1.0 CHAPTER A – DESCRIPTION OF THE CURRENT MARITIME ENVIRONMENT TO WHICH THE APPLICATION RELATES

1.1 General

Noble Energy Mediterranean Ltd (Noble Energy) is planning to develop the Leviathan Field, which is located approximately 125 km west of Haifa, Israel, in the Mediterranean Sea at a water depth of approximately 1,700 m. Additionally, Noble Energy is developing a gas production and transportation system connecting the Leviathan Field to the Israeli gas market infrastructure off the northern coast of Israel, herein termed the Leviathan Field Development (Figure 1-1). Natural gas from the North and South Leviathan lease blocks will be produced from subsea wells in the Leviathan Field and transported through subsea production flowlines to a production platform and then to a landing location in the vicinity of Dor through a transportation system (pipeline). The Leviathan facilities will be operated by Noble Energy.

The pipeline has been separated into three sections for the purpose of describing the existing environment. The base of the continental slope is not well defined in this area. Based on examination of biological (infaunal) data, an order of magnitude increase in the density of infaunal organisms occurs between the 500- and 1,000-m depth contours. Consequently, Pipeline Section 1 is defined as the area located between the Leviathan Field and the 500-m depth contour (i.e., 500 to > 1,600 m). Pipeline Section 2 is defined as the area located between the 200- and 500-m depth contours. Pipeline Section 3 is defined as the area located between the 200-m depth contour and the pipeline landing near Dor (i.e., 0 to 200 m).

Noble Energy plans to conduct well drilling, completion activities, and infrastructure installation for gas and condensate production in the Leviathan Field offshore Israel. Noble Energy's development plan for the Leviathan Field includes the drilling and completion of up to 29 wells, the installation of a subsea pipeline between the Leviathan Field and a production platform, and continuing to a landing near Dor. The final number and locations of wells will be selected based on factors such as reservoir performance, reservoir connectivity, development phases, production profile, shallow hazards, and future appraisal.

The Environmental Impact Assessment (EIA) was prepared for the Ministry of National Infrastructures, Energy and Water Resources (MNIEWR) and the Ministry of Environmental Protection (MoEP, formerly the Ministry of the Environment) in accordance with the "Instructions for Preparation of an Environmental Impact Document in the Economic Waters for the Installation, Operation and Maintenance of Submarine Systems and Laying of Pipelines in the Leviathan Field Development Project (Leases I/14 and I/15)" dated 14 April 2016 (Appendix A-1).

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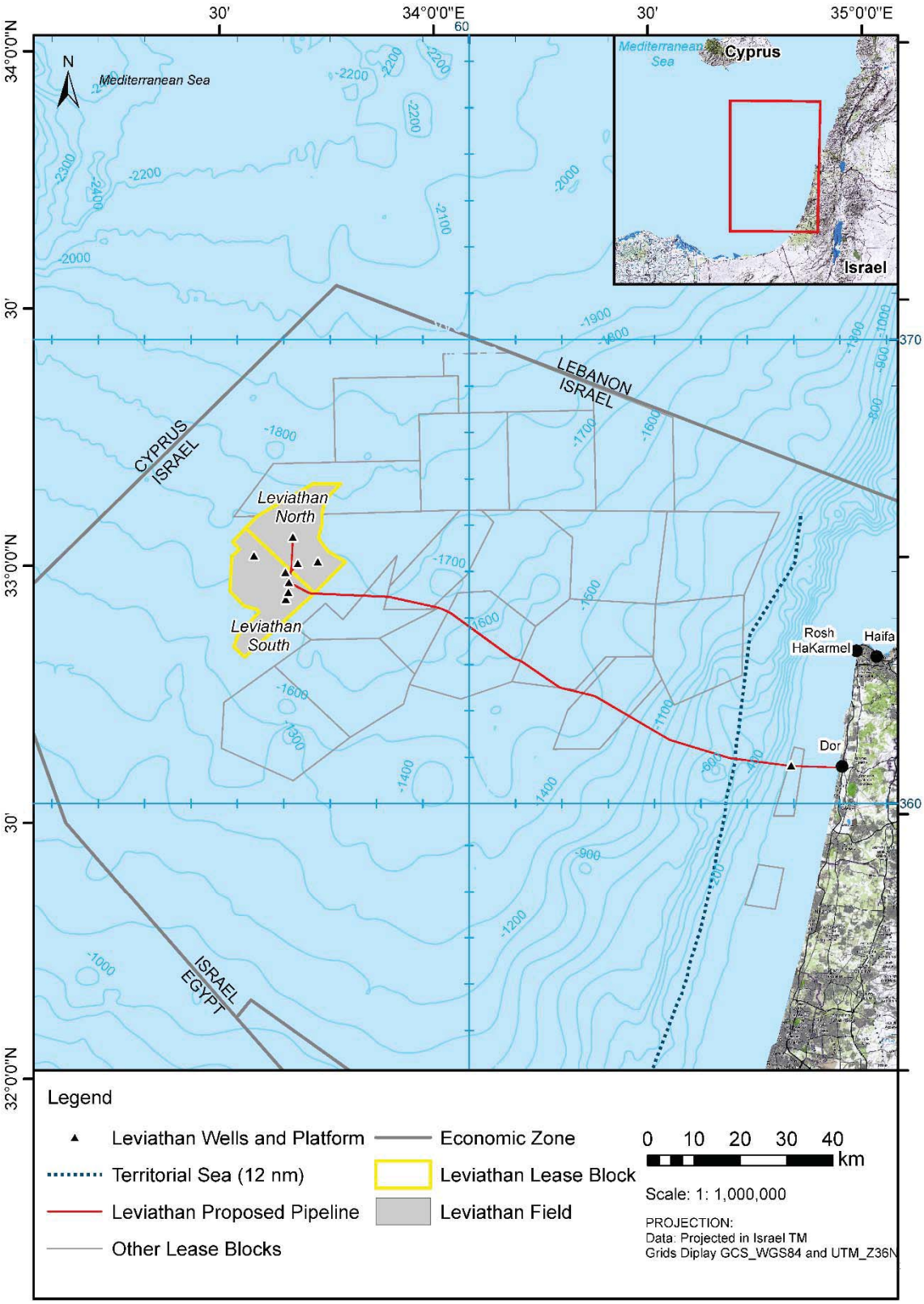
Figure 1-1: Location of the Leviathan Field, offshore Israel.



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The EIA consists of five key chapters, as required by the "Instructions for Preparation of an Environmental Impact Document in the Economic Waters for the Installation, Operation and Maintenance of Submarine Systems and Laying of Pipelines in the Leviathan Field Development Project (Leases I/14 and I/15)":

- Chapter A: Description of the Current Maritime Environment. This chapter describes the baseline environment, including site-specific data from the Leviathan Field Development Background Monitoring Survey conducted.
- Chapter B: Location and Technology Alternatives and Reasons for Preferring the Proposed Alternative. This chapter reviews alternatives considered by Noble Energy, including location, technologies, and infrastructure for future production.
- Chapter C: Description of Actions Stemming from Performance of the Application. This chapter describes Noble Energy's subsea campaign, including wellheads and Xmas tree installation; pipelay schedule; pipelay and support vessels; infield facilities installation; tie-in pre-commissioning and commissioning and the gathering facilities installation; tie-in and commissioning noise hazards, air quality, hazardous materials, discharges to sea, and geological and seismic risk; and field abandonment and dismantling of infrastructure.
- Chapter D: Evaluation of the Environmental Impacts Expected to Develop Due to Performance of the Application and Measures to be Taken to Prevent / Minimize Such. This chapter evaluates potential impacts on the environment from routine activities and accidental events.
- Chapter E: Proposed Instructions for a Plan for Preservation and Prevention of Harm to the Application Environment. This chapter outlines environmental management and mitigation measures.

Literature cited is provided in Chapter F, and supporting information is provided in the appendices, which are referenced where appropriate. Appendix A.2 provides a summary of experience of those authors that contributed to the development of the EIA

1.2 Boundaries of Application and Area of Influence

1.1.2 Detailed Area of Application

The Leviathan Field Application Area consists of the marine zone up to 2 km from all proposed infrastructure exclusive of the pipeline. The pipeline Application Area varies depending on geographic location, with dimensions varying as follows: 1) extending from the Leviathan Field to 1 km west of the continental slope bottom, the Application Area is 0.3 km on each side of the pipeline, and 2) extending from 1 km west of the continental slope bottom to the production platform, the Application Area is 1 km on each side of the pipeline. The Application Area (Figure 1-2) consists of the following offshore facilities associated with the Leviathan Field Development:

- Subsea systems, including high-rate wells and subsea production flowlines and risers to the connection to the Shallow Water Fixed Leviathan Production Platform (LPP).

The following facilities associated with the Leviathan Field Development are excluded from the scope of the EIA because they are included in the TAMA-37H process, which addresses the permitting and approvals of Oil and Gas Projects in Israel up to the limit of Israel territorial waters (i.e., 12 nautical miles [nmi] from shore):

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- Shallow Water Fixed Leviathan Production Platform (LPP) comprising a Domestic Supply Module (DSM) and a Regional Export Module (REM); and
- Onshore tie-in of the REM DSM to the Israel Natural Gas Line (INGL) system.

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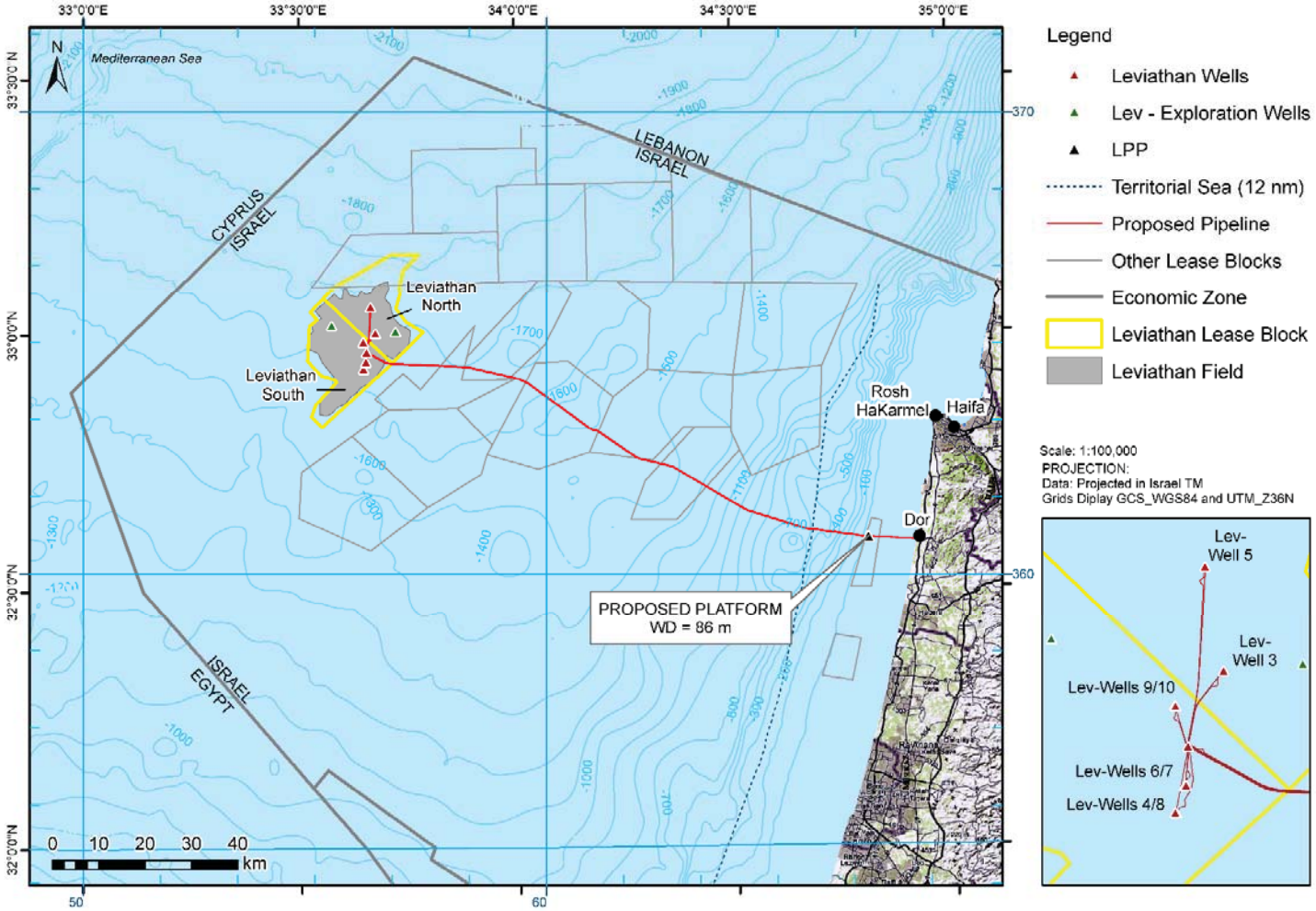
Figure 1-2: Area of Application including the Leviathan wells and manifolds and proposed pipeline corridor to the Leviathan Production Platform.



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1.2.2 Area of Impact of Application

The Area of Influence of the Application includes the entire marine zone that might be environmentally affected as a result of routine operations or accidental events. Routine operations occur from the offshore subsea facilities locations and the support vessel route between the offshore facilities and the onshore base in Haifa.

1.3 Maps and Orthophotos

1.3.1 Map Requirements

Per requirements specified in EIA Instruction 1.3.1, all maps and orthophotos that are prepared for the purpose of the Environmental Document shall be on the New Israeli Grid, and in accordance with the regulations of the Israel Mapping Center.

1.3.2 Geographic Grid Requirements

In addition, the location of all components of the Application are marked on a geographic grid (latitude, longitude, and Universal Transverse Mercator [UTM] grid), per requirements specified in EIA Instruction 1.3.2.

1.3.3 Distance Between Project Components

The Leviathan Field is located in the I/15 Leviathan North and I/14 Leviathan South lease areas (Figure 1-1), hereafter referred to as Leviathan North and Leviathan South. The water depth and distances from each well and associated manifold to the nearest shoreline, Rosh Hacarmel and Hadera, are listed in Table 1-1.

Table 1-1: Water depth of proposed facility locations in the Leviathan Field and distances from each facility to the nearest shoreline (Rosh Hacarmel and Hadera) and Leviathan Production Platform (LPP).

Well Name	Water Depth (m)	Distance (km)[a]			
		LLP	Nearest Shoreline	Rosh Hacarmel	Hadera
Leviathan-3	1,670	115.00	121.30	121.97	131.53
Leviathan-4	1,619	114.77	122.70	123.67	130.58
Leviathan-5	1,709	118.22	123.31	123.94	135.13
Leviathan-6	1,626	114.69	122.45	123.23	130.66
Leviathan-7	1,627	114.70	122.51	123.29	130.71
Leviathan-8	1,619	114.65	122.63	123.61	130.51
Leviathan-9	1,650	116.71	123.61	124.29	133.01
Leviathan-10	1,649	116.73	123.66	124.34	133.07

[a] Distances were calculated using the New Israeli Grid.

1.3.4 General Depth Map

Figure 1-3 provides a general depth map of the project area, including the Leviathan Field and wellsites, proposed pipeline route, and proposed platform location relative to regional maritime boundaries and shipping routes. Contours on the map indicate water depth in meters. A scaled version of this figure (as required under EIA Instruction 1.3.4) is provided in Appendix A-3.

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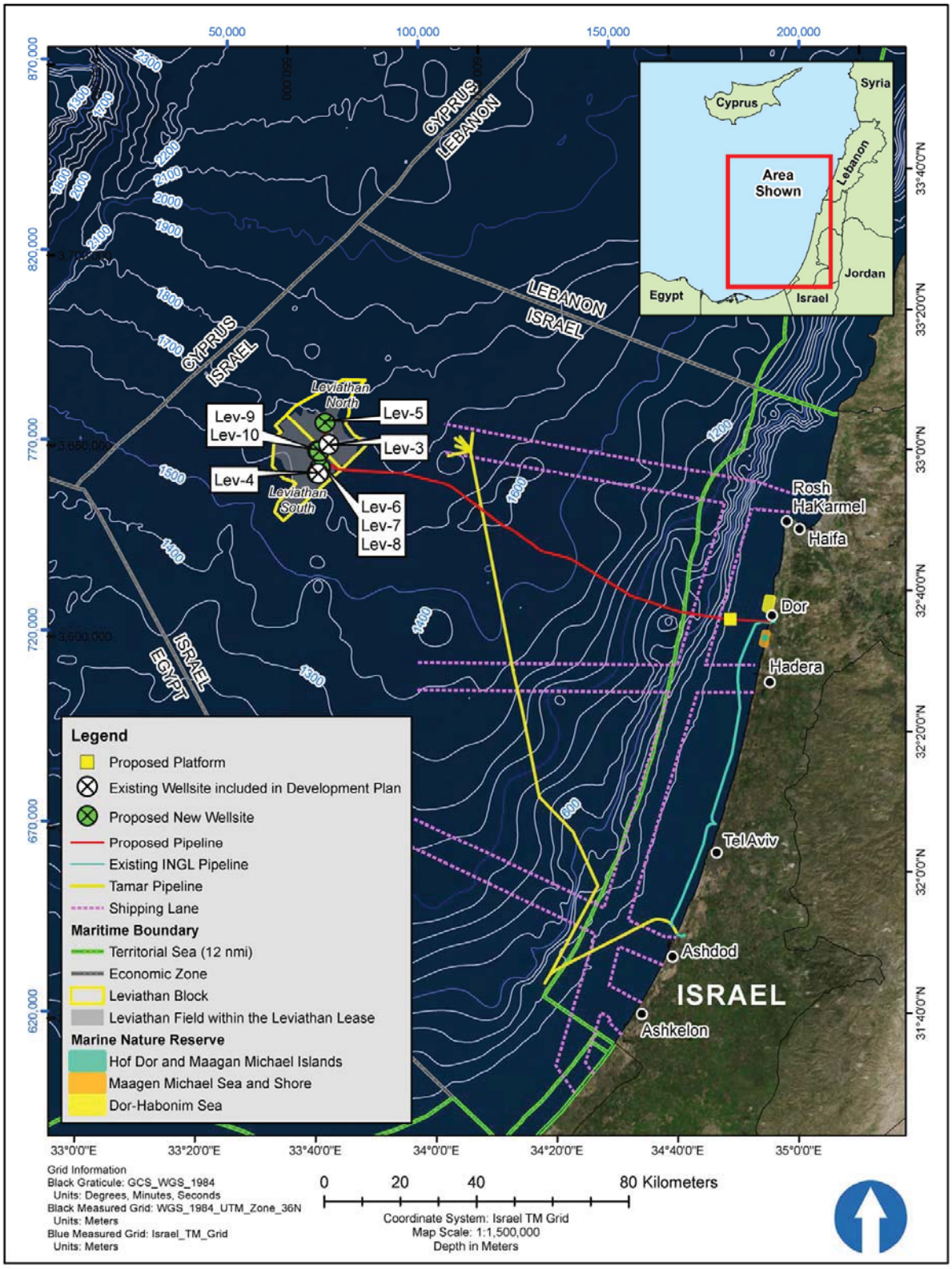
Figure 1-3: General Depth Map showing the Leviathan Field and proposed drill sites.



1.3.5 Regional Depth Maps

Regional depth maps, as required under EIA Instruction 1.3.5, and are provided in Appendix A-4.

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1.3.6 Maritime Agricultural

EIA Instruction 1.3.6 states that if there is maritime agricultural activity within a field of less than 30 km from the transmission/supply/service pipeline, the location of such activity and the location of it and any other adjacent facilities or components must be noted on a map at a scale of 1:50,000. However, no maritime agricultural activity occurs within a field of less than 30 km, therefore, a figure is not presented.

1.3.7 Detailed Depth Maps

Detailed depth maps, as required under EIA Instruction 1.3.7, are provided in Appendix A-5.

1.3.8 Maritime Transportation and Infrastructure Map

A map of maritime transportation and infrastructure is provided in Figure 1-4. A scaled version of this map (required under EIA Instruction 1.3.8) is provided in Appendix A-6.

1.4 Geological, Seismic, and Sedimentological Characteristics

1.4.1 General Geological / Geomorphological / Bathymetric Map

A bathymetric map of the seabed off the coast of Israel with historical earthquakes and fault zones in the region is provided in Figure 1-5. In addition, Appendix A-7 shows areas liable to landslides and other notable geological and geomorphological phenomena, which are required under EIA Instruction 1.4.1.

1.4.2 Regional Geological / Geomorphological / Bathymetric Map

Appendix A-8 provides areas of historical earthquakes and fault zones as well as areas liable to landslides and other notable geological and geomorphological phenomena, which are required under EIA Instruction 1.4.2.

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Figure 1-4: Bathymetric map showing the Leviathan Field and proposed drillsites relative to regional maritime boundaries and shipping routes.

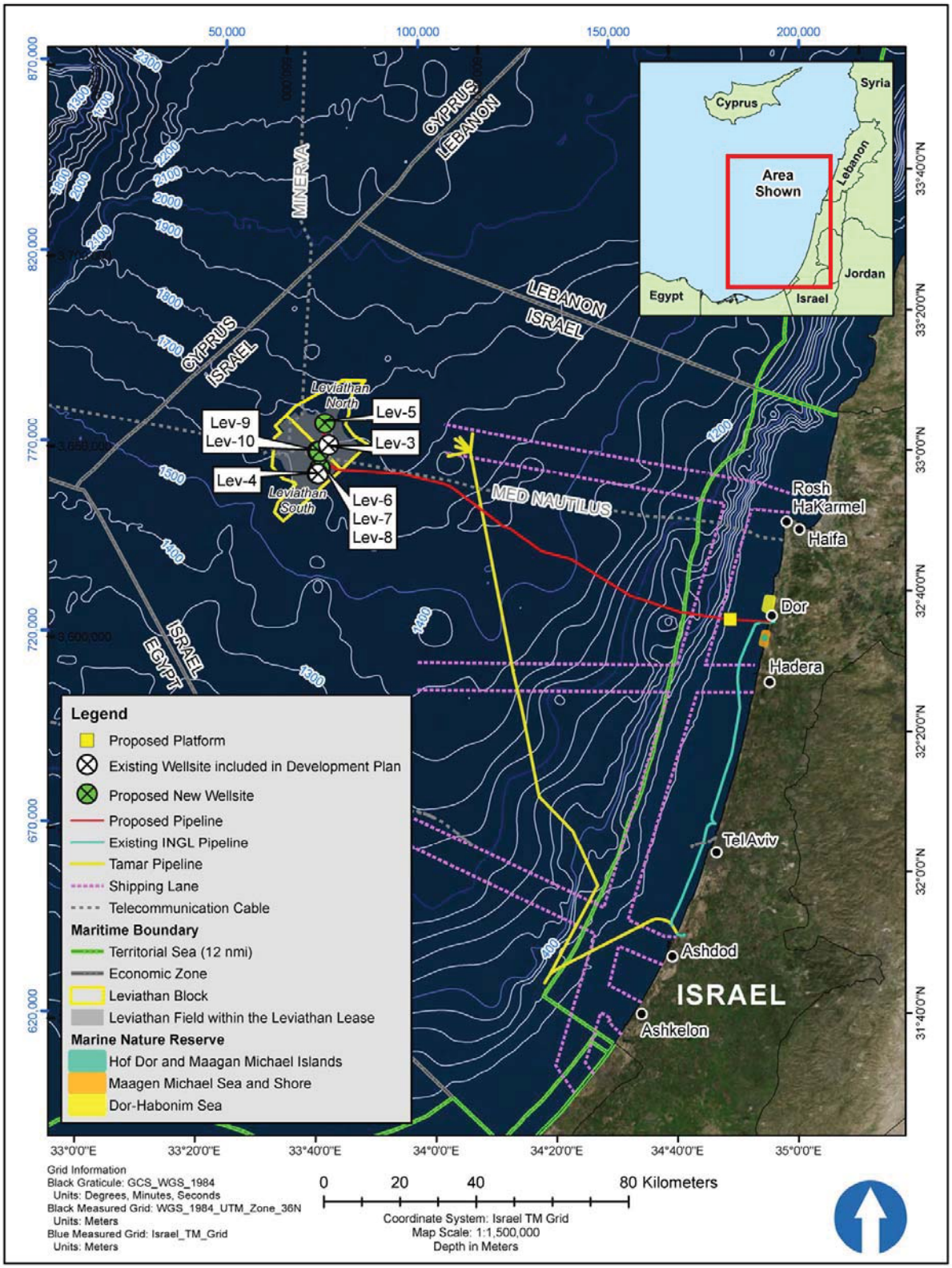

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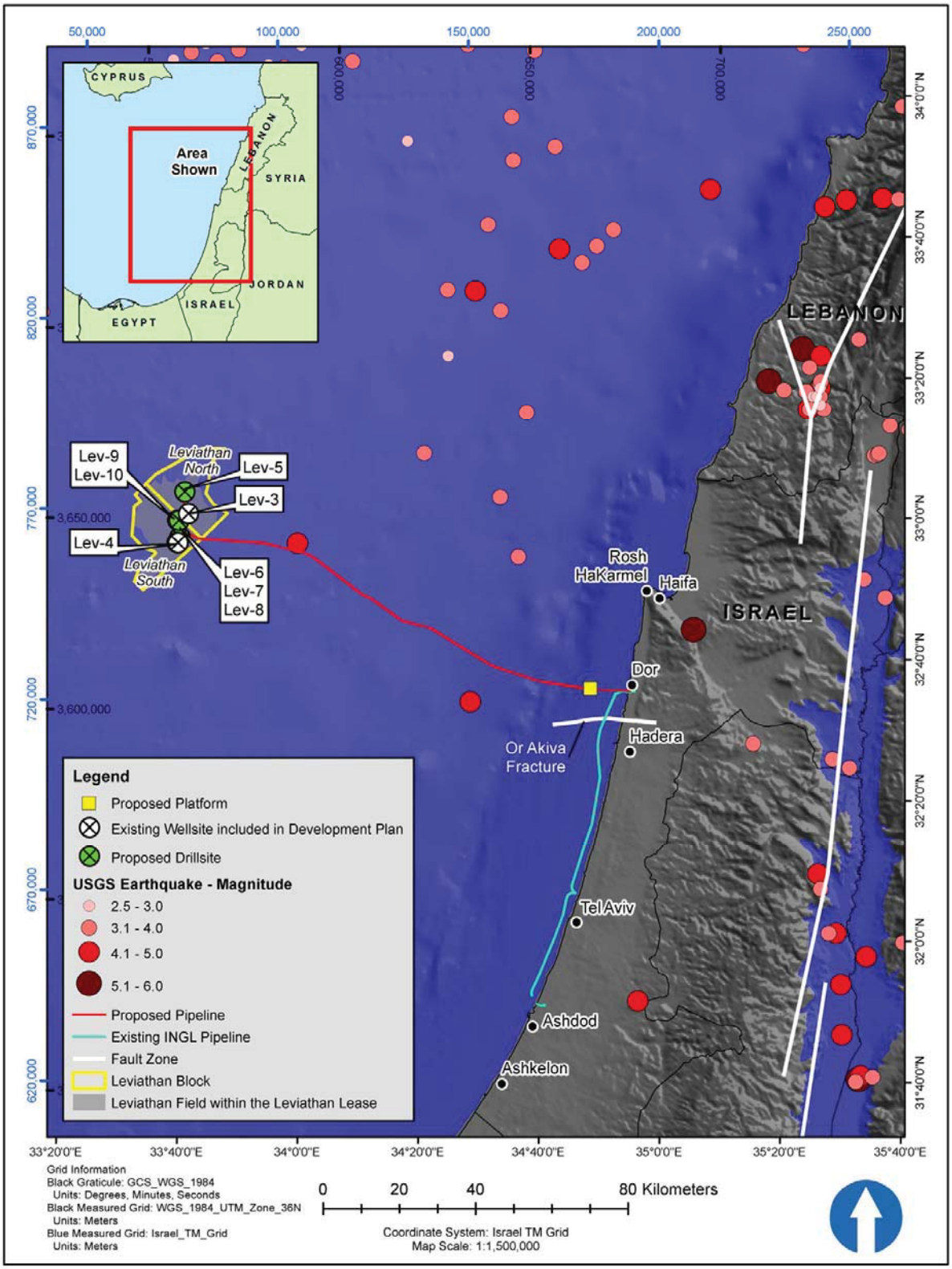
Figure 1-5: Location and magnitude of historical earthquakes in the region (1979 to 2014) relative to the Leviathan Field and proposed pipeline corridor (Data from: U.S. Geological Survey, 2014).



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1.4.3 Description of Geological, Seismic, and Sedimentological Characteristics

1.4.3.1 Geologic Setting

The Eastern Mediterranean region has been shaped by the interactions of the African, Arabian, and Eurasian plates since the Permo-Triassic Period. The current geotectonic framework of the region is dominated by the collision of the Arabian and African plates with the Anatolian Plate. Recent characterizations of the tectonics of the Eastern Mediterranean region include the work of Dilek and Sandvol (2009) and Özbakir et al. (2010). A brief descriptive summary of prominent geological features and events of the region is described below.

Levant Margin: Much of the research on the Levant Margin has been carried out along its southern flank, in connection with onshore and offshore exploration in Israel. Garfunkel (2004) proposed that north-trending normal faults with large throws, down to the west and active since the Late Permian, were the primary mechanism for the formation of the Levantine Basin. As rifting continued, the underlying continental crust would thin and form the basement to the Levantine Basin, instead of oceanic crust as proposed by Makris et al. (1983).

Levantine Basin: The work of Abdel Aal et al. (2001) and Garfunkel (2004) has shown the basement of the Levantine Basin to consist of faulted blocks, making a horst (elevated) and graben (recessed) basin floor topography covered by 10 to 15 km of sediments, ranging in age from the Late Permian to Recent. Their evolutionary model shows the generation of the Levantine Basin by intercontinental rifting and extension that stops short of seafloor spreading and oceanic crust formation. Under this model, basal sediments everywhere would be shallow-water clastics and carbonates. In deeper water, turbidites and pelagic carbonates with shales would be dominant, with basin floor sediments mostly consisting of shales and distal turbidites (sheet sands).

Nile Cone: The Nile Cone has been a major contributor of sediment to the Levantine Basin since the Oligocene, with increased thicknesses from the late Miocene to Recent. Total thickness is up to 10 km, including 1.5 km of Messinian (late Miocene) evaporites (Mascle et al., 2006). The post-Messinian sediments have undergone significant thin-skin deformation due to downslope movement along slip surfaces in the underlying evaporites.

Messinian Salinity Crisis: The Mediterranean Sea went through a cycle of partial desiccation known as the Messinian Salinity Crisis, one of the most unusual oceanic events to occur in the last 20 million years. The widespread evaporation sequence that resulted from the event could be important as a top seal to offshore hydrocarbon accumulations. Early documentation of this evaporate section includes an assessment by Hsü et al. (1973). The evaporative event, which occurred between 5.3 and 6 million years ago, was attributed to the periodic restriction of seawater inflow from the Atlantic Ocean, leading to hypersalinity and deposition of gypsum in shallow-water areas and halite in the deep basins. The Mediterranean Sea did not dry completely, but the overall sea level dropped as much as 1,500 m. This fall in water level led to dramatic erosion, including the formation of large canyons and deposition of coarse sediments that can result in excellent reservoir rocks.

Continental Slope: The lower continental slope in proximity to the study area is characterized by a disturbed area (Almagor and Hall, 1984) designated as the Dor disturbances. The disturbed areas where mass slumping has occurred are in a zone of diapirs (e.g., vertically

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upward geological movement) and associated with Messinian drainage systems such as offshore canyons. These canyons, acting as conduits for the transport of materials from the shelf into the basin, developed and were incised onto the Levantine continental slope during the Oligocene and Miocene on through the Messinian. They are partly reflected in present day submarine features (Gardosh et al., 2008).

1.4.3.2 Bathymetry and Seafloor Morphology

Leviathan Field

The regional bathymetry of the Leviathan Field is depicted in Figure 1-6. Water depth in the Leviathan Field varies from 1,540 m in the south to 1,800 m in the north. Seafloor gradients average approximately 2° and locally increase to more than 15° on the flanks of seafloor drainage channels and seafloor ridges. The seafloor is incised from the south to the north by three active channels occurring in the center and east of the Leviathan Field (Figure 1-7 and 1-8). All three channels are approximately 20 to 40 m deep and 300 m across. Their meandering character is suggestive of relatively low internal current velocities. Surficial failure is observed locally on the flanks of the channels within the meandering bends. In addition to the active drainage channels, several abandoned, inactive channels traverse in a general south-to-north direction across the study area.

The seafloor is intersected by three north-northeast, south-southwest trending strike-slip faults (highlighted in Figure 1-8). Occasional elongate ovate ridges up to 45 m high and 500 m across are observed along the intersection of the strike-slip faults at the seafloor.

The seafloor also is disrupted by several reverse fault intersections that trend southeast-northwest (Figure 1-8). The intersections present linear elongate ridges of variable height (up to 45 m) and can be up to 600 m across, aligned along the fault intersection with the seafloor.

At the southwest edge of the area, a complex reverse fault/strike-slip fault system is observed (Figure 1-8). A well-defined reverse fault intersects the seafloor, trending sinuously south to north. Adjacent smaller scale strike-slip faults occur at right angles to this fault-induced ridge. Aside from these channel and fault-related features, the seafloor is generally smooth and featureless.

Full-scale versions of Figure 1-7 and 1-8 are provided in Appendix A-9.

Pipeline Corridor

The seafloor gradient of the pipeline corridor ranges from 0° to 52° (Geoscience Earth & Marine Services [GEMS], 2014). The water depth along the pipeline corridor ranges from 1,696 m near the Leviathan Field to 83 m near the coast. The pipeline route will cross the Tamar Channel with the seafloor gradient approaching 20°. The channel trends north-to-south, measures approximately 700 to 900 m across, and ranges in water depth from 30 to 35 m. Two near-surface faults were found in the channel area.

The seafloor along the pipeline corridor is disrupted by large offset faults with a dominant fault trend on the shelf break oriented from northeast to southwest (Appendix A-10). Few faults in this area trend north-to-south and east-to-west.

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Figure 1-6: Location of existing marine infrastructure (telecommunications cable and previous drillsites) in relation to the eight initial wellsites included in the Leviathan Field Development Plan. Proposed new wellsite locations are preliminary; final well locations may vary slightly. Contours indicate water depth in meters.

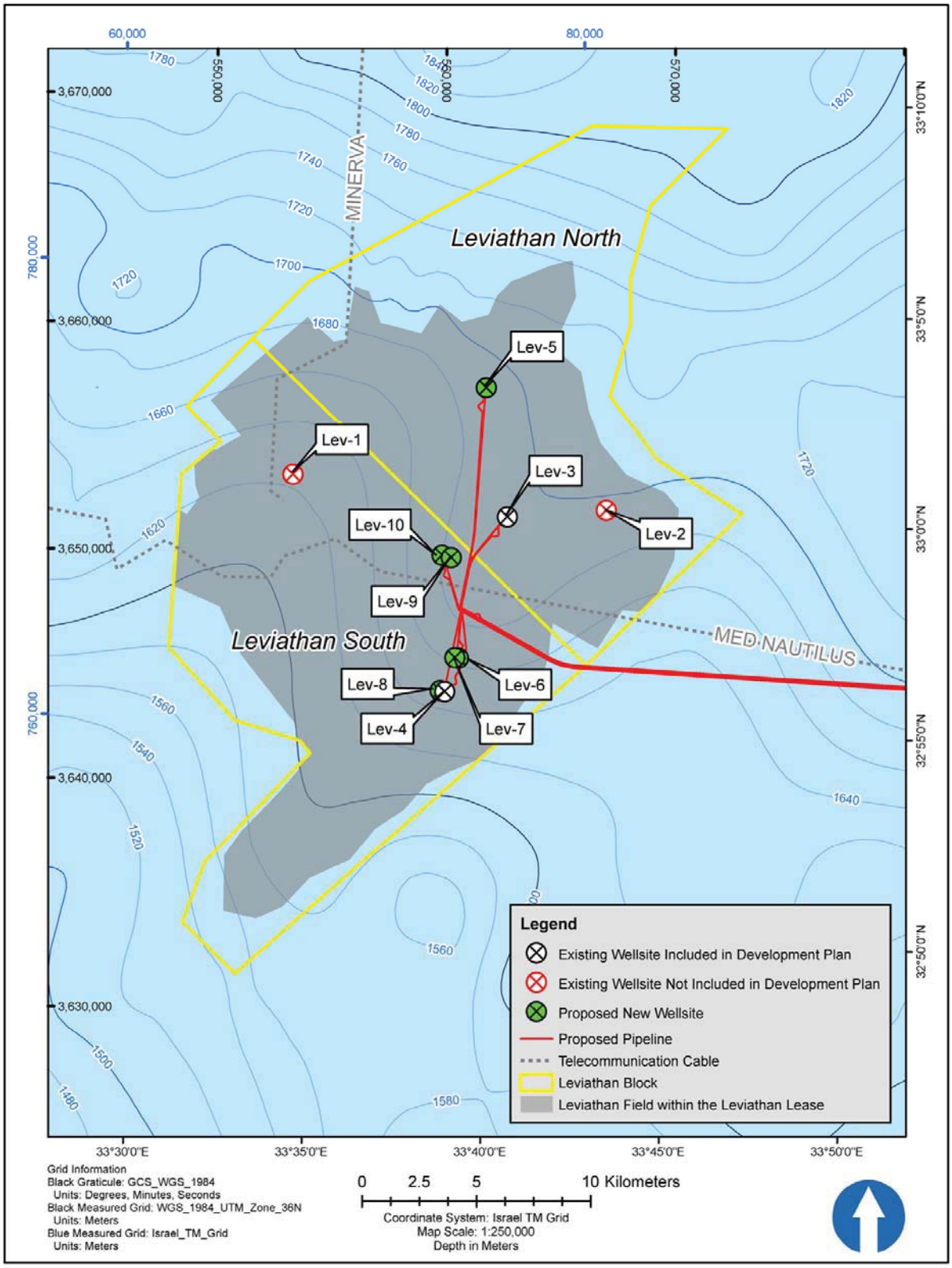

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Figure 1-7: Bathymetry of the Leviathan Field (Adapted from: Gardline Surveys Inc., 2015). Proposed new wellsite locations are preliminary; final well locations may vary slightly.

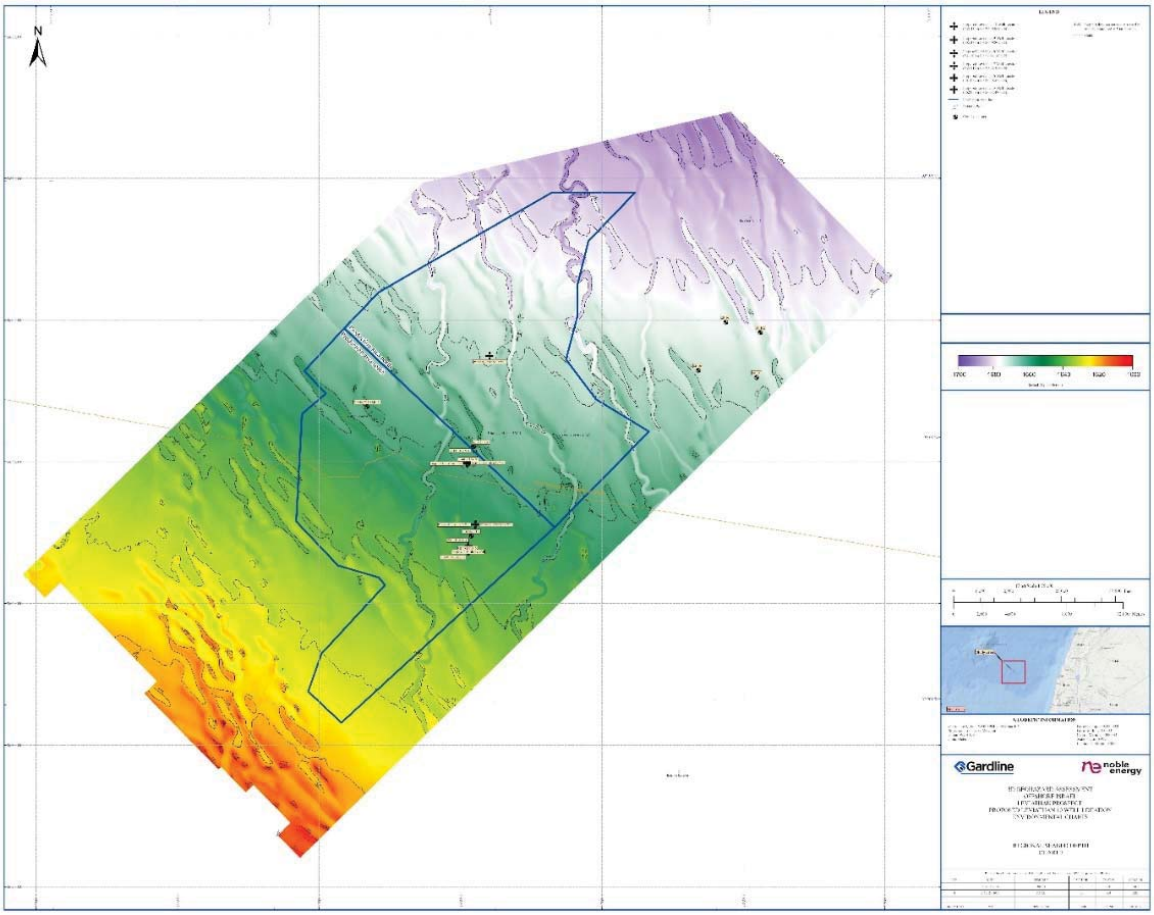

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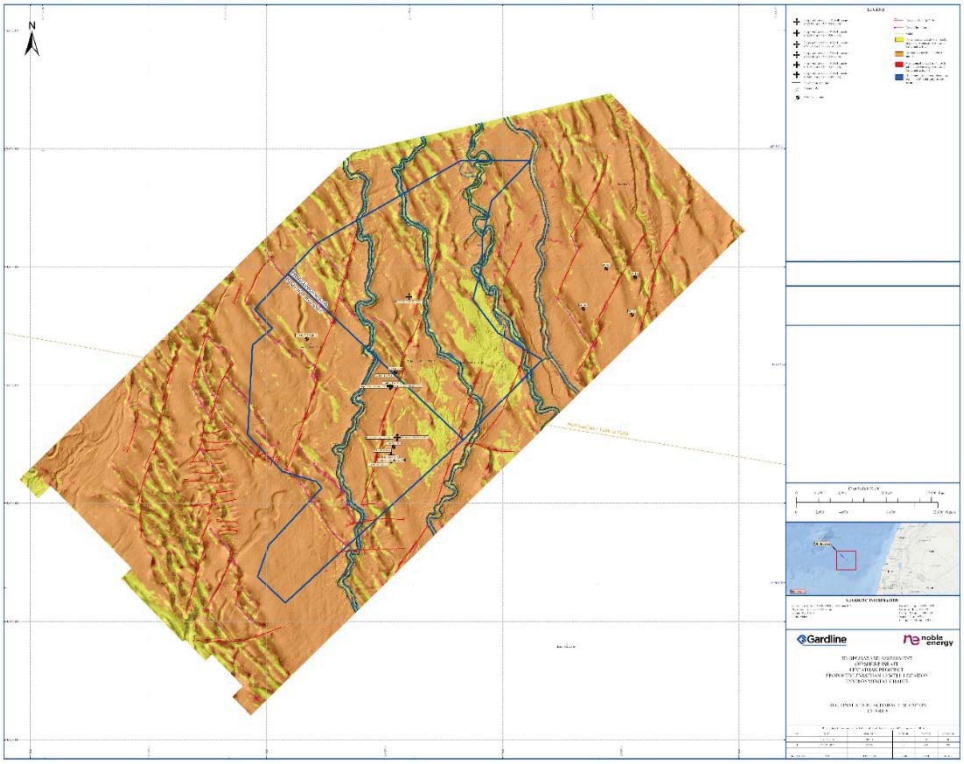
Figure 1-8: Seafloor morphology of the Leviathan Field (Adapted from: Gardline Surveys Inc., 2015). Proposed new wellsite locations are preliminary; final well locations may vary slightly.



1.4.3.3 Shallow Stratigraphy

Leviathan Field

Figure 1-9 is a typical seismic display illustrating the shallow stratigraphy across the southern Leviathan Field, interpreted by Gardline Surveys Inc. (2010). The analysis identified the three shallowest units below the seafloor (A, B, and C), separated by Horizons H05, H10 (top of salt), and H20 (base of salt).

- Unit A is interpreted as clays and silts with occasional sandy interbeds and lenses.
- Unit B is interpreted as clay and silt with more numerous sandy interbeds.
- Unit C is interpreted as dominantly halite with relatively thin gypsum, anhydrite, and clastic interbeds and lenses.

Gardline Surveys Inc. (2010) examined each interval for lithologic composition and additional geohazards. Attribute studies of the three units identified no significant anomalous amplitudes indicative of shallow gas.

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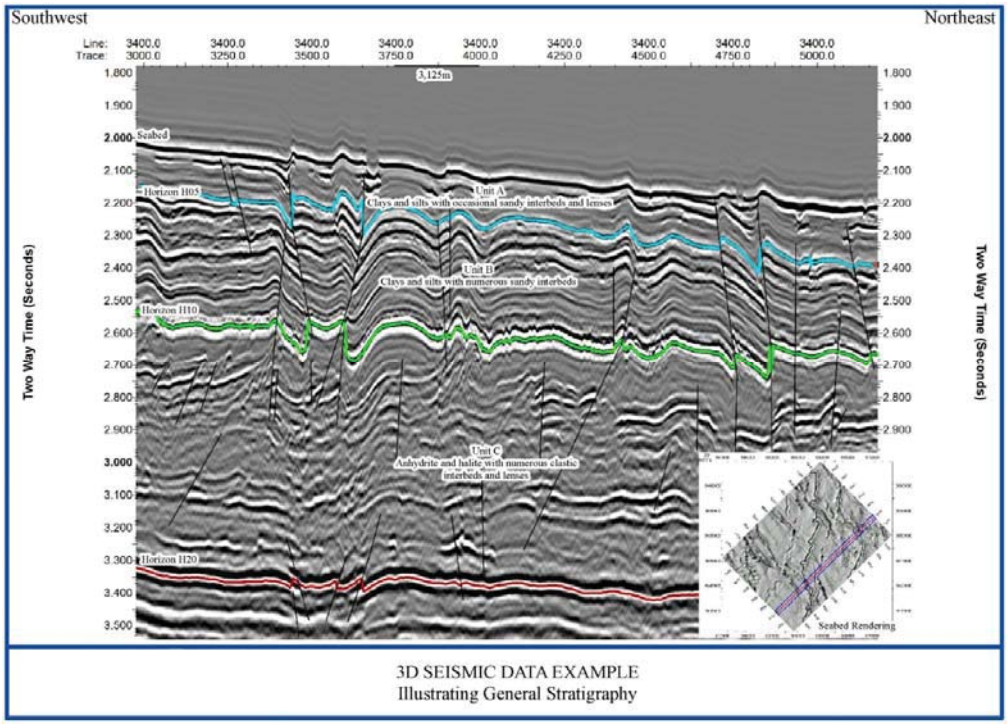
Figure 1-9: Seismic line illustrating the shallow stratigraphy of the Leviathan Field (From: Gardline Surveys Inc., 2010).



Pipeline Corridor and Leviathan Production Platform

Surficial sediments collected by geotechnical sampling along the pipeline route to the approximate location of the proposed platform show that the upper meters of sediment consists of very soft clays (GEMS, 2014). DOF Subsea (2015) conducted a geophysical survey of the proposed pipeline corridor and LPP location from approximately 360-m water depth to approximately 7- to 10-m water depth and identified an escarpment, mass movements and their deposits, large-scale sediment bedforms, and outcrops as the main morphological features present in the survey area. A northeast-southwest trending escarpment marks the boundary between the upper continental slope and the shelf at approximately 100 m water depth (DOF Subsea, 2015). DOF Subsea (2015) characterized the shelf area as generally flat and smooth, except for the presence of bedforms, depressions, and ridge outcrops primarily found at water depths <80 m; at water depths >80 m the shelf is characterized by an undulated seafloor. DOF Subsea (2015) identified a few exposed outcrops in <105 m water depth along the proposed pipeline corridor.

1.4.3.4 Geohazards

Leviathan Field

An area-wide geohazard assessment of the Leviathan Field was conducted by Gardline Surveys Inc. (2010). The principal conclusions of the geohazards assessment were as follows:

- Seafloor drainage channels, strike-slip faults, fault-induced ridges, and the fault complex in the west are areas considered unsuitable for future well locations or seafloor infrastructure.

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- Sandy interbeds and fault intersections in Unit A may cause problems with jetting of seafloor casing and wellbore instability.
- Sandy interbeds and fault intersections in Unit B may present minor risk of drilling fluid circulation and wellbore stability problems.
- Thin clastic interbeds and fault intersections in Unit C may cause minor drilling fluid circulation and wellbore stability problems. These muddy interbeds are primarily clay and silt with minor amounts of sand and mud. Minor amounts of sand and mud were associated with an overpressure event in the Tamar-1 well. However, other wells have contacted similar interbeds with no reported problems.
- Sub-seafloor faults should be considered for all proposed well locations. Wells should be designed to avoid setting casing seats at the level of fault intersections to avoid problems with well integrity.

Results of the geohazards assessment did not identify any significant problems for the proposed Leviathan Field production activities. With careful pre-screening of potential locations and casing design, the potential issues noted in the geohazards assessment have been avoided during well siting and the design of production facilities.

Pipeline Corridor

An archaeological assessment was completed by GEMS (2014) for the Leviathan pipeline (i.e., flowlines) route to approximately 360-m water depth. The pipeline corridor from the production manifold (-1,629 m depth) to the production platform 10.3 km off the Israeli coast in 87 m of water will encounter several geologic features such as strike-slip faults, seabed ridges underlain by reverse faults, sediment slumps adjacent to seabed channels, active and inactive seabed channels, normal faults, and surficial failures at the slope break. DOF Subsea (2015) identified the following potential geohazards along the pipeline corridor from approximately 360-m water depth to 7- to 10-m water depth:

- Faults are present, but they are generally deeply buried and are not considered a hazard for the development;
- Steep slopes and consequent submarine mass wasting processes along the lower shelf and escarpment (slope stability at headscarps/shelf break should be further investigated);
- Bottom and deep tidal currents and associated features (north-northeast to south-southwest trending depressions are present below approximately 75-m water depth and should be further evaluated with metocean studies);
- Seafloor roughness (e.g., areas of rocky outcrop, depressions);
- Presence of shallow gas and fluid infiltration, presence of seabed seeps needs to be verified;
- Environmental constraint, aquatic plants (possibly seagrass) are present between approximately 9- and 30-m water depth; and
- Man-made features (e.g., trawl scars, borehole marks, drill spoils, two north-northeast to south-southwest oriented cables, and a pipeline).

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The primary conclusions of the archaeological assessment of the pipeline corridor from the Leviathan Field to approximately 360-m water depth were as follows:

- The pipeline route crosses through a seismically active region that includes numerous faults. Earthquakes could cause submarine landslides or mass flows.
- The pipeline route crosses the Tamar Channel with seafloor gradients of nearly 20°. The margins of the channel could be subject to slope stability problems.
- The surficial drape has been eroded in some areas, thereby exposing older, firmer sediments. Other areas have hummocky, irregular seafloor that could cause spanning and stressing of the pipeline.
- Irregular mounds and pockmarks in areas found from KP 75.43 to 75.51 and KP 76.92 to 77.09 along the pipeline route (possibly caused by local variations in shear strength) could potentially impact pipe embedment.

1.4.3.5 Seismicity

Locations and magnitudes of historical earthquakes relative to the Leviathan Field and proposed pipeline corridor are shown in Figure 1-10. One earthquake (magnitude 4.0) has been recorded within approximately 40 km of the Leviathan Field and near the proposed pipeline corridor since 1979. No strong regional earthquakes (magnitude 5.6 or greater) have been recorded since 1983 that are within 200 km of the proposed drillsites or the proposed pipeline corridor.

Salamon et al. (2010) states that most tsunamis in the Mediterranean are caused by earthquakes, either through seafloor rupture or submarine slumping. Ambrasseys (1962) conducted a survey of reported sea waves from Antiquity to 1961 and concluded that the region from Cyprus to Jubeil and Acre on the Levantine coast is prone to sea waves of light to rather strong intensity. The term “rather strong” on this intensity scale means that the waves would flood gently sloping areas. The height and destructive power of such waves is by far greater in coastal areas where they traverse shallow water than out in the open seas. Kelletat and Schellmann (2002) examined the western and southeastern coasts of Cyprus for evidence of tsunamis and reported movement of boulders weighing several tons by an event that took place more than 200 years ago. However, the earthquake zone along the south coast of Cyprus appears to provide the most significant overall tsunami threat to the coast of Israel (URS Corporation, 2009).

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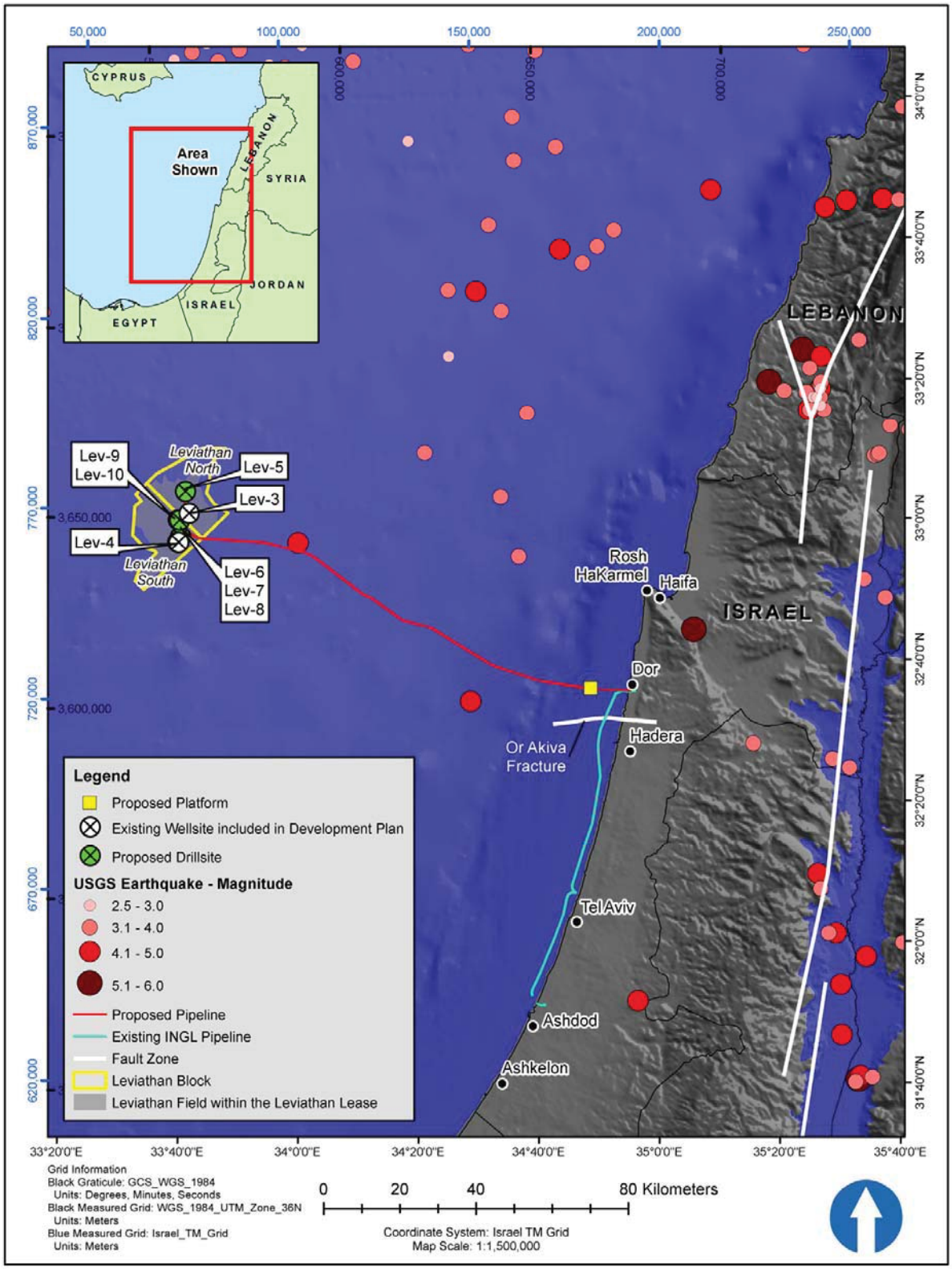
Figure 1-10: Locations and magnitudes of historical earthquakes in region (1979 to 2014) relative to the Leviathan Field (From U.S. Geological Survey, 2014).



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1.4.3.6 Sediment Grain Size

Leviathan Field

Seafloor sediment in the Leviathan Field consists primarily of clay and silt with localized sand (mainly confined to the active channels). This interpretation is consistent with video observations from the Background Monitoring Survey (CSA Ocean Sciences Inc., 2016a), indicating that the seafloor around the proposed drillsites is smooth and relatively flat with sediments consisting primarily of clay and silt. No sand waves were observed, which would indicate low current speeds near the seafloor. No consolidated substrates (hard bottom features) were observed within the survey area. Sediment sampling has been conducted within 117 grid cells in the Leviathan Field and is summarized in CSA Ocean Sciences Inc. (2016a).

Pipeline Corridor

Sediment sampling has been conducted offshore Israel in depths equivalent to the pipeline segments at a distance of 0 to approximately 10 km away from the proposed pipeline corridor, including stations sampled during the Background Monitoring Survey. Seafloor sediment samples were analyzed for grain size, discussed here, as well as other sediment quality parameters discussed in Section 1.7.2. Sediment grain size was generally silty clay in deeper waters, clayey silt in water of intermediate depth, and a mixture of clayey silt and sand/silt/clay in shallow waters near the proposed production platform. See CSA Ocean Sciences (2016b) for detailed survey methods and data analysis.

1.5 Geological Risks

The eastern Mediterranean Sea is divided into the Aegean Sea and the Levantine Sea. The Levantine Sea is bordered by Egypt, Israel, Lebanon, Syria, and Turkey, with its western limit defined by Crete. The Levantine Sea is approximately 320,000 km^2 in size and has a maximum depth of 4,384 m. The most prominent feature is the Mediterranean Rise, continuing from the Ionian Sea. Continental shelf widths vary, with the largest shelf off the Nile Delta followed by the composite delta off of the Gulf of Iskenderun. The eastern continental shelf has three major canyons: Gaza, Akziv, and Beirut. At the perimeter of the Mediterranean Rise is the Herodotus Basin and Herodotus Trough to the south; the Cyprus Basin to the east; and Antalya Basin, Cilicia Basin, and Rhodes Basin along the coast of Turkey.

The African and Anatolian plates move generally north-northeast, grinding past each other at the Dead Sea Transform (DST) (~70 km east of the pipeline corridor). The DST is a seismogenic fault where recent GPS global positioning system (GPS) measurements indicate that current movement is on the order of 4 to 5 mm y^{-1} of relative left-lateral displacement, accounting for 105 to 100 km of offset during the last 15 million years (Salamon, 2007). The Carmel Fault (~30 km northeast of the pipeline corridor) splays off the DST and continues northwest into the Mediterranean Sea. North of the study area, seismicity is also associated with a subduction zone along the Cyprus Trench. The relationship to the major structural faults, the location of earthquake epicenters, and the soil acceleration are presented in Figure 1-18. Extrapolating ground accelerations from onshore observations to the offshore into another stress regime is of limited use. The risk of earthquakes from the DST is primarily from submarine landslides.

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The pipeline corridor will traverse 117.7 km of seabed from the production manifold at a depth of 1,629 m to the production platform 10.3 km off the Israeli coast in 87 m of water, with the pipeline making landfall near Dor. The route will encounter several geologic features: strike-slip faults, seabed ridges underlain by reverse faults, sediment slumps adjacent to seabed channels, active and inactive seabed channels, normal faults, and surficial failures at the slope break. Earthquakes, tsunamis, and underwater landslides are included in the risk profile. For this discussion, earthquakes and tsunamis will be considered as a common threat.

In the past 2,500 years, several catastrophic tsunamis have occurred in the Mediterranean Sea originating along the Hellenic Arc and the Straights of Messina with well-documented events in A.D. years 365, 1303, and 1908. The most recent tsunamis occurred in the Aegean Sea in 1956 with runup heights reaching 25 m and north of Algeria in 2003 with runup heights of 2 m in the Balearic Islands. Each tsunami was associated with strong earthquakes. Large tsunamis also have been associated with volcanic eruptions, such as the 1650 eruption of the Thera (Santorini) volcano in the southern Aegean Sea. Thera also caused a strong tsunami around 1627 B.C. and has been cited for the destruction of the Minoan civilization. The European GITEC-TWO tsunami catalog contains 94 reliably assessed earthquake-generated tsunami events during the last 2,500 years, making these rare but significant events that are occurring once or twice a century or likely over the lifetime of the Leviathan Field.

In the eastern Mediterranean Sea, tsunamis have a long and significant history. Tsunamis in the Middle East were first described in written history a few thousand years ago with early cuneiform texts reporting the flooding of Ugarit, a city near the current Latakia, Syria. Many tsunamis are associated with onshore earthquakes along the DST, making it likely that they result from seimogenically inducted submarine landslides. There is evidence of more than 800 years of seismic quiescence along several segments of the DST, suggesting that a low but credible threat is present.

There is ample evidence of submarine slump complexes off the coast of Israel. The largest of these complexes is the Palmachim Disturbance, which is located 55 km to the south of the pipeline corridor and west of Tel Aviv. It consists of three stacked mass transport deposits (MTD) that vary in lateral extent from approximately 350 to 750 km^2 (Figure 1-11), accounting for a remobilized sediment volume of approximately 35 and 94 km^3, respectively. Within the study area, the Dor Disturbance has been the subject of several studies by the Geological Institute of Israel (Katz et al., 2015) (Figure 1-12). The area of this mega-structure exceeds 100 km^2, and the depth involves the entire post-Messinian sediment sequence.

The Israel coast is controlled by northward, long-shore transport of sediments from the Nile Delta (Katz et al., 2015). During the Pliocene-Quaternary, a 1 to 2 km thick wedge of clay-rich siliclastic sediments accumulated over sandy turbidites and Messinian evaporites. Recent sedimentation rates on the continental slope, based on cores up to depths of 900 m, are 25 to 130 centimeters per thousand years (cm ky^{-1}). Sediment rates in deeper water beyond the continental slope are significantly lower, <5 cm ky^{-1} (Katz et al., 2015). The submarine morphology on the Israel continental shelf to 200 m water depth is up to 20 km in the south and narrows northward to approximately 10 km at the LPP. Slope gradients on the shelf are generally not more than 2°. Along the route of the LPP, as water depth increases from 200 to 600 m, the slope increases from 4° to 7°, with local slopes greater than 20° along fault scarps and slump head walls. West of the growth faults, slopes are generally less than 3°, with local variations due to seabed ridges and submarine channels (Figure 1-13). Two main types of

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mass movements are observed along the route of the LPP. The first type consists of large rotational slumps greater than 1 km thick, with their primary slide-plane located within the Messianian evaporates. The internal deformation consists of landward block rotation on listric growth faults and some folding and disruption of the internal bedding of the slump blocks (Figure 1-14). This subsurface salt tectonic results in extensional deformation of the overlying Pliocene-Quaternary sequence near the continental slope.

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Figure 1-11: Earthquake epicenters (1917-2016) color coded by magnitude (Pink M6, Red M5, Orange M4, Yellow M3, Black M2 or unknown). Soil Acceleration from Israel Standard SI 413, Amendment No.2, May 2004. A large-scale, submarine landslide is visible at this scale with the Palmachim Disturbance, Leviathan Production Pipeline (LPP), and Leviathan Production Platform (Lpp).

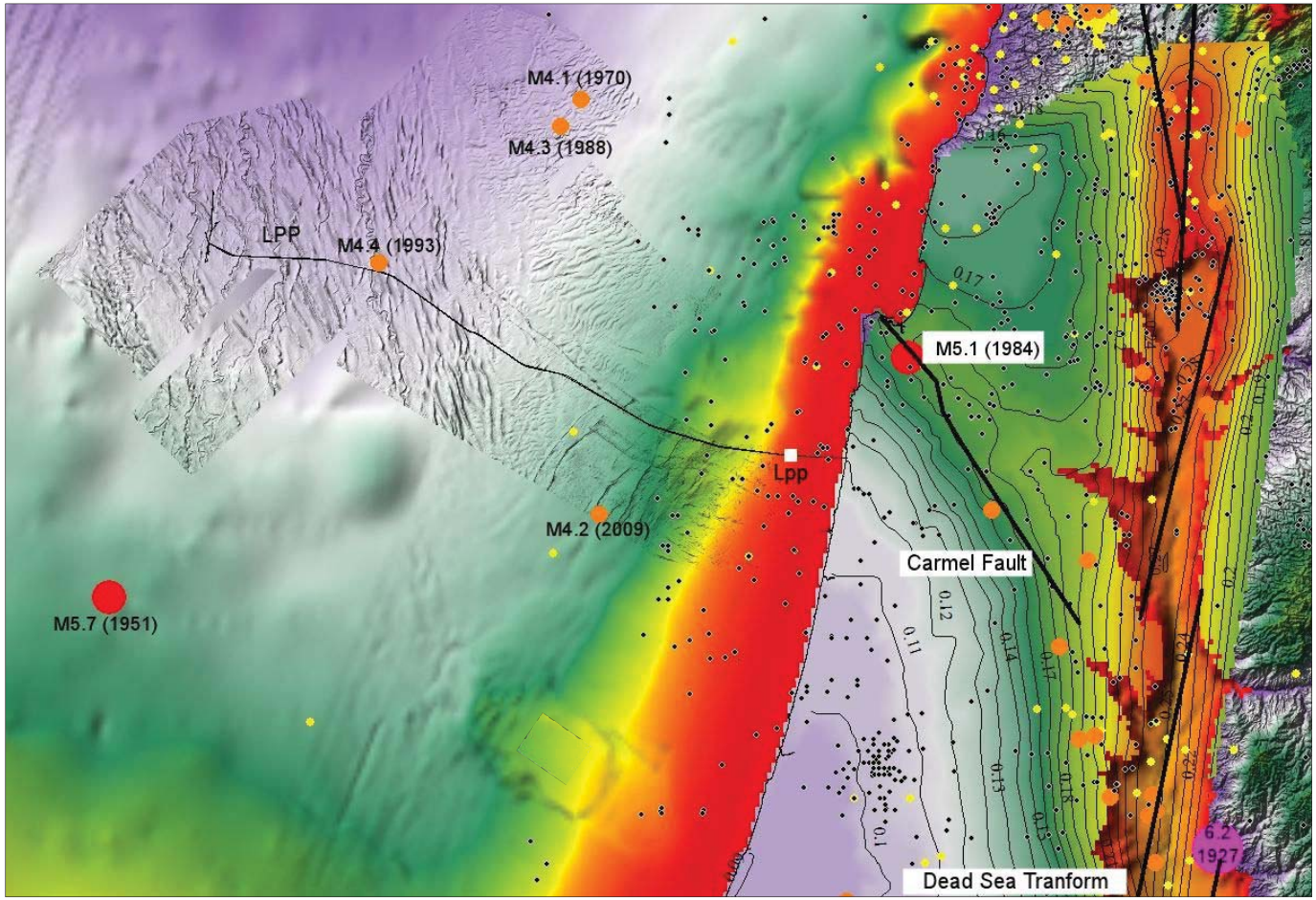

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Figure 1-12: Large vertical displacements along the shelf break, shown in the two 2D seismic lines, are related to listric, normal faults whose slide-planes are connected to the mobile Messinian evaporate layer. Smaller scale sediment slumps can be related to the steeply dipping fault scarps. Others cut the fault scarp and are the result of the seabed slope exceeding a critical angle and/or earthquake.

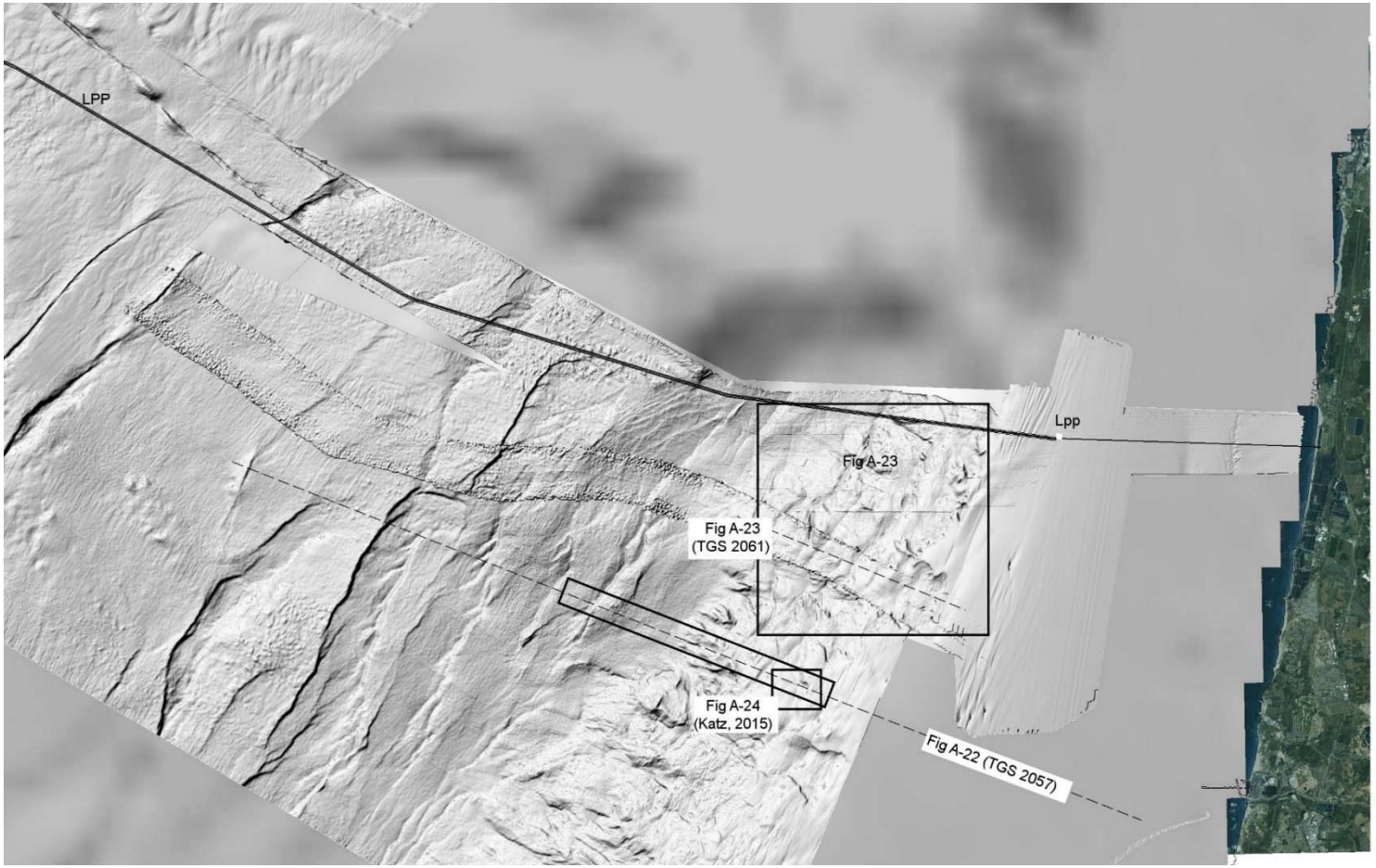

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Figure 1-13: Seabed depth and slope along the route of the proposed pipeline corridor. A 1-km moving average shows the seabed slope changing from below 2° on the shelf to 4° to 7° at the shelf break, interspersed with high values from fault scarps and slump head walls. West of the growth faults (~KP 100), seabed slope is again on the order of 2°, with local variations generally less than 10˚.

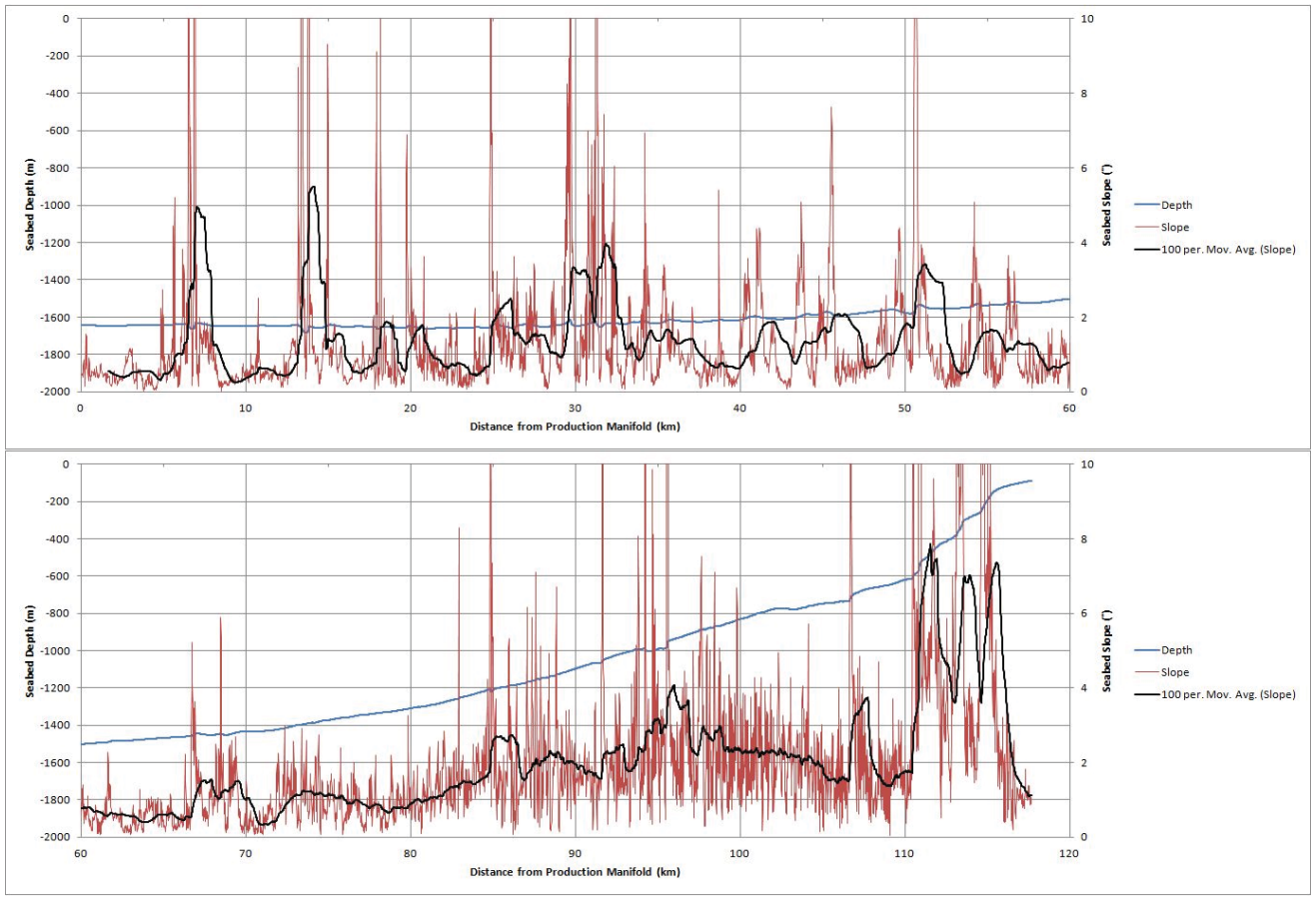

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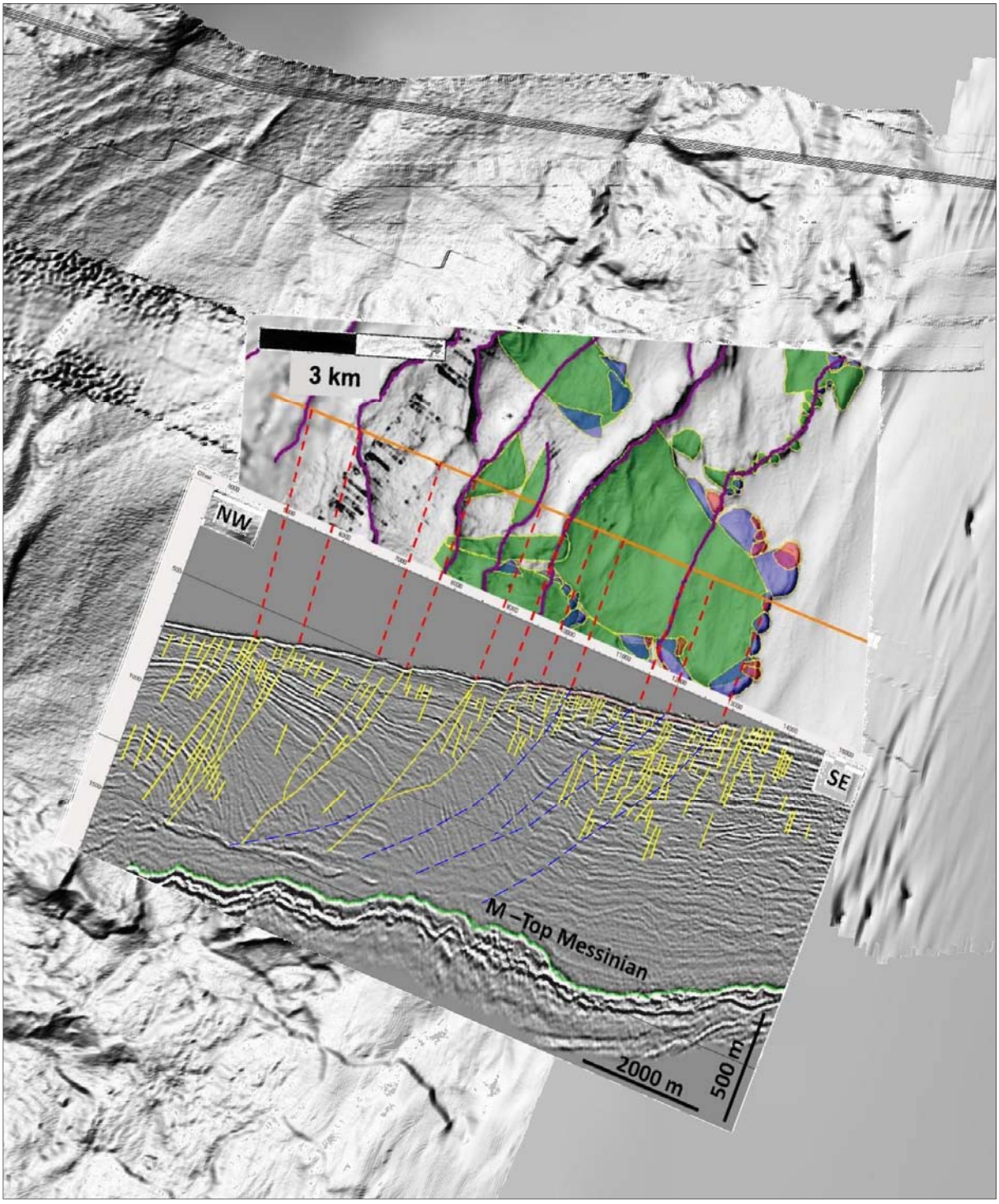
Figure 1-14: TGS Line 2061 superimposed on multibeam bathymetry showing correlation between fault scarps at seabed to listric faults. The interpretation by Katz (2012; yellow faults) over relies on vertical faults to account for lithologic variation and misses some of the listric faults (blue) that support his observations.



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The second type of submarine mass movement is a submarine landslide, which initiates as a slope-material failure followed by down-slope movements of coherent masses of sediment of discrete failure planes. These features have distinct morphological and structural indicators. The head wall is often scalloped and irregular with steep, unstable slopes. Debris aprons are often present, distinctive from the adjacent seabed. The runout of landslides is highly variable. The mass may arrest soon after failure; it may creep, or it may turn into rapid debris or turbidity flows, running up to hundreds of kilometers. For this reason, submarine landslides may endanger offshore submerged facilities.

The distinct circular scar morphology suggests that small-to-medium size landslides within the study area are of the slump type. Following slope failure, the failed material either keeps some of its consistency and is deposited down slope relatively close to the scar at a distance of up to 1 km forming a typical toe structure, or it disintegrates, possibly liquefies, and moves down slope as distributed debris avalanche away from the scar to a distance of 10 km or more. Sliding distance is affected by sliding volume. In this area, landslide size may be restricted by the proximity to earthquake sources, e.g., the DST (~M7) and the Carmel Fault (~M6.5). The shorter reoccurrence time of seismic accelerations exceeding critical acceleration for slope stability limits the amount of sediment that accumulates between sliding events, reducing the likelihood of larger landslides. The route of the LPP ranges from

1. a stable shelf with slopes less than 2°;
2. an extension regime at the shelf break with slopes of 4° to 7° and local variations of 30° or more associated with fault scarps and slump scars;
3. a transitional stress regime along the continental slope with a seabed of composite debris deposits; and
4. a compressional environment of seabed ridges, strike-slip faults and incised submarine channels.

The compressional regime is expressed at the seabed westward from KP 85 beginning with a series of right-stepping, sinistral, strike slip faults oriented N50W. These faults are considered active and are north of the LPP.

The crustal-scale strike-slip faults in the Levantine Basin are sinistral to accommodate the counter clockwise rotation of the Anatolian Plate relative to the African Plate. Along the route of the LPP, west to the Leviathan Field, the smaller scale strike-slip faults are generally oriented N25E and may be either sinistral or dextral. Fault displacement can be up to 800 m with the direction and magnitude determined by dislocation of seismic events or buried channels on time-slices. Most strike-slip faults are associated with compression ridges or step over, pop-up structures (Figure 1-15 through 1-17). If a seabed trough is present along the axis of the fault, that fault is considered active. Numerous other oblique, strike-slip faults are buried.

The seabed presented in the accompanying 1:50,000 scale charts has several submarine channels that support sediment transport through turbidity currents from the Nile Delta 200 km to the southwest. The channels tend to be more active west to east, and those east of KP 15 are inactive. At vertical exaggeration common in seismic data presentations, the active channels have a “V” shaped profile while the abandoned channels have a “U” shaped profile

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with a flat bottom. “Active” is a relative term, with perhaps decades, centuries, or millennia between flow events.

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Seabed stability along the route of the LPP exhibits a range of surficial failures (some described earlier near the shelf break) with fault scarps and slump scars on the order of tens of meters. Along the banks of the seabed channels, smaller scale slumps less than 100 m wide are common. When the seabed features are viewed with a 1:1 vertical exaggeration, the seabed channels and compression ridges/step over pop-up structures appear quite manageable (Figure 1-18). However, as observed from high-resolution multibeam bathymetry, surficial failures are apparent on seabed slopes less than 10° (Figure 1-19).

Soil liquefaction is the phenomenon where the soil loses a significant part, or all, of its shear strength. Liquefaction may occur due to cyclic shear stresses, imposed by waves or earthquakes, that generate excessive pore pressure until the soil loses a significant part of its shear strength (residual liquefaction) or if a steep wave travels over a loose soil inducing a upward-directed pressure gradient under the wave through (instantaneous liquefaction). Soil liquefaction will affect both vertical stability (sinking and floatation) and lateral stability. Depending on the specific gravity of the pipe, soil liquefaction may cause a heavy pipe laid on the seabed to sink into the soil and bury itself or it cause a light (and buried) pipe to float up through the soil. Models do exist to predict possible liquefaction; however, some rather sophisticated (*in situ* and laboratory) soil tests are required in order to quantify the parameters that enter these models.

Locations of the seven seafloor risks identified along the proposed pipeline alignment are summarized in Table 1-2. Identified risks include both man-made infrastructure and natural seafloor characteristics that should be avoided or considered during pipeline engineering and emplacement. Pipeline alignment with a summary risk map are required under EIA Instruction 1.5.3 and are provided in Appendix A-10.

Table 1-2: Summary risk map for the proposed pipeline alignment.

KP	Identified Risk
-0.35	Lev-6 flowline. Abandoned seabed channel, vertical relief <1 m. Softer sediment in channel thalweg likely.
-0.26	Lev-4 flowline. Abandoned seabed channel, vertical relief <1 m. Softer sediment in channel thalweg likely.
-1.1	Lev-9 flowline. Med Nautilus fiber optic communications cable.
-1.22	Lev-9 flowline. Active strike-slip fault with up to 450 m left-lateral displacement.
-0.90	Lev-5 flowline. Med Nautilus fiber optic communications cable.
-5.0	Lev-5 flowline. Active strike-slip fault with up to 450 m left-lateral displacement.
-0.88	Lev-3 flowline. Med Nautilus fiber optic communications cable.

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Figure 1-15: Near KP 5 two seabed risks are shown in a three-dimensional (3D) data example which is coincident with the pipeline route. While the crustal-scale, strike-slip faults have left-lateral displacement, smaller scale strike slip faults can be in either direction, alternating orientation along the route of the proposed pipeline corridor. The fault shown here has approximately 400 m of displacement measured from event dislocation on time-slices. An active seabed channel has maximum slopes of 15° (W) and 32° (E) and an elevation difference of 30 m. Vertical exaggeration is 5:1.

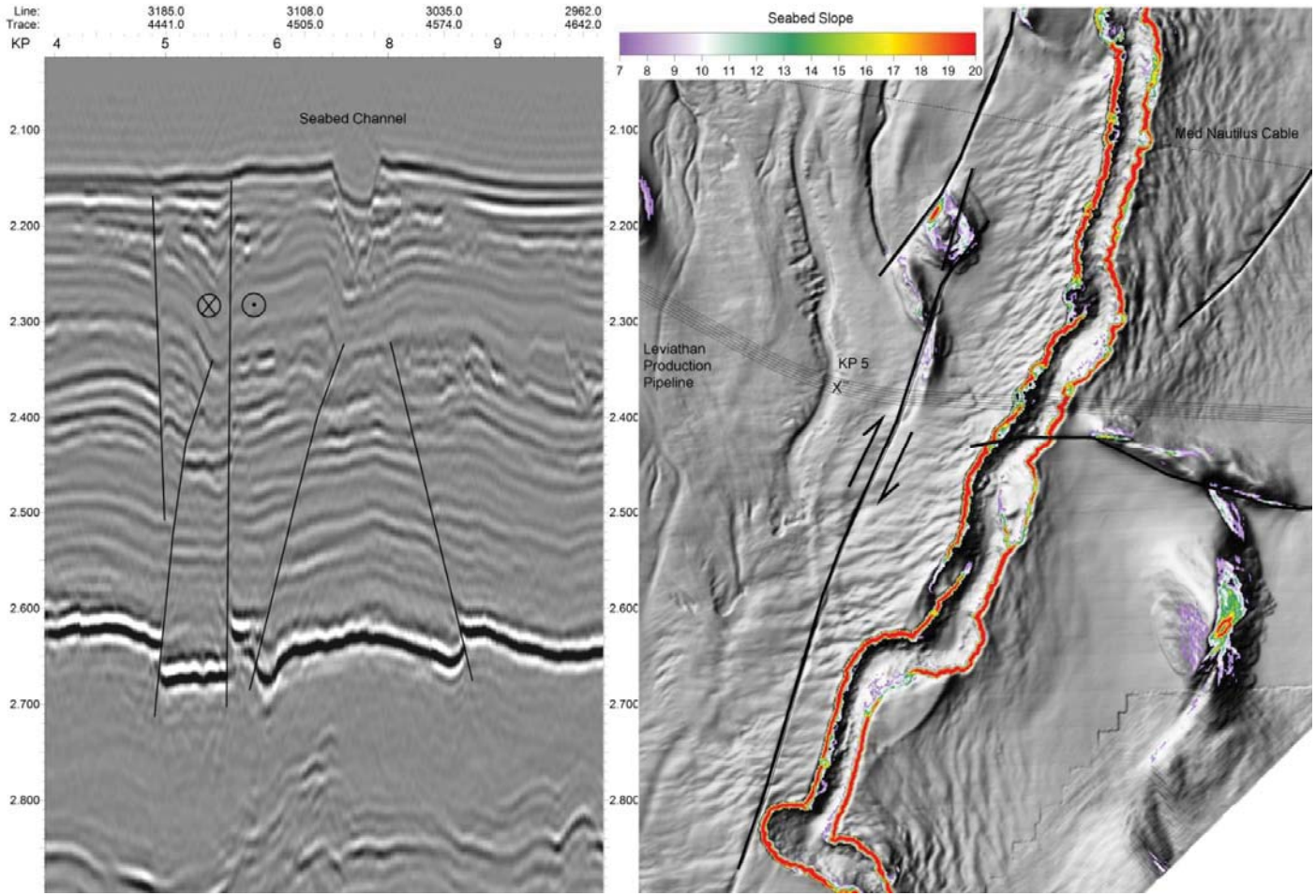

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Figure 1-16: East of KP 29 a strike-slip fault, shown with up to 800 m of right-lateral displacement, is associated with a compressional seabed ridge. An abandoned seabed channel is flanked by surficial failures with slump scars at seabed. Active seabed channels have more of a "V" shaped profile while abandoned channels are more "U" shaped with flat bottoms. Vertical exaggeration is 5:1.

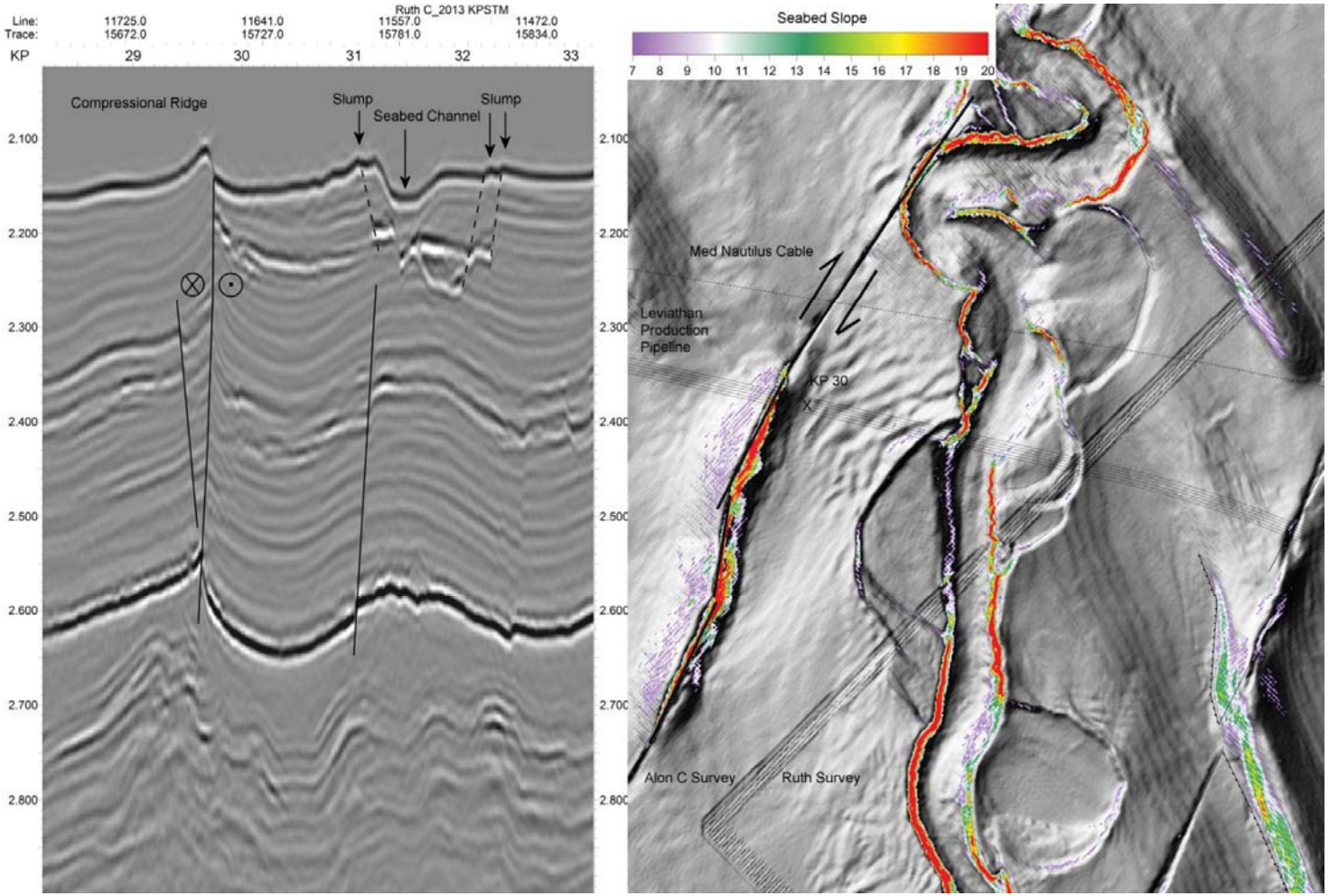

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Figure 1-17: West of KP 55 the post-salt sediments are in compression-forming networks of seabed ridges that are often offset hundreds of meters by strike-slip faults. The reverse faults will often alternate orientation as the strike-slip faults alternate from sinistral to dextral. Vertical exaggeration is 5:1.

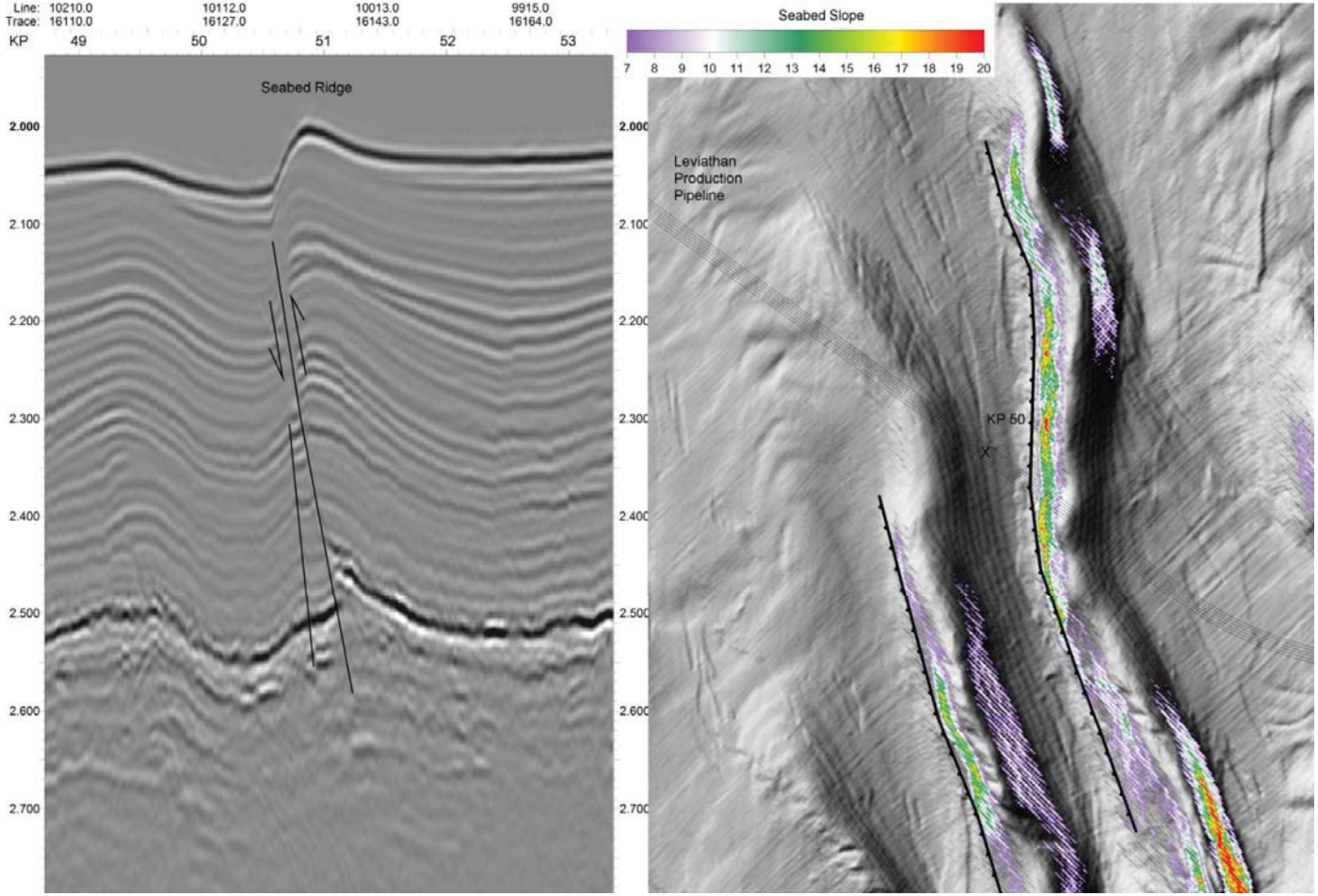

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Figure 1-18: Two seabed features with the highest slopes along the proposed pipeline route are seabed channels at KP 6.5 and compressional ridges/step-over pop-up structures at KP 29.7. Vertical exaggeration is approximately 1:1 (none).

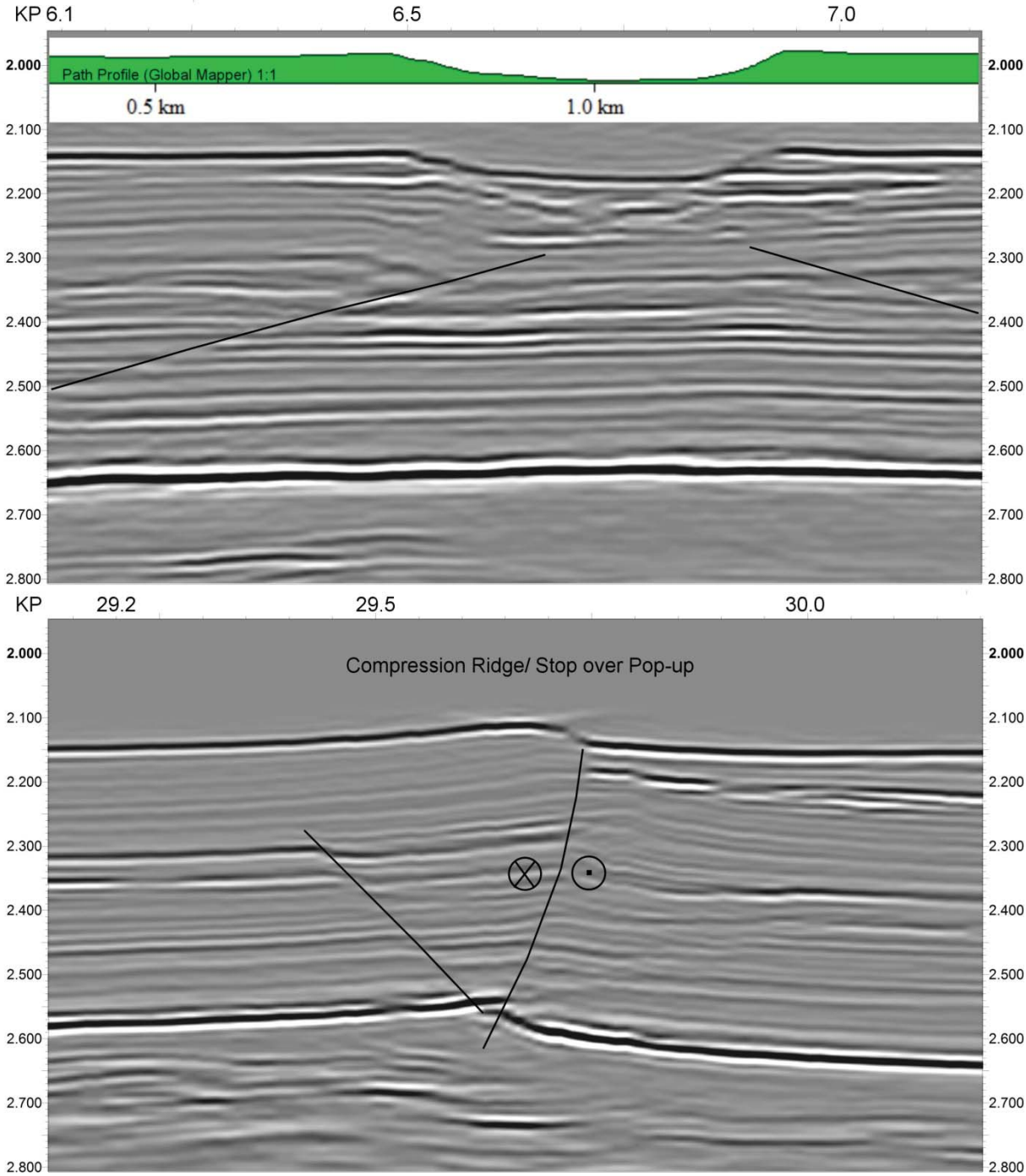

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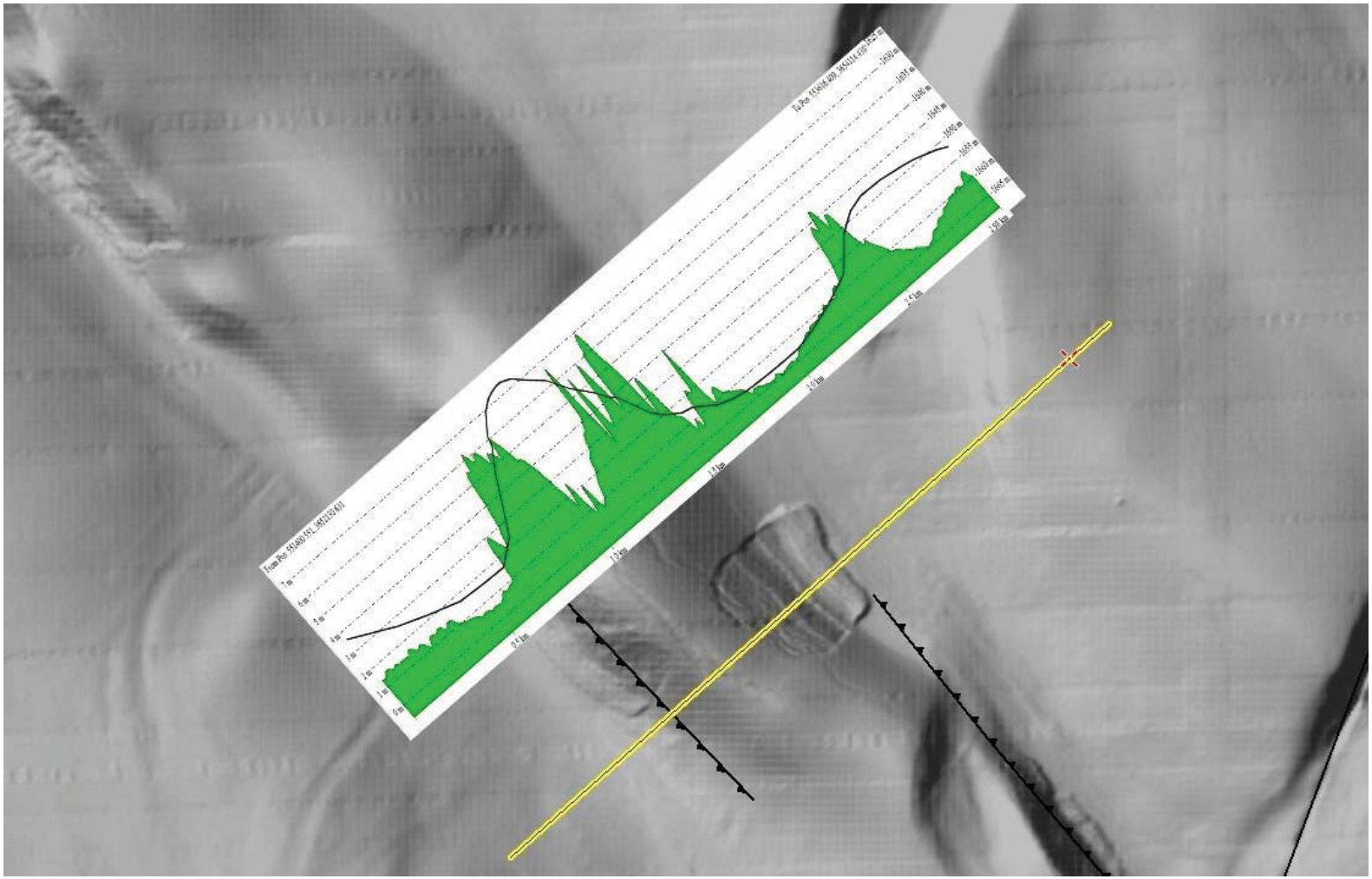
Figure 1-19: The high-resolution multibeam bathymetry can show features below the resolution of three-dimensional (3D) seismic data. The elevation profile (black line) scale on the right is from -1625 to -1665 m below sea surface. The background slope profile scale is from 0° to 7°, indicating that surficial failures can occur on very low-angle slopes.



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1.6 Nature and Ecology

1.6.1 Coastal Habitats and Infrastructure

The Leviathan Field is located approximately 120 km from the nearest shoreline (northern Israel near Rosh HaKarmel) and is not near any coastal habitats. The export pipeline will be installed on the seafloor from the Leviathan Field to the production platform offshore of Dor.

Data presented below summarize analyses from environmental baseline surveys conducted in the Leviathan Field (CSA Ocean Sciences Inc., 2016a) and along the proposed pipeline route (CSA Ocean Sciences Inc., 2016b). Further detailed analysis and presentation of raw data can be found in those respective reports. No known chemosynthetic communities are known to exist in the Application Area. However, chemosynthetic communities have been identified in the area of the Palmachim disturbance, located west- Tel-Aviv (Rubin-Blum et al., 2014).

Leviathan Field

This area of the Levantine Basin is characterized by smooth, relatively flat soft bottoms. Sediments in the Leviathan Field generally are composed of clay and silt (see Section 1.4.6). Soft bottom assemblages are composed of biota (typically fauna in depths below the photic zone) living within the sediments (infauna) and on the sediment surface (epifauna). Several studies have documented the composition of these communities in the general area of the Leviathan Field (Kress et al., 1993; Galil and Goren, 1994; Kröncke et al., 2003; Galil, 2004). These studies, as well as other Noble Energy surveys, have shown that infauna and epifauna generally are in low abundance compared with nearshore environments (CSA Ocean Sciences Inc., 2013a,b, 2015). Other surveys conducted in the deepwater Levantine Basin provide generally similar results, with low abundance of infauna in offshore waters. Taxonomic analysis of infauna from the Leviathan Field are presented in CSA Ocean Sciences (2016a) and in previous surveys conducted by CSA in the Leviathan blocks (CSA International, Inc., 2011, 2012; CSA Ocean Sciences Inc., 2013a,b, 2014a,b).

Pipeline Corridor

Pipeline Section 1: 500 m to >1600 m Depth Stratum

Raw macroinfaunal data collected along the pipeline corridor are provided in CSA Ocean Sciences Inc., 2016b. The majority of individuals collected (i.e., highest densities) were found between 500- and 1,000-m water depths. The most common taxa were from the phylum Annelida (Class Polychaeta), which accounted for 71.1% of all infauna collected along this segment of the offshore pipeline corridor. Crustacea and Mollusca accounted for 21.1% and 3.5% of all infauna, respectively. The dominant taxon was *Spio* sp., a polychaete annelid that accounted for 17.54% of all taxa found within this pipeline section. Three other relatively abundant taxa (*Notomastus* sp., *Cirrophorus branchiatus*, and Cirolanidae) each accounted for 7.02% of the offshore pipeline taxa. A more detailed analysis of the benthic community parameters along the proposed pipeline route is presented in CSA Ocean Sciences Inc. (2016b)

Pipeline Section 2: 200 m to 500 m Depth Stratum

Raw macroinfaunal data collected along the pipeline corridor are provided in CSA Ocean Sciences Inc., 2016b. In Pipleline Section 2, polychaete annelids were the dominant taxa,

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accounting for 61.5% of all infauna. Three polychaetes (*Cossura pygodactylata, Dipolydora* sp., and *Aricidea [Aedicira]* sp. 1 EcoA) accounted for 29.6% of the total infauna. Mollusks were the second most dominant group and accounted for 26.2% of all infauna. Bivalvia sp. was the dominant mollusk, accounting for 9.9% of all infauna. A more detailed analysis of the benthic community parameters along the proposed pipeline route is presented in CSA Ocean Sciences Inc. (2016b).

Pipeline Section 3: 0 m to 200 m Depth Stratum

Raw macroinfaunal data collected in water depths between 0 and 200 m is provided in CSA Ocean Sciences Inc., 2016b. Annelid polychaetes (*Prionospio* sp., *Harpinia* sp., *Nephtys* sp.,*Salmacinia* sp., Caprellidae, and *Exogone* sp.) were the most abundant taxa in water depths between 50 to 150 m. Other phyla such as Arthropoda (*Leptochelia tanykeraia*, *Leptocheirus* sp., Synopiidae sp., and Paranthuridae), Mollusca (Chaetodermatidae sp.), and Echinodermata (Spatangoida) contributed to the list of the most abundant taxa along with Annelida at stations located in shallower water depths between 0 to 60 m. A more detailed analysis of the benthic community parameters along the proposed pipeline route is presented in CSA Ocean Sciences Inc. (2016b).

1.6.3 Marine Mammals, Sea Turtles, Birds, and Fishes

1.6.3.1 Marine Mammals

There are no known site-specific marine mammal data from the Application Area. Regional sightings and strandings data for marine mammals in the Mediterranean Sea have been reviewed and summarized by Notarbartolo di Sciara and Birkun (2010) and Reeves and Notarbartolo di Sciara (2006). Kerem et al. (2012, 2014) reviewed the status of cetaceans in the Levantine Basin and Israeli waters, respectively. Based on these studies, Table 1-4 lists marine mammal species that may be present in the Application Area. The table has been edited to include updates in accordance with the most recent information available from the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (2016).

Table 1-3: Marine mammal species potentially occurring in the Application Area based on Kerem et al. (2012), ACCOBAMS (2012), and Notarbartolo di Sciara and Birkun (2010), as modified by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, 2016.

Common Name	Scientific Name	IUCN Status[1]	Presence Confirmed in Israeli Waters
Regular Species (Levantine Basin)			
Short-beaked common dolphin	*Delphinus delphis*	EN[2]	Yes
Risso's dolphin	*Grampus griseus*	DD[2]	Yes
Striped dolphin	*Stenella coeruleoalba*	VU[2]	Yes
Rough-toothed dolphin	*Steno bredanensis*	LC	Yes
Common bottlenose dolphin	*Tursiops truncatus*	VU[2]	Yes
Visitor[3] Species (Levantine Basin)			
Fin whale	*Balaenoptera physalus*	VU[2]	Yes
Minke whale	*Balaenoptera acutorostrata*	LC	Yes
Sperm whale	*Physeter macrocephalus*	EN[2]	Yes
False killer whale	*Pseudorca crassidens*	DD	Yes
Cuvier's beaked whale	*Ziphius cavirostris*	DD[2]	Yes
Vagrant[4] Species (Levantine Basin)			

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Common Name	Scientific Name	IUCN Status[1]	Presence Confirmed in Israeli Waters
Indo-Pacific humpback dolphin	*Sousa chinensis*	NT	Yes
Humpback whale	*Megaptera novaeangliae*	LC	No
Killer whale	*Orcinus orca*	DD	Possibly
Other Vagrant Species (Mediterranean Sea)			
Sei whale	*Balaenoptera borealis*	EN	No
North Atlantic right whale	*Eubalaena glacialis*	EN	No
Long-finned pilot whale	*Globicephala melas*	DD	No
Dwarf sperm whale	*Kogia sima*	DD	No
Sowerby's beaked whale	*Mesoplodon bidens*	DD	No
Blainville's beaked whale	*Mesoplodon densirostris*	DD	No
Gervais' beaked whale	*Mesoplodon europaeus*	DD	No
Harbor porpoise	*Phocoena phocoena*	LC	No
Mediterranean monk seal	*Monachus monachus*	EN	Yes

ACCOBAMS = Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area.

[1] IUCN status: CR = Critically Endangered; DD = Data Deficient; EN = Endangered; LC = Least Concern; VU = Vulnerable.

[2] The designation is specific to the Mediterranean subpopulation.

[3] Based on the IUCN (2010) definition, 'visitor' species are defined as: a species that does not reproduce within a region but regularly occurs within its boundaries

[4] Based on the IUCN (2010) definition, 'vagrant' species are defined as: a species that is currently found only occasionally within the boundaries of a region.

Small cetacean species that are considered regular species or visitors in the Levantine Basin include the common bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphus*), Risso's dolphin (*Grampus griseus*), rough-toothed dolphin (*Steno bredanensis*), striped dolphin (*Stenella coeruleoalba*), and false killer whale (*Pseudorca crassidens*). Large cetaceans that are considered regular residents or visitors in the Levantine Basin include the fin whale (*Balaenoptera physalus*), minke whale (*Balaenoptera acutorostrata*), and sperm whale (*Physeter macrocephalus*). The humpback whale (*Megaptera novaeangliae*) and killer whale (*Orcinus orca*) are considered vagrants in the Levantine Basin, along with the Indo-Pacific humpback dolphin (*Sousa chinensis*), a Lessepsian migrant introduced through the Suez Canal. Several other marine mammal species are considered vagrants elsewhere in the Mediterranean and their presence is not confirmed in Israeli waters (Table 1--4). There is one report of a gray whale (*Eschrichtius robustus*) sighting offshore Israel, but it is considered an extreme example of a vagrant species (Kerem et al., 2012).

Eight of the species in Table 1-4 are listed as either Endangered (Mediterranean monk sea, fin whale, short-beaked common dolphin, sperm whale, sei whale, and north Atlantic right whale), or Vulnerable (striped dolphin, common bottlenose dolphin, and fin whale) in the IUCN Red List (2016). Of these, the common bottlenose dolphin is the most abundant in the region and the only one that is a regular resident of the Levantine Basin (Kerem et al., 2012). The fin whale and sperm whale are visitors, whereas the sei whale and North Atlantic right whale are vagrants in the Mediterranean and are not reported from Israeli waters. The Mediterranean monk seal (*Monachus monachus*), a Critically Endangered species, is the only pinniped found in the Mediterranean region. The Mediterranean monk seal population is estimated at approximately 350 to 450 surviving individuals, making it one of the world's most Critically Endangered mammals (International Union for Conservation of Nature, 2016). It is very unlikely that monk seals will be present in the Application Area because they are extremely

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rare within waters offshore Israel. A single monk seal was spotted off the coast of Herzliya in January 2010, the first such sighting in recent decades (Scheinin et al., 2011). Several other sightings have been reported in recent years, including sightings in 2014 and 2015 offshore Rosh HaNikra by the Israeli navy (Erlichman, 2015). Photographs of the seal taken in 2014 and 2015 suggest that the 2010 sighting near Herzliya and the 2014 and 2015 sightings near Rosh Kerem et al. (2014) assessed the status of small cetacean species offshore Israel, including bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, rough-toothed dolphin, and Cuvier's beaked whale. Abundance was not estimated for any of these species. Based on strandings and sightings data, common bottlenose dolphin appears to be the most abundant. Rough-toothed dolphin is the only Mediterranean cetacean species for which the Levantine Basin may be the critical habitat for the subpopulation (Notarbartolo di Sciara and Birkun, 2010; Kerem et al., 2012). According to Kerem et al. (2012), the common bottlenose dolphin accounts for 85% of all reported marine mammal sightings and 60% of strandings. Although most of the sightings are in shallow coastal waters, there have been sightings up to 30 km offshore, over water depths of approximately 1,300 m. CSA Ocean Sciences Inc. (2014c) conducted a marine protected species survey as part of a two-dimensional (2D) bathymetric survey offshore Israel from 29 September to 24 October 2014. There were five marine mammal sightings during the survey period, and all were bottlenose dolphins. No sea turtle or whale species were observed during the survey.

1.6.3.2 Sea Turtles

There are no known site-specific sea turtle data from the Application Area. However, tracking studies indicate that sea turtles could occur in the Application Area (Seaturtle.org, 2008). Three sea turtle species are known to occur in the Levantine Basin: green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), and loggerhead turtle (*Caretta caretta*) (Table 1-5). Green turtles are listed as Endangered, the Mediterranean subpopulation of the loggerhead turtle is listed as Least Concern, and leatherback turtle is are listed as Vulnerable in the IUCN Red List (2016). The hawksbill turtle (*Eretmochelys imbricata*), a Critically Endangered species, also occurs occasionally in the Mediterranean Sea (Camiñas, 2004) but it would not be expected within the Levantine Basin (Kot et al., 2013).

Table 1-4: Sea turtle species potentially occurring in the Application Area.

Common Name	Scientific Name	IUCN Status[1]	Nesting in Israel
Loggerhead turtle	*Caretta caretta*	LC[2]	Yes
Green turtle	*Chelonia mydas*	EN	Yes
Leatherback turtle	*Dermochelys coriacea*	VU	No

[1] International Union for Conservation of Nature (IUCN) Red List of Threatened Species status: EN = Endangered; LC = Least Concern; VU = Vulnerable.
[2] The designation is specific to the Mediterranean subpopulation.

Loggerhead turtles and green turtles nest along the Israeli coast, with the loggerhead turtle being more common. While the primary nesting grounds for the Mediterranean loggerhead turtle population are located along the shores of Greece, Cyprus, and Turkey, the Israeli coast has historically provided habitat for hundreds of nests. Nesting starts at the end of May for loggerhead turtles and in mid-June for green turtles, continuing until the end of July and mid-August, respectively. According to data from the Israel Nature and Parks Authority (2011), the number of loggerhead turtle nests was 98 in 2009, 132 in 2010, and 139 in 2011; and the number of green turtle nests was 17 in 2009, 10 in 2010, and 25 in 2011 (Levy, 2011).

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1.6.3.3 Seabirds and Migratory Birds

No known site-specific bird data are available from the Application Area. However, the Mediterranean is home to several hundred bird species, many of which could occur in the area. This discussion includes seabirds as well as migratory birds that pass through the area.

Seabirds. At least 38 seabird species are native to Israeli waters (Table 1--6). This includes 36 seabird species listed by BirdLife International (2014a), plus two others based on additional information (International Union for Conservation of Nature, 2016; Palomares and Pauly, 2014). Because the Application Area is more than 100 km offshore, the avifauna is likely to consist mainly of pelagic seabirds – those that spend most of their life cycle in the marine environment, often far offshore over the open ocean. Examples of pelagic seabirds native to Israeli waters include Cory's Shearwater (*Calonectris diomedea*), Leach's StormPetrel- (*Oceanodroma leucorhoa*), Sooty Shearwater (*Puffinus griseus*), and Yelkouan Shearwater (*Puffinus yelkouan*). Other seabirds, including various species of gulls, terns, pelicans, and cormorants, could occur in the Application Area but are likely to be more abundant in near-coastal waters.

Two seabirds listed in Table 1-6 are listed as Vulnerable in the IUCN Red List (2016). The Yelkouan Shearwater is endemic to the Mediterranean basin, but its precise distribution is not well known and numbers are disputed (Bourgeois and Vidal, 2008). The main breeding colonies are in the central and eastern basins of the Mediterranean, from Corsica and Sardinia through the central Mediterranean and into the Adriatic and the Aegean (International Union for Conservation of Nature, 2016). There is no reported breeding in Israel. The Dalmatian Pelican (*Pelecanus crispus*) breeds in eastern Europe and east-central Asia; there is no reported breeding in Israel.

Several pelagic seabird species in Table 1-6 are listed in Annex II of the Protocol Concerning Specially Protected Areas and Biological Diversity of the Mediterranean (United Nations Environment Programme, 2013) as endangered or threatened avifauna of the Mediterranean region. These include Cory's Shearwater, Slender-Billed Gull (*Larus genei*), Mediterranean Gull (*Larus melanocephalus*), Dalmatian Pelican, Great White Pelican (*Pelecanus onocrotalus*), Pygmy Cormorant (*Phalacrocorax pygmeus*), Levantine or Yelkouan Shearwater, Little Tern (*Sterna albifrons*), Lesser Crested Tern (*Sterna bengalensis*), Caspian Tern (*Sterna caspia*), Gull-Billed Tern (*Sterna nilotica*), and Sandwich Tern (*Sterna sandvicensis*). Two of these pelagic seabird species, the Great White Pelican and Little Tern, breed in Israel and are listed as Least Concern in the IUCN Red List.

Table 1-5 : Seabird species occurring in Israeli waters (Adapted from: BirdLife International, 2014a).

Common Name	Scientific Name	IUCN Status[1]	Listed in Annex II[2]	Breeding in Israel[3]
Cory's Shearwater	*Calonectris diomedea*	LC	Yes	--
Black Tern	*Chlidonias niger*	LC	--	--
Caspian Gull	*Larus cachinnans*	LC	--	--
Mew Gull	*Larus canus*	LC	--	--
Lesser Black-Backed Gull	*Larus fuscus*	LC		--
Slender-Billed Gull	*Larus genei*	LC	Yes	--
Pallas's Gull	*Larus ichthyaetus*	LC	--	--

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Common Name	Scientific Name	IUCN Status[1]	Listed in Annex II[2]	Breeding in Israel[3]
White-Eyed Gull	*Larus leucophthalmus*	NT	--	--
Mediterranean Gull	*Larus melanocephalus*	LC	Yes	--
Yellow-Legged Gull	*Larus michahellis*	LC	--	--
Little Gull	*Larus minutus*	LC	--	--
Black-Headed Gull	*Larus ridibundus*	LC	--	--
Red-Breasted Merganser	*Mergus serrator*	LC	--	--
Northern Gannet	*Morus bassanus*	LC	--	--
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	LC	--	--
Dalmatian Pelican[4]	*Pelecanus crispus*	VU	Yes	--
Great White Pelican	*Pelecanus onocrotalus*	LC	Yes	Yes
Great Cormorant	*Phalacrocorax carbo*	LC	--	--
Pygmy Cormorant[4]	*Phalacrocorax pygmeus*	LC	Yes	--
Red Phalarope	*Phalaropus fulicarius*	LC	--	--
Red-Necked Phalarope	*Phalaropus lobatus*	LC	--	--
Great-Crested Grebe	*Podiceps cristatus*	LC	--	--
Black-Necked Grebe	*Podiceps nigricollis*	LC	--	--
Sooty Shearwater	*Puffinus griseus*	NT	--	--
Yelkouan Shearwater	*Puffinus yelkouan*	VU	Yes	--
Long-Tailed Jaeger	*Stercorarius longicaudus*	LC	--	--
Parasitic Jaeger	*Stercorarius parasiticus*	LC	--	--
Pomarine Jaeger	*Stercorarius pomarinus*	LC	--	--
Little Tern	*Sterna albifrons*	LC	Yes	Yes
Bridled Tern	*Sterna anaethetus*	LC	--	--
Lesser Crested Tern	*Sterna bengalensis*	LC	Yes	--
Great Crested Tern	*Sterna bergii*	LC	--	--
Caspian Tern	*Sterna caspia*	LC	Yes	--
Common Tern	*Sterna hirundo*	LC	--	Yes
Gull-Billed Tern	*Gelochelidon nilotica*	LC	Yes	--
White-Cheeked Tern	*Sterna repressa*	LC	--	--
Sandwich Tern	*Thallasseus sandvicensis*	LC	Yes	--
Brown Booby	*Sula leucogaster*	LC	--	--

1 International Union for Conservation of Nature (IUCN) Red List of Threatened Species status: LC = Least Concern;
NT = Near Threatened; VU = Vulnerable.
2 Annex II of the Protocol Concerning Specially Protected Areas and Biological Diversity of the Mediterranean (United Nations Environment Programme, 2013).
3 Breeding in Israel based on BirdLife International (2014a) map viewer showing range and breeding locations.
4 Dalmatian Pelican and Pygmy Cormorant are not listed as native to Israel by BirdLife International (2014a) but have been added based on IUCN (2016) and their individual species descriptions on the BirdLife International website.

Annex II also includes several shorebirds reported from Israel and are listed in Table 1-7. The Slender-Billed Curlew (*Numenius tenuirostris*) is listed as Critically Endangered in the IUCN Red List, but it is considered a vagrant species in Israel and does not breed there. None of these species are likely to be present in the Application Area.

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Table 1-6: Shorebird species occurring in Israel that are on the Annex II list.

Common Name	Scientific Name	IUCN Status[1]	Israel Occurrence[2]	Breeding in Israel[3]
Kentish Plover	*Charadrius alexandrinus*	LC	Native	No
Greater Sand plover	*Charadrius leschenaultii columbinus*	LC	Native	No
Pied Kingfisher	*Ceryle rudis*	LC	Native	Yes
White-Throated Kingfisher	*Halcyon gularis*	LC	Native	Yes
Slender-Billed Curlew	*Numenius tenuirostris*	CR	Vagrant	No
Osprey	*Pandion haliaetus*	LC	Native	No
Eleonora's Falcon	*Falco eleonorae*	LC	Native	No

[1] International Union for Conservation of Nature (IUCN) Red List of Threatened Species status: CR = Critically Endangered; LC = Least Concern.
[2] Occurrence in Israel based on IUCN (2016).
[3] Breeding in Israel based on BirdLife International (2014a) map viewer showing range and breeding locations.

Migratory Birds. Israel is well known as one of two major migratory pathways in the Mediterranean region, with the other being Gibraltar. Research over the past decade has shown that approximately 500 million migrating birds fly over Israel's narrow airspace (Leshem and Atrash, 1998). The location is a "bottleneck" of the migration route for approximately 85% of the world's White Stork (*Ciconia ciconia*) population, many species of birds of prey, and most of the Paleartic population of White Pelicans. The Mediterranean lies along seasonal migratory pathways for several European and African species; several species that breed in Europe over-winter in the Mediterranean basin. Autumn and spring are the busiest times of the year for migrating birds. Many of the migratory species seasonally traverse the expanses of Europe and Asia from the high Arctic to Africa and the Indian subcontinent. Migrating shorebirds feed and reside in coastal areas along sandy beaches, embayments, shallow tidal flats, and brackish ponds. Mudflats are the often the last refueling stopover for migratory birds traveling from their Northern Hemisphere breeding grounds (Siberia, Russia) on their way to the Southern Hemisphere wintering grounds before crossing the thousands kilometers of Arabian desert. They also provide a respite for these flying migrants on their way back.

BirdLife International (2014b) lists 315 migratory bird species as occurring in Israel. Of these, the following bird species are listed as Endangered, Critically Endangered, or Vulnerable in the IUCN Red List (2016): Basra Reed-Warbler (*Acrocephalus griseldis*), Greater Spotted Eagle (*Aquila clanga*), Eastern Imperial Eagle (*Aquila heliaca*), Houbara Bustard (*Chlamydotis undulata*), Saker Falcon (*Falco cherrug*), Northern Bald Ibis (*Geronticus eremita*), Marbled Teal (*Marmaronetta angustirostris*), Egyptian Vulture (*Neophron percnopterus*), White-Headed Duck (*Oxyura leucocephala*), Dalmatian Pelican, Yelkouan Shearwater, Syrian Serin (*Serinus syriacus*), and Sociable Lapwing (*Vanellus gregarius*).

Of the 15 Important Bird Areas (IBAs) designated in Israel, two include coastal habitats (BirdLife International, 2014c). The Zevulun Valley IBA within the coastal plain north of Haifa is largely developed or agricultural, with fish ponds and some other small wetlands, including the marsh at Ein Afeq (a nature reserve and Ramsar wetlands site), approximately 8 km south of Akko. The Carmel Coast IBA is a 20 km strip along the Mediterranean coast, from Atlit south to the Taninim River Nature Reserve. The site includes the Atlit saltpans (8 km south of Haifa), a large complex of fish ponds at Ma'agan Mikhael and Ma'ayan Zvi (25 km north of Netanya), and some small islands off Ma'agan Mikhael.

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1.6.3.4 Fishes

The Mediterranean Sea supports more than 700 fish species (Froese and Pauly, 2014). There are 636 marine fish species reported from Israeli waters, including 582 natives and 54 introduced species (Froese and Pauly, 2014). The distribution of these species varies in relation to hydrography, physiography, and environmental factors over multiple basins and ridges that shape the Mediterranean. A broad pattern within the Mediterranean is that the number of species decreases from west to east. This gradient of richness is thought to be correlated with gradients of increasing temperature and salinity and decreasing productivity. The waters of the Levantine Basin are considered oligotrophic (nutrient-starved) and do not support particularly rich fisheries.

The ichthyofauna is generally composed of species with Atlantic (75%) and cosmopolitan (20%) origins (Golani, 2005). Important additions to this ichthyofauna are the numerous Indo-Pacific species introduced through the Suez Canal (e.g., 54 introduced species in Israel, as noted previously). This invasion is significant for local ecosystems as well as fisheries because several invaders have become numerically dominant in some habitats. Marine fishes may be broadly classified as either demersal (bottom dwelling) or pelagic (water column dwelling). Demersal species can be further subdivided into soft bottom and hard bottom species, depending on the type of substrate.

The regional ichthyofauna can be summarized based on surveys conducted by Galil (2004). A series of 12 cruises were conducted between 1988 and 1991 to study the bathyal environment off the coast of Israel (i.e., along the 1,500 m depth contour west of Dor). A total of 566 specimens from 31 fish species was collected. Mediterranean spiderfish (*Bathypterois mediterraneus,* synonymous with *B. dubius*) and roughtip grenadier (*Nezumia sclerorhynchus*) were the most common, representing 38% and 27% of the specimens, respectively. Cusk eels (*Cataetyx laticeps*), Sloane's viperfish (*Chauliodus sloani*), and the ubiquitous Mediterranean spiderfish were photographed at a depth of 2,900 m. Other fishes included anglerfish (*Lophius piscatorius*), forkbeards (*Phycis phycis* and *Phycis blennioides*), ghost shark (*Chimaera monstrosa*), a dragonfish (*Stomias boa*), and several unidentified hatchetfishes (Sternoptychidae), scorpionfishes (Scorpaenidae), gurnards (Triglidae), and flatfishes (Bothidae and Scophthalmidae). Several deep-dwelling shark species such as bluntnose sixgill shark (*Hexanchus griseus*), blackmouth catshark (*Galeus melanostomus*), several gulper shark species (*Centrophorus* spp.), Portuguese dogfish (*Centroscymnus coelolepis*), and velvet belly (*Etmopterus spinax*) also were recorded.

The Levantin basin is populated by opportunistic and resilient ichthyofaunal that recolonized the deep sea following the last anoxic event, forming assemblages that are distinct from those in the western Mediterranean (Goren and Galil, 2015). Sixty five species of fish were collected at depths greater than 500 m in the Levant Basin. Eighteen of thoses fish species were found at depths greater than elsewhere in the Mediterranean Sea. The families with the greatest number of species were Myctophidae (10 species) and Macrouridae (6 species). The ichthyoplankton assemblage was considered to be sparse but diverse. A recent set of cruises by the R/V *Nautilus* was performed at depths of 650 to 1,600 m in 2010 (Bell and Fuller, 2011). Several species emerged as dominant, namely the wreckfish *Polyprion americanus* and the Mediterranean spiderfish *Bathypterois mediterraneus* (synonymous with *B. dubius),* which was the most common fish species observed near the Application Area. Other fishes included shark (*Centrophorus* spp.) and skate (*Dipturus oxyrhinchus*), the anglerfish *Lophius*

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piscatorius, the forkbeards *Phycis phycis* and *Phycis blennoides,* the ghost shark *Chimaera monstrosa,* the dragonfish *Stomias boa*, and several unidentified hatchetfish, scorpionfishes, triglids, and flatfishes.

The pelagic offshore environment includes both small and large pelagic fish species. Whereas small pelagics tend to be more concentrated in shallow waters, larger pelagics may be found farther offshore in blue water as well. Of the large pelagics, special note is warranted for Atlantic bluefin tuna (*Thunnus thynnus*). Considered one of the most valuable fish species, if not the most valuable, it is undergoing a commercial collapse and is currently listed by IUCN (2016) as Endangered. Bluefin tuna enter the Mediterranean Sea to spawn in spring. Specimens caught in Israeli waters are almost always observed with ripe gonads. Other large offshore pelagic fishes in the Levantine Basin include albacore tuna (*Thunnus alalunga*) and other scombrids (e.g., *Euthynnus alletteratus*), dolphinfish, swordfish, sailfish, and pelagic sharks (e.g., smooth hammerhead shark, *Sphyrna zygaena* [listed by IUCN, 2016 as Vulnerable], and blue shark, *Prionace glauca* [listed by IUCN, 2016 as Near Threatened]). Of the deepwater ichthyofauna, hake (*Merluccius merluccius)* is worthy of special mention. This species, once caught by Israeli trawlers on the slope in hundreds of tons (Shapiro, 2007), has all but disappeared in recent years due to either higher sea water temperatures or overfishing (Edelist et al., 2010). Other deepwater species that show significant declines include the wreckfish (*P. americanus*) and the Haifa grouper (*Hyporthodus haifensis*).

1.6.4 Detailed Nature and Ecology Analysis

Detailed analysis of nature and ecology of area of Application is discussed in Sections 1.6.2 and 1.6.3.

1.7 Sea Water and Sediment Quality

Data presented below are summaries analyses from environmental baseline surveys conducted in the Leviathan Field (CSA Ocean Sciences Inc., 2016a) and along the proposed pipeline route (CSA Ocean Sciences Inc., 2016b). More detailed analysis and presentation of raw data can be found in those respective reports.

1.7.1 Water Quality

1.7.1.1 Hydrography

Leviathan Field

The deepwater environment of the eastern Mediterranean Sea is characterized by relatively high salinity, low turbidity, low nutrients, and high dissolved oxygen (DO). The yearly ranges for surface salinity and temperature in the eastern Mediterranean Sea are approximately 39.0 to 39.5 and 17°C to 28°C, respectively. Salinity remains fairly constant with depth, while temperature decreases with depth to the range of 14°C to 17°C (Zodiatis et al., 2001). The entire water column is well oxygenated; even the deep waters (e.g., 1,000-m depth) have saturation values greater than 70% to 80%. DO concentrations generally range from approximately 4.8 mg L^{-1} at the surface, increasing to 5.4 mg L^{-1} through the surface-mixed layer before gradually stabilizing to 4.1 mg L^{-1} for the remainder of the water column to the seafloor (Krom et al., 2005).

CSA has conducted several environmental baseline surveys in the Levantine Basin offshore Israel since mid-2011. During the Background Monitoring Survey, hydrographic data were

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acquired on 2 May 2014 at five stations in the Leviathan Field in water depths between 1,550 and 1,730 m (CSA Ocean Sciences Inc., 2016a). The results were typical of deepwater conditions in the eastern Mediterranean Sea during early to mid-spring.

The hydrographic profiles conducted during the Background Monitoring Survey showed the first signs of seasonal stratification in the upper surface waters (< 200 m). Water temperature reached a maximum of 21.03°C at the surface, decreasing steeply through the permanent thermocline, then slowly stabilizing and reaching a minimum of 13.72°C at a depth of 915 m, and slightly increasing near the bottom to 13.85°C. Salinity was highest (39.32) at the surface and decreased to a stable reading of 38.77 from the base of the permanent halocline to the bottom of the water column (See CSA Ocean Sciences Inc. (2016a) for all hydrographic profiles). DO concentrations were highest in the upper mixed layer, with a maximum concentration of 6.98 mg L^{-1} and 98% saturation. Below the deep chlorophyll maximum (DCM) at 9 5m depth, due to the lack of photosynthetic activity, oxygen followed seawater temperature, decreasing through the water column with a minimum of 5.45 mg L^{-1} and 67% saturation at 576 m and a slight increase near the bottom to 5.74 mg L^{-1} and 70.6% saturation. Turbidity was consistently low throughout the water column ranging from 0.03 nephelometric turbidity units (NTU) at the surface to 0.19 NTU near the bottom. Fluorescence (an indicator of phytoplankton biomass) was highest in the photic zone (<200 m), with a DCM at 95 m. Data collected at different times throughout the day showed a pattern of diel vertical migration of phytoplankton in response to changing light intensities. Fluorescence was high in shallow depths at midday, reaching a maximum value of 0.98 mg m^{-3} at the DCM, where the combination of nutrients and light are sufficient for photosynthesis. Later in the day, fluorescence values declined and the highest values were deeper in the water column.

Pipeline Corridor Section 1: 500 m to >1600 m Depth Stratum

Hydrographic data representative of Pipeline Section 1 acquired during water column profiling of four stations were typical of deepwater conditions in the eastern Levantine Basin in early to mid-spring (Kress et al., 2014). All hydrographic profiles from stations representing the pipeline were similar in all examined hydrographic parameters. Therefore, the profile from Station M05, located approximately halfway between the Leviathan Field and the proposed platform location was selected to represent the vertical water column profile in the survey area. Water temperatures ranged from approximately 21°C in surface waters to approximately 14°C in near-bottom water. Salinity was consistent throughout the water column, with a small halocline occurring between 300 and 500 m where salinity declined from approximately 39.2 in surface waters to 38.8 in near-bottom water. DO generally ranged from 7.25 mg L^{-1} and 98% saturation in near-surface water to 5.38 mg L^{-1} and 66% saturation in near-bottom water. Fluorescence and turbidity were similar to values recorded at stations within the Leviathan Field, with maximum fluorescence of approximately 0.47 mg m^{-3} at 100 m and turbidity not exceeding 0.19 NTU at any water depth.

Pipeline Corridor Sections 2 and 3: 0 m to 500 m Depth Stratum

Four water sampling stations representing Pipeline Sections 2 and 3 were located in relatively shallow waters (<200 m depth). The water depth at the deepest station was approximately 200 m, while the water depth at the station nearest to shore was approximately 30 m. Two

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stations near the location of the proposed platform also were profiled in water depth of approximately 80 m to 90 m water depth.

Water column sampling parameters generally were consistent among the four stations sampled. Only small differences in most water parameters were observed between near-surface and near-bottom water due to shallow water depths that were well mixed throughout the water column. Water temperatures generally ranged from approximately 20.5°C in near-surface water to approximately 18°C in near-bottom water. It should be noted that the near-surface water temperature at station M21 was lower than the other stations, likely due to strong winds of up to 41 knots in the days preceding water sampling that cooled the mixed water closer to shore. Salinity for all four stations stayed relatively constant throughout the water column, with small fluctuations that are expected for shallow water profiles. DO at all stations was approximately 7.0 mg L^{-1} and 98% saturation in near-surface water and slowly decreased with depth to approximately 6.85 mg L^{-1} and 91% saturation in near-bottom water. Fluorescence generally increased with depth until reaching the deep chlorophyll maximum (approximately 110 m at station M16). High concentrations of fluorescence at station M21 (0.185 to 0.27 mg m^{-3}) can likely be explained by the station's proximity to shore and shallow water (25 m) as well as increased solar radiation at the time of sampling. Turbidity remained very low at all stations, ranging between 0.2 NTU at the near-surface and 0.06 NTU at the near-bottom.

1.7.1.2 Seawater Quality

Leviathan Field

CSA conducted several environmental baseline surveys in the Levantine Basin offshore Israel since mid-2011. Based on these surveys and peer-reviewed literature, seawater in the region has the following characteristics:

- Very low nutrient concentrations;
- Metal concentrations that are below detection limits and/or below the relevant criteria and standards;
- Concentrations of total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAHs) that are below detection limits; and
- Radionuclide concentrations that are below the U.S. Environmental Protection Agency (USEPA) established maximum contaminant level.

During the Background Monitoring Survey, water quality sampling was conducted at five stations in the Leviathan Field. See CSA Ocean Sciences Inc. (2016a) for detailed results and analysis of seawater quality in the Leviathan Field.

Total Organic Carbon

Total organic carbon (TOC) in the form of carbohydrates, oils, proteins, and amino acids is a natural component of the water column in the marine environment typically resulting from the mineralization of organic matter and biological activity. During the Background Monitoring Survey, TOC concentrations near the surface averaged 0.86 mg L^{-1} ± 0.13, decreasing at mid-depth to 0.58 mg L^{-1} ± 0.13 and stabilizing near the bottom at 0.53 mg L^{-1} ± 0.08. Results were within or below the Levantine Basin values and the mean permissible level according to the proposed Mediterranean Environmental Water Quality Standards (MEWQS).

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Nutrients

The eastern Levantine Basin is considered "ultra-oligotrophic" with extremely low levels of nutrients (Krom et al., 2005). Concentrations of nitrogen bound within nitrate and ammonium in surface waters in the eastern Mediterranean Sea are one-half their concentrations in the western basin (Bethoux et al., 1992). The nitrogen:phosphorus (N:P) ratio in the southeastern Levantine Basin deep water ranges from 25:1 to 28:1, suggesting that the basin is phosphorus limited (Krom et al., 2005). This severe nutrient deficit is apparently due to a combination of high N:P values in all the external nutrient inputs and low denitrification rates in the Eastern Mediterranean Sea (Krom et al., 2010). Additionally, the Atlantic inflow brings in nutrientdepleted surface waters, and there is very little nutrient input from rivers in the eastern Levantine Basin (Krom, 1995; Tanhua et al., 2013), especially after the construction of the Aswan Dam across the Nile River.

Total Suspended Solids and Discrete Turbidity

The eastern Mediterranean Sea is a highly oligotrophic body of water with high water column transparency. The low total suspended solids (TSS) levels and high underwater transparency expected in the eastern Mediterranean Sea are attributed to low water column productivity and low terrestrial inputs from riverine discharges. In the deep sea, near-bottom waters generally have few suspended solids due to few disturbances that stir up the sediment on the seafloor; small particles transported from the surface usually are entrained in subsurface currents or pycnoclines (i.e., density gradient). Mean TSS concentrations observed in the Leviathan Field were below the Levantine Basin baseline mean and in agreement with results from recent studies conducted in the northeastern Mediterranean (Yilmaz et al., 1998; Uysal and Köksalan, 2006, 2010). TSS values averaged 4.7 mg L^{-1} ± 0.49 in near-surface water, 5.56 mg L^{-1} ± 1.24 at mid-depth, and 5.3 mg L^{-1} ± 2.51 in the near-bottom. Discrete turbidity measured on board the vessel (<0.37 NTU) was found to be consistent with these TSS results and the turbidity readings taken during the conductivity-temperature-depth (CTD) cast. Both TSS and discrete turbidity values were well below the proposed MEWQS maximum permissible levels.

pH and Chlorophyll a

pH is an important property of aqueous solutions, including seawater, because it affects chemical and biochemical properties such as chemical reactions, equilibrium conditions, and biological toxicity (Bates, 1982; Dickson, 1984, 1993; Millero, 2001). The pH of most surface seawater in equilibrium with the atmosphere is 8.2 ± 0.1, and the gross trends in pH are those expected from the surface pCO_2 (higher carbon dioxide [CO_2] would yield lower pH) (Millero, 2005). Onboard pH measurements of seawater samples resulted in normal readings, consistent among depths and stations and averaging 8.09 ± 0.01 at near-surface, 8.05 ± 0.01 at mid-depth, and 8.07 ± 0.03 at near-bottom. These results are well within the given mean range provided in the proposed MEWQS.

Very low nutrient concentrations are the key factor in limiting the biological activity and primary production in the area. Chlorophyll *a* concentrations ranged from 0.23 to 0.56 µg L^{-1}. Chlorophyll *a* concentrations coincide with fluorescence results described in Section 1.7.1.1, exhibiting highest concentrations at approximately noon (0.56 µg L^{-1}). However, while *in situ* fluorescence and extracted chlorophyll *a* measurement show similar daily trends, the relation between them is somewhat variable (Kiefer et al., 1989) as fluorescence in living cells depends

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on the ongoing rate of photosynthesis (Mauzerall, 1990) and the physiological status of cells (Morales et al., 1994). Following winter mixing and the injection of nutrients into the upper layers, in early to mid-spring concentrations are expected to be higher than observed for the euphotic zone (0 to 100 m) off the coast of Israel (0.06 to 0.12 µg L^{-1}) as recorded by Berman et al. (1986), and the 0.1 to 0.30 µg L^{-1} observed by Kress et al. (2014). Near-surface water samples were collected between 90 and 95 m near the observed DCM (see Section 1.7.1.1).

Cations and Anions

Ion composition from water stations at the Leviathan Field were compared with the major ion composition of average seawater under standard conditions (salinity = 35; pH = 8.1; and temperature = 25°C) and typical eastern Mediterranean values. According to American Society for Testing and Materials (ASTM) Standard D 596-83, a clean water sample with an anion sum between 10 and 800 milliequivalents per liter (meq L^{-1}) (typical of seawater) should not exceed ±5%. The cation/anion balance for several water samples was slightly greater than the recommended ±5% analytical difference for seawater samples; however, all ion concentrations were similar to average seawater and typical of the eastern Mediterranean Sea.

Dissolved Metals

Previous regional sampling indicates that metal concentrations in seawater are below detection limits and/or below the relevant criteria and standards. The results from the Background Monitoring Survey are consistent with previous findings. The results are compared with Israel's MEWQS (Ministry of Environmental Protection, 2002), European Union Commission Environmental Quality Standard (EUCEQS) for priority substances in the field of water policy (Directive 2008/105/EC and proposed amendment COM (2011)876), and toxicity reference values (marine Criterion Continuous Concentrations [CCCs] from Buchman, 2008). All seawater dissolved metals concentrations were either below the laboratory's quantification limit or within the Levantine Basin baseline standard deviation (SD) and 99% confidence interval. Furthermore, all metals at all depths (near-surface, mid-depth, and near-bottom) were well below Israel's MEWQS, EUCEQS, and CCC reference values. No unusual and or exceptional observations were made.

Hydrocarbons

Previous regional sampling indicates that TPH concentrations are below detection limits. Results from the Background Monitoring Survey are consistent with previous findings. TPH was not detected in any of the seawater samples collected for the Leviathan Field (CSA Ocean Sciences Inc., 2016a). In accordance with the described methodology for hydrocarbons analysis and the approved Scope of Work, samples were not analyzed further.

Radionuclides

Previous regional sampling indicates that radionuclide concentrations are below the relevant criteria and standards. Results from the Background Monitoring Survey are consistent with previous findings. During the Background Monitoring Survey, approximately 15% of the seawater samples from the Leviathan Field were sampled for radium (Ra) 226 and Ra 228 (n = 4). Station J01 was the only sampled station for the Leviathan Field area that was sampled at all water depths. Due to the high natural concentration of sulfate in the ocean, radium has a low solubility in seawater (Neff, 2005) and is unlikely to contribute to seawater radioactivity. All Ra 226 and Ra 228 concentrations were within the Levantine Basin baseline SD and 99%

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confidence interval. Combined Ra 226 and Ra 228 values for seawater were well below the USEPA's (1976) established maximum contaminant level of 5 pCi L^{-1}.

Pipeline Corridor Section 1: 500 m to >1600 m Depth Stratum

Four stations representative of Pipeline Section 1 were sampled exclusively for near-bottom water. Sampling started at the deepest station (M01 [1,516 m]), continued to M05 (1,358 m) and M09 (900 m), and ended at M12 (585 m). See CSA Ocean Sciences Inc. (2016b) for detailed results and analysis.

Total Organic Carbon

TOC concentrations were similar among stations, ranging from 0.46 mg L^{-1} at station M01 and 0.52 mg L^{-1} at station M12. Results were similar to those of the Leviathan Field where the near-bottom mean concentration was 0.53 mg L^{-1} ± 0.08. TOC concentrations at all pipeline stations representing Pipeline Section 1 were lower than the Levantine Basin baseline values and lower than the mean permissible level according to the proposed MEWQS in Israel.

Nutrients

All analyzed nutrients along the planned pipeline corridor were found in concentrations similar to those measured at the Leviathan Field. For samples collected that represented Pipeline Section 1, TP ranged between 0.46 and 0.52 mg L^{-1} and TN ranged between 0.15 and 0.17 mg L^{-1}. Phosphorous bound in phosphate accounted for a minimum of 51% of TP at station M05 and a maximum of 76% of TP at station M12. Nitrogen bound in ammonium, nitrate, and nitrite accounted for a minimum of 55% of TN at station M05 and a maximum of 73% of TN at station M12. This proportion shows that nutrients at these water depths are available for consumption by organisms after being recycled within the water column by excretion and microbial breakdown of organic particulate matter (detritus). Overall, nutrient concentrations are consistent with previous studies from the Levantine Basin (Azov, 1986; Herut et al., 1999; Kress et al., 2005) and, where applicable, are below the established Levantine Basin baseline means and the proposed MEWQS mean and/or maximum permissible levels.

Total Suspended Solids and Discrete Turbidity

Mean TSS concentrations in near-bottom water representative of Pipeline Section 1 were below the Levantine Basin baseline 99% confidence limit (CL) and in agreement with results from recent studies conducted in the northeastern Mediterranean (Yilmaz et al., 1998; Uysal and Köksalan, 2006, 2010). TSS values ranged from 2.6 mg L^{-1} at station M09 to 12.7 mg L^{-1} at station M12. Discrete turbidity measured on board the vessel was less than 0.35 NTU for all stations, which is consistent with the TSS results and the turbidity readings taken during the CTD cast. An exception to this is station M12, where TSS values appeared to be elevated but discrete turbidity readings showed that turbidity was similar to water from other sampled stations. The TSS level from station M12 was elevated compared with the other three stations representing Pipeline Section 1, but was well within 1 SD of the Levantine Basin baseline mean and substantially below the Levantine Basin baseline 99% CL. Both TSS and discrete turbidity were below the proposed MEWQS maximum permissible levels for all stations that represent Pipeline Section 1.

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pH

Onboard pH measurements of seawater samples from stations representing Pipeline Section 1 were consistent among stations, ranging between 8.03 and 8.10. These results are within the mean range provided by the proposed MEWQS and do not exceed the maximum permissible levels.

Cations and Anions

Ion composition from water stations representing Pipeline Section 1 were compared with the major ion composition of average seawater under standard conditions (salinity = 35, pH = 8.1, and temperature = 25°C) and to typical eastern Mediterranean Sea values. The cation/anion balance for all water samples was slightly greater than the acceptable ±5% analytical difference for seawater samples; however, all ion concentrations were generally similar to average seawater and typical of the eastern Mediterranean Sea.

Dissolved Metals

Dissolved metals concentrations representative of Pipeline Section 1 were below the laboratory's quantification limit or within the Levantine Basin baseline SD and 99% CL. Dissolved metals concentrations at all stations were well below MEWQS, EUCEQS, and CCC reference values. No unusual or exceptional observations were made.

Hydrocarbons

TPH was not detected in any seawater samples collected at water stations representing Pipeline Section 1. In accordance with the described methodology for hydrocarbons analysis and the approved SOW, samples were not further analyzed for PAHs.

Radionuclides

Approximately 15% of the seawater samples in the Leviathan Field Development were analyzed for Ra 226 and Ra 228 (n = 4). Station M16 was the only station sampled for radionuclides which represented Pipeline Section 1. Ra 226 and Ra 228 concentrations at station M16 were below the Levantine Basin baseline 99% CL. The combined Ra 226 and Ra 228 concentration at station M16 was well below the USEPA's (1976) established MCL of 5 pCi L^{-1} for combined Ra 226 and Ra 228.

Pipeline Corridor Sections 2 and 3: 0 m to 500 m Depth Stratum

Four stations representative of Pipeline Sections 2 and 3 were sampled exclusively for near-bottom water. Sampling began at the deepest station (182 m water depth) and proceeded shoreward to the shallowest station (20 m water depth).

Total Organic Carbon

TOC concentrations were generally similar among stations, ranging from 0.82 mg L^{-1} at to 1.06 mg L^{-1}. Results were similar to those of near-surface water samples collected at the Leviathan Field where the near-surface mean was 0.86 mg L^{-1} ± 0.13. Mean TOC concentrations were above the Levantine Basin baseline mean at stations M21, N01, and M16. However, TOC concentrations at all stations were below the Levantine Basin baseline 99% CL and the mean permissible level according to the proposed MEWQS in Israel.

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Nutrients

All analyzed nutrients were found in similar concentrations to those of the near-surface water samples collected at the Leviathan Field, which was expected because the samples were taken from the top 200 m of water. At nearshore stations along Pipeline Sections 2 and 3, TP ranged between 0.54 and 0.70 mg L^{-1} and TN ranged between 0.08 and 0.14 mg L^{-1}. Phosphorous bound within phosphate accounted for a minimum of 22% of TP at station O01 and a maximum of 35% of TP at station M16. Nitrogen bound in ammonium, nitrate, and nitrite accounted for a minimum of 8% of TN at station O01 and a maximum of 10% of TN at station M16. This proportion presents a depletion of the few existing nutrients in the nearshore system, with nutrients likely being consumed in primary production and incorporated into organic forms. Overall, nutrient concentrations were consistent with previous studies from the Levantine Basin (Azov, 1986; Herut et al., 1999; Kress et al., 2005) and, where applicable, were below the established Levantine Basin baseline means and the proposed MEWQS mean or maximum permissible levels.

Total Suspended Solids and Discrete Turbidity

Mean TSS concentrations representative of Pipeline Sections 2 and 3 were above the Levantine Basin baseline mean at most stations but below the 99% CL of the Levantine Basin baseline mean at all stations. TSS concentrations were in agreement with results from recent studies conducted in the northeastern Mediterranean (Yilmaz et al., 1998; Uysal and Köksalan, 2006, 2010). TSS values ranged from 7.8 mg L^{-1} at station N01 to 12.6 mg L^{-1} at station O01. Discrete turbidity measured on board the vessel was below 0.47 NTU at all stations, which is consistent with turbidity readings taken during the CTD cast. Discrete turbidity values were below the proposed MEWQS maximum permissible levels.

pH

Onboard pH measurements of seawater samples representative of Pipeline Sections 2 and 3 were consistent among stations, ranging between 8.06 at stations M16 and O01 and 8.09 at station M21. These results are within the given mean range provided at the proposed MEWQS and do not exceed the maximum permissible levels.

Cations and Anions

Ion composition from water stations representative of Pipeline Sections 2 and 3 were compared with major ion compositions of average seawater under standard conditions (salinity = 35, pH = 8.1, and temperature = 25°C) and typical eastern Mediterranean Sea values. The cation/anion balance for stations M01, M05, and M12 is within the acceptable ±5% analytical difference for seawater samples while station M09 has a difference of 5.2%. However, all ion concentrations were generally similar to average seawater and typical eastern Mediterranean values.

Dissolved Metals

Dissolved metals concentrations from stations were below the laboratory's quantification limit or within the Levantine Basin baseline SD and 99% CL except for dissolved copper at station M21. The dissolved copper concentration at station M21 (0.60 µg L^{-1}) was higher than the Levantine Basin baseline 99% CL, but is well below Israel's proposed MEWQS (5.0 µg L^{-1}) and the CCC value of 3.1 µg L^{-1}. All dissolved metals concentrations at all stations representing Pipeline Sections 2 and 3 were well below Israel's MEWQS, EUCEQS, and CCC reference values. No unusual or exceptional observations were made.

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Hydrocarbons

TPH was not detected in any of the seawater samples collected at water stations representing Pipeline Sections 2 and 3. In accordance with the described methodology for hydrocarbons analysis and the approved SOW, samples were not further analyzed for PAHs.

Radionuclides

Approximately 15% of the seawater samples in the Leviathan Field were analyzed for Ra 226 and Ra 228 (n = 4). Stations N01 and O01 were sampled for radionuclides to represent Pipeline Section 2. Ra 226 and Ra 228 concentrations at stations N01 and O01 were low and generally less than or similar to the Levantine Basin Baseline mean. All values, including combined Ra 226 and Ra 228 values, were less than the Levantine Basin baseline 99% CL. The combined Ra 226 and Ra 228 concentration at both stations was well below the USEPA's (1976) established MCL of 5 pCi L^{-1} for combined Ra 226 and Ra 228.

1.7.2 Sediment Quality

1.7.2.1 Leviathan Field

Sediment sampling has been conducted at 117 grid cells in the Leviathan Field (CSA Ocean Sciences, Inc., 2016a). This includes 79 stations sampled during the Background Monitoring Survey, as well as stations previously sampled near the Leviathan-2, Leviathan-3, and Leviathan-4 wellsites and near the ML-1X, Leviathan-5, and Leviathan Deep proposed wellsites. The Leviathan-2 and Leviathan-4 samples included post-drilling surveys. Sediment samples were analyzed for grain size, TOC, metals, hydrocarbons (TPH and PAHs), radionuclides, and polychlorinated biphenyls (PCBs). See CSA Ocean Sciences Inc. (2016a) for detailed results and analysis. Sediment grain size was discussed in Section 1.4.6.

Sediment Total Organic Carbon

Sediment TOC concentrations were low and uniform (0.43% ± 0.05%) throughout the Leviathan Field. TOC concentrations were within the 99% CL of the Leviathan Field mean and also within the 99% CL of the Levantine Basin baseline for TOC concentration.

Sediment Metals

Concentrations of all metals were below effects range low (ERL) values with the exception of arsenic, copper, and nickel, and only nickel exceeded the effects range median. However, these three metals are within the upper 99% CL of the Levantine Basin baseline and are naturally found in high concentrations throughout the Levantine Basin. Thus, ambient concentrations of arsenic and copper are above the ERL, and ambient concentrations of nickel are above the effects range median (ERM). Selenium and silver concentrations generally were not detectable within the Leviathan Field (>84% were non-detects). Additionally, most of the other metals with concentrations above detection limits were within the 99% CL of the Levantine Basin baseline (e.g., aluminum, arsenic, beryllium, chromium, copper, iron, mercury, nickel, vanadium, and zinc). The metals that were found to have some concentrations above the 99% CL of the Levantine Basin baseline were antimony, barium, cadmium, lead, and thallium. Antimony concentrations ranged from 0.2 to 1.8 parts per million (ppm), the majority were below the Levantine Basin baseline (0.62 ppm ± 0.25). Antimony

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concentrations near the Leviathan-4 wellsite were elevated above the upper 99% CL for the Levantine Basin baseline (1.27 ppm), while concentrations surrounding the Leviathan-2 wellsite were not. Antimony concentrations in drilling mud (from Tamar Field samples) are about twice the Levantine Basin baseline, and therefore elevated concentrations near a wellsite is not surprising. However, the T_{50} concentration (the chemical concentration that corresponded to the 50% probability of observing sediment toxicity) for antimony is 2.4 ppm (Buchman, 2008). This indicates that elevated concentrations of antimony (<1.8 ppm) within the field were low and do not pose a threat to the environment.

Barium concentrations within the Leviathan Field were highly elevated in grid cells containing the Leviathan-2 (12,263 ppm) and Leviathan-4 (8,218 ppm) wellsites. This was not unexpected because barite is a major constituent of drilling mud and barium concentrations in drilling mud are much higher than the Levantine Basin baseline (173.4 ppm ± 30.1). The elevated barium concentrations were primarily within 500 m of these wellsites, which is consistent with the dispersion modeling that predicted that there could be bottom deposition of particles from the discharge plume out to 676 to 775 m from the wellsite. Barium concentrations elsewhere within the Leviathan Field ranged from 113 to 375 ppm. Barium is not considered to be toxic to marine organisms and there is no established ERL/ERM concentration for this metal; therefore, the high concentrations of barium reported around the wellsites are not expected to negatively affect the environment.

Cadmium concentrations ranged from below the detection limit (0.16 ppm) to 1.04 ppm. Cadmium concentrations were slightly elevated at various locations throughout the field when compared with the upper 99% CL of the Levantine Basin baseline (0.36 ppm). Relatively high concentrations of cadmium were found in proximity to the Leviathan-2 and Leviathan-4 wellsites. Cadmium concentrations ranged between 0.26 and 0.74 near the Leviathan-4 wellsite, and between below the detection limit of 0.16 to 0.64 near the Leviathan-2 wellsite. These concentrations may be due to drilling muds, as cadmium is a component of drilling mud barite. However, other areas of elevated cadmium concentrations, relative to the Levantine Basin baseline, were located far from drilling activities and were relatively patchy in distribution. This finding indicates that the distribution of cadmium concentrations above the upper 99% CL of the Levantine Basin baseline within the Leviathan Field may be due to natural variation of this metal within seafloor sediments of the region. Cadmium concentrations within the Leviathan Field were well below the ERM value (9.6 ppm) and ERL value (1.2 ppm) for cadmium (Long and Morgan, 1990), and therefore do not pose a threat to the environment.

Lead concentrations were generally below the upper 99% CL of the Levantine Basin baseline (49.1 ppm), with the exception of locations near the Leviathan-2 and Leviathan-4 wellsites. Lead is a component of drilling mud and barite and has been found in cuttings, so its presence in the field near the existing wellsites is unsurprising. A single high lead concentration (48.3 ppm), located in the grid cell containing Leviathan-2, was just above the ERL concentration (46.7 ppm), but well below the T_{50} concentration (94 ppm) and ERM concentration (218 ppm) for this metal. Lead concentrations elsewhere in the Leviathan Field ranged from 11.9 to 39.3 ppm. These results indicate that lead concentrations within the Leviathan Field are not expected to negatively affect the environment.

Some thallium concentrations were elevated above the upper 99% CL of the Levantine Basin baseline (0.86 ppm) in the northern portion of the Leviathan Field. Thallium concentrations reached a maximum of 2.8 ppm in this region. This location is more than 10 km from any

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known areas of previous drilling or anthropogenic activity; therefore, elevated concentrations of this metal within this region likely reflect natural concentration variations within seafloor sediments. There are no ERL or ERM values for thallium concentrations in marine sediments.

Sediment Hydrocarbons

Sediment TPH concentrations within the Leviathan Field ranged from 4.0 to 27.1 ppm, and had a mean (± SD) of 13.2 ppm ± 4.8. TPH concentrations throughout the entire survey area were within the 99% CL of the Levantine Basin baseline of 21.85 ppm. TPH concentrations in the middle of the Leviathan Field were sampled prior to this survey and were analyzed by ALS Kelso. ALS Kelso had a method reporting limit of approximately 50 ppm, which is substantially higher than the method detection limit of 1.4 ppm for the analytical laboratory, TDI-Brooks. While all TPH concentrations in these grid cells were below ALS Kelso's method reporting limit, the usual substitution of half the method reporting limit was not utilized because this value was above the 99% CL of the Levantine Basin baseline. Its inclusion in the interpretation would have grossly overestimated TPH concentrations in the middle of the field.

Studies done in the Arabian Gulf have shown ambient background TPH concentrations of 10 to 15 ppm (Massoud et al., 1996; Tehrani et al., 2012), which are similar to those of the eastern Levantine Basin. These studies have characterized TPH concentrations between 15 and 50 ppm as "slightly polluted" and concentrations greater than 200 ppm as "heavily polluted." Mean (± SD) TPH concentrations within the Leviathan Field (13.2 ppm ± 4.8) were comparable with Tamar Reservoir mean (13.3 ppm ± 10.6) (CSA Ocean Sciences Inc., 2014d). Using the classification scheme above, TPH concentrations within the Leviathan Field would be classified as either ambient or slightly polluted because several grid cells have TPH concentrations above 15 ppm. However, these terms are highly qualitative and there are no official established toxicity thresholds for TPH concentrations. The results indicate that TPH concentrations, even in the slightly elevated grid cells, were consistent with the region and are at concentrations that do not pose a threat to the environment.

Hydrocarbons were analyzed further to determine concentrations of the 16 USEPA priority PAHs. PAHs were analyzed only in samples that had a TPH concentration above the 95% CL of the Levantine Basin baseline at the time of sample submission to the laboratory (15.9 ppm). Individual and total PAH data are available from 44 grid cells within the Leviathan Field (27 from previously sampled grid cells). Few individual PAHs had concentrations that were higher than the Levantine Basin baseline. The total PAH concentration within the Leviathan Field (72.9 ± 45.4 parts per billion [ppb]) was above the Levantine Basin baseline (55.4 ppb ± 23.4) and the Tamar Reservoir mean (48.9 ppb ± 45.3) (CSA Ocean Sciences Inc., 2014d). Total PAHs concentration was below the 99% CL for the Levantine Basin baseline (115.8 ppb) and was well below the ERL (4,022 ppb) and ERM (44,702 ppb) values for total PAHs in marine sediment.

The Fossil Fuel Pollution Index (FFPI) was calculated to determine the percentage of fossil fuel PAHs relative to total PAHs (Boehm and Farrington, 1984). The FFPI is based on the knowledge that combustion-derived (pyrogenic) PAH assemblages are rich in three- to five-ringed PAH compounds while fossil fuels (petrogenic) are rich in polynuclear organosulfur compounds (e.g., dibenzothiophene) and two- to three-ringed PAH assemblages (Steinhauer and Boehm, 1992). An FFPI ratio of 0 to 0.25 indicates PAH assemblages dominated by pyrogenic sources, a ratio of approximately 0.25 to 0.49 is indicative of intermediate PAH

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assemblages containing a mix of pyrogenic and petrogenic sources, and a ratio of 0.5 to 1.0 is indicative of PAH assemblages dominated by petrogenic sources (Boehm and Farrington, 1984). Hydrocarbons from sediments from the Leviathan Field are from a mix of pyrogenic and petrogenic sources. Elevated FFPI ratios between 0.25 and 0.5 were found in undeveloped and developed grid cells, indicating that this is due to natural variation in the region.

Sediment Radionuclides

A total of 10% of all sampled sediment stations in the Leviathan Development Program were sampled for radionuclides (Ra 226, Ra 228, and thorium [Th] 228). Of that representative sample, eight stations were in the Leviathan Field. Ambient radium concentrations in most soils and rocks are approximately 0.5 to 5.0 pCi g^{-1} of total radium (U.S. Geological Survey, 1999). Ambient concentrations of thorium (Th) 228 in sediments range from 0.36 to 1.93 pCi g^{-1} (Agency for Toxic Substances and Disease Registry, 1990). The USEPA (1998) established a protective health based level for radium and thorium of 5 pCi g^{-1} at the sediment surface as a threshold for the clean up of the top 15 cm of soil from contaminated U.S. Superfund sites. Mean radium and thorium concentrations within the Leviathan Field survey area were well below this threshold. Mean radium and thorium concentrations generally were similar to the Levantine Basin baseline concentrations, and all samples (except one) were within the 99% CL of the Levantine Basin baseline. The Ra 228 concentration from the E05 sampling station was 1.15 pCi g^{-1}, just above the 99% CL of 1.14 pCi g^{-1}. This minor deviation from the Levantine Basin baseline is unlikely to be biologically significant.

Sediment Polychlorinated Biphenyls

A representative 10% of all sampled sediment stations in the Leviathan Development Program were sampled for 44 PCB congeners. Of that representative sample, eight stations were in the Leviathan Field. PCBs were not detected from the eight sediment samples from the Leviathan Field sampling grid.

1.7.2.2 Pipeline Corridor Section 1: 500 m to >1600 m Depth Stratum

Total Organic Carbon

TOC concentrations at stations representing Pipeline Section 1 were low, ranging from 0.426% to 0.711% and averaging 0.59% ± 0.11%. A significant negative correlation was found between TOC concentrations and distance to the shoreline ($r = -0.834$, $p = 0.0004$), with TOC increasing closer to the nearest shoreline. All TOC values along Pipeline Section 1 were below the Levantine Basin baseline 99% CL.

Metals

Most values of metals representing Pipeline Section 1 were lower than the ERL and ERM values. Exceptions included arsenic, chromium, and copper where a metals concentration was higher than the corresponding ERL value but much lower than the corresponding ERM value. Nickel exceeded both the ERL and ERM values; however, mean marine sediment and continental crust concentrations also exceeded the ERM value. Reported concentrations of arsenic, chromium, and copper were similar to the Levantine Basin baseline mean and below the 99% CL.

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In order to normalize metals concentrations with sediment grain size, each metal was plotted against aluminum. Concentrations of aluminum and other trace metals vary naturally in ambient seafloor sediments, primarily due to differences in sediment grain sizes. Clay sediments are primarily composed of aluminosilicates and typically have higher concentrations of metals. Sediments classified as silt or sand are primarily composed of quartz and fragments of carbonate shell, which dilute ambient metals concentrations (Herut and Sandler, 2006). Aluminum concentrations are assumed to correlate linearly with other metals concentrations when there is no anthropogenic input (Trefry et al., 2003, 2013). It is reasonable to assume that a particular metal concentration may be considered enhanced above ambient seafloor concentrations by anthropogenic activity if the metal concentration of a sample deviates greatly from a prediction interval calculated from that seen for the linear regression of aluminum versus that metal for sediments of a particular particle size range. Based on produced plots, all metals were within the ambient Levantine Basin baseline concentrations and within the 99% prediction interval (CSA Ocean Sciences, 2016b).

TPH and PAHs

TPH concentrations in Pipeline Section 1 ranged from 8.5 to 13.3 ppm and were well below the Levantine Basin baseline 99% CL (21.85 ppm). TPH concentrations were not significant among pipeline strata, despite a slight increase between 1,000- and 1,300-m water depths. PAHs were analyzed from samples with TPH concentrations higher than 15.9 ppm. One sample was analyzed in the 1,300- to 1,000-m stratum. Most of the individual PAHs and total PAHs were lower than the Levantine Basin baseline mean and the corresponding ERL (4,022 ppb) and ERM (44,702 ppb) values. The FFPI ratio (0.26) indicated that the hydrocarbons come from a mix of pyrogenic and petrogenic sources. It is important to note that the PAH concentrations found in this sample may not be representative of the hydrocarbon concentrations along the pipeline, rather they represent data from a sample with already elevated hydrocarbons. All TPH and PAH concentrations were low and do not pose a threat to the environment.

Radionuclides

In accordance with the MoEP partial approval letter (dated 9 April 2014), 10% of all sampled sediment stations in the Leviathan Field Development were randomly sampled for radionuclides (Ra 226, Ra 228, and Th 228). A single station (M07) was sampled for radionuclides and represents Pipeline Section 1. Ambient radium concentrations in most soils and rocks are approximately 0.5 to 5.0 pCi g^{-1} (U.S. Geological Survey, 1999). Ambient concentrations of Th 228 in sediments range from 0.36 to 1.93 pCi g^{-1} (Agency for Toxic Substances and Disease Registry, 1990). The USEPA (1998) established a protective health-based level for radium and thorium of 5 pCi g^{-1} at the sediment surface as a threshold for the clean up of the top 15 cm of soil from contaminated U.S. Superfund sites. The radium and thorium concentrations at station M07 within the Pipeline Section 1 corridor were low, and well below this clean up threshold. Analytical results from station M07 were similar to the Levantine Basin baseline mean and were well below the 99% CL of the Levantine Basin baseline mean.

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Polychlorinated Biphenyls

In accordance with the MoEP partial approval letter (dated 9 April 2014), 10% of all sampled sediment stations in the Leviathan Field Development were randomly sampled for 44 PCB congeners, including one sediment sample representing Pipeline Section 1 (M07). No detectable concentrations of any tested PCB congener were found.

1.7.2.3 Pipeline Corridor Sections 2 and 3: 0 m to 500 m Depth Stratum

Total Organic Carbon

TOC concentrations along Pipeline Sections 2 and 3 were low, ranging from 0.04% to 1.09% and averaging 0.49% ± 0.21%. A significant positive correlation was found between TOC concentration and distance to the shoreline ($r = 0.870$, $p < 0.0001$). This indicates that there is a relationship between TOC concentration and distance to shore, with TOC decreasing closer to the nearest shoreline. Lower TOC concentrations close to shore are likely due to the high sand content of nearshore sediments. TOC concentrations for all nearshore stations were within the Levantine Basin baseline 99% CL.

Metals

Concentrations of all metals at stations located near the Israeli shoreline to a water depth of 50 m were lower than the ERL and ERM values. Concentrations of metals at stations located in water depths of 50 to 500 m generally were lower than ERL except for arsenic, chromium, and copper; however, these metals were below their corresponding ERM values. These three metals are naturally found in high concentrations throughout the Levantine Basin. Therefore, concentrations above the ERL should be considered ambient for arsenic, chromium, and copper. Nickel concentrations exceeded both ERL and ERM values; however, mean marine sediment and continental crust concentrations also exceed the ERM value. Arsenic, chromium, copper, and nickel concentrations are not elevated relative to Levantine Basin baseline means and should be considered ambient.

In order to normalize metals concentrations with sediment grain size, each metal was plotted against aluminum. Concentrations of aluminum and other trace metals concentrations vary naturally in ambient seafloor sediments, primarily due to differences in sediment grain sizes. Clay sediments are composed primarily of aluminosilicates and typically have higher concentrations of metals. Sediments classified as silt or sand are primarily composed of quartz and fragments of carbonate shell, which dilute ambient metals concentrations (Herut and Sandler, 2006). Aluminum concentration is assumed to correlate linearly with other metals concentrations when there is no anthropogenic input (Trefry et al., 2003, 2013). It is reasonable to assume that a particular metal concentration may be considered enhanced above ambient seafloor concentrations by anthropogenic activity if the metal concentration of a sample deviates greatly from a prediction interval calculated from that seen for the linear regression of aluminum versus that metal for sediments of a particular particle size range.

Similar to Pipeline Section 1, most metals for the 50- to 200-m and 0- to 50-m depth strata and all metals for the 200- to 500-m depth stratum were within the ambient Levantine Basin baseline concentrations and generally within the 99% prediction interval. Barium concentrations were greater than the Levantine Basin baseline data and slightly elevated above the 99% prediction interval for all stations located from 50 to 200 m, except at station M16. In the 0- to 50-m depth strata, a similar trend was noted except at stations M21 and M22.

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The reason for these elevated values is unknown as there has been no known drilling activity in the region. Barium is not considered a toxic chemical and is insoluble in seawater (Neff, 2005), therefore, no ecological impact is anticipated.

TPH and PAHs

Stations were grouped into two strata: 200 to 500 m (Pipeline Section 2) and 0 to 200 m (Pipeline Section 3). TPH concentrations in these strata ranged from below the detection limit (<1.4 parts per million [ppm]) to 42.4 ppm. Average TPH concentrations within the 200- to 500-m depth stratum were higher and more variable than within the 0- to 200-m stratum and greater than the Levantine Basin baseline 99% CL. TPH concentrations in these strata were lower than in the nearshore Tamar pipeline strata located approximately 100 km to the south (CSA Ocean Sciences Inc., 2014d).

PAHs were analyzed from samples with TPH concentrations higher than the upper 99% CL of the Levantine Basin baseline (15.9 ppm), indicating hydrocarbon concentrations above background means. Few individual PAHs had concentrations that were higher than the Levantine Basin baseline means. Total PAHs for both strata were higher than the Levantine Basin baseline mean, and lower than the Levantine Basin baseline 99% CL (101.3 parts per billion [ppb]). Additionally, total PAHs within the strata were lower than total PAHs within nearshore strata (CSA Ocean Sciences Inc., 2014d). The difference in hydrocarbon concentrations between the two areas may be due to the location of the nearshore sample stations near the oil refineries in Ashdod. FFPI ratios indicate that hydrocarbons in sediments in the nearshore samples are from pyrogenic sources. The PAH concentrations and FFPI ratios found in these samples may not be representative of the hydrocarbon concentrations along the pipeline, rather they represent data from samples with elevated TPH concentrations.

Radionuclides

In accordance with the MoEP partial approval letter (dated 9 April 2014), 10% of all sampled sediment stations in the Leviathan Field Development were randomly sampled for radionuclides (Ra 226, Ra 228, and Th 228). Four stations representing Pipeline Sections 2 and 3 were selected for radionuclides sampling and analysis. Ra 226, Ra 228, and Th 228 concentrations at stations representing Pipeline Sections 2 and 3 were low. Ambient radium concentrations in most soils and rocks are approximately 0.5 to 5.0 pCi g^{-1} (U.S. Geological Survey, 1999). Ambient concentrations of Th 228 in sediments range from 0.36 to 1.93 pCi g^{-1} (Agency for Toxic Substances and Disease Registry, 1990). The USEPA (1998) established a protective health-based level for radium and thorium of 5 pCi g^{-1} at the sediment surface as a threshold for the clean up of the top 15 cm of soil from contaminated U.S. Superfund sites. Average radium and thorium concentrations within the nearshore strata survey area were well below this clean up threshold. Average radium and thorium concentrations were nearly identical to the Levantine Basin baseline concentrations, and all sample concentrations were within the Levantine Basin baseline 99% CL.

Polychlorinated Biphenyls

In accordance with the MoEP partial approval letter (dated 9 April 2014), 10% of all sampled sediment stations in the Leviathan Field Development were randomly sampled for 44 PCB congeners, including four sediment samples representing Pipeline Sections 2 and 3. Low PCB

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concentrations were detected at stations M16 and P04. PCB concentrations were below the detection limit at stations N01 and O01. The ERL for the sum of all PCB congeners in sediment as provided by Buchman (2008) is 22.7 µg kg^{-1}. Analysis of all 209 PCB congeners was not completed for the Leviathan Field Development, therefore, no direct comparison can be made between the analytical results and the reported ERL for the sum of all PCB congeners.

PCB pollution is considered to be globally ubiquitous due to its environmental persistence and tendency to bioaccumulate (Erickson, 1997). Previous surveys conducted by Israel Oceanographic and Limnological Research Institute (IOLR) have indicated elevated levels of PCB concentrations in the nearshore habitat offshore of Israel (MoEP, verbal communication). Given the very low detected PCB concentrations at stations M16 and P04, and the lack of detected PCBs in the remaining two nearshore samples, it is unlikely that the detected PCBs are biologically significant and likely do not indicate widespread PCB contamination in the nearshore environment.

1.8 Cultural and Heritage Sites

As the cradle of civilization, it is little surprise that the Fertile Crescent (the Levant and Mesopotamia) contains some of the oldest evidence of seafaring in the world. The shipwrecks and submerged cultural heritage that lie on the seafloor of the eastern Mediterranean Sea often include intact ship remains and cargo. The maritime trade routes of ancient seafaring cultures such as the Greeks, Phoenicians, and Romans indicate heavy traffic in the region. The hull remains and artifacts from wreck sites represent an enormous wealth of knowledge on ancient seafaring history, culture, and technology.

Noble Energy contracted GEMS to conduct seafloor, shallow geologic, and archaeological assessments along the proposed Leviathan pipeline route. GEMS used high-resolution subbottom profiler, side-scan sonar, and multibeam bathymetry and backscatter data collected by an autonomous underwater vehicle (AUV) for this assessment. An archaeological assessment was prepared (GEMS, 2014).

High-resolution digital side-scan sonar, subbottom profiler, multibeam backscatter, and multibeam bathymetry data were collected along the proposed pipeline route (Figure 1-20). The surveyed area included a 600-m swath overlayed on the proposed pipeline route between the Leviathan Field and the beginning of Israel's territorial sea 12 nmi offshore. Within 12 nmi, the surveyed area was a 2,000-m swath overlayed on the proposed pipeline. GEMS reviewed the side-scan sonar data to delineate potential submerged cultural resources with dimensions greater than 5 m long and 2 m wide and a length to width ratio of at least 2.5 to 1. GEMS established these mapping parameters to eliminate a potentially large number of smaller dimension contacts without significance scattered throughout the Leviathan Field.

The archaeological assessment was submitted directly to the Israel Antiquities Authority for further assessment. Appendix A-10 provides a copy of a letter received (10 February 2016) by the authority acknowledging that "the material submitted to the Israel Antiquities Authority is satisfactory and meets the Authority's needs, and therefore the Israel Antiquities Authority has authorized continued development activity."

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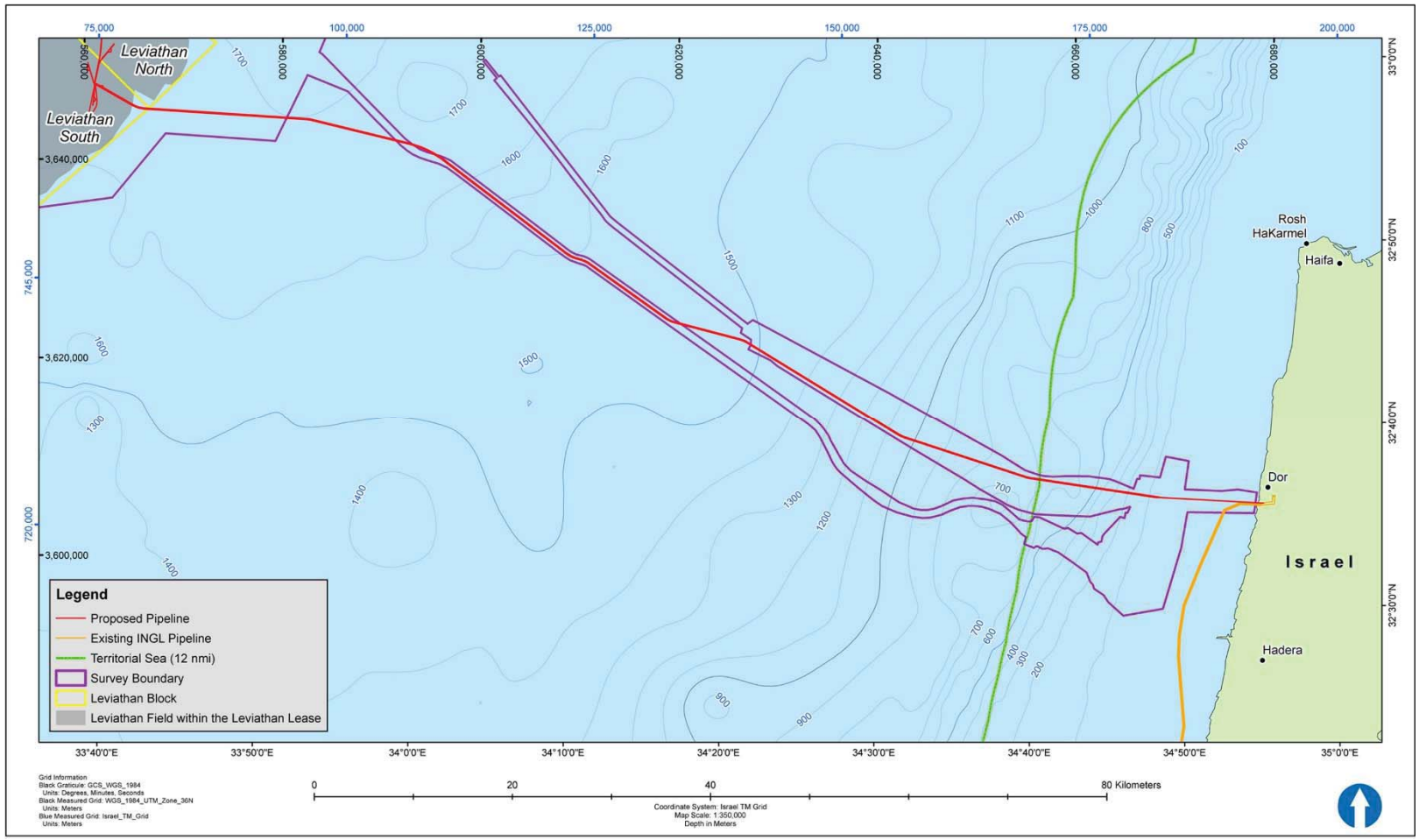
Figure 1-20: Pipeline Survey Corridor



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1.9 Meteorology and Air Quality

1.9.1 Existing Meteorological Conditions

There are no site-specific meteorological data from the Application Area. However, regional data are available to describe representative conditions. Israel's subtropical location between 29° and 33° north of the Equator generally brings long, hot, dry summers and short, cool, rainy winters, as modified locally by altitude and latitude. Israel experiences a climate between the subtropical aridity characteristic of Egypt and the subtropical humidity of the Eastern Mediterranean.

The climate conditions of the Eastern Mediterranean region can be divided into cold and warm periods. The cold period (December to March) is characterized by the low circulation associated with intense cyclogenetic activity. The anticyclonic type of circulation during this period is associated with cold core anticyclones laying over the central Europe or Balkan region. The warm period (June to September) is characterized by high circulation where the North Atlantic lows pass over Europe and only edges of the fronts reach the northeastern part of the Mediterranean (Kallos et al., 1993; Kassomenos et al., 1995). During the warm period, the entire Mediterranean region is occupied by anticyclonic activity and large-scale subsidence. This period of the year is highly controlled by the balance between the North Atlantic anticyclone (that extends toward the Mediterranean) and the monsoon activity over the Indian Ocean and the Middle East. During the transitional seasons of spring (April to May) and autumn (October to November), the synoptic circulation varies between cold and warm types.

An oppressive hot, dry desert wind called the sharav or khamsin "east wind" blows from the Arabian Desert from May to mid-June and from September to October. The sharav or khamsin can be triggered by depressions that move eastward along the southern parts of the Mediterranean or along the North African coast from February to June and lasts for 2 to 5 days at a time.

Meteorological data from 2007 to 2012 recorded at Haifa are available for reference (Israel Meteorological Service, 2014; Weatherspark, 2014). Highest daily air temperatures range from approximately 25°C in January to 42°C in April, May, and June. Lowest daily air temperatures range from approximately 0.7°C in January to 16.6°C in August. The mean and extreme temperatures are moderated by Haifa's coastal location. Haifa receives an annual mean rainfall of 539 mm, with the greatest amounts during the cold period (December to March) and virtually no precipitation during the warm period (June to September). Relative humidity ranges from 35% in November to 85% in April. Humidity conditions during May through October, when temperatures are still high (24°C to 26°C) and winds are relatively low, lead to high humidity levels, especially in the coastal areas.

1.9.2 Special Meteorological Conditions Cause Dispersal

No special meteorological conditions are known that might cause conditions of dispersal that will give rise to high air pollution concentrations in the proposed platform location. In general, there are three major synoptic weather types that are conducive to short-term air quality problems in coastal Israel (Dayan and Levy, 2002):

- Red Sea Trough – occurs 29% of the time, mainly during autumn, and brings regimes of light winds transporting hot and dry air from eastern origins;

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- Anticyclone – occurs 25% of the time, mainly during spring and is often accompanied by an upper-air ridge, which usually leads to stagnation caused by the very weak pressure gradient formed over Israel; and
- Shallow Persian Trough – occurs 20% of the time, typically during summer whenever the extensive North-African upper-air subtropic anticyclone advances to the region, leading to subsidence and stabilization of the atmosphere.

Other weather types associated with air pollution periods (e.g., high-ozone days) and their frequency of occurrence include Turkish high (8%), Persian trough (7%), Col (4%), Egyptian low (4%), a western axis Red Sea Trough (1%), and undefined (2%) (Dayan and Levy, 2002).

1.9.3 Air Quality

The major pollutant sources of anthropogenic origin in the Mediterranean region are located in central and southern Europe, with minor contribution from North Africa and the Middle East (Asaf et al., 2008). Major sources of domestic air pollutants in Israel include vehicle emissions in the metropolitan areas, the Haifa Power Station in Haifa, the Eshkol Power Station in Ashdod, and the Orot Rabin coal fired power station in Hadera.

1.10 Noise

There are no site-specific measurements of underwater noise in the Application Area. The most likely dominant source of ambient noise is shipping. Shipping noise is ubiquitous in the world's oceans and is the dominant source of underwater noise at frequencies below 300 Hz in many areas (Wenz, 1962; Ross, 1976; Hildebrand, 2009; McKenna et al., 2012). The Eastern Mediterranean region is one of the busiest sea routes in the world, with several high-volume port facilities and crowded shipping lanes. The opening of the Suez Canal significantly increased the volume of shipping traffic, particularly in the Eastern Mediterranean region. Broadband source levels for ships typically increase with increasing vessel size, with source levels of 160 to 175 decibels relative to 1 micropascal) (dB re 1 μPa) for smaller vessels (<50 m), 165 to 180 dB re 1 μPa for medium size vessels (50 to 100 m), and 180 to 190 dB re 1 μPa for large vessels (>100 m) such as supertankers, large bulk carriers, container ships (Richardson et al., 1995; Convention for the Protection of Marine Environment in the Northeast Atlantic [OSPAR] Commission, 2009). The main noise sources from shipping include propellers and thrusters, machinery, sea connected systems (e.g., pumps), and hydrodynamic noise caused by the movement of the hull through the water (Spence et al., 2007). Propeller cavitation is usually the dominant source for large commercial vessels (Brown, 2007).

Potter et al. (1997) measured ambient noise levels in shallow water (i.e., 4- to 5 m depth) offshore Haifa. At low frequencies (a few hundred hertz or less), the ambient noise spectra exhibited characteristics of medium to heavy shipping noise. Biological sound sources (i.e., snapping shrimp) dominated the spectrum for frequencies above a few hundred hertz. Site-specific data are not available on underwater noise from "representative points near to each of the components of the Application." A general description is presented based on available data.

1.11 Marine Transportation System and Infrastructure

Existing maritime infrastructure within the Application Area includes four previously drilled wells (Leviathan-1 through Leviathan-4) and one telecommunications cable. Shipping lanes are present in coastal waters inshore of the Application Area. There are no shipping lanes

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within the Field Application area. While the pipeline corridor traverses a shipping lane, presence of the pipeline will not impact shipping activities. Therefore, a discussion of traffic volumes etc. is not presented. Existing infrastructure in the Leviathan Field is limited to telecommunications cables and existing wellsites. A map of the existing infrastructure is presented in Figure 1-4.

1.11.1 Telecommunications Cables

DOF (2015) mapped two telecommunication cables in the project area, although neither was observed during their survey and were presumed to be covered by sediment. Both were within the potential anchoring area for the project and ran in a north-south direction, with one cable located approximately 1 km to the east and the other cable located approximately 2 km to the west of the proposed platform location. The MedNautilus telecommunication cable runs somewhat parallel to the coastline approximately 15 km offshore from the proposed platform location (see Figure 1-21 and 1-22; Table 1-8).

Table 1-7: Minimum distances to the nearest telecommunications cable for each wellsite (From: MedNautilus. 2014a,b).

Drillsite	Proximity to Telecommunication Cables	
	Nearest Cable	Minimum Distance (km)
Leviathan-3	MedNautilus	3.37
Leviathan-4	MedNautilus	4.65
Leviathan-5	MedNautilus	8.82
Leviathan-6	MedNautilus	3.09
Leviathan-7	MedNautilus	3.13
Leviathan-8	MedNautilus	4.67
Leviathan-9	MedNautilus	1.04
Leviathan-10	MedNautilus	1.09

1.11.2 Shipping Lanes

Numerous shipping lanes cross Israel's territorial waters, including those from the ports of Israel to destinations in southern Europe, Cyprus, and North Africa, and routes between Alexandria and Port Said in Egypt to destinations in Lebanon and Syria. The Leviathan Field, pipeline route, and the proposed platform location are not located within a shipping lane as shown in Figure 1-23. The proposed platform location is shoreward of the major north-south shipping lane in Israeli waters and north of the shipping lane leading offshore from the Hadera area.

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Figure 1-21: Locations of existing marine infrastructure (telecommunications cable and previous drillsites) in relation to the eight initial wellsites included in the Leviathan Field Development Plan. Contours indicate water depth in meters.

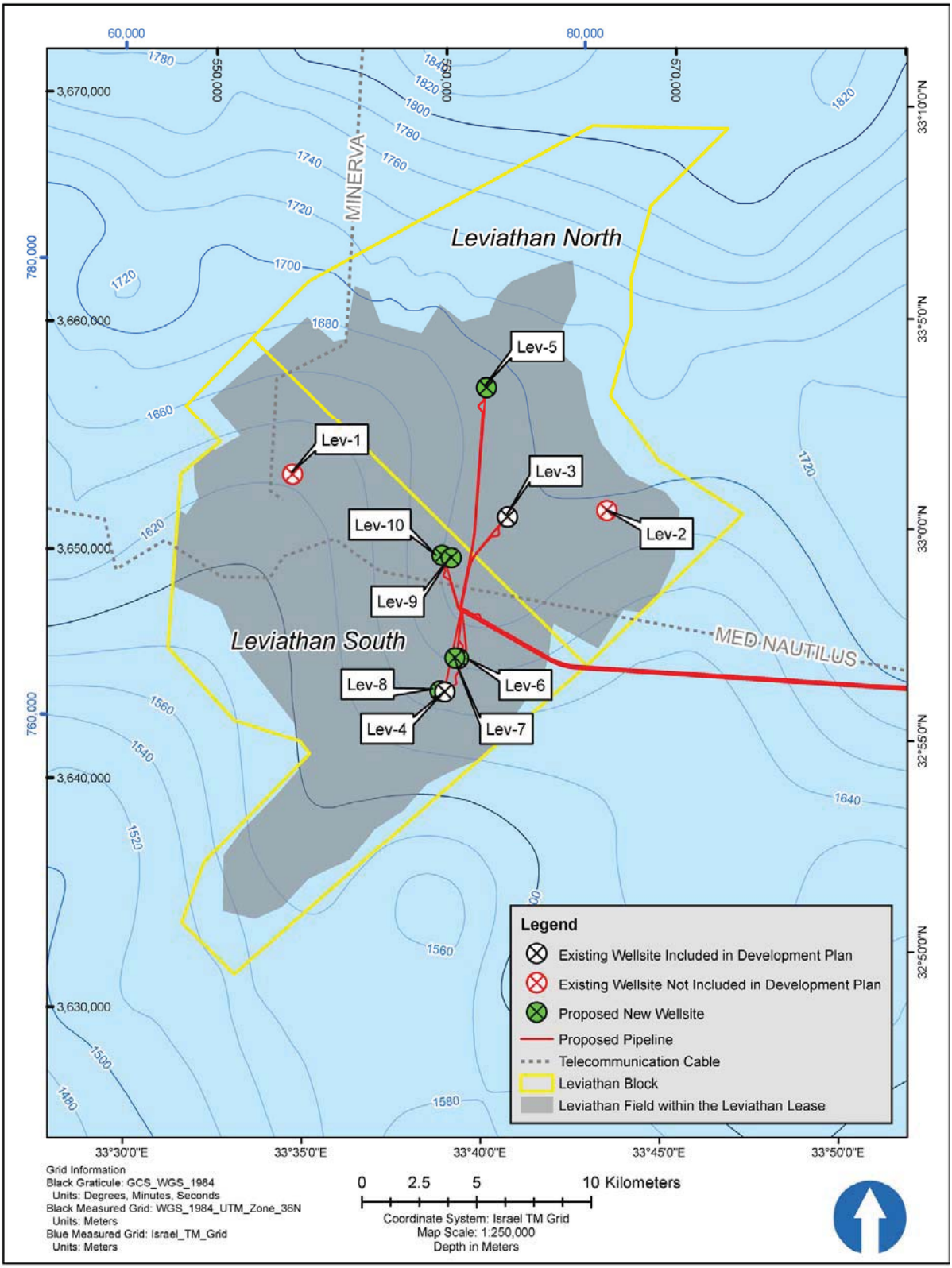

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Figure 1-22: Proposed platform in relation to the MedNautilus cable.

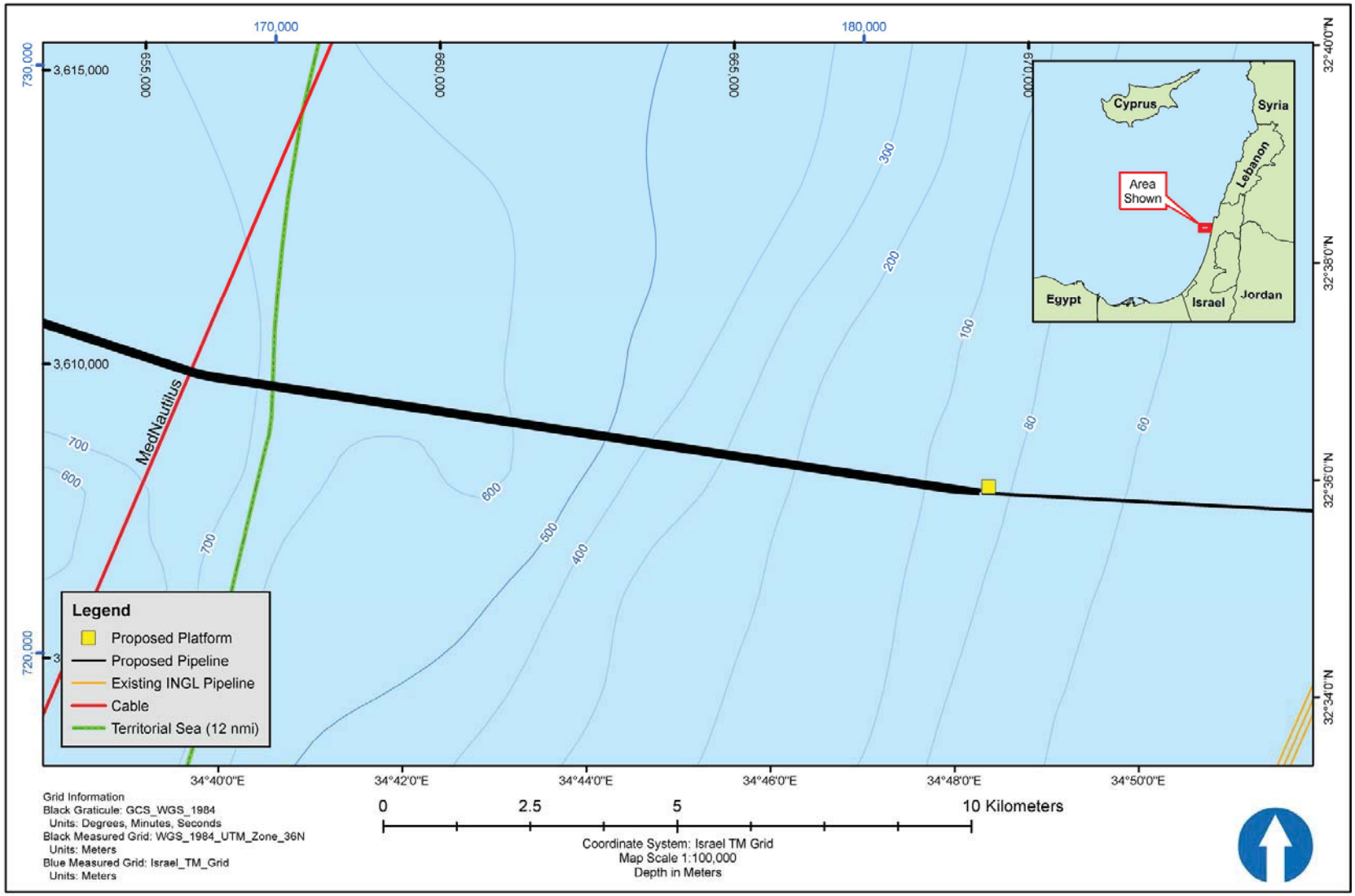

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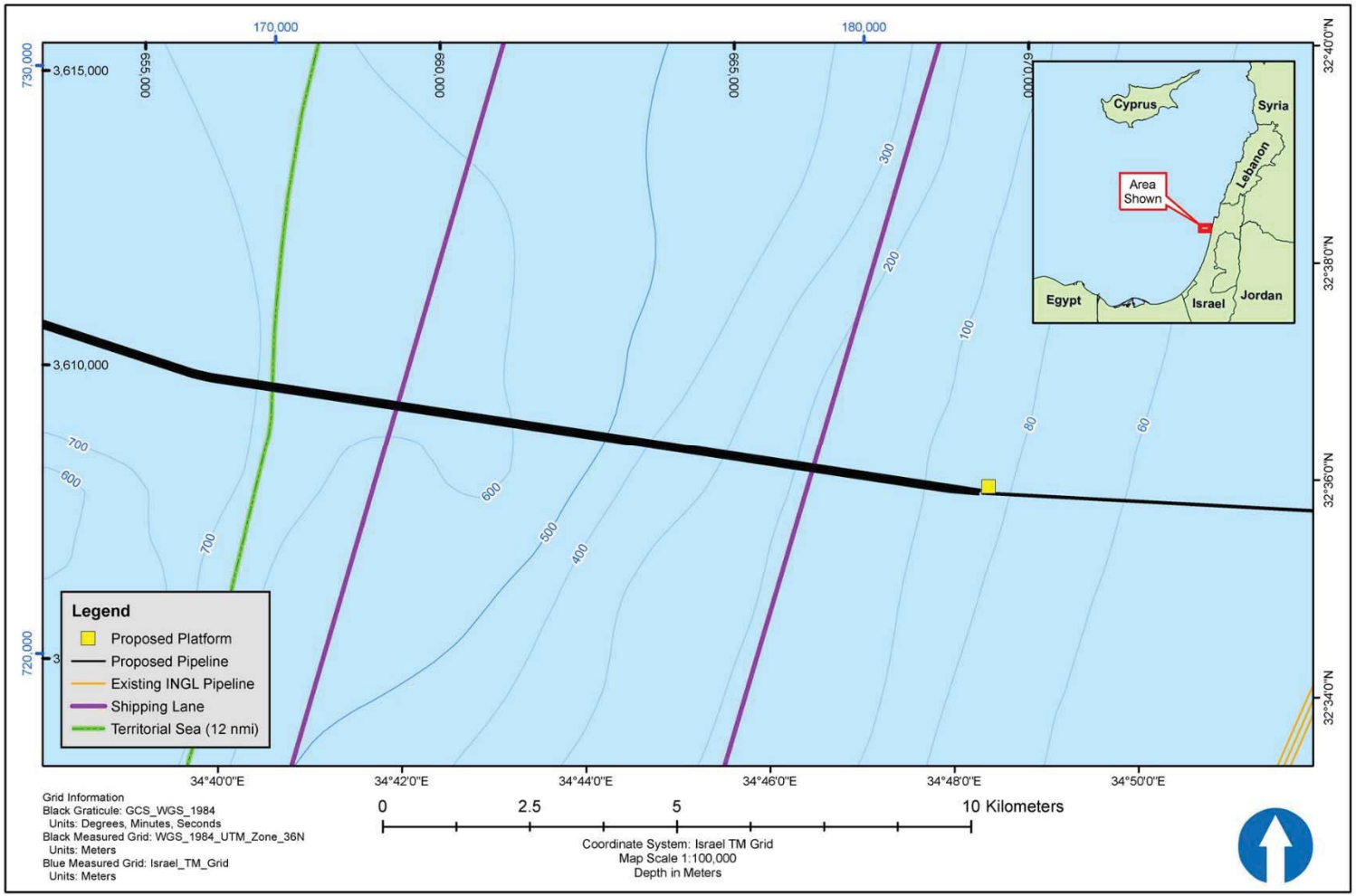
Figure 1-23: Shipping Lanes



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