).

(4) Losses of Income to Residents

It is assumed that disruption caused by flooding will result in loss of income to residents and households. Population density is based on socio-economic data collected for the areas, or if not available, data for neighboring areas has been used. In Oued Hammam this is estimated to be 200 persons per ha. In Sousse the general criteria used for Planning is assumed at 5 persons per household.

The number of workers per household will vary according to the active population and the level of unemployment in different areas. Official figures are likely to be misleading since they do not take into account the informal sector. For example, a survey carried out in 1984, showed that in the Sousse area, unemployment rates ranged from 4.3% in Hammam Sousse to 19.2 % in M'Saken. Employment data for the towns concerned for 1984 is shown in Table 10.8. This indicates that generally employment was around 1.6 workers per household. For the purposes of estimating damages, it is assumed that there will be 2 workers in each household affected.

Projections of wages have been made till the year 2020 based on increasing incomes in line with expected growth of GDP (6% p.a. till the year 2000, 5.5% between 2000 and 2010 and 5% between 2010 and 2020). On this basis the estimates for skilled labor are DT16 per day at present and DT67 per day in 2020, and for unskilled labor DT5 and DT22 respectively.

2.2.3 Losses to Industry and Commercial Enterprises

Losses can be measured in this sector in terms of loss of income for workers, actual damage to the physical assets of a company and disruption to factories resulting in higher costs for the delivery of raw materials and transport of finished products. In order to account for periods of starting up after flood, additional days of inconvenience will be felt

beyond the period of flooding.

It is assumed that damage to industrial buildings will be less than to residential buildings, in view of their more basic construction and simpler decoration. Since most of the industry is of a light or commercial nature, actual physical damage will not be significant, and damage is assumed at 5% of construction cost, estimated at DT300/m2 i.e. DT15/m2. The loss of income for workers for the duration of the flooding is based on the estimated wages, as calculated above.

2.2.4 Losses to Agriculture

Flooding will result in damage to crops. It is, however, considered that there will be no loss of further agricultural land through erosion. Agricultural areas prone to flooding are estimated below on present and future land uses.

Major crops grown in the Oued Hammam include vegetables, market produce, and olives. Productivity of the land varies enormously as do prices. It is expected that the flood damage will be serious enough to cause a loss of one harvest. In order to arrive at general estimates of damage, it is assumed that production is shared equally between olives and vegetable products. The range of olive production in areas adjacent to the Oued Hammam varies from 27 kg/tree to 150 kg/tree. Assuming a density of 200 trees per hectare, and an average productivity of 50 kg per tree, total production is estimated at 10,000 kg, which at current prices (DT0.160/kg), puts a value of the crop at around DT1,600 per hectare.

With regard to vegetables, typically, potatoes are grown in the area at a productivity of 12 Tons/ha. on the basis of two crops per year. Current market prices range between DT0.150 and DT0.300. Assuming a medium price level of DT0.200/kg, losses are estimated at DT1,200 per ha per crop. For agricultural areas in general, the loss is therefore assumed at an average of these crops of DT1,400 per ha.

2.2.5 Losses to Transport

(1) Road Damage
It is assumed that in both present land use conditions and expected future land use, roads flooded will need rehabilitation. Construction costs for a new two way road are estimated at around DT240,000 (excluding taxes). Rehabilitation costs are estimated at 50% of the construction cost, and are assumed at DT120,000 per km for primary roads and DT80,000/km for secondary roads, based on a general estimate provided by the

Department of Bridges and Roads. The construction costs for basic agricultural roads (pistes) are estimated at DT25,000 per km. However in order to avoid such damage in the future, and to improve the general environment for tourism, it is proposed that a bridge replace the crossing of the Oued Hammam on the RVE 835 Tourist road. This is costed at DT2.1 million.

(2) Traffic Delays and Value of Time

For the purposes of the evaluation, it is assumed that the roads will under a 100-yr flood be cut off for the duration of the floods. This will entail delays and diversions to other roads, and will result in loss of income. The number of passengers affected is based on the vehicle occupancy rates from the latest surveys, and on traffic projections based on the latest traffic data available, as estimated in Section 10.3. The value of time of passengers is calculated on forecasts of wages to the year 2020 (see Paragraph 2.2.2). In transport studies generally, the loss of leisure time is calculated at 20% of salary levels, and that of business time at 33% of hourly income. Due to lack of sufficient data in the traffic surveys on purpose of journeys it is proposed to apply an average factor to all journeys. The value of time is therefore taken at 25% of earnings.

At current rates the appropriate value is estimated to be DT0.5 per hour for skilled labor and DT 0.16 per hour for unskilled labor at present. These are assumed to increase in line with expected GDP growth and to be DT2.1/hour and DT0.7/hour respectively in the year 2020. It is further assumed that passengers in private cars and taxis will be in the skilled labor bracket and all others (using buses, trucks and passengers on two wheels) will be unskilled. Tourist traffic will be affected and, it is proposed to use the additional taxi fares concerned as a proxy for the inconvenience caused.

(3) Increased Vehicle Operating Costs

There are two elements of costs involved here. Additional operating costs due to the diversion, and increased vehicle costs due to travel on damaged roads. While it is assumed that the level of flooding will be sufficient to halt traffic completely during the period of inundation, a further impact will be felt in the increased operating costs experienced by vehicles both as a result of more difficult operating conditions and following the degradation in the road surface. This additional cost should be included in the damage assessment. For the purposes of the evaluation it is assumed that the increased operating costs apply for the duration until the road is repaired, and that it will take 30 days to repair the damaged roads. The costs of increased vehicle operation are based on assumptions from the World Bank HDM III model, assuming different degrees of roughness of surfaces in a "with" and "without" situation.

On the basis of the HDM III model, it is assumed that in the "without project case" the section of road affected by flooding is in poor shape, with visible irregularities and shape defects, (this represents a "roughness " level of 71.5 to 91 m/km). In the "with project case" i.e. without flooding, the state of the road is considered as high quality asphalt road (i.e. with a specification of 21-33 m/km). The difference in vehicle operating costs between these categories of road are shown in Table 2.9. These rates are applied to the existing and forecast traffic flows. It is assumed that damage to road surfaces will be the same in cases of present and future land use conditions, but duration of flooding will be different.

2.2.6 Other Factors

The major unquantifiable factor here is the impact on health. This is difficult to assess due to lack of sufficient data, and the problem of attributing diseases to local flooding problems, rather than other causes which may lie outside the study area. Interviews with the Health Authorities indicate that flooding and stagnant water has not hitherto caused the contraction of any serious water-borne diseases among residential populations. This is a potential problem for which concern has been expressed. An analysis of present flooding shows that overflows from the oueds are only one of several causes creating unhealthy environments.

The following are contributory factors for which solutions will need to be found:

-the overloading of networks due to encumbrance from solids - erosion of hills, as well as waste from housing and other works
-the malfunctioning of the secondary networks particularly in housing areas
-Increased flows due to high rates of urbanization in previously agricultural areas
-Construction of numerous obstacles and the infilling of the Oueds, particularly in zones of spontaneous housing
-Insufficient maintenance works

Another major unquantifiable factor of flooding in Hammam Sousse is the impact of adverse publicity on tourism. A further potential hazard is the damage and disruption likely to be caused to the ONAS treatment plant located at the side of the oued.

2.2.7 Summary of Coefficients used in Estimating Flood Damages

The various factors and coefficients used for estimating flood damage are summarized as follows; It is difficult to estimate future inflation rates for property and commodities;

Wages are assumed to be in line with GDP. For other factors, present rates are maintained. Future damage estimates can therefore be considered to be conservative, and these items can be subject to sensitivity studies.

Summary of Coefficients Used to Estimate Flood Damage (DT)

Category	Coefficient	
	Present (1993)	Future (2020)
1. Residential Areas		
(i) Damage to Buildings		
*Popular/Spontaneous Housing	$15/m^2$	$15/m^2$
*Medium Standard	$25/m^2$	$25/m^2$
(ii) Damage to Household Articles		
(per household)	350	350
(iii) Loss of Income to Households		
(DT per day)		
*Skilled	16	67
*Unskilled	5	22
2. Industrial Sector		
(i) Damage to Buildings	$15/m^2$	$15/m^2$
(ii)Loss of Income to workers		(as per households)
3. Agricultural Sector (per hectare)		
(i) Value of Olive Crops	1,600	1,600
(ii)Value of vegetable crops	1,200	1,200
4. Transport		
(i) Rehabilitation of Roads (per km)		
*Primary120,000	120,000	
*Secondary	80,000	80,000
*Agricultural Roads	25,000	25,000
(ii) Traffic Delays/Value of Time (DT per hour)		
*Skilled Labor	0.5	2.1
* Unskilled Labor	0.16	0.7
*Tourists	1.0	4.0
(iii) Additional Vehicle Operating Costs		
(DT per 1,000 km)		
*Private Cars/taxis	28.79	28.79
*Buses	51.60	51.60
*Light/Medium trucks	86.11	86.11
*Heavy trucks	236.73	236.73

2.3 Evaluation of Flood Damages

2.3.1 Introduction

Given the different socio-economic mix of parts of the Oued Hammam, it is convenient to analyze the damage attributable to potential flooding in several distinct areas, as indicated in Figure 2.1. For each case assessments are made on the basis of present and future land use conditions and in the context of a 100-year flood. Potential damages under 1-yr

and 10-yr return period floods are summarized in Section 2.4.2.

2.3.2 Estimation of Flood Damages - Zone A

(1) Characteristics of the Zone

This area is located on the coast, from the River mouth to GP-1 road. Land utilization is mixed, consisting of tourist, residential, industrial, agricultural areas. Experience of the major flood in 1969 shows that in some places water remained generally for one to three days, but in low lying areas it persisted for up to 20 days. Depth varied between 0.2 and 1.5 meters. The tourist road was closed for at least two days. Maximum flood duration will be 36 to 39 hours. A breakdown of the different categories of land affected under present and future land use are as follows;

<div align="center">

Land Use Characteristics of Flooded Areas in Zone A (Ha)
Conditions

	Present Land Use	Future Land Use
Agricultural	107	74
Urban	30	70
Open	16	16
TOTAL	153	160

</div>

Although there is no tourist development directly affected by the flooding in the oued, there will be an impact on neighboring Hotels in terms of unpleasantness, as well as considerable inconvenience to movement from and to El Kantaoui, and other future tourist developments such as Hergla.

The zone also has the ONAS sewage treatment plant (Sousse Nord SE5) with an average daily discharge of 8,700m3 per day, and treatment of 2,700 kg per day. Expansion plans are underway, and capacity is expected to rise in the near future to 17,430m3 and 4,750 kg respectively. The plant serves an estimated 66,500 inhabitants and 19,200 hotel residents. The plant is a primary treatment plant only, and there is likely to be some effect in overflow of sewage from the network. The closure of operations of the plant from the network will have a major effect on hygiene and health conditions in the north of Sousse. There will also be adverse publicity through the pollution of the coastal area. However, this element of potential damage is not costed.

(2) Loss of Income to Residents

The main area where residents will be affected is Hammam Sousse. The built up areas affected are estimated at 30 ha under the present land use conditions, and 70 ha in future land use conditions. Within Zone A, some of these areas are commercial and light industrial, particularly in the area near ONAS, and on the GP-1. It is estimated that 75%

of the built-up area will consist of residential property, i.e. 22.5 ha and 52.5 ha respectively.

In order to calculate the number of households affected, socio-economic criteria from planning documents from Hammam Sousse and Sousse town are used. Density in Sousse town is estimated on average at 275 persons per ha. Site visits, however indicate that at present housing is more scattered. It is therefore proposed to use a lower density of 200 persons per ha., for the area likely to be affected. This represents a population affected of 4,500 under present land use conditions. Given the rapid rate of urbanization expected density can be expected to increase and it is proposed to use a density of 275 for the year 2020. On this basis future population affected will be in the region of 14,500 persons.

According to the population census there were 5.48 persons per household in Hammam Sousse. On this basis the total number of households affected at present will be 820. The Master Plan for Sousse estimates future household size at 5 persons per household, and on this basis one can expect there to be 2,900 households in the flood prone areas.

On the basis of 2 workers per household, and average salaries of DT67 per day in the year 2020, income losses will amount to DT330,000 on the basis of 3 days loss of work, (under present land use conditions), and DT1,554,000 (assuming 4 days loss of work, under future land use conditions).

(3) Damage to Residential Buildings
In order to estimate the amount of constructed areas, it is assumed that 50% of the households inhabit popular or standard housing (average areas 60m2), and the rest in medium type housing (100m2). Residential areas are therefore estimated at 65,600m2 under present land use conditions and 232,000m2 under future conditions. On the basis of damages at DT15/m2, DT 25/m2 respectively, total flood damage to residential building is estimated at DT1,394,000 and DT4,930,000 respectively.

(4) Damage to Household Articles
Although there are certain areas in the zone where the height of the water surpassed 1 meter in the great flood of 1969, it is unlikely that this will be exceeded. Under present land use conditions with 820 households affected damage is estimated at DT287,000, and in future land use conditions 2,900 households at DT1,015,000.

(5) Damage to the Industrial Sector
Losses can be measured in this sector in terms of disruption to factories resulting in

higher costs for the delivery of raw materials and transport of finished products, loss of income for workers and actual damage to the physical assets of a company. Sufficient data is not available on individual companies in terms of output and revenue. Costs of flooding are based on the loss of income to workers.

In estimating the number of employees in the floodable areas, it is proposed to use the average employment per factory in Hammam Sousse. Table 2.10 gives data on employment in the Industrial Sector in the area. The average number of employees per factory in the area is estimated at 29.

A survey of the area shows that apart from ONAS, most of the buildings are used for light industry and commercial enterprises. Several of these are under construction at present and it is understood that more are proposed. Under the present land use situation, it is assumed that there will be 25 units affected and that these will double in the future to 50, representing 725 and 1,450 employees respectively.

During the flood period, the industries will be unable to work, and that there will be supplementary delays in order to restart production and repair damages. Under present land use conditions, it is estimated that 5 days losses will be incurred, and under future conditions, 6 days. In terms of income loss, this represents DT243,000 and DT583,000 respectively.

Structural damage to industrial and commercial buildings will be far less than to residential buildings. These areas are estimated at 8 ha. Under present land use conditions and 18 ha. under future conditions. Assuming 50% of the area will be occupied with built-up areas, these are estimated at 4,000m2 and 18,000m2. On a basis of flood damage at 5% of construction costs of DT300/m2, the damage to buildings is estimated at DT60,000 and DT270,000.

There will also be damage to stock and assets. This element is difficult to estimate in view of the lack of data, and the fact that most of these light industrial and commercial activities are still under construction. A notional amount of DT100,000 is proposed for the present land use condition, and this is increased pro-rata to DT450,000.

(6) Losses in the Agricultural Sector
Although there are an estimated 107 ha in the zone which are likely to be flooded, this number is expected to reduce significantly due to increased urbanization to 74 ha by 2020. At present the zone grows olive trees, vegetables and market produce, such as potatoes. It is assumed that 50% of the area (37 ha) is cultivated with olives and the

remainder with potatoes. Value of production has been estimated at DT1,600 per ha. for olives, resulting in a loss of DT59,200. It is assumed that vegetable crops are grown in the other half of the area affected (37 ha). Typically, potatoes are grown in the area. On the basis of a loss of DT1,200/ha per crop, losses are estimated at DT44,000. Total losses in agricultural production will therefore be around DT103,000 under future land use conditions. On a pro-rata basis losses under present land use (107 ha) will amount to DT149,000.

(7) Transport and Traffic Losses
(a) Loss of Income to Passengers
It is assumed that the tourist road (RVE 835) and local roads bordering the oued including the road in the industrial estate and local agricultural roads, will be cut off for the duration of the flooding. According to the experience of the 1969 flood, the main road was closed for up to 3 days. It is probable that this could be a longer period due to clearing up operations, but for the purposes of the evaluation it is assumed that the roads will be cut off for 3 days in present land use conditions and 4 days in future land use conditions. Traffic will divert to using the by-pass of the GP-1 which will remain unaffected by the flood - a diversion of nearly 5 km. This will entail increased Vehicle Operating Costs (VOCs), as well as longer journey times. The diversion of traffic will as a result of congestion add one extra hour's journey time to passengers.

The estimates of the number of passengers affected is 52,700 at present rising to 143,000 in the year 2020 (see Table 2.7). Passengers can be divided into three categories: tourists, skilled labor and unskilled labor. A significant part of this traffic will be related to tourism. Latest figures show that Sousse received 634,000 tourists in 1992. Since the Oued Hammam effectively divides the tourist areas, movements in both directions will be affected. The El Kantaoui area has a large number of important hotels (Hannibal, Bulla Regia, Hasdrubal, Kantaoui, Marhaba etc.), with an estimated 9,000 beds at present. Two further hotels are under construction - the Club Tergui, and the Club Mediterranee. In the Master Plan for Sousse it is proposed to intensify the density of tourist development from 110 beds/ha to 170 beds/ha. The total number of hotel beds in El Kantaoui is expected to reach 20,000 in the future. With an average occupation rate of 60% over the year, it is therefore likely that an average number of tourists in Kantaoui will be 5,400 at present and 12,000 in the future. This figure can be considered to be conservative since future tourist developments along the coast (e.g. Hergla) are not taken into account. In addition, there is considerable movement of traffic from Sousse to Kantaoui of other tourists staying in Sousse. Total existing beds in Sousse are estimated to be 23,000. At an occupancy rate of 60%, this will amount to an average of around 14,000 tourists in Sousse town. Future development will be limited due to space

restrictions. Assuming higher rates of occupancy, the number of tourists in Sousse is assumed to be 20,000 by the year 2020.

In order to arrive at approximate estimates of the number of tourists wishing to move between El Kantaoui and Sousse on any one day, it is assumed that one third will wish to make the journey in both directions. On this basis out of nearly 20,000 tourists at present, 6000 will want to travel (12,000 movements); in the future this figure will be 10,000 tourists (20,000 movements). It is difficult to impute a value to the time of tourists since their leisure time cannot be costed at their own domestic earnings. For the purposes of the analysis, taxi fares for the additional journeys via the deviation are used as a proxy. These are estimated at DT1.0 at present and DT4.0 in the future.

It is assumed that other passengers using private cars and taxis will be at skilled labor rates and those in buses and trucks at unskilled rates. Table 2.11 shows the breakdown by different categories of passenger and estimates of the value of time lost over 3 days (present land use conditions) and 4 days (future land use conditions). Estimated loss of income in this category is DT317,000 under present land use conditions, and DT1,053,000 under Future land use conditions.

(b) Increased Vehicle Operating Costs

These costs will be related to additional running costs on damaged roads, and, for the period of flooding, costs of diversion. It is assumed that 1 km of the RVE 835 will be affected by the flooding, and that traffic will face increased costs for a period of 30 days. In applying the rates for operating costs between the assumed conditions of non flooded and flooded roads, according to the World Bank HDM model, the increased vehicle operating costs are shown in Table 2.12 for existing and future traffic, as forecast above. These costs are estimated at DT16,200 at present, and DT44,200 in the year 2020.

With regard to diversion costs it is assumed that traffic will be diverted for a period of 4 days (under present land use conditions), and 5 days (under future land use conditions). The diversion is estimated at 5 km. These costs are shown in Table 2.13, and are estimated at DT8,400 under present and DT27,750 under future land use conditions. In total, additional vehicle operating costs due to flooding are estimated at DT24,600 for present traffic and DT72,000 for future traffic.

(c) Damage to Roads

Approximately 1 km of the main roads will be damaged. It is proposed that a bridge be constructed in order to avoid future problems. This is estimated at a cost of DT2.1 million. In addition, secondary and agricultural roads alongside the oued will be

affected. These are estimated at 5 km. With a rehabilitation cost of DT80,000 per km, the costs are estimated at DT400,000. Total road rehabilitation costs and the cost of the bridge are therefore estimated at DT2.5 million.

(8) Summary of Flood Damages - Zone A

The estimation of potential flood damage in Zone A under 100-yr flood conditions is summarized as follows:

Oued Hammam - Zone A : Estimated Potential Flood Damage (DT1,000)

Category	Present Land Use Conditions	Future Land Use Conditions
Losses to Residents		
Loss of Income to Residents	330.0	1,554.0
Damage to Residential Buildings	1,394.0	4,930.0
Damages to Household Articles	287.0	1,015.0
Losses to Industrial Sector		
Loss of Income	243.0	583.0
Damage to Buildings	60.0	270.0
Damage to equipment/Assets	100.0	450.0
Losses to Agricultural Sector	149.0	103.0
Losses in the Transport Sector		
Passenger Delays	317.0	1,053.0
Increased VOCs	25.0	72.0
Road Rehabilitation	2,500.0	2,500.0
TOTAL	5,405.0	12,530.0

NOTE: Other unquantifiable damages include the health hazards resulting from damage to and stoppage of the ONAS plant during the flood period, and the adverse impact on the tourism.

2.3.3   Estimation of Flood Damages - ZONE B

(1) Characteristics of the Zone

The area affected in this zone is located between the GP-1 and the GP-1 Bypass. The characteristics of the flood prone areas in a 100-yr flood are as follows;

Land Use Characteristics of Flooded Areas in Zone B (Ha)

	Conditions	
	Present Land Use	Future Land Use
Agricultural	23	20
Urban	10	16
Open	6	6
TOTAL	39	42

Flooding in this zone varied between 0.5 and 1.2 meters in 1969. Duration of flooding was generally between 1 and 3 days, but in some low lying areas water was observed to lie for 15 days. One of the major impacts of flooding will be the closure of the GP-1 road for between 33 and 37 hours.

Zone B is a primarily agricultural area with an increasing urban component, consisting of commercial (30%) and residential areas (70%). Traffic will be diverted from the GP-1 to the GP-1 bypass. However this involves a diversion of only 0.5 km and benefits are not likely to be significant on the transport side.

(2) Loss of Income to Residents

The urban residential areas affected are estimated at 7 ha under the present land use conditions, and 11 ha. in future land use conditions. Assuming a density of 200 persons per ha., population affected will be 1,400 and 2,200 respectively, representing 280 and 440 households. On the basis of 2 workers per household, income losses will amount to DT112,500 on the basis of 3 days loss of work under present land use conditions, and DT236,000 (assuming 4 days loss of work).

(3) Damage to Residential Buildings

10% of the residential area consists of constructed areas (i.e. 7,000m2 and 11,000m2). Assuming flood damage at DT 25/m2, damages to buildings are estimated at DT175,000 and DT 275,000.

(4) Damage to Household Articles

Assuming an average of 60 m2 per house, the number of houses affected are estimated to be around 110 under present conditions, and 180 in the future. with an average loss estimate per house of DT350, total damage to household articles is DT38,500 and DT63,000 respectively

(5) Losses in the Industrial and Commercial Sectors

Commercial areas are estimated at 3 ha under present and 5 ha under future land use. This represents built-up areas of 2,400m2, and 4,000m2 respectively. Structural damage is estimated at DT15/m2, with total damage estimated at DT36,000 and DT60,000. In addition, there will be income losses due to factory closures for the period of flooding. In order to estimate the number of factories affected, a ratio of 160 m2 per commercial unit is used; on this basis, there are 15 units at present and 25 in the future. At an average employment of 29 workers, total workers affected are estimated at 435 under present conditions and 725 in the future. With a loss of 5 days and 6 days respectively, losses attributable to flood damage are estimated at DT145,725 and DT291,450.

(6) Losses in the Agricultural Sector

Under present land use conditions 23 ha will be affected and in the future 20 ha. Assuming a 50% breakdown between olives and other crops, losses will be DT53,000

under present conditions and DT46,000 under future land use conditions.

(7) Transport and Traffic Losses
(a)Loss of Income to Passengers
There will be diversion of local traffic to the GP-1 bypass. However the distance is not too great. On a pro-rata basis with benefits in Zone A and taking into account the shorter distance, benefits in terms of loss of income are likely to be 10% of those of zone A i.e. DT5,000 and DT45,000 under present and future conditions respectively.

(b) Increased Vehicle Operating Costs
Most traffic will divert to the GP-1 Bypass which will remain unaffected by the flood. Losses will be small in view of the short diversion distance. Increased costs will occur from greater congestion. This aspect has, however, not been costed in the evaluation.

(c) Damage to Roads
A major impact of flooding will be damage to the GP-1, and to local roads. It is expected that 1 km of the GP-1 will be damaged by the flood. A rehabilitation cost of DT120,000 is assumed in this case. In addition 2 km of local roads will need to be repaired. Cost of these roads is estimated at DT80,000 per km- a total of DT160,000. Total damage to roads is estimated at DT280,000.

(8) Summary of Flood Damages to Zone B
Potential flood damages in this zone under 100-yr flood conditions are summarized as follows;

Oued Hammam - Zone B - Estimated Flood Damage (DT1,000)

Category	Land Use Conditions	
	Present	Future
Losses to Residents		
Loss of Income to Residents	112.5	236.0
Damages to Household Articles	38.5	63.0
Damage to Residential Buildings	175.0	275.0
Losses to Industrial Sector		
Loss of Income	145.7	291.4
Damage to Buildings	36.0	60.0
Losses to Agricultural Sector	53.0	46.0
Losses in the Transport Sector		
Loss of Income	5.0	45.0
Road Rehabilitation	280.0	280.0
TOTAL	845.7	1,296.4

2.3.4 Estimation of Flood Damages - ZONE C

(1) Characteristics of the Zone

Zone C stretches from the By-pass road of GP- 1 to the junction with Oued Kebir. Land use in the flood-prone areas is summarized as follows for 100-yr flood conditions.

Land Use Characteristics of Flooded Areas in Zone C (Ha)

	Conditions	
	Present Land Use	Future Land Use
Agricultural	25	25
Urban	3	6
Open	10	10
TOTAL	38	41

Flooding depth experienced in the past was up to 1.2 meters and in some low lying areas flood waters remained for between 3 days to 1 week. Duration of flooding under a 100-year flood, is estimated to be 30 hours under present land use condition, and 33 hours in the future.

(2) Loss of Income to Residents

Housing in the flood prone areas is scattered, and it is assumed that 30 houses will be affected at present representing 60 workers. Assuming a loss of 3 days work, losses in income will amount to DT12,000. Urban areas are expected to double by the year 2020, and losses are estimated at DT24,000.

(3) Damage to Residential Buildings

Most of the houses in the area are of a middle to high quality and average constructed areas are estimated at 100 m2 per house. Under present conditions damage will be caused to 30 houses. Assuming damage at 10% of construction cost (i.e.DT25 per m2), losses will amount to DT75,000 at present, and DT150,000 in the future.

(4) Damage to Household Articles

On the basis of likely flood damage of DT350 per household total damages in this category are estimated at DT10,500 under present, and DT21,000 under future conditions.

(5) Losses in the Industrial Sector

Both Kalaa Kebira and Akouda are important centers for light industry. Although these industries will not be directly affected by the flooding there will nevertheless be delays to traffic in terms of movement of raw materials and workers. Table 10.14 shows the number and employment of different categories of industry in Akouda and Kalaa Kebira.

The inconvenience to workers in this sector will be reflected in the delays expected to passenger traffic.

(6) Losses in the Agricultural Sector

Agricultural areas will be the same in both present and future land use conditions.(25 ha) On the assumptions used in the methodology and assuming a 50% breakdown of crops between olives and vegetables, losses in both cases are estimated at DT57,500.

(7) Transport and Traffic Losses

(a) Loss of Income to Passengers

Road access to Akouda will be affected through flooding, but only in the case of the 100-year flood, on a stretch of road on the MC48 approaching the GP-1. Traffic bound for Akouda, Kalaa Kebira and the Autoroute will be affected and will need to take a diversion. It is assumed that this will amount to an extra 5 km, involving an extra hour's travel time. Assuming flood duration of 40 hours and 41 hours under present and future land use conditions respectively, it is assumed that traffic delays will cause loss of income for two days in either case.

Traffic estimates indicate that at present 21,200 passengers travel in private cars and taxis, and 24,000 by bus truck and on two wheels. Assuming the former to be skilled and the latter unskilled, income loss is estimated at DT21,000 and DT7,700 respectively. In 2020 there will be an estimated 57,800 skilled and 66,000 unskilled passengers, with an income loss of DT250,000, and DT92,500 respectively. Total losses for the value of time are therefore estimated to be DT28,700 in present conditions and DT342,500 in future conditions.

(b) Increased Vehicle Operating Costs

There will be two elements of costs to consider here -the impact of road damage, and diversion costs. Damage to the roads will cause additional VOCs for the period during which the road is damaged and under repair. It is assumed that for a period of thirty days there will be difficulties in traversing the flooded road under 100-yr flood conditions. It is assumed that 0.5 km of the road will be affected. These costs are estimated in Table 2.15, and are estimated at DT9,550 under present land use conditions, and DT25,750 under future conditions.

The second element will be the diversion costs over 5 km. estimated for the period of flooding. Given a flooding duration of 30 hours it is assumed that the road will be closed for three days. These costs are estimated in Table 2.16, at DT31,300 under present land use, and DT84,800 under future land use conditions.

(c) Damage to Roads

It is expected that 500 meters of the MC 48 road will be damaged; reconstruction costs are estimated at DT40,000.

(8) Summary of Flood Damages to Zone C

Damages in flood prone areas in this zone for 100-yr flood conditions are estimated as follows;

Oued Hammam - Zones C - Estimated Flood Damage (DT1,000)

Category	Land Use Conditions	
	Present	Future
Losses to Residents		
Loss of Income to Residents	12.0	24.0
Damages to Household Articles	10.5	21.0
Damage to Residential Buildings	75.0	150.0
Losses to Agricultural Sector	57.5	57.5
Losses in the Transport Sector		
Road Rehabilitation	40.0	40.0
Loss of Income	28.7	342.5
Increased VOCs	9.6	25.7
Diversion costs (VOCs)	31.3	84.8
TOTAL	264.6	745.5

2.3.5 Estimation of Flood Damages - ZONE D

(1) Characteristics of the Zone

The flood prone area extends from the Junction with Oued Kebir to upstream. It is largely an agricultural area with some open spaces. There are no residential areas affected. Land utilization is estimated as follows for flood damages under 100-yr conditions.

Land Use Characteristics of Flooded Areas in Zone D (DT1,000)

Category	Conditions	
	Present Land Use	Future Land Use
Agricultural	13	15
Urban	0	0
Open	6	6
TOTAL	19	21

Flooding depth varied between 0.3 and 1.2 meters in 1969 and 1973 with duration from 1 hour to 2 days. According to local farmers floods in the past have resulted in the loss of about 3 ha. of agricultural land in the Akouda area.

(2) Loss of Income to Residents

No residential areas will be affected by flooding.

(3) Damage to Residential Buildings

No residential areas will be affected by flooding.

(4) Damage to Household Articles

No residential areas will be affected by flooding.

(5) Losses in the Industrial Sector

No industrial areas will be affected by flooding.

(6) Losses in the Agricultural Sector

Under present land use conditions 13 ha. and under future land use conditions 15 ha. will be affected by flooding. Assuming that 50% of the land will be used for olives and the rest for vegetables, total damages are estimated at DT30,000 under present and DT34,500 under future conditions.

(7) Transport and Traffic Losses

Flooding in this zone will have no impact on transport movements.

(8) Summary of Flood Damages to Zone D

The only damages in this zone will be to agricultural crops estimated at DT30,000 under present land use conditions and DT34,500 under future conditions.

2.3.6   Estimation of Flood Damages - ZONE E

(1) Flooding Characteristics of the Zone

The flood prone areas extend from the junction with Oued Laia to the MC 48 road. According to past experience water on the road has lasted for a period of 4 hours. Under a 100-year flood, it is expected that the bridge over the Oued will be affected for a period of around 10 hours.

The land use characteristics of the flooded areas are as follows;

Land Use Characteristics of Flooded Areas in Zone E (Ha)

	Conditions	
	Present Land Use	Future Land Use
Agricultural	5	7
Urban	1	3
Open	5	5
TOTAL	11	15

(2) Loss of Income to Residents

With only 1 ha. affected under present land use conditions and 3ha under future conditions benefits will be limited. At a density of 200 persons per ha. this represents about 40 households affected at present and 120 in the future. Income loss over two days is estimated at DT2,500 at present and DT32,000 in the future.

(3) Damage to Residential Buildings

Assuming that half of the housing in the Oued is of medium standard and 50% popular or spontaneous, damage is estimated at DT68,000 at present and DT204,000 in the future.

(4) Damage to Household Articles

This is estimated at DT14,000 under present conditions and DT42,000 under future conditions.

(5) Losses in the Industrial Sector

No industrial areas will be affected.

(6) Losses in the Agricultural Sector

Losses of agricultural crops are estimated at DT7,000 under present conditions and DT9,800 in the future.

(7) Transport and Traffic Losses

Specific transport data is not available for this section of the MC 48. Given that some traffic from the GP-1 is destined for Akouda, it is proposed to take two-thirds of the traffic estimated for the MC 48 (on the basis of population comparison of the two towns), as being destined either for Kalaa Kebira or for the Autoroute.

(a) Loss of Income to Passengers

On the basis of the traffic counts for the road as a whole, it is assumed that 14,000 passengers will be in the skilled labor category, and 16 000 unskilled (see estimates for Akouda). With a flood duration of 10 hours, traffic should only be delayed for one day at the maximum. As in the case of Akouda, it is assumed that diversions will result in 1 hours extra travel time. Costs are therefore estimated to be DT9,500 at present. In the future passenger traffic will increase to 38,200 skilled and 43,500 unskilled workers, with income losses of DT111,000.

(b) Increased Vehicle Operating Costs

These will be minimal since only a small section of the road will be affected.

(c) Damage to Roads

A nominal amount of DT10,000 is included.

(8) Summary of Flood Damages to Zone E

Potential damage caused by flooding under 100-yr flood conditions is estimated as follows;

Oued Hammam - Zone E - Estimated Flood Damage (DT1,000)

Category	Land Use Conditions	
	Present	Future
Losses to Residents		
Loss of Income to Residents	2.5	32.0
Damages to Household Articles	14 .0	42 .0
Damage to Residential Buildings	68 .0	204 .0
Losses to Agricultural Sector	7 .0	10 .0
Losses in the Transport Sector		
Road Rehabilitation	10 .0	10 .0
Loss of Income	9 .5	111 .0
TOTAL	111 .0	409 .0

2.3.7 Estimation of Flood Damages - ZONE F

(1) Characteristics

This zone is located between the MC 48 road to the Railway line. The characteristics of the flood prone areas under 100-yr flood conditions are as follows;

Land Use Characteristics of Flooded Areas in Zone F (Ha)

	Conditions	
	Present Land Use	Future Land Use
Agricultural	12	13
Urban	1	1
Open	3	3
TOTAL	16	17

(2) Loss of Income to Residents

One hectare of residential land will be flooded. With a duration of flooding of 8 hours it is assumed that one day's income will be lost. Assuming a density of 40 households per ha, lost income will amount to DT2,500 at present and DT5,000 in the future.

(3) Damage to Residential Buildings

Kalaa Kebira has a high incidence of spontaneous housing (nearly 70% in 1984). Housing in the flood prone areas is likely to be of this type. Damage is therefore estimated at DT36,000.

(4) Damage to Household Articles

Assuming 40 households, damage are estimated at DT14,000.

(5) Losses in the Industrial Sector

No industries will be affected in this area.

(6) Losses in the Agricultural Sector

Losses in this sector are estimated to be DT17,000 under present conditions and DT18,000 in the future.

(7) Transport and Traffic Losses

There will be no damages suffered in this area.

(8) Summary of Flood Damages to Zone F

Potential flood damage in this zone under 100-yr flood conditions is summarized below;

Oued Hammam - Zone F - Estimated Flood Damage (DT1,000)

Category	Land Use Conditions	
	Present	Future
Losses to Residents		
Loss of Income to Residents	2.5	5.0
Damages to Household Articles	14.0	14.0
Damage to Residential Buildings	36.0	36.0
Losses to Agricultural Sector	17.0	18.0
Losses in the Transport Sector	nil	nil
TOTAL	69.5	73.0

2.3.8 Estimation of Flood Damages - ZONE G

(1) Characteristics of the Flooded Areas

This zone extends from the railway line to upstream. Experience of past flooding indicated depths of up to 1.5 meters for a duration of 3 to 6 hours. Under a 100-year flood, some local roads will be blocked due to rubbish and detritus, for a period of up to 5 to 6 days. The land use characteristics of this zone under 100-yr flood conditions are summarized as follows;

Land Use Characteristics of Flooded Areas in Zone G (Ha)

	Conditions	
	Present Land Use	Future Land Use
Agricultural	5	5
Urban	1	2
Open	6	6
TOTAL	12	13

(2) Loss of Income to Residents

Losses are estimated at DT2,500 at present and DT10,000 in the future.

(3) Damage to Residential Buildings

The housing in the flood prone areas is considered to be spontaneous. Damage is therefore estimated at DT36,000 under present conditions and DT72,000 in the future.

(4) Damage to Household Articles

Damages are estimated at DT14,000 under present conditions and DT28,000 in the future.

(5) Losses in the Industrial Sector

No industrial areas will be affected.

(6) Losses in the Agricultural Sector

Damages to crops are estimated at DT7,000.

(7) Transport and Traffic Losses

Specific transport data is not available for this section of the MC 48. It is assumed that traffic levels at this stretch of the road will be the same as those estimated in Zone E, as being destined either for Kalaa Kebira or for the Autoroute, or Kalaa Seghira.

(a) Loss of Income to Passengers

On the basis of the traffic counts for the road as a whole, it is assuming that 14,000 passengers will be in the skilled labor category, and 16,000 unskilled (see estimates for Akouda). With a flood duration of 10 hours, traffic should only be delayed for one day at the maximum. As in the case of Akouda, it is assumed that diversions will result in one hour extra travel time. Costs are therefore estimated to be DT9,500 at present. In the future passenger traffic will increase to 38,200 skilled and 43,500 unskilled workers, with income losses of DT111,000.

(b) Increased Vehicle Operationg Costs

These will be minimal since only a small section of the road will be affected.

(c) Damage to Roads

A nominal amount of DT10,000 is included.

(8) Summary of Flood Damages to Zone G

Potential damage by flooding under 100-yr flood conditions is summarized below;

Oued Hammam - Zone G - Estimated Flood Damage (DT1,000)		
Category	Land Use Conditions	
	Present	Future
Losses to Residents		
Loss of Income to Residents	2.5	10.0
Damages to Household Articles	14.0	8.0
Damage to Residential Buildings	36.0	72.0
Losses to Agricultural Sector	7.0	7.0
Losses in the Transport Sector		
Loss of Income	9.5	111.0
Damage to Roads	10.0	10.0
TOTAL	79.0	218.0

2.4 Summary of Flood Damages in the Oued Hammam

2.4.1 Potential Damages in a 100-yr Return Period Flood

The overall potential damage likely to be caused in the Oued Hammam under a 100-year flood is estimated at DT6,804,800 under present land use conditions, and DT15,306,400 under future land use conditions. Details by zone are summarized below.

Evaluation of Flood Damage in the Flood Prone Areas Oued Hammam (DT1,000)		
Zone	Present Land Use Conditions	Future Land Use Conditions
A	5,405.0	12,530.0
B	845.7	1,296.4
C	264.6	745.5
D	30.0	34.5
E	111.0	409.0
F	69.5	73.0
G	79.0	218.0
TOTAL	6,804.8	15,306.4

2.4.2 Potential damages in 1-yr and 10-yr Return Period Floods

The overall potential damage likely to be caused in 1-yr and 10-yr flood return period floods under present and future land use conditions are shown below. These are based on estimates of flooded areas and duration of flooding (see Chapter 7, Main Report). Details of flood damage by zone for 1-yr and 10-yr return period floods are presented in Tables 2.17 to 2.20.

Evaluation of flood Damage in Flood Areas - Oued Hammam
(1-yr and 10-yr floods, Unit:DT1,000)

	Present Land Use		Future Land Use	
	1-yr	10-yr	1-yr	10-yr
A	261	2,030	498	4,993
B	75	459	84	771
C	57	66	250	261
D	0	5	0	7
E	10	20	40	72
F	5	10	5	13
G	23	46	75	127
Total:	431	2,636	952	6,244

Table 1.1 Industrial Zone at Charguia/Ariana: Employment by Subsector, 1990

Subsector	Units	Employees	Employees per unit
Agriculture/Food	148	2,687	18.16
Building Materials/ Construction	32	690	21.56
Mechanical/Electrical	75	2,820	37.60
Chemical/Plastics	22	343	15.59
Textiles/Leather	209	10,558	50.52
Others	84	1,811	21.56
Total	570	18,909	33.17

Source: District of Tunis

Table 1.2 Commune of Ariana: Estimated Agricultural Production and Productivity

Crop	Production	Area Cultivated (Tonnes)	Productivity (Tonnes/Ha.)
Winter Crops	3,000	27,050	9.02
Summer Crops (Vegetables)	6,500	123,300	18.97
Irrigated Cereals (Haboub)	2,800	8,900	3.18
Animal Feedstuff	2,500	11,250	4.50
Cotton	80	160	2.00
Root Crops	100	3,500	35.00

Source: Note relating to the flood prone areas of Soukra-Chotrana, Ministry of Interior, District of Tunis

Table 1.3 Difference in Vehicle Operating Costs in Flooded and Non Flooded Cases (TD per 1000 vehicle/km)

Vehicle Type	Non-Flooded Case	Flooded Case	Difference
Private Car/Taxi	114.51	143.30	28.79
Bus	459.57	511.17	51.60
Light/Medium Goods	247.59	333.70	86.11
Heavy Goods	663.81	900.54	236.73

Source: World Bank H. D. M. Model

Table 1.4 Zone A: Estimated Flood Prone Areas and Damages to Buildings

Category	Present Land Use			Future Land Use		
	H/holds (No.)	Areas (m²)	Damages (DT1000)	H/holds (No.)	Areas (m²)	Damages (DT1000)
Popular	810	48,600	729	2,400	144,000	2,160
Medium	184	18,400	460	544	544,000	3,600
High	86	12,900	451	256	38,400	1,344
Total			1,641			17,104

Table 1.5 Oued Ennkhilet: Estimate of Daily Passenger Flow on GP8 in 2020

Category	Vehicles	Occup. Rate	Total Passengers
Private Cars and Taxis	43,100	3.8	163,780
Buses	1,700	45.0	76,500
Light Vehicles	20,300	2.0	40,600
Heavy Vehicles	18,600	2.0	37,200
Two Wheels	800	1.5	1,200
Total	84,500		319,280

Table 1.6   Oued Ennkhilet: Summary of Flood Damage by Zone
One Year Flood Return Period: Present Land Use Conditions

	Zones				Total
	A	B	C/D	E/F	
Losses to Residents					
Loss of Income	12	17	4	1	34
Damage to Buildings	269	138	69	10	487
Damage to Household Goods	63	48	11	6	128
Losses to Industrial Sector					
Loss of Income	64	0	0	0	64
Damage to Buildings	40	0	0	0	40
Damage to Assets	0	0	0	0	0
Losses in Agriculture	12	23	0	4	39
Losses in Transport					
Passenger Delays	19	0	0	0	19
Increased VOCs	13	3	0	0	16
Road Rehabilitation	100	100	20	7	227
Total	592	329	105	28	1,054

Table 1.7   Oued Ennkhilet: Summary of Flood Damage by Zone
One Year Flood Return Period: Future Land Use Conditions

	Zones				Total
	A	B	C/D	E/F	
Losses to Residents					
Loss of Income	220	334	30	5	589
Damage to Buildings	2,138	1,200	170	53	3,561
Damage to Household Goods	0	263	23	9	295
Losses to Industrial Sector					
Loss of Income	58	0	0	0	58
Damage to Buildings	45	0	0	0	45
Damage to Assets	0	0	0	0	0
Losses in Agriculture	0	14	0	1	15
Losses in Transport					
Passenger Delays	298	0	0	0	298
Increased VOCs	4	4	0	0	8
Road Rehabilitation	100	320	40	16	476
Total	2,863	2,135	263	83	5,344

Table 1.8 Oued Ennkhilet: Summary of Flood Damage by Zone
Ten Year Flood Return Period: Present Land Use Conditions

	Zones				Total
	A	B	C/D	E/F	
Losses to Residents					
Loss of Income	12	17	5	1	35
Damage to Buildings	673	378	187	28	1,266
Damage to Household Goods	158	132	32	16	338
Losses to Industrial Sector					
Loss of Income	64	0	0	0	64
Damage to Buildings	100	0	0	0	100
Damage to Assets	0	0	0	0	0
Losses in Agriculture	40	58	2	10	109
Losses in Transport					
Passenger Delays	57	0	0	0	57
Increased VOCs	5	5	0	0	10
Road Rehabilitation	400	400	30	20	850
Total	1,509	990	256	75	2,830

Table 1.9 Oued Ennkhilet: Summary of Flood Damage by Zone
Ten Year Flood Return Period: Future Land Use Conditions

	Zones				Total
	A	B	C/D	E/F	
Losses to Residents					
Loss of Income	220	668	61	12	961
Damage to Buildings	7,127	3,086	424	157	10,794
Damage to Household Goods	467	675	60	26	1,228
Losses to Industrial Sector					
Loss of Income	116	0	0	0	116
Damage to Buildings	150	0	0	0	150
Damage to Assets	0	0	0	0	0
Losses in Agriculture	0	32	0	1	33
Losses in Transport					
Passenger Delays	995	0	0	0	995
Increased VOCs	13	10	0	3	26
Road Rehabilitation	330	823	100	40	1,293
Total	9,418	5,294	645	240	15,597

Table 2.1 Estimates of Traffic Flows on the GP-1 and the GP-1 Bypass, Traffic Census 1992

Category	Bypass of GP-1			GP-1		
	March	April	Average	March	April	Average
A+B: 2 Wheels	350	320	335	2,879	2,119	2,499
C: Taxis and Private Cars	4,487	5,469	4,978	11,727	9,817	10,772
D+E: Light Trucks	3,474	5,053	4,263	4,531	3,985	4,258
F: Heavy Vehicles	1,720	2,642	2,181	502	709	605
Autobus	111	120	115	470	497	483
Total	10,142	13,604	11,873	20,109	17,127	18,618

Table 2.2 Estimated Flows of Traffic on the GP-1 and GP-1 Bypass, 1993

Category	Bypass of GP-1			GP-1		
	March	April	Average	March	April	Average
A+B: 2 Wheels	175	160	167.5	1,439.5	1,059.5	1,249.5
C: Taxis and Private Cars	2,243.5	2,734.5	2,489	5,863.5	4,908.5	5,386
D+E: Light Trucks	1,737	2,526.5	2,131.5	2,265.5	1,992.5	2,129
F: Heavy Vehicles	860	1,321	1,090.5	251	354.5	302.5
Autobus	55.5	60	57.5	235	248.5	241.5
Total	5,071	6,802	5,936.5	10,054.5	8,563.5	9,309

Table 2.3 Results of the Traffic Census on the MC 48 and the RVE 835, 1992

Category	MC 48			RVE 845		
	March	April	Average	March	April	Average
A+B: 2 Wheels	2,806	2,265	2,535	1,750	1,656	1,703
C: Taxis and Private Cars	6,568	4,583	5,575	7,569	9,611	8,634
D+E: Light Trucks	3,316	2,577	2,946	2,772	2,068	2,420
F: Heavy Vehicles	938	802	870	392	177	284
Autobus	354	242	298	188	368	278
Total	13,982	10,469	12,225	12,671	13,968	13,319

Table 2.4 Estimates of Present and Future Traffic Flows on the GP-1 Bypass, 1993 and 2020

Category	Occup. (person/veh)	1993		2020	
		Veh/day	Passenger	Veh/day	Passenger
A+B: 2 Wheels	1.2	167.5	201	910	1,092
C: Taxis and Private Cars	3.8	2,489	9,458.2	13,500	51,300
D+E: Light Trucks	2	2,131.5	4,263	11,600	23,200
F: Heavy Vehicles	2	1,090.5	2,181	6,000	12,000
Autobus	45	57.5	2,587.5	300	13,500
Total		5,936.5	18,690.7	32,310	101,092

Table 2.5 Estimates of Present and Future Traffic Flows on the GP-1, 1993 and 2020

Category	Occup. (person/veh)	1993		2020	
		Veh/day	Passenger	Veh/day	Passenger
A+B: 2 Wheels	1.2	1,250	1,499	3,400	4,080
C: Taxis and Private Cars	3.8	5,386	20,467	14,600	55,480
D+E: Light Trucks	2	2,129	4,258	5,200	10,400
F: Heavy Vehicles	2	303	605	800	1,600
Autobus	45	242	10,868	650	29,250
Total		9,309	37,697	24,650	100,810