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AE Services for the Transportation Feasibility for Linking the West Bank and Gaza Strip (294-C-00-05-00233-00) Draft Final Report

Volume I – Main Report

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CHAPTER 1

INTRODUCTION AND SUMMARY

The Draft Final Report summarizes the work accomplished on AE Services for the Transportation Feasibility Study for Linking the West Bank to Gaza Strip (Contract 294-C-00-05-00233-00) from October 2006 to the end of the first week of March 2006. It also presents a summary of findings of the study to date.

1.1 Introduction

The Consultant evaluated a total of 10 transport alignments connecting the West Bank to the Gaza Strip along with a number of modal combinations, road only, rail only, and road and rail within the same corridor and with different cross-sectional configurations, "at grade" or ground level, sunken cross section for a road, and tunnel alternatives for rail.

The analysis of these alignments is done in four stages that can be briefly described as follows:

- The initial evaluation included at grade or ground level alternatives with two alternative end points on the West Bank – Tarkumiya almost directly east from the start point in the North West corner of the Gaza Strip and a second end point at a more southerly location in the West Bank. At this stage, the three southern alignments (Alignments 4, 5 and 6 and one northern alignment (Alignment 3) were dropped leaving Alignments 1 and 2;
- Detailed evaluation of only Alignments 1 and 2 and their modal options.
- Modification 1 to the contract requiring an investigation of a tunnel connection through Israel added two new alignments to the study (Alignments 7 and 8).
- Toward the end of the study, USAID requested an investigation of an interim solution that would entail using Israel Railways infrastructure between Gaza Strip to a turnout south of Kiryat Gat connecting to a bored tunnel for the remainder of the distance to the West Bank (Alignment 9). A further request made by USAID is a variation of this alternative substituting a ground level rail connection to the West Bank in lieu of a tunnel (Alignment 10). In both cases, the long-term solution would be an independent rail connection without the need to utilize Israel Railways' infrastructure.

Table 1-1 briefly describes the 11 alternatives for which a detailed review was undertaken giving the construction length of each alternative.

Table 1-1: Description and Construction Length of Each Alternative (1)

No.	Alignment & Mode Designation	Align-ment Number	Transport Mode	Cross Section	Length in Kilometers				
					Israel	Palestine			Grand Total
						Gaza	West B	Subtotal	
1	1Road	1	Road	At grade	42.0	0.6	1.4	2.0	44.0
2	1Rail	1	Rail	At grade	42.0	0.6	0.7	1.3	43.3
3	1Combine	1	Road/Rail	At grade	42.0	0.6	1.4	2.0	44.0
4	2 Road	2	Road	At grade	42.0	0.6	1.4	2.0	44.0
5	2 Rail	2	Rail	At grade	42.0	0.6	0.7	1.3	43.3
6	2Combine	2	Road/Rail	At grade	42.0	0.6	1.4	2.0	44.0
7	2 Road (Partially Sunken)	2	Road	Sunken	42.0	0.6	1.4	2.0	44.0
8	7 Rail (C&C + Bored Tunnel)	7	Rail	Tunnel	37.8	0.6	0.5	1.1	38.9
9	8 Rail (Bored Tunnel)	8	Rail	Tunnel	36.4	0.6	0.5	1.1	37.5
10	9 Rail (IR + Bored Tunnel)(2)	9	Rail	Tunnel	52.3	0.6	0.5	1.1	53.4
11	10 Rail (IR + At grade)	10	Rail	At grade	52.2	0.6	0.7	1.3	53.5

Notes: 1. The rail length is to the terminal boundary. Operating distances may be different.
2. C&C = Cut and cover tunnel construction method.
3. IR = Israel Railways

The analysis of the alignments was done with no official inputs from the Government of Israel, except for the Israel Antiquities Authorities, which provided extensive technical support. Unofficial data was provided by various Israeli Government Agencies. However, additional critical information is expected once authorization paths are open. Similar official channel obstacles forced the Palestinian Authority to provide limited unofficial inputs on environmental issues. This has limited to some extent the Consultant's access to important data and reports; even so, a substantive amount of information needed to complete this report was amassed.

1.2 Summary of Main Findings

Traffic: The variation in traffic is assumed to be mainly a function of the mode of transport. Three alternative traffic estimates were prepared. For the Road Only alternative, traffic levels in 2015 are projected for the Medium Growth Scenario to be around 13,000 AADT[1]. For the Rail Only, it is forecast in the same year to be about 62 thousand passengers per day and nearly 6 tons of cargo. For the Combine Road/Rail, the total traffic in terms of passengers and cargo is projected to be the greater than either of the other modes.

Length: As Table 1-1 indicates, the differences in the length among the at grade alternatives is negligible except for Alignments 9 and 10 that make use of Israel Railways' infrastructure. The full-length tunnel alternatives (Alignments 7 and 8) provide the shorter distances with Alignment 8 having the shortest distance of 37.5 km.

[1] AADT = Annual average daily traffic.

Utilities: A transportation link connecting the West Bank to Gaza Strip would provide the opportunity to incorporate within its right-of-way the utility transmission lines for water, power (electricity), natural gas and telecommunications. The technical and economic evaluations indicate that the proposed transportation link should be sized to accommodate the transmission of all four utilities. However, the economic data do not support the construction of any of the transmission lines in the near future. For example, in the absence of a major discovery of additional natural gas reserves off Gaza, there is no economic rationale for installing a gas transmission line connecting the two areas. Similarly, the large and rapid changes in the telecommunications industry would render a current decision based on present technology for transmission of electronic data in, say, the 2015 period as highly risky. Similar high levels of risk would also be associated with any decision to build electricity and water transmission lines within the corridor. Uncertainty about the timing of a future desalinization plant, for example, and the potential for large changes to demographic patterns once the transportation link is built would greatly influence the economic viability of these projects. Nonetheless, one or more of these transmission lines might become important to the long-term economic development in a future Palestinian State, and therefore it would be prudent not to foreclose the opportunity to construct utility transmission lines within the proposed transportation corridor as needed.

Land Acquisition: The area of land needed to build the transport link across Israel connecting the West Bank to the Gaza Strip varies substantively. At one extreme, almost no land is required in Israel for the bored tunnel alternative; in the case of the combined road/rail and the sunken alternatives, the expropriated land area is the greatest, 4,100,000 square meters. The land requirements in Palestinian territory are negligible for the road alternatives, but all the rail alternatives need two terminal facilities – the larger one is located in Gaza Strip (600,000 square meters), and a smaller one is in the West Bank (400,000 square meters).

Travel Time: The average time to complete the trip will be less than 30 minutes by car. However, even though the speed of the train will be higher than a car, the travel time by rail will be longer. Passenger trains will be scheduled to travel only once every half hour so many passengers will have to wait for the train to depart; on the average this might be 15 minutes. On arrival, the passengers will have to walk out of the terminal and wait for on going transportation, a further delay. Estimated lapse time between start and completion of the trip by rail will be less than an hour.

Time to Completion: The estimated time to complete the construction of the proposed projects is estimated to vary from a low of 7.1 years for Alignment 10 to 10.6 years for the tunnel alternative, Alignment 7, the combination of a cut and cover and bored tunnel. Construction times for the tunnel alternatives are the longest. For instance, to order, ship and assemble a tunnel boring machine takes between 15 and 18 months after the construction contract has been awarded.

Initial Investment Costs: The initial investment costs include the following:

- Various services and studies (preliminary and final designs, environmental and permitting studies, project management and construction supervision);
- Land acquisition,
- Construction costs, and
- Procurement of equipment for the rail alternatives including initial rolling stock.

The initial investment costs are summarized in Table 1-2.

Table 1-2: Initial Investment Costs
(in millions of US $)

No.	Alignment & Mode Designation	Studies, Designs, & Supervision	Land Acquisi-tion	Construc-tion Costs	Equipment Cost	Total
1	1 Road	22.90	27.30	199.12	-	249.32
2	1 Rail	26.77	47.45	232.80	132.00	439.02
3	1 Combine	36.26	64.35	378.47	70.20	549.28
4	2 Road	21.68	17.49	188.57	-	227.74
5	2 Rail	27.12	42.68	235.79	132.00	437.58
6	2 Combine	36.02	54.01	376.27	70.20	536.49
7	2 Road (Partially Sunken)	22.27	20.42	193.69	-	236.39
8	7 Rail (C&C+Bored Tunnel)	40.88	33.80	1,161.50	135.10	1,371.28
9	8 Rail (Bored Tunnel)	52.52	33.80	1,656.92	135.10	1,878.34
10	9 Rail (IR + Bored Tunnel)	34.07	35.36	765.57	135.10	970.09
11	10 Rail (IR + At grade)	18.24	42.45	158.64	132.00	351.33

The initial investment costs do not include VAT nor do they include the costs of the security infrastructure that will be required by the Government of Israel. As requested in the Scope of Work, the Consultant is not to propose or design security infrastructure for the project.

Cost effectiveness: From the perspective of the donor(s) who are likely to finance most of the project costs through a grant(s), the least cost solution would be one of the Road Only alternatives. Even build at grade, all the rail alternatives have high initial capital costs because of the two terminals and the equipment costs. Tunneling is very costly. This study shows almost a 1 to 8.25 ratio between the lowest cost road and the bored tunnel alternatives. But, this is only a portion of the picture; once a project is completed recurring costs occur in operating and maintaining the infrastructure.

The Palestinian economy will have to absorb all the recurring costs needed to maintain the transport link. Recurring costs include operation and maintenance costs funded by the organization managing the project, the vehicle operating costs for road users and time cost for passengers and cargo. These organizations include the railway company or agency that will provide the transport services and maintaining the rail infrastructure, and the road agency, which will be responsible for maintaining the road. The present value of the recurring costs is estimated in Table 1-3. From the perspective of the Palestinian economy, the most cost effective alternatives are the two rail alternatives. The lowest recurring costs are for the two long tunnels.

Table 1-3: Present Value of the Recurring and Investment Costs to the Palestinian Economy (in millions of US $)

No.	Alignment & Modal Designation	Total Recurring Cost	Rank by Total Recurring Cost	Initial Investment Costs	Total Project Cost	Rank by Total Project Cost
1	1 Road	255.1	8	91.1	124.6	3
2	1 Rail	132.8	3	106.5	209.8	5
3	1 Combine	191.4	5	147.8	234.0	7
4	2 Road	255.1	8	86.3	112.1	2
5	2 Rail	132.8	3	107.9	208.1	4
6	2 Combine	191.4	5	147.0	226.2	6
7	2 Road (Partially Sunken)	211.0	7	79.2	105.1	1
8	7 Rail (C&C + Bored Tunnel)	94.4	2	424.2	507.7	8
9	8 Rail (Bored Tunnel)	93.7	1	676.7	771.3	9
10	9 Rail (IR + Bored Tunnel)	N/C	N/C	N/C	N/C	N/C
11	10 Rail (IR + At grade)	N/C	N/C	N/C	N/C	N/C

Note: 1. N/C = not computed since recurring costs were not analyzed for Alignments 9 and 10.
2. The present value costs are more heavily weighted against early completing projects than for projects that have long gestation periods.

Another measure of the cost effectiveness of the project is to compute the present value of the initial investments with the recurring costs to obtain the total project cost for each alternative. The road alternatives have the lowest total present value and are easier to construct that some of the more complex rail alternatives.

Environmental: In addition to the protection of critical habitats and area watersheds, the evaluation of the alternatives took into consideration the central role conservation of open spaces, wildlife, and biodiversity, plays for the Israeli population, NGOs, and the Israeli Ministry of Environment. Avoidance of nature reserves, forested areas, water bodies, wildlife bottlenecks (known areas heavily utilized as a passage by wildlife), and other critical habitats, was used to reshape proposed alignments, and to screen selected alternatives. Impacts to areas such as existing biological corridors cannot be avoided since they usually run in a North-South direction and all potential alignments cross these areas from west to east. Streams and watersheds in the region are scarce but also the main source of water for wildlife. Consequently, reducing proximity to these areas was a key driver in the establishment of alignments. The impact analysis for each alternative (action) was based on location (plains, hills, mountain), receiving media (nature reserves, streams, open spaces, etc.), and time (during construction and operation). The impacts identified for each action included:

Construction Impacts

- The Sunken Road option causes the highest impacts across all factors evaluated both during construction and operation of the alignment
- At-grade roads (Alignments 1 and 2) show similar construction impacts, although due to nature reserve crossings Alignment 2 displays a higher impact importance in the plains than Alignment 1.

- Alignments 1 and 2 show higher impacts over landscapes and biological corridors than over nature reserves, forests and streams.
- All 4 "surface" alternatives evaluated (A-1, A-2, A-7) have similar impacts on the planned Biosphere to be established in the Plains.
- Alternative Alignment 8 showed the lowest localized environmental impact of all alternatives (except when considering potential impacts of discharge of excavation material outside the study area).

Operational Impacts

- In general terms operational impacts are lesser than those expected during construction activities (except for Sunken Road alternative which continues to show high impact importance).
- When compared to construction related impacts, Alignments 1 and 2 showed higher impact importance over forests, nature reserves, and other protected habitats. This is primarily due to noise and emission pollution, as well as the cumulative space fragmentation caused by an enclosed alignment and a road.
- When compared to construction related impacts, Alignments 1 and 2 showed lower impact importance over stream alteration during operation of the alignments.
- Once in operation Alignment 7 produces the same impacts than that produced by Alignment 8 (bored-tunnel).
- No difference expected for alternative Alignments 7 and 8.

Social: The social factors affecting the selection of alignments and alternatives are listed below in order of relative importance:

- Resettlement and Compensation.
- Distribution of population and industrial/commercial/agricultural activity relative to the proposed alignments.
- Access to Employment Opportunities, Educational and Health Facilities.
- Integration with Regional Planning and Transportation Initiatives.
- Impairment of Existing Utility Lines.
- Degradation of natural areas used for recreation.
- Restriction of activities of the Bedouin Inhabitants.

Of the four main alignments still under consideration, the rail only alignment and tunnel alignments would require the least amount of resettlement and compensation. In addition, the rail only alignment would have the smallest social impact in terms of the other social factors identified in Section 9.3.4. Almost every person contacted during the field mission in Israel expressed the preference for the use of alignments that follow existing road and rail rights-of-way. The use of existing rights of way would also help to minimize adverse social impacts and disruption of economic activities.

The tunnel option would also minimize the need for resettlement in Israel, though resettlement would still be necessary in the Gaza Strip and also in the West Bank near Tarkumiya. Some compensation in Israel would be necessary for ventilation shafts and access points to the tunnel. The tunnel option was preferred by many of the individuals interviewed, as the adverse impact on economic activities in Israel would be minimized.

resettlement and compensation in Israel, as well as in the West Bank and Gaza Strip. Alignment 1 uses a corridor partly defined by existing roads and a section of abandoned railway. Alignment 2, the road only option, would have the greatest adverse impact, as this alignment is slightly longer than alignment 1 and makes less use of existing rights of way. Most individuals interviewed thought there would be a substantial social impact from a road and were more receptive to the rail alternatives.

1.3 The Draft Final Report

The draft Final Report encompasses three volumes: Volume 1, the Main Report, Volume 2, Appendixes and Volume 3, Drawings. The Main Report consists of five chapters and covers the work activities defined in the Scope of Work (See Annex 1-1). Volume 3 includes detailed drawings of each of the alignments studied, location maps and typical cross sections.

The following subsections summarize the contents of each of the Main Report's chapters and appendixes found in Volume 2.

Chapter 2, Forecasts. This chapter presents the population and economic forecasts for the West Bank and Gaza Strip (Gaza) covering the feasibility study period (2005 to 2030). These projections are largely refinements and modifications of work done by others, including the World Bank, IMF, and FAFO. The population projections take into account the potential in-migration of Palestinians from abroad.

Traffic forecasts for the proposed link are also presented. Because the transportation link would be without precedent and historical traffic data between the two territories are of limited value, it was necessary to develop a new traffic model that could provide results that were not dependent on having survey or other primary data. This model forecasts are for Medium, High and Low growth scenarios.

Chapter 3, Route Selection This chapter briefly reviews the six alternative alignments (18 combinations of road only, rail only, and road/rail options) initially investigated with a more detailed evaluation of Alignments 1 and 2.

Five technical appendixes explain the proposed design standards used by the study, geological considerations in selecting the alternative alignments, a hydrological assessment of the alternative alignments and electrical power requirements for railways and roads.

Chapter 4, Tunnel Alternatives This chapter describes the two tunnel alignments considering the route topography and geology, construction methods and duration, and finally costs associated with different technologies. Two technical appendixes give: 1) An overview of tunnel projects around the world with case studies for long rail and road tunnel and the costs associated with tunnel construction, and 2) A brief technical explanation of the ventilation and safety concept designs and cost estimate.

Chapter 5, Interim Alignments This chapter gives a brief overview of the two possible interim solutions using Israel Railways infrastructure between Gaza Strip and a turnout south of Kiryat Gat connecting to rail tunnel or to an at grade rail line to the West Bank terminus. Israel Railways' infrastructure will need to be upgraded and a connection between Gaza Strip and the first phase of Ashkelon-Be'er Sheva line now under construction. In the case of the tunnel alternative, the portion of the Israel Railways' infrastructure that is utilized will need to be electrified.

Chapter 6, Utilities Chapter 6 presents the feasibility study's findings on economic viability of using the transportation corridor for the transmission of water, electric power, and gas and communication utilities. The chapter describes current supply and demand issues associated with water, electricity, natural gas in the West Bank and Gaza Strip and their ramifications for building utility links between the two regions. An evaluation of these requirements indicated that there is no present need to incorporate any of these utilities within the corridor; however, there is sufficient uncertainty that an area should allocated within the right-of-way to accommodate at some future date these utilities. In the case of the tunnels, no additional space was reserved of them since the cost of reserving this space within the tunnel's cross section would add substantially to the initial cost of the project.

Chapter 7, Costs and Operational Requirements Chapter 7 reviews all the costs that are associated with the project, the project scheduling to accommodate the various activities that must be completed prior to commencement of construction, contracting packaging and scheduling, operational requirements for railways, operating and maintenance costs for railways, vehicle operating costs for cars, buses, and medium and heavy trucks and time costs for passengers and cargoes.

A number of appendixes help describe the different assumptions and calculations used. They include detailed gnat charts; unit pricing and contingencies, operational plan for the railway alternatives, railway operating and maintenance costing, land appraiser's report, and an explanation of the methodology utilized in computing the vehicle operating costs and the road maintenance costs.

Chapter 8, Comparison of the Alternative Transport Links In a manner similar to section 1 of this chapter, Chapter 8 summarizes and compares the different alternatives. Length, time to completion, travel time, various costs and the present value of these costs are compared. In many cases, the alternatives are ranked.

Chapter 9, Environmental Considerations This Chapter describes the existing environmental, cultural resources, and socio-economic conditions and data collected during this study; it provides an analysis of the different alignments and the environmental factors that played a central role in the adjustments made of the proposed routes as they were being developed (e.g. minimize proximity to nature reserves and national parks), and describes the potential environmental issues to consider during the impact analysis of alternatives. It is important to emphasize the difference between analysis of proposed alignments and of proposed alternatives. An alignment can have diverse environmental effects depending on the design and construction types selected, e.g. cut-and-cover, at-grade road, sunken road, segmented tunnels, railroad vs. road. A comparative impact analysis of the possible alternatives was conducted for each of the alignments and modal alternatives.

CHAPTER 2

DEMOGRAPHIC, ECONOMIC, AND TRAFFIC FORECASTS

2.1 Population and the Economy

The population and economic forecasts used in the feasibility study and presented in this chapter are primarily derived using previous projections (e.g., World Bank) and represent more of a consensus of opinion rather than a purely original effort.

The Palestinian Territory is encompasses two separate areas, the larger land locked West Bank located in the east and the Gaza Strip on the Mediterranean Sea.. The West Bank comprises eleven (11) Governorates covering 5,740 sq km. West Bank Governorates north of Jerusalem are: Jenin, Jerico, Nablus, Qalqiliya, Ramallah, Salfit, Tubas and Tulkarm and West Bank Governorates south of and including Jerusalem are: Bethlehem, Hebron and Jerusalem. The Gaza Strip consists of five (5) Governorates covering an area of 360 sq km. Gaza Governorates are North Gaza, Deir El-Balah, Gaza, Khan Yunis and Rafah

2.1.1 Population Projections for West Bank and Gaza Strip

2.1.1.1 Overview

Discussions regarding the current and future demography of the West Bank and Gaza Strip invariably elicit strong responses from the spectrum of stakeholders involved in Palestinian/Israeli planning issues. The continuing conflict, inadequate institutional capacity, and other socio-political and cultural factors have prevented the conduct of regular and definitive census counts over the last five decades. Because there are no reliable historical series of demographic data for any of the administrative or geographical regions comprising the Palestinian territories, efforts to establish a baseline population and develop even short-term demographic forecasts are inherently fraught with a high level of uncertainty and subject to wide interpretation. For example, recent estimates of the 2005 Arab population in the West Bank and Gaza Strip range from a high of 3.82 million (PCBS 2005)[1] to a low of 2.4 million (AEI, 2005)[2], a discrepancy exceeding 1.4 million persons. Using these figures, as alternative baseline years for a 25-year population projection would lead to a highly divergent set of end- year estimates. Such a large discrepancy would have a major impact on how planners could address the potential long-term availability of scarce resources or estimate the demand for infrastructure. The political ramifications of demographic projections cannot be overstated in a region with such a large and conflicted population residing in a small area.

Because of the contentious issues associated with population estimates and the limited scope of this study, no new baseline projections have been developed. Instead, a review was conducted of existing studies, including those conducted by the Palestinian Authority, Israeli Demographers, and independent organizations. Based on this review, it was determined that the population projections developed by Norwegian researchers associated with the Fafo, Institute for Advanced

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[1] Palestinian Central Bureau of Statistics**.** *Palestine in Figures 2004*, 2005, Ramallah, Palestine.
[2] American Enterprise Institute, *Arab Population in the West Bank and Gaza*, January, 2005

International Studies (2004) would be suitable for this study[3]. The study builds upon earlier demographic research efforts conducted by Fafo in the 1990s and employs well established and widely accepted methodologies. Furthermore, since it was published in December 2004, it is the most recently publicly available demographic study on the Palestinian Territories. The only significant modification of the Fafo projections for use in this feasibility study is an extrapolation from 2015 (the last year of that study's forecast) to 2030, the end-year for the current study.

The Fafo Study (Dalen and Pedersen, 2004), "The Future Size of the Palestinian Population of the West Bank and Gaza Strip" characterizes the size and composition of the Palestinian population based on the December 1997 Census. Using these data and trends in fertility rates, the Fafo Study developed high and low growth rate scenarios for estimating the Palestinian population through the year 2015, at five-year intervals.

The Fafo Study uses the Palestinian 1997 as a baseline for its projections, albeit with one modification; the Norwegians assumed an undercount of approximately 2.4 percent. It should also be noted that the Fafo population baseline also included the Arab population of East Jerusalem, which totaled about 210,000 at the time.

The population projections generated by the Fafo study were developed using the cohort-component method, which essentially uses the age and gender structure of the current population to simulate changes to each cohort with regard to births, deaths, and migration, based on age-specific fertility, death, and migration rates. It is important to note that this study only took into account natural changes to the population and assumed a net zero migration rate. The study's authors noted that future migration rates would be dependent on too many unpredictable variables to develop accurate projections. It should also be noted that recent migrations rates have not had a substantial affect on population levels in either the West Bank or Gaza. For example, net migration to the West Bank has averaged 2.82 migrants per 1,000 population over the past 6 years, and only 1. The net migration on average would only have added about 6,000 person per year to the indigenous West Bank Population and 2,000 persons per year to the Gaza Strip Population. These estimates would be considerably lower than the projections developed by the Palestinian Central Bureau of Statistics, which in 1999, assumed a net positive migration of 45,000 per year from 2001 to 2010.

Because of the significant uncertainties associated with projecting migration rates, especially with the ongoing political conflict and a poorly performing Palestinian economy, the study author's assumed a zero net migration for the forecast period 2005 to 2015. The recent Palestinian elections have engendered even greater uncertainty in terms of future economic performance and migration patterns. In principal, because only natural population growth is considered, the Fafo approach is by definition conservative and avoids bringing into the analysis scenarios that are inherently speculative. Furthermore as noted above, issues related to demography, especially immigration are highly charged and controversial. Therefore, the Fafo population estimates, which encompass three different growth scenarios, are reasonable and methodologically correct. Nonetheless, for purposes of estimating traffic counts on the proposed transportation link for the 25 year study period, it would be prudent to evaluate the potential impacts of immigration scenarios. These additional scenarios will serve as a sensitivity analysis for the traffic and freight forecasts.

[3] Dalen and Pedersen**,** *The Future Size of the Palestinian Population of the West Bank and Gaza Strip*, 2004, FAFO, Oslo Norway

The following sections present the Fafo study projections with and without migration estimates.

2.1.1.2 Population Estimates and Projections 1997 to 2030 – Based on FAFO Demographic Projections

As described above, the Fafo study developed projections to 2015, using data from the 1997 Palestinian Census along with other sources on West Bank and Gaza (WB/G) demographics. the total WB/G population in 1997 was estimated at 2.83 million, with 64 percent of the inhabitants residing in the West Bank.

Using high and low growth rate scenarios, the Fafo study projected the total 2005 population to range from approximately 3.51 million to 3.61 million. For purposes of the feasibility study, a medium forecast was also generated, using the midpoint of the Fafo low and high growth rate scenarios. Table 2-1 presents population projections f or the period 2005 to 2020.

Table 2-1 Projected Populations for the West Bank and Gaza Strip 2005 to 2030 Based on Natural Growth Rates Only (in thousands)

High Growth Scenario	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
West Bank	2,265	2,558	2,854	3,184	3,553	3,964
Gaza Strip	1,350	1,579	1,815	2,087	2,399	2,758
Total	**3,615**	**4,137**	**4,669**	**5,271**	**5,952**	**6,722**
Medium Growth Scenario						
West Bank	2,228	2,472	2,703	2,956	3,233	3,535
Gaza Strip	1,332	1,525	1,709	1,915	2,147	2,406
Total	3,560	3,997	4,412	4,871	5,380	5,941
Low Growth Scenario						
West Bank	2,193	2,389	2,562	2,746	2,944	3,156
Gaza Strip	1,314	1,473	1,609	1,758	1,921	2,098
Total	3,507	3,862	4,171	4,504	4,865	5,254

Adapted from Dalen and Pedersen

Central to the Fafo forecast is the assumption that fertility rates in the Palestinian Territories have decreased since 1997 and will continue to do so until birth rates become more in line with other Arab countries in the region. Nonetheless, growth rates are projected to be sufficiently high to cause a doubling of the 1997 population before 2025 under the high growth rate scenario and before 2035 under the low growth scenario.

For the WB/G as a whole, under the high growth scenario, estimated average annual growth of 3.14 percent for the period 1997-2002 is projected to decrease to 2.41 percent annually by 2015. Under the low growth scenario, annual percentage increases are projected to drop from 2.86 percent to 1.54 percent over the same period.

Within the Palestinian Territories there are large differences in population growth rates. For example, the Gaza has a much higher growth rate than does the West Bank Region and within the

West Bank, the urban populations around Jerusalem have lower fertility rates than in the rural areas of the southern West Bank. The Gaza Region was estimated to have an average annual growth rate of 3.76 percent during the period 1997 to 2002 compared to a 2.78 percent growth rate for the West Bank (under the high-growth scenario). These growth rates are projected to decrease to 2.79 and 2.19 percent, respectively, by the year 2015.

To project population levels outward from 2015 to 2030, the feasibility study assumes a stabilizing of the projected fertility rates. Specifically, it is assumed that the lower growth rates achieved by the year 2015 continue for the remainder of the forecast period. Accordingly, in the year 2030, the total WB/G population is estimated to range from a low of 5.25 million under the low growth scenario to more than 6.72 million under the high growth scenario. The proportion of the West Bank population under all of the scenarios decrease from 64 percent of the total Palestinian population in 1997 to about 58 and 60 percent by 2030, under the high and low growth scenarios, respectively.

2.1.1.3 Population Estimates and Projections 1997 to 2030 – Modified for Net Migration

Migration to the Palestinian Territories has been relatively small over the past six years. Uncertainties associated with the future status of the region and economic and political instability that beleaguered the West Bank and Gaza areas have undoubtedly deterred Palestinians living abroad from returning. The net migration rates for West Bank and Gaza on per thousand population basis has averaged 2.82 and 1.53, respectively. Put into perspective, however, the West Bank's net migration rate of 2.88 during 2005 ranked 33rd among all countries for which data are available (CIA World Factbook, 2005). Gaza ranked 54th out of 224. Hence, relative to much of the world, net migration to the Palestinian Territories has remained somewhat robust.

Because of the ongoing uncertainties, especially after the recent elections, it would be difficult to project future migration rates with a high degree of confidence. Nonetheless, not accounting for any migration would likely lead to an underestimate of future travel demand. Hence for the transportation link feasibility study, recent net migration rates have been applied to the three Fafo population growth scenarios to account for net positive migration. This will allow the study to assess how additional population demand for the travel would affect the economic viability of the alternative alignments. Table 2-2 presents the modified population estimates for the period 2005-2030.

Table 2-2 Projected Populations for the West Bank and Gaza Strip 2005 to 2030 Accounting for Natural Growth and Net Migration						
High Growth Scenario	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
West Bank	2,265	2,592	2,927	3,299	3,716	4,180
Gaza Strip	1,350	1,590	1,839	2,126	2,455	2,834
Total Population	**3,615**	**4,182**	**4,766**	**5,425**	**6,171**	**7,014**
Medium Growth Scenario						
West Bank	2,228	2,506	2,778	3,066	3,386	3,736
Gaza strip	1,332	1,536	1,732	1,952	2,200	2,476
Total Population	**3,560**	**4,042**	**4,510**	**5,018**	**5,586**	**6,212**
Low Growth Scenario						
West Bank	2,193	2,422	2,629	2,851	3,089	3,311
Gaza Strip	1,314	1,484	1,631	1,793	1,970	2,152
Total Population	**3,507**	**3,906**	**4,261**	**4,644**	**5,059**	**5,464**

As shown in the table, the differences are modest, with the projected total population of the Palestinian Territories differing by about 292,000 or about 4 percent over the Fafo projections in the Year 2030 (under the high growth scenario). For the low-growth scenario the difference is reduced to about 212,000. It must be emphasized that these estimates are being used more to test the sensitivity of the travel demand model than for providing accurate projections of future migration levels

2.1.2 The Palestinian Economy

The following sections present an overview of the Palestinian economy, including a discussion of current conditions, distribution of output by major sector, sector employment external trade, and projections of future economic performance. Each of these factors, together with future demographic changes will strongly influence transportation demand for the proposed linkage between West Bank and Gaza Strip. The primary source of data for these discussions is the Palestinian Central Bureau of Statistics, although many of the estimates of changes in socioeconomic indicators during the last five years have been estimated by the World Bank. It should be noted that economic data collection efforts were severely impeded during the worst violence of the second *Infitada*, leaving significant gaps in the availability of information on national accounts.

2.1.2.1 Overview of Current Conditions

The current status of the Palestinian economy can at best be characterized as fragile, despite some modest improvement from the precipitous decline in almost all socioeconomic indicators during 2001 and 2002. During the two-year period following the inception of the second *Intifada*, Palestinian real gross domestic product (GDP) per capita decreased by almost 40 percent (World Bank, 2004). This decline, however, does not begin to capture the magnitude of losses felt by Palestinian inhabitants of the West Bank and Gaza Strip. For example, at peak levels, Israel and Israeli settlements generated about 128,000 jobs and employed 25 percent of the Palestinian labor force. Following the outbreak of the second *Intifada* in September 2000, this figure dropped substantially, and by the end of 2002 Israeli employment of Palestinians decreased to 16,000 (Rand, 2005). Unemployment increased from 14 percent to above 30 percent. By 2004, approximately half the Palestinian population (and nearly two-thirds in Gaza) was living below the official poverty line of US$2.20 a day. Those living in severe poverty (below US$1.50 per day) were estimated at 16 percent.

By 2003, the Palestinian economy had somewhat stabilized and the steep declines of the previous two-years turned modestly positive for several key economic indicators.. According to the World Bank, real GDP per capita increased by one percent, but real Gross Disposable Income (GDI) – which includes remittances from abroad and foreign assistance – increased by over 11 percent per capita. Contributing factors to these economic gains were an overall reduction in violence, and fewer restrictions of movement on Palestinian workers, as well as a resumption of transfers by the Government of Israel (along with the return of US$178 million in withheld revenues). The World Bank also estimates that approximately 100,000 jobs were created.

Although the tenuous recovery of 2003 continued through 2004 in the West Bank, the Gaza economy regressed, with the imposition of stiff restrictions on movements of goods and people across the borders with Israel and Egypt. The volume of Gaza's exports was further reduced and humanitarian assistance temporarily curtailed. For example, worker access to the Erez Industrial Estate and to Israel from Gaza declined to a daily average of less than 1,000 in the second and third quarters (compared with 6,000 the previous year); at the same time, an additional 8,900 jobs have been lost within Gaza – resulting in a 6 percent increase in the unemployment rate in Gaza to 35 percent. In the West Bank, employment increased slightly, with unemployment averaging 23 percent in 2004, an improvement of 5 percentage points from 2002.

Recent data from the Palestinian Central Bureau of Statistics (PCBS, 2005) indicate some improvement to the overall Palestinian economy compared to 2004. For example, the third quarter, 2005 labor survey conducted by the PCBS, estimated that West Bank unemployment at 19.9 percent, while the Gaza unemployment rate dropped to 29 percent[4]. Nonetheless, the economy remains extremely fragile and most of the indicators are well below levels attained in the period preceding the second *Intifada*. For example, the quality of the jobs recently generated is well below that prior to the year 2000. For example, the percentage of employees whose monthly wages are below the poverty line reached 57 percent in the 3rd Quarter of 2005, compared to 43 percent in 2000. Similarly the economic dependency ratio[5] continues to rise, reaching 5.1 and 7.5 in the West Bank and Gaza Strip, respectively (PCBS, 2005). The comparable ratios for the year 2000 were 4.3 and 5.9, respectively. Almost all other socioeconomic indicators remain significantly below 2000 levels. In short, the Palestinian economy has made modest gains in the past 3 years, but has yet to regain the huge losses of economic output and quality of life experienced in the two-year period following the second *Intifada.* The economy remains extremely weak and highly vulnerable to exogenous political and economic events. In the absence of institutional reforms together with further abatement of restrictions to the movement of goods, services, and people, and improvements in infrastructure, the Palestinian economy will be hard pressed to attain significant economic development in the future.

[4] Includes those persons in the labor force who are unemployed and are seeking a job.
[5] Number of population divided by the number of persons employed.

2.1.2.2 Composition of Palestinian Economy

The PCBS has published data on economic activity by sector only through the year 2000. To some extent, these data might not accurately reflect the current distribution of economic output because the ongoing conflict has not affected all sectors equally. For example, prior to the second *Infitada*, almost a quarter of the labor force was employed by establishments in Israel or by Israeli settlements. Currently, the figure is greatly reduced, with more laborers working in establishments in their village, including agriculture. Hence, employment and output in this sector has increased relative to other sectors, despite a downward trend over the last decade.

In terms of value of gross output, in the year 2000, according to PCBS figures, manufacturing accounted for 17 percent of the total output of the Palestinian economy. The service sector generated 16.5 percent of the output, followed by public administration (13.3 percent), construction (11 percent), and agriculture (9.6 percent). Wholesale trade, transport, financial institutions, and other services accounted for the remainder of the output. As noted above the Infitada has in some ways restructured the economy. UNCTAD estimated that by the end of 2002, the manufacturing sectors contribution to the economy decreased to 16 percent and construction lost half its share of GDP (UNCTAD). Agriculture increased to about 15 percent of the GDP in 2002.

The PCBS has been able to conduct regular labor force surveys, with the most recent data collected for the third quarter of 2005 and these surveys provide a snapshot view of Palestinian employment distribution by sector. The service sector, which includes a large public sector component, generates the largest proportion of jobs in both the West Bank and Gaza. Historically, the public sector has played a disproportionately large role in the economy. As recent as 1999, public administration and services accounted for approximately 23 percent of the domestic employment (Rand, 2005). Commerce, restaurants, and hotels still account for almost a fifth of the jobs in both regions, whereas agriculture generates about 18 percent of the employment in the West Bank but only 10 percent in Gaza. The largest proportion of Palestinian workers associated with Israeli employment is in the construction industry, although the number of employed Palestinians working in Israel or on the Settlements has been drastically reduced. This has also had a disproportionate effect on the economy because Israeli employment on average paid almost double the amount earned by Palestinian employees working in either the West Bank or Gaza. Finally, it should be noted that the Palestinian economy is driven almost totally by small business enterprises. According to UNCTAD, 90 percent of the establishments employed fewer than five workers (UNCTAD, 2005).

Table 2-3: Economic Activity and Place of Work (percentage) 3rd Quarter 2005				
Economic Activity	West Bank	Gaza	Israel and Settlements	Total
Agriculture, fishing, forestry	18.4	10.4	5.6	14.9
Mining, quarrying Manufacturing	13.9	7.9	22	13
Construction	10.1	8.5	43.6	13.0
Commerce, restaurants, and hotels	21.4	17.5	19.3	20.1
Transportation, storage, communication	5.7	5.6	2.2	5.3
Services	30.5	50.1	7.3	33.7
Total	100	100	100	100

Source: PCBS 2005

2.1.2.3 External Trade

Despite severe constraints, trade has filled an important role in sustaining the Palestinian economy. Imports of final goods, services, equipment and intermediate inputs have historically accounted for approximately 70 percent of GDP, while exports of goods and services represented less than 20 percent of GDP (World Bank, 2004). However, external trade like all other components of the Palestinian economy had decreased dramatically since the year 2000. Disruptions in production, restrictions on movement, and the large increases in transaction costs have rendered the Palestinian exports less competitive

As seen in the table below, total exports decreased from almost $395 million in 1998 to about $241 million in 2002. Exports to regions in the world, except for Arab Countries and the Americas declined. These two regions together, however still accounted for only about 6.4 percent of the total value of exports. Israel share of the exports decreased from almost 97 percent to 84 percent. Jordan is the primary destination of exports to the Arab region, accounting for more than 82 percent of the total exports to Arab Countries.

Table 2-4: Palestinian Exports to the Rest of World 1998-2002 (million US$)					
Country	1998	1999	2000	2001	2002
American Countries	$82	$365	$71	$128	$203
Arab Countries	$11,498	$9,631	$29,122	$14,576	$15,093
EUCC Countries	$1,636	$1,506	$1,675	$2,453	$8,921
Eastern European Countries	$45	$7	$0	$29	$1
Israel	$381,517	$360,469	$369,988	$273,164	$216,409
Other Countries	$68	$170	$0	0	0
Total	$394,846	$372,148	$400,856	$290,350	$240,627

Source: PCBS 2005

Table 2-5 presents export data by sector and show similar reductions for all export factors. Manufacture goods and articles, and food and live animals were the three largest exporting sectors and accounted for about 74 percent of the export value in 1998 and about 71 percent of the export value in 2002.

Table 2-5: Palestinian Exports by Sector – 1998 to 2002 (million US$)					
Sector	1998	1999	2000	2001	2002
Food and live animals	$61,793	$60,878	$84,552	$34,073	$27,036
Beverages and Tobacco	$25,432	$14,567	$13,573	$13,478	$13,657
Crude materials Inedible except fuels	$17,566	$13,406	$15,670	$12,887	$14,375
Mineral fuels Lubricants and related materials	$7,006	$4,952	$3,671	$2,161	$2,481
Animal and Vegetable oils Fats and waxes	$5,343	$4,133	$5,713	$5,755	$5,720
Chemicals and related products n.e.s (not elsewhere specified)	$24,631	$30,250	$29,687	$27,594	$20,263
Manufactured goods classified chiefly by material	$165,862	$151,240	$153,239	$120,473	$94,954
Machinery and transport equipment	$21,736	$20,758	$23,958	$16,920	$12,042
Miscellaneous manufactured articles	$64,397	$71,545	$70,596	$56,496	$49,834
Commodities and transactions n.e.s in the SITC-3	$1,080	$419	$198	$512	$505
Total	$394,846	$372,148	$400,857	$290,349	$240,867

Source: PCBS 2005

The World Bank estimates that exports continued to decline in 2003 (-4 percent in nominal and real terms) and remained some 30 percent below their *pre-intifada* level by the second quarter of 2004. A significant consequence of the *Intifada* is that producers have been targeting production to meet internal demand rather than world markets.

The economic crisis, which has greatly reduced the purchasing power of Palestinian households, has also dampened their demand for imports. Reduced output of the manufacturing industry also decreased demand for production inputs including equipment. As seen in Table 2-6, imports have also contracted by roughly one-third compared to year 2000 levels

Table 2-6: Palestinian Imports from the Rest of World 1998-2002

	1998	1999	2000	2001	2002
American Countries	$40,385	$99,868	$66,966	$52,242	$8,186
Arab Countries	$85,339	$81,085	$39,668	$36,781	$31,074
EUCC Countries	$226,028	$484,644	$263,605	$358,829	$16,116
Eastern European Countries	$12,089	$29,541	$26,802	$26,976	$23,089
Israel	$1,983,253	$2,285,629	$1,958,322	$1,534,842	$1,274,234
Other Countries	$28,008	$26,460	$27,444	$23,978	$162,909
Total	$2,375,102	$3,007,227	$2,382,807	$2,033,648	$1,515,608

Source: PCBS 2005

Imports from other Arab countries have dropped by more than 60 percent and imports from the EU have decreased by more than 93 percent. As seen in Table 2-7, machinery and transport equipment imports decreased by more than 50 percent and manufactured good by 48 percent. Food and live animal importation dropped by about a third.

Table 2-7: Palestinian Imports by Sector – 1998 to 2002 (million US$)

Sector	1998	1999	2000	2001	2002
Food and live animals	$447,195	$524,314	$431,837	$408,615	$324,628
Beverages and Tobacco	$97,494	$104,929	$101,711	$97,172	$75,811
Crude materials Inedible except fuels	$67,185	$73,321	$62,136	$42,094	$35,502
Mineral fuels Lubricants and related materials	$409,881	$391,547	$455,507	$377,478	$361,339
Animal and Vegetable oils Fats and waxes	$19,558	$23,528	$17,942	$15,930	$15,468
Chemicals and related products n.e.s (not elsewhere specified)	$189,737	$225,559	$230,765	$163,519	$139,632
Manufactured goods classified chiefly by material	$567,422	$715,674	$522,204	$498,404	$291,502
Machinery and transport equipment	$386,625	$616,903	$352,360	$248,323	$180,835
Miscellaneous manufactured articles	$175,642	$321,232	$199,200	$180,962	$90,882
Commodities and transactions n.e.s in the SITC-3	$14,363	$10,221	$9,145	$1,150	$9
Total	$2,375,102	$3,007,228	$2,382,807	$2,033,647	$1,515,608

Source: PCBS 2005

2.1.2.4 Economic Outlook for Palestinian Economy Based on Previous Studies

Given the continuing political volatility affecting the region and poor quality of historical data, economic forecasts, especially one covering 25-years will be inherently speculative. The Palestinian economy is vulnerable to a myriad of internal and exogenous political, social and economic forces any of which could significantly affect short-term and long-term performance. As described above, it took only two-years of the *Intifada* to reduce the Palestinian economy by 40 percent. The relative clam during the past two-years has allowed to economy to recover only a portion of these losses. Continued volatility in the future is likely to render any single-point forecast obsolete before it is published. Accordingly, most attempts to forecast the future performance of the Palestinian economy have developed alternative growth scenarios in order to capture a broad range of outcomes. Proposed policy or project impacts can then be evaluated to determine their relative efficacy under conditions ranging from pessimistic to optimistic. The approach used for this feasibility study is to present three alternatives economic scenarios (low, medium, and high) based on previous forecasts developed by the World Bank and the Rand Corporation. The following provides an overview of the two forecasts; much more detail is provided in the actual reports.

World Bank Economic Forecasts: As part of its 2004 study on the potential effects of the Israeli disengagement the World Bank(the "Bank") developed a medium-term economic forecast (2004-2008) for the Palestinian economy under three different scenarios; (1) *Status quo*; (2) *Disengagement Plus*; and (3) *Economic Recovery (World Bank, 2004a).* The Bank also simulated impacts under a disengagement alone scenario and found that the differences between that scenario and Status Quo Scenario were so negligible that the Status Quo Scenario was used as a baseline and the Disengagement alone scenario was dropped from the forecast. Under the Status Quo scenario the Bank assumed that the closure regime that existed at the time would remain essentially unchanged, with no appreciable revival in private investment would be expected. Under the Disengagement Plus Scenario the Bank assumed the removal of internal closures in Gaza and the Northern West Bank, and the completion of the Separation Barrier in 2005. Closures were assumed to remain in place in other parts of the West Bank. *Relevant to the current study, the Bank assumed that access between Gaza and the West Bank would though the inauguration of a Gaza/Tulkarm rail link by end-2007.* The Bank's high growth scenario or the Economic Recovery Scenario encompasses the Disengagement Plus scenario, but assumes a much improved trade regime. Specifically, under this scenario it is assumed border cargo facilitation measures would be implemented, including the abolishment of the back-to-back system; all internal closures are dismantled, the flow of goods and people between Gaza and the West Bank is significantly improved, a Gaza Roll-on Roll-off port comes into operation at the end of 2007, and Israelis are permitted to enter border-industrial estates (triggering appreciable job creation in the Erez, Karni and Jenin industrial estates by 2008). It should be noted that the Bank assumes annual Donor assistance of approximately $3.6 billion for the period 2005 through 2008 under the Disengagement Plus and Economic Recovery Scenarios. Donor assistance under the Status Quo was assumed to be $3.4 billion annually for the same period. Table 2-9 presents the outputs of the Bank's forecast of Gross Domestic Product (GDP) and Gross Disposable Income (GDI) per capita under the 4 scenarios.

As seen in Table 2-8, the Bank's prognosis for the next four years is quite pessimistic, except even under the high growth scenario. Under the high growth scenario, nominal GDP would grow by 40 percent and real GDP would increase by 30 percent. However, due to a high relative population growth rate, nominal GDI per capita would increase by only 6.5 percent and real GDI per capita by only 1 percent. Under the other scenarios, economic indicators in real terms would actually decrease. For example, under the Disengagement Plus Scenario real GDI per capita would fall 14 per cent from 2004 levels. Decreases would be more steep and rapid under the Status Quo Scenario.

Table 2-8: World Bank Projections of GDP and GDI Per Capita under Three Scenarios (US$)

Scenario	2004 GDP	2008 GDP	2004 GDI per capita	2008 GDI per capita
Economic Recovery	$3,336	$4,687	$1,393	1,484
Disengagement Plus	$3,366	$3,778	$1,393	1,227
Status Quo	$3,336	$3,472	$1,393	1,156

Source: World Bank, 2004

In sum, the medium term Bank forecasts presume limited opportunity for rapid economic growth. A scenario involving a rail linkage with other trade reforms leads to a modest growth pattern over the period 2005 to 2008. The scenarios without trade reforms and greater connectivity between the West Bank and Gaza project continued stagnation and growing poverty throughout the Palestinian Territories.

The RAND Economic Forecasts: In support of its study "Building a Successful Palestinian State" (RAND, 2004), the RAND Corporation, developed a series of forecasts for the Palestinian economy for the period 2004-2019. The RAND forecasts encompassed four scenarios: (1) high geographical contiguity/high economic integration (*Scenario HH*); (2) high geographical contiguity/low economic integration (*Scenario HL*); (3) low geographical contiguity/high economic integration (*Scenario LH*); and (4) low geographical contiguity/low economic integration (*Scenario LL*).

Although there are common elements to the RAND and World Bank analytical approaches, they employ different assumptions on the evolution of the political process and consequently differ in how quickly the Palestinian economy revitalizes. Of course the RAND forecasts are for a much longer time-frame, but its short-term assumptions are much more optimistic than the Bank's assumptions. For example, the RAND HH study assumes a much higher degree of autonomy than does the World Bank study, in the short-term. The major assumptions for each RAND Scenario are as follows:

> Scenario HH: Provides a high degree of geographical contiguity under which Palestinians would have control over more land (e.g., Jordan valley, Dead Seas Coast) and rights to water resources; movement of people would be unimpeded, Road and Rail Link between Gaza and West Bank. Economic integration is also implemented through free trade agreement, reopening of Israeli labor market to Palestinian workers, transit and travel procedures would be simplified.

> Scenario HL: Assumptions regarding Palestinian control of land and water resources are the same as for the HH Scenario. The primary difference is that economic links with

Israel remain undeveloped and Palestinian workers have little or no access to the Israeli labor market.

Scenario LH: Under low geographical contiguity assumptions, Israel would retain over land and water resources, external borders, and existing settlements. It does assume less Israeli control over internal movement, although closures could be imposed if the government chose to do so. A level of economic integration approaching that of Scenario HH is attained.

Scenario LL: Assumes limited connectivity across Palestinian Territory and low economic integration with Israel.

The Rand Study divides the forecast time-frame into 3 phases;

- 2005-2009 Economic Recovery
- 2010-2014 Economic modernization
- 2014-2019 Consolidation of gains and sustainable growth

Table 2-9 present RAND's projections for GDP and per capita Gross National Income (GNI) for the years 2014-2019.

Table 2-9: RAND Projections of GDP and GDI Per Capita under Four Scenarios (US$)

GDP					GNI per capita			
Scenario	2004	2009	2014	2019	2004	2009	2014	2019
HH	3,420	7,480	11,710	17,810	1,110	2,160	2,860	3,740
HL	3.420	7,610	11,680	17,040	1,110	2,000	2,640	3,370
LH	3,420	7,260	10,960	15,910	1,110	2,100	2,690	3,370
LL	3,420	7.020	10.180	14,180	1,110	1,185	2,310	2,810

Adapted from RAND 2004

The RAND projections are certainly more optimistic in the early years than are the World Bank forecasts for which there is an overlap in the timeframe. The HH Scenario, for example projects a 23.7 percent average annual growth rate for the years 2005 to 2009, with GDP reaching $ 7.5 billion at the end of 2009. The HL Scenario also projects high growth rates for the first 5-year period, in fact reaching a 2009 GDP of $7.6 billion. Both the LH and LL Scenarios are less robust than the HH and HL Scenarios. The RAND model also indicates that high geographical contiguity is a greater stimulant to economic growth than economic integration. As shown in the Table, the HL Scenario always performs better than the LH Scenario.

2.1.2.5 Feasibility Study Economic Forecast

Using either the World Bank or the RAND economic forecasts for purposes of the transportation feasibility study poses numerous challenges. Neither forecast covers the full time-frame used in the current study (2005 to 2030); the World Bank forecast covers the time-frame of (2004 to 2008 and the RAND forecast covers the longer period 2005 to 2019. Both forecasts also encompass scenarios that would not be applicable to the current study. For example, the World Bank's Status Quo Scenario and the RAND's low contiguity scenarios (LH and LL) assume no connectivity between the West Bank and Gaza. The more optimistic of the World Bank scenarios include a rail link in 2007, but no road. The RAND's high contiguity scenarios do include rail and road links, but also assume the implementation of political changes that do not appear to be realistic in the short-term, such as significant land and resource rights concessions to the Palestinian Authority. Consequently, the RAND study assumes a rapidly developing economic recovery period beginning in 2005, such that average annual GDP growth for the period 2005-2009 exceeds 20 percent for all scenarios. Although no GDP figures are yet available for 2005, PCBS surveys on labor force as well as other economic data, indicate that the Palestinian economy, while stabilizing from its recent crisis, is not yet poised to accelerate to growth levels assumed in RAND study. Other recent developments, including the call for new Israeli elections in 2006 are likely to delay the implementation of agreements that would increase the geographical contiguity and economic integration of Palestinian Economy that are the primary drivers of economic recovery and growth in the RAND forecast model. The RAND assumptions are not necessarily incorrect; however, it appears that the timing of critical assumption used in their forecasting model may be premature.

The methodological differences between RAND and World Bank studies preclude the assimilation of the two forecasts into a single coherent detailed model. Nonetheless, for purposes of generating three generic growth scenarios (high, medium, and low) it is reasonable to use the more conservative World Bank forecast as a basis for the period 2005 to 2010 and then use the RAND more robust scenarios for beginning in the out-years, albeit modified to account for differences between the assumptions used by RAND and those used this feasibility study. In particular, the current study does not make assumptions regarding territorial changes, removal of settlements, or transfer of land and water resource rights. Therefore, economic growth rates estimated in the RAND forecast for the period 2010 to 2020 are reduced to more modest levels to take into account the removal of these positive growth factors.

As noted above, the operation of a permanent road and/or rail link is not likely to begin until after 2010. Political, environmental, economic, and other legal compliance issues would prevent construction start-up for at least 2 to 3 years. A basic premise of this study is that the transportation link could provide a powerful economic stimulus to the Palestinian economy by reducing its fragmentation and by the synergy that it could create with other infrastructure projects. For example, the full economic benefits from development of a Gaza Seaport[6] and the reopening of the Gaza Airport would only be achieved if goods produced from the West Bank could be cheaply transported to these facilities and goods imported through Gaza could be efficiently transferred to the West Bank and even on to Jordan. The importance of connectivity between the two regions as an economic stimulus is supported by the RAND forecast model. The HL Scenario, for example, performed better than the LH Scenario over the full forecast period.

[6] The feasibility study assumed that the Gaza Airport were to reopen, it would primarily provide passenger service and would not provide transshipment of commercial goods.

Hence, geographical connectivity influences Palestinian economic performance more than improved economic integration with Israel.

An overall characterization of the three scenarios used for this study is as follows:

High Growth Scenario: The economic and political relationships with Israel will remain cordial and good allowing trade and commerce to develop between the two. Initially, internal growth will depend to a large extent on the remittances and investments received from Palestinians living abroad. However, with greater openness of the economy, Palestinian entrepreneurs as well as other investors will make good use of the comparative advantage that it will have relative to the Israeli economy. With greater demand for labor in Palestine, growth will depend on less on remittances from labor and from funds provided by overseas investors. Emphasis will on developing increased value added domestic opportunities in services and high tech light industry.

Initially, linkages between Israel and Palestinian economies will occur in the area of tourism, agriculture services, and light industries and then in higher tech industries. They will help to develop synergies with other sectors of their economies. Due to continued reforms to the Palestinian economy it will become more competitive and streamlined resulting in large improvements in productivity. The dependence on the public sector will be greatly reduced, and the private sector will be the primary "engine" of growth for the economy. External trade and economic relations with its other immediate neighbors, Egypt and Jordan, will also grow but not to the extent that they do with Israel.

Medium Growth Scenario: The economic and political relationships with Israel will remain correct but will not be strong. Over the period to 2030, internal growth will depend to a large extent on the remittances, funds and investments received from the Palestinian in the region. However, the openness of the Palestinian economy will be constrained from achieving its full potential due to only undertaking a limited number of political and economic reforms. Because of these constraints, Palestinian entrepreneurs will have only limited access to the Israeli economy. Its comparative advantage with its neighbor will not be fully realized. For these reasons, opportunities to absorb investments will be limited.

Cooperation between both economies will occur mainly in the areas of tourism, agriculture and low-tech light industries such as textiles and building materials, and some types of services. Due to partial and incomplete reforms to the economy, long-term improvements in productivity will be modest. The dependence on the public sector is reduced, but will remain an important component of the economy. Although the private sector will take on greater economic importance it will not be seen as an "engine" of growth. It will be constrained by regulation, control and the lack of transparency. External trade and economic relations with its immediate neighbors, Egypt and Jordan, will grow but will not achieve their potential because of internal restrictions.

Low Growth Scenario: The economic and political relationships with Israel will remain highly variable from good to poor, but they will create an economic environment of uncertainty. Over the period to 2030, internal growth will overly depend on: (1) the remittances and investments received from Palestinians working abroad; (2) the donor community; and (3) limited foreign direct investment. The lack of openness of the Palestinian economy will limit internal growth due not only to a lack of political reforms but to economic reforms as well.

Palestinian entrepreneurs will have very limited access to the Israeli economy due to limited cooperation between the two countries in economic matters. Cooperation, which will occur, will be mainly in the areas of tourism, agriculture and light industry in low tech sectors.

Due to partial and incomplete reforms to the economy improvements in productivity will be small. This will be reflected in an overdependence on the public sector. Private sector will continue to be constrained by over regulation and control and by corruption and lack of transparency in the Government. External trade and economic relations with its other immediate neighbors, Egypt and Jordan, will grow and be seen as the main bright spots. Even so, this growth will not achieve its full potential because of internal restrictions.

The actual forecast for this study derives from the World Bank and RAND forecast with several modifications;

- For the Period 2005 to 2010, the forecast employs the Bank's growth rates for the three Scenarios (high, medium, low). The Bank's projected growth rates are extended until 2010. Although the short-term low growth scenario is based on the Bank's Status Quo Scenario, which assumes no linkages, that assumption is consistent with the feasibility study, which assumes that the link will not be operational until 2010.

- For the period 2011-2030, the forecast uses the growth rates developed by RAND, but reduced by 25 percent to account for the fact that the feasibility study does not assume implementation of agreements (e.g., land and water concessions) that account for a portion of RAND's projected growth estimates. The final years of the forecast assumes a further 25 percent reduction in growth rates. It is assumed that by 2025, the economy will have assimilated most of the benefits of economic reform and geographical connectivity. Under ever the most auspicious conditions the economy would not likely sustain double digit growth throughout the final 20 years of the forecast period.

Table 2-9 presents the projected GDP for 5-year intervals from 2005 to 2030, with the World Bank's 2004GDP estimate of $3.3 billion serving as the baseline year. Consistent the RAND projections the difference between the high and medium growth scenarios is rather modest; average annual growth rates for the 25 year period are 7.6 and 6.6 percent, respectively. Nonetheless, the result is that the high growth rate leads to a 30 percent larger GDP by 2030 than the medium growth scenario. The low growth scenario is significantly lower with an average growth rate of 4.7 percent leading to a GDP almost half of the other tow scenarios in the year 2030. By reducing the RAND growth rates by 15 percent rather than 25 percent yields 2030 GDP levels of $28.7, $ 21.7 and $12.5 billion, respectively.

Table 2-9: Projected GDP for the Palestinian Economy
2004 to 2030 in million of US$

	2004	2005	2010	2015	2020	2025	2030
High	$ 3,336	$ 3,620	$ 5,556	$ 9,992	$ 13,984	$ 19,152	$ 24,247
Medium	$ 3,336	$ 3,440	$ 4,020	$ 7,324	$ 10,099	$ 14,734	$ 18,721
Low	$ 3,336	$ 3,369	$ 3,542	$ 5,554	$ 7,067	$ 9,382	$ 11,002

Source: Consultant's Estimate

Projected per capita will depend on which of the demographic scenarios materialized over the 25-year study period. Under the medium economic growth and moderate population growth scenario, per capita GDP reaches $3,067 in year 2030. That figure reaches $4,615 under a high economic growth, low population growth scenario. The worst case scenario would be a low economic growth high population growth scenario, which would lead to a GDP per capita of only 1,637 in the year 2030.

Table 2-10: Projected GDP per Capita through 2030 in US $

	2005	2010	2015	2020	2025	2030
MM	966	1006	1,660	2,073	2,739	3,067
MH	952	972	1,569	1,916	2,476	2,711
ML	981	1,041	1,756	2,242	3,029	3,468
HL	1,032	1,439	2,369	3,105	3,937	4,615
LH	932	856	1190	1,341	1,576	1,637

Source: Consultant's Estimate

It must be emphasized that this analysis does not take into account how changing demographics would affect output. The RAND economic forecast uses a set of assumptions regarding demographic changes for each scenario. Hence, using the high economic growth scenario with a low population growth scenario developed independent of the RAND study is not methodologically appropriate. However, for the purposes of generating order of magnitude estimates for the feasibility study, this approach is reasonable.

Finally, it is noted that the feasibility forecast addresses only GDP and GDP per capita. It does not forecast gross national income (GNI) or gross national income per capita. The RAND study assumes for each scenario a level of Palestinian remittances from work in Israel. In fact, it assumed 130,000 Palestinians working in Israel during 2005, a figure far above the 39,000 workers estimated to be working in Israel or on Israeli settlements during the 3rd Quarter of 2005 (PCBS, 2005). It should also be noted that the Israeli government has indicated that all work permits would expire after 2008. Given the uncertainty of remittances and other external aid this study opted not estimate these potential contributions to future income levels. Consequently, GDP per capita is used as a surrogate for estimating elasticity for transport demand.

2.2 Traffic Forecasts

The purpose for traffic analysis is to determine the demand for and characteristics of the passenger and freight traveling between the West Bank and Gaza Strip given the proposed transport link.

The proposed WBG link passes through Israel connecting the north end of the Gaza with the West Bank in the area of Hebron Governorate either as an all road link, all rail or a combination of rail and road.

2.2.1 Traffic Scenarios

The traffic forecasts take into consideration the population and economic forecasts described in the preceding sections and modal or infrastructure alternatives.

Economic Development Scenarios: Travel demand is forecasted for each of the three (3) alternative economic development Scenarios, which are defined as: (A) the Medium Growth Scenario; (B) the High Growth Scenario and (C) the Low Growth Scenario.

Transport Infrastructure Scenarios: Modal choice (road or rail) for the forecasted passenger and freight travel demand will be affected by the alternative transport infrastructure. There are three Transport Infrastructure Scenarios, which are the road only solution, rail only solution or a combination of both road and rail.

2.2.2 Methodology for Forecasting Travel Demand

There is presently very little traffic going between Gaza and the West Bank due to restrictions placed on vehicles crossing Israel. They act to increase costs and make travel uncertain to impossible resulting in very low volumes of passenger traffic traversing the approximately 40 to 50 kilometers of Israeli territory. Likewise, freight traffic is also greatly reduced because the delays are long, and the costs are high. The present traffic cannot provide a basis for analyzing travel demand in terms of population, land use and economic activities. Even if security considerations permitted the conduct of traffic counts, origin and destination and other types of traffic surveys, the information obtained would account for very little of the current unfulfilled travel demand in the WBG corridor. The relationships that would result from these surveys cannot be used to predict future travel demand. Simply stated, the forecasts of passenger and freight demand cannot be based on projections of present traffic or of present travel patterns. The potential demand for travel between the West Bank and the Gaza will be considerably higher than what is presently observed and will involve applying international experience to the forecasts of population, economic and trade characteristics of the West Bank and the Gaza.

The flow chart given in Figure 2-1 is a schematic outline of the methodology utilized in forecasting passenger and freight travel demand in the WBG link. Passenger forecasts are prepared separate from the freight forecasts. Some important elements of the forecast methodology include the following:

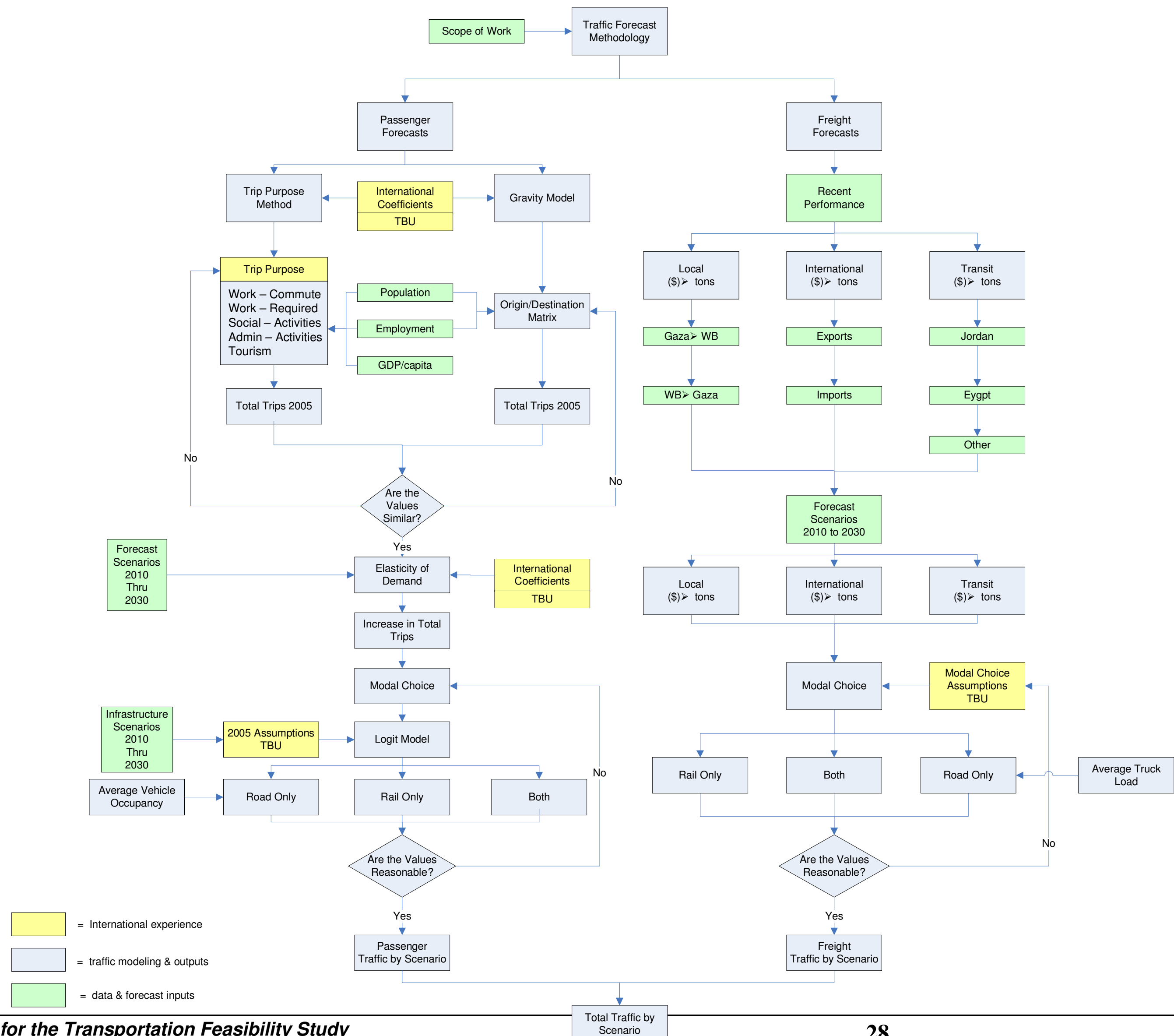
Passenger Demand in 2005: Passenger demand was estimated using trip generation based on trip purpose using international coefficients developed for the study. Trip generation is the number of person-trips generated by the population and economic activities in the West Bank and the Gaza. The results were compared with an estimate made with a gravity model utilizing international coefficients.

Passenger Forecasts: Used the forecasts of population and GDP for each of the forecast scenarios between 2010 and 2030. The increase in transport demand was based on income elasticity of demand; again reliance was placed on the use of international values for this variable.

Freight Forecasts: Forecasts were based on estimates of flows of goods and commodities: 1) Locally transported goods between the West Bank and Gaza, 2) Imports and exports and 3) Transit goods with neighboring countries.

Modal Choice: Modal choice is the allocation of traffic between road and rail and between vehicle types (for example, cars and buses) in the case of the road scenarios. The distribution is estimated for passenger demand between travel by light passenger vehicle (e.g. car) and public transport (bus). In the case of the combined road and rail scenario, the distribution is among light passenger vehicle, bus and passenger rail usage. For the combined road and rail scenario, the distribution of freight traffic between road truck and rail freight is also considered. The distribution of traffic is done using a Logit Model that estimates the probability of the generated West Bank and Gaza passenger and freight travel demand being destined from origins in the West Bank or Gaza to destinations at the opposite end of the WBG Corridor. Outputs were checked to determine how reasonable the results are for the 2005 estimate of passenger and freight flows and for the general level of traffic.

Figure 2-1: Traffic Forecast Methodology – WBG Link



TBU – To be updated using international data or coefficients

Employment Forecasts: Population and GDP forecasts are described in section 2.1 of this chapter. In addition, employment forecasts were prepared. Employment is currently estimated to be 20%[7] of total population and by year 2030 is forecasted to be: 24% with Scenario "A", 32% with Scenario "B", and 17% with Scenario "C".

2.2.3 Passenger Travel.

2.2.3.1 Trip Generations

In developing passenger demand, indications of travel preferences of Palestinians are reviewed. Reference is made to pre-2000 traffic studies. For instance, a month-long traffic survey conducted in the West Bank by ARIJ during 1997 determined that about 60% of intra-district (Governorate) trips were work trips and trips for such purposes as shopping, family visits and recreational excursions accounted for most of the remainder of the trips[8]. Other more recent studies were reviewed for the West Bank[9]. But, this data is probably not as applicable to the present forecasts as the earlier studies because of the deteriorating security situation, the large number of checkpoints and trips that often require taking circuitous routes. Components of future motorized (by light passenger vehicles or public transport) passenger travel in the West Bank - Gaza Corridor are expected to include the following trip purposes.

Commuter Related Travel: Commuter travel in which some residents of the Gaza will commute to their work sites in the West Bank and some residents of the West Bank will commute to their work sites in the Gaza. It is estimated that 1% of the employed workers living in the three southern Governorates of the West Bank will commute to their work sites in the Gaza and 4% of the workers living in the Gaza will commute to their work sites in the West Bank. Half of the workers will make five (5) daily round-trips every week and the other half will make the trip one time per week, staying near the work site during the days of the work week. In 2005, this is equivalent to 10,000 one-way person-trips per day, or about 25% of the total person-trips that would be made in the WBG Corridor.

Work Related Travel: Some jobs located in the West Bank and the Gaza will require occasional trips between the West Bank and the Gaza. It is estimated that 3.0% of the employed workers in the three (3) southern Governorates of the West Bank and in the Gaza will make one (1) round trip in the WBG Corridor every two (2) weeks. In 2005, this is equivalent to 2,200 one-way person-trips per day or about 6% of the total person-trips that would be made in the WBG Corridor.

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7 This estimate is based on a consensus of several sources: (a) *Review of the Humanitarian Situation in the Occupied Palestinian Territory for 2004*, United Nations Office for the Coordination of Humanitarian Affairs (OCHA) occupied Palestinian territory (oPt). (b): PCBS Second Quarter 2004 Report on Palestinian Socio-Economic Conditions, December 2004. "In 2004, every working individual supported 6.4 non-employed persons." (c): PCBS Second Quarter 2004 Report on Palestinian Socio-Economic Conditions, December 2004. Thus, workers accounted for 15.6% of the total persons.

8 Hanna Maoh and Jad Isaac*, The Status of Transportation in the West Bank*, 1997, Applied Research Institute – Jerusalem (ARIJ), pg 21

9 Khaled A. Al-Sahili and Abdelmajid H. Sadeq, *Ridership Demand Analysis for Palestinian Intercity Public Transport*, 2003, An-Najah National University. The paper gives percentage distribution of person-trips by trip purpose for intercity public transport (bus) travel between six (6) Governorates in the northern and central districts of the West Bank.

Social and Other Related Activities: The category of trips includes travel for social, shopping, educational, religious or recreational activities for which some residents of the West Bank will travel to the Gaza and residents of the Gaza will travel to the West Bank. It is estimated that 6% of the residents of the West Bank and 24% of the residents of the Gaza will make ten (10) round trips per year in the WBG Corridor. In 2005, this is equivalent to 24,500 one-way person-trips per day or about 62% of the total person-trips that would be made in the WBG Corridor.

Administrative Travel: Administrative travel by Palestinian Authority and other governmental officials who will need to travel between the West Bank and the Gaza to fulfill their administrative responsibilities. It is estimated that 2.5% of the employed workers in the West Bank or in the Gaza will make two (2) roundtrips every month in the WBG Corridor. In 2005, this is equivalent to 2,200 one-way person-trips per day or about 6% of the total person-trips that would be made in the WBG Corridor.

Tourism: Tourism travel between the West Bank and the Gaza. It is estimated that the number of round trips per year in the WBG Corridor for tourism will be equal to 2.0% of the population residing in the West Bank and the Gaza making two (2) roundtrips per year. In 2005, this is equivalent to 770 one-way person-trips per day or about 2% of the total person-trips that would be made in the WBG Corridor.

Total 2005: The above five (5) trip purposes for personal travel in the WBG Corridor would account for a year 2005 total of 40,000 one-way person-trips per day.

2.2.3.2 Gravity Model.

A gravity-type model provides an alternative method for predicting one-way person-trips in 2005 within the WBG corridor.

The general form of a gravity-type model can be:

$$T_{ij} = A * \frac{SQRT\left(P_i^{B} * P_j^{C} \right)}{d_{ij}^{D}}$$

Where:

Pi and P**j** are population of Governorates I and J
d_{ij} is travel distance, time or cost for travel from Governorate I to J
A, B, C and D are calibration coefficients with A = 1.0, B =1.0, C = 1.0 and D = 1.35

The 2005 population for the Governorates in the West Bank and the Gaza for the values of P_i, and P_j are used, and the road network travel distance separation between centers of the Governorates for the values d_{ij}, were estimated. The total passenger-trips by motorized vehicles are estimated to be 450,000 total trips in the West Bank and Gaza with average trip length of 20 km; 208,000 of the trips being intra-Governorate and 242,000 inter-Governorate; and with 42,000 of the trips along the WBG Corridor between the West Bank and the Gaza.

This value is relatively close to the one determined using the trip generating methodology by trip purpose.

2.2.4 Passenger Traffic Forecasts

Forecast of Total Demand: Estimates of total demand for each forecast scenario were based on income elasticity of demand. With increasing GDP per capita, it is expected that trip rates per person for commuter travel and for social, shopping, educational, religious or recreational purposes will increase; a one 1.0% increase in GDP per capita will result in a 0.1% increase in commuter, work-related and administrative trips per employed person and a 1.0% increase in the trips per person for social, shopping, educational, religious, recreational and tourism activities.

Modal Choice: Travel demand, both passenger travel and freight transport, can be affected by the transport services to be provided in the WBG Corridor. With the road only solution, some of the passenger travel demand will use light passenger vehicles (e.g. private cars) and the remainder will travel by public transport vehicles (buses). With the combined road and rail solution, passenger travel will have the choice of traveling by light passenger vehicle, by bus or by rail passenger service; freight can be shipped by either highway truck or by rail.

Passenger motor vehicles using the West Bank – Gaza Corridor will include both light passenger vehicles and buses. It is estimated that initially the mode choice of passengers traveling in the Corridor will be 20% in light passenger vehicles for (a) the commuters to work sites, (b) the person-trips made for social, shopping, educational, religious or recreational purposes, and (c) the tourist travel; and 90% of the work-required and administrative travel will be made by light passenger vehicles. With the forecasted increased GDP per capita, there will be an increase in the percentage of trips made by light passenger vehicles for commuter, social, shopping, educational, religious, recreational and tourist trip purposes.

The logit model provides a method for predicting the probability of person-trips using the available alternative modes of travel (light passenger vehicle, bus and a potential future rail alternative) for travel between each combination of Governorate origins and destinations and also the probability of freight shipments using road truck or rail.

Logit models, either multinomial logit (MNL) or nested logit (NL) are the most common model type for discrete choice models. Under the theory of utility maximization, a decision-maker will generally choose the alternative that maximizes his utility. However, one cannot simply calculate the utilities for each alternative and for each decision-maker, and then determine which one is the maximum. One must transform the utility values into probability values. Each utility function is assumed to have a random error term and the distribution of this random error term determines the functional form of the logit equation. In this case, the logit equation is derived from the fact that the error term is logistically distributed. The logit equation gives the probability P that a decision-maker i will choose alternative j, given a utility U for each alternative (where n is the set of available alternatives). It is basically a way to transform utility values into probabilities. The utility is generally expressed as a linear function.

The general form of a logit model is:

$$P_{ijm} = \frac{e^{U_{ijm}}}{\text{Sum } e^{U_{ijm}}}$$

where:

P_{ijm} is the probability of trips from I to J using mode M

U_{ijm} is the utility of mode M for travel from I to J

U_{ijm} is A + B * travel time + C * travel cost
where
A is a dummy variable
B and C are coefficients

Vehicle Occupancy: For the light passenger vehicles, the average vehicle occupancy is estimated to be 2.6 passengers per vehicle and for buses 20 passengers per bus.

2.2.5 Freight Transport.

2.2.5.1 2005 Estimates

The components of future freight transport through the WBG Corridor include the following: 1) Local traffic, 2) Foreign trade traffic and 3) Transit traffic.

Local Traffic: Local traffic consists of: 1) commodities produced and goods with origins on the West Bank and transported to and consumed in the Gaza Strip and 2) commodities produced and goods with origins in the Gaza Strip and transported to and consumed on the West Bank. For a base year of 2005, this is estimated to generate nearly 300,000 tons of freight per year in each direction.

Foreign Trade: Foreign trade shipments consist of: 1) exports and 2) imports.

Exports from the southern portion of the West Bank and exported by way of the proposed new international seaport at Gaza or exported through Egypt are estimated as follows:

- Bethlehem Governorate exports (year 2003) excluding exports to Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 2,206,000. With an average value of U$S 1.20 per kg, this would be about 1,838 tons per year.
- Hebron Governorate exports (year 2003) excluding exports to Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 762,000. With an average value of U$S 1.20 per kg, this would be 635 tons per year.
- Jerusalem Governorate exports (year 2003) excluding exports to Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 204,000. With an average value of U$S 1.20 per kg, this would be 170 tons per year.

Exports from the remaining central and northern Governorates of the West Bank and exported by way of the proposed new international seaport at Gaza or exported through Egypt are estimated as follows:

- These exports (year 2003) from the central and northern Governorates and excluding exports to Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 4,649,000. With an average value of U$S 1.20 per kg, this would be about 3,918 tons per year. It is estimated that 2,678 (about 70%) of this total tons per year would be exported by way of the proposed new international seaport at Gaza or through Egypt.

During year 2003, the total value of exports from the Gaza to Jordan was valued at U$S 1,343,000; at an average value of U$S 1.20 per kg, this would have been about 1,119 tons per year.

Imports to the southern portion of the West Bank and imported by way of the proposed new international seaport at Gaza are estimated as follows:

- Bethlehem Governorate imports (year 2003) excluding imports from Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 12,318,000. However, the value of imports to Bethlehem has varied greatly during the years from 1996 to 2003, averaging a value of U$S 53 million per year. With an average value of U$S 1.20 per kg, U$S 53 million per year would account for about 44,600 tons per year.
- Hebron Governorate imports (year 2003) excluding imports from Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 72,186,000 and averaging about U$S 85 million per year during the years from 1996 to 2003. With an average value of U$S 1.20 per kg, U$S 85 million per year would account for about 71,150 tons per year.
- Jerusalem Governorate imports (year 2003) excluding imports from Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 3,933,000 and averaging about U$S 6.6 million per year during the years from 1996 to 2003. With an average value of U$S 1.20 per kg, U$S 6.6 million per year would account for about 5,500 tons per year.

Imports to the remaining central and northern Governorates of the West Bank and imported by way of the proposed new international seaport at Gaza or through Egypt are estimated as follows:

- These imports (year 2003) to the central and northern Governorates and excluding imports from Israel, Jordan, Lebanon, Syria and Iraq had a total value of U$S 277 million. With an average value of U$S 1.20 per kg, this would be about 273,000 tons per year. It is estimated that about 200,000 (about 75%) of this total tons per year would be imported by way of the proposed new international seaport at Gaza or through Egypt.

Imports from Jordan to the Gaza for 2003 had the total value of U$S 5,978,000. At an average value of U$S 1.20 per kg, this would have been about 5,000 tons per year.

Transit Trade: Transit goods transported from Egypt to Jordan or visa versa via the West Bank and Gaza are estimated for the base year, 2005, at 300,000 tons per year from Egypt to Jordan and 30,000 tons per year from Jordan to Egypt.

Truck Characteristics: It is expected that the trucks transporting commodities in the West Bank – Gaza Corridor will have average loads of eight (8) tons per truck with 60% of the trucks having loads and the other 40% of the truck traffic not having back-hauls[10].

Present Traffic Levels: Before the Israeli withdrawal from Gaza Strip, the number and amount of freight movement was limited (40-50 trucks/day). According to the agreement with the Israelis, the daily number of vehicles will reach 150 trucks/day. This number will reach up to 400 trucks/day by the end of 2006[11]. These values compare with the estimated year 2005 truck traffic demand of 430 trucks per day along the West Bank – Gaza Corridor based on the values of imports and exports and other freight transport mentioned above.

[10] Based on UN shipments, the average truckload is 12 tons and that of container is 12.8 tons. Transit Trade and Maritime Transport Facilitation for the Rehabilitation and Development of the Palestinian Economy, United Nations Conference on Trade and Development (UNCTAD), 2004
[11] Palestinian Ministry of National Economy; November 30, 2005)

2.2.5.2 Forecast of Freight Traffic

For each of the alternative Economic Development Scenarios, the forecasted future freight traffic demand in the West Bank – Gaza Corridor is related to the forecasted annual rate of future increases in the Gross Domestic Product (GDP) for the West Bank and the Gaza: with a 1.0% increase in GDP producing a 1.0% increase in tons of freight transported in the Corridor.

2.2.6 Variation of Traffic by Infrastructure Scenario

The estimated traffic for each of the three scenarios is summarized on the following page in Table 2-11.

Table 2-11: Variation of Traffic by Infrastructure Scenario

Scenario "A" - Medium Growth					Scenario "B" - High Growth					Scenario "C" - Low Growth				
WBG Corridor - Road Only Solution (Road Traffic, AADT, vehicles per day)					WBG Corridor - Road Only Solution (Road Traffic, AADT, vehicles per day)					WBG Corridor - Road Only Solution (Road Traffic, AADT, vehicles per day)				
2025		59,291		3,270	2025		85,840		4,072	2025		32,741		2,109
2030		74,304		4,004	2030		114,636		5,116	2030		36,545		2,444
year	light pass veh	bus	truck	Total Vehicles	year	light pass veh	bus	truck	Total Vehicles	year	light pass veh	bus	truck	Total Vehicles
2015	7,706	2,796	762	11,263	2015	12,107	3,544	989	16,640	2015	4,914	2,180	589	7,683
2020	11,629	3,656	1,047	16,331	2020	19,767	4,912	1,381	26,059	2020	6,141	2,541	746	9,429
2025	18,497	5,007	1,522	25,025	2025	31,662	6,614	1,885	40,162	2025	7,941	3,060	986	11,987
2030	25,708	5,946	1,875	33,529	2030	47,225	8,190	2,380	57,795	2030	9,350	3,353	1,152	13,855

WBG Corridor - Rail Only Solution (Rail Passengers and Tons per day)			WBG Corridor - Rail Only Solution (Rail Passengers and Tons per day)			WBG Corridor - Rail Only Solution (Rail Passengers and Tons per day)		
year	passengers	freight, tons	year	passengers	freight, tons	year	passengers	freight, tons
2015	34,178	1,949	2015	46,059	2,537	2015	25,371	1,505
2020	46,508	2,662	2020	67,333	3,524	2020	30,054	1,892
2025	66,703	3,847	2025	96,570	4,790	2025	36,834	2,482
2030	83,592	4,710	2030	128,966	6,019	2030	41,113	2,875

WBG Corridor - (Road + Rail) Solution (Road Traffic, AADT, vehicles per day)					WBG Corridor - (Road + Rail) Solution (Road Traffic, AADT, vehicles per day)					WBG Corridor - (Road + Rail) Solution (Road Traffic, AADT, vehicles per day)				
year	light pass veh	bus	truck	Total Vehicles	year	light pass veh	bus	truck	Total Vehicles	year	light pass veh	bus	truck	Total Vehicles
2015	6,742	839	419	8,000	2015	10,594	1,063	544	12,201	2015	4,300	654	324	5,278
2020	10,175	1,097	576	11,848	2020	17,296	1,474	759	19,529	2020	5,374	762	411	6,546
2025	16,185	1,502	837	18,524	2025	27,705	1,984	1,037	30,726	2025	6,948	918	543	8,409
2030	22,494	1,784	1,031	25,309	2030	41,322	2,457	1,309	45,088	2030	8,182	1,006	633	9,821

WBG Corridor - (Road + Rail) Solution (Rail Passengers and Tons per day)			WBG Corridor - (Road + Rail) Solution (Rail Passengers and Tons per day)			WBG Corridor - (Road + Rail) Solution (Rail Passengers and Tons per day)		
year	passengers	freight, tons	year	passengers	freight, tons	year	passengers	freight, tons
2015	30,380	1,657	2015	40,941	2,156	2015	22,552	1,279
2020	41,341	2,263	2020	59,851	2,995	2020	26,714	1,608

CHAPTER 3

SELECTION OF TRANSPORTATION ALIGNMENTS

This chapter presents the technical findings of Berger's investigation and selection of alternative route alignments for the proposed West Bank-Gaza Transportation link. The investigation was conducted based primarily on desk study reviews of existing information, including topographical, geological, land-use, and environmental data as well as previous alignment studies. Field visits were also made to the area to verify selected data and clarify various technical issues. The methodology for identification of alternative alignments is described, as also is the selection of preferred alternatives for preparation of estimated costs and schedules for implementation.

3.1 General Considerations

Route selection is influenced by a multitude of factors, including, but not limited to terrain, hydrologic considerations, land use, and population concentrations and distributions. The shortest road alignment does not necessarily yield the most economical alternative. Often, topography, flood hazard, erosion potential, and slope stability can be significant factors in identifying the most cost effective alignment and design of cross-section. Variations in geology and slope, for example, greatly influence road design and cost of construction, and these changes can occur over very short lengths of alignment. Other factors are also important in constructing roads or railways in an environmentally sound way. Alignment geometry, earthworks, retaining structures and drainage measures must be designed to minimize the impact on the surrounding land, land use and natural drainage systems. Although many adverse effects are often unavoidable, the design and the construction methods adopted should aim to minimize them.

An overview of the method utilized to select and evaluate the alternative alignments based on technical engineering factors is shown in Figure 3-1.

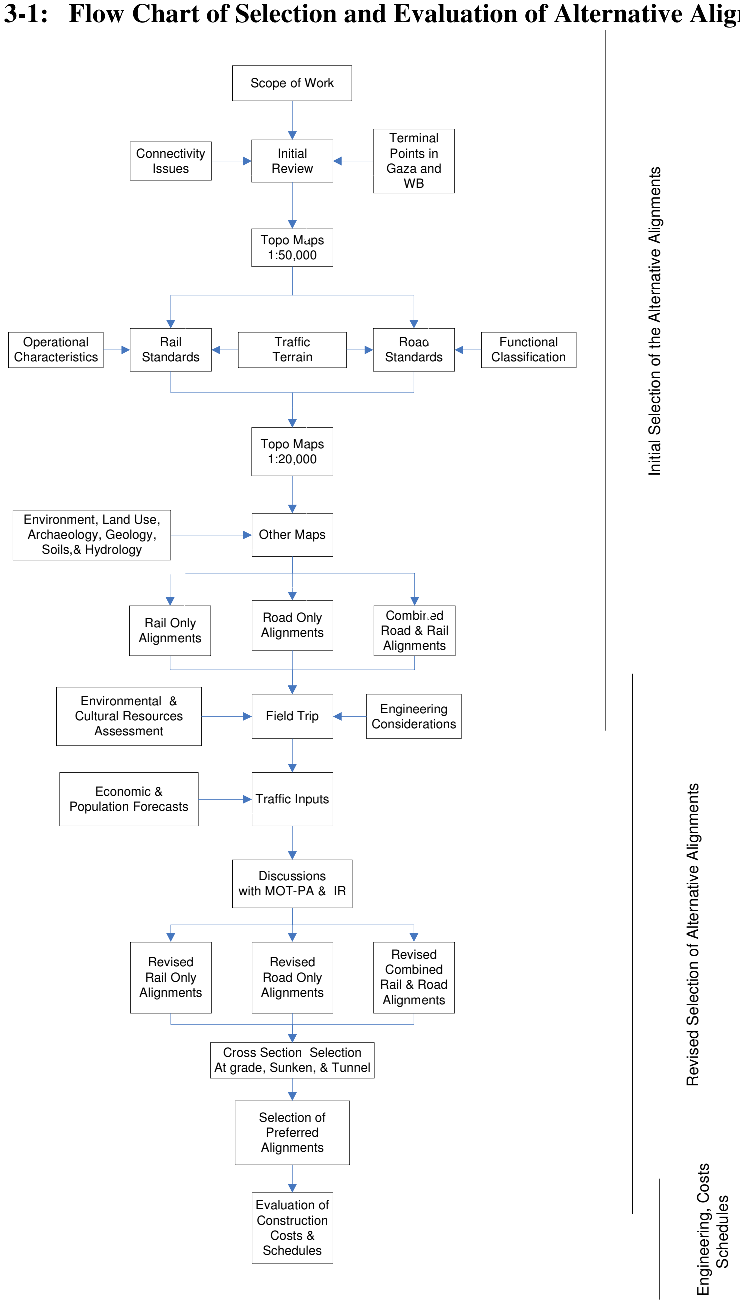
Selections of the route corridors were preceded by first defining the controlling requirements of each alignment. Specifically, for each route or alignment, the following issues were addressed:

1) What are the constraints in regard to the beginning and ending points of each alignment?

   The scope of work for this project identifies the terminals as being the two geographic areas of the West Bank and Gaza Strip (Gaza), and the scope further emphasizes the examination of alignments which minimize the distance between the crossings. Hence, this limited the study to some terminal points within a few kilometers of the boundary of both the West Bank and Gaza. The terminal points therefore do not necessarily tie to existing junctions in a Palestinian village or town: in fact, there is a desire, given the anticipated traffic volumes, to avoid villages and towns en route to the larger, ultimate destinations; for instance, the proposed Seaport in Gaza, and a West Bank city such as Hebron. The railway only or a combined railway/road route requires a termination at a location where a trans-shipment area is a possibility, or the identification of a further corridor deeper into Palestinian territory. Avoiding built-up areas in Gaza, and the urban area of Sderot, limits the possibilities to two Gaza entry points; one along an alignment north of Sderot and one south of this town.

Terrain considerations at the approach to and in the West Bank, the need to connect to an existing transportation network, the need to provide access to major Palestinian production and population centers, and the need to avoid opening an entirely new corridor in the border vicinity, limit the road and railway possibilities here to two locations. Regional connectivity is also a consideration in the location of the terminus of the transport link.

Figure 3-1: Flow Chart of Selection and Evaluation of Alternative Alignments



2) What types of facilities must the route include or avoid?

In Israeli territory, the route must avoid crossing urban and heavily trafficked areas, so as to minimize delays and security concerns. To the extent permitted by alignment geometric constraints the route should avoid productive agricultural areas, forested areas, national parks, cultural resource (archaeological) sites, streams and gullies. Security concerns are paramount. Even so, to the extent possible, Israeli policy requires that the alignment of new transport projects follow existing transport corridors in preference to opening new corridors. To the extent possible, the alignments should follow existing transport corridors and comprise a parallel facility to these corridors. Within these constraints, the route should limit the length of the interconnection within Israel.

3) If major wadis (rivers) are to be crossed, what are the possible crossing locations, given constraints of topography and geology? What are the economics of the alternative bridge sites with the corresponding road and/or rail geometrics?

While wadi bridges are few, there are underpass/overpass requirements for crossings of existing roads, railways, power transmission and other utilities lines. The route must cross the underground Kinneret Negev Water Pipeline.

4) What are the desired design speed and design standards? How does this standard fit the terrain in terms of geometric parameters such as gradients, and horizontal and vertical curves?

The highest possible design speed and design standards are utilized. The road only alternative would hence involve a design speed of 120 km/h, with a possible reduction to 100 km/h if necessary while traversing more problematic terrain. This equates to alignments with a minimum horizontal radius of 750 m (450 m for 100 km/h), and a maximum gradient of 3 percent.

For the rail only alternative, or for a combined road/rail facility, railway design standards will prevail. These call for a design speed of either 160 km/h, reflective of the present maximum operating speed of Israel Railways, or more favorably 200 km/h, with a minimum desirable horizontal radius of 2,000 m, and a maximum gradient of 1.3 percent.

The initial desk study comprised in part a review of published and unpublished information concerning the physical, economic and environmental characteristics of the study area. For studying and selecting suitable alignment corridors, a detailed analysis was based on the following references, maps, and aerial photography.

Table 3-1: Basic Mapping and Reference Material Utilized

Reference:	Formal Source	Availability
- A Carta Map Israel (and Autonomous Areas) Scale 1:270,000	Carta Jerusalem	Yes
- West Bank Closures scale 1:150,000	UN OCHA August 2005	Yes
- Gaza Closures scale 1:150,000	UN OCHA August 2005	Yes
- Topographic Maps scale 1:50,000	Geological Survey of Israel	Yes
- Topographic Maps scale 1:20,000	Geological Survey of Israel	Yes
- Aerial photographs, approximate scale 1:50,000	Geological Survey of Israel	Yes
- Outcrop and Subgroup Geological Maps of The Coastal Plain and Hashephela Regions: Map 1 Outcrops 1:100,000	Geological Survey of Israel, 1967	Yes
- Outcrop and Subgroup Geological Maps of the Coastal Plain and Hashephela Regions: Map 2 Subgroups of the Base of "Kurkar" Group1:100,000	Geological Survey of Israel, 1967	Yes
- Hydrological map of Israel, scale 1:2,000,000		Yes
- Land Use and Land Cover Map, scale 1:1,000,000		Yes
- Wildlife Corridor Map		No

The above data sources were determined sufficient to analyze various alternatives; consequently neither SPOT satellite imagery nor Land System Maps were deemed necessary to complete the study.

In addition, a review of several previous alignment studies provided useful background material. However, none of the previous studies were carried out to a level of detail sufficient to integrate or build upon for use in the present conceptual study.

3.2 Design Standards

Design standards for road and railway modes were developed for the study. A discussion of the road and railway standards is presented in Appendix 3-1 and Appendix 3-2 respectively.

The road design standards used for this feasibility study are based on Israeli standards and international "best practice". Israeli road standards were used instead of AASHTO (American Association of State Highways and Transportation Officials) because they are generally the more stringent but impose few additional costs. The basic criteria for this study, upon which road alignment alternatives were developed, were a maximum gradient of 3% and minimum horizontal radius 870m, corresponding to a 120 km/h design speed.

The railway design standards are similarly based on Israeli standards, but also take into account European and UIC13 standards. The basic criteria adopted for this study, upon which railway alignment alternatives were developed, were a preferred maximum gradient of 1.3% and minimum horizontal radius 2,000m, corresponding to a design speed of 200 km/h.

For combined railway/road alignments, the railway design criteria were adopted.

3.3 Preliminary Identification of Potential Corridors for Surface Alignments: Common Railway/Road End Points and Connectivity Issues

Using the 1:20,000 scale maps and the constraints listed in Section 3.1, several alternative alignments were identified. With relatively flat terrain traversed along most of the Israeli portion of all possible routes, the initial constraints are the beginning and ending points of the route in Palestinian Territory.

3.3.1 End Points in Gaza

The transportation link should incorporate a terminal located at a suitable site on Palestinian territory, with consideration of future access to the planned deep-water port and the possibility of a direct connection south along the border with Israel to the airport (as shown in Figure 3-2).

Figure 3-3, provided by the UN, shows possible connections within Gaza to an area in the north where settlements have been evacuated, and a possible corridor south of Gaza City proceeding along the border and hence westward towards the coast at the proposed seaport. A terminus in this corridor could readily be connected to the north to south Salah Al Deen Road in Gaza, and to the Coastal Road which has been proposed for upgrading in a recent report by IMG for the European Commission [1].

Hence, for the Gaza Strip, the terminal point logically is either a point near the north-eastern extremity of the Gaza Strip (Point A on Figure 3-3), which would minimize the link route length; or a point which would provide the closest congestion-free connection to the major traffic generators: i.e., Gaza City, the Gaza Airport and/or the planned Seaport (Point B on Figure 3-3). These points represent the northern and southern extremities within which a terminus could be located.

These alternatives would also facilitate a continuation of the corridor in Gaza to the Ezer Industrial Zone.

3.3.2. End Points in West Bank

For the West Bank, topography is a constraint. Figure 3-4, based on UN data, shows possible connections to Tarkumiya and Meitar.

To provide the best vertical alignment through the shortest distance, a connection terminating near Tarkumiya is possible (Point C on Figure 3-4). Relatively flat areas exist north and south-west of Tarkumyia, which could be utilized for a terminal. The alignment alternatives allowing direct access to Hebron end in the vicinity of this town. The terrain steeply rises towards Hebron from this area and would require capital-intensive engineering structures to continue through the Judean Mountains to Hebron. For this reason, future extension of the route and its direction is closely related to future transportation demand.

[1] Situation Paper for the Development of the Coastal Road, Provisional, IMG, July 30, 2005.

In fact, due largely to terrain constraints, there are no other realistic possibilities along the entire border of the West Bank heading south from Tarkumiya until a possibility is reached much further to the south near Meitar (Point D on Figure 3-4). Even if there were feasible alternatives between these points, they would represent an unsatisfactory compromise between the options at Tarkumiya and Meitar.

There are trade-offs between these alternatives. For the first alternative, the route terminates closest to the population centers in the West Bank, and the connecting route bypasses to the north of the traffic congestion in Hebron. However, in proceeding east from a potential terminal site near Tarkumiya towards Hebron, and thence to all other population centers in the West Bank, the existing Highway 35 ascends from an elevation of about 385 metres at a junction west of Tarkumiya to approximately 1,000 metres at the junction with Highway 60 north of Hebron, over a distance of approximately 13 kilometres (an average 4.7% gradient). While this ascent is acceptable for a road route through difficult terrain, it would not allow for easy railway access, and may dictate that any railway connection would terminate at Tarkumiya for trans-shipment by truck. It should be noted that although such a route might not preclude a railway connection from Tarkumiya to Bethlehem and further north; it would and involve major earthworks and bridge construction while traversing difficult terrain.

For the second alternative, the route terminates at the southern extremity of the West Bank near Meitar, far from the population centers in the West Bank. However, in proceeding north from Meitar towards Hebron and to all other population centers in the West Bank, the existing Highway 60, or a second, more western possibility ascends from approximately 400 metres at a junction near Meitar to about 1,000 metres at the junction with Route 60 north of Hebron, over a distance of about 30 kilometres, (an average 2.0% gradient). A feasible railway route might result in a longer alignment. An advantage of this alternative is that it would allow for a future north/south West Bank rail connection, although it would increase the overall road connection length from NE Gaza to Hebron from about 61 km to approximately 77 km.

3.3.3 Common Intermediate Node Points

Starting from the two alternative West Bank terminal points, it is geometry that determines alignment paths for some distance.

From Point C, the original consideration was for a surface alignment to follow the existing Highway 35 corridor in a westerly descent to a location north of Lahish. Highway 35 follows a valley from Tarkumiya through Beit Govrin. However, it is necessary to take the alignment on the north side of Beit Govrin, to avoid known archaeological sites in that area. This established an intermediate node point based on geometric constraints at about Point E on Figure 3-5 (see also the drawings in Volume 3 for the further detail). A more direct surface route between Point C and Point E is not possible, as it would traverse very hilly terrain. From this Point E, Highway 35 continues on an alignment to the northwest rather than to the west, traverses a forested area, and proceeds through the village of Kiryat Gat, all making a further common alignment here an unviable option.

For the southern West Bank terminus, considerable effort was spent to identify an alignment which would meet the rail criterion of a maximum gradient of 1.3 percent. From Point D near Meitar, it is possible to select a rail route which, to avoid the Lahav Hills, would need to proceed in a southwest direction and result in a very lengthy alignment. Another possibility considered was a route parallel to proposed Highway 9 northwest to Beit Kama; however, the gradient of this alignment proved to be too steep. Similarly, the alignment of Highway 325 past Dvira to Beit Kama was also too steep.

The only feasible railway or combined railway/road alignment would be to proceed from Meitar along the boundary through the Givat Lahad Hill, and through a tunnel section of approximate length of 700 metres, continuing along the boundary to a point a few kilometres north of Highway 325. The alignment would then traverse the foothills to a Point F near the crossing of proposed Highway 9, Highway 40, and the Tel Aviv-Beer Sheva Railway. This route established a further intermediate node point based on geometric constraints at about Point F on Figure 3-5.

Figure 3-2: General Location Map – Showing Potential Connectors

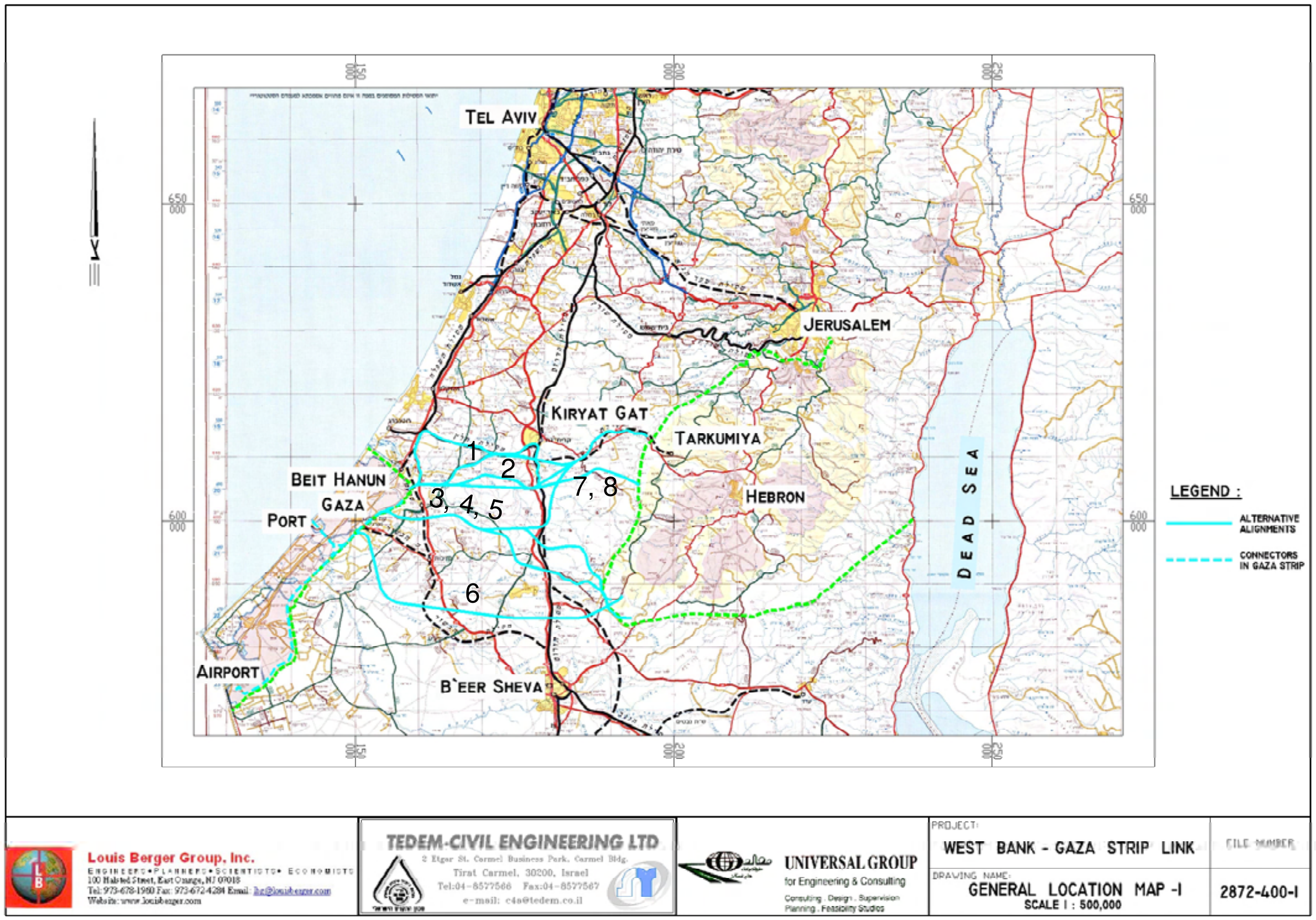
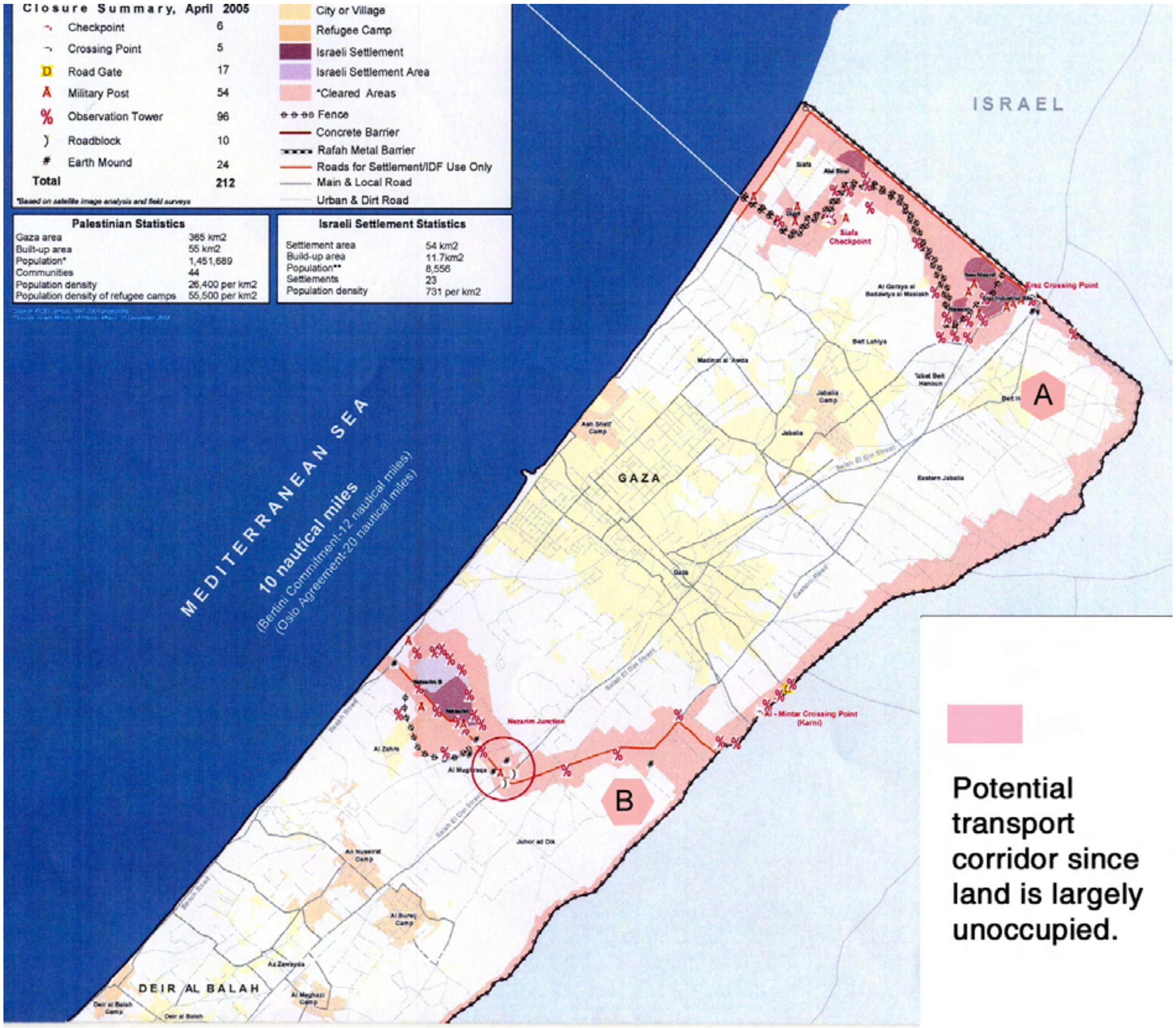


Figure 3-3: Gaza Strip Entry Points, and Potential Transport Corridor to Ezer and Seaport

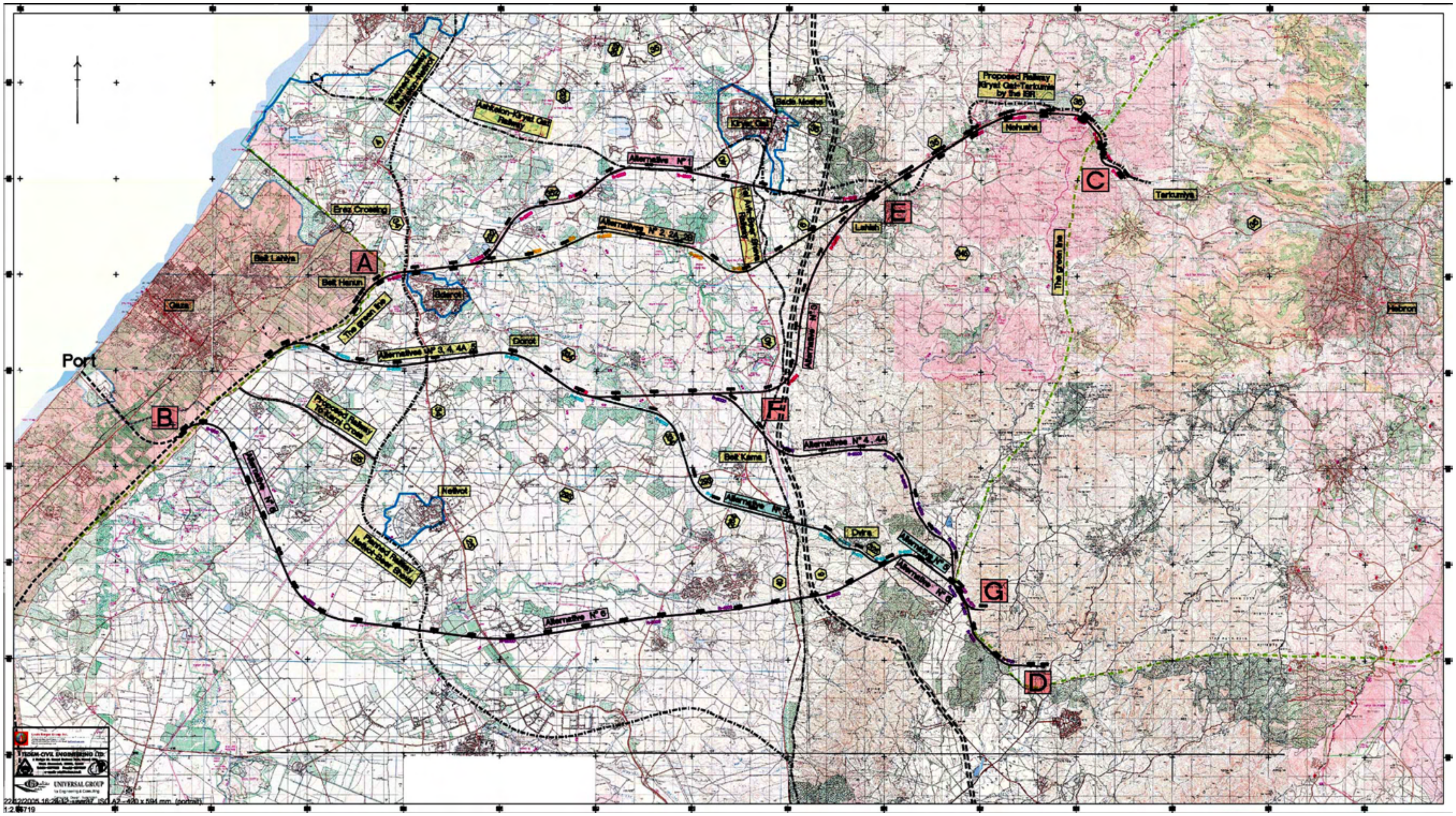


Source: Gaza Closures, April 2005, UN Office for the Coordination of Humanitarian Affairs

Figure 3-4: West Bank Entry Points

Source: Gaza Closures, August 2005, UN Office for the Coordination of Humanitarian A

Figure 3-5: Alternative Alignments



Although the C and D end points at Tarkumiya and north of the town of Meitar, respectively, are 24 km distance from each other along a north south axis, the possible road/rail corridors at end points E and F are but 13 km distant from each other along the same axis, effectively "squeezing" the width of the band of road/rail alternatives between A/B in Gaza and C/D in the West Bank.

3.4 Identification of Surface Alignment Alternatives

Geometry plays a secondary role in the selection of alignment alternatives between the Gaza end Points A/B and the intermediate node Points E/F. The primary constraints instead are avoidance of communities, agricultural and forest lands, and cultural resource sites, while attempting to reduce distance and to utilize existing corridors where possible.

Reviews were conducted of previously identified and newly proposed alignments that would minimize the distance traversed between Gaza and West Bank, or which would offer other advantages. The initial examination was made using the topographical data and mapping. This was used to determine general alignments taking into account the limitation on grade, further assuming that the right-of-way would where possible be conducive to both road and railway traffic, and allowing for an accommodation of both freight and passenger railroad operations. The studies also considered the objectives of avoiding urban areas, intensive agricultural regions, forest areas and cultural resource sites. This was accomplished by superimposing layers of data showing such features over base maps and selecting those routes demonstrating the least disruptions in terms of these features. The study team then conducted a visual inspection of the routes to identify any difficulties with existing land use or ground conditions.

The study team subsequently developed conceptual designs and determined the spatial requirements for the transportation and utility transmission systems to be located in the right-of-way. The locations allow for easy access for maintenance and expansion, and limit risks of disruption of services or accidents involving transport and utilities.

The purpose of this reconnaissance stage of the route selection process was to identify alternative routes in terms of the "corridors" within which they lie. Within these corridors, several alternative alignments were developed. Six surface alignments, either new alignments or refinements to alignments from earlier studies, were investigated on the basis of 1:20,000 scale mapping, and are shown on Figure 3-5 (see also the drawings in Volume 2).

Although it might first appear that a road only, or a road and passenger rail route, would allow for steeper maximum gradient and hence open up further possibilities for alignments, this in fact turns out not to be the case. The Tarkumiya and Meitar alternatives options, at 1.3% and 1.5% gradients respectively, yield these gradients based more on topography than geometric requirements. Options between these two extremes for end points would give higher gradients but would result in an unnecessarily longer route to West Bank destinations, would traverse and open up new corridors, and/or would involve conflict with environmentally sensitive areas.

Possible routes were examined using maps and aerial photos. Following this, visits were made to the sites to check interpretations, and findings were summarized to assist in planning and the next phase of the analysis.

Aerial photos and topographical maps were used to interpret boundaries between terrain types, and to determine where changes in topography, geology, development, drainage pattern or vegetation (land use) occur. A change in any of these gives rise to different engineering conditions, which could affect the design of the road. The following factors were considered:

- Drainage areas of major catchments;
- Number, type and characteristics of water courses and wadis;
- Extent of flooding of low-lying areas, if any;
- Forestation and agriculture;
- Urban areas and human settlements affected by the road;
- Known and potential cultural resource (archaeological) sites;
- Assessment of land acquisition;
- Location of possible bridge sites;
- Topographical, geological, and physical characteristics;
- Environmental impact of the selected route.

The initial alignments studied, generally from north to south, were as follows (refer to Figure 3-5):

Alignment 1: This alignment uses a corridor mostly defined by existing roads, and a short section of an existing freight railway. Exiting the Gaza Strip at its northeastern extremity, it avoids the community of Sderot by swinging in a large radius arc from an initial north-easterly heading, to an easterly heading to intersect with Highway 232. It parallels Highway 232 and then Highway 352 in a north-easterly direction for about 9 km until it meets the Ashkelom-Kiryat Gat railway. The alignment turns east to parallel the railway for about 3.5 km. From here, to avoid the built-up area of Kiryat Gat, an agricultural region to the east of Kiryat Gat, and an unnecessarily curvilinear alignment, the alignment continues easterly to connect with Highway 35 north of Lahish. Highway 35 then follows a river valley through the village of Beit Govrin all the way to Tarkumiya. However, the alignment must swing in an arc through hilly terrain to pass north of known archaeological sites at Beit Govrin. The alignment then rejoins the Highway 35 valley at the West Bank border east of Beit Govrin, proceeding to a terminus just beyond the border. From the terminus, Highway 35 proceeds south of Tarkumiya to the northern outskirts of Hebron. Alignment 1 can be achieved without exceeding a 1.3% gradient, and is therefore suitable as a **railway only, road only or combined railway/road alignment**.

Alignment 2: Exiting the Gaza Strip at its north-eastern extremity, this alignment proceeds eastward following Alignment 1 until it meets Highway 232. From this point it continues eastward just to the north of the riverbed of Hashikma that carries water in winter time. This alignment avoids the separation of nearby communities from their fields, and would allow for gravity drainage into the Shikma Stream. Heading further east, it crosses over and parallels the Shikma Stream to the south. It crosses Highway 40 and the Tel Aviv-Beer Sheva Railway Line, avoiding several smaller communities south of Kiryat Gat to rejoin the Alignment 1 at Highway 35 north of Lahish. From this point it follows Alignment 1 to a terminus in the West Bank near Tarkumiya. Unlike Alignment 1, this Alignment 2 does not follow existing road and railway corridors between Sderot and Lahish. Alignment 2 can be achieved without exceeding a 1.3% gradient, and is therefore suitable as a **railway only, road only or combined railway/road alignment**.

Alignment 2s: This was conceived as a sunken alternative for a road link only. A sunken option is not technically or economically feasible for a railway or combined railway/road link due to their more stringent vertical alignment design criteria. The elevations of a sunken road are envisaged to be some 3m to 7m below existing ground level, with excavated material placed as fill embankments adjacent to the road cut on both sides. The 7m depth is necessitated to underpass crossings of existing (or proposed) roads, railways and watercourses, with a 5m clearance to the underside of such bridge crossings and viaducts. Nonetheless, some deeper cuts will be necessary to maintain an acceptable vertical design profile. This option was studied using Alignment 2 for which the terrain is relatively flat (gently undulating) from its Gaza start point for about 24 km to a crossing of the proposed route of Highway 6. Thereafter, for the final 19 km from the crossing of the proposed Highway 6 to a terminus just inside the West Bank near Tarkumiya, Alignment 2 (or any other route) traverses hilly terrain through which an at-surface profile alternates between cut and fill sections, and to obviate fill sections for a sunken alternative would necessitate excessively deep cuts elsewhere. Consequently, a sunken road through the eastern hills of Alignment 2 (or any other east-west route) is not technically feasible or economically viable. Therefore Alignment 2s is presented with the westerly 24 km sunken and the easterly 19 km following a surface profile through alternating cuts and fills.

Alignment 3: This alignment originated as an effort to follow Highway 334 toward Beit Kama, but striking east to meet and follow the corridor of the proposed Highway 6 northward to a junction with Highway 35 whereafter it would follow Highway 35 to Tarkumiya. This route is longer than Alignments 1 or 2. To reduce its length, the selected alignment exits Gaza midway between Beit Hanun and the Kari Border Crossing, heading east, passing south of Sderot. The alignment continues east, passing south of Dorot, then south of Ruhama until it crosses Highway 40, the Tel Aviv-Beer Sheva railway line and the corridor for the proposed Highway 6. Whilst this easterly alignment avoids villages, it interferes with agricultural lands. From its crossing the proposed Highway 6 the alignment turns north following the Highway 6 corridor until it meets Highway 35 north of Lahish, from which point it follows the common Alignment 1 & 2 to a terminus just inside to West Bank border near Tarkumiya. Alignment 3 can be achieved without exceeding a 1.3% gradient, and is therefore suitable as a **railway only, road only or combined railway/road alignment**.

Alignment 4: This alignment originated as an effort to follow Highway 334 to Beit Kama to the southwest, then follow Highway 325 south of Dvira and on to the southern extremity of the West Bank. The alignment exits Gaza midway between Beit Hanun and the Kari Border Crossing. It represents the first attempt to connect to the West Bank near Meitar, a location which would allow a more favorable possible future rail connection to the north through the West Bank. The alignment follows Alignment 3 for the first 24 km to a point south-east of Ruhana. Therefore, as with Alignment 3, the western portion would traverse agricultural lands. From this point south-east of Ruhama the alignment strikes southwest to cross Highway 40, the Tel Aviv-Beer Sheva railway line and the corridor for the proposed Highway 6, whereafter it heads east and then south through hilly terrain. From a point north-west of Lahav the alignment would approximately follow the West Bank border south, again in hilly terrain, until it crosses the border into the West Bank about 4 km north-west of Meitar. In general the alignment can maintain a 1.3 percent maximum gradient except for a short section of 1.5% percent where it follows the border, and would also require a tunnel section of about 700 m. Nevertheless, Alignment 4 can be considered as suitable as a **railway only, road only or combined railway/road alignment**.

Alignment 5: This was conceived as a **road only** alignment to provide the shortest route between Gaza and the West Bank near Meitar. Such short route could be achieved by adopting road alignment geometric design criteria that are less stringent than the railway design criteria of Alignment 4. From Gaza the alignment follows Alignment 4 for 18 km to a point south-west of Ruhama. Thereafter it joins and follows Highway 334 south to its junction with Highway 293. The alignment then swings south of Beit Kama in a south-easterly direction, crosses Highway 40, the Tel Aviv-Beer Sheva railway line and the corridor for the proposed Highway 6, then passes south of Dvira through hilly terrain until finally crossing into the West Bank about 8 km north-west of Meitar. Unlike the Alignment 4 (for railway), Alignment 5 (for road only) can, by careful selection, avoid need for a tunnel section.

Alignment 6: Other possibilities for more southern alignments were investigated. As an example, Alignment 6 was conceived as a **road only** alignment passing south of Netivot and Rahat. Existing route alignments in this southern area of Israel are generally on north-south alignments, which largely precludes the possibility of any such southern alignment being able to parallel existing transportation corridors. The length of such a southern route across Israeli territory, exemplified by Alignment 6, is significantly longer than the more northern alignments.

Features of the alternative at-surface and sunken alignments are summarized in Table 3-1.

3.5 Identification of Tunnel Alignments Alternatives

By Modification No.1 to the AE Services Contract, the Consultant was required to prepare concepts for a railway tunnel connection between Gaza and the West Bank, since a tunnel option should provide the shortest route across Israeli territory and, being underground would provide the least obtrusive transportation facility.

The shortest tunnel route would be from Beit Hanun at the north-eastern extremity of the Gaza Strip to a terminal near Tarkumiya in the West Bank, passing south of Lahish. A relatively straight alignment, with gradients well below 1.3%, is easily attained across the western portion to the beginning of the hilly terrain south of Lahish. At first, an alignment was investigated to terminate at the same West Bank terminal location adopted for at-surface alignments (about 7 km north-west of Tarkumiya), but a curvilinear route would be required after Lahish to keep within a maximum railway gradient of 1.3%. It was found that by allowing a gradient of about 1.65%, a relatively straight alignment could be achieved which would shorten the tunnel by about 5 km (a very significant construction cost saving in the order of US$150 million). Further topographical map studies showed that an even shorter route, cutting about a further 2 km from the total length (a further construction cost saving of about US$60 million), could be achieved at a maximum 1.65% gradient by locating a railway terminal in a valley 7 km south-west of Tarkumiya, some 3.5 km south-west of the village of Idna. Accordingly this alignment (to a terminal near Idna) has been adopted for this study, resulting in a total 37.5 km tunnel alignment. This terminal location affords connection by existing roads heading westerly to a junction with Highway 60 at the southern limits of Hebron. Access by existing roads to join Highway 35, about 5 km to the north-east, can presently be achieved only by passing through Idna, but the terrain is suitable to construct a bypass of the village. Highway 35 proceeds westerly to a junction with Highway 60 on the northern outskirts of Hebron.

For the 14.5 km eastern portion of the alignment, which is very hilly, only a deep, bored tunnel is technically practicable; a cut-and-cover tunnel through this terrain would require excessively deep cuts.

The western portion of the alignment (about 23 km), traversing relatively flat terrain, is suitable for a cut-and-cover tunnel. However, a cut-and-cover tunnel, although much less expensive that a bored tunnel, will entail deep excavations in Israeli territory that will cause land-use disruptions and may experience construction delays due to environmental and archaeological considerations.

Consequently two tunnel alignments have been conceptualized for this study (as shown on Figure 3-5):

Alignment 7: A 23.5 km cut-and-cover tunnel from Beit Hanun in Gaza following Alignment 2 for the first 20 km, then proceeding westerly to a point approximately where it would pass under the north-south corridor of the proposed Highway 6. From this point the alignment would proceed westerly in a deep, bored tunnel, south of Lahish, railway terminal just inside the West Bank border in a valley 7 km south-west of Tarkumiya.

Alignment 8: A 37.5 km, deep, bored tunnel throughout the whole alignment length. The alignment follows Alignment 2 for the first 7.5 km then strikes due west to a point approximately where it would pass under the north-south corridor of the proposed Highway 6, and thereon to a railway terminal just inside the West Bank border in a valley 7 km south-west of Tarkumiya.

A fuller discussion of technical considerations for the tunnel alignment is presented in Section 4.

Features of the alternative at-surface, sunken, and tunnel alignments are summarized in Table 3-1.

3.6 Alignment Development

Using the existing maps and aerial photography and the criteria discussed in Sections 3.1 and 3.2, 1:20,000-scale topographic maps were further analyzed to conduct a more detailed study of the corridors and to develop horizontal and vertical alignments.

Horizontal alignments were evaluated using the following criteria:

- What are the relative lengths of the alignments, within Palestinian territory, Israeli territory, and in total?
- What are the average and mean gradients of the alignments? The least severe grade alignment is generally preferred. However, the relation of minimum grade may be the inverse to the shortest route length.
- Which alignment more closely follows an existing road or track? This makes survey and construction easier, minimizes land use impacts, and may indicate the route of least earthworks.
- Which alignment follows the least severe terrain type? An alignment through, for instance, flat terrain should be less costly to construct, have lower vehicle operating and maintenance costs, and less severe horizontal curves than a route through hilly or mountainous terrain.

- Which route remains for a longer period on the crest of the terrain? Such an alignment minimizes the need for drainage structures.
- Which alignment minimizes the need for land acquisition? Which alignment minimizes the need to demolish buildings and houses?
- What is the total number of overpasses/underpasses required for each alignment? What is the total aggregate length of these bridges?
- Which route results in the least environmental disturbance to the surrounding area?
- Which route has the least overall project cost, including both design and construction?

The terrain level and its variations along the proposed alignment corridors are shown in longitudinal profiles (see Volume 3) at scale 1:20,000/ 1:2,000 horizontal/vertical.

Vertical Profiles: Longitudinal/vertical profiles were developed for the selected alignments and transportation modes as follows:

- Horizontal Alignment 1:
  - Profile for at-surface Railway Only alternative;
  - Profile for at-surface Road Only alternative;
  - Profile for at-surface Combined Railway/Road alternative.
- Horizontal Alignment 2:
  - Profile for at-surface Railway Only alternative;
  - Profile for at-surface Road Only alternative;
  - Profile for at-surface Combined Railway/Road alternative.
- Horizontal Alignment 2s:
  - Profile for sunken Road Only alternative.
- Horizontal Alignment 3:
  - Profile for at-surface Railway Only alternative;
  - Profile for at-surface Road Only alternative;
  - Profile for at-surface Combined Railway/Road alternative.
- Horizontal Alignment 4:
  - Profile for at-surface Railway Only alternative;
  - Profile for at-surface Road Only alternative;
  - Profile for at-surface Combined Railway/Road alternative.
- Horizontal Alignment 5:
  - Profile for at-surface Road Only alternative.
- Horizontal Alignment 6:
  - Profile for at-surface Road Only alternative.
- Horizontal Alignment 7:
  - Profile for Railway Tunnel alternative (combination of cut-&-cover tunnel and bored tunnel).
- Horizontal Alignment 8:
  - Profile for Railway Tunnel alternative (bored tunnel throughout).

For the at-surface alternatives, these profiles were developed by establishing the ground level profile from interpretation of topographical mapping, and following this as closely as possible while paying attention to the design standards for gradient and vertical curves, observing control points at crossings (by underpass or overpass) of existing roads, railways and watercourses, and attempting to approximately balance earthworks cut and fill quantities. For underpass control points, the profile was established 9m below overpassing railways and 7m below overpassing roads. For overpass control points, the profile was established 9m above underpassing railways, 7m above underpassing roads, and 5m above underpassing watercourses.

The sunken road option was similarly developed, except that the profile was allowed to underpasses watercourses; i.e. a watercourse could pass over the sunken road in a conduit, but with at least a 5 m clearance above road level. Although attempting to place the sunken road about 3m below existing ground levels, vertical alignment design constraints, undulating terrain and control points necessitate that the road often has to be sunken 7m or more. In the undulating hilly terrain approaching the West Bank it is not practicable to maintain a sunken alignment – cut depths would be excessive. Thus, for the latter portion of this alignment the profile follows that of an at-surface profile (i.e. alternating cut and fill sections).

The profile for bored tunnels was established to maintain a minimum overburden depth of 20 m, except at chosen tunneling adit locations (serving also as ventilation shaft locations) where short cut-and cover sections could be constructed.

The profile for cut-and-cover tunnels was established to maintain a minimum overburden depth of 2 m.

3.7 Site Reconnaissance Visits

After potential route corridors were identified from the desk study, a site reconnaissance was conducted to verify interpretations, to help determine the preferred corridor, and to identify factors that will influence the feasibility design concept and cost comparisons.

A site reconnaissance was performed on Sunday, 20 November 2005. The field trip team consisted of the following personnel:

- Derek Sherman, Team Leader
- Jan Zicha, Railway Engineer
- Ariel Cuschnir, Environmental Specialist
- Michael Nyquist, Highway Engineer
- Kobi Satat, Senior Consultant
- Udi Yohay, Senior Engineer

During this reconnaissance, the following was assessed:

- terrain classification, noting the location of topographical constrains, such as gorges, ravines, rock out crops, and any other features not identified by the desk study;
- slope steepness and limiting slope angles identified from natural and artificial slopes (cutting for existing roads in the region), and slope stability;
- rock types, geological structures, dip orientations, rock strength and rippability;
- percentage of rock in excavations;
- materials sources, presence and distribution;
- water sources;
- soil types and depth, soil erosion and soil erodibility;

- slope drainage and groundwater conditions, including drainage stability and the location of shifting channels and bank erosion;
- land use and its likely effect on drainage, especially through irrigation;
- likely foundation conditions for major structures;
- approximate bridge spans and the sizing and frequency of culverts;
- flood levels and river training/protection requirements;
- environmental considerations, including forest resources, land-use impacts and socio-economic considerations; verification of the information collected during the desk study;
- the possibility of using any existing road alignments including local re-alignment; and
- information on the physical accessibility to bridge sites and the proposed corridors, including the geomorphology of drainage basins, soil characteristics, slopes, vegetation, erosion and scouring.

During the site inspection the team examined all at-surface and sunken alignments considered. Gathered information was combined with the results of the desk study to evaluate the alignment alternatives. The reconnaissance data, recorded onto topographical maps and aerial photographs, was used to modify the desk study interpretations. The geological and geomorphological study was received in early December 2005. It did not result in any further revisions to the alignment alternatives. The drainage study, also received in early December 2005, suggested minor modifications to certain alignments, particularly Alignments 2 and 3, in the interest of eliminating unnecessary channel crossings, and as pertaining to the location of various natural drainage courses. The results of the field survey and related studies were used to modify the findings as follows (refer to Figure 3-5):

- For Alignments 1 and 2, the most western section (near Gaza) interfered with agricultural lands and a kibbutz. It was ascertained that that a preferred route would be to traverse a rock outcrop north and west of Sderot which will require sections of rock cuts. Further on, to avoid a curvilinear route and a water course near the junction of Highways 232 and 352, the alignment could follow a tangent close to Highway 232 and 352 before joining Highway 352 near Khelets/Tlamim, hence following the same alignment discussed earlier. A continuation of a tangent line through this hilly section straight across and slightly south of Highway 232 and 352 would still follow the route corridor albeit about 0.5 km south of it, and avoid the wadi in the vicinity of the Highway 232/352 junction. However, subsequent discussions with representatives of Israel Railways indicated that, in considering such alignment for the Ashkelon-Beer Sheva route, they had to avoid these rock outcrops as they contained several cemetery and burial sites.

- For Alignments 1 and 2, the eastern portion (past Lahish) was initially routed on the south side of Highway 35 to avoid Beit Govrin, ensure sufficient space for the new alignment, and to minimize conflicts with Highway 35. However, we found in our meeting with representatives of Israel Railways that they had investigated a similar alignment for a proposed rail line and found it to be too difficult in terms of avoidance of major archeological sites. Consequently, an alignment was developed through the hills north of Beit Govrin and rejoining Highway 35 near the West Bank border.

- For Alignments 1 and 2 (road only) the study considered a continuation east of Lahish along one of several valleys south of the one traversed by Highway 35, to reduce the overall distance. However, all of these valleys are also rich in archeological artifacts, and the possibility of an alignment through them was discarded.

- For the sunken Alignment 2s, the initial study evaluated an alignment which hugged the Shikma Wadi to avoid cutting access from communities to their fields, and to provide possible gravity drainage for the sunken alignment to the wadi. However, the field survey revealed that the wadi, was rather narrow and shallow. If the sunken alignment is at a depth of approximately 6 metres, it is likely to be problematic to drain it to the adjacent wadi at a depth of 4 metres. Hence, to avoid the need of a costly pumped drainage system, it may be advantageous to consider a typical section which balances an approximate 3-metre cut with an adjacent fill (see Volume 3: Drawings, Typical Sections). This typical section would also reduce costs by reducing haul distances for excavated materials.

- For Alignment 4, although the original intent was to follow an existing corridor, the result was an alignment which traversed no existing corridor and which exited Gaza south of Sderot. Further, to give an acceptable gradient on the approach to the West Bank the alignment also follows a new corridor. The only portion of an existing corridor that remained was about 7 km beginning just east of Dorot. However, even here, conflicts with parklands on both sides of Highway 334 dictated a deviation from that route.

- For Alignment 4, it is possible to separate the road alignment from the rail alignment once the Green Line is reached north of Lahav, and locate the continuation of the road through Ramadin and Dahariya. This results in a single road/rail corridor through Israel while allowing a road distance savings to Hebron of approximately 4 kms over Alignment 4, and avoids the steep gradients near the rail tunnel location at the Givat Lahad Hill. The road alignment would end at Point G on Figure 3-5.

A second site reconnaissance was performed on Friday, 17 February 2006. The field trip team consisted of the following personnel:

- Derek Sherman, Team Leader
- Jan Zicha, Railway Engineer
- Terry Anstey, Construction Specialist
- Garry Stevenson, Geotechnical Engineer / Tunneling Specialist

This second reconnaissance was performed to determining the suitability for location of a railway terminal in the West Bank near Tarkumiya:

- For at-surface Alignments 1, 2 and 3: In the Highway 35 valley entering the West Bank about 6 km north-west of Tarkumiya.
  It was determined that the topography well suited location of a terminal starting immediately after crossing the border into Palestinian territory. Such location would also facilitate future terminal expansion.
- For the railway tunnel Alignments 7 and 8: Where the tunnel would emerge at about the West Bank border into a valley located about 7 km south-west of Tarkumiya and 3.5 km south-west of the village of Idna.
  It was determined that this valley was well suited for a railway terminal, and for future expansion of such terminal.

With minor refinements the site reconnaissance visits confirmed the identified at-surface Alignments described under Section 3.4 and the suitability of valley sites near Tarkumiya for locations for a railway terminal.

3.8 Typical Cross-sections and Other Considerations

3.8.1 Provision for Traffic Projections and Future Expandability

The selection of the number of rail tracks and/or of road traffic lanes should be predicated on the forecasted traffic.

For **Railway Only** options traffic projections predict that, in the initial years, a single track with sidings would be sufficient, with later staged construction eventually leading to two tracks. However, 2 tracks can be built at the outset with a relatively small increase in initial capital cost. Furthermore it would be better to secure right-of-way for a 2-track configuration at the beginning.

For the **At-surface Railway Only** option, it is envisaged that that a 2-track diesel railway system will be installed as a '**First Stage**'. A possible '**Future Stage**' envisages electrification of the railway together with the addition of catenaries.

For **Road Only** options, the traffic analysis indicates that a mere two-lane road facility (one lane in each direction) would likely suffice for several years following the opening of the road. Sometime between 2020 and 2030, a 4-lane facility would be required. Nevertheless, it would be technically expedient to provide for an initial year 2 x 2-lane divided highway (2 lanes in each direction), particularly as the lack of an existing facility and the inapplicability of previous years' traffic to our study leaves questions as to its accuracy since all traffic projections are based almost entirely on generated, diverted and induced traffic; in the present environment, they are difficult to predict.

Secondly, it would not be practical to revisit the project in the year 2030, to acquire additional right-of-way to upgrade the roadway to a six-lane facility. This leads to a staged construction solution whereby four-lanes are constructed initially, and sufficient room is provided within the right-of-way to facilitate expansion to a 6-lane facility.

In developing typical cross-sections for the road, railway and combined road/railway options, consideration was given to the aforesaid future expandability of the modal systems.

For the **At-surface and Sunken Road Only** options, cross-sections were developed based on acquisition of sufficient right-of-way and on execution of requisite earthworks, drainage and other construction provisions to permit future construction of a 2 x 3-lane divided highway. However, the adopted cross-section conceives that a minimum 2 x 2-lane divided highway will initially be built – which is referred to as '**First Stage**'. The future possible expansion to a 2 x 3-lane highway is referred to as '**Future Stage**'. It is envisaged that the outer 2 lanes each side of an 8.1 m wide highway median reservation will be constructed in the First Stage. Then, in a Future Stage, 2 inner lanes could easily and economically be added with a resultant median width of 2 m.

For the **At-surface Combined Railway/Road** option, the '**First Stage**' represents initial construction of a 2 x 2-lane road, with a 2-track diesel railway located in the central median of the road. In this First Stage the 2 inner road lanes each side of the railway would be built. '**Future Stage**' expansion is represented by electrification of the railway and the addition of an outer road lane to each of the 2 carriageways.

For the **Railway Tunnel** options, expandability is not relevant. Tunnel dimensions are limited, practicably, to accommodation of 2 tracks, and the railway must be electrified from the start.

3.8.2 Utilities Corridors:

It is envisaged that utilities corridors can, optionally, be located within the right-of-way of the Alignment corridor. For the at-surface alignments (road only, rail only or combined road/railway) or a sunken alignment (road only), water, gas and telecommunications can be placed together in a common, 8-metre wide utility corridor located on one side of the transport infrastructure. Alternatively, for the at-suface or sunken alignments (road only), water, gas and telecommunications can be placed together in the central median of the divided highway. The utilities would be buried, with a gravel service road built over them. In this way, the utility lines could be easily maintained without disrupting main road traffic or rail operations.

Power transmission lines (161 to 400 kV), however, require a separate corridor located on one side of the transport infrastructure (on the opposite side to that utilized by water, gas and telecommunications). Power transmission can be effected by overhead lines or be buried. An overhead high voltage transmission line would require up to a 30-metre wide corridor. Alternatively, a buried power transmission line would require only a 5-metre wide corridor. Although the cost of a buried power line is estimated to be up to five times the cost of an overhead power line of the same voltage, this study assumes provision of a corridor for buried lines – thus reducing the right-of-way width for land acquisition.

3.8.3 Access Zones

For all at-surface and sunken alignments, it is probable that an access road would be required on each side of transport infrastructure corridor. Although the Consultant's Terms of Reference instruct that "the security requirements for each transportation mode" will not be discussed, it is possible that such access zones would be required also as security zones. This study envisions optional provision of such access zones, as indicated on the cross-sectional drawings of Volume 3, but costs (for right-of-way acquisition and construction) for such access zones has not been included in the cost estimates of this report.

3.8.4 Cross-sections of Transportation Alignments

Volume 3, Drawings, shows the typical cross sections developed for the various transportation modes; they are briefly described below:

Alternative A: Road only Alignments

- Typical shallow and high fill sections - First Stage
- Typical cut section in rock and in soil - First Stage
- Typical sunken sections with side spoil embankments, either without retaining walls or (to reduce right-of-way width) with retaining walls – First Stage

- Typical sunken sections with side spoil embankments – Future Stage
- Typical fill and cut sections – Future Stage
- Typical fill sections with optional utilities corridors and access zones outside the road prism – First Stage
- Typical fill sections with optional utilities corridor (for water, telecommunications & gas) inside central median of the divided road, and optional utility corridor (for electricity) and access zones outside the road prism – First Stage

Alternative B: Railway only Alignments

- Typical shallow and fill sections – First Stage
- Typical cut section in rock and in soil - First Stage
- Typical fill and cut sections – Future Stage
- Typical fill sections with optional utilities corridors and access zones outside the railway prism – First Stage
- Cross-section of twin bored tunnels
- Cross-section of twin bored tunnels with Cross-passage

Alternative C: Combined Road/Railway Alignments

- Typical shallow and fill sections – First Stage
- Typical cut section in rock and in soil - First Stage
- Typical fill and cut sections – Future Stage
- Typical fill sections with optional utilities corridors and access zones outside the road/railway prism – First Stage

3.9 Summary and Selection of Alignment Alternatives for Further Analysis

A summary and features of the developed alignment alternatives is presented in Table 3-1.

Table 3-1: Alignment Alternatives - Features and Comments

Alignment No.	Railway Only	Road Only	Combined Railway/Road	Project Length (km)	Length in Israel (km)	Length in Gaza to Terminal (km)	Length in Gaza from Terminal to Seaport (km)	Length in WB from Terminal to Hebron (km)	Length in WB to Terminal (km)	Total Length: Gaza Seaport to North Hebron (km)	Comments
1	√	√	√	44	42	1	19	17	1	80	Surface alignment follows existing route corridors north of Sderot to near Tarkumiya.
2	√	√	√	44	42	1	19	17	1	80	Surface alignment follows new corridor north of Sderot to near Tarkumiya.
2s		√		44	42	1	19	17	1	80	Sunken alignment following Alignment 2.
3	√	√	√	57	52	2	12	17	2	86	Surface alignment south of Sderot to near Tarkumiya.
4	√	√	√	50	46	2	12	32	2	94	Surface alignment south of Sderot, north of Beit Kama, to near Meitar (requires 700m tunnel).
5		√		43	39	2	12	34	2	89	Surface alignment south of Sderot, south of Beit Kama, to near Meitar.
6		√		51	48	1	8	33	2	92	Surface alignment south of Netivot to near Meitar.
7	√			38	37	1	19	18	1	75	Shallow cut-&-cover tunnel across western plain, and deep bored tunnel under eastern hills to Tarkumiya.
8	√			38	37	1	19	18	1	75	Deep bored tunnel throughout to Tarkumiya.

As shown in Table 3-2, a total of seventeen alignments were investigated based on selection of at-grade, sunken, or tunnel configurations, and selection of road only, railway only, or the combined road/railway options.

It is necessary to reduce this number of alternatives to a more workable set of options. Accordingly all alternatives which would terminate in the West Bank at the southern terminus located north of Meitar have been eliminated from further study. This decision is based on several factors, including:

- In discussions with Palestinian officials, they did not view southern railway alignment alternatives favorably, questioning whether continuation of a rail route from its southern terminus (near Meitar) to points north would ever prove viable. The officials viewed more favorably the possibility, albeit difficult, of a rail continuation within the West Bank from Tarkumiya.

- Only one of the four southern alignments allowed for a combined road/railway possibility, but which represents a 14 km increase in length between Gaza Sea Port and North Hebron, with no tangible advantages or benefits;
- All origin/destinations using the southern alignments would require substantially longer trip lengths and consequently increased travel costs and travel time in a new corridor. These added costs come with no tangible benefits to the Palestinians.

Alternative Alignment 3 was eliminated, for several reasons, including:

- It could not follow the Route 334 corridor as originally envisaged, due to conflicts near Sderot, and with park lands east of Dorot;
- It added 10 km length across Israeli territory, or an increase in distance of 24%, over all other options terminating at Tarkumiya;
- It added approximately 6 km over the northern alignments for total distance between Gaza Sea Port and the Highway 35/60 junction north of Hebron; and
- The additional length occurs primarily at a location in the eastern hilly terrain, creating a more expensive and problematic alignment in this geographic area.

The elimination of these routes resulted in the following nine Alternatives (four alignments) selected for further review, including profile development, unit costs and construction costs. The Alternatives are presented in Table 3-3.

Table 3-3: Alternative Alignments Selected for Further Analysis

Alignment	Railway	Road	Combined	Type	West Bank Destination
1	√	√	√	At-Surface	Tarkumiya (1)
2	√	√	√	Part Sunken / Part At-Surface	Tarkumiya (1)
2s		√		At -Surface	Tarkumiya (1)
7	√			Part Cut-&-Cover Tunnel / Part Bored Tunnel	Tarkumiya (2)
8	√			Bored Tunnels only	Tarkumiya (2)

(1) In Highway 35 valley 7 km north-west of Tarkumiya
(2) In valley 7 km south-west of Tarkumiya

For these selected alignments, cost estimates and implementation schedules have been prepared; see Section 6 of this Report.

3.10 Terminal Requirements in Palestinian Territory for Railway Operations

Terminals of the Gaza-West Bank Transport Link constitute two major separate railway facilities located at each end of the line, one in Gaza and the other one near Tarkumyia or Idna on the West Bank. In order to provide self-sufficient railway services, the terminals have to perform all necessary operational, technological, and maintenance functions in a largely independent manner. The design features of terminals reflect the distinct operational requirements in connecting two geographically separate parts of a country.

The efficiency of terminals directly influences the capacity and operational performance of the entire railway line. The layouts of the terminals enhance operational efficiency and provide the following essential services:

A. Passenger Transportation Support

   a. Loading and unloading of passengers
   b. Safe flow of passengers through the station building and areas occupied by tracks
   c. Entry and egress control
   d. Provision of passenger services
   e. Accommodating special needs of traveling public
   f. Facilitating inter-modal passenger transfer

B. Freight Transportation Support

   a. Inter-modal freight transfer including loading, unloading, and temporary storage
   b. Reception, processing and assembly of trains
   c. Entry and egress facilities and control
   d. Freight flow management

C. Operational Management of the Mainline and Terminals

D. Track Control Management

E. Traction Power Supply and Control

F. Maintenance of Rail Vehicles

G. Infrastructure Maintenance, Component Storage and Staging Areas

   a. Track and structures
   b. Train control
   c. Communications
   d. Power supply

3.10.1 Gaza Terminal

Gaza terminal has been selected as the operational and maintenance center of the line. The Gaza terminal will be fully equipped to provide comprehensive maintenance services for the entire fleet of passenger cars, freight cars, and locomotives, and for infrastructure maintenance. As a result of these requirements, the layout of the terminal facility appears to be disproportionately large in its relation to the length of the line. An alternative outsourcing of major inspection and maintenance tasks to a railway facility that serves the neighboring regional railway network has been considered. However, it is an unpredictable and currently unforeseeable option.

The Gaza Terminal is planned to expand as traffic requires. As a consequence, the area required is a much longer facility able to serve:

a. Future regional economic growth and potential expansions of the line within the Palestinian Territory, for instance to the proposed sea port.
b Potential railway connections to future lines in the West Bank, Gaza-Harbor, Tel Aviv, Beer-Sheva, Jordan, and Egypt. A major demand for classification services of freight trains and for passenger service can be expected in the future if these developments occur.

A space sufficient for future expansions should be reserved at the critical stage of the Project. Ideally, the area reserved for trackwork should be approximately 150 m wide and 4 km long except for the loop that has a radius of 300m and an approximate construction width of 10m. In addition to this area, a road access, a paved loading/unloading area for trucks, and paved container storage areas should be provided at suitable locations to accommodate intermodal transfers.

The Gaza Terminal has been introduced as a station with linear configuration of track groups and mainline tracks continuing through the station. They will be temporarily terminated past the terminal to serve as by-pass tracks, as test tracks for repaired vehicles, and for various yard operations. The through-tracks will remain available to provide future mainline continuation to Gaza Harbor and Egypt, if and when needed.

3.10.1.1 Passenger Terminal Operations

The passenger station and its track configuration currently considered for implementation consists of three tracks and two platforms. One platform is placed directly next to the building and it is served by one track. The second platform is accessible by an underpass and it is served by two additional tracks. For future expansion, space is left between this platform and the continuation of the mainline tracks to facilitate placement of an additional two platforms served by four additional tracks.

The passenger trains will be stored in a separate storage/inspection group. This group can be accessed though a car wash. The tracks are placed at staggered 5m and 6.5m intervals to facilitate access of servicing carts, inspection equipment and minor maintenance vehicles. Selected vehicles continue to the shop building placed within a separate track group.

3.10.1.2 Freight Terminal Operations

The freight group consists of a loading/unloading subgroup, storage and classification subgroup, and arrival/departure subgroup. The incoming train enters preferably one of the unloading tracks. If these tracks are occupied, the train enters the arrival/departure subgroup and the locomotive leaves the train. The emptied train is processed as necessary, individual cars accumulated in the storage/classification subgroup and assembled into sections of a train. The full train is assembled in the departure subgroup. Reversal movements are needed at the track configuration currently considered for implementation.

As pictured in the Operation Diagram for Gaza Terminal (see Volume 3), the loading/unloading, storage/classification and arrival/departure subgroups are placed in parallel at this stage of the project. They will be replaced by a sequential linear configuration in the future when the reversal movements become too obstructive and cause operational capacity losses of the line.

The physical features of future expansions include separate classification and departure track groups to be added to the primarily loading/unloading track group currently considered for implementation.

3.10.1.3 Shop Track Group and Shop Building

The shop activities consist of major scheduled inspection, wheel turning of worn wheels, and repairs requiring shop equipment such as wheel lathe, cranes, lifts, bottom access, special tooling, replacement of parts, body work and painting.

The vehicular maintenance building should be expandable to include two more tracks and additional repair shop areas. The locomotive maintenance function may require further expansions or an additional building.

3.10.1.4 Infrastructure Maintenance Staging Tracks and Building

The infrastructure maintenance building includes the headquarters of infrastructure maintenance, administrative offices, classrooms, shops, indoor component storage and a storage track for track maintenance machineries.

The infrastructure maintenance tracks include a track maintenance staging area next to outdoor storage of rails and ties. A separate fuelling facility will be placed next to a separate track.

3.10.1.5 Loop

A loop of minimum radius 300m is placed at the end of the terminal to serve the following functions:

a. A periodical change of the trains' position on the line. This provision eliminates asymmetric wheel wear and ensures major reductions of the wheel turning frequency. The trains should be reversed once a week.
b. An alternative exit from the terminal, in case one of the main entry turnouts malfunctions, or in a case of an accident.

3.10.3 West Bank Terminal

3.10.3.1 Location of West Bank Terminals, Mainline Access and Operational Concept

The West Bank Terminal will function as a passenger stations, and as loading and unloading facilities for freight. Only minor services and emergency maintenance of rolling stock will be performed at the West Bank Terminal. The land acquisition should take into consideration the future capacity increases of Gaza-West Bank transportation volume and the corresponding extensions of the Gaza Terminal.

There are two possible locations for railway terminal on the West Bank. They are identified as follows:

a. Tarkumyia area for At-Grade Railway Alternatives
b. Area south-west of the village of Idna for Railway Tunnel Alternatives

The layouts of both terminals are similar because the traffic flows in them are based on the same operational scheme. The mainline double-track splits into a separate passenger lead double-track, and into a separate freight double-track. The passenger station and the freight loading/unloading area can be thus established at separate locations. This separation of activities suites well the topographic conditions of both terminals, enhances the safety of train operations, and improves the road access.

The passage of one passenger lead track to the other side of the mainline will be grade separated so that the passenger lead track will pass over the mainline as indicated in the Operational Diagrams of Tarkumiya and Idna and Siding (see Volume 3).

Since the traffic density on the separate lead double-tracks will be considerably reduced in comparison with the traffic density of the mainline, some reverse movements can be temporarily permitted as long as the operational scenario that corresponds to the number and configuration of the terminal tracks currently considered for implementation is in effect. However, these movements will be considerably reduced by the presence of the separate shunting track parallel to the freight lead double-track.

3.10.3.2 Passenger Terminal

The track configuration, the operational scheme and future expansion of the passenger station are the same as the ones provided for the Gaza Terminal. However, the passenger station building does not include the operational center and administrative offices located in the Gaza's passenger station building. The platform tracks could be temporarily dead-ended until the traffic volume increases. However, in the design of the terminal would be probably introduced track branching at the initial stage of the project to facilitate easier egress of locomotives.

A potential future extension of the line further to the West Bank would likely require a continuation of mainline tracks to the east.

3.10.3.3 Freight Terminal

The number and function of the tracks within the freight track group currently considered for implementation is the same as in the Gaza terminal. The tracks could be temporarily dead-ended until the transportation volume increases. However, in the design of the terminal would probably incorporate track branching at the initial stage of the project to facilitate easier egress of locomotives. The track branching of the loading/unloading group will become necessary under the following conditions:

a. The operational intensity reaches a level that prevents shunting on the main freight access tracks in the direction opposite to the incoming trains.
b. The tonnage of the freight trains is too high to be handled by a shunting locomotive on the 1.3% gradient of the freight lead double track.
c. The operational intensity reaches a level that would require a potential extension of the freight track group, or addition of a group or groups.
d. A future extension of the line further to the West Bank requires a continuation of mainline tracks to the east.

One of the storage tracks functions as a staging track for infrastructure maintenance.

3.11 Road Connections in Palestinian Territory

This section describes the possibilities for road connections within Palestinian territory, at the Gaza and West Bank terminus points, of the selected Alignments 1 and 2 (at-surface road only or combined road/railway) and Alignment 2s (sunken road only).

3.11.1 Gaza Road Connections

It is envisaged that a Gaza / West Bank link road will terminate at a new traffic circle (roundabout) just inside the north the Gaza border at the north-eastern extremity of the Gaza Strip near Beit Hanun. From such traffic circle, the following road connections will be facilitated:

- A new north-west connector road, about 3 km, to connect with Highway 4 near the Ezra border crossing. From the Ezra Crossing, Highway 4 runs south-west along the Gaza Strip with connections to Beit Lahiya, Gaza City, the proposed Gaza sea port, and onward to the Gaza International Airport and Egyptian border crossing at the south-eastern extremity of the Gaza Strip.
- A new connector road, south-west, paralleling the Israeli border, to connect with Highway 4 somewhere in the vicinity of the Karni border crossing.

In the case of a combined road/railway link, a railway terminal is proposed to run south-west, following the Israeli border. Thus, the component road link would parallel the 4-km long (approximately) terminal before continuing to a junction with Highway 4.

For a combined road/railway link, a conceptual arrangement has been selected whereby the railway would be located within the central median of a divided highway. Consequently, a grade-separation structure would be required to separate the road lanes from the railway before the latter enters its terminal. If this grade-separation structure is to be located completely within Palestinian territory, its configuration (the design of which is beyond this conceptual design study) will influence the locations of the link road terminus and the railway terminal.

For a railway only link, road connections within the Gaza Strip to/from the railway terminal would also be as described above.

3.11.2 West Bank Road Connections

A road link will parallel Highway 35, entering the West Bank about 7 km north-west of the village of Tarkumiya. A junction will be required to connect the divided highway with the 2-lane Highway 35. Highway 25 proceeds south of Tarkumiya in a westerly direction to a junction with Highway 60 on the northern outskirts of Hebron. The distance from the border crossing to the Highway 35/60 junction is about 17 km. From this junction, Highway 60 proceeds north to Bethlehem and onward to Jerusalem, Ramala and Nablus.

For a combined road/railway link, with the railway located within the central median of the divided highway, a grade-separation structure will be required to separate the road lanes from the railway before the latter enters its terminal. If this grade-separation structure is to be located completely within Palestinian territory, its configuration (the design of which is beyond this conceptual design study) will influence the locations of the link road terminus and the railway terminal.

As described earlier in this chapter, a railway tunnel link alternative is proposed to terminate at a railway terminal located in a valley 7 km south-west of Tarkumiya and 3.5 km southwest of the village of Idna – a different location than that of a terminal for the at-surface alignments. From such terminal there are possibilities via secondary roads that would need to be upgraded:

- North-east via secondary road 364 through Idna village to connect with Highway 35, a distance of some 6 km; and onward to a junction with Highway 60 on the northern outskirts of Hebron. However, a route through the village may not be an acceptable proposition.
- A circuitous route heading east, joining secondary road 364 to pass south of Idna, then departing north to join Highway 35 – a distance of some 8 km; then onward to north Hebron.
- A route initially south-west via secondary road 364 to its junction with Highway 5, and then westerly via Highway 5 through Dora to a junction with Highway 60 on the southern outskirts of Hebron.

CHAPTER 4

TUNNEL ALIGNMENTS ALTERNATIVES FOR A RAILWAY LINKAGE

4.1 Overview

Because tunnelling is an invariably costly proposition, road and rail tunnels are typically constructed only when topographical and environmental constraints preclude all other options. When tunnels are required for a road or railway project, engineers select the shortest distance feasible to minimize cost, while addressing fire and safety concerns. Appendix 4.1 provides numerous examples of tunnel projects completed in various locations and describes the high costs associated with their construction.

The current study initially evaluated a tunnelled transportation link as a viable alternative, because of unique factors associated with this proposed project including the objective of maximizing separation between the users of the transportation link and the Israeli population. The proposed transportation corridors do not contain the types of environmental and other physical factors that alone would justify pursuing a tunnel option. However, even taking into account the special issues associated with this proposed project, the option for constructing a road tunnel was rejected for the following reasons:

- Twin tunnels would be required for the 2 x 2-lane highway proposed in this conceptual study.
- An inside width of a 2-lane tunnel (requiring a shoulder lane for stopped or broken-down vehicles) would be about 12 m. This is an inordinately large tunnel that would be prohibitively expensive. High costs and safety concerns are why long road tunnels are constructed only when there are no other alternatives.
- For the at-surface or sunken road alternatives, the cross-sectional arrangements proposed in this conceptual study will facilitate their future expansion to a 2 x 3-lane highway. Enlargement of a tunnel facility would require constructing at least a third tunnel to accommodate the two additional lanes, but since these adjacent lanes would not be unidirectional, this would be an unsafe and therefore an unacceptable solution. The construction of two additional tunnels would be extremely expensive.

The option of constructing a road using partial tunnels was not evaluated because it would be far more costly than all of the other proposed road alternatives, and would not satisfy the non-economic factors described above. Accordingly, tunnel options were evaluated for a “railway only” alternative

A railway tunnel alignment would be subject to the same geometric design criteria as a surface rail alignment. The primary benefit of a tunnel option, compared to a surface option, is that a more direct route could be constructed, assuming that the maximum permissible gradient can be accommodated within that length.

Topographic and geological factors constrain tunnel options to two types; a "cut-and-cover" tunnel and a "bored" tunnel. In the western portion of the route, the subdued topography permits consideration of either type. Cut-and-cover would be the least expensive option, but due to the necessary open excavation during construction (before the tunnel is constructed and the excavation back-filled), its adoption would be subject to provision and acceptance of appropriate environmental mitigations. However, hilly terrain in the eastern portion of the alignment would require use of a bored tunnel to maintain reasonable gradients.

Alignment No.7, shown on the drawings of Volume 3, has been selected as a plan alignment of a shallow cut-and-cover railway tunnel across the relatively flat western terrain, with a deep, bored tunnel traversing the eastern hills. A location for the eastern railway terminal has been selected in a valley approximately 3.5 km southwest of the village of Idna, southwest of Tarkumiya. Total tunnel length would be approximately 38.9 km. This alignment provides a gradient under the western plain well within the preferred maximum gradient of 1.3 percent, and about 1.65 percent under the eastern hills.

Alignment 8, shown on the drawings of Volume 3, has been selected as a plan alignment for a deep, bored railway tunnel throughout – a total tunnel length of about 37.5 km.

4.2 Geological Conditions

The proposed tunnel route would transverse two geological settings. The western portion of the route covers approximately 17.5 km and is located in overburden. The remaining 20 km of the route to the east is located mainly in soft and limey chalk of the Zora Formation. The geological and geotechnical conditions have been determined based on a review of available information and from site visits to inspect the soil and bedrock exposures in the vicinity of the proposed tunnel alignments. Appendix 3.4 "Geological / Geotechnical Assessment" presents the detailed findings of these efforts. The following summarizes these findings.

The overburden in the western portion of the route includes kurkar and overlying clayey sand and loess. The kurkar is typically fine sand to silty sand, cemented with a variable content of carbonate which provides cohesion. Kurkar with carbonate content in excess of 20% is regarded as a weak sandstone rock. The clayey soils are CL to CH clays in the Unified Classification system. The water content is equal to or less than the plastic limit, indicating that they are over-consolidated. The loess and clay have shear strengths in the order of 450 to 500 kPa (determined by vane tests) and are of a reasonable strength that will be beneficial during excavation. The loess would be expected to be "metastable" due to its mode of deposition (by wind); that is, it is stable under existing, dry conditions but can collapse (settle substantially) when saturated. Based on limited well records, the water table is estimated to occur at depths of 30 m or more in the overburden.

The eastern section of the proposed tunnel route would be situated primarily in the Zora Formation. The upper Maresha Member is a massive, very weak to weak rock. The lower, Adulam Member is well-bedded, weak chalk containing chert horizons. The contact between these two members is unconformable (i.e., deposition was interrupted at the top of the lower member), so may be irregular. Near streams, the water table has been found as close as 3 m to the ground surface.

4.3 Selection of Tunneling Methodologies

Cut-and-Cover Tunnel: In the region of the coastal plain from near Sderot to near the Tel Aviv – Beer Sheva Railway, the ground surface is relatively uniform, with no significant ridges or valleys present. A cut-and-cover tunnel is proposed for this section of Alignment 7. Substantial temporary excavation would be required as well as provisions for diverting watercourses or using temporary viaducts to carry the water during the construction phase. Utilities, roads, and the railway crossing the alignment would have to be supported or (for the roads) diverted during construction. The water table is very deep, which is beneficial for excavation stability and for design of the permanent structure. The main geotechnical risk would be encountering loess below the invert of the tunnel. In general, the loess is less than 10 m thick and would be excavated. Loess, however, can be found at depth of 20 m, which would necessitate consolidating or compacting. In-situ and laboratory testing would be performed to determine the stability of the loess.

Bored Tunnel: The ground conditions are favourable for use of tunnel boring machines (TBMs) for the full length of the tunnel crossing. In the overburden of the western portion, the low water table and cohesive nature (whether due to clay content or carbonate cementation) are beneficial for tunneling. Both of these factors would minimize the potential for failure of the tunnel face during excavation. Support would be provided by means of a precast concrete lining, installed at the end of the TBM as it advances, so that the soil is never unsupported.

For tunnelling in the kurkar of the western plains, it would be necessary to anticipate cohesionless soil, where the carbonate content is low. Most soils encountered along the route are relatively fine grained, and earth pressure balance (EPB) TBMs (designed to maintain a fluid pressure against the excavated face during excavation, to provide face support) will likely be suitable for the variable conditions.

The Zora Formation of the eastern hills is relatively weak, and massive or well-bedded chalk. An open TBM (not requiring isolation of the face by slurry or earth pressure) would be suitable for excavation of these materials. It will be necessary to define the location of the contact between the Adulam and Maresha Members in future investigations in order to optimize the tunnel design and final selection of TBM features. In particular, the Maresha Member is very weak and would likely require permanent support, while the Adulam is stronger and may stand unsupported, or with local support installed on an as-required basis depending on the geological conditions. The Adulam contains flint or chert, which could cause a high rate of wear of the picks or cutters on the face of the TBM. The tunnel will be located below the water table at least locally. If a precast lining is not installed, measures such as grouting or a local lining to direct water to the drainage system would be required to deal with inflows.

The very weak to weak Zora Formation could also be excavated by road header. In this case the tunnel shape could be optimized, compared to the TBM option which can only be circular. Support would be installed as required during excavation. However, for the purpose of this conceptual design, TBM technology has been envisaged.

Cross-passages would be required between the twin tunnels for safety reasons, as described below. For TBM tunnels in overburden, ground treatment such as grouting will likely be required if uncemented kurkar is encountered. The cemented kurkar may have adequate strength that it can be excavated in short sections, then supported with shotcrete. Passages excavated in clay may require support measures such as forepoling (drilling and grouting in a ring of steel rods or "poles" above and ahead of the tunnel to provide support of the excavation until measures such as shotcrete and/or steel sets are installed) to permit excavation and installation of a permanent (likely concrete) lining.

In areas where the tunnel would traverse chalk, the cross passages could be excavated with a road header or a breaker (a pneumatically operated pick, usually mounted on a backhoe or excavator in place of the bucket). Assessment of geological data for the area indicates blasting would not be required. The cross- passages would be permanently lined with shotcrete or concrete.

4.4 Tunnel Construction Considerations

Cut-and-Cover Tunnel: A typical cross-section of a reinforced concrete, cut-and-cover tunnel for two railway tracks is shown in the Volume 3 drawings. The tunnel arrangement would be sized to provide approximately the same clearance from top-of-rail to crown-of-tunnel as the TBM tunnels to suit the catenary installation for train power supply and to provide about the same cross sectional area as the TBM tunnel, so that the dynamic effects will be similar. The cut-and-cover tunnel would have a central dividing wall separating the two railway tracks. The cross-sectional shape has not been optimized at this conceptual stage. The temporary excavation slopes would vary according to the soil type encountered, with steeper slopes in well-cemented kurkar and flatter slopes in clay. Space would be required for temporary storage of the excavated soil until it is compacted in place beside and over the completed tunnel structure. Excess material would have to be disposed.

The thicknesses of the concrete members were estimated based on comparison with similar structures designed for other applications. Although a structural design has not been completed for this study, the adopted cross-section is considered adequate for developing a preliminary construction cost estimate. The entire concrete section could be cast-in-place. Alternatively, the walls and roof of the tunnel structure could be precast off-site, and then assembled in place. Emergency access doors would be installed in the central wall at about 250 m centers.

Alignment 7, which would involve approximately 23.7 km of cut-and-cover tunnel, would likely be constructed to minimize the time that the excavation is open and so minimize the likelihood of handling significant rainfalls at the stream crossings. It is also assumed that the ventilation works for the cut-and-cover tunnel would be similar to those used for the bored tunnel (i.e., employed at proximately 8 km intervals along the route). This approach would require a non-standard concrete structure with the fan installation on the outside of each running tunnel. An emergency escape and a platform area to serve as a collection point could also be installed.

A crossover, permitting trains to cross from one rail track to the other, together with sidings where trains could pull off the running track, would be installed at about the midpoint of the tunnel, in the cut-and-cover section rather than in the bored tunnel section where the excavation of a large cavern would be relatively expensive.

Tunnel Boring Machine Tunnel: TBM twin tunnels (each for one railway track) with a precast concrete lining would be used in both the overburden of the western plain (Alignment 8 only) and in chalk of the eastern hills (Alignments 7 and 8). The internal diameter is assumed to be 8.8 m and is based on a review of current European standards for high speed (200 km/h) electrified rail way tunnels and the proposed tunnel arrangement for a TBM alternative of a tunnel in Jerusalem. It is recognized that the actual tunnel size will depend on the selection of train type (dimensions). The assumed diameter would accommodate Eurotunnel type cars with drive-on / drive-off arrangements for transporting cargo trucks (the Eurotunnel, or “Chunnel”, “running tunnels” are 7.6 m inner diameter).

The precast lining thickness is assumed to be 350 mm, as has been used in other tunnels of similar diameter. It is possible that a thinner lining could be designed at a later stage, at least for the tunnel in rock. The lining would be gasketed between segments to prevent water inflow.

The twin tunnel longitudinal profile, presented in Volume 3, shows the tunnel with generally a minimum cover of 20 m in overburden. This design would provide adequate cover to avoid significant settlement of the ground surface, while keeping the tunnel invert at about 30 m depth and, therefore, generally above the water table. In the western section of the route, the tunnel may be in either kurkar or the overlying clay, between Sderot and the contact with bedrock in the vicinity of Sta 8340; there is insufficient information to estimate confidently the location of this contact. In the chalk from Sta 8340 to the eastern terminus, the location of the unconformable contact between the two Zora Formation Members is similarly unknown at this time.

For safety purposes, trains operating in opposite directions would use separate tunnels. The tunnel separation between centerlines is assumed to be 25 m, approximately 2.5 times the tunnel diameter, so that excavation of one tunnel does not affect the other. Cross-passages would be provided between the two tunnels at approximately 250 m intervals, as required by the National Fire Protection Agency (2003), or similar spacing required by European codes, for emergency egress in case of a fire or accident in one tunnel. The passages would be fitted with “fire doors” at each tunnel. If it is necessary to connect utilities in the tunnels or permit service vehicles (on tires, not rails) to pass between the tunnels, the passages would be enlarged for these purposes.

Ventilation shafts for the tunnels would be excavated to ground surface at selected locations. The shafts would require temporary support, such as by sheet piles or concrete (tangent pile wall or slurry wall construction) in the overburden of the west portion of the alignment. The chalk would likely stand unsupported, as evidenced by the man-made caves near Beit Govrin. For the TBM-bored tunnels, these shafts (or local cut-and-cover sections) would be used for intermediate access points between the two extreme ends during tunnel excavation, to break the tunnel into reasonable lengths for scheduling reasons and to facilitate separate construction contracts. For conceptual ventilation design and construction planning, it is assumed that the shafts would be spaced at approximately 8 km intervals along the route. For the TBM-bored tunnels of Alignment 7, there would be one shaft in rock, while for Alignment 8 there would be an additional three shafts in soil. The shafts would likely be in the order of 35 m diameter, to accommodate concurrent construction of both tunnels. They would subsequently be the locations of the ventilation works, emergency escape from the tunnel, and a refuge or collection point as it would be convenient to widen the tunnel at this location to create a large platform area.

A cross-over, permitting trains to cross from one rail track to the other, together with sidings where trains could pull off the running track, would be provided at about the midpoint of the tunnel. The cross-over would be located in chalk rather than overburden, to minimize the cost of excavation and support. The crossover would require a door or special ventilation measures to separate the air flows in the two tunnels in case of fire. A siding could be provided for each tunnel, in the chalk section, by widening a length of the tunnel, excavating to the outside of each tunnel to minimize the effect of one tunnel on the other.

The precast concrete tunnel lining would be manufactured in a plant devoted to the project. With several sections of the tunnel eventually under way concurrently, it would be necessary for the plant to start manufacture well in advance of tunneling in order to have a stockpile of several thousand lining segments at the commencement of tunnel boring.

Tunnel muck, the excavated material, would total in the order of 3.5 million cubic meters for the full length of TBM-bored tunnels of Alignment 8, assuming a bulking factor (volume increase of excavated, disturbed material compared to in-situ material) of 25 percent. The soils of the western plain are fine-grained and would not be useful except as fill. The chalk in the eastern hills is very weak to weak, and would likewise not be useful except as higher quality fill.

4.5 Tunnel Ventilation, Fire, and Safety Considerations

A detailed description of the requirements for air handling, and tunnel evacuation in the event of fire within the tunnels, is presented in Appendix 4.2. The following summarizes these requirements.

Ventilation would be provided at the two end portals of the tunnels and at four ventilation shafts along the tunnel alignment, spaced at about 8 km intervals. Fans would be installed in each ventilation shaft. Passenger evacuation facilities would be at the ventilation shaft locations. During train operations, the tunnels would be ventilated by the piston effect created as the train moves along the tracks. This effect would draw air from the up-shaft and blows air through the down-shaft, creating air flow in the tunnels to ventilate them. In case of a train stopping in the tunnel, or during maintenance, the fans would operate to create a satisfactory environment.

In case of a fire that would cause a train to stop while in the tunnel, the fan system would direct smoke away from the evacuation route to assist passengers in evacuating to a clean and safe atmosphere. In the unaffected tunnel, the fans would work to create an over-pressure so that the clean air would flow through the tunnels' cross-passages to the affected tunnel and prevent smoke reaching the clean tunnel, while passengers escape to the clean tunnel. The fans will be reversible. Passengers would evacuate upstream to the nearest ventilation shaft location or tunnel portal.

4.6 Bored Tunnel Costs and Schedules

The costs and construction schedules for Alignment 7 (Part Cut-and-Cover Tunnel/Part Bored Tunnel) and Alignment 8 (Bored Tunnel throughout) are summarized in Sections 6.2.1 and 6.2.2 of this Report. The detailed cost estimates are presented in Appendix 6.3.

The cost estimate for Alignment 7 is predicated on the use of 4 open TBMs to excavate the 15.2 km bored tunnel through the soft rock of the eastern hills. The cost estimate for Alignment 8 is predicated on using 6 EPB TBMs to excavate the 22.5 km through the overburden soils of the western plain, and 4 open TBMs to excavate the 15 km bored tunnel through the soft rock of the eastern hills.

The cost of manufacture and delivery of each TBM would be approximately US$15 million, resulting in a total cost of US$60 million for Alternative 7 and US$150 million for Alternative 8. Using fewer TBMs would result in lower construction costs, but would significantly increase the duration of the construction phase. Tables 4.6-1 and 4.6-1.1 show the potential time-cost tradeoffs for using different numbers of TBMS for the two Alignment Alternatives.

Table 4.6-1: Estimated Project Construction Periods and Costs as a Function of the Number of TBMs Used on Alignment 7

Alignment 7	Time for Excavation (Years)[1] .	Project Construction Period (Years)			Potential Cost Saving	Total Project Construction Cost[2]
N° of TMBs Used		Short	Long	Most Likely	(US$ million)	
4 TBMs	1.5	4.5	6.0	5.0	Base Case	1,161
2 TBMs	2.5	5.5	7.0	6.0	30	1,131
1 TBM	4.5	7.5	9.0	8.0	45	1,116

[1]Exclusding land acquisition
[2]Including assembly, disassembly, move to new location, re-assembly

Table 4.6-1.1: Estimated Project Construction Periods and Costs as a Function of the Number of TBMs Used on Alignment 8

Alignment 8	Time for Excavation (Years)[1]	Project Construction Period (Years)			Potential Cost Saving	Total Project Construction Cost[2]
N° of TMBs Used		Short	Long	Most Likely	(US$ million)	
6 EPB TBMs + 4 TBMs	2.0	5.0	6.0	5.5	Base Case	1,657
4 EPB TBMs + 4 TBMs	3.5	6.5	7.5	7.0	30	1,627
2 EPB TBMs + 2 TBMs	5.0	8.0	9.0	8.5	60	1,567
2 EPB TBMs + 1 TBM	5.0	8.0	9.0	8.5	105	1,552
1 EPB TBM + 1 TBM	9.5	12.5	13.5	13.0	135	1,537

[1]Exclusding land acquisition
[2]Including assembly, disassembly, move to new location, re-assembly

The potential cost savings from using fewer TBMs is not insignificant, but in comparison with the total project cost, the percentage reduction is rather small while the duration of the construction period, especially for Alignment 8 becomes quite protracted. For this reason the number of TBMs proposed to be used by this conceptual study is as presented in Table 4.6-1 as the 'Base Case'.

CHAPTER 5

ALIGNMENTS USING THE ISRAEL RAILWAY SYSTEM AS AN INTERIM SOLUTION

This chapter summarizes the results of a preliminary evaluation of two railway-only alternatives that would make extensive use of the existing Israeli Railway system. The first alternative, Alignment 9, would achieve in the long term a completely tunneled railway connection. The second alternative, Alignment 10 would be built as an at grade solution. The evaluation was performed primarily to determine if these alternatives could serve as viable interim solution to linking the two Palestinian territories.

5.1 Alignments 9 and 10: Using Israel Railways System as an Interim Solution

As interim solutions, these alternatives would make the maximum use of the existing Israel Railways network (including a section now under construction). For Alignment 9, this would be a combination of at-grade and tunnelled sections. The tunnelled section length of 15.8 km follows the same alignment used for Alignments 7 and 8 as they approach the West Bank terminus.

It has been reported to the consultant that there are studies of the Interim Solution prepared by the Government of Israel. These studies have not been communicated to the consultants. As a consequence, the evaluation that follows does not reflect the work done in these earlier studies.

5.1.1 Israel Railways Development Program

Passenger traffic on the Israel Railways has increased on significantly during the past five years. In 2004, for example, passenger traffic increased to 24 million, an increase of 17 percent over the previous year. Notably, freight shipments have stagnated at around 10 million tons. To accommodate and maintain the future passenger growth, Israel Railways is expanding the coverage and capacity of its network. In the planning stage is the project to build the new A1 line to Jerusalem, which will reduce travel time between that city and Tel Aviv to less than half an hour. In addition, Israel Railways plans to improve capacity and the quality of service through double tracking much of the system and by the electrification of the network in a staged program.

As part of the 5-year plan for Israel Railways, the connections to Be'er Sheva will be improved by two projects: double tracking the Tel Aviv – Be'er Sheva Line and constructing the new double track line between Ashkelon – Be'er Sheva. The first stage of the latter line from Askelon to Nativot (30 km) is now under construction and will be completed in 2010[1]. The double tracking of the Tel Aviv to Be'er Sheva line is now under way and will include improvements in its alignment to allow higher operating speeds. This project is planned for completion by 2009.

The electrification of the Israel Railways network is also planned. A key feature is the electrification of the A1 line to Jerusalem, which requires several tunnelled sections. Once the

[1] The estimated cost of this project is 600 million NIS.

decision is made to electrify a portion of the network it is a matter of time before other highly trafficked sections are also electrified. Due to the high costs of implementing many of the projects included in the 5 year plan for Israel Railways, the schedule for electrification has been put back by a couple of years. As a consequence the lines connecting Be'er Sheva have not benn given high priority for electrification and will be served by diesel locomotives.

Sections of the Ashkilon - Kiryat Gat line are in poor condition. Many of the ties along these sections have failed; there are reports of past subsidence of the embankment. At present, the line is used only for freight traffic. Trains operate with speed restrictions on this line to avoid derailments.

5.2 Interim Solution-Alignment 9

Alignment 9 commences in the west at the Gaza terminal complex and terminates at the West Bank terminus. As described below, this interim solution could be eventually extended to become an option to Alternative 7.

Phase 1- Interim Solution

1. A short section of double track rail would have to be constructed to connect to the Ashkelon – Nativot section of the Ashkelon – Be'er Sheva Line. The Ashkelon – Nativot section is now under construction as a double track line, so the connection will also have to be double tracked. The line is west of route 34 so no structure will be needed to cross this road. Length of construction is about 2.4 km. See Table 4.6-1 below.
2. This section of the alignment would use a 7.7 km section of the Askelon – Nativot Line. Because this would be a non-electrified line, an overhead centenary system (OCS) for both tracks will be installed. The route traverses relatively level coastal terrain.
3. A turnout connecting to the Ashkelon-Nativot Line with the existing Ashkelon – Kiryat Gat line would have to be built.
4. The route heading in a eastward direction will use the existing single track Ashkelon – Kiryat Gat line. The route traverses relatively flat terrain. The line would have to be upgraded and improve to accommodate the Interim Solution including constructing a single track OCS.
5. At Kiryat Gat, the proposed alignment heads south using the Tel Aviv – Be'er Sheva line for about 5.3 km where it leaves the Israel Railway system. A new line, including double track OCS would have to be installed along this line.
6. A1.6 km connection would link the Tel Aviv – Be'er Sheva line to the bored tunnel section. A portal (entrance) structure would need to be built along this section of line.
7. The tunnelled section would follow the eastern portion of Alignments 7 and 8 through the hilly terrain to the West Bank.

Table 5.2-1 summarizes each section of this alignment.

Table 5.2-1: Description of Alignment 9 Including Type of Intervention Proposed

Section		Length (km)	Description of Alignment 9 from Gaza to West Bank	No. Tracks	Type of Intervention		
Start	End				Track Works	Electri-fication	Other
At Grade Section							
			Construct terminal at Gaza Strip	Multiple	Construct	Yes	Various
9.1	9.2	2.4	Construct connection from Gaza Strip Terminal to IR System	Double	Construct	Construct	Earthworks
9.2	9.3	7.7	Use IR System on Ashkelon - Nativot Section now under construction	Double	IR	Install	IR
9.3	9.4	1.3	Construct turnout connecting Ashkelon-Nativot Section to Ashkelon - Kiryat Gat Line	Single	Construct	Construct	Construct
9.4	9.5	19.1	Upgrade IR System Ashkelon - Kiryat Gat Line Section which is in poor condition	Single	Construct	Construct	Strengthen
9.5	9.6	5.3	Use IR System on Tel Aviv - Be'er Sheva now being upgraded to double track	Double	IR	Install	IR
9.6	9.7	1.6	Construct turnout connecting Tel Aviv - Be'er Sheva Line to bored tunnel section	Double	Construct	Construct	Portal
Subtotal		37.4					
Tunnel Section		15.8	Construct new bored tunnel along same alignment as either Alignment 7 or 8.	Double	Construct	Double	Bored tunnel
At Grade Section			Construct Terminal south of Idna, West Bank	Multiple	Construct	Yes	Various
Total length		53.2					

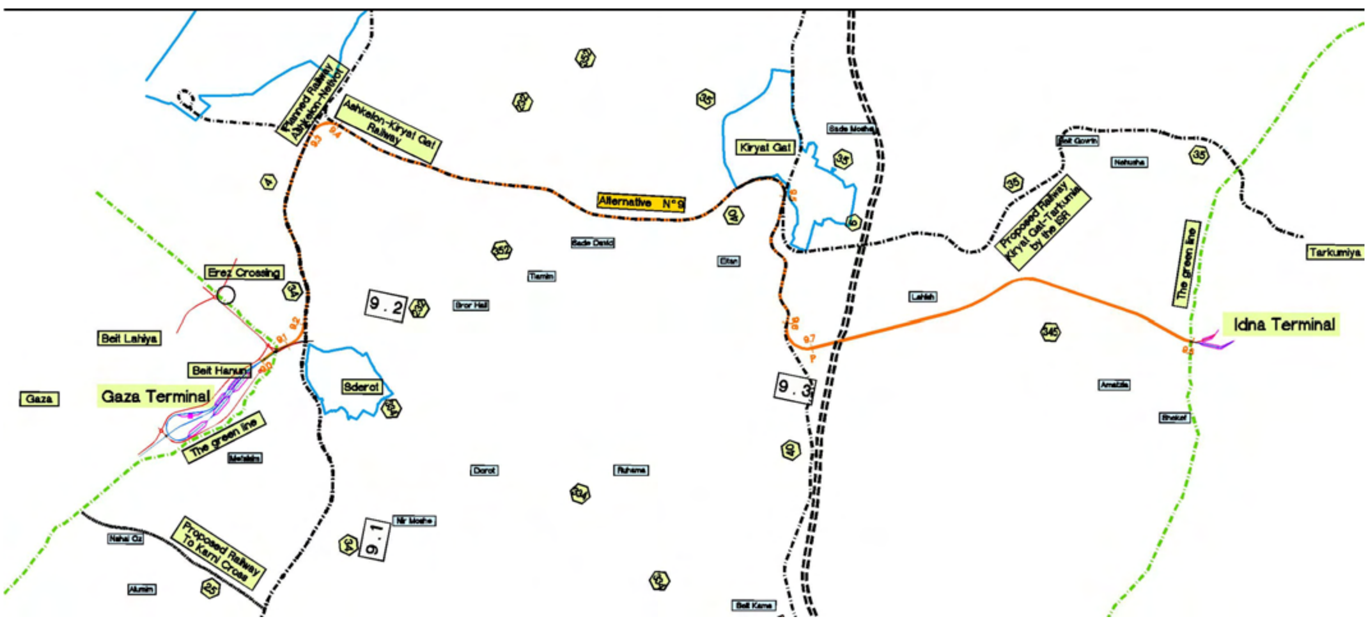
Red = Interventions to be done under this program
IR = Interventions to being done by Israel Railways

Phase II. Long-Term Solution

After Phase I is completed and operational, it is envisioned that a cut-and-cover tunnel (about23 km long) would be constructed following Alignment 7 from Gaza to link up with the operational bored tunnel, just east of the Tel Aviv-Be'er Sheva railway line. Completion of Phase II would, in effect, result in an alignment similar to Alignment 7.

Figure 5-1 is a schematic location map of the proposed alignment. Volume 3 provides more detailed information on this alignment.

Figure 5-1: Alignment 9 Location Map



In the planning and design of the Interim Solution, it would be necessary to decide whether the link across the western plain would be a cut-and-cover tunnel (Alignment 7) or as a deeper bored tunnel (Alignment 8). The decision would influence the design of the interim connection from the IR system to the eventual full tunnel alignment.

5.2.2 Operational Considerations for Alignment 9

No separate operating plan has been developed for this alternative. However, there are a number of issues that would have to be addressed in a more detailed analysis of this alignment.

Israel Railways Operations: The development of an operation plan for the Interim Solution for West Bank – Gaza railway would have to consider Israel Railways operations along the three sections of its network involved. This might require revising the construction timetable described in Chapter 7.

Diesel versus Electrical Operations: For the purposes of this analysis, it has been assumed that the railway would operate throughout with electric locomotives. However this is not the only operational solution. For example, it might be possible to operate a train with a combination of diesel and electric locomotives with the diesel operating over the Israel Railways network (non-electrified tracks) and the electrical locomotive would operate in the tunnel, which would be electrified. This type of operation requires twice the number of many locomotives. This is not recommended since capital costs for locomotives are considerably higher, and they are costly to operate. A thorough analysis of this alternative is desirable.

Single Track Section: Depending on the operating schedule there might be a need for one or more sidings along the 19.1 km section of single track Ashkelon to Kiryat Gat line.

5.2.3 Schedule and Cost of Alignment 9

Schedule: As described in Chapter 4 (See Table 4.6-1) constructing the bored tunnel section would take 5 years using 4 TBMs. The improvements to Israel Railways network and other at grade civil works described above would require a much shorter construction phase. Therefore, in terms of time needed to implement the Interim Solution, its duration would be approximately the same as for Alignment 7. The two phases of the Interim Solution would add another 3 to 4 years time to completing the cut and cover section of about 23 km.

Although Alignment 9 is proposed as an interim solution, the designs and environmental studies would be required for the entire alignment and not just for the initial phase of the project. This would include any additional land that might have to be acquired for the full build-out of the project. Therefore, there would be some minor savings in time for completing some of the preparatory studies.

Cost: The cost of construction for Alignment 9 for Phase I would total $801 million. This total would include construction, land acquisition, cost of railway connections to existing IR lines, upgrading IR lines, bored tunnels under eastern hills, and railway terminals. Implementation of Phase II would add an additional $470 million to construct 23 km of cut-and-cover tunnels across the western plains and for electrification and communications equipment for the new section. The total cost for the two phases would reach $1,271 million. This total does not include equipment costs for rolling stock estimated to be approximately $132 million and security infrastructure[2]. The final project would be similar in scope to that of Alignment 7, which was estimated to cost $1,195 million, or about $76 million less.

5.3 Alignment 10, A Second Interim Solution Using Israel Railways System

This is a variation of Alignment 9. It too represents an interim solution; its main difference is that all new construction east of the existing Israel Railways network would be at grade. The eastern portion of the alignment would follow Alignment 1 to the West Bank rail terminal at Tarkumiya.

5.3.1 Operating Considerations

This alternative has the advantage of not requiring the electrification of a portion of the Israel Railways. Diesel locomotives would be able to operate over the entire connection between Gaza and the West Bank. As with Alternative 9, the operating plan would have to be coordinated with that of Israel Railways to allow the movement of traffic between the West Bank and Gaza on a fixed schedule.

5.3.2 Description of the Alignment

For the Israel Railways portion of this alternative, Alignment 10 is similar to that of Alignment 9. However, the connection south of Kiryat Gat to the turnout to Alignment 1 is shorter. Table 5.3-1 describes the route taken by Alignment 10.

Table 5.3-1: Description of Alignment 10 Including Type of Intervention Proposed

Section		Length (km)	Description of Alignment 10 from Gaza to West Bank	No. Tracks	Type of Intervention	
Start	End				Track Works	Other
At Grade Section - IR						
			Construct terminal at Gaza Strip	Multiple	Construct	Various
10.1	10.2	2.4	Construct connection from Gaza Strip Terminal to IR System	Double	Construct	Earthworks
10.2	10.3	7.7	Use IR System on Ashkelon - Nativot Section now under construction	Double	IR	IR
10.3	10.4	1.3	Construct turnout connecting Ashkelon-Nativot Section to Ashkelon - Kiryat Gat Line	Single	Construct	Earthworks
10.4	10.5	19.1	Upgrade IR System Ashkelon - Kiryat Gat Line Section which is in poor condition	Single	Construct	Strengthen
10.5	10.6	1	Use IR System on Tel Aviv - Be'er Sheva now being upgraded to double track	Double	IR	IR
10.6	10.7	1.3	Construct turnout connecting Tel Aviv - Be'er Sheva Line to bored tunnel section	Double	Construct	Turnout
Subtotal		32.8				
At Grade Section		19.4	Construct at grade section following Alignment 1	Double	Construct	At grade
New Construction			Construct terminal south at Tarkumiya, West Bank	Multiple	Construct	Various
Total length		52.2				

Red = Interventions to be done under this program
IR = Interventions being done by Israel Railways

5.3.3 Schedule and Cost of Alignment 10

Schedule: Because this interim solution requires approximately 24 km of new construction, the construction period would be relatively shorter than required to build the full 44-km of Alignment 1. However, the terminals at both ends would probably require as much if not more time to

[2] The Consultant has not determined the security infrastructure needed nor its cost.

complete than the 24 km of new line construction. Construction would require between 2 and 3 years, about the same as the time required to construct an at-grade railway throughout as proposed for Alignments 1 and 2. Consequently, it appears that no timesavings would be obtained by adopting Alignment 10 as an interim solution.

Cost: The estimated cost of construction with the inclusion of land acquisition is US$ 201 million, about fourth of Alignment 9. Equipment costs for each would be approximately the same.

CHAPTER 6

UTILITY TRANSMISSION REQUIREMENTS

6.1 Introduction

A transportation link connecting the West Bank to Gaza Strip would provide the opportunity to incorporate within its right-of-way the utility transmission lines for water, power (electricity), natural gas and telecommunications. This chapter assesses the economic viability of using the proposed transportation corridor to accommodate these utility lines. The cost estimates provided in this chapter, especially those for water and electricity should be considered preliminary and are subject to change as additional analyses are performed over the next several months of the project

The Consultants findings lead to a recommendation that for the at grade alternatives, the proposed rights of way of the transport link be sized to accommodate the transmission of all four utilities. However, there is no economic basis for initiating construction of any of the transmission lines in the near future. For example, in the absence of a major discovery of natural gas reserves off Gaza, there is no economic rationale for installing a gas transmission line connecting the two areas. Similarly, the large and rapid changes in the telecommunications industry would render a current decision based on present technology for transmission of electronic data in 2015 as highly risky. Similar high levels of risk would also be associated with any decision to build electricity and water transmission lines within the corridor. Uncertainty about the timing of a future desalinization plant, for example, and the potential large changes to demographic patterns once the transportation link is built would greatly influence the economic viability of these projects. Nonetheless, one or more of these transmission lines might become important to the long-term economic development in a future Palestinian State, and therefore it would be myopic to foreclose the opportunity to construct utility transmission lines within the proposed transportation corridor as needed. The following sections describe current supply and demand issues associated with water, electricity, natural gas in the West Bank and Gaza Strip and their ramifications for building utility links between the two regions. The viability of building telecommunications links within the proposed transport corridor is also discussed.

In the case of the tunneled alternative, it is recommended that the proposed transport link not be sized to accommodate the transmission of the utilities. In the case of a cut and covered tunnel, the utilities could be buried as part of the cover above the cut and cover structure. For the bored tunnels, to accommodate the three of the four utilities, the cost of including water and electric power transmission lines other than for operations purposes associated with the tunnel, will be very high since it would increase the area of the tunnel and increasing its costs. In any case, gas transmission within the tunnel should not be considered for safety and security reasons.

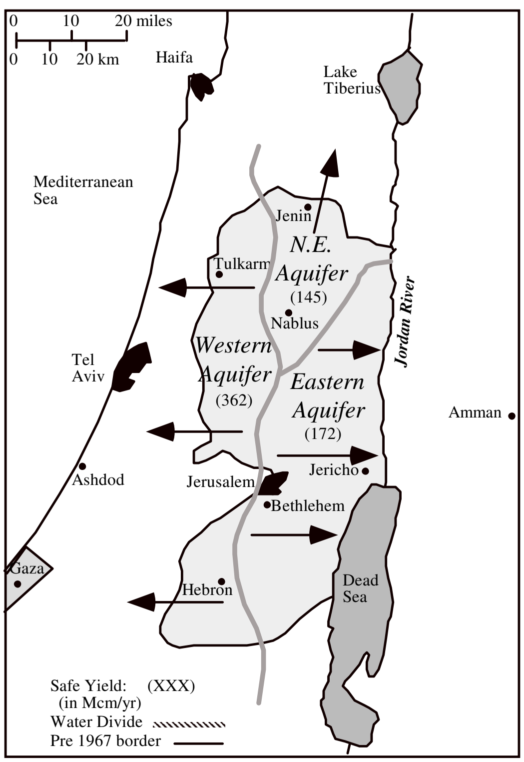
6.2 Water Transmission

6.2.1 Existing Water Resources and Allocation Thereof

6.2.1.1 General

The vast majority of water supply to the Palestinian Territories is derived from natural surface and underground sources. By their nature, these sources are, in the first instance, independent of political boundaries.

Various agreements exist for the allocation of water between Israel and the Palestinian Territories, most notably, the Oslo Agreement[1] and various current agreements between Mekoroth, the Israeli water supply organization, and the Palestinian Water Authority (PWA). The Oslo Agreement provides an interim arrangement for the division of natural water resources between Israel and the Palestinian Territories, but this has not been fully implemented. It can not be automatically assumed that the Oslo Agreement will be fully implemented in the future; neither can it be assumed that it will even be the basis for future allocations. The majority of Palestinian potable water supply, particularly in the West Bank, is derived from sources currently controlled by Mekoroth. But while the magnitude of these supplies is based on various agreements which currently, on a day-to-day basis, are honored, these will not necessarily form the basis of future arrangements.



As a consequence of the aforementioned physical and administrative realities, an assessment of resources must, in the first instance, be broadly based.

The discussion of "allocation" hereunder, relates to the division between Palestinian and Israeli consumers. Further subdivision between potable and agricultural use is discussed later in this study.

6.2.1.2 West Bank

At the present time, groundwater and springs provide essentially all the water available for Palestinian use in the West Bank. The existing water resources are derived from three major groundwater aquifer systems, a series of springs that emanate from these aquifers, and, to a very modest extent, surface runoff. The West Bank is a hilly area, with elevations varying from 400 m below sea level in the Jordan Valley to 1,000 m above sea level in the hills. The West Bank receives rainfall averaging about

[1] Israeli-Palestinian Agreement on the West Bank and the Gaza Strip ("Oslo II"), signed September 28, 1995, Annex III, Article 40

600 mm per year, but this is not evenly distributed. Annual rainfall generally varies from less than 100 mm in the east and south to 700 mm in the north and west[2].

Groundwater Resources

Water is supplied to the West Bank area from a series of groundwater aquifers contained within three groundwater systems, Northeastern, Eastern, and Western Aquifers, typically referred to collectively as the Mountain Aquifer System. The aquifers contain many of the same formations; however, the aquifer boundaries are established as a result of flow patterns. The total renewable groundwater resources in the West Bank were estimated in 1993[3] to be between 590 and 690mcm/year as indicated below.

Table 6.1.1: Estimated Safe Yield of the West Bank Aquifers

Aquifer	Estimates of safe yield (mcm/year)*
Northeastern	140-200
Eastern	100-130
Western	350-360
Total	590-690

* mcm = millions of cubic meters

Most of this potential is exploited either naturally (through natural springs) or artificially (through wells). It is generally accepted that the combined Palestinian and Israeli use of the groundwater resources of the West Bank is approaching the annual renewable recharge or even exceeding it. The PWA suggests that the groundwater table in some wells has dropped by as much as 25 meters in the past 10 years, which, if true, is indicative of serious over-exploitation.

Under the Oslo Agreement, the total recharge was estimated as 679 mcm/year. Allocation of this resource over the interim period pending a permanent political settlement is as indicated below.

Table 6.1.2: Allocation of Water under the Oslo Agreement

Aquifer	Allocation (mcm/year)			
	Palestine	Israel	Unallocated	Total
Northeastern	42	103	0	145
Eastern	54	40	78*	172
Western	22	340	0	362
Total	118	483	78	679

* Of the unallocated 78 mcm/year in the Eastern Aquifer, 50 mcm/year is considered to be brackish and consequently of only limited value without treatment. Implicitly, the remaining 28 mcm/year is considered to be potable without treatment

Surface Water Resources – Wadis

Wadis in the West Bank are divided into two major groups; eastern wadis and western wadis. Eastern wadis flow from the central mountains towards the Jordan Valley, and contribute to the recharge of shallow aquifers and flows in the Jordan River. Western wadis flow from the central

[2] Ministry of Planning and International Cooperation (MOPIC) - 1997
[3] Comprehensive Planning Framework for Palestinian Water Resource Development – Camp Dresser & McKee (CDM) – July 1997

mountains in a westerly direction towards the Mediterranean Sea. Surface water flow in wadis is intermittent, resulting from rainfall events that occur during the wet season. The total runoff in the West Bank is estimated[4] at 64 mcm/year. A study on water and wastewater[5] shows that some 20 mcm/year could realistically be utilized from surface flood water by the construction of storage dams in major wadis.

Wadis are substantially unexploited, partly because the rainfall occurs during the period of the year when it is least needed for irrigation purposes. Use of wadis would require construction of relatively expensive dams, and use of this water for potable purposes would also require provision of treatment facilities.

Surface Water Resources – The Jordan River System

The Jordan River flows from north to south from an elevation of 2,200 m above mean sea level at Mount Hermon to about 395 m below mean sea level at the Dead Sea. The Jordan River passes a straight distance of about 140 km, but with a river length of about 350 km due to its tortuous path. The catchment area of the Jordan River and Dead Sea basin is approximately 40,650 km^2, while the exploitable water quantity from the Jordan River system[6] is estimated at 1,300 mcm/year.

The October 26, 1994 Peace Treaty between Jordan and Israel discusses allocation of Jordan River abstraction rights between the two nations, while the Oslo Agreements between Israel and the Palestinian Territories carry no mention of the Jordan River. The clear implication is that there is no anticipation (on the parts of Israel and Jordan, at least,) of a future Palestinian nation having river abstraction rights.

6.2.1.3 Gaza

Groundwater Resources

Groundwater, which accounts for almost 98 percent of the current supply, is the most significant source of water in Gaza. The remaining supplies are purchased from Mekoroth. Surface water that might otherwise be available from Wadi Gaza is diverted in Israel before it can reach the Gaza Strip, while rainfall either recharges the groundwater or is collected in cisterns and used immediately. Other sources of groundwater replenishment include groundwater flow from the east, return flow from irrigation, infiltration from surface water runoff, pipe leakage, and untreated wastewater. 1997 estimates[7] of the recharge into the Gaza Aquifer from the various sources are summarized below.

[4] Environmental Profile – ARIJ 1997
[5] Ministry of Planning and International Cooperation (MOPIC) - 1997
[6] El-Musa – 1996
[7] Comprehensive Planning Framework for Palestinian Water Resource Development – Camp Dresser & McKee (CDM) – July 1997

Table 6.1.3: Groundwater Replenishment for the Gaza Aquifer System

Sources of return flow	Estimated quantity (mcm/year)	Percentage of total
Rainfall	46	41.2
Groundwater flow from the east	7	6.3
Surface water infiltration	2	1.6
Pipe leakage	13	11.6
Untreated wastewater	14	12.5
Irrigation	30	26.8
Total	112	100

The groundwater replenishment of 112 mcm/year can be subdivided into 55 cum/year of natural recharge plus 57 mcm/year of recharge from human sources.

All groundwater resources in Gaza are allocated for use by the Palestinian Territories.

Piped supply
A piped supply of potable water from Israel with a design capacity of 5 mcm per year is currently being commissioned. This is discussed in the Oslo Agreement as an "interim" arrangement.

6.2.1.4 Assumptions for the Future

The concept of a fixed dedicated transportation link between Gaza and the West Bank, presumes the future existence of two separate political entities (the Palestinian Territories and Israel) and broad (either temporary or permanent) agreement on issues of mutual interest.

As discussed later in this chapter, existing water resources being utilized by the Palestinian Territories are already insufficient to satisfy current requirements, and the situation will deteriorate in the future unless additional resources are identified. Increased efficiency in the use of water by means of reduced leakage could provide at least some short term respite.

Overlapping with the general situation of Palestinian water supply, is the fact that the Mountain Aquifer which supplies water to both the Palestinian Territories and Israel is already being fully exploited, or possibly even over-exploited. "Israel recognizes the Palestinian water rights in the West Bank."[8] However, while this implies that the Palestinian Territories can always be confident of being able to draw water from the Mountain Aquifer, this Israeli recognition in principle, does not imply that figures accepted for the interim arrangement will necessarily be used in a final agreement.

For purposes of this study, the following assumptions with regard to future availability of existing water resources are made:

[8] Oslo Agreement II, Annex III, Article 40, Principle 1

1. The Oslo Agreement allocations which were established as an interim arrangement will be fully implemented as a long term arrangement and the unallocated yield from the Eastern Aquifer will be allocated to the Palestinian Territories. The Territories will therefore receive a gross allocation from the Mountain Aquifer of 146 (118+28) mcm/year of potable water plus 50 mcm/year of brackish water.

2. The Palestinian Territories will be free to construct dams on wadis within the West Bank and utilize collected water.

3. Gaza will continue to have unrestricted use of the Gaza aquifer with a natural recharge of 55 mcm/year plus recharge from human activities. Notwithstanding the fact that groundwater quality in Gaza is extremely poor and deteriorating further, it is assumed that if abstraction is, in the future, limited to the rate of recharge, the water will remain usable.

4. Existing piped supplies from Israel to the West Bank and Gaza will be discontinued.

6.2.2 Current Palestinian Utilization of Water Resources

6.2.2.1 West Bank

Gross potable supply in the year 2002[9] was approximately 62.8 mcm, which equates to a unit consumption rate of about 86 l/c/d, while the net per capita consumption was estimated at only 51 l/c/d. The difference between the gross supply rate and the net consumption rate is attributed to various types of losses, the greatest being leakage. Such a loss rate of around 40% is unacceptably high, but nevertheless, is not unexpected in an environment in which there are logistical and administrative difficulties and inadequate funds for proper maintenance. Detailed figures relating to the year 2002 are presented hereunder.

Table 6.1.4: West Bank Municipal and Industrial Water Consumption in 2002

Area	**Population ('000)***	**Percentage population served**	**Supply (mcm)**		**Per capita** consumption (l/c/d)**	
			Gross	**Net**	**Gross**	**Net**
North	904	69	24.4	14.6	75	33
Central & south	1,104	83	38.4	23.0	97	57
Total	2,008	76	62.8	37.7	86	51

* Population figures used in the above table are those used by PWA and are slightly different to those used for projection purposes elsewhere in this report.
** It should be noted that the per capita figures in the above table relate to the total population. If they are presented in terms of consumption by members of the population actually served, the figures of 86 and 51 l/c/d become 113 and 68 l/c/d respectively.

[9] Various PWA reports, 2000-2003

Annual water usage for agricultural purposes is harder to estimate, as a significant proportion of boreholes are un-metered. Two alternatives are 89.3 mcm (1991)[10] and 85 mcm per year (1998)[11]. Significantly, both of these figures are much higher than the figure for Municipal and Industrial (M&I) water consumption.

6.2.2.2 Gaza

M&I data for Gaza, from the same source as that for West Bank, is presented below.

Table 6.1.5: Gaza Municipal and Industrial Consumption in 2002

Population ('000)*	Percentage population served	Supply (mcm)		Per capita consumption (l/c/d)	
		Gross	Net	Gross	Net
1,250	98	62.7	40.1	138	88

* Observations on the West Bank data apply equally to Gaza data

Gaza agricultural usage is estimated at 83 mcm (1991)[12] which, as in the West Bank, is much greater than M&I consumption.

6.2.3 Population Projections

Various scenarios for future population have been studied and are discussed elsewhere in this report.

For purposes of assessing water supply needs, the figures presented in Table 2.2 entitled "Projected Populations for the West Bank and Gaza Strip 2005 to 2030 Accounting for Natural Growth and Net Migration" are used herein without further comment.

6.2.4 Water Demand Projections

6.2.4.1 Municipal and Industrial (M&I)

Domestic

In 1997, Consultants to PWA[13] recommended the adoption of World Health Organization standards[14] for domestic water supply. These standards recommend targets for minimum and average rates of supply to domestic consumers in small communities of 100 l/c/d and 150 l/c/d respectively. At that time, the PWA Consultants recommended a 10 year horizon to achieve the lower supply rate and a 20 year horizon to achieve the higher.

[10] The Department of Agriculture in the West Bank (data published by the Rural Research Center, An-Najah National University)
[11] MOPIC Regional Plan – December 1998
[12] The Department of Agriculture in the West Bank (data published by the Rural Research Center, An-Najah National University)
[13] Comprehensive Planning Framework for Palestinian Water Resource Development – Camp Dresser & McKee (CDM) – July 1997
[14] WHO Guidelines on Technologies for Water Supply Systems in Small Communities – 1993

These targets remain realistic today, except that events over recent years have been such that little effective progress has been made to date in achieving them. Consequently, for purposes of this study, 2005 is taken as the base year from which improvements will be implemented.

Miscellaneous (public, livestock, commercial and industrial)
Separate data on existing public, livestock, commercial and industrial water consumption does not appear to be available. The 1997 Consultants made projections for these various demands starting at a total of 30 l/c/d when the target domestic supply of 100 l/c/d is achieved, rising to 39 l/c/d when the target of 150 l/c/d is achieved. These figures are reasonable and will be adopted for purposes of this study.

System Losses
As indicated in earlier sections of this study, system losses are currently of the order of 40% in the West Bank and 36% in Gaza. These figures are unacceptably high, and their reduction must be a fundamental component of the overall program to improve water supply. Projections of supply requirements should therefore assume a phased reduction in losses from current levels to something more realistic. For purposes of this study, it is assumed that losses will be reduced at a steady pace to 20% of gross supply within twenty years.

On the basis of the foregoing, projected per capita potable water demand will be as indicated below.

Table 6.1.6: Projected per Capita M&I Water Demand

Year	Net Demand (l/c/d)			Losses		Gross demand (l/c/d)
	Domestic	Misc.	Total	% of supply	l/c/d	
2005*	68		68	40	45	113
2010	68	26	94	35	51	145
2015	100	30	130	30	56	186
2020	123	34	157	25	52	209
2025	150	39	189	20	47	236
2030	150	39	189	20	47	236

* figures for the year 2005 are assumed to be identical to those recorded for 2002

Applying these demand rates to the population projections discussed earlier in this report, provides the gross potable water supply requirements over the next twenty five years as summarized below.

Table 6.1.7: Projected Gross M&I Water Demand

Year	Gross supply (l/c/d)	Gross supply (mcm/year)								
		High Growth Scenario			Medium Growth Scenario			Low Growth Scenrario		
		W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	113	93.4	55.7	149.1	91.9	54.9	146.8	90.5	54.2	144.6
2010	145	137.2	84.2	221.3	132.6	81.3	213.9	128.2	78.5	206.7
2015	186	198.7	124.8	323.6	188.6	117.6	306.2	178.5	110.7	289.2
2020	209	251.7	162.2	413.8	233.9	148.9	382.8	217.5	136.8	354.3
2025	236	320.1	211.5	531.6	291.7	189.5	481.2	266.1	169.7	435.8
2030	236	360.1	244.1	604.2	321.8	213.3	535.1	285.2	185.4	470.6

6.2.4.2 Agricultural

As discussed above, the current usage of potable water for agricultural purposes is far in excess of that for M&I purposes, and this; in an environment of acute water scarcity. The significance of agriculture and its place in the future economy of the Palestinian Territories was acknowledged in 1997 in the rationale for development of water resources as follows[15]:

> *It is unlikely that future development in the agricultural sector will be able to provide sufficient employment and economic opportunity to support the growing Palestinian population at an economic level which matches the aspirations and capabilities of the Palestinian people. It is assumed therefore, that the economic future of the West Bank and Gaza will be largely based upon the development of light industry and regional commerce, and that the assumed future demand for, and value of, water will reflect these characteristics of the Palestinian economy.*

Based on this broad philosophy, the 1997 study went on to establish key principles for the assessment of how future agricultural demands should be satisfied. These included:

- the employment of lower-quality water (such as treated wastewater, flood water, wadi runoff or brackish water) for irrigation wherever realistic;
- no increase of fresh water supply to the agricultural sector beyond current levels;
- a minimum supply of fresh water should be maintained to cater for select high-value sensitive crops, for blending and for periodic soil flushing;
- use of flood water and wadi run-off will lead to a corresponding reduction in use of fresh water; and
- the rate of increase in the area of irrigated land will be limited to what can be sustained by the above principles.

These broad principles are as appropriate today as they were in 1997.

The 1997 study concluded that use of potable water for irrigation would gradually be replaced by use of brackish water; surface water collected in wadis and treated sewage effluent. As a result of these changes, use of potable water for irrigation purposes would remain at the same level until 2000 and decline thereafter. For the West Bank, the study anticipated consumption of potable water for irrigation purposes declining at a rate of approximately 0.5 mcm per year until 2020 and at an accelerated rate of about 1.0 mcm per year thereafter. For Gaza, it anticipated a more rapidly declining rate of about 2.5 mcm per year.

The scenario of "freezing" the rate of usage of potable water for irrigation at current rates and assuming a reduction in the future remains appropriate today.

[15] Comprehensive Planning Framework for Palestinian Water Resource Development – Camp Dresser & McKee (CDM)– July 1997

Estimated use of water for irrigation purposes in 1991[16] was 89.3 mcm in the West Bank and 83 mcm in Gaza, while corresponding with 1997 figures, according to the CDM 1997 study were 80.6 mcm and 88.7mcm respectively. There do not appear to be more recent statistics, so the 1997 figures, applied to the year 2000 will be adopted, as recommended by CDM.

Events over recent years have been such that much of the economic development of the Palestinian Territories has been stalled and anticipated reductions in usage of potable water for irrigation purposes have not been achieved. However, there is a very high level of enthusiasm on the part of the international donor community for investment in infrastructure and it can be assumed that when the most pressing political issues have been resolved, improvements in infrastructure will be rapid in the short term. Consequently, while the short term improvements anticipated by CDM in 1997 are not materializing, the medium and longer term expectations remain valid. Thus for purposes of this study, the CDM projections will be adopted.

Projected bulk potable water requirements for irrigation are summarized in hereunder.

Table 6.1.8: Potable Water Demand for Irrigation (mcm per year)

Year	West Bank	Gaza	Total
2000	80.6	88.7	169.3
2005	78.1	76.2	154.3
2010	75.6	63.7	139.3
2015	73.1	51.2	124.3
2020	70.6	38.7	109.3
2025	65.6	26.2	91.8
2030	60.6	13.7	74.3

5.1.4.3 Total PotableWater Demand

Combining domestic and agricultural demand projections, results in composite figures as summarized hereunder.

Table 6.1.9: Total Potable Water Demand

Table 6.1.9.1 – High Growth Scenario

Year	M&I requirement (mcm/year)			Irrigation requirement (mcm/year)			Total requirement (mcm/year)		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	93.4	55.7	149.1	78.1	76.2	154.3	171.5	131.9	303.4
2010	137.2	84.2	221.3	75.6	63.7	139.3	212.8	147.9	360.6
2015	198.7	124.8	323.6	73.1	51.2	124.3	271.8	176.0	447.9
2020	251.7	162.2	413.8	70.6	38.7	109.3	322.3	200.9	523.1
2025	320.1	211.5	531.6	65.6	26.2	91.8	385.7	237.7	623.4
2030	360.1	244.1	604.2	60.6	13.7	74.3	420.7	257.8	678.5

[16] Land survey conducted by the Department of Agriculture in the West Bank and published by the Rural Research Center, An-Najah National University.

Table 6.1.9.2 – Medium Growth Scenario

Year	M&I requirement (mcm/year)			Irrigation requirement (mcm/year)			Total requirement (mcm/year)		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	91.9	54.9	146.8	78.1	76.2	154.3	170.0	131.1	301.1
2010	132.6	81.3	213.9	75.6	63.7	139.3	208.2	145.0	353.2
2015	188.6	117.6	306.2	73.1	51.2	124.3	261.7	168.8	430.5
2020	233.9	148.9	382.8	70.6	38.7	109.3	304.5	187.6	492.1
2025	291.7	189.5	481.2	65.6	26.2	91.8	357.3	215.7	573.0
2030	321.8	213.3	535.1	60.6	13.7	74.3	382.4	227.0	609.4

Table 6.1.9.3 – Low Growth Scenario

Year	M&I requirement (mcm/year)			Irrigation requirement (mcm/year)			Total requirement (mcm/year)		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	90.5	54.2	144.6	78.1	76.2	154.3	168.6	130.4	298.9
2010	128.2	78.5	206.7	75.6	63.7	139.3	203.8	142.2	346.0
2015	178.5	110.7	289.2	73.1	51.2	124.3	251.6	161.9	413.5
2020	217.5	136.8	354.3	70.6	38.7	109.3	288.1	175.5	463.6
2025	266.1	169.7	435.8	65.6	26.2	91.8	331.7	195.9	527.6
2030	285.2	185.4	470.6	60.6	13.7	74.3	345.8	199.1	544.9

6.2.5 Requirements for Augmented Water Supply

Having established the gross water supply demand for the West Bank and Gaza under various population development scenarios, the requirements for additional potable water supply can be determined. These are summarized hereunder.

Table 6.1.10: Additional Potable Water Requirements

Table 6.1.10.1 – High Growth Scenario

Year	Total requirement (mcm/year)			Available supply (mcm/year)			Shortfall in supply (mcm/year)		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	171.5	131.9	303.4	146.0	112.0	258.0	25.5	19.9	45.4
2010	212.8	147.9	360.6	146.0	112.0	258.0	66.8	35.9	102.6
2015	271.8	176.0	447.9	146.0	112.0	258.0	125.8	64.0	189.9
2020	322.3	200.9	523.1	146.0	112.0	258.0	176.3	88.9	265.1
2025	385.7	237.7	623.4	146.0	112.0	258.0	239.7	125.7	365.4
2030	420.7	257.8	678.5	146.0	112.0	258.0	274.7	145.8	420.5

Table 6.1.10.2 – Medium Growth Scenario

Year	Total requirement (mcm/year)			Available supply (mcm/year)			Shortfall in supply (mcm/year)		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	170.0	131.1	301.1	146.0	112.0	258.0	24.0	19.1	43.1
2010	208.2	145.0	353.2	146.0	112.0	258.0	62.2	33.0	95.2
2015	261.7	168.8	430.5	146.0	112.0	258.0	115.7	56.8	172.5
2020	304.5	187.6	492.1	146.0	112.0	258.0	158.5	75.6	234.1
2025	357.3	215.7	573.0	146.0	112.0	258.0	211.3	103.7	315.0
2030	382.4	227.0	609.4	146.0	112.0	258.0	236.4	115.0	351.4

Table 6.1.10.3 – Low Growth Scenario

Year	Total requirement (mcm/year)			Available supply (mcm/year)			Shortfall in supply (mcm/year)		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	168.6	130.4	298.9	146.0	112.0	258.0	22.6	18.4	40.9
2010	203.8	142.2	346.0	146.0	112.0	258.0	57.8	30.2	88.0
2015	251.6	161.9	413.5	146.0	112.0	258.0	105.6	49.9	155.5
2020	288.1	175.5	463.6	146.0	112.0	258.0	142.1	63.5	205.6
2025	331.7	195.9	527.6	146.0	112.0	258.0	185.7	83.9	269.6
2030	345.8	199.1	544.9	146.0	112.0	258.0	199.8	87.1	286.9

The above tables indicate that under all three growth scenarios, there is already a shortfall in supply in both the West Bank and Gaza in 2005, and the situation will continue to deteriorate unless alternative supply options are developed. The different supply shortfall scenarios can be summarized in a single table as indicated below.

Table 6.1.11 – Water Supply Shortfall Scenarios

Year	Potable water supply shortfall (mcm/year)								
	High growth scenario			Medium growth scenario			Low growth scenario		
	W. Bank	Gaza	Total	W. Bank	Gaza	Total	W. Bank	Gaza	Total
2005	25.5	19.9	45.4	24.0	19.1	43.1	22.6	18.4	40.9
2010	66.8	35.9	102.6	62.2	33.0	95.2	57.8	30.2	88.0
2015	125.8	64.0	189.9	115.7	56.8	172.5	105.6	49.9	155.5
2020	176.3	88.9	265.1	158.5	75.6	234.1	142.1	63.5	205.6
2025	239.7	125.7	365.4	211.3	103.7	315.0	185.7	83.9	269.6
2030	274.7	145.8	420.5	236.4	115.0	351.4	199.8	87.1	286.9

6.2.6 Conceptual Options for Augmented Water Supply

6.2.6.1 Groundwater

It has already been assumed for purposes of this study that the interim allocation of groundwater between the Palestinian Territories and Israel, agreed under the Oslo Agreement will translate into a permanent arrangement using the same proportional distribution. If this assumption is accepted, then there is no potential to increase the availability of potable groundwater to the Palestinian Territories beyond the levels already assumed. If, on the other hand, the Palestinian Territories receive a greater allocation in the future, this will lead to a corresponding reduction in the quantities of water required from other sources. The decision on final sizing of any pipeline between Gaza and the West Bank should be preceded by a more rigorous study of the anticipated long term division of Mountain Aquifer water between the Palestinian Territories and Israel.

As discussed earlier, there is 50 mcm/year of brackish water available from the Mountain Aquifer, which has not been allocated under the Oslo Agreement. Conceivably this could be desalinated and made available for M&I uses. However, the 1997 calculations on future reduction in use of potable water for irrigation, presupposed increased use of other sources, including brackish groundwater, for irrigation purposes. Thus treatment of brackish water for M&I use would not lead to a net reduction in the need for the importation of potable water to the West Bank.

6.2.6.2 Surface Water and Treated Sewage Effluent

The situation with regard to surface water and treated sewage effluent is identical to that for brackish groundwater. Any allocation for M&I use would not lead to a net reduction in the need for the importation of potable water.

6.2.6.3 Desalination

The need for desalination of seawater to satisfy the future potable water needs of the region has already been recognized. Israel has constructed a plant at Zikkim (Ashqelon), close to the northern border of Gaza and at least three additional plants are envisaged in the future. USAID are considering funding the construction of a plant in Gaza.

In practical terms, there is effectively no limit to how much raw water can be desalinated in Gaza to satisfy the needs of the Palestinian people, both in Gaza and in the West Bank. It must however be acknowledged that costs will be much higher than the costs associated with use of natural groundwater.

6.2.6.4 Bulk Importation

Over recent years, there has been much discussion on the possibility of importing water to help satisfy the future needs of Israel. The most common arrangements being considered; have been either a piped supply or tanker supply from Turkey. While no firm arrangements have been made, the potential for importing water remains.

The concept of importing water into Gaza for local use or for onward transmission to the West Bank is as feasible as for importation to Israel.

6.2.7 Scenarios for Water Transfer between Gaza and the West Bank

As already noted, there is a shortage of potable water in both the West Bank and Gaza. This shortage is currently more acute in Gaza than the West Bank, but even if a connecting pipeline were to exist today, it would be unrealistic to consider transfer from the West Bank to Gaza of anything more than a very modest flow, and that only on a short term basis. In the longer term, in the absence of any potential to increase the availability of potable water from within the West Bank, there is no realistic likelihood of transferring large quantities of water to Gaza from the West Bank on a regular basis.

Thus, any pipeline to be constructed between Gaza and the West Bank should be sized and designed to cater primarily for the needs of the West Bank rather than the needs of Gaza. Control arrangements could of course be designed to allow for the possibility of transfer of limited quantities of water in the opposite direction in case of an emergency such as a major failure of desalination facilities.

Assuming that all additional water supply for the West Bank is to be derived from either desalination or bulk importation and delivered from Gaza, it will be necessary to construct major transfer pipelines, either in the proposed transportation corridor or by alternative routes. There are practical limitations to the maximum size of any pipeline, and for purposes of this study, a nominal diameter of 1219mm (48") is assumed. Similarly there are cost/benefit limitations on the flow velocities in pumping systems and a figure of 1.2 meters per second is assumed for present purposes. On the basis of these parameters and the water supply shortfall scenarios already discussed, the program for development of the transfer pipelines would be as indicated hereunder.

Table 6.1.12: Program for Completion of Gaza-West Bank Pipelines

1.2m dia. (48") pipelines	Population growth scenario		
	High growth	Medium growth	Low growth
First pipeline	Immediate	Immediate	Immediate
Second pipeline	2008	2008	2008
Third pipeline	2013	2013	2013
Fourth pipeline	2016	2017	2018
Fifth pipeline	2020	2022	2024
Sixth pipeline	2024	2027	2030

This program is of course only realistic if it is assumed that there will be adequate water available in Gaza to justify the transfer pipelines and there will be appropriate infrastructure in the West Bank to receive and distribute the supply. In the short term at least, these are clearly unrealistic assumptions.

In 2003, USAID issued a Request for Proposals for the construction of a desalination plant in Gaza with a fixed maximum output of 18.25 mcm/year. The RfP also allowed for an optional capacity of 21.90 mcm/year with provision for long term expansion to 54.75 mcm/year. Although not explicitly stated in the RfP, it is understood that the plant is intended to supply Gaza only. This project is currently on hold, but these figures are indicative of current expectations for short and medium term expansion of water supply in Gaza.

Reference to Table 6.1.12 above shows a year 2010 shortfall in supply in Gaza of 30 to 36 mcm/year depending on growth scenario. These figures rise to 50 to 64 mcm/year in 2015. Thus the proposed plant will cater only for short term local requirements and even the ultimate capacity of the larger option will only cater for the year 2015 on a medium population growth scenario. Therefore, even assuming the immediate construction of a desalination plant in Gaza, there is little short term prospect of making water available for West Bank consumption, unless:

a) it is at the expense of local Gaza consumption;
b) an additional or much larger desalination plant than is currently envisaged is constructed; or
c) bulk water is imported from overseas.

These options each have their limitations, but all are possible. It is consequently appropriate to consider short term pipeline alternatives, based on realistic supply options rather than the theoretical demand options from which Table 6.1.11 is derived. The following table provides order-of-magnitude capacities and costs for various pipeline sizes, each of which could be incorporated in the transportation corridor.

Table 6.1.13: Estimated Cost of a Pipeline from Gaza (desalination plant) to the West Bank (Tarkumiya)

Pipe diameter	Capacity mcm/year	Capital cost $	Recovery $/cum	Operating cost $/cum			Total cost $/cum
				Power	O&M	Total	
20”	7.67	16,040,000	0.31	0.30	0.06	0.36	0.67
24”	11.05	20,200,000	0.27	0.28	0.05	0.33	0.60
30”	17.26	28,420,000	0.25	0.25	0.04	0.30	0.54
36”	24.85	36,890,000	0.22	0.24	0.04	0.28	0.50
42”	33.83	51,600,000	0.23	0.23	0.04	0.27	0.49
48”	44.19	69,390,000	0.24	0.22	0.04	0.26	0.49

Notes - Capacity is based on a velocity of 1.2 m/s, 2 stage pumping and pumpset efficiency of 60%
- Capital cost includes pumping stations and six hours of storage in Tarkumiya
- Recovery cost is based on an interest rate of 15% per annum
- O&M cost includes maintenance at 5% p.a. for mechanical equipment and 2% p.a. for other

In the above table, the upper terminal of any pipeline is assumed to be Tarkumiya, from where water would still have to be pumped in a south easterly direction to Hebron or north easterly towards other major urban centers. To establish the true cost of water at Tarkumiya, one must add the cost of desalination. The most appropriate estimate for this is $0.58 per cubic meter, being the rate set on the recent build-operate-transfer (BOT) contract for the Israeli Zikkim desalination plant, just north of the Gaza border. By design or coincidence, this is also the rate currently being charged by Mekoroth for sale of groundwater to the West Bank Water Authority.

The pipeline sizes discussed above cater for a range of capacities from 42% of the output of the smaller option being considered for a Gaza desalination plant, up to 81% of the long term maximum output being considered. Unless there are immediate plans to construct an even larger desalination plant in Gaza than the one currently being considered by USAID, anything more than a single 48” diameter pipeline to the West Bank, would be of no short term value.

6.2.8 The Relevance of the Transportation Corridor to Pipeline Routing

Before making a commitment to the inclusion of pipelines in the proposed transportation corridor, it is important to assess the relevance, advantages and disadvantages of using the corridor rather than independent routes.

Table 6.1.14: Reasons to Include Water Pipelines in the Transportation Corridor

	Applicability to		
	Surface route	**Cut/cover tunnel**	**Conventional tunnel**
Lower linear meter cost of construction (first phase): By combining the construction of a pipeline with the construction of the transportation corridor, the marginal costs of land acquisition, site access and general overheads would be much lower than the costs associated with an independent pipeline	Applicable	Applicable	Not applicable
Palestinian sense of ownership: Pipelines constructed in the transportation corridor would, psychologically, appear to be more "Palestinian" than pipelines traversing open Israeli territory.	Applicable	Applicable only if land permanently acquired	Not applicable
Ease of maintenance access: Construction of pipelines within a surface transportation corridor would ensure easy high quality access to pipelines for maintenance purposes.	Applicable	Applicable only if land permanently acquired	Not applicable
Availability of water for tunnel firefighting purposes: Subject to appropriate hydraulic control arrangements, a pipeline constructed in a transportation corridor could provide a fire-fighting water supply, obviating the need for a dedicated fire-fighting line.	Not applicable	Applicable	Not applicable

Table 6.1.15: Reasons to Exclude Water Pipelines from the Transportation Corridor

	Applicable to		
	Surface route	**Cut/cover tunnel**	**Conventional tunnel**
Potentially inappropriate routing: Assuming that the only future source of water for the West Bank would be Gaza, then the transportation corridor would represent an economically realistic route for transfer. However, if other coastal water sources were considered, the corridor route becomes very uneconomic. This is discussed further in the general text below.	Applicable	Applicable	Not applicable
Additional width of corridor: As indicated in Table 6.1.12 there is a potential need for up to six, 1.2 meter diameter pipelines to satisfy year 2030 West Bank water supply requirements. If provision is made for these to be included in the transportation corridor, this would require an additional corridor width of up to 20 meters. In agricultural areas this greater width would increase Right of Way problems while in mountainous areas; the greater width would significantly increase earthworks volumes. Routing water pipelines separately would allow greater flexibility and reduced costs.	Applicable	Applicable only if land permanently acquired	Not applicable
Potentially inappropriate width of corridor: Considerable uncertainty exists with regard to long term West Bank water requirements but if a commitment were to be made to route all future pipelines in the corridor, it would be necessary to make a potentially over-generous space allocation now. If pipelines were to follow independent routes, these could be defined later on an as-required basis.	Applicable	Applicable only if land permanently acquired	Not applicable
Risks associated with major pipeline bursts: Any major structural damage to high pressure high capacity pipelines adjacent to road or rail routes could cause serious damage to pavements, foundations, etc.	Applicable	Applicable	Not applicable

Potentially inappropriate routing: The foregoing discussion is based on the general assumption that the long term supply of additional water for the West Bank will be from or via Gaza. However, there are major capital and operational cost benefits in designing on the basis of supply being from existing or proposed Israeli desalination plants, simply by virtue of the shorter distances. Supply routes from Gaza desalination plant and from existing or proposed Israeli desalination plants to various West Bank urban areas can be compared as follows:

Supply to Hebron:	from Gaza:	85 km
	from Zikkim:	72 km
Supply to Ramallah:	from Gaza:	120 km
	from Dan Region:	55 km
Supply to Nablus:	from Gaza:	160 km
	from Hadera:	55 km
Supply to Jenin:	from Gaza:	190 km
	from Hadera:	50 km

Thus, even for supply to Hebron, direct supply from Zikkim would be 15% shorter than from Gaza. At the other extreme of Jenin, direct supply from Hadera would be 74% shorter than from Gaza.

In this comparison, it is also worth noting that following recent completion of various USAID funded wells in the Hebron area, supply of potable water to the southern West Bank is currently adequate and consequently there is little justification in immediate improvement in supply to this area. Therefore any pipeline constructed from Gaza in the near future would have to extend to at least Bethlehem or Ramallah to be of practical benefit. Such a pipeline would follow a route double the length of a direct connection from Dan Region where the Israeli authorities are considering construction of a new plant.

6.2.9 The Relationship between Palestinian and Israeli Supply Authorities

Supply of water in Gaza is substantially under the control of the Palestinian Water Authority. The Authority receives a piped supply from the Israeli water company Mekoroth of 5 mcm per year, equivalent to about 3% of gross consumption, while the balance of supply is from locally controlled wells.

The situation in the West Bank is more complex. Virtually all water consumed is groundwater and while the Palestinian Water Authority and the West Bank Water Department have day-to-day control over many of the wells supplying Palestinian areas, rates of abstraction are dictated by Mekoroth. A high proportion of wells are operated by Mekoroth and they sell water to the Palestinian operators at acceptable commercial rates. It is understandably difficult to obtain truly objective views on the effectiveness of the relationship between Palestinian and Israeli authorities. However discussions with both the Palestinian Water Authority and the West Bank Water Department suggest that while Palestinian parties would like to receive a higher proportion of the water available from the Mountain Aquifer System, whenever agreements are signed for the supply of water, these agreements are generally honoured and there is little evidence of Israeli authorities using their control over water supply as a short-term political tool in specific geographical areas.

6.2.10 Summary

Water resources in both Gaza and the West Bank are restricted primarily to groundwater. In Gaza there is a serious shortage of potable water and this can only be relieved by desalination or by importation either from Israel or from a foreign source. In the West Bank, assuming that Palestinian consumers will not receive an allocation of potable water greater than was envisaged under the Oslo Agreement, the situation is the same, except that any desalinated supply will either have to come from an Israeli plant or across Israeli territory from Gaza.

Pipelines could be constructed in the Gaza/West Bank transportation corridor, but this would only be of value in association with either bulk importation of water or desalination. The currently envisaged Gaza desalination plant is intended to cater for Gaza only, and consequently either a significant proportion of the water envisaged to cater for Gaza's short and medium term needs would have to be diverted to the West Bank, or the overall scale of the plant would require reconsideration. Depending on its size, a single pipe could carry up to 80% of the anticipated ultimate capacity of the currently envisaged Gaza plant. At it's realistic maximum size of 1.2m diameter, this pipe could carry a flow adequate to satisfy reasonable West Bank needs up to 2008, but of course this would have to be supported by major improvements in trunk distribution and storage within the West Bank.

To cater for a twenty year horizon and realistic per capita water demands, there will be a need to construct, in a phased manner, six 1.2m diameter pipes from coastal water sources to the West Bank. To supply all West Bank water needs from Gaza would be very inefficient in terms of pipeline lengths and operating costs, particularly for the more northerly urban settlements. For the more southerly areas such as Hebron, the inefficiency would not be so great, but as a consequence of recent well construction, there is not such an urgent need to supplement water supply in this area.

The relationship between Palestinian and Israeli water supply authorities appears to be adequate. Israeli long term planning envisages the possibility of including provision for supply to the West Bank in the design of new desalination plants. In purely technical and economic terms, such arrangements would be preferable to supplying the West Bank from Gaza.

6.3 Energy Transmission

The aim of this study is to analyze the feasibility of a transport link between Gaza and the West Bank to facilitate the movement of people and cargo between the two regions, without dependence on the existing Israeli infrastructure. The availability of reliable and continuous sources of energy and electric power is essential to maintain and expand the economy of the Palestinian region. A dedicated Gaza to West Bank link could potentially provide a corridor for the transmission of electric power and natural gas between the two regions. This section of the analysis is designed to explore the current and perspective energy and electric power resources available in this region, expected supply and demand requirements and options for utilizing this corridor for expanding energy resource transfer between West Bank and Gaza consumers. Figure 4-1 gives an overview of the present situation described below.

6.3.1 Current Situation – Electric Power Generation

Israel: The electric power supplied to the West Bank and Gaza is almost entirely produced by IEC (Israel Electric Company) generation facilities and is transmitted over its lines to the four regional companies for distribution to the consumers. The IEC, the national electric utility monopoly for Israel, has 10,190 MW [2004] of installed generation capacity from a number of generating facilities located throughout Israel with the larger facilities located along the Mediterranean coast.

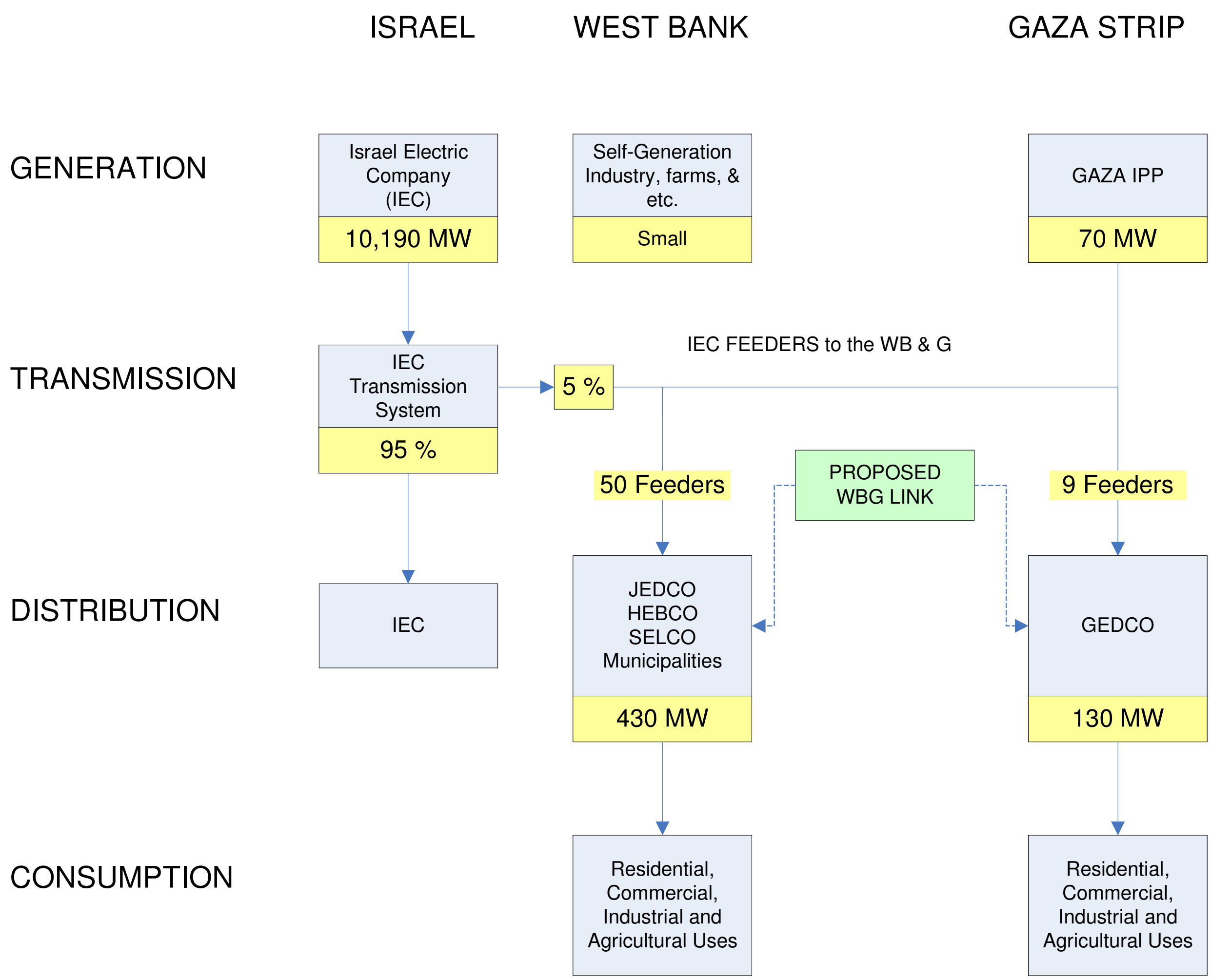
Table 6.3-1: Electric Generation Capacity of IEC by Facility as of January 2005

Type of Unit	Site	Capacity in MW
Coal/Fuel oil	Haifa	426
	Riding	428
	Eshkol	912
	Oret Rabin	2,590
	Eshkol 2	150
	Ratenberg	2,250
	Eshkogen 2	26
	Sub-Total	**6,782**
Gas Turbines	Kinoret	80
	Haifa	80
	Kesaria	130
	Raanana	22
	Hartov	40
	Eitan	40
	MD	15
	Rutenberg	40
	Eshkol	10
	Eilat	65
	Sub-Total	**522**
Industrial Gas Turbines	Ramat Hovov	200
	Tzafit	220
	Alon Tavor	220
	Eilat	34
	Atarot	68
	Gezer	592
	Sub-Total	**1,334**
Combined Cycle	Ramat Hovav	335
	Hagit	660
	Alon Tavor	240
	Eshkol	236
	Sub-Total	**1,471**
	Total	**10,109**

Source: IEC, Jan 2005

In 2003, the fuel used by IEC was predominantly coal [79%] and fuel oil [17%].

Fig.4-1: Electricity Flows in the West Bank and Gaza Strip - 2005



Palestine: A Gaza IPP was established in 1999 to meet the local electricity demand and has the capacity to produce about 140 MW from diesel fuel. There are plans to expand this facility to 490 MW; however it is currently operating at 50% capacity due to the high cost of fuel and operating constraints. Some of the municipalities in the northern West Bank have small diesel power plants, which are inoperative due to noncompetitive fuel costs and technical problems. These small facilities are utilized on an emergency basis for water pumping stations, hospitals and other sensitive loads when alternative power is curtailed. The capacity of the reserve generators is small, each normally below 1 MW.

Comparison: Compared to the diesel powered West Bank plants, the IEC power is primarily generated from low cost coal and is moving to lower cost natural gas for new facilities. The IEC bulk selling price to the distribution companies in WBG is $0.06 per kWh, compared to the recent range of $0.12 to $0.18 for the cost of the small self generated local West Bank plants. The aim of increased energy independence would require the construction of new plants similar to the Gaza model at a cost of a least US$ 250 million each. However, due to the uncertain economic conditions this is considered a high risk investment for independent investors and donor organizations do not see this as a high priority requirement.

Potential for Renewable Energy Technologies: The entire region has the potential of utilizing a range of renewable technologies for electric power generation. Strong wind levels can be captured for wind turbines along the Gaza coast, at the Jordan-Israeli corridor near the Aqaba-Elait valley, and the GEF has plans for a joint wind generation plant. Israel is a world leader in advanced solar technologies, but passive solar hot water systems are ubiquitous. Solar technology in Israel is essential to supplement the residential electricity demand. Each new home in Israel is required by law to include a solar water heater, and 84% of homes have solar supplemental energy which reduced the demand load in this solar positive environment. A similar approach has been applied in WBG, and about 74% of new homes have solar power systems, which will reduce the requirement for hot water heating in residences and small commercial buildings. An advanced solar power facility is scheduled for the Negev.

6.3.2 Transmission – Electric Power

The transmission system operated by IEC is a 1000 km closed loop system connecting the electric generating stations to the load centers throughout Israel, the West Bank and Gaza. The current system includes EHV-400 kV transmission and 161 kV sub-station grids to distribute the power to the consumers. The Northern West Bank substations are supplied by 27 feeders of 36 kV and 3 feeders of 24 kV. The power demand is 170 MW. Due to the problems of heavy loading of the long feeders, a new substation will be operational in the Northern West Bank during 2006. The Southern part of the West Bank, (SELCO) primarily Hebron, has 10 feeders of 36 kV for a power demand of 100 MW. A new 45 MVA power transformer will be in operation at the Hebron station in 2006. The East Jerusalem distributing company (JEDCO) is fed by 10 feeders of 36 kV for a power demand of 160 MW. The Gaza district substation (GEDCO), is supplied by 9 feeders of 24 kV, with a power demand of 130 MW. A new 161 kV line is being installed to connect the Netivot substation with the Gaza North substation. At the first stage 70 MW will be supplied by this line, although an increase to 150 MW will be available to match the load demand growth.

The total peak demand of electric power supplied to WBG by IEC and transmitted to the local distribution companies is indicated in Table 6.3-2.

Table 6.3-2: WBG Peak Electric Demand (2004)

Region	***MW***
N West Bank	170
C West Bank	160
S West Bank	100
Gaza	130
Total	**560**

Bulk power is transmitted by IEC to the regional distribution companies located in the West Bank and Gaza. The system development is externally financed, and there has been inadequate investment in the supply chain, from the bulk supply points where IEC transfers power to the sub-stations, to the distribution lines supplying the consumers. Distribution of electricity is controlled by the existing local utilities: JDECO (The Jerusalem District Electricity Company); SELCO (Southern Electricity Company); HEPCO (Hebron Electricity Power) and GEDCO (The Gaza Electricity Company) and by the small municipalities in the northern West Bank that have not been incorporated as utilities. The distribution system in WBG is relatively inefficient with system loses of over 20% compared with 4% for Israel. This reflects the small conductor sizes, the long length of feeders and overloading of the transformers and system network. It also indicates ineffective maintenance and unauthorized consumption (theft). The most cost effective process of increasing supplies of electric power for the long term, with minimal investments, is to reduce losses from the current high level to approach the IEC level of 4% by improved management of the system.

The following is a brief description of the distribution system for each of the four WBG sub-systems:

- The *Northern West Bank Sub-System* is the least developed. This includes the Governates of Nablus, Tulkarem, Qalqilia, Tubas and Salfeet, which collectively include about 40% of the West Bank population. The municipality of Nablus manages the electrical network within the city and the surrounding 14 villages. The grid includes 65 km of 33kV lines, and 170 km of 11 and 6.6 kV lines, and 200 km of low voltage lines. Peak demand was 35 MW and system loses were 11%. The Jenin municipality manages the system within the city boundaries and 6 surrounding villages. The grid totals 76 km with a peak demand of 12 MW and system loses of 11%. The Qalqilia Municipality manages the system within the city. The grid total 111 km with a peak demand of 12 MW and system loses of 11%. The Tulkarem Municipality manages the system within the city and nearby village. The grid totals 278 km, with a peak demand of 12 MW and system loses of 12%.

- The *Central West Bank Sub-System* (JEDCO) was created in 1927 and is co-owned by the municipalities and the private sector. It distributes electricity over a small but dense population and commercial area, including East Jerusalem, Ramallah, Bethlehem and Jericho. The JEDCO network includes 700 km of 33, 11 and 6.6 kV feeder and 350 km of low voltage lines, and 450 MVA in transformer capacity. Peak load is 160 MW, which is 37% of the West bank requirements. Non-technical loses are 18% and non-payments are high.

- The *Southern West Bank Sub-System* provides distribution services for the Hebron district which are supplied by HEPCO and SELCO. HEPCO is limited to the Hebron municipality area and supplies 30% of the area customers. It includes 131 km of high tension lines and 372 km of low tension grid. Peak demand was 12 MW with system loses of 24%. The SELCO mandate includes the other municipalities in the Governate. Peak demand was 23 MW and systems loses are 24%, exceptionally high.

- The *Gaza Sub-District* or GEDCO is the only distributor for the Gaza region. The GEDCO grid includes 310km of 22 kV lines and 350 km of low tension lines. The peak load was 154 MW with loses, primary non-technical, of 27%. Electrical outages are the longest due to the overloaded system and inadequate distribution system.

6.3.3 Demand for Electric Power

The demand for electricity grew at an average annual rate of 5.3% in Israel [1995-2004] and 7.2% [1995-2001] in WBG. The demand for electricity paralleled economic conditions and declined in WBG between 2001 and 2004. The IEC has projected a resumption of demand growth in the region after 2005, which would require an increase in generation capacity from 10 GW to 15 GW by 2010. Accordingly, IEC plans to invest over $1.2 billion per year over the next five years for an improved generation, transmission and distribution system. This will increase reserves from the current low level of 5% to the 20% level, and include the capacity to meet the anticipated demand from WBG customers.

Table 5.3-3: Electricity Flow in West Bank and Gaza

Region	North WB	Central WB	South WB	West Bank	Gaza	West Bank and Gaza
Population	910,000	605,000	490,000	2,005,000	1,255,000	3,260,000
Consumers	632,000	600,000	485,000	1,717,000	1,240,000	2,957,000
Accounts	57,000	117,000	52,000	226,000	120,000	346,000
Supply [GWh]	256	891	271	1,363	835	2,198
Demand [MW]	85	200	52	337	154	491
Load [%]	64	51	46	50	62	54
Losses %]	11-15	18	24	18	27	19

Source: *West Bank and Gaza Infrastructure Assessment*, World Bank, 2002

6.3.4 Natural Gas

Natural Gas resources are located offshore Gaza and can potentially be used to generate electric power in Gaza; however investment uncertainties impeded development of these reserves. BG (British Gas), the developer of the large Gaza Marine field gas resources, has recently signed a contract to transport the Gaza Marine 1 & 2 field gas by pipeline to El Arish in Egypt, for transshipment via an LNG tanker to the US. Gas is being used in Israel from the Yam Theis field and there are natural gas reserves located offshore Israel at the Or, Nao, Mari and Nir fields. There are substantial natural gas resources in Egypt that could potentially be linked to Gaza. The environmental, economic and security concerns of the current dependency on large coal powered electric powered facilities in Israel have prompted IEC to move to natural gas for the two planned 1000 MW facilities. An offshore pipeline will supply gas from El Arish, Egypt to Ashkelon and Ashdod, Israel and will be operational by 2006. IEC has negotiated a long term contract for the import of gas to supply electric power and industry in Israel for the equivalent of $ 21 per barrel of oil. The gas line will be extended along the Israeli coast, initially to Ashdod and then it is designed to reach Nahsholim and north of Haifa. A southern loop will transport gas from Gezer to Ramat Hovav and to Sadom on the Dead Sea by 2007. This loop is designed to accelerate the move to expand the distribution of natural gas for industrial and commercial facilities and smaller consumers. Currently, about 60% of natural gas is consumed in the south, and this line could be extended to include West Bank consumers. INGL (Israel Natural Gas Lines) holds the license to construct, distribute and operate the natural gas pipeline system. The shift to natural gas for generating electric power and for industrial use will reduce electricity prices and industrial energy costs significantly while improving the environment. The INGL plans to bring the gas grid east from the major distribution points at Haifa to the Galilee region in 2007, and indicated they can directly provide gas to meet the requirements for the northern and central West Bank.

6.3.5 Power Supply through Regional Cooperation

An area of potential cooperation involves the integration of the national power grids of Egypt, Jordan, Palestine and Israel into a regional power network. The development of a regional network would allow the power companies to take advantage of the differences in daily, weekly and seasonal peak demand periods, reduce the requirement for the instillation and maintenance of new generating capacity, and provide an outlet for existing reserve capacity.

Jordan and Israel have discussed several joint electric power stations, including a $1 billion, 1000 MW plant to be located on the border, a 100 mw wind farm, a 50 mw solar thermal plant in the southern Avara desert near Eilat, and an 800 MW plant in Jordan that would supply power to the grid. This could mitigate the need to transfer electric power via the corridor since it would duplicate an existing network. Table 6.3-4 gives comparative data on electric power infrastructure.

Table 6.3-4: Comparative Infrastructure Data

Country	Population	Per Capita	Electric Supply	Capacity installed	Generated	Consumed	EP Losses
	Million	[US$]	kW per 100	GW	Bkwh	Bkwh	%
Egypt	77.0	650	21.0	17.6	81.3		14
Jordan	3.9	1120	25.0	1.7	7.5	8.0	10
WBG	2.4	1064	13.0	0.2	0.2	0.6	24
Lebanon	4.0	2500	32.0	2.0	10.7	10.7	
Syria	13.0	2800	30.0	6.1	27.2	25.3	
Israel	5.1	13500	82.0	10.1	47.2	42.9	4

Source: World Bank 2005

Arab Middle East Electrical Alliance: There are plans for an Arab Middle East Electric Alliance, or Arab Network, linking seven countries: Jordan, Iraq, Syria, Egypt, Lebanon, Libya and Turkey. The plan to include Palestine within this network could potentially provide significant external electric resources. The initial project for this grid would be to link Gaza to the Egyptian grid at El-Arish. The link could be constructed and activated with nine months after an agreement. When the tie is functional, the electricity can be transmitted via the connector link from Gaza to the West Bank. Jordan has been connected to the Egyptian electrical grid through an underwater cable between Taba and Aqaba since March 1999, providing 10% of Jordan's electricity requirements. This electrical alliance can be expanded to include a link between Jordan and the West Bank. If this becomes functional, electrical power can potentially be transferred from the West Bank to Gaza, or in reverse, via the connector. The initial plan is to provide supplemental electric power by 2007 to Gaza from Egypt and to the West Bank from Egypt via Jordan, providing power to each region independently, and bypassing the need for an electric connection between Gaza and the West Bank.

Power from Natural Gas: The natural gas available offshore Gaza and from Egypt could be used directly for a large electric power and associated degasification system in Gaza, or extended gas system via the corridor to provide industry and small electric power facilities in the West Bank. A planned 1000 MW natural gas facility could theoretically provide electricity to consumers in Gaza at a cost of $.035 per kWh, about half of the current cost from IEC. However, the uncertain situation in Gaza has defined this plan as a high-risk project and deterred foreign investments. Instead the offshore Gaza gas has been committed for a transshipment requirement in Egypt.

At present, there is no discussion of building a power plant in the West Bank using gas as a source of fuel. Consequently, there appears to be no requirement to build a natural gas pipeline to the West Bank.

6.3.6 Projected Electricity Demand

A projection of the potential peak electricity demand in the West Bank and Gaza is provided for the period to 2030. As noted above, IEC has projected that recovery of Palestinian economy from the second *Intifada* will stimulate an increased demand for electricity, reversing the severe declines from the period 2001 to2003. The West Bank is projected to grow at a faster rate than Gaza, reflecting a more diverse and vibrant economy and a larger population.

IEC production capacity is expected to increase from the 10 GW level in 2005 to the 15GW level by 2015, and will be able to accommodate the anticipated WBG demand. During the past decade here have been no restrictions on electricity supplied to the WBG from the IEC, and non-payments by the distributing companies have been deducted from the Palestine taxes and other funds available. The forecasts in **Tables 6.3-4 and 6.3-5** are based on an economic recovery scenario robust economy scenario, respectively[17]. The forecasts indicate that the central West Bank will consume an increasing portion of the electric power in Palestine. Any new electric facilities constructed in the West Bank would be dedicated to meet local requirements, while a new Gaza electric plant may initially have excess capacity that could be transferred via the corridor the West Bank for a short period. However, over the longer period the availability of low priced and secure sources of electric power could attract vital industrial facilities to the industrial park in Gaza, reducing the incentive to transfer the residual power to the West Bank via the corridor.

Table 6.3-4: Economic Recovery Case: West Bank and Gaza Peak Electricity Demand (MW)

Year	North WB	Central WB	South WB	West Bank	Gaza	Palestine
2002	85	200	52	337	154	491
2005	88	212	54	353	159	512
2010	129	327	79	534	203	736
2015	180	480	110	771	271	1042
2020	242	673	148	1062	346	1408
2025	308	859	189	1356	421	1777
2030	393	1096	241	1730	512	2242

[17] The unstable situation in the West Bank and Gaza is been reflected in the uncertain validity for the baseline data and concerns for projections not only for population but economic demand and electric power requirements. These forecasts are presented with the caveats that inherent uncertainties are prevalent and the data may present a reduced confidence level.

Table 6.3.-5: Robust Electricity Growth in West Bank and Gaza Peak Electricity Demand (MW)

Year	North WB	Central WB	South WB	West Bank	Gaza	Palestine
2002	85	200	52	337	154	491
2005	88	212	54	353	159	512
2010	135	342	82	559	212	771
2015	198	526	121	845	298	1143
2020	276	773	170	1220	399	1619
2025	372	1084	227	1683	509	2191
2030	497	1520	304	2322	649	2971

6.3.7 Marginal Costs

The IEC grid is providing power to the West Bank primarily via the existing west to east transmission links to the distribution companies. The shift to an independent self-contained electric power network in the West Bank and Gaza would require developing a new north-south transmission system in the West Bank from Jenin to Hebron, to link to the connector. Gaza has a coastal transmission network supported by IEC which can be linked to the connector system. It is also essential that the current operating system be rehabilitated to improve the effectiveness of the operations, reduce technical and non-technical losses (theft) and expand maintenance. This approach could be the most expedient process of increasing capacity at the lowest cost. The development of the new north-south West Bank and Gaza transmission network is estimated to cost US$ 188 million [World Bank 2005]. *The estimated cost of an underground transmission link as part of the connector is estimated at US$ 75 to 125 million compared to US$ 10 to 40 million for overhead lines for the same nominal 50 km distance as part of the corridor*, between Gaza and the West Bank[18]. An additional link must be provided to the substation at each end for the 161 kV line. The total cost for building a transmission system to provide electric power to the main consumers in the West Bank via the underground connector would range from $260 to $ 315 million. This could add an additional $0.06 per kWh to the cost of electricity provided to consumers in the West Bank region utilizing this link. The PEA cost estimates may be low since they are based on construction costs in the West Bank. IEC indicated that only IEC approved contractors are permitted to construct electrical transmission systems within Israel.

A comparison of estimated cost of building an electric power transmission line is given in Table 6.3-6 for overhead and underground transmission lines. In the case of a transmission line built in a tunnel it does not include the cost of providing the additional area for the transmission lines within the tunnel's cross section. A discussion of the development of these costs is given in Annex 6-1.

[18] As are all the costs indicated in this chapter, they are subject to change based on further analysis.

Table 6.3-6: Cost Estimate for Building an Electric Power Transmission Line (Costs in million US$)

Transmission System 161kV	Power Capacity in MVA	Cost per km	Cost for 40km	Sub-station Cost	System Cost
Overhead Transmission	500	1	40	24	64
Underground within "at grade" road right-of-way	200	2.5	100	24	124
Underground within a Railway Tunnel	200	2.5	100	24	124

6.3.8 Summary of Findings

From an energy perspective, the West Bank and Gaza can be considered two independent regions with their own production, transmission and distribution systems. The current electric power production for Israel, West Bank and Gaza is almost entirely based on facilities located in Israel. The IEC has an extensive system supplying and transmitting electricity throughout Israel, West Bank and Gaza. The bulk electricity supplied by IEC is distributed to customers in WBG via the links to the four primary distribution networks: [HEPCO, JDECO, SELCO, GEDCO, etc.] located in WBG.

From the economic perspective the transmission of power via the link would be positive if either region has an exportable surplus of electricity which can be profitable sent via the link to the other region. Based on the current dependency on electric power resources from Israel, and the extensive generation and transmission network currently available to the demand nodes in both the WBG, it does not appear that utilizing this corridor will provide a positive economic choice for either region. However, over the longer-term here might be a number of options for developing new power facilities, including a gas power electric plant located in Gaza, adjacent to the offshore natural gas reserves, imports of electricity from Jordan or Egypt, or new alternative resources provided from facilities located in the West Bank or Gaza. A generic assessment of these options indicted that any additional resources would be entirely dedicated to supplying incremental electric power to the local region within the West Bank or Gaza and the least cost approach for incremental electricity will utilize the existing transmission grid for distribution, or develop a new grid to provide power within either the West Bank or Gaza instead of constructing a new transmission line for the corridor. In the interim period, electricity will continue to be purchased from IEC to meet the anticipated demand. One goal could be to increase the self-generation capacity until the level of comfort is achieved, and improve the low quality, high loss distribution system.

Considerable more analysis and resources should be given to looking into the long-term power demand and infrastructure requirements for the WBG.

Conclusions: Based on a review of the existing data, information, reports and studies available and analysis of the current energy and electric power situation in the West Bank and Gaza there does not appear to be an economic or technical requirement for the inclusion of an electric power transmission link as part of the corridor design. Energy autarky can provide independence at a very high economic and technical cost, and may not be financially feasible. The current high level of dependence on Israel for energy resources may be the least cost option due to the economics of scale and limited alternatives available in the near to mid term period. However, decisions factors not based on economic or technical requirements including territorial integrity could encourage the move to a more energy independent system within Palestine.

From the Israeli Perspective: There is no technical or economic requirement for a dedicated electric transmission line between Gaza and West Bank since IEC has in the past and will continue to provide any anticipated demand. In addition, there is no need for a separate natural gas line as part of the corridor since the existing and planned natural gas grid in Israel can provide gas easily to any major consumption point in the West Bank, and based on the Aqaba agreement they will not permit a direct electric power line to be constructed connecting Gaza to Hebron through Israel. The solution should be technical not geographic.

From the Palestinian Perspective: The energy connection line is essential to present territorial integrity and create energy independence even though it might not be cost effective in the short to medium term. Having multiple sources of electric power supply is prudent and desirable over the long-term and avoids over dependence on a single supplier. Providing a means of transmitting power between the West Bank and Gaza allows for this possibility.

Recommendations: Based on the analysis to date, two general recommendations could be made at this point:

1: The corridor should not include provisions for an underground or tower electrical transmission connection or natural gas line due to economic and technical deficiencies, that this link would duplicate existing transmission infrastructure currently operational and provided by IEC, and in addition there is no existing or planned capability to generate sufficient power to transfer electricity between Gaza and the West Bank. If electric power is transmitted to a node in the southern end of the West Bank, there is no existing South-North link to transmit the electricity to the primary consumers in the north. If the transmission cable is installed there is a low probability that it will be used;

2: As indicated in the scope of work, physical provisions for an electrical and natural gas connection should be included in the design of the transportation link due to the potential for planned development, expansion and transmission of electricity and/or natural gas between Gaza and West Bank. However, the actual construction and implementation of the transmission cable and/or gas pipeline should be delayed until the required excess electric power and transfer support facilities are available in either Gaza or the West Bank. This would require provision of sufficient space within the right-of-way to accommodate a power transmission line or gas pipeline. The transmission line can be buried or built above ground.

Because of the high degree of uncertainty associated with estimates of future demand and supply, the second recommendation is preferred. It allows the greatest flexibility to accommodate any possible future need.

6.4 Telecom and Communications

Telecom using cellular and landlines, broadcasts by radio and television and computer internet connections are essential assets for a modern communication society. The WBG has consumed these assets at a very rapid pace. Cell phones are now ubiquitous and exceed the number of fixed landline telephones, in part due to flexibility of use, relative low price and expeditious access to new service. Relay towers permit cell phone operation in most of the region. Ghd Palestine Telecommunications Company (Paltel) is the domestic telecom provider for both land and cell phone via Jawwal, its subsidiary.

Computer use has expanded, and internet shops are widely available. The radio and television transmission permits stations to broadcast across the region, although the hilly terrain presents some constraints for smaller radio stations. Potentially, the connector could be used to transmit landlines for telephone, radio, television and internet between Gaza and the West Bank or visa versa using existing equipment. At present there are low cost fiber optic cables, microwave transmissions and other increasing competitive technologies for communications that will probably be able to bypass the short distance between Gaza and the West Bank. However, new ones, including VoIP (Voice over Internet Protocol), for the telecom and communication sector are evolving at a rapid rate and diverse equipment emerging now will dominate the industry by 2010. It would be difficult to select the winning communication protocols for the next decade, since they will be independently funded and not be a factor in the corridor design.

The telecommunication provider generally pays for the inclusion of telecommunication infrastructure within the right-of-way. As in the other cases, the provision of the telecommunication infrastructure should be allowed within the right of way of the transportation link, and the decision to include it and its should be left to its provider who would cover the cost of its installation.

Table 6.4-1: Telecommunication Indicators for West Bank and Gaza

Radio Stations	29
Television Stations	33
Land Telephones	243,500
Cell Telephones	264,100
% Homes with TV	93.4
% Homes with Radio	82.8
% Homes with Telephone Lines	40.8
% Homes with Cell Phones	72.8
% Homes with Computers	26.4
% Homes with Internet	9.2

Source: Palestine Central Bureau of Statistics, 2004

CHAPTER 7

COSTS AND OPERATIONAL REQUIREMENTS

This chapter's main focus is the various costs associated with the implementation and operation of the project. The largest cost by far is the initial construction costs. However, operation and maintenance costs play an important role over the long term and in determining the cost effectiveness of the alternative projects being evaluated.

The main activities for project implementation are:

- Preliminary designs including supporting studies,:
- Permitting procedures consisting of environmental, cultural and regulatory activities in support of the project, and land acquisition;
- Preparation of final engineering designs and bid documents;
- Project management including construction supervision;
- Construction including commissioning and handover.

For each activity, there are costs incurred; they need to be tracked in order to have a more complete understanding the overall cost of each alternative. For each, a project implementation schedule has to be developed to assist in the analysis of the project from

- Development of project timeline, that is, how long will it take to implement the project and to compare each alternative;
- Identification of potential bottlenecks,
- Assignment of costs by year for estimating and budgetary purposes and for the economic analysis.

A summary of the estimated project timeline is presented in Table 7.1-1. The derivation of the component time requirements is described in the following sections.

Table 7.1-1: Estimated Timeline for Component Activities of the Project

	At-surface Alignments 1 & 2								
	Road			**Railway**			**Combined Road / Railway**		
Activity	Duration (Years)			Duration (Years)			Duration (Years)		
	Short	Long	ML	Short	Long	ML	Short	Long	ML
Preliminary Design Studies	0.75	1.50	1.00	0.75	1.50	1.00	1.00	2.00	1.25
Environmental, Cultural & Permitting Activities	2.00	3.50	2.50	2.00	3.50	2.50	2.00	3.50	3.00
Land Acquisition (Israel)	0.50	1,25	0.75	0.50	1.25	0.75	0.50	1.50	1.00
Final Design & Bid Documents	1.25	2.25	1.75	1.25	2.50	2.00	1.50	3.00	2.25
Tendering & Contract Awards	0.50	1.00	0.75	0.50	1.00	0.75	0.75	1.25	1.00
Project Management & Construction Supervision	4.00	5.50	4.50	4.00	5.50	4.50	5.00	6.50	5.50
Construction	3.00	4.50	3.50	3.00	4.50	3.50	4.00	5.50	4.50

Activity	Part Sunken / Part At-surface Alignment 2s			Part Cut-& Cover / Part Bored Tunnel Alignment 7			Bored Tunnel Alignment 8		
	Road			**Railway**			**Railway**		
	Duration (Years)			Duration (Years)			Duration (Years)		
	Short	Long	ML	Short	Long	ML	Short	Long	ML
Preliminary Design Studies	1.00	1.50	1.25	1.25	2.00	1.50	1.25	2.00	1.50
Environmental, Cultural & Permitting Activities	2.00	3.50	3.00	2.00	3.50	3.00	2.00	3.00	2.25
Land Aquisition	0.75	1.75	1.00	0.25	1.25	1.00	0.25	0.75	0.50
Final Design & Bid Documents	1.50	2.50	2.00	1.50	3.00	2.25	1.50	3.00	2.25
Tendering & Contract Awards	0.50	1.00	0.75	0.75	1.25	1.00	0.75	1.25	1.00
Project Management & Construction Supervision	4.50	6.00	5.00	5.50	7.00	6.00	6.00	7.00	6.50
Construction	3.50	5.00	4.00	4.50	6.00	5.00	5.00	6.00	5.50

ML = Most Likely

7.1 Pre-construction Activities, Project Management and Construction Supervision

7.1.1 Preliminary Design and Supporting Studies

Brief Description: It is assumed that, on the basis of this conceptual design study, a decision in principle will be made of the chosen mode of the transportation link (road only, or railway only or combined road/railway), the proposed type of construction (at-surface, or sunken, or by tunnel), and the general alignment to be followed (established end points in Gaza and the West Bank). This activity will then focus on undertaking a more rigorous technical evaluation of the chosen alternative(s) than was possible in this conceptual study. It will include various types of field surveys. They include but are not necessarily limited to topographic, geotechnical and geological surveys. More rigorous analysis of the environmental and archeological concerns will be addressed with field investigations along the alignment(s).

The preliminary design will consider all mitigating factors and to establish the corridor to be adopted and the engineering and operational features to be developed in the final design. The preliminary designs will aim to help decision makers by giving them more information to guide them to assist in more precise determination of project cost for those organizations that will finance the project.

Timeline: These studies will take between 9 months and 2 years depending on the level of detail required and the completeness of the supporting studies. For more complex projects such as the Combined Road/Railway alternative more time will be needed than for the more conventional road only and railway only projects. Likewise, the preliminary designs for the tunnel alternatives require more detailed geotechnical and geological surveys, which will also require additional time to analyze and incorporate into the preliminary designs. This will increase the preliminary design period for this alternative by up to half a year.

Costs: Preliminary design costs vary with the size and complexity of the project. For the purposes of conceptual planning and preparing budgetary estimates, the costs associated with preliminary design, final design and project management, and project management and construction supervision are estimated as a percentage of the cost of constructing projection. For smaller to larger projects, these costs in percentage of terms of construction costs tend to decrease as the size of project increases. It is also assumed that this occurs to some degree for environmental studies as well. Table 7.1-2 gives indicative values of these costs based on international experience gained from undertaking similar types of projects. As shown in the table, these costs have to consider projects with construction costs that range from about 160 million to almost 1,700 million US dollar or a ratio of roughly 1 to 10. A preliminary design cost of 2% of construction cost is reasonable for a project of less than 500 million dollars, but out of line for a project of over 1.5 billion dollars.

Table 7.1-2: Preliminary and Final Designs, Environmental Studies and Construction Supervision as a Percentage of Construction Cost

Item	Range of construction cost in millions					Comments
	0 to 300	>300 - 500	>500 - 1000	>1000 - 1500	>1500	
Preliminary design	2.00%	1.75%	1.10%	0.67%	0.67%	Of construction cost
Final design	3.00%	2.50%	1.10%	0.85%	0.85%	Of construction cost
Environment studies	1.50%	1.35%	0.50%	0.50%	0.25%	Of construction cost
Project Management & Construction Supervision	5.00%	3.75%	1.75%	1.50%	1.40%	Of construction cost

Project Management and Construction Supervision costs are also a function of the duration of the project..

7.1.2 Permitting Procedures

Brief Description: These activities are directed toward meeting all the legal and regulatory requirements needed to allow for the implementation of the project including incorporating mitigating measures into the final designs. Since most of the alignment fall within Israeli territory emphasis has been placed on its requirements. However, in the case of the rail projects, sizable areas will be required for terminals in Palestine at the Gaza and West Bank terminals. Because of the legal aspects of the permitting process, costs and time to complete various activities can increase through stakeholders seeking legal redress through the courts. To facilitate the permitting process, it might be advantageous to employ a public relations firm.

In the case of Israel the permitting procedure will include a full environmental impact assessment (statement) with archeological and cultural investigations as required to meet all regulatory requirements. The time and resources needed for these studies can vary considerably because of the uncertainty with respect to the extensiveness of the archeological surveys required. During the permitting process, the objections that might be raised by stakeholders will have to be addressed. Again, time and resources will be required to redress them.

The studies done during preliminary design should be able to identify where more extensive investigates will be required and/or the alignment modified to avoid extensive archeological examination and digs.

Timeline: For the more conventional projects such as at grade road and rail alternatives, these investigations should fall between 2 and 3.5 years based on recent experience in Israel for projects designated as national in scope and are not required to follow regional statutory process. However, narrower rights-of-way have smaller impact areas. This suggests that the rail projects might take less time than the road alternative. However, the greater flexibility that highway design engineers have in setting the vertical and horizontal profiles offsets this advantage in favor of a railway. The combine road/railway and sunken road alignments have non-conventional cross sections and need wider rights-of-way. More time-consuming mitigation studies and measures will be needed to redress potentially adverse impacts. In general, the time required to complete these studies and the permitting process will be greater than for road only or railway only alternatives.

In the case of the cut and cover tunnel, this non-conventional cross-section will have considerable impact on the environment during construction even though its right of way requirements are minimal. During construction, the movement of large quantities of materials including their storage and disposition suggest that the permitting procedures will take longer than more convention road or rail projects.

The permitting procedures for deep bored tunnels will be the shortest. The most difficult aspect of its construction will be the disposition of the waste material.

Costs: The costs are difficult to estimate and are not easily evaluated since they include a large variety of different services provided by engineering, environmental, archeological, legal, public relations firms or through individuals. For the purposes of estimation, they are included at $1 million per year.

7.1.3 Land Expropriation and Acquisition

Brief Description: These activities are one distinct aspect of the permitting process that is needed to be completed prior to construction. Normally, construction should not begin until the land is acquired. Land expropriation will be the most difficult for the Sunken and Combined Road/Rail projects because of the more extensive land requirements. Among the alternatives, the difference in the time required to complete this task is not that large, and it is expected to take place in parallel with other permitting activities.

Timeline: The permitting process must be well advanced to allow the expropriation of land and it acquisition. It requires less time than the entire permitting procedure. Once the green light is received, the period of about 0.75 years is allowed for this activity on road only and railway only projects. A shorter period would be required for the deep bored tunnel alternative compared to the cut-and-cover tunnel alternative.

Costs: The land acquisition activities and costs are described in another section of this chapter.

7.1.4 Preparation of the Final Engineering Designs and Bid Documents

Brief Description: These activities will be done in parallel with the permitting procedures since the final designs will need to consider the mitigating measures prescribed as a result of the permitting process. The final design includes all the design drawings, which will incorporate a variety of data such as the geological reports and studies, topographical survey data, design calculations, technical specifications, bills of quantities and cost estimates. The final designs would be performed together with the bid documents, which describe the Conditions of Contract for the various construction contracts, tendering procedures and Instructions to Bidders. Generally, the bid documents would be completed after the designs are finalized.

Timeline: Depending on the complexity of the project the estimated time needed to prepare the final engineering and bid documents will vary but falls between 1.5 and 2.5 years, and should be performed in tandem with the permitting procedures so that little time is lost between a successful conclusion of the permitting process and this activity. For the more conventional projects, the time needed would be about two years. For more complex projects the time requirement will depend on the extent of the field surveys and the complexity of the design. For the more conventional projects, 2 years are required; for the more complex ones, 2.5 years.

Cost: See Table 7.1-2.

7.1.5 Project Management and Construction Supervision

Brief Description: For more costly, and complex and consequently challenging projects, clients typically engage a Project Manager to oversee the day-to-day management of the overall project, supervise its implementation and act on their behalf. The project manager would oversee the tendering and construction activities. As part of the tender process, the project manager would assist the client in prequalifying the bidders, and assist in the tendering process and the evaluation of the bids. During construction the Project Manager would be located in a central project office supported by an administrative support staff. He would certify payment entitlements to the contractors for works satisfactorily completed, and would prepare regular reports of the progress of the project and its constituent construction contracts.

For each construction contract, a Resident Engineer would be assigned to supervise the contractor by ensuring that the contract specifications and terms are satisfactorily met, determining the quality and quantity of work performed by the contractor, updating schedules, and preparing certifications of payment entitlements to the contractor. Each Resident Engineer would be located in a site office supported by a site staff of specialized engineers (civil, mechanical, electrical – as required), quantities surveyor, setting-out/measurement surveyors, inspectors, materials testing laboratory personnel and facilities, and site office support staff.

Timeline: The Project Manager would be employed about a year before the construction would commence to help with the tendering. The construction supervision activities would last through to the end of construction and the subsequent defects liability periods.

Costs: See Table 7.1-2.

7.2 Construction Costs, Contracting Strategy and Schedules

7.2.1 Construction Costs

Construction costs with contingencies have been estimated for the preferred options and are summarized in Table 7.2-1 and do not include VAT or the cost of security infrastructure that may be required by the Government of Israel. The more detailed cost estimates are presented in Appendix 7.2.

Table 7.2-1: Summary of Construction Cost Estimates with Contingencies and Without VAT or Security Infrastructure

Alignment	Transport Mode	Construction Type	Construction Cost (US$ million)
1	Road	At-surface	199.120
	Railway (incl. terminals)		232.796
	Combined Road/Railway (incl. railway terminals)		378.472
2	Road	At-surface	188.565
	Railway (incl. terminals)		235.785
	Combined Road/Railway (incl. railway terminals		376.266
2s	Road	Part Sunken / Part At-surface	193.694
7	Railway (incl. terminals)	Part Cut-&-Cover Tunnel / Part Bored Tunnel	1,161.498
8	Railway (incl. terminals)	Bored Tunnel throughout	1,656.915
9	Railway with interim use of IR Infrastructure (incl. terminals)	Bored Tunnel eastern section	765.565
10	Railway with interim use of I R Infrastructure (incl. terminals)	At grade alignment eastern section	158.638

Notes: 1. IR = Israel Railways
2. In addition to the construction works, all rail projects include equipment costs.

Because these construction costs are based on conceptual studies only, they include contingencies as explained in the more detailed estimates in Appendix 7.2.

7.2.2 Construction Contracting Strategy and Schedules

The construction schedule will be dependent upon:

- Type of transportation mode implemented (road only, railway only or combined road/railway);
- Type of construction (at-surface, sunken or tunnel);
- Selected alignment;
- Number of construction contracts into which the project is divided.

The time schedules are summarized in Table 7.2-2. The derivation of these timelines is explained below.

Table 7.2-2: Estimated Construction Schedules

Alignment	Transport Mode	Construction Type	Approx. Construction Duration (Years)		
			Short	Long	ML
1	Road	At-surface	3.0	4.5	3.5
	Railway (incl. terminals)		3.0	4.5	3.5
	Combined Road/Railway (incl. railway terminals)		4.0	5.5	4.5
2	Road	At-surface	3.0	4.5	3.5
	Railway (incl. terminals)		3.0	4.5	3.5
	Combined Road/Railway (incl. railway terminals)		4.0	5.5	4.5
2s	Road	Part Sunken / Part At-surface	3.5	5.0	4.0
7	Railway (incl. terminals)	Part Cut-&-Cover Tunnel / Part Bored Tunnel	4.5	6.0	5.0
8	Railway (incl. terminals)	Bored tunnel throughout	5.0	6.0	5.5
9	Railway with interim use of IR Infrastructure (incl. terminals)	Bored Tunnel eastern section	4.5	6.0	5.0
10	Railway with interim use of I R Infrastructure (incl. terminals)	At grade alignment eastern section	2.5	3.5	3.0

ML = Most Likely

The indicated “Construction Duration” represents the time for substantial completion of the construction works, after which the facility would be handed over to the stakeholders. This would be followed by a 1- or 2-year defects liability period, wherein the contractors would be contractually responsible for the rectification of any defective works.

Construction strategy (into how many construction contracts will projects be divided) will affect the construction period. Also, there is the possibility in Israel that construction may be delayed by archaeological finds during the works. Thus, in Table 7.2-2, a range of ‘construction durations’ is given, as explained below:

Short: The least time that would be required assuming no delays.
Most likely: The likely time that would be required assuming no significant delays.
Long: The longest time that would be required assuming a 6-month delay.

Road At-surface: The preliminary construction cost estimate for Alignments 1 and 2, each about 44 km long, is about US$200 million. We have been informed that there are up to ten Israeli civil engineering contractors capable of performing contracts up to US$100 million in value. However, in order to minimize the construction schedule it is envisaged that the project would be divided into 4 construction contracts. Contracts of about US$50 million, each of about 11 km length, would be of a scope that would attract bids from international contractors. The construction period for each contract would be about 3.0 to 4.5 years, the most likely period being 3.5 years.

Railway At-surface: The preliminary construction cost estimate for Alignments 1 and 2, is about US$155 million for the 44 km (approximately) main line, about US$57 million for the Gaza terminal and about US$23 million for the West Bank terminal. In order to minimize the construction schedule, it is envisaged that the project would be divided into 1 construction contract for the Gaza terminal, 1 for the West Bank terminal, and 3 contracts for the main line (each of about US$50 million value). The construction period would be about 3.0 to 4.5 years the most likely period being 3.5 years.

Combined Road/Railway At-surface: This option is more complicated than the road only or railway only options. The preliminary cost estimate is about US$300 million for the mainline works, plus about US$57 million for the Gaza terminal and about US$23 million for the West Bank terminal. One option would be to divide the mainline works into 5 or 6 construction contracts, each of about US$50 to 60 million. Another option would be to divide the main line civil works and road construction into 5 or 6 contracts, and perform the railway bed and track work under a separate contract. It is envisaged that the Gaza and West Bank terminals would be constructed under 2 separate contracts. The construction period would be about 4.0 to 5.5 years, the most likely period being 4.5 years.

Part Sunken / Part At-surface Sunken Road: With a preliminary cost estimate of about US$200 million, this option is similar in value to that for an at-surface road. However, the construction will be a little more complex. At-surface alignments will generally cross over existing roads and railways by overpass bridges, and watercourses will pass under the fill sections of the alignment in culverts. However, a sunken alignment must pass under roads, railways and watercourses. The roads and railways will have to be temporarily diverted while underpass bridges are constructed. Streams will have to be diverted before viaducts are constructed across the sunken alignment, or the alignment work must be confined to periods when watercourse will be dry, and such works will be subject to stringent environmental constraints. It is envisaged that the 20.5 km of sunken alignment traversing the western plain would be divided into 2 construction contracts, and the 23.5 km at-surface alignment traversing the eastern hills would be constructed under 2 or 3 contracts. The construction period would be about 3.5 to 5.0 years, the most likely period being 4.0 years.

Part Cut-and-Cover tunnel / Part Bored Tunnel: The conceptual design for this option is that a cut-and-cover tunnel will traverse the western plain from Gaza for about 23.7 km, and the TBM-bored tunnels will traverse the eastern hills for about 15.2 km to the West Bank. The length bored tunnels is divided into two sections, 7.2 km and 8 km respectively. The estimate of construction duration for this option is based on the construction time needed for boring the 8 km section. For this 8 km section it is envisaged that two tunnel boring machines (TBMs) would be employed, one for each of the twin tunnels. The twin tunnels of this 8 km section would be excavated concurrently, one in advance of the other, with excavation of the cross-tunnels following behind. The estimated rate of progress for excavating a bored tunnel through the weak rock of the eastern hills is about 25 m per day. Thus, assuming a continual operation, the excavation activities would theoretically take about 1 year, say 1.5 years to allow contingency for unforeseen difficulty. To this must be added about 1 to 1.5 years for manufacture of the TBMs – the actual period will depend on how busy the limited number of TBM manufacturers are - and 3 to 6 months for delivery, assembly and installation. To this must be added about 1.5 years for construction of the tunnel ventilation shaft and system, rail bed and track, and electrical, control and communication works. For the TBM-bored tunnels only, the construction period would be about 4.5 to 5.5 years the most likely period being 5.0 years. For the bored tunnel works there would be negligible risk of delays arising from archaeological finds.

It is envisaged that two additional TBMs would be used to excavate the other 7.2 km section of bored tunnel. Whether the bored tunnels sections are performed under one or two construction contracts would not significantly affect the overall construction period.

The use of 4 TBMs has been adopted to minimize the time for excavating the bored tunnels. The affect upon the construction schedule of employing less than 4 TBMs is discussed under Section 4.6.

It is envisaged that the 23.7 km cut-and-cover tunnel section would be divided into 3 or 4 contracts, each of about 6 to 8 km lengths, such that the overall construction period for the TBM tunnels is not exceeded. Over passing roads and railways will have to be temporarily diverted while underlying portions of the tunnel are constructed. Streams crossing the alignment will also require temporary diversions.

For the cut-and-cover tunnel works there is the possibility of delays arising from archaeological finds in the open excavations, and allowance should be made for this. Thus the construction period for both cut-and-cover and bored tunnels would be about 4.5 to 6.0 years the most likely period being 5.0 years.

Bored Tunnel Throughout: This alignment is 37.5 km long. Different TBM technologies will be required. Open TBMs will likely be able to excavate the 15 km of tunnels through the weak rock of the eastern hills, but earth pressure balance (EPB) TBMs will likely be required to excavate the 22.5 km through the overburden of the western plain. Whereas TBM tunnel excavation through the weak rock will probably be achieved at the rate of about 25 m per day, a lower rate of about 15 m per day is anticipated by EPB TBM through the overburden. This conceptual study envisages that the EPB TBM technology will be required for the 22.5 km of the alignment through overburden with vertical heading shafts (ultimately to be utilized for ventilation shafts) at mid-third points. Consequently each section of EPB TMB tunnels will be about 7.5 km long. It is envisaged that 6 EPB TBMs will be used to excavate the 3 tunnel sections concurrently. At the rate of 15 m per day the excavation activities would theoretically take about 1.5 year, say 2 years to allow contingency for unforeseen difficulty. To this must be added about 1 to 1.5 years for manufacture of the TBMs, and 3 to 6 months for delivery, assembly and installation. To this must be added about 1.5 years for construction of the tunnel ventilation shaft and system, rail bed and track, and electrical, control and communication works. For the deep bored tunnels there is negligible risk that there would be archaeological delays. Thus the construction period for both cut-and-cover and bored tunnels would be about 5.0 to 6.0 years the most likely period being 5.5 years.

Whether the EPB TBM bored tunnels sections are performed under one or three construction contracts would not significantly affect the overall construction period.

This schedule would accommodate completion of the open TBM-bored tunnels through the eastern hills, as described under the “Part Cut-and-Cover tunnel / Part Bored Tunnel” option. The schedule would also accommodate construction of the railway terminals in Gaza and the West Bank that would likely be completed fewer than two separate contracts.

The use of 6 EPB TBMs and 4 open TBMs has been adopted to minimize the time for excavating the bored tunnels. The affect upon the construction schedule of employing less EPB TBMs and less open TBMs is discussed under Section 4.6.

7.3 Land Acquisition Costs

The land acquisition requirements vary considerably among the different alternatives analyzed. Ribbon development caused by the construction of the transport link will require sufficient land to initially build the infrastructure and to allow additional space to accommodate its future expansion. Almost all of this land occurs in Israel

Two general types of cross sections are considered in this study – at grade or at ground level construction and below ground or tunneled construction. The construction at grade has the greatest long-term requirements for land. Right-of-way requirements for the rail only alternatives are less intense than they are for the road only alternatives and the combination of road and rail requires the most. The sunken road cross section consumes much more land that the road only alternate as much as the combine road/rail alternative. In terms of land acquisition in Israel, the tunnel alternatives require almost no long-term land area; a negligible amount of land will be taken for ventilation and emergency safety shafts and possibly for electric substations located at ground level.

During the construction of the cut and cover tunnels, considerable land area will be impacted:

- To provide temporary access to the work area,
- To allow the contractors to excavate surface material to the required depth of the works, and
- To utilize the land for temporary storage of excavated material, this would then be used for fill.

Upon completion of the tunnel the land will be returned to its original use. Likewise, for the deep bored tunnels temporarily works will scare the land at the surface to construct deep access shafts and to evacuate the surplus materials produced. All the surface area disturbed by these construction activities will be returned to its original use.

In the case of all the railway alternatives, terminals are needed at the Gaza and West Bank termini of the transport link. The areas needed for the terminals are relative large. In the case of all the road only alternates, there will be almost no land taken[1].

Israel: An appraisal of the land in Israel was undertaken for the study; the results of this study are summarized in Appendix 7.3, Land Appraiser's Report. Alignments 1 and 2 are analyzed in this report. The land values (per square meter) along the northern alignment, Alignment 1, are higher than those along Alignment 2. This is not surprising since the area along the Alignment 1 is more developed, and 2 or 3 buildings are in the path by this alignment. In the case of Alignment 2, every attempt was made to avoid settled areas and use lower valued agricultural lands and other low value lands; consequently, its average land value is lower. Briefly, the unit rates are summarized in the following table:

[1] In the case of the road only alternatives, the road ends shortly within Gaza and connects directly to Route 35 once inside the West Bank. See chapter 3.

Table 7.3-1: Land Values in Israel in $ per Square Meter in the Cost Estimates

Alignment	Agricultural Land	Other Types of Land
1	5	6
2	4.1	3

All the agricultural land through which these alignments pass is owned by the Government of Israel and leased for a set period of time. If title of the land were with its present occupant whether it is a private person, kibbutz, company, etc, the unit rates would be higher than indicated above.

A summary of the area of land required for each of the alternatives is given in the following table:

Table 7.3-2: Land Area Required for Each Alignment in Israel

Align-ment	Transport Mode	Construction Type	Land Area in Square Meters		
			Agriculture	Other	Total
1	Road	At-surface	1,800,000	2,000,000	3,800,000
	Railway (incl. terminals)		900,000	1,000,000	1,900,000
	Combined Road/Railway		2,000,000	2,250,000	4,250,000
2	Road	At-surface	2,550,000	1,000,000	3,550,000
	Railway (incl. terminals)		1,300,000	500,000	1,800,000
	Combined Road/Railway (incl. railway terminals)		2,950,000	1,150,000	4,100,000
2s	Road	Part Sunken / Part At-surface	3,100,000	1,000,000	4,100,000
7	Railway (incl. terminals)	Part Cut-&-Cover Tunnel / Part Bored Tunnel			Negligible
8	Railway (incl. terminals)	Bored tunnel throughout			Negligible
9	Railway with interim use of IR Infrastructure (incl. terminals)	Bored Tunnel eastern section of alignment	200,000		200,000
10	Railway with interim use of I R Infrastructure (incl. terminals)	At grade alignment eastern section of alignment	130,000	1,000,000	1,130,000

Palestine: The land area requirements in Palestine are negligible for all the road alternatives. In the case of all the rail alternatives, terminals at both ends of the line will have to be built with the following land areas:

- Gaza Strip main terminal 600,000 square meters and
- West Bank terminal 400,000 square meters.

The unit cost of level land is considerably higher in Palestine reflecting its scarcity and the assumed private ownership of all the land required:

- Gaza Strip main terminal at US $ 30 per square meters and
- West Bank terminal at US $ 20 per square meters.

7.4 Summary of the Initial Investment Costs of the Projects

7.4.1 Equipment Costs for the Railway Options

Equipment costs required to start up a new railway are an important component of the initial investment costs since it covers rolling stock (locomotives and cars), specialized maintenance equipment for track and way, and supplying the maintenance depots with specialized equipment necessary to maintain the rolling stock. Tables 7.4-1 and 7.4-2 summarize these costs for diesel and electrical operations, respectively. Each table shows the equipment required in 2015 and 2030. Table 7.4-1 includes at grade options with Rail Only and Combine Road/Rail modal options.

Table 7.4-1: Equipment and Cost for At Grade Options
(Cost in Million of US $)

Item	Unit Cost U.S. $ (Million)	Units Required				Investment Cost			
		2015		2030		2015		2030	
		Rail Only	Road Rail	Rail Only	Road Rail	Rail Only	Road Rail	Rail Only	Road Rail
Locomotives - Diesel	3	10	6	14	10	30.0	18.0	12.0	12.0
Control Coaches	2.32	9	3	7	9	20.9	7.0		13.9
Coaches	1.62	40	20	54	40	64.8	32.4	22.7	32.4
Flatcars	0.07	110	60	170	110	7.7	4.2	4.2	3.5
Track Inspection	0.1	2	2	2	2	0.2	0.2	0.0	0.0
H.R. Crane	0.4	1	1	1	1	0.4	0.4	0.0	0.0
Lighting Truck	0.1	2	2	2	2	0.2	0.2	0.0	0.0
Track Crew Transport	0.7	2	2	2	2	1.4	1.4	0.0	0.0
Tamper	0.4	1	1	1	1	0.4	0.4	0.0	0.0
Ballast Regulator	0.2	1	1	1	1	0.2	0.2	0.0	0.0
OH Crane included in bldg cost		1	1	1	1	0.0	0.0	0.0	0.0
Drop Pit included in bldg cost		1	1	1	1	0.0	0.0	0.0	0.0
Wheel lathe	4.5	1	1	1	1	4.5	4.5	0.0	0.0
Car Maintenance. Truck	0.3	1	1	1	1	0.3	0.3	0.0	0.0
Tools (RS + Track)	0.2	1	1	1	1	0.2	0.2	0.0	0.0
Train Control Computer	0.4	1	1	1	1	0.4	0.4	0.0	0.0
Dispatch	0.4	1	1	1	1	0.4	0.4	0.0	0.0
Total						132.0	70.2	38.9	61.8

Table 7.4-2: Equipment and Cost for Tunneled Options (Cost in Million of US $)

Item	Unit Cost U.S. $ (Million)	Units Required				Investment Cost			
		2015		2030		2015		2030	
		Rail Only	Road Rail	Rail Only	Road Rail	Rail Only	Road Rail	Rail Only	Road Rail
Locomotives - Electric 6.4kW	3.24	10		14		32.4		13.0	
Control Coaches	2.32	9		7		20.9			
Coaches	1.62	40		54		64.8		22.7	
Flatcars	0.07	110		170		7.7		4.2	
Track Inspection	0.1	2		2		0.2		0.0	
H.R. Crane	0.4	1		1		0.4		0.0	
Lighting Truck	0.1	2		2		0.2		0.0	
Track Crew Transport Vehicle	0.7	2		2		1.4		0.0	
Tamper	0.4					0.0		0.0	
Ballast Regulator	0.2					0.0		0.0	
OH Crane included in bldg cost		1		1		0.0		0.0	
Drop Pit included in bldg cost		1		1		0.0		0.0	
Catenary Maintenance Vehicle	1.5	1		1		1.5		0.0	
Wheel lathe	4.5	1		1		4.5		0.0	
Car Maintenance. Truck	0.3	1		1		0.3		0.0	
Train Control Computer	0.4	1		1		0.4		0.0	
Dispatch	0.4	1		1		0.4		0.0	
Total						135.1		39.8	

7.4.2 Initial Investment Costs

The initial investment costs for all 11 options are summarized in Table 7.4-3.

Table 7.4-3: Initial Investment Costs
(Million US $)

No.	Alignment & Mode Designation	Prelim-inary Designs	Final Design	Environ-mental Studies	Land Acquisi-tion	PM & Con. Super-vision	Construc-tion	Equip-ment	Total
1	1 Road	3.98	5.97	2.99	27.30	9.96	199.12		249.32
2	1 Rail	4.66	6.98	3.49	47.45	11.64	232.80	132.00	439.02
3	1 Combine	6.62	10.33	5.11	64.35	14.19	378.47	70.20	549.28
4	2 Road	3.77	5.66	2.83	17.49	9.43	188.57		227.74
5	2 Rail	4.72	7.07	3.54	42.68	11.79	235.79	132.00	437.58
6	2 Combine	6.58	10.24	5.08	54.01	14.11	376.27	70.20	536.49
7	2 Road (Partially Sunken)	3.87	5.81	2.91	20.42	9.68	193.69		236.39
8	7 Rail (C&C+Bored Tunnel)	7.78	9.87	5.81	33.80	17.42	1,161.50	135.10	1,371.28
9	8 Rail (Bored Tunnel)	11.10	14.08	4.14	33.80	23.20	1,656.92	135.10	1,878.34
10	9 Rail (IR + Bored Tunnel)	8.42	8.42	3.83	35.36	13.40	765.57	135.10	970.09
11	10 Rail (IR + At grade)	3.17	4.76	2.38	42.45	7.93	158.64	132.00	351.33

Note:PM & Con. Supervision = Project management and construction supervision

7.5 Railway Operating Scenarios and Operating and Maintenance (O&M) Costs

The operation of the railway is a complex undertaking, and unlike a road it requires that a robust management structure be in place to sustain a high level of service and reliability. For the rail, three basic operating scenarios are analyzed:

- Rail only for at grade or ground level operations with diesel locomotives;
- Rail only for operating in a tunneled cross section requiring electric power;
- Combine road/rail for an above ground operation with diesel locomotives but with reduced traffic.

From an operating viewpoint, there are no significant differences among the four alternatives. The operating plan presented here applies to all three. The operations of Alignments 9 and 10, which are interim solutions utilizing Israel Railways infrastructure, have not been analyzed. In both cases, the operating plan would have to consider the ongoing operations of Israel Railways and the interaction between both systems.

A more detailed discussion of the different railway operating scenarios is found in Appendix 7.4, and the computation of the O&M costs based on them is found in Appendix 7.5.

If the railway is placed underground, it will be necessary to electrify it. The pollution resulting form operating diesel locomotives in a long tunnel and safety issues that result precludes their use under these circumstance. The choice of electrical traction power affects the type of equipment, staffing and operating costs, principally energy, but does not require alterations in the operating plan.

The proposed railway extends from a point near the northwest corner of the Gaza Strip to a point in the West Bank. It will have only two stations, one at each terminal, and will provide non-stop service between them for both passengers and freight. Passengers will not be permitted to leave or board the train except at the two stations. Likewise, freight will move through Israel in a single non-stop train.

7.5.1 Traffic and Operational Considerations

The operating plan is based upon passenger and freight volumes projected for 2015 and 2030 under the Rail Only and Combined Road/Rail options[2] based on the forecasts in Chapter 2. Traffic projections assume that the railway will have been in operation for a sufficient time to penetrate the market and secure the anticipated volume[3]. Even so, the full 2015 traffic estimates are utilized in the opening year.

During peak hours, two passenger trains depart from each station; in off peak hours one train per hour would be dispatched. A passenger train consists of 10 cars. As suggested, the number of trains per hour and the number of cars per train can vary depending on demand.

The freight operations are based on having trucks usually transporting containers drive up a ramp and onto flatbed car. This type of operation is utilized in Europe and the USA, and it reduces the time it takes to load and unload the vehicles. The drivers would travel in a separate passenger coach while the train is transporting their trucks. This type of operation could involve transporting buses and cars on the train; in some cases the passengers remain in the vehicles (Eurotunnel practice) or could be transported in a separate coach; however, this alternative was not analyzed due to security considerations. Freight trains will depart once every 3 hours in each direction and consist of 25 wagons. Because the rail traffic for the combine road/rail alternatives is lower than it is for the rail only option, various operating parameters are reduced. For instance, the size of the train is 8 cars instead of 10.

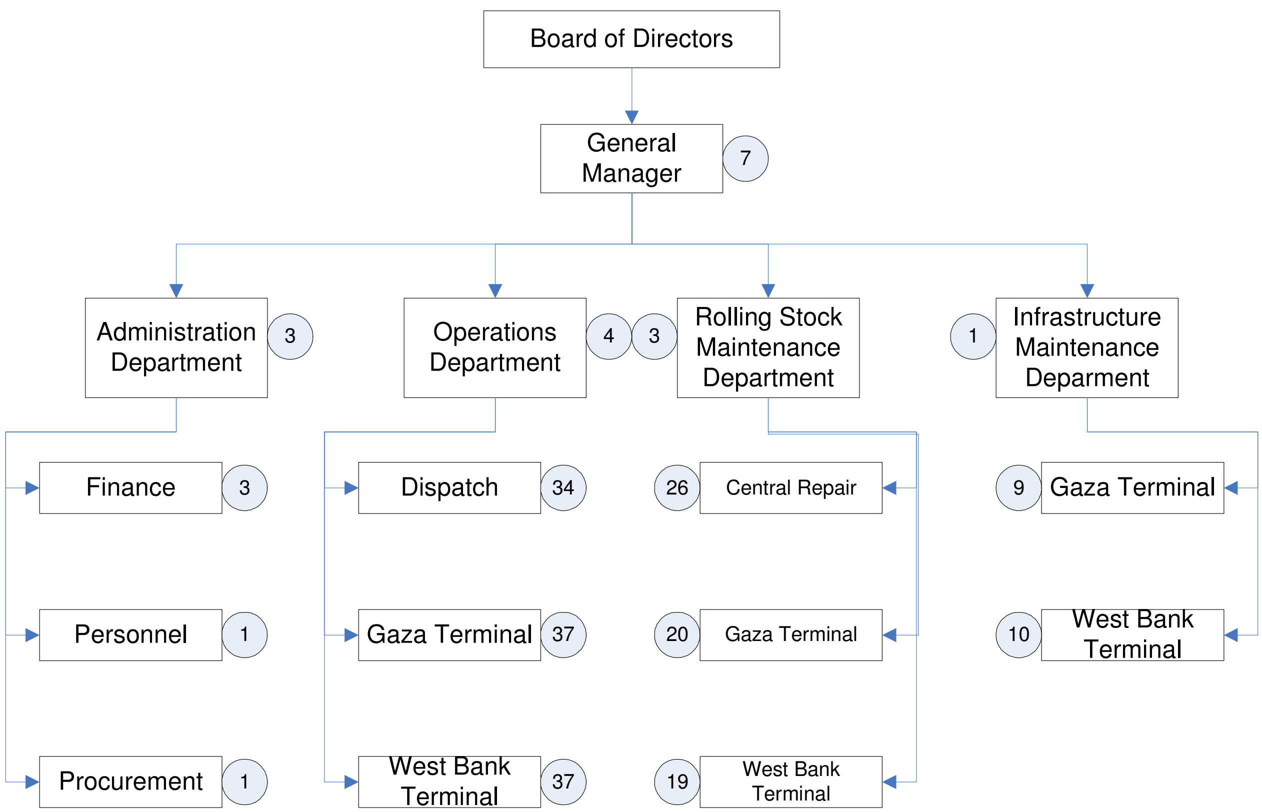
[2] From the operational perspective, the Rail Only includes at grade and tunnel cross sections. Both have the same operational plan.
[3] During the initial stages of operation, volumes are often low until customers become aware that the railway exists and familiar with its services. When the railway first begins operation, volumes may be well below what is projected. This will be reflected in a reduced level of train operations, possibly no more than two passenger and two freight round-trips per day. This will be reflected in reduced staff and equipment requirements.

7.5.2 Railway Organization

The proposed railway is conceived as an independent, stand-alone operation. There are no connections to other railways. Its ownership, management, or operational rights are outside the scope of this study. When the railway initiates operations, it will be faced with a lack of experienced railway personnel. In order to minimize this problem, it is possible that the new railway might contract with Israel Railways or another rail organization to assist in the management of the railway and to train its personnel in various aspects of railway operations. These seconded experts will gradually be replaced with Palestinians.

For a modern railways organization, following staffing levels are assumed in 2015 as shown in the organization chart in Figure 7.4-1. A total of 160 persons will be required in that year increasing to 212 by 2030.

Figure 7.5-1: Railways Organization Chart



The numbers indicate the personnel assigned in 2015 for Rail Only.

The combine road/rail alternative has the same basic organization but with lower staffing levels.

7.5.3 The Tunnel Options

If the tunnel option is selected, the line must be electrified. This requires that electric locomotives replace the diesel locomotives. As the same service frequency is maintained there is no change in the number of locomotives required. Reflecting Eurotunnel's experience, it is not anticipated that the flatcars will require enclosures.

There are some cost impacts from the electrification, principally in fuel cost and infrastructure maintenance. The electricity cost per train kilometer is estimated to be less than diesel fuel. There will be a need to add four infrastructure maintenance persons and to acquire a catenary maintenance vehicle. There should also be some changes in locomotive maintenance costs although these should be minor. The cost impacts of these changes are discussed in Appendices 7.4 and 7.5.

7.5.4 Railway O&M Costing Summary

Staffing costs are based on private sector rates utilized in Palestine. Operating and maintenance costs are largely derived from Israel Railways and international experience. Operating and maintenance costs cover:

- Labor based on staffing levels shown above;
- Motive energy estimated for diesel and electric traction;
- Lubricants as a proportion of motive energy costs;
- Rolling stock parts based on Israel Railways experience;
- Infrastructure maintenance based on international and USA norms;
- Accidents based on the consultants estimates;
- Utilities based on estimated consumption of power and water;
- Office expenses;
- Staff training.

These costs are summarized in Table 7.5–1 for the opening year assumed to be 2015 and for 2030.

Table 7.5-1: Railways Operating and Maintenance Cost Summary.

Item	At Opening			2030		
	Rail Only	Road/Rail	Rail Tunnel	Rail Only	Road/Rail	Rail Tunnel
Labor	6,924,400	5,438,067	6,924,400	10,893,867	6,924,400	10,893,867
Motive Energy	4,237,061	2,831,278	3,816,300	15,925,547	3,762,639	13,194,158
Lubricants	423,706	283,128	317,780	1,592,555	376,264	1,194,416
Rolling Stock - Parts	1,928,236	1,017,474	1,824,014	2,958,301	1,871,862	2,853,697
Infrastructure Maintenance	430,643	328,247	2,171,400	471,215	430,643	2,605,680
Accidents & Derailment	123,000	62,000	184,500	246,000	124,000	369,000
Utilities	555,500	471,000	885,500	754,200	555,500	1,084,200
Office Expenses	44,500	30,000	44,500	66,750	45,000	66,750
Staff Training	360,000	257,000	360,000	360,000	257,000	360,000
Total	**$ 15,027,046**	**$ 10,718,192**	**$ 16,528,394**	**$ 33,268,435**	**$ 14,347,308**	**$ 32,621,768**

7.6 Road Operating and Maintenance Costs

7.6.1 Methodological Differences between Railways and Road O&M Costs

A fundamental difference exists between the analysis of the O&M costs for railways and roads. As described above, the railway costs are based on a self-contained organization, that is, all the O&M costs are the responsibility of the railways itself. In the case of the road O&M costs, the vehicle operating costs are borne by the vehicle owners or operators and the various types of maintenance costs are the responsibility of the road agency. As a consequence, the vehicle operating costs are estimated separately form the road maintenance costs.

The O& M costs for the road options are computed using a standard computer model. Routine and periodic maintenance operations and vehicle operating costs (VOC) are derived from the Highway Deterioration Model – version 4 (HDM-4)[4]. It estimates the VOC based on the traffic levels, vehicle types, geometrics of the highway, and condition of the pavement using unit costs for various components of the operating costs such as fuel, labor, vehicle, and etc. Maintenance costs consist of annual routine maintenance including patching and other minor repairs and of periodic maintenance that occurs once the pavement has deteriorated to the point where its roughness has appreciably increased to warrant its repair and strengthening. Pavement deterioration is based on a complex set of equations of which climate, quality of construction, traffic and axle loads are important variables.

In addition to these costs, there are time costs for passengers and freight that are important when comparisons are made between alternative routes and modes of transport. Time costs are handled separately.

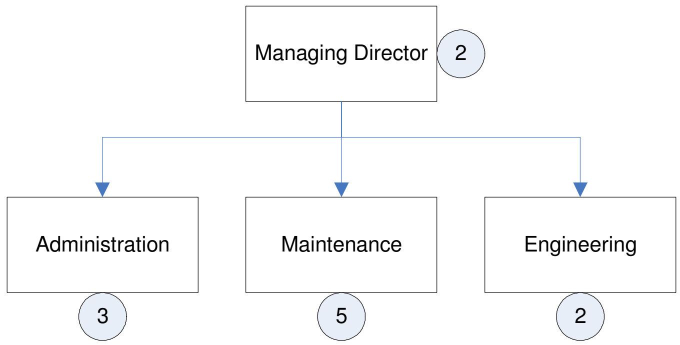
7.6.2 Road Agency Costs (Maintenance Costs)

For the purposes of this study, the road connecting the Gaza Strip to the West Bank is conceived as an independent, stand-alone operation even though it will connect to the road network in both parts of Palestine. It is possible that the proposed highway will be operated as a toll road; this possibility has not been analyzed. Its ownership, management, or operational rights are outside the scope of this study.

From operating and organizational perspectives, the road agency responsible for the road will not be tasked with the actual transportation of passengers and freight; the vehicle owners and operators will do this. As shown in Figure 7.6-1, the task of only supervising the maintenance of the road will be left to a leaner organization than required by the railway. In the case of a toll road, a much larger organization will be needed to collect the tolls.

[4] HDM-4 is the results of over 15 years of development. The original work on the model was done through the International Study of Highway Development and Management Tools (ISOHDM), sponsored by the World Bank, the Asian Development Bank and the Department for International Development (UK), the Swedish National Road Administration as well as other sponsors. The HDM-4 products are jointly published by the World Road Association (PIARC), Paris and the World Bank, Washington, DC.

Figure 7.6-1: Road Agency Organization Chart



The staffing levels shown in the circles for this agency are modest and assume that the work can be accomplished through contract maintenance in which case a much larger organization would not be necessary. The costs for the various maintenance activities include labor charge; they cover the costs of these additional employees of the road agency if it were to undertake the maintenance on its own account.

For the purpose of this study, the main maintenance activities of the four-lane carriageway bituminous pavement cover the following operations:

- Drainage and other routine maintenance is done every year where required; the operation consists in repairing and cleaning shoulders, side slopes, ditches and culverts by using a grader, roller, water tanker and laborers and includes grass cutting and picking up waste. Average cost is US$ 3,614 per kilometer.
- Patching is carried out every year where required, with 100% of potholes repaired. This operation consists in cutting the defective area by saw, removing the old asphalt, replacing 20 cm thick of the base course, compacting, applying a prime coat and paving with asphalt as per the existing. Average cost is US$ 14.5 per square meter.
- Edge repair is carried out every year where required, with 100% of edge breaks repaired. This operation consists in cutting the edge by saw, compacting the base course and applying a prime coat and asphalt thickness as per the existing pavement. Average cost is US$ 18.1 per square meter.
- Thick overlay (periodic maintenance) is required when roughness reaches 4[5]. The operation consists in cleaning the existing surface by air compressor, applying asphalt tack coat and paving 50 mm thick dense graded asphalt. Average cost is US$ 10.4 per square meter.

The average road maintenance cost per year for both alignments is approximately US $720,000, and an overlay costing just over US $7 million is needed about 13 or 14 years after construction is completed.

[5] Based on the International Roughness Index (IRI).

7.6.3 Vehicle Operating Costs

VOC consist of:

- Representative cost of new vehicles;
- Cost of replacement tires;
- Cost of fuel (gasoline or diesel);
- Lubricating oil;
- Maintenance labor costs; and
- Crew wages.

The VOC per km are computed, using the HDM-4 Model for four main types of vehicles that are representative of the Palestinian vehicle fleet, are as follows:

- Cars
- Large buses
- Medium trucks
- Heavy trucks

The Consultant calculated vehicle operating costs per kilometer for several levels of deterioration of the road (using roughness based on IRI measurement) and for each category of vehicle. Characteristics are found in Appendix 7.6, as well as typical outcomes of the HDM-4 Model. The vehicle operating costs borne by the future road users of the West Bank-Gaza Transport Link are shown in the table below per category of vehicles. Note that the VOC are similar for all road options, as the impact of the road on the vehicles is basically the same for all the alignments studied and because their lengths are about equal.

Table 7.6-2: VOC Incurred between Gaza and the West Bank by Vehicle Type (At the opening year – in US$)

	Car	Large Bus	Medium Truck	Heavy Truck
All options	14	25	22	37

7.7 Time Costs

7.7.1 Railways

Time costs are important in evaluating alternative transport routes and modes for passenger and freight. In the case of rail transport, the time that it takes to complete a trip consists of: (i) the time spent at the terminal; and (ii) the travel time spent on the train. These values are assumed to be constant over time and are similar in the various investment options.

For passengers, it is assumed that a person would spend an average of: (i) 25 minutes in the departure terminal to walk to the ticket booth, purchase the ticket and wait for the next train – based on departures every half hour during peak hours and every hour otherwise; (ii) 15 minutes at the arrival terminal, to walk out of the terminal and to catch a connecting mode of transport; and (iii) slightly less than 25 minutes for the trip, based on an average speed of 120 km/hr.

For cargo, travel time on the corridor is assumed to be about 35 minutes, at an average speed of 80 km/hr. In addition, assumptions were made regarding paper work, loading/unloading and waiting time. In the departure terminal, a truck would have an average waiting time of one hour and 10 minutes, based on a train departing once every three hours. In the arrival terminal, the waiting time is much shorter – estimated to be 15 minutes – as it is only a question of unloading the truck from the train. Estimated travel time for railways is given

Table 7.7-1: Railway Crossing Time

	Passengers	Freight vehicles
For all options	About 1 hour	About 2 hours and 45 minutes

7.7.2 Roads

Time costs are function of: (i) the characteristics of vehicles, especially in terms of their capacity; and (ii) the travel time in the different transport scenarios.

Based on traffic counts in Palestine, it is assumed that a car carries an average of 2.6 passengers and a large bus carries an average of 20 passengers, out of a capacity of 50. No passengers are assumed for trucks. In terms of crew, there is one driver for each of the commercial vehicles: (i) large bus; (ii) medium truck; and (iii) heavy truck.

Transport time is also linked with the average speed along the 45 km road. The average speed assumed is : (i) 110 km/hr for cars; (ii) 100 km/hr for large buses; (iii) 90 km/hr for medium trucks; and (iv) 80 km/hr for heavy trucks. Since there will be no waiting time at the border crossing, the overall time for the trips are shown in the table below:

Table 7.7-2: Road Crossing Time by Vehicle Type

	Car	Large Bus	Medium Truck	Heavy Truck
For all options	24 minutes	Less than 27 minutes	Less than 30 minutes	33 minutes

7.7.3 Value of Time

In deciding which route to take and which mode to use, travel time plays an important role in a person's decision. From the economic perspective, time represents a cost. Travel time affects the transport costs for passengers and for cargo and for crew. Consequently, it needs to be considered in any evaluation of alternative alignments and modes of transport[6].

Passenger Travel Time: The first step in calculating the cost of time is to determine the hourly value of passenger time; the distinction between working and non-working time is an important aspect of valuing time. Work related travel comprises all sorts of business and work activities and

[6] / Note that because the value of time is an economic concept, the costs used below are economic costs.

is normally valued at its full cost. Valuing non-work related travel is more complex since it encompasses leisure journeys, social visits, personal business errands, school and health related trips, and etc; only a portion of this time is considered to have an economic value.

The value of time is estimated based on an average yearly income in Palestine of US$ 4,314[7] and a working hypothesis of 2,300 working hours per year. Passenger working time is worth US$ 1.87 per hour.

Accounting for non-working time is trickier; leisure travelers still would rather spend less time traveling, and are often willing to pay "something" in order to save time. How much a person is willing to pay usually depends on an appreciation of his/her wealth and therefore on income. It is common practice among transport economists to assume a value of personal time related to the individual's income. A common and conservative assumption is to take the value of non-working time at 25% this of working time.

Value of Time of Cargo: To determine the value of cargo shipped via the West Bank Gaza Transport Link is more complicated, due to the limited amount of information available, the diversity of cargo transported and time sensitivity of different types of products. For example, perishable cargo such as tomatoes can be extremely sensitive to time as its value is closely correlated to how it looks and to its freshness. The cost of delays for computers, other "high valued" or technologically sensitive goods can be substantial for the simple reason that "time is money", and that businesses might depend on the shipment's arrival to survive. On the other hand, some products that are kept in storage for periods of time such as grains are not time sensitive during their transportation. It is assumed that on average 50 percent of the cargo is time sensitive and, as elsewhere in this study, its value is US$ 1,200 per ton[8]. The time cost is assessed at a yearly interest rate of 12 percent. Based on these assumptions, the time value of cargo is 8 cents per hour for medium trucks and 13 cents per hour for heavy trucks.

Vehicles: The time value of vehicles that is a function of the time when it is not idle and available for work based average life of vehicles, its costs and the interest rate. A straight-line amortization method was used to determine the value of the vehicle per hour. The assumptions made regarding the value of the crew, the vehicles and the cargo are illustrated in the table below

Table 7.7-3: Time-related Costs

Cost	Car	Large Bus	Medium Truck	Heavy Truck
Passengers – work related	1.87	1.87	1.87	1.87
Passengers – non-work related	0.47	0.47		
Cargo per hour			0.08	0.13
Crew	1.10	1.85	1.85	1.85
Vehicle	0.17	0.81	0.55	0.72

Source: Consultant's estimates

[7] / From selected ratios in remaining West Bank & Gaza Strip by Economic Activities 2003. Palestine Central Bureau of Statistics.
[8]/ Construction & Transportation Research Center. An-Najah National University, 2005.

In comparing the different modes, the road alternatives and then the combination of road and railways have the lowest time costs followed by all the rail only alternatives. The direct tunneled Alignments 7 and 8 have lower costs that at grade or ground level alternative – Alignments 1 and 2. A more detailed analysis regarding cost of time can be found in Section 8.3.3 in the following Chapter.

CHAPTER 8

COMPARISON OF THE ALTERNATIVE TRANSPORT LINKS

8.1 Overview

This chapter evaluates different alternative alignments to give decision-makers a factual and common basis with which to compare them. The comparisons are as simple and quantitative.

8.1.1 Characteristics of the Projects

The basic characteristics of the alternatives are their total length, length in Israel, and land area required to accommodate the infrastructure in Israel and Palestine. In addition, there are the environmental and social impacts to consider during construction and in use.

From the perspective of the donors, that is, the organizations that are likely to finance the construction of the transport link, the initial investment costs of the different alternatives are of considerable interest. From the perspective of the Palestinian economy, the recurring operating and maintenance costs and the user costs of each alternative are of greater concern.

8.1.2 Analytical Perspective – What are costs?

Costs can be evaluated in several ways and even what is considered a cost to an individual user or worker may or may not be considered a project cost. For instance, costs are what one pays, or they might be the costs of foregone opportunities if an action is not taken.

Costs That Are Considered: Costs are divided into two broad categories:

- Initial Investment costs; and
- Recurring costs.

The main distinction made between them is that the initial investment costs come prior to the operation of the transport facility. Recurring costs occur year after year once the project is completed; they vary from year to year. As discussed in Chapter 7, the initial capital costs cover the following activities:

- Preliminary designs, environmental, archeological, cultural and other studies for project preparation, and permitting,
- Final design and contract document preparation,
- Land acquisition,
- Construction,
- Equipment acquisition,
- Project management and construction supervision;
- Security infrastructure (not considered in this study).

Recurring costs include:

- Agency or the organizational costs associated with the operation and maintenance of the infrastructure.
- Various user costs including the operating costs of the trains or the vehicle operating costs, and
- Time costs.

There is a distinction between financial and economic costs. Simply put, the financial costs are what is actually paid to obtain the goods or services including all taxes and subsidies. Economic costs are the actual opportunity costs to society as if there were no distortions caused by taxes, subsidies, pollution, or restrictions on types of economic activities.

Allocation of Costs: As with most transnational projects, the analytical perspective is not easily determined. In the case of the West Bank Gaza Transport Link, it is further complicated since a least-cost solution might not be the selected alternative due to political reasons. Furthermore, a large proportion of the initial investment cost is most likely to be given as a grant[1]. An indication of the allocation of costs is given below in Table 7.1-1.

Table 8.1-1: Indicative Allocation of Costs

Type of Cost	Palestinian Economy	Borne by Donors	Israeli Economy	Comments
1. Initial Capital cost				
Various Studies		Yes		
Final Designs		Yes		
Land Acquisition		Yes		Might be considered as an input provided by the beneficiaries
PM & CS(1)		Yes		
Construction		Yes		
Equipment		Yes		
Security infrastructure				Not considered in this study.
2. Recurring costs				
Operation of infrastructure	Yes			By agency
Maintenance of infrastructure	Yes			By agency
User costs of various types	Yes			By various types of users
Security infrastructure			Yes	Not considered in this study.

Notes: (1) Project management and construction supervision.

The direct beneficiaries of the proposed project will be the Palestinians. Indirectly, the Israel will benefit from the project. The main point of the table is that the Palestinian economy will have to bear most if not all of the recurring costs associated with the operation and maintenance of the proposed transport link but not the initial capital costs unless it is loan, which it would be obligated to repay.

For the purpose of this analysis, only the recurring costs are measured in terms of their impact on the Palestinian economy.

[1] In the case of the USAID, any financing of the transport link will be a grant. For the World Bank, it is assumed that whatever is not financed through USAID would most likely be a concessionary loan for reconstruction and for development of the Palestinian economy.

8.2 General Characteristics of Each Alternative

8.2.1 Length

By happenstance, Alignments 1 and 2 are the same length, 44 km for the road alternatives, and 43.3 km for the rail alternatives. The length for the rail options only includes mainline distances and does not include additional track that will have to be built in the West Bank and Gaza Strip for the terminals (otherwise the distance is also 44 km, as for the road options).

The tunnel alternatives are shorter, but they are not substantially different from at grade alternatives. The completed bored tunnel, Alignment 8, is ranked 1 by length only at a total length of 37.8 kilometers. A summary of the total distance and distances in Israel and Palestine is given in Table 8.2-1 for the 11 options evaluated.

Table 8.2-1: Comparison of the Length of Each Alternative

No.	Alignment & Mode Designation	Length in Kilometers					Ranking Shortest Length
		Israel	Palestine			Grand Total	
			Gaza	West B	Subtotal		
1	1Road	42.0	0.6	1.4	2.0	44.0	4
2	1Rail	42.0	0.6	0.7	1.3	43.3	3
3	1Combine (1)	42.0	0.6	1.4	2.0	44.0	4
4	2 Road	42.0	0.6	1.4	2.0	44.0	4
5	2 Rail	42.0	0.6	0.7	1.3	43.3	3
6	2Combine (1)	42.0	0.6	1.4	2.0	44.0	4
7	2 Road (Partially Sunken)	42.0	0.6	1.4	2.0	44.0	4
8	7 Rail (C&C + Bored Tunnel)	37.8	0.6	0.5	1.1	38.9	2
9	8 Rail (Bored Tunnel)	36.4	0.6	0.5	1.1	37.5	1
10	9 Rail (IR + Bored Tunnel)	52.3	0.6	0.5	1.1	53.4	5
11	10 Rail (IR + At grade)	52.2	0.6	0.7	1.3	53.5	6

Notes:

(1) The distance differs slightly between road and rail; the longer of the two is used.
(2) C&C = cut and cover and IR = Israel Railways.

8.2.2 Land Acquisition Requirements

The land required to build each alignment has been estimated. The “at grade” alternatives involve the greatest use of land in Israel. In contrast, the rail alternatives require the most land in Palestine because of the two terminals; the largest one is located in Gaza and the smaller one is in the West Bank.

Table 8.2-1: Comparison of the Areas Required for Land Acquisition of Each Alternative

No.	Alignment & Mode Designation	Area in 1,000 square meters					Rank Least Area
		Israel	Palestine			Grand Total	
			Gaza	West B	Subtotal		
1	1Road	3,800			Marginal	3,800	7
2	1Rail	1,900	600	400	1,000	2,900	5
3	1Combine (1)	4,250	600	400	1,000	5,250	10
4	2 Road	3,550			Marginal	3,550	6
5	2 Rail	1,800	600	400	1,000	2,800	4
6	2Combine (1)	4,100	600	400	1,000	5,100	9
7	2 Road (Partially Sunken)	4,100			Marginal	4,100	8
8	7 Rail (C&C+Bored Tunnel)	Marginal	600	400	1,000	1,000	1
9	8 Rail (Bored Tunnel)	Marginal	600	400	1,000	1,000	1
10	9 Rail (IR + Bored Tunnel)	200	600	400	1,000	1,200	2
11	10 Rail (IR + At grade)	1,130	600	400	1,000	2,130	3

Notes:

(3) The distance differs slightly between road and rail; the longer of the two is used.

(4) C&C = cut and cover and IR = Israel Railways.

Not surprisingly, the tunnel alternatives (Alignments 7 and 8) are ranked first. The amount of land required in Israel for these alignments are negligible. The Combined Road/Rail alternatives (Alignments 1 and 2) require the most land and are respectively ranked 10 and 9.

8.2.3 Traffic

For similar modal alternatives (road only, rail only or combined road/rail), the traffic levels are equivalent so there is no differentiation among the different alignments on the basis of traffic. See Chapter 2 for the traffic forecasts.

8.2.4 Travel Time

Based on the analysis in Chapter 7, travel time by car will be less than 30 minutes; this will be substantially less than the average estimated crossing time by rail of one hour. The big difference will not be the journey time – it will be shorter by rail – but there will be added times needed to walk into the station purchase the ticket and walk to the boarding spot on the platform. Since trains will depart once or twice an hour, there could be long waits until the train departs. Likewise, on arrival, there will be additional time to walk from the platform to waiting private or public transport. Likewise for freight transport, travel by rail will take longer.

8.2.5 Time to Completion

The time to complete the alternatives was discussed in Chapter 7, and the schedule for each alternative is found in Annex 7.1. Road and Rail Only alternatives will take approximately the same duration. The shortest project duration is Alignment 10, which makes use of Israel Railways infrastructure on an interim basis and which has its eastern section built as ground level railway. Table 8.2-2 summarizes the time to completion. The difference in time between the alternative with shortest (Alignment 10) duration and the one with longest, Alternative 7 which is the cut and cover and bored tunnel alternative, is 3.5 years.

Table 8.2-2: Comparison of the Time to Completion

No.	Alignment & Mode Designation	Start Date	End of Construction	Time in		Rank Shortest	Time Saved in Years
				Days	Years		
1	1 Road	01/01/07	11/20/14	2,880	7.89	2	0.75
2	1Rail	01/01/07	11/20/14	2,880	7.89	2	0.75
3	1Combine (1)	01/01/07	11/21/16	3,612	9.89	4	2.75
4	2 Road	01/01/07	11/20/14	2,880	7.89	2	0.75
5	2 Rail	01/01/07	11/20/14	2,880	7.89	2	0.75
6	2Combine (1)	01/01/07	11/21/16	3,612	9.89	4	2.75
7	2 Road (Partially Sunken)	01/01/07	04/02/16	3,379	9.25	3	2.12
8	7 Rail (C&C + Bored Tunnel)	01/01/07	08/22/17	3,886	10.64	6	3.50
9	8 Rail (Bored Tunnel)	01/01/07	05/22/17	3,794	10.39	5	3.25
10	9 Rail (IR + Bored Tunnel)	01/01/07	05/22/17	3,794	10.39	5	3.25
11	10 Rail (IR + At grade)	01/02/07	02/20/14	2,606	7.13	1	0.00

8.2.6 Environmental Impacts

A final ranking of alternatives will be completed for the Draft Final Report once critical additional data is received from government officials. However, the analysis conducted can already provide guidance into which alternatives are the most problematic from the environmental point of view, and which are more feasible if mitigation measures are adopted during both construction and operation of the alignments.

Construction Impacts

- The Sunken Road option causes the highest impacts across all factors evaluated both during construction and operation of the alignment
- At-grade roads (Alignments 1 and 2) show similar construction impacts although due to nature reserve crossings Alignments 2 displays a higher impact importance in the plains than Alignment1
- Alignments 1 and 2 show higher impacts over landscapes and biological corridors than over nature reserves, forests and streams.
- There is a slight tendency for lesser impacts with increases in topography height. The plains show the highest impacts, followed by the hills region, and the mountain areas.
- All 4 “surface” alternatives evaluated (Alignments1, 2, and 7) have similar impacts on the planned Biosphere to be established in the Plains.
- Alternative Alignment 8 showed the lowest localized environmental impact of all alternatives (except when considering potential impacts of discharge of excavation material outside the study area).

Operational Impacts (Enclosed Alignment)

- In general terms operational impacts are lesser than those expected during construction activities (except for Sunken Road alternative which continues to show high impact importance).
- When compared to construction related impacts, Alignments 1 and 2 showed higher impact importance over forests, nature reserves, and other protected habitats. This is primarily due to noise and emission pollution, as well as the space fragmentation due to enclosed alignment.
- When compared to construction related impacts, Alignments 1 and 2 showed lower impact importance over stream alteration during operation of the alignments.
- Once in operation A-7 produces the same impacts than that produced by Alignment 8 (bored-tunnel).

Operational Impacts (Open Alignment)

- Main differences observed in the analysis originate in the higher fragmentation produced by a fenced alignment when compared with an open one. However, open alignments also offer access of general public to areas previously restricted and problems with wildlife crossings over roads, creating higher levels of ecological disturbances.
- No difference expected for alternatives Alignments 7 and 8.

8.2.7 Social Impacts

The main social impacts of the project, as discussed in greater detail in Section 7, involve compensation for land appropriation, as well as the disruption of economic activities in Israel and proximity of the alignments to the main population centers in the study area. Of the four alignments still under consideration, Alignment 7, the Bored Tunnel and Rail Option, (C&C + Bored Tunnel) have the smallest adverse social impact.

The tunnel requires the least appropriation of land and would only minimally interfere with economic activities in Israel. Alignment 7 partially uses existing rights of way, reducing the need for land appropriation and the disruption of economic activities in Israel. The main drawback of the rail alignment is that it passes in close proximity to developed areas in Kiryat Gat. Due to their lower social impact during the construction and operation phases, these two alignments were favored by a number of Israeli social and transportation experts.

Alignments 1 and 2 will have a greater adverse social impact than Alignment 7 or the cut and cover and bored tunnel option due to the increased requirements for land appropriation. Both of these alignments pass close to developed areas in Israel. Alignment 2 passes close to Sderot, but avoids Kiryat Gat, while Alignment 1 passes close to both cities, including an area in Kiryat Gat currently under development. These alignments will also have a negative impact on economic activities in an area of Israel suffering from high rates of unemployment and poverty. Great care will need to be taken to ensure that these alignments do not impair access to economic opportunities, as well as educational and health facilities.

8.2.8 Cultural Resources

Figure 9.7.1, based on map data from the IAA, shows where cultural resource investigations have been conducted along each corridor. Table 8.2-3 lists nine previously recorded archaeological sites and the corresponding alternative and station where the sites are located. Alignments 1, 2, and 4 each affect four to six archaeological sites, and Alignment 8 impacts two sites. However, additional information from the IAA on cultural sites and surveys is pending and will show additional cultural sites along each alternative. Approximately 50 percent of each alternative has not been surveyed, and there is a high potential for unrecorded cultural sites in each alternative.

A surface survey of archaeological sites and recordation of significant standing structures will be required for the selected alternative, including the bored-tunnel alternative where there are concerns for the stability of surface ruins and structures during construction and operation of the railway. At this stage, it is difficult to assess the cost for the cultural resources survey of any given alternative. Driving factors in the cost of survey will include the amount of previously disturbed ground within each alternative and the amount of previous archaeological survey. The cost of survey is unlikely to be dramatically different between alternatives because the length of the alternatives is roughly equal, ranging from 38.9 to 44.0 kilometers.

Additional costs to evaluate cultural resources and mitigate impacts from construction and operation of the transportation corridor can be expected for the alternative selected. Until the results of the initial survey are available, the additional costs for any given alternative cannot be estimated.

TABLE 8.2-3

CULTURAL SITES IN STUDY AREA AND APPROXIMATE STATIONING

Site Name	Alignment 1	Alignment 2	Alignment 7	Alignment 8
Tel Beror	Sta. 1265	--	--	--
Tel Ma'aglan	Sta. 1470	Sta. 2475	--	--
Tel Eter	Sta. 1520	Sta. 2520	--	--
Tel Goded	Sta. 1550	Sta. 2550	--	--
Horvat Kefar Bish	Sta. 1600	--	--	--
Horvat Kefa Seora	--	Sta. 2265	Sta. 7565	--
Tel Sheqer	--	--	Sta. 7330	--
Tel Lachish	--	--	Sta. 7470	Sta. 8470
Horvat Lehen	--	--	Sta. 7530	Sta. 8530

8.3 Cost Comparisons

8.3.1 Initial Investment Costs

The detailed discussion of the development of these costs and the assumptions utilized is found in Chapter 7. This chapter summarizes these initial capital costs so that they may be compared as shown in Table 8.3-1.

Table 8.3-1: Ranking by Initial Investment Costs

No.	Alignment & Modal Designation	Construc-tion Cost	Total Cost	Rank by Total Cost	Rank by Construc-tion Cost
1	1 Road	199.12	249.32	3	4
2	1 Rail	232.80	439.02	6	5
3	1 Combine (1)	378.47	549.28	8	8
4	2 Road	188.57	227.74	1	2
5	2 Rail	235.79	437.58	5	6
6	2 Combine (1)	376.27	536.49	7	7
7	2 Road (Partially Sunken)	193.69	236.39	2	3
8	7 Rail (C&C + Bored Tunnel)	1,161.50	1,371.28	10	10
9	8 Rail (Bored Tunnel)	1,656.92	1,878.34	11	11
10	9 Rail (IR + Bored Tunnel)	765.57	970.09	9	9
11	10 Rail (IR + At grade)	158.64	351.33	4	1

Notes: 1. C&C = Cut and cover.
2. IR = Use of Israel Railways' infrastructure as an interim alternative

Alignment 2 - Road Only has the least total cost and is ranked one. This is due to its slightly lower land acquisition cost compared to Alignment 1 – Road Only even though its construction costs are higher than those of Alignment 1. In terms of construction costs, Alignment 11, rail alternative, has the lowest costs. The highest total costs and construction costs are associated with the rail tunnels.

8.3.2 Recurring Costs

As indicated above, the recurring costs of operating and maintaining the transport link will be borne by the Palestinian economy. As such the treatment of these costs are analyzed differently than the financial costs, that is, the actual costs paid by the consumers of the services and goods purchased. Adjustments to these financial costs are made to reflect the real social costs to the economy. For instance, taxes are removed, and the opportunity cost of goods traded is determined. The Consultant using generally accepted procedures developed by the World Bank and other multilateral donors has done this analysis. The total recurring costs borne by the Palestinian economy consists of:

- Roads:

- Maintenance and other costs borne by the Road Agency;
- Vehicle operating costs as described in Chapter 7;
- Time costs for passengers and cargo.

- Railways:
  - Operation and maintenance costs borne by the railway operator;
  - Time costs for passengers and cargo.

To compare these costs, since they vary from year to year, they are discounted to obtain their present values over the life of the project.

Table 8.3-2: Comparison to the Present Value of the Recurring Costs (in million of US $)

No.	Alignment & Modal Designation	Operating and Maintenance Costs	Vehicle Operating Costs	Time Costs	Total Recurring Cost	Rank by Total Recurring Cost	Additional Recurring Cost (3)	Initial Investment Costs	Total Project Cost	Rank by Total Project Cost
1	1 Road	2.0	207.7	45.3	255.1	8	161.4	91.1	124.6	3
2	1 Rail	47.8	3.8	81.2	132.8	3	39.0	106.5	209.8	5
3	1 Combine	24.8	113.2	53.4	191.4	5	97.7	147.8	234.0	7
4	2 Road	2.0	207.7	45.3	255.1	8	161.4	86.3	112.1	2
5	2 Rail	47.8	3.8	81.2	132.8	3	39.0	107.9	208.1	4
6	2 Combine	24.8	113.2	53.4	191.4	5	97.7	147.0	226.2	6
7	2 Road (Partially Sunken)	1.4	172.4	37.3	211.0	7	117.3	79.2	105.1	1
8	7 Rail (C&C + Bored Tunnel)	33.7	2.8	57.8	94.4	2	0.7	424.2	507.7	8
9	8 Rail (Bored Tunnel)	33.7	2.8	57.1	93.7	1	0.0	676.7	771.3	9
10	9 Rail (IR + Bored Tunnel)	N/C	N/C	N/C	N/C	N/C	N/C	N/C	N/C	N/C
11	10 Rail (IR + At grade)	N/C	N/C	N/C	N/C	N/C	N/C	N/C	N/C	N/C

Note: 1. N/C = not computed since recurring costs were not analyzed for Alignments 9 and 10.
2. The relatively high discrepancy in operating & maintenance costs between: (i) sunken road at road at grade; and (ii) rail with tunnel and rail at grade is due to different starting dates and discounting values. In effect, present value costs are more heavily weighted against early completing projects than for projects that have long gestation periods.
(All compared to the cheapest option.)

Recurring costs are highest for the road options (and to some extent to the road & rail combined options). The table above includes the present value of the investment costs to show the almost reverse ranking between these capital costs and the recurring costs. In other words, the higher the initial capital costs are for the transport infrastructure, the lower the recurring costs are; this analysis bears this out. For these transport projects, there is a clear tradeoff between high investment costs and low operating costs.

8.4 Benefits

The implementation of the proposed West Bank Gaza Transport Link will have a positive impact on Palestinian society and its economy by assisting with national integration through providing uninterrupted access between the West Bank and Gaza Strip, and by improving economic efficiency through reduced transport costs for goods and people. Under these circumstances new developmental and employment opportunities will occur. For most transport projects, the economic benefits are estimated, and the project is evaluated in terms of its net present value or economic internal rate of return.

As a transport investment projects, the West Bank Gaza Strip transport link does not lend itself to conventional economic analysis. This is mainly due to the difficulty in estimating and quantifying the economic benefits. Under normal conditions, benefits are measured as the difference between all the transport costs incurred "with" and "without" the project. The difficulty for this project is estimating the benefits in the "without" scenario. Transport costs are artificially high for non-economic reasons; likewise traffic levels are low or non-existent for the same reasons. Estimating economic benefits under these conditions would be unrealistic. For these reasons, the scope of work did not require to assess the project using standard methods of economic evaluation.

8.4.1 Economic Development Opportunities.

Even when traveling between the Gaza Strip and the West Bank is possible – which is not presently the case – it is expensive and consumes a great deal of energy for whomever whishes to undertake the journey. Furthermore, it is impossible to know for sure if the trip will actually be feasible or not, adding an element of uncertainty extremely detrimental to businesses of all size and shape. Many economic activities are restrained and hindered by the obvious lack of transport system and their costs increase.

The improvement to the transport system between the West Bank and the Gaza strip are therefore likely to induce an increase of outputs by regional industries. Although the quantification of the magnitude of such an increase is difficult to assess, it is likely to be significant due to the large deduction in transport cost and time. Almost as important is the certainty that once the trip begins it will be completed on schedule and at a determinable cost.

Lower transportation costs will facilitate increased production and lower costs for goods and services in several ways:

- Fewer resources are utilized to transport a given amount of goods and services allowing the resources that are saved to be used to expand operations – hired additional workers, buy new equipment, etc. and
- Entrepreneurs, producers and workers will be able to expand operations increasing production or enter markets that were inaccessible when transportation costs were high;
- Inventories can be reduced;
- Greater competition results from easier entry into markets causing established enterprises to low prices to remain competitive.

The economic opportunities caused by renewed optimism can trigger a macroeconomic cycle as economic conditions improve resulting in:

- Increased business related investments;
- Reducing or preventing further emigration;
- Better employment, social and cultural opportunities; and
- Increased consumption levels.

8.4.2 Assessing the Benefits

To assess the economic benefits derived from a transport project, a comparison of the costs that society would incur "with" and "without" project is made and the project with the least costs is generally the economically preferred choice. In the case of Palestine, the "without" project conditions are so atypical and they do not lend themselves to economic analysis. Clearly, all the alternatives, once implemented, will bring about a large improvement in the economic situation in Gaza and the West Bank. The best assessment of the relative benefits among the different alternatives is to compare their recurring costs. The most economical alternative is the one with the lowest recurring costs. On this basis, it would appear that a rail alternative would be the best. Between the two at grade alignments, Alignment 2 would probably be the preferred one; not on the basis of cost but because it would have the least impact on the environment. Of all the alternatives, Alignment 8 has the lowest recurring costs and would be most provide the most benefits to the Palestinian economy based on only an assessment of the transport costs. However, over the long term, infrastructure has a finite life and eventually has to be renewed. In the case of the tunnel alternatives this would incur the greatest future cost for the Palestinian economy.

CHAPTER 9

ENVIRONMENTAL CONDITIONS AND IMPACTS

9.1 Introduction

This section of the report describes the existing environmental, cultural resources and socio-economic conditions as identified during the course of this study; and includes data collected between November 2005 and January 2006. It provides an environmental analysis of the selected alignments and the environmental factors that played a central role in the adjustment of the proposed routes as they were being developed by the transport engineers in conjunction with environmental experts.

It is important to emphasize that both Israeli and Palestinian Governments did not provide all the available official information/data on time to complete this report. Consequently, some sections of this report include secondary information obtained from interviews with academic institutions, un-official interviews with Israeli and Palestinian government officials, information obtained from various electronic sources and reports, and professional judgment from observations during site visits.

The comparative impact analysis of the selected alternatives was conducted once the alignments and engineering options were developed in more detail.

The evaluation of the alternatives also take into consideration the central role conservation of open spaces, wildlife, and biodiversity, plays for the Israeli population, NGOs, and the Israeli Ministry of Environment. As an example, the recently published "The Red Book of Threatened Species in Israel – Vertebrates" was used as part of the evaluation of alternatives, since it provides an important measure of the critical condition of Israel's local fauna and emphasizes the need for protection as well as mitigation measures for future habitat alteration. In addition, in a final environmental evaluation, a close analysis of alternatives should take into consideration the extensive scientific data on the wildlife of the study area, as well as full official consultation with Israeli and Palestinian experts and Government officials.

Avoidance of nature reserves, forested areas, water bodies, wildlife bottlenecks (known areas heavily utilized as a passage by wildlife) and other critical habitats was used to reshape proposed alignments and to screen selected alternatives. However, the presence of wildlife is not limited only to the nature reserves and parks; wildlife is also known to exist in anthropogenically-modified areas such as agricultural fields and production centers, environments in which they sometimes thrive as well as in the wilderness. Impacts to areas such as existing biological corridors cannot be avoided since they usually run in a North-South direction and almost all potential alignments cross these areas from west to east. However, mitigation measures can be developed to reduce potential environmental impacts as long as they address the biological requirements of each assessed species. For some species the continuity of biological corridors is crucial for their survival. Other species are highly dependent on site-specific habitats and consequently susceptible to adverse effects at the local level.

In spite of its small size, and due to its geographic location, Israel plays a pivotal role in inter-continental biota migration, allowing for a rich variety of fauna and flora with greater biodiversity than other countries in the region. In reality, faunal migration patterns and the progressive advance of species along biological corridors create a condition where the country as a whole can be considered a "biodiversity spot". In general terms the guidelines of the Israeli government are to direct development outside the biological corridors so they can continue providing conduits for the passage of animals. The preliminary screening and alignment adjustment conducted for the WBG Connector took these guidelines into consideration and tried to minimize crossing of corridors. However, in many cases this avoidance or minimization of crossings was not possible, and the necessary mitigation plans should be developed for the final design of alternatives.

Streams and watersheds in the region are scarce but also the main source of water for wildlife. Habitats used by migratory species are usually concentrated almost exclusively in the vicinity of water bodies such as lakes, ponds, and running streams. Consequently, reducing proximity to these areas was a key driver in the establishment of alignments. The aim was to select alignments with the fewest stream crossings. To achieve this Berger's engineers designed alignments to run as much as possible along streams and developed crossings in areas where the topography of the terrain allows for implementation of better mitigation measures.

Future environmental impact studies to be developed for the selected alternatives should take into consideration the National Biodiversity Strategy and Action Plan under development. Simultaneously, the National Master Plan on Open Space will become a Law and consequently all future planning and development (including the designs of final alternatives for the West Bank and Gaza Connector) will be subject to its provisions.

9.2 Environmental Factors Affecting the Selection of Alignments and Alternatives

Although costs of construction, length of alignments, and other engineering limitations were the determining factors in the selection, rejection, or modification of an alternative, the environmental factors that were considered during this study included, among others:

- Avoidance of nature reserves, national forests, and other sensitive habitats
- Minimization of alignment crossings over streams
- Compliance with environmental regulations (National and International)
- Landscape considerations (visual effects, free wildlife passage, open spaces)
- Minimization of impacts to biological corridors and biological bottlenecks
- Minimization of impacts to planned biosphere within Israeli territory
- Maximal possible distance from optimal habitats (water sources) for migratory species (birds)
- Maximal possible distance from cultural resources sites
- Maximal possible distance from population centers
- Minimization of road crossings (social impact)

Similarly to many road development projects it is expected that the proposed West Bank – Gaza Transport Connector will cause direct and indirect environmental impacts, as well as positive and negative ones. Although security and legal issues were out of the scope of this project, certain considerations (such as the possible need of a fence for at-grade road segments) were evaluated since they represent primarily negative effects for humans and wildlife crossing. On the Palestinian segments there would be primarily positive impacts associated with the construction and operation of the transport corridor since it would open traffic flow between both Palestinian territories and increase economic development. From the point of view of wildlife passage, the connector, both in Israel and in Palestine, can negatively affect the biological corridors, wildlife movement, and agricultural activities in the region if appropriate mitigation measures are not adopted.

In addition to environmental guidelines and concerns expressed by Israeli and Palestinian Agencies and the evaluation of drivers discussed in this report, the study took into consideration those guidelines developed by the World Bank for the development of roads. An environmental sensitivity list for road development is provided in Table 5.1 below:

Table 5.1 Environmental Sensitivity (Roads and the Environment - A World Bank Handbook. 1997)

Urban centers	Dense urbanization	Strong sensitivity with respect to noise and changes in rights-of-way
	Sparse urbanization	Strong sensitivity to noise and changes in rights-of-way
Industrial zone	Commercial activity	Sensitive to changes in access and disruptions of interaction
Agricultural land	Good agricultural land	Strong sensitivity to severance of interactions, loss of land, groundwater alterations, and erosion
	Medium grade agricultural land	Strong sensitivity to severance of interactions, loss of land, groundwater alterations, and erosion
	Tree plantations	Vulnerable to alterations in groundwater flow
Natural habitats	Undisturbed flood plain	Valuable wildlife habitat. Sensitive to changes in water flow and quality
	Woodland Slope	Susceptible to erosion
	Significant ecosystem	Harbors rare or especially sensitive species, and as such is vulnerable to any modification
	Valuable wildlife habitat	Sensitive to encroachment and alterations in water flow and quality
	Mixed forest	Sensitive to disturbance of wildlife, alterations in groundwater flow, and encroachment
	Hunting reserve	Sensitive to disturbance of wildlife
	High-use animal corridor	Threatened by high traffic volume
	Secondary faunal corridor	Threatened by high traffic volume
	Valuable spawning grounds	Very sensitivity to changes in water quality and flow
	Good fish habitat	Sensitivity to changes in water quality and flow, access important for fishing
	Drinking water source and protective perimeter	Sensitive to contamination and alteration of groundwater flow
	Cultural heritage site	Sensitive to vibration, uncontrolled access

9.2.1 Other Environmental Concerns

Other environmental concerns evaluated through the implementation of this project included:

- Land use and development policies and controls
- Use of Natural/Depletable Resources
- Urban Quality
- Conservation
- Noise
- Other Infrastructure Systems
- Aesthetics and landscapes

These and several other factors have been accurately defined in the planning document prepared by more than 250 Israeli leading professionals (under the supervision of a joint inter-ministerial committee) that during a period of more than 6 years prepared a non-statutory master plan called Israel 2020. This important document constitutes today the backbone master plan for all local, regional, and national plans developed by the Israeli government, and it directs future development according to the principle of concentrated dispersal. This means that the Government's approved development is dispersed nationally but concentrated regionally (Ministry of Environment's website, 2005). The increased development seen in the central region of the country in recent decades is causing an environmental and socio-economic imbalance in which open spaces are being eliminated and economic development focuses in the central region. Consequently, Israel 2020 redirects development to the North and South of the country to decrease socio-economic disparities and preserve open space in the central region.

9.3 Objectives and Requirements

The objective of this Study is to provide USAID with information that resulted from an analysis of the environmental conditions of the area to be affected by the construction and operation of the transport corridor, and to provide a pre-feasibility screening level of alignments that will assist in focusing these studies and subsequent EIA for this corridor.

9.4 Project Description

The project assesses the feasibility of a transport corridor linking the West Bank and Gaza Strip. Berger is evaluating three basic transport links:

1. Road-Only Alternative
2. Rail-Only Alternative; and
3. Multi-Modal Alternative

In addition, a Sunken Road alternative was evaluated for a segment of an alignment, as well as cut-and-cover and bored tunnel options.

Although the primary decision-making variable recommended was "cost effectiveness", there will be inevitable trade-offs because of externalities associated with each alternative. The criteria for an initial screening of the alternative corridors were:

- Shortest Distance
- Connection with Existing Points
- Minimum Interference with Israeli Activities

9.5 Existing Environmental Conditions

9.5.1 Site Visits

From the environmental point of view the site visits conducted in the area of the proposed alignments revealed the presence of typical rural settings with scattered populations, forested areas, nature reserves, and a number of streams many of which originate in the Judean Hills and discharge into the coastal plains and ultimately the Mediterranean Sea.

Many of these streams are only seasonal in nature but, nevertheless, they play an important ecological role. Consequently, the usual impacts associated with stream or nature reserves crossings, elimination of certain amounts of agricultural land, the ecological fragmentation of these lands, and, in certain cases, the physical separation of landowners from part or most of their properties, were also evaluated. Since the study area also includes scattered population centers, and the proposed alignments will cross several of the access roads to these centers, the effects on communication between population centers was also addressed in the socio-economic evaluations to be implemented under this study.

Examples of visited areas can be observed in the following photographs:

Figure 9.1– Erez Crossing – This site is located at the entrance to the Gaza Strip and shows an active stream (Nahal Shikma) running along the Northern border of Gaza and into the Mediterranean Sea. Although a small stream, it has a high ecological value and it has been

declared a protected habitat. Ecosystems like this one will require efficient mitigation measures to reduce potential impacts.

Figure 9.2 and 9.3 - Beth Gobrin area – Valley shown above includes agricultural lands, National Jewish Fund (NJF) forested areas (far right), and bush habitats on the side of the existing road. New road adjacent to existing road will require compensation of land loss or other mitigation measures. Below is the Beth Gobrin archeological site.

The Beth Gobrin valley is an important crossroads for alternatives selected during this study. Alternatives 1, 2, and 3 use this passage into Hebron.

Figure 9.4 and 9.5 - Shikma Creek – This reach of the creek is located in between two Kibbutzim lands (Or-Haner and Bror Hail). Although dry during the site visit, this is one of the most important streams of the region, its watershed was delineated with the purpose of establishing the Shikma Park (Master Plan was developed in August 2005 by the Shaar HaNegev Regional Council) under is the protection of environmental laws. Below it is possible to see the portion of Shikma Creek in the border between Israel and Gaza near Route 4.

Figure 9.6 – Dorot-Shikma – This area is known for being important agricultural land. Crossings by the alignments will require implementation of sets of mitigation options including land-loss compensation, habitat restoration, habitat compensation, etc.

9.5.2 Interviews of Government Officials (Bio-regions, Wildlife Passages, and other Environmental Concerns)

On November 16th, 2005, a meeting took place with Israeli government officials at the Nature Reserves and National Parks Authority (Ministry of Environment / MOE). Dr Yehoshua Shkedi (Head of the Ecological Department), and Dr. Reuben Ortal (Science Division), were interviewed in order to obtain information for this study. These officials provided valuable data regarding the existing ecological conditions of the area, and also provided recommendations and names for interviews at other government agencies.

According to Dr Shkedi, the Israeli Nature Reserves and National Parks Authority focuses its activities at two ecological levels: a) The protection of rare and endangered species, and sensitive habitats; b) Protection of large ecosystems and biological corridors that help preserve large populations and genetic pools.

Dr Shkedi emphasized the concerns of the Israeli Government that the proposed Connector not only avoids nature reserves and other sensitive habitats (e.g. Shikma watershed) but also that measures be taken to minimize impacts to the region's biological corridors and wildlife bottlenecks, as well as the planned Biosphere to be developed by the MOE. The difference between a Nature Reserve and Biosphere Reserve resides in the flexibility of the system to preserve both natural processes and human interests. Biosphere reserves are areas of ecosystems, which are internationally recognized within the framework of UNESCO's Program on Man and the Biosphere (MAB). To be recognized as a Biosphere Reserve the area must meet a minimal set of criteria, having: a) a conservation function, to preserve genetic resources, species, ecosystems and landscapes; b) a development function, to foster sustainable economic and human development, and c) a logistic support function such as support demonstration projects, environmental education and training, and research, etc.(UNESCO, 1995). In addition, it should contain three elements: one or more core areas, a clearly identified buffer zone, and a flexible transition area, or area of cooperation (between economic interests, conservation needs, and NGOs and responsible agencies). Israel is creating "Biospheres" with the purpose of protecting ecosystems of special ecological value and restoring the area's historical biota. An important one has been created on the Carmel Mountain Range. A new Biosphere proposed by the MOE extends in a broad area between Beth Shemesh (northern limit) and Lahav (southern limit). Its importance in the eyes of the general public and the MOE is rapidly growing, to such an extent that 9 settlements proposed by the current Prime Minister Sharon Government have been stopped for having an adverse effect on the proposed location for the Biosphere.

The Israeli-Palestinian region is centrally located in the pathway of various historical ecological migration patterns and can be classified (from the zoogeographic point of view) according to 4 main faunistic and floral distributions, which cross the area through existing biological corridors or bio-axes. These corridors run primarily in a North-South direction however, several passages extending east to west are also located within the area of the proposed Connector. The importance of these corridors is that they represent 4 different types of fauna and flora historically linked to other regions in Africa and in Asia (Israel is known to play an important role as a transit station for migratory birds and as a migration route for other fauna and flora from Africa to Asia and vice-versa). In addition, an endemic biota component also exists in the region. These endemic populations and 4 eco-regions include the:

1. ***The endemic component:*** comprised of some of the species of flora and fauna that have remained in this country and its vicinity from prehistoric times when climatic conditions were different from those prevailing today.

2. ***The northern (Mediterranean) component*** is especially significant in Israel's world of flora and fauna and encompasses species that exist along Israel's Mediterranean coastline. These species may have invaded this area from the north at a relatively late period, when present climatic conditions began to stabilize in this region, along with the development of the evergreen scrubland.

3. ***The steppe (Irano-Turanian) component*** originated in the upland areas northeast of Israel.

4. ***The desert (Saharo-Arabian) component*** is prevalent in the Negev from which point it reaches northward in two arms: along the strip of coastal sand dunes and into the Dead Sea and Jordan Valley.

5. ***The equatorial (Sudanese) component*** includes a number of species, which originated in the forests and savannahs of Africa.

It is recommended that the Israel Ministry of Interior's Planning Division and his Chief Mr. Shamai Assif be consulted during future evaluations. This agency is in charge of all infrastructures planning for the entire country and has developed a 20-year development plan, which should be taken into consideration during the development of final corridor alternatives.

On November 23th an unofficial meeting took place at the Ministry of Environment (MOE) offices in Tel Aviv. The meeting with Ms Valery Brachya (Director Planning Division of the Ministry of Environment) provided crucial information on the necessary regulatory and approval process required for any recommended alternative, the main concerns and critical issues as seen by the Ministry, and the main objections the Division might have in siting and design issues. Ms. Brachya presented the land use planning process and the two main approval paths the Connector might undergo. The first option might be to evaluate this project at the National level simply as a road. A second path is also at the National level but seen as a multiuse project. This means that the National Board Planning will be in charge of establishing a special multi-ministry committee in charge of reviewing and approving the project (Committee for National Infrastructure). More specific information is provided in the socioeconomic section of this report.

In both cases the required Environmental Impact Assessments are very similar with variations depending on which specific studies a member of the Committee might require. Consequently, each project has specific guidelines that are defined after the project is submitted to the Board. If the first option (path) is selected, then the Ministry of Environment would be in charge of directing the EIA requirements and would also review the submitted documents. In case the second path is selected, the structure and contents of the EIA would be decided by the National Planning Board which would hire a consultant. This consultant then would submit a report to the Ministry of Environment's representative at the National Board.

Among the main environmental concerns expressed by the Ministry were:

- USAID should consider not only the protection of established nature reserves and critical areas, but also the issue of fragmentation or landscape continuity of "Open Spaces" which is of great political relevance nowadays in Israel. Open Spaces are important not only for migratory wildlife but also for aesthetic values for the Israeli population, particularly trekkers, wildlife supporters, and for recreational values for families. Any design that restricts free movement of people will not be seen positively. Consequently, they think that a tunnel or a "cut-and-cover" option are the most feasible ones.
- A Connector alignment that cuts Israel from West to East (e.g. continuous sunken road or at-grade road) will encounter much opposition from the Ministry (quote: "…Totally Unacceptable…").
- Designs of wildlife passages are not seen as a sufficient measure to mitigate fauna's movement restrictions. This problem was already observed during the design of Highway #6 which included engineering measures that did not mitigate the problem. As an example, although some of these wildlife passages are significantly wide (up to 500 meters), and some mid-size or large mammals "learned" to use them, predators also adapted to this new environment and in some cases they establish "prey-traps" at the end of a passage.
- Contrary to early information (which indicated that the Government of Israel is interested in the shortest alignment possible to reduce security exposure surface area), the Ministry of Environment indicated that they will be in favor of an alignment that puts environmental considerations ahead of length.

- The Ministry recommended assessing all the environmental considerations and solutions developed for Segment # 18 of Highway 6. They see this segment as a good model for replication.

In order to overcome the problem of habitat fragmentation in Israel, the Nature Reserves Authority and the Jewish National Fund have cooperated on a so called “Open Landscapes Plan” for Israel. Extensive geographical and lithological data, collected by the JNF, and botanic data, collected by the NRA, is currently being compiled, evaluated and mapped on the Geographical Information System of the NRA. The result of these efforts will be an ecosystem assessment of the remaining open natural landscapes in Israel which will include an evaluation of each area based on such criteria as unique or rare elements, biodiversity in terms of species and communities, and potential for sustainability based on size and connectivity to other areas (Nature Reserves Authority, personal communication, Nov. 2005). Although this document will not be available by the time this feasibility study is completed, efforts should be made to obtain direct information from these agencies for a final analysis and EIA for the Connector.

On November 27th the Berger Team also met with the Palestinian Environmental Quality Authority (EQA) in Ramallah. Similarly to what was expressed by Israeli agencies, the EQA mentioned their limitations in providing extensive documentation until an official communication from their central government is funneled to them. As an example, they showed us a report (Emergency Plan for Protecting Nature Reserves) that would be useful in determining areas of environmental concern within the Palestinian controlled areas. The EQA expressed their own concerns regarding the segments of the alignments that will cross through their territory. They requested that the following issues be addressed in our assessment:

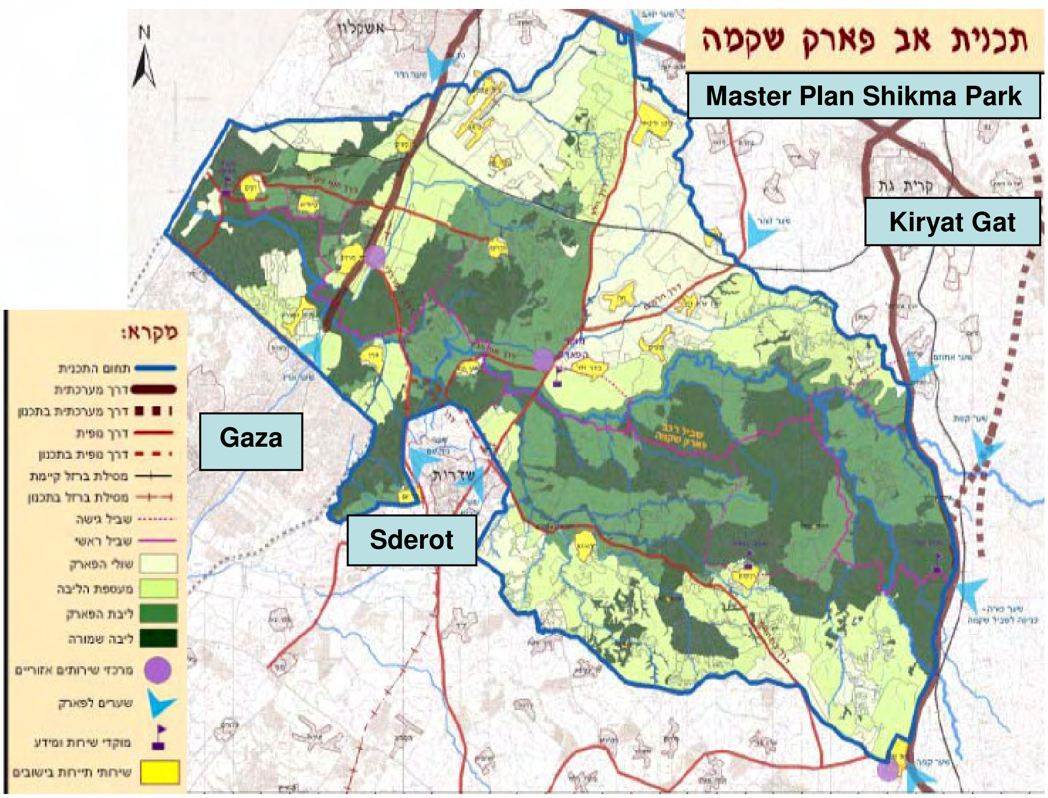
- Vehicular emissions (wind patterns moving in a west-east direction bring particulates into Hebron)
- Effects on agricultural lands, groundwater, biodiversity, and public health
- Requested avoidance of Wadi Al-Quf (there is an existing Nature Reserve there) and Khirbet Bit Khahel (archeological site)
- Effects on social life (labor, communications, fragmentation of local communities)
- Noise pollution
- Landscape (concerns about aesthetics and its relationship to and harmony with local villages)
- Open Spaces. They are concerned about the free passage of Bedouins and their herds on their way to pasture lands.
- Concerns about affecting the drainage of rainwater from West Bank to Gaza
- Concerns about deposition of excavation material and where it will be located.

On Tuesday, January 24th, Mr Alex Riley and Dr. Ariel Cuschnir met with the Head of the Shaar Hanegev Regional council, the Mayor Alon Schuster, and his Treasurer, Mr Shimon Keren-Tzvi (the Coucnil’s engineer joined the meeting later).

At the meeting we presented a brief description of the purpose of our visit, our study, and the need to obtain their feedback in relation to this project.

Mr. Schuster first introduced the Regional Council area on an orthophotograpic map. This included a description of the population distribution, overlook on jobs, occupations, and industries in the area that might be affected by the alignments, environmental issues, and other:

- In general terms, he did not see potential for significant impacts that might disturb the normal functioning of community lives and employment (as long as proper mitigation measures are implemented during construction). However, he did express his concerns on a variety of regional issues, mainly environmental and future regional development plans.
- The main partners of this regional council (10 Kibbutzim, 1 Moshav, the town of Sderot, as well as PM Sharon's ranch) are interested in developing the industrial capabilities of the region through the creation of 2 industrial centers and a multi-use Shikma Park. The industrial centers will be located one at the Karni cross and the other at the Erez cross, and will be utilized for processing goods and other businesses. The Karni Cross Center will be located just east of the border, while the Erez center was planned to be located East of the old rail alignment.
- They mentioned their concerns regarding the potential adverse environmental effects of the project on the planned Regional Najal Shikma Protected Watershed Park (approved on August 2005 by the central government). This protected area is oriented to protect the entire Shikma watershed through a strict implementation of the Shikma Park Master Plan and its related regulations and guidelines. Simultaneously, the purpose is to transform the Park into a multi-use habitat to include approved businesses, nature trails, archeological sighting, etc. Below is a map describing the location and potential development elements planned for the Park.



Source: www.ios.org.il/site/pdf/Shikma_3.pdf

Symbols:

Dark green: Nature Reserve
Light Green: Buffer area (certain businesses/industries allowed)
Blue line: Park Boundaries
Light blue arrows: Park entrances
Purple circles: Services to visitors
Purple line: Trekking path

- The Council is interested in preserving "Open Spaces" and to have "focused" developments either in spots or just expansion of existing settlements rather than creating new ones. An example of this approach is the construction (in existing towns and kibbutzim) of new housing for former Gaza Settlers.
- They will see as a positive action the development of the rail alignment (e.g. railroad) along existing alignments. As an example they see the potential for a railroad in a North direction along Route 4 and then East along the existing Israeli railroad or along route 35.
- The Mayor also inquired if the alignment can be located in a more southern position (although we did not present a map of our alignments his description coincided with our original alignments 3 and 4).
- They also expressed their preference for a combined design that will include rail alignment (along existing ones) and "tunnel" options (either tunnel or "cut-and-cover").

9.5.3 Environmental Regulations and Guidelines

This Environmental Progress Report takes also into consideration national and international guidelines used for road development projects. Since the majority of the corridor will be located on land under the jurisdiction of Israeli law, most of the regulatory considerations are those related to the State of Israel.

In Israel the environmental legislation covers important topics such as the protection of nature and natural resources, the control and safe treatment of contaminants, pollutants, and other nuisances, and legislation related to development projects that are also strictly controlled by the Planning and Building Law in order to promote sustainable development. The purpose of this report is not to provide a detailed description of all environmental laws and regulations developed by Israel, but to point out many that play a direct role in the determination of the siting, design, and construction of the preferred alignment. As new regulations are being developed and since the final Ministerial jurisdiction of this project is yet to be determined (will it be under the responsibility of a National Commission or an Infrastructure Commission) it is difficult to clearly establish which regulations will play a more central role in the decision-making process. A complete description of relevant regulations will be provided as information becomes available.

Some of the principal laws are described below:

- Planning and Building Law (1965) (updated in 2003)
- Planning and Building Regulations (Environmental Impact Statements) (1982; updated in 2003)
- Wildlife Protection Law of 1955 (updated in 2003)
- Roads (Affixing of Signs) Law, 1966 (updated in 2003)

- National Parks, Nature Reserves, National Sites, and Memorial Sites Law, 1998 (updated in 2003)
- Abatement of Nuisances Law, 1961 (updated in 2003)
- Abatement of Nuisances (Unreasonable Noise from Construction Equipment) Regulations, 1979 (updated in 2003)
- Abatement of Nuisances (Unreasonable Noise) Regulations, 1990
- Abatement of Nuisances (Unreasonable Noise) Regulations, 1992 (updated in 2005)
- Water Law, 1959 (updated in 2003)
- Streams and Springs Authorities Law, 1965
- Water Regulations (Prevention of Water Pollution), 1991 (updated 2003)
- Water Regulations (Prevention of Water Pollution)(Gasoline Stations), 1997 (updated 2003)
- The Forests Ordinance of 1926
- The Antiquities Law of 1978

In addition, Israel is signatory to a wide array of international environmental conventions which would be evaluated for compliance for this project. These include biodiversity and chemical related conventions:

- Convention to Combat Desertification
- International Convention for the Protection of New Varieties of Plants
- Convention Concerning the Protection of the World Cultural and Natural Heritage
- Convention on the Conservation of Migratory Species of Wild Animals
- Convention on International Trade in Endangered Species of Wild Fauna and Flora
- Convention on Wetlands of International Importance Especially as Waterfowl Habitats
- Convention on Biological Diversity
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
- Endangered Fauna (IUCN)

The following environmental planning principles were developed by the Government of Israel (MOE) and were considered during the final screening of alignments as well as the design of the alternatives:

- Using environmental resources wisely and efficiently, promoting conservation, and preventing irreversible damage to resources through planning, technological and economic measures
- Preventing processes and plans that threaten to cause irreversible and irreparable environmental damage
- Minimizing environmental damages and impacts
- Responding to building and development needs while directing most of the development to urban fabrics and minimizing suburbanization processes
- Minimizing damage to open space and preserving land reserves for future generations while protecting nature, landscape and heritage values and the rural character of agricultural settlements
- Distinguishing between areas appropriate for development and areas worthy of conservation and accentuating the continuity of open spaces

- Improving urban fabrics through renewal processes and relatively dense building and infrastructure development while emphasizing public transport, which is adapted to urban development
- Refraining from planning solutions that merely move a problem from one place to another instead of treating it
- Encouraging planning and technological solutions to environmental problems through prevention, removal or reduction at source
- Applying the precautionary principle when confronting environmental problems.
-

9.5.4 Physical Environment

Partial description of the physical environment is described in Section 3 of this report (Selection of Alignments). Additional maps will be provided once detailed information is obtained from various Government agencies and presented in the Draft Final Report.

9.5.5 Natural/Biological Environment

9.5.5.1 Wildlife and Endangered/Protected Species

The current status of vertebrate fauna in Israel is clearly defined in the "*Red Book of Threatened Species in Israel – Vertebrates",* which was published in 2002 (in Hebrew) by the Nature and Parks Authority and the Society for the Protection of Nature in Israel. An English version was published in 2005. The book provides an important measure of the critical condition of Israel's local fauna (see Table 5.2) and emphasizes the need for protection as well as mitigation measures for future habitat alteration.

	Documented Species	Extinct Species	Endangered Species	Percent of Endangered Species
Mammals	104	9	57	62%
Amphibians	7	1	5	83%
Reptiles	103	3	35	35%
Stream & lake fish	32	6	6	23%
Nesting birds	206	15	39	20%

Table 9.2 – Status of Biodiversity and Endangered Species

The critical condition of many species and the areas they inhabit was already emphasized by Prof. H. Mendelssohn, one of Israel's foremost zoologists (Mendelssohn, 1988). According to this author, the biodiversity of the region has been historically high, primarily due to its strategic geographic location constituting a "bridge" between continents. The anthropogenic influence on the local wildlife has been in existence since prehistoric times but it is in recent years that the fast growth of the human population and development is creating important adverse conditions. Some of the typical animals historically found in the region were only recently extinct. The last cheetah was seen in 1958 and the last Anatolian leopards in the 1960s. Some species are still in existence today (e.g. hyenas, wolves and Arabian leopards) and their protection is of importance for the Ministry of Environment.

According to Prof. Mendelssohn, many reptile species have a very restricted geographic distribution increasing their susceptibility to extinction. An example is the lizard, *Acanthodactylus schreiberi*, which lives on sand-loam soils which are developed for agriculture and settlements, and *Acanthodactylus pardalis*, a species in the Negev that lives on loess soils that are now grain fields.

9.5.5.2 Nature Reserves, National Parks and Forests

Avoidance or minimization of crossings over or near nature reserves, national parks, and other forests (natural and planted) has been one of the driving factors that affected the design of alignments for the West Bank and Gaza Connector. This section will be fully described once official communication from the Israeli Government clearly defines the boundaries of existing and planned reserves and parks. A map describing current sites and how the alignments were designed to avoid these areas is presented and analyzed in section 9.9 of this report. A textual description of the existing nature reserves, National Parks, and forests that fall under the influence of these alignments is also included.

9.5.5.3 Biodiversity

It is estimated that the country contains some 2,500 plant species and more than 800 species of animals (amphibians, reptiles, birds, and mammals). In addition to the role Israel plays as a bridge between continents, there are also climatic reasons that enhance biodiversity. The two main climatic regions include the Mediterranean in the north and desert in the south. The area of the proposed Connector (which include the fertile Shaar Hanegev) is located just in between these two regions, providing an opportunity for the presence of a diverse fauna and flora. As an example, the area contains Asian desert species and Irano-Turanian species.

The major threats to biodiversity include habitat destruction, habitat fragmentation, invasive species, non-sustainable exploitation of natural resources, uncontrolled development, an increased demand in water resources, and pollution. Due to the importance of the biodiversity of the area, the Ministry of Environment considers this issue a primary one in its national strategy. As a consequence, it is preparing a National Biodiversity Strategy and an Action Plan, which are being prepared by a joint task force of government agencies. In addition, the government of Israel is currently developing and implementing action plans for the conservation of various species of fauna. These action plans are broad in scope and implemented by various government agencies. An example of such an action plan for the country’s raptors includes four components:

1. Management measures such as protection of habitats as nesting sites and establishment of feeding stations;
2. Surveys and research;
3. Captive breeding for the purpose of bolstering endangered species and vulnerable populations; and
4. Captive breeding for the purpose of reintroduction.

9.5.5.4 Biological Corridors and Bottlenecks

Biodiversity conservation is a central aim of the Israel Nature and Parks Authority. Policy documents published by the Science Division of the Authority propose that in order to conserve biodiversity, the Authority should act on two levels:

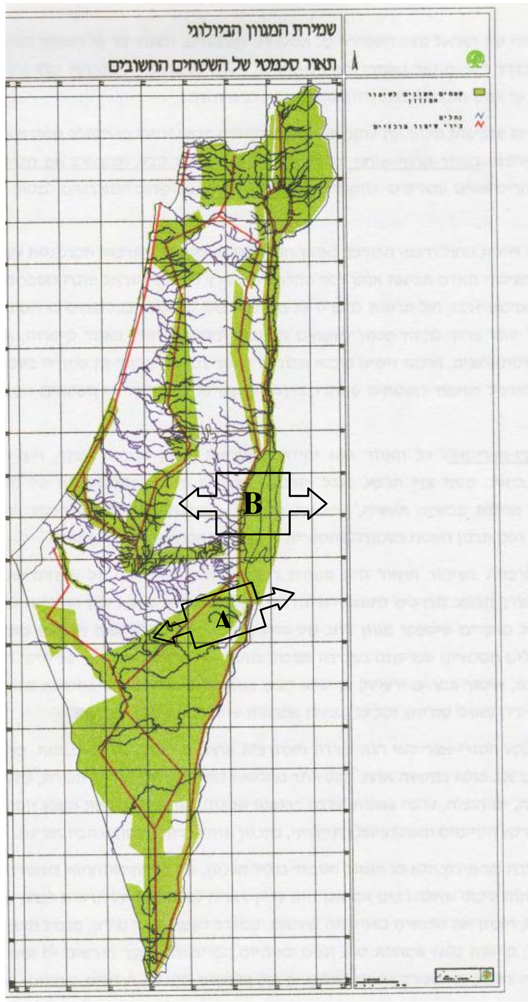
- Promote the conservation of rare species and threatened species and ecosystems that represent the biodiversity of nature in Israel, especially aquatic ecosystems and sand and other ecosystems along the Mediterranean Sea;
- Promote the preservation of large and continuous areas (corridors) that allow the well-being of large populations that exchange genetic material with neighboring populations.

Israel's fauna and flora is being severely affected by habitat fragmentation (road construction and other developments), pollution, and other adverse environmental factors. Biological corridors are those areas that play a crucial role of connecting broad ecosystems constricted by development. The protection of these biological corridors can assist in preserving the dynamics of the ecosystems they connect. Impacts to their functions can have serious environmental consequences to ecosystems that are sometimes separated by large distances. In many cases biological corridors connect legally protected spaces and open spaces and may thus connect different types of landscapes including nature reserves, forests, agriculture and rural settlements.

The idea behind the protection of these environments is to direct building and development to spaces outside these corridors and to encourage countryside recreation and open agriculture in corridor areas which are not legally protected. The protected corridors would then continue to provide conduits for the passage of animals and plants in a fragmented landscape. Based on comprehensive surveys of open spaces in Israel four major zoogeographic distribution axes were recommended for protection as ecological corridors, preferably within the framework of connectivity with biosphere reserves (Dr. Shkedi, pers. comm. 2005; Shkedi and Sadot, 2000). These include:

1. The Rift Valley. This area is under protection through cooperation with the Kingdom of Jordan
2. The Mediterranean-desert axis. This area connects 3 major biogeographically zones of Israel (the Mediterranean, the Irano-Turanean, and the Saharo-Arabian) and consequently are crucial areas for preserving biodiversity.
3. A Broken Axis along the Mediterranean Sea, which will assist in preserving the threatened ecosystems previously mentioned
4. The Desert Axis, which will assist in preserving the Negev desert.

The biota connectivity axes previously mentioned are recommended for protection by the Nature and Parks Authority and are described in the following map of the country (red lines within green natural habitats) where it is possible to observe the current areas that offer continuity and those already affected by development:



(Source: Shkedi and Sadot, 2000)

Figure 9.7 - Biological corridors and axes in Israel

As it can be observed in this map of the country, the areas between Gaza and the Negev are characterized by the presence of a broad network of streams and watersheds and a partial loss of connectivity among North-South axes (A). The MOE intends to improve this condition through the implementation of conservation programs and regional planning.

The Study Area (B) falls within critical biological axes, and it is important to take these factors into consideration when designing mitigation alternatives (wildlife passages, habitat enhancement, etc.).

A more detailed description of the biological corridors and critical areas (protected and planned forested areas) can be observed in the following enlarged map of the region (Figure 9.8).

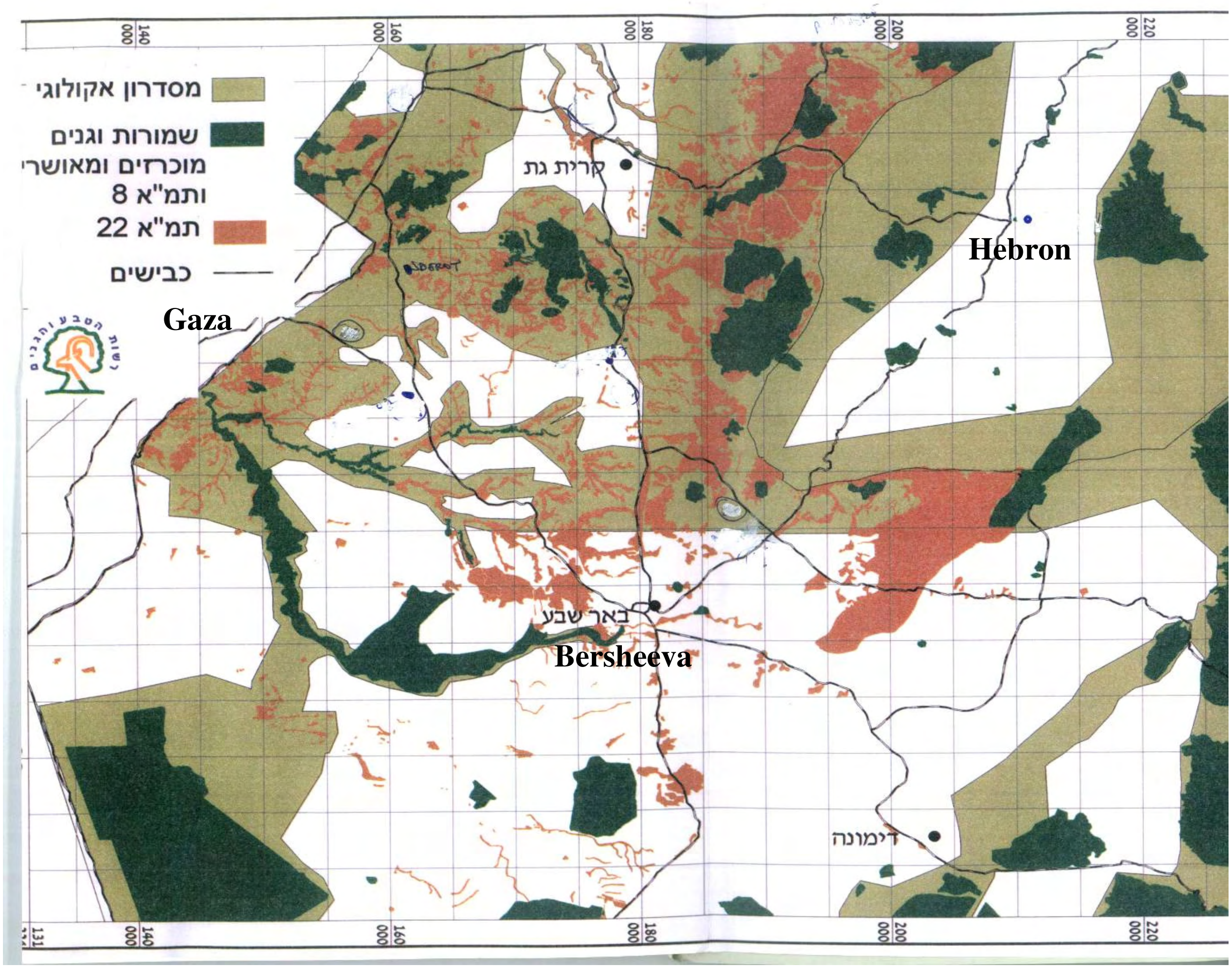


Figure 9.8 Biological Corridors and Protected Areas (Source: National Park Authority, 2002)

The map shows the biological/ecological corridors (light brown), the existing forested areas (dark green), and the proposed reforestation program (red). Due to the existence of the previously described biological corridors and their importance in the preservation of biodiversity and critical habitats, the Nature and Parks Authority conducted an in-depth investigation in order to assess the effects of development on these corridors. They identified the presence of critical passages called "Biological Bottlenecks" that serve as a bridge between constricted biological corridor areas. The elimination of these bottlenecks would cause the complete isolation of areas within a corridor and played an important role in the definition of alignments.

Several bottlenecks can be observed in the Study Area (see Figure 9.9 below).

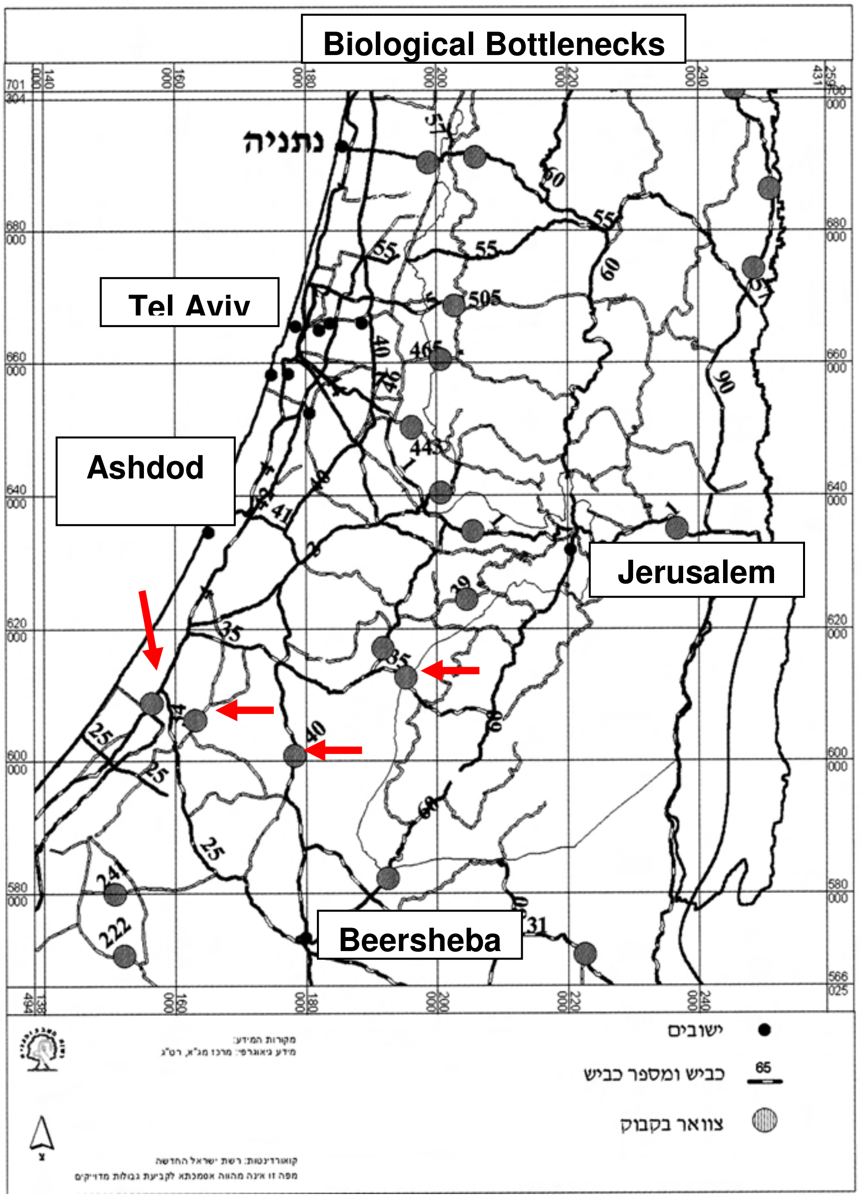


Figure 9.9 Biological Bottlenecks (Highly critical areas)
(Source: National Park Authority, 2002)

The bottlenecks shown in the map (indicated with red arrows) are areas already in critical state that must be preserved in order to avoid any habitat isolation within biological corridors.

9.5.5.5 Watersheds

Streams and watersheds in the region are scarce and influenced by the climate regime, which is usually dry during most of the summer and fall, with rains prevalent in the winter months. In recent years, water in the natural environment, as well as drinking water from wells, has been suffering a major overdraft. Annual rain averages up to 900mm/year in the north of the country and around 25mm in the southern end of the Negev. Simultaneously, in past decades, industrial discharges, over-exploitation of water resources, and poor management have created unsustainable conditions. Consequently, rivers in Israel have suffered from severe conditions that in many cases caused streams to dry up or to become much polluted.

However, "…the situation began to change in the past 15 years and particularly in 1993 when the National River Administration was established…" (Source: Israel Ministry of Environment's website). The role of this administration is multiple, including: inter-governmental coordination for activities that have a direct or indirect effect on Israel's streams; management of restoration and conservation activities, as well as renovation of historic sites along river banks. In order to effectively coordinate the activities of various government agencies this Administration includes representatives of the Ministry of Interior, Tourism, Environment, National Park Authorities, the Jewish National Fund (which among other activities has a large program for reforestation along rivers), and the National Infrastructures (water commission). Due to its important role, it is crucial that any final design of alignment and alternatives that will cross over streams or creeks be developed in coordination with this Administration.

9.5.5.6 Migratory Species and their Habitats

Open spaces and water sources are key habitats used by migratory species (particularly birds), which use Israel as an international corridor for migration. Israel is a crossroads for intercontinental bird migration on a North-South axis. The conservation of these habitats is of crucial importance for the successful migration of these species. Many migratory birds depend almost exclusively on these habitats as a source of water and resting stations. During seasonal migrations it is possible to observe resting stations concentrated almost exclusively in the vicinity of water bodies such as lakes, ponds, and running streams. Other factors affecting biota migration include habitat reduction and fragmentation; disturbance; pollution and pesticides.

As a signatory member of the Convention on the Conservation of Migratory Species, Israel prepares (voluntarily) updated reports on the presence of these species. The Israel Nature and National Parks Reserve Authority is the responsible government Agency. The environmental laws under which this Agency regulates its activities and has the authority to preserve these migratory species are:

Wildlife Protection Law, 1955 (as amended in 1990)
Plant Protection Law, 1956
Water Law, 1959
Streams and Springs Authorities Law, 1965
Planning and Building Law, 1965
Prevention of Marine Pollution by Oil Ordinance, 1980
Planning and Building Regulations (Environmental Impact Statements), 1982
Prevention of Marine Pollution (Dumping of Waste) Law, 1983
Prevention of Marine Pollution from Land Based Sources Law, 1988

Hazardous Substances Law, 1993
National Parks, Nature Reserves, Memorial Sites, and National Sites Law, 1998 (first enacted 1963, revised 1992 and 1998) ("the Nature Reserves Law")

Other Conventions that Israel is signatory to and oblige the country to protect migratory species and their habitats include:

Convention on Wetlands of International Importance ("Ramsar Convention")
Convention on Biological Diversity
Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention)
Convention on Climate Change
Convention on International Trade of Endangered Species of Wild Fauna and Flora ("CITES")
World Heritage Convention
Convention to Combat Desertification

The national policy instruments available to the Nature and Park Authority include:

National protected areas: nature reserves and national parks.
National Strategy for the Conservation of Nature and
Biodiversity
National Plan for the Conservation of Bats

In the Period 2000-2001 the Nature and Park Authority reported the following information on sightings of migratory birds:

<u>Birds Observed Nesting or Transient in the Region</u>

Pelecanus crispus – Common Name(s) Dalmatian Pelican
Pelecanus onocrotalus – Common Name(s) White Pelican
Anser erythropus – Common Name(s) Lesser White-fronted Goose
Branta ruficollis – Common Name(s) Red-breasted Goose
Marmaronetta angustirostris – Common Name(s) Marbled Teal
Aythya nyroca – Common Name(s) Ferruginous Pochard/Ferruginous Duck
Oxyura leucocephala – Common Name(s)White-headed Duck
Halaeetus albicilla – Common Name(s) White-tailed Eagle
Aquila clanga – Common Name(s) Spotted Eagle
Aquila heliaca – Common Name(s) Imperial Eagle
Falco naumanni – Common Name(s) Lesser Kestrel
Vanellus gregarius – Common Name(s) Sociable Plover
Numenius tenuirostris – Common Name(s) Slender-billed Curlew
Larus leucophthalmus – Common Name(s) White-eyed Gull
Larus audouinii – Common Name(s) Audouin's Gull
Serinus syriacus – Common Name(s) Syrian Serin

Some of these species were observed during the winter waterfowl census and it is important to emphasize that there is a possibility that they may be two distinct wintering and breeding populations. Some populations are showing a clear decline in numbers. In the case of *Falco naumani* (lesser Kestrel), the survey done in the year 2000 showed an estimated 550 nesting pairs, approximately 10% of the population in the 1950's.

An important study on the critical status and importance of Israel and the West bank as a biodiversity spot and migratory crossroad for inter-continental migration was prepared by USAID in 2005. In it the Agency identifies the risks and threats to biodiversity of the region, as well as existing conditions.

9.6 Social Analysis

9.6.1 Objectives and Requirements

The objective of the preliminary social analysis presented in this section is to identify the most significant potential social impacts of the proposed alignments, as well as to provide USAID with a description of the social and economic conditions of the area most directly affected by project activities. The social analysis also suggests ways to mitigate adverse social impacts and provides recommendations in Section 7.3.8 for a full social impact analysis, as a component of the future feasibility study conducted to determine the final alignment. It should be noted that USAID does not have specific requirements or guidelines for the implementation of preliminary or full social impact assessments, as is the case for the World Bank (WB) and the Asian Development Bank (ADB).

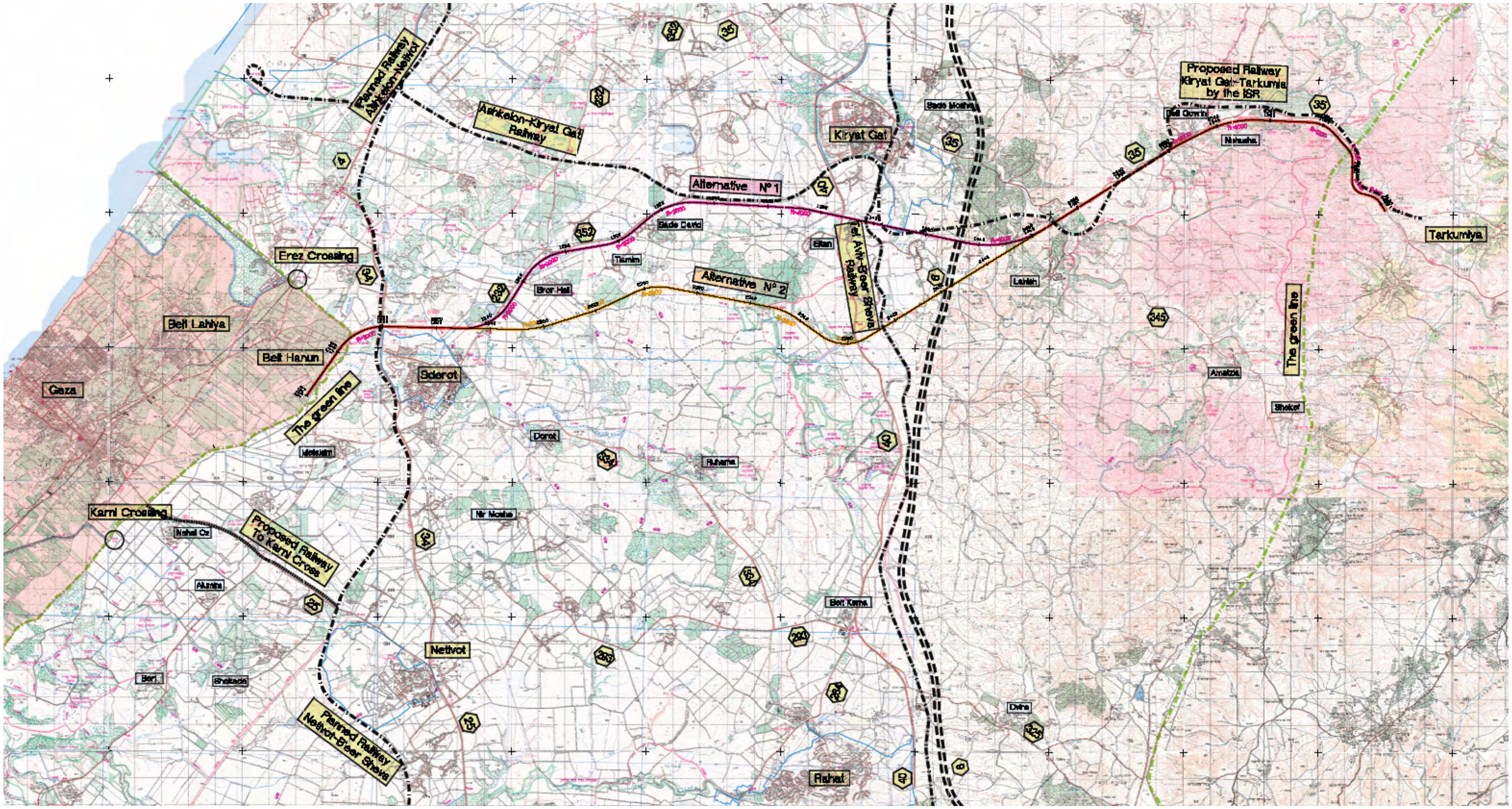
9.6.2 Introduction

While the Gaza Strip-West Bank Connector Project will create important economic and social benefits described in detail in other sections of this report, the project will also produce a number of adverse social impacts. The social analysis provides a preliminary analysis of the main social impacts of the different alternatives proposed for the Gaza-West Bank Connector Project. The negative social impacts of the project, in both the construction and operation stages, must be minimized to ensure the successful completion of the project.

The proposed road, rail or combined road and rail alignments cut across mainly agricultural land currently under cultivation by Kibbutzim and Moshavim, while skirting several small cities including Sderot and Kiryat Gat. The urban areas affected by the proposed alignments have a high incidence of poverty and unemployment rate relative to Israel as a whole. In order to improve the area’s economy, the Government of Israel (GOI) currently offers special incentives for businesses that establish operations in Sderot and Kiryat Gat in order to spur economic growth and create employment opportunities. In the agricultural areas surrounding the proposed alignments, many of the kibbutzim are undergoing a slow and ongoing process of partial privatization, in some cases after struggling financially. Therefore, it is critical that the final alignment minimizes interference with economic and agricultural activities. Alignments should also avoid areas set aside for future industrial and commercial development where possible.

The overwhelming majority of the land affected by the proposed alignments is owned by the GOI and then leased for agricultural purposes. The proposed alignments also affect owners of private property, primarily in the Beit Hanun area in Gaza and in the West Bank where the alignments terminate. Compensation will have to be paid to both lessees and to property owners and will be determined based on the procedures used by the GOI and the Palestinian Authority (PA). Conflicting land claims among private land owners are not expected to be a significant issue and there are both legal and traditional mechanisms used in the PA for resolving land disputes.

Figure 9.6.1 Social Analysis Study Area Map



9.6.3 Definition of the Study Area

The study area for the social analysis is defined as the area and surrounding communities most directly affected by the proposed alignments. The rough boundaries of the study area are shown in Figure 7.3.1 on the following page and include a corridor from Gaza to Tarkumiya, as well as the communities of Sderot and Kiryat Gat. The study area for the social analysis has been defined as a narrow corridor, rather than a 15 kilometer zone of influence on each side of the alignment, since there will be no access to the alignment for the Israeli population and access will likely be tightly controlled in the Palestinian Authority.

9.6.4 Social Factors Affecting the Selection of Alignments/Alternatives

The following social factors affecting the selection of alignments and alternatives are listed below in order of relative importance. The discussion of the social factors is based on the site visit to the study area, secondary data collected in Israel and in Washington DC, information provided by Tedem Engineers and Universal Group and key informant interviews conducted with officials from the GOI, representatives of a Regional Council, academia and NGOs.

- **Resettlement and Compensation.** While many of the alignments use existing rights of way and avoid populated areas, compensation will have to be paid to lessees and to private owners of land. Very few structures will be affected by the alignments. Both the GOI and the PA have procedures for resettlement requiring that compensation be paid for any losses suffered by property owners. Brief overview descriptions of the compensation process for the GOI and PA are provided in Section 7.3.7.

- **Distribution of population and industrial/commercial/agricultural activity relative to the proposed alignments.** All of the various experts and Government officials interviewed expressed a strong preference for the use of existing alignments, where feasible, in order to minimize the project's impact.

- **Access to Employment Opportunities, Educational and Health Facilities.** Access to employment opportunities as well as educational and health facilities must be maintained during the construction and operation phases.

    - ***Separation of Agricultural Land.*** A number of fields will be cut by the proposed alignments, in some cases reducing the viability of farming or rendering the land completely unviable for agricultural activities.

    - ***Planned Industrial and Commercial Sites.*** Planning for commercial and industrial developments is conducted at the Regional Council level and the Sha'ar Hanegev Regional Council is currently planning industrial/commercial parks adjacent to the north and east of the Erez Crossing.

    - ***Educational Facilities.*** Sapir College, the largest undergraduate institution in Israel is located in close proximity to the proposed alignments.

- **Integration with Regional Planning and Transportation Initiatives**. The proposed alignments and measures (with the exception of the tunnel cut across the Trans-Israel Highway) will have to be taken in order to accommodate both routes.

- **Impairment of Existing Utility Lines.** Engineering solutions will have to be proposed to maintain existing power lines, irrigation and gas pipelines.

- **Degradation of natural areas used for recreation.** A number of small nature reserves and public parks are located close to proposed alignments.

- **Restriction of activities of the Bedouin Inhabitants.** Based on information from Universal Group, the there are no Bedouin Communities that utilize land needed for the proposed alignments in the Gaza Strip or in the West Bank. In addition, according to Tedem Engineers, the majority of Bedouin communities are located far enough south of proposal alignments. Therefore the project is expected to have only minimal, if any, interference with Bedouin activities.

9.6.5 Existing Social Conditions in the Study Area

Israel
The study area, as defined in Section 7.3.3, is primarily a rural agricultural area with agricultural production dominated by Kibbutzim and Moshavim. However, many of these collective farms are changing with a growing number of residents now working in the private sector outside of the Kibbutz or Moshav. A number of former settlers in Gaza have relocated to Kibbutzim in the study area, after the unilateral Israeli withdrawal from settlements in the Gaza Strip. In addition to these rural communities, there are several important urban centers including Sderot and Kiryat Gat.

The economy of the region has undergone a shift away from traditional activities in agriculture with a significant percentage of more recent employment being generated in the service and manufacturing sectors. There is also a slow process of ongoing privatization of Kibbutzim. Many of the communities in the study area are also undergoing significant structural changes including planning for new neighborhoods and additional industrial estates to attract foreign investors. Despite these developments, security remains a concern. Since the outbreak of the Intifada in September 2000, hundreds of Kassam rockets have fallen in the backyards of local houses and in agricultural fields in the study area. The Kassam attacks have intensified after the withdrawal from Gaza and after the victory of Hamas in the Palestinian elections.

Both Sderot and Kiryat Gat have seen large immigration from Jewish communities in the Arab world and the former Soviet Union. These urban areas also are poorer with a larger number of receivers of unemployment assistance and supplemental income than Israel as a whole[i].

Sderot has a population of approximately 20,000 and is a "frontline" community located a kilometer from the Gaza Strip[ii]. Unemployment in Sderot is estimated at close to 30% versus the national unemployment rate of 8.9%[iii]. Sderot is in worse shape economically than Kiryat Gat, in part due to Sderot's proximity to the Gaza Strip and the Kassam attacks, which have had a severe impact on the local economy.

Kiryat Gat has a population of approximately 48,000 and has had more success than Sderot at attracting investment[iv]. The city has an industrial manufacturing base that accounts for the employment of 43% of city residents. The main employers are Polgat (clothing), Bagil (textiles) Shiryonit (security doors and domestic doors), and Electra (food processing)[v]. In 1991, Center for Advanced Technology was built in order to attract high tech investors, a move that paid off after Intel established a factory on the city's outskirts.

Due to the economic situation in these cities, Sderot and Kiryat Gat have received the designation of "Development Zones" by the GOI and a number of tax incentives are offered for businesses that locate in these areas.

Incentives offered by the GOI include the following:

- 24% government allowance (break on municipal taxes).
- 0% corporate tax for the first two years, and only 10% corporate tax from the 3rd to the 10th year.
- Tax on expatriation of corporate dividends is only 15%.

One industrial site that has been established to take advantage of these incentives is Sapirm Industrial Park. The facility is located in close proximity to Sderot and is one of several industrial sites in the study area that will be affected by the proposed alignments. There are more than 17 operating businesses in Sapirm Industrial Park that provide employment for 600 people.

The study area also has important educational facilities including Sapir College, located in the Sha'ar Hanegev. Sapir College is currently the largest public college in Israel with approximately 7,000 students and was established in 1975. Enrollment at Sapir College is projected to increase to approximately 10,000 students by 2008.

West Bank and Gaza

Several areas under the administration of the Palestinian Authority were also included in the study area including the Beit Hanun area of the Gaza Strip and an area from the Green Line to just north of Tarkumiya. The Tarkumiya area is primarily agricultural and sparsely populated due to the relatively rugged terrain. In Gaza, the project will affect an area that includes Beit Hanun and the Erez Crossing. The areas of Beit Hanun affected by the proposed alignments are primarily an agricultural area used mainly for citrus farming.

Erez is surrounded by commercial farming operations and an industrial estate. It is one of the three main crossings that connect Gaza to the outside world and the main gateway for thousands of Palestinian workers who earn their livelihoods as laborers in Israel and is therefore critical to the Palestinian economy. The Erez Industrial Estate (EIE) is located on the northern tip of the Gaza Strip adjacent to the Erez crossing point. The EIE has expanded to cover 47 hectares and approximately 200 enterprises have been established, approximately half of them Palestinian-owned, in a wide mix of industries including textiles and garments, plastics and chemicals, wood furniture, metal working, service and repair shops[vi]. These enterprises employed more than 4,000 workers as recently as April 2004[vii]. The proposed routes must carefully consider the impact on the EIE given its importance as a provider of employment in Gaza.

9.6.5.1 Site Visit

A visit to the site of the proposed alignments was conducted on Friday January 20, 2006. The team visiting the site consisted of the Derek Sherman- Team Leader, Ariel Cuschnir- Environmental Specialist and Alex Riley -Sociologist. The team traveled the length of the proposed alignments from the Green Line to the Erez Checkpoint in Gaza.

The site visit confirmed that the majority of land in the area is presently used for agricultural purposes and that the alignments generally avoid developed areas and population centers. However, care must be taken to avoid areas planned for future development, particularly in Kiryat Gat. Construction in the southern section of Kiryat Gat was visible from the road and cut through the area of proposed alignment 1 and the existing Ashkelon-Kiryat Gat railway alignment used for the rail only option. The proposed alignments may need to be shifted south by a few hundred meters in order to accommodate planned development on the outskirts of Kiryat Gat.

Another important finding during the site visit was confirmation of the economic condition of Sderot. Very little commercial activity was observed during a brief tour of the city. The site visit was also useful for determining that several natural areas presently used for recreation purposes will be affected by the proposed alignments.

The team visited Kibbutz Or Haner, which is affected by the proposed alignments, and was able to meet briefly with one of the residents. It was very useful to hear their opinion on both the local economy, which has suffered in recent years, and changes to many of the Kibbutzim in the area due to partial privatization. Kibbutz Or Haner has experienced an influx of settlers after the Government of Israel ordered the withdrawal from settlements in the Gaza Strip.

9.6.6 Key Informant Interviews

Key informant interviews were conducted with government officials, academics as well as other members of civil society including NGOs. One difficulty encountered during the field mission to Israel (February 14th, 2006 to February 30th, 2006) to gather data was that officials representing various ministries in the Government of Israel were only willing to discuss the project on an informal basis. In addition, officials from the Palestinian Authority were unable to be contacted as elections were taking place.

One of the main themes heard from a number of individuals interviewed was the strong preference for using existing alignments in order to minimize adverse social and environmental impacts. Another preference expressed was for the use of railway or tunnel options, rather than a road.

Key informant interviews were conducted with Dr. Eliza Ephrat, University Department of Geography, Tel Aviv University, as well as Dr. Ephrahim Yaar, Department of Political Science, Tel Aviv University and Dr. Gideon Bigger, University Department of Geography, Tel Aviv University, who were able to provide historical and socioeconomic background on the study area. These interviews also helped in the identification of the main social impacts.

An interview was conducted with Mr. Alon Schuster, the Mayor of the Sha'ar Hanegev Regional Council, which highlighted the importance of coordination with the planning currently conducted at the regional council level. Mr. Schuster discussed the location of several planned industrial sites, including one located adjacent to the Erez Crossing.

Discussions were held with Mr. Yoav Sagi, Director of the Society for the Protection of Nature in Israel (SPNI) to determine the main environmental impacts. Mr. Sagi was very receptive to the project and interested in SPNI assisting in the full feasibility environmental impact assessment.

A meeting was arranged with Mr. Charlie Solomon, Vice President, Ministry of Transport to discuss social impacts, as well as land compensation and resettlement procedures. Mr. Solomon was willing to discuss the project only in an informal way and expressed a strong preference for a rail option.

Compensation and resettlement procedures used by the GOI were discussed with Mr. Joseph Steinman, Managing Director of DIUR B.P. LTD. Mr. Steinman recently retired from teaching at Tel Aviv University, where he was a professor specializing in real estate appraisal. He has experience with large infrastructure projects and was able to provide suggestions to minimize the time needed for GOI compensation and resettlement procedures.

9.6.7 Preliminary Screening of Proposed Alignments- Key Issues

Land compensation and resettlement are expected to be the most important social issues of all the social factors identified in Section 7.3.4. Therefore, an overview of GOI and PA land compensation procedures related to infrastructure projects is discussed below.

Overview of Israeli Government Compensation and Resettlement Procedures

The land tenure situation in Israel is straightforward and no disputes regarding land ownership are expected, as the GOI owns almost all of the land needed for the proposed alignments. There are a number of lengthy GOI procedures regarding land compensation for infrastructure and railway projects. Based on discussions with Joseph Steinman, there are two main phases to GOI resettlement and compensation procedures. The GOI first needs to obtain the right to confiscate the land for the project. Obtaining the approvals for this phase can take a number of years, even with only mild opposition to the project. The second phase occurs once the approval for land appropriation has been granted and the GOI will determine the appropriate compensation based on a court based mechanism. The second phase will proceed relatively quickly, as it is limited to a discussion of how much compensation should be paid, rather than if the land should be appropriated. Dr. Steinman also mentioned that for the construction of the Trans-Israel Highway (Highway 6), a special law was passed by the Knesset in order to enable the GOI to bypass the first phase of lengthy approvals and directly seize the land. According to Dr. Steinman, without this law, it would have been extremely difficult to complete the Trans-Israel Highway within a reasonable timeframe.

Without the passage of a law, similar to the Trans-Israel Highway Law by the Knesset, the following planning procedures will be followed at the national level before the land needed for the alignments can be appropriated. The process will take a minimum of up to 18 months for final approval.

GOI Approval Process for National Infrastructure Plans

Step	Time Needed
Preparation of Plan by National Planning Committee	Up to 160 days
Review Time/Incorporation of Changes	Up to 279 days
Government Debate and Discussion	Up to 100 days
Total Time Needed to Gain Final Approval	**Up to 18 months**

Overview of Palestinian Authority Compensation and Resettlement Issues

Land Tenure

The majority of the parcels in Beit Hanun and in Tarkumiya are owned by the private sector and very few, if any, of the parcels are expected to be owned by PA government entities. According to a preliminary investigation by Universal Group, the land claims situation is generally straightforward with completed registration of land. Some parcels may have uncompleted registration, however, this is expected to be a relatively minor issue. In case of land disputes, both formal and informal mechanisms exist to settle land claims. The legal system offers one means of recourse; however, claims filed in court may take a long time to be resolved. Alternately, "popular reconciliation committees" are a quicker method that have enjoyed good past success in solving land claim disputes.

Overview of Palestinian Authority Procedures for Land Acquisition and Compensation

The PA Land Acquisition and compensation procedures outlined below are not likely to cause significant delays for the project.

1. If the Palestinian Authority decides to implement the highway project, the Council of Ministers will form a committee to discuss the issues related to the project.

2. The committee will be composed of the Council of Ministers and will form the Higher Organization Council, under the leadership of the Ministry of Local Government. This council will coordinate and cooperate with the Municipalities and Local Government entities in the project area, through the local organization committees.

3. The Higher Organization Council will apply the Jordanian law No. 79 for the year 1966 for cities, villages and buildings organization and planning. In Gaza they will apply law No. 36 from 1936 (used for compensation and land acquisition since the British Mandate).

4. The law applied in the West Bank indicates that the Government has the right to acquire up to 30% of any land, for purposes including road construction. If the percent of the required land exceeds 30%, the Government must compensate the

owners. On the other hand, the law applied in Gaza strip indicates that the Government has the right to acquire up to 25% of any land. The Government needs to compensate the owners for any area beyond this 25%.

9.6.7.1 Proposed Alignments and Potential Social Impacts

Of the four main alignments still under consideration, the rail only alignment and tunnel alignments would require the least amount of resettlement and compensation. In addition, the rail only alignment would have the smallest social impact in terms of the other social factors identified in Section 7.3.4. The rail alignment follows existing rights of way for the majority of the distance between Gaza and the West Bank. The preference for the use of alignments that follow existing rights and of rail alignments way was expressed by almost every person contacted during the field mission in Israel. The use of existing rights of way would also help to minimize adverse social impacts and disruption of economic activities. The rail alignment also does not pass in close proximity to Sderot, although it does pass closer to Kiryat Gat than alignments 1 & 2.

The tunnel option would also minimize the need for resettlement in Israel, though resettlement would still be necessary in the Gaza Strip and also in the West Bank near Tarkumiya. Some compensation in Israel would be necessary for ventilation shafts and access points to the tunnel. The tunnel option was preferred by many of the individuals interviewed, as the adverse impact on economic activities in Israel would be minimized.

Alignments 1 & 2 have a significantly greater social impact as they require substantial resettlement and compensation in Israel, as well as in the West Bank and Gaza Strip. Alignment 1 uses a corridor partly defined by existing roads and a section of abandoned railway. Alignment 2, the road only option, would have the greatest adverse impact, as this alignment is slightly longer than alignment 1 and makes less use of existing rights of way. Most individuals interviewed thought there would be a substantial social impact from a road and were more receptive to the rail alternatives.

9.6.8 Recommendations for Full Social Impact Assessment and Project Implementation

- The Knesset will need to pass a law, similar to the Trans-Israel Highway Law, in order to enable the GOI to quickly appropriate the land needed for construction. Without such a law, the project will be subject to a lengthy approvals process outlined in section 7.3.7 that could take years to resolve.

- The full social impact assessment should utilize the World Bank's Involuntary Resettlement Operational Policy (OP) 4.12 and Bank Procedure 4.12. These protocols are not limited to those who hold direct rights, e.g. landowners, but cover potentially all affected users of land, where formal property rights exist or not, as well as loss of access to income producing assets.

- The full social impact assessment will also have to prepare a Resettlement Action Plan in accordance with World Bank OP 412, Involuntary Resettlement. The RAP will provide a preliminary description of affected persons, as well as a more detailed picture of land administration and land use controls.

- In addition to the World Bank guidelines for the full feasibility, the actual resettlement and compensation process will need to follow Israeli and Palestinian laws and procedures.

- Based on the discussion with Mr. Alon Schuster, Mayor of the Sha'ar Hanegev Regional Council, the full feasibility study should determine what planning has been conducted at the regional council level. This will ensure that local efforts to promote economic development in a relatively economically depressed area are integrated into the planning of the final alignment.

- Care must be taken in the construction and operation phases to ensure that the final alignment does not impair access to employment opportunities, as well as health care and educational facilities by cutting off roads.

[1] Central Bureau of Statistics. 2003.
[1] Central Bureau of Statistics. 2005. http://www.cbs.gov.il/population/new_2006/table3.pdf.
[1] Unemployment rate in Sderot from Yad Ezra VeShulamit. National unemployment rate from CIA World Fact Book (2005 estimate). http://www.cia.gov/cia/publications/factbook/index.html.
[1]Central Bureau of Statistics. 2005. http://www.cbs.gov.il/population/new_2006/table3.pdf.
[1] www.index.co.il.
[1] "Stagnation or Revival: Israeli Disengagement and Palestinian Economic Prospects". The Services Group. USAID/World Bank. December 2004.

[1] Ibid.

9.7 Cultural Resources

9.7.1 Regulations and Guidelines

Antiquities in Israel are considered to be any object made by man before 1700 of the Christian Era (CE), as well as any zoological or botanical remains from before the year 1300 CE. The Antiquities Law of 1978 (Israel Government 1978) was enacted in order to protect the antiquities of Israel, and cultural resource investigations that may be conducted in association with the proposed West Bank-Gaza Transportation Corridor will be governed by the Antiquities Law. The law is organized into the following chapters that outline the ownership, excavation, and handling of antiquities items, as well as civil penalties that can be imposed under the law:

- Chapter One: Interpretation
- Chapter Two: State Ownership of Antiquities
- Chapter Three: Excavations
- Chapter Four: Dealing in and Export of Antiquities
- Chapter Five: Collectors of Antiquities
- Chapter Six: Museums
- Chapter Seven: Antiquity Sites
- Chapter Eight: Expropriation
- Chapter Nine: Archaeological Council and Objection Committee
- Chapter Ten: Offences and Penalties
- Chapter Eleven: Miscellaneous

The Israel Antiquities Authority (IAA) was established in 1989 by the Law of the Israel Antiquities Authority (Israel Government 1989). That law states that the IAA is the organization responsible for all the antiquities of the country, including the underwater finds. The IAA is authorized to excavate, preserve, conserve and administrate antiquities when necessary, and is the agency through which all cultural resources investigations within the country, including those that may be conducted for this study, are coordinated.

Cultural heritage sites in the Palestinian Territories of Gaza and the West Bank fall under the jurisdiction of the Palestinian Department of Tourism and Antiquities. Draft Bill no. (6) of 1999 for Environment includes Article 44 banning activities that endanger "historical and archaeological sites or affect the aesthetic level of such areas" (Palestinian National Information Center 2005).

The significance of cultural heritage sites worldwide is also recognized by international conventions, particularly the International Council on Monuments and Sites (ICOMOS) Charter for the Protection and Management of the Archaeological Heritage (ICOMOS 1990) and other documents referenced therein. The provisions outlined in that charter parallel provisions contained in the Israel Antiquities Law and the Law of the Israel Antiquities Authority.

9.7.2 Interviews with Government Officials

Dr. Ariel Cuschnir, Berger Environmental Specialist, contacted Dr. Uzi Dahari, Deputy Director for Archaeology for IAA, in Israel during November 2005. He delivered a letter on behalf of the cultural resources team introducing the project and requesting IAA assistance in gathering information regarding known cultural resources in the study area. Dr. Dahari was subsequently contacted via telephone on 12 December 2005 by Thomas J. Chadderdon, Berger Senior Archaeologist, to further discuss the project. Dr. Dahari agreed to assist the team and provide data that the IAA has on file regarding known cultural resources in the study area. Information was emailed to Dr. Dahari on 16 December 2005 showing geographic boundaries of a study area that encompassed all of the alternatives. Because the study is at a preliminary stage, individual alternatives were not shown.

Digital files of maps showing the locations of archaeological surveys and sites were received from Dr. Dahari on 22 January 2006, and hardcopy of the maps were provided to Berger personnel in-country and subsequently forwarded to the cultural resources team. In a 14 February 2006 conversation with Dr. Dahari, Mr. Chadderdon was instructed to contact Dr. Yehuda Dagan, IAA GIS and Surveys Coordinator, to obtain further information on the mapped surveys and sites. Dr. Dagan has sent the information by surface mail and the cultural resources team is currently (24 March 2006) awaiting arrival of that data.

No systematic cultural resources investigation has been conducted in-country by the Berger team, and none are planned for the current level of investigation. However, based on the results of the current study and IAA policy as stated by Dr. Dahari, a recommendation will be made for an intensive investigation of the preferred alternative(s).

9.7.3 Cultural Resources

The term "cultural resources" includes individual objects of antiquity as well as antiquity sites, both of which can be expected in the study area. Antiquity sites, a term synonymous with archaeological sites, are defined as areas that are declared by the Director of the IAA to contain antiquities. Individual objects that may be found isolated from archaeological sites include, but are not limited to, items such as statuary, ceramic pots, metal tool, or scrolls. The most visible archaeological site in the study area is undoubtedly the *tel* (or *tell*), and such sites can be often be found on modern maps prefaced by that word. A tel represents hundreds or thousands of years of continuous occupation at the same location, and is an artificial mound created by the accumulate remains of ancient settlements. Tels may range in height from as little as 10-15 meters to more than hundred meters, and have a footprint that covers in excess of 10 hectares.

Archaeological sites may also be the ruins of ancient structures and settlements found on the ground surface. Such sites are frequently prefaced with the word *Horvat* on modern maps. Natural or human-made caves that were used as mortuary chambers may also be found associated with tels and ruins. Other types of archaeological sites consist of scatters of artifacts consisting of chipped stone tools and chipping debris, pottery, and metal artifacts. Extant structures including mosques, churches, synagogues, memorials, and other standing structures that are part of the cultural patrimony of the region also constitute potentially significant cultural resources.

9.7.4 Cultural Chronology

Library research was conducted in the United States to establish the basic cultural history of the region and identify well known cultural resources in the study area. It should be noted that a voluminous corpus of additional material is available in Hebrew, but was not reviewed at the current stage of investigation. The study area is part of a larger region that can be referred to as the Levant, encompassing the modern nations of Israel and Jordan, as well as Gaza and the West Bank. The cultural chronology that follows is a brief overview of a very long and complex culture history that extends back more than 1.5 million years and documents much of the human physical and cultural evolution that has occurred during that time. Table 9.1 is a chronological chart of the prehistoric and historical cultural context of the region following Stern et al. (1993). The dates in Table 1 are presented as Before Christian Era (BCE) and Christian Era (CE). Different dates may be given for periods and cultures in subregions and at individual

TABLE 9.1

REGIONAL PREHISTORIC AND HISTORICAL ARCH ARCHAEOLOGICAL CHRONOLOGY

Period	Culture	Approx. Dates (BCE)
Prehistoric Archaeological Periods		
Lower Paleolithic	Oldowan Acheulian	1,800,000-200,000
Middle Paleolithic	Levallois/Mousterian	120,000-45,000
Upper Paleolithic	Phase I (Emireh, Boqer Tahtit)	45,000-35,000
	Phase II (Ahmarian Tradition) Phase III-V (Aurignacian Tradition)	35,000-18,000
Epipaleolithic (Mesolithic)	Kebaran Geometric Kebaran Natufian	18,000-8300
Pre-Pottery Neolithic	Phase A Phase B Phase C	8300-5500
Pottery Neolithic		5500-4500
Chalcolithic	Early Phase Ghassulian Phase	4500-3300
Historical Archaeological Periods		
Bronze Age (Canaanite Period)	Early Bronze Age IA-B	3300-3000 BCE
	Early Bronze Age II	3000-2700
	Early Bronze Age III	2700-2200
	Middle Bronze Age I	2200-2000
	Middle Bronze Age IIA	2000-1750
	Middle Bronze Age IIB	1750-1550
	Late Bronze Age I	1550-1400
	Late Bronze Age IIA	1400-1300
	Late Bronze Age IIB	1300-1200
Iron Age (Israelite Period)	Iron Age IA	1200-1150
	Iron Age IB	1150-1000
	Iron Age IIA	1000-900
	Iron Age IIB	900-700
	Iron Age IIC	700-586
Babylonian and Persian Periods		586-332
Hellenistic Period	Early Hellenistic Period	332-167
	Late Hellenistic Period	167-37
Roman and Byzantine Periods	Early Roman Period (Herodian Period 37BC-70 CE)	37 BCE-132 CE
	Late Roman Period	132-324
	Byzantine Period	324-638
Early Arab to Ottoman Periods	Early Arab Period (Umayyad and Abbasid)	638-1099
	Crusader and Ayyubid Periods	1099-1291
	Late Arab Period (Fatimid and Mameluke)	1291-1516
	Ottoman Period	1516-1917

archaeological sites, but the framework presented here is broadly applicable to the entire region (Bar-Yosef 1994).

The Paleolithic is divided into three periods. During the Lower Paleolithic early species of the genus *Homo (ergaster, erectus, heidelbergensis)* making Oldowan pebble tools and Acheulian handaxes, emigrated from Africa through the Levant. An early population is known from Dmanisi in Georgia (in central Asia) and dates from about 1.8 million years BCE. The ancestors of that population must have migrated from Africa through the Levant and perhaps through the study area. Because population levels were very low and the material cultural very insubstantial, archaeological sites from this period are rare. However, Lower Paleolithic site are found in Israel and include Ubeidiya in the Jordan Valley (ca. 1.5 million years old) and Erk el Ahmar (about 1.7 to 2 million years old). Middle Paleolithic (Levallois/Mousterian) flake tools are associated with Neandertals in Israel (e.g., at Amud, Kebara) and date from about 200,000 to 50,000 years ago. There was a brief interlude at about 100,000-90,000 BCE before present when anatomically modern *Homo sapiens* intruded from East Africa into the Levant, but that population appears to have been displaced by Neandertals. A much later and ultimately successful expansion of H. sapiens into the Levant and on into Europe about 40,000 years ago is marked by the spread of Upper Paleolithic stone tools of Aurignacian type (Shea 2005).

The Epipaleolithic (18,000 BCE) was a time when wild cereals and legumes were being "managed" by people (Bernbeck and Pollock 2005:12-15). While those foods were not yet domesticates, the intensified utilization of those wild cereals and legumes provided sufficient food resources to spark the transition from a hunting-gathering way of life to settled village life that manifested in the Natufian culture. From that managing of wild foods came the eventual domestication of plants and animals and the so-called "Neolithic Revolution." By Pre-Pottery Neolithic times (8300 BCE) villages displayed an array of non-domestic structures (such as the stone tower at Jericho) and ritual artifacts that point to elaborate communal and regional ritual practices. At the end of the Pre-Pottery Neolithic period there appears to have been a collapse of the social order, perhaps brought about by climatic deterioration and over-exploitation of resources (Gopher 1995:207). The Pottery Neolithic period that followed (5500 BCE) was marked not only by the introduction of ceramic technology, but by population shifts and smaller settlements.

The Chalcolithic period (4500 BCE) was a time of increasing population and an expansion of mixed farming/herding communities into semi-arid regions (Levy 1995). Craft specialization developed, including copper metallurgy, and a size hierarchy of archaeological sites suggests that a chiefdom level of social organization tied Chalcolithic communities together. With the Early Bronze Age (3300 BCE) came the beginning of urban culture. The term implies the use of the metal bronze to manufacture tools and vessels, but in the region of Palestine that metal was not common until early in the second millennium BCE (Ben-Tor 1992:81). Early Bronze Age settlement patterns shifted from the semi-arid regions favored during Chalcolithic times to the hills, plains, and valleys of the region where a more Mediterranean climate prevailed. Gophna (1995) notes, however, that Early Bronze Age sites are found situated on top of Chalcolithic sites at locations where there was abundant water and where the land had already been cleared and prepared for cultivation.

Population growth continued through the Middle Bronze Age (2200 BCE) that coincided with agricultural intensification of agricultural, specialized craft production, and development of regional exchange systems. A hierarchy of settlements included regional centers, subregional centers or specialist production facilities, villages, and farmsteads (Ilan 1995). The Palestine region was clearly linked to Egypt by political and economic interests during the Middle Bronze Age (Kempinski 1992). Canaanite rulers became so powerful that they conquered much of Lower Egypt, ruling there from about 1720 to 1560 BCE. The Middle Bronze Age ended and the Late Bronze Age began ca. 1550 BCE when the native Egyptians overthrew the foreign rulers and Egypt was reunited under the Pharaoh Ahmose, who then began a series of military campaigns across the Sinai Peninsula (Gonen 1992). Although the military forays brought about a decline in the urban culture and population of Sinai, they also opened that region to Egyptian religious and artistic influence that manifested as changes in burial customs and artistic styles during the Late Bronze Age (Gonen 1992:257). The Late Bronze Age represents a pinnacle of cultural and economic interaction in the eastern Mediterranean basin.

The inception of the Iron Age, ca. 1200 BCE, saw the technological transition from bronze to iron as the dominant metal used for tools and weapons. International trade had collapsed at the end of the Late Bronze Age, and during the Iron Age IA period trade was much more regional (Mazar 1992). The origin of the Israelite people in the hill country dates from this period (ca. 1250 BCE), though it is not clear if nomadic invasions or the expansion of native Canaanite peasants populations play a greater role in this process of ethnogenesis. Israelite culture flourished during the united monarchy of David and Solomon, and subsequently during the divided kingdoms of Israel and Judah (Barkay 1992). The southern coastal region was occupied around 1200 BCE by the Philistines, whose origins are in the Aegean region. The end of the Iron Age is marked by the fall of Jerusalem and destruction of the Temple in 586 BCE. The Persian and Hellenistic periods that followed are marked by changes in the material culture of Palestine. In the coastal region that was formerly Philistine territory there are distinct Greek and Cypriot influences on material culture, while in the mountains of Judea and Transjordan the Israelite Tradition continued (Stern 1995).

After 100 years of independence under the Hasmoneans (140 BCE - 37 CE)), the Romans arrived and imposed an imperial government on the region. Under the so-called "*pax Romana*," however, the Judaeans continued to develop as a distinct culture (Anderson 1995). Jewish resistance to Roman rule culminated in massive, but failed, revolts in 66 CE, 115 CE (in diaspora communities), and 132 CE.

The Byzantine Period (324 CE) saw the transformation of the region from *Provincia Palaestina* when it was a remote eastern province of the Roman Empire, to *Terra Sancta*, the Holy Land (Patrich 1995) when a network of holy places, churches, and memorials was established and pilgrims flocked to the region. This led to a great increase in population, particularly the Christian population. The Byzantine period was one of economic prosperity in the region, and archaeological surveys consistently turn up a high number of settlements and religious installations from that period (Patrich 1995:473).

The Arab conquest of the Holy Land by 638 CE made Islam the dominant religious and cultural power. However, repeated military movements, internal revolts, and political instability resulted in chronic anarchy and general cultural decline (Whitcomb 1995:488). A 200-year period of Frankish rule began with the First Crusade, ca. 1099 CE, and ended in 1291 CE after the Third Crusade and the fall of Acre (Ellenblum 1995). There followed a 700-year period when the region was under the control of Ayyubid, Mameluke, and Ottoman empires (Rosen-Ayalon 1995) when the Holy Land was caught in the sway of Damascus, Cairo, or Istanbul, depending on the period. This period ended in 1917 CE with the end of World War I that saw the dismantling of the Ottoman Empire and the beginning of the modern era.

9.7.5 Known Cultural Resources

The IAA provided map data for archaeological sites in the study area. The IAA map data shows squares of various sizes that are labeled as archaeological sites. Topographic maps at a 1:250,000 scale produced by the Survey of Israel (1961) and dating to ca. 1960 were also examined for known cultural resources. Table 5.7.2 is a list of sites identified on those maps that are located along the alternatives under study. The station on the respective alternates where the site is located is also listed.

The most prominent type of site is the tel, and among the most prominent of tels in the study area is Tel Lachish; Alternates 7 and 8 pass near the site. Lachish covers some 12 hectares at the edge of a wadi that, in antiquity, was a major route from the Coastal Plains to the Hebron Hills. Several wells provided water for the city, and the city was surrounded by fertile land. Each of those factors contributed to the development of a major urban center. Excavations began in 1932, the most recent worked ended in 1981. Occupation at the site began in the Pottery Neolithic period and extended through the Hellenistic period.

Bet Gurvin is an archaeological site and National Park in the northeast part of the study area; the east end of Alternates 1 and 2 run just north of the site. The site flourished during the Roman period. The site includes an amphitheater, a Roman inn, a Crusader-period church, a Mameluke period fortress, and spectacular hewn caves that served as burial chambers, water cisterns, and olive presses.

9.7.6 Data Gaps

We are currently (24 March 2006) awaiting additional information from the IAA. The data are expected to include detailed information on cultural resource investigations and recorded archaeological sites along the alternatives. The information to be obtained from the IAA is also expected to cover those potions of Gaza and the West Bank that will potentially be impacted by any of the alternatives (see Figure 9.7.1).

9.7.7 Selection and Screening of Impact Drivers for Screening the Alignments and Future Alternatives.

9.7.7.1 Known and Expected Cultural Resources

Table 9.2 is a list of nine archaeological sites shown on topographic maps (Survey of Israel 1961) that are located along the alternatives under study. The station along each alternative where a site is located is also listed. The majority of large habitation sites (e.g. tels) in the study area have been recorded. However, additional unrecorded archaeological sites can also be expected along the alignments. Those sites are likely to be small, less obvious surface structural remains and artifact scatters from all time periods. Such sites also have the potential to contain important archaeological data.

TABLE 9.2

CULTURAL SITES IN STUDY AREA AND APPROXIMATE STATIONING

Site Name	Alternative 1	Alternative 2	Alternative 7	Alternative 8
Tel Beror	Sta. 1265	--	--	--
Tel Ma'aglan	Sta. 1470	Sta. 2475	--	--
Tel Eter	Sta. 1520	Sta. 2520	--	--
Tel Goded	Sta. 1550	Sta. 2550	--	--
Horvat Kefar Bish	Sta. 1600	--	--	--
Horvat Kefa Seora	--	Sta. 2265	Sta. 7565	--
Tel Sheqer	--	--	Sta. 7330	--
Tel Lachish	--	--	Sta. 7470	Sta. 8470
Horvat Lehen	--	--	Sta. 7530	Sta. 8530

9.7.7.2 Recommendation for Additional Cultural Resource Investigations

Additional cultural resource investigations will be required for any alternate that is selected. A staged approach to the investigations is recommended. Once the preferred alternative is selected, detailed map information will be provided to the IAA so that they may further assess the potential for the project to impact significant cultural resources. The IAA should be consulted at all stages of design and construction to minimize impacts to cultural resources. Additional coordination with the Palestinian Department of Tourism and Antiquity may also be undertaken regarding cultural resources located along Gaza and the West Bank borders.

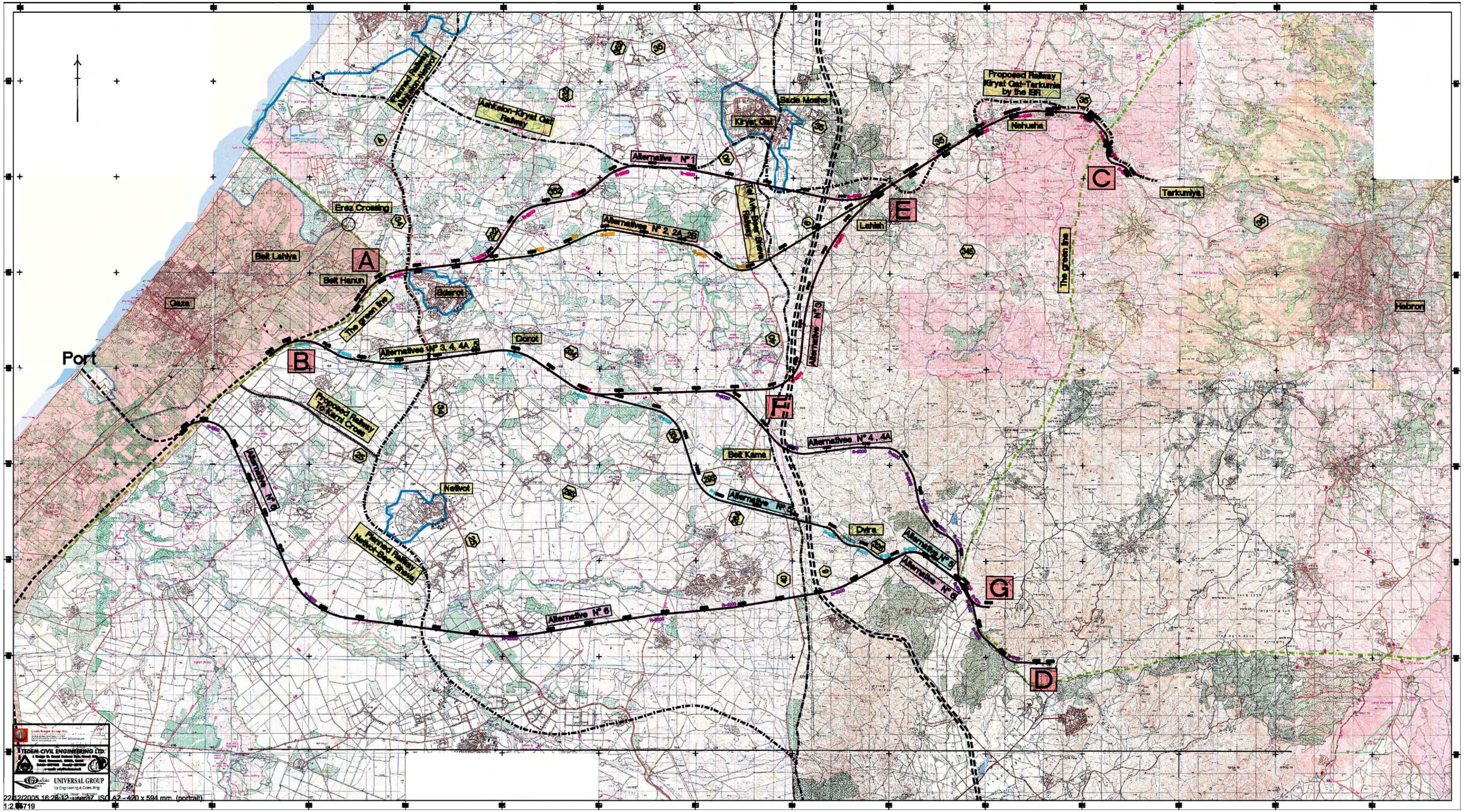
It is IAA policy that they conduct the systematic survey for cultural resources of the preferred alternative as a fee-based service. The goal of the survey will be to relocate and update information on previously identified cultural sites, and to identify any previously unrecorded cultural sites that may be present. Cultural sites may include archaeological sites, standing structures of historic importance, or other sites of important cultural patrimony. Upon completion of the survey, an evaluation of individual cultural sites and the effects of the undertaking on those sites can be made. Where possible, the undertaking should be redesigned to avoid impacts to archaeological and cultural sites that are considered important in regional history and prehistory. If direct or indirect impacts to important cultural sites are unavoidable, measures may be taken to mitigate the adverse effects through archaeological data recovery, architectural recordation, or other means that may be arrived at during consultation with the IAA and any other parties with interests in specific cultural sites.

9.8 Screening and Adjustment of Proposed Alignments

Berger's environmental experts worked closely with the transport engineers in order to defining and adjusting proposed alignments. In some cases, topography was one of the important drivers, particularly for railroad alignment selection. This was particularly true for the eastern portion of the region at the foothills of Judean Mountains where topographic conditions limited in some cases the deployment of a railroad line. In other areas such as the coastal plains, the main driving factors were avoidance of critical areas and minimization of environmental impacts. Based on the information gathered until now, it was possible to develop a map, which shows the current location of proposed alignments and the critical areas (environmental and cultural resources) that are being avoided or that will require mitigation measures. As more environmental information becomes available these alignments may suffer additional changes.

The following map (Figure 9.10) shows proposed alignments and their location in relation to nature reserves, forests, and other protected areas (green shaded), main urban centers (blue circled), and important streams and water-bodies:

(*Note: Additional environmental maps and data to be received from Israel/Palestine will be processed and included in the Final Report of this study*)


Proposed Railway Kiryat Gat-Tarkumia by the ISR
Nehusha
Tarkumiya
C
Hebron
The green line
E
Lahish
Bade Moshe
Kiryat Gat
Ashkelon-Kiryat Gat Railway
Alternative N° 1
Alternatives N° 2, 2A, 2B
Tel Aviv-Beer Sheva Railway
Erez Crossing
Beit Lahiya
Beit Hanun
A
Gaza
Sderot
The green line
Port
B
Alternatives N° 3, 4, 4A, 5
Dorot
Alternative N° 3
F
Proposed Railway to Karni Cross
Alternative N° 6
Beit Kama
Alternatives N° 4, 4A
Alternative N° 5
Netivot
Planned Railway Netivot-Beer Sheva
Dvira
Alternative N° 5
Alternative N° 6
G
Alternative N° 6
D
TEDEM-CIVIL ENGINEERING LTD.
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9.8.1 Proposed Alignments and Environmental Issues by Segments

The proposed alignments are described in previous sections of this Progress Report and were designed taking into consideration the environmental factors previously described in this document. A brief recap is provided below for the purpose of understanding outstanding environmental issues associated with each alignment.

Alignment 1: This **rail only, road only or combined multi-modal** alignment utilizes a corridor mostly defined by existing roads, and a short section of an existing freight railway. Exiting the Gaza Strip at its northeastern extremity, and avoids the vicinity of Sderot by swinging in a large radius arc from a initial northeastern heading, to an easterly heading to intersect with Highway 352 near its junction with Highway 232. Hence, it parallels Highway 352 to the south to the above-mentioned railway, paralleling this also to the south for approx. 3.5 kms. From here, to avoid the built-up area of Kiryat Gat, an agricultural region to the east of Kiryat Gat, and an unnecessarily curvilinear alignment, the route heads easterly to connect north of Lahish with Highway 35. It parallels this route to the south all the way to Tarkumiya. The mountain pass used by Hw 35 appears to offers also a suitable railway approach to Tarkumyia near Hebron without a tunnel, and under 1.3 percent gradient.

Some Outstanding Environmental Issues:

- Sufficient land-clearance area in existing roads without intrusion in new pristine habitats
- Impacts to agriculture land and economic drivers
- Proximity to urban centers and smaller settlements
- Impacts to communication/connectivity
- Impacts to Biological Corridors and Bio-Bottlenecks (explanations in subsequent sections)
- Proximity to the following Nature Reserves, Parks, and Forests:
    - Reches Gvaram Reserve
    - Kiryat Gat Forest
    - Malachim Forest
    - Beit Guvrin Forest
    - Gever Reserve
    - Nehusha Forest
    - National Park Beit Guvrin-Maresha
- Stream Crossings/Proximity;
    - HaShikma Creek
    - Guvrin Creek
    - Lachish Creek

Alignment 2: This alignment roughly follows a previously studied alignment chosen as a **sunken road only** alternative (as a matter of fact the Sunken Road alternative was also evaluated from the point of view of environmental impacts). It proceeds on the same course as Alignment 1 to the curve to the east, crossing Highway 232 and hence continuing easterly just to the north of the riverbed of Hashikma that carries water in winter time. This alignment avoids the separation of nearby communities from their fields, and could allow for gravity drainage of the sunken configuration into the Shikma Stream. Heading further east, it crosses over and parallels the Shikma Stream to the south, with similar advantages. It crosses Highway 40 and the Tel Aviv-Beer Sheva Railroad, avoiding several smaller communities south of Kiryart Gat to join the Alignment 1 alignment at highway 35 north of Lahish, and hence to Tarkumiya. In contrast with Alignment 1, this alignment studiously avoids any existing road or rail alignments.

Some Outstanding Environmental Issues:

- Impacts to agriculture land and economic drivers
- Proximity to smaller settlements
- Impacts to communication/connectivity
- Impacts to Biological Corridors and Bio-Bottlenecks (explanations in subsequent sections)
- Proximity to the following Nature Reserves, Parks, and Forests:
    - Reches Gvaram Reserve
    - Nachal Shikma Reserve
    - Beit Guvrin Forest
    - Gever Reserve
    - Nehusha Forest
    - National Park Beit Guvrin-Maresha
- Stream Crossings/Proximity;
    - Shikma Creek
    - Guvrin Creek
    - Lachish Creek

Alignment 2a: While initially conceived as a **sunken alignment**, it is possible to follow the same course as Alignment 2 at grade, and it is also possible to use a **rail road, road only, or combined multi-modal** alternative along this alignment.

Alignment 7: The Consultants were asked to investigate a **rail only tunnel** option, likely a cut and cover tunnel. A consideration for such an option would be to minimize the length of the crossing, placing it in the vicinity of Alignments 1 and 2 above. While the resultant length of a tunnel only alignment would be excessive, there could be scope for tunnel sections in the hilly region just outside of the Gaza border and north of Sederot, for 2-3 kms, and in the vicinity of the road and rail crossings south of Kiryat Gat, a distance of approx. 3 kms, leaving approx 33 kms of sunken or at grade alignment.

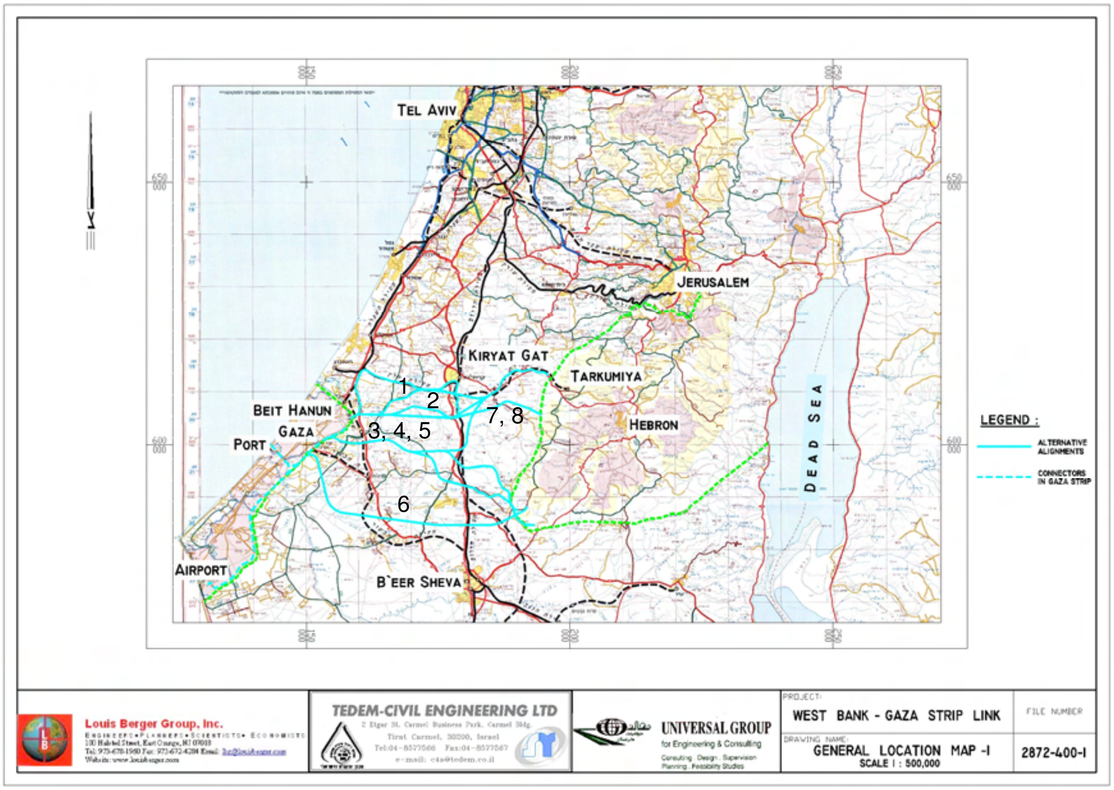
Alignment 8: Comprises a bored tunnel throughout the alignment for rail only (electric train).

Some Outstanding Environmental Issues:

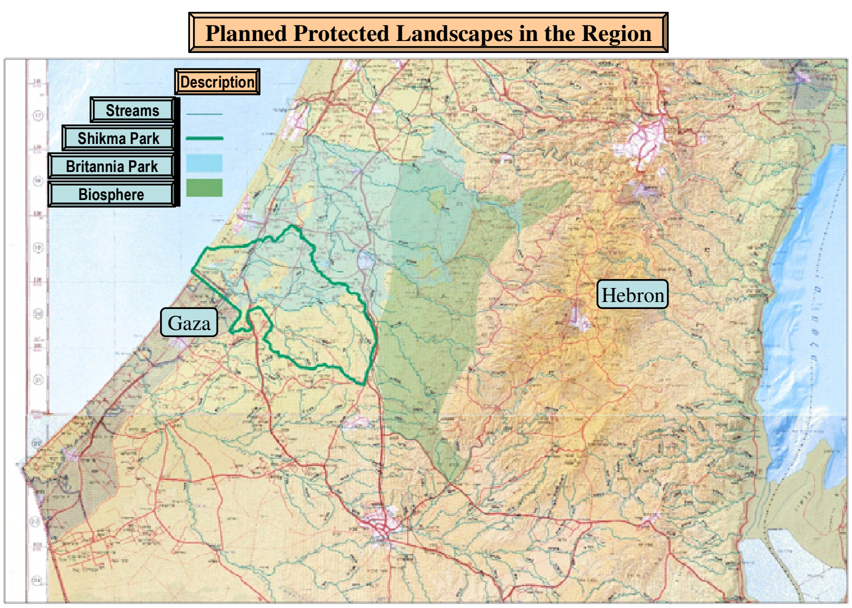
- Impacts to agriculture land and economic drivers
- Impacts associated with disposal of excavation materials
- Proximity to smaller settlements
- Impacts to communication/connectivity
- Impacts to Biological Corridors and Bio-Bottlenecks (explanations in subsequent sections)
- Proximity to the following Nature Reserves, Parks, and Forests:
    - Reches Gvaram Reserve
    - Nachal Shikma Reserve
    - Beit Guvrin Forest
    - Gever Reserve
    - Nehusha Forest
    - National Park Beit Guvrin-Maresha
- Stream Crossings/Proximity;

- Shikma Creek
- Guvrin Creek
- Lachish Creek

The following map shows the location of the alignments (blue lines)



As can be seen in the following map of Planned Protected Landscapes of the Region, northern alignments such as A1 and A2 (which are preferred from the engineering point of view due to length, topogra



9.9 Environmental Impact Analysis

Due to the level of investigations for this study (which excluded in-depth field investigations) the impacts on environmental media by the various sets of alternatives were identified using the following sources:

- Data (limited) provided by Israeli and Palestinian government agencies,
- Publications and interviews at academic institutions and Non-Governmental Organizations,
- Site visits and professional judgment of our environmental experts; and
- Applying a semi-quantitative analysis developed by Conesa-Fernandez (1995).

It is important to emphasize that even though semi-quantitative analyses were conducted, this environmental assessment was not designed to establish impact levels (it is only a preliminary evaluation based on professional judgment and limited information from sources listed above), but to assist in the alignment/alternative selection process. Full Environmental Impact Assessments (EIA) must be conducted in the future. Since the longest segments of the alignments are on Israeli territory and security concerns might require the fencing or concealment of proposed surface (at-grade) alignments, mainly negative impacts were considered; identification of potential positive impacts may result from more in depth EIA studies and most likely related to Indirect Impact Areas (IIAs) rather than Direct Impact Areas (DIAs). In addition, potential positive impacts (e.g. utilization of excavation material for construction purposes) are also discussed in this section.

Impacts were separated in three main groups:

a) those originated as a consequence of construction activities;
b) those originated as a consequence of operation activities under current conditions (as previously indicated it is expected that initially the alignments will be fenced in or concealed due to security concerns), and
c) those originated as a consequence of operation activities under future peace conditions (Open Alignments). It is expected that at-grade roads will be re-opened to Israelis and wildlife crossings in a distant future. This change in the geopolitical conditions and subsequent physical changes to the alignment (removal of fence, open transit for Israelis) will also change the environmental impact of the alignment.

For the purpose of facilitating impact identification, habitats crossed by the alignments were divided into three categories:

a) Coastal Plains (CP): from Gaza border to Lahish
b) Hilly Slopes (HS): between Lahish and Tarkumiya, and
c) Mountains (MT): between Tarkumiya and Hebron

This distinction was based on:

a) The difference in the type of potential impacts identified. Coastal plains are primarily agricultural lands but contain nature reserves and other critical habitats, while hill areas contain open semi-arid habitats.

b) Topography was an important driving engineering factor and although hilly slopes and mountain terrain shows a continuous habitat transition, the political boundaries (Green Line) will de-facto separate the alignments (and local environments) into fenced areas and unfenced areas.

Some alignments were defined as establishing a specific mean of transportation; others contain various options such as:

- Road only
- Rail Only
- Combination
- Tunnel and/or Cut-and-Cover

For each of the previously described parameters (alignment location, alignment type, construction or operation) the following impacts, among others, were evaluated:

- Impacts to nearby nature reserves, national forests, and other sensitive habitats (e.g. water sources, resting stations for migratory species).
- Impacts to nearby streams and associated habitats
- Landscape Impacts (visual effects, free wildlife passage, open spaces)
- Impacts to biological corridors and biological bottlenecks
- Impacts to planned biosphere (within Israeli territory) and regional parks

Among the environmental elements also considered during the site visits and subsequent impact evaluations were:

- Effects over the hydrology and aquatic habitats: impacts on the hydrology included effects on water courses (although most are intermittent/seasonal streams they were considered as they represent important life-supporting habitats in the region).
- Habitat loss and related impacts on fauna and flora: Impacts caused by removal, burial and / or disturbance of flora and fauna were identified as the second significant group of impacts affecting the terrestrial environment.
- Forest succession characteristics (degree of disturbance) and the presence of protected/endemic/interest species, both flora and fauna, and the support of migratory birds were considered crucial in determining the environmental value of the studied areas.
- Landscape and open space modification
- Effects to biodiversity, biological corridors, and protected environments

Detailed environmental studies on the effects of winds (seasonal wind direction) on the transport (impacts) of noise or particulates over critical habitats should be conducted in order to accurately characterize the extent of impacts presented by each alternative. However, for the purpose of this study, it was assume an equal level of impact of wind-transported pollutants (noise or particulates from traffic emissions), on a 360-degree, 1-km radius of influence. At this stage, the use of a more classical approach, like the Leopold Matrix, was not recommended because:

- Taking into account the large number of alternative-combinations and surface area, a per site analysis, including several environmental elements and project actions, both during the construction and operation stages, would encompass a considerable interdisciplinary effort beyond the scope of work of this study.

- It would "conceal" the most concerning issues among the abundance of variables considered
- It would yet involve a high dose of subjectivity

9.9.1 Impact quantification (Significance)

Impacts were quantified using a methodology developed by Vicente Conesa-Fernández (1995) which establishes an Impact Significance Matrix through the use of a multi- criteria approach. The purpose of this semi-quantitative environmental impact analysis was not to establish true impact levels (these can only be obtained through an in-depth impact analysis sustained by field work and sampling efforts), but to provide a guiding framework for the selection or modification of proposed alignments and alternatives. Elements encompassed in the matrix include the following:

- Sign of the impact (+/-)
- Perturbation (DP)
- Risk of occurrence (RO)
- Extension (EX)
- Duration (D)
- Reversibility (RV)

Sign (+/-): Impact sign refers to the beneficial or prejudicial character of the different Project actions on environmental elements.

Degree of Perturbation (DP): Refers to the degree of disturb the action causes over a particular environmental factor in the specific field of occurrence. It ranges between 1-12 where 12 correspond to a total destruction situation and 1 is a minimal effect.

Risk of Occurrence (RO): Refers to the frequency of the effect, whether cyclical or recurrent, unpredictable or constant in time. Continuous effects are assigned a value of 4, periodical is 2, and 1 to those of irregular or discontinuous occurrence.

Extension (EX): Refers to the theoretical area of influence of the impact related to the Project overall area (% of impacted area). If the action produces a spot effect, the impact is considered localized (1). If, on the contrary, it has a generalized influence over the project, the impact shall be considered total (8); intermediate situations correspond to partial impacts (2) and extensive impacts (4).

Duration (D): Refers to the period the effect remains and after which the affected environmental factor would return to the initial condition either by natural or corrective means. If the effect lasts less than one year, it is considered that the action produces a short effect (1); between 1 and 10 years, it is considered permanent (4).

Reversibility (RV): Refers to the possibility of reconstitution of the affected element, that is, the possibility to return to the initial conditions previous to the action, by natural means, once the former stops acting over the affected media. A short term is assigned a value of 1; mid term is 2, and irreversible effects are assigned a value of 4.

The significance of the impact derives from the following equation

$$IS = +/- (PD+RO+EX+D+RV)$$

ENVIRONMENTAL IMPACT SIGNIFICANCE RANK

SIGN		**DEGREE OF PERTURBATION (DP)**	
Beneficial Impacts	+	Low	1
Negative Impacts	-	Medium	2
		High	4
		Very high	8
		Total	12
EXTENSION (EX)		**DURATION (D)**	
Localized	1	Brief	1
Partial	2	Temporary	2
Extensive	4	Permanent	4
Total	8		
Critical	12		
RISK OF OCCURRENCE (RO)		**IMPACT SIGNIFICANCE (IS)**	
Irregular or discontinued	1	The significance of the impact varies between 5 and 36. Scores between 29 and 36 are very high; high between 23 and 28; medium between 17 y 22; low between 11 and 16, and very low between 5 and 10.	
Periodical	2		
Continuous	4		
REVERSIBILITY (RV)			
Short term	1		
Middle term	2		
Irreversible	4		

Source: Adapted from "Guía Metodológica para la Evaluación del Impacto Ambiental", 2nd Edition, Madrid, 1995", by Vicente Conesa F.

Although the impact significance has an established range-value (as described in the Table above), the level if impact (Low, Medium, High) depends on the nature of the impact (cumulative, synergic, simple) and on the feasibility for mitigation. As an example, for a same type of impact 2 different levels can be obtained depending on impact nature and mitigation:

Impact	**Valuation**		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-20**
Importance		***Medium***	
Nature of the Impact		Simple	
Mitigation/Restoration		Feasible	

Impact	**Valuation**		
Character	(+ o -)	Detrimental	-1
Characteristic	Disturbance (DD) =	High	4
	Extend (EX) =	Extensive	4
	Duration (D) =	Permanent	4
	Reversibility (RV) =	Long-term	4
	Ocurrence (RO) =	Continuous	4
	Value = + / - (DD+EX+D+RV+RO)		**-20**
Importance		***Very High***	
Nature of the Impact		Cummulative	
Mitigation/Restoration		Not Feasible	

The impact significance in these 2 examples shows a value of 20 (Medium), but in the second case a cumulative impact and irreversible mitigation make the importance very high.

9.9.2 Ranking of Alternatives

After all alternatives were evaluated they were screened for ranking purposes. All impacts identified were classified into five categories:

Low (1); Very Low (2); Medium (3); High (4); Very High (5)

The following table and maps illustrate the evaluated alignments and alternatives. As described in previous sections, avoidance of protected areas (forests, nature reserves, etc.) was a pre-requisite for continue evaluation of an alternative during the first screening stage. Additional factors included number of stream crossings, biodiversity axes, biological corridors, wildlife movement, and landscape considerations. These factors were used during the first screening of the originally proposed alternatives in order to modify (and in some cases eliminate) a proposed alignment or alternative. However, certain determining factors such as the planned biosphere, Britannia Biblical Forest Park, and Shikma Regional Park (which are planned protected landscapes and extend into vast surface areas) create a geographic/ecological barrier that in many cases (such as northern alignments) cannot be avoided. Consequently, if these alternatives are selected for further evaluation, it will require engineering modifications and mitigations before they can be implemented. Although all the alignments are shown below, only Alternatives 1, 2, 7, and 8 (tunnel) were further evaluated during the impact analysis presented in this report. The following tables provides a brief summary and introduction of significant impacts evaluated, ecological receptors, time (construction and operation), and geographic differences of impacts (plains vs. hills, etc.).

Alignment	**<u>Construction Environmental Impacts</u> (low, high, direct, or indirect impacts excluding those to cultural resources or socio-economic conditions):**	Nearby JNF forests	Agricultural Land	Nearby Landscapes Reserves (T.M.A. 8)	Nearby Nature Reserves (declared, in deposit, or proposed)(T.	Nearby National Parks (T.M.A. 8)	National Outline Plan for Streams and Drainage(T.M.A. 34-B/	Open Landscape (Aesthetic)	Open Landscape (Wildlife Movement)	Open Landscape (Human movement)	Biological Corridors (Biodiversity Axes)	Biological Bottlenecks	Planned Biosphere	Planned Shikmah Regional Park	Planned Brittania Biblical Forest park	Planned Afforestation Areas (T.M.A. 22)	Critical habitat (water source)	Noise pollution	Air quality (dust and emissions)	Light Pollution
A1 (at-grade)	Road Only																			
	Rail Only																			
	Combination																			
A2 (at-grade)	Road Only																			
	Rail Only																			
	Combination																			
	Sunken Road (in the plains)																			
A7	Rail Only (Cut-and-cover across plains)																			
	Rail Only (Bored-tunnel in hilly areas)																			
A8	Deep Rail only (bored-tunnel throughout alignment)																			
A3, A4, A5, A6	Not developed further, description in report Chapter 3																			

In the case of impacts associated with construction activities in almost every alternative it was possible to identify impacted ecological receptors. Exceptions included impacts to Brittania Biblical Park by Alternative 2 (situated south of that critical area), and bored-tunnels which due produce environmental impacts but show significantly higher levels in areas of disposal of excavation materials than in areas of excavations.

Alignment	Operational Environmental Impacts (Enclosed Alignment) to Selection Drivers (low, high, direct, or indirect impacts excluding those to cultural resources or socio-economic conditions):	Nearby JNF forests	Agricultural Land	Nearby Landscapes Reserves (T.M.A. 8)	Nearby Nature Reserves (declared, in deposit, or proposed)(T.	Nearby National Parks (T.M.A. 8)	National Outline Plan for Streams and Drainage(T.M.A. 34-B/	Open Landscape (Aesthetic)	Open Landscape (Wildlife Movement)	Open Landscape (Human movement)	Biological Corridors	Biological Bottlenecks	Planned Biosphere	Planned Shikmah Regional Park	Planned Brittania Biblical Forest park	Planned Afforestation Areas (T.M.A. 22)	Critical habitat (water source)	Noise pollution	Air quality (dust and emissions)	Light Pollution
A1 (at-grade)	Road Only																			
	Rail Only																			
	Combination																			
A2 (at-grade)	Road Only																			
	Rail Only																			
	Combination																			
	Sunken Road (in the plains)																			
A7	Rail Only (Cut-and-cover across plains)		`																	
	Rail Only (Bored-tunnel in hilly areas)																			
A8	Deep Rail only (bored-tunnel throughout alignment)																			
A3, A4, A5, A6	Not developed further, description in report Chapter 3																			

In the case of operational activities the impacts in many cases are reduced (e.g. agricultural land), while others show a larger effect (e.g. enclosed alignment and wildlife movement or landscape/open spaces limitations). A site-specific / Action Specific impact analysis is provided in the following section.

Alignment	Operational Environmental Impacts (Open Alignment) to Selection Drivers (low, high, direct, or indirect impacts excluding those to cultural resources or socio-economic conditions):	Nearby JNF forests	Agricultural Land	Nearby Landscapes Reserves (T.M.A. 8)	Nearby Nature Reserves (declared, in deposit, or proposed)(T.	Nearby National Parks (T.M.A. 8)	National Outline Plan for Streams and Drainage(T.M.A. 34-B/	Open Landscape (Aesthetic)	Open Landscape (Wildlife Movement)	Open Landscape (Human movement)	Biological Corridors	Biological Bottlenecks	Planned Biosphere	Planned Shikmah Regional Park	Planned Brittania Biblical Forest park	Planned Afforestation Areas (T.M.A. 22)	Critical habitat (water source)	Noise pollution	Air quality (dust and emissions)	Light Pollution
A1 (at-grade)	Road Only																			
	Rail Only																			
	Combination																			
A2 (at-grade)	Road Only																			
	Rail Only																			
	Combination																			
	Sunken Road (in the plains)																			
A7	Rail Only (Cut-and-cover across plains)		`																	
	Rail Only (Bored-tunnel in hilly areas)																			
A8	Deep Rail only (bored-tunnel throughout alignment)																			
A3, A4, A5, A6	Not developed further, description in report Chapter 3.																			

9.9.3 Actions and Specific Impacts

The following section provides an analysis of the impact that each alternative (action) might have on the environment, based on location (plains, hills, mountain), receiving media (nature reserves, streams, open spaces, etc.), and time (during construction and operation).

As previously indicated, the following semi-quantitative environmental impact analysis was based on the ecological information collected from government agencies and academic institutions, interviews with experts, secondary data, site visits, and professional judgment. In-depth environmental assessments will be required for the recommended alternatives.

A detailed description of the semi-quantitative analysis performed on each alternative, as well as of the explanatory text is provided in Annex 9-1. Below is a summary of the results that can provide guidance on the impact importance of each alternative and their ranking.

Impacts from road construction activities on nearby nature reserves and forests are considered to be low due to the distances established during the design. Preliminary screenings of alignments took this element into consideration for the design and siting of the alignments by avoiding (to the extent possible) a close proximity to these areas. Some of the potential indirect impacts during construction include increased traffic (emissions), noise, air particulates, and they have a cumulative effect on these habitats. However, some of these impacts (e.g. increased air particulates, emissions from heavy machinery) are mitigable, temporary, and reversible upon completion of works. Operational impacts derived from an at-grade road (e.g. emissions, noise) near protected areas are permanent, irreversible, but of low intensity. Some impacts such as emissions can be reduced through implementation of typical transport emission minimization environmental guidelines. The segment of the road between the Gaza-border and the hills of

Lahish is located in the proximity (100 meters to 1 km) of the some National Parks, water bodies, and forests.

Impacts to nearby streams and associated habitats derived from the construction of an at-grade road are significant but can be appropriately mitigated through the implementation of engineering mitigation and restoration measures that include river bank stabilization, restoration of riparian vegetation in affected areas, and seasonal construction measures such as avoidance of rainy seasons in intermittent streams. Effects of construction and operation activities are summarized below. It is important to emphasize that the assessment of potential impacts took into consideration the previously recommended mitigation measures. In addition, the impacts of an At-grade road will probably depend on topography (in the mountains the impact is lesser due to bridging) and number of stream-crossings.

The potential environmental impacts from tunnel construction are listed at the beginning of this section. In general terms the impacts of construction are not minimal but are manageable. Significantly higher impacts are usually expected on the infrastructure system (roads) that will be recipients of heavy truck traffic, and in deposition areas of excavation material. Punctual impacts are associated with the required excavation points and construction of maintenance, emergency exits, and aeration points to be located at 250meter-intervals.

The characterizations of environmental impacts from tunnel construction require additional information on the nature of the project, the geological characteristics of the excavation areas, and environmental conditions of the disposal sites for the excavated material. For the purpose of this study it is important to identify those drivers that will need to be considered during the full Environmental Impact Studies. These include, among others:

- Extent of impacts at the local level
  - Excavations sites
  - Punctual impacts from operations, which are “punctual” because they refer to exit and support facilities for the “buried rail” which are located at 250-meter intervals along the alignment.
  - Transport of extensive amounts of excavation material and its effect on local infrastructure (roads), noise and emissions of heavy machinery operation
  - Potential impacts to groundwater flows
  - Potential impacts to cultural resources (vibrations)
  - Potential impacts of disruption of local populations (traffic increases, etc.)

- Impacts related to deposition areas of excavation material
  - Identification of discharge areas
  - Identification of positive uses of excavation material

These are some examples associated with tunnel construction. The following analysis takes into consideration the potential impacts previously described.

9.9.4 Summary of Impacts and Ranking of Alternatives

CONSTRUCTION IMPACTS		A1 (At-Grade Combination)	A2 (At-Grade Combination)	A2 (Sunken Combination)	A7 (Rail Cut-and-Cover in Plains, Tunnel in Hills)	A8 (Rail Deep Tunnel)
Impacts to nearby nature reserves, forests, and critical habitats	Plains	3	4	5	5	2
	Hills	3	3		2	2
	Mountains	2	2		2	1
Impacts to nearby streams and associated habitats	Plains	3	3	5	4	2
	Hills	2	2		2	2
	Mountains	1	1		2	2
Impacts to Landscapes (visual effects, wildlife movement, open spaces)	Plains	5	5	5	5	3
	Hills	5	5		3	3
	Mountains	5	5		3	3
Impacts to biological corridors and biological bottlenecks	Plains	5	5	5	5	2
	Hills	4	4		3	2
	Mountains	4	4		2	2
Impacts to planned Biosphere	Plains	5	5	5	5	2
	Hills					
	Mountains					
Sub-Total Impacts	Plains	4.2	4.4	5	4.8	2.2
	Hills	3.5	3.5		2.5	2.25
	Mountains	3	3		2.25	2

Important Note: A tunnel requires the evaluation of factors other than those evaluated for the previous alternatives, including environmental evaluations of areas outside the Study Area (disposal of excavation material). The proposed biosphere occupies only the coastal plains.

OPERATIONS IMPACTS (Enclosed Alignment)		A1 (At-Grade Combination)	A2 (At-Grade Combination)	A2 (Sunken Combination)	A7 (Rail Cut-and-Cover in Plains, Tunnel in Hills)	A8 (Rail Deep Tunnel)
Impacts to nearby nature reserves, forests, and critical habitats	Plains	4	4	5	2	2
	Hills	4	4		2	2
	Mountains				2	2
Impacts to nearby streams and associated habitats	Plains	2	2	5	2	2
	Hills	2	2		2	2
	Mountains				2	2
Impacts to Landscapes (visual effects, wildlife movement, open spaces)	Plains	5	5	5	2	3
	Hills	5	5		2	3
	Mountains		5		2	3
Impacts to biological corridors and biological bottlenecks	Plains	5	5	5	2	2
	Hills	4	4		2	2
	Mountains	4			2	2
Impacts to planned Biosphere	Plains	5	5	5	2	2
	Hills					
	Mountains					
Sub-Total Impacts	Plains	4.2	4.2	5	2	2.2
	Hills	3.75	3.75		2	2.25
	Mountains				2	2.25

Important Note: A tunnel requires the evaluation of factors other than those evaluated for the previous alternatives, including environmental evaluations of areas outside the Study Area (disposal of excavation material). Operational impacts in mountain areas were not evaluated since the alignment in Palestinian territories will not be enclosed. The proposed biosphere occupies only the coastal plains.

OPERATIONS IMPACTS (Open Alignment)		A1 (At-Grade Combination)	A2 (At-Grade Combination)	A2 (Sunken Combination)	A7 (Rail Cut-and-Cover in Plains, Tunnel in Hills)	A8 (Rail Deep Tunnel)
Impacts to nearby nature reserves, forests, and critical habitats	Plains	3	4	5	2	2
	Hills	3	3		2	2
	Mountains	3	3		2	2
Impacts to nearby streams and associated habitats	Plains	2	2	5	2	2
	Hills	2	2		2	2
	Mountains	2	2		2	2
Impacts to Landscapes (visual effects, wildlife movement, open spaces)	Plains	5	5	5	2	3
	Hills	5	5		2	3
	Mountains	5	5		2	3
Impacts to biological corridors and biological bottlenecks	Plains	5	5	5	2	2
	Hills	4	4		2	2
	Mountains	4	4		2	2
Impacts to planned Biosphere	Plains	5	5	5	2	2
	Hills					
	Mountains					
Sub-Total Impacts	Plains	4	4.2	5	2	2.2
	Hills	3.5	3.5		2	2.25
	Mountains	3.5	3.5		2	2.25

Important Note: A tunnel requires the evaluation of factors other than those evaluated for the previous alternatives, including environmental evaluations of areas outside the Study Area (disposal of excavation material). The proposed biosphere occupies only the coastal plains.

A final ranking of alternatives will be completed for the Draft Final Report once critical additional data is received from government officials. However, the analysis conducted can already provide guidance into which alternatives are the most problematic from the environmental point of view, and which are more feasible if mitigation measures are adopted during both construction and operation of the alignments.

From the previous summary tables it is possible to observe the following conditions:

Construction Impacts

- The Sunken Road option causes the highest impacts across all factors evaluated both during construction and operation of the alignment
- At-grade roads (A-1 and A-2) show similar construction impacts although due to nature reserve crossings A-2 displays a higher impact importance in the plains than A-1
- A-1 and A-2 show higher impacts over landscapes and biological corridors than over nature reserves, forests and streams.
- There is a slight tendency for lesser impacts with increase in topography height. The plains show the highest impact importance, followed by the hills region, and the mountain areas.
- All 4 "surface" alternatives evaluated (A-1, A-2, A-7) have similar impacts on the planned Biosphere to be established in the Plains.
- Alternative A-8 showed the lowest localized environmental impact of all alternatives (except when considering potential impacts of discharge of excavation material outside the study area).

Operational Impacts (Enclosed Alignment)

- In general terms operational impacts are lesser than those expected during construction activities (except for Sunken Road alternative which continues to show high impact importance).
- When compared to construction related impacts, A-1 and A-2 showed higher impact importance over forests, nature reserves, and other protected habitats. This is primarily

due to noise and emission pollution, as well as the space fragmentation due to enclosed alignment.

- When compared to construction related impacts, A-1 and A-2 showed lower impact importance over stream alteration during operation of the alignments.
- Once in operation A-7 produces the same impacts than that produced by A-8 (bored-tunnel).

Operational Impacts (Open Alignment)

- Main differences observed in the analysis originate in the higher fragmentation produced by a fenced alignment when compared with an open one. However, open alignments also offer access of general public to areas previously restricted and problems with wildlife crossings over roads, creating higher levels of ecological disturbances.
- No difference expected for alternatives A-7 and A-8.

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