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Ministry of Energy and Water Resources

National Outline Plan NOP 37/H

For Natural Gas Treatment Facilities

Environmental Impact Assesment

Chapters 1 – 2 – Marine Environment

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Unofficial Translation

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Abstract

Chapter 1 – Description of the environment addressed by the plan

The main goal of NOP 37/H is to establish a planning infrastructure that will allow gas companies to produce, transport, and transmit natural gas from present and future discoveries to the existing and planned national transmission system in offshore drillings opposite the Israeli coast.

The goal of the present stage (Stage 3 of the planning procedure) is to examine alternative locations for the treatment systems, *inter alia*, by implementing Chapters 1-2 of the Environmental Impact Survey for five onshore location alternatives and three offshore location alternatives for placement of the gas treatment system and the accompanying pipeline alignment. An inspection of the onshore and offshore alternatives has been conducted in the context of the Environmental Impact Survey for the onshore environment which was submitted to the Ministry of Environmental Protection in October 2012.

This document deals with the marine environment for NOP 37/H and is submitted as a supplement to the Environmental Impact Survey for the land environment. In the context of this document, we will consider three alternative locations for offshore sites in the section between Dor and Netanya and the accompanying pipeline for the natural gas treatment system:

1. Hadera
2. Havatzelet HaSharon
3. Netanya

Location alternatives have been surveyed under the assumption of maximum treatment at sea in order to examine the maximum impact of the offshore treatment facility under each of the alternatives. **It should be emphasized that as at this stage there is a shortage of information regarding the marine environment, the inspection is a generic one, and is based on existing information**. In the next stages we will conduct field surveys and more individual testing of the marine environment in order to complete Chapters 3 -5 of the Environmental Impact Survey. The inspection is carried out in accordance with the guidelines provided the Ministry of Environmental Protection, dated March 29, 2012 and approved by a meeting of the National Board, which are appended as Appendix A, and in coordination with the Ministry of Environment Protection in accordance with the meeting summary, dated August 1, 2012, enclosed as Appendix A-1.

Chapter 1 of the Environmental Impact Survey presents the prevailing conditions at the three alternative sites in the offshore area and surveys the aspects detailed below:

Land zoning and use – A survey of land zoning and use is presented both in text and in maps in order to describe the alternative sites within the marine environment, including offshore infrastructures, port areas, sailing routes, nature reserves, and the like.

Appearance – An analysis of visibility aspects, including reference to visual elements that impact the visibility and appearance of the facilities to one extent or another. The analysis presents each visual element and aspect, but it should be noted that it is not possible to distinguish between the elements and that the totality of the components comprises the full visual picture obtained following construction of the offshore gas treatment facilities.

The main landscape elements are: components of the offshore facility, the facility's visibility from the shore and its environs, and the landscape significance of the offshore facility.

Seismology – The seismic risks to which gas facilities and marine elements are liable to be exposed. This section presents a survey of the total possible seismic risks and a detailed estimation of the feasibility of each one of them within the inspection space based on existing available information. The criteria used to evaluate the various seismic risks within the inspection space and their analyses on the basis of these criteria are presented below.

Natural values – An evaluation of the breeding habitats and their sensitivity was conducted on the basis of existing information and details were provided regarding the soft benthic environment and the rigid seabed environment (kurkar ridges) with an appropriate note of the extent of sensitivity.

Oceanographic and meteorological conditions – A survey of existing conditions with consideration of current wind and wave regimes in the site alternatives, and their environment. Since the materials for these subjects are based on information that has not been made public yet, this section was submitted in a separate appendix to the Ministry of Environmental Protection.

Noise in a marine environment – The main aspect considered is the noise characteristics in a generic marine environment similar to the marine environment along the Israeli coast with respect to proximity to the shore, water depth, and the rest of the parameters that determine the acoustic behavior of sound waves at sea.

Chapter 2 – Examination of alternatives

Chapter 2 examines the various alternatives on the basis of the information presented in Chapter 1 and ranks them according to the inspected criteria in order of preference.

As stated, the examination of alternatives for the marine environment is performed based on existing information only. In some of the examined areas, there were information gaps as a consequence of the absence of data for these areas and the inspection was conducted on the basis of assumptions using existing information. At future stages field surveys will be conducted along with more individual testing of the marine environment in order to complete Chapters 3-5 of the Environmental Impact Survey, and the options available for promoting a detailed plan.

According to **existing information** and its analysis, it appears that the Havatzelet HaSharon site has a certain advantage over the Netanya and Hadera alternatives, mainly from the point of view of land zoning uses and geological and ecological aspects.

In addition, it seems that at this stage, **in light of the existing information**, there are no fundamental differences in the pipeline alignment between the three proposed sites, especially given the fact that the pipeline alignment that will be selected depends on the location of future offshore drilling locations **and the onshore treatment system that will be selected for development from among the Dor System and the Hadera-Neurim system alternatives (currently being considered in the framework of the onshore Environmental Impact Survey).**

From among the pipeline alignment alternatives there is an advantage to Corridor A + Alternative 3 (and Alternatives 4 and 2 as secondary priorities) in the western pipeline alignment (from the area of Israel's territorial waters to the offshore sites), mainly from seismic and ecological aspects. When the eastern pipeline alignment is considered (from the offshore site to the coastal entry system) the pipeline alignment leading to Dor receives higher priority. In the Hadera-Neurim system, the alignment to Neurim was found to be preferable (and the rest receive secondary priority with a certain preference for Hadera).

As stated, examination of the alternatives was performed in three stages as detailed below:

A. Comparison of alternatives for each element in the offshore setup: (1) the western pipeline alignment, (2) offshore sites, (3) the eastern pipeline alignment.

B. Selecting the preferred treatment system setup for each of the alternative search sites (as stated, the setup comprises elements 1 to 3 above).

C. Comparison of three alternatives of the complete setup and ranking them according to development priorities by the aspects considered in accordance with following color key:

High preference – green.

Medium preference – yellow.

Low preference –red.

High preference alternative	Medium preference alternative	Low preference alternative

The following table summarizes the ranking and evaluation of the setup comprising the treatment system:

Alternative / Element in the treatment system	Hadera	Havatzelet HaSharon	Netanya
Western pipeline alignment	Corridor A + Alternative 3 (Alternatives 4 and 2 are given secondary preference)	Alternative 3 (Alternatives 4 and 2 are given secondary preference)	Alternative 3 (Alternatives 4 and 2 are given secondary preference)
Offshore site			
Eastern pipeline alignment (Dor system/Hadera-Neurim)	Dor / Neurim	Dor / Neurim	Dor / Neurim
Summary	Medium-High	High	Medium-High

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Chapter 1

Description of the Environment Addressed by the Plan

1 Chapter 1 - The Description of the Environment Addressed by the Plan

1.0. General

The main goal of NOP 37/H is to establish a planning infrastructure that will allow gas companies to produce, transport, and transmit natural gas from present and future discoveries to the existing and planned national transmission system in offshore drillings opposite the Israeli coast.

The goal of the present stage (Stage 3 of the planning procedure) is to examine alternative locations for the treatment systems, *inter alia*, by implementing Chapters 1-2 of the Environmental Impact Survey for five onshore location alternatives and three offshore location alternatives for placement of the gas treatment system and the accompanying pipeline alignment. An inspection of the onshore and offshore alternatives has been conducted in the context of the Environmental Impact Survey for the onshore environment presented to the Ministry of Environmental Protection in October 2012. It should be noted that an additional alternative at the Haifa Bay was rejected in a decision by the National Board on September 4, 2012[1], an early stage of the present stage because of a clear uncertain unsuitability arising from expected disruption of port activities, considerations of the defense system and conflicts involving geological safety and environmental aspects.

This document deals with the marine environment for NOP 37/H and is submitted as a supplement to the Environmental Impact Survey for the offshore environment. In the context of this document, we will consider three alternative locations for offshore sites in the section between Dor and Netanya and the accompanying pipeline for the natural gas treatment system:

1. Hadera
2. Havatzelet
3. Netanya

Location alternatives have been surveyed under the assumption of maximum treatment at sea in order to examine the maximum impact of the offshore treatment facility under each of the alternatives. **It should be emphasized that at this stage there is a shortage of information regarding the marine environment, the inspection is a generic one, and is based on existing information**. In the next stages we will conduct field surveys and more individual testing of the marine environment in order to complete Chapters 3 -5 of the Environmental Impact Survey. The inspection is carried out in accordance with the

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1 http://mavat.moin.gov.il/MavatPS/Forms/SV4.aspx?tid=4&pid=99007844

guidelines provided the Ministry of Environmental Protection, dated March 29, 2012 and approved by a meeting of the National Board, which are appended as Appendix A.

Chapter 1 of the survey presents the current state of the marine environment at the site of three alternatives and their accompanying pipeline alignment. Chapter 2 examines the alternatives on the basis of the information presented in the previous chapter and ranks them according to the priorities of the examined criteria.

Note: As stated about this document deals with the marine environment only and therefore presents the sections relevant to that environment as detailed below. The rest of the survey sections are presented in the onshore Environmental Impact Survey:

- **Section 1.1 - Background maps for the marine environment**
- **Section 1.2 – Land uses and zoning**
- **Section 1.1.2 – Offshore infrastructures**
- **Section 1.5 - Appearance**
- **Section 1.6 - Seismology**
- **Section 1.9 - Natural values**
- **Section 1.10 - Oceanographic and meteorological conditions**
- **Section 1.11.2 - Noise in the marine environment**

1.1. Background Maps

1.1.1. Marine Infrastructures

The marine information maps enclosed comprise the following information:

- Figure 1.1.2-1 – The alternatives against the background of a bathymetric map.
- Figure 1.1.2-2 – The alternatives against the background of a bathymetric map that includes the marine infrastructures, firing zones according to NOP 35, information regarding shipping and fishing such as mooring points, sailing routes, etc., and areas intended for marine agriculture.
- Figure 1.1.2-3 – The alternatives against the background of a bathymetric map that includes zones intended for nature reserves and national parks as well as archeological sites along with the seabed data for exposed rock and kurkar ranges according to the information given the design team.

It should be emphasized that the information for the marine environment is partial and requires completion and individual field surveys for specific areas. At the next stages, marine field surveys are planned in order to increase the resolution of the existing information within the plan area.

Figure 1.1.2- 1: General Bathymetric Map

Figure 1.1.2- 2: Infrastructure, Uses, and Marine Zones

Figure 1.1.2- 3: Land Cover, Uses and Dedicated Environmental Zones

1.2. Existing Land Uses and Planned Land Zones

This section presents details of land uses and land zones within the area of the offshore site alternatives and the accompanying pipeline. The information is presented in Figures 1.1.2-2/3[2]:

1.2.1. Hadera

Uses and land zoning within the area of the Hadera alternative are detailed in the following table:

Table 1.2.1: Uses and Land Zoning in the Hadera Site

		Reference to the proposed alternative and its environment		
Serial No.	**Usage/Zoning**	**Offshore site for the location of gas treatment facilities**	**Western pipeline alignment (from the territorial waters to the facility)**	**Eastern pipeline alignment (from the offshore sites to the coastal entry system)**
1.	Communication cables	Cross the area of the alternative in a north-south direction	Within the alignment	None
2.	Trolling lines of fishing trawlers	Within the area of the alternative in its central-south area and its north-east area	Within the alignment areas	Within the alignment of the door system and the Hadera-Neurim systems
3.	Sailing routes	Abut the alternative from the south	Within the alignment area	Crosses the alignment area to the Hadera-Neurim systems
4.	Approved strip for the offshore transmission	None	Corridor A-within the area of the alignment: NOP 37/6/2	With the alignment: NOP 37/A/1 NOP 37/A/6/2 within the alignment of the

[2] Reference to marine antiquities sites was made in the context of the onshore Environmental Impact Survey.

	pipe of the gas system			Hadera-Neurim systems
5.	Port	None	None	Within the alignment of the entry system at Hadera
6.	NOP 34/B/2 Desalination	None	None	Within the alignment to Hadera-within the area of the marine infrastructures in NOP 34/B/2, 34//B/2/1 and at the entry to Michmoret within the area of NOP 34/B/2/2
7.	Nature Reserves	None	Alternatives 1 and 2 within the area of a proposed nature reserve - Yam Poleg	The alignment to the entry system at Michmoret with the area of the declared marine nature reserve - Yam Gador. The alignment to the entry system at Alexander River within the proposed marine nature reserve - Yam Michmoret

1.2.2. Havatzelet HaSharon

Uses and land zoning within the area of the Havatzelet HaSharon alternative are detailed in the following table:

Table 1.2.2: Uses and Land Zoning in the Havatzelet HaSharon Site

		Reference to the proposed alternative and its environment		
Serial No.	**Usage/Zoning**	**Offshore site for the location of gas treatment facilities**	**Western pipeline alignment (from the territorial waters to the facility)**	**Eastern pipeline alignment (from the offshore sites to the coastal entry system)**
1.	Trolling lines of fishing trawlers	Along the length of the area of the alternative	Within the alignment	Within the alignment
2.	Sailing routes	None	Within the alignment areas	Within the alignment to the north of the entrance from Michmoret
3.	Approved strip for the offshore transmission pipe of the gas system	None	None	Within the alignment NOP 37/A/1, NOP 37/A/6/2-within the alignment of the Hadera and Dor Systems
4.	Port	None	None	Within the possible alignment for the Hadera entry
5.	NOP 34/B/2 Desalination	None	None	In the alignment to Hadera-within the area of the marine infrastructures in NOP 34/B/2, 34/B/2/1, and entrance to Michmoret within NOP 34/B/2/2

6.	Nature reserves	None	Alternatives 1 and 2 within the area of a proposed nature reserve - Yam Poleg	The alignment to the entry system at Michmoret with the area of the declared marine nature reserve - Yam Gador the alignment to the entry system at Alexander River within the proposed marine nature reserve - Yam Michmoret

1.2.3. Netanya

Uses and land zoning within the area of the Netanya alternative are detailed in the following table:

Table 1.2.3: Uses and Land Zoning in the Netanya Site

		Reference to the proposed alternative and its environment		
Serial No.	**Usage/Zoning**	**Offshore site for the location of gas treatment facilities**	**Western pipeline alignment (from the territorial waters to the facility)**	**Eastern pipeline alignment (from the offshore sites to the coastal entry system)**
1.	Trolling lines of fishing trawlers	Along the length of the area of the alternative	Within the alignment	Within the alignment
2.	Sailing routes	None	Within the alignment areas	Within the alignment to the north of the entrance from Michmoret
3.	Approved strip for the offshore transmission pipe of the gas system	None	None	Within the alignment NOP 37/A/1, NOP 37/A/6/2-within the alignment of the Hadera and Dor systems

4.	Port	None	None	Within the possible alignment for the Hadera entry
5.	Nature reserves	Abut the alternative from the south- proposed nature reserve - Yam Poleg	Alternatives 1 and 2 within the area of a proposed nature reserve - Yam Poleg	The alignment to the entry system at Michmoret with the area of the declared marine nature reserve - Yam Gador the alignment to the entry system at Alexander River within the proposed marine nature reserve - Yam Michmoret
6.	NOP 34/B/2 desalination	None	None	In the alignment to Hadera-within the area of the marine infrastructures in NOP 34/B/2, 34/B/2/1, and entrance to Michmoret within NOP 34/B/2/2

1.5. Appearance

As part of the construction of the gas treatment facilities system, various offshore installations are planned. The visual aspects related to their construction is the subject of this chapter. The analysis below includes reference to visual elements that impact (to some extent or another) on the facilities' visibility and appearance. The analysis will present visual elements, but it should be noted that it is not possible to distinguish between them, and that totality of the elements is what creates the full visual picture received following construction of offshore gas treatment facilities.

The main issues comprising the analysis of the landscape aspects are: characteristics of the offshore facility elements, the landscape significance of the offshore facility and visibility of the facility from the shore and its environs.

It is important to note that the criteria consider the landscape element on a relative basis, comparing between the three alternatives.

1.5.1. Elements of the offshore facility

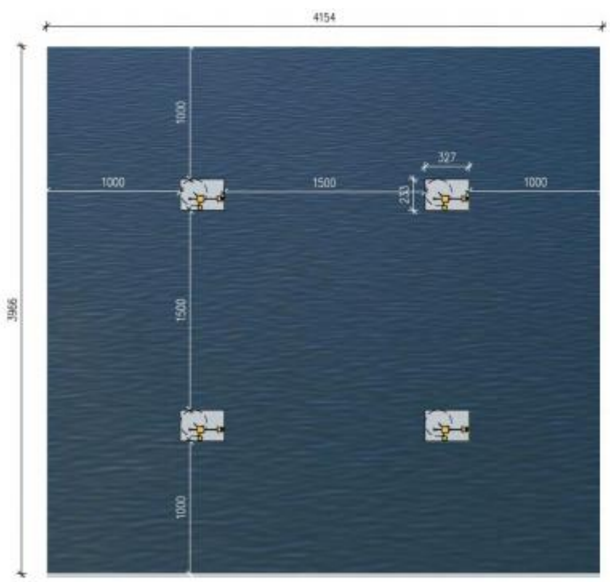
This section includes a description of the elements of the offshore facility and their characteristics, with focus on their visual significance.

The proposed offshore facility is a facility for maximum/full treatment at sea that comprises four elements (see illustration in Figure 1.5.1-1): The main structure – the platform for gas treatment from which the torch extends, the platform for receiving the gas pipeline from the well, and an additional platform provided for various installations and for residents and the fourth facility – the gas compression facility – in future. Total area of the facility is about 76 dunams. There are four facilities of this type included in the offshore site.

Figure 1.5.1-2 presents the marine area spread out over 16,500 dunams, which will enable the construction of up to four offshore facilities.

Figure 1.5.2-1: Illustration of an offshore facility for maximum/full treatment

Figure 1.5.2-2: Illustration of an offshore site including four facilities



It is important to emphasize that the structure of the facility has landscape significance in its own right. The structure comprises a central body, that is positioned on four feet in the water and that is the main mass observed from the shore, while the upper parts are long and narrow installations that have a minor landscape impact.

1.5.2. Landscape significance of an offshore facility

This section relates to the landscape implications deriving from the construction of an offshore facility, mainly with regard to the facility's disruption of the horizon. The sea is perceived as an open natural area that constitutes and undisturbed space from both visual and functional points of view, and has a significant role for land uses on the coast – as well as functional uses (uses for leisure, ports, etc.), a landscape aspect as regards the provision of a sense of space for observers standing on the shore, the value of which increases as the population density increases especially in the context of the urban shore. Therefore, construction of a facility with high visibility creates disruption when gazing out to the open sea, and thus it is expected that the facility will have considerable landscape significance. At the same time, the offshore facility is located at a considerable distance from the coastline, at least 7.5 kilometers away, and similarly to vessels that are integrated within the marine space, so too the offshore facility may also constitute a point of interest.

Another element that should be addressed from this aspect is the facility's integration within the horizon. In cases where the facility is higher than the horizon, the landscape significance is that it will impact the horizon and therefore will be more visible to observers. This disruption to the horizon will be mainly felt when the observer is located at a rather low level relative to the sea, such as people on the beach, walking along urban promenades, visiting historical sites that abut the water and walking along the kurkar cliffs. In cases where the facility is lower than the horizon it will not constitute an obstruction for the line of the horizon and will be absorbed in the general sea landscape, and therefore its visibility will be less significant. This is the usual case where higher points are concerned, such as high-rise towers, hotels and elevated built areas. Nevertheless, it should be added that despite the fact that the facility is less visible from these elements, the openness from such elements to the sea is greater and there are less elements that can help ameliorate the visibility, such as trees, structures and the like, as compared with lower areas.

Notwithstanding the above, even in cases where the facility is more visible to those observing it (relative to the horizon), the landscape significance is less so when compared to the significance of facilities located onshore, and this in view of the fact that it is a small body relative to the open space in which it is situated.

The landscape significance is also expressed in the facility's duration of exposure to population centers as well, where there is an advantage for areas in which the observers are transient (such as roads and railway tracks) rather than permanent (such as localities). However our examination indicated that the facility's visibility is present in many areas and there is no specific alternative that is less visible, neither from residential areas nor from bathing beaches.

Another point that should be addressed is the way in which installations are deployed within the offshore site area. Apparently there are a number of ways in which the installations can be positioned: serially, in a row or in a square structure. All of these models have advantages and disadvantages from the point of view of the landscape. But in actual fact it is important to note that the main guiding considerations for positioning the installations are geological and biological considerations as well as those of the security system and port activities. Moreover, the dimensions of the area under examination and the data relating to the separation distances required limit the above alternatives and do not make all of them possible. Moreover, the ability to curtail the extent of the facility's visibility is limited, as there is no way to hide the facility within the open landscape, and this is opposed to onshore facilities for which one can align the facility elements in a way that is more concealed by the topography and by other means of concealment that may ameliorate the extent of the visual impact.

Nevertheless, by means of the appropriate use of lighting it is possible to minimize the facility's visual impact at night (and moderate its ecological impact as well).

1.5.3. Tools for Analyzing Visibility and Appearance

Analysis of the impact of visibility and appearance from construction of an offshore facility was based on the following tools that were available to the design team:

1. **Field tours.**
2. **Study of the characteristics of the area facing the facility** – study of the terrestrial topography facing the facility, land uses and land cover facing the coast and its characteristics. **Computerized analysis of the visibility of the facility and its significance from various points in the area** – analysis of the site's visibility from varying points of view was performed using a computerized analysis (GIS), that took account of the topography and the main land cover elements, in order to identify areas from which the facility is visible in its entirety; areas from which the facility was only partially visible (low elements); areas in which only the higher elements of the facility were visible, and areas in which the only element visible was the torch. See Figures 1.5-1, 1.5-2, 1.5-3.
3. It is important to note that the computerized analysis does not take into account the significance of the observer's distance from the proposed facility and only takes into consideration the main built areas, rather than additional significant land cover that may exist in the area, such as vegetation. For this reason we find that areas indicated as being different distances from the coast on the same topographic level are seen in the figure as having identical visibility for the facility. Obviously, this is not possible in reality, both because of the distance and because of the land cover that considerably impacts visibility. For example visibility from Ramot Hashavim as indicated by the computerized analysis is of

low elements within the facility – after 12 meters, where in actual fact there is no visibility from the sea to the locality at all. Therefore, the computerized analysis comprises certain inaccuracies. The main visibility obtained is along the coastline and from elevated areas that are relatively close to the coast, as described in Section 1.5.4 below. For this reason this tool is only one of a whole toolbox, and it should be used with due consideration in combination with other tools and professional knowledge.

4. **Computerized simulations –** in areas where the extent of visibility was identified as high and in areas frequented by many people or population centers that look out onto the various alternatives, we conducted simulations that demonstrate the extent of the treatment facility's visibility from areas that look out to it. In order to perform the simulations we defined the following principles:

   From any location where an analysis was performed the visibility was evaluated from points of different heights, all of them located along the coastline or in its approximate area, as follows:

   - Sea level – the coastline. The height represents streets facing the sea in a flat city, or vacationers on the seashore.
   - Height of about 30 meters – a height representing the kurkar cliff in Netanya.
   - Height of 60 to 70 meters – representing a residential building in the city of Hadera (of about 20 floors), and/or residential buildings or hotels of about 10 stories on the Netanya cliff.

In addition, the views from Zichron Yaakov and from Haifa (south) at various heights were selected in accordance with the topography and the average height of the streets facing the sea in the city, about 130 meters and about 380 meters, respectively.

The simulations were conducted on the basis of a distance of about 7.5 kilometers between the first line of facilities and the coastline. The distance between the first line of facilities and the second line is about 1.5 kilometers.

Moreover, for the purpose of the examination, the facilities were located at the center of each alternative's polygon.

Figure 1.5-4 presents simulations representing the three alternatives.

It is important to note that the differences between these simulations arise from the location of the perspective and the distances from the shore. These impact the extent of the facility's visibility at each point, as do the size of the installations that are visible to the eye relative to the horizon. The relationship between the background and the objects in the environment and the facilities and their scale are identical for all simulations.

1.5.4. Visibility of the Facility from the Shore and its Environs

The appearance and visibility aspects of the offshore facility are impacted by many factors including distance from the shore, the onshore topography facing the facility, land zoning and the land cover opposite the shore and its characteristics, additional marine installations in the vicinity, etc. This examination is based on the assumption that the offshore facility has considerable visibility, and yet, at the same time, this visibility is not necessarily negative.

Each of the offshore alternatives were visually analyzed, including reference to the visibility characteristics and the various locations in which the offshore facility may be exposed to permanent populations, both protracted or temporary. Characteristics and locations included: the coastline, population centers along the shore, population centers that are distant and elevated and tourism centers and road infrastructures and railroad infrastructures.

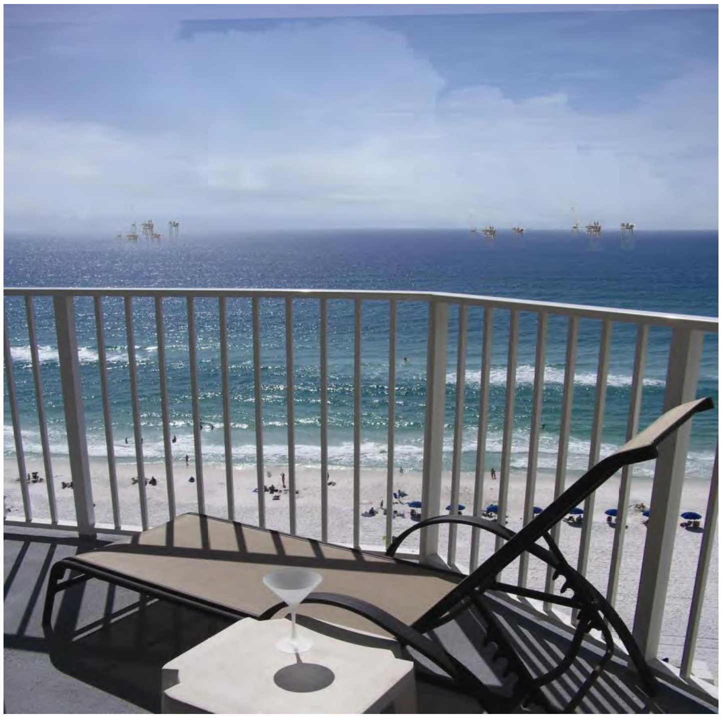
An analysis of the visibility element is presented from north to south:

A. <u>Visibility from the coastline</u> – as stated above, this visibility is mainly with regard to vacationers on beaches or in cases of city streets facing the sea, as well as the promenade in Netanya. In this view, there is no significant difference between the alternatives, since the installations have high visibility and can be observed very clearly from the coastline. Moreover, for one installation the visibility along the coastline is as high as 30 kilometers and more. Nevertheless, it should be considered that in those cities that abut the seashore and therefore have promenades, the exposure and landscape impact is not only a concern for those vacationing on the seashore, but also penetrates the domain of the city's public space. A simulation of the visibility obtained from the shoreline is presented in Figure 1.5.4-1 below.

Figure 1.5.4-1: Simulation of visibility on the coastline

B. Population centers along the coast – The intention here is mostly structures – residential towers or hotels, located along the beach or in its close proximity. Within the areas of the alternatives, these characteristics are mainly found in Hadera and Netanya, where there are hotel areas and especially residential towers close to the sea. In these areas the exposure of population centers to the installations is both continuous and permanent (except for the hotels). Therefore, from a landscape point of view it may be stated that in these features the landscape impact is more significant. A generic simulation presenting the visibility obtained from towers located in proximity to the coastline is presented in Figure 1.5.4-2 below.

Figure 1.5.4-2: Generic simulation representing the visibility received from towers near the beach



C. Population centers that are distant and elevated – In general because of the distance, as well as the local topography created by the kurkar ranges and the urban areas along the shore, the further east we move, the less the visibility of the facility or even no visibility at all. At the same time, from certain areas in which the topography is higher, such as the Carmel range and the localities located on top of it, the installations are visible. An analysis of the visibility was conducted from the south of Haifa and Tirat HaCarmel and from there the most northern alternative was visible – only the alternative in the Zichron area. Moreover the facility is relatively far off and its visual impact on Haifa is not significant. From Zichron Yaakov, despite the distance from the coast, the offshore facility is seen very clearly.

D. Tourism centers and visitors sites – in cities located on the coastline there are various tourism areas, either existing or planned, and these include hotels and tourist sites as well as visiting areas that have a natural interface with the seashore. Tourism centers also include rural tourism, such as the Nachsholim holiday village and the like. All tourism uses of this type, because of their natural interface with the seashore, create high visibility, but the exposure duration for visitors is temporary and not ongoing. Moreover, there is an impact of the type and nature of the hotel – the higher the structure as stated above, we expect that the visual disruption created by the facility will be somewhat curtailed, when compared to structures that are located at sea level. Moreover, consideration should be given as well to existing and planned visitor sites in Caesarea, Tel Dor and so on, that have a line of sight to the offshore sites, and also impact the general landscape of the site itself. From the Carmel range in its south part where hiking routes and visiting sites are located, the installations are visible, but the facility's location is at a great distance from the Carmel shore, and will therefore have a significantly lower impact.

E. Road Infrastructures – Visibility is also a problem for people traveling along roads and railway tracks that pass alongside the shore, and these are mainly those aligned with Road Number 2, the shore road from which the facilities are visible along certain segments in which the road is elevated compared to its environment: the Dor-Nachsholim segment (for those traveling south), and the Michmoret-Beit Yanai segment. The Tel Aviv-Haifa railway track passes to the west of the shore road only in the Dor-Nachsholim area and from regional areas, such as the Zichron road that turns towards the sea for those who are traveling westwards. Nevertheless, it should be recalled that from these features the exposure for travelers who are traveling fast is limited to a very brief period only.

Visibility maps and simulations present various points of view (from various heights) for the three alternatives and are presented in Figures 1.5-1, 1.5-2, 1.5-3, and 1.5-4 below.

In summary, all offshore alternatives are visible, whether temporarily or continuously or permanently, according to various visibility elements for the offshore alternatives.

1.6. Seismology

<u>Introduction</u>

This section deals with the seismic risks to which the offshore gas installations planned in the context of NOP 37/H are liable to be exposed. The chapter presents a survey of all possible seismic risks and a detailed evaluation of the probability of each one within the inspection space, based on existing information. Below is a general geological and geographical background description of the local infrastructure within the inspection space and details of the seismotectonic model that served to characterize the regional seismogenic sources and that constitutes the basis for the peak ground acceleration calculations (PGA) within the inspection space. The criteria used to evaluate the various seismic risks within the inspection space are presented subsequently as well as their analysis on the basis of these criteria (Sections 1.6.1-1.6.6).

Seismic risk surveys usually describe the risk level in accordance with the value of the seismic intensity coefficient. Calculation of the seismic intensity coefficient in the survey (Sections 1.6.1 and 1.6.3 below) is intended to provide an indication of the level of seismic risk within the inspection space and the way this risk changes within the space, and for the purpose of characterizing <u>the relative risk level</u> among the areas of the offshore alternatives for construction of the facilities. Calculation of the seismic intensity coefficient for the purpose of engineering design, <u>once the precise location of the facilities is determined</u>, will require the use of measured values of the strength of the soil layers at those points within the inspection space where the facilities are to be located.

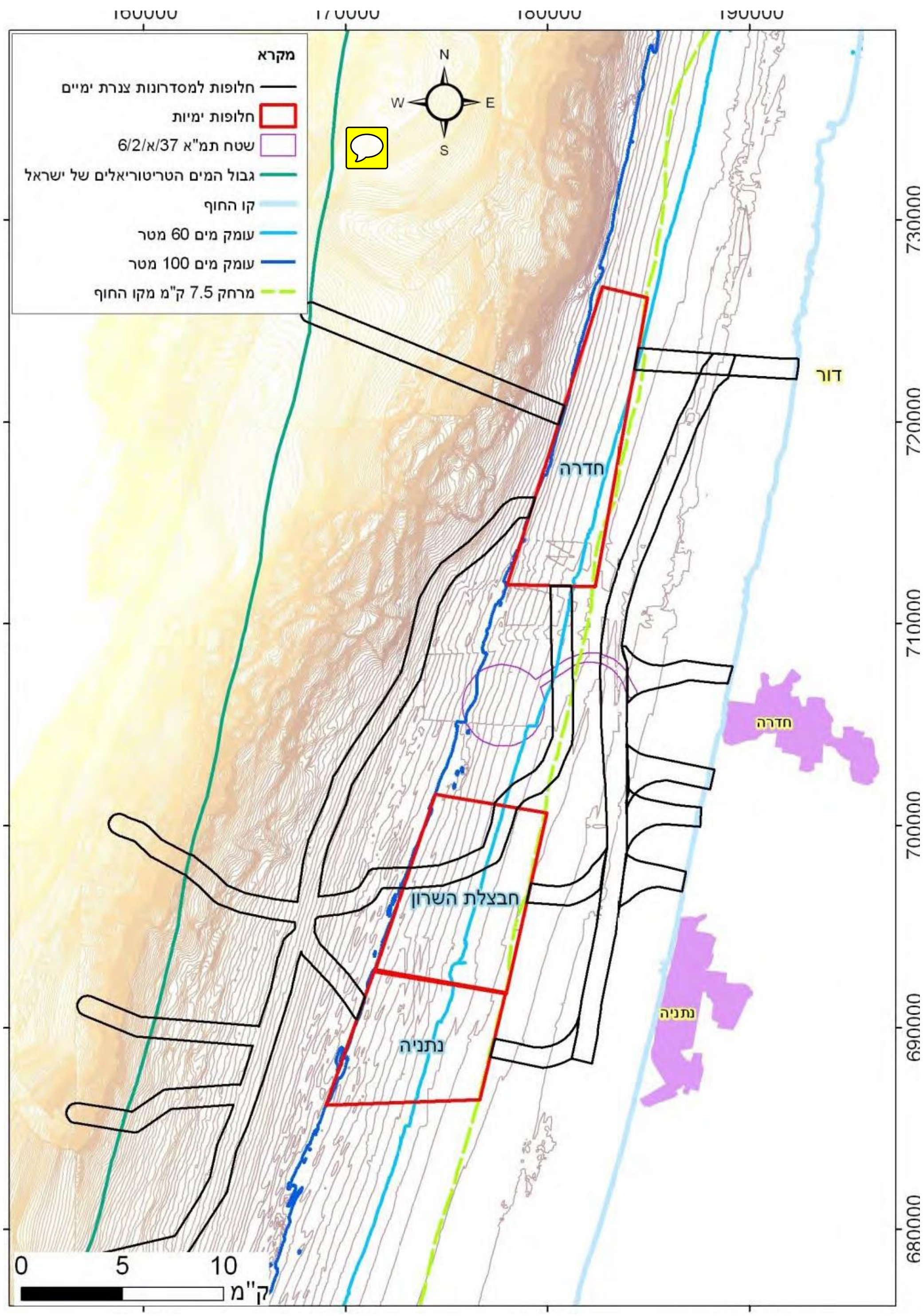
A. Geographical and Geological Environment

This section includes a description of the geographic units included within the inspection space or abutting it with an emphasis on the geomorphology, geology, and stratigraphy of these units. Some of the aspects discussed in this section are presented below in a more detailed way within the required contexts.

Boundaries of the inspection space and its geographical location

The inspection space is located on Israel's continental shelf opposite the north-central part of the coastal plain (the area between Netanya and Dor; Figure 1.6-1A). The boundaries of the inspection space were established in the following way: The eastern boundary was established at one kilometer west of the offshore gas supply pipe due to operational considerations of the platform. The regulatory boundary to the east for construction of the installations is located at a distance of 7.5 kilometers from the coastline. The western boundary was established at a water depth of 100 meters for operational considerations related to the construction and operation of the platform. The northern boundary of the inspection space was established opposite the area of Dor, to the west of which one of the largest slumpings in the eastern Mediterranean (the Dor slumping); the southern boundary was established slightly south of Netanya for design considerations of the system, which requires that some of the installations be located opposite Israel's northern coast. The depth of the seabed within the inspection space lies in the range of 40-100 meters. The Dahlia, Taninim, Hadera, Alexander, and Poleg rivers all flow into the planned area from the north to the south respectively. Along the coastline, just as on the continental shelf, there are strips of kurkar ranges that are bisected by the rivers that descend from the plain to the sea (Almagor, 2005). Within the inspection space and its environs there are no exposed underwater canyons.

Figure 1.6-A1: Location map of the inspection space and area of the offshore alternative on a bathymetric map



Morphology of the Continental Shelf

The continental shelf is an area at the margins of the continent that continues from the coastline beneath the surface of the sea on a moderate gradient (usually at an angle of less than one degree) until a place where a considerable change in the gradient angle is discernible. The continental shelf is shaped by two complementary processes: (1) construction – continuous layering of sediments mainly coming from land. (2) Destruction – the removal of these sediments in a continuous process (conducted in channels) or catastrophic (slumpings). The ratio between the rate of construction and destruction processes dictates the morphology of the continental shelf, so that when the rate of construction is faster than the rate of destruction the shelf is wide and stable, while when the rate of construction is slower than the rate of destruction a narrow shelf is created with irregular margins. Another factor that determines the stability of the shelf is the rate of tectonic activity, in particular the vertical movements capable of causing an increase in the rate of erosion, and earthquake events capable of causing gravitational slumpings. This indicates that a stable continental shelf is characteristic of relatively "calm" geological environments, i.e., areas where tectonic activity is limited over long periods and the supply of sediments in them is irregular and takes place at a rate exceeding the rate of shelf destruction. The following sections describe the correlation between the seismic activity within the tectonic area that surrounds the inspection space and its morphological characteristics.

Sediments that build up the continental shelf sink in the vicinity of the shore (within the delta); or are conveyed into adjacent sedimentation basins by underwater currents. As a general rule, the courser the material (sand) the closer it sinks to the coastline and finer the material (silts) the further away it is sedimented. Thus changes in the location of the coastline will lead to an accumulation of various sediments one on top of the other. The differential accumulation of sediments is reflected in the vertical lithological variety of the stratigraphic section, as well as in an increase in the gravitational load, plaining of the deep area and the "vacating" of room for additional sediments. In places where the bathymetric incline exceeds the critical specific gradient, slumping of sediment takes place and "slumping scars" are created in the part of the continental shelf that faces the continental slope. This process is intensified in the presence of weak/plastic layers (such as clays, salt) in the subsoil. Various additional factors that increase slumping are described in Section 1.6.4.

Israel's Continental Shelf

Israel's continental shelf extends from the coastline westward into the depth of the Mediterranean, to a distance that ranges from 30 kilometers from the coastline in the Rafiah area and up to 2-3 kilometers from the coastline in the Rosh Hanikra area (Almagor 2005; Figure 1.6-2A). Respectively, the sea floor gradually spreads out from the coastline in its east margins to a depth of over 100 meters in its west margins, or down to a depth of about 50 meters and less in the area north of the Carmel head. Beyond these depths the gradient increases and/or there are prominent phenomena of gradient slumping as part of the shift to the continental incline that declines in a sharper angle into the Levant Basin. In places, the increase in the gradient of the incline is continuous while in other places it is gradated as a consequence of slumping.

Israel's continental margins including the continental shelf are divided into two provinces:

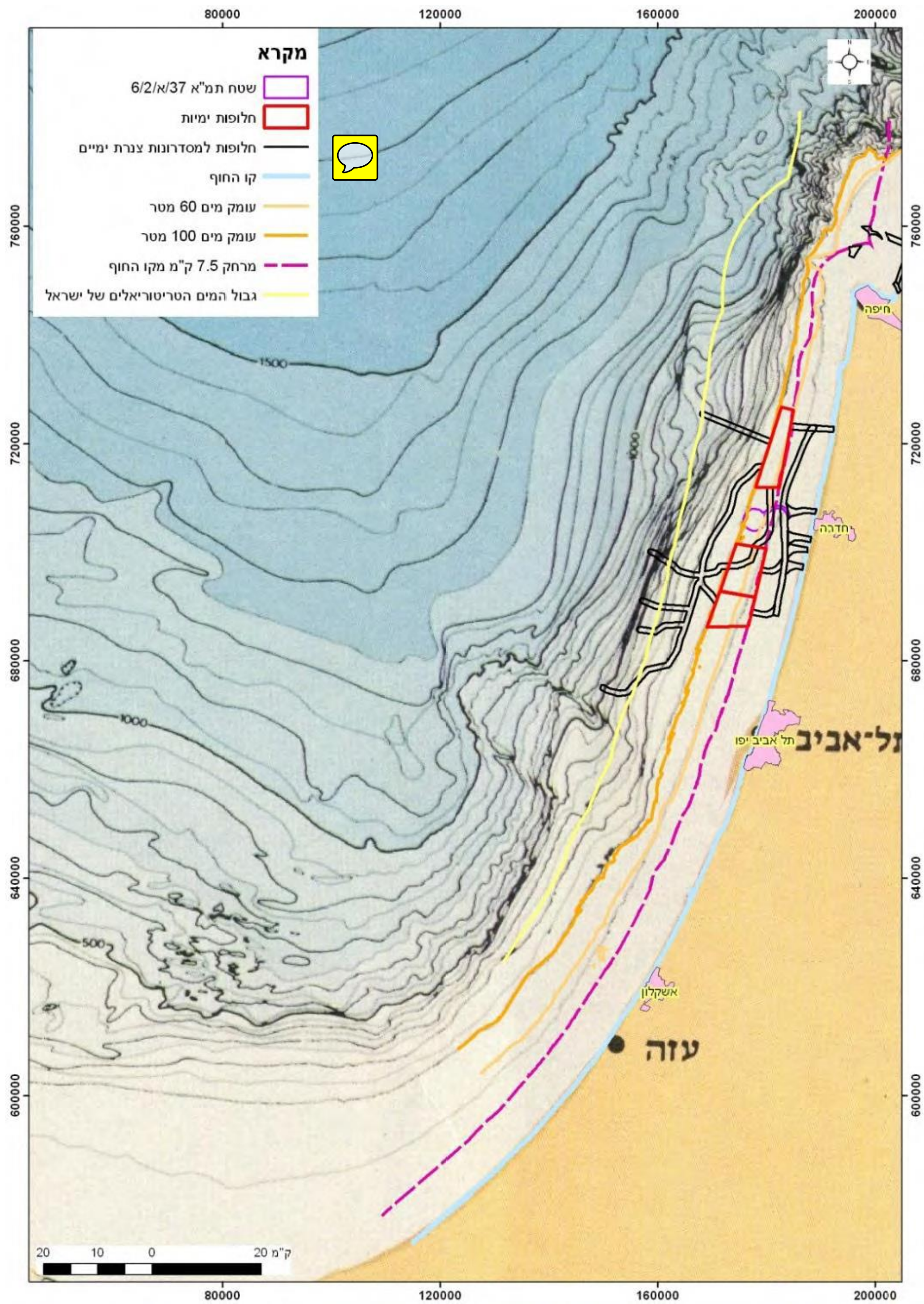
Southern Province – from the area of Rafiah up to the Carmel head

This province is located in the vicinity of the north-east branch of the Nile Delta and its underwater extension (the Nile fan), that juts out about 150 kilometers from the coastline into the depth of the Mediterranean. This proximity impacts the character of the sediments that reach the shelf and also correspondingly its morphological character. The inclination of the continental shelf is very low; its width is in the range of about 30 kilometers opposite Rafiah and it narrows up to 5 kilometers in the Carmel head area. The continental shelf in the Southern Province, which is in the area of the littoral cell of the Nile, is built by continuous accumulation of sediments that are driven from the Nile Delta and reach up to the Carmel head, since the coastline that connects them is continuous and does not include any natural topographical barriers (the ports and marinas constructed during the modern era constitute barriers for the progress of Nile sediments in a northerly direction). In this area of the continental shelf, two extensive slumpings are identified: the Dor slumping and the Palmachim slumping; see details in the chapter that deals with this subject.

Northern Province – from the Carmel head up to Rosh Hanikra

The maximum width of the shelf in this province is about 14 kilometers in the central area of the Haifa Bay and its relatively serrated edges as a consequence of slumping and the excavation of underwater canyons. The shelf has been excavated in its most northern part within the territorial area of Israel by the Achziv Canyon, which limits its widths to two-three kilometers. The narrowing of the width of the continental shelf to the north of Acre arises from the fact that this area is located to the north of the Nile's littoral cell, and since the sediment accumulation processes are balanced by vertical movements of 0.2 to 0.05 millimeters per year (Sivan and Galili, 1999) as a consequence of the West Galilee fault system activities. The faults cross the shelf in an east-west direction and split the continental shelf in the north into 1-2 kilometer strips and encouraged the development of canyons through which materials are removed from the continental shelf into the deep sea.

Figure 1.6-A2: Israel's continental shelf and incline[3]



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[3] (Dor and Palmachim overflows are distinctly seated in bathymetric, a vertical distance between contours: 50 meters).

Description of Sediments and the Rocky Infrastructure of the Continental Shelf

This section provides a survey of the sedimentology, lithology and stratigraphy of the continental shelf.

i. Sedimentation model for the continental shelf (beyond the wave break line)

The area of the sea bed in the continental shelf that is not composed of exposed kurkar (see next section) is covered with non-cohesive sediment from the Holocene period. The sediment is a granular layer made up of changing quantities of sand, silt, and clay-sized particles. Most of the sediments are led along Israel's shores as part of the littoral transmission system along the Nile littoral cell. The sand balance within the Nile littoral cell indicates that close to one million cubic meters per year pass the eastern Delta, about 400,000 cubic meters per year pass the Gaza Strip, while about 80,000 meters per year reach the Haifa Bay (Zviely et al., 2007). A small part of this sand is blown to the coastal plain and the rest, about 250,000-300,000 cubic meters per year are sedimented in the sea on top of the continental shelf.

From a mineralogical point of view, the sediment is mainly comprised of quartz particles and clay minerals, as well as a calciferous element. The calciferous element includes carbonate bioclastic sand made up of a mash of seaweeds and the faunal skeletons of the littoral area and decomposition products of the kurkar ranges. The contribution of the Nileotic component to the sands in Israel, decreases as one moves north while the biogenic element is contributed at constant rates along the entire length of Israel's coastline. Thus, the relative volume of the biogenic element increases when moving northwards.

From the coastline down to a depth of 30 meters the sediment is mainly comprised of sand with a variable particle size between 0.17 – 0.25 millimeters along the coastline to 0.11-0.16 millimeters east of the kurkar range (for a description of the kurkar ranges, see the next section). As compared with sand that sinks in shallow water, silt and clay appear in significant quantities on the sea floor, beginning from water depths of 15-25 meters at a distance of 1-2.2 kilometers from the shore (mainly west of the kurkar range). At a depth of 30-50 meters they are mixed with sand, but the quantity of sand decreases the further away one moves from the shore and the deeper the seabed. The rate of accumulation of the silt and clay is high, about 0.3-3 meters per thousand years (Neev et al., 1996; Tibor et al., 1992).

The silt and the clay are colored dark brown to olive black, and are quite monochrome: the silt constitutes 25-60% of the sediment volume, and the clay 40-75%. The rate of clay in the sediment increases as the distance from the shore increases, and the clay constitutes the dominant element of the sediment mainly to the north of Hadera. In their mineral composition, 80-90% of their volume includes clayey minerals: 50-70% montmorillonite, 20-30% caulinite, and 10-15% percent illite. The rest of the volume comprises fine quartz granules (silt-clay sized) – up to 12%, while carbonate and feldspar comprise 1-9% each of the sediment volume (Almagor, 1976). Geotechnically, the sediments are defined as clayey silts with high plasticity and high wetness content in values of 80-105%.

ii. Kurkar ranges and exposed rock

Israel's coastal plain and a considerable part of the current continental shelf are characterized by an Aeolian morphology that is expressed in the cover of sand dunes from the Gaza area and northwards. Dunes developed in the past have stabilized, petrified and created kurkar ranges that parallel the shore and are bisected by troughs. The eastern ranges exposed in the coastal plain are more narrow and crowded than the western ranges, which are presently submerged in the sea. The western ranges have large amplitude of hundreds of meters and a wide and "wavelike" structure. The westernmost range is located at the very edge of the continental shelf at its typical water depth of 90-120 meters and constitutes a block against the slumping of non-cohesive sediments. The kurkar at the seabed is mainly exposed in places where there is slumping along this range. The edges of the ranges are covered with aeoliated sand and sandy loam while the troughs between the ranges are padded with sandy soils and swamp sediments (Almagor, 2005 and the references mentioned there).

In a seismic survey (Golik et al., 1999) that was conducted along the continental shelf two types of kurkar were identified:

"Regular" kurkar: Sandstone comprised of quartz granules with a particle size of 0.075-0.3 millimeters with a changing percentage of cohesive carbonate material. The rock is usually comprised of alternating thin layers of quartzy sandstone that is strongly consolidated quartzy sandstone, quartzy sandstone that is not poorly consolidated and sand with a presence of heavy minerals and skeletal fragments.

Calcernite: Porous calciferous sandstone characterized by a particle size of 0.075-0.2 millimeters and made up of bioclastic particles of algae shell shards, foraminifera remains, quartz and more. The calcernite is consolidated via carbonate arising from the remains of bioclastic skeletons. The rock is very porous and the voids constitute more than 50% of its volume. The calcernite is more consolidated and less brittle in comparison to the kurkar and does not have stacks, voids and free sand pockets.

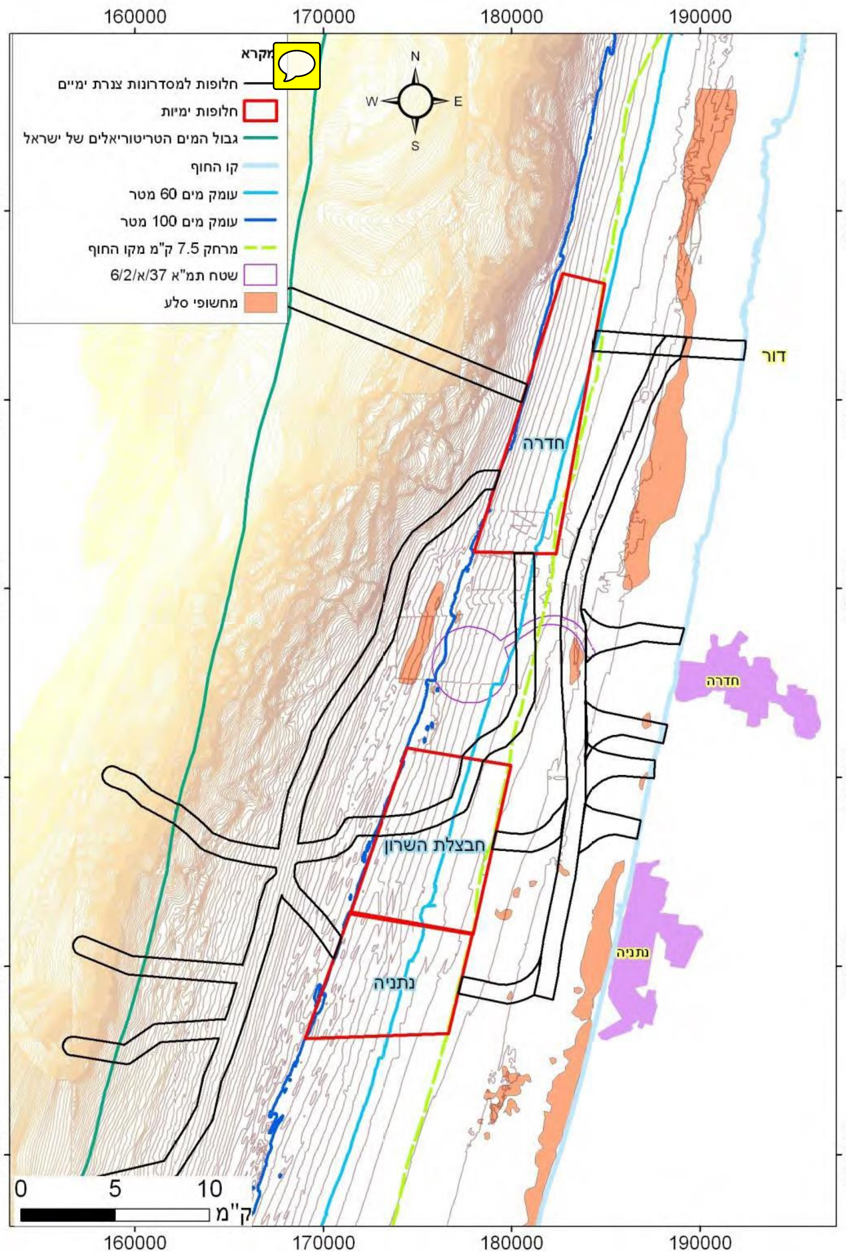
The alignment of exposed rock mapped on the seabed within the inspection space and its environment is presented in Figure 1.6-A3. The mapping is based on a lithological map of the seabed taken from Gill et al., 2000, presenting the results of a seismic analysis conducted along the general alignment of the gas pipe approximately parallel to the Israeli coastline, and a local mapping conducted as part of the works involved in NOP 37/A/2/6 (the LNG float opposite Hadera). The map shows that the kurkar range with the greatest, continuous and widespread distribution opposite the Israeli coast lies from the northern boundary of the map to the Hadera area along about 49 kilometers. The width of this range from the Haifa area to Kibbutz Hahotrim is between 3-8 kilometers and its distance from the shore is between 0-1.3 kilometers. The range becomes narrower between Kibbutz Hahotrim and Hadera so that its width along this segment is in the range of 300 meters to 2.5 kilometers and its distance from the shore is about 2-3.5 kilometers.

In parallel and in proximity to the shore in the segment between Netanya and Herzliya lies another kurkar range that is 20 kilometers long, about one kilometer wide, and located at a distance of 0-650 meters from the shore. West of this range opposite Kibbutz Ga'ash, at a distance of 3 kilometers from the shore, there are two additional 3-kilometer long ranges.

iii. <u>Rock infrastructure: Lithology and stratigraphy</u>

The continental shelf comprises a thick column of rocks (1-2 kilometers) that accumulated from the Pliocene period to the present day, mainly originating from sediments that were transported to the sea by the Nile. These rocks were laid on top of the topography that characterized the continental shelf at the end of the Miocene event (lowering of the sea level, erosion along the edges and sinking of evaporite layers). This section describes the lithology and stratigraphy of the "rocky base" on top of which the post Miocenian sedimental column has accumulated. Figure 1.6-A4 presents the typical stratigraphic column for the continental shelf area.

Figure 1.6-A3: Exposed underwater rock areas mapped in the environment of the inspection space (various sources)



The Judea Group (Cenomanian-Turonian; Upper Cretaceous) – the Judea Group is characterized by a carbonate platform made up of deep sea marl, chalk, rock and limestone. In the continental shelf area this group is mainly represented by the Negba, Dalya and Bina formations. This group also includes a complex of limestone rocks in the Carmel that are exposed at the seabed.

The Mount Scopus Group (Santonian-Paleocene/Upper-Cretaceous-Lower Tertiary – a massive unit of deep sea carbonate that covers extensive areas of the Levant, from Egypt in the south up to Lebanon and Syria in the north. The Mount Scopus Group is mainly comprised of chalk, marl, and shale and comprises flint, phosphates and bituminous materials. In the continental shelf this group is represented by the En Zetim, Ghareb and Taquiye formations.

The Avedat Group (Eocene; Lower Tertiary – deep-sea carbonates at the basis of this group are shale that characterize the Paleocene period. On this basis there is an Eocene unit comprised of chalk, marl, and limestone from pelagic eukaryotes. In the continental shelf this group is represented by the Adulam and Marsha formations.

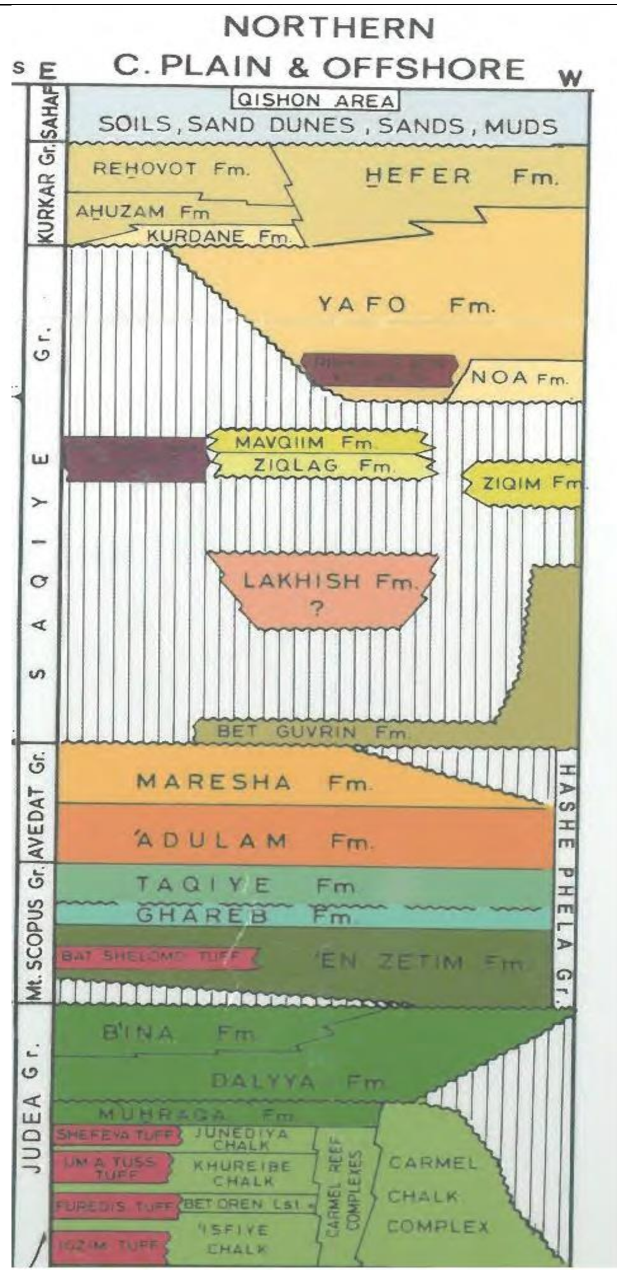
The Saqiye Group (Tertiary) – represents a change in the sedimentation regime of the Levant Region beginning at the end of the Eocene at which time the volume of clastic sediments becomes greater than the volume of carbonate sediments. In the area of the Israeli coastline and the continental shelf hemiplegic chalk was deposited during this period, then marl, and subsequently also typical clastic sediments.

The Saqiye Group is characterized by a gradual shallowing of the sedimentation environment. The lower part of the stratigraphic section at this period includes the Beit Jubrim, Ziqim, and Ziqlag formations. This part is mainly comprised of deep-sea clastic sediments. The upper part (the Pliocene) of the section is comprised of the Jaffa formation, which is mainly made up of clastic sediments of Nileotic origin (Gardosh et al., 2008).

The Mavkiim Formation (Upper Miocene; Tertiary-Included in the Saqiye Group – the sedimentation of this formation is ascribed to the sharp decline in level that occurred during the Miocenian period following the Mediterranean's disconnection from the global oceans system (e.g., Gvirtzman and Buchbinder, 1978). This formation is made up of evaporates (halite, anhydrate, and gypsum) which create a layer that is more than one kilometer thick in the central part of the basin, but it grows thinner and disappears in the direction of the present shore along the east edges of the continental shelf (Gardosh and Druckman, 2006). This salt layer is plastic and responds to compression stresses (including gravity) in movements that lead to the destabilization of the sediments above it and to slumping.

The Kurkar Group (Pleistocene; Tertiary) – this group was sedimented under conditions of a shallow sea and a land environment and comprises clastic sediments: sands, conglomerate, and sediments in the east part. Open sea sediments appear in the western part (Steinberg et al., 2010). The lithological description of this unit is detailed above in Section ii –"kurkar ranges and exposed rocks."

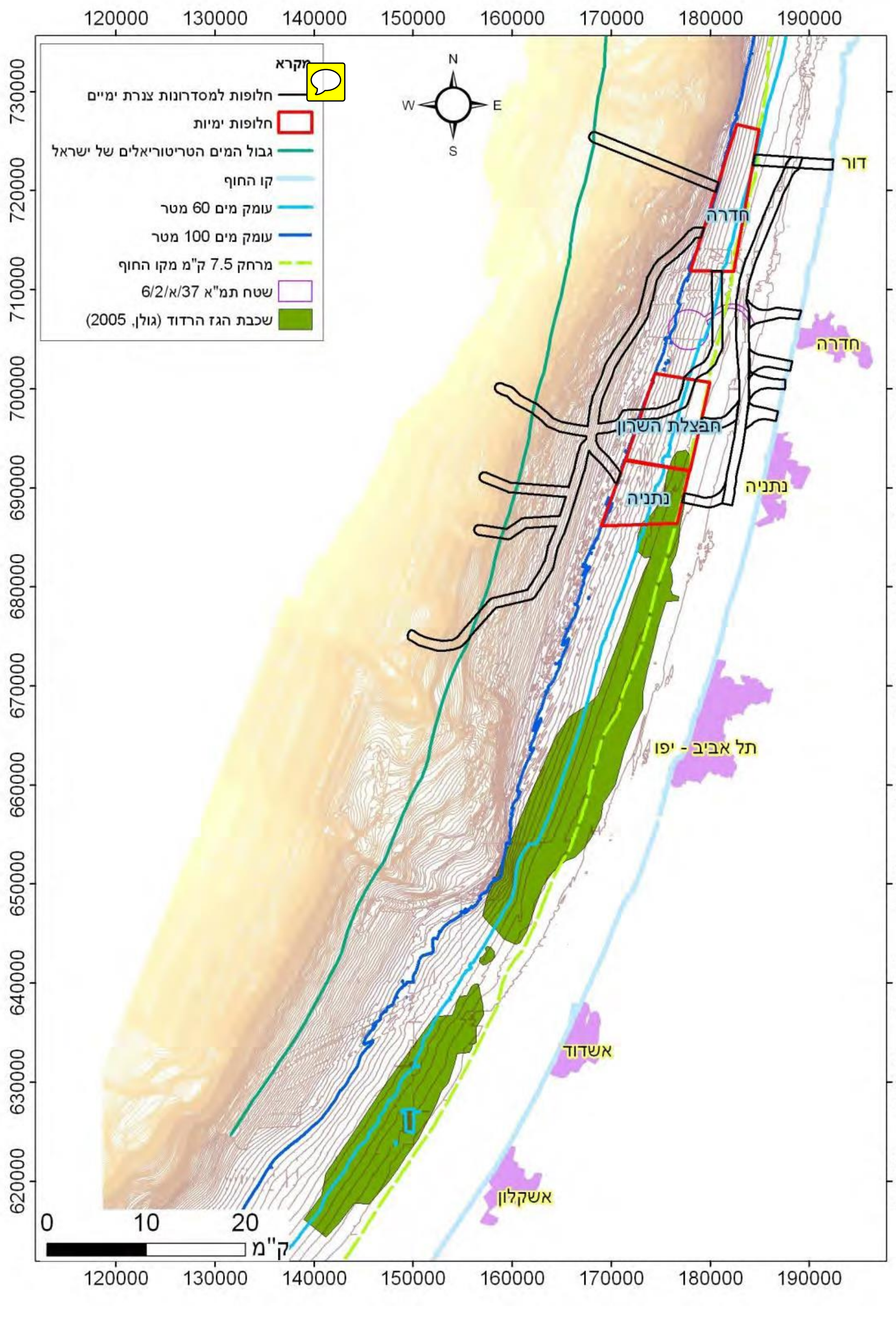
Figure 1.6-A4: Stratigraphic column of the continental shelf (After Fleischer, 2002)

Sahaf	
The Kurkar Group	
The Saqiye Group	
The Avedat Group	
The Mount Scopus Group	
The Judea Group	

iv. <u>Phenomena related to the creation and accumulation of gas within shallow sediment layers in the continental shelf</u>

A seismic mapping performed by Golek at al. (1999) along a strip with an average width of about 10 kilometers west of the Israeli coastline found that at water depth of 40-60 meters in the continental shelf area there is, within the shallow sand layers, a layer of biogenic gas that masks the seismic information from the layer itself and the layers below it. The extent of this layer is presented in Figure 1.6-5A, and comprises the southern part of the inspection space, so that the northern boundary of the gas strip is located opposite Netanya (the Netanya alternative and the south of the Havatzelet HaSharon alternative). It is possible that there are also islands of gas in the sediment that have not been mapped, in particular north of Hadera where the seismic information is very sparse (Golan 2012 A). A complementary account of the shallow gas layer and the phenomena associated with it is presented in Section 1.6.4.3.

Figure 1.6-A5: Extension of the shallow gas layer (Golik et al., 1999; Golan, 2006)



B. Description of the Local Infrastructure within the Inspection Space

This chapter describes the natural infrastructure within the inspection space. For the purpose of preparing this Chapter, available information regarding the geological structure and composition of the seabed within the inspection space was collected as well as information regarding the subsoil with particular focus on the dozens of meters in the upper subsoil layers. The analysis is based on drilling data and data provided by penetrative geotechnical testing, seismic surveys, reports presenting analyses of drilling data, and previous surveys relevant to this area. This chapter presents the sources of information that were used to prepare the survey, followed by a stratigraphic section included in the inspection space, the spatial deployment of the litho-stratigraphic units and the geotechnical characteristics, and finally the geological-granulometric description of the seabed within the inspection space.

Sources of Information

The main sources of information for the data presented in this chapter include the following works/databases:

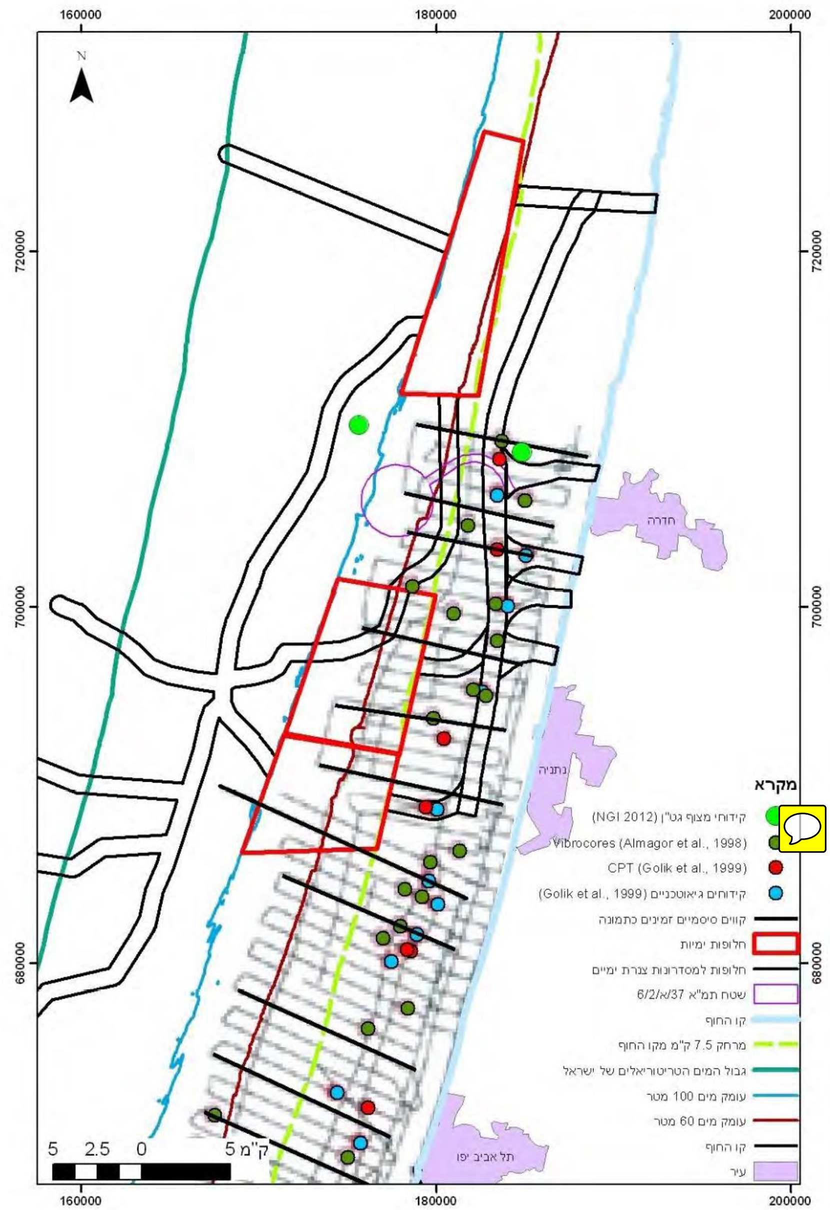
- The Royal Islands Project (for example Golik et al., 1999; Gill et al., 2000). This project comprises a shallow geophysical survey in water depths of up to 70 meters by means of the CHIRP device. The survey covers the area from Ziqim in the south to Hadera in the north (Figure 1.6-1B). As part of the project and in addition to the geophysical survey a land survey was also conducted down to a water depth of about 45 meters, including: 44 samples of sediments from the seabed that were sampled using a Vibracore, 32 measurements of the Cone Penetration Test (CPT) and 19 drillings into exposed kurkar ranges on the seabed (Figure 1.6-1B). The geophysical survey covers about half of the inspection space and overlays its south-eastern part. The data available for the purpose of preparing this chapter in the survey based on the data described above, include:
    - Images (JPEG) of a number of seismic profiles;
    - The full Vibracore data from the (Almagor et al., 1998);
    - A summary report regarding the CPT and drillings without data (Golik et al., 1999).
- Report regarding the structure and stability of the upper continental shelf, Eric Golan, IOLR (Golan, 2012 A): Includes images of a number of seismic profiles conducted in the year 2011, by means of the CHIRP system in the Dor-Hadera area.
- Geotechnical survey for the LNG float (NGI, 2012): Data from drillings performed at water depths of 44 and 72 meters, including geotechnical tests for the various sediment layers.

- An environmental document for NOP 37/A/2/6 – LNG float opposite Hadera (Tahal, 2011): data from seabed samples, granulometrics, seismic lines.
- MA Thesis (Almagor, 1964): Data from core samples taken from the seabed opposite Tel Aviv and Palmachim.
- Geological Institute Report (Lazar, 2007): Analysis data of cores taken near the Ashkelon shore.

Typical stratigraphy of the inspection space along the continental shelf

The purpose of this subchapter is to present typical stratigraphic/lithological columns for the shallow part of the continental shelf included within the inspection space. The penetrative data on which the columns are based are local ones and their deployment within the inspection space is not uniform (Figure 1.6-1B): for the southeastern part of the inspection space there are scattered data that make it possible to derive an approximate characterization of this area, but for the north and west most part of the inspection space there are in fact no data. In addition, the seismic sections indicate that along the length and breadth of the Israeli continental shelf there are lateral changes within the character of the layers and the field relations between them. Drilling data taken from the continental shelf opposite Ashkelon (Lazar, 2007) indicate a different section than that which characterizes the inspection space drillings (the existence of a clay layer between the sand kurkar lays at a water depth of under 30 meters, the discontinuity of the kurkar layer). In view of the above, the relevance of the stratigraphic columns presented for the north and west part of the inspection space should be investigated in comparison with additional information.

Figure 1.6-B1: Inspection space region drawn over the alignment of seismic lines derived from the Royal Islands survey (after Golnik et al., 1999) and the location of drillings and various soil tests (various sources)

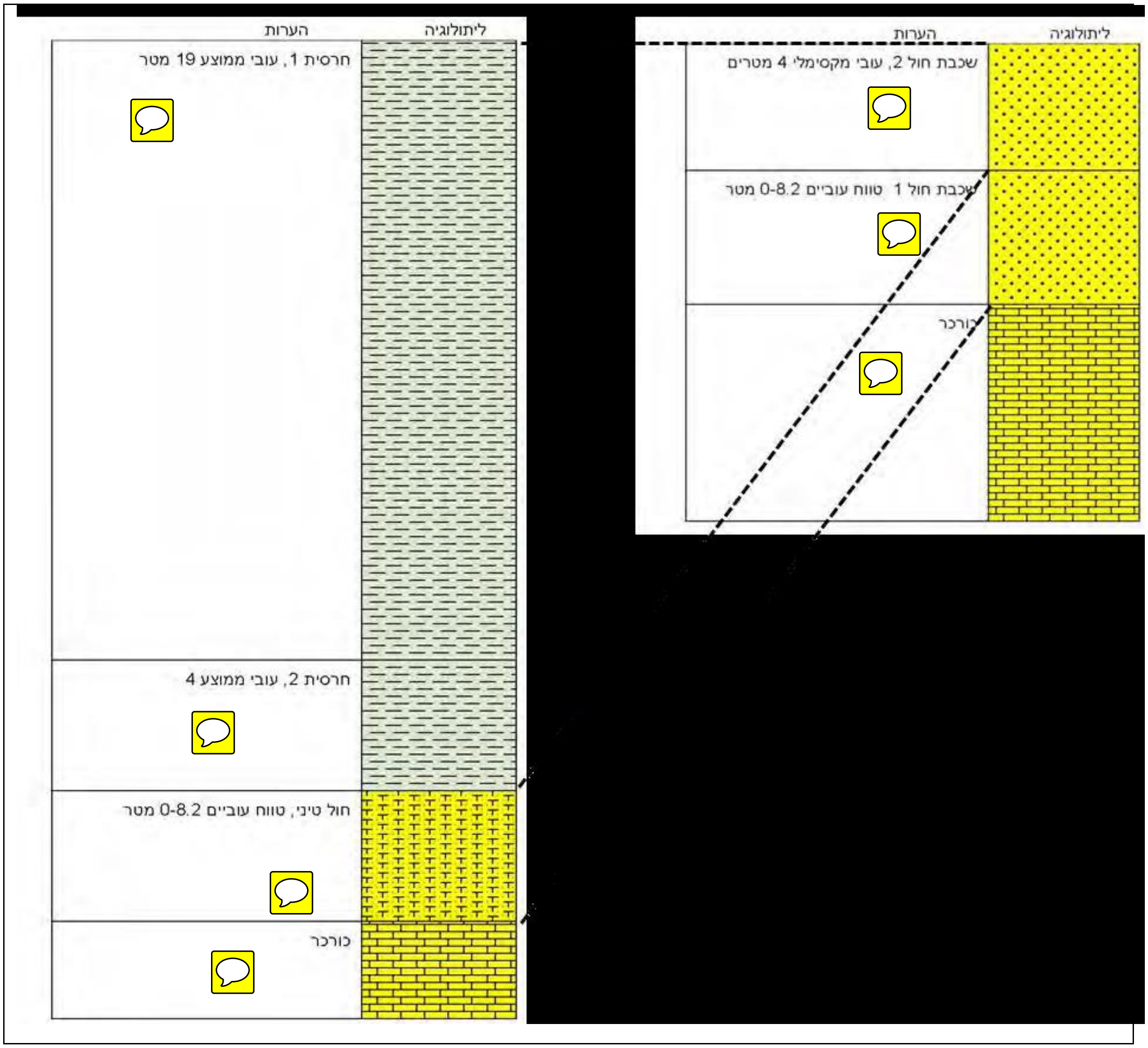


The data indicate a typical lateral shift takes place at a water depth of about 30 meters, and for this reason we present here two inclusive columns that represent the litho-stratigraphic structure at depths that are both over and under 30 meters. These columns (Figure 1.6-2B) represent the main vertical stratigraphic/lithological shifts expected and their typical depth over most of the inspection space, whereas their level of certainty is relatively high in the center-south area and the eastern part of the region.

Figure 1.6-B2: Inclusive stratigraphic columns within the survey space according to varying water depth

A. Inclusive stratigraphic column for water depth shallower than 30 meters

B. Inclusive stratigraphic column for water depth deeper than 30 meters



Below is a description of the rock units within the inspection space from the lowest to the uppermost.

Kurkar – The kurkar rock is comprised of aeoliated sand (dune sand) with a carbonate aggregation from the Pleistocene Age. The kurkar layer is spread (although there is no indication regarding its continuity/discontinuity within the inspection space) along the entire area of the continental shelf and in places it is exposed on the seabed. Drillings have distinguished two types of kurkar rock compositions: in the first, the dominant element comprises fossilized algae and shale fragments with a particle size of 0.075-0.2 millimeters, and in the second the dominant element is quartz granules with a particle size of 0.074-0.3 millimeters with a carbonate aggregation. The carbonate content of the kurkar rocks was in the range of 7-20%, the block density was 2.7 grams per cubic centimeter. The tensile strength was 1.1-12.3 kilograms to square centimeter and the unconfined compressive strength was less than 100 kilograms per square centimeter.

Non-aggregated silty sand – Appears on top of the kurkar with incompatibility. The thickness of the sand layer is less towards the west. The sand unit is divided into two layers, where the upper sand layer can be mainly mapped at a water depth less than 30 meters. The upper sand layer undergoes a facies change from sand in the vicinity of the shore to clay at depths greater than 30 meters (Figure 1.6-3B). The thickness of the sand layer in the drillings used to characterize the columns is in the range of 0-8.2 meters with an average of 3.2 meters. The sand units comprise silty sand and silt horizons in thicknesses of up to 30 centimeters, where the general silt content is in the range of 35-50% (Golik et al., 1999).

Clay – Clay constitutes the upper layer in water depths exceeding 30 meters. Its thickness is 3-23 meters with an average of 7.2 meters. The composition of this layer is relatively uniform within the inspection space and typically contains 67% clay, 29% silt and 4% sand. In the LNG float drillings, at water depth of about 72 meters (see below) two layers of clay may be distinguished: the first has an average thickness of 19 meters and comprises soft to very soft homogenous clay with very little fossilized fragments; beneath it is a layer of about four meters that comprises harder clay. The clay layers undergo a facies change in the east direction towards the upper sand layer (Golik et al., 1999).

Figure 1.6-3B below presents a seismic profile in the east-west direction to the south of Tel Aviv. The upper panel – without analysis. The lower panel – includes the analysis (after Golik et al., 1999). The stratigraphic identification of the units is presented alongside the profile. The red line is common to the roof of the kurkar layer and the roof of the gas unit. The facial shift between the upper sand unit and the clay is discernible at the east of the profile.

Figure 1.6-B3: Seismic profile in the east-west direction to the south of Tel Aviv

Clay 1

Clay 2

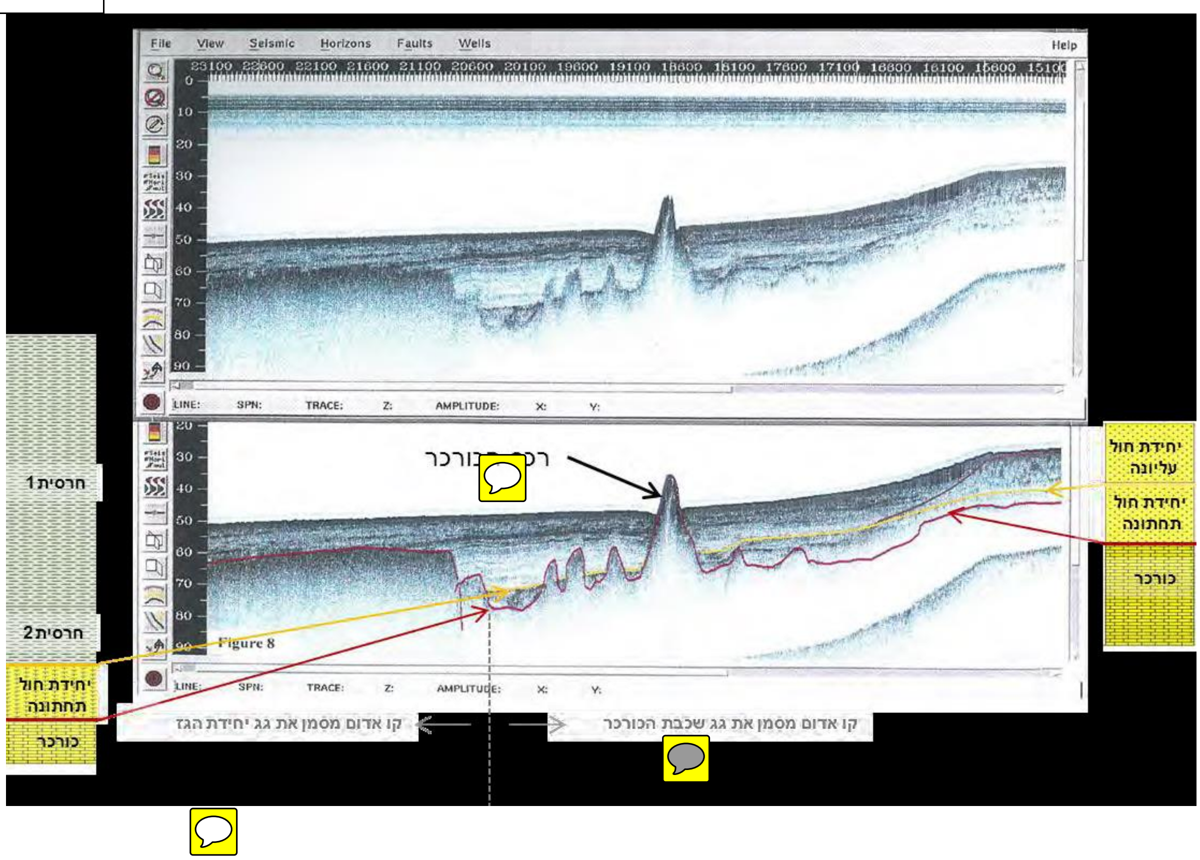
Lower sand layer

Kurkar

Upper sand layer

Lower sand layer

Kurkar



Red line denotes the roof of the kurkar layer

Red line denotes the roof of the gas unit

Spatial spread of the litho-stratigraphic units within the inspection space

Drilling data:

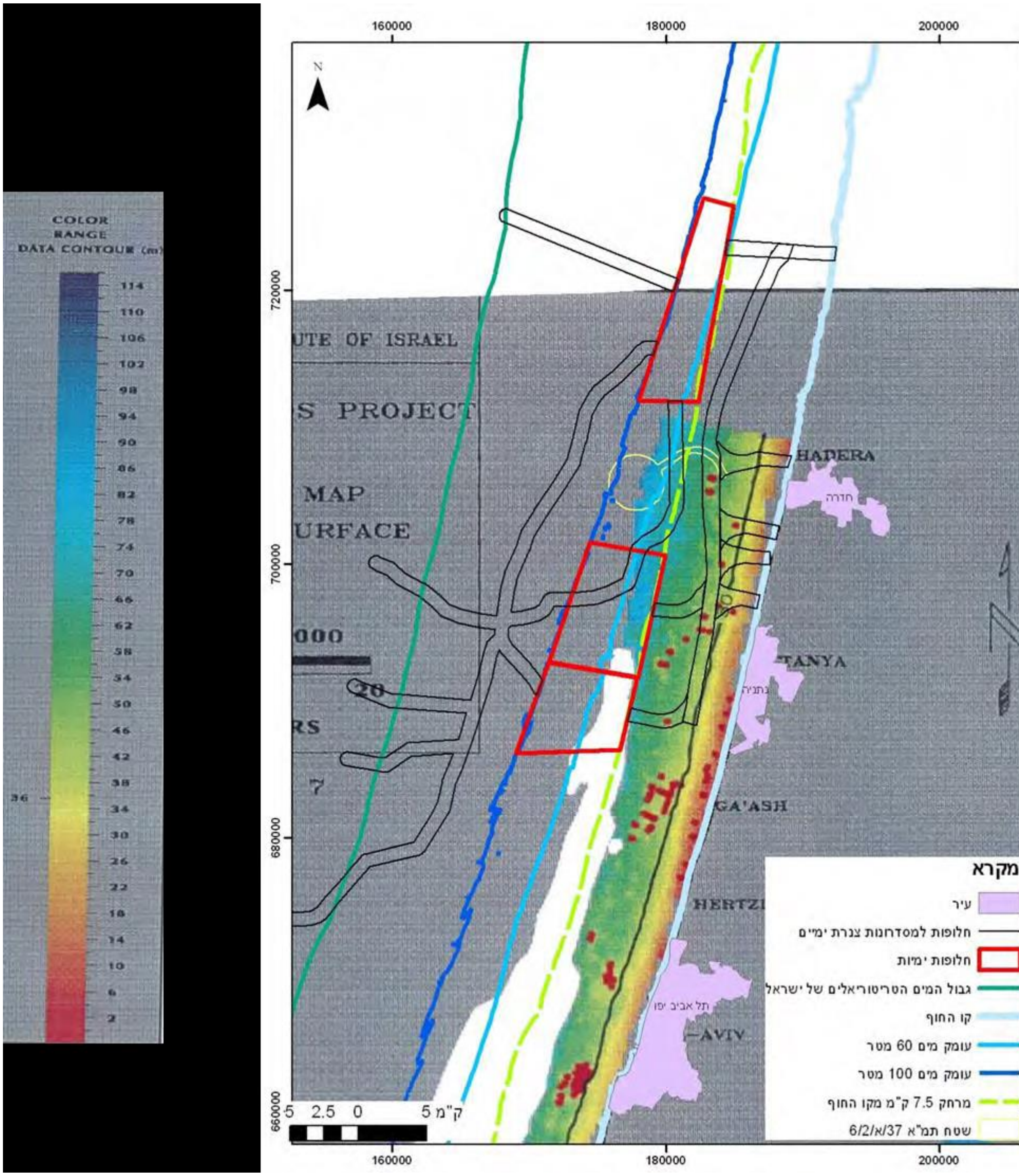
In a geotechnical survey conducted opposite Hadera for the purpose of planning an LNG float (NGI, 2012), a drill hole was drilled down to a depth of 12 meters in a water depth of 44 meters at a distance of about 4.5 kilometers from the shore, and four drill holes down to a depth of 27 meters in water depth of about 72 meters at a distance of about 13.5 kilometers from the shore where drilled (the drillings are presented as bright green points in Figure 1.6-1B). The stratigraphic sequence visible in the drillings made at a water depth of 72 meters is similar to the stratigraphic sequence that characterizes the drillings in the Royal Islands Project. These drillings show a thickening of the clay layer for 19 meters. Geotechnical tests of the clay layer indicate that it can be divided into two horizons distinguished by their density, their moisture content, and their un-drained sheering strength (see next section as well as Table 1.6-1B). The sand and silt layers sampled from a drilling conducted at a water depth of 44 meters have similar geotechnical parameters and similar thickness to the samples taken from drillings at a water depth of 72 meters, but in contrast to the other drillings beneath the sand layer in this drilling there is an additional clay layer in the place where the drilling ends (Table 1.6-2B). On the basis of the spatial continuity of the kurkar layer in this area as reflected in seismic lines (see below), it may be assumed that the kurkar layer is located at the base of this clay layer and that the clay layer beneath the sand layer constitutes a lens with no more than local spread.

Sequence and nature of the litho-stratigraphic units within seismic profiles:

The seismic profiles presented in the Royal Islands reports (for example Golik et al., 1999) have mapped three horizons along the temporal dimension. The names of the horizons from bottom to top are: kurkar roof, roof of the lower sand unit, and seabed. Above the lower sand unit at a water depth less than 30 meters is the upper sand unit, while at a water depth greater than 30 meters is the clay unit (Figure 1.6-b3: Golik et al., 1999). The conversion from the temporal dimension to the depth dimension was carried out through connecting CPT measurements, Vibracore samples and drillings in the kurkar ranges.

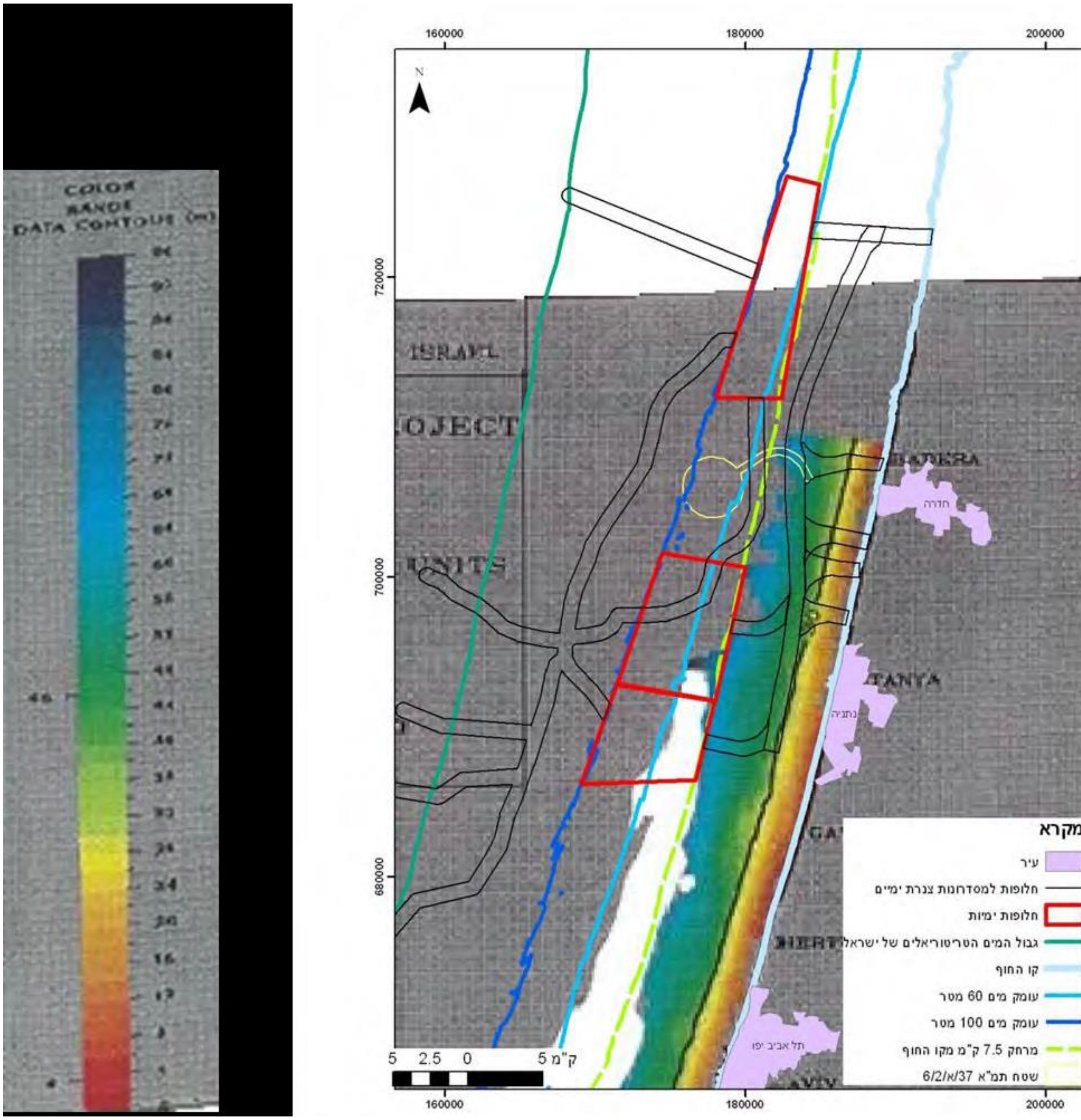
The kurkar roof horizon – the kurkar roof is clearly distinguishable in the seismic profiles as a strong and prominent reflector with a wide spread (Figure 1.6-3B). The kurkar layer roof slants to the west from a height of a few meters beneath the level of the sea surface in the vicinity of the shore to a height that is lower than 100 meters at the western edge of the seismic survey. From the structural map of the kurkar roof (Figure 1.6-4B below) and the seismic profiles (Figure 1.6-3B), it can be seen that the kurkar roof comprises ranges with a longitudinal axis that parallels the shore. A description of the spread of exposed kurkar within the inspection space is presented in the introduction to this section, subsection A-ii- "Kurkar ranges and exposed rock," and in Figure 1.6-7B presented below on the basis of work produced by Gill et al., (2000).

Figure 1.6-B4: Structural map of the kurkar roof (after Golik et al., 1999)



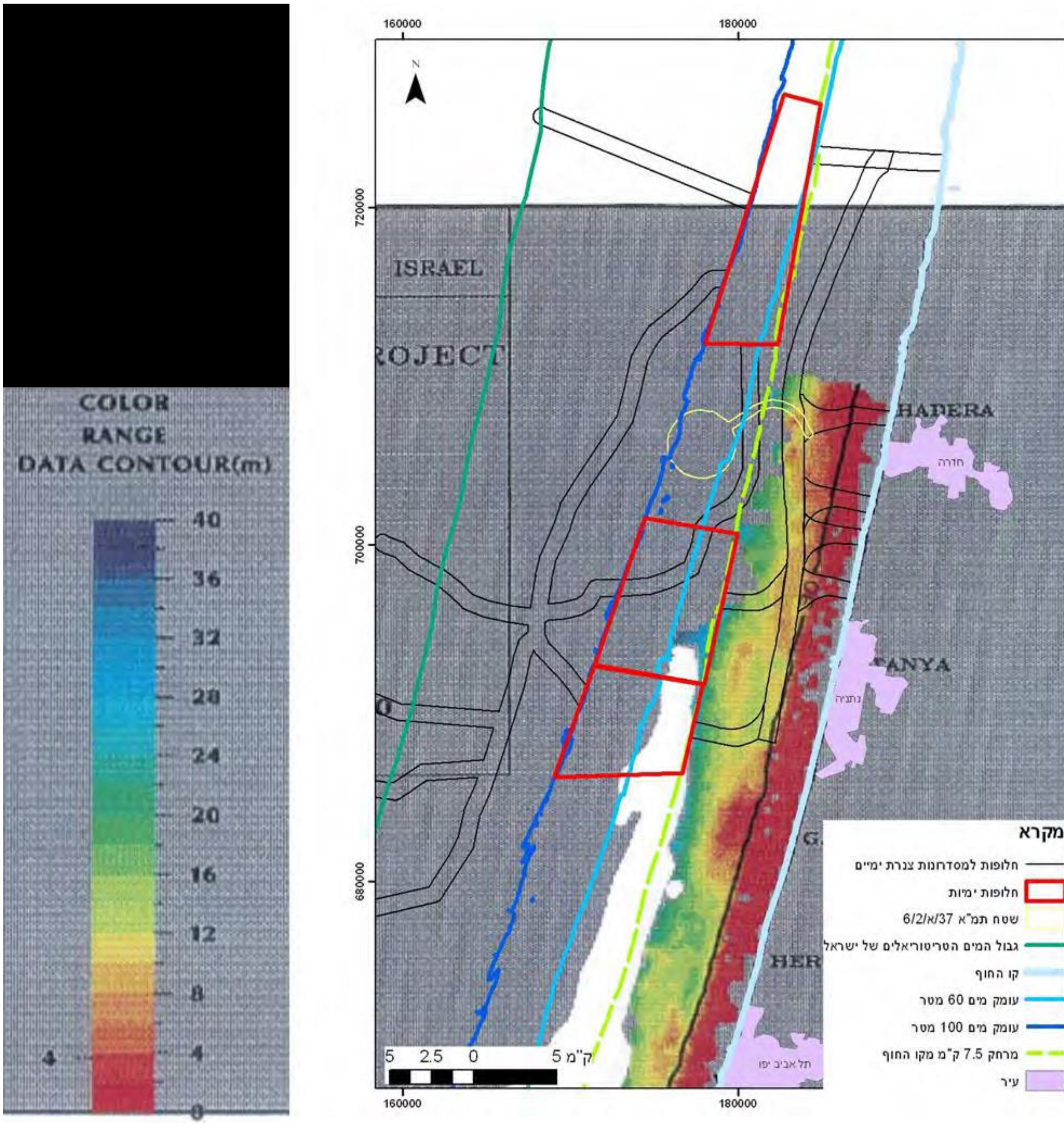
<u>The lower sand unit roof horizon</u> - Figure 1.6-5B presents a structural map of the said unit roof, including the upper sand unit (Golik et al., 1999). The unit roof slants in the west direction from the level of the sea surface in the vicinity of the shore and up to a height of 70 meters at a distance of seven kilometers from the shore. The map's resolution does not allow the identification of morphological elements in this layer.

Figure 1.6-B5: Structural map of the sand unit roof (after Golik et al., 1999)



Clay unit - figure 1.6-6B presents an isopach map of the clay layer (Golik et al., 1999). This map indicates that the clay layer becomes thicker in a westerly direction in accordance with the same trend that can be seen from the LNG float drillings. The clay layer becomes thinner in those areas where the kurkar roof is relatively shallow in Figure 1.6-3B, i.e., in the area of the ranges.

Figure 1.6-B6: An isopach map of clay units (after Golik et al., 1999)



Geotechnical Qualities of the Litho-stratigraphic Units

This part presents geotechnical data measured in a number of soil investigation drillings in the context of the LNG float planning (NGI, 2012). The data only represent the drilling point, but in view of the considerable spatial spread of the litho-stratigraphic units within the inspection space, these data may be considered representative of a typical spread within the region.

Table 1.6-1B:

Table 1.6-B1: Summary of geotechnical characteristics of sediment units sampled in the LNG float drillings opposite Hadera at a water depth of 72 meters (NGI, 2012)

Unit	Average thickness in meters	Water content, %	Density, kN/m^3	Plasticity index I_p, %	Clay content, %	Clay + silt content, %	Undrained sheering strength S_u^c, kPa
Clay 1	19	78	5151	84	15	51	2-54
Clay 2	4	60	5.55	84	15	51	54-8
Sand	4	NA	NA	NA	NA	NA	NA

**NA-Not Available*

Table 1.6-B2: Summary of geotechnical characteristics of sediment units sampled in the LNG float drillings opposite Hadera at a water depth of 44 meters (NGI, 2012)

Unit	Average thickness in meters	Water content, %	Density, kN/m^3	Plasticity index I_p, %	Clay content, %	Clay + silt content, %	Undrained sheering strength S_u^c, kPa
Clay 1	551	42	15.2	48	53	95	2-16
Clay 2	5	NA	NA	NA	NA	NA	NA
Sand	555	NA	NA	NA	NA	NA	NA
Clay 3	555	NA	NA	NA	NA	NA	NA

**NA-Not Available*

Geological Description of the Service Profile in the Marine Area Facing Hadera

This description is based on the findings of the NOP 37/A2/6 (2011) environmental document that surveys the marine area facing the shores of Hadera at a water depth of 39-100 meters. There are two ranges opposite Hadera ("west" and "east") and between the kurkar ranges there is a 15-30 meter deep trough that relative to the ranges includes horizons of sand, silt and clay soil. The kurkar ranges were created along the coastlines during periods in which the sea level was stable for a period of 1,000-2,000 years. The access of the kurkar ranges is approximately parallel to the current coastline.

Division of the NOP 37/1/2/6 (2011) survey area into area cells

The division described below is presented in Figure 1.6-7B.

A. The west kurkar range – the range is exposed at a water depth of 92-125 meters, its width (from east to west) is about 750 meters, the incline of the ridge head area is 0.8-1.2% and the incline of the west slope of the range is 3.0-3.5%. This range was identified in a survey conducted in the context of NOP 37/A/2/6 kurkar range, but no evidence was found for this in the bathymetric information and/or the seismic surveys.

B. The trough area – this area is positioned between two kurkar ranges at a water depth of 49-85 meters. This area is covered with sandy to clayey sediments. The seabed in this area is flat and level with pits and protrusions with diameters and heights, ranging between 5 to 25 centimeters indicating biological activity. The incline of the seabed is 0.6-1.12%.

C. East kurkar range – the kurkar is exposed at a water depth of 32-47 meters. Its length is 1,600 meters, its width is 750 meters, the west and east slope inclines are in the range of 6-9%. On top of the range there are indentations filled with sand with a particle size range of 125-250 microns.

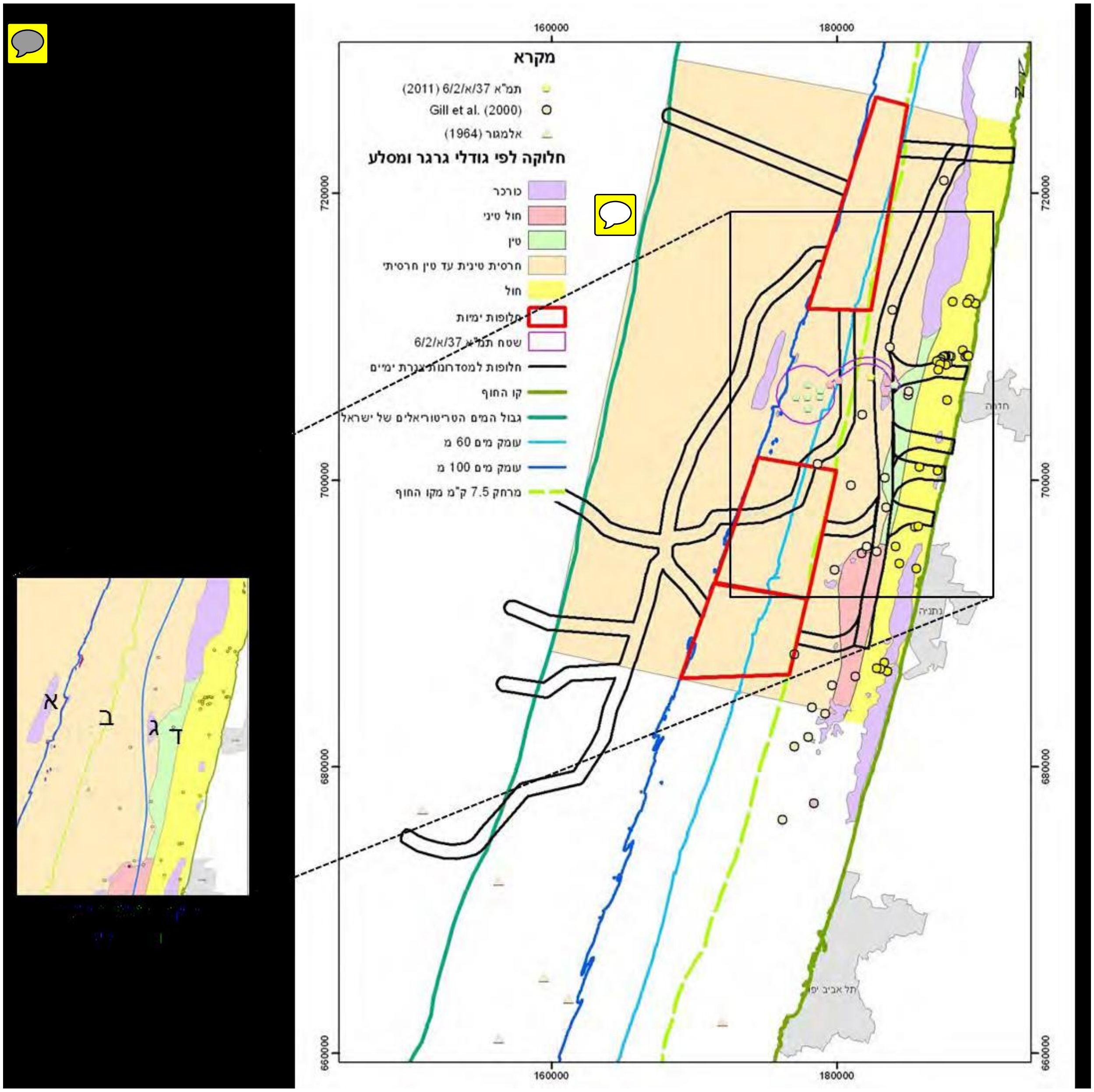
D. East to the east kurkar range – at a water depth of 40-44 meters the area is covered with silty, sandy soil with an incline 0.6%. The relatively flat soil surface includes pits and protrusions similar to those observed in the trough area or smaller.

Granular Metric Map of the Inspection Space

Figure 1.6-7B presents a granular metric map of the seabed in the area of the inspection space for the gas installations and the pipeline. The map is based on Vibracone samples derived from the Royal Islands survey (Almagor et al., 1998), data from Almagor's MA thesis (1964), the natural gas project report (Gill et al., 2000), and the environmental document provided NOP 37/A/2/6 (2011). Most of the surveys provide data up to a distance of about nine kilometers from the shore. The data provided by Almagor (1964) are unusual in that they include samples that were taken opposite the Palmachim shore and the Tel Aviv down to a water depth of 300 meters at a distance of 26 kilometers from the shore. According to these data, assuming a relative uniformity of the character of the sediments in the north-south direction in this area (the possibility that the granule size decreases northward has been taken into account), an extrapolation has been done for the granulometric map (Figure 1.6-7B) within the inspection space west of the territorial waters boundary. The seeming anomaly of the data provided by NOP 37/A/2/6 (2011) when compared with the model of the map in the vicinity of the LNG float (opposite Hadera at a water depth of 60-100 meters) stems from a different methodology of definition for particle sizes adopted by the NOP writers and Almagor (1964). The granulometric map shows the gradual shift from the sandy face (the upper sand unit) and the silt and clay.

Figure 1.6-7B presents a granulometric map of the seabed within the inspection space on the basis of various sources. The small map presents the division into area cells as discussed in section B above - "Description of the local infrastructure within the inspection space."

Figure 1.6-B7: Granulometric map of the seabed within the inspection space



C. Seismotectonic Model

The seismotectonic model is the model that characterizes seismogenic sources according to their geometry and their distance from a certain site along with the history of the seismic activity of each source. The goal of the model is to evaluate the expected soil fluctuations within the site while evaluating the damping of soil movement (as a consequence of the distance of the inspected site from the foci of the vibrations and the properties of the medium through which the waves pass). The model products are the response spectra of the site.

In this work, a deterministic analysis of the seismic risk sources has been performed for the marine inspection space for the gas installations. Accordingly, the maximum soil accelerations expected within the inspection space following earthquakes were calculated for each of the main seismogenic sources using the maximum credible earthquake (MCE) approach and as a control for the probabilistic analysis presented in the standard map of correction sheet 5 of standard 413. Further in this chapter the seismogenic sources within the inspection space are described, and the approach of this work and the way in which accelerations have been calculated the results of the model are presented in Chapters 1.6.1 and 1.6.3.

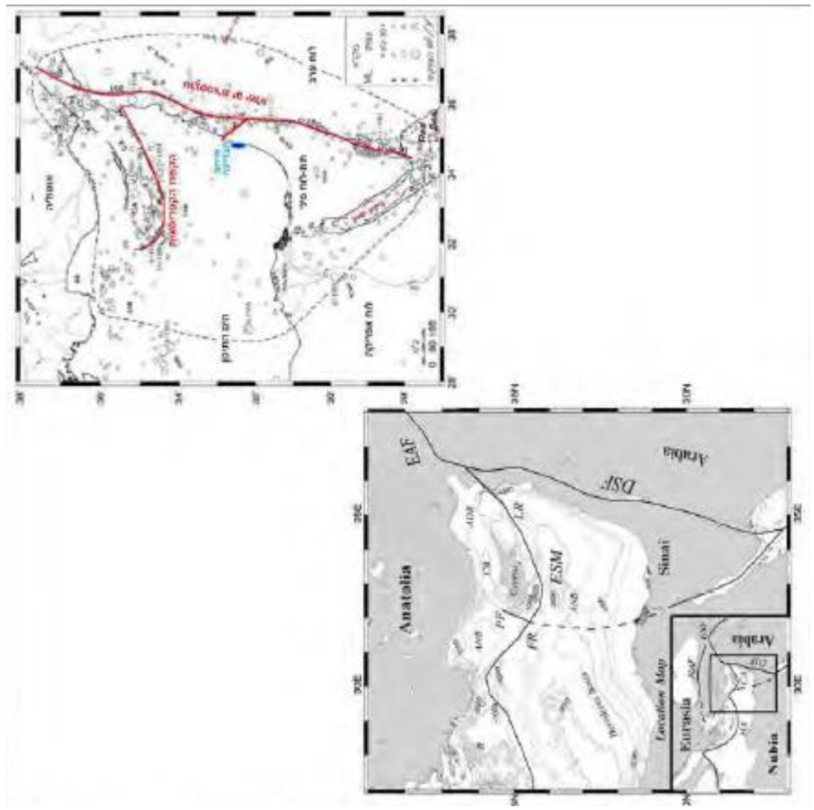
The Regional Tectonic Environment of the Inspection Space

Israel's continental shelf, which includes the inspection space, is located on the Sinai sub-plate (Figure 1.6-C1) located in the area at which the African (Nubian) plate meets the Arabian plate and the Anatolian Block (part of the Eurasian plate). The Sinai sub-plate is a young tectonic element created in through Cenozoic fracture processes. These processes isolated the Mediterranean and Levant Basin during creation of the edges of the ancient continent of Gondwana, a process that began in the early Mesozoic (Garfunkel, 1998). The boundaries of the Sinai sub-plate, the Dead Sea transform-DST in the east that constitutes the tectonic boundary between the Arabian plate and the Sinai sub-plate, the Cyprian Arc in the north and the rift of the Suez Bay in the southwest. These elements constitute the main sources of earthquakes in the east Levant (Figure 1.6-1C). The west boundary of the Sinai sub-plate does not have any clear structural and/or seismic expression and is only defined conceptually (Salamon et al., 2003).

Sources of Seismic Risks for the Inspection Space

The faults included in the seismotectonic model are the main seismogenic sources in a radius of 200 kilometers from the inspection space, as is customary for considerations of soil acceleration damping. The dominant faults in the tectonic system of the Dead Sea transform are the Yamona, Rom, Rachiya Emek HaYarden, Jericho, and Araba faults (Figure 1.6-2C). The parts of the transform located to the south and the north of these faults are not expected to have any significant impact on the inspection space. In addition, the regional tectonic system also includes the Carmel and the Gilboa faults. The Cyprian Arc is located outside a radius of 200 kilometers from the inspection space, but is included in the model since earthquakes of greater magnitudes than the reference events presented in the model are liable to take place there and constitute a contributive source of seismic risks and this due to the content of long waves. In addition, in view of it being a significant seismic source it was found that it should be included in the model given the possibility that the range of error that includes the low-borderline accelerations generated by earthquakes scenarios in this area the margin is great, or that there are significant errors in the models assumptions. All faults included in the seismotectonic model are described in the following sections.

Figure 1.6-C1



NOP 37H

Planning and consulting services regarding natural gas receiving and treatment facilities prior to transmission system connection

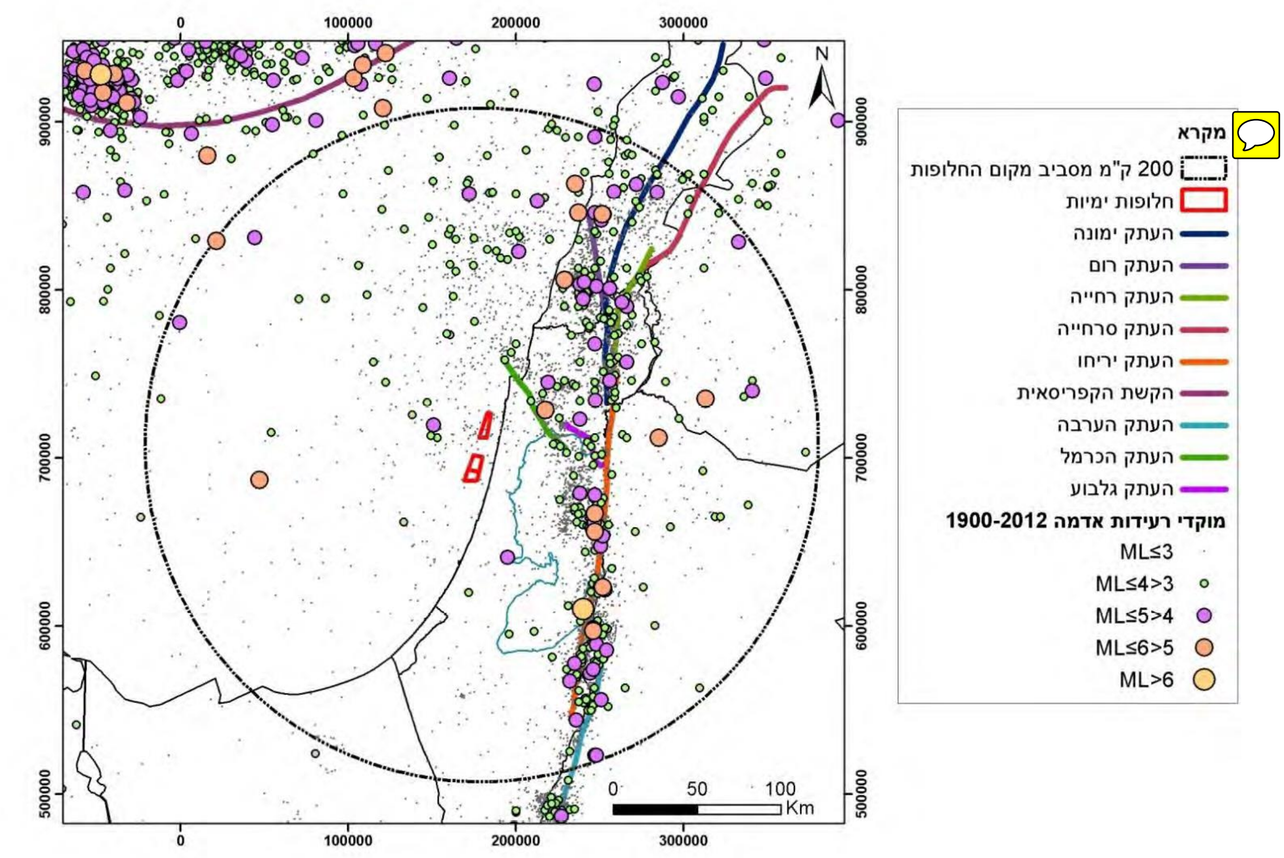
Stage C - Environmental Impact Survey

Offshore Alternatives

Figure number 1.6-1C:A. The inspection space on the background of the scatter of earthquake foci in the environs of the Sinai sub-plate (following Salamon et al., 2003), B. a bathymetric map of the Middle East that demonstrates the morphology of the seabed and regional tectonic elements in the lower left corner – a location map presenting the boundaries of the tectonic plates and sub-plates (following Wdowinski et al., 2006)

Figure 1.6-C2: The marine inspection space and the inspection points on top of an earthquake foci dispersion map (data provided by the geophysical institute) along a

range of 200 kilometers from the inspection space and the faults included in the seismotectonic model



The Cyprian Arc

The Cyprian Arc constitutes a plate boundary between the Anatolian plate to the north and the Sinai sub-plate and the Nubian plate to the south (Figure 1.6-1C). The movement of the plates along the arc is in a NE-SW direction and the rates of its diversion are 7-8 millimeters per year between the Anatolian plate and the Sinai sub-plate with a combined converging horizontal deviation trend and 8-9 millimeters per year between the Anatolian plate and the Nubian sub-plate in a trend of convergence. Based on seismological testimonies Salamon et al., (1996) claim that the west boundary of the Sinai sub-plate continues west to the west of Eratosthenes Seamount, and connects to the Cyprian Arc.

Wdowinski et al., (2006) divide the Cyprian Arc into three main segments based on the geometry of the Arc (with reference marine seismic surveys and on the solution of earthquake foci: (1) the east segment parallel in the direction of the relative movement between the Anatolian plate and the Sinai sub-plate (northeast-southwest) so that the main active structures along this segment are horizontal movement faults. (2) A central segment located to the southeast of Cyprian and characterized by a collision in a northeast-southwest direction between the Anatolian plate and the Sinai sub-plate. (3) A western segment with a vertical orientation towards the direction of the reduction of the Nubian sub-plate under the Anatolian plate and accordingly its main movement is convergence (Figure 1.6-C1/B). The boundary between the main segment and the west segment is a transform fault lying in a northeast-southwest direction (PF in Figure 1.6-1C/B) that generates medium to large strike slip earthquakes such as the Paphos earthquake of 1996 with a magnitude of M_w=6.8 and the Adana earthquake in 1998 with a magnitude of M_w=6.2. These earthquakes are relatively deep (30-40 kilometers) (Arvidsson et al., 1998; Aktar et al., 2000). The assumptions regarding the geometry of the fault segments described above include a dip of 15 degrees and a ruptured depth of 30 kilometers. The evaluation according to Wells and Coppersmith (1994) indicate that the western segment is capable of creating an earthquake with a magnitude of M_w=8.0 (according to a ruptured length of 130 kilometers) and the central and east segments can generate an earthquake with a magnitude of M_w=7.8 (according to the rupture length of 100 kilometers). A combination of such ruptures along the entire length of all segments is liable to generate an earthquake with a maximum magnitude of M_w=8.4 (Ecolog, 2010).

The Dead Sea Transform

The Dead Sea Transform (DST) is the main seismogenic source in the east of the Sinai sub-plate (Figure 1.6-C1 and Figure 1.6-C2). This is a left fault system that constitutes the plate boundary between the Arabian plate and the African plate (the Sinai sub-plate). The Dead Sea Transform spreads in an approximate north-west direction along about 1,000 kilometers from the Red Sea and the Aqaba Bay in the south and up to Turkey in the north (Anatolia). The seismic activity along the transform is mainly concentrated in deep recesses and in the vicinity of fault branching along the Lebanese shear band and along the west side of the transform (Salamon et al., 1996).

The DST is divided into segments that are distinguished from each other by the alignment of their spread, the seismic activity that can be observed along them, and their structural style. These segments are separated by large tectonic indentations, such as the Dead Sea, the Sea of Galilee, and the Hula Basin (Garfunkel et al., 1981). The following sections present these segments along the DST that are relevant to the seismotectonic model.

Seismic Activity

The DST has a long history of significant earthquakes almost along its entire length (Figure 1.6-C1, 1.6-C2). This history combines with the descriptions of the appearance and impacts of earthquakes in the east Mediterranean Basin from the dawn of written history. The earthquakes along the DST are richly expressed geologically and are documented by recording instruments in the past decades. The regional and local catalogues of earthquakes have been developed by various researchers (e.g., Ambraseys et al., 1994; Meghraoui et al., 2003; Migowski et al., 2004; Salamon et al., 2007) and are based on geological, historical, and modern (instrumental) documentation. Since the beginning of the 20th century, 11 strong earthquakes have been documented ($M_L \geq 5$) along the center and north of the transform (from the Dead Sea northwards) the largest of which (1927; $M_L = 6.2$) has taken place on the Jericho fault.

The Jericho Fault

The Jericho fault is a horizontal left strike slip along the south-central part of the Dead Sea Transform. It spreads from the Dead Sea Basin through the Jordan Valley and up to the Sea of Galilee (also the called the Jordan Valley fault; Figure 1.6-C2). The exact alignment of the Jericho fault has no continuous morphological/geological and/or geophysical expression. To the north of the Dead Sea it is identified on the surface by Sagy and Nachmias (2010). A number of researchers (for example, Ben-Avraham and Schubert, 2006; Marco, 2007) ascribe the clear scar in the bathymetry of the west Dead Sea to the alignment of this fault. The expression of this fault is limited in the south part of the Dead Sea beside the site of the Mor faults that was identified with the horizontal movement center in the area (Bartov and Sagy, 2004).

The last strong earthquake that occurred in our area in 1927 $M_L = 6.2$ is ascribed to the Jericho fault (according to the data provided by the Geophysical Institute). Moreover, new outcrops along the alignment indicate a history of earthquakes during the late Pleistocene and the Holocene (Sagy and Nachmias, 2010). The historical documentation for the south part of the Dead Sea Transform indicates that in this part a moderate-strong earthquake takes place once every 100 years on average (Garfunkel and Ben-Avraham, 1996), wherein the largest events ($M \geq 7$) took place to the south of the Dead Sea Basin along the Arava fault.

The typical horizontal slip rates of the Jericho fault are estimated at about 4.9-5.1 millimeters per year over the past 47,000 years in the Jordan Valley, according to the slip of the drainage systems (Ferry et al., 2007), and at 3.5 millimeters per year over the last 30,000 years in the southern part of the fault (Bartov and Sagy, 2004). Examples of movement rates estimated by geodesic (GPS) means include 3.7 ± 0.4 millimeters per year (Wdowinski et al., 2004), and 7.5 ± 0.8 millimeters per year (Ostrovsky, 2005) in the Dead Sea region itself.

The seismic regime along the Jericho fault is characterized by long recovery times for strong earthquakes in addition to a significant component of non-seismic slip (Begin et al., 2005). Begin et al., (2005) also claimed that the seismic regime along the Jericho fault has been stable for the past tens of thousands of years and for this reason the purported difference between the geological rates and geodesic rates published actually arise from measurement errors and the limitations of the method. A comprehensive analysis of earthquake data along the Jericho faults and calculation of their recovery times was performed by Hamiel et al., (2009) and is used in this work in order to establish the magnitude of the reference events of this fault (Table 1.6-C1).

The Arava Fault

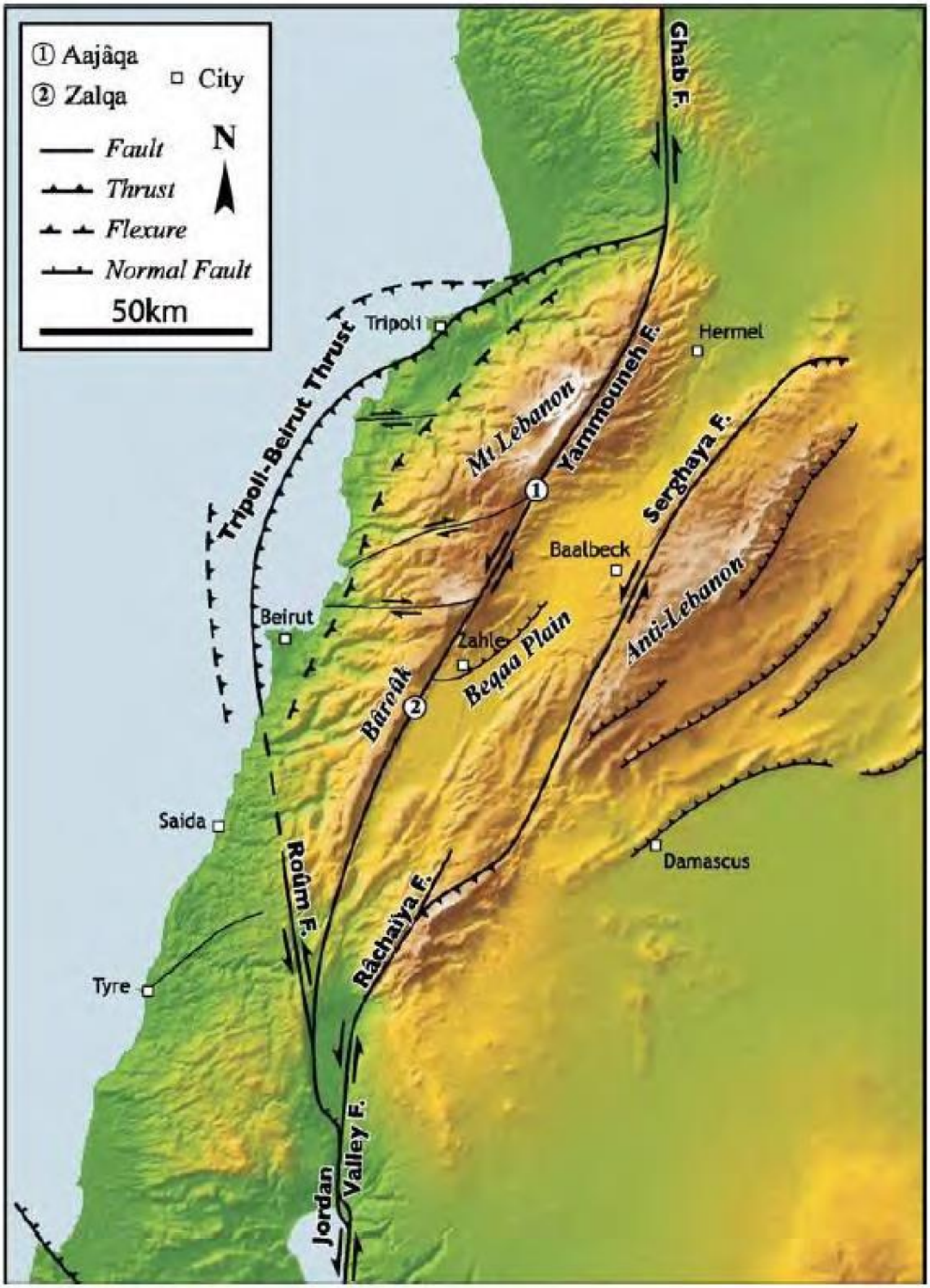
The Arava fault lies along the Arava Valley up to the east of the Dead Sea Basin. Alignment of this fault in the east of the Dead Sea Basin is subject to disagreement. Garfunkel et at., (1981) claim that this fault may be recognized in the sediments to be found on the surface in the area where it meets the Amatziya fault (the south area of the south basin of the Dead Sea). In various publications this fault is marked to the east of the basin at varying levels of precision on the basis of information from the subsoil and depending on the tectonic model adopted by the researchers. In the past 100 years there have been no earthquakes greater than M = $\geq$ 5 along this fault (Figure 1.6-C2).

The Lebanese Restraining Band

North of the Hula Basin, in the area of the 33N-34.5N latitudes, the Dead Sea Transform curves by about 25 degrees towards the east. This change in the fault alignment and its continued curving along its central part create a pressure area expressed in sharp topography (for example the mountains of Lebanon); this area is also called the Lebanese restraining band. Accordingly, the Dead Sea Transform can be divided into a north segment and south segment separated by the Lebanese restraining band.

The length of the restraining band is about 170 kilometers and within it the Dead Sea Transform is split into five main faults (Figure 1.6-C3): the Yammouneh fault, the Roum fault, the Tripoli-Beirut fault, the Rachaya fault and the Serghaya fault, wherein only the Yammouneh fault crosses the entire Lebanese restraining band (Gomez et al., 2003; Nemer and Meghraoui, 2006; Khair, 2001). The faults liable to be formed in an earthquake that will disrupt the integrity of the offshore gas facilities are Yammouneh, Roum, Rachaya, and the Tripoli-Beirut fault, and it is for this reason that these faults have been included in the model and their description is presented below.

Figure 1.6-C3: The Lebanese restraining band (after Daeron et al., 2004)



The Yammouneh Fault

The Yammouneh fault is a left strike slip fault with a clear topographic trace alone 160 kilometers. This fault incorporates the main relative motion of the African and Arabian plates, one against the other within the Lebanese restraining band (Figures 1.6-C2; 1.6-C3). The horizontal rate of motion of the fault from the late Pleistocene until the present is about 5.1 $\pm$ 1.3 millimeters per year (Daeron et al., 2004). Nemer et al., (2008) estimate that for this fault the maximum moment magnitude is M_W = 7.3-7.5. The last strong earthquake on the Yammouneh fault took place on May 20, 1202 and its magnitude was estimated at about M_W = 7.5 (Daeron et al., 2007). The rupture of the surface as consequence of the earthquake was observed in the Yammouneh Basin in Vadum Jacob and in the Bet Tzayda Valley along the Jordan fault, along a total length of about 145 kilometers (Nemer et al., 2008 and references there). Gomez et al., (2007) estimate that the present scarcity of seismic activity along the Yammouneh fault does not indicate that the fault is inactive, but rather the opposite, that the Yammouneh fault is a locked fault that is destined to release the strains accumulating within it through a strong and significant earthquake.

This model take two possible scenarios into account, one according to which the south tip of the Yammouneh fault is located at the northwest corner of the Hula Valley (as drawn by Daeron et at., 2004) and its length is 187 kilometers; and the second scenario according to which the south tip of the Yammouneh fault is located at the Kinorot Valley and in fact, also comprises the fault of the Sea of Galilee's western edges (as drawn by Ecolog, 2010) and according to that alignment the length of the fault is about 230 kilometers. This scenario is supported by the estimated spread of the surface rupture in the 1202 earthquake from the Yammouneh Basin in the north to the Sea of Galilee in the south.

The Roum Fault

The Roum fault spreads from the northwest part of the Hula Basin in the north-northwest direction up to Jbaa, where it is replaced by folding structures (Figures 1.6-C2; 1.6-C3). Among the faults of the Lebanese band, the Roum fault is the only one with a similar direction to the general direction of the Dead Sea Transform, south of the Lebanese band. Because of this, and contrary to what has been claimed above in regard to the Yammouneh fault, there are those who claim that on top of the Roum fault most of the Lebanese restraining bands strains are concentrated (e.g., Girdler, 1990; Butler et al., 1998). The Roum fault is a left strike slip fault with normal slip trends in its north part. In accordance with last strong earthquake that took place on the Roum fault on January 1, 1837, the maximum earthquake magnitude estimated for the Roum fault is about M_S=7.1 (Nemer and Meghraoui, 2006).

The Rechaya Fault and the Jordan Valley Fault

The Rechaya fault spreads from Rechaya in the north up to the Hula Valley in the south. Its trend is north-northeast and its length is about 40 kilometers. The Jordan Valley fault spreads from the Hula Valley in the north up to the Sea of Galilee in the south (Figures 1.6-C2; 1.6-C3). Its trend is northerly and its length is about 38 kilometers. Because of uncertainty in regard to the alignment that connects between these faults (for example, see Daeron et al., 2004) two possible scenarios have been examined: one scenario examines a separate activation of each fault, while the second scenario examines the joint activation of these faults.

The Tripoli-Beirut Fault

Also known as the Tripoli-Roum fault, the Mount Lebanon Thrust, and the Offshore Monocline. This inverted fault that mostly spreads underneath the surface of the sea along the Lebanese shore (Figures 1.6-C2; 1.6-C3). Elias et al., (2007) claim that the length of the fault is about 100 kilometers at least. In Figure 1.6-C2, the land extension of this fault is presented in a conceptual way in accordance with Daeron et al., (2004). Nemer and Meghraoui, (2006) and Elias et al., (2007) ascribe this fault to the historical earthquake of July 9, 551 CE, which caused a tsunami along the east coast of the Mediterranean Basin. The intensity of this earthquake is estimated by Nemer and Maghraoui, (2006) on the basis of Byzantine documentation at about M_S=7.1-7.3. Elias et al., (2007) estimate in accordance with the equations of Wells and Coppersmith, (1994), that its intensity was about M_W=7.4-7.6 and also note that according to a typical earthquake model the recovery time of an earthquake such as that of the year 551 CE is approximately 1,500 years so that we are in fact at the end of a seismic cycle. There is some obscurity regarding the question if the Tripoli-Beirut fault is a continuation of the Roum fault or not (for example Darawcheh et al., 2000). Geophysical mapping of the seabed (Shalimar, 2003) that describes the inverted fault along the Lebanese shores does not support the assumption that this fault is the marine continuation of the Roum fault.

The Carmel and Gilboa Faults

The Carmel-Tirtzah (or Carmel-Periyah) faults system branches out from the west side of the Dead Sea Transform and continues to the northwest from it into the Mediterranean Basin (Figure 1.6-C2). This system includes the Carmel fault and the Gilboa fault and its total length is about 67 kilometers.

The marine alignment of the Carmel fault is a matter of contention. Kafri and Folkman, (1981) identified its extension at about 13 kilometers from the shore in the northwest direction and estimate that the fault extends into the sea about 55 kilometers in the northwest direction. In contrast, Schattner and Ben-Avraham (2007) estimate that the fault continues in the north-northeast direction along the basis of the continental slope up to Beirut where it crosses the Tripoli-Beirut fault. In this model we draw the marine extension of this fault on the basis of the findings of Kafri and Folkman (1981) and in accordance with the alignment of the Kishon segment of the fault. The total length of the Kishon segment is 28 kilometers, of which 13 kilometers are from the coastline in the direction of the continental shelf of the Levant Basin; its direction is northwest to southeast and it passes through the city of Haifa and along the basis of the Carmel range (Egolog, 2010). The documented history of the seismic activity of the Carmel fault is sparse and does not provide information that makes it possible to determine at a reasonable level of certainty the magnitude of the maximum/typical earthquake that may take place there as well as the recovery time of such earthquakes. It is not known, for example, if the earthquakes on the Carmel fault tend to act on each segment separately or to connect its various segments. In view of the importance of the installations, the present model adopt and a somewhat stringent approach as regards the length of the fault and assumes that earthquakes are capable of increasing and passing through geometrically complex areas along its length (as observed on many other faults, for example the Landers earthquake, 1992).

The Carmel-Tirtzah fault system seems to be following the ancient flow plain in the earth's crust that has been active since the Paleozoic (Ben-Avraham and Ginzburg, 1990). Since the Pliocene and later the early Pleistocene with the shift to the present regime of the regional activities, the slip of the Carmel fault has character that combines a left horizontal motion with tension. This shift transfers the left horizontal motion from the Dead Sea fault in the direction of the Levant Basin to the southwest (Achmon, 1998) and is the factor responsible for the present morphological and tectonic character of the fault; including a shift from the east to west from a dispersed fault model (that comprises many sub faults spread over an extensive area) to a concentrated fault model (that comprises a single dominant central fault and a limited number of small sub faults) as demonstrated by Hofstteter et at., (1996).

Along the northeast boundary of the Carmel range, the Carmel fault is expressed in a prominent rock escarpment that faces northeast. The marine continuation of the Carmel fault does not have any expression on the surface, but is clearly discernible in seismic sections (for example see Ben-Gai and Ben-Avraham, 1995; Scattner et al., 2006). The extent of the Carmel fault horizontal slip is estimated at about 4-10 kilometers (for example Freund, 1970) in combination with determination of ages of the slipped Neocene basalts. It may be seen that the long-range horizontal slip rate of the Carmel fault is about 0.3 to 0.5 millimeters per year.

The southeast boundary of the Carmel-Tirtzah area is defined by a series of earthquake foci along the Gilboa fault and its continuation to the northwest. Shamir (2007) notes a conglomeration of prominent foci in the Ganeen Ta'anach area within the Gilboa-Carmel fault area. The northwest boundary of the fault area is the edges of the Israel valley without any clear lineation of the earthquake foci. The Gilboa fault constitutes a boundary to the north and the east of a tension area of 10 kilometers between it and the south segment of the Carmel fault and seems to be transferring the motion from the Dead Sea fault to the Carmel fault through this tension area (Rotstein et al., 2004). Its trend is to the northwest and it passes along the base of the northeastern escarpment of the Gilboa Mountain.

Seismic Activity

Hofstetter et al., that the seismic activity in the Carmel-Tirtzah system concentrates along the traces of faults laid out in northwest-southeast direction or in local grabens. The number of events increases as one approaches the Dead Sea faults (in the southeast part of the Carmel-Tirtzah system, the seismic activity spreads over a number of faults with traces on the surface). In the area to the south of the Gilboa fault, the seismic activity is not concentrated around a single fault on the service, but is characterized a wide formation area as proposed by Rotstein et al., (1993). The depth of the seismogenic crust along this system is 10-12 kilometers according to Hofstetter et al., (1996) and 9-17 kilometers according to Shamir (2007).

Hofstetter et al., (1996) conclude that the earthquake that took place on August 24, 1984 (M_L=5.3) in the Jezreel valley (close to Kfar Baruch) took place on a fault that belongs to the Carmel-Gilboa fault system. This earthquake is the strongest earthquake recorded in the north of Israel, outside the Dead Sea rift since the beginning of instrumental recording in Israel. Despite all of the above, the extent of motion in each element of the Carmel fault is still a matter of contention (for example Scattner et al., 2006) and in view of the obscurity regarding the extent of its current seismic activity it is defined "suspected to be active" (Bartov et al., 2009).

In Shamir's (2007) work, that includes the retrieval of 256 earthquakes at level $M_L \geq 1$ that took place in the north of Israel since 1984, there is a clear decline in the frequency of the earthquake foci to the southwest of the Israel valley in the northwest direction, so that the share of the fault in the Zebulon Valley and the Haifa Bay area indicates a seismic gap during the measurement period.

The Approach of the Work

❖ Probabilistic Model Versus Deterministic Model

The probabilistic analysis of the SH (Probabilistic Seismic Hazard Analysis, PSHA) weighs the results of the parameterization of tectonic elements (for example type of fault, recovery time of a maximum earthquake, etc.) and estimates the probability for the occurrence of soil movements at certain intensity along a specific time interval (reference events) within the project site. The analysis takes into account the various probabilities regarding the data of seismogenic sources, such as the rate of earthquake occurrence on the various faults.

While a probabilistic analysis is quantitatively seductive, i.e., it provides quantitative information regarding the expected seismic risk level (PGA according the recovery period), the main weakness of a full probabilistic analysis is exactly its analytic results that are used to determine seismic parameters, for they are not proportional with the precision of the information that served as input for the analysis. In other words, the error margins of the geological seismic information used for the purpose of the probabilistic analysis and the assumptions that were used are sometimes significantly greater (by orders of magnitude) and they are not proportional to the error margins of the analytic products. In addition, a probabilistic analysis is liable to yield unrealistic estimations, such as an earthquake scenario on a fault in a place where there is no fault etc. (FEMA 451 Complimentary Material), as is reflected from this aggregation results of these analyses. The enhancement of the seismogenic areas in which there is only weak seismic activity without any dominant fault biases the true contribution of the main seismogenic sources (Shamir, 2002; Keller et al., 2011). Since the seismologic information used to evaluate the statistical parameters is limited in the case of Israel in view of the low-medium level of seismic activity, the error margins of the received accelerations are very great.

In many cases, it is customary to overcome such limitations by means of a Deterministic Seismic Hazard Assessment, DSHA as presented by Bommer (2002) and other writers before and after. The DSHA does not present recovery times and the probability for the occurrence of events, but rather presents the maximum risk level that the inspected facility is expected to sustain. The DSHA is particularly efficient in cases where the seismic risk is inducted by a number of dominant seismogenic sources (faults) and where the facilities concerned are vital facilities that must be protected from seismic events with high recovery times. This approach is based on the Maximum Credible Earthquake (MCE) approach: the PGA expected at the site following the greatest earthquake/the earthquakes at a very long recovery time that may take place on a specific seismogenic source on the basis of geological and seismological observations. Since the project site is liable to be impacted by a number of seismogenic sources, one may define a number of MCEs for it according to the type of source, its size, its distance from the project site and the maximum possible earthquake capable of occurring there. In this work we have adopted a deterministic approach. The PGA estimations obtained are used to control the probabilistic analysis given in correction sheet number 5, of IS 413 (Keller et al., 2011). The use of linear seismogenic sources provides the physical basis for the probabilistic analysis of the seismogenic areas, although some of the assumptions on which the present model is based differ from those used by Keller et al., (2011). The PGA values for various reference events (475, 975, and 2475 years) as calculated by Keller et al., (2011) are presented, therefore in comparison with the MCE values obtained.

- **Calculations of maximum magnitude**

A maximum has been calculated for each fault M_W, according the empirical ratios of Wells and Coppersmith (1994) that indicate a relationship between the size of the rupture and the magnitude of the earthquake. According to accepted practice in the professional literature, the evaluation of magnitude can be based on the surface data of the inspected faults – an approach that assumes the rupture spreads along the entire area of the fault (M_{MAX}). Although there are no well-founded empirical relationships regarding the relationship between the rupture areas and the fault areas, a qualitative experience indicates that earthquakes usually do not rupture the entire fault area on which they take place.

The relationships are defined in the following way according of types of faults:

(1) $M_W = 1.02 \log A + 3.93$ for normal faults

(2) $M_W = 1.02 \log A + 3.98$ for horizontal faults

(3) $M_W = 0.98 \log A + 4.07$ for all slip mechanisms

Where A is the fault area (length by breadth [depth]) and M_W is the expected magnitude (moment magnitude). The width of the faults is based on an estimation of the depth of the seismogenic crust with a representative value of 15 kilometers (Garfunkel, 1981; Salamon et al., 2003). For the Cyprian Arc, a seismogenic depth of about 30 kilometers was chosen in accordance with the earthquake foci observed in the area.

Attention should be paid to the fact that the relationship between the rupture area and the magnitude is not a linear one. Thus for example, according to equation 3, for fault areas of 500 and 300 square kilometers, magnitudes of $M_W = 6.71$ and $M_W = 6.50$, are obtained respectively.

Equations (1) and (2) were used for faults that have a known motion mechanism. Equation (3) served for faults with a motion mechanism that is unknown. In addition, the maximum magnitude was also calculated according to Hanks and Bakun's equations (2002):

(4) $M_W = \log A + 3.98$ for faults where $A \leq 537$

(5) $M_W = 4/3 \log A + 3.07$ for faults where $A \geq 537$

These equations are more precise for a large horizontal faults (magnitude M > 7), and were accordingly used in order to determine the magnitude of these faults. For smaller faults the results of the calculations made in accordance with these equations were used for smaller faults in order to compare them with the calculations results according to Wells and Coppersmith (1994).

- **Attenuation Relationships**

When an earthquake takes place the movement of the soil dies down with the distance from the earthquake source. This dying down is characterized by empirical attenuation relationships that characterize the peak accelerations (PGA) and the spectral accelerations received at the roof of the rock layer at the site (without amplification/attenuation of the layers above the rock roof and the basis of the structure) as a function of the distance from the source of the earthquake and its magnitude. The attenuation equations comprise parameters that are related to the speed of the shear waves in rocks and for this reason the peak acceleration value depends on the elasticity of the rocks in the medium between the source of the earthquake and the site for which the acceleration is being calculated.

In recent years new attenuation relationships known as Next Generation Attenuation (NGA) have been developed, for example Abrahamson and Silva (2008). The advantage of the "new generation" relationships is that they are based on a wider database that is significantly greater than that used to develop the "old generation" attenuation relationships, e.g., Boore et al., (1997). Moreover, they weigh more tectonic, geological, and statistical parameters relative to the "old generation" relationships, such as the depth of the rupture during an earthquake and the speed of the shear waves in the soil. The new relationships also include a more precise distinction between vertical slip faults and horizontal faults. Out of the "new generation" relationships, the present analysis has selected the attenuation relationships of Abrahamson and Silva (2008), Campbell and Bozorgnia (2008), and Boore and Atkinson (2008) (B&A 2008 and C&B 2008 and A&S 2008, respectively). These relationships were chosen since they are based on analysis of earthquakes in shallow crust areas that are tectonically active mainly in the US west and in the Mediterranean Basin. The attenuation relationship of Campbell and Bozorgnia (2008) also serves as the basis for calculating the seismic coefficient and for the new spectral maps created in the context of correction sheet number 5, of the IS 413 (Keller et al., 2011).

For each fault, the minimum from three points within the inspection space was calculated and the PGA values were calculated for the attenuation of the maximum magnitude calculated for each of the main seismogenic sources. The accelerations values presented include both the expectancy values of the models accelerations and the higher acceleration values that incorporate the standard deviation within them; this in parallel to the accelerations values received in accordance with correction sheet number 5, of IS 413 (Keller et al., 2011) that include the standard deviation. The final PGA value of the fault was determined by an average calculation of the values received from the three attenuation relationships presented. The PGA calculations were made using the Attenuation Relationship Plotter 1.23 software.

1.6.1 Creations of Accelerations and the Exertion of Horizontal Forces on Structures and Infrastructures According to Israeli Standard 413

1.6.1.1 Calculation of horizontal soil accelerations within the inspection space

The horizontal soil accelerations expected for the rocky base are given in accordance with various reference events. A reference event is the expected soil movements (Peak Ground Acceleration: PGA, g) at the site during a specific repeat period. The greater the recovery time the more severe the reverence event (higher PGA). The PGA estimations suggested in this model correspond to an MCE reference event these estimations complete the probabilistic analysis based on correction sheet number 5 of IS 413 (Keller et al., 2011) in that they provide deterministic values and anchor the probabilistic analysis results in actual and linear seismogenic sources. The identification of the dominant seismogenic source allows discussion of the risk level of the facility relative to the information existing in regard to that source. The PGA estimations for the various seismogenic sources in the inspection space are presented in Table 1.6.1-1.

The soil accelerations were calculated for three points in the marine inspection space: in its north end, at its center, and in the south (Figure 1.6.1-1; Table 1.6.1-1). For each fault a minimum distance was calculated from each of the points. The PGA values were calculated for the maximum magnitude attenuation calculated for each of the major seismogenic sources. The values of the accelerations presented also include the model accelerations expectation values (PGA-mean) and these are higher acceleration values that incorporate the standard deviation (PGA - 1σ).

The horizontal soil accelerations data expected for the rocky base in the inspection space according to correction sheet number 5 of IS 413 (Keller et al., 2011) are presented in table 1.6.1-2 for an earthquake with a recovery period 475 years, 975 years, and 2,475 years which parallel event probabilities of 10%, 5% and 2% over 50 years respectively.

Table 1.6.1-1[4]: Maximum magnitude values calculated for each of the main seismogenic sources and the accelerations derived from them for three points (A-C) within the inspection space (Figure 1.6.1-1)[4]

A. North Point

Fault	Slip Mechanism	MMAX	PGA-mean	PGA-1□
Cyprian Arc	Inverted	8.0	0.03	5.8
Jericho	Horizontal	7.7	0.08	552
Arava	Horizontal	7.4	0.02	5.8
Yammouneh	Horizontal, normal in its south part	554	0.08	552
Roum	Horizontal	555	0.05	5.5
Rachiya	Horizontal	7.2	0.05	5.4
Carmel	Normal	7.0	0.11	7.10
Gilboa	Normal	6.7	0.06	5.5

B. Center Point

Fault	Slip Mechanism	Mmax	PGA-mean	PGA-1□
Cyprian Arc	Inverted	8.0	0.03	5.8
Jericho	Horizontal	7.7	0.07	555
Arava	Horizontal	7.4	0.03	5.8
Yammouneh	Horizontal, normal in its south part	554	0.07	555
Roum	Horizontal	555	0.04	5..
Rachiya	Horizontal	7.2	0.04	5.5
Carmel	Normal	7.0	0.08	7.11
Gilboa	Normal	6.7	0.05	5.4

[4] The results of the calculations for the seismogenic source expected to create the highest accelerations are marked in red.

C. South Point

Fault	Slip Mechanism	Mmax	PGA-mean	PGA-1
Cyprian Arc	Inverted	8.0	0.03	5.8
Jericho	Horizontal	7.7	0.07	7.11
Arava	Horizontal	7.4	0.03	5.1
Yammouneh	Horizontal, normal in its south part	554	0.06	5.5
Roum	Horizontal	555	0.03	5.1
Rachiya	Horizontal	7.2	0.04	5.1
Carmel	Normal	7.0	0.06	5.5
Gilboa	Normal	6.7	0.04	5..

Table 1.6.1-2: Soil acceleration values for three points (A-C) within the inspection space according to correction sheet number 5 for IS 413 (Keller et al., 2011)

Reference event	2% in 50 years	5% in 57 years	17% in 57 years
North Point	.558	.55.	0.08
Center Point	.552	.5.5	0.07
South Point	.555	.5.4	0.06

The calculation results indicate that for the north and center points the dominant seismogenic source is the Carmel fault, while for the south point the dominant seismogenic source is the Jericho fault (the Dead Sea Transform segment between the south of the Dead Sea and the south of the Sea of the Galilee). By comparing this to the accelerations provided by Keller et al., (2011), we see that the maximum acceleration values that incorporate the standard deviation for the central and south points are identical to the values presented in the correction sheet number 5 map for a recurrence of 2% in 50 years that also include the standard deviation. For the north point, the maximum acceleration value is greater than that appearing in the standard.

According to Hamiel et al. (2009), the size of a maximum earthquake in the north area (M_{MAX}) is 7.6 (smaller by 0.1 than the M_{MAX} magnitude of the present model), while the earthquake size for a recurrence time of 2,500 years is 7.3. The maximum earthquake value for the seismogenic areas of the Jordan valley and the Dead Sea according the standard is M_{MAX} = 7.5. The significance of the results of calculations and observations presented above is:

A. It would be expected that this aggregation of the calculation in the standard for a recurrence period of 2% in 50 years for the south point will show that the dominant earthquake is located in the environs of the Jericho fault. However, for the same acceleration value, the present model requires an earthquake with a magnitude of 7.7 while the standard requires an earthquake magnitude that is of necessity smaller than 7.5. There may be various reasons for this difference, including the use of different variables in the attenuation equations. It seems that another reason for the difference is the impact of additional seismogenic areas on the results of the Keller et al. (2011) calculations, including areas with low seismic activities without any known fault that dominates the seismic moment that is seemingly contributed by the area.

B. The difference in the maximum acceleration value between the present calculation and the standard values for the north point is mainly impacted by the fact that M_{MAX} in the standard is 6.5, while the present model stipulates 7.0.

C. At the central point the maximum acceleration values are identical for the standard and the model presented despite the difference in the maximum magnitude of the two calculations. It is possible that this difference arises *inter alia* from the contribution of additional seismogenic areas to calculation of the standard.

The dominant seismogenic sources for marine gas facilities are the Jericho fault and the Carmel fault. The information for the Jericho fault is relatively rich, and therefore the level of reliability in determining the seismic parameters and the level of risk derived from them are relatively high, in other words the maximum size of the earthquake and the recurrence period of the received accelerations reflect a relatively reliable physical reality. It is not possible to base a similar determination on the Carmel fault since there is no satisfactory historical, Plioseismological and instrumental information regarding the large earthquakes that took place over this fault and their recurrence period. M_{MAX} for the Carmel fault is a hypothesized value that arises from geometric considerations of the length of the fault and its area (parameters that are debatable especially as regards the alignment of the fault at sea and its ability to activate a number of segments in the course of a single earthquake) without any seismic historical support. As stated in the explanatory passage, the model adopts a conservative approach to the length of the Carmel fault and the character of the earthquakes along it, and assumes on the basis of the activity of other faults that earthquakes may pass through areas of geometric complexity. Given the slow rate of motion the Carmel fault, such earthquakes seem to be extremely rare (the standard assumes that an M = 6 magnitude earthquake takes place on the Carmel fault every 300 years).

In view of said findings, it should be assumed that the design acceleration value for planning the facilities will increase in a north direction. At this stage that does not seem to be ay expected limitation on any type of development as regard the soil accelerations in view of the spatial model delineated by the accelerations values.

1.6.2 Surface Rupture over Active Geological Faults

1.6.2.1 Defining active faults/faults suspected as active according to IS 413

In the explanatory text provided for the map of faults that are either active or suspected of being active (Bartov et al., 2009), these faults are defined in the following way:

Active faults: faults for which there is evidence of activity over the past 11,000 years.

Faults suspected as active: faults that break layers dated from the Pliocene onwards and that belong to a fault system in which active faults have been defined.

Note that the map of faults suspected of being active/active only encompasses the land surface of the State of Israel, while those faults that were mapped in the marine part of Israel were not systematically sorted according to this classification. For the purpose of the present survey, many works that included mapping of faults at the bottom or in the subsoil of the Israeli marine area were examined. In this survey the rule applied to all those faults suspected as active within the marine region was identical to that applied to active faults for the purpose of determining the risk level of their environment and this is also the approach adopted by IS 413. This stringent approach also stems from the absence of certainty that is sometimes involved in establishing the age of a fault at sea.

1.6.2.2 Faults within the inspection space and its environs

Figure 1.6.1-1 presents the alignment of the faults within the inspection space and its environment as mapped by various authors. The following sections describe the faults presented in the figures with reference to the professional literature in which they are mentioned.

Active faults/Faults suspected as active

A. A map of faults and earthquake foci in Israel (Bartov et al., 2009). This map presents *inter alia*, the location of faults that are suspected as active in Israel. According to the work of Bartov et al. (2009), the only three faults that are suspected as active within the land area that is proximate to the inspection space are the Carmel fault, the Usfiya-Shalala fault, and the Akeda fault. Despite the fact that this map only covers Israel's land area, its presentation is important in order to establish the affiliation of marine environment faults to the faults system defined in it as active faults.

B. Faults mapped within the marine area of the Haifa Bay by Ben-Gai and Ben-Avraham (1995), and including the estimated marine extension of the Carmel fault (or one of its branches) and a fault running parallel to it to the north. These faults have been identified as the edge faults of the marine extension of the Kishon Graben.

C. Active faults (indicating a slip of the seabed and a corresponding slip of layers within the subsoil) and faults that are suspected as being active presenting a slip of the seabed only) that have been mapped within the marine area of the Haifa Bay by Ben-Avraham et al. (1998). The faults in these two groups are short and have a serrated alignment. Ben-Avraham et al. (1998) note that the series of faults appearing in the south of the Haifa Bay seemingly constitutes the marine extension of the Carmel fault. This conclusion is based on the location of these faults along the area of the estimated marine alignment of the Carmel fault and on evidence of a normal slip with a descending block in the north direction within seismic sections that bisect these faults.

D. Active faults according to Mart (1996): faults mapped in a reflection survey within the Atlit area whose activity time is dated to the late Pleistocene.

E. The Ohr Akiva fault (Steinberg et al., 2010): this fault seems to slip layers at the base of the Pliocene, and therefore is defined by Bartov et al. (2009) as "suspected as active." According to the active faults map provided by Sagy et al. (2012), which has not yet been validated as a map in Standard 413, this fault is not defined as a "suspected active."

Faults not defined as active

The various mapping activities indicate the absence of active faults within the Israeli marine region, to the south of the Carmel-Yagur fault system (except for faults mapped in the vicinity of the Atlit shore by (Mart, 1996). The alignment of the faults marked in Figure 1.6.1-1 to the south of the Carmel fault in the Palmachim area is taken from a compilation map created by Ben-Avraham (1999) after surveying a number of mapping works on this subject. These faults were not identified as active. It is possible that some of these faults are but slumping scars (the Palmachim slumping) for there are no testimonies to their existence under the salt layer. Integration of these faults within the drawing stems from Ben-Avraham's (1999) conclusion that during an earthquake taking place on a distant active fault a slip is possible on existing fault areas as a consequence of the process of release and the transfer of strains within the crust.

1.6.2.3 Reference of building standards to active faults

The gas platform will be built in Israel's territorial waters and is therefore subject to guidelines and standards defined by the State of Israel. Standard 413 determines that structures to which this standard is applicable should not be located on a trace of an "active fault" and/or 15 meters from the edges of such trace (Section 202.1A). Within an area of 200 meters from the trace, the construction of buildings belonging to priority group A or B (structures with varying levels of public importance in accordance with Table 4 in the standard – see Table 1.6.3-1 in the present document) will require the professional opinion of an engineer and geologist. Standard 413 does not apply to the gas platform, but it notes (Section 105) that as regards "security facilities, chemical industry structures and others that may put a large segment of population at risk if destroyed" even more stringent requirements apply. In addition, in the structure priority coefficient table (Table 4 of the standard), it is stated that structures from priority group A, in regard to which there are strict limitations in everything regarding seismic planning, include "structures with a high degree of public importance that are supposed to function with their systems during an earthquake and after it: power stations, …". Hence, the building limitations for the gas platform must be similar to those defined in Standard 413 or more stringent.

In these requirements, the Israeli standard <u>generally</u> adopts the principles of the Californian standard (Alquist-Priolo Earthquake Fault Zoning Act, e.g., Special Publication 42, Interim Revision 2007).

The Californian standard defines three types of faults that have statutory meaning:

5i. An active fault: a fault that has caused a slip in the surface in the past 11,000 years (during the Holocene).

5ii. A sufficiently active fault: a fault where along one of its branches or parts there is evidence of surface slippage during the Holocene.

5iii. A well defined fault: a fault whose trace has been identified either directly or indirectly by a trained geologist either on the surface or immediately below the surface.

The Californian law stipulates that around said faults, there should be a definition within the standard maps titled "the fault region." The fault region comprises a band of about 150-200 meters on each side of the fault according to the conditions prevailing in the field. "The fault region" is defined in order to include any possible inaccuracy in the location of the fault and because of the possible existence of sub-branches.

The maps appended to the California standard require the planning parties (local authorities, committees, landowners, etc.) to conduct a geological investigation for any development within a "fault region" defined in the maps. The reason for this is the fact that the marking on maps does not have any planning validity as regards the location of the fault and the damage area surrounding it, and it is intended to delineate the area in which research work is required in order to study the geological phenomena related to the fault in depth before development is executed.

At the same time, it is important to remember that building standards including those mentioned above do not track the very forefront of geological and engineering knowledge that accumulates within the discipline. Up-to-date studies show that the damage band surrounding an active fault, i.e., an area in which the development of sub-faults distorting the surface after an earthquake have been observed, may attain a width of a number of hundreds of meters and more (for example, Lazarate et al., 1994; Dor et al., 2006). Therefore, it is possible that a conservative approach should be adopted in defining the damage areas in the environs of a fault defined as active in everything regarding the selection of allocation for large and sensitive infrastructure facilities. It is therefore recommended to avoid any developments within a range of 300 meters to each side of the projection onto the surface of a fault that is either active or suspected of being active.

1.6.2.4 Location of faults that are either active or suspected of being active relative to the location of the alternatives

At present, it is known that a single fault defined as a "suspected of being active" passes through the inspection space: the Ohr Akiva fault (Figure 1.6.1-1). The fault crosses the Hadera alternative in a general east to west direction along its central part. This fault is not considered as "suspected active" according the new faults map (Sagy et al., 2012) which has not yet received the status of a standard document. According to existing/available information there are no active/suspected active faults within the alternatives of Havatzelet HaSharon and Netanya.

In regard to the alignment of additional active/suspected active faults that may be discovered in the course of future surveys within the inspection space (and afterwards within the plan area) it is recommended to impose development limitations as a function of the mapping resolution. Moreover, in accordance with this conservative approach and since a certain motion maybe possible on continental shelf faults that are unknown or suspected as active as part of a regional release of strains it is recommended that any construction in the vicinity of the alignment of such faults be considered in accordance with the findings of high resolution local surveys. Appropriate recommendations and instructions are given in the survey's advanced chapters.

תמ"א 37 ח'

תכנון וייעוץ תכנוני בנושא מתקנים לקבלת גז טבעי גולמי ולטיפול בו עד כניסתו אל מערכת ההולכה

שלב ג'- תסקיר השפעה על הסביבה

חלופות המערך הימי

תשריט מס' 1.6.1-1: מפת קומפילציה של ההעתקים ממקורות שונים (כמפורט במקרא) ומיקומן של הנקודות שנבחרו לצורך חישובי תאוצת קרקע וספקטרום תגובה.

National Outline

Planning and Consulting Services Regarding ... Gas Reception and Treatment Facilities Prior to Their ... System Connection

Stage C - Environmental Impact Report

Offshore Alternatives

Map No. 1.6.1-1

מקרא

(Ben-Gal and Ben-Avraham, 1995)

(Ben-Gal and Ben-Avraham, 1995)

Mart 1986

(Ben-Avraham et al., 1998)

(Ben-Avraham et al., 1998)

(Steinberg et al. 2010)

עומק מים 60 מטר

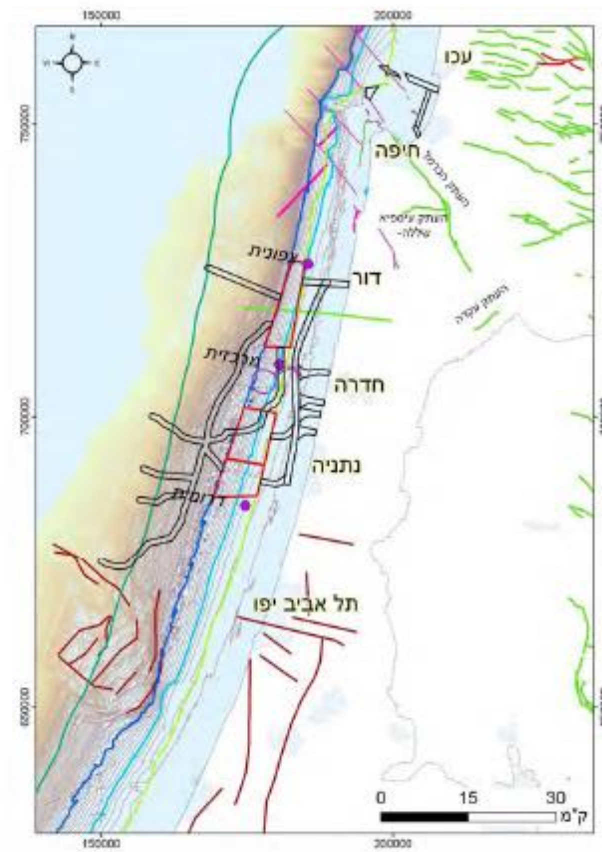
עומק מים 100 מטר

מרחק 7.5 ק"מ מקו החוף

תמ"א 37 ח'

אקולוג ECOLOG

לרמן אדריכלים ומתכנני ערים בע"מ



1.6.3 Increase of seismic vibrations due to geological and topographical conditions

1.6.3.1. Background

The augmentation of soil vibrations during an earthquake arises from a reduction in the speed of the seismic waves as they pass through rigid rocks at the depth to softer rocks and the soils that are nearer the surface. When the change in speed is not gradual and there is a sharp shift between the hard rocky substratum and the soft soil layer, the phenomenon of amplification is considerably reinforced as a consequence of the trapping of seismic energy within the upper layer. The seismic waves that are reflected from the surface downwards create an interference with the waves reflected from the hard stratum upwards, thus creating a resonance with the typical frequency and amplitude (Gvirtzman and Zoslavski, 2009). In areas where there is a soft soil/rock cover over an existing hard base, a strong seismic reflector is created in the roof of the rigid stratum.

Within Israel's land environment, such a reflector is created in areas where there are soft rocks (soils and sandstone of kurkar groups or the Yaffo formation clays) directly over hard rocks (limestone and dolomite of the Yehuda groups and Avedat group or the chalk rocks of the Mount Scopus group). At the same time, the deeper such a reflector goes, the less the intensity of the resonance created above it, until such a state where such residence is not considered to be exceptional at all. In addition, it is possible that such a reflector may be created (during an earthquake) along the coastal plain in places where under the soil coverage or the soft sand there are very hard layers of chalky sandstone ("kurkar"), and on condition that such layers are thick enough to create amplification in the medium above them. The depth of this reflector does not usually exceed more than a few dozen meters and is limited in any case within the kurkar group, whose maximum thickness in the coastal plain is about 200 meters (Gvirtzman and Zoslavski, 2009). The kurkar group known in the coastal plain is also found in the continental shelf and in accordance with the typical stratigraphic column described in the introductory sections, we may expect to encounter a geological system that fosters amplification in this region.

Amplification of seismic motion is also possible in sites in which there are deep and narrow geological/topographical basins, but since the existence of such basins in the inspection space is not known, no amplification is expected for this reason.

A committee of specialists from the Israeli Standards Institute determined that a site response survey should be performed in those regions where the soil is classified as Type F (IS 413, correction sheet number 3, 2009, Section 202.2.1-C). One of the criteria for classifying soil as F is when structures ascribed to priority group A (Table 1.6.3-1) are located within an area that is suspected of exceptional sub-base amplification. An additional criterion is "a soil type that is liable to reach failure or collapse under the influence of seismic loads, such as a spoil type that is liable to liquefy and sensitive clays."

The facilities planned within the context of NOP 37/H serve structures assigned to priority group A according to Table 4 of IS 413. The present work presents a survey of site response for three points within the inspection space. These data relating to the geotechnical characteristics of the rock column were taken from the database of the LNG float drillings. These data do not represent the soil section at the inspection points or within the area of the alternatives, and therefore the amplification calculations based upon them are only intended to demonstrate the scope of the amplification phenomenon rather than serve as any indication of the amplification level at any point within the inspection space.

Table 1.6.3-1: Priority coefficient of structures (Table 4) from IS 413, Amendment 3)

Group	Type of Structure	Importance coefficient
A	Structures with high public importance intended to function with their systems during an earthquake and following it: power station structures, hospitals, fire brigade stations, police stations, telephone exchanges, first-aid stations (including entrances and passages as well as service structures and the water tanks that serve them)	1.50
B	Structures of public importance that are intended to allow the evacuation of people without risking their lives such as schools, daycare centers, cinemas, houses of prayer, dance and event halls, public buildings, jails, and building in which crowding is expected including buildings with high populations (250 persons and more), whether such have been established as such by the competent authority or not	1.25
C	All other structures not included in groups A and B.	1.00

1.6.3.2 The response spectrum

The design response spectrum (Figure 1.6.3-1) constitutes input for evaluating the loads exerted on the structure during an earthquake. The response spectrum represents the impact of soil conditions on site on amplification of acceleration within rock. The amplification calculations as presented in this report have been performed by using the equation system provided by the standard, according to which values are assigned that represent the type of soil at the site (in the absence of specific information regarding its properties). The acceleration values in the hard rock roof (PGA) were selected in accordance with the results of the seismotectonic model for each of the inspection points within the inspection space (Figure 1.6.1-1). In order to evaluate the response spectrum at each response point, a soil profile was selected to represent the entire area based on an analysis of existing geological-geotechnical information.

Soil classification for seismic planning at the site may be weighed as detailed in Table 1.6.3-2 (IS 413 based on American Standard ASCE 7-05). Soil at the site is classified from A to F based on a weighing of the parameters of the various layers and their thickness in the first upper 30 meters of the subsoil. Without direct geotechnical information at the test point, soil classification was done through qualitative means on the basis of geological considerations (rock, thickness) and geotechnical data taken as stated above from the LNG float drillings in the vicinity of the center of the inspection space.

Table 1.6.3-2: Soil classification (according to IS 413, based on American Standard ASCE 7-05)

Type of soil at the site	Description	Shearing wave speed in the upper 30 meters (meters per second)	Resistance during standard penetration tests (SPT)	Undrained shearing strength (Kilopascal)
A	Hard rock	> 1500	-	-
B	Rock	760 - 1500	-	-
C	Very dense soil or soft rock	360 - 760	> 50	> 100
D	Rigid soil	180 - 360	15 - 50	50 - 100
E	Soft clay	< 180	< 15	< 50
F	(Specifics are provided in IS 413)			

The horizontal spectral acceleration coefficients S_1 and S_2 for a short cycle time and a cycle of one second respectively for different reference events (recovery times) were calculated by Keller et al. (2011). Based on these values, we established the site coefficients for short and long cycle times, F_a and F_v, respectively (Table 2 and 3 of IS 413).

The response spectrum is calculated according to a reference event with a probability of 2% of occurring in 50 years (or greater), i.e., an earthquake that recurs every 2,475 years, because of the importance of the structure.

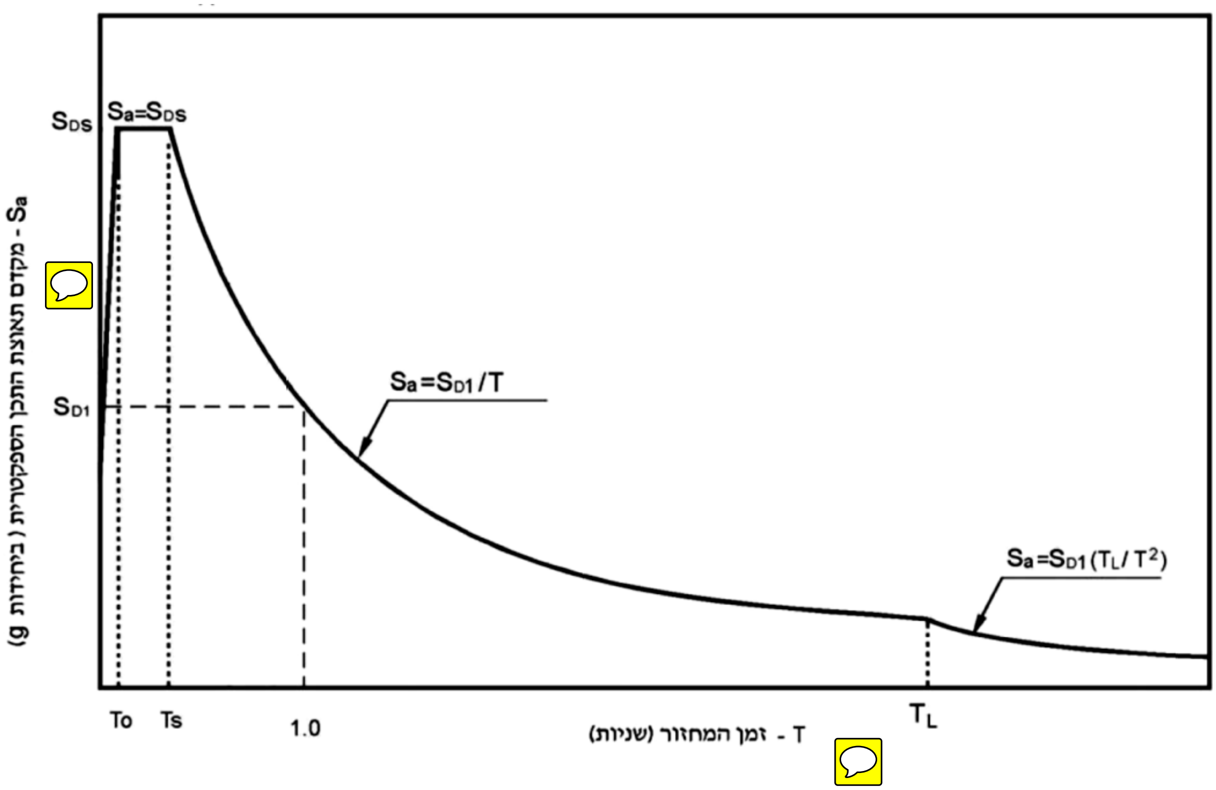
The spectral acceleration coefficients under the influence of soil conditions at the site S_{D1} and S_{DS} (Figure 1.6.3-1), for both short and long cycle times are established in accordance with the soil type at the site and according to values S_S S_1 and values F_a and F_v respectively:

$S_{DS} = F_a S_S$ *(1)*

$S_{D1} + F_v S_1$ *(2)*

The acceleration coefficient, S_a, is established according to the basic cycle time of the structure, T. The response spectrum is determined by dividing the cycle time into four divisions of cycle time (Figure 1.6.3-1) as detailed in IS 413 (202.3).

Figure 1.6.3-1: Schematic drawing of the design response spectrum (from IS 413)

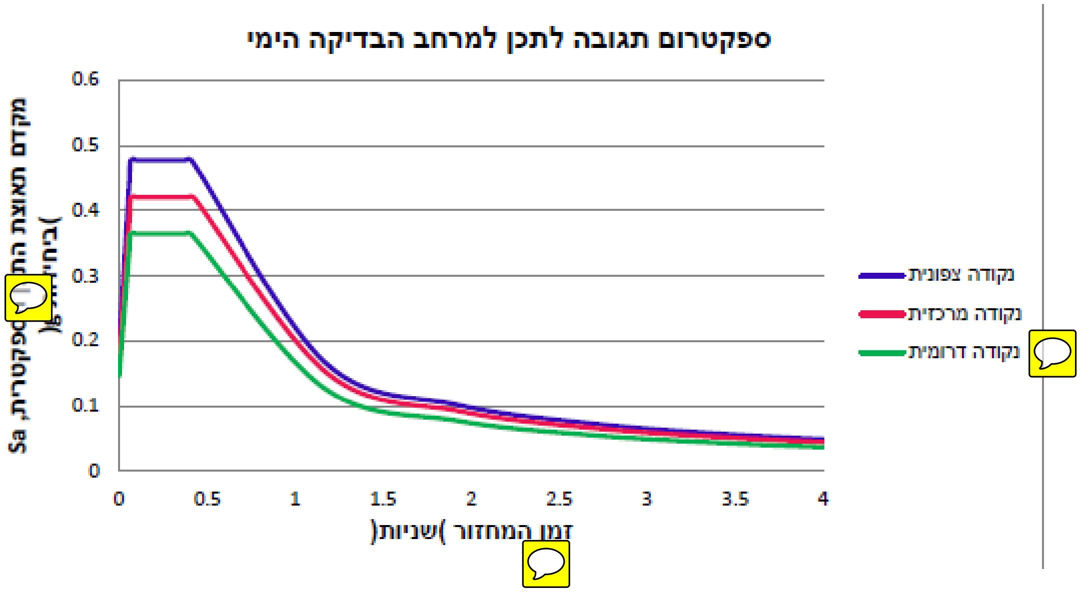


1.6.3.3 Response spectrum within the inspection space and calculation of the amplification phenomenon

The inspection space is mostly within a trough between two kurkar ranges. The soft fill includes clays, silts, and sands with a total thickness amounting to meters to dozens of meters and overlaying kurkar layer (see Figure 1.6.3-3B), which is a few meters think to a few dozen meters thick. The geotechnical properties of the marine sediment units opposite Hadera were sampled using drillings for the LNG float project at a water depth of 44 meters and 72 meters (NGI, 2012). These drilling data indicate that the undrained shear strength, S_u, is S_u = 2-38 kiloPascal for the upper clay unit (clay 1) and S_u = 38-kiloPascal 46 for the upper clay unit (clay 2) (see Tables 1.6-B1, 1.6-B2 above). Therefore, it is necessary to sort the clay units as type E soil in accordance with IS 413.

The spectral design accelerations for soil E at the inspection points for earthquakes with a recurrence period of 975 years and a restraining factor of 5% are presented in Figure 1.6.3-2.

Figure 1.6.3-2: Spectral design accelerations for soil type E within the inspection space for an earthquake with a recurrence period of 2,475 years and a restraining coefficient of 2%



For different cycle times the spectral design acceleration coefficients within the Netanya and Havatzelet HaSharon alternatives are expected to fall in the range between the values obtained for the south point and center point (between the green and red curves in Figure 1.6.3-2). For different cycle times the values of the spectral design acceleration coefficients within the Hadera alternative are expected to fall within the range between the values obtained for the central point and the north point (between the red and blue curves in Figure 1.6.3-2). As expected, the response spectrum values increase from south to north proportionately to the accelerations values received (Section 1.6.1).

1.6.4 Possibility of phenomena of soil failure as a consequence of soil slumping

1.6.4.1 Introduction: Main types of failure in the continental shelf and contents of the chapter

Within the Israeli continental shelf and along its edges there were and are a variety of mechanisms of soil failure that were active and are still active today that lead to deformations of various orders of magnitude in the sediments of the Plio-Pleistocene section that comprises the shelf. For the purpose of the description presented in this chapter of the survey, failure phenomena have been subdivided into two main classifications in accordance with the dimensions of the failure and the nature of the mechanism at their root. Two groups of phenomena and main soil failure mechanisms were defined:

A. Gravity collapse of the continental slope and shelf: Slumping on top of fault plains without any deep tectonic root (Thin Skin Deformation) that lead to a deformation of all/most of the Plio-Pleistocene section. These slumpings are genetically associated with deformations in the Miocene salt layer located at the basis of the section, some of them active and many of them created or activated as a response to seismic activity.

B. Soil failure in the shallow soil section of the internal continental shelf: the formation of sediments within the upper dozens of meters of the section (according to existing seismic simulations) including phenomena of bloat and collapse of sediments, young rifts, waviness at the seabed, pockmarks and the like. There is a hypothesis that these phenomena are genetically related to the presence of shallow gas trapped between layers of young sediments.

This chapter of the survey comprises a review of these phenomena on the basis of public information and on the basis of information provided to the design team and analyzed by it. The review includes a survey of the literature relevant to the phenomenon of slumping that arises from the gravity collapse of the continental slope and shelf; the survey of the literature touches on the phenomena of soil failure within the shallow soil section of the internal continental shelf in the context of the shallow gas layer; a description of the existing information (bathymetry, seismic lines, drillings, etc.) and from this the available information for the purpose of analyzing these phenomena by the design team; results of the analysis of available information relating to the two main failure groups; and finally the conclusion of the examination regarding the alternatives that have been defined in general and the location of offshore installations in order to receive and process gas from the discoveries in particular.

1.6.4.2 Background: Slumping arising from gravitational collapse of continental shelf and slope

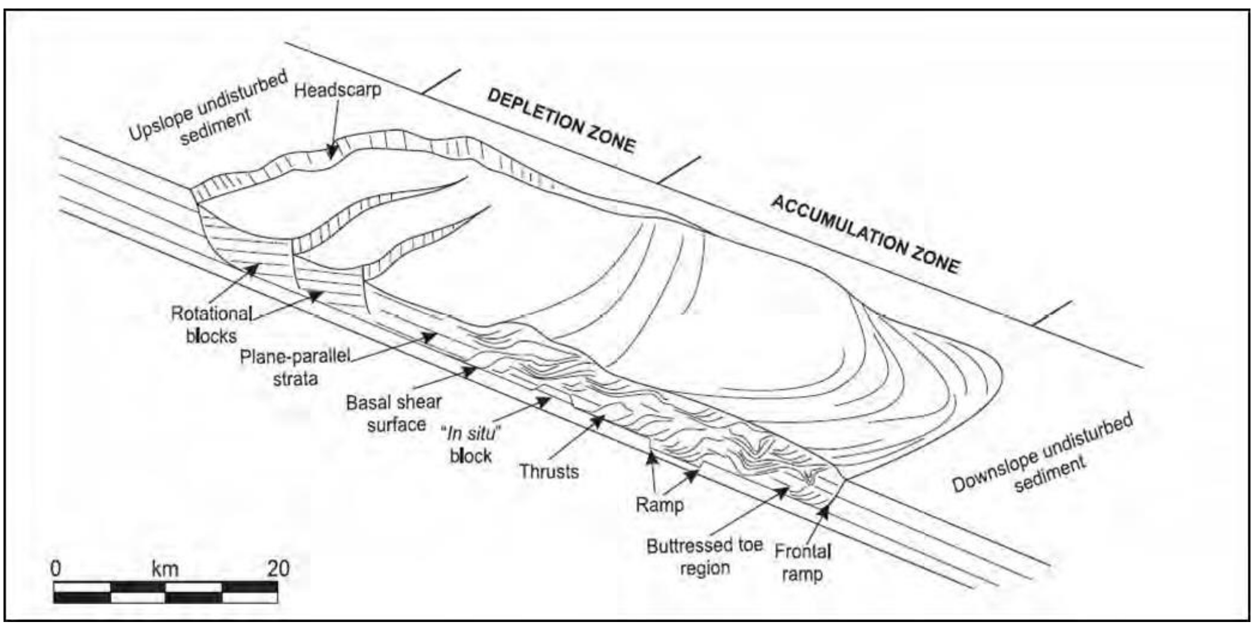
At the edges of the Israeli continental shelf, and along the continental slope, there is a widespread phenomenon of slumps in various orders of magnitude. This phenomenon is ascribed to the marginal static gravitational stability of the sediment column in these areas that maybe disrupted during the occurrence of a seismic event in the general tectonic area of the Levant Basin. The description in the following sections is based on various publications that relate to the phenomenon of the slumpings in the continental shelf and slope including Almagor (2005), Almagor (1983), Almagor (1986), Almagor (1993), Frydman and Talesnick (1988), Garfunkel et al. (1979), Garfunkel and Almagor (1984), Garfunkel (1984), Gradmann et al. (2005),Mart and Ryan (2007), Martinez et al. (2005), Martinez et al. (2006). In addition, the description relies on consultations with a number of researchers based on their experience and information available to them that has not yet come to fruition or that is not yet ready for publication (including some leading researchers from the Geophysical Department at Tel Aviv University, the School of Oceanographic Studies at Haifa University and the Geological Institute).

1.6.4.2.1 General description of the slumping phenomenon along the edges of the continental shelf

Slumps along the continental shelf are also called disturbances in order to emphasize the fact that these phenomena do not have a deep tectonic root. The typical morphology of slumps in the continental shelf usually includes, from east to west, the following elements (Figure 1.6.4-1): The area where sediments are depleted, i.e., the depletion zone which includes the headscarp, subsidiary scars parallel, inclined blocks and the slumping area parallel to the bottom of the slump (basal shear surface); and area in which sediments are accumulated (accumulation zones) and there are inverse faults (thrusts) and the slumping front (slump toe or frontal ramp).

The stratigraphic framework in which the slumping takes place includes a section with a thickness of hundreds of meters, up to two kilometers of clastic sediments (sands, clays, etc.) which go back to the Pliocene or the Quaternary (5.3 million years up to the present) and their main source is in the Nile Delta. These sediments have accumulated on a layer of evaporates that sank at the end of the Miocene era – the Miocenian period (the Miocene event about 7-5 million years ago) in the area of the Mediterranean Basin (as detailed in Section A of the introduction).

Figure 1.6.4-1: A schematic description of the slumping structure at the edges of the Israeli continental shelf/slope. From Martinez et al. (2005)



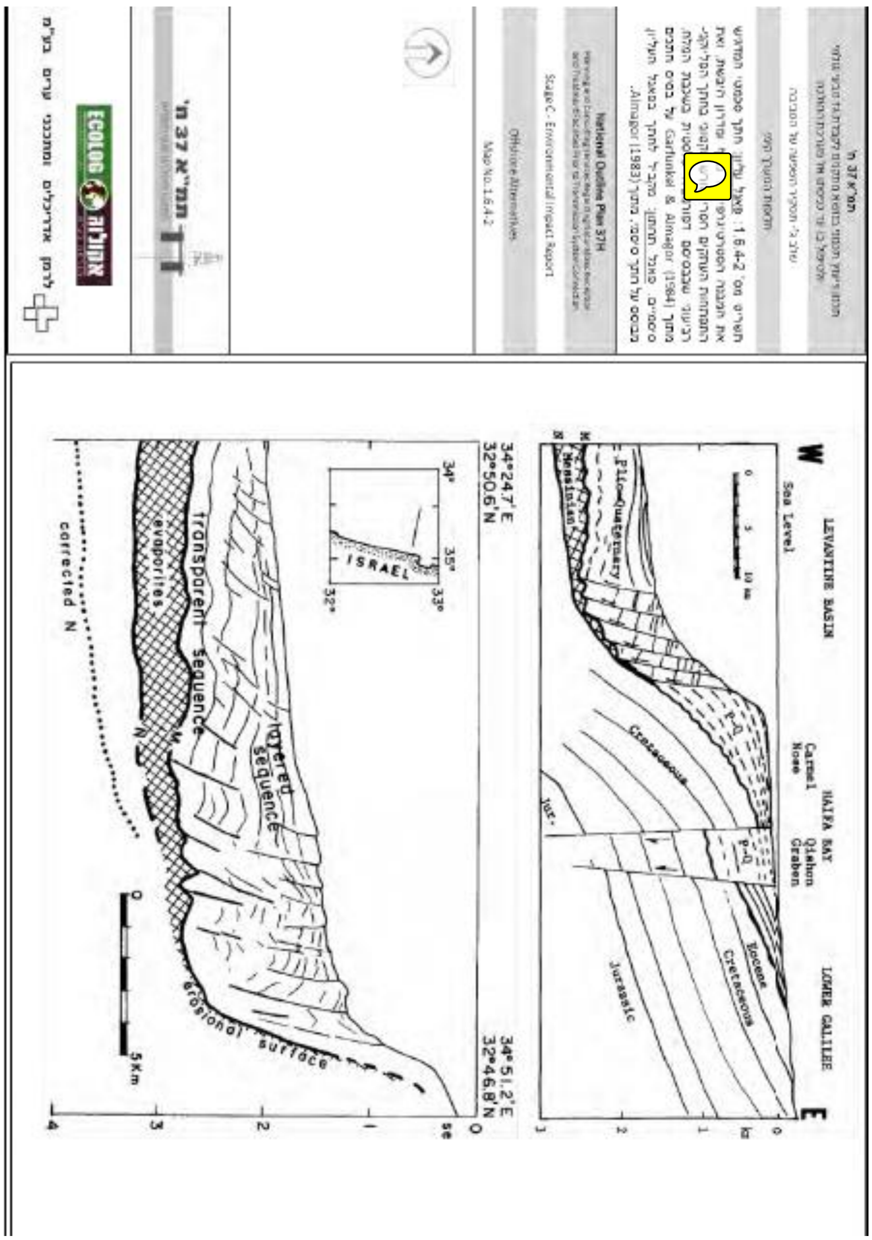
In the course of the Miocene event, circulation of the Mediterranean was limited as a consequence of the blockage of the Gibraltar Strait and the sea became a terminal or pseudo terminal basin. Accordingly, the water concentration rose to the point that evaporated sediments began accumulating (salt, dolomite, anhydrate, gypsum, and more) at thicknesses of up to two kilometers in various parts of the basin where the brine existed. The evaporites layer, which reaches a thickness of about 200 meters at the bottom of the continental slope, becomes increasingly thinner until it completely disappears in the direction of the east edges of the continental slope (Figure 1.6.4-2). The area exposed during the Miocene event underwent erosion (channeling) that finds expression in the development of deep canyons that led sediments from land to the Miocene erosion basis area at the center of the present basin. There, too, the brine penetrated as a function of the sea level. At the edges we therefore find the Miocene event represented as a layer of evaporites with a non-continuous character and with non corresponding regions.

The basis of the evaporite layer is identified within seismic sections as reflector N (Figure 1.6.4-2). This plain is relatively granular and seems that it does not correspond to the deformation phenomena of the Plio-Pleistocene sediment section. The roof of the evaporite layer is identified in the seismic sections as reflector M, and it is discernible that its upper area is complex, irregular, and includes domes and faults that are appropriate to a deformation in the Plio- Pleistocene cover above the evaporites layer. Reflectors M and N coalesce along the zero thickness align of the evaporite layer in an area where attrition processes overcame sedimentation processes.

Slumpings in various orders of magnitude have been observed all along the edges of the continental shelf and slope. In most of them, the headscarp is parallel to the shoreline and the direction in which the sediments are transported is perpendicular to the shoreline. Some of the slumpings developed along deep canyons or within existing slump areas and their orientation is different or is perpendicular to the common orientation described above. Slumping scars and lineaments identified as the scars of active faults were identified within the inspection space at water depths greater than 100 meters (see results of initial mapping below) and therefore their precise location should be taken into account in designing the pipeline that will lead the gas to offshore facilities that are to be erected in future at water depths that are less than 100 meters. The next section presents the two largest slumping systems in the Israeli continental shelf.

The continental shelf slumping is a common phenomena that is frequently discussed in the literature (for example, Locat and Lee, 2002). Twichell et al. (2009) described a large slumping system spread over the continental shelf along the east coast of the eastern United States. Their work indicates that the main motive factor of slumping in that area is seismic activity. They showed that the slumping systems identified in bathymetric information usually represent a number of slumping events so that a number of scars and various generations of disturbed material are visible along them. The slumpings originating from the open shelf are usually larger and have a significantly greater distance of advancement than those originating in an underwater canyons, yet slumping length is not correlated with the incline at the headscarp area. Among the factors that foster slumping Twichell et al. (2009) noted two phenomena that may be particularly relevant to the geological reality of the Israeli continental shelf and slope: the orientation of the layers in the direction of the downward slope a phenomenon that sometimes causes bedding plains to become fault plains; and the release of gas into the sediment layers as a factor that weakens the strength of the rocks.

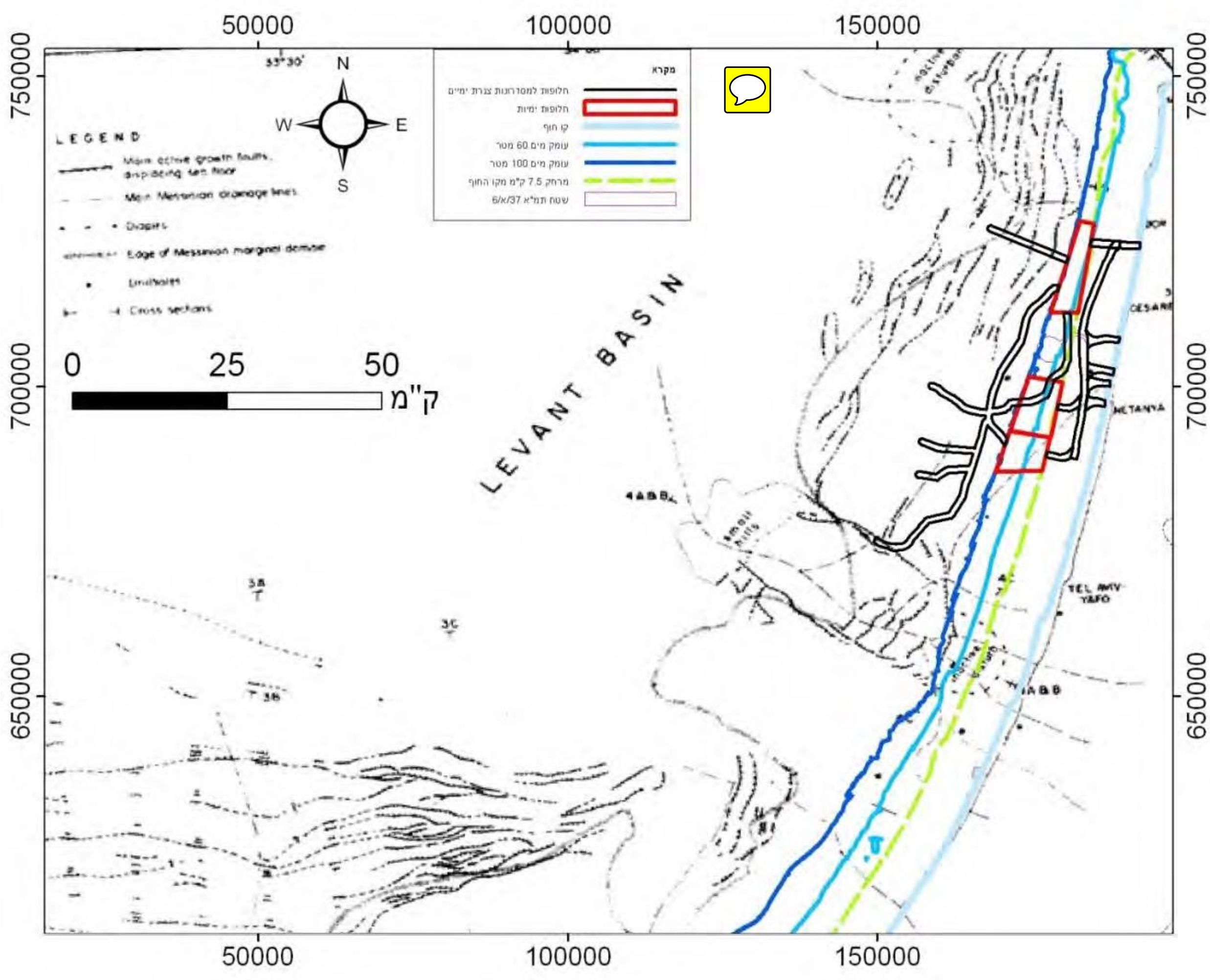
Figure 1.6.4-2



1.6.4.2.2 Dor and Palmachim slumpings

Figure 1.6-A2 presents the location of the Dor and Palmachim slumpings on a regional bathymetric map. Figure 1.6.4-3 presents a mapping of the main faults and slumpings in the east of the Levant Basin.

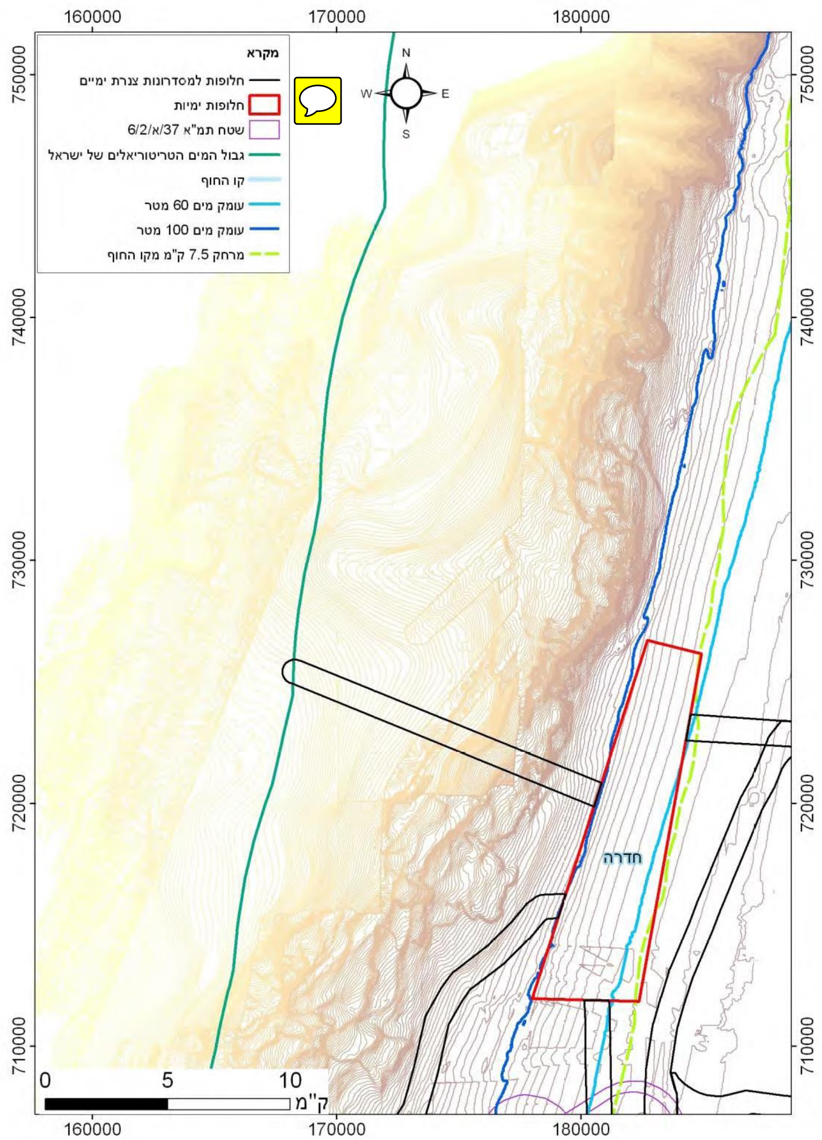
Figure 1.6.4-3: Mapping of the main faults and slumpings in the east of the Levant Basin (following Garfunkel, 1984)



<u>The Dor slumping</u>: The Dor slumping ("disturbance") is in fact a system of slumpings that spreads over a total area of 650 square kilometers between the Carmel Head area in the north to the Dor area in the south. This slumping has been described in many places as one of the most central and salient elements of the north part of Israel's continental shelf and slope. The headscarp is clear and discernible in a bathymetry of the area where there are depth lines crowded together about 8.5-9.5 kilometers to the west-northwest of the Dor shore (Figure 1.6.4-4). According to the bathymetric model, the disturbance itself spreads

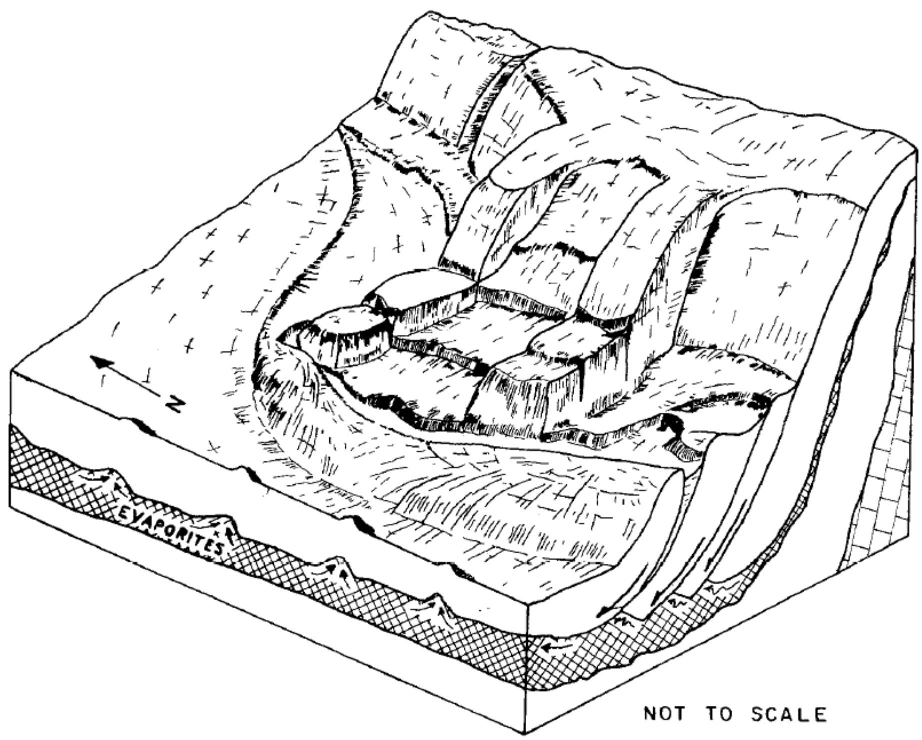
up to a minimum depth of less than 100, it is therefore clear that the isobaths line of minus 100 meters is the most shallow line whose shape is not impacted by the presence of the slumping. This depth line was established therefore as the east boundary of the present impact area of the Dor slumping.

Figure 1.6.4-4: A close-up of the bathymetric model for the Dor slumping area



The Dor slumping is made up of four blocks that slumped and left between them underwater ridges in the east-west direction. These blocks are internally subdivided into slipped blocks that have undergone rotation and deformation. The two north blocks are seen in the schematic block of Figure 1.6.4-5. Almagor (1983) notes that it is possible that a relationship exists between the location of the Dor slump and the ancient Caesarean canyon that is currently buried under a pack of Plio-Pleistocene layers.

Figure 1.6.4-5: Schematic diagram block that presents the structure of the Dor slump



Up-to-date findings from the sailing expedition of the Nautilus in September 2010, including unpublished pictures that were presented in seminars, indicate the existence of exposed fault scars at the base of the Dor slumping. In the assumption that the sedimentation rate in this area will be capable of covering and obscuring fault scars at relatively high rate, the existence of the scars indicates current activity of slipping and block movement and accordingly that the slumping or parts of it are active.

The Palmachim slumping: the Palmachim slumping ("disturbance") is the most prominent physiographic element along the Israeli continental shelf to the south of the Carmel Head (Figure 1.6-A2). The slumping is recognizable as an elongated structure in northwest direction approximately perpendicular to the shoreline), 50 kilometers long and more than 20 kilometers wide. According to the nature of the depth lines we can see that its east boundary is in the area of the 60 meter bathymetric line (Figure 1.6-A2). According to mapping conducted in the slumping area it may be seen that a genetic relationship exists between the slumping and the faults system mapped in this region (Figure 1.6.4-3; Garfunkel et al., 1979).

The slumping developed on top of a trench from the late Miocene at the basis of which there is a thick Miocene-evaporative depression cut as an offshoot of the evaporite body at the center of the basin.

Seismic data collected from the sailing expedition of the Nautilus in September 2010 that have been presented in seminars but are not yet published indicate a slip of the reflector that was initially dated at about 20,000 years. The reflector was identified in the east area of the slumping and its fault supports the theory that this area was active in the near geological past and perhaps is still subject to faulting.

1.6.4.2.3 The mechanical and structural framework of the slumping phenomenon

The estimated mechanism for slumping at the edges of the continental shelf and slope assumes that the salt layer at the basis of the young sedimetric section creeps (or flows) as a result of two complimentary processes:

A. Increase in gravity stress, caused as a consequence of the accumulation of the post-Miocene sediment prism (the Nilotic Plio-Pleistocene section).

B. A gravitational response of the evaporites themselves to the gradually increasing incline as a consequence of the settling of the basin and the rising of the continental edges.

The salt serves as a lubricant that allows detachment, sliding downwards, and rotation of large blocks from the sediment section above it. The blocks themselves undergo secondary deformation, develop a secondary fault, and present in places where the stratigraphic texture has been destroyed to the point of moving the sediments in the form of turbidity flows.

In addition to the plastic response of the salt to the stress of gravity and the increase of the gradient, the movement of the Miocene sediments in general is made possible by the existence of clay layers trapped under high pressure between the salt layers and creating internal lubrication as a consequence of the pressures exerted on them. The deformation process described does not have any deep tectonic roots ("thin skin deformation") i.e., it seems that it is not part of the regional tectonic deformation and lacks expression in deeper layers. Evidence of this fact mainly includes the absence of any slip in the direction of the continent of layers/blocks under the Miocene unit. The absence of continuity of faults through Miocene unit and in a larger perspective the deformation of the evaporite sediments that allow connecting the deformation of the post Miocene section and which does not find expression at the basis of the evaporite layer (reflector N). At the edges of the continental slope, at approximate water depth of about 1,000 meters we see a group of exceptional faults running continuously from the depths, through the Miocene section and up to the surface (Gradmann et al., 2005). This area coalesces with the tectonic line (the Pelusium Line) whose hypothetical existence was proposed by a number of researchers (for example Neev et al., 1976) as a shear region that constituted in the past the tectonic boundary before the regional horizontal shear activity migrated to the Dead Sea rift. The intersection of the faults with the surface supports current geotectonic activity along this line of movement.

The east Levant Basin is one of the clearest places in the world for demonstrating the phenomena of salt tectonics that include significant horizontal motions of the salt itself and accordingly has lateral transforming faulting styles in the sediment column above. A detailed seismic analysis of the salt layer at the edges of the basin reveals that its lower part it mostly behaves in a ductile fashion while its upper part displays clear faulting, *inter alia* by the prominent discontinuities of reflector M (Gradmann et al., 2005). Reflector M is also the detachment plain of the Listerian faults at the edges of the shelf and the slope. As a result of the lateral component of salt movement, three types of deformation have developed in accordance with their morphological location at the shelf's edge, the slope, and the basin: the extension area, translation area and the compression area, respectively (Figure 1.6.4-6).

The following is a description of these three structural areas:

<u>Extension area</u>: in the edges of the shelf there is an extension regime that includes, beside the Listerian faults, a number of slipped blocks, grabens, internal deformation structures, slumping with sediments at the seabed, and complimentary deformation within the salt layer. All these express motion with a significant lateral component of the post-Miocene sediments probably as a consequence of motion along the incline of the Miocene sediments themselves (gravity gliding), a process that intensified as a consequence of the passage of water along the disengagement plains, the mass of the evaporites in the east edges of the Miocene sediment body (coalescing of reflectors N and M at the bottom of the continental slope) and the creation of the "Phoenician bodies" described by Mart and Ryan (2007). Some of the faults cause the seabed to slip, so that they can be categorized as active faults. According to Gradmann et al. (2005) the extension area includes the west of the inspection space (the area of the pipeline corridors; Figure 1.6.4-7) and most of Israel's territorial waters.

<u>Translation area</u>: does not include clear evidence of translation, but there is sedimentation with a deformation of the sediments. In this area sediments are transported from the edges of the continental shelf and slope and to the deep part of the basin where the compression area exists.

<u>Compression area</u>: this refers to an area where the sediments accumulate and which is the slumping front (Figure 1.6.4-6 slump toe and accumulation zone). The roof of the salt layer undergoes a combined plastic and brittle deformation that comprises both faults and buckling as well as a differential motion along internal detachment plains as proposed by Garfunkel (1984). The post-Miocenian sediment column undergoes compression that is mainly expressed in inverted faults.

Figure 1.6.4-6: Three types of deformations according to their morphological location at the edges of the shelf, slope and basin out of Gradmann et al., 2005

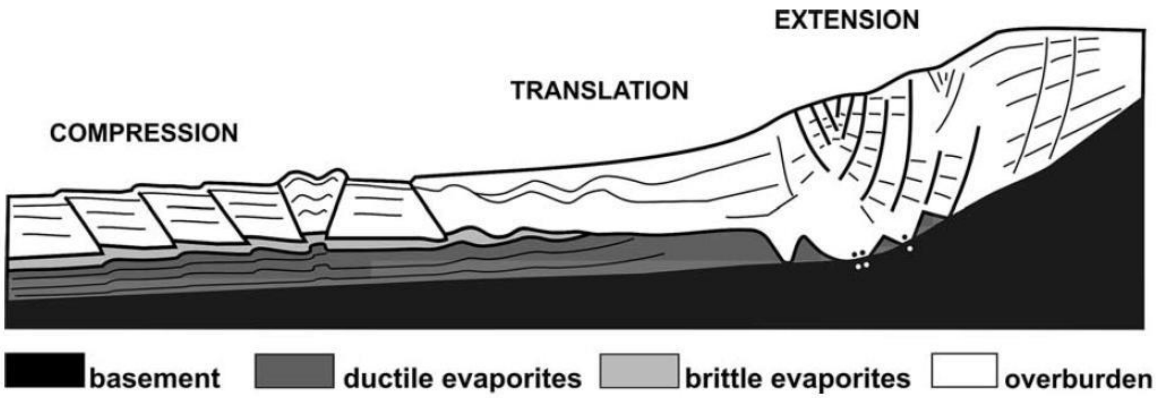
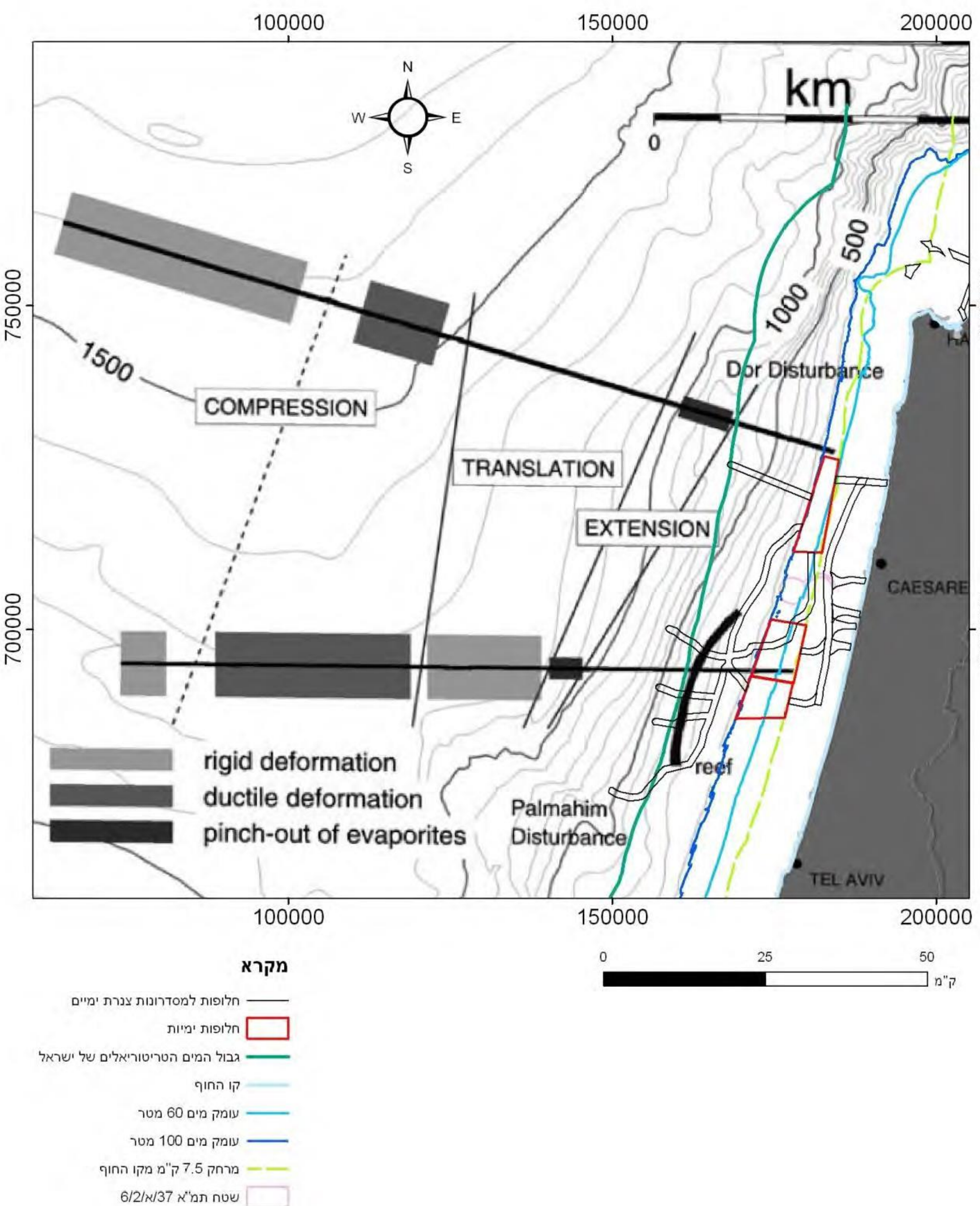


Figure 1.6.4-7: Structural areas defined by Gradmann et al. (2005) relative to the inspection space



It may be assumed that in considerable areas within the continental slope and shelf the conditions prevailing make slumping possible: the depth of the sediments, the gradient of the slope, the liquids in the subsoil, and the layers that serve as a lubricant (sand or clays at the bases or within the Pliocene-quaternary section). The conditions that foster slumping are not uniform within the space: the thicker the layer of evaporites and the thicker the sedimentary cut above the evaporites, the greater the risk for the development of slumping.

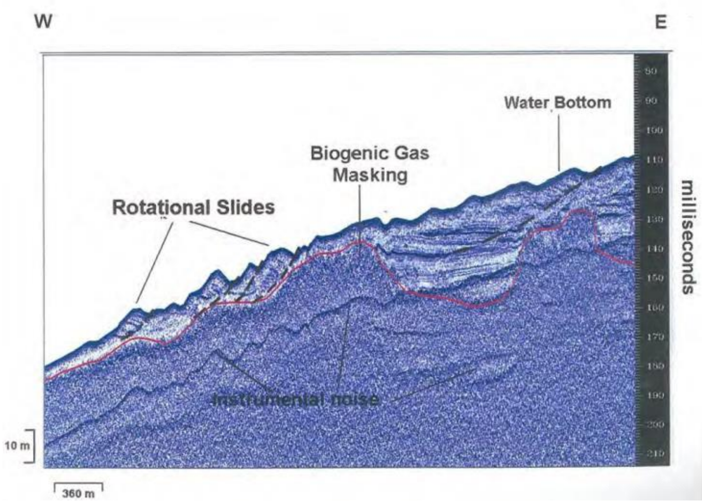
Accordingly, considerable pars of the areas in the edges of the shelf and the slope are in a state of borderline static equilibrium. Deviation from this equilibrium is usually possible through seismic events on faults in the regional tectonic space (Dead Sea fault, the Cypress Arc, etc.)which cause the mass of rock to slip into a dynamic field of this equilibrium. Frydman and Talesnick (1998) have shown by means of a stability analysis that horizontal accelerations as well as the deformation required for the development of slumping are liable to develop in the continental shelf in response to large earthquake events at distances of 100-200 kilometers from the areas (for example on the Dead Sea Transform) and may lead to the development of slumping. Most slumpings, therefore, seem to be the result of seismic events that serve as a trigger for the process.

In addition to the formation and rupture of the surface, the large (fast) catastrophic slumpings are capable of causing tsunamis. In fact most of the tsunami events documented in the east Mediterranean space are ascribed to underwater slumpings (Salomon, 2010).

1.6.4.3 Soil failure phenomena within the shallow soil section of the internal continental shelf

In a seismic mapping conducted by Golik et al. (1999) along a band with an average width of about 10 kilometers located to the west of the Israeli shore it was found that in water depths ranging approximately between 40-60 meters there is a layer of biogenic gas between the shallow sand layers, and these gas layers mask the seismic information from the layer itself and the layers beneath it. The spread of this layer is presented in Figure 1.6-A5. Bruner et al. (2000) have conducted a seismic mapping of the gas line alignment between Ashkelon and Haifa Bay and have discovered that in the area where this gas layer appears local rotational slides have been observed; the size of such slides is up to hundreds of meters (Figure1.6.4-8). These slides were ascribed by Bruner et al. (2000) *inter alia* to the dynamic weakening of the sediment under high gas pressure, i.e., to the sediments being particularly sensitive to slumping on account of weakening created by the gas pressure.

Figure 1.6.4-8: Seismic line in the east-west direction (from Bruner et al., 2000)[5]



Golan (2006), who deciphered seismic sections from the above surveys, concluded that the layer that blocks the gas (or prevents it from progressing up the cut) is a clay layer with a thickness of up to one meter that reflects a climatic event (Younger Dryas) that included dust storms arising from the Sahara. In places where the layers continuity is interrupted, the gas migrates more easily to the surface, to the water column, and to the atmosphere. The west boundary of the gas layer at a depth of about 60 meters and commencing from a gradient of about 0.5 degrees was determined as a consequence of soil slumpings that impair its integrity (as depicted in Figure 1.6.4-8). The east boundary of the gas layer is determined by the entrainment boundary of the gas layer that provides a seal as a result of shore attrition ("closure depth"). In this area there have been observations of springs of potable water accompanied by shallow pits in the seabed.

By analyzing seismic information at a higher resolution from single and multichannel surveys conducted in the Haifa Bay with correlation to the Kishon Yam 1 drillings (water depth of 102 meters) and use of bathymetric information (multibeam), Shattner et al. (2012) presented a number of expressions of the phenomenon of the shallow gas (Figure 1.6.4-9): gas chimneys, the upper part of which is located under the reflector that marks the last glacial maximum (LGM) estimated as being about 18,000 years old. The gas accumulated above the LGM over an area of about 72 square kilometers and at water depth shallower than 120 meters masks the seismic signal in the layer in which it accumulates.

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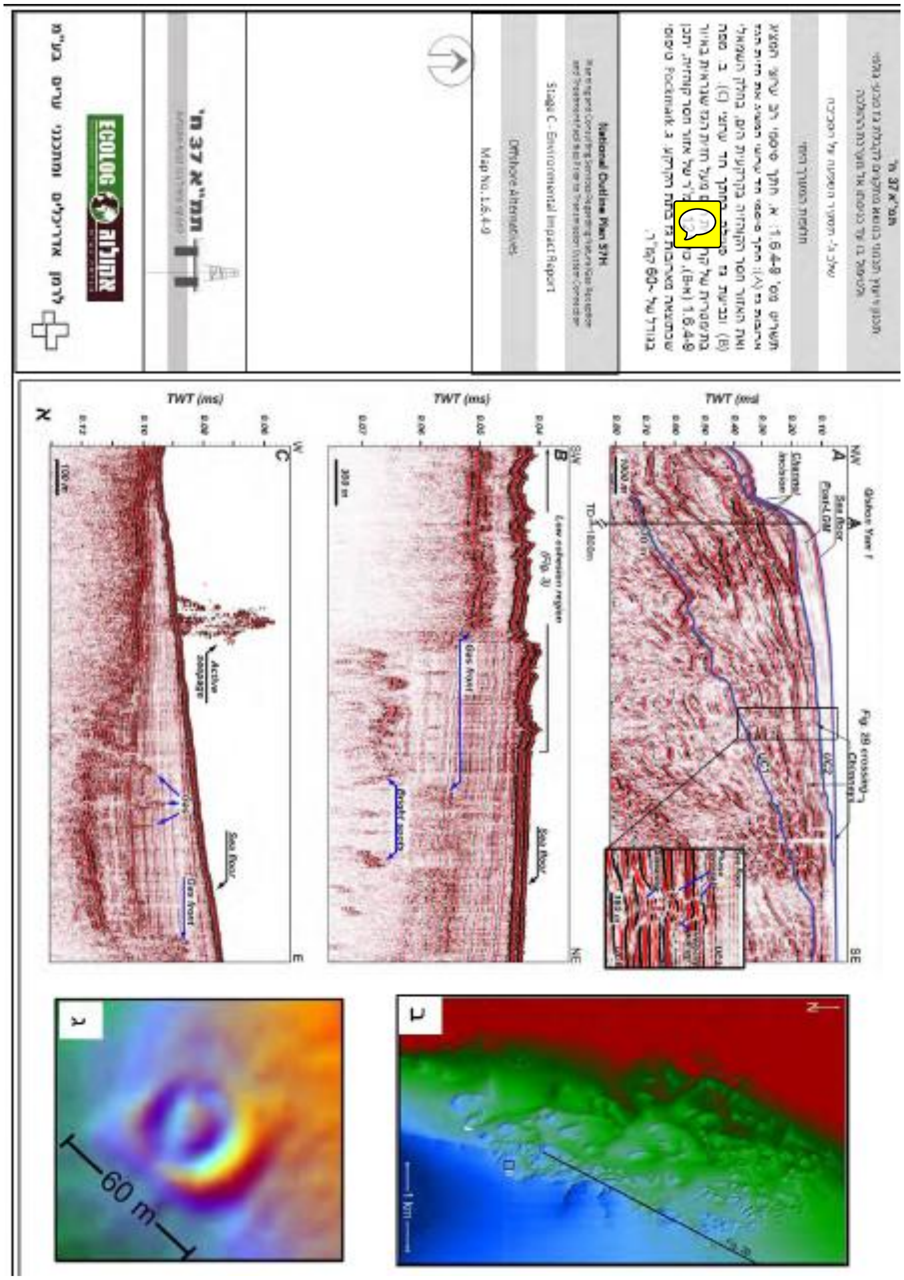
[5] The shallow gas layer and above it the local rotational slides are visible.

Its front (the roof of the gas layer) is ascribed to the Younger Dryas climatic event. The expression for the flow of gas at the seabed includes pockmarks, seismic testimonies to the presence of gas in the water column, and an area with low seabed cohesion in the area above the gas accumulation. Figure 1.6.4-A9 (B) presents a disruption in the continuity of the seismic reflectors on the seabed in the area where the gas front is shallow. Such disruptions also find expression in the deformation (earthflow) of the seabed (Figure 1.6.4-B9). The gas source seems to be organic material that has accumulated on the continental shelf mainly during periods when the sea level was low. According to the ages of the sedimentary units in which the gas release and accumulation system is embedded, it seems that its development began in the middle of the Pleistocene. In the investigation space no study has yet been conducted in the aim of characterizing the phenomena associated with the shallow gas at a separation level similar to that presented in the works of Shattner et al. (2012). Pockmarks, the seabed deformation which is expressed in the area with "low cohesion" and other phenomena of soil failure arising from the activity of shallow gas, may constitute a limitation from the point of view of positioning the facilities and/or may impact their design. For an additional discussion of this issue see Sections 1.6.4.7 and 1.6.4.8.

Figure 1.6.4- 9


Offshore Alternatives
Map No. 1.6.4-9
60 m
1 km
Sea floor
Gas front
Active seepage
TWT (ms)

1.6.4.4 Available existing information for the purpose of characterizing failure phenomena within the inspection space

In the course of the investigation undertaken prior to preparing the slumping chapter of the survey, information sources currently held by various parties in regard to the seabed and the subsoil within the inspection space were mapped. The investigation indicated that there are many gaps in the available information relating to the geological characterization of the inspection space, and that in regard to considerable parts of this space there is no basic information available at a satisfactory level of resolution (such as dense shallow seismic surveys). In addition, the scope of geological research within the inspection space regarding the phenomena of soil failure of the types that were discussed in the previous sections is limited and does not provide a detailed enough picture relating to their character and the model of their deployment in space. Hence, the need to analyze the basic existing information. The results of the mapping of this information are presented in Table 1.6.4-1 below. The table focuses on original/processed information databases, usually in digital formats such as bathymetric information and information derived from seismic surveys, or reports that describe such information databases.

Table 1.6.4-1: Databases and information sources relating to the seabed and subsoil within the inspection space[6]

	Details regarding the information	Source
1	Data from a shallow geophysical survey between Zikkim and Hadera using a CHIRP system collected for the artificial islands project (1997-8) down to a general water depth of about 60 meters plus	IOLR (+GII)
2	Vibracore data, drillings and CPT tests of the seabed collected in the context of the Artificial Islands project	IOLR
3	Shallow geophysical survey data (2011) that supplements the information from Section 1	IOLR
4	IOLR report (Arik Golan, 2012 A) that summarizes and analyzes the data from geophysical surveys held by them (based on times 1 + 3 above)	IOLR*

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[6] Information partially or fully held by the design team is marked in Table 1.6.4-1 with an asterisk. The analysis and conclusions of the following sections are presented on the basis of this information together with public literature sources.

	Details regarding the information	Source
5	Bathymetric information (multibeam) from the national mapping project	IOLR/GII*
6	Raster maps based on bathymetric information, item 5 above (Arik Golan, 2012 B)	IOLR*
7	Data/analysis report of a survey conducted by Noble Energy along the alignment of the pipe planned by them in the Hadera and Dor area	Noble/Ministry of Energy and Water
8	Shallow geophysical survey in the Hadera power station region conducted for INGL as part of the design of the LNG terminal plus a summary report (Hartman, 2011)	INGL
9	Data from drillings/CPT in the Hadera power station area conducted for INGL as part of the design of the LNG terminal	INGL*
10	Environmental document for NOP 37/A/2/6-LNG float opposite Hadera	INGL*
11	Data from shallow geophysical surveys conducted by means of the sparker system performed by the Marine Sciences Department at the University of Haifa at depths exceeding 20 meters	University of Haifa
12	Reports of artificial islands prepared by the Geophysical Institute	Geophysical institute*
13	Low horizontal resolution multichannel seismic surveys (EM, 1983; TGS, 2000) that cover part of Israel's EEZ waters, including most of the inspection space	Ministry of Energy and Water/ Geophysical Institute*

1.6.4.5 Analysis of the mechanism and spread of the slumping phenomena within the inspection space

For the purpose of analyzing the nature and spread of the slumping along the edges of the continental slope within the space, a mapping of slumping and lineaments was performed by means of a GIS station utilizing bathymetric information. In addition, a number of seismic lines derived from TGS (1983) EM, (2000) surveys were analyzed. The analysis was conducted by means of Kingdom © Software Version 8.6 station. Reflectors M and N were marked on top of these seismic lines (roof and base of the salt layer respectively) and faults were also deciphered and mapped. Following this, the points in which faults mapped on top of seismic lines coalesce with the seabed were marked on top of the bathymetric information.

1.6.4.5.1 Mapping of slumpings on top of bathymetric information

The mapping of slumpings (Figure 1.6.4-10; close-up in Figure 1.6.4-11) included the marking of slumping scars and boundaries of slumpings. These slumping scars were identified as a topographic step that prominently separates between surface areas with a low level of roughness and a level nature usually to the east of the scar and an area with a high morphological roughness and an irregular structure in which one can clearly see that the sediment underwent transport and deformation. In addition, secondary slumping scars were identified within the irregular area as lines along which in addition to the morphological step there is a difference between the two sides of the scar at the level of surface roughness. The water depth in the area of the headscarp area in the easternmost slumping region was in the range of 110 meters in the north end of the inspection space and 250 meters in the south end of the inspection space. A sequence of slumping scars is found along the entire length of the mapping area. In cases where, in addition to the headscarp, it was also possible to identify the sediment reduction area, the sediment accumulation area, and the slump toe, the slumping was marked as a polygon.

Figure 1.6.4-10: Mapping slumpings and lineaments on top of a bathymetric information image

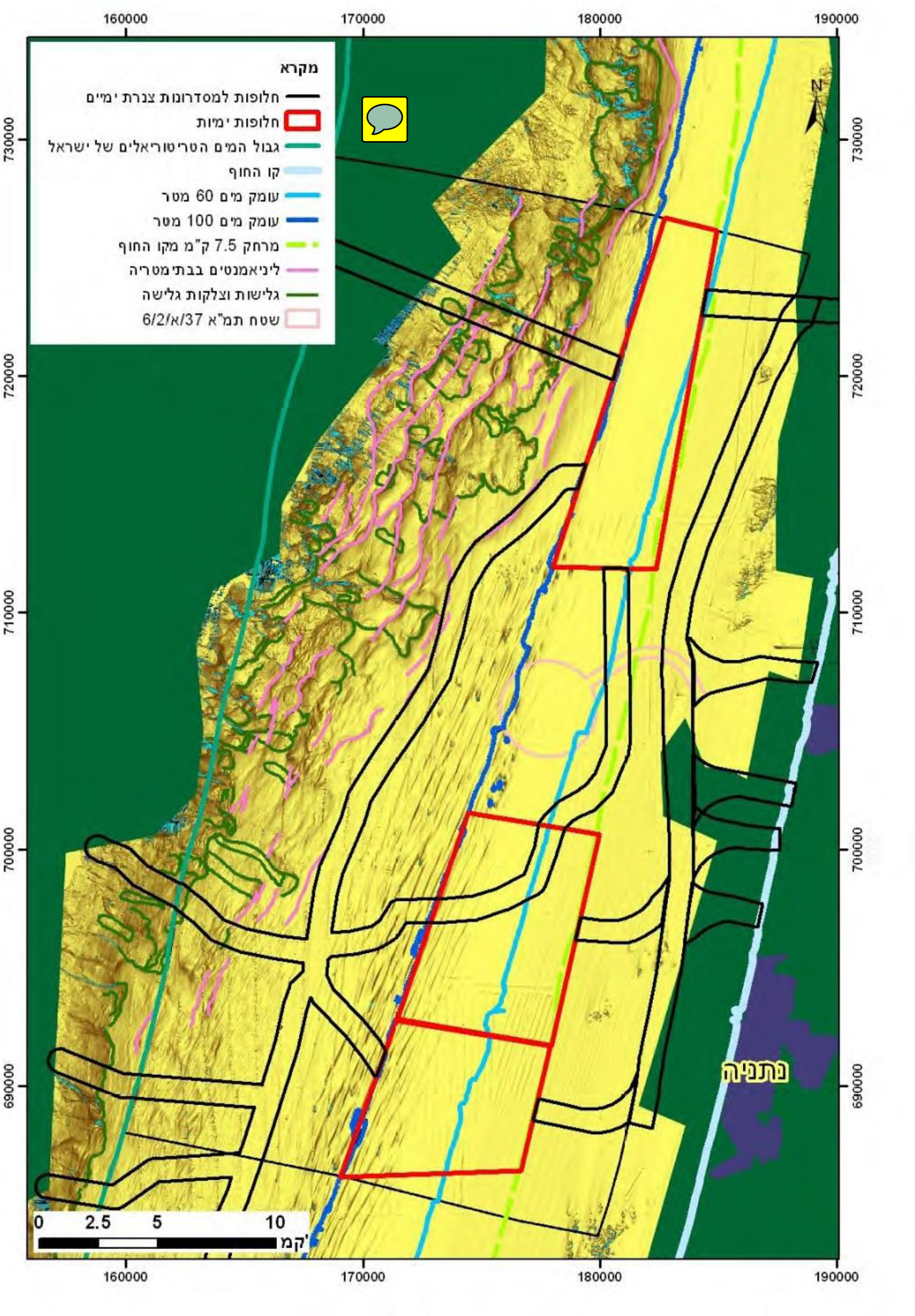
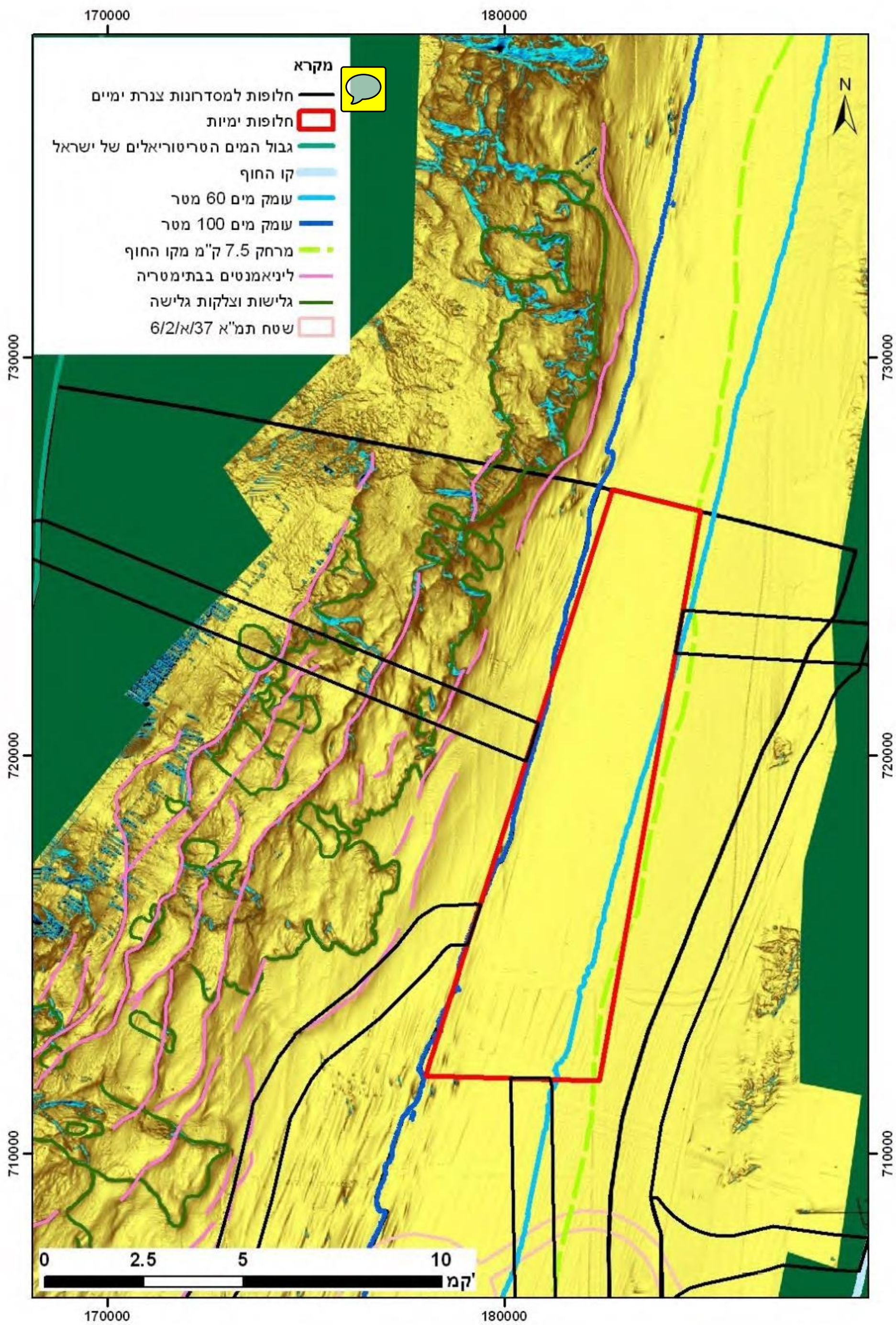


Figure 1.6.4-11: Mapping slumpings and lineaments on top of a bathymetric information image -close-up of the Hadera alternative area



1.6.4.5.2 Mapping of lineaments/faults and correlation between bathymetric information and seismic information

The generic name, lineaments, serves in the present work to describe linear elements that are sub-parallel to the shoreline and were mapped on top of bathymetric information. Lineaments are seen as morphological steps and they represent a significant lateral continuity so that they can be tracked through slumping regions. In a number of locations, lineaments cross and give rise to a model of approximate rhomboid polygons. Usually they do not differentiate between areas of different roughness (i.e., between disturbed and undisturbed regions), but in many cases headscarps develop along them. The lateral orientation and continuity of the lineaments conform to the fact that they express on the surface the young faulting of the post-Miocenian sediment column by faults that belong to the tension area created over the reduction and slumping area of the Miocenian evaporites layer (see discussion above as well as Grandmann et al., 2005; Mart and Ryan, 2007).

In order to examine this comparison, seismic profiles perpendicular to the shoreline were deciphered. Figure 1.6.4-12 presents an example of a seismic section taken from survey TGS, which bisects the northern part of the inspection space. The deciphering of the section supports Grandmann's et al. (2005) model and presents the extension transform and compression regions that were discussed above. Figure 1.6.4-13 presents a close-up of the eastern part of the section included in the inspection space. This is a part where the deformed character arises from tensile stresses and the faults are accordingly normal with an increasingly diminishing slip as the depth increases in the direction of reflector M. In this section we see the morphological steps created on the seabed in places where faults reach the surface. This observation clearly supports the morphological steps being a function of recent slippage in a normal orientation on top of the mapped faults.

The spatial relationship between faults and lineaments on the surface is presented in Figure 1.6.4-14 (Figure 1.6.4-15: close-up). The dots coded in color according to the seismic survey used as the basis of the analysis denote the intersection between the faults and the surface or a projection of faults that have been deciphered in the shallow subsoil on the surface. There is good correspondence between the location of these points and the mapped lineaments. In Figure 1.6.4-13 the lineaments represent the assumed alignment of the faults mapped in the subsoil, so that it becomes evident that the faults, while crossing, define clear blocks with an approximate rhomboid (horizontal) section between which there are shearing actions. Alignment of the faults is not mappable using seismic surveys alone in view of the low spatial resolution (density of lines) in the scale presented on the map.

Garfunkel (1984) describes the same lineaments as crossing arc- shaped faults that are sub-parallel to the shoreline (Figure 1.6.4-3), which create steps of up to 10 meters in the bathymetry in those locations where they intersect with the seabed. The faults mapped in this work present slippages of 45-60 degrees in the vicinity of the seabed and they level out to slippages of 30-40 degrees in the area over the roof of the Miocenian evaporites layer, so that in actual fact the fault is listeric with descending blocks in the direction of motion towards the center of the basin. Garfunkel (1984) mentions similar slips (or even lower for the abutting area) for the faults that he describes in this environment and comments that changes in the slip of the layers within the slipped blocks indicate the beginning of faulting events after the beginning of the settlement of the Plio-Pleistocene section and the continued faulting activities as this section settles.

Figure 1.6.4- 12

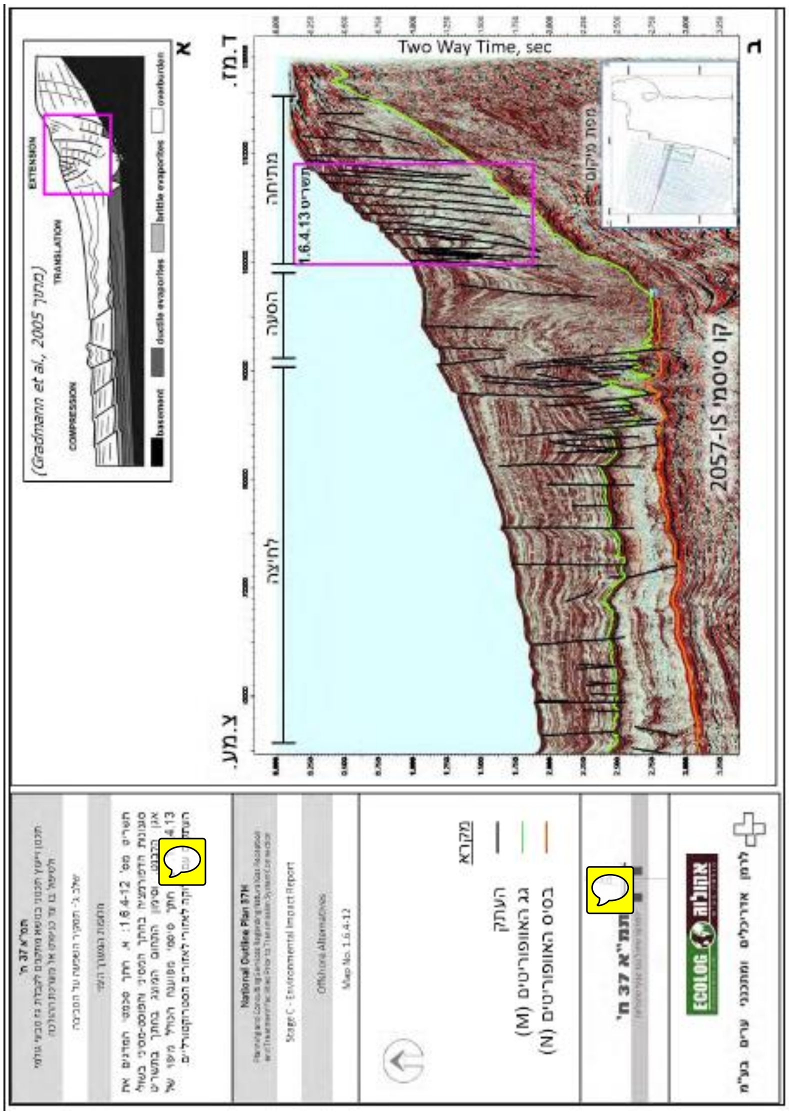


Figure 1.6.4- 13

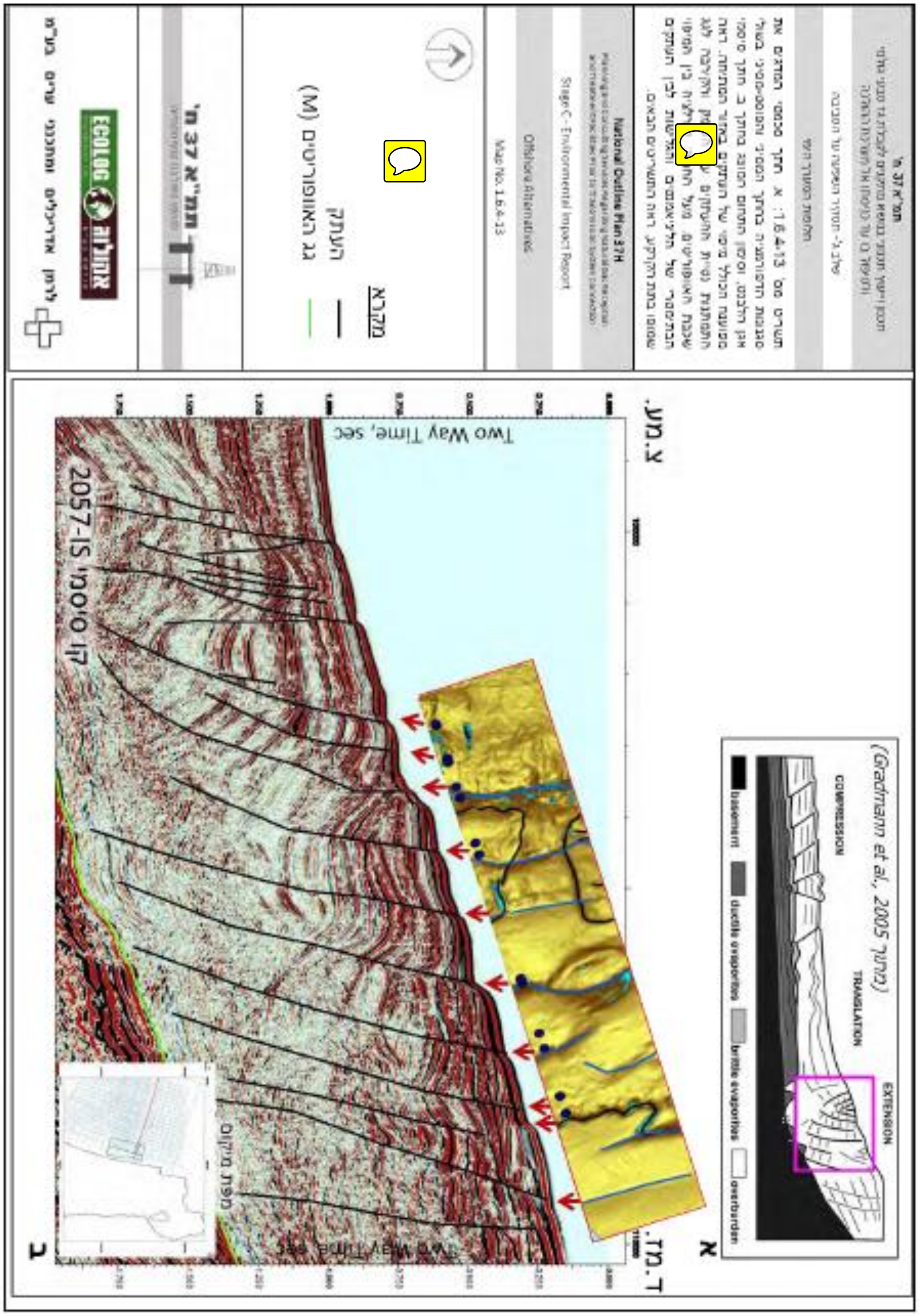


Figure 1.6.4-14: Mapping of slumping and lineaments on top of a bathymetric information image with the addition of section points of faults that have been mapped on top of seismic lines with the surface (or projection on to the surface of faults that have been mapped in the vicinity of the surface)

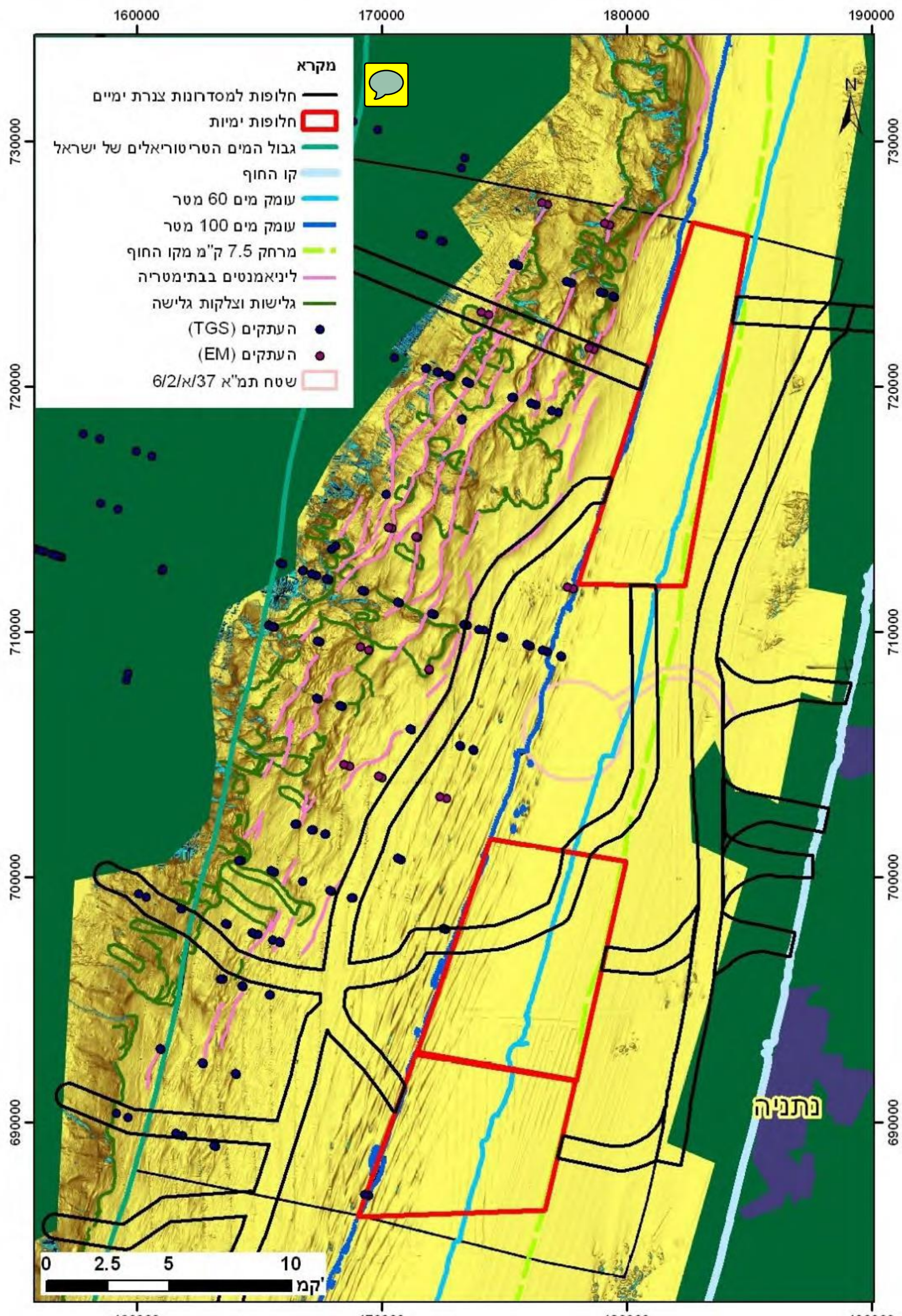
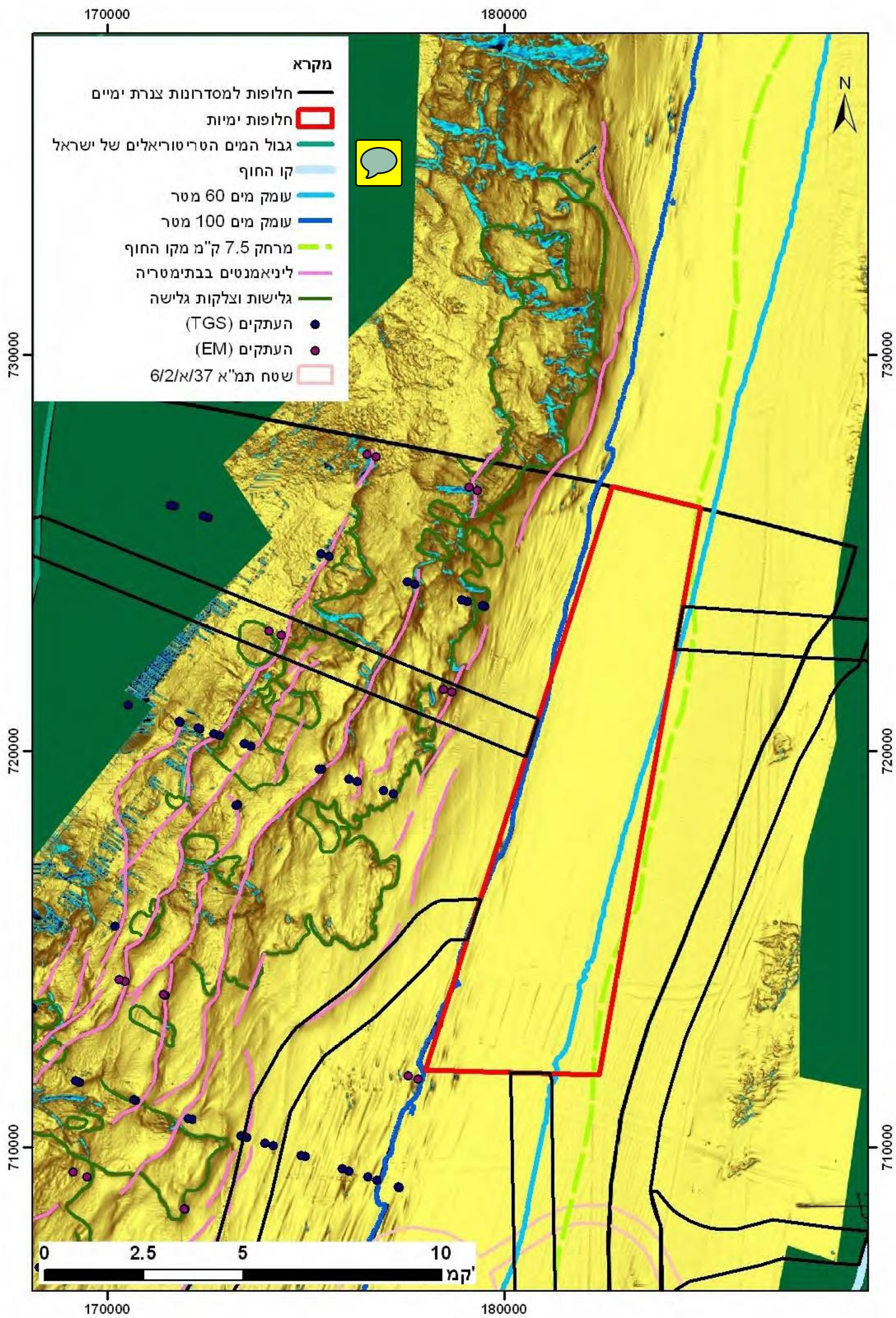


Figure 1.6.4-15: Close-up of Figure 1.6.4-14



1.6.4.6 Analysis of the mechanism and spread of soil failure phenomena within the shallow section of the inspection space

The relevant databases for examining these phenomena are the shallow seismic surveys conducted in parts of the inspection space and the soil tests that accompanied these surveys (items 1, 2, 3, 8, 9, and 11 in Table 1.6.4-1 in combination with the bathymetric information item 5 in the table). The reports submitted to the design team or available to the design team were written on the basis of these databases (items 4, 10, and 12 in Table 1.6.4-1). The observations and their interpretation as presented in these reports and in particular in item 4: "Structure and stability of the upper continental shelf" (Golan, 2012 A), constitute the basis for the description of the formation phenomena and/or geotechnical failure phenomena within the inspection space, in the area of the alternatives proposed for the erection of marine facilities. A description of the phenomena is presented in the following sections and the reference to their spatial location is given in Figure 1.6.4-16:

1.6.4.6.1 Faulting of young sediment layers

Within the inspection space discontinuities identified as a fault in phenomena of young sediment layers were observed in a number of sites (Figure 1.6.4-16). These sites are located at water depth between approximately 80 and 100 meters within the inspection space.

1.6.4.6.2 The shallow gas layer

Mainly concentrated in water depth of 40-60 meters (Figure 1.6-A5). Its north boundary according the present mapping is in the Netanya region, however it is possible that north of Netanya where the information is extremely sparse, there are additional islands of gas accumulations within sediments.

1.6.4.6.3 Formation of the sediments comprising discontinuity plains, volume changes, and liquefaction

These are common, starting from a water depth of about 60 meters and westwards. Among others observed by Golan (2012 A) are phenomena that are identified as volume changes and which Golan interpreted as the settlement and collapse of sediments that lost the gas that was entrapped within them and of sediments that swelled as a consequence of gas accumulation (Figure 1.6.4-17). It is reasonable to assume that such phenomena are genetically related to the concentration of gas in sediments.

1.6.4.6.4 The phenomenon of corrugation in the sediments

An individual case of the volumetric changes phenomena described above (Figure 1.6.4-18). In cases where the collapse is symmetrical pockmarks may be formed. This phenomenon appears starting from a water depth of about 70-80 meters (Figure 1.6.4-15).

Golan (2012 A) notes that the observations and conclusions described are based on information with a low spatial density and therefore after rejecting sites in view of the above observations and for additional reasons there will be a need for a bathymetric seismic and geotechnical mapping in order to take account of sub-base defects at the selected sites. In addition, the information on which the above observations are based relates to the shallow sedimetric medium (so that, for example, in most cases we cannot see the kurkar layer there) and therefore we should reject risk factors at greater depths.

Figure 1.6.4-16

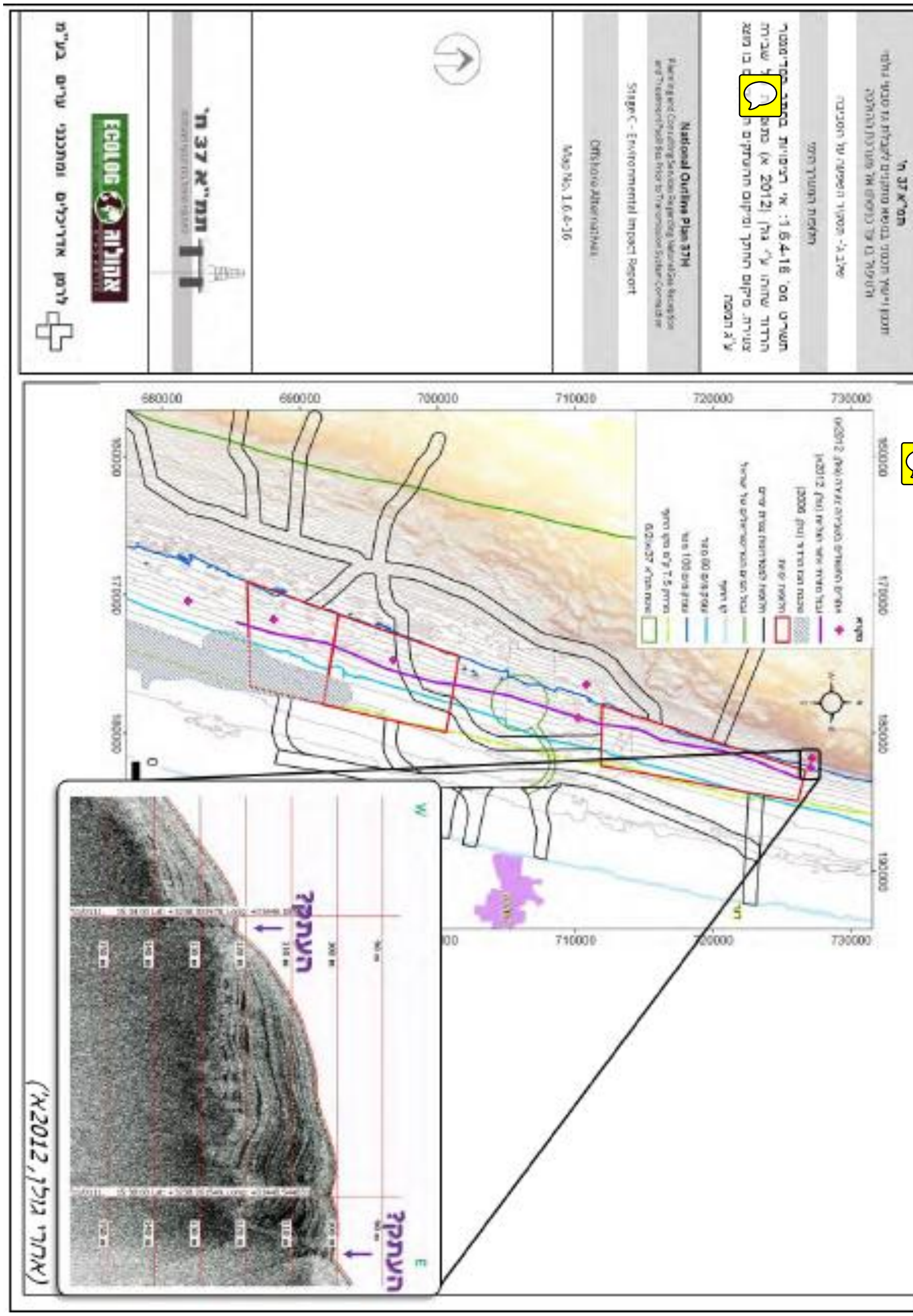


Figure 1.6.4-17: Formation of sediments including phenomena identified by Golan (2012 A) as the collapse and swelling of sediments

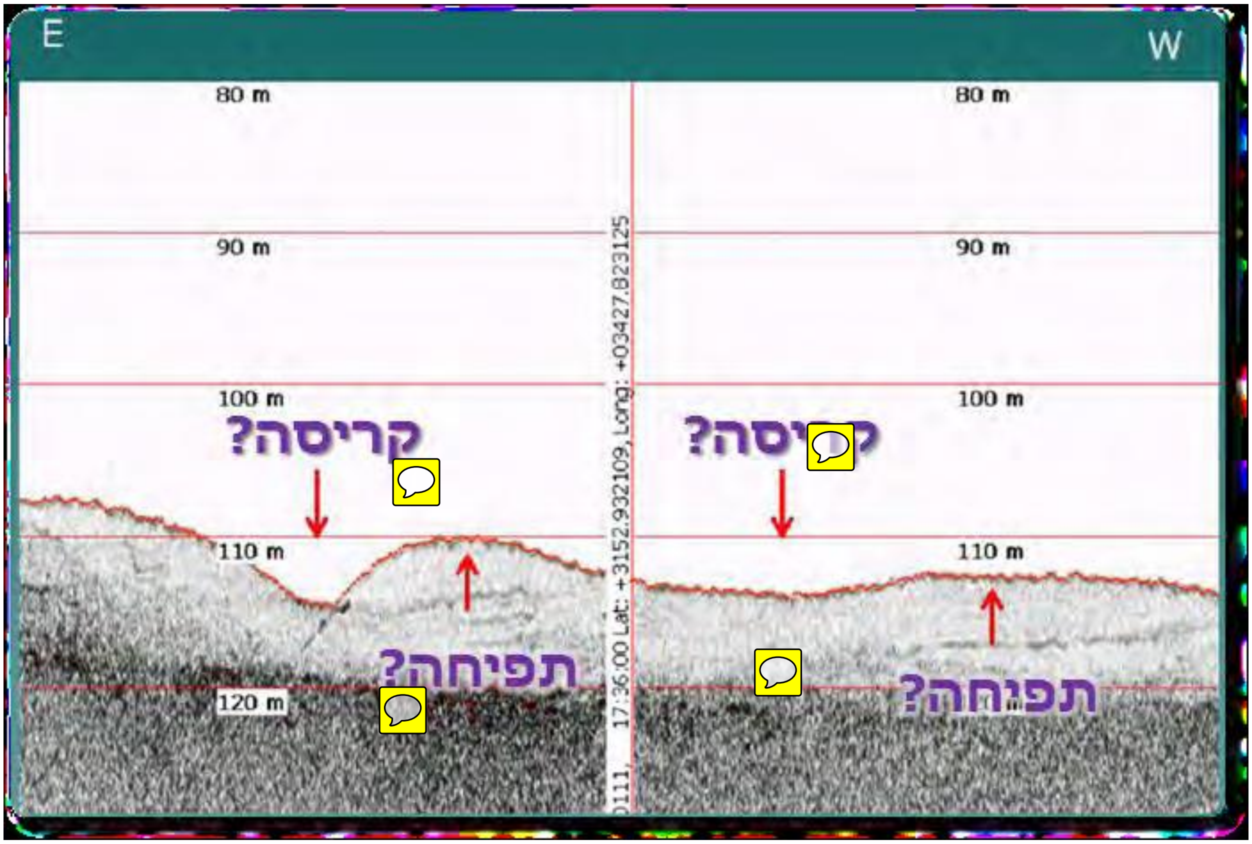
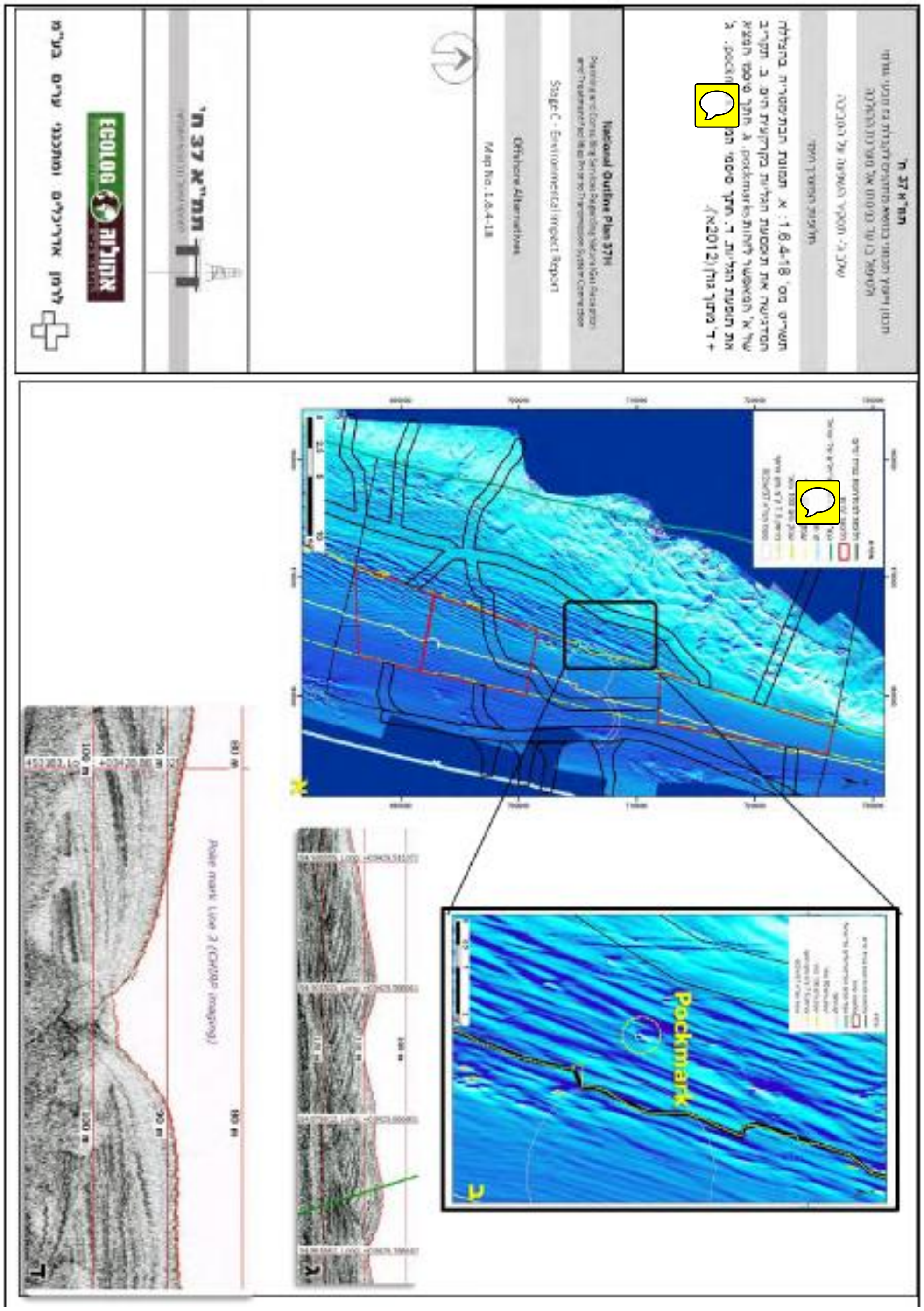


Figure 1.6.4-18



1.6.4.7 Conclusions regarding the development of slumping arising from gravitational collapse in the continental shelf and slope within the inspection space

Figures 1.6-A2 and 1.6.4-3 demonstrate the two salient disturbances of the Israeli continental shelf which are the Dor and Palmachim slumpings. As stated above an increase in the thickness of the Miocenian evaporites layer and of the clastic section above it increases the possibility for the development of slumping (for example, Garfunkel et al., 1984; Mart and Ryan, 2007). Therefore, sites that are at risk of slumping are those regions where deep canyons have developed and a thick lens has been sedimented (relative to its environment) of evaporative rock during the Miocenian event, above which a thick column of sediments (relative to its environment) has accumulated (mainly from Nilotic origin) since the beginning of the Pliocene.

Figure 1.6.4-19 presents an isochrone of the entire Plio-Quaternary section. The isochrone is based on time maps of the roof of the salt layer (reflector M) and of the seabed, and is presented on top of a mapping of faults and slumping created by Garfunkel (1984). There is correspondence between the areas in which Garfunkel (1984) mapped concentration of faults and the areas in which the Plio-Quaternary section is thickest. This correspondence supports two hypotheses:

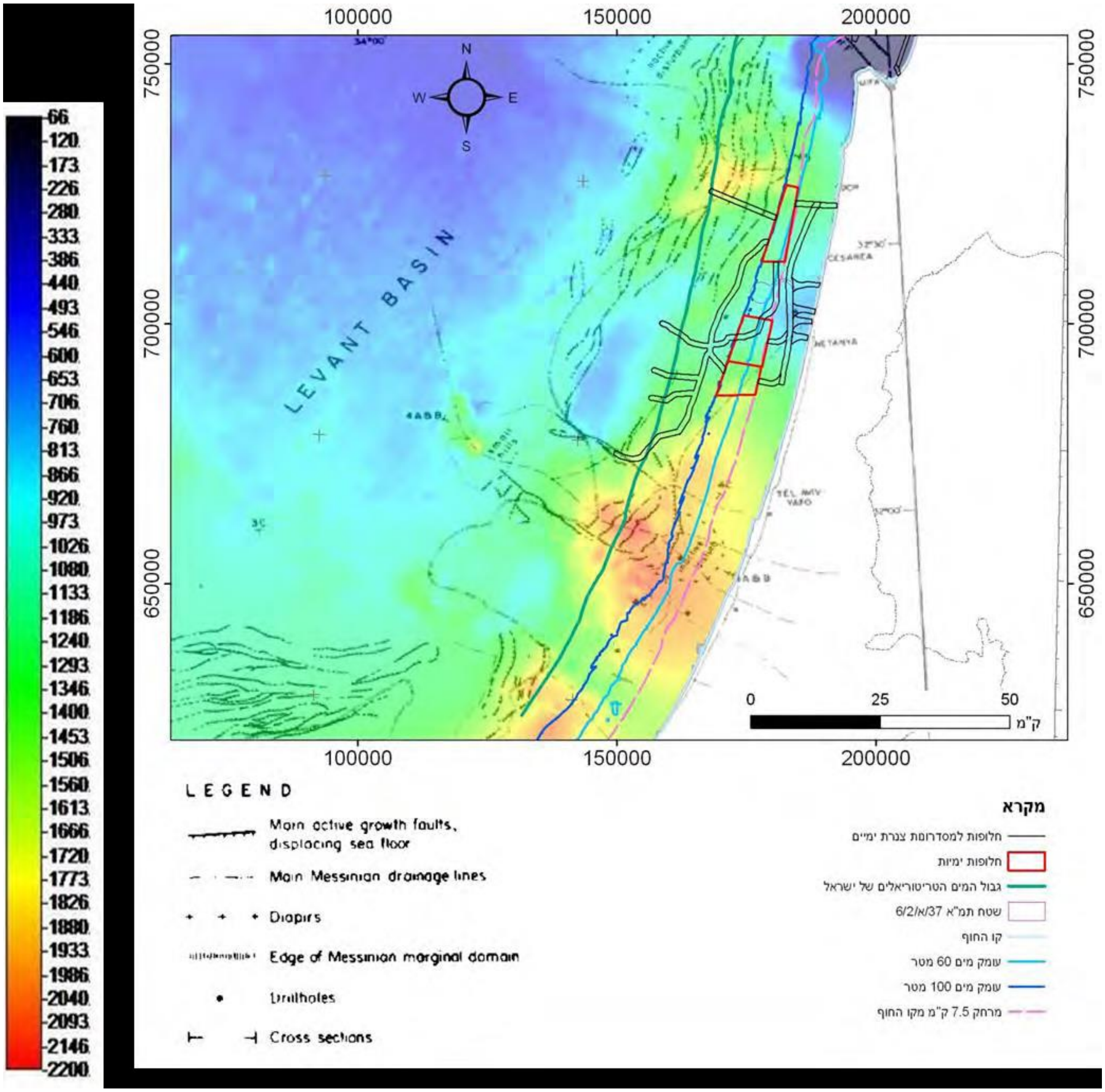
A. Thickening of the post-Miocenian section fosters the formation of the sediments by increasing the gravitational stress exerted on the Miocene evaporites layer.

B. There is a causal spatial relationship between the faults mapped and the slumpings. This relationship arises from the formations and a decrease in the cohesion of sediments along the fault lines. These weakened regions relative to their environment are optimum sites as nucleation sites for the development of slumping. This mechanism underlies the Gradmann et al. (2005) model of failures in the continental shelf.

1.6.4.7.1 Conclusions regarding the spatial development of soil failure phenomena within a shallow section of the inspection space

Section 1.6.4.6 presents conclusions regarding the spatial spread of failure phenomena in a shallow sedimentric section of the inspection space. As stated above, a young fault has been observed at a water depth in the range of between approximately 80 and 100 meters; the shallow gas layer is mostly concentrated at water depth of 40-60 meters and spreads according to available information northward up to Netanya (although it is possible that additional gas islands are present north of that region); the deformation of sediments is common, starting from a water depth of about 60 meters and westwards, and the phenomena of sediment corrugation appears starting from a water depth of about 70-80 meters.

Figure 1.6.4-19: Isochrone of the entire Plio-Quaternary section based on an analysis of TGS (2000) survey lines, the isochrone are presented on top of a mapping of faults and slumping created by Garfunkel (1984)



1.6.4.7.2 Conclusions regarding the characterization of marine alternatives for offshore facilities

The implications relating to the deployment of the risk factors presented in relation to the location of the marine alternatives for gas facilities are presented in the following table.

Table 1.6.4-2: Implications of the conclusions regarding the spread of risk factors within the inspection space as regards the location of alternatives

Alternative	Spread of risk factors within the platform area	Spread of risk factors within the pipeline area -from the discoveries to platforms
Hadera	The northernmost alternative in the known area of shallow gas layer spread. It is possible that there are gas concentrations in this area that have not been mapped. If there is indeed a correlation between soil failures and gas and if indeed gas concentrations are lower the more we move to the north then it is expected that within the alternative site there will be extremely reduced risk factors. In the absence of direct observations in support of these hypotheses, we cannot determine the relative risk. In addition, this alternative is closer when compared to the other alternatives, to the slumping, and faulting areas related to the Dor slumping and the thickness of the post Miocenian sediments in its area is the greatest. The Ohr Akiva fault passes within the area of this alternative, whereas the definition of this fault (still not included in Standard 413) was changed from "suspected as active" to "not active" (Sagy et al., 2012).	This alternative is close to a high concentration of faulting and slumping. Within the latitude of this alternative, the east boundary of the faulting and slumping band is the easternmost. Accordingly, this is the highest risk area to lay pipeline directly in a westerly direction.
Havatzelet HaSharon	Most of it is located north to the main area of the shallow gas layer spread. If there is indeed a correlation between soil failures and shallow gas, it is possible that within the area of this alternative there will be low risk factors as compared with the Netanya alternative. In the absence of direct observations in support of these hypotheses, we cannot determine the relative risk.	Sparse spread of faulting and slumping from the west to this alternative partially supports the option of laying pipeline directly towards the west
Netanya	Located within the known area of shallow gas layer spread. If there is indeed a correlation	Very sparse spread of slumping and faulting from the

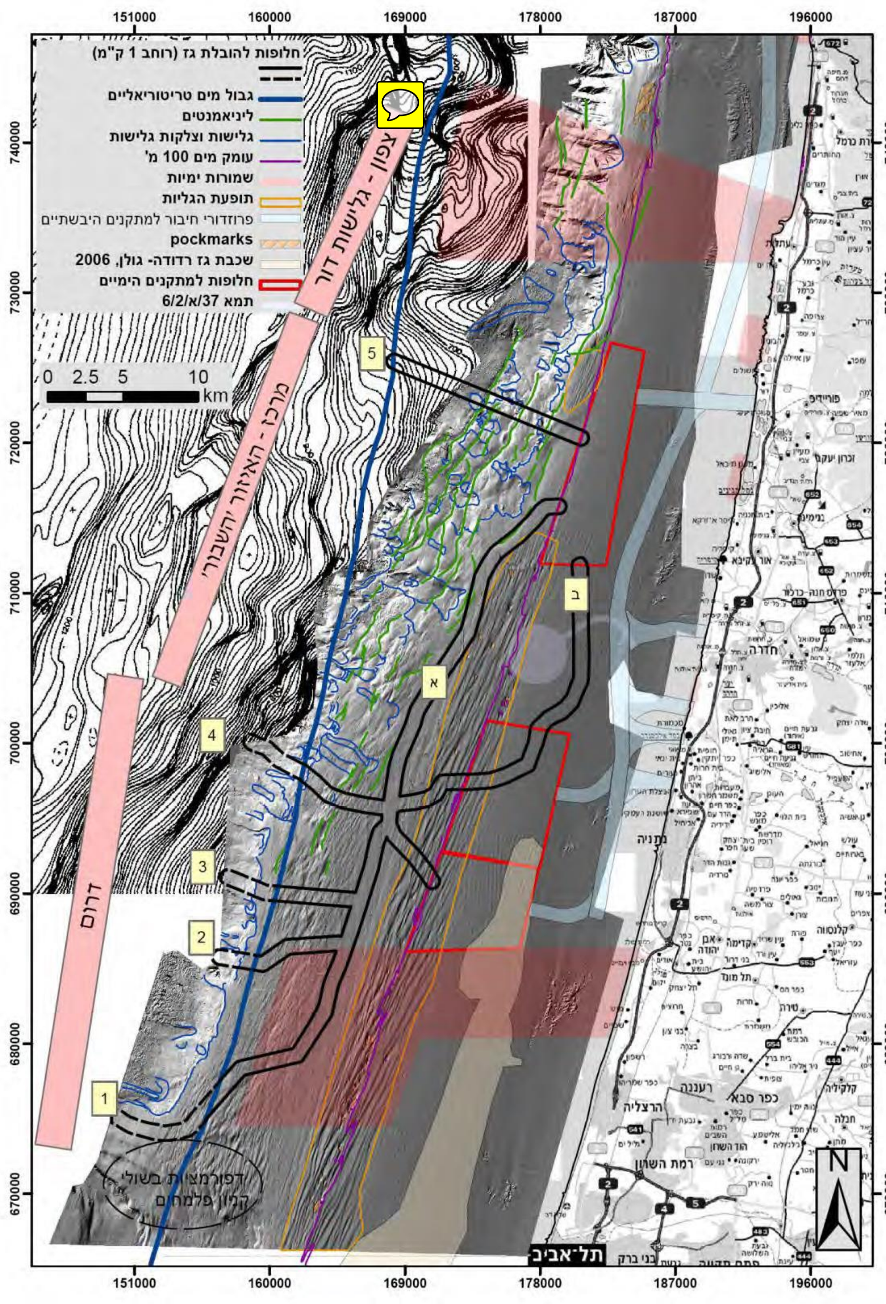
Alternative	Spread of risk factors within the platform area	Spread of risk factors within the pipeline area -from the discoveries to platforms
	between soil failures and the shallow gas, it is expected that risk factors will be found within the area of this alternative.	west to this alternative supports the option of laying pipeline directly westwards.

1.6.4.8 Alternatives for the transmission of gas from the discoveries to the gas facilities sites in the continental shelf

1.6.4.8.1 Description of the morphology of the space in which the pipeline alignment alternatives are situated

A bathymetric analysis was performed in the space surrounding the alternatives for installation of offshore gas facilities in the aim of discovering testimonies to an active deformation or young deformation that is liable to constitute a risk for the future gas pipeline that will connect the gas reservoirs and the offshore facilities. The results of this analysis make it possible to delineate pipeline corridors (one kilometer wide) that avoid passing through areas impacted by a young deformation (Figure 1.6.4-20). The area included in this analysis comprises the continental shelf, the edge of the continental shelf (shelf break), and the upper part of the continental shelf up to a water depth of about 600 meters. The analysis was carried out according to multibeam data with a resolution of five meters within the national mapping project provided by IOLR (for a description of this project, see Sade et al., 2007, 2008). The alternatives for gas transmission corridors in the plan were delineated within Israel's territorial waters, but the considerations for selecting their alignment take a account also the bathymetry of the continental slope to the west of the territorial waters of Israel. In areas to the west of the area the alternatives for gas facilities where there is no coverage of multibeam data were selected by means of a bathymetric map with a format of an image of northern Israel (Almagor and Hall, 1983), which presents contours with a vertical intervals of 10 meters. The delineation of the gas transmission alternatives along the continental slope is based on an analysis of gradients and the identification of past slumpings, on the assumption that an area with greater gradients and/or slumpings is more "prone" than other areas to additional failures in future since it indicates recent/current activity. The reason for this is that the active sedimentation in these areas is liable to cover staggering and to level out inclines unless such have been created in the near geological past and not yet covered with sediments, and/or their rate of formation in the present is higher than the sedimentation rate. This analysis does not provide any predictions regarding future failures and does not constitute a substitute for a full slopes stability survey that takes into account the geotechnical parameters of the sediment column at sea as well and additional conditions that are liable to have an impact, such as the welling of gasses and bedding orientation.

Figure 1.6.4-20: Map of alternatives for gas transmission corridors from the reservoirs to the treatment facilities sites. Location of topographic sections are marked with yellow lines



The deformations and morphological elements found at the seabed are divided into two according to the areas in which they appear:

On the continental shelf: the width of the continental shelf is less than 25 kilometers facing Tel Aviv and up to about 10 kilometers facing Atlit in the north. The morphological elements of the continental shelf include kurkar ranges, corrugation phenomena of the seabed surface, pockmarks, and lineaments. The kurkar ranges are spread in parallel to the shoreline in a non-continuous fashion, whereas from the north for each protrusion of the kurkar range there is an elongated depression in a northwardly direction that was created as a result of erosion by sea-bottom currents. The exposed kurkar ranges are located to the east of the polygons proposed for the marine facilities and therefore have no impact on the selection of the alternatives for gas corridors to the west in the direction of the discoveries. The lineaments suspected as faults mostly appear close to the edge of the continental shelf in the north-south direction and this hints of a relationship to gravitational failures further on down the continental slope. Some of them were also identified in shallow seismic cuts that cross them (Figure 1.6.4-13). The corrugation effect (Section 1.6.4.6.4) appears in a band about four kilometers wide that overlaps the west boundaries of the alternatives for the marine facilities and is characterized by long and smooth parallel ranges in a north-northeast-south-southwest direction with a maximum amplitude of about 10 meters and wavelengths of about 100 meters up to a number of hundreds of meters (Figures 1.6.4-21 and 1.6.4-22). Pockmarks-ellipsoid/round concave indentations with a diameter in the range of a number of dozen meters to more than 100 meters and a maximum depth of about 10 meters (Figure 1.6.4-21, 1.6.4-22). Most of the pockmarks are bounded within the corrugation effect, something that indicates a genetic connection between the two. Golan (2006, 2011) relates these two phenomena to the presence of a methane gas layer in the subsoil. It is possible that the depth of the pockmarks is dictated by a known cohesive clay layer that is relatively soft (and sensitive to liquefaction processes (with a typical thickness of about 19 meters (the LNG float drillings data NGI, 2012) that overlays a layer of thicker clay. Sometimes the pockmarks appear in dense groups in a certain area or along a line. No pockmarks from different generations were found or such that become refilled with sediment and this fact indicated a continuous and active process that maintains their young morphology. The current pockmarks activity was demonstrated by time sequence bathymetric surveys (Golan, 2006). A rough seabed morphology different from the corrugation effect mentioned above and not accompanied by pockmarks was observed. Close to the edge of the continental shelf (shelf break) the source for this morphology is unclear, but it is possibly connected to the tension regime to which the continental slope is subject.

The continental slope: the morphology of the continental slope in this area indicates active processes that shape the slope in a continuous fashion. Evidence of slumpings are found along the entire length of the slope in the form of slumping headscarps in the upper part of the slope and the bodies of the slumpings themselves that have accumulated in the bottom part of the slope, similar to the morphology that is presented in Figure 1.6.4-1. Linear escarpments parallel to the shoreline indicate the vertical motion on top of active faults, a hypothesis that was validated by means of correlating the faults on the surface with subsoil expressions. This correlation is presented in Figure 1.6.4-13. In Figure 1.6.4-23 topographic profiles are presented on the basis of the bathymetric information ,in addition to the location of faults identified in seismic information, which are presented along with the kinematic interpretation of their activity. In the "faulted" central area (Figure 1.6.4-B23), we can clearly see a correlation between the fault location and the location of the steps in the topographic profile. In the north area (Figure 1.6.4-A23) we can see steps, but not faults were mapped in this area. In the south region (Figure 1.6.4-C23) we cannot see any clear steps in profile and the faults mapped do not reach the surface. In general, the continental slope region to the west of the inspection space can be divided into three segments (Figure 1.6.4-20): 1) The Dor slumpings, located in the northern area (from Dor northwards) and characterized by a huge number of slumpings, scars, and underwater canyons. The Dor slumpings disruption area covers an extensive region that spreads westwards up to a depth of more than 1,000 meters. 2) "The faulted/slumped" area in the segment between Michmoret and Dor. This area is characterized by parallel escarpments that are organized very densely (lineaments) and by slumpings. 3) The area to the south of Michmoret is characterized by fewer lineaments and slumping scars; the slope is more uniform in its gradient and includes less escarpments. Topographic sections, representative of these areas, in addition to a profile of the average gradients are presented in Figure 1.6.4-23.

Figure 1.6.4-21

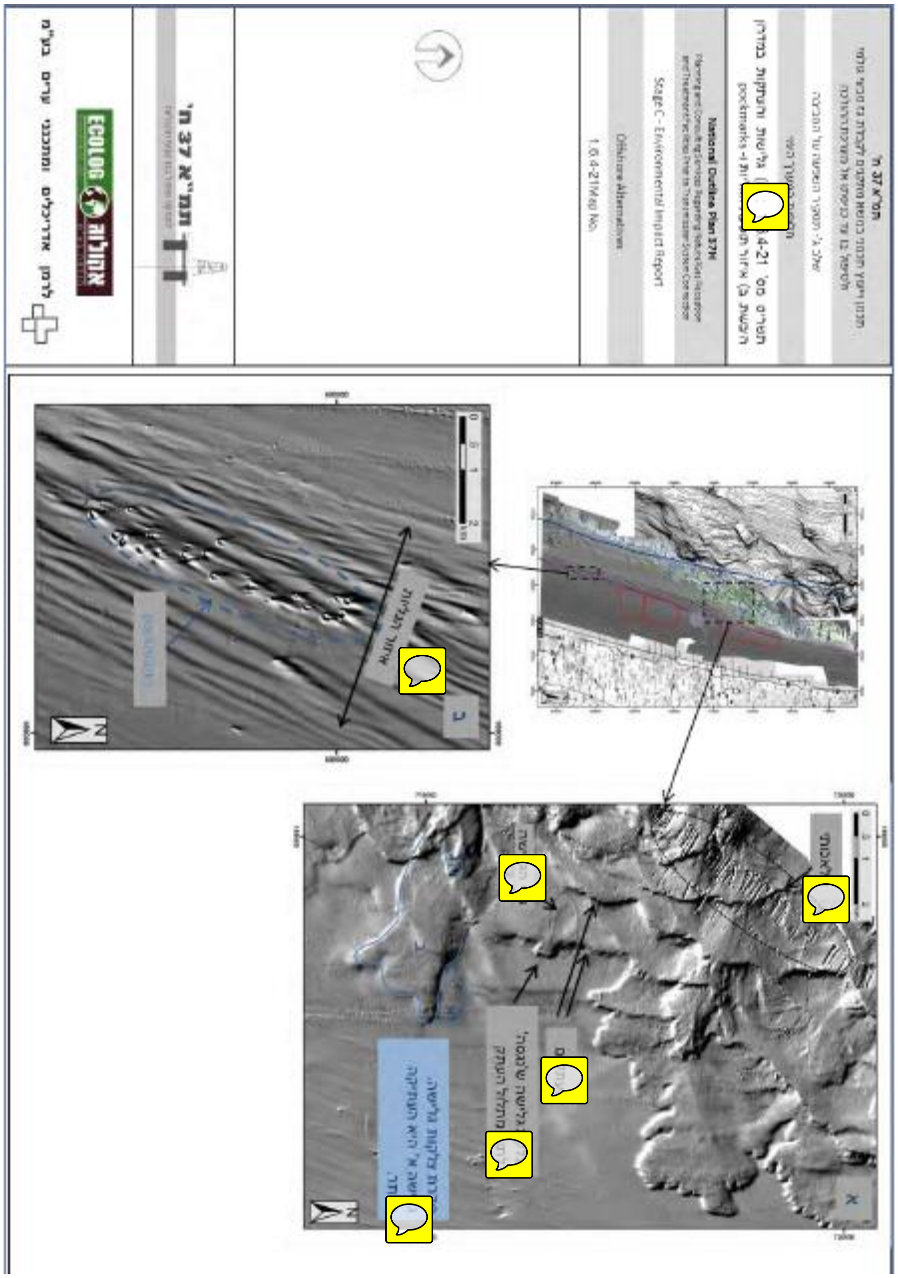


Figure 1.6.4-22

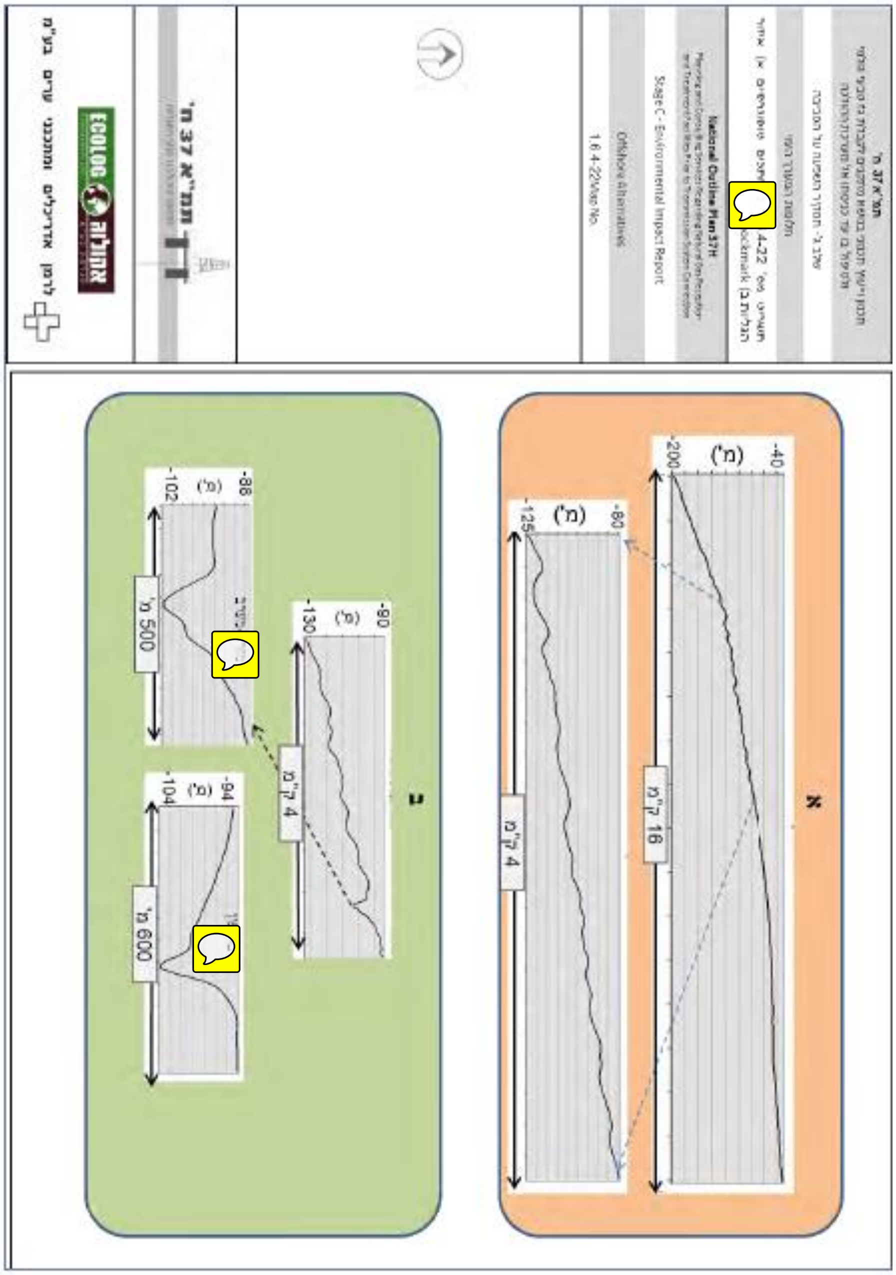
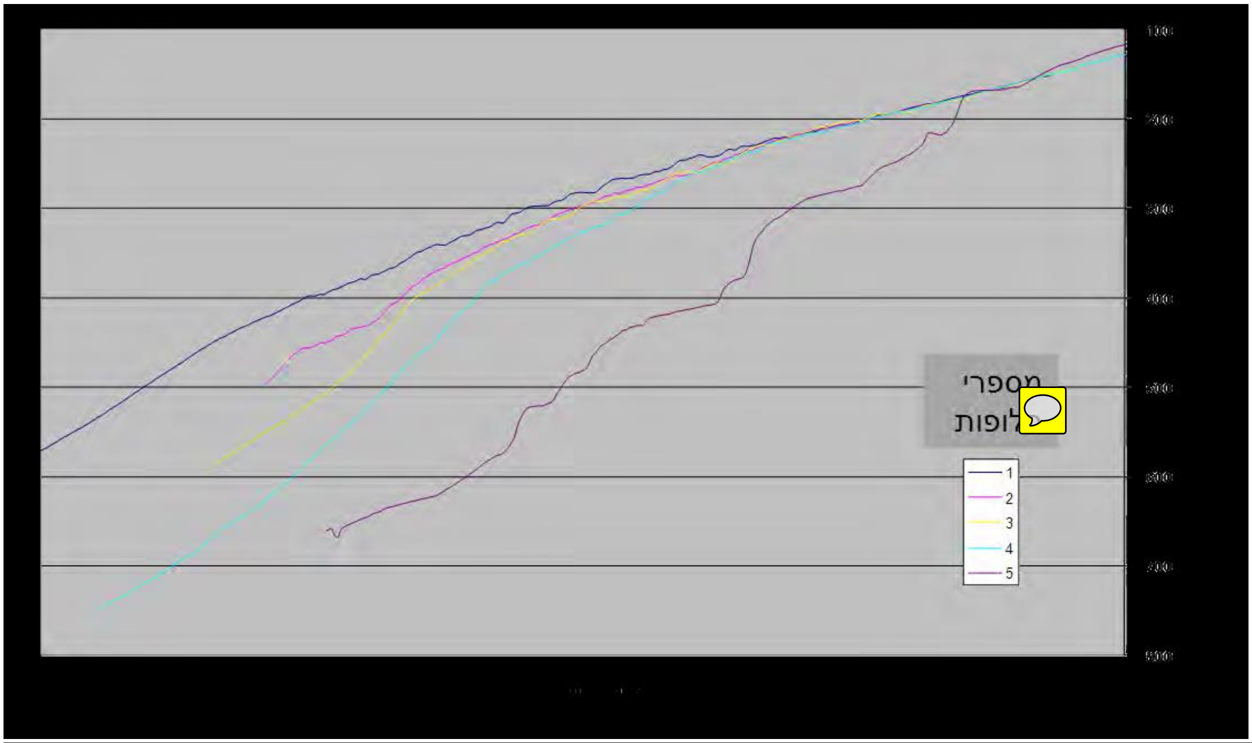


Figure 1.6.4-23: Topographic sections along the gas transmission alternatives[7]



1.6.4.8.2 Description of the alternative alignment for pipeline corridors

Figure 1.6.4-20 shows five possible pipeline alternatives (marked 1-5) that connect between the mapping boundary in the west (the territorial waterline) and the continental shelf. In general, the further north one moves the greater the average gradient of the alternatives. In addition, we can see an increase in the number of lineaments and slumpings in the northern direction, which finds expression in greater local gradients (Figure 1.6.4-23, 1.6.4-24). Local gradients were calculated as a running average of 50 meters along a given topographic section.

- ❖ **Alternative 1**: The southernmost alternative (opposite Herzliya). This alternative does not cross slumping areas and lineaments and it passes where the shift between the continental shelf and the continental slope is the most gradual. On the other hand, there is insufficient bathymetric information regarding continuation of the

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[7] Along alternative 5 we can discern significantly higher gradients relative to other alternatives.

pipeline corridor to the west of the territorial waters and beyond the continental slope area for this alternative. An additional drawback is the proximity (less than one kilometer) to the Palmachim slumping to the south and deformations that appear along the edges of this slumping. The maximum local gradient is seven degrees.

- **Alternative 2**: Opposite Ga'ash. This alternative crosses a single local escarpment in a shelf break (approximately 10 degrees) and there is no indication of slumpings down the slope. For this alternative there is an absence of sufficient bathymetric information regarding the rest of the incline down the continental slope.
- **Alterative 3**: Opposite south Netanya. This alternative crosses a single local escarpment at shelf break (approximately 10 degrees) and there is no indication of slumping down the incline. The bathymetric is available in a lower resolution (Almagor and Hall, 1983) which indicates that this alternative continues in a westerly direction without significant disruption down the continental slope until it reaches the deep-seabed (more than 1,000 meters).
- **Alternative 4**: Opposite the north of Netanya. This alternative crosses three local escarpments (approximately eight degrees) at shelf break and passes between two slumping scars (east-west) down the slope. The bathymetric information available is of very low resolution (Almagor and Hall, 1983) indicating that the extension of this alternative towards the west continues without significant disruption down the continental slope.
- **Alternative 5**: Opposite Dor. This is the "default" alternative for connecting the Hadera alternative along the shortest possible alignment westwards in the direction of the deep-sea discoveries through an area that is intensively faulted and slumped. This alternative crosses at least three escarpments with local gradients of 15-20 degrees and a number of slumping blocks. Most/some of these elements are liable to be active.

Drawing of the pipeline corridors in the continental shelf, between the sites of the alternatives for the facilities and the area where the continental shelf is crossed to the west was carried out in an attempt to avoid the passage through the corrugation area and through areas where pockmarks are particularly dense. Since the corrugation area in fact "blocks" the access to the south polygons, the crossing of that band was drawn in places where the lowest concentration of pockmarks was found. There are two alternatives for connecting the Hadera alternative with pipeline alternatives 1-4 in the south (Figure 1.6.4-20). These corridors (A and B) circumvent the area of the corrugation phenomenon from the east and from the west.

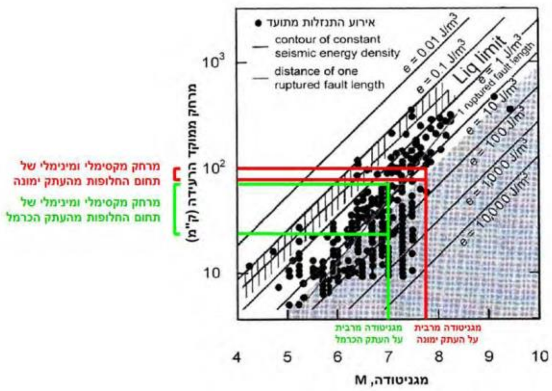
1.6.4.9 Alternatives for gas transmission from gas facility sites at the continental shelf to coastal entry systems

For all pipeline corridors alternatives, no indication was found in the bathymetric analysis of any active deformation of the seabed in the shallow area between the alternatives of the offshore facilities and the shore. It should be noted that along the shore there is an absence of bathymetric information with sufficiently high resolution (multibeam) along a band that is about five kilometers wide in its widest part (drawing 1.6.4-20) and a focused bathymetric survey will be required for the alternative that will be selected. In combination with low gradients in the shallow part of the continental shelf it may be said that there is no great risk or difference between the alternatives regarding the risk arising from underwater slumpings. No active/suspected as active fault is known in the area of the alternatives and therefore the surface is not expected to rupture here. The risk of soil liquefaction exists in all alternatives, for all of them are located on the seabed with a column of un-agglomerated and saturated sediments where the risk of liquefaction will be ultimately determined by the geotechnical parameters of the sediments (1.6.5). All pipeline alternatives are exposed to the risk of tsunami. In view of the location of the alternatives relative to the test points of the soil acceleration values, the acceleration coefficients, and the response spectrum values are expected to increase in a northerly direction, i.e., to be lowest along the Neurim alternative and the highest along the Dor alternative. This change is not expected to have any implication for the relative applicability of the various alternatives.

1.6.5 Possibility of Soil Failure as a Consequence of Liquefaction

Liquefaction is a process in which water saturated granular sediment loses its strength and behaves as a liquid during a seismic quake. Liquefaction takes place naturally when there is a combination between a nonconsolidated porous rock, surface water (or water close to the surface) and strong soil accelerations caused by the earthquake. During the earthquake there is a sudden increase in the pressure of the liquids within the voids in the rock layers, and the sediment with the nonconsolidated component which had been supported up to that moment by granules becomes liquid and loses its strength and its resistance to shear. As a consequence the soil loses its ability to support the structural elements on top of it. Sediment density (for example sand), distribution of particle size, soil acceleration, and duration of the earthquake are the main factors that determine if sand should turn liquid during an earthquake (Salamon et al., 2008). Thus, the qualities of the rock sub-base, extent of sediment water saturation, earthquake level, and distance of the site from the epicenter of the earthquake are all very important. Figure 1.6.5-1 presents an empirical correlation between documented liquefaction events and the distance from the epicenter of an earthquake (as an approximation of the rate of seismic energy to which the sediment is exposed). For the purpose of demonstration, typical data ranges for seismic sources are presented on top of the drawing in relation to the inspection space.

Figure 1.6.5-1: Liquefaction as a function of the empirical relationship between earthquake magnitude and distance from the epicenter (according to Wang, 2007)

	Maximum and minimum distance of the area of the alternatives from the Yammouneh fault
Maximum magnitude of the Yammouneh fault and maximum magnitude of the Carmel fault	Maximum and minimum distance of the area of the alternatives from the Carmel fault

Distance from the earthquake focus (kilometers and magnitude M)

<u>From a geological point of view</u> it is customary to estimate that soil liquefaction potential exists in areas where there are sand sediment horizons or saturated sandy silty sediment horizons in the upper 20 meters of a rock column. The presence of clay in the sediment fills the voids between the particles and strengthens their cohesion so that soil with high clay content does not tend to liquefy. Nevertheless, the presence of clay in a layer above sandy sedimentation may prevent the escape of water during an earthquake out of the sand layer and thus in fact lead to an acceleration of the liquefaction process (Salamon et al., 2008).

<u>From a geotechnical point of view</u> the liquefaction potential may be evaluated according to soil quantitative measurements. Wang (1981) notes the sensitivity range of liquefaction for three geotechnical measures:

- Liquidity index I_L: soft clays with $I_L > 0.75$.

- Resistance in the standard penetration test, N: soils with $N < 4$ (N = the number of blows).

- Sensitivity index, S_t: soils where $S_t > 4$.

In the estimation of Seed et al. (1983), fine-grained soils will be vulnerable to liquefaction if the following three indices apply:

- Percent of fines: soils in which the fine particular sediment percentage (five microns and less) < 15%.

- Liquidity limit, L_L: soils in which L_L < 35 %.

- Water content, WC: soils in which WC > 90% L_L.

1.6.5.1 Liquefaction within the inspection space

The local infrastructure in the inspection space is described in Section A of the introductory chapter. According to the description in said chapter, it becomes evident that the inspection space is mostly located within a trough between two kurkar ranges. The soft fill mostly comprises clays and clayey silts with a thickness exceeding 20 meters (Figure 1.6-B2). Beneath the clays there are sandy units a number of meters thick. In the southeast (the shallow) part of the inspection space, there is also silt and sand on the surface (Figure 1.6-B7). Both the clays and the sands are saturated with water. Expected soil accelerations within the inspection space are 0.06-0.08g for the various test points (Section 1.6.1).

In geotechnical tests conducted for drilling samples taken from water depths of 44 and 72 meters opposite the Hadera coast (for the LNG float, NGI, 2012) a number of relevant indices for evaluation of liquefaction potential were examined for the clay layers. The values obtained are presented in Table 1.6.5-1.

Table 1.6.5-1: Geotechnical measures collected for the clay layer opposite the Hadera coast (for the LNG float, NGI, 2012) as compared to liquefaction threshold values

Index*:	Liquefaction Index	Sensitivity Index	Percent Fines**	Liquid Limit	Water Content
Value received:	0.5 < IL < 1.4	0.5 < St < 4.5	Clay: 40-65% Clay + silt: 90-99%	60% < LL < 120%	60% < WC < 110%
Threshold conditions for liquefaction:	IL > 0.75	St > 4	Percent finds < 15%	LL < 35%	WC > 90%LL

Index*:	Liquefaction Index	Sensitivity Index	Percent Fines**	Liquid Limit	Water Content
Is the condition met?	The threshold condition for liquefaction is met	The threshold condition for liquefaction is met in a borderline manner	Two out three of the threshold conditions for liquefaction do not obtain, and therefore in total the conditions for liquefaction are not met		

* The report (NGI, 2012) does not present SPT data.

** The NGI (2012) report states that the silt particles are 2-20 microns in size while the clay particles are 2 > microns in size.

From the point of view of the geotechnical measures for the clay layers at the drilling points, the liquidity index values (L_L) indicate the potential for liquefaction and in a borderline way also the values of the sensitivity index (S_t) (according to Wang, 1981; Table 1.6.5-1). Nevertheless, out of the indices noted by Seed et al. (1983) only the water content value corresponds to the sensitivity conditions necessary for liquefaction so that according to their method no potential for liquefaction of the clay layer at the drill point exists (Table 1.6.5-1). It should be remembered that both the geological data and the geotechnical data noted above are local and therefore, in order to evaluate the sensitivity for liquefaction the clay layer is only represented at the sampling points. For saturated sand and silt layers at a shallow depth from 20 meters (for which the above indices were not measured) there is potential for liquefaction; however, such depths are beyond the inspection space.

From the point of view of the distance between the alternatives area and the main relevant seismogenic sources, the empirical relationships are presented in Figure 1.6.5-1 and support the existence of potential for liquefaction under maximum earthquake (M_W = 7.8) on the Yammouneh fault (a reference scenario of 975 years). For similar considerations, there is also liquefaction potential for the maximum scenario on the Carmel fault (M_W = 6.5), though to a lesser extent for the southern part of the inspection space (the Netanya alternative). This potential can be realized within the inspection space at sites where the soil section includes sediments that are sensitive to liquefaction to the extent that such exist.

1.6.6 Formation of a Tsunami

This section deals with an evaluation of the chances for a tsunami within the inspection space. The information and conclusions presented in this section are based on a survey of previous studies that evaluated the characteristics of the tsunami phenomenon along Israel's coast and the probability for a tsunami strike. In addition, existing knowledge regarding the tsunami events that took place in our region, a survey of the tsunami genetic potential sources within the Mediterranean area with an impact for the central-north part of Israel's shores, and simulations that simulate tsunami scenarios along Israel's coast are all presented.

1.6.6.1 The tsunami phenomenon

A tsunami comprises a series of very long waves (up to hundreds of kilometers) that develop following a disturbance in the marine medium. Possible sources of tsunamis include marine earthquakes (especially vertical movements), slumpings, volcanic eruptions, the fall of meteorites, nuclear explosions at sea, and the like. Tsunamis usually take place in a cyclic retreat and flooding of the sea along the coastline. The first wave in the series of waves that make up a tsunami is not necessarily the most destructive one. Because of the long wavelength and the low amplitude of tsunamis, it is usually not possible to distinguish its advance in the open sea without appropriate equipment. Equipment of identifying tsunamis include a title gauge, a satellite detector, or advanced systems such as the Dart System that measures hydrostatic pressures on the seabed (developed for the Pacific Ocean).

The powerful shore waves of a tsunami are created as a consequence of an interaction between the wave front and the seabed: where the depth of the water column decreases the speed of the wave also decreases (equation 1) and its energy thus becomes concentrated in a smaller body of water – the wavelength shortens and the wave amplitude increases, i.e. the height of the wave over the water the increases (The Shoaling Effect). For this reason, a tsunami wave that can be barely distinguished in the open sea can reach a height of dozens of meters in the vicinity of the shore.

(1) An equation describing the change in the speed of a tsunami waves group, C, as a function of the water column depth, H. g is the gravity acceleration g=9.796 m/s^2 (gravity acceleration along Israel's coast).

$$C = \sqrt{gH}$$

Cycle times and wavelength received in earthquake scenarios described by Galanty et al. (2009) are 14-23 minutes, with a wavelength of 100-200 kilometers for a water depth of 1,500-2,200 respectively. These cycle times correspond to accepted values found in the literature that comprise typical cycle times of 25 minutes for tsunamis created as a consequence of earthquakes and between 2.5-3.33 minutes for tsunamis created following slumpings (Favalli et al., 2009). Figure 1.6.6-1 demonstrates the change in the tsunami wave height factor as a consequence of the interaction with the seabed for a wave with a cycle time of 2.5 minutes (in the figure this appears as 150 seconds). It can be seen from this drawing that at a depth of 125 meters the wave amplitude already increases by a factor of two (Ward, 2002).

The damage caused by flooding during a tsunami is not only generated by the penetration of seawater inland, but also in the moving and sweeping of alluvium and broken objects as well as damage to structures located in the vicinity of the shore. In addition, the retreat stage of the wave can also be destructive since a significant lowering of the sea level is liable to cause heavy damages to sea vessels. Shore instillations, buried infrastructure, and marine infrastructure facilities are liable to suffer damages following the intensive sweeping away of sediments from the sandy shore strip to the sea (Galanty et al., 2009).

1.6.6.2 Tsunami within the Eastern Mediterranean basin

The average return time of a significant tsunami along Israel's Mediterranean coast over the past 2,150 years is about 200 years (with significant deviations from the mean; Salamon et al., 2009). The main mechanisms for the formation of a tsunami along the shores of the east Mediterranean basin are earthquakes and underwater soil slumpings. Over the past 2,000 years there have been 21 prominent tsunami events that have struck the shores of the east basin of the Mediterranean (Egypt, Israel, Lebanon, and Syria). On the basis of correlations between the tsunami events and the timing of earthquakes recorded in historical catalogues, Salamon et al. (2007) have concluded that the source of nine tsunamis lay in distant earthquakes (four following seismic events in the vicinity of Cyprus and another four following seismic events in the Hellenic Arc and the Aegean Sea and one from a very far source in Sicily), the source of 10 tsunami events was in local seismic activity in various segments of the Dead Sea Transform and the source of two additional events is unknown. Following an earthquake in the Aegean Sea in July 1956, a weak tsunami was recorded in the tide records of the Jaffa Harbor (Beisel et al., 2009). This tsunami was not discernible at the shore and it is possible that in the course of history there have been other events of the same kind that were not documented. These events were not weighed by Salamon et al. (2007) in evaluating the average return time of tsunamis to Israel's coast.

1.6.6.3 Tsunamis following earthquakes

Following an earthquake, a tsunami is liable to develop and spread around an earthquake epicenter (in the event that the seabed shifted) or as a consequence of tectonic movements (in the event of a distant earthquake). The spectral composition of the wave, its spatial shape and its height are influenced by the dimensions and the power of the earthquake source (Galanty et al., 2009).

Possible foci of strong earthquakes in the east Mediterranean Basin are:

- The Cyprian Arc: a reduction area liable to significant vertical motion;
- The Hellenic Arc (Crete) – the most seismically active location in the Mediterranean Basin and with a potential for a significant vertical motion (mega-thrusts) on to the reduction area. The east part of the Hellenic Arc is in a preferred orientation towards Israel (perpendicular to the strike) and earthquakes taking place on the arc have created a number of historical tsunami events;
- Sicily – a fault with a convergence (reduction) trend that caused one of the largest and most destructive earthquakes of the Mediterranean Basin, the Messina 1908 earthquake. This earthquake also caused local tsunami events;
- Lebanon – the inverted fault system along the shores of Lebanon known as the Tripoli-Beirut thrust. Israel is in the direction of the fault strike and therefore, this fault system has a reduced destructive potential in the area of the Israeli continental shelf; the tsunami of July 9, 551 is ascribed to this source following an earthquake at a level of M_W=7.4-7.6, which is considered one of the most destructive underwater earthquakes in the history of the east Mediterranean (Elias et al. , 2007). There are additional estimations of the magnitude of this earthquake; see discussion in Section 1.6-C.
- Egypt – an unstable continental shelf because of a tension regime in the northern part of Egypt. The fault system to the east of the delta has a preferred orientation towards Israel (Thio, 2009 and references quoted within it).

Out of the tsunami events in the eastern Mediterranean Basin generated by distant earthquakes, only a single tsunami event in the area of Crete in 1303 caused great destruction along Israel's coast. Through an additional event in the Crete area in the year 365, an estimation of the rate of the movement of tectonic plates in this area (using GPS measurements – at a relative speed of about 35 millimeter per year), the return period of a tsunami from this source was calculated at about 800 years (Shaw et al., 2008). If this conclusion is correct, the seismic cycle that began with the tsunami of 1303 may end in the present century or the next one.

1.6.6.4 Tsunami following underwater slumping

One of the potential factors that are liable to cause a tsunami along Israel's coast is an underwater slumping. Sometimes this slumping is the result of an onshore earthquake that shakes the stability of the continental shelf. Underwater slumpings usually take place within a small area on the same scale (or even smaller) as that of a typical tsunamigenic earthquake, and for this reason the tsunami caused by soil slumping is usually more focused and local at the stage where it hits the shore.

Most of the historical tsunami events that occurred along the shores of the Levant over the past 2,000 years were caused by slumping generated by on-land earthquakes mostly of the Dead Sea Transform system (Salamon, 2010). The minimum size of a tsunamigenic earthquake on the Dead Sea Transform system is estimated at approximately M=6-6.5. Out of the tsunami events originating in earthquakes on the Dead Sea Transforms, four tsunami events (in the years 551, 1068, 1202, and 1546) were particularly destructive. For two of these events it was possible to establish return periods at a high level of probability: about 1,500 years for the tsunami event of the year 551 (originating from the Beirut fault) and about 800 years for the tsunami event of the year 1202, originating from the Yammouneh fault (Kit et al., 2009).

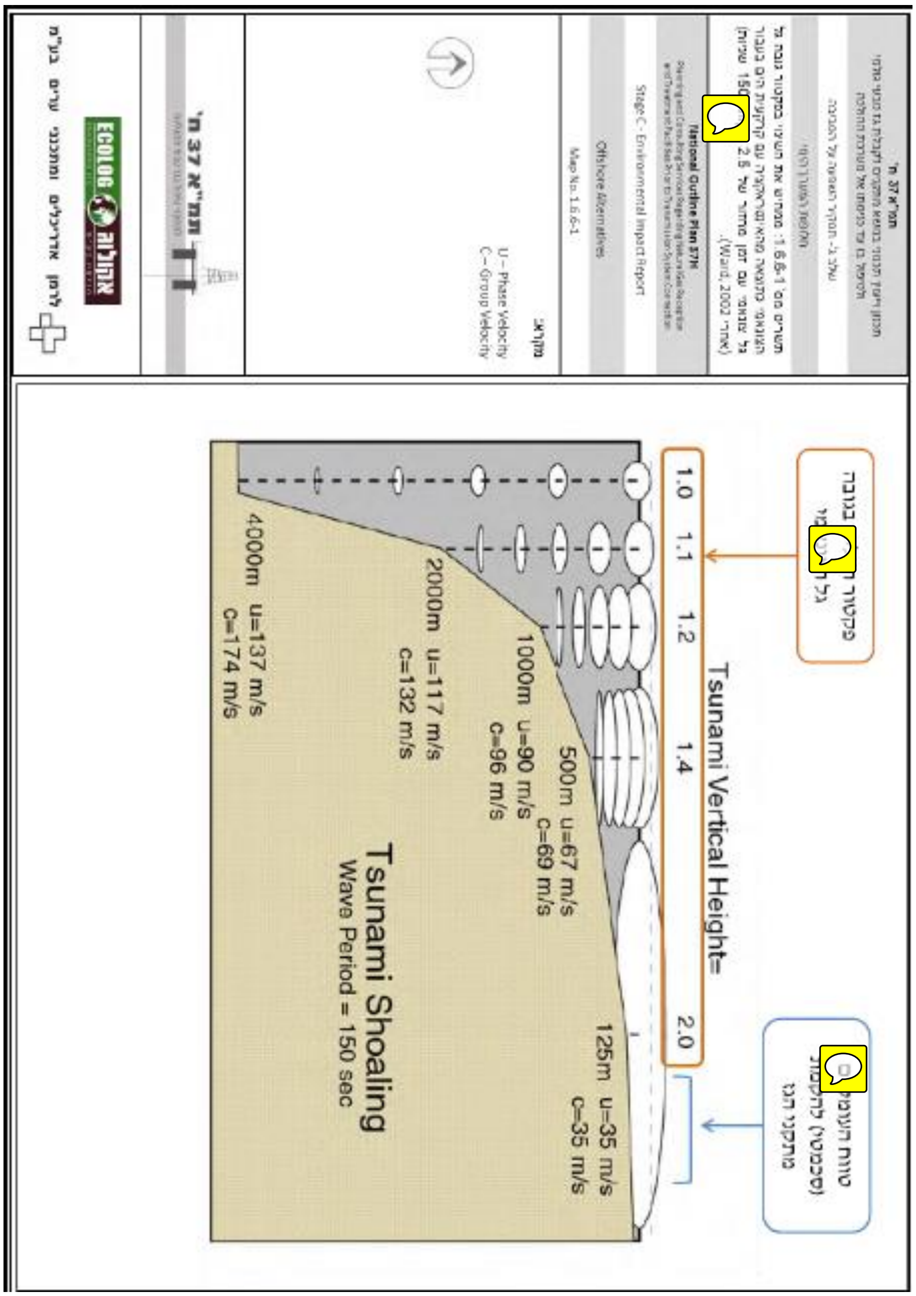
1.6.6.5 Effect of a tsunami on the gas platform

According to the explanations of Section A of the introduction, the water depth within the inspection space, 40-100 meters, is sufficiently shallow to allow an interaction between a tsunami wave and the seabed in a way that is liable to lead to considerable augmentation of wave height (Figure 1.6.6-1). In the scenarios presented by Galanty et al. (2009) the wave amplitude in the continental shelf is liable to reach a height of six meters. Similar or higher wave heights may be significant from the point of view of the stability of the gas platform and/or its accompanying facilities and require appropriate preparations. Moreover, according to the information presented in previous sections, the probability that a tsunami event should take place within the inspection space is not negligible, particularly in view of the approximate dates and return times for historical tsunami events.

In addition, in the event of an underwater slumping it is possible that the tsunami wave front could advance under the surface of the sea in a way that is liable to impact the underwater elements of the platform. In order to estimate the nature and intensity of a tsunami strike on the gas platform, it is possible to perform individual simulations, as have been carried out for the Tel Aviv and Haifa area (Galanty et al., 2.5, 2.5), and estimate the engineering parameters derived from this accordingly.

In view of a government decision (May 2012) to establish a tsunami shore warning system, it is possible to make sure that the gas platform is connected to the required warning means in the event that it is operational during its activity. This will make it possible to neutralize sensitive systems before the tsunami wave hits.

Figure 1.6.6-1


Tsunami Vertical Height=
1.0
1.1
1.2
1.4
2.0
500m u=67 m/s
c=69 m/s
1000m u=90 m/s
c=96 m/s
2000m u=117 m/s
c=132 m/s
4000m u=137 m/s
c=174 m/s
125m u=35 m/s
c=35 m/s
Tsunami Shoaling
Wave Period = 150 sec
National Outline Plan 37H
Stage C - Environmental Impact Report
Offshore Alternatives
Map No. 1.6.6-1
U – Phase Velocity
C – Group Velocity
ECOLOG

1.9 Nature, Landscape, and Heritage Values

Introduction

This section addresses nature and ecology values within the plan area. Since the guidelines regarding the survey of the environmental impact issued on March 29, 2012 (attached as Appendix A) did not include any details regarding an examination of the ecology of the marine environment, this section was based on the guidelines included in Appendix 10 (guidelines for an environmental impact survey, Chapters 1 and 2) of tender number 36/10 on the subject of "planning and design consultation for natural gas receiving and treatment facilities until the gas enters the transmission system." An evaluation of the seabed habitats and their sensitivity was performed on the basis of existing information and details regarding the soft soil environment and the rigid bed environment (the kurkar ranges), with attention to the extent of sensitivity.

The reference to the three alternatives: Hadera, Havatzelet HaSharon, and Netanya for the platform site was done in a single iteration since the three alternative sites are all located as adjacent sites on the same silty/sandy sub base strip ("the polygon") between depth lines 60-80 meters. This strip is bounded between two kurkar ranges that run parallel to the shore (the east range at a depth of 37-47 meters and the west range at a depth of 90-120 meters – see Appendix B). A reading of the bathymetric map of the area of the alternatives indicates that within the boundaries of the polygon there does not seem to be any presence of underwater ranges/exposed kurkar rock areas. Despite the above, there may be patches of exposed kurkar that can be detected in a higher resolution bathymetric mapping. When such information becomes available the sites will be scanned and the presence of such elements will be considered. An inspection of the sites also includes the alignment of the pipeline to the east of the sites up to one kilometer from the shore (the HDD entry area) as described below.

1.9.1 The platform area

The location of the long polygon that comprises the three sites (Figure 1.1.2-1) between two strips (running parallel to the shore) of underwater kurkar ranges is highly significant where the pipeline alignment is concerned. The pipeline intended to convey the gas from the gas fields (to the west of the platform) to the platform and the pipeline that will lead from the platform in the direction of the shore (to the east of the platform) are potentially positioned to cross one or more of the ranges. In the discussion below known ranges that have already been surveyed or in regard to which there is available information will be noted along with the location of ranges in regard to which there is not enough information to enable decision makers to make an informed decision regarding the pipeline alignment.

The most up-to-date source of information available with regard to habitats and biological features within the depth range of 60-80 meters in a silty/sandy bottom environment in geographical proximity to the above three sites is a biological survey conducted in August 2011 for the gas float project NOP 37A/6/2 (the work was carried out by Rami Tzadok and Orit Barnea for Tahal Engineering Consultants, Ltd.). The survey studied the features of the seabed (using ROV photographs and grain sized analyses as well as analyses of organic materials), described habitats and surveyed the infauna (sampling using a marine grab excavator) as well as collected background data (solidity, temperature, dissolve oxygen, and pH using CTD). The survey was conducted at various sampling points and varying depths from which information relevant to the area of the platform's offshore sites will be presented. It should be emphasized that the composition of the infauna population indicates a direct correlation with the seabed characteristics, such as particle size and quantity of organic material (see also Section 1.9.1.2 below in this document). Therefore it is reasonable to assume that the infauna will display similar features along the same depth line (for this reason data relating to the gas float survey are applicable to sites located on the same depth line to the north and south of the survey site as well). The biological information received is "point-specific" information as regards the temporal dimension (for it is known that there is a seasonal influence on the biological inventory), but it nevertheless provides an up-to-date situational picture for the area of the three sites.

Figure 1.9-1: Relevant sampling points of the LNG float survey on a Google Earth map

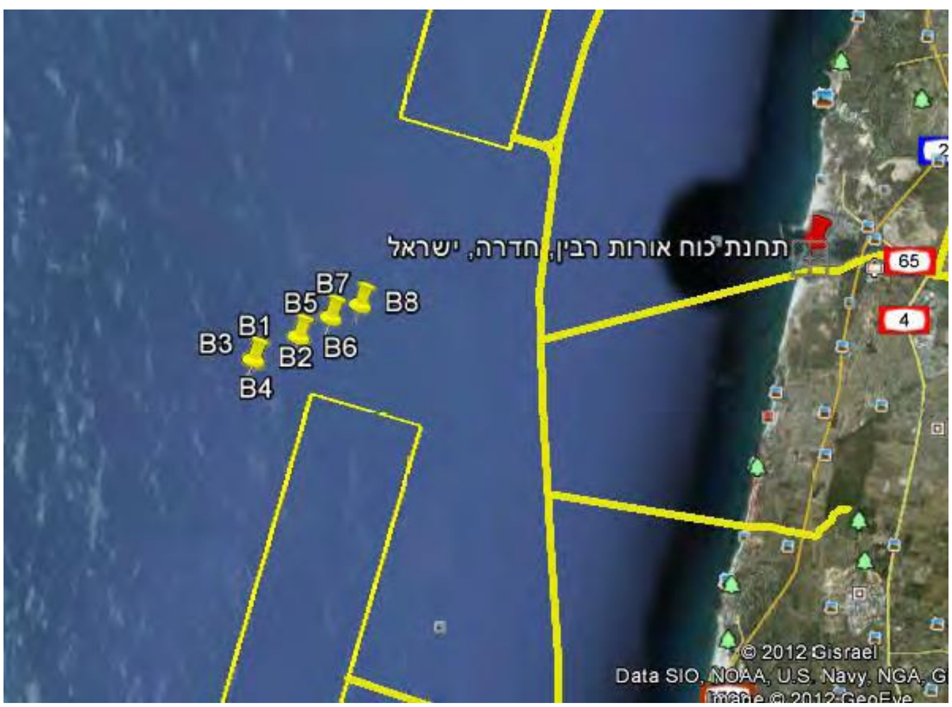


Figure 1.9-1 shows the relevant sampling points on a Google Earth map. The locations of the points are detailed in Table 1.9-1. In addition, the table presents depth data, sub-base

type, dominant particle size, and the concentration of organic materials within the sampling points.

Table 1.9-1: Concentration of location data, depth, type of infrastructure, particle size, and concentration of organic material for the sampling stations of the liquid gas receiving float project within a depth range of 60-85 meters

Station	Depth (meters)	Length/width	LAT/LONG WGS 84	Sub-base	Dominant particle size (microns)	Concentration of organic material (%)
B1 West mooring site	85	555599.425 705756.187	32º26'40.729N 34º45'13.4755E	Silt	<63	0.660936
B2 North mooring site	78	177962.372 706613.872	32º27'8.6816N 34º45'44.7865E	Silt	<63	1.14584
B3 East mooring site	67	178807.977 705780.347	32º26'41.7362N 34º46'17.290E	Silt	<63	0.64766
B4 South mooring site	70	177980.492 704952.862	32º26'14.7642N 34º45'.7433E	Silt	<63	0.648
B5 Central mooring site	75	177944.252 705774.307	32º26'41.452N 34º45'44.2259E	Silt	<63	0.668
B6 Pipeline alignment	67	178880.458 706245.307	32º26'56.8432N 34º46'19.9933E	Silt	<63	0.671
B7 Pipeline alignment	64	179544.862 706644.072	32º27'9.8706N 34º46'45.3689E	Silt + sand	63<, 180<	0.6453
B8 Pipeline alignment	60	180154.905 706903.794	32º27'18.3800N 34º47'8.6860E	Silt + sand	125<	1.01207

1.9.1.1 Sand, clay, and silt

Section 1.6 above describes the features of sediments and rocky sub-base of the continental shelf. The sections below provide the details of the ecologic aspects of various habitats accompanying these characteristics.

1.9.1.2 Ecological aspects of sandy habitats

Sandy soils constitute a homogeneous habitat (with relatively few ecological niches) with low stability (the sand/silt particles constitute a sub-base subject to the influence of currents and mechanical disturbances that do not allow fauna to cling to them). This dictates a relatively low number of species when compared to the variety of species within rocky habitats. The further one moves from the shore and out to sea the less the impact of waves on the seabed, thus leading to more stable conditions. The sandy sub-bases mostly support the existence of various faunal populations (on the seabed and between sand particles) located in strips that parallel the shore. Composition of the population of the seabed is determined on the basis of a collection of conditions such as: physical-chemical conditions (chemical composition of the water, currents, sediment composition, particle size, depth, organic content) biological interactions (competition, predation, etc.) that shape the population, modification of the physical and chemical conditions arising from biological sources (fauna impacting the seabed, turning the sand over, creating holes, secreting materials) and ultimately anthropogenic influences that are forced onto the system (Gray and Elliot, 2009). In an environment with stable conditions, the benthic faunal populations undergo minor changes over time (Pearson and Rosenberg, 1978). Changes in environmental conditions (both from natural and anthropogenic sources) are liable to lead to changes in the basic parameters of the faunal population such as changes in the composition of species, changes in the frequency of species, and in the total biomass (Pearson and Rosenberg, 1978).

1.9.1.2.1 Description of a silt bottom habitat at a depth of 67-85 meters, (points 1-6 of the gas float survey)

This habitat is characterized by a soft sandy soil that by definition is silty/muddy with a dominant particle size < 63 microns. The depth range is between 67-85 meters. The seabed in this habitat is characterized by the presence of small pits, indentations, and bumps. Most of the pits and indentations are no larger than 5-10 centimeters in diameter while the protrusions are 10-25 centimeters in diameter and about 10 centimeters high (see Figure 1.9-2). This topography is usually formed by the activity of various organisms. In the course of the survey, which was conducted during the daytime, the seabed seemed to have sparse fauna, yet such individual members of the Pennatula rubra had a noticeable presence. These creatures belong to the subclass cnidarians, which are recognizable by their orange color. The Pennatula rubra or the Red Sea Feather has the ability to extrude water from their bodies and to compress themselves to the point of significant change in their size. Photographs taken by the robot show individuals of this species in intervals of a number of meters from each other and in view of the "plowing" marks of trawling nets. It may be estimated that their population was far denser in the past. The photographs also show individuals of the species Mediterranean feather star (*Antedon mediterrane*) as they feed from the collection of organic material on the sandy bottom. The sand mounds observed on the seabed seemed to belong to a worm from the Echiura system that belongs to the Bonellia species. Also, observed on the bottom were tube building polychaete worms belonging to the Sabellidae family and in some of the photographs we can only see the case in which they live as it protrudes from the seabed, while in other photographs we see their radioles (the annelids feet) as it is spread and pulled quickly in following the robot's motion. At the B1 station a *Seriola dumerili* type fish was observed, which is an open water species associated with the seabed (Campbell, 1982). The photographs of the habitat may be viewed in a film taken in the course of the survey in the following link:

http://www.youtube.com/watch?v=cni7JhgNkvA

Infauna: in this station many polychaete annelids were found from the Maldanidae, Nephtydae, Magelonidae, etc. families, the most dominant among them belonging to the Spionidae family, which was found in all iterations. The annelids from this family feed on organic particles that have sunk to the bottom (deposit feeders). From among the crustaceans, individuals belonging to the Amphipoda, Tanaidacea, and Copepoda families were observed as well as individuals from the Ostracoda and clayed characterized by two valves (similar to oysters) these stations were characterized by the sparse presence of mollusks, but individuals from the species *Gari fervensis* were observed in two of the sampling stations. Annelids from the Nematoda system were observed at all stations. It should be noted that in station B1 an individual sea spider from the Pantopoda class was observed. Sea spiders are usually associated with algae or other organisms such as hydrates or sponges and they are usually predators.

Figure 1.9-2: The seabed at a depth of 60 meters opposite Hadera

1.9.1.2.2 Description of silty bottom habitat at a depth of 49-60 meters, (points 7-10 in the gas float survey

This is characterized by a sandy bottom (silt + sand). The dominant particle size is in the range of 63-180 microns. The range of depth lies between 49-64 meters. The bottom is relatively flat and characterized by the presence of pits, indentations, and protrusions similar to the environment described in Section 1.9.1.2.1. In this habitat were observed red sea feathers, sea lilies, and polychaete annelids from the Sabellidae family. In addition, a rare observation of a naked sea slug was made (lacking in external shell) of the species *Tethys fimbria*. Such slugs reach a size of up to 30 centimeters and are recognizable by their white body that bears two rows of vermiform appendages along their back (in purple color) and their flat heads that bear lashes on the ventral side. These slugs move along the sandy seabed and feed off small crustaceans (Campbell, 1982).

The infauna: these stations were characterized by the presence of polychaete annelids of the types that were noted in the connecting area, and also individuals from the families: Onuphidae, Capitellidae, Ciratullidae, Sabellidae, Spionidae, and Chaetopteridae. From among the crustaceans individuals of *Tanaissus* sp. were seen in most iterations as well as individuals from the subclass Copepoda that belong to the orders Calanoida and Harpacticoida. Also note the presence of brittle stars Ophiuridae at stations B6, B7, B8, and B10. It should be noted that plastic trash particles were found in one of the iterations of station B7. Station B8 was characterized by the intense presence of organic material visible in samples (plant parts and decayed material), originating it seems from the population of the adjacent rocks as well as the presence of carbon parts that seem to originate from the power station. At this station a relatively high number of Apseudes type crustaceans were found which feed on organic materials found on the seabed.

In general, it seems that the characteristics of the infauna in the sandy bed in the depth range of 49-85 is generally similar (the two habitats described above in Section 1.9.1.2.1/2) and also from the point of view of the groups of organisms detected on the seabed by the photographic survey. It should be emphasized that the survey was only made at a specific point in time and that seasonal sampling would emphasize possible differences between the various depths. From the faunal data within the seabed, it may be noted that at the more shallow stations (B7 and B8) echinoids from the Capitellidae family were observed and that their presence serves as an indication of enrichment with organic material (Pearson and Rosenberg, 1978).

1.9.1.3 Marine mammals

There is at present a lack of information regarding marine mammals in the Eastern Mediterranean Basin as regards the number of species, their frequency, and the patterns of their distribution. Despite the fact that marine mammals are capable of motion and it is known that they swim over great distances, there should be information regarding the populations of the various species that exist along Israel's coast, and this includes the area of the polygon under discussion (some of the species are found in our region permanently). A recently published article provides up-to-date and valuable information regarding the variety of species and locations of observations and summarizes the stranding data and observations of live individuals as collected by the IMMRAC (Israel Marine Mammal Research and Assistance Center) between the years 1993-2009 (Kerem et al., 2012). The data collected indicate the existence of populations of marine mammals from a number of species that are frequently found opposite Israel's coast. The article defines these species as "ordinary": a species that reproduce in the region of the Israeli coast and/or there is a high chance of observing them in Israel's littoral waters on an annual basis. The "ordinary" species include: *Grampus griseus, Tursiops truncatus, Stenella coeruleoalba, Ziphius, Steno bredanensis*, and *Delphinus delphis*. With respect to the latter, it should be noted that medium and large groups of these species were not observed north of the Netanya area. Information collected also indicates the existence of "guests" or "migrating" species, which are defined as those that do not reproduce in the area and are observed within the boundaries of the region at a low frequency. The Common Bottlenose Dolphin (*Tursiops truncatus*) is the most common species found along Israel's coast, with a segmented population. A genetic characterization conducted for individuals from the local population found that it differs from a population of the same species found in the Western Mediterranean (see Kerem et al., 2012). Figure 1.9-3 clearly shows that in the area extending from Netanya to Dor the following species of marine mammals were observed: *Delphinus delphis, Grampus griseus, Stenella coeruleoalba, Tursiops truncatus,* and *Physeter macrocephalus* which is a "guest" species.

Figure 1.9-3: Areas in which various species of marine mammals were observed (apart from the common species *Tursiops truncatus*) along Israel's contiguous coastal waters (up to a distance of 50 kilometers from the coast)[8]

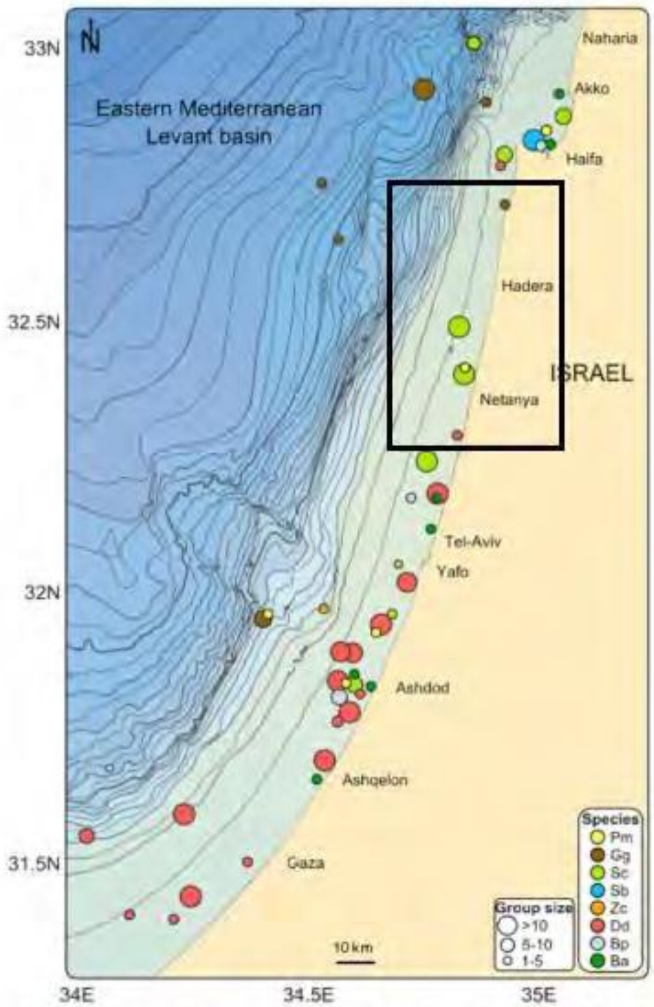


Fig. (7). Sighting sites of identified cetacean groups within Israeli coastal waters (out to 50 km), 1993-2009. Isobaths are 50m apart. Bathymetric map origin is: Hall, J.K. 1994. Bathymetric chart of the Eastern Mediterranean Sea, in: V.A. Krasheninnikov, J.K. Hall, (Eds). Geologic structure of the northeastern Mediterranean (cruise 5 of the Akademic Nikolaj Strakhov), Geological Survey of Israel, Marine Geology, Mapping & Tectonics Division, Jerusalem. Pm-*Physeter macrocephalus*, Gg-*Grampus griseus*, Sc-*Stenella coeruleoalba*, Sb-*Steno bredanensis*, Zc-*Ziphius cavirostris*, Dd-*Delphinus delphis*, Bp-*Balaenoptera physalus*, Ba-*Balaenoptera acutorostrata*.

[8] Between the years 1993-2009 (Kerem et al., 2012). The polygon area, Hadera-Havatzelet HaSharon-Netanya is marked within a black rectangle.

1.9.2 Information on Underwater Kurkar Ranges

As mentioned in Section 1.9.1, information regarding the underwater kurkar ranges outside the boundaries of the polygon intended for construction of a gas treatment platform is very important, mainly because of the need to pass pipes from the discoveries area to the platform and from the platform to the coastal receiving station. The sections below present information regarding kurkar ranges located to the west and to the east of the polygon. It should be emphasized that the information presented here is partial and that a comprehensive survey is required in order to identify all of the points in which exposed kurkar ranges are located.

*Note: In Sections 1.9.2.1-5 the concepts "west" and "east" refer to the polygon (which is intended for the location of the platform) as a reference axis.

1.9.2.1 Deep west range opposite Dor

This range was surveyed in a sailing expedition conducted by the Nature and Parks Authority in October 2009 (Engert and Yahel, 2011). The range is located at a depth of about 100-110 meters, part of it covered with silty soil and part of it exposed and protruding from the seabed (see Appendix C of the "Carmel continental shelf" region). The range seems to have been created about 8,000-16,000 years ago and is composed of the skeletons of foraminifera, bivalvia and various snails that have undergone a process of fossilization and have created rigid bedding. The exposed parts of this range constitute the base of a population of a variety of sessile invertebrates such as sponges, worms and coral as well as the habitat for an additional variety of invertebrates and fish (Engert and Yahel, 2011). In the course of the survey along the ridge area various sponges from the species *Axinella verrucosa* and *Axinella polypoides* were observed as well as a white lumpy sponge. Also observed were a variety of fish, schools of fish feeding on *Antias*-type plankton and additional fish such as *Apogon, Gobby*, *Caranx* species, *Dentex macrophthalmus* (Yahel, unpublished information).

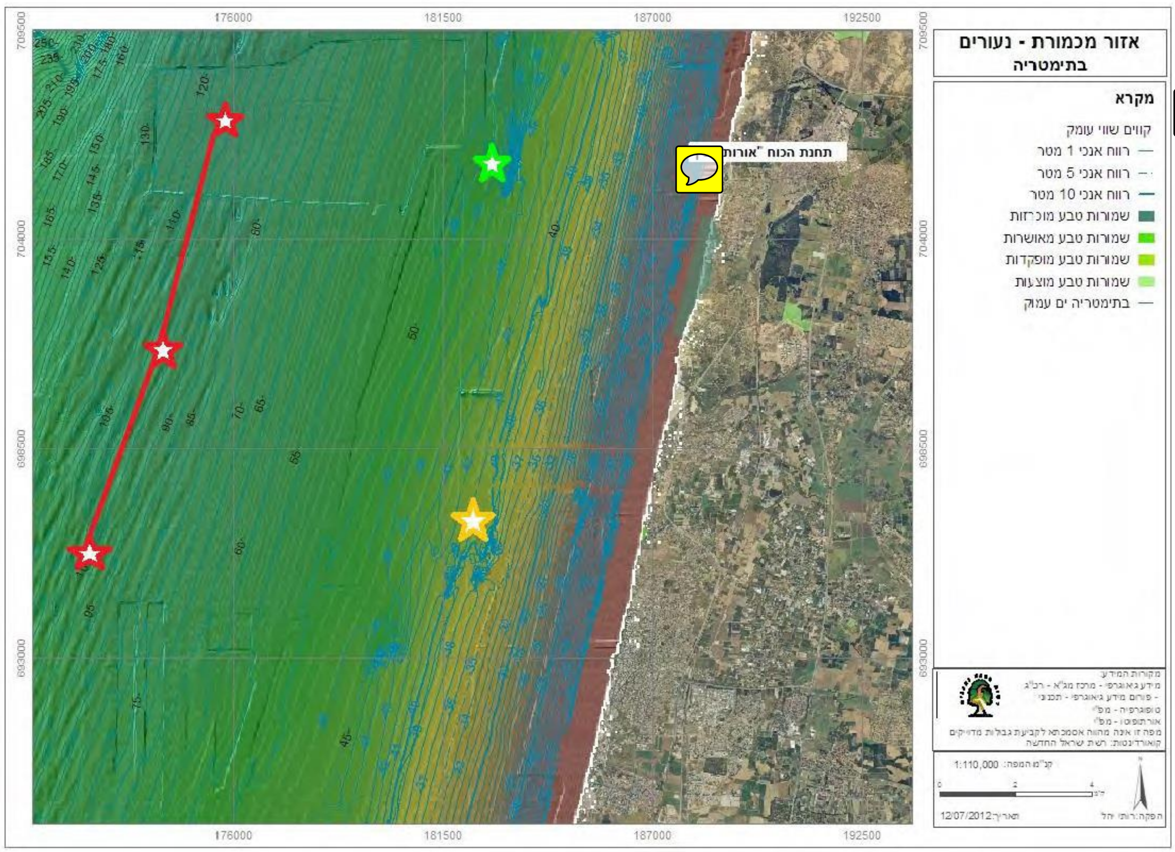
It should be emphasized that the same survey also surveyed the area stretching out from the upper boundary of the continental shelf down to a depth of about 1,000 meters (the border of Israel's territorial waters) and it was found that this is a steep incline characterized by many channels and canyons, the most significant of which is the Dor slumping. This slumping reflects the instability of the upper rock column close to the seabed, which causes the motion of sediments that slide towards the base of the slope. Since the sediments are saturated with water, once the slope angle increases to 2-4 degrees there is an inclination towards instability. Close to this slumping we find the extension of the Carmel fault which is an active seismic area. In the course of the survey a new fault was observed that was not covered with young sediments and possibly constitutes evidence of current motion in this area (Engert and Yahel, 2011). These findings raise questions regarding the region's suitability for laying a gas pipeline from the discoveries area towards the shore. The following is a quote of a paragraph taken from the document prepared by the Nature and Parks Authority (Engert and Yahel, 2011): "The findings reinforce the need to declare a large marine nature reserve within the survey area that will provide special protection for sensitive habitats present in the area and the geological phenomena discovered within it that were not known within this region. This is particularly appropriate in view of the underwater infrastructure works carried out to connect the Tamar and Dalit gas drilling sites located at a distance of about 100 kilometers from Israel's coast and which are planned to be connected in future to a national network by means of a pipeline system that will pass through the surveyed area."

In view of the above, it is preferable to shift the pipeline alignment southwards from the Dor slumping region and try to find a corridor with relative stability that may be used to convey the pipeline from the base of the continental shelf to its upper part.

1.9.2.2 Deep west ridge opposite Kibbutz Sdot Yam (depth 90-125 meters)

The kurkar range opposite Kibbutz Sdot Yam has a unique structural complexity distinguishing it from kurkar ranges submerged to the east of it. This range is exposed along an impressive range of depths that shifts from a depth of 92 meters to a depth of 125 meters along the west side (Tzadok, unpublished information). The width of the range area is a slightly more than 2,000 meters and its western slope is mostly exposed. The upper region of the range has a slope of 0.8-1.2% while its west side is characterized by a steeper gradient than 3-3.5%. The range is rich with slopes deep crevices, niches, and high protrusions. The west "wall" is particularly developed in all that regards the variety and richness of species and during the survey and in past observations (the years 2007-2009) these areas were observed to be rich in young fisheries. It is possible that this area has a crucial importance as a fostering area for a large variety of species. The seabed is mostly rocky with area of sand "pools." The sandy regions contain a mix of Nilotic sand, skeleton shards of marine organisms, organic material that sinks from the body of water and mechanical and biological erosion matter from the rock itself. In the rocky area the remains of fishing lines (long line/trawl line fishing method) as well as plastic trash were observed. The particle size of these sand "pools" is relatively large and has a typical widespread size distribution spread typical of areas that are adjacent to rocks (125-500 microns, with a collection of larger particles). The rock parts are loaded with organisms that utilize any vacant area for settlement, a considerable part of them in symbiosis between various species. Among the organisms observed were various types of sponges, corals, sea urchins, polychaete annelids, starfish, hydrates, moss animals, cuttlefish clutches and various other species of fish (Tzadok, unpublished information).

Figure 1.9-4: Bathymetric map of the Michmoret-Neurim region (received from the Nature and Parks Authority)*[9]



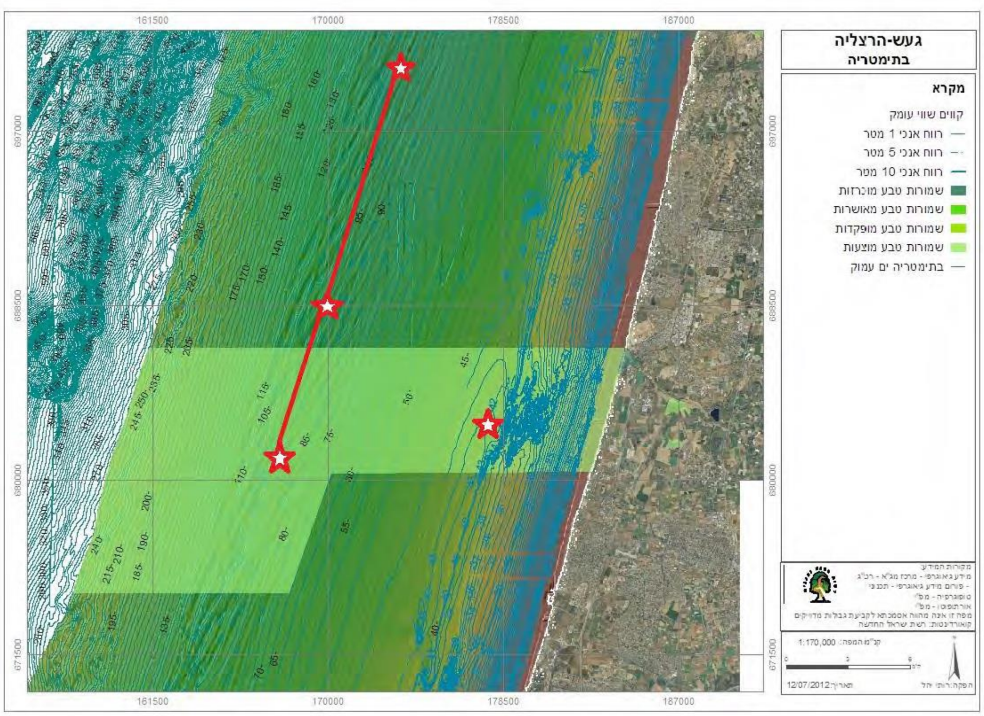
1.9.2.3 Deep west ridge facing Ga'ash/Herzliya

The ridge is located about 10 nautical miles west of the Ga'ash shore at a depth ranging between 90 and 125 meters (see Appendix C "deep kurkar ridge of the Sharon") and was surveyed in the course of a sailing expedition by the Nature and Parks Authority that took place in September 2010 (Yahel, unpublished information). The rocky sub-base is

[9] In the northern part a deep underwater kurkar range (90-120 meters) may be observed lying continuously opposite the shore (marked with red stars) and continuing on to the north. Opposite the Orot Rabin power station there is a range at a depth of 37-45 meters (marked with a green star) that was surveyed as part of the Environmental Impact Survey of the LNG float project. To the south of Michmoret there is a 40 meter deep underwater range that was partially surveyed by Gal Ayal (marked with an orange star).

comprised of porous kurkar rock, non-uniform, and lumpy. The rocky infauna comprises sessile invertebrates such as moss animals, hydrates, and sponges. These invertebrates constitute the basis of a population that undoubtedly includes symbiotic relationships between various fauna and create a high level of structural complexity (Yahel, unpublished information). The great variety of fauna dictates the existence of a complex food web as compared with the populations of the soft seabed. In addition, the rigid bed also serves as a reproduction and fostering site for the young levels of fish and vagile invertebrates (Yahel, unpublished information). Following the survey, a number of sponge species sampled in its course were defined and it was found that some of these species were known to be distributed in the Western Mediterranean and to a lesser extent in the Eastern Mediterranean. Today we hardly find them in our area because of intensive trawling fishing operations (Yahel, verbally). It appears that the kurkar range serves as a refuge for these species of sponges and it seems also for other species (Yahel, verbally). In the course of the survey, evidence was found of trawl fishing in the area. Along the slope of the ridge (facing west) a silty bed was observed with islands of harder material and in addition to sponges, worms and soft coral (still unidentified) additional organisms were observed of the type that characterizes soft beds such as sea feathers, sea urchins of the (Cidaris type) and a number of types of fish (Yahel, unpublished information).

Figure 1.9-5: Bathymetric map of the sea area opposite Ga'ash-Herzliya (received from the Nature and Parks Authority)



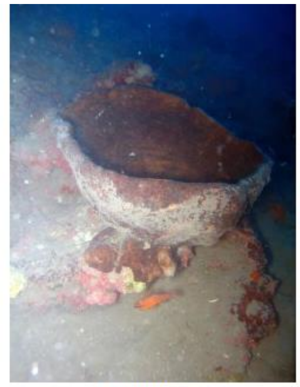
1.9.2.4 The East Ridge opposite the Orot Rabin power station

This kurkar ridge (Figure 1.9-4) is part of the kurkar ridge that runs parallel to the shore and which is typical for such depth (25-40 meters). This ridge was studied in a survey conducted for an environmental survey of the gas float (environmental document NOP 37A/6/2, 2011). The length of the exposed area within the survey region was about 1,600 meters (south-north) and its width up to 200 meters (west-east). This ridge is a rocky terrain with high structural complexity, the base of the east side of the ridge begins from a sandy bed at a depth of 42-43 meters and rises at its center up to a height of 38-39 meters. Its west slope is the longer one and the rock ends with a sand cover at a depth of 46-47 meters. Along the east and west slopes there are gradients of 6-9%. Within the ridge areas there are many "sand pools" especially along the west slope. These sand pools comprise a mixture of Nilotic sand, skeletal fragments of marine organisms, organic materials that sink from the body of the water, and mechanical and biological erosion material from the rock itself. The distribution of particle size is narrow relative to the rocky area and lies in the range of >125 to >250 in over 70% of the sampling. The rock is characterized by many protrusions, not particularly large (presented in the link attached to the clip above) and no deep ravines or sharp topographical structures were observed. The kurkar ridge within the survey area constitutes a unique habitat in the sandy environment that surrounds it. The presence of the rigid bed creates a complex and stable spatial structure that constitutes an infrastructure for a wide variety of organisms and algae as described below. The kurkar rock is entirely covered with a biotic coverage that is mainly comprised of such algae as the *Caulerpa scalpelliformis* with its green and serrated leaves, the *Peyssonnelia squamarina* with its wide leaves and such calcareous algae as the *Lythophylum*, which creates a calcareous skeleton (the skeletons of these algae contribute also to the composition of the sand). It should be noted that the presence of algae is seasonal and therefore different species may be found in different seasons. The algae in themselves constitute a rich habitat and serve as "foster homes" for the young stages of various invertebrates such as mollusks and crustaceans. The larval stages find refuge from predation and food sources among the branches of the algae. In addition, the leaves of the algae serve as the habitat of sessile polychaete annelids such as the *Spirorbis*. Beside sessile algae, there are also many Hydrozoa colonies on the kurkar which are characterized by featherlike branches. We can discern the colony coral *Madracis pharensis* and the details of the solitaire coral *Phyllangia*, which are two species commonly found in deep water. In addition, a number of representatives of the sponge phylum were observed, such as the two species *Axinella (polypoides and verrucosa), Ircinia sp., Oscarella lobularis, Petrosia ficiformis, Chondrosia reniformis,* and the drilling sponge *Cliona*. It should be noted that Axinella type sponges are very prominent in their presence thanks to their strong orange color and the presence of invertebrates that live in symbiosis with them: a type of sea cucumber that is frequently observed between its branches (*Synaptula sp*.) a species of slug that feeds off its tissue (*Phyllidia flava*) as well as an tunicate connected with a connecting membrane to the branches of a sponge. From the Mollusca phylum the survey observed individuals of the *Charonia nodifera* and *Cerithium* species as well as an *Octopus vulgaris*. From the Bryozoa phylum the survey observed a number of branching species *Myriopora truncata, Margaretta cereoides* and *Bugula neritina* and from the Ascidiacea class, a type of the *Didemnum* was observed as well as a number of unidentified solitary individuals. In the course of the survey various osteichthyes were observed, including a school of *Chromis chromis* fish that were observed over the rocky region, as well as fish from the Blennioidea and the perciformes and snappers and three species from the perciformes family. In addition to the fauna described above there are also organisms with habitats within the rock itself and these usually include Sipuncula annelids, drilling bivalvia such as *Lithophaga* and *Petricola*, percussive crabs of the *Alpheus* type, and various species of polychaete annelids and snails. Figure 1.9-6 presents images of fauna that represent the ridge area.

Figure 1.9-6: Representative invertebrates from the kurkar ridge at a depth of 37-45 meters opposite the Orot Rabin power station (Document NOP 37A/2/6

(photographs: Yaniv Aluma and Gal Ayal))

Crambe crambe



Petrosia sp.

Chondrosia reniformis

Axinella verrucosa

Caulerpa scalpelliformis
אצה ירוקית

Synaptula sp.
מלפפון ים

Serpula sp. תולעת רב-זיפית

Centrostephanus longispinus
קיפוד ים

1.9.2.5 The east ridge facing Michmoret-Beit Yanai

Opposite the localities of Michmoret and Beit Yanai there are a number of underwater ridge areas in between the depth of 26-40 meters (see Figure 1.9-7 and Table 1.9-2 Ayal, unpublished information). In this area a number of dives were carried out and a rich habitat was documented in photographs, some of which have been presented below in Figure 9. These images lead to the conclusion that the rock area serves as a habitat for a large variety of sessile invertebrates such as sponges, octopi, squids, crustaceans, and various echinoderm pyuridae, hydrates, corals, annelids, moss animals, and bivalvia as well as vagile invertebrates such as snails, octopi, squids, crustaceans and various echinoderm (sea urchins, starfish). In addition we see different types of fish in the pictures such as a *Sargocentron rubrum*, *Diplodus vulgaris*, and a white grouper. In order to receive more precise information regarding the location of additional ridges and the extent of their exposure, additional surveys will have to be conducted.

Figure 1.9-7: Diving points where preliminary information was collected regarding rock areas opposite Michmoret and Beit Yanai (Ayal, unpublished information)

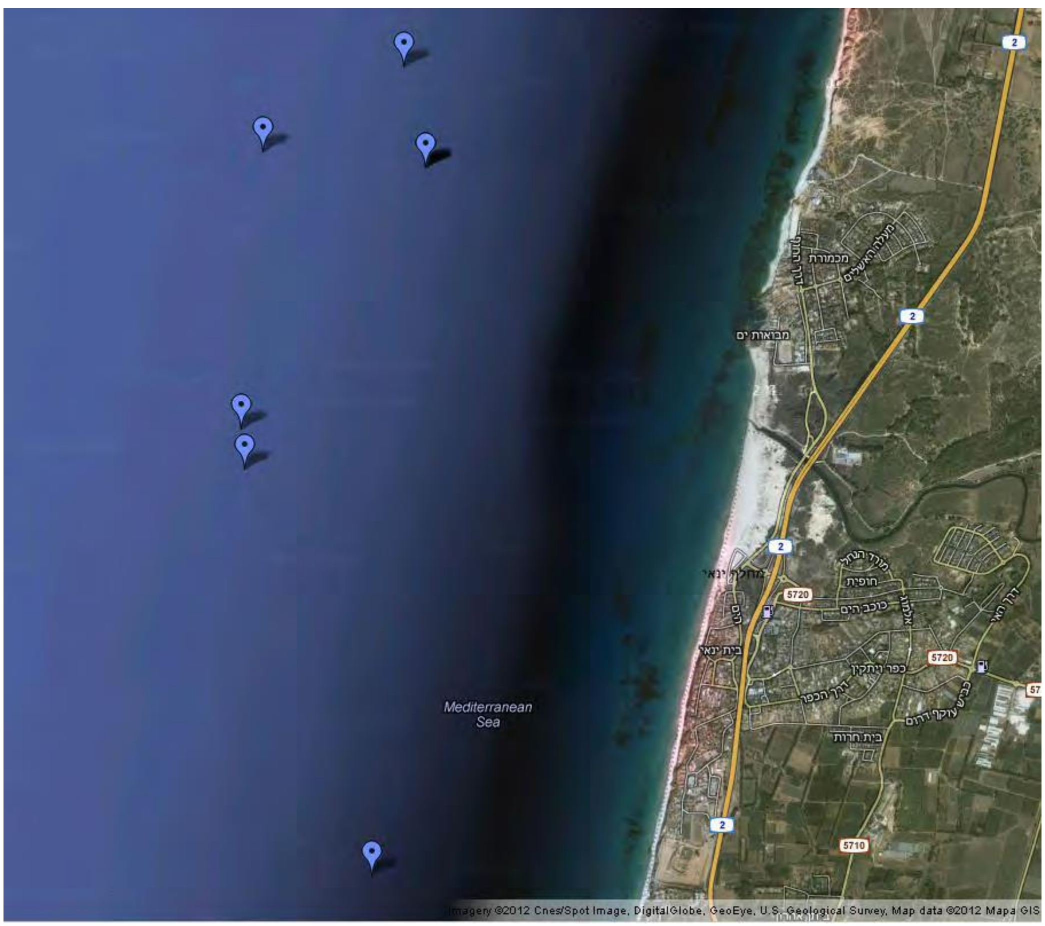


Table 1.9-2: Location and depth of rocky ridges opposite Michmoret and Beit Yanai (information received from Gal Ayal)

Point number	Location	Depth in meters
1	32.39310°N 034.82780°E	39
2	32.39310°N 034.82780°E	36
3	32.41849°N 034.83968°E	33
4	32.41317°N 034.82917°E	40
5	32.41215°N 034.84137°E	31
6	32.36733°N 034.83733°E	26

Figure 1.9-8: Representative fauna from the kurkar range at a depth of 26-40 meters opposite Michmoret-Beit Yanai (photographs: Gal Ayal)

 *Axinella* type sponge and a starfish	 Slug on a solitary tunicate
 Slug in the vicinity of the orange sponge. The dense coverage of algae and hydrates is also visible.	 Stony coral of the type *Phyllangia*
 Fish from the Serranidae family hiding beneath the rocky bed.	 A sessile polychaete annelid from the Sabellidae family

1.9.2.6 Pipeline corridors from the area of the offshore sites in the direction of the shore

The pipeline corridors to the east of the offshore sites include short corridors that extend from the platform sites and hook up to a longitudinal corridor that is flush (on the west side) with existing gas pipeline that is deployed from Ashkelon to Dor. The short corridors mostly traverse sandy areas except for the corridor that extends from the Netanya side that can be seen to pass a region in which there is a rocky bed. Along the longitudinal corridor described above there are a number of problematic areas as detailed below:

1. In the region that is opposite Netanya there is a structure of a small kurkar ridge within the corridor.
2. Opposite Hadera the pipeline alignment passes over a known and acknowledged kurkar ridge that has been surveyed as part of the environmental document prepared for the LNG float (see Section 1.9.2.4). It should be emphasized that in view of the information received from the environmental survey conducted in the context of the LNG float project the alignment of the pipe has been deflected in order to prevent damage to this rocky habitat.
3. Slightly to the north of Ma'agan Michael a small kurkar ridge structure can be seen within the corridor.

In view of the presence of kurkar ridges within the alignment of the east corridors, some of which have already been surveyed, it is recommended to consider shifting the alignment in problematic locations during execution in light of the existing information (for example, the information derived from the LNG float survey) and additional information that may be received from future field surveys in the context of this plan.

1.9.3 Marine pipeline alignment at the entry to the coast

The onshore part of the coastal entry systems were surveyed as part of the environmental impact survey for the onshore environment. In this document the marine pipeline of the systems entering the shore has been surveyed. The area considered for each alternative has been approximately one kilometer to the west of the shoreline: the entry point of the pipeline at HDD in the direction of the shore is located at about 900 meters to the west of the coast and the breakout of the pipeline onshore (the area where the block and valve is located) which is located 0.5-1 kilometers east of the coastline.

1.9.3.1 The Dor alternative

This alternative site is located within an existing marine corridor in accordance with an approved NOP. Adjacent to it there is already a gas pipeline landing that leads to the Hagit site. The site of the alternative is located at about one kilometer to the south of the Dor

Beach Islands area and the HDD exit point is located at about 0.5 kilometers to the north of the Dalia river mouth. It should be noted that in the segment under consideration there are no abrasion platforms structures that encircle the coastal strip.

1.9.3.1.1 Habitats

Common in the sandy shore area bordering the sea are invertebrates such as the *Ocypoda cursor* beach crab and small crabs such as the *Gastrosaccus mediterraneus* and the *Talitrus saltator*.

Note that the sandy beach area serves as the sight of sea turtle layings. In Figure 1.9.3.3.3.2-2 a map documents the location of natural nests of sea turtles along the Israeli coastline between the years 1993-2008. According to the map, we see that along the shore area to the south of Dor only a medium number of layings has been documented (40-80). It is important to note that in the vicinity of the Dalia River mouth a sea turtle egg incubation farm has been established and that the turtle nests are transferred to that spot whenever there is concern for their safety.

1.9.3.1.2 Nature reserves

The coastal segment from the "tank hill" of Dor and up to the Nachal Taninim along a beach strip of seven kilometers has been allocated in NOP 13 for a beach reserve with a variable width of 100-200 meters. District Outline Plan No. 6 establishes this strip of coast as a protected beach. To the rear, NOP 13 has allocated fish pools for agricultural use. Planning is coordinated along the boundaries and essentially between an expansion plan for the kibbutz and a plan for a nature reserve in accordance to which a beach strip covering an area of about 644 dunams, between the Dalia River and the Nachal Taninim, will be allocated for a nature reserve.

The Dalia River mouth area is also designated as a nature reserve. The Nature and Parks Authority is promoting detailed plan number HK/415/T for a nature reserve at the Dalia River mouth.

1.9.3.2 The Hadera alternative

The area designated for the Hadera alternative is located in the vicinity of the Hadera River mouth and to the south of it in proximity to an existing pipeline (to the Hadera Paper Mill). The river is contaminated with wastewater and there are plans for its rehabilitation. The river mouth region is located in proximity to the cooling water outlet of the Orot Rabin power station. Outlets of the IEC, located about 50 meters northward of the mouth discharge cooling waters at temperatures that are higher than that of the seawater at a throughput of 320,000 cubic meters per hour into the sea and there is also a small outlet that discharges cooling water to the river itself at a throughput of 16,000 cubic meters per hour (Glazer, verbally). The outlets area is a region where strong water flow conditions lead to changes in environmental conditions. In addition to the high temperature of the discharged water, over the last two years the brines produced by the desalination plant located within the premises of the power station have also been discharged into the sea. According to IEC data based on a biannual monitoring of the environment (Glazer, 2012) it is known that the warm water plume moves southward under the influence of the outlet flows. During the two sampling seasons of the year 2011, the highest water temperature was measured at the sampling point located about 600 meters south of the outlets and 120 meters from the beach. The temperature differences measured between the inlet water pumped into the station and the outlet water was 5.33 degrees Celsius in spring and 5.19 degrees centigrade in autumn.

An analysis of the infaunal data (collected in the context of the power station monitoring program in 2011) at the sampling points adjacent to the outlets established that these are points where the infaunal populations were exceedingly sparse (Glazer, 2012). This phenomenon indicates disturbed conditions in the region of the outlets and may be ascribed to the strong outlet currents that contribute to instability of the seabed and the removal of fine sand and the accumulation of bivalvia and stones. At these points the temperatures and the solidity values were also high.

1.9.3.2.1 Habitats

The biota in the region located to the south of the Orot Rabin power station water outlets was investigated in the context of a comparative study that was intended to document the sedimentalogical and littoral changes surrounding the power station and their impact on the marine biota (Sivan and Shpanyer, 2004). The relevant sampling points for the Hadera alternative area are two points at a depth of five meters and seven meters. In both points the seabed was rocky and the biota documented on top of it as detailed in Table 1.9.1.2.5 are worthy of note. It should be noted that this study found that the number of invertebrates and fish at the sites that are subject to the influence of the warm water plume flowing from the power station was higher than in the control site located to the north of the power station (Sivan and Shpanyer, 2004). A similar result was also obtained for the biota on the seabed as received through the monitoring of the Orot Rabin power station during the year 2011 (Glazer, 2012).

Table 1.9.3.2.1: List of organisms and algae present at two sampling points to the south of the Orot Rabin power station as surveyed between 2001-2003 (Sivan and Shpanyer, 2004)

Phylum	Biota
Bryozoa	*Bugula* sp., *Watersipora* sp.
Porifera	*Chondrilla* sp., *Geodia* sp., *Ircinia sp., Spirastrella* sp.
Cnidaria	*Oculina patagonica, Penaria* sp., *Aglaophenia pluma*
Annelida	*Eurythoe complanata, Dasychone lucullana,*
Mollusca	*Octopus vulgaris, Ostreoidae, Conomurex persicus, Spondilus* sp., *Malleus* sp., *Hypselodoris elegance*
Arthropoda	*Charybdis longicollis, Atergatis roseus, Balanoeidea, Paguridea*
Chordata	*Didemnum* sp., *Herdmania* sp., *Phallusia nigra*
Echinodermata	*Holothuria forskally*
Fish	*Diplodus vulgaris, Thalassoma pavo, Coris julis, Sargocentron rubrum, Epinephleus alexndrinus*
Algae	*Jania* sp.

1.9.3.2.2 Reproduction area of two types of Serranidae subfamily of Epinephelinae

In Aharonov's master's thesis (2002) three types of Serranidae found along Israel's coast were investigated at three different sites along the Mediterranean coastline. One of the sites where observations were made is located opposite the fishing marina of Givat Olga at a distance of 0.7-0.9 kilometers from the shore at a depth of 8-15 meters. At this site reproduction groupings of the *Mycteroperca rubra* species were observed during the period from mid-April to mid-May. A maximum of 500 individuals were observed in the region. In the estimation of the investigator during the period between mid-January to the beginning of June Mycteroperca rubra group in fixed sites characterized by a complex and unique topography such as caves and niches with a flatbed (sandy or rocky) drain.

Additional reproduction groupings of the *Epinephelus marginatus* species were observed on the same site from the end of April to the beginning of June. The maximum number of individuals was lower than that of the *Mycteroperca rubra* and was about 30 individuals (Aharonov, 2002).

The observation site of the reproduction groupings is located between the alternatives of Hadera and Michmoret and at a distance from the coast where the pipeline is planned to exit after the push with HDD (from the shore in the direction of the sea). At the present stage it is not known if similar reproductive groupings are found in additional adjacent sites, but such a possibility cannot be negated. When the precise location of the pipe inlet/outlet is known further observations should be conducted at relevant sites in order to prevent the possibility that the reproduction groupings of the two types of Serranidae should be damaged or alternatively if things should be timed in such a way that will not disrupt the reproduction groupings. Damage to reproduction groupings as a consequence of fishing, for example, is known to damage the population and its ability to recruit new individuals (see Aharonov, 2002).

1.9.3.3 The Michmoret and Nachal Alexander alternatives

Because of the proximity of the sites, the survey of the separating area characteristics and habitats (Sections 1.9.3.3.1/2) for the two sites is presented together.

1.9.3.3.1 Characteristics of the sea-shore separating area

A description of the coastal formations at Michmoret has been taken from a biological document describing the Yam-Michmoret reserve that was prepared for the Nature and Parks Authority (Ben-David Zaslow, 2005). The coastal formations within the Michmoret area are many and varied and include sandy areas protrusions of kurkar that are separated one from the other, ridges of flat large platforms, and flat rock heads that have been shaped by wind activity drawn from ridges that run parallel to the coastline (Emery & Neev, 1960). The sandy region constitutes a narrow strip about 10 meters wide that separates between the kurkar ridges and the protrusions scattered throughout the area. There are regions in which the rock heads create a kind of small baylets usually as wide as about 20 meters that simulate pools and along the walls of which one finds narrow and shaded cracks. There are areas with a deep region that faces the sea and a more moderate region that faces the shore and is covered by small kurkar hills. Subsequently, in the direction of the sea at a distance of about 30 meters from the coast, there are horizontal and semi-horizontal shelves whose upper parts are usually immersed in water except at times of extreme low tide. These rock tables can become detached from the shore and constitute a structure of an encircling surface. At a distance of 40 meters from the coast there is a narrow region that emulates a reef. On the proximate side of the coast it descends and reaches right under the surface of the sea creating a shallow area with small and deep pools. In the area facing the sea the surface descends sharply to a depth of one meter and continues from there on in a non-uniform surface of rock, up to a distance of about 200 meters from the coastline and a depth of about four meters, where in this region the rock is replaced by sand (Ben-David

Zaslow, 2005). The range of formations that have been described above that comprise sandy areas and rocky areas in a variety of orientations and different affinities to the water (areas exposed to wind and wave spray/infralittoral, areas covered and exposed alternatively/midlittoral, and areas always covered with water/superlittoral) support a wide variety of organisms in different ecological niches.

1.9.3.3.2 Description of habitats

The description of the habitats in the region is mostly derived from the biological document describing the Yam-Michmoret reserve prepared for the Nature and Parks Authority (Ben-David Zaslow, 2005). The habitats are described in accordance with their distribution along various littoral zones (areas that are located along a vertical gradient and are distinguished from each other by the conditions of exposure and immersion in water) and refer to a hard-kurkar base.

Superlittoral fringe area – this area is never covered by the tide, but is frequently washed by waves and is exposed to spray. The upper boundary is in the range of 60-280 centimeters in accordance with the fluctuations of exposure to wave activity. Prominent organisms are green endolithic algae, types of snails from the Littorinidae family and the isopod Ligia italica. There are two types of periwinkles (*Littorina punctata, L. neritoides*) that distribute the superlittoral area among them and feed off of the endolithic algae. The latter create a thin green layer about one millimeter below the surface of the rock.

The bottom third of the superlittoral area constitutes a separate layer whose boundaries are sometimes difficult to define. It is characterized by the settlement of sea barnacles mostly from the species *Chthamalus depressus*, and in a minor way along the upper part of this zone from the species *C. stellatus*. Among the hidden areas where the breaking of the waves is forceful we can also find the species *Balanus Amphitrite*. Additional prominent species that populate this area are the *Pachygrapsus spp* crab and the *Monodanta turbinata* snail.

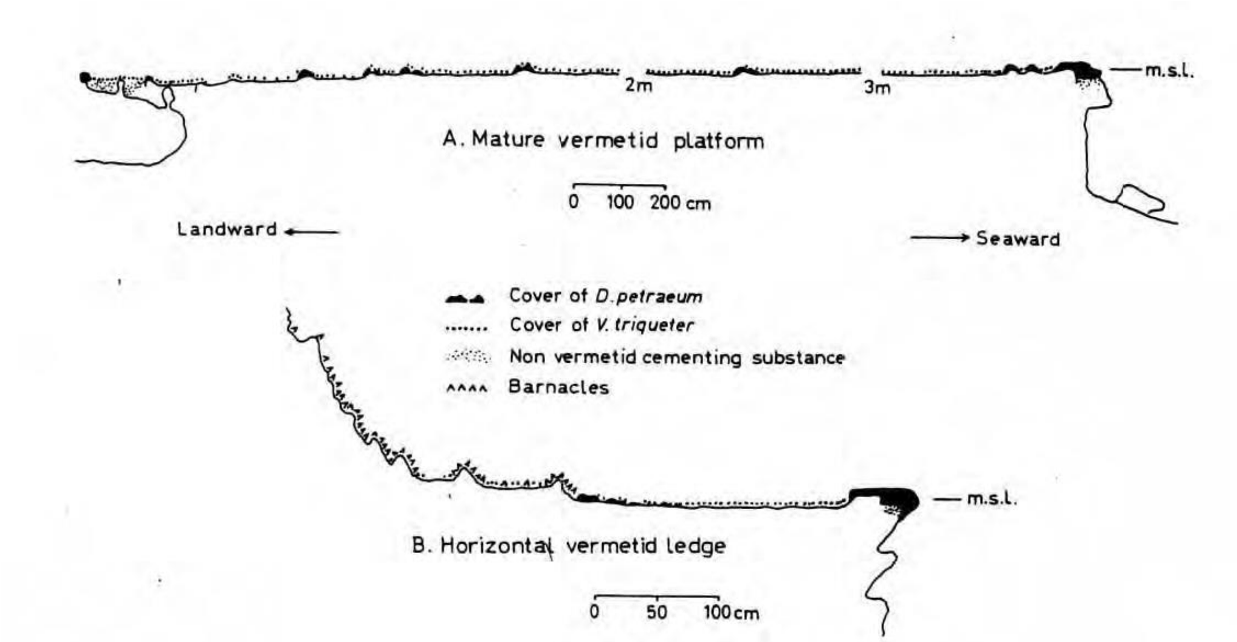
Midlittoral zone – the midlittoral zone is usually covered by sessile organisms: barnacles in the upper midlittoral zone, barnacles and algae in the mid-midlittoral zone, and algae and snails from the Vermetidae family in the lower midlittoral zone. We also find various types of Arthropoda and fast moving crabs (Figure 1.9.3.3.2).

Figure No. 1.9.3.3.2 below presents a Vermetidae reef at Michmoret:

A. A detailed section describing the structure of the reef platform, organic covering, and distribution of the Vermetidae species.

B. A section of the exposed rock face surrounded at the boundary of the Vermetidae at the midlittoral zone. This section represents the initial condition of the reef platform. The barcacles are exchanged by *Dendropoma* at the point where the rock becomes horizontal. m.s.l. represents mean sea level (Safriel, 1966).

Figure 1.9.3.2.1: Vermetidae reef in Michmoret (Safriel, 1966)



Upper midlittoral zone – this area may be covered by the tide, but is usually only washed by waves. Its upper boundary is in the range of 10-80 centimeters in accordance with the intensity of exposure to wave action. It is mostly covered by the barnacle *C. stellatus* and various species of endolithic algae. In its upper part that abuts the superlittoral zone we can find the species *C. depressus* and *B. amphitrite*. Along its lower area, in shaded regions we find the algae *Gelidiella tenuissima*. During the winter the algae *Nemalion helminthoides* appears in large quantities and covers the lower part of the barnacles belt, thereby creating a narrow subzone.

Periwinkles from the edges of the superlittoral zone also populate the barnacles strip, but they avoid exposed vertical surfaces. The density of *L. punctata* is higher along the upper region of the zone, while the number of the two species gradually decreases along its lower part. In the past it was possible to find within the barnacles zone a type of bivalvia species, *Mytilaster minimus*, as well, usually in its lower area, but today the more common is an immigrant bivalvia (from the Red Sea) (Galil and Zenetos, 2002) that belongs to the same family and is known by the name *Brachidontes pharaonis*.

Mid midlittoral zone – in this zone the high and low tides have an important role in shaping the faunal population. The upper limit of this zone is in the range of 5-65 centimeters, and is also dependent on the extent of exposure to wave action. The barnacle population *C. stellatus*, despite the fact that it still appears, is usually overrun by algae, but individuals do manage to survive under the cover of the algae. In the semi-horizontal areas the coverage of the surface by algae is divided in the following way: in the open area we have *Alsidium helminthochorton*, in the shaded area we have *Spyridia filamentosa*, and in the very shady areas we have *Sphacelaria tribuloides*. Overrun groups of the snail *Vermetus triqueter* may appear in the lower part of the zone and in the winter the brown algae *Scytosiphon lomentaria* appears in the upper part of the zone.

In the horizontal areas there is a considerable coverage of green algae: *Ulva lactuca, Enteromorpha compressa*, and *Cladophora* sp., as well as individuals of the red algae *Neogoniolithon notarisi*. Indentations in small basins, exposed in this zone as well as vertical surfaces in this zone are populated by a small number of individual *V. triqueter*. In the past individuals of the snail species *Dendropoma (novastoa) petraeum* snail were also observed, but in recent years almost no individuals of this species have been seen.

Lower midlittoral zone – in most sites the lower midlittoral zone is immersed daily by the tide. This region is characterized by the presence of the *V. triqueter* snail. In summer it is covered by the *Jania rubens* epiphytic red algae. Distribution of the typical populations is determined by the extent of exposure to wave action. In protected sites that are relatively shaded there are solitary species without a rigid carapace of annelids, crustaceans, red algae, moss animals, and tunicates. In sites that are exposed partially there are a few individuals of the *Vermetus* species, and a considerable population of algae, mostly *S. filamentosa*. Where the exposure increases, the density of the *Vermetus* also increases, and the dominant algae become the *Laurencia papillosa*.

The surface of the erosion platforms is bisected by ridges and their upper area is usually covered by *V. triqueter* and *D. petraeum*, most of them dead under the cover of algae. The ridges close around shallow basins about 7-10 centimeters deep that are never exposed to the air, but are nevertheless exposed to extreme changes in weather conditions, especially when the tide is out and there are no waves. On the abrasion platforms there are bivalvia from the Mytilidae family *Brachidontes pharaonis*, and *M. barbatus*. The crab *Eriphia verrucosa* populates holes mostly in basins within the platforms as well as additional mollusks species that are not found in the midlittoral area, but only in the infralittoral area.

The midlittoral area is characterized by rich fauna that inhabits the algae concealment places within the rock, under the cover of the algae or on top of other sessile organisms. This includes all of the species that populate algae in the midlittoral zone, but also in other zones. Tiny cracks are populated by endolithic species, some of which are true burrowing species that lives within the rock. The endolithic fauna is mainly found in the abrasion platforms.

Infralittoral fringe zone – This area is only rarely exposed and even then only for a very brief periods of time. Its upper boundary is in the range of 15-20 centimeters. Its lower boundary, which in fact constitutes the lower boundary of the entire littoral zone, has not been established precisely, but is in the range of 30-40 centimeters. In horizontal areas that are not particularly exposed, the infralittoral fringe zone is clear thanks to the dense coverage of algae populations organized in a kind of layering. The bottom part is comprised of calcareous algae that together with annelids from the Serpullidae family create a rigid coat about five centimeters thick, of which only the upper layer of about one centimeter is alive. This coat constitutes the settlement basis for other populations in the area. There are various species of algae that settle on this coat and other species on top of them. The composition of the population changes seasonally and in accordance with the contours of the terrain. In this area we also commonly finds the *Clibanarius erythropus* crab and the *Zoobotryon verticillatum* moss animal that sometimes appears in huge colonies. Scattered throughout the area are also individuals of such sessile fauna as the sea *Anemonia sulcata*, a colony of hydrates and the annelid *Dasychona cingulata*.

1.9.3.3.2.1 Abrasion platforms

The unique characteristic of the Michmoret-Nachal Alexander coastal area is presence of reefs comprised of sessile snails of the Vermetidae family, which are the southernmost along the Israeli coast and one of the very last sites along the Israeli coastline where such reefs have remained in their full integrity (Ben-David Zaslow, 2005). Abrasion platforms are kurkar structures that have been subject to physical erosion as a result of the action of the waves and the wind on the one hand and the biogenic construction of a sessile snail known as the *Dendropoma petraeum* (Safriel, 1966). The snails sit along the edges of the abrasion platforms and clusters of their rigid shells create a kind of raised edge known as a rim. These platforms constitute one of the main structural elements of the Israeli rocky shore (Rilov et at., 1996).

The two species of snails that contribute to the construction of the rims in the abrasion platforms are endemic species to the Mediterranean: *Dendropoma petraeum* and *Vermetus triquetus* (Safriel, 1966). The *Dendropoma petraeum* is found in dense clusters along the edge of the reef and in the rims of the abrasion platforms that are exposed to breaking waves. Its shell is thick and the snail is able to seal it using a "covering button" attached to its foot – thereby protecting itself from breaking waves or exposure to air during low tide. The *Vermetus triquetus* inhabits quieter waters in shallow pools and the surfaces of the abrasion platforms. The Vermetidae reef is built on platforms of kurkar/limestone rock within the midlittoral zone and its vertical growth is limited by the height above the sea surface. The edges of the reef that are comprised of *Dendropoma petraeum* shells are higher than the central surface that is covered by *Vermetus triquetus* shells. The reef edges, especially those that face the open sea, are alternatively washed under breaking waves and exposed to the air while the surface of the reef is more protected from the waves on the one hand and from drying out on the other hand. Sessile Vermetidae that are capable of building reefs are found along all the Levant coast from Israel up to Syria, and also in a few segments in Sicily and Algiers. In the past, such Vermetidae reefs were also common in the subtropical zone of the western Atlantic as can be seen from their fossilized remains. The importance of Vermetidae reefs is in the fact that they are a unique and rare phenomenon, in the richness of the fauna that find shelter and food under their auspices and the physical protection that they provide the coastline (Galil et al., 2001). Reefs are living structures, and it is therefore enough to disrupt one of their components to endanger the entire system. Only protection from environmental damage can preserve the reef and its inhabitants from destruction. Observations recently conducted along the Bonim coastal area indicate that the *Dendropoma petraeum* snail species population has suffered damage (Rilov, personal communication). According to the report received it is very difficult to locate any living individuals of this species. Additional reports indicate a similar situation at Sdot Yam and Michmoret (Tzadok, personal communication) and Shikmona as well (Barne'a and Tzadok, 2011). In addition, a report on the quality of the littoral waters of Israel published in 2010 (Cherut et al., 2011) notes that the abrasion platforms along the shores of Israel are a unique rock habitat that is currently undergoing transformational processes that are liable to significantly damage it. In surveys conducted during the years 2009 and 2010, no living specimens of the *Dendropoma petraeum* snail were found and in certain platforms the rim itself is almost completely missing. Disappearance of the rim building snail is liable to have far reaching implications for the entire habitat and ecological population that exists within it.

1.9.3.3.3 Michmoret alternative

1.9.3.3.3.1 Sites for preservation

The Yam-Gadur reserve – the area is proposed for the entry system to the shore abuts the locality of Michmoret to the north and is within the Yam-Gadur reserve. The reserve is located between Michmoret and the bathing beaches of Givat Olga. The reserve area is characterized by many reefs at the foothills of the kurkar cliffs and a number of sandy bays. The reserve's habitats and natural values have been described in the above sections.

Planning status of the Gadur beach area – the coastal segment between south Givat Olga and north Michmoret, which lies along about 2.3 kilometers, is intended for a nature reserve (Gadur beach) and a national park in NOP 13, NOP 8, and District Outline Plan 6. In its northern part, the width of the proposed reserve is 300-500 meters and along its back part a residential neighborhood is currently being built. Along its south part a nature reserve and a national park that will constitute part of the area intended for the HaSharon Park is being planned (Engert and Yahel, 2011).

1.9.3.3.3.2 Sea turtles

Sandy beach areas spread to the south and to the north and area used as potential laying sites for two types of sea turtles: the brown sea turtle (*Caretta caretta caretta*) and the green sea turtle (*Chelonia mydas mydas*). Like all species of sea turtles over the world, these species, too, are at risk of extinction. Efforts to conserve the sea turtles in Israel are integrated within regional and international plans. In Israel today, a national center for the rescue of sea turtles operates as a department of the Nature and Parks Authority and under its auspices various interfaced plans are being implemented with the aim of expanding the knowledge available regarding local populations of sea turtles to help their reproductive success, to restore rehabilitated turtles and young individual specimens to nature, and to establish reproductive nuclei (Levy, 2011). As part of the interface plan, various hatching stations have been established along the Israel coast and sea turtle nests are relocated to these hatching farms whenever there is a concern that leaving them in their natural location would put them at risk. At the hatching farms there are high survival chances as the eggs are kept within fenced perimeters and are subject to guarding and supervision (even the hatching process itself) of skilled supervisors. One of the hatching stations is located within the Gadur beach area. Figure 1.9.3.3.3.2-1 shows that for nearly two decades, dozens of nests of green sea turtles and hundreds of nests of brown sea turtles have been relocated to the farm at Gador (Levy, 2011).

Figure 1.9.3.3.3.2- 1: Percentage of natural hatching from 1993-2011 at each hatching farm (the number at the center of the column indicates the number of nests that have been relocated to each farm) (Levy, 2009)

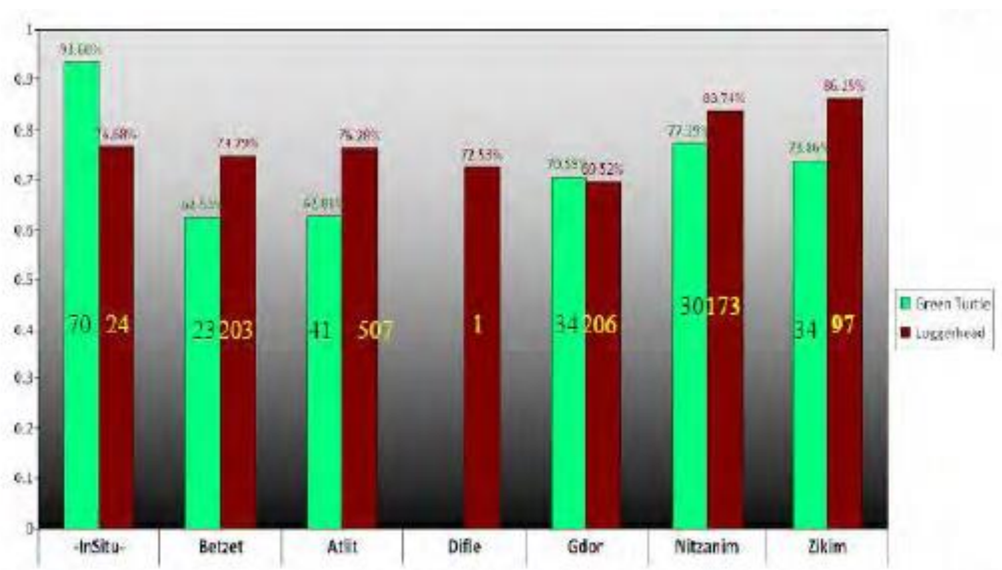
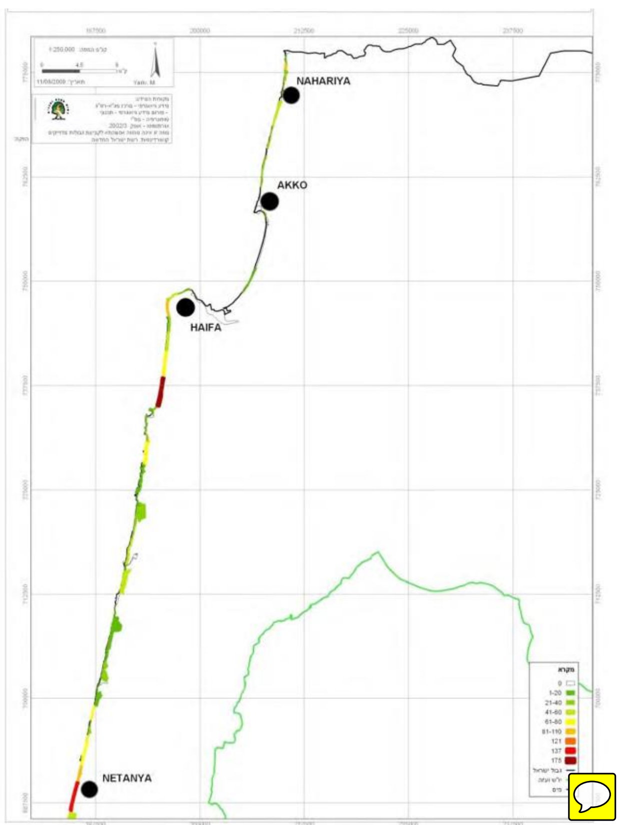


Figure 1.9.3.3.3.2-2 presents information regarding the location of natural nests of sea turtles along Israel's coast between the years 1993-2008. An inspection of the Michmoret-

Olga beach area shows that this region is characterized by an intermediate number of nests in the range of 40-60. It is important to note that every year reports are received regarding futile beaching of female turtles, where the female turtles came to the shore but did not lay any eggs. This phenomenon of multiple futile beaching is probably the consequence of the continued destruction of the sandy strip on the shore and additional disturbances (illumination, human activity at night, travel along the shore, etc.). This destruction finds expression in the narrowing of the sand strip between the sea and the foothills of the cliff and a reduction in the sand layer depth. It is possible that female turtles coming onto the beach to lay their eggs along a section of shore on which they imprinted, having hatched there many years ago, currently encounter difficulties in finding appropriate conditions for laying. Female green sea turtles are very loyal to their laying beach and return to lie on the same shore with a precision of no more a few meters (Cooler, 2002).

Figure 1.9.3.3.3.2-2 Location of natural sea turtle nests along the Israeli shoreline between the years 1993-2008 (courtesy of Yaniv Levy, Nature and Parks Authority)



1.9.3.3.4 The Nachal Alexander alternative

1.9.3.3.4.1 The Nature Reserves and National Parks

The Yam-Michmoret reserve is located between Michmoret and Beit Yanai, it covers an area of 1,210 dunams, and the length of its shoreline is about four kilometers. It represents a unique beach strip located on the seam line between Israel's sandy and rocky beaches. Within this area there are ecological habitats and niches that support the existence of a highly varied flora and faunal population. In addition, the Alexander River, which flows out to sea within the area of the reserve, constitutes an additional important element that characterizes and shapes the fauna in this area (Engert and Yahel, 2011). The main representatives of the Yam-Michmoret sea reserve are the Vermetidae reefs that constitute a unique phenomenon in this region. These reefs create a unique habitat and living environment, and are vital for the continued existence of the flora and fauna in this area. A deterioration in their condition impacts the entire system of life in the region. Within the reserve, we find a unique variety of different algae and invertebrates including stone corals, sea anemones, snails, and more. Moreover, the reserve also includes a sandy beach strip that serves as the laying site for sea turtles under risk of extinction. It is now more than 50 years that this reserve is being used as the site of research work from a variety of disciplines of marine ecology, a fact that makes it possible to track and monitor it over time. According to the first studies conducted on this coast, the littoral zoning model of the East Mediterranean was established (Ben-David Zaslow, 2005). It is therefore extremely important to preserve this coastal section for the purpose of comparative studies in future relating to the rocky shore of Israel and the Levant, as it constitutes a unique natural phenomenon on an international scale (Engert and Yahel, 2011).

The Alexander River National Park – the Alexander River National Park lies on both sides of the coastal road (Road No. 2). Along the western part the river mouth flows into the sea, in an area of shifting dunes. The river mouth is preserved in almost its natural state and the sand dunes surrounding it are among the last remaining in Israel. Between the mouth of the river and Road No. 2 the river is wide and its bottom is lower than sea level, so that seawater penetrates upriver. At the edge of the coastal strip there is growth of a three-cornered jack and the sea daffodil. On the dunes there is marram grass in the indentations and where the underground waters are high one there is also sharp rush, *holoschoenus vulgaris*, and bulrushes. In the marine area there are fishing activities and the collection of young fish for growing in pools during the season where the fish hatch.

<u>Planning status (in accordance with a document provided by the Nature and Parks Authority/Engert and Yahel, 2011):</u>

The Alexander River National Park is a park declared according to detailed plan AH/3/91. The plan is based on a national park dedicated in NOP 13, NOP 8, and DOP 3/21.

On the river's northern bank, in the region of the old boat houses, there is a 1.5 dunam plot allocated for marine sports and educational uses. The plan allows for the construction of sheds for surfboards and boats, operations rooms, instruction rooms and structures on an area of up to 300 square meters and up to two floors high.

The Nature and Parks Authority promotes a development plan for a center to rescue sea turtles to the marine environment planned in the boathouse region to the north of the Alexander River. The plan includes seawater pools to provide a reproduction nucleus for sea turtles, a visitors center and laboratories.

Plan AH/3/91 offers intensive development of a national park as a public bathing beach along the entire coast.

1.9.3.4 Neurim

The Neurim beach-Beit Yanai area is characterized by a narrow sandy strip located at the foothills of a high and steep kurkar ridge on which a built area has been established. The cliff constitutes a high valued landscape area (Engert and Yahel, 2011). In this area the cliff has collapsed in the Beit Yanai region dangerously close to the homes of residential areas and at the Mosaad Neurim region these collapses have caused the fence to collapse and be moved eastwards (Almagor, 2005). In the coastal area at the foothills of regions that collapsed in the past, large rock banks have been setup in order to protect the base of the cliff, but these do not prevent erosion and sweeping of sand from the foot of the cliff (Almagor, 2005).

Figure 1.9.3.4-1: The Neurim alternative region on a Google Earth map

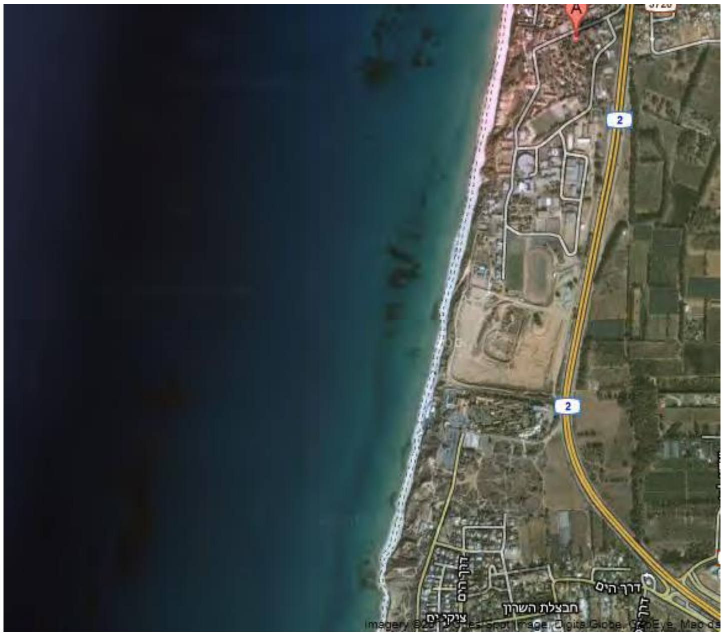
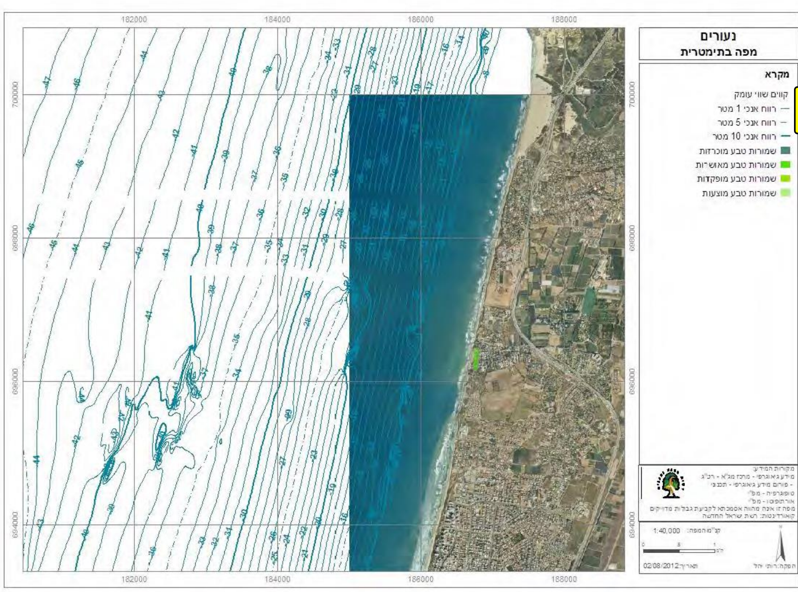


Figure 1.9.3.4-2: Bathymetric map of the marine area in the Neurim alternative region (map courtesy of the Nature and Parks Authority



1.9.3.4.1 Habitats

There is no local information specifically regarding the region of the coast and the sea opposite Neurim, but study of the Google maps (see Figure 1.9.3.4-1) and bathymetric map (see Figure 1.9.3.4-2) indicates a number of rock regions:

1. Along the coastline at the foothills of the cliff in the northern region of the alternative.
2. At a distance of about 500 meters from the coastline the bathymetric indicate irregular areas with the contours of an underwater ridge.
3. At a distance of about 1,000 meters from the coastline, the bathymetric map indicates irregular areas with the contours of an underwater ridge.
4. At a distance of about 3,500 meters from the coastline at a depth of 37-40 meters it is possible to see a region with irregular bathymetric lines that resembles a kurkar ridge.

The rocky areas more distant from the coast seem to constitute a rich habitat similar to other rocky habitats that are found in the region (Michmoret and Gador to the north and the Poleg area to the south), and this includes an underwater ridge located opposite the shore at a distance of about four kilometers (a depth of 26 meters) where observations have been made and photographs taken during a dive (Ayal, unpublished information). The rocky areas that merit particular attention in the context of this project are those located at a distance of about 1,000 meters from the shore, since they overlap the point where the pipe is to enter/exit in the HDD process. In order to evaluate the risk to the rocky habitat, a relevant survey should be conducted along the ridge.

1.10 Oceanographic and Meteorological Conditions

1.10.1 Winds, currents, and waves

This section comprises a description of their regimes of winds, currents, and waves. As agreed with the Ministry of Environmental Protection (enclosed as Appendix A1), the description of the winds regime will be described on the basis of existing material as detailed in Appendix A1. Since the material is based on information not yet made public, it is submitted as a separate Appendix for the inspection of the Ministry of Environmental Protection.

1.10.2 Movement of sands

This section has been submitted in the context of the onshore Environmental Impact Survey.

1.11 Noise

1.11.1 Onshore environment

This section has been submitted in the context of the onshore Environmental Impact Survey.

1.11.2 Marine environment

1.11.2.1 Introduction

This section addresses the issue of noise in a marine environment. It mainly deals with the noise characteristics of a generic marine environment similar to the marine environment along the Israeli coast as regards proximity to the shore, water depth, and the rest of the parameters that determine the acoustic behavior of sound waves at sea. <u>The entire content of this section reflects the acoustic climate expected to prevail at each of the sites included in the plan.</u>

A number of the main noise characteristics of the marine environment are as follows:

- It is easy to evoke sound waves at sea.
- Sound waves disperse in all directions at a relatively high speed.
- Sound waves are caused by such phenomena as rain, waves, non-human biological sources (such as invertebrates, fish, marine mammals), and anthropogenic sources (such as various types of sea vessels, quarrying, and production of the gas and petroleum industry's sonar).
- Sound waves may be beneficial or harmful – for example, marine mammals use sonar waves or alternatively marine explosions are liable to disrupt the behavior of such mammals.
- Sound waves are liable to impact the environment in which living beings of all kinds reside.

The following are the basic principles guiding sound waves in a marine environment, the acoustic climate of the sea, the main noise sources, and their characteristics, and the levels of noise expected along the continental shelf where construction of a marine platform for the treatment of natural gas is being considered.

1.11.2.2 Basic principles

Noise and sound waves are a result of a mechanical "disruption" that moves within an elastic medium – such as air, water, or solids. Sound waves are in fact small differences in the constant pressure prevailing within the medium. Thus, for example, the constant pressure of air at sea level is one atmosphere. Changes in pressure during a conversation using regular speech, reaches no more that ± 0.000,000,2 of atmosphere (two tenths of millions of an atmosphere).

Acoustic professionals use many parameters in order to describe wave phenomena. The main parameters are the level of sound pressure (or the noise), level of sound output, and the speed at which the sound waves progress within the acoustic medium.

The sea or the atmosphere, are never devoid of sound waves. When there are no identifiable noise sources that create the sound waves, the acoustic field is called background noise or background conditions.

A pressure disturbance causes sound to advance by moving the molecules of the medium in which the waves progress. Movement of the molecules gives rise to a wave of compression and sub-pressure to advance within the medium and the speed of progression depends on the qualities of the medium. This speed is called the speed of sound.

The speed of sound in air is approximately 340 meters per second. The speed of sound in water is about 1,500 meters per second.

The frequency of sound waves can change over long ranges and the wave length depends on the frequency and speed of sound wave dispersion.

Table 1.11-1: Typical acoustic parameters in air and in water

Acoustic parameter	Very low frequency	Low frequency	Medium frequency	High frequency	Very high frequency
Frequency in Hertz (Hz)	10	100	1,000	10,000	100,000
Cycle time in seconds	0.1	0.01	0.001	0.0001	0.00001
Wavelength in air	34 meters	3.4 meters	34 centimeters	3.4 centimeters	0.34 centimeters
Wavelength in water	150 meters	15 meters	1.5 meters	15 centimeters	1.5 centimeters

Noise intensity or volume is measured in decibels. The decibel is a unit of measurement appropriate for magnitudes in very large range, such as the pressure of sound waves.

The decibel expresses the ratio between the measured parameter (such as pressure) and a fixed reference quantity so that the decibel actually expresses a level rather than an absolute value.

A definition of the noise pressure level or sound pressure level, Lp, is as follows:

$$\mathbf{Lp=20*log(p/p_{ref})}$$

Where p is the measured pressure and P_{ref} is the reference pressure.

The reference pressure for sound born in air is 20 micropascals (μPa) while the reference pressure for sound carried in water is one micropascal. The difference in the reference pressures causes a difference of 26 decibels between sound in air and sound in water for the same acoustic pressure. In other words:

The noise pressure level of 80 decibels in air will be equal, from the point of view of sound pressure, to a level of 56 decibels in water. The use of different values for the reference value requires mention of the reference value that is being used.

In this section, which deals with underwater noise, the reference value is one micropascal for all noise values.

1.11.2.3 The marine environment

Seas and oceans have two boundaries – the interface with the atmosphere (the air) and the seabed. The interface between the air and the sea is a very dynamic surface that constantly changes. The interface with the seabed also changes, but at a far slower pace. The speed of sound in the sea also changes, *inter alia*, as a function of temperature, solidity, and depth.

The sound regime at sea may be divided into two categories:

1. Continuous noise that always exists and is caused by both proximate and distant noise sources, including waves.

2. Noise that is not fixed and is caused by passing sources such as earthquakes and explosions, marine animals, local rain and hail, and the passage of sea vessels in the proximate environment.

The spectrum of noise at sea constantly changes and can be only ascribed to average values. Figure number 1.11 presents the variety of sound levels at sea.

The spectrum of underwater noise lies from a very low frequency of one Hertz to a very high frequency of 100,000 Hertz.

The Figure also presents the ranges of frequencies of different noise sources, both continuous and occasional.

For the purpose of this plan we may consider data indicating the range of intensity and spectrum for the marine motion of ships in shallow water, i.e. in the vicinity of the shore. The range of frequency of this noise source is between 8-1,000 Hertz and its intensity is in the range of 35-80 decibels. This intensity may change if a vessel passes at a point that is close to the location at which the noise is being measured. In such cases the noise level may be as high as 120 decibels.

Within higher frequency ranges between 500 and 30,000 Hertz, the prevailing noise is that of the waves that are controlled by the wind.

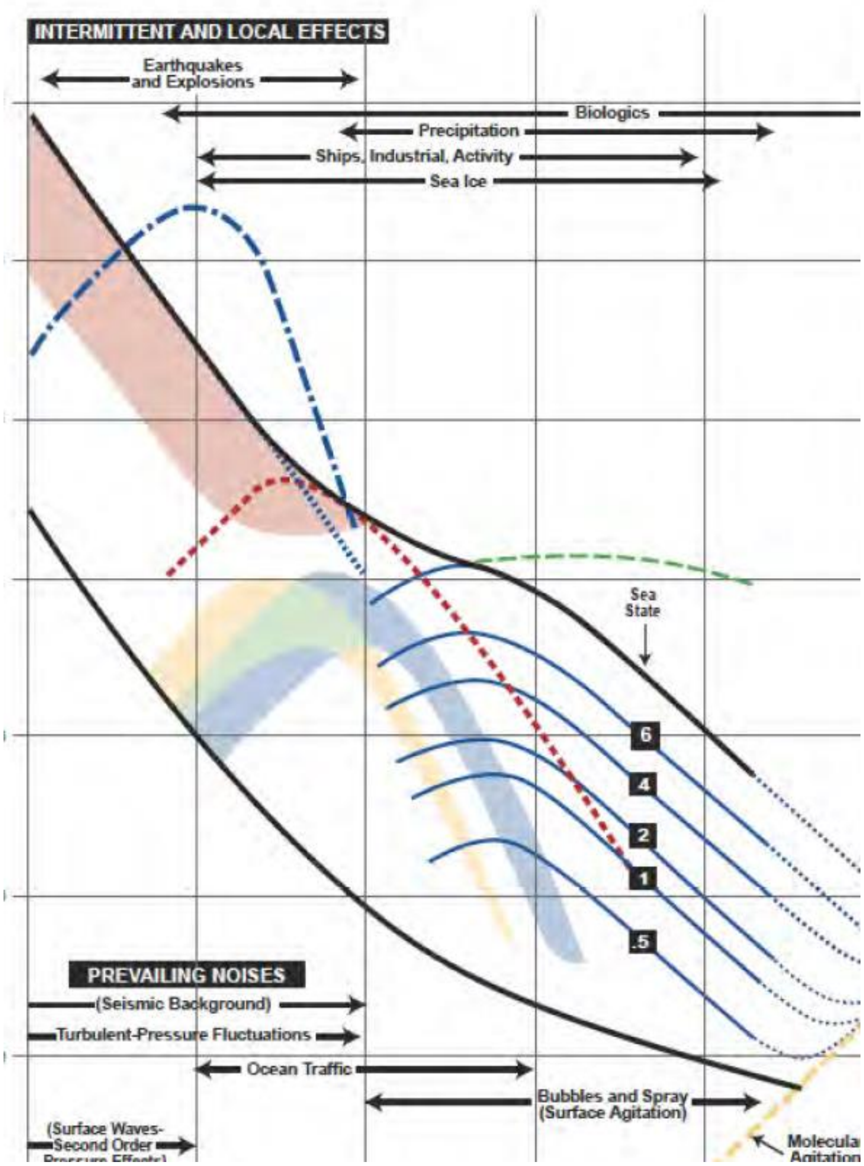
The noise of the waves changes within wide boundaries and for this reason there is a definition of a sea state that describes the changing intensity of the waves and the acoustic noise they create.

The following is a rating of the various sea states where a sea state of zero is the most calm. Sea states above six are very rare in the proximity of the shore.

Table 1.11-2: Rating of sea states

Sea state code	Wave Height (meters)	Characteristics
0	0	Calm (glassy)
1	0 to 0.1	Calm (rippled)
2	0.1 to 0.5	Smooth (wavelets)
3	0.5 to 1.25	Slight
4	1.25 to 2.5	Moderate
5	2.5 to 4	Rough
6	4 to 6	Very rough
7	6 to 9	High
8	9 to 14	Very high
9	Over 14	Phenomenal

Figure 1.11-1: Noise in the oceans and the seas[10]



[10] The values presented in the drawing are typical values of the spectrum and range of frequencies and noise intensities (based on an article by Wenz, published in 1962 by JASA).

1.11.2.4 Summary

The location of the plan in the vicinity of the coast and in areas of brisk sea vessel traffic makes it possible to evaluate the underwater noise levels within the space where the plan may be implemented.

Under conditions of calm seas in a sea stage of 0 or 0.5, we can expect the dominant noise sources to be ships sailing along the shore. We can expect noise levels of about 80 decibels within frequency ranges of 10-1,000 Hertz. The noise level in the immediate vicinity of a commercial marine vessel may reach 120 decibels within the same range of frequencies.

Obviously, sounds of explosion, earthquakes, and infrastructure works in ports are liable to create much higher noise levels.

CHAPTER 2

EXAMINATION OF THE ALTERNATIVES

2. Chapter 2 - Examination of the Alternatives

2.0 Introduction

This chapter examines the systems of location alternatives on the basis of the information presented in Chapter 1 with regard to the following subjects:

A. Uses and zoning

B. Appearance

C. Seismics

D. Ecology

E. Oceanographic and meteorological conditions

F. Noise

The location alternatives for gas treatment were examined according to setup elements from west to east:

- Comparison of the alternatives for the western pipeline alignment – from the border of Israel's territorial waters up to the offshore sites.
- Comparison of the offshore sites alternatives.
- Comparison of the alternatives for the eastern pipeline alignment – from the offshore sites up to the coastal entrance system.

After considering the elements the treatment system was selected (comprising the three elements) that had the highest priority vis-à-vis the above detailed aspects, for each of the exploration site alternatives:

A. Hadera

B. Havatzelet HaSharon

C. Netanya

In summary, a comparison was made between the alternative setup elements in order to rank the proposed systems.

Methodology used for investigating the alternatives:

Examination of the alternatives was carried out in three stages as detailed below:

A. Comparison of alternatives for each element within the offshore setup: (1) alignment of the western pipeline. (2) Offshore sites. (3) Alignment of the eastern pipeline.

B. Selection of a preferred treatment system setup for each of the exploration site alternatives (as stated the setup comprises elements 1-3 as described above).

C. Comparison of the three complete setup alternatives and their ranking according to order of priorities for the aspects examined.

It should be noted that such issues as the survey of engineering technologies, parameters relating to the offshore facilities and the pipeline, report regarding separation distances and additional issues mentioned in Section 2.1 according to the survey guidelines were all examined in the context of the onshore environmental survey. As stated above, this document only included reference to the offshore alternatives for the issues surveyed in Chapter 1 above.

Location Alternatives

This section will comprise a general description of the offshore site alternatives and a description of the marine pipeline corridor alignment proposed for the various alternatives. A description of the alternatives will be presented in accordance with the geographical location of the offshore setups and facilities from north to south (the alternatives are presented in Figure 1.1.1.2-1, which is presented in Chapter 1).

As stated in this document, the marine environment database that is available at the present time makes it possible to conduct a generic evaluation of the presented alternatives. A number of principles (some of which are detailed in Chapter 1 above) were used to determine the area of the offshore sites and the alignment of the marine pipeline:

A. The western boundary – a depth limitation of about 100 meters for the offshore sites – at this depth the continental slope begins.

B. The southern boundary of the inspection space was determined opposite the Dor locality area, to the west of which is one of the largest slumpings in the Eastern Mediterranean (the Dor slumping).

C. The southern boundary of the offshore sites was established slightly to the south of Netanya for design considerations of the system that requires some of the facilities to be located opposite Israel's northern coast.

D. The eastern boundary – the offshore sites are placed at a distance of 7.5 kilometers from the coastline in accordance with guidelines provided by the Ministry of Environmental Protection based on visibility considerations. The western pipeline alignment – boundary of Israel's territorial waters (to which the Planning and Building Law applies).

E. The eastern pipeline (from the exploration sites to the marine facility to the shore entrances) passes in parallel and in proximity, as far as possible, to the marine gas transmission pipeline alignment already present according to NOP 37/A/2 and its amendments.

F. Distancing the systems, as far as possible, from the more ecologically sensitive kurkar ridges.

G. Maintaining a separation distance of five kilometers from the LNG float approved in the context of NOP 37/A/2/6 for considerations of safety.

The following is a description of the alternative location of offshore sites and the accompanying pipeline alignment to the west and to the east:

Offshore alternatives

1. The Hadera site – this alternative lies offshore opposite the Dor coast to the north and Or Akiva to the south, occupying a total area of about 43 square kilometers.
2. The Havatzelet HaSharon site – this alternative lies offshore opposite Beit Yanai to the north and Netanya to the south, occupying a total area of about 55 square kilometers.
3. The Netanya site – this alternative lies offshore opposite the south coast of Netanya until the Poleg reserve in the south, occupying a total area of about 50 square kilometers.

Western pipeline alignment alternatives

The western pipeline alignment – there are five alternatives for the western pipeline alignment (in the direction of the territorial waters). These alternatives were delineated in accordance with an analysis of the biological and seismic aspects solely on the basis of existing information and there are gaps in the information along the complete alignment:

– Alternative 1: opposite Herzliya (the southernmost alternative)

– Alternative 2: opposite Ga'ash

– Alternative 3: opposite south Netanya

– Alternative 4: opposite north Netanya

– Alternative 5: opposite Dor (the northernmost alternative)

In addition, there are two alternatives for the pipeline corridors (A and B) for connecting the Hadera alternative with alternatives 1-4 in the south. Corridors A and B bypass the corrugation phenomenon region from the east and from the west (see details in Section 1.6 above).

Eastern pipeline alignment alternatives

1. Hadera offshore site –eastern pipeline alignment alternative (intended to connect to the coastal entry system), extends eastwards from the region facing Dor in order to distance the system from the kurkar ridges, and continues, in parallel and flush with the existing and approved marine pipeline alignment northward in the direction of the alternatives of the Dor entry setup or southward in the direction of the alternatives of the Hadera/Michmoret/Nachal Alexander and Neurim entry setups.

2. Havatzelet HaSharon offshore site – eastern pipeline alignment alternative, extends eastwards from the region facing Havatzelet HaSharon in order to distance the system from the kurkar ridges, and continues, in parallel and flush with the existing and approved marine pipeline alignment northward in the direction of the alternatives of the Dor/Hadera/Michmoret/Nachal Alexander or continues eastward to the entry setup alternative at Neurim.

3. Netanya offshore site – eastern pipeline alignment alternative, extends eastwards from the region opposite Ramat Poleg and continues, in parallel and flush with the existing and approved marine pipeline northward in the direction of the entry setup at Dor/Hadera/Michmoret/Nachal Alexander/Neurim.

2.1 Presentation of Criteria for the Consideration of Alternatives

The following table presents and provides details of the criteria used to evaluate the alternatives. The criteria expand and specify the issues proposed in the guidelines to the survey, but at the same time it should be noted that in conjunction with the Environmental Impact Survey the design team also prepared a planning document that will compare additional aspects of the alternatives that are not environmental, such as economic, security, engineering, and the like, and therefore these parameters are examined in the parallel document.

It should be noted as well that all of the alternatives considered in this survey have in fact passed the threshold requirements for all the relevant parameters and were recommended in the second stage of the promotion work performed as part of the Environmental Impact Survey.

For this reason, this chapter attempts to select the most preferred site, examine the advantages and disadvantages of each of the proposed sites and pipeline alignments, and ultimately to recommend the most appropriate setups that achieve a minimum of conflicts, in the event that a detailed plan should be promoted for them.

A detailed inspection of each of the criteria listed for the various facility alternatives is presented in Section 2.1.3.

Method for ranking the alternatives – The alternatives were ranked according to each of the criteria using a qualitative scale of three ranks in accordance with the opinion of the relevant professional consultant – preferable, medium, and inferior (in three corresponding colors). This qualitative ranking was assigned in accordance with how the alternatives conformed to the various considerations listed. The process ends with a recommendation of the preferred alternatives for further investigation in Chapters 3-5 of the Environmental Impact Survey.

Non-assignment of weightings – Design projects and environmental documents utilize a variety of methods for evaluating and weighting alternatives. Adding a weight to each criterion establishes its importance relative to other criteria. For example, the criterion of visibility will be 15% while the criterion of savings in land resources will be 10%. Due to the fact that there is no written and agreed theory regarding the weightings to be assigned to the criteria, and the fact that the resolution of the information at this stage is mostly based on existing material only and there are additional unknown factors involved in the parameters examined for each of the alternatives, the present survey team reached the conclusion that in our case it would not be appropriate to propose weightings for the criteria.

Thus, we assumed that the appropriate approach would be to evaluate the preference/inferiority of each alternative as regards all of the criteria, to be accompanied by a detailed explanation and comprehensive estimation of the extent to which the alternative is appropriate for the proposed development, with reference to its meeting or not meeting the various criteria. This summary is a qualitative one and is not based on weightings and percentages, some of which are subjective – from the perspective of the evaluating party.

Nonetheless, it is indeed possible that for some of the criteria a different importance will be defined, but it, too, will be analyzed qualitatively and be accompanied by an explanation. This importance will contribute to a comprehensive understanding and to an analysis and conclusions relating to the preferred alternatives.

Table 2.1.2-1: Criteria for the examination of alternatives

Section	Issue	Definitions
A	**Suitability for land uses and zoning**	An examination of the alternatives in comparison with land uses and zoning in national outline plans, and detailed plans that are promoted within the area of the alternative and in the proximity of the pipeline alignment. **The greater the extent to which the land uses and zoning in the environment of the plan do not constitute an obstacle to the construction of the treatment platform or limit the range of exploration for its construction, the more preferable the alternative.**
B	**Scope of region's visibility from various points in the area**	The extent of the facility's visibility and visual presence, in its proximate and distant environment. An inspection of the landscape suitability included: land uses in the areas surrounding the facilities and the characteristics of these uses, with a distinction made between visibility from localities and residential population centers and visitor sites, with values of regional or national importance and the extent of exposure to passing traffic along main roads or railway lines. **The lower the level of visibility, the more preferable the alternative.**
C	**Seismic**	The extent of seismic risk was examined in accordance with the existence of geological faults that are either active or suspected of being active within the region of the proposed alternative, as well as the horizontal soil accelerations expected on the surface, the potential for soil failure and the liquefaction of soil, and the risk for a tsunami strike against the site. **The further away an alternative lies from an active fault, the more preferable it is. The lower its potential for the collapse of the slope, the lower its vulnerability for liquefaction, the lower**

Section	Issue	Definitions
		the land accelerations within it, and the lower the risk for a tsunami strike – the more preferable it is.
D	**Ecology**	The areas of the sites intended for construction of the platform and the laying of the pipeline alignment were examined in accordance with the following criteria: their proximity to offshore reserves (both declared or proposed) and national parks (a high proximity or presence within a reserve area will give the alternative a low level of preference). The type of sub-base within the alternative area – a rigid base (kurkar rock/other rock) is a limited resource within the marine environment and supports the existence of rich and valuable habitats (including abrasion platforms that are located in the vicinity of the coast and constitute habitats in risk of extinction). The sandy bed is more frequent in the marine environment along Israel's coast. For this reason, the presence of a rigid bed or a proximity to a rigid bed will give the alternative lower preference. The presence of unique habitats: seaweed, abrasion platforms, various types of reefs (sponges/annelids/bivalvia), deep-sea canyons. There are habitats that are under risk of extinction and necessitate preservation. The presence of fish reproduction areas (such as groupers) – certain types of fish are territorial and known to inhabit specific reproduction areas. Some of these species are rare and care must therefore be taken to ensure that no damage is caused in the reproduction areas of species at risk. The presence of species at risk according to the Barcelona Treaty and CITES and species that are protected under Israeli law – the presence of such

Section	Issue	Definitions
		species within the areas planned for implementation of the plan must be determined. **The lower the disruption caused by the plan to the specified criteria, the more preferable the alternative.**
E	**Oceanographic and meteorological conditions**	**The greater the extent to which currents, wind, and wave regimes within the area of the alternative constitute a limitation on the construction of a treatment platform and limit the range of exploration, the less preferable the alternative.**
F	**Noise**	**The less the plan impacts on security systems and marine mammals, the more preferable the alternative.**

2.2 Examination of Alternatives

A. Uses and zoning

This parameter considers the extent to which the offshore exploration site is compatible with other uses, activities, and purposes within the area of the alternative and the limitations that they impose on this site. The following is a ranking of alternatives under Section 1.2 of Chapter 1:

1. **Western pipeline alternatives (from the boundary of the territorial waters to the exploration sites)**

Alternatives 1-5 –all of these alternatives are located within the area of sailing routes and trawling lines of trawlers. Alternatives 1 and 2 are relatively inferior to the other alternatives since they are located within the area of a proposed marine nature reserve, whereas Alternative 2 has priority since it lies along the margins of the proposed marine preservation area and may be diverted towards the north to improve its applicability. Alternative 5 crosses communication cables.

Corridors A and B –Corridor B is inferior since it is located within the area of NOP 37/A/6/2 that has been allocated to the LNG float. The two corridors are located within the area of sailing routes and trawling lines of trawlers.

For this reason the alternatives of the western alignment were ranked as follows:

- **Alternatives 1 and 2 – low**
- **Alternatives 3-4 – high**
- **Alternative 5 – medium to high**
- **Corridor A – high grade**
- **Corridor B – low grade**

2. Site alternatives

There is no significant difference between the three sites. Trawling lines pass through all sites (the least prominently within the Hadera alternative). There is a certain advantage to the Havatzelet HaSharon alternative since it is relatively distant from sailing routes (that are closer to the Hadera alternative) and the proposed nature reserve (that is closer to the Netanya alternative). In addition, it should be noted that a communication cables alignment passes through the proposed Hadera alternative.

The site alternatives may be ranked as follows:

- **Hadera alternative – medium-high**
- **Havatzelet HaSharon alternative – high**
- **Netanya alternative – medium-high**

3. Eastern pipeline alternatives (from offshore sites to coastal entry systems)

Trawling lines and the area of NOP 37/A/1 pass through all of the alternatives. The following is a summary of the differences and a ranking of the alternatives for the eastern pipeline alignment as surveyed from north to south:

- **Dor alternative** –The alignment lies within the area of NOP 37/A/6/2 and sailing routes, when the alignment comes from the Havatzelet HaSharon and Netanya sites. **High.**
- **Hadera alternative** – The alignment passes in the area of 37/A/6/2. In addition, it passes within the area of the Hadera Port, NOP 34/B/2 and sailing routes. **Low.**

- **Michmoret alternative –** Within the area of the NOP 37/A/6/2 and sailing routes when the alignment arrives from the Hadera site. Within the area of NOP 34/B/2/2 (in preparation) and declared nature reserve – Yam Gadur (but within the shallow region and relatively distant from the HDD drillings so that the reserve is left almost undisturbed). **Medium.**
- **Nachal Alexander alternative –** Lies within the area of NOP 37/A/6/2 and sailing routes, when the alignment arrives from the Hadera site. Within the area of a proposed nature reserve – Yam Michmoret. **Low-medium.**
- **Neurim alternative –** Lies within the area of NOP 37/A/6/2 and sailing routes when the alignment arrives from the Hadera site. **High.**

B. Appearance

From the point of view of landscape, each alternative has not inconsiderable landscape significance. At the same time, the alternatives are similar in their elements, in the visibility they present, and in their general landscape significance.

The findings of the landscape examination indicate that there is no significant difference between the offshore alternatives as regard the landscape aspect and that this consideration cannot be used as a key indicator for preferring one alternative over another from among the three alternatives under consideration.

In later stages, guidelines and tools will be developed in order to examine and limit the landscape impact of various aspects of the facilities' arrangement within the polygon, night illumination, etc.

C. Seismic

Further to the descriptions provided in Section 1.6 above, an evaluation of the alternatives from the various aspects presented in Chapter 1 was carried out in accordance with the various seismic risk factors. In the summary tables the alternatives classified according to the various criteria are presented by the following key: (1) green color – an alternative that received a high ranking. (2) Yellow color – medium ranking. (3) Red color – low ranking potential for a high level of risk.

1. **Western pipeline alternatives (from the boundary of the territorial waters to the exploration sites)**

   i. <u>Rupture of the surface on top of active geological faults or faults at the base of rotational slumpings</u>: Alternatives 1 to 3 do not cross clear lineaments and are therefore less vulnerable to the rupture of the surface. However, it should be emphasized that it is possible that in the subsoil underneath these alternatives there are faults that are not visible in the bathymetric analysis. Corridor 4 does not cross lineaments, but does pass in the vicinity of a number of lineaments from the north and from the south that it is possible that are connected between them. Corridor 5 crosses at least three lineaments characterized by high local mounds. <u>Along the continental shelf (Alternatives A and B) it seems that there is no concern for rupturing of the surface</u>.

ii. <u>Possibility of soil failure phenomena along the segment of the shallow soil</u>: Alternatives (A, B) in the continental shelf pass close to areas that undergo active failure and that seemingly accompanying a shallow gas layer (pockmarks and corrugation). This area's boundaries are not specifically defined and therefore there is a risk for failure even though it is a smaller one in the area of these alternatives as well. <u>There is no direct evidence indicating the existence of these risk factors in the subsoil of Alternatives 1-5, but we cannot completely deny the possibility of their existence at this stage.</u>

iii. <u>Possibility of soil failure phenomena as a consequence of liquefaction</u>: The potential for liquefaction is connected with the geotechnical characteristics of the soil for each and every alternative. Since these data are not available there is no difference between the various alternatives as regards the potential for liquefaction. All alternatives are within a range where accelerations are liable to develop, and such accelerations according to empirical data may in turn lead to liquefaction.

iv. <u>Underwater slumpings</u>: The risk has been determined on the basis of an analysis of the gradient of the various alternatives and a number of slumpings and slumping scars that appear within the course of the alternative. In general, the risk increases from south to north except for Alternative number 1, where there is a medium risk of slumping as a consequence of its proximity to the influence area (whose boundaries are not accurately defined) of the Palmachim slumping to the south.

Table 2.2-C1: Summary of an examination of alternatives for the western pipeline alignment vis-à-vis seismic aspects

Risk factors	Corridor 1	Corridor 2	Corridor 3	Corridor 4	Corridor 5	Corridor A	Corridor B
	Alternatives for gas transmission pipeline corridors from reservoirs to treatment platforms						
	The Continental Slope					**The Continental Shelf**	
Rupture of the surface on top of active geological faults or faults at the base of rotational slumpings							
Possibility of soil failure phenomena within the section of shallow soil							
Possibility of soil failure phenomena as a consequence of liquefaction							
Underwater slumpings							

2. Site alternatives and the eastern pipeline alignment

i. Calculation of horizontal soil accelerations within the inspection space:
Despite the fact that the calculated acceleration level decreases from north to

south as a consequence of the multitude of seismogenic sources to the north of the inspection space (in accordance with the model received from the data provided by Standard 413), there is nothing in the difference in the values obtained to indicate that the seismic risk level of the Hadera alternative is significantly more severe than the more southern alternatives. The design acceleration values will be dependent in any case on the extent of amplification onsite (see below). In the event that once the amplification calculations are added the design accelerations obtained for the Hadera alternative will be higher, the difference is not expected to lead to a significant change in the planning of the facility's setup, and it is possible that it will only find expression in a more stringent seismic design for the northern facilities.

ii. <u>Rupture of the surface on top of active geological faults</u>: in the Hadera alternative the Or Akiva fault, which is formerly defined according to the map of active faults, is a fault that is suspected of being active since it deflects the Pliocene base. As there are no indications for its activity within the system past tens of thousands of years, the risk for the rupture of the surface on account of a deflection of a seismic line is low. It should be noted that according to the up-to-date proposal that is still not enforced regarding the map of faults that are either active or suspected of being active (Sagy, et al., 2012), this fault is not defined as suspected of being active. Hence, from a practical point of view the potential for surface rupture in all alternatives is similar.

iii. <u>Amplification of seismic vibrations on account of geological and topographical conditions</u>: in the absence of specific geotechnical information that would allow comparison between the soil profiles of the various alternatives, it is not possible to determine the relative risk level prevailing among them. In any event such information is specific to the inspection point so that we cannot apply a practical comparison between the alternatives as regards this risk factor.

iv. <u>Possibility of soil failure phenomena</u>: in view of the information available (and its limitations) regarding failure phenomena and their spatial deployment, each alternative is suspect for the presence of failure factors or potential failure factors. Assuming that the deformation of the upper sediment layer is genetically linked to the accumulation of gas, it seems that the Netanya alternative and the southern part of the Havatzelet HaSharon alternative should be expected to display more failure factors than the parts that lie further to the north. Nevertheless, the mapping region for the gas layer does not cover the entire area of the alternatives, so that it is possible that additional gas islands exist in parts that lay further to the north, including the Hadera alternative. It seems that the corrugation phenomenon exists within the area or in the proximity of all of the alternatives. The greater proximity of the Hadera alternative to the slumpings area associated with the deformation of the salt layer increases the probability that within its area are faults within the subsoil that are liable to operate as a consequence of a significant seismic event and cause surface deformation. In summary, according to the information available there is no practical difference in the risk level of the alternatives as regards soil failure.

v. Possibility of soil failure phenomena arising from liquefaction: similar to the amplification phenomenon, an evaluation of the liquefaction potential requires information that is specific to the site under consideration. In general, it may be determined that as a consequence of expected higher accelerations in the northern direction the potential for liquefaction also increases as one moves north. According to empirical relationships, all alternatives are within the range where soil accelerations are capable of causing liquefaction. Nevertheless, the fact that a site meets the criteria for the liquefaction threshold depends first and foremost on the properties of the site soil, which are liable to change across distances of mere dozens of meters. Hence, on the basis of currently available information there is no significant difference between the alternatives as regards their potential for liquefaction.

vi. Appearance of a tidal wave (tsunami): there is no significant difference between the alternatives as regards the potential for a tsunami strike. An estimation of the maximum expected wave height for each alternative requires specific simulations.

The following table summarizes the evaluation of the alternatives from the point of view of each of the parameters reviewed above for the sites of the alternatives and the alignment of the pipeline from the sea to the treatment platform, and from the treatment platform to the shore.

Table 2.2-C2: Summary of the western pipeline alternatives examination vis-à-vis seismic aspects

Seismic risk factor	Hadera Alternative	Havatzelet HaSharon Alternative	Netanya Alternative
Treatment Platforms			
Calculation of horizontal soil accelerations within the inspection space			
Rupture of the surface on top of active geological faults			
Increase of seismic vibrations due to geological and topographical conditions			
Possibility of soil failure phenomena			
Possibility of soil failure phenomena arising from liquefaction			
Tidal wave (tsunami) phenomenon			
Pipeline Corridors to the Shore			
Seismic stability of the pipeline corridor leading eastwards (in the direction of the shore up to the existing corridor)			

D. Ecology

The ecological analysis refers to the alternatives of the western pipeline alignment (from the boundary of the territorial waters to the offshore sites), from the exploration sites to the location of the offshore treatment facility and to the eastern pipeline alignment (from the offshore site to the coastal entry system):

1. **Western pipeline alignment alternatives (from the boundary of the territorial waters to the exploration sites)**

The reference to the various alternatives is given in accordance with the numbers that are presented on the background drawings of Section 1.1.2 above. In general, it is important to note that the information gathered with regard to the continental shelf area and the deep sea facing Israel's coast has been accumulated relatively slowly and in anecdotal fashion. At this stage there is no continuous and fundamental documentation for all of the area of Israel's territorial waters as far as the type of sub-base and marine habitats are concerned. The Nature and Parks Authority has recently published a document that contains important information relating to marine habitats and both existing and proposed marine reserves (Yahel and Engert, 2012), and relevant information from that document has been incorporated in the present text. Nevertheless, in view of the above each proposed corridor will require a survey utilizing photography of the seabed before a final decision can be made regarding the precise alignment in the event that it is decided to develop that corridor. It is important to emphasize that such photography provides valuable and unequivocal information as far as biological values are concerned.

A. The southernmost alternative, which is numbered 1, is located within the area of a large marine reserve proposed by the Nature and Parks Authority and defined as Marine Protected Area (MPA) [11](see details in Section 1.9.2.3 above). Alternative 2 abuts the northern boundary of this reserve. The purpose of the planned marine reserve Poleg, which will spread from the HaSharon coast up to the territorial waters of Israel, is to protect a variety of habitats from the coastline, continental shelf, and slope as well as deep water (Yahel and Engert, 2012). The area proposed as a large marine reserve also comprises areas of rigid seabed at a depth in the range of 90-125 meters (see Yahel and Engert, 2012) and was surveyed in the course of a Nature and Parks Authority sailing expedition during the month of September 2010. It should be emphasized that

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[11] A protected marine area where the definitions of protection are relatively flexible for a marine reserve (a reserve is usually defined as a no take area).

Alternatives 1 and 2 do not lie within the range of depth of 90-125. At this stage it is not known where unique habitats exist and where habitats are based on a rigid seabed at a depth greater than 125 meters. In the context of Alternative 1, we cannot ignore the area's zoning as a large marine reserve and cannot ignore the position of the Nature and Parks Authority on the issue, which is to avoid passing pipeline corridors within the area of the proposed reserve, and to first examine the possibility of other alternatives that do meet the geological criteria (Yahel, verbally). Thus, from the point of view of the biological aspect Alternative 1 is inferior when compared to the other alternatives detailed below. As regards Alternative 2, owing to an absence of up-to-date information regarding the habitats to be found within the boundaries of this area and since its location abuts that of a marine reserve, it is therefore proposed to rank its suitability as medium at this stage. In the event that it turns out that the corridor alignment does not include unique and valuable habitats, it will be possible to increase its ranking.

B. Alternative 3 is located slightly to the south of Netanya and there is no up-to-date information regarding deep-sea habitats in this area.

C. Alternative 4 is located opposite Netanya and there is no up-to-date information regarding deep-sea habitats in this area. The splits in this corridor as it reaches the Havatzelet HaSharon and Netanya sites are located in an area where a kurkar ridge (depth of 90-120 meters) may possibly be found.

D. Alternative 5 is located opposite Ma'agan Michael and some seven kilometers to the south of the area facing Dor, which has been surveyed in the past by the Nature and Parks Authority (see Section 1.9.2.1). In this case, too, there is no available up-to-date information regarding the alignment of the corridor and it is possible that the corridor bisects an exposed kurkar ridge at a depth of 90-120 meters (such an exposed ridge was observed opposite Dor and opposite the Kibbutz Sdot Yam).

The ability to serve as a corridor for the western pipeline alignment from the point of view of biology is summarized in the following table:

Table 2.2-D1: Ranking of alternatives for the western pipeline corridor vis-à-vis biological considerations[12]

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Ecology	Located within the area of the proposed marine reservation Poleg	Abuts the north boundary of the proposed marine reservation Poleg. Diverting the alternative to the north may improve its applicability.	There is no specific information.	There is no specific information	Close to the area of the deep sea in the Dor region where unique habitats have been discovered

E. The longitudinal corridors (parallel to the coastline) A, and B are located within areas that seem to be sandy regions according to the bathymetric maps. Corridor A is mostly located on a uniform depth line, but its northern end "climbs" into the area of the Hadera offshore site and there is concern that it crosses an area of exposed kurkar ridge (such an exposed ridge has been observed opposite Sdot Yam). Corridor B after splitting off from corridor A, "climbs" into the offshore site area of Havatzelet HaSharon offshore site area and here, too, there is concern that it crosses an exposed kurkar ridge. Thus, according to available information **it seems that there is no difference between corridors A and B and both of them are accorded medium to high development priority.**

[12] Red color: low suitability; orange color: medium suitability; green color: high suitability (pending the results of the seabed survey).

2. The Site Alternatives

As already noted in Chapter 1 above, the examination of the various sites also includes the alignment of the eastern pipeline extending from the sites up to one kilometer from the coast (the HDD entry area). On the basis of the data presented in Section 1.9, it can be seen that the alternatives area (of all of the offshore site alternatives) is located within a strip mainly characterized by its soft sub-base. An examination of the bathymetric maps indicates that in this area there is no continuous underwater ridge, but this assumption must be reexamined once high-resolution mapping of the area is received. As explained in Chapter 1, the soft sub-base of the clayey-silty seabed at a depth of 60-80 meters supports the existence of a large variety of different organisms that subsist on the seabed within it and above it. The biological findings received in the survey conducted for the LNG reception float project (environmental document NOP 37A/6/2, 2011) indicate the main elements of the infaunal population of the area that constitutes part of the large polygon. The characteristics of the sediment (particle size and organic material content, etc.) constitute a vital factor in shaping the elements of the faunal population within the seabed environment. Therefore it is reasonable to assume that there are no significant differences in the composition of this infaunal population within the area of the sites. In view of this, it seems that from the biological aspect the location of the platform within the space of the polygons is optional (see detailed recommendations below). Nevertheless, when reaching a decision regarding the location of an infrastructure facility on this scale it is worthwhile looking at the total sum of the elements, including the gas pipeline (from the discoveries to the platform and from the platform to the onshore receiving facility) and determine an optimum location that also takes into consideration the alignment areas for the pipeline to the west and to the east of the sites. To this end, the present document has presented a number of underwater ridge areas, some of which have been surveyed in an orderly fashion and some of which have not yet been surveyed. Moreover, there are areas that are identified in bathymetric maps as underwater ridge areas, in regard to which it is not yet known which parts are exposed and which parts are buried under a thick layer of sand/silt. It is important to emphasize that underwater ridges that are exposed constitute extremely rich habitats for fauna and are also nurseries for a large variety of invertebrates and fish and are considered both rare and extremely valuable. As far as it known at present to the west of the sites, area a kurkar ridge spreads out a depth of 90-125 meters and some of that ridge is exposed opposite the Dor area, opposite Kibbutz Sdot-Yam, and opposite the Ga'ash Herzliya area (where there is a proposal also for a large marine reserve[13] that will include

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[13] In recent years the Nature and Parks Authority has formulated a plan to declare marine nature reserves in order to protect a representative ecological systems within the marine medium and the biodiversity of the species in the marine environment. According the Barcelona Treaty for protection of the Mediterranean Sea environment, the role of marine reserves is to protect areas

the deep ridge area). The bathymetric map shows bathymetry lines that indicate the presence of a continuous ridge from the Sdot Yam area to Herzliya (and even further south from there). From the north of Sdot Yam and up to Dor, there is also an indication of the presence of a deep ridge, but it seems that in the narrow area between Nachsholim and Maayan Tzvi there is a region in which the ridge is buried under a thick cover of sediment (Tzadok, verbally). To the east of the polygon the presence of a ridge at a depth of 37-45 meters is known opposite the Orot Rabin power station. Also known are a number of ridge segments opposite Michmoret and Beit Yanai at a depth in the range of 26-40 meters and opposite Poleg at a depth of 40 meters (a ridge located within the area of the proposed marine reserve).

In view of the information presented it appears that during the period of detailed planning, an in-depth investigation of the bathymetric data will be required (at high resolutions) in the areas intended for the platform and the pipeline, as well as up-to-date photographs of the seabed along each alignment proposed, in order to locate exposed underwater kurkar ridge areas and prevent any damage to them.

Specific recommendations for the alternatives:

- ❖ In view of the information presented regarding the deep ridge area at Dor (Section 1.9.2) it is recommended to move southwards from this area.
- ❖ In view of the fact that the southern boundary of the polygon abuts the northern boundary of a large (proposed) marine reserve it is recommended to move north of the area (see map in Appendix C).

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that include representative types of both littoral and marine ecological systems, natural environments that are under risk of disappearance in their natural distribution region or with naturally low areas; natural areas that are vital to the survival, reproduction, and rehabilitation of species under risk of extinction and of threatened or endemic species of flora and fauna; sites that are uniquely important owing to a scientific, aesthetic, cultural, or educational interest (Yahel, 2011). The main guiding principles in the planning of marine reserves lead to proposals for declaring large reserves that make it possible to protect entire ecological systems, as well as large marine animals with wide-ranging living grounds (Yahel, 2011). One of the large reserves proposed by the Nature and Parks Authority is the Poleg Reserve (appended as Appendix C), which spreads from the coastline up to the boundary of the territorial waters of Israel. This reserve comprises in its deepest area a variety of habitats, among them kurkar ridges at a depth of 100 meters, sponge reefs, and areas of soft bedding (Yahel, 2011).

- ❖ As regards the eastern pipeline corridor – in view of the presence of kurkar ridges, some of which are known (as detailed in the chapter in Section 1.9 above) consideration should be given to diverting the alignment at the problematic locations at the time of actual execution in view of existing information and any additional information that may be obtained from future field studies in the context of this plan.

In view of the recommendations presented below and with consideration for the three sites defined in the NOP 37H framework, the Havatzelet HaSharon site may be recommended as the most suitable for construction of the platform. It should be emphasized that in order to make a final decision on the precise location, a detailed survey of the seabed in the relevant areas will be required.

3. Eastern pipeline (from the site to the coastal entry system)

- ❖ **Dor –** The pipeline coastal entry area is located at the heart of a sandy region (although it is possible that there may be patches of rocks here and there) and there are no abrasion platforms close to the shore in that location. According to a Nature and Parks Authority document (Engert and Yahel, 2011) the coastal strip within the area of the proposed alternative is intended in future for inclusion in a nature reserve that is planned to spread from the Dor coast up to Nachal Taninim. Additionally, the Dalia River mouth area is also intended for a nature reserve. It should be noted that there is already an entry of the gas pipeline transmitting to the Hagit site in the vicinity of the Elyakim Junction in that location. At this site too, work has already been done using the HDD method, and it is therefore reasonable to assume that this method is applicable in that specific area. Nevertheless, we cannot disregard concerns for unexpected failures during the works and in such cases there is a risk that sediment may float and or contaminations may spread in the direction of the Dor reserve area and rocky habitats and abrasion platforms. Emergence of the pipe at the shore is expected to be located at the area of the fish pools to the north of the Dalia River mouth reserve, which is an area rich in fowl and offers a unique environment of brackish water. A tour of the area which observed the existing pipeline made it possible to estimate that the area of the new pipe block and valve is not expected to cause any environmental problems during the operational stage. A temporary disruption is possible during the project works stage. **The suitability of the Dor alternative for a coastal entry system is defined as medium.**

- ❖ **Hadera –** the proximate marine environment is subject to environmental influences caused by the outlet of cooling waters from the IEC and the discharge of desalination concentrate. Nevertheless, in the area to the south of the cooling waters outlet within a range that is still subject to the effects of temperature and solidity, there is a rich faunal environment on rocky beds at depths shallower than 10 meters. The ability to juxtapose the infrastructures is a guiding principle in selection of an appropriate alternative. Since the Hadera River mouth was found appropriate from an engineering point of view, and since HDD method has already been used in that location in the past, it is reasonable to assume that the risk of failure during performance of the works is small. Moreover, the area where the pipe jacking begins (approximately 900 meters from the coast) also abuts an infrastructure region (the Orot Rabin power station coal wharf). The distance to the Sdot Yam abrasion platforms exceeds one kilometer so that there is no immediate risk to habitats in the event that sediment or contamination are floated into the water. In view of the information regarding the reproduction groupings of two types of groupers in the vicinity of the adjacent Olga shore (see Section 1.9.3.2.2), it is recommended to check if there is a similar phenomenon within the area of this alternative and if so, will be necessary to take steps to avoid damaging these two types of fish. **The suitability of the Hadera alternative for a coastal entry system is defined as high.**

- **Michmoret –** the coastal entry area is located within the Yam Gedor Nature Reserve. The area is characterized by a kurkar cliff that descends to the sea in a steep gradient and gives rise to rock falls shoals and abrasion platforms at sea. This meeting of the kurkar and the sea create a variety of marine littoral habitats with a rich variety of flora and fauna. The abrasion platforms support the existence of a great variety of invertebrates and are defined as a habitat at risk (in particular following the high mortality rate of the snail species known as *Dendropoma petraeum*). Also located within the area of the proposed alternative is an incubation farm for sea turtle eggs that are transferred to it from all shores in the region. Excavation works within the shore region are liable to cause damage to the incubation farm if such works take place during the laying season. In view of the information on reproduction groupings of two types of groupers in the vicinity of the adjacent Olga shore (see Section 1.9.3.2.2), it would be appropriate to check if a similar phenomenon exists within this alternative, and if so, it will be necessary to take steps to prevent any damage to these two types of fish. **The suitability of the Michmoret alternative for a coastal entry system is defined as low.**

- **Nachal Alexander –** the coastal entry area is located within the Yam-Michmoret reserve and within Nachal Alexander National Park. This region is unique and lies on the seam between rocky shores and sandy shores, as explained in Section 1.9.3.3 above. The reserve and national park area comprise habitats of rocky bedding and abrasion platforms that have been studied for a number of decades and represent an incomparable database. The Nachal Alexander mouth area intensifies the uniqueness of the region and its complexity and supports additional habitats. The performance of works aimed at introducing pipeline into a 350 meter wide corridor in proximity of a few dozen meters from such valuable habitats constitute a risk (even though the relatively safe HDD insertion method is to be used). The duration of the works involved in inserting the pipeline is approximately 35 days and in the course of this period it is possible that sediments and contaminants from various sources in the area may float at the site, which is located at a low point in the direction of the flow of the stream. In other words, it is possible that remains from the work area will find their way downstream (in a general south to north direction) into the rocky regions in the vicinity of the shore. The emergence point of the pipeline onto the shore is planned in the area of the old boathouses. This region is located within the heart of a national park that is frequented by many visitors. As described below the boathouse area is part of a plan for establishment of a national center for the rescue of sea turtles as well as a marine educational center. In my opinion, such plans conflict with the existence of a block and valve for the gas pipe at that location. In view of the above**, the suitability of the Nachal Alexander alternative for a coastal entry system is defined as low.**

- **Neurim –**execution of works for the burial of pipeline in a 350 meter wide corridor and execution of the HDD process in the vicinity of rocky habitats (at a distance of four kilometer and one kilometer, respectively), which are potentially of similarly high value to such habitats located to the north and the south constitute a risk. **At this stage (on account of the absence of any specific information), the suitability of the Neurim alternative for a coastal entry system is defined as low-medium.**

E. Oceanographic and Meteorological Conditions

All alternatives for the construction of an offshore facility for a gas platform are located within a offshore site situated about 10 kilometers from the coast, from Netanya in the south and up to Dor in the north (a distance of about 20 kilometers). In terms of open seas, this is considered a relatively small area. In this area, bathymetric lines run parallel to the coastline from the point of view of the seas meteorological and physical characteristics. Within such a relatively small area, we usually expect rather weak spatial gradients, and **it is therefore reasonable to assume that there is no difference between the proposed alternative sites from this aspect.**

F. Noise

An analysis of the situation within the marine environment is presented in Chapter 1-Section 1.11.2, and indicates that a survey of the literature does not point to any individual characteristics that make it possible to examine and rank alternatives at this stage.

The characteristics detailed in Section 1.11.2 refer to the marine environment in general to the west of the Israeli coastline strip where we may expect an underwater acoustic climate impacted by the movement of sea vessels and oceanographic features (which have been surveyed in the appendix to Section 1.10) of relative similarity oceanographic characteristics.

At this stage, it is therefore not possible to point to a preferred alternative with respect to acoustic aspects.

2.3 Evaluation of Criteria

The evaluation of criteria is qualitative, as stated above, and no weightings have been established for the various parameters. The alternatives were evaluated on the basis of the information presented in Chapter 1 and is based on the following existing information:

The more suitable the alternative is in accordance with the examined parameters – the preference given to its development is high (high ranking).

In the event that the alternative does not have any preference or inferiority vis-à-vis other alternatives – then the priority given to development is medium (medium ranking).

Alternatives that are found to be inferior in accordance with the criteria being examined and are less suitable receive a lower development priority (low ranking).

For the convenience of summarizing and presenting the conclusions, the following key was used to present the bottom line of the summary evaluation of the alternatives' setup elements:

High priority - in green.

Medium priority - in yellow.

Low priority - in red.

Therefore the bottom line of each summary table looks like this:

High priority alternative	**Low priority alternative**	**Medium priority alternative**

Tables 2.3-1/2/3 summarize the evaluation of the alternatives for the western pipeline alignment (from the boundary of the territorial waters to the exploration site), the

exploration sites and the eastern pipeline alignment (from the exploration site to the coastal entry system) respectively.

Evaluation of the alternatives was carried out according to all of the parameters specified above. **The ranking was established vis-à-vis parallel alternatives and is not an absolute value.**

Table 2.3-1: Summary table for the examination of alternatives for the western pipeline (from the boundary of the territorial waters)

Section	Criteria	Corridor 1	Corridor 2	Corridor 3	Corridor 4	Corridor 5	Corridor A	Corridor B
A.	**Land uses and zoning**	**Medium**	**Medium-high**	**High**	**High**	**Medium-high**	**High**	**Low**
B.	**Seismic**	**Medium**	**High**	**High**	**Medium**	**Low**	**Medium-high**	**High**
C.	**Ecology**	**Low**	**Medium**	**High**	**High**	**Medium**	**Medium-high**	**Medium-high**
D.	**Oceanographic and meteorological conditions**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
E.	**Noise**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
Summary		**Low**	**Medium**	**High**	**Medium**	**Low**	**Medium-high**	**Medium**

Table 2.3-2: Summary table for the examination of offshore site alternatives

Section	Criteria	Hadera	Havatzelet HaSharon	Netanya
A.	**Land uses and zoning**	**Medium-high**	**High**	**Medium-high**
B.	**Appearance**	**Medium**	**Medium**	**Medium**
C.	**Seismic**	**Medium**	**Medium**	**Medium**
D.	**Ecology**	**Medium**	**Medium-high**	**Medium**
E.	**Oceanographic and meteorological conditions**	**Medium**	**Medium**	**Medium**

F.	Noise	**Medium**	**Medium**	**Medium**
Summary		**Medium-high**	**High**	**Medium-high**

Table 2.3-3: Summary table for examination of alternatives for the eastern pipeline to the coastal entry systems

Section	Criteria	Marine pipeline alignment up to the coastal entry systems				
		Dor	Hadera	Michmoret	Nachal Alexander	Neurim
A.	**Land uses and zoning**	**High**	**Low**	**Medium**	**Low-medium**	**High**
B.	**Seismic**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
C.	**Ecology**	**Medium**	**High**	**Low**	**Low**	**Low-medium**
D.	**Oceanographic and meteorological**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
E.	**Noise**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
Summary		**High**	**Medium**	**Low-medium**	**Low-medium**	**Medium-high**

2.4 Summary of the examination of alternatives

As already mentioned a number of times in this document, examination of the alternatives for the marine environment was conducted out according to an analysis of existing information only. In some of the areas examined there were information gaps owing to an absence of data and the inspection was performed as stated above on the basis of assumptions relying on existing information. At the next stages, field studies and more specific investigations of the marine environment will be conducted in order to complete Chapters 3-5 of the Environmental Impact Survey and make it possible to promote a detailed plan.

The goal of this chapter is to select the most preferable site, to examine the advantages and disadvantages of each of the proposed sites and pipeline alignments, based on existing information and ultimately to recommend the most suitable setup within the total range of aspects that we have considered, in which it is possible to achieve a minimum of conflicts in the event that the plan is promoted there.

On the basis of existing information and its analysis, it appears that none of the alternative locations for the facilities was found to be significantly more suitable than the other alternatives. All three sites were found to be appropriate and suitable. Nevertheless, weighting the ecological and geological aspects give a certain priority or preference to the Havatzelet HaSharon site. From a geological point of view, on the basis of existing information, the area of spread of the shallow gas layer within the Havatzelet HaSharon alternative is more limited as compared to the Netanya alternative. If there is indeed a connection between the existence of shallow gas and geotechnical failures (as proposed by Golan, 2012) then the probability that such failures will be found within the Havatzelet HaSharon alternative is lower than the probability of their existence within the Netanya alternative.

In addition, alignment of the pipeline to the coast also depends on the location of future offshore drillings and the onshore treatment setup that has been considered in the context of the onshore environmental impact survey, which considered two treatment setups: Dor and Hadera-Neurim. An examination of the offshore alternatives also takes these setups into consideration.

For each of the three sites considered for a treatment facility, we recommend the following component setup:

Hadera – Western pipeline alignment: Corridor A and from it to Alternative 3 and with secondary preference given to Alternatives 4 and 2.

Eastern pipeline alignment: For the Hadera-Neurim setup – an alignment to Neurim is given high preference and more secondary preference is given to the other alternatives with a certain preference for the alignment that proposes entry at Hadera. For the Dor setup - the alignment leading to Dor.

Havatzelet HaSharon – Western pipeline alignment: Alternative 3 and secondary preference for Alternatives 4 and 2.

Eastern pipeline alignment: For the Hadera-Neurim setup – the alignment to Neurim has higher preference and the other alternatives have secondary preference with a certain preference for the alignment entering at Hadera. For the Dor setup – the alignment leading to Dor.

Netanya –Western pipeline alignment: Alternative 3 and secondary preference for Alternatives 4 and 2.

Eastern pipeline alignment: For the Hadera-Neurim setup – the alignment to Neurim has higher preference and the rest of the alternatives have secondary preference with a certain preference for the alignment entering at Hadera. For the Dor setup – the alignment leading to Dor.

Note – Given the absence of up-to-date information regarding the marine environment, it is recommended at this stage to maintain maximum flexibility regarding the planning of the offshore setup (for example, by maintaining a number of possible corridors for the pipeline) for the execution stage in order to avoid obstacles or damage to environmental values that maybe found by the developer only during the execution stage.

As stated above, the examination of the alternatives was conducted in three stages as detailed below:

A. Comparison of alternatives for each element in the total array: (1) Western pipeline alignment (2) Offshore sites (3) Eastern pipeline alignment.

B. Selection of the total preferred treatment setup for each of the alternatives from among the exploration sites (as stated the total array includes 1-3 above).

C. Comparison of the three alternatives for the total array and their ranking according to preference vis-à-vis the aspects considered.

In view of the above and Tables 2.3.1-3 above, the following table summarizes the ranking and evaluation of the total array of components within the treatment setup:

Table 2.4-1: Summary table of examining the alternatives

Alternative / Component in the treatment setup	Hadera	Havatzelet HaSharon	Netanya
Western pipeline alignment	Corridor A + Alternative 3 (alternative 4 and 2 have secondary preference)	Alternative 3	Alternative 3
Offshore site			
Eastern pipeline alignment	Dor	Dor	Dor

	Neurim	Neurim	Neurim
Summary	**Medium-high**	**High**	**Medium-high**

Appendices

Appendix A - Survey Guidelines

State of Israel
Ministry of Environmental Protection
Policy and Planning Cluster
Planning Division

Nissan 6, 5772

March 29, 2012

To Mr. Amram Kalaji

Chair of the National Planning of Building Board

Director-general, Ministry of the Interior

Jerusalem

<u>Updated Guidelines for the Environmental Impact Survey Chapters 1-2 NOP 37/H – Treatment Setups for Offshore Natural Gas Discoveries and their Connection to the National Transmission System</u>
<u>Onshore Facilities Component</u>

Dear Mr. Kalaji,

Enclosed please find a draft of guidelines for the Environmental Impact Survey for the entry setups and onshore components of the treatment facilities for offshore natural gas discoveries. This draft of guidelines is intended for discussion and approval by the National Planning and Building Board at its meeting scheduled to take place on April 3, 2012.

These guidelines are intended to provide an appropriate environmental response for the coastal entry systems and for the onshore components of the gas treatment facilities and are submitted following a decision of the sub-Committee for Essential Planning Issues of March 13, 2012 and the progress of the plan in two parts: one part which is mostly marine (from the boundary of the territorial waters to the offshore transmission system) and is covered by guidelines approved in the past by the National Board, and one part that is mainly onshore that begins from the offshore transmission system through coastal entry systems, the onshore block and valve, onshore pipeline setups, the treatment system, the INGL measuring facility and connections to the onshore transmission system and additional systems (such as fuel, electricity, roads, etc.).

The purpose of these guidelines is to examine the optimum alternative for construction of the entry setup and the onshore component of the natural gas treatment facilities.

Respectfully,

Shahar Solar
Head, Environmental Planning Division
and Green Construction

cc:
MK Gilad Erdan - Minister of Environmental Protection
Advocate Alona Sheffer Caro – Director-General, Ministry of Environmental Protection
Mr. Shaul Tzemach - Director-General, Ministry of National Infrastructures, Energy and Water Resources
Ms. Binat Schwartz – Director of the Planning Administration, Ministry of the Interior
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Ms. Dorit Hochner - Ministry of National Infrastructures, Energy and Water Resources
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State of Israel
Ministry of Environmental Protection
Policy and Planning Cluster
Planning Division

Nissan 2, 5772
March 25, 2012

Updated Guidelines for the Environmental Impact Survey Chapters 1-2 NOP 37/H – Treatment Setups for Offshore Natural Gas Discoveries and their Connection to the National Transmission System
Onshore Facilities Component

Introduction

In accordance with the guidelines of the sub-Committee for Essential Planning Issues of March 13, 2012, enclosed are guidelines for the preparation of Chapters 1 and 2 of an Environmental Impact Survey for treatment facilities for offshore natural gas discoveries and their connection to the national transmission system.

The guidelines apply to offshore pipelines (from the offshore transmission pipeline up to the coast), the setup that crosses the shore, the onshore block and valve, the onshore pipeline that leads to the treatment facility, the treatment facility itself, the onshore pipeline that connects to the INGL facility and the pipeline that connects between the INGL facility and the national transmission system. In addition, the guidelines also address all of the pipelines and infrastructures that accompany these systems such as roads, voltage lines, gas pipes, fuel pipes, etc.

With regard to the offshore pipelines, there are three possible laying systems:

1. HDD/jacking.

2. Burial that may create significant disruption of the seabed.

3. Laying the pipeline on the seabed itself.

Therefore, all three methods must be addressed in accordance with the relevant issue under consideration.

General

A. The guidelines in this document are intended for the approval of the National Planning and Building Board at its meeting of April 3, 2012.

B. The survey will be prepared under the responsibility of the plan developer.

C. The survey will include the name of the person responsible for conducting it as well as the names of professional service providers that will participate in preparing the survey and in evaluating the various environmental impacts.

D. The survey preparer and professional consultants will complete and sign appropriate affidavits (Forms 1, 2) in accordance with Regulation 14-C of the Planning and Building Regulations (Environmental Impact Surveys) 5763 2003.

E. The survey will begin with an abstract that presents the main findings.

F. The survey will be submitted on digital media – a <u>continuous</u> doc or PDF file. The document figures will be presented in a DWG file (in a vector mapping format compatible with AutoCad software).

G. The survey will address all of the plans elements at as detailed a level of planning as possible.

H. The survey will include full reference to each section of the guidelines according to the order of the guidelines. <u>A survey that is not submitted in full will be returned without being reviewed.</u>

I. In the event that a certain section is submitted in a different format than requested, the submitter will attach the reasons for the change.

J. These guidelines will constitute part of the survey and will be appended to it as an appendix.

K. The document will include a bibliographic list and data sources used by the survey preparer.

L. The survey will be submitted in five copies to the Ministry of Environmental Protection – Planning Division. In accordance with Section 9-A of the regulations, the survey will also be submitted to the planning institute (the National Board) and to the relevant local planning and building boards.

M. These guidelines are valid for three years from the date on which they are approved by the National Board.

N. The survey will comprise the following chapters as detailed below.

Chapter 1: Description of the Environment Addressed by the Plan

1.0. General

The existing environmental system is the starting point for predicting future environmental impacts. For this reason the environmental issues presented in this chapter will be used in subsequent stages of the process for describing and examining the impacts following the project's construction and operation and its various parts including the treatment facilities, pipelines, block and valve stations, and all of the accompanying infrastructures.

As a consequence, the description of the environment will focus on the project area, project parts and their immediate environment as well as the corridors through which the various pipelines are to be placed, but must also cover additional areas that are liable to be impacted by the project's construction and operation. The environmental data required for this chapter must focus on the appropriate areas for the expected impact, so that they can serve as a basis for examining alternatives in a detailed way in subsequent chapters.

It is important to use up-to-date maps and up-to-date graphic descriptions in order to ensure that the description is both clear and concise. Note should be made of the various information sources: such as field measurements, literature, approved outlined plans, environmental impact surveys, and the like.

1.1. Background maps

1.1.1. Treatment facilities, the onshore block and valve and additional onshore infrastructures (separate maps may be appended as necessary):

These maps will cover the sites and transmission systems leading to and from them (including all accompanying infrastructures):

1.1.1.1. Topographic map on a 1:10,000 scale covering a radius of two kilometers around the boundaries of the sites. The map will cover such data as roads, localities, structures, and facilities. Moreover, the gas, electricity, and fuel lines existing in the area should be marked on the map. This map will serve as a background map.

1.1.1.2. A 1:2,500 scale map that covers the entire site area, separation distances from hazardous materials as well as a radius of 500 meters beyond them. Site boundaries must be marked on the map. The map will cover roads, settlements, various types of residential areas, agricultural activity zones, tourist activities, infrastructure facilities and lines (such as gas/fuel/electricity), industrial plants, existing and planned sewage facilities, etc.

1.1.1.3. Up-to-date color aerial photograph on a scale to 1:5,000 of the plan environment within its onshore area up to a distance of one kilometer from its boundaries, including 300 meters west of the coastline and including a marking of the proposed plan area. Photographs must be taken under quiet sea conditions with a wave height of less than 30 centimeters during the autumn season (second preference for the spring season).

1.1.2. Offshore infrastructures:

The following three maps are to be prepared:

1. General bathymetric map for each offshore part of the project of a scale of 1:50,000.
2. A detailed bathymetric map of the coastal area on a scale of 1:50,000 from a depth line of 10 meters from the HDD entrance area, the furthest among them, up to a height of three meters above the national zero balance line.

Emphasis of the three above maps:

- The vertical gap will be no more than one meter.
- The maps will cover a distance of at least 250 meters, on each side of the pipeline corridor.
- The maps will cover offshore infrastructure facilities, outlets to the sea, artificial structures and objects at sea (buoys, sunken ships, etc.), archeological sites, port areas, sailing routes, nature and national parks, marinas and surf breakers, offshore firing areas and any other relevant information.
- The maps should also show the proposed pipeline alignment. The pipeline boundaries should be marked to according to the various segments: the HDD, the seabed burial area and the areas in which the pipeline is to be merely placed onto the seabed.

1.2. <u>Existing and planned land usage</u>

1.2.1. Two maps will be submitted (that cover the sites and the transmission systems to and from them):

- These maps will cover the treatment facilities, the onshore pipeline and the accompanying infrastructures including block and valve stations and will cover an area of 300 meters (at least) west of the shoreline.

A. Land zoning map (for approved usage or land uses that are currently being planned).

B. Existing land usage (in actual practice).

Maps A and B will be presented on the background of a topographic map drawn to a scale of 1:25,000 within an area of one kilometer around the site boundaries. Maps will address the following issues:

- Residential buildings and public institutions (both existing and planned).
- Industrial zones and plants.
- Quarrying and excavation sites.
- Military and defense system areas and facilities.
- Nature reserves, national parks and landscape reserves, rivers.
- Heritage sites.
- Tourism, hotel and leisure facilities.
- Ecological corridors on a national level.
- Roads (including both paved and unpaved roads) and railway tracks.
- Paths and hiking routes.
- Agricultural and fish pools and cultivated areas.
- Infrastructure facilities such as electricity production, electricity transmission lines, petroleum and gas transmission pipeline.
- Facilities for handling existing and planned wastewater.
- Other.

1.2.2. The land zoning map will include reference to the relevant National Outline Plans including NOP 35, NOP 8, NOP 13, NOP 22. Refer as well to other relevant District Outline Plans and detailed local plans. Reference should also be made to outline plans that are relevant to open areas.

- The pipeline alignment will be surveyed at a radius of 100 meters around the pipeline corridor and at the relevant scale that will allow clear presentation of the information.

1.3. <u>Population centers</u>

1.3.1. The following data should be presented graphically in tables and with explanatory texts. Various populations should be described both in their existing status and in their planned status (demographic forecast for five and 10 years):

A. Residential populations and sensitive uses**,** such as hospitals, sheltered housing, public buildings, and the like.

B. Permanent population in occupational centers.

C. Transient populations (commercial centers, sport and leisure sites, hotels, entertainment venues, etc.).

1.3.2. The data will presented in the following way:

A. Distribution of the population in rings (every 100 meters) and in regions surrounding each site up to a distance of 600 meters from the site.

B. Accumulated populations in rings and regions.

1.4. <u>Meteorology and air quality</u>

1.4.1. General: Present the background data of the existing air quality in this section in accordance with the requirements presented in the following sections.

1.4.2. Basic meteorological data that include the relative frequency of wind speed and direction (wind vane), temperature, relative humidity, and atmospheric stability. Data will be collected from a meteorological station that represents the conditions prevailing in the proposed station area in the most optimal fashion and will be based on multiannual measurements conducted in the area of each of the sites on both a seasonal and 24-hour basis. The source of the data, the location of the measuring stations, and the duration of the measurement should all be noted with reference to their compatibility with the site terrain.

1.4.3. Note particular meteorological conditions that are liable to cause problematic conditions of spread for the environment, such as strong western winds, unstable situations, etc. and note their relative frequency.

1.4.4. Status of air quality today and forecast for the future (5 years, 10 years). The description will cover the main air pollution sources and quantity of pollutants that are discharged from them. Air pollutants to be considered are: sulfuric oxides, all volatile hydrocarbons, nitrogen oxides, and ozone about 40 kilometers in the direction of the prevailing downwind in the area during the day. The option of unifying the gas exhausted from the facility and the smoke rising from stacks in the vicinity should be considered.

1.4.5. The conditions of the dispersion of air pollutants in the surveyed region and its immediate environs. The description will also include a graphic depiction using isoplates.

1.5. Appearance

1.5.1. Present a visual analysis (using photographs and a verbal description) of the planned site against the background of the environment. The analysis will include the visual basin from which the facility and its associated infrastructures are seen (such as roads and electricity, infrastructures, engineering facilities, pipeline works, etc.).

1.5.2. Provide sections from prominent points in the field and from points of localities (such as from the north and the west, the Givat Eden neighborhood in Zichron Yaakov, from the south, from the center, and from the north the village of Fureidis, from the Zichron Yaakov Interchange on the coastal road, and from the direction of Moshav Dor), roads and paths, from hiking routes, parking lots, and observation points from nature landscape and heritage sites.

1.5.3. Present gate valves along the alignment in similar fashion.

1.6. Seismology

1.6.1. Identify the level of seismic intensity coefficient according to the specifics provided by the existing Israeli Standard 413. In addition, reference should be made to the coefficients provided by the proposed amendment sheet number 3, of IS 413.

1.6.2. Reference should be made to the possibility of the existence of active geological faults within the plan area.

1.6.3. Address the phenomenon of increased seismic vibrations following certain sub-base conditions or topographic conditions.

1.6.4. Address the phenomenon of soil failure as a consequence of soil slumping (with special emphasis on the continental slope in accordance with the location of the facilities, pipeline, etc.).

1.6.5. Address the phenomena of soil failure as a consequence of liquefaction.

1.6.6. Address the possibility that a tsunami will develop and strike the shore, including a temporary decline in sea level and retreat of the waterline.

1.7. Hydrology and soil

1.7.1. Employ a 1:20,000 scale aerial photograph to present the following data along with appropriate texts. The data will be presented up to a distance of two kilometers from the plan area (treatment facilities, block and valve stations, and their accompanying infrastructures):

- Drainage system, both artificial and natural drainage alignments, valleys and springs.
- Wells and drillings for potable water, water for desalination, irrigation or dewatering in the request area, as well as protected radiuses around them.
- A risk level for groundwater contamination .
- Catchment facilities for runoff.
- Areas in which there is suspected contaminated soil as a consequence of storage work or industry activities within the area of the plan under consideration.

1.7.2. Describe the soil structure for the purpose of addressing mechanical engineering qualities such as: stability, erosion, structure, and texture.

1.7.3. Describe the structure of the soil for the purpose of reference to hydraulic qualities such as: hydraulic conductivity, penetrability to groundwater.

1.7.4. Describe the hydrological system and present data regarding groundwater basins, their quality and their sensitivity to contamination, the geomorphological data that influenced the drainage system, the extent of runoff penetration, and the connection between runoff and the underground aquifers.

1.8. Hazardous materials

Append a report stating the separation distances in accordance with the circular of the Director-general of the Ministry of Environmental Protection (for each relevant element of the project!).

1.9. Nature, landscape, and heritage values

- **Landscape unit –** Map and provide a textual description of landscape units and landscape features of the plan areas and its immediate environment. Provide details of natural landscape systems and those that are natural and anthropogenic landscape systems. Provide details regarding the specific locations of the sites from the aspect of habitat segmentation.

- **Flora** – Present the spread of natural flora populations within the plan area up to a relative range surrounding its boundaries. The data should be presented both in text and on a map drawn to a relevant scale. This will include focus on red, rare, unique (endemic) species or species worthy of preservation. If necessary, note centers of invasive species. (The Biogis website, the Israel plants information center website, surveys of the Society for the Protection of Nature, the website of the Ministry of Environmental Protection, the Red Book, and similar websites may be used).

- **Fauna** – Mark the existence of faunal populations on a map drawn to a relevant scale including reproduction sites and fowl nesting sites, with an emphasis on rare animals living within the plan area and the plan's expected impact. (Reference may be made to the Society for the Protection of Nature surveys, the Ministry of Environmental Protection website, the Red Book of Invertebrates in Israel, and the like).

- **Heritage** – Provide details of heritage sites and historical sites located within the plan area.

1.10. <u>Oceanographic and meteorological conditions</u>

1.10.1. Describe the relative frequency of wind speed and direction (wind vane) from the coast to a seabed depth of 60 meters and the wave regime at this depth.

1.10.2. Note meteorological conditions that are liable to cause problems with the motion of sand in the area including removal of sand layers and exposure of the pipe.

1.11. <u>Noise</u>

1.11.1. Onshore environment – Describe the noise levels measured today at various points within the plan boundary and the sensitive uses that exist and are planned within that environment (measurements will be carried out day and night, and for minimum time durations of a number of minutes), up to a distance of one kilometer from the plan boundary. Noise levels should be measured and defined in accordance with Regulations for the Prevention of Hazards (Unreasonable Noise) – 1992, including a spectrum of 1/3 octave.

1.11.2. Marine environment – on the basis of existing data (literature and existing information basis) describe the noise intensities currently prevailing within the plan area.

Chapter 2: Examination of Alternatives

2.0. This chapter will present the characteristics and requirements of the plan elements, including: offshore and onshore pipeline systems (from the offshore transmission system and eastwards); the gate valve at the coastal entry point; the onshore pipeline corridor; the gas treatment facility; the INGL receiving facility and onshore pipeline systems; accompanying infrastructures (voltage lines, access routes, security installations). The purpose of this chapter is to present a full picture of the plan elements in order to examine the optimum alternative.

- Address separately both technological alternatives and location alternatives. It is permitted to maintain the option for a number of technological alternatives within the same area cell as a function of location rather than determine a single technological alternative.
- Address each element in the system separately so that it will be possible to isolate its impact as well as examine the plan's impact in general. If there are significant elements such as ventilation stacks, fuel containers, and the like, also present micro alternatives for these that can lead to minimizing their environmental impact.

Design principles guiding the selection of alternatives:

- Preventing risk to the population.
- Minimizing damage to valuable open spaces.
- Minimum footprint, and adhering as much as possible to existing structures and infrastructures or location within development-oriented areas.
- Minimum damage to the space (appearance, visibility).
- Maintenance of the existing human and ecological function, within the offshore littoral and onshore space.

In evaluating the alternatives the following issues should be addressed, *inter alia* and as detailed in the methodology below:

- The required scope of the area, with an emphasis on: the number of facilities; area of the facilities; width of the strip that crosses the coast; area required for the gate valve, including alternatives for its location and an option for burying it; construction adjacent to existing/planned infrastructure;

- Parameters related to safety and prevention of environment risks.
- Ecological limitations.
- Possible damage to various land uses, including agricultural areas and the coastal strip.
- Environmental considerations: disruption of open areas of value and other types of areas; deterioration of air quality; exceptional visibility (preference to small containers); spatial prominence (preference to construction without a torch).
- Use of existing infrastructures and construction adjacent to such infrastructures (including connection to the national electricity grid, gas transmission system, fuel transportation system, systems for removal of water, effluents, and the like. Special emphasis will be placed on building onshore pipeline systems adjacent to existing infrastructures and roads).
- Defense system limitations.
- Planning availability of the soil.
- Options for future development including gas receiving at varying qualities and from other drillings.
- The various station facilities and their environmental impact (communications antennae, vent stack, fuel containers and facilities, storage and handling of chemicals, and the like).

2.1. Methodology to be used for presentation and evaluation of the alternatives

This section should present the facilities being examined in general (using text and graphics). Address the various alternatives separately with reference both to technological alternatives and location alternatives.

Technological alternatives

Itemize the advantages and disadvantages of each technological alternative with a description of the main features of the facilities and their operation, including the main components, and to note, with regard to each component, facility, or stage of production the environmental implications of each: its footprint, its environmental impact as regards to air pollutants, the risk to the population, noise, water pollution, and minimizing the damage to landscape and the ecology created by the facility and the infrastructure lines leading to and from it, and so on.

Address the various technology of different components, such as the technology of the onshore gate valve, and not just the technology of the main treatment facility.

<u>Location alternatives</u>

Present location alternatives for the various facilities. The alternatives will be presented for all elements in the system (as relevant) including pipelines, the gate valve, the treatment facilities, the INLG facility, and all accompanying infrastructures.

2.1.1. Submit relevant documents and drawings describing the facility for each alternative.

2.1.2. Present the criteria used for the consideration and comparison of alternatives, features, and characteristics for each alternative as well as any requirements that influence the facility location, including planning considerations (including reference to approved plans and plans in various planning stages), safety considerations, transportation considerations, environmental considerations, landscape considerations, visual considerations, and others.

2.1.3. Submit a <u>report for separating distances</u> for each alternative. This report will describe, analyze, and examine the implications arising from the implementation of each alternative for its environment with reference to the difference between alternatives.

2.1.4. Submit an essential <u>landscape analysis</u> for each alternative describing, analyzing, and examining the landscape implications arising from implementation of each alternative by means of simulations, photographs, and sections.

2.1.5. Examination of the alternatives will be carried out on the basis of the following issues and criteria:

A. The expected level of risk, as regards the population within the facility and in its vicinity.

   – Safety distances around the facility.

B. Savings in soil resources.

   – The difference in the consumption of land areas by the various alternatives.

C. Proximity to existing and planned infrastructures.

- Drainage system.
- Electrical conductivity lines.
- Proximity to the gas supply pipeline system.
- Proximity to existing ways and roads.

D. Building limitations surrounding the facility as a result of its construction.

   - Safety distances around the facility.
   - Analysis of the activities to be limited following operation of the facility.
   - The way in which the limitations have been quantified and weighted.

E. Fill surpluses – total scope of earthworks (divided according to quarrying and filling) for the purpose of construction the facility, including possible solutions.

F. Natural resources

   - The facility's ecological impact range within each alternative.
   - The extent of damage to the biodiversity of habitats in the area (onshore and offshore).
   - Sedimentology aspects.
   - The extent of damage to the sea and the beaches.
   - Emergency preparation methods.

G. Air pollution – the extent of the difference in the impact on air quality as a consequence of malfunctions as compared between the various alternatives.

H. Onshore and offshore antiquities and heritage sites.

   - The extent of proximity to archeological sites.
   - The ability to preserve archeological and heritage sites.

I. The potential for conflicts between the proposed facility and its immediate environs.

- Comparative presentation (either via graphics or text) of the level of environmental sensitivity as compared with the expected level of damage (for example, the intensity of the landscape hazard, the intensity of damage to open areas, etc.).

- A list of possible conflicts, including an analysis and characterization of the intensity of the conflict, its complexity, and proposals for its solution.

J. The way in which the facility is integrated into its environment in view of future land use designations.

K. Continuity and sensitivity of open spaces.

- The damage to continuity (segmentation) of open spaces caused by the facility.

- The extent of damage (intensity of the damage) to various protected areas either approved or proposed in national, district, and local plans.

- Potential for additional future damage to open areas as a result of the facility and maintaining land reserves for future development.

L. Leisure and recreation – the extent of damage to leisure and recreational land uses.

- The extent of damage to the experience of being in an open space in nature.

- The expected impact on and accessibility to visitor sites and hiking routes in the plan vicinity.

M. Landscape - visual.

- The level of damage to the quality of the open space vis-à-vis the landscape.

- The scope of visibility towards the region from various spots in the area.

- What is the extent of integration in the skyline and the plan's presence in the environment.

- Potential for and intensity of additional damage as a result of accompanying infrastructures (roads, voltage lines, etc.).
- To what extent will the existing landscape be damaged by earthworks associated with construction of the facility.

2.1.6. The evaluation of each criterion, for each alternative, will be determined on a scale of three ranks: significant damage, medium damage, and minimum/no damage.

2.1.7. The points or evaluation given for each criterion will be detailed and justified by text, graphics, by data from various information sources such as on site measurements, reports, literature, plans, etc., and will be based *inter alia* on the data and analysis carried out in Chapter 1 of the survey.

2.1.8. In cases where the criterion is a quantitative one, note the quantitative data for each alternative and give a relative ranking to each alternative in accordance with the quantitative data received.

2.1.9. Present micro-alternatives for the station with reference to the facility's physical dimensions: the option for limiting the area by making more efficient use of the soil, visual aspects – height, color, form. Present the considerations that led to the choice of the micro-alternative.

2.1.10. For the summary of the alternatives selection process, provide details and present the selected alternatives, both technologically and from the point of view of location, and analyze the environmental and other advantages and disadvantages of these alternatives as compared with other alternatives that were examined in accordance with these instructions.

Appendix A1 - Summary of Meeting with the Ministry of Environmental Protection on the Subject of Oceanographic and Meteorological Conditions

Summary of Discussion Dated August 1, 2012, on the Subject of "Oceanographic And Meteorological Conditions" in the Guidelines to Chapter 1 of the Environmental Impact Survey for NOP 37/H

Participants: Dr. Dov Tzvieli consultant to the Ministry of Environmental Protection

Professor Steve Brenner, Professor Yuval Cohen, design team for NOP 37/H

Background

In the section "Oceanographic and Meteorological Conditions" in the guidelines to Chapter 1 of the Environmental Impact Survey for NOP 37/H, it was stated "describe the relative frequency of wind, speed, and direction (wind vane) from the coast to a seabed depth of 60 meters and the wave regime at this depth." In a discussion with the Ministry of Environmental Protection (Shahar Solar) on July 11, 2012, the planning team has proposed to utilize the existing information provided by the Environmental Impact Survey carried out for the LNG buoy as the basis of the information for the purpose of this guideline, and it was agreed that the matter will be checked with Dov Tzvieli on behalf of the Ministry of Environmental Protection.

Agreed

Wind – the winds regime will be described in the survey on the basis of a re-analysis of NCEP (the National Center for Environmental Prediction of the US Meteorological Service).

Waves – the text provided by the LNG survey (Section 1.8.1 ibid) is inappropriate for the requirements of the above guideline for the NOP 37/H Survey. The report provided by the Institute for Marine Engineering Research (CAMERI) number 751/11 that was submitted following the LNG survey as a precondition for receiving the construction license for the LNG buoy does meet the requirements of said guidelines for the NOP 37/H survey. For this reason, in the body of the survey a synopsis of said CAMERI report will be presented and the report itself will be enclosed as an appendix to the survey.

Recorded by: Y. Cohen

Appendix B – Kurkar Ridges on the Israeli Coastal Continental Shelf

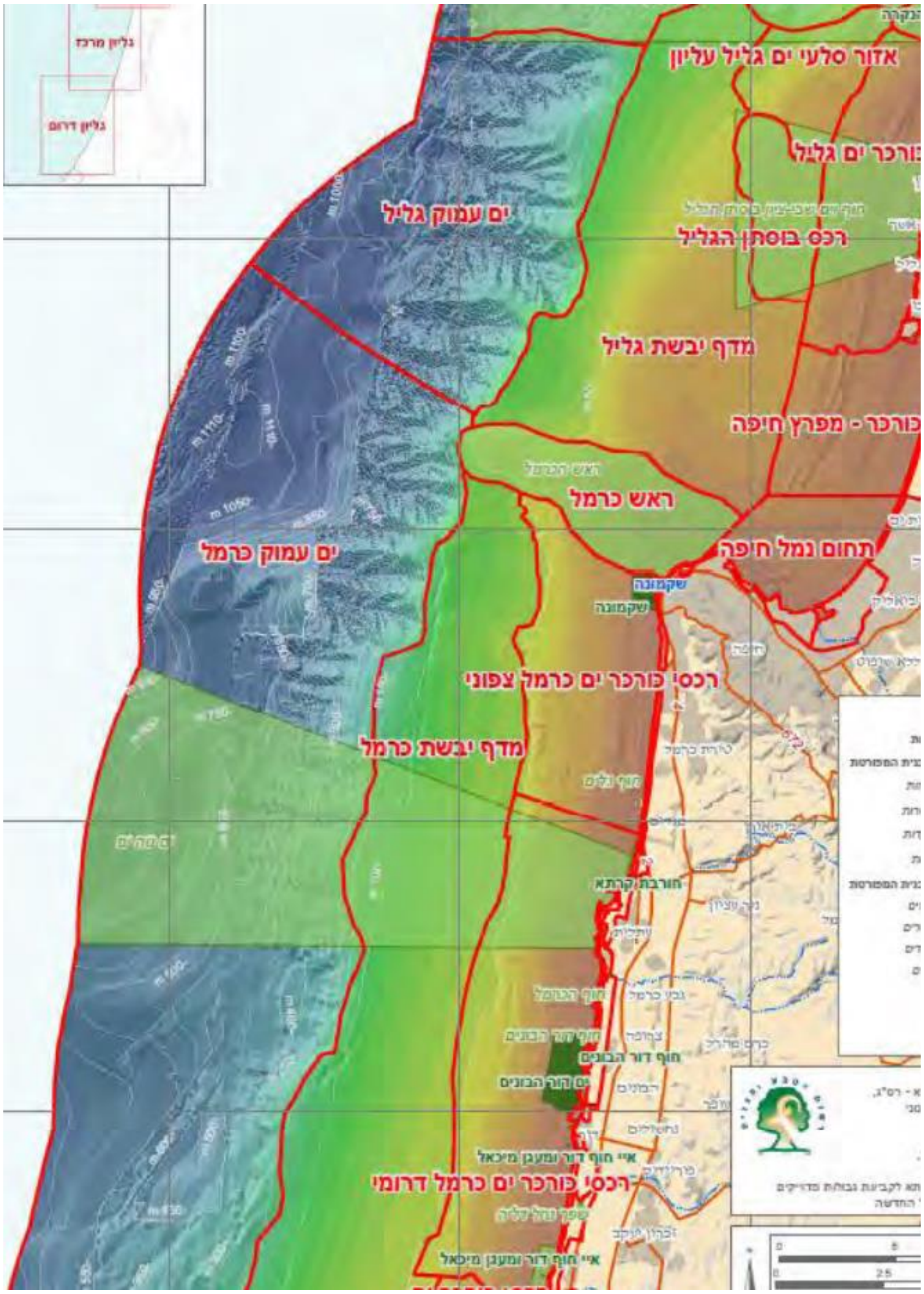
The coastal plains of the northern Sinai and Israel and a considerable part of the continental threshold are currently covered with dunes that slowly stabilize from the Gaza area northward, and have even undergone some extent of fossilization that led to the formation of kurkar ranges running parallel to the coast and troughs (longitudinal depth) between them. (5). Long and narrow kurkar ridges form an arc shaped beam in parallel with direction of the shore that becomes increasingly narrow towards the north (5). The kurkar ridges that are imprinted within the continental threshold continue from the area of the Bardeweel Lake opposite Sinai and up to Rosh Hanikra. They, too, are organized in the shape of a beam that becomes increasingly narrow as towards the north (they are mostly covered by a layer of silt and clay originating in the Nile, but there are various places where the peaks of these ridges protrude from the silt of the seabed (Almagor, 52.2).

The easternmost submerged ridge that continues from the shores of northern Sinai to the underwater Carmel snout, it is the most prominent and continuous of the ridges in the continental threshold opposite the Sinai coast, about two kilometers from the shore (a water depth of 2.5-51). This is a low hump a few kilometers wide, but its height just 2-51 meters only (5) opposite the Peleshet coast, its width about one meter and its distance from the shore about two kilometers, depth 2.5 (and opposite the Sharon coast, Caesarea, and the Carmel it is 5-8 kilometers from the shore (depth 1-5). Its width narrows down to a few hundred meters and its peaks rise to 21 meters above at the bottom of the troughs buried on both its sides and about five meters above the seabed opposite the Sharon coast. This ridge is not continuous – long segments are buried under silt and clay a few meters thick and there are some sections where the ridge does not exist at all from Atlit to the Carmel snout. The kurkar ridges and the troughs between them are exposed in the submerged Carmel snout, where three wide abrasion platforms are visible and there are no kurkar ridges (Almagor, 5.22).

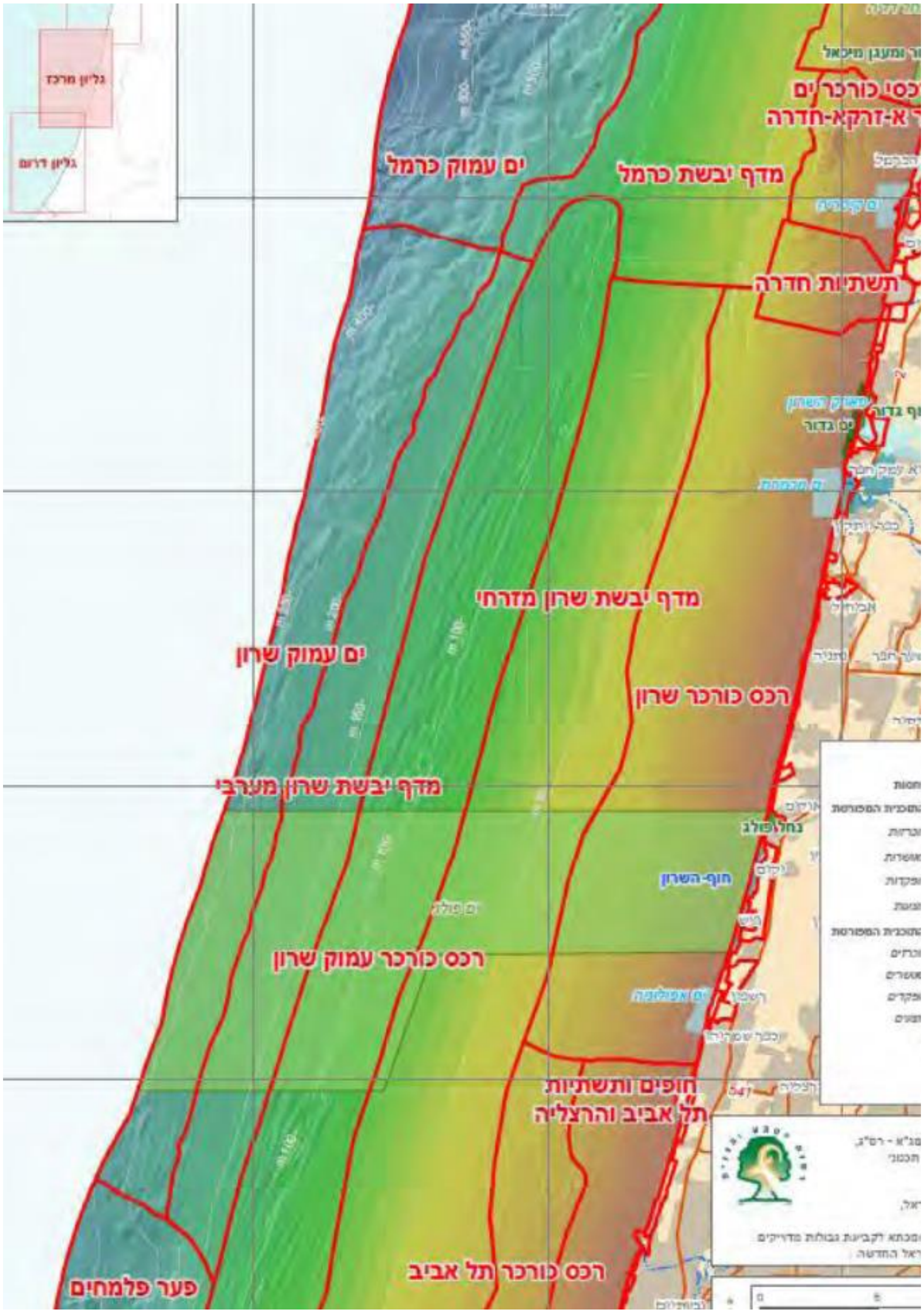
The westernmost ridges of the Mediterranean continental threshold and those at its deep end are more moderate than the eastern ridges, and they are shaped like wide waves a number of kilometers facing El-Arish, hundreds of meters facing Atlit with a wave trough of up to five meters. Because of the width of their waves and the shallowness of their amplitude, it is very difficult to map them. Opposite the Sinai coast and the south of Peleshet the ridges are continuous in the Mediterranean threshold up to a depth of five meters. They are covered with silt and clay up to a thickness of 21 meters, but at greater depths they are exposed for considerable distances. The morphology of the exposed kurkar is rocky, sharp, and irregular. Opposite Israel's coast the western submerged ridges are very much segmented and are covered with a thick layer of silt and clay with a thickness is as high as eight meters in the troughs facing Givat Olga and the Carmel coast.

Only a few kurkar peaks protrude from the surface of the seabed and they emerge as ridges up to a height of 21 meters (Almagor, 5.22).

Appendix C – Reference Segments in the Marine Environment (Engert and Yahel, 2011)



(Engert and Yahel, 2.55)



(Engert and Yahel, 2.55)

Bibliography