Tamar Field Development Project
Environmental Impact Assessment
Volume II

Matan Block Offshore Israel

February 2015

NOTE:

"ANY INVESTMENT TO BE MADE IN TAMAR FIELD DEVELOPMENT PROJECT, BY NOBLE ENERGY OR ITS PARTNERS, IS SUBJECT TO ACHIEVING, INTER ALIA, REGULATORY CERTAINTY OVER THOSE INVESTMENTS, NECESSARY INVESTMENT & REGULATORY APPROVALS, AND SATISFACTORY COMMERCIAL ARRANGEMENTS."

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TAMAR FIELD DEVELOPMENT PROJECT ENVIRONMENTAL IMPACT ASSESSMENT, VOLUME II

MATAN BLOCK OFFSHORE ISRAEL

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EXECUTIVE SUMMARY

Noble Energy Mediterranean Ltd (Noble Energy) has prepared this Environmental Impact Assessment (EIA) for the Tamar Field Development Project, which includes the drilling of three wells and the installation of subsea infrastructure (i.e., umbilical lines, utility lines, pipelines). Noble Energy has been active in the Tamar Field since 2006 with initial drilling activities starting in 2008. To date, seven wells have been drilled in the field (Tamar-1 through Tamar-6 and Tamar SW-1). Of these, five wells, Tamar-2 through Tamar-6, are currently producing. A gas production and transportation system composed of subsea trees, infield flowlines and umbilicals, and a pipeline currently links the Tamar Field to the Tamar Offshore Receiving and Processing Platform (Tamar Platform), located approximately 149 km south-southeast of the field (**Figure ES-1**).

The proposed Tamar Field Development Project includes the completion of the Tamar SW-1 well, the drilling of three additional wells in the Tamar Reservoir (Tamar-7, Tamar-8, and Tamar-9), and the installation of the infrastructure to tie these wells into the existing Tamar subsea equipment. The umbilical line, utility lines, and pipelines proposed for the Tamar Field Development Project are shown in **Figure ES-2** along with the existing infrastructure and the Tamar Reservoir.

The Tamar Field is located in License 309 in the Matan Block, which is approximately 90 km west of Haifa in the Levantine Basin. The Matan Block covers 318 km^2, of which the Tamar Field covers 250 km^2. The proposed Tamar Field Development Project Application Area is located in the Tamar Field, which is at a depth of 1,600 to 1,700 m and includes the Tamar SW-1 well area in the Tamar SW Reservoir, the area around the three wells to be drilled in the Tamar Reservoir, and the infrastructure (pipelines, umbilicals, fiber optic cables) from these wells to the existing infrastructure. This EIA examines activities and potential impacts within these areas of influence, including areas within 2 km of the proposed activities, as well as other areas that may be environmentally affected as a result of the potential transport of discharges or emissions.

This EIA presents a summary of the regional environment, including environmental studies that have been performed for the Tamar Field, and assesses the potential impacts that could result from the proposed Tamar Field Development Project. To present the most complete review of the conditions in the field and the potential impacts, the activities and studies completed in the Tamar Field to date are reviewed and the results of completed monitoring throughout the field are presented. The data provide the appropriate characterization of the environment to assess field-wide impacts that may occur as a result of the proposed completion, drilling, and installation activities. Mitigation measures to reduce or eliminate potential impacts are presented in this analysis.

Two surveys performed for Noble Energy provide important data regarding background conditions. These are referred to in this report as the Tamar Field Background Monitoring Survey performed in February 2014 and the Tamar Field and Pipeline Survey performed in March of 2013. The surveys provide background information on physicochemical conditions and the benthic community.

The EIA was prepared and organized in accordance with the Ministry of National Infrastructures, Energy and Water Resources (MNIEWR) and the Ministry of Environmental Protection (MoEP, formerly the Ministry of the Environment) “Framework Guidelines for the Preparation of Environmental Document Accompanying License for Exploration Purposes”.

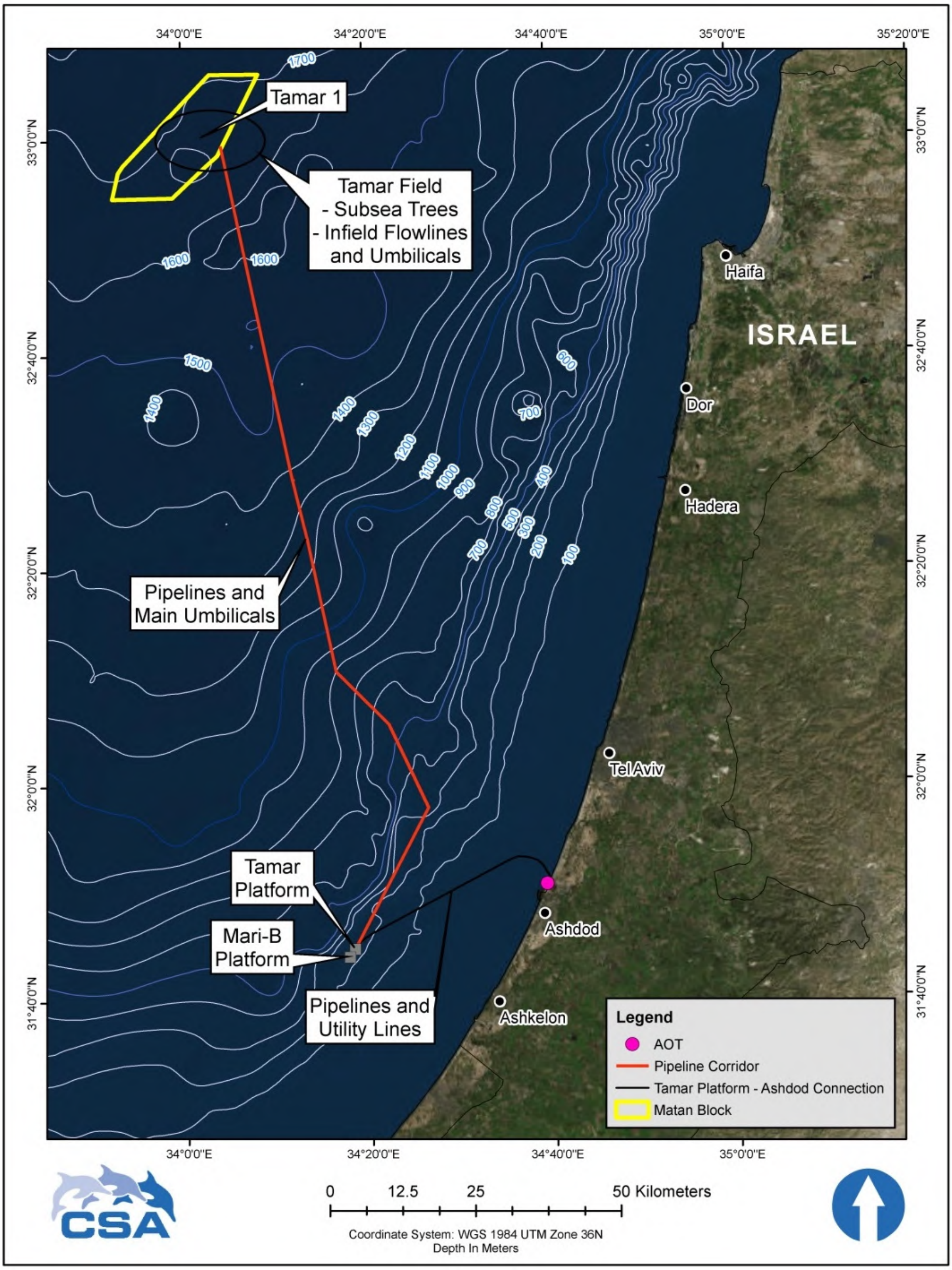

Figure ES-1. Tamar Field Development components. Water depth is in meters.

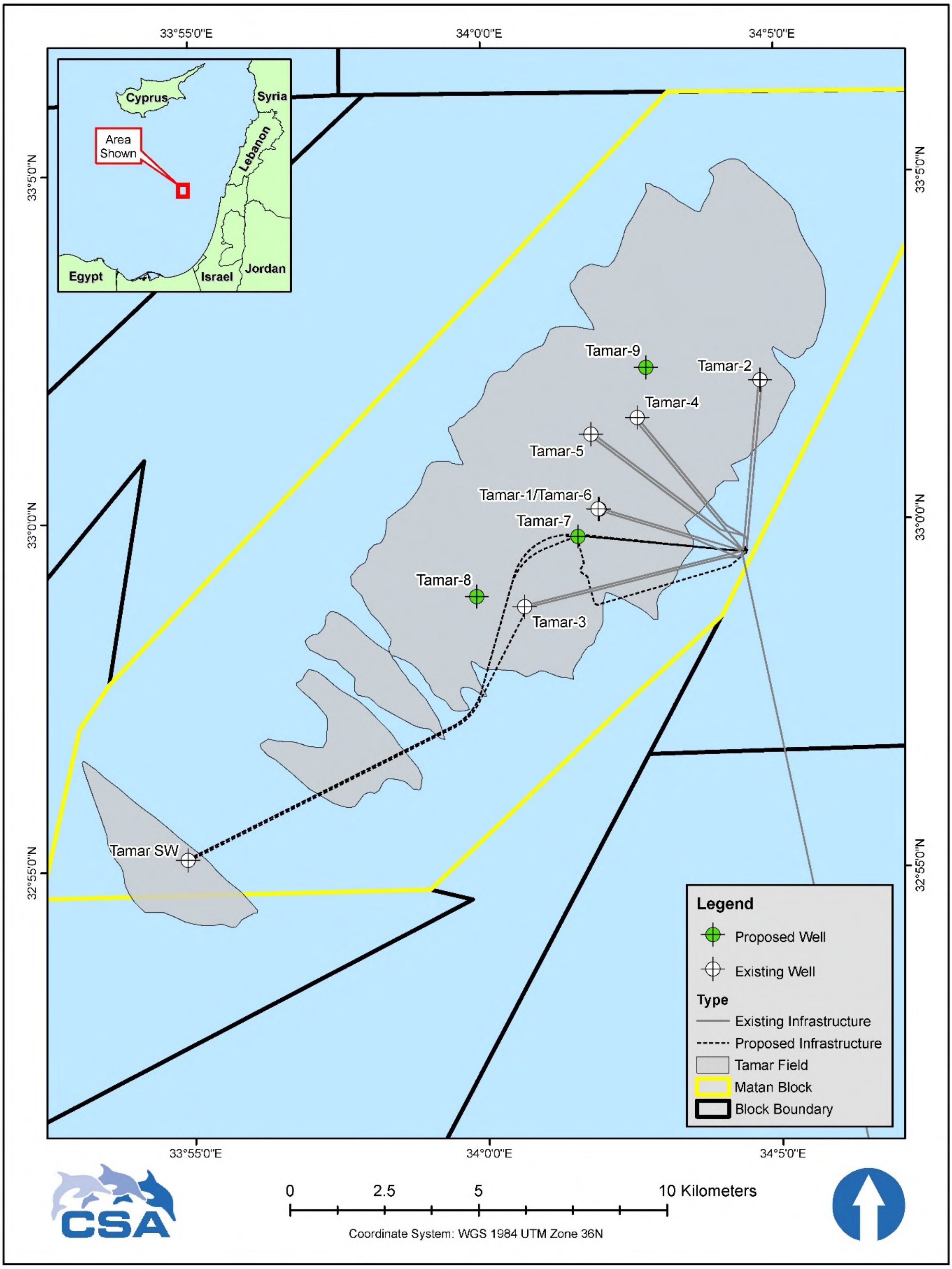

Figure ES-2. Locations of existing and proposed wells and infrastructure in the Tamar Field Development.

BASELINE ENVIRONMENT

The EIA presents detailed information on each proposed well location as well as for the region, based on survey data and other available references.

Seafloor depth at the proposed Tamar-7 well location is 1,665 m below the sea surface. The well location is on the crest of a northwest-to-southeast trending, low-relief seafloor ridge. The relief of the seafloor ridge increases to the southeast and is the result of compression in the underlying evaporite section. A northeast-to-southwest trending seafloor strike-slip fault is located approximately 500 m west of the proposed location.

Seafloor depth at the proposed Tamar-8 well location is 1,670 m below the sea surface. The seafloor slopes less than 0.4° and is essentially horizontal. The well location is on a featureless, undulating abyssal plain, 1.0 km east of a meandering channel and 1.6 km southwest of a low-relief ridge.

Seafloor depth at the proposed Tamar-9 well location is 1,690 m below the sea surface. Like the Tamar-8 location, the seafloor slopes less than 0.4°. The well location is on a featureless, undulating abyssal plain. Seafloor sediments are expected to comprise clays and silts, becoming firmer with depth.

Seismic Activity

There has been one recorded earthquake within 25 km of the Tamar SW-1 drillsite since 1979; the magnitude of the earthquake was 4.0. There have been no strong (magnitude 5.6 or greater on the Richter scale) regional earthquakes recorded within 200 km of the Tamar SW-1 drillsite since 1983. The data suggest that historic earthquakes within the Tamar Field are extremely rare events; when they occur, their magnitude has been moderate to low (i.e., less than 5.6 on the Richter scale).

Winds

Based on National Center for Environmental Predictions data, the wind regime is characterized by predominant westerly winds throughout most of the year (January through October) and varied winds in November and December. Winds generally are moderate in speed, with average monthly speeds of approximately 5 m/s. Overall, strong seasonal variability is not evident in the wind data. Winter winds (December through February) have higher maximum speeds than the rest of the year; however, average winds are relatively comparable throughout the year.

Waves

Nearly all of the waves in the region are less than 1.5 m in height, and wave direction is nearly always due eastward at this location (mean of 116°T, standard deviation of 53°) because of the strong westerly winds.

Oceanographic Currents

The upper water column currents at the current meter location were dominated by episodes of strong flows, particularly in the winter. At 25 m depth, the maximum recorded current speed was 53.6 cm/s, measured in January 2011. Mean current speeds at this depth were estimated to be as fast as 25 cm/s. At 73 m depth, the maximum current speed was 49.1 cm/s, measured in April 2011. Mean current speeds at this depth were estimated to be as fast as 22 cm/s. At 121 m depth, the maximum current speed was 41.5 cm/s. Mean currents were estimated to be as fast as 17 cm/s. At 233 m depth, the maximum current speed was 25.8 cm/s, measured in January 2011. The dominant flow direction at the near-surface was towards the south and west. Near-bottom currents do not appear to have a significant seasonal trend, with a maximum speed of only 8.7 cm/s.

Hydrographic Information

Surveys determined that surface waters were cool and isothermal (approximately 17°C to 18°C, depending on the season) to a depth of 100 m, then decreased to 15°C through the thermocline, and gradually stabilized to 14°C through the remainder of the water column to the seafloor. Salinity was recorded near the surface between 38.7 and 39.3 and gradually stabilized with increasing water depth to 38.8 at the seafloor. Turbidity was low (0.10 to 0.15 nephelometric turbidity units [NTU]) throughout the water column. The water column was well oxygenated at the surface (7.4 to 7.5 mg/L) and gradually stabilized to between 5.7 and 6.0 mg/L throughout the water column to the seafloor. Fluorescence, an indicator of photosynthetic activity, peaked at a depth of approximately 100 to 175 m with a concentration of approximately 0.32 to 0.35 mg/m^3, depending on the season.

Nature and Ecology

Phytoplankton in the study area are found primarily in the surface waters (0 to 150 m) where light levels are sufficient for growth; the euphotic zone, with maximum phytoplankton productivity, occurs in the surface mixed layer.

Zooplankton in the eastern Levantine Basin are extremely diverse, consisting of copepods and at least 21 other zooplankton taxa.

Within the Tamar Field, 667 individual infaunal organisms were collected during the 2013 and 2014 surveys. Infaunal abundance within the Tamar Field was patchy and ranged from 25 to 125 individuals per m^2. Infaunal abundance and species richness were low. The dominant infauna within the region were worms, consisting primarily of the polychaete *Notomastus* sp.

More than 400 fish species from 130 families are known from the coast of Israel. Results of site-specific surveys in the Tamar Field indicate the presence of several demersal fish species. The most common fish species observed during the July 2012 Environmental Baseline Survey at the Tamar SW-1 drillsite were tripodfish (*Bathypterois* sp.) and halosaurs (*Halosaurus* sp.).

Six marine mammal species potentially occurring in the Application Area are listed by the International Union for Conservation of Nature (IUCN) as critically endangered (Mediterranean monk seal), endangered (fin whale, sei whale, and north Atlantic right whale), or vulnerable (sperm whale and common bottlenose dolphin). Of these, the common bottlenose dolphin is the most abundant in the region and the only species that is a regular resident of the Levantine Basin. The fin whale and sperm whale are visitors, and the sei whale and north Atlantic right whale are vagrants in the Mediterranean Sea and have not been reported in Israeli waters

The primary nesting grounds for the Mediterranean loggerhead turtle population are located along the shores of Greece, Cyprus, and Turkey; the Israeli coast has provided habitat for hundreds of sea turtle nests. Sea turtle 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.

At least 38 seabird species are native to Israeli waters, including 36 seabird species. 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 lifecycle in the marine environment, often far offshore over the open ocean. Two seabirds, the Levantine Shearwater and the Dalmatian Pelican, are vulnerable according to the IUCN Red List. There is no reported breeding for either species in Israel. Several pelagic seabird species are listed in Annex II of the Protocol Concerning Specially Protected Areas and Biological Diversity of the Mediterranean as endangered or threatened avifauna of the Mediterranean region. Two of these, the Great White Pelican and the Little Tern, breed in Israel; their IUCN status is “least concern.”

Seawater and Sediment Quality

Seawater Quality

Testing determined that the quality of the seawater in the Tamar area did not differ from the Levantine Basin means, with few exceptions. Total suspended solids concentrations in the near-bottom samples generally were similar among stations and surveys. Concentrations from within the Tamar Field were slightly higher (0.4 to 0.9 mg/L) than stations located at the perimeter of the field; however, all values were well below the Levantine Basin mean concentrations. All ion concentrations were similar to worldwide and Mediterranean Sea means with the exception of sulfate, which was slightly elevated over Mediterranean Sea means at a few locations.

Sediment Quality

Testing of sediment samples determined that the sediment quality in the Tamar area did not differ from the Levantine Basin averages with few exceptions.

Sediment metals concentrations were overwhelmingly within the 99% confidence limit (CL) of the Levantine Basin means, with the exception of barium (247 parts per million [ppm]). Barium concentrations within the Tamar Field were approximately two times higher (600 to 800 ppm) than the Levantine Basin mean over large areas of the seafloor in the southern (around the Tamar SW-1 wellsite) and middle (around the Tamar-3, Tamar-4, Tamar-5, and Tamar-6 wellsites) portions of the field. Within these areas, isolated pockets of barium concentrations were three to five times greater (800 to 1,200 ppm) than the Levantine Basin mean. Two of these pockets were centered on existing wellsites (Tamar SW-1 and Tamar-3); however, two pockets of elevated barium concentrations occurred approximately 3 km from any existing infrastructure. The sources of these anomalies are unknown and cannot be interpreted from the data. Lead concentrations around the manifold were slightly higher than ambient concentrations within the Tamar Field, but also within the 99% CL of the Levantine Basin mean. Concentrations of all metals within the field and along the pipeline corridor were below effects range low (ERL) and effects range median (ERM) values, with the exception of arsenic, copper, and nickel. These three metals are naturally found in high concentrations throughout the Levantine Basin. Therefore, concentrations above the ERL should be considered ambient for arsenic and copper, and concentrations above the ERM should be considered ambient for nickel.

Polycyclic aromatic hydrocarbon (PAH) concentrations in sediment were similar between surveys with the exception of the relatively high values reported for one station during the March 2013 Tamar Field and Pipeline Survey.

PROJECT DESCRIPTION

The Tamar and Tamar SW Reservoirs are located within the Levantine Basin in the Tamar License (#309) in the Matan Block, approximately 90 km west of Haifa (**Figure ES-1**). Noble Energy has been active in the license area since 2006 and has drilled six gas wells in the Tamar Reservoir (Tamar-1 through Tamar-6; Tamar-6 was a re-drill/completion of Tamar-1) and one in the Tamar SW Reservoir (Tamar SW-1). Tamar-2 through Tamar-6 were competed in 2012. In 2013, Noble Energy drilled the Tamar SW-1 well and installed the Tamar Platform close to the existing Mari-B Platform. At that time, flowlines and utility lines were laid to tie the Tamar Reservoir production together through subsea infrastructure projects to send the production to the Tamar Platform. From the Tamar Platform, production is sent to the Ashdod Onshore Terminal (AOT) via a 30-in. pipeline.

Proposed Activities – Tamar Lease Development Project

The proposed Tamar Field Development Project is expected to start in 2015, and will include the following activities:

- Completion of the Tamar SW-1 well;
- Drilling and completion of the Tamar-7, Tamar-8, and Tamar-9 wells;
- Infield flowline (12¾-in.) from the Tamar SW-1 well to the Tamar-7 well location;
- Infield flowline (16-in.) from the Tamar-7 well to the Tamar production manifold;
- Infield flowlines from Tamar-8 and Tamar-9 to the Tamar production manifold;
- Jumper from Tamar SW-1 to flowline end termination (FLET) on 12-in. west end flowline, 8⅝-in. outer diameter (OD);
- Jumper from FLET on 12-in. east end flowline to 16-in. FLET/flowline west end, 10¾-in. OD;
- Jumper from 16-in. FLET on east end 16-in. flowline to intermediate jumper starter (IJS), 10¾-in. OD;
- Jumper from IJS to manifold, 10¾-in. OD;
- Installation of electrical, hydraulic, flexible, and optical flying leads; and
- Post-installation testing and pre-commissioning.

A drilling vessel has not been identified but is expected to be similar to the *Atwood Advantage*. Support vessels and aircrafts to be used will be similar to those used for the drilling of Tamar SW-1.

Drilling Fluid System

The initial well intervals (before the marine riser is set) will be drilled using a water-based "spud mud," and the cuttings and "spud mud" will be released at the seafloor. For the intervals drilled after the riser is set, Noble Energy has selected INNOVERT CFMOB, a high-performance invert emulsion fluid system developed by Baroid (a product service line of Halliburton). It offers high drilling performance and enhanced rates of penetration and shale inhibition.

INNOVERT is classified as a "Group III NADF" based on its aromatic content of less than 0.5% and PAH content of less than 0.001%.

The advantages of this formulation are as follows:

- Stable mud properties over a wide temperature and density range; suitable for high-temperature/high-pressure applications;
- A better seal than conventional technologies;
- Reduced downhole losses of drilling mud;
- Unique rheological properties that eliminate the need for fine-ground weighting agents while providing excellent hole cleaning;
- Increased tolerance to contaminants such as solids and water influxes;
- Significantly lower solids content to help increase penetration rates;
- Fewer products than for conventional synthetics, improving logistics and rig space usage;
- Real-time response to chemical treatments; and
- Enhanced electrical formation evaluation.

Cuttings Treatment

Cuttings will be separated from the mineral oil-based mud (MOBM) prior to discharge (if approved) or transport for shore disposal. If the cuttings will be discharged, they will be treated using a thermomechanical cuttings cleaner (or equivalent system) cuttings handling process unit to process the cuttings to less than 1% oil on cuttings. On the drilling rig, the mud and cuttings are passed through solids control equipment designed to separate the drill cuttings so that the mud can be pumped back down the hole. The cuttings are initially separated using mesh screens on shale shakers and then transferred to a process plant that uses mechanical action applied directly to the drill cuttings to create temperatures (260°C to 280°C) that rise above the boiling points of water and oil. Reaching these temperatures removes the hydrocarbons from the solids to less than 1% oil on cuttings. Key advantages of the cuttings treatment system are as follows:

- Direct heating of the waste stream, resulting in maximum energy efficiency;
- Recovered base oil which can be directly recycled;
- Dried solids that are clean and can be disposed of on site;
- An easily relocated unit that is ideal for offshore use; and
- Rapid start-up and shutdown, which facilitates simple maintenance tasks.

DISCHARGES

Non-Drilling Discharges

Table ES-1 presents the non-drilling discharges expected for the *Atwood Advantage*. This information is expected to be representative of the Tamar-7 through Tamar-9 wells.

Table ES-1. Summary of estimated non-drilling discharges from the *Atwood Advantage*.

Source	Estimated Volume (m^3/day)	Pipe Diameter (in.)	Discharge Depth (m)
Sanitary Waste (black water effluent)	10-14 (est.)	4	-7
Domestic Waste (gray water)	20-24 (est.)	6	-8
Water Maker Brine*	318	4	-8
Cooling Water	105,360	12	-8
Organic Waste	100-150 kg/day	6	-8

* There are two production units installed on the drillship that are capable of producing 156 m^3/day. Water production will be based on expected demand; no additives are added to the process.

Drilling Mud, Drill Cuttings, and Concrete Discharge

Drilling discharges include used drilling muds and drill cuttings as well as cement.

All wells drilled to date have used water-based mud (WBM), which was discharged at the wellsite. For the proposed wells (Tamar-7, Tamar-8, and Tamar-9), Noble Energy plans to use a MOBM for all sections following spudding of the well. Because MOBM will be used, there will be no discharge of drilling muds other than WBM discharged at the seafloor from the initial section drilled. The MOBM fluid will be retained and brought to shore at the end of the project for reuse or recycling. Noble Energy has applied to MoEP for approval to discharge MOBM-associated cuttings from the proposed wells. If approved, the cuttings will be treated to remove the majority of the MOBM and then discharged. If approval is not received, the cuttings will be hauled to shore for disposal.

Total cuttings volumes are estimated to be 2,841 barrels (bbl) (1,059 metric tons [MT]), including 28.4 bbl (3.6 MT) of MOBM base fluid adhering to cuttings. These totals do not include the initial riserless well intervals where WBM and associated cuttings will be released at the seafloor.

NON-ROUTINE EVENTS

Three different non-routine events were evaluated for the Tamar Field activities: 1) a continuous 30-day discharge of condensate with API 35 at a rate of 3,369 bbl/day from the Tamar SW-1 exploration well occurring at a depth of approximately 1,650 m; 2) an instantaneous discharge of 16,500 bbl of diesel fuel from the drilling rig; and 3) the accidental loss of solid waste.

Trajectory modeling for the study was conducted for Noble Energy by Dr. Steve Brenner of Bar-Ilan University. Four time periods representative of various climatic conditions over the eastern Mediterranean were considered. The model analyzed the potential for spill weathering to estimate how much condensate and diesel fuel would remain on the sea surface at various times following a spill.

The results for the spill scenarios indicate that a condensate or diesel spill from the Tamar SW-1 exploration well would affect both offshore and coastal resources to varying extents depending on environmental conditions. Overall, coastal impacts to Israel are expected for approximately 117 km from just south of Tel Aviv to the Israel/Lebanon border for a condensate spill, and for approximately 60 km from Zichron Yaakov northward to the Israel/Lebanon border for a diesel spill.

EVALUATION OF ENVIRONMENTAL IMPACTS

Impact Assessment Methodology

Two factors are used to determine the significance of an impact: impact consequence and impact likelihood.

Impact consequence refers to an impact's characteristics on a specific resource (e.g., air quality, water quality, benthic communities, etc.). Such determinations take into account resource-specific sensitivity to an impact, recovery capability, and spatial and temporal occurrence. Impact consequence classifications include *beneficial*, *negligible*, *low*, *medium*, and *high* as described in **Table ES-2**.

Table ES-2. Definitions of impact consequence.

<table>
<tr><th>Consequence</th><th>Physical/Chemical Environment</th><th>Biological Environment</th><th>Socioeconomic and Cultural Environment</th></tr>
<tr><td>High</td><td>One or more of the following impacts:
• Widespread, persistent contamination of air, water, or sediment
• Frequent, severe violations of air or water quality standards or guidelines</td><td>One or more of the following impacts:
• Extensive, irreversible damage to sensitive habitats such as sensitive deepwater communities, hard/live bottom communities, seagrass beds, marshes, and/or coral reefs, and other sites identified as MPAs, marine protected habitats, or areas of special concern
• Death or injury of large numbers of a species listed by the IUCN as endangered, critically endangered, or vulnerable, or irreversible damage to their critical habitat</td><td>One or more of the following impacts:
• Extensive, irreversible damage to recreational resources such as beaches, boating areas, and/or tourism
• Impacts posing a significant threat to public health or public safety
• Impacts of a magnitude sufficient to alter the nation's social, economic, or cultural characteristics, or result in social unrest</td></tr>
<tr><td>Medium</td><td>One or more of the following impacts:
• Occasional and/or localized violation of air or water quality standards or guidelines
• Persistent sediment toxicity or anoxia in a small area</td><td>One or more of the following impacts:
• Localized, reversible damage to sensitive habitats such as sensitive deepwater communities, hard/live bottom communities, seagrass beds, marshes, and/or coral reefs, and other sites identified as MPAs, marine protected habitats, or areas of special concern
• Extensive damage to non-sensitive habitats to the degree that ecosystem function and ecological relationships could be altered
• Death, injury, disruption of critical activities (e.g., breeding, nesting, nursing), or damage to critical habitat of individuals of a species listed by the IUCN as endangered, critically endangered, or vulnerable</td><td>One or more of the following impacts:
• Disruption of fishing activities at any location for more than 30 days or exclusion from more than 10% of the fishable area at a given time
• Impacts leading to greater than a 10% change in fishery harvest
• Localized, reversible impacts on recreational resources such as beaches, boating areas, and/or tourist area</td></tr>
<tr><td>Low</td><td colspan="3">• Changes that can be monitored and/or noticed but are within the scope of existing variability, and do not meet any of the High or Medium definitions (above)</td></tr>
<tr><td>Negligible</td><td colspan="3">• Changes unlikely to be noticed or measurable against background activities</td></tr>
<tr><td>Beneficial</td><td colspan="3">• Likely to cause some enhancement to the environment or the social/economic system</td></tr>
</table>

IUCN = International Union for Conservation of Nature; MPA = Marine Protected Area.

Impact likelihood is rated according to its estimated potential for occurrence:

- likely (>50% to 100%);
- occasional (>10% to 50%);
- rare (1% to 10%); or
- remote (<1%).

The impact analysis completed for the Tamar Field projects considered both factors – impact consequence and impact likelihood – to determine overall impact significance. The matrix integrating impact consequence with impact likelihood (**Table ES-3**) provides the basis for determining overall impact significance. The result is an impact significance rating that includes beneficial and several negative impact levels that range from Negligible to High. Impacts rated as High or Medium in significance are priorities for mitigation. Mitigation is also considered for less significant impacts to further reduce the likelihood or consequence of impacts.

Table ES-3. Matrix combining impact consequence and impact likelihood to determine overall impact significance.

Likelihood vs. Consequence		Decreasing Impact Consequence				
		Beneficial	Negligible	Low	Medium	High
Decreasing Impact Likelihood	Likely	Beneficial	Negligible	Low	Medium	High
	Occasional	Beneficial	Negligible	Low	Medium	High
	Rare	Beneficial	Negligible	Negligible	Low	High
	Remote	Beneficial	Negligible	Negligible	Low	Medium

A series of impact-producing factors (IPFs) was developed and evaluated against the environmental resources which have the potential to be impacted. **Table ES-4** presents the results of the EIA evaluation, showing the IPFs in the left column and the environmental resources across the top. The table indicates the resultant impact significance for each identified potential impact as identified and discussed in the EIA.

Most of the evaluated impacts have an expected impact significance of negligible to low. Six of the potential impacts were ranked as medium impact significance. Four of these were expected to result from the worst case discharge, and two were from drilling activities. The potential worst case discharge impacts included impacts on water quality; plankton, fish, and fishery resources; benthic communities; and marine and coastal birds. The medium impact of a worst case discharge on benthic communities would only occur if the released material reached coastal waters; the impact would be expected to be low if the material remained in deep water. The two medium-rated potential impacts resulting from drilling included impacts on sediments/sediment quality and on benthic communities. The medium impact of drilling on benthic communities would only occur if MOBM cuttings are discharged. No impacts were expected to be of high significance.

Table ES-4. Summary matrix of overall impact significance. If a potential impact ranges between two categories, the higher category is presented.

Project Activity/ Impact-Producing Factor	Environmental Resource											
	Physical/Chemical			Biological				Socioeconomic and Cultural				
	Air Quality	Sediments/Sediment Quality	Water Quality	Plankton, Fish, and Fishery Resources	Benthic Communities	Marine Mammals and Sea Turtles	Marine and Coastal Birds	Protected Marine Species and Habitats, Marine Habitats of Interest, and Areas of Special Concern	Fishing and Marine Farming	Shipping and Maritime Industry	Recreation and Aesthetics/Tourism	Archaeological Resources
NON-ROUTINE (ACCIDENTAL) EVENTS (4.3)												
Drilling Worst Case Gas Discharge					*							
Large Diesel Fuel Spill												
Solid Waste (Accidental Loss)												
ROUTINE PROJECT-RELATED ACTIVITIES												
Drilling Activities												
Drillship Arrival, Departure, and Stationkeeping												
Drilling (including release/discharge of drill muds and cuttings, flaring, and other well operations					**							
Physical Presence												
Lights												
Noise (including support vessels and aircrafts)												
Routine (non-drilling related) Discharges												
Solid Waste												
Infrastructure Installation and Operation (platform, pipelines, umbilicals)												
Installation Vessel Arrival, Operation, and Departure												
Installation Activities												
Physical Presence												
Combustion Emissions												
Noise												
Solid Waste												
Support Vessel and Helicopter Traffic												
Support Vessel Traffic												
Helicopter Traffic												

* The impact of a worst case discharge is expected to be low for offshore areas, and medium if the discharge reaches the shoreline.
** The impact of drilling cuttings discharges is expected to be low if the mineral oil-based mud (MOBM) cuttings are not discharged.

Key:
- Negligible Impact
- Low Impact
- Medium Impact

MONITORING

Monitoring will be performed at all levels and phases of the work, including during drilling, installation activities, and ongoing operations. Discharges to be tested, the frequency of testing, and analyses will comply with all applicable permits and regulations, Noble Energy policy, and best industry practice.

Surveys specific to post-drill analysis of each new wellsite/drillsite will be conducted as per regulations. Area-wide monitoring surveys of the Tamar Field will be conducted periodically as well.

MITIGATION

Environmental management of Noble Energy activities is implemented through a hierarchy of policies, plans, and procedures that cascade from the corporate level to the business units and their individual operations. To ensure that Noble Energy's corporate environmental, health, and safety policies are systematically applied and that industry best practices are adopted within all of its operations, Noble Energy has developed its Environmental, Health, and Safety Global Management System (GMS) that integrates health, safety, and environmental considerations into all elements of the management process.

Because the Tamar Field Development Project will be undertaken using equipment and personnel provided by third parties (e.g., owner/operators of selected vessels), the Noble Energy GMS will be implemented by personnel who will operate under their respective corporate Environmental Management System and safety systems. These systems include elements such as the environment; general shipboard management; and procedures for the bridge, engine room, deck, cargo, and the use of activity-specific equipment. Noble Energy will ensure that vessel plans are aligned with Noble Energy's GMS by use of an Interface Document.

The GMS Interface Document will identify common processes and approaches to address any differences in procedures between Noble Energy and the vessel contractor as well as any site-specific hazards of the Tamar Field Development Project. Noble Energy will conduct an extensive comparison and review of vessel plans, processes, and procedures relative to the Noble Energy GMS to ensure that the contractor's plans are acceptable for use as the primary system during the Tamar Field Development Project.

The project will follow best industry guidelines or internal Noble Energy procedures, whichever are more stringent, and will comply with all applicable regulations, permits, and best practices. The EIA discusses the specific steps to be taken to mitigate each potential impact.

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LIST OF ACRONYMS AND ABBREVIATIONS

3D	three-dimensional
AAC	annual average concentration
AHTS	anchor handling towing supply
AOT	Ashdod Onshore Terminal
bbl	barrel
B.C.E.	Before Common Era
bhp	brake horsepower
BOP	blowout preventer
CCC	Criterion Continuous Concentration
CDC	Climate Diagnostics Center
CH_4	methane
CL	confidence limit
CO	carbon monoxide
CO_2	carbon dioxide
DNV	Det Norske Veritas
DO	dissolved oxygen
DP	dynamically positioned
DST	Dead Sea Transform
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
ERL	effects range low
ERM	effects range median
EUCEQS	European Union Commission on Environmental Quality Standards
FFPI	Fossil Fuel Pollution Index
FLET	flowline end termination
GMS	Global Management System
H_2S	hydrogen sulfide
hp	horsepower
IJS	intermediate jumper starter
IPF	impact-producing factor
IUCN	International Union for Conservation of Nature
LC_{50}	lethal concentration 50 (50% mortality)
LWD	logging while drilling
MAC	maximum allowable concentration
MARPOL	International Convention for the Prevention of Pollution from Ships
MASP	maximum anticipated surface pressure
MAWP	maximum anticipated wellhead pressure
MD	measured depth
MEG	monoethylene glycol
MFS	Mediterranean Forecasting System
mmscfd	million standard cubic feet per day
MNIEWR	Ministry of National Infrastructures, Energy and Water Resources
MOBM	mineral oil-based mud
MoEP	Ministry of Environmental Protection
MT	metric ton
MWD	measurement while drilling
NCEP	National Center for Environmental Predictions
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NOAA	U.S. National Oceanic and Atmospheric Administration
Noble Energy	Noble Energy Mediterranean Ltd

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

NTU	nephelometric turbidity unit
OD	outer diameter
PAH	polycyclic aromatic hydrocarbon
PM	particulate matter
ppb	parts per billion
ppg	pounds per gallon
ppm	parts per million
psi	pounds per square inch
RDIF	reservoir drill-in-fluid
rms	root mean square
RO	reverse osmosis
ROV	remotely operated vehicle
RSS	rotary steerable system
SCSSV	surface-controlled subsurface safety valve
SDS	safety data sheet
SEMS	Safety and Environmental Management System
SFRDIF	solids-free drill-in-fluid
SO_x	sulfur oxides
SPL	sound pressure level
Tamar Platform	Tamar Offshore Receiving and Processing Platform
TEU	20-ft equivalent units
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TPH	total petroleum hydrocarbons
TSS	total suspended solids
TVD	total vertical depth
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
WBM	water-based mud
WP	working pressure

CHAPTER 1: DESCRIPTION OF THE CURRENT MARITIME ENVIRONMENT

1.1 GENERAL OVERVIEW

Noble Energy Mediterranean Ltd (Noble Energy) has prepared this Environmental Impact Assessment (EIA) for the Tamar Field Development Project, which includes the drilling of three wells and the installation of subsea infrastructure (i.e., umbilical/utility lines, pipelines). Noble Energy has been active in the Tamar Field since 2006 with initial drilling activities starting in 2008. To date, seven wells have been drilled in the Tamar Field (Tamar-1 through Tamar-6 and Tamar SW-1). Of these, five wells, Tamar-2 through Tamar-6, are currently producing. A gas production and transportation system, composed of subsea trees, infield flowlines and umbilicals, and a pipeline, currently links the Tamar Field to the Tamar Offshore Receiving and Processing Platform (Tamar Platform), located approximately 149 km south-southeast of the field (**Figure 1-1**).

The proposed Tamar Field Development Project, which is the focus of this EIA, includes the completion of the Tamar SW-1 well, the drilling of three additional wells in the Tamar Reservoir (Tamar-7, Tamar-8, and Tamar-9), and the installation of the infrastructure to tie these wells into the existing Tamar subsea equipment. The umbilical line, utility lines, and pipelines proposed for the Tamar Field Development Project are shown in **Figure 1-2**, along with the existing infrastructure and the Tamar Reservoir.

This EIA presents a summary of the regional environment, including environmental studies that have been performed for the Tamar Field, and assesses the potential impacts that could result from the proposed Tamar Field Development Project. To present the most complete review of the conditions in the Tamar Field and the potential impacts, the activities and studies completed in the field to date are reviewed and the results of completed monitoring throughout the field are presented. The data provide the appropriate characterization of the environment to assess field-wide impacts that may occur as a result of the proposed completion, drilling, and installation activities. Mitigation measures to reduce or eliminate potential impacts are presented in this analysis.

Two surveys performed for Noble Energy provide important data regarding background conditions. These are referred to in this report as the Tamar Field Background Monitoring Survey performed in February 2014 and the Tamar Field and Pipeline Survey performed in March of 2013. The surveys provide background information on physicochemical conditions and the benthic community (CSA Ocean Sciences Inc., 2014). The field survey reports and station locations for the field surveys are presented in **Appendix A**.

The EIA was prepared and organized in accordance with the Ministry of National Infrastructures, Energy and Water Resources (MNIEWR) and the Ministry of Environmental Protection (MoEP, formerly the Ministry of the Environment) “Framework Guidelines for Preparation of Environmental Document Accompanying License for Exploration Purposes” (Framework) (**Appendix B**). The material is presented in sections that do not match the order of the Framework; **Appendix C** presents a list of the sections required by the Framework and the corresponding sections of this EIA in which the information is presented.

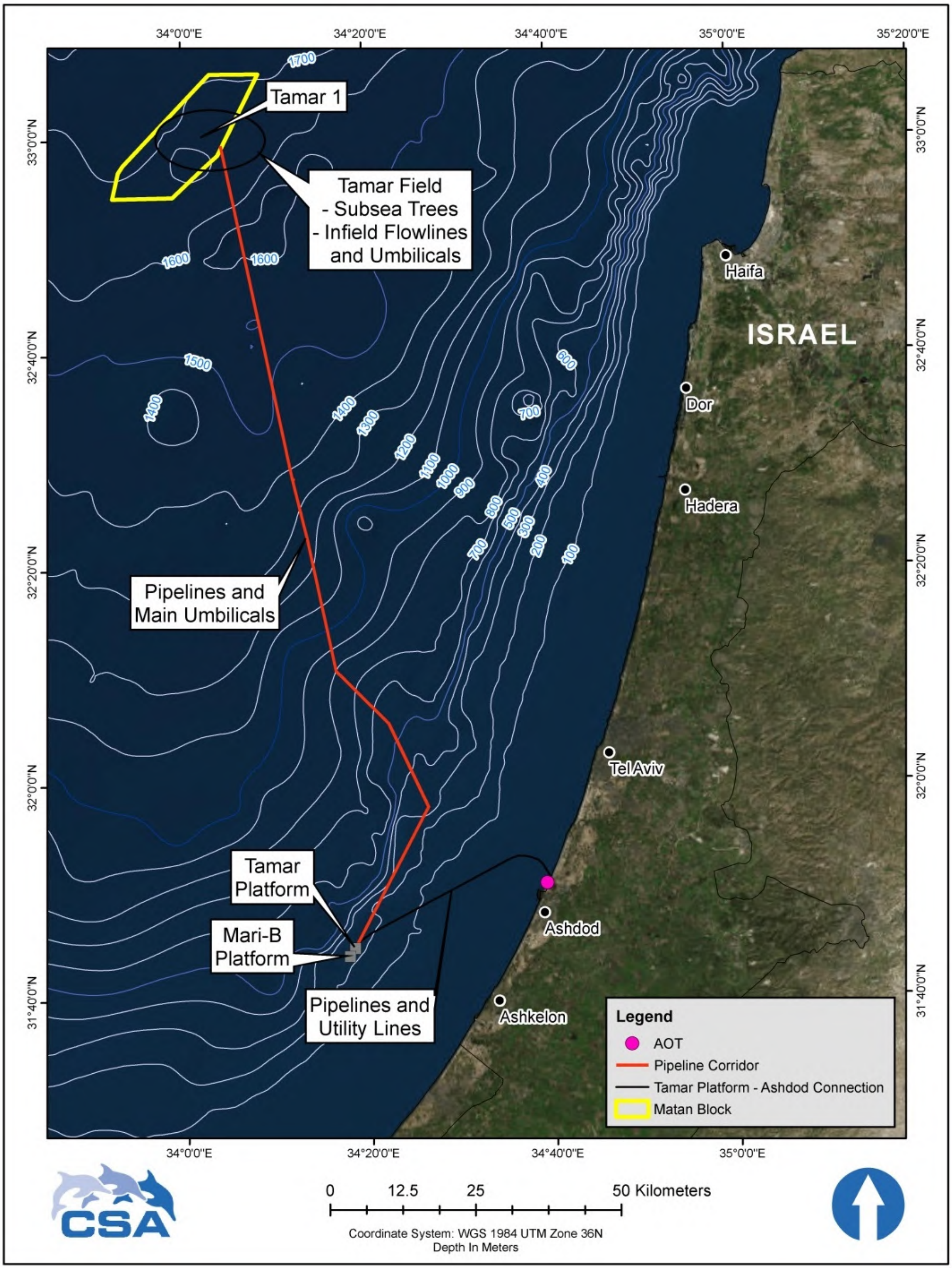


Figure 1-1. Tamar Field Development components. Water depth is in meters.

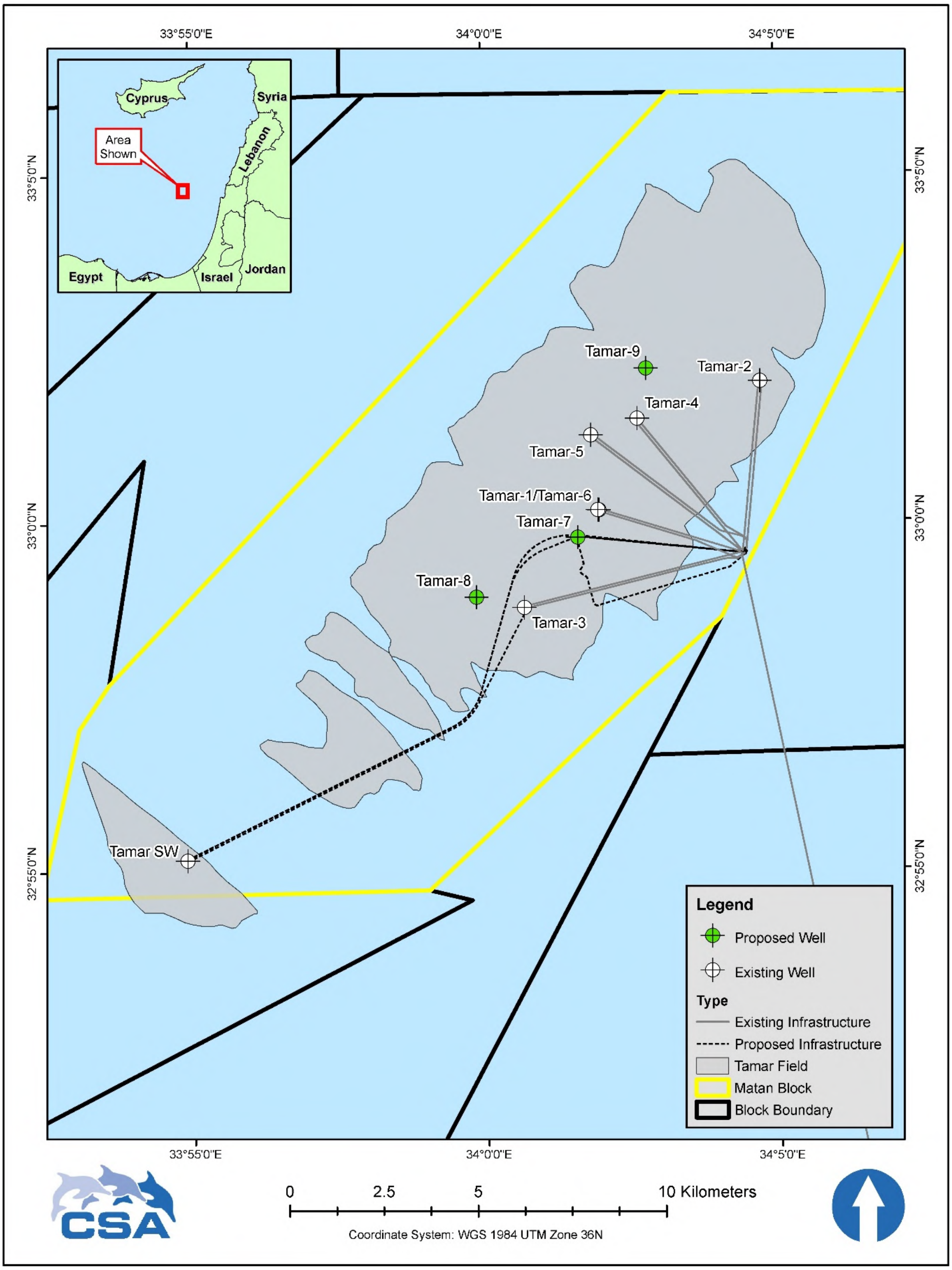


Figure 1-2. Locations of existing and proposed wells and infrastructure in the Tamar Field Development.

1.1.1 Boundaries of Application and Area of Influence

The Tamar Field is located in License 309 in the Matan Block which is approximately 90 km west of Haifa in the Levantine Basin. The Matan Block covers 318 km^2, of which the Tamar Field covers 250 km^2. The proposed Tamar Field Development Project Application Area is located in the Tamar Field, which is at a depth of 1,600 to 1,700 m and includes the Tamar SW-1 well area in the Tamar SW Reservoir, the area around the three wells to be drilled in the Tamar Reservoir, and the infrastructure (pipelines, umbilicals, fiber optic cables) from these wells to the existing infrastructure. This EIA examines activities and potential impacts within these areas of influence, including areas within 2 km of the proposed activities, as well as other areas that may be environmentally affected as a result of the potential transport of discharges or emissions.

1.1.2 Maps and Orthophotos

The current and proposed Tamar Field Development Project pipeline routes are depicted by the dotted lines shown in **Figure 1-2**, which also shows the locations of Tamar-7 through Tamar-9.

The Tamar well coordinates for Tamar SW-1, which will be completed, and for Tamar-7, Tamar-8, and Tamar-9, which will be drilled, are shown in **Table 1-1**. The project location is more than 1,000 m from the coastline, so an orthophoto is not included in this report. No maritime agricultural activity is known within 30 km of the project area. **Figure 1-3** illustrates the shipping lanes, mariculture sites, and submarine cables in the area. A map of the Tamar Field showing depth contours is presented in **Figure 1-4**.

Table 1-1. Coordinates for the proposed project sites.

Name	X (UTM)	Y (UTM)	X (ITM)	Y (ITM)	Lat. (DMS)	Long. (DMS)	Lat. (DM)	Long. (DM)	Lat. (DD)	Long. (DD)
Tamar-7*	595,918.50	3,651,335.30	109,385.96	767,411.87	32°59'46.3710" N	34°01'36.2072" E	32°59.7728' N	34°01.6035' E	32.9962° N	34.0267° E
Tamar-8*	593,227.30	3,649,740.60	106,660.70	765,873.20	32°58'55.4343" N	33°59'51.9333" E	32°58.9239' N	33°59.8656' E	32.9821° N	33.9978° E
Tamar-9*	597,717.36	3,655,824.81	111,279.38	771,864.66	33°02'11.5603" N	34°02'47.2377" E	33°02.1927' N	34°02.7873' E	33.0365° N	34.0465° E
Tamar SW-1**	585,564.89	3,642,733.79	98,849.58	759,024.98	32°55'10.1888" N	33°54'54.3991" E	32°55.1698' N	33°54.9067' E	32.9195° N	33.9151° E

* Proposed well.
** Existing well to be completed.
XY (UTM) Coordinate System: WGS84; UTM Zone 36N; Units: Meters.
Latitude-Longitude Coordinate System: WGS84; Units: Degrees, Minutes, Seconds (DMS); Degrees, Decimal Minutes (DM); Decimal Degrees (DD).
XY (ITM) Coordinate System: Israel TM Grid; Units: Meters.

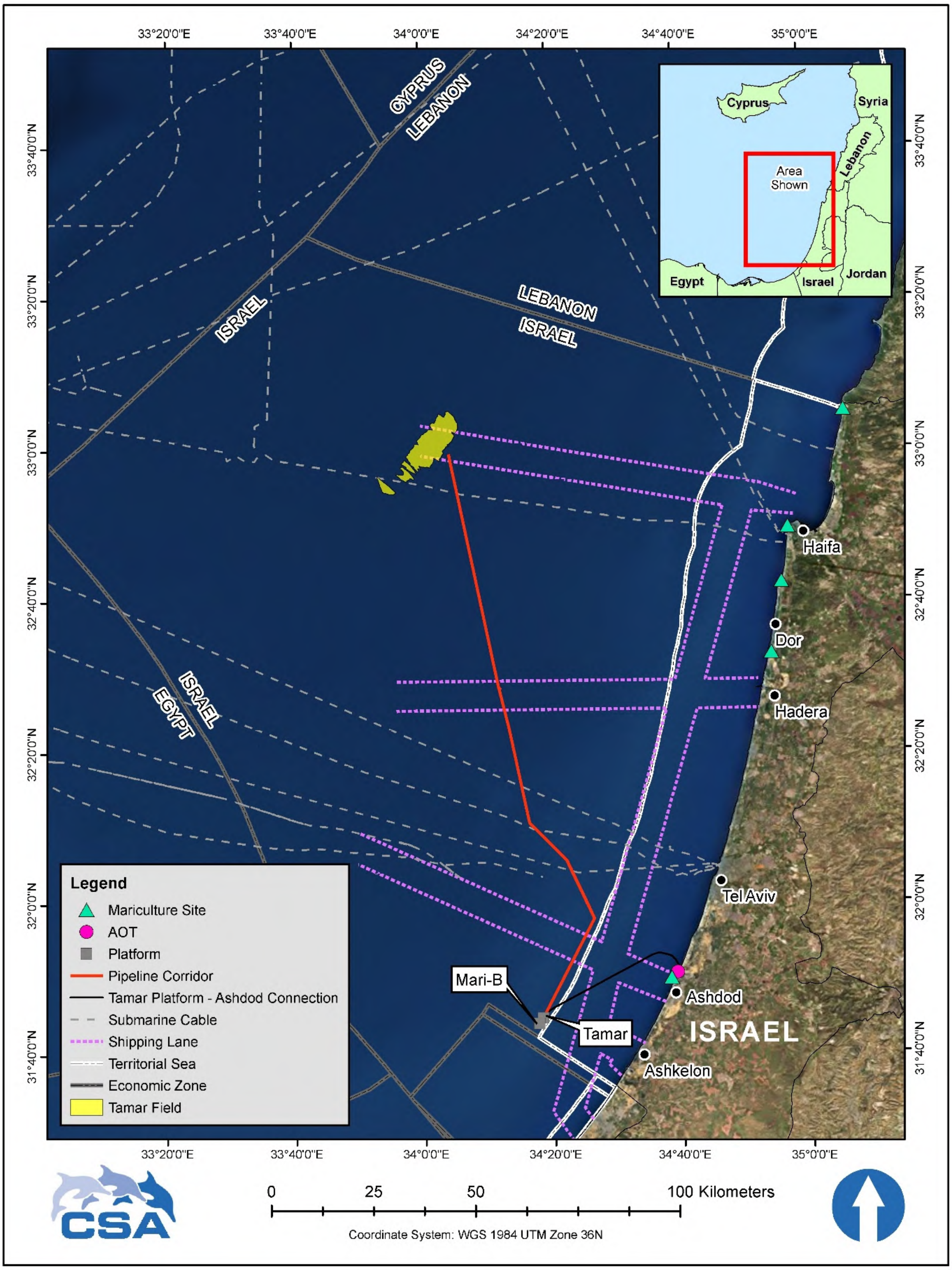


Figure 1-3. Location of the Tamar Field relative to regional maritime boundaries, submarine cables, mariculture sites, and shipping fairways off the Israeli coastline.

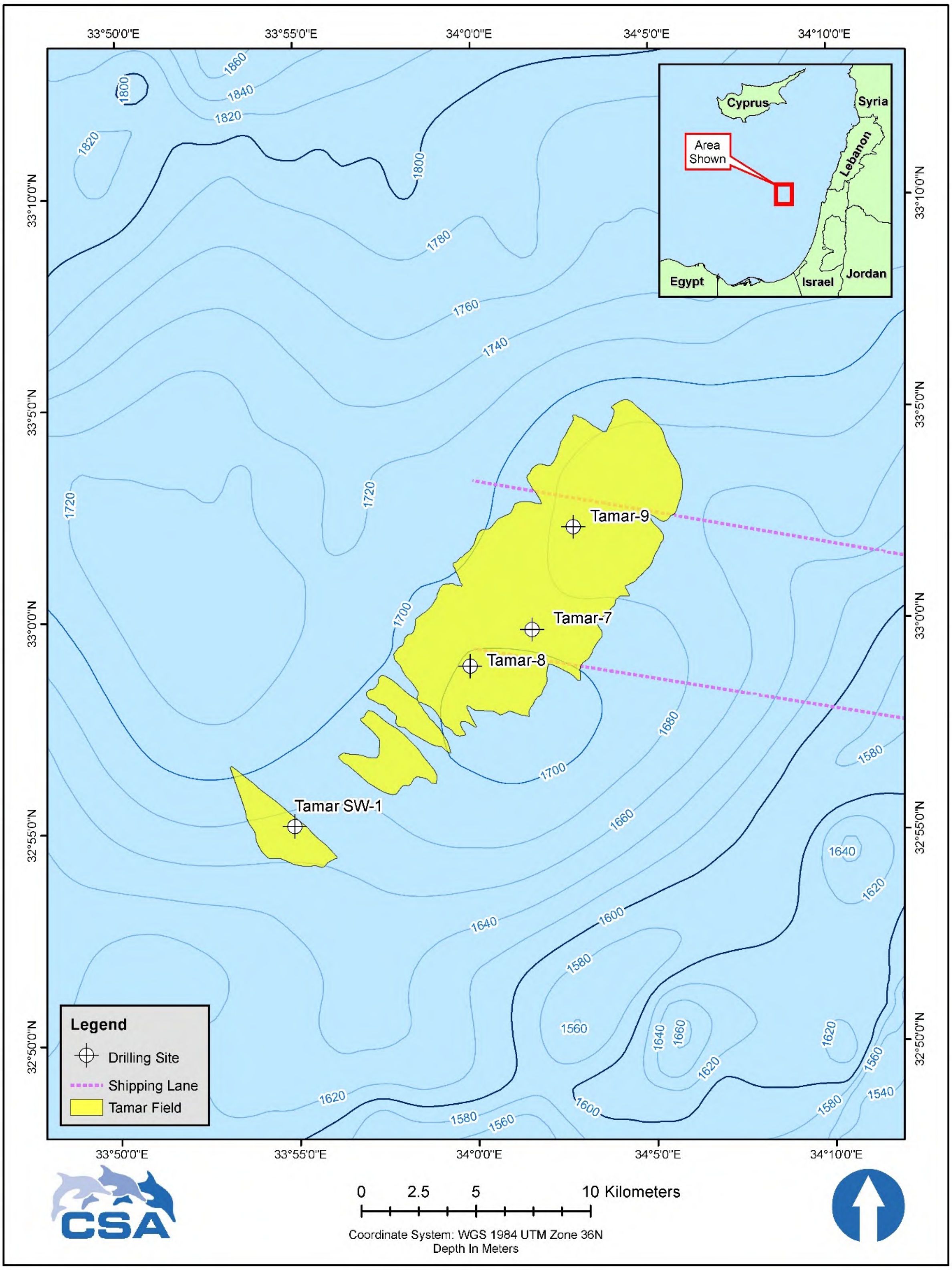


Figure 1-4. Tamar Field depth contour map at scale of 1:250,000.

A series of four figures indicates the route of the proposed pipeline route from Tamar SW-1 to Tamar-7. These are shown in **Figures 1-5** through **1-8**.

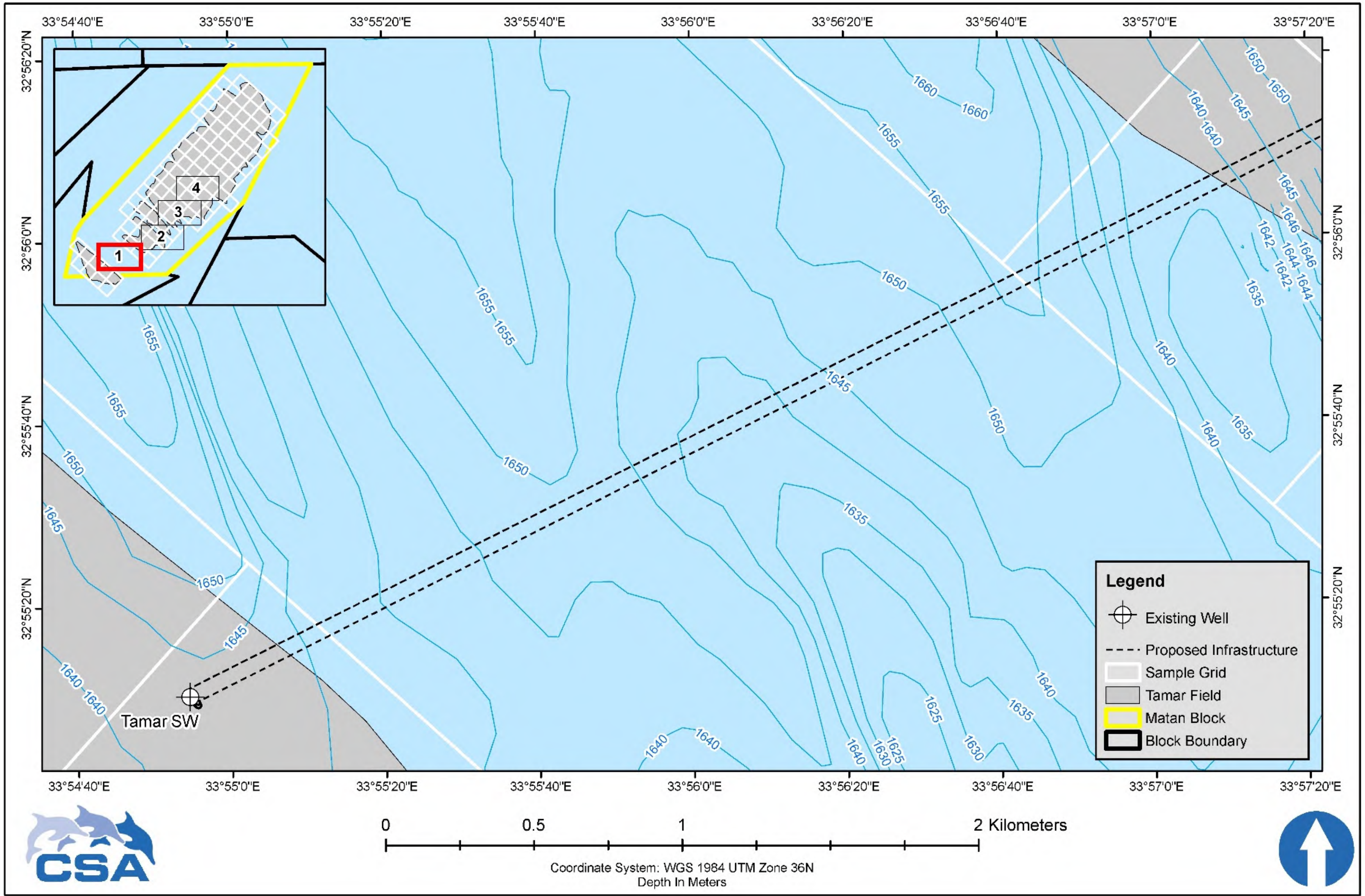


Figure 1-5. Regional depth map for 2 km around pipeline route from Tamar SW-1 to Tamar-7 at 1:20,000 with 5-m isobaths. The square in the upper left is a larger scale map of the area; the red box indicates the area of the enlargement.

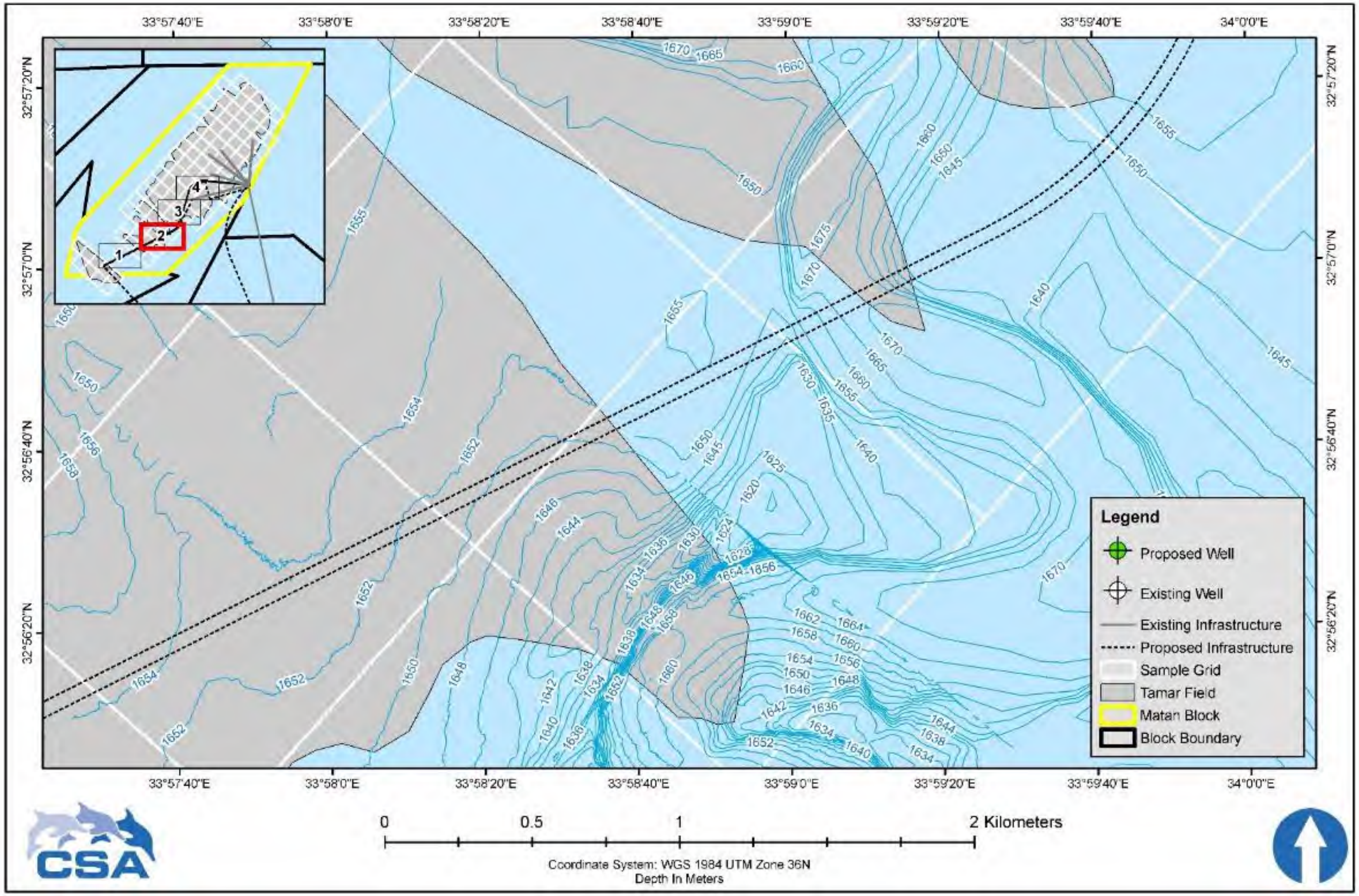


Figure 1-6. Regional depth map for 2 km around pipeline route from Tamar SW-1 to Tamar-7 at 1:20,000 with 5-m isobaths. The square in the upper left is a larger scale map of the area; the red box indicates the area of the enlargement.

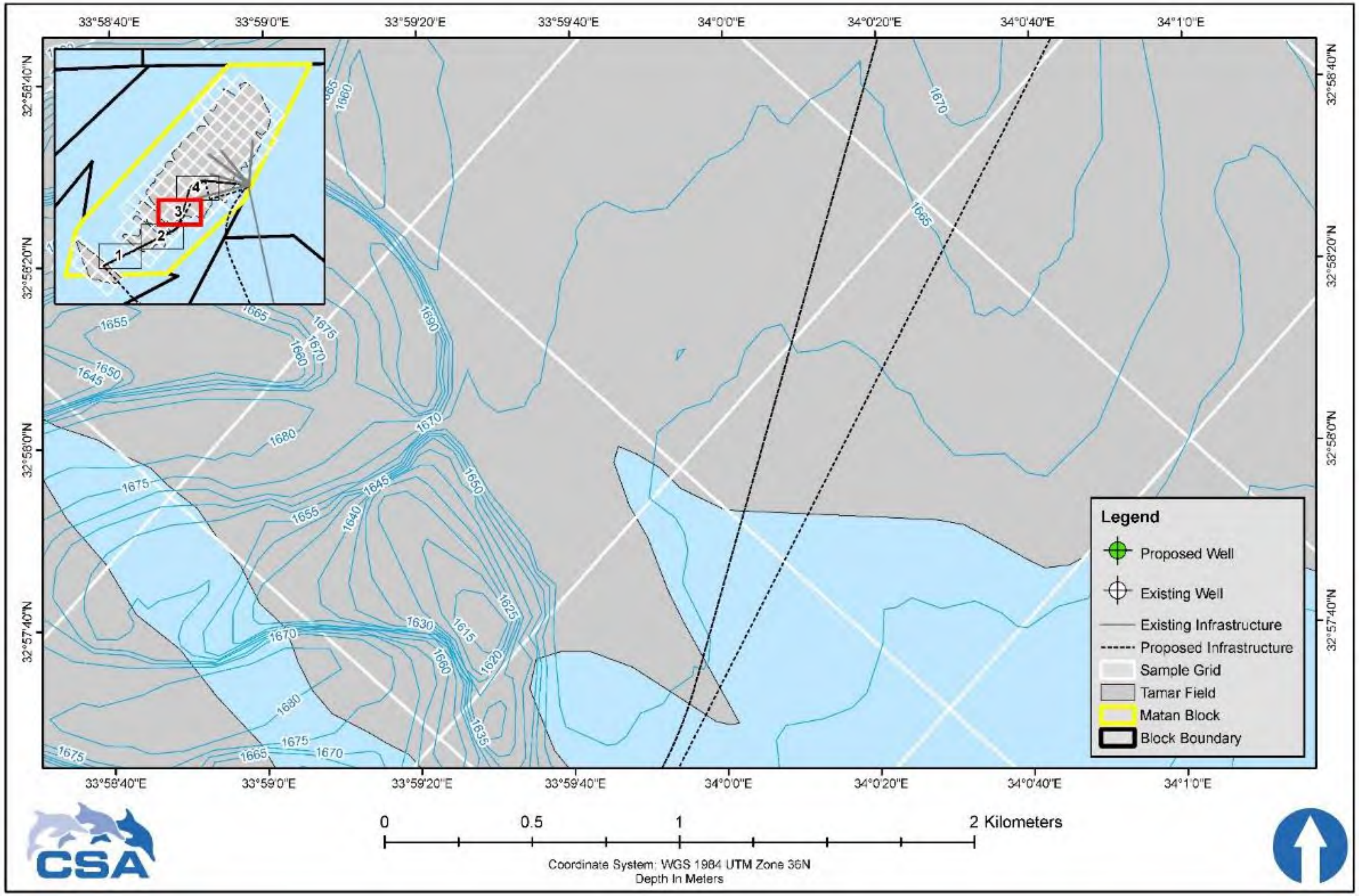


Figure 1-7. Regional depth map for 2 km around pipeline route from Tamar SW-1 to Tamar-7 at 1:20,000 with 5-m isobaths. The square in the upper left is a larger scale map of the area; the red box indicates the area of the enlargement.

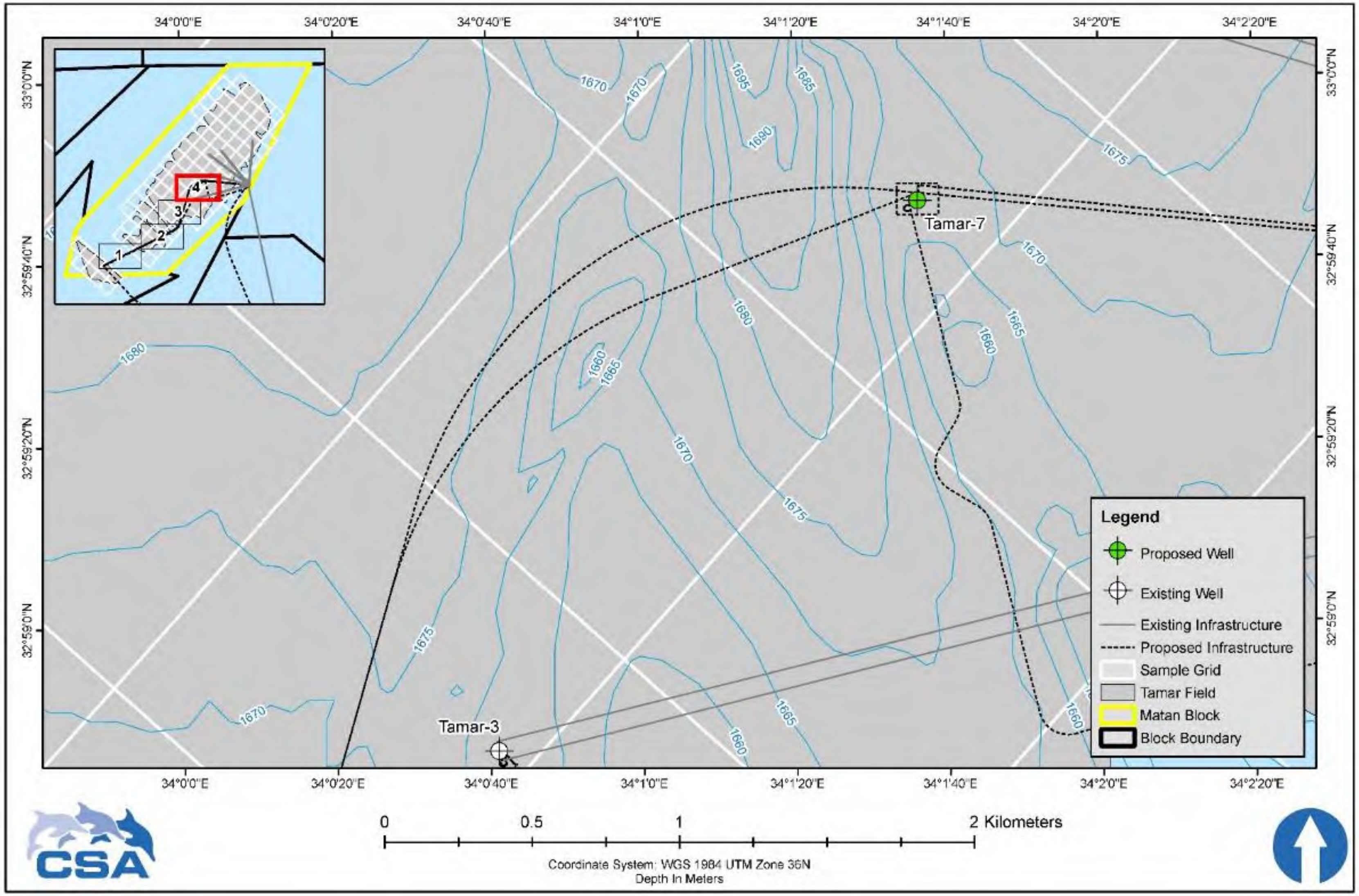


Figure 1-8. Regional depth map for 2 km around pipeline route from Tamar SW-1 to Tamar-7 at 1:20,000 with 5-m isobaths. The square in the upper left is a larger scale map of the area; the red box indicates the area of the enlargement.

1.2 BASELINE ENVIRONMENT

1.2.1 Geological, Seismic, and Sediment Characteristics

Geological, seismic, and sediment characteristics are discussed in this section. Site-specific information for each well is presented, followed by general information on the area of the proposed project.

1.2.1.1 Tamar-7

Information on the geological, seismic, and sediment characteristics of the Tamar-7 well are discussed in the Well Clearance Letter prepared by Gardline Surveys Inc. (2013a); excerpts from the report are provided in this section. The report addresses seafloor and shallow geologic conditions that may impact exploratory drilling operations within 500 m of the proposed well location. The depth limit of this geohazard assessment is Horizon H20 (3,581 m below the sea surface; 1,916 m below the seafloor).

The seafloor at the proposed Tamar-7 well location is on the crest of a northwest-to-southeast trending, low-relief seafloor ridge (**Figure 1-9**). The relief of the seafloor ridge increases to the southeast and is the result of compression in the underlying evaporite section. A northeast-to-southwest trending seafloor strike-slip fault is located approximately 500 m west of the proposed location.

Seafloor sediments are expected to be composed of clays and silts, becoming firmer with depth. There are no anomalous seafloor amplitudes indicative of any fluid seep within 500 m of the proposed well location (**Figure 1-10**). No other seafloor features were observed within a 500-m radius that could affect well emplacement. The sedimentary sequence has been subdivided into two major units on the basis of the geology at the proposed well location: 1) the clastic section of Unit A; and 2) the salt sequence of Unit B (**Figures 1-11** to **1-14**). Unit B was further subdivided into upper and lower units, B Upper and B Lower. An intermediate horizon, H15, was mapped in between the intermittent clastic interbed markers of ME40 and ME50. The seafloor and sediments within Unit A are expected to consist of clays and silts, with intermittent sand interbeds and lenses. Unit A is bounded at its base by an irregular, complex reflector (Horizon H10) that marks the top of Messinian evaporates at 2,040 m below the sea surface (375 m below the seafloor). The unit has an average thickness of 450 m and thickens to the southeast. It generally is thinner along the axis of the seafloor ridges.

In the uppermost interval from seafloor to 1,737 m below the sea surface (72 m below the seafloor) seismic data indicates a uniform, low amplitude character. No sandy interbeds or hard grounds are expected in this interval. Sediments appear favorable to jetting of seafloor casing, though a slightly firmer sedimentary section is predicted as the location is on the crest of a low-relief seafloor ridge.

In the interval between 1,737 to 1,850 m below the sea surface (72 to 185 m below the seafloor), higher energy sediments are interpreted as clays and silts with occasional sandy interbeds and lenses. Given the possibility for the presence of minor sands within this interval, minor drilling fluid circulation and wellbore stability problems are considered possible.

The lower interval within Unit A, 1,850 to 2,040 m below the sea surface (185 to 375 m below the seafloor), is interpreted as clays and silts. Immediately above the top of salt at 2,040 m below the sea surface (375 m below the seafloor), there is the possibility of encountering 10 to 20 m of clastic interbeds, anhydrite, or limestone; these may induce some minor drilling fluid circulation and wellbore stability problems. While a vertical borehole will not penetrate an interpreted fault in this interval, there are several small normal faults in the immediate vicinity. Drilling caution is advised. Minor drilling fluid circulation and wellbore stability problems are possible if a fault is intersected.

There is no risk of gas to the proposed location within Unit A. Horizon H10 marks the base of this unit at 2,040 m below the sea surface (375 m below the seafloor).

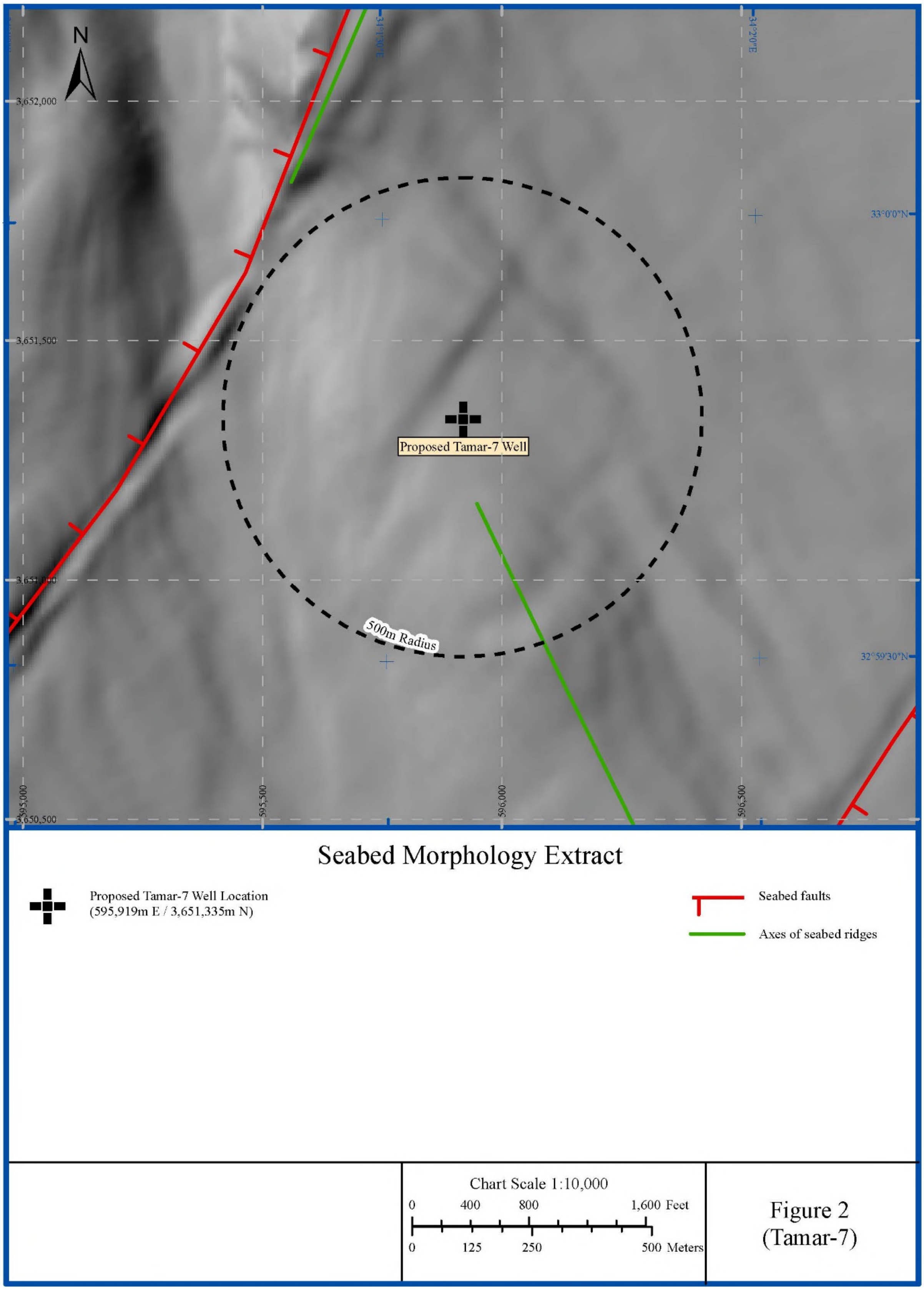


Figure 1-9. Tamar-7 seafloor morphology (From: Gardline Surveys Inc., 2013a).

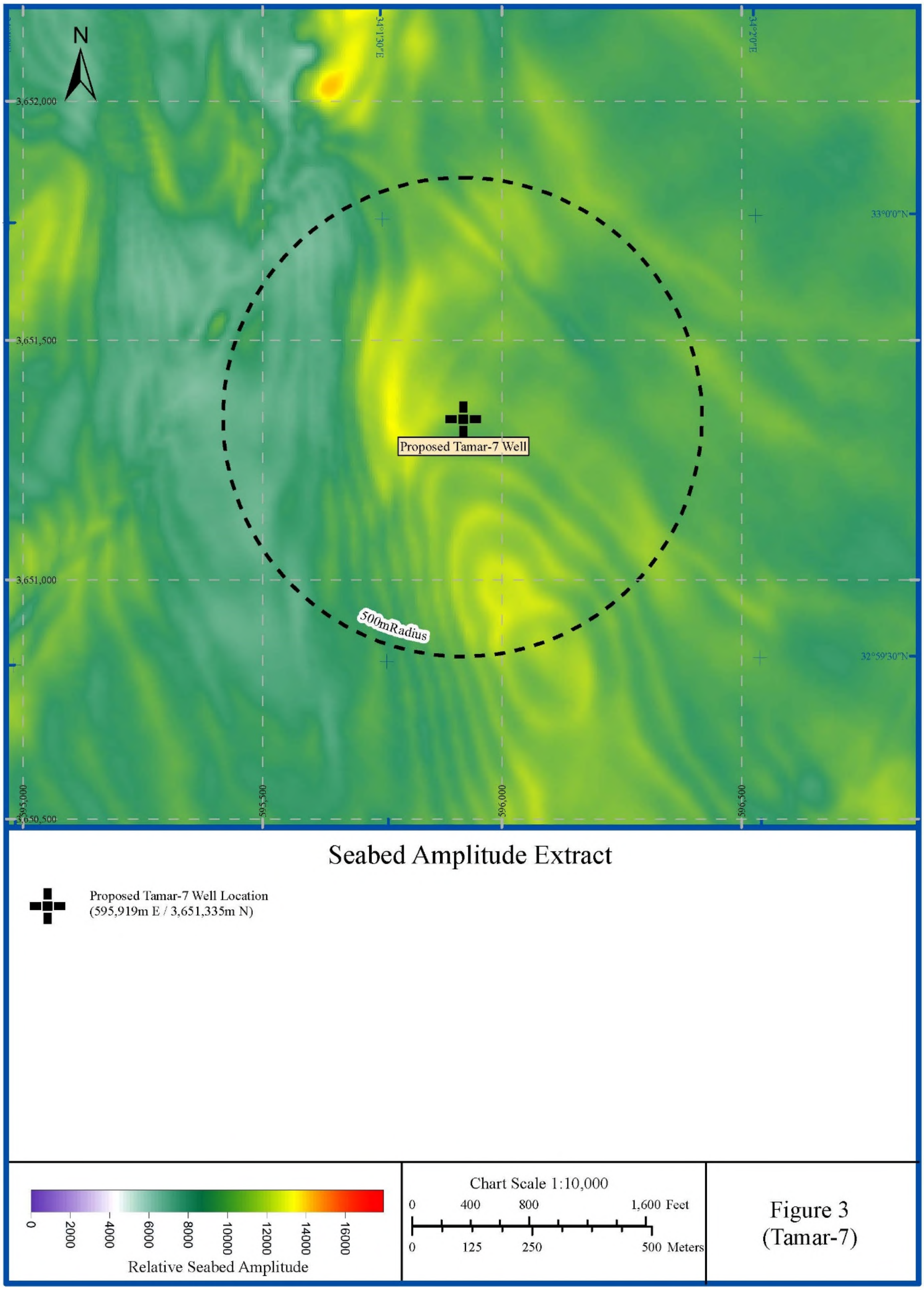


Figure 1-10. Tamar-7 seafloor amplitudes (From: Gardline Surveys Inc., 2013a).

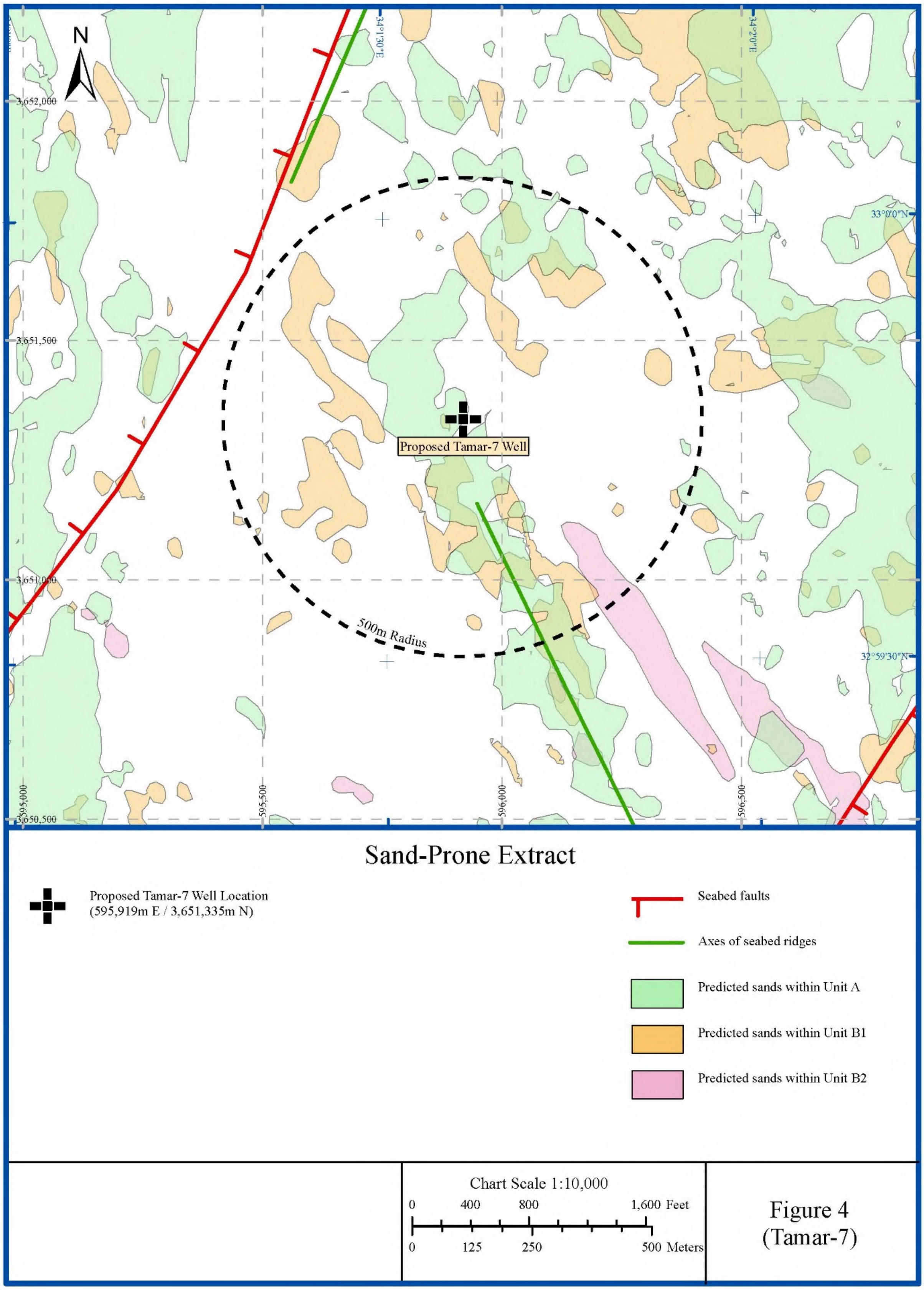


Figure 1-11. Tamar-7 sand-prone figure (From: Gardline Surveys Inc., 2013a).

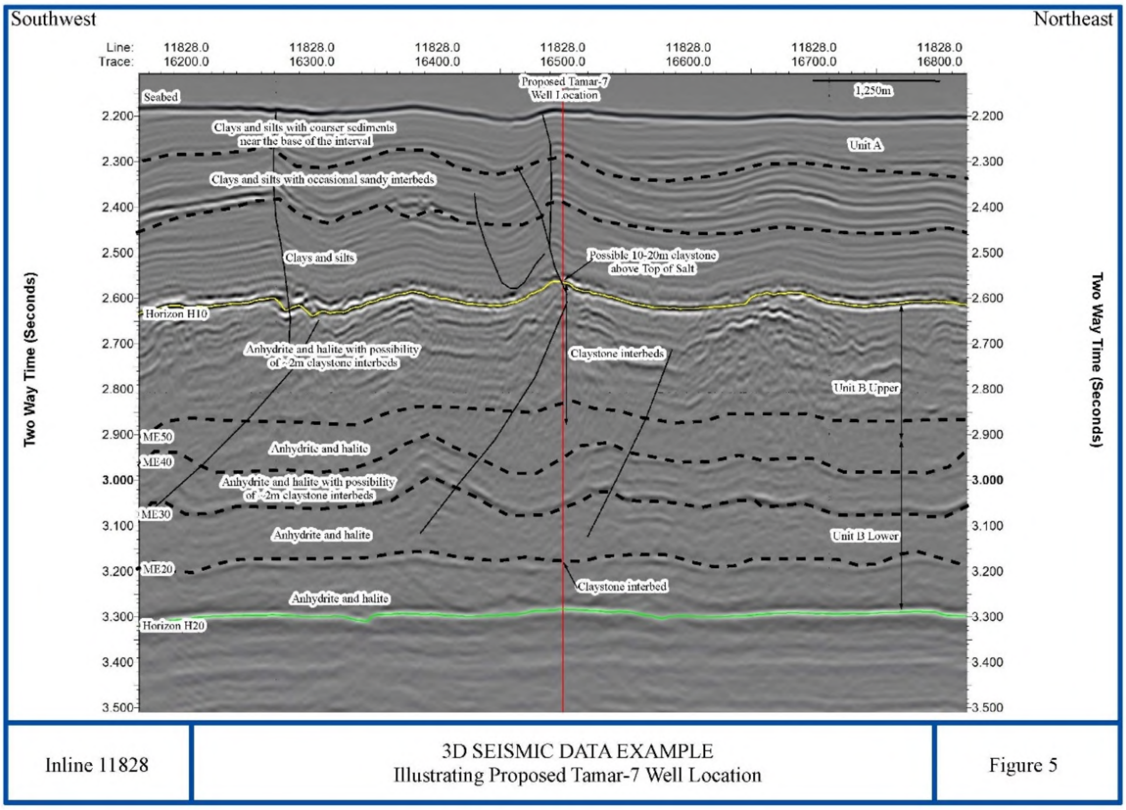


Figure 1-12. Tamar-7 seismic data example from Inline 11828 (From: Gardline Surveys Inc., 2013a).

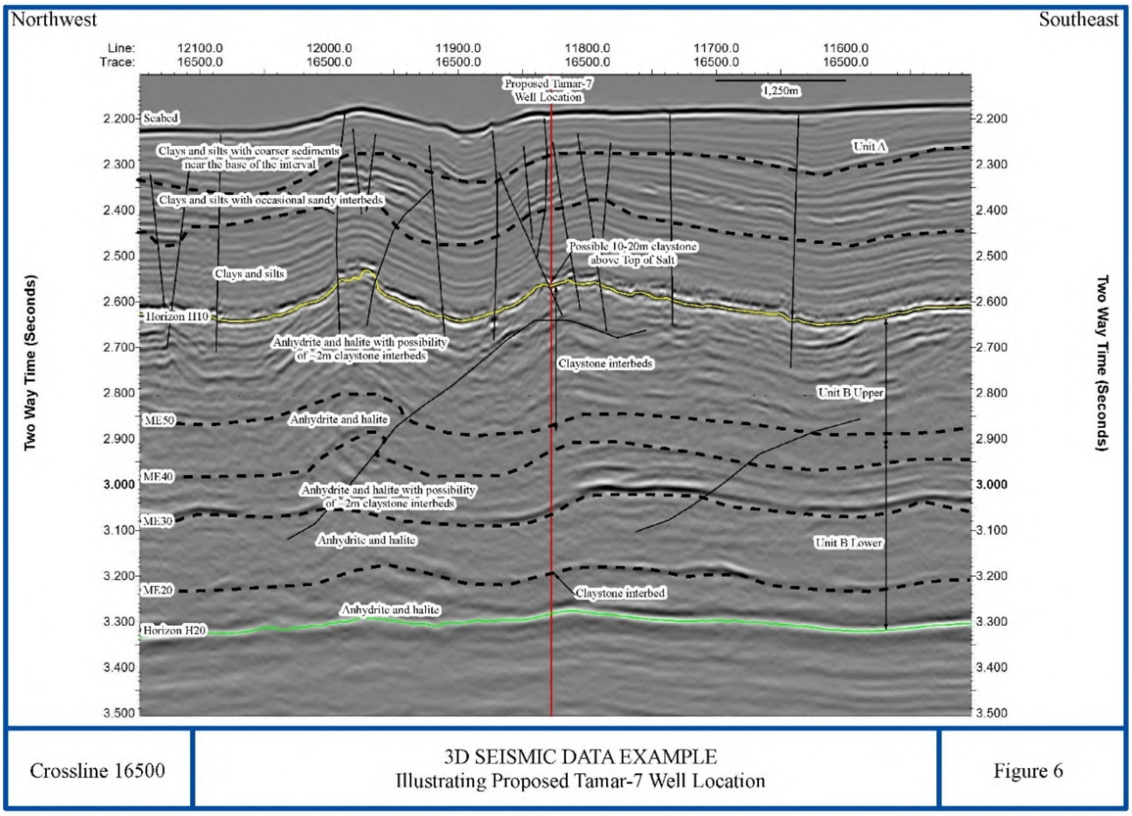


Figure 1-13. Tamar-7 seismic data example from Crossline 165000 (From: Gardline Surveys Inc., 2013a).

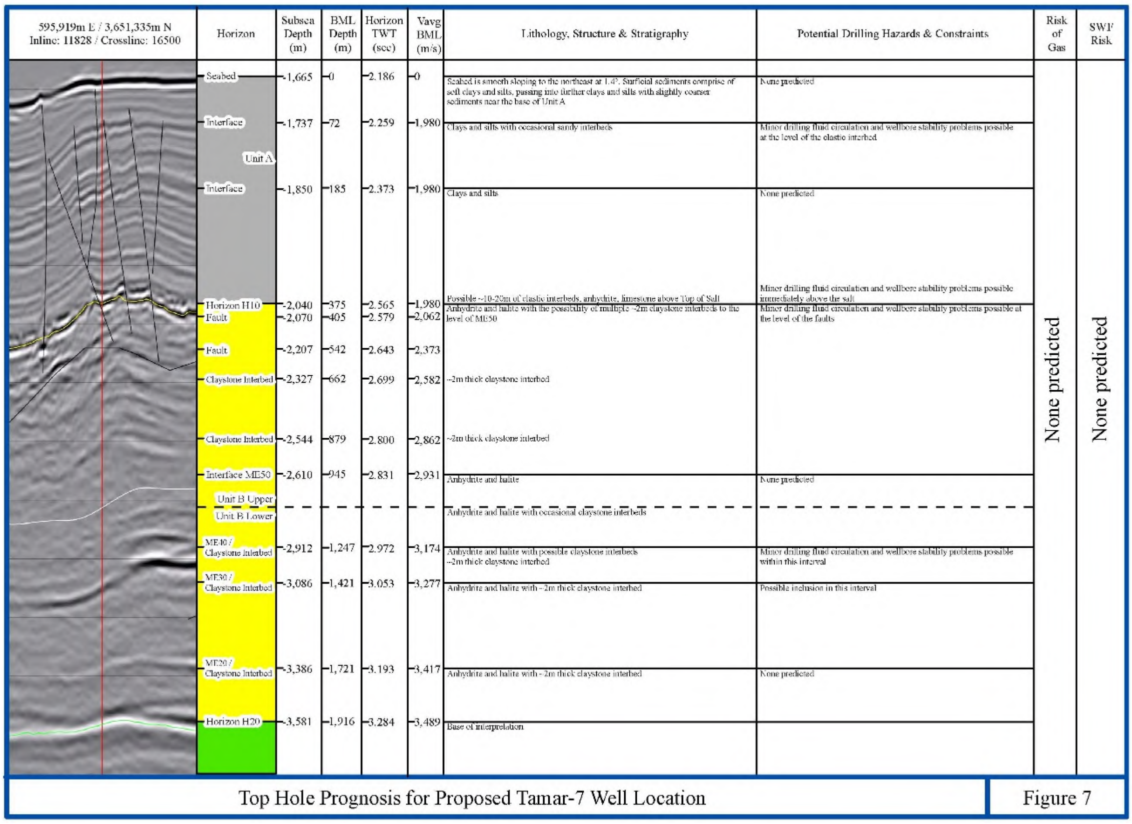


Figure 1-14. Tamar-7 top hole prognosis (From: Gardline Surveys Inc., 2013a).

Unit B consists of discontinuous, low amplitude to transparent seismic reflectors that are locally interbedded with semi-continuous moderate amplitude reflectors. Unit B represents a thick sequence of evaporites that were deposited over the former abyssal plain during the Messinian Salinity Crisis (Druckman et al., 1995, as cited in Gardline Surveys Inc., 2013a) with occasional clastic interbeds in the lower intervals of the unit. The clastic interbeds within this unit represent sediments deposited during flood events, and probably are composed predominantly of clays and silts with the possibility of some coarser interbeds. According to Druckman et al. (1995), the sediments of Unit B consist of thin interbeds of compacted nodular halite and anhydrite interbedded with medium to dark gray and moderately firm claystones, limestones, and sandstones.

Based on structural models of top Messinian salt and base Messinian salt, it is clear that the topography of these two layers have little similarity. This indicates that sediments above base Messinian salt were mobilized. One theory suggests that local earthquakes could have generated local overpressures and triggered sediment mobilization (Frey-Mart et al., 2007, as cited in Gardline Surveys Inc., 2013a).

For the purpose of geohazard identification, Unit B has been separated into Unit B Upper and Unit B Lower. An intermediate horizon (H15) was mapped in the interval between the interfaces identified as ME50 and ME40. The purpose of this division is to enable mapping of the extent of the zones of mechanical weakness, the claystone interbeds, and within the upper and lower salt sequence (**Figure 1-11**).

Within Unit B Upper in the larger Levantine Basin, the uppermost interval of the evaporite sequence from Horizon H10 to ME60 is characterized by acoustically quiet salt deposits; this interval is not present at the proposed location. The seismic character below Horizon H10 more closely resembles the interval found elsewhere between ME60 and ME50, 2,610 m below the sea surface (945 m below the seafloor), which is characterized by a number of higher amplitude reflectors correlating with approximately 2-m thick claystone interbeds at the Tamar-1 and Tamar-2 wells. Minor drilling fluid circulation and wellbore stability problems are possible at the level of the claystone interbeds.

A vertical borehole may intersect two faults within this interval, at 2,070 and 2,207 m below the sea surface (405 and 542 m below the seafloor). The upper fault is well-defined in the clastic section above Horizon H10, and the inferred intersection with the wellbore is a projection to depth. The lower fault is not as well defined, and is projected into the time data from an interpretation of the depth image. Drilling caution is advised due to the presence of faults and claystone interbeds. Minor drilling fluid circulation and wellbore stability problems are possible at the level of the faults.

Unit B Lower is a section of predominantly anhydrite and halite with occasional claystone interbeds from ME50 to Horizon H20, 2,610 to 3,581 m below the sea surface (945 to 1,916 m below the seafloor).

In the interval ME40 to ME30, from 2,912 to 3,086 m below the sea surface (1,247 to 1,421 m below the seafloor), is a section of anhydrite and halite with the potential for multiple claystone interbeds. Minor drilling fluid circulation and wellbore stability problems are possible throughout this interval.

The interval between ME30 and ME20, from 3,086 to 3,386 m below the sea surface (1,421 to 1,721 m below the seafloor), presents a transparent section and is expected to consist of anhydrite and halite.

The interval from ME20 to Horizon H20 is interpreted as anhydrite and halite with an approximately 2-m claystone interbed near 3,386 m below the sea surface (1,721 m below the seafloor). Minor drilling fluid circulation and wellbore stability problems are possible at the claystone interbed level.

Horizon H20 marks the base of this unit at 3,581 m below the sea surface (1,916 m below the seafloor), and it marks the depth limit of this evaluation.

1.2.1.2 Tamar-8

Information on the geological, seismic, and sediment characteristics of the Tamar-8 well are discussed in the Well Clearance Letter prepared by Gardline Surveys Inc. (2013b); excerpts from the report are provided in this section. The report addresses seafloor and shallow geologic conditions that may impact exploratory drilling operations within 500 m of the proposed well location. The depth limit of this geohazard assessment is Horizon H20 (3,563 m below the sea surface; 1,893 m below the seafloor).

Seafloor depth at the proposed Tamar-8 well location is 1,670 m below the sea surface. The seafloor slopes less than 0.4° and is essentially horizontal. The seafloor at the proposed Tamar-8 well location is on a featureless, undulating abyssal plain 1.0 km east of a meandering channel and 1.6 km southwest of a low-relief ridge.

A northeast-to-southwest trending seafloor strike-slip fault is located approximately 730 m southeast of the proposed location (**Figure 1-15**).

Seafloor sediments are expected to be composed of clays and silts, becoming firmer with depth. There are no anomalous seafloor amplitudes indicative of any fluid seep within 500 m of the proposed well location (**Figure 1-16**). No other seafloor features are observed within a 500-m radius that could affect well emplacement.

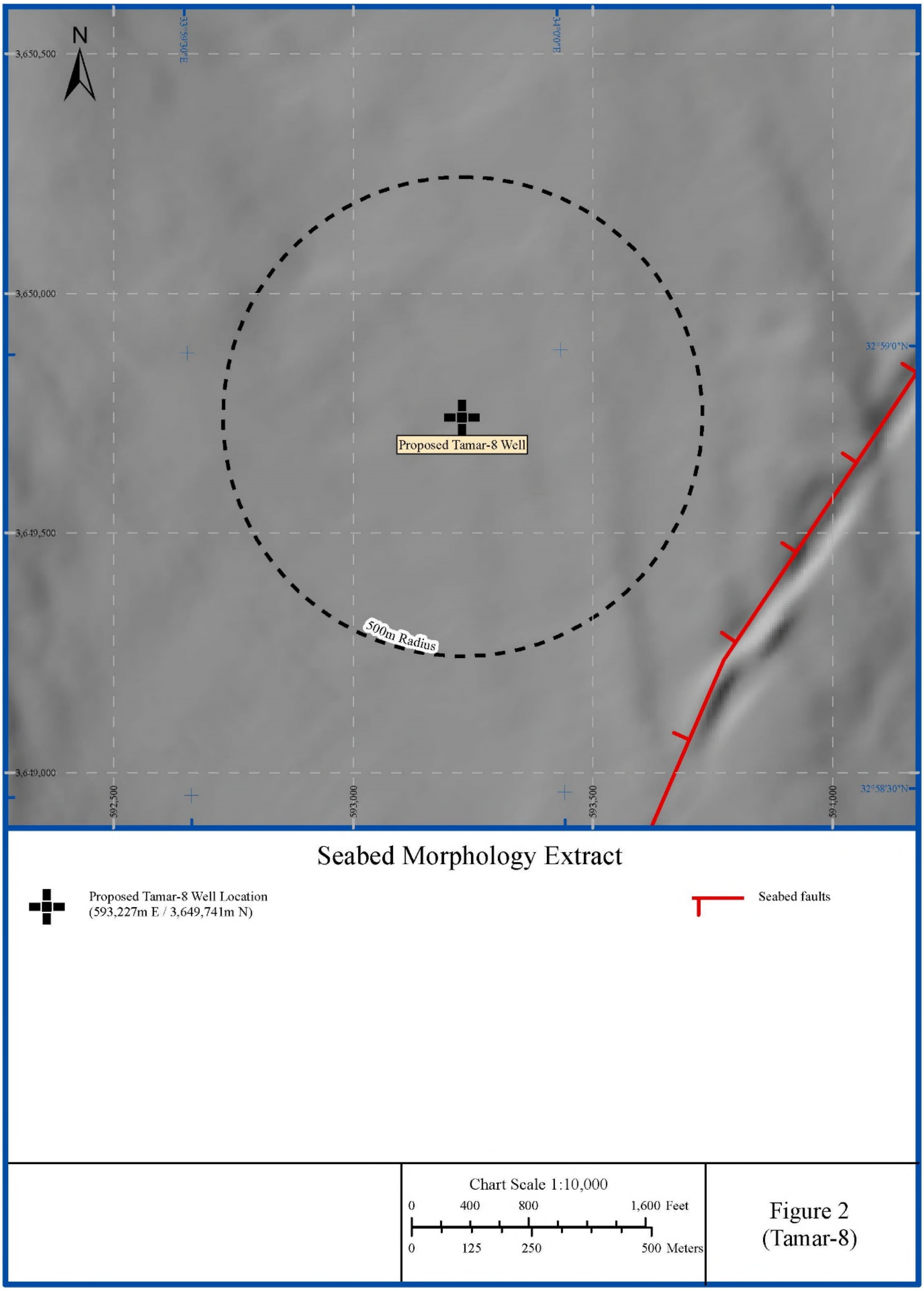


Figure 1-15. Tamar-8 seafloor morphology (From: Gardline Surveys Inc., 2013b).

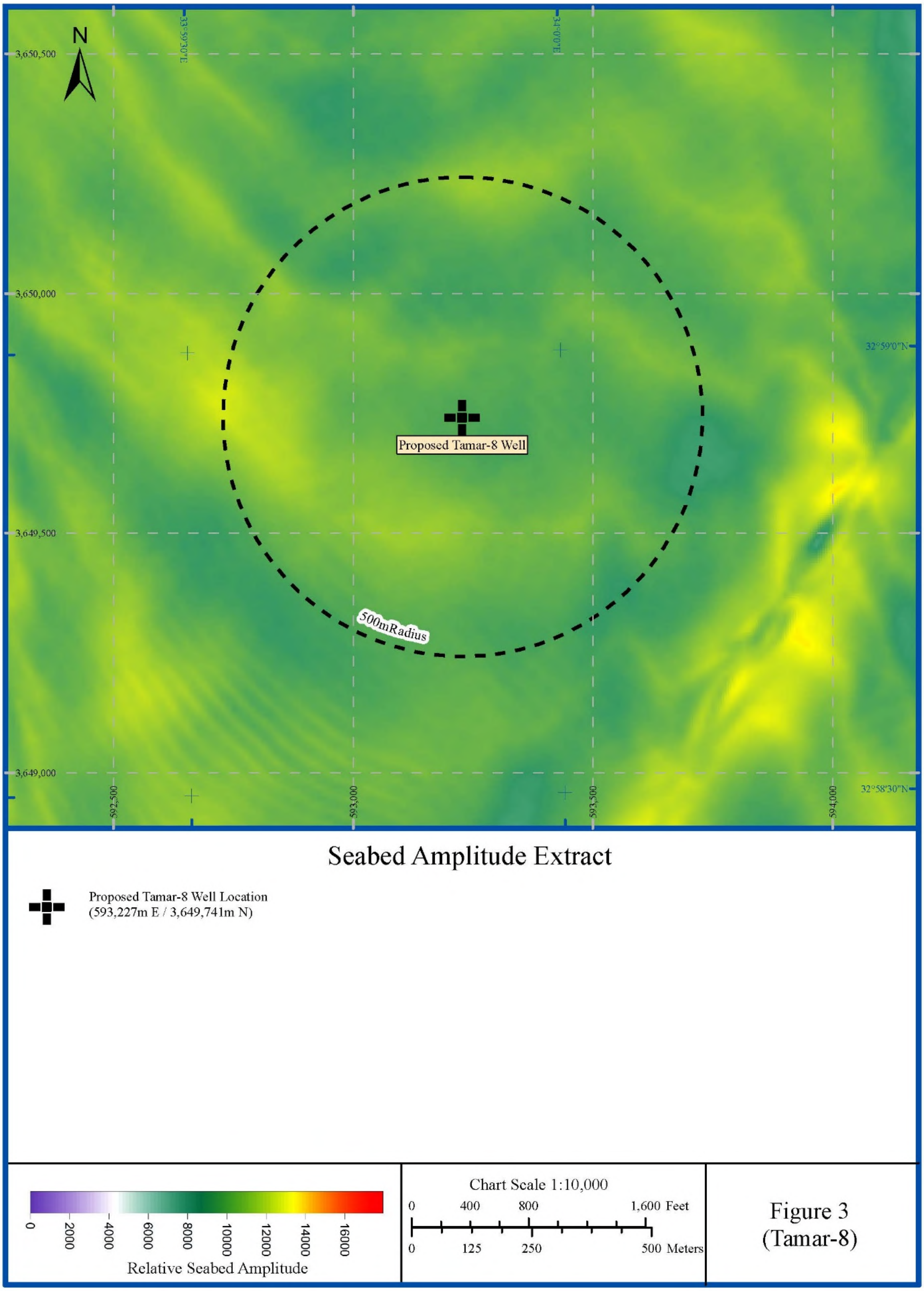


Figure 1-16. Tamar-8 seafloor amplitudes (From: Gardline Surveys Inc., 2013b).

The sedimentary sequence has been subdivided into two major units on the basis of the geology at the proposed well location: 1) the clastic section of Unit A; and 2) the salt sequence of Unit B (**Figures 1-17** to **1-20**). Unit B was further subdivided into upper and lower units, B Upper and B Lower. An intermediate horizon, H15, was mapped in between the intermittent clastic interbed markers of ME40 and ME50.

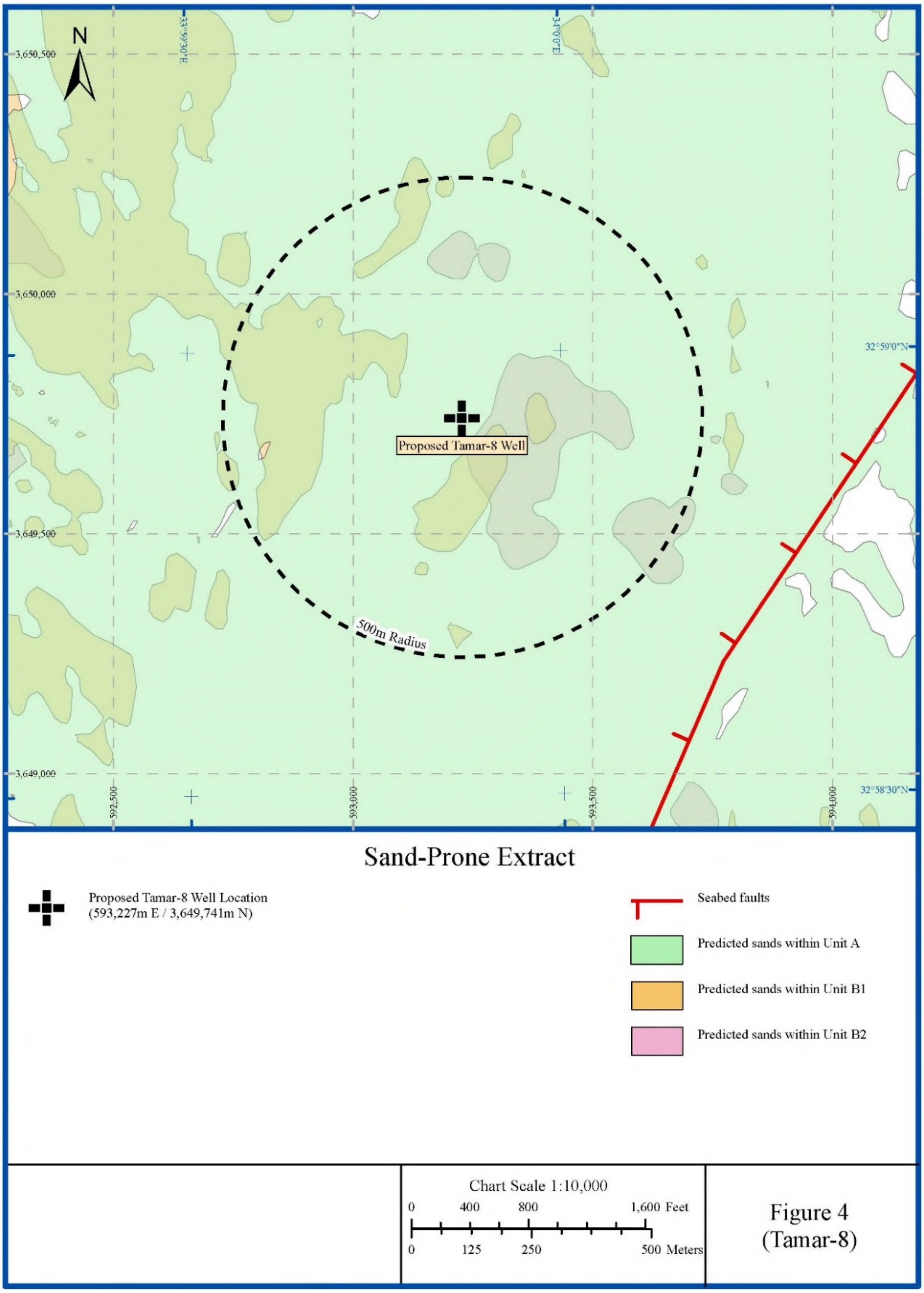


Figure 1-17. Tamar-8 sand-prone figure (From: Gardline Surveys Inc., 2013b).

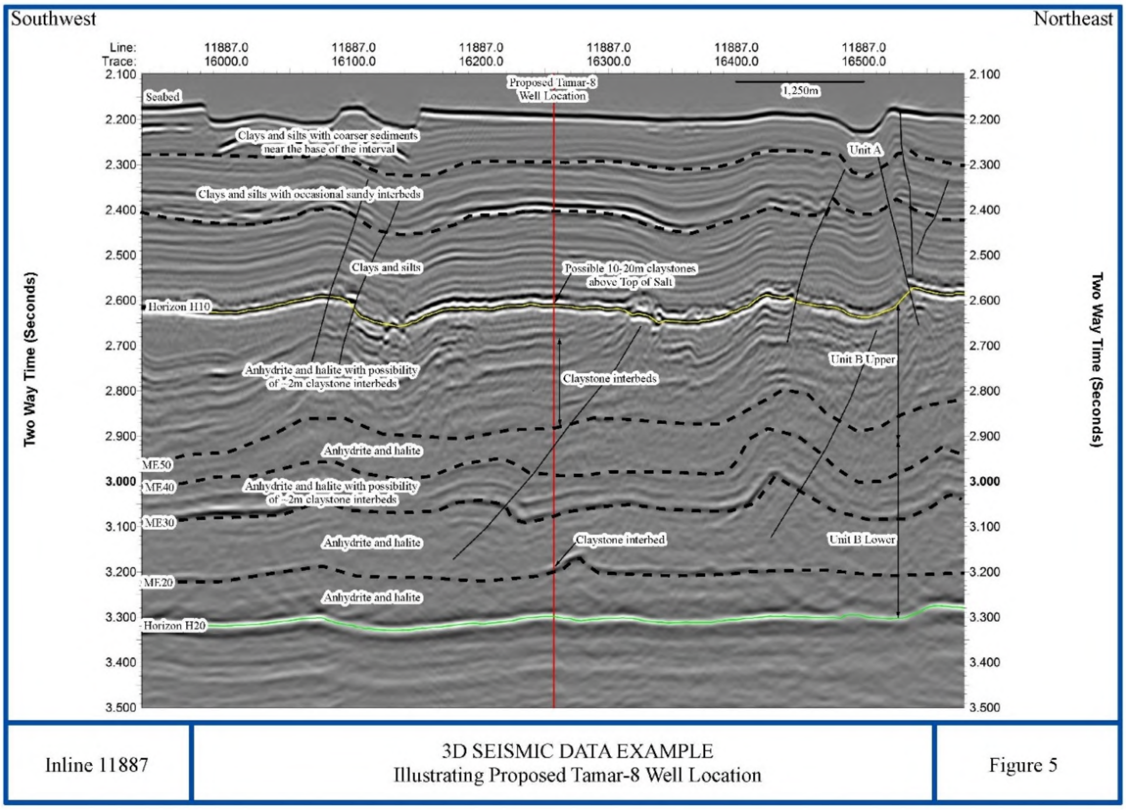


Figure 1-18. Tamar-8 seismic data example from Inline 11887 (From: Gardline Surveys Inc., 2013b).

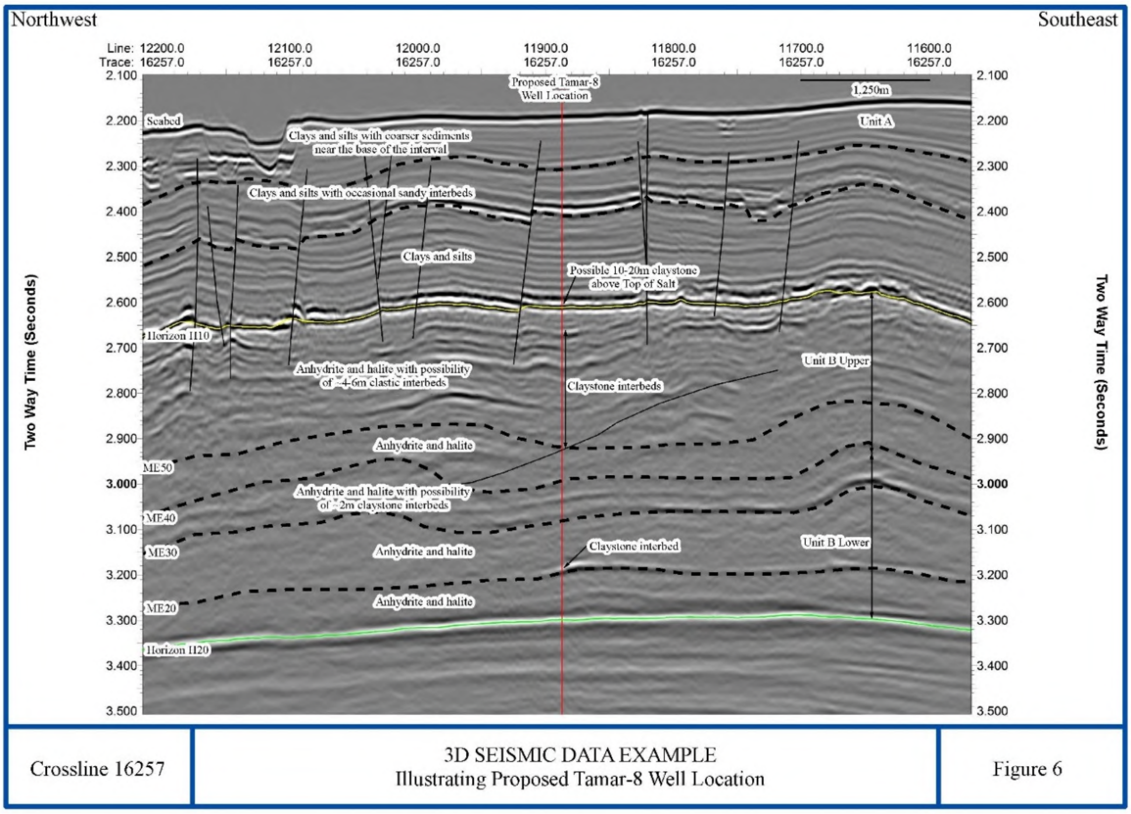


Figure 1-19. Tamar-8 seismic data example from Crossline 16257 (From: Gardline Surveys Inc., 2013b).

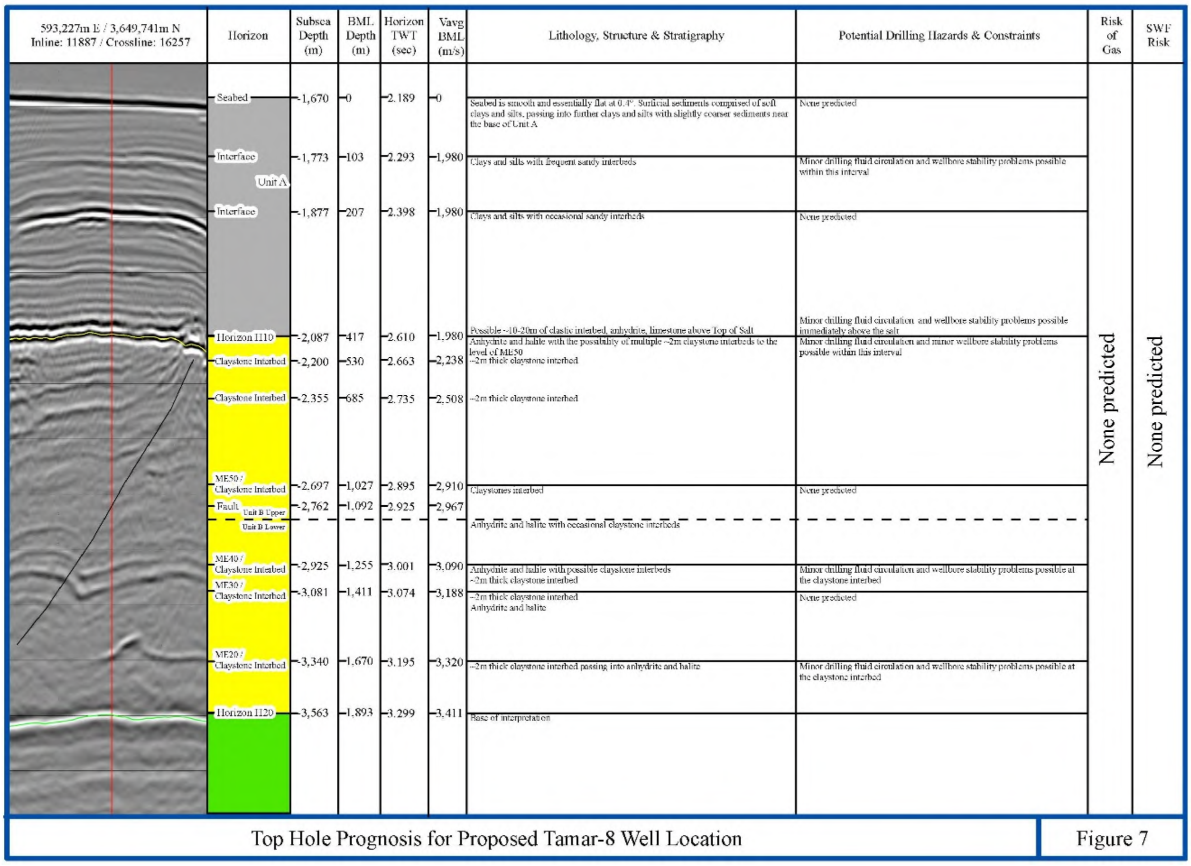


Figure 1-20. Tamar-8 top hole prognosis (From: Gardline Surveys Inc., 2013b).

The seafloor and sediments within Unit A are expected to consist of clays and silts, with intermittent sand interbeds and lenses. Unit A is bounded at its base by an irregular, complex reflector (Horizon H10) that marks the top of Messinian evaporites at 2,087 m below the sea surface (417 m below the seafloor). The unit has an average thickness of 450 m and thickens to the southeast. It is generally thinner along the axes of the seafloor ridges.

From the seafloor to 1,773 m below the sea surface (103 m below the seafloor), the three-dimensional (3D) seismic data indicates a uniform, low amplitude character. No sandy interbeds or hard grounds are expected in this interval. Sediments appear favorable for jetting of seafloor casing.

In the interval between 1,773 and 1,877 m below the sea surface (103 and 207 m below the seafloor), higher energy sediments are interpreted as clays and silts with frequent sandy interbeds and lenses. Given the possibility for the presence of minor sands within this interval, minor drilling fluid circulation and wellbore stability problems are considered possible.

The lower interval within Unit A, from 1,877 to 2,087 m below the sea surface (207 to 417 m below the seafloor), is interpreted as clays and silts; however, immediately above the top of salt at 2,087 m below the sea surface (417 m below the seafloor) there is the possibility of encountering 10 to 20 m of clastic interbeds, anhydrite, or limestone. These may induce some minor drilling fluid circulation and wellbore stability problems.

There is no risk of gas at the proposed location within Unit A.

Horizon H10 marks the base of this unit at 2,087 m below the sea surface (417 m below the seafloor).

Unit B consists of discontinuous to transparent, low amplitude seismic reflectors that are locally interbedded with semi-continuous moderate amplitude reflectors. Unit B represents thick deposits of evaporites that were deposited over the former abyssal plain during the Messinian Salinity Crisis (Druckman et al., 1995), with occasional clastic interbeds in the lower intervals of the unit. The clastic interbeds within this unit represent sediments deposited during flood events, and probably are composed predominantly of clays and silts, with the possibility of some coarser interbeds. According to Druckman et al. (1995), the sediments of Unit B consist of thin areas of compacted nodular halite and anhydrite interbedded with medium to dark gray and moderately firm claystones, limestones, and sandstones.

Based on structural models of top Messinian salt and base Messinian salt, it is clear that the topography of these two layers have little similarity. This indicates that sediments above base Messinian salt were mobilized. One theory suggests that local earthquakes could have generated local overpressures and triggered sediment mobilization (Frey-Mart et al., 2007).

For the purpose of geohazard identification, Unit B has been separated into Unit B Upper and Unit B Lower. An intermediate horizon (H15) was mapped in the interval between the interfaces identified as ME50 and ME40. The purpose of this division is to enable mapping of the zones of mechanical weakness, the claystone interbeds, and within the upper and lower salt sequence (**Figure 1-17**).

Within Unit B Upper in the larger Levantine Basin, the uppermost interval of the evaporite sequence from Horizon H10 to ME60 is characterized by acoustically quiet salt deposits; this interval is not present at the proposed location. The seismic character below Horizon H10 more closely resembles the interval found elsewhere between ME60 and ME50, 2,697 m below the sea surface (1,027 m below the seafloor), which is characterized by a number of higher amplitude reflectors, which correlate with approximately 2-m thick claystone interbeds at the Tamar-1 and Tamar-2 wells. Minor drilling fluid circulation and wellbore stability problems are possible at the level of the claystone interbeds in this interval.

A vertical borehole may intersect a fault at 2,762 m below the sea surface (1,092 m below the seafloor). The fault is ill-defined and is projected into the time data from an interpretation from the depth image. This fault occurs in a relatively clean section of salt and is most likely healed. No drilling fluid circulation problems are anticipated at the fault level.

Unit B Lower is predominantly anhydrite and halite with occasional claystone interbeds from below ME50 to Horizon H20, 2,697 to 3,563 m below the sea surface (1,027 to 1,893 m below the seafloor).

In the interval ME40 to ME30, from 2,925 to 3,081 m below the sea surface (1,255 to 1,411 m below the seafloor), is a section of anhydrite and halite with the possibility of multiple claystone interbeds. Minor drilling fluid circulation and wellbore stability problems are possible throughout this interval.

The interval between ME30 and ME20, from 3,081 to 3,340 m below the sea surface (1,411 to 1,670 m below the seafloor), presents a transparent section and is expected to consist of anhydrite and halite.

The interval between ME20 and Horizon H20 is interpreted as anhydrite and halite with the possibility of an approximately 2-m claystone interbed near 3,340 m below the sea surface (1,670 m below the seafloor). Minor drilling fluid circulation and wellbore stability problems are possible at the level of the claystone interbed.

1.2.1.3 Tamar-9

Information on the geological, seismic, and sediment characteristics of the Tamar-9 well are discussed in the Well Clearance Letter prepared by Gardline Surveys Inc. (2014); excerpts from the report are provided in this section. The report addresses seafloor and shallow geologic conditions that may impact exploratory drilling operations within 500 m of the proposed well location. The depth limit of the geohazard assessment was Horizon H20 (3,571 m below the sea surface; 1,869 m below the seafloor).

Seafloor depth at the proposed Tamar-9 well location is 1,690 m below the sea surface. The seafloor slopes less than 0.4° and is essentially flat. The seafloor at the proposed Tamar-9 well location is on a featureless, undulating abyssal plain. Seafloor sediments are expected to be composed of clays and silts, becoming firmer with depth.

A northeast-to-southwest trending seafloor strike-slip fault is located approximately 680 m southeast of the proposed location (**Figure 1-21**). There are no anomalous seafloor amplitudes indicative of any fluid seep within 500 m of the proposed well location (**Figure 1-22**). No other seafloor features were observed within a 500-m radius that could affect well emplacement.

The sedimentary sequence has been subdivided into two major units on the basis of the geology at the proposed well location: 1) the clastic section of Unit A; and 2) the salt sequence of Unit B (**Figures 1-23** through **1-26**). Unit B was further subdivided into upper and lower units, B Upper and B Lower. An intermediate horizon, H15, was mapped in between the intermittent clastic interbed markers of ME40 and ME50.

The seafloor and sediments within Unit A are expected to consist of clays and silts, with intermittent sand interbeds and lenses. Unit A is bounded at its base by an irregular, complex reflector (Horizon H10) that marks the top of Messinian evaporates at 2,085 m below the sea surface (395 m below the seafloor). The unit has an average thickness of 450 m and thickens to the southeast. It generally is thinner along the axis of the seafloor ridges.

In the first 75 m, 3D seismic data indicated a uniform, low amplitude character. No sandy interbeds or hard grounds are expected in this section. Sediments appear favorable to jetting of seafloor casing. Between 1,765 and 1,906 m below the sea surface (75 and 216 m below the seafloor), the lithology is composed of higher-energy sediments that are interpreted as clays and silts with frequent sandy interbeds and lenses.

The lower interval within Unit A, from 1,906 to 2,085 m below the sea surface (216 to 395 m below the seafloor), is interpreted as clays and silts; however, immediately above the top of salt at 2,085 m below the sea surface (395 m below the seafloor), there is the possibility of encountering 10 to 20 m of clastic interbeds, anhydrite, or limestone. These may induce some minor drilling fluid circulation and wellbore stability problems.

There is no risk of gas to the proposed location within Unit A.

Horizon H10 marks the base of this unit at 2,085 m below the sea surface (395 m below the seafloor).

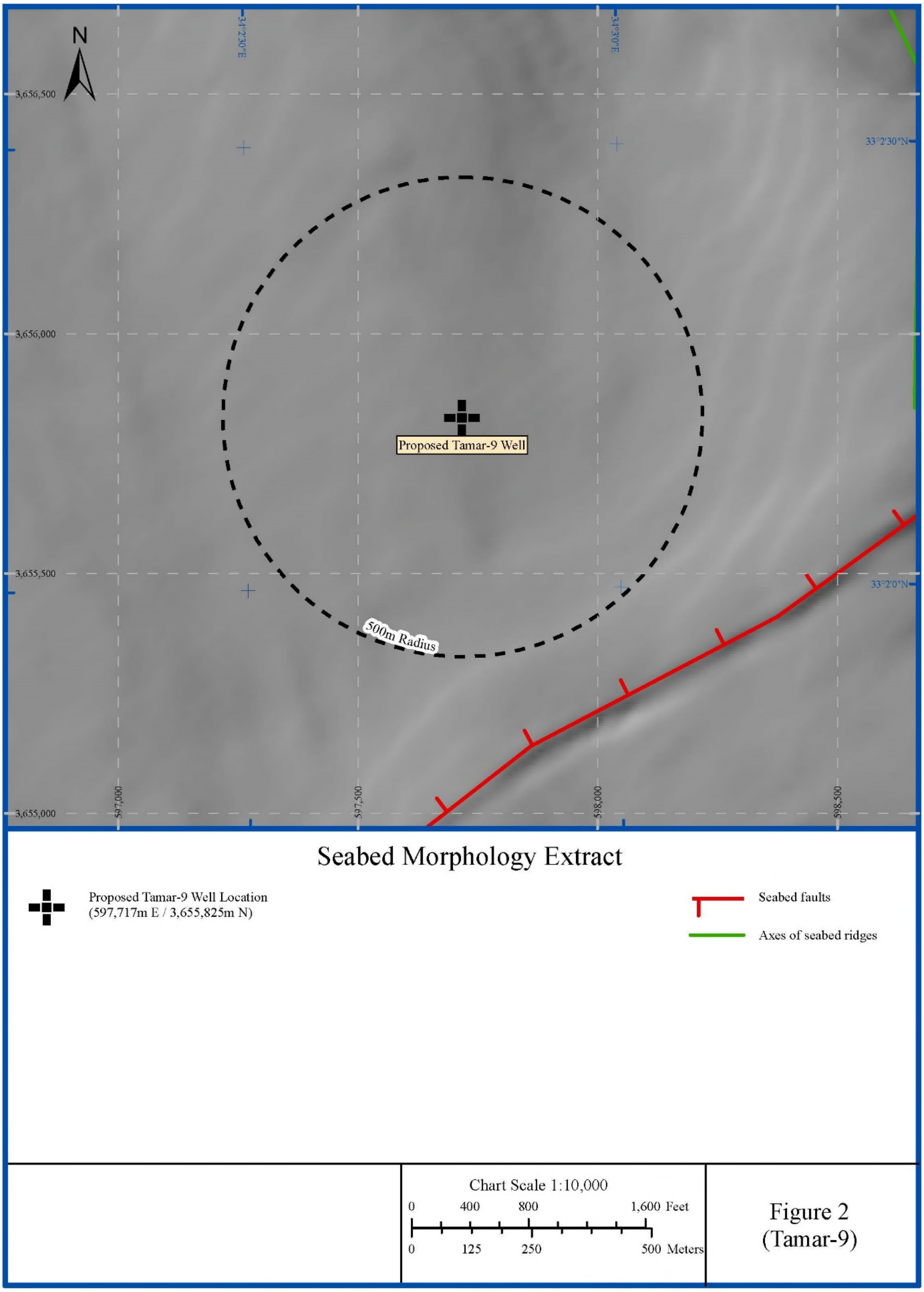


Figure 1-21. Tamar-9 seafloor morphology (From: Gardline Surveys Inc., 2014).

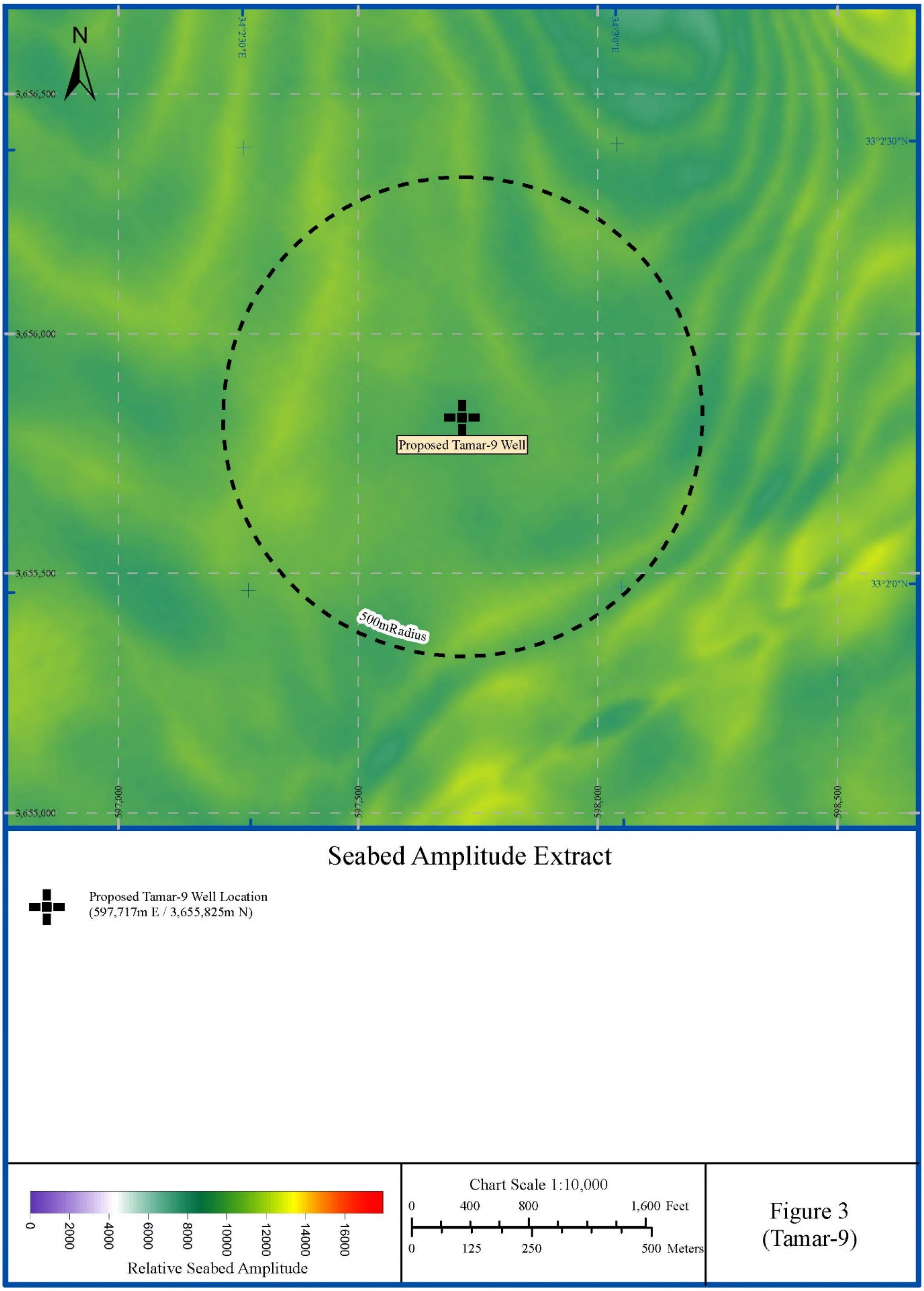


Figure 1-22. Tamar-9 seafloor amplitudes (From: Gardline Surveys Inc., 2014).

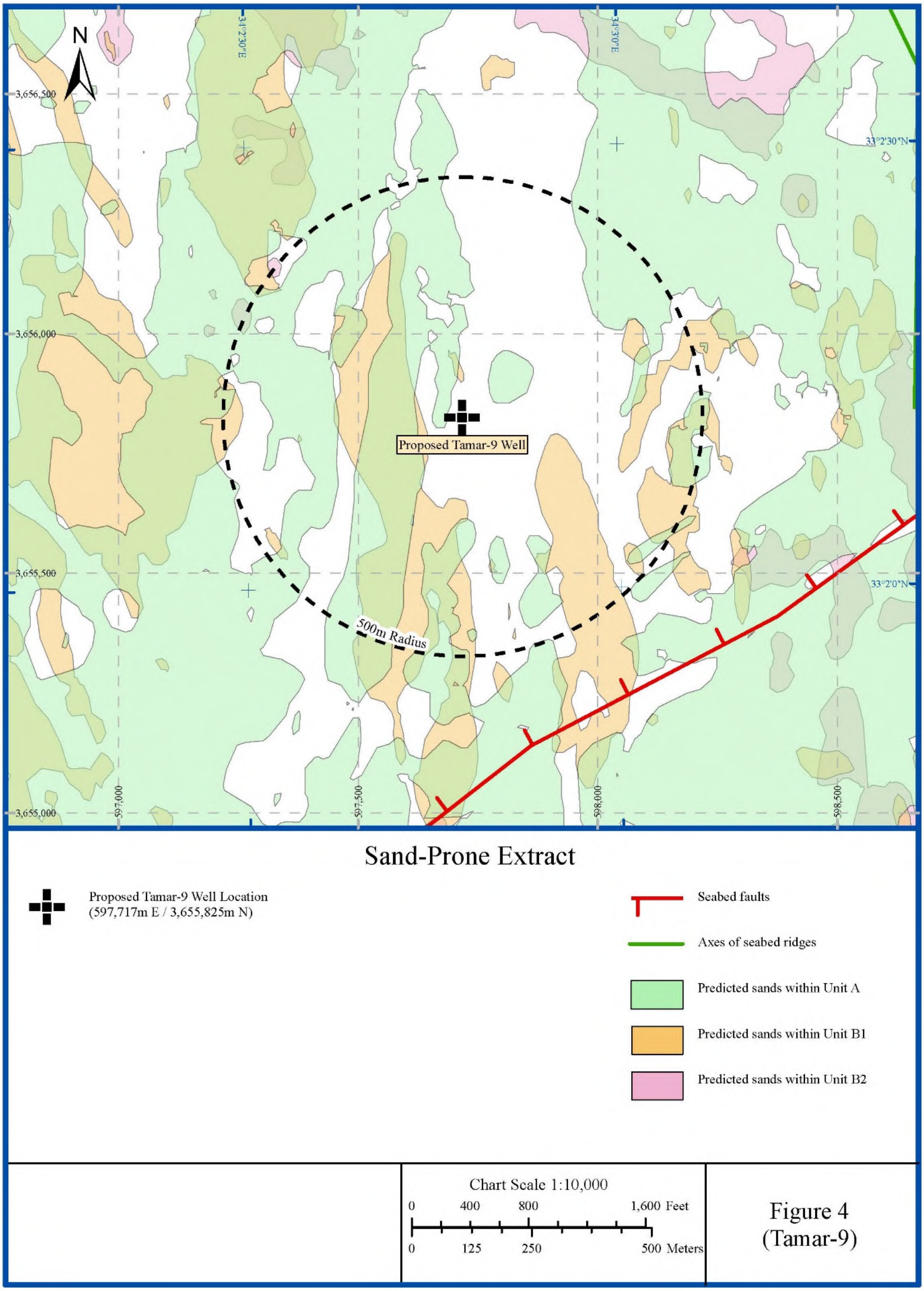


Figure 1-23. Tamar-9 sand-prone figure (From: Gardline Surveys Inc., 2014).

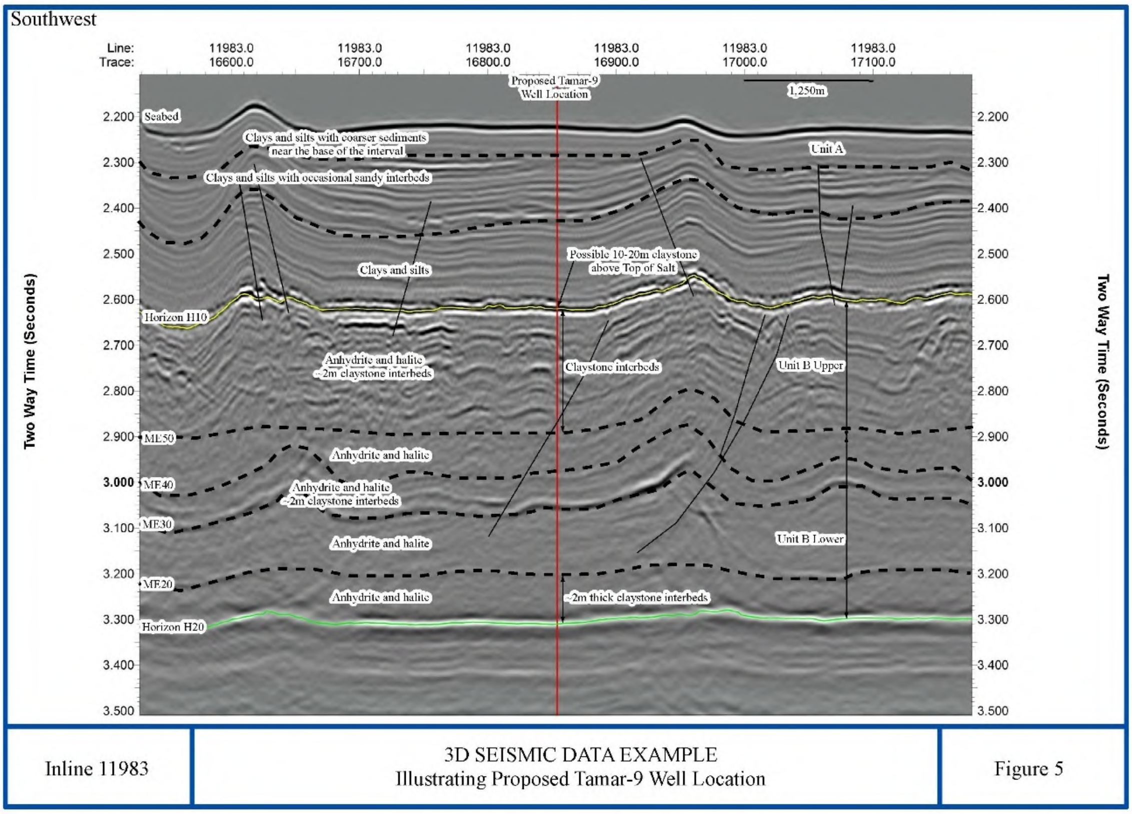


Figure 1-24. Tamar-9 seismic data example from Inline 11983 (From: Gardline Surveys Inc., 2014).

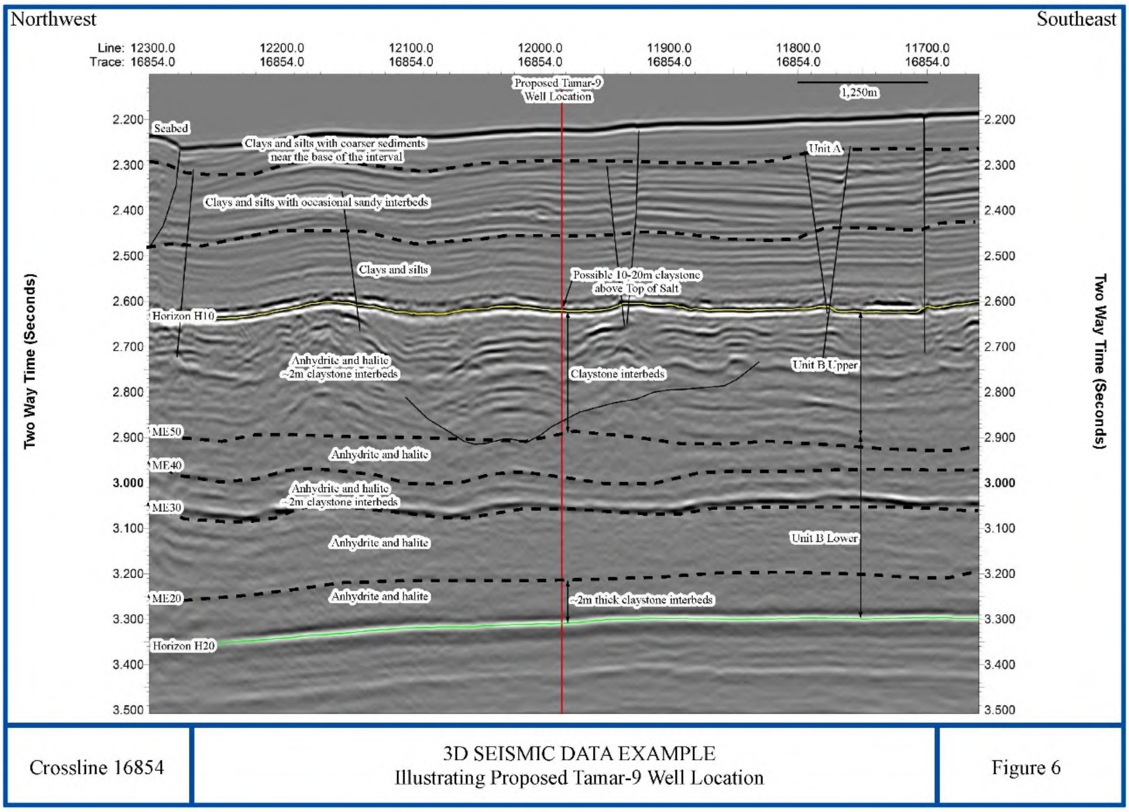


Figure 1-25. Tamar-9 seismic data example from Crossline 16854 (From: Gardline Surveys Inc., 2014).

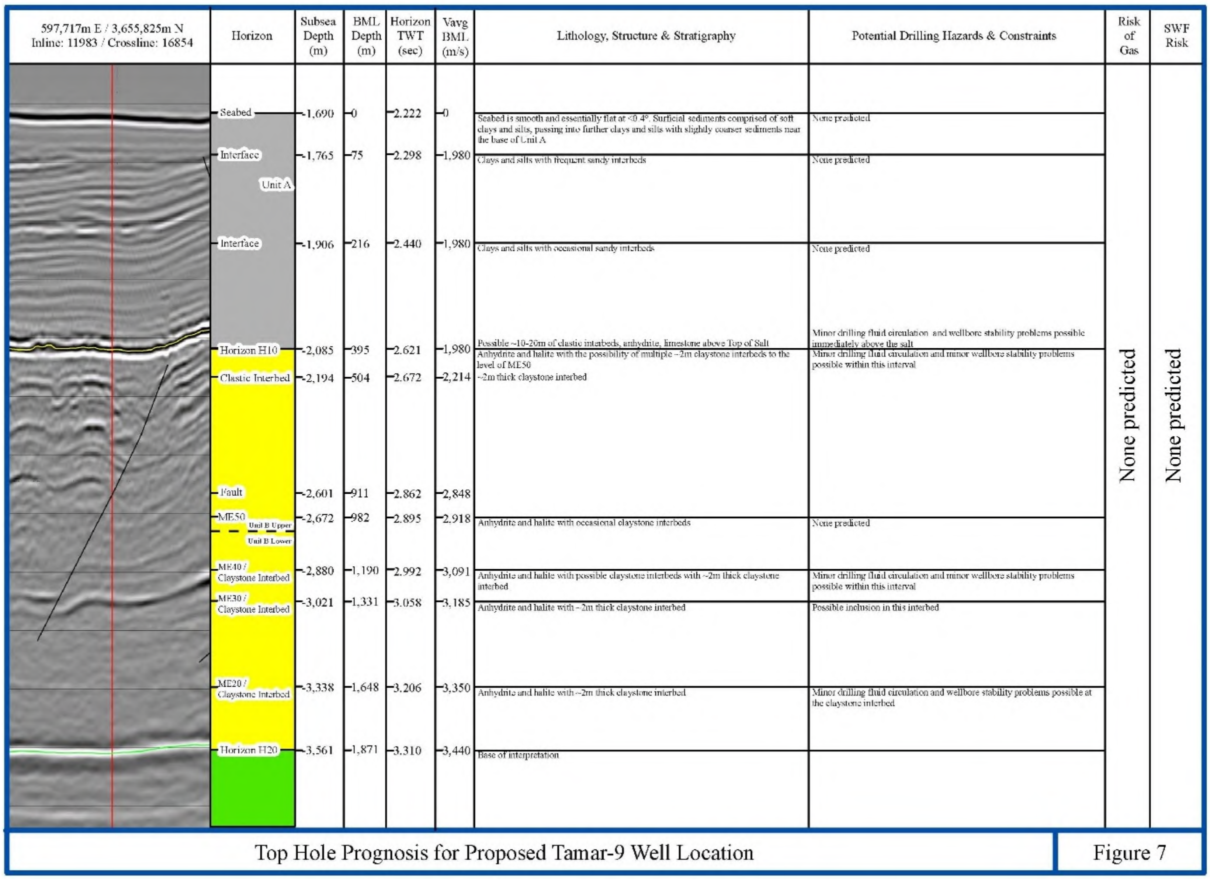


Figure 1-26. Tamar-9 top hole prognosis (From: Gardline Surveys Inc., 2014).

Unit B consists of discontinuous to transparent, low amplitude seismic reflectors that are locally interbedded with semi-continuous moderate amplitude reflectors. Unit B represents thick deposits of evaporites that were deposited over the former abyssal plain during the Messinian Salinity Crisis (Druckman et al., 1995), with occasional clastic interbeds in the lower part of the unit. The clastic interbeds within the unit represent sediments deposited during flood events, and probably are composed predominantly of clays and silts, with the possibility of some coarser interbeds. According to Druckman et al. (1995), the sediments of Unit B consist of thin areas of compacted nodular halite and anhydrite interbedded with medium to dark gray and moderately firm claystones, limestones, and sandstones.

Based on structural models of top Messinian salt and base Messinian salt, it is clear that the topography of these two layers have little similarity. This indicates that sediments above base Messinian salt were mobilized. One theory suggests that local earthquakes could have generated local overpressures and triggered sediment mobilization (Frey-Mart et al., 2007).

For the purpose of geohazard identification, Unit B has been separated into Unit B Upper and Unit B Lower. An intermediate horizon (H15) was mapped in the interval between the interfaces identified as ME50 and ME40. The purpose of this division is to enable mapping of the extent of the zones of mechanical weakness, the claystone interbeds, and within the upper and lower salt sequence (**Figure 1-23**).

Within Unit B Upper in the larger Levantine Basin, the uppermost interval of the evaporite sequence from Horizon H10 to ME60 is characterized by acoustically quiet salt deposits; this interval is not present at the proposed location. The seismic character below Horizon H10 more closely resembles the interval found elsewhere between ME60 and ME50, 2,672 m below the sea surface (982 m below the seafloor), which is characterized by a number of higher amplitude reflectors, correlating with approximately 2-m thick claystone interbeds at the Tamar-1 and Tamar-2 wells. An approximately 2-m thick claystone interbed was identified at 2,194 m below the sea surface (504 m below the seafloor). Minor drilling fluid circulation and wellbore stability problems are possible at the level of the claystone interbeds in this interval.

A vertical borehole may intersect a fault at 2,601 m below the sea surface (911 m below the seafloor) near the base of the ME60-ME50 complex. The fault is ill-defined and projected into the time data from an interpretation from the depth image. The fault occurs in a relatively clean section of salt and is most likely healed. No drilling fluid circulation problems are anticipated at the fault level.

Unit B Lower from the intermediate horizon (H15) to ME40, 2,880 m below the sea surface (1,190 m below the seafloor), is interpreted as predominantly consisting of anhydrite and halite with possible claystone interbeds.

Between ME40 to ME30, from 2,880 to 3,021 m below the sea surface (1,190 to 1,331 m below the seafloor), the lithology consists of anhydrite and halite, with the possibility of multiple claystone interbeds. Minor drilling fluid circulation and wellbore stability problems are possible throughout this interval.

The interval between ME30 and ME20, from 3,021 to 3,338 m below the sea surface (1,331 to 1,648 m below the seafloor), presents a transparent section expected to consist of anhydrite and halite.

The interval between ME20 to Horizon H20 is interpreted as anhydrite and halite with the possibility of an approximately 2-m claystone interbed near 3,338 m below the sea surface (1,648 m below the seafloor). Minor drilling fluid circulation and wellbore stability problems are possible.

Horizon H20 marks the base of this unit at 3,561 m below the sea surface (1,871 m below the seafloor) as well as the depth limit of this evaluation.

1.2.1.4 Regional Information

The Eastern Mediterranean region has been shaped by the interactions of the African, Arabian, and Eurasian tectonic plates since the Permo-Triassic Period. The present 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 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 as follows:

Levant Margin: All available information relating to the nature of the Levant Margin comes from its southern portion through the work carried out for on-land and offshore exploration in Israel. Garfunkel (2004) proposed that north-trending normal faults with large throws to the west, 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 of the Levantine Basin instead of oceanic crust as proposed by Makris et al. (1983).

Levantine Basin: The work of Garfunkel (2004) and Abdel Aal et al. (2001) 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 with an age range from the Late Permian to Recent. Their evolutionary model suggests 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 being mostly shales and distal turbidites (sheet sands).

Nile Cone: The Nile Cone is chiefly a post-Upper Miocene sedimentary wedge that covers a much older marginal basin sequence. Together, they have a thickness of 9 to 10 km, including 1.5 km of Messinian evaporites (Mascle et al., 2006). These post-Messinian sediments, supplied by the Nile River, have undergone significant thin-skin deformation due to downslope movement along slip-surfaces in the underlying evaporites.

Messinian Salinity Crisis: The Messinian Salinity Crisis, when the Mediterranean Sea went through a cycle of partial desiccation, is one of the most unusual oceanic events in the last 20 million years. The result of this unique event was significant deposition of sediments that formed a perfect seal to any hydrocarbons present offshore. The evaporite sediments were first discovered by Hsü et al. (1973). Their formation is attributed to the periodic restriction of seawater inflow from the Atlantic, leading to hypersalinity and deposition of gypsum in shallower basins and halite in deeper basins. The Mediterranean Sea did not dry completely, but sea level dropped by as much as 1,500 m at times. This fall led to dramatic erosion, with the formation of large canyons and deposition of coarse sediments that make good 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 Disturbance (**Figure 1-27**). The disturbed areas where mass slumping has occurred are in a zone of diapirs (e.g., vertically upward geological movement) and associated with Messinian drainage systems such as offshore canyons. These canyons act as conduits for transporting materials from the shelf into the basin developed and were incised onto the Levant continental slope during the Oligocene and Miocene on through the Messinian and are partly reflected in the present day submarine features (Gardosh et al., 2008).

1.2.1.5 Seismic Activity

There is very little information available regarding seismic sea waves. Ambrasseys (1962) conducted a survey of reported sea waves from Antiquity to 1961 and came to the conclusion 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 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 tsunami evidence 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).

The primary sources of tsunamis are earthquakes and offshore landslides. Salamon et al. (2007) constructed a list of 21 reliably reported tsunamis that have struck the Levant coast, along with 57 moderate-to-large earthquakes that have occurred along the Dead Sea Transform (DST) system (geological fault between the Arabian and African tectonic plates), since about the mid-second century B.C.E. Ten of the tsunamis were triggered by earthquakes that originated along the DST system, six of which followed moderate earthquakes and four that followed large earthquakes. These observations indicate that approximately 14% of the moderate and 27% of the large DST earthquakes were tsunamigenic.

Geological fault zones, locations of historical earthquakes, and regional bathymetric contours relative to the Tamar Field are shown in **Figure 1-28**. There has been one recorded earthquake within 25 km of the Tamar SW-1 drillsite since 1979; the magnitude of the earthquake was 4.0 on the Richter scale. There have been no strong (magnitude 5.6 or greater on the Richter scale) regional earthquakes recorded within 200 km of the Tamar SW-1 drillsite since 1983. The data suggest that historic earthquakes within the Tamar Field are extremely rare events; when they occur, their magnitude has been moderate to low (i.e., less than 5.6 on the Richter scale).

Salamon et al. (2007) estimated that the threshold of tsunamigenic DST earthquakes likely ranges in magnitude from 6 to 6.5. Meral Ozel et al. (2011) have reported on the tsunami hazard in the eastern Mediterranean and its connected seas, with an emphasis on Turkey. The number of tsunamis attributable to submarine landslides is poorly understood because there are virtually no direct observations of their occurrence. Even in cases where the evidence points to a landslide origin for the tsunami, there are usually no reliable estimates of their extent or the manner in which the movement took place (URS Corporation, 2009). Slump deposits associated with submarine landslides along the continental margin of Israel have been described by Martinez et al. (2005) using 3D seismic data. The high occurrence of slumping processes along the Israeli continental margin was possible because of a combination of seismic activity, presence of gas within the sediments, and relatively steep slopes (Martinez et al., 2005).

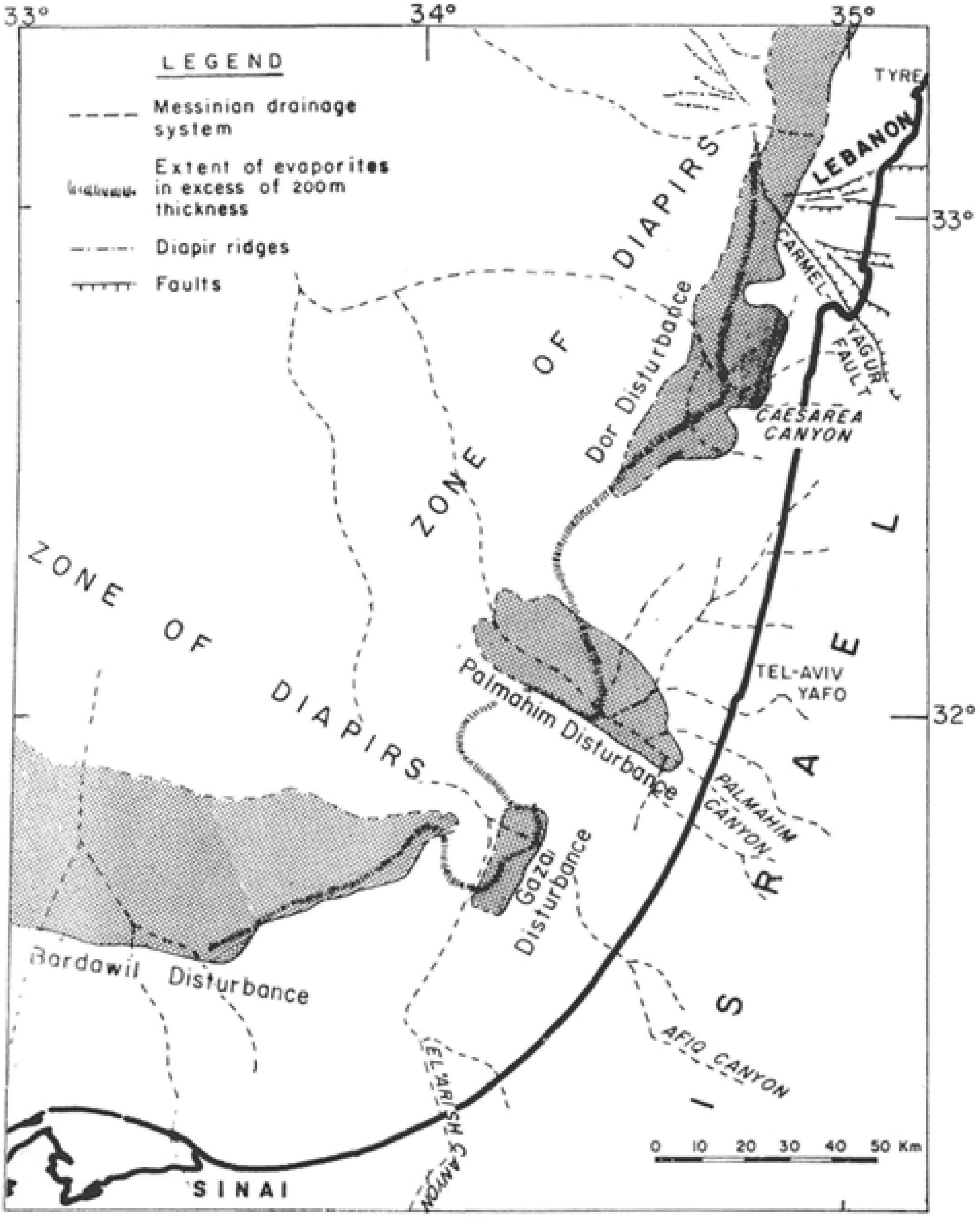


Figure 1-27. Seafloor areas of disturbance on the Mediterranean continental slope off the Israeli coast (From: Almagor and Hall, 1984).

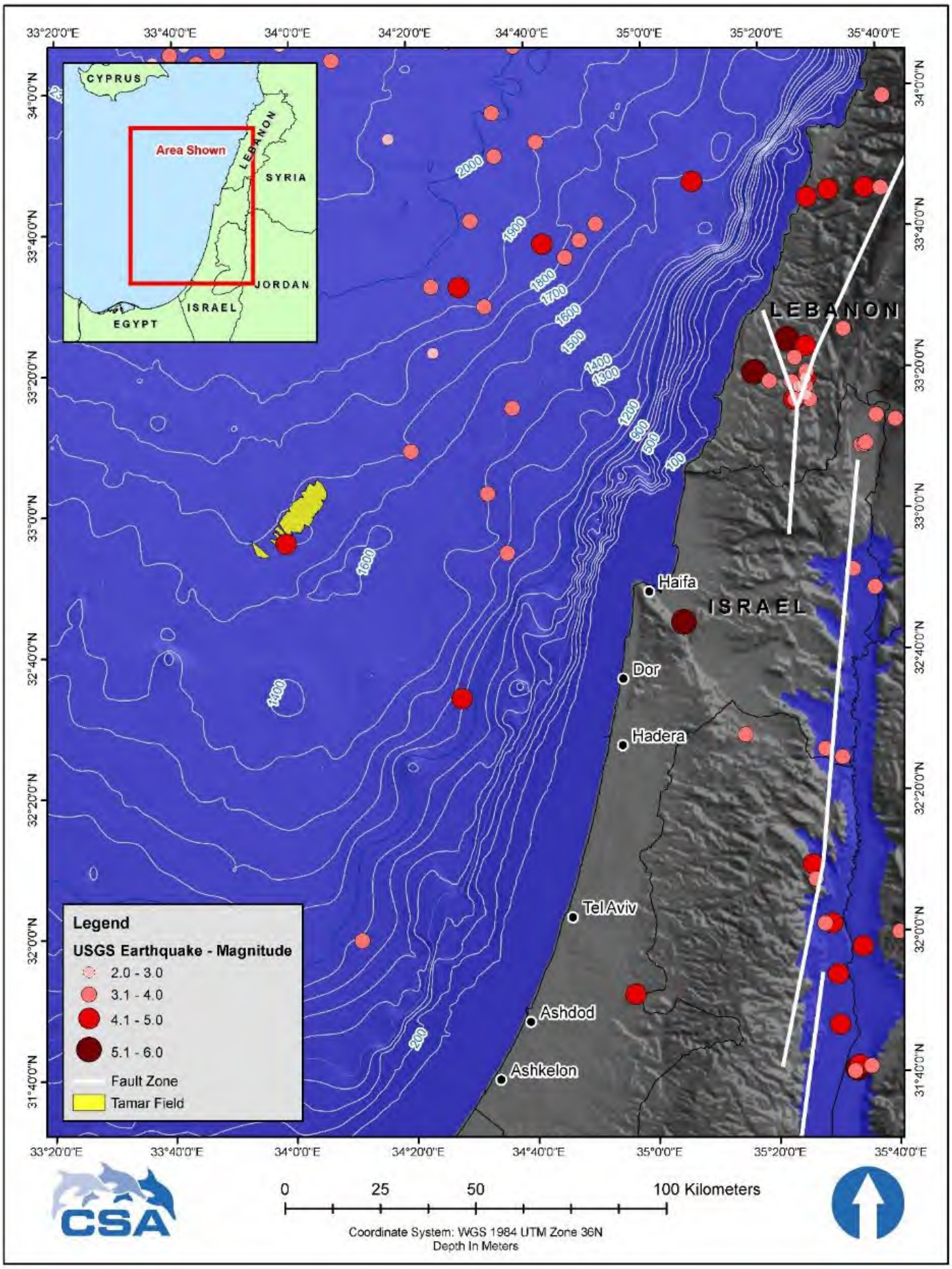


Figure 1-28. Geological fault zones, locations of historical earthquakes, and regional bathymetric contours relative to the Tamar Field. Earthquake data were provided by the U.S. Geological Survey (2014).

1.2.2 Physical Oceanography

Wind, waves, weather, oceanographic currents, and hydrographic profiles are presented in this section. Information on seawater and sediment quality is presented in **Section 1.2.4**.

1.2.2.1 Winds

There is no known wind data set representative of the Tamar Field. In the absence of an observed data set, wind data can be obtained from the output of a numerical atmospheric model. Data were assessed from the National Center for Environmental Predictions (NCEP) Environmental Modeling Center Regional Spectral Model provided by the U.S. National Oceanic and Atmospheric Administration – Cooperative Institute for Research in Environmental Studies (NOAA – CIRES) Climate Diagnostics Center (CDC) (http://www.cdc.noaa.gov).

Wind speed and direction data at a 10-m height from the NCEP model grid location closest to the Tamar Field (approximately 50 km north-northwest of the Tamar SW-1 well; closer to remaining Tamar wells) were obtained from the NOAA/CDC data server for the 10-year period from January 1999 to January 2009 as representative of the Tamar Field environs.

Figure 1-29 shows monthly and yearly wind roses developed from the NCEP model grid location. Based on the NCEP data set, the wind regime is characterized by predominant westerly winds throughout most of the year (January through October) and varied winds in November and December. Winds are generally moderate in speed, with average monthly speeds of approximately 5 m/s. Overall, strong seasonal variability is not evident in the wind data. Winter winds (December through February) have higher maximum speeds than the remainder of the year; however, average winds are relatively comparable throughout the year.

1.2.2.2 Waves

Table 1-2 presents significant wave height distribution for a point near the Cyprus Coastal Ocean Forecasting and Observing System (CYCOFOS) MedGoos-3 buoy (33°42' N, 32°08' E) from July 2005 to February 2008. This station is located approximately 200 km from the Tamar SW-1 wellsite. Nearly all of the waves are less than 1.5 m in height, and wave direction is nearly always due eastward at this location (mean of 116°T, standard deviation of 53°) because of the strong westerly winds. While wave height and direction vary daily across the Levantine Basin, the yearly statistics can be regarded as representative values spatially and temporally for the entire basin (**Figure 1-30**).

1.2.2.3 Weather

The Eastern Mediterranean region lies between the subtropics and mid-latitudes, and cyclones that develop in the area obtain significant energy from both baroclinicity and surface fluxes (Flocas et al., 2010, 2011). **Figure 1-31** shows the mean annual cycle of the number of storm tracks that pass through the Eastern Mediterranean region, based on an analysis of storm data for the period 1962 to 2001. Storm tracks are most numerous during the winter and spring months, from December to April. The occurrence of storms decreases during the warm period, with a tendency to increase again in September/October. According to Flocas et al. (2011), the maximum number of cyclonic tracks over the area is observed in January (11.2% of the annual total) and March (10.3%); the minimum number of tracks occurs in July (5.3%).

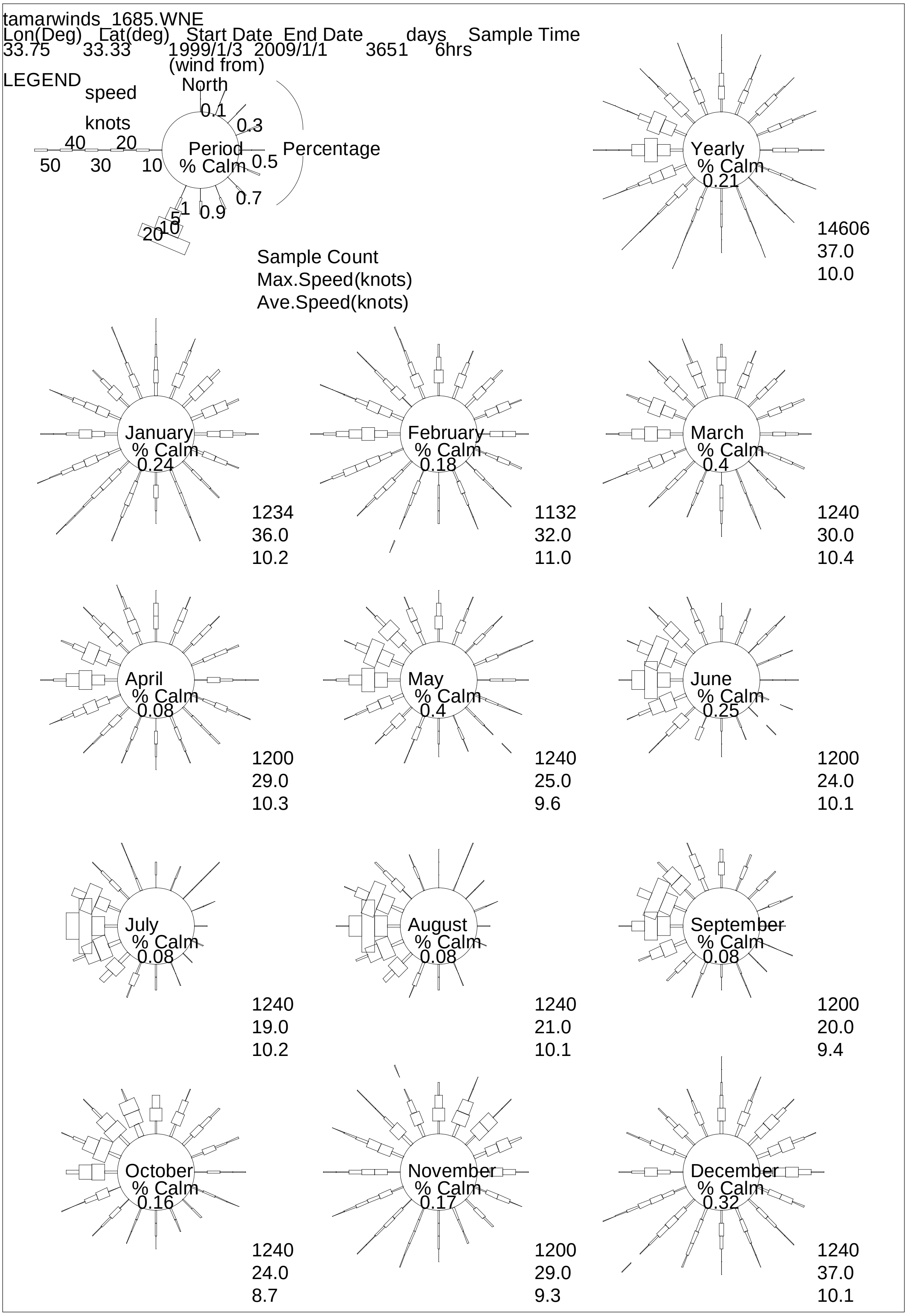


Figure 1-29. Monthly and yearly wind roses of National Center for Environmental Predictions Wind Station 1685, January 1999 through January 2009.

Table 1-2. Significant wave heights and their frequency of occurrence in the Levantine Basin during the period from July 2005 to February 2008.

Wave Height Range[a] (m)	Frequency (Occurrences over Period of Record)	Percentage (%)
0 to 0.2500	91	1.5230
0.5000	1,132	18.9456
0.7500	2,183	36.5356
1.0000	1,388	23.2301
1.2500	565	9.4561
1.5000	261	4.3682
1.7500	140	2.3431
2.0000	69	1.1548
2.2500	52	0.8703
2.5000	21	0.3515
2.7500	14	0.2343
3.0000	10	0.1674
3.2500	11	0.1841
3.5000	4	0.0669
3.7500	7	0.1172
4.0000	11	0.1841
4.2500	9	0.1506
4.5000	6	0.1004
4.7500	1	0.0167
Total	**5,975**	**100**

[a] Upper limit of bin.

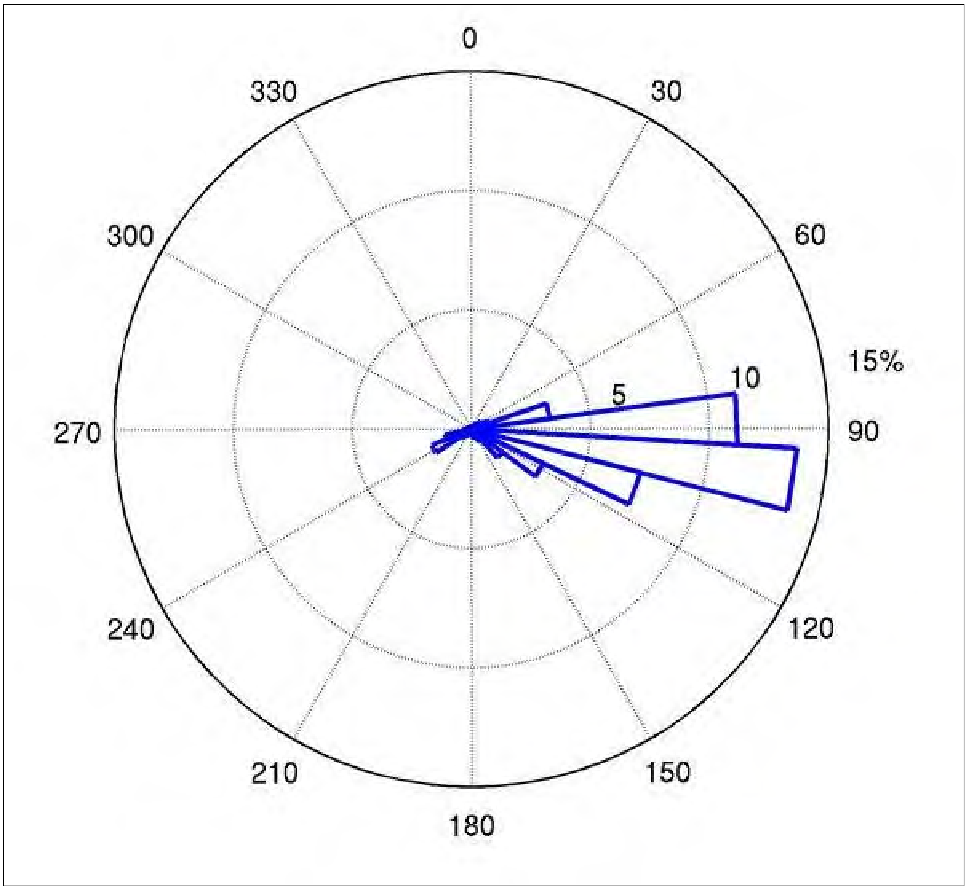


Figure 1-30. Rose diagram for annual frequency of wave direction per 10° sector across the Levantine Basin. Waves predominantly travel towards the east.

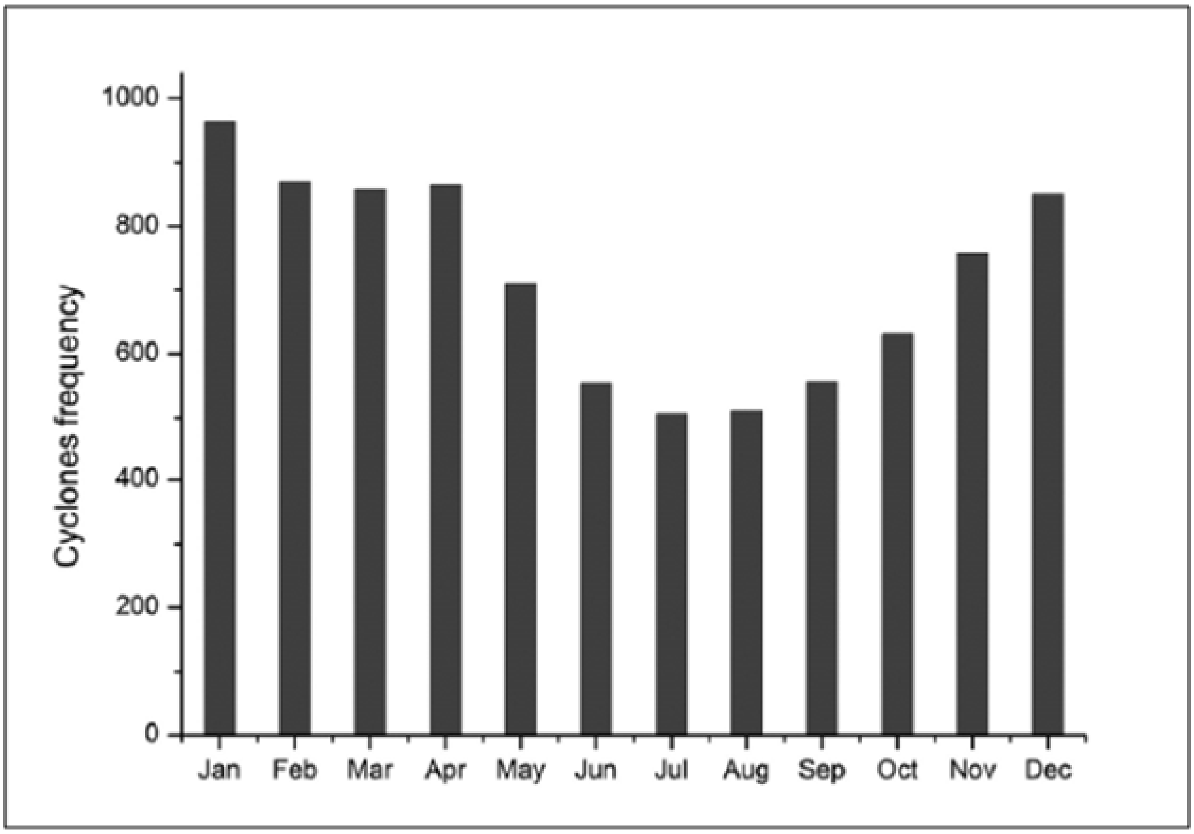


Figure 1-31. Mean annual cycle of the number of storm tracks that passed through the Eastern Mediterranean region, 1962 to 2001 (From: Flocas et al., 2011).

On a seasonal basis, Mandel et al. (2006) describe winter in the Eastern Mediterranean region as concomitantly/alternatively dominating or dominated by interconnected successions of Red Sea Trough, Winter Lows, polar cyclones, and Siberian and Mediterranean subtropical anticyclones. The northward and southward advance and withdrawal of the Red Sea Trough during 5 to 7 months of the year (to the Intertropical Convergence Zone) and Persian Trough variability affect the large-scale succession of the temporary cyclonic systems (i.e., Winter Lows, Cyprus Lows, and Sharav). The Red Sea Trough conditions dominate during the winter, while Winter Lows and Cyprus Lows are less prevalent.

During the summer, the Persian Trough is the dominant weather type, with subtropical anticyclones dominating at upper levels. At daily intervals, the Persian Trough has the largest persistence, rarely being interfered by other weather types. For example, the Sharav Cyclones, as temporary partners of the Persian or Red Sea Troughs, have a horizontal scale less than 1,000 km (Alpert and Ziv, 1989), while the trajectory of Cyprus cyclones is greater than 2,500 km, occurring 8 to 13 times/year and lasting 5 to 7 days (Mandel et al., 2006).

1.2.2.4 Oceanographic Currents

Noble Energy conducted a metocean study offshore Israel near the Tamar Field (Lawrence et al., 2011). Currents were measured at four depths in the water column at a site in the Tamar Field (33"03.901' N, 34"06.926' E).

The upper water column currents at the current meter location were dominated by episodes of strong flows, particularly in the winter. At 25 m depth, the maximum recorded current speed was 53.6 cm/s, measured in January 2011. Mean current speeds at this depth were estimated to be as fast as 25 cm/s. At 73 m depth, the maximum current speed was 49.1 cm/s, measured in April 2011. Mean current speeds at this depth were estimated to be as fast as 22 cm/s. At 121 m depth, the maximum current speed was 41.5 cm/s. Mean currents were estimated to be as fast as 17 cm/s. At 233 m depth, the maximum current speed was 25.8 cm/s in January 2011. The dominant flow direction at the near-surface was toward the south and west. Near-bottom currents do not appear to have a significant seasonal trend, with a maximum speed of only 8.7 cm/s. **Figures 1-32** through **1-36** show recorded current speed and direction for the 25-, 73-, 121-, 233-, and 1,680-m depths.

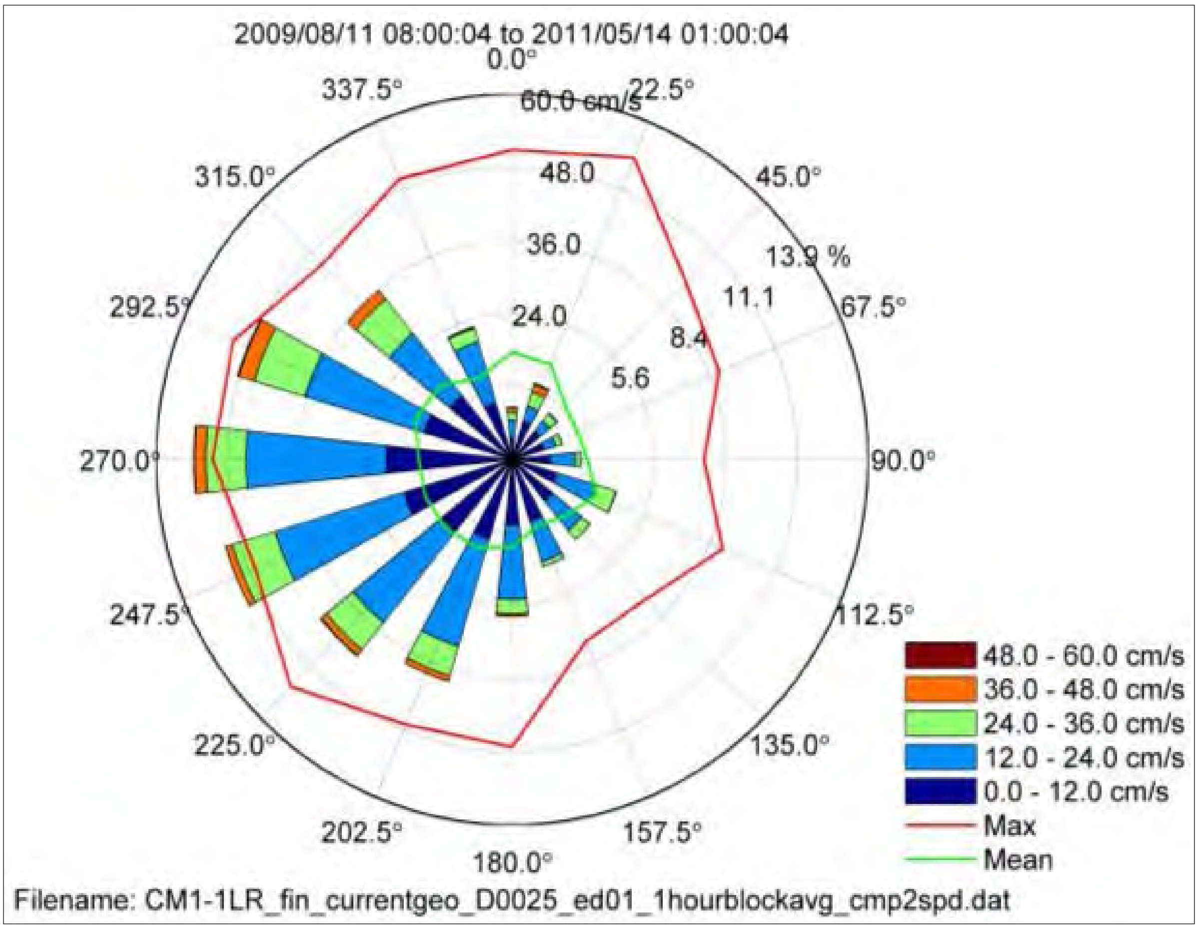


Figure 1-32. Compass rose plot of the directional distribution of currents recorded at a depth of 25 m near the Tamar Field.

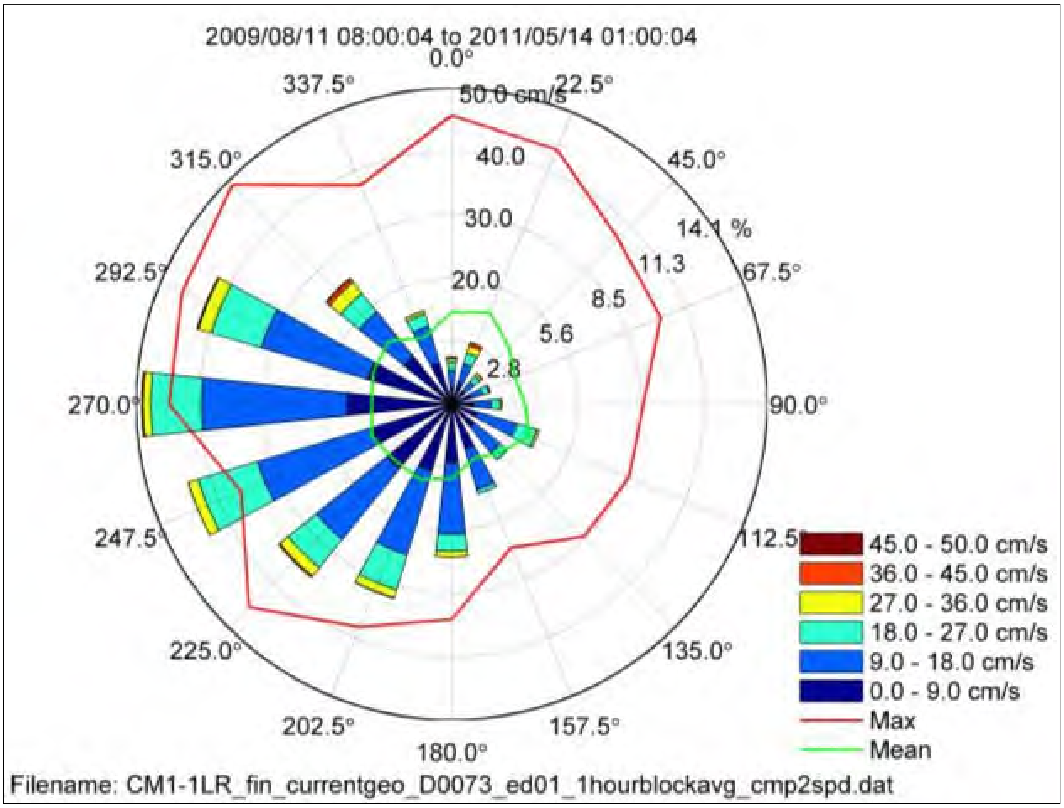


Figure 1-33. Compass rose plot of the directional distribution of currents recorded at a depth of 73 m near the Tamar Field.

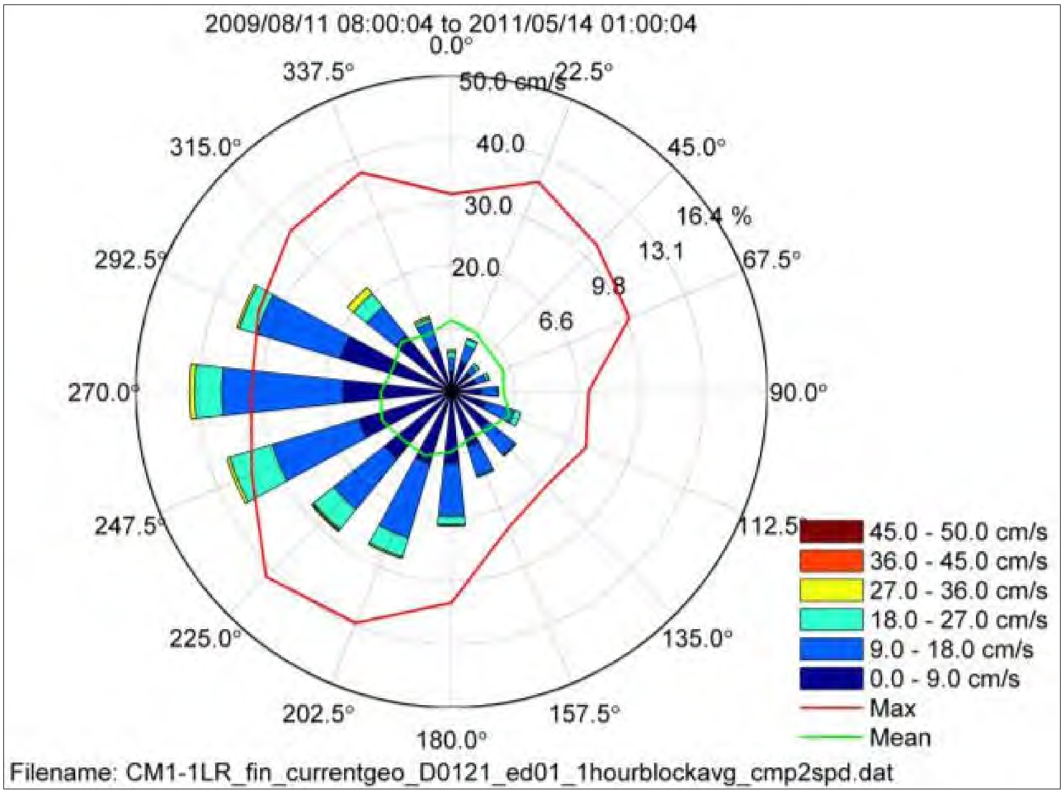


Figure 1-34. Compass rose plot of the directional distribution of currents recorded at a depth of 121 m near the Tamar Field.

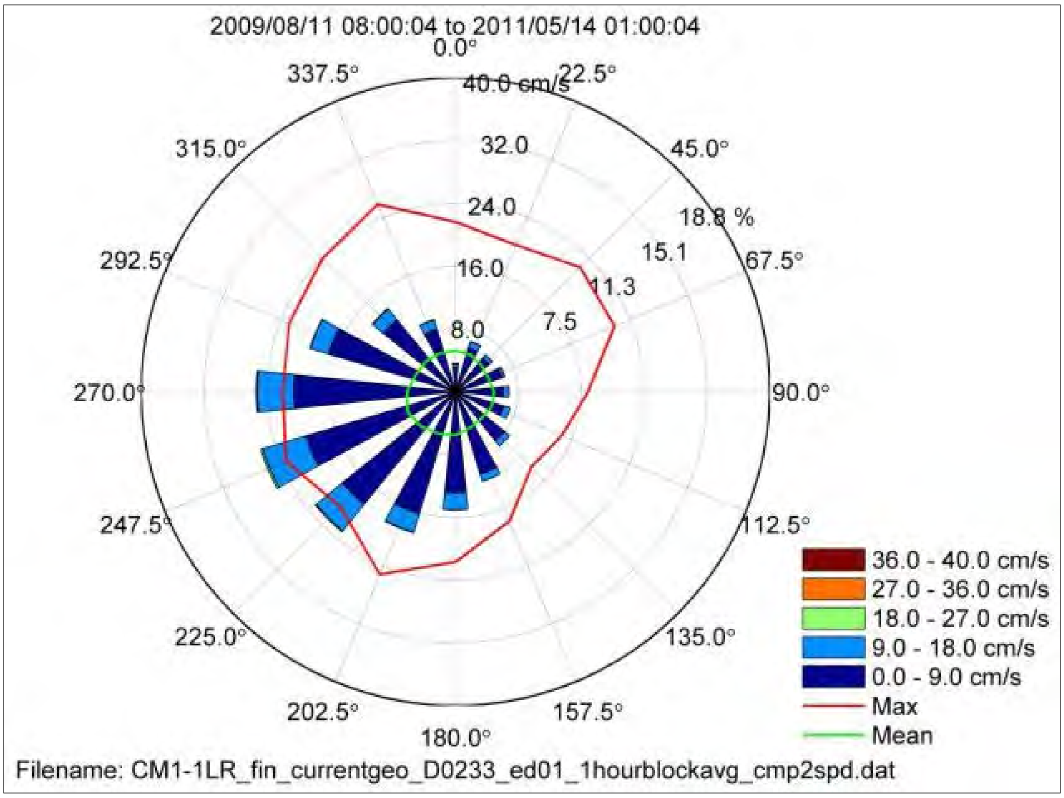


Figure 1-35. Compass rose plot of the directional distribution of currents recorded at a depth of 233 m near the Tamar Field.

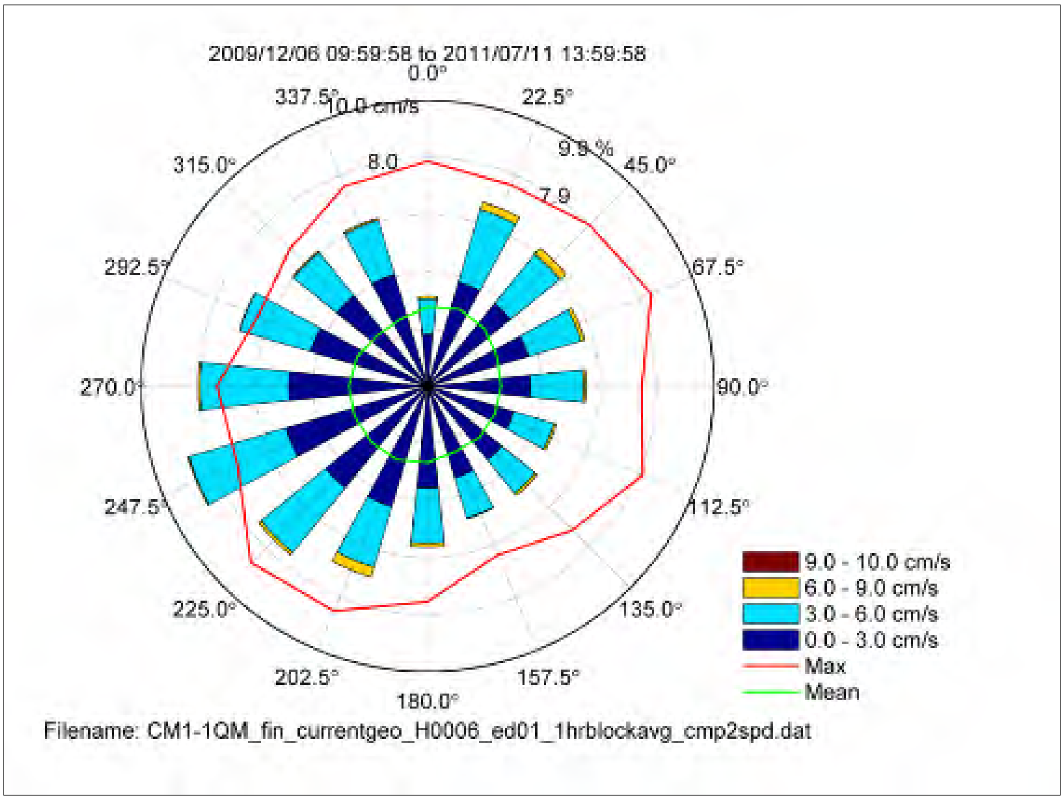


Figure 1-36. Compass rose plot of the directional distribution of currents recorded at a depth of 1,680 m near the Tamar Field.

1.2.2.5 Hydrographic Profiles

The following hydrographic profile information was collected during the February 2014 Tamar Field Background Monitoring Survey and the March 2013 Tamar Field and Pipeline Survey (CSA Ocean Sciences Inc., 2013a, 2014). Results from the February 2014 Survey are presented first because they constitute a more complete picture of the environmental conditions within the Tamar Field. The field survey reports and station locations from the February 2014 Tamar Field Background Monitoring Survey and the March 2013 Tamar Field and Pipeline Survey are provided in **Appendix A** for reference.

February 2014 Tamar Field Background Monitoring Survey

All hydrographic data for the Tamar Field Background Monitoring Survey were collected between 10:30 and 20:00 on 13 February 2014. Four stations (B08, C01, D17, and H09) were sampled around the perimeter of the field, and one station (E11) was sampled from the middle of the field (**Figure 1-3**). Hydrographic profiles of temperature, salinity, dissolved oxygen (DO), turbidity, and fluorescence were recorded continuously from the near-surface (top 10% of the water column), mid-depth, and near-bottom (bottom 10% of the water column) both descending and ascending. Profiles from each station located on the perimeter of the field are shown in **Figure 1-37** (ascending data are presented because historically they are less susceptible to effects of transition through the air-water interface during lowering). The profile from the station located from the center of the field is shown in **Figure 1-38**. All stations have nearly identical profiles, indicating no difference in water column hydrographic parameters throughout the region.

As observed during previous surveys, surface waters were cool and isothermal (approximately 18°C) to a depth of 100 m, then decreased to 15°C through the thermocline, and gradually stabilized to 14°C through the remainder of the water column to the seafloor (**Figures 1-37** and **1-38**). Salinity was recorded near the surface at 39.3 and gradually stabilized with increasing water depth to 38.8 at the seafloor (**Figures 1-37** and **1-38**). Turbidity was low (0.10 to 0.15 nephelometric turbidity units [NTU]) throughout the water column.

As seen previously, the water column was well oxygenated at the surface (7.5 mg/L) and gradually stabilized to 6.0 mg/L throughout the water column to the seafloor (**Figures 1-37** and **1-38**). Fluorescence, an indicator of photosynthetic activity, peaked at a depth of approximately 100 m with a concentration of approximately 0.32 mg/m^3.

March 2013 Tamar Field and Pipeline Survey

During the March 2013 Tamar Field and Pipeline Survey, all hydrographic profiles were collected in a 24-hour period between 21:29 on 25 March 2013 and 18:00 on 26 March 2013. Nine stations were sampled within the developed portion of the reservoir among existing infrastructure consisting of wellsites (Tamar-1 to Tamar-6), flowlines, and umbilicals (**Figure 1-27**). Hydrographic profiles of temperature, salinity, DO, turbidity, and fluorescence were recorded continuously from the near-surface (top 10% of the water column), mid-depth, and near-bottom (bottom 10% of the water column). All nine stations had virtually identical hydrographic profiles; therefore, the profile of one station (TF7) is shown in **Figure 1-39** as representative of the survey region.

Surface waters were cool and isothermal (17°C), then water temperatures decreased through the thermocline and stabilized to 14°C through the remainder of the water column to the seafloor. Salinity varied between 38.7 and 39.1 through the halocline (salinity gradient) and gradually stabilized with increasing water depth to 38.7 at the seafloor. Turbidity was low (0.10 to 0.15 NTU) throughout the water column.

The water column was well oxygenated at the surface (7.4 mg/L) and through the surface-mixed layer before stabilizing to approximately 5.7 mg/L above the seafloor (**Figure 1-39**). Fluorescence peaked at a depth of approximately 175 m with a concentration of approximately 0.35 mg/m^3.

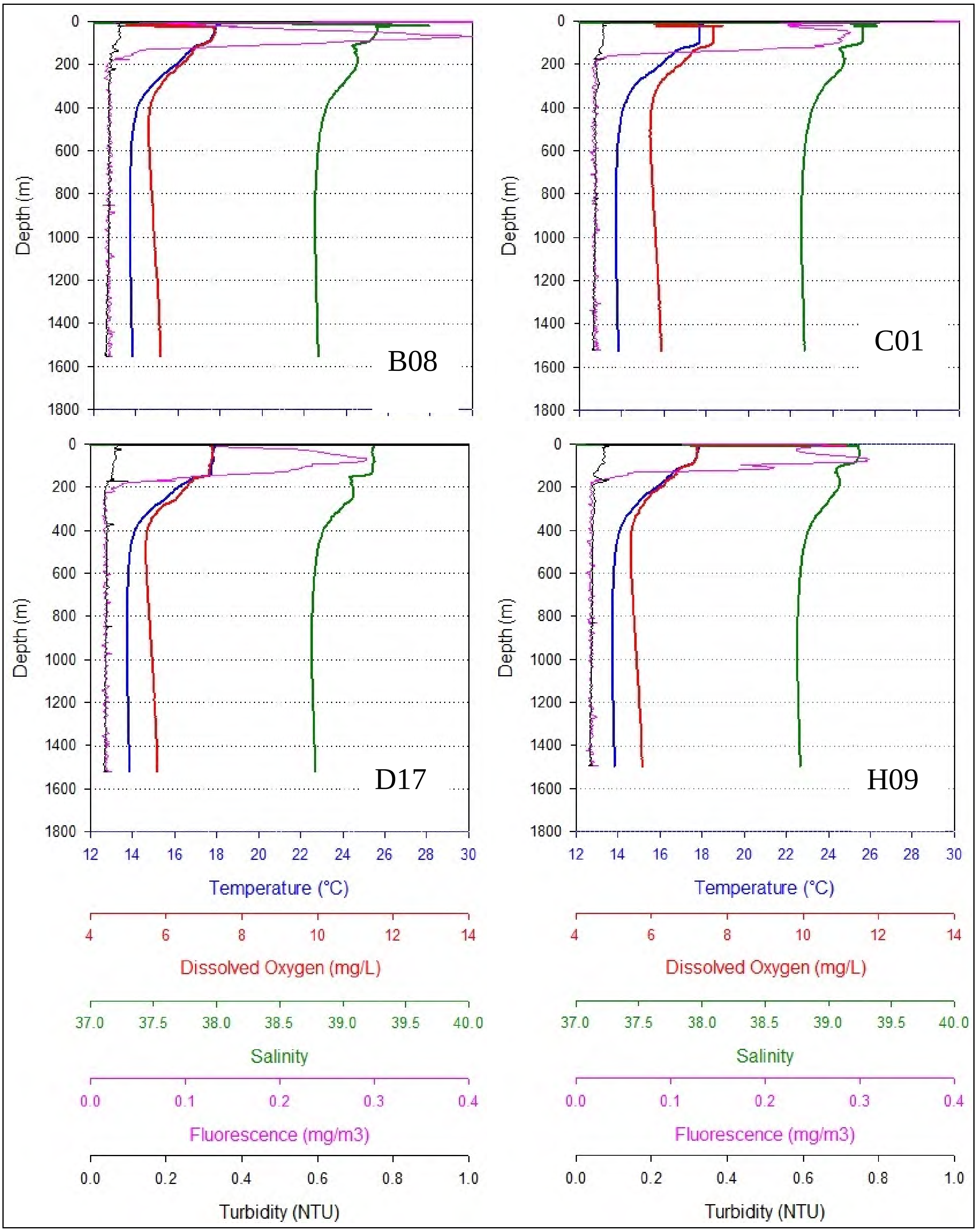


Figure 1-37. Hydrographic profiles of the water column collected between 10:30 and 20:00 on 13 February 2014 at four stations (B08, C01, D17, H09) located on the perimeter of Tamar Field (From: CSA Ocean Sciences Inc., 2014).

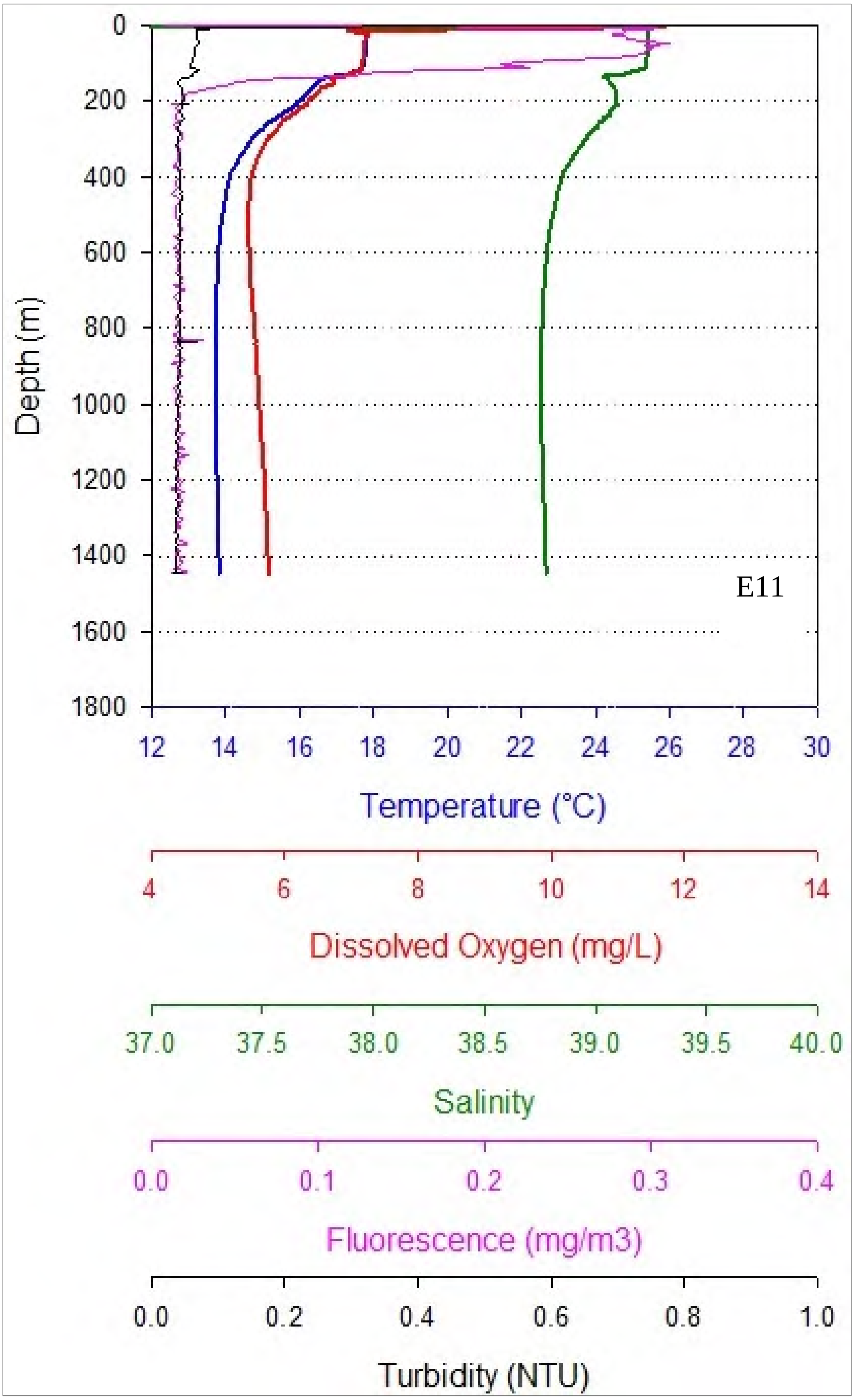


Figure 1-38. Hydrographic profile of the water column collected at approximately 17:30 on 13 February 2014 at a station located in the middle of the field (E11) (From: CSA Ocean Sciences Inc., 2014).

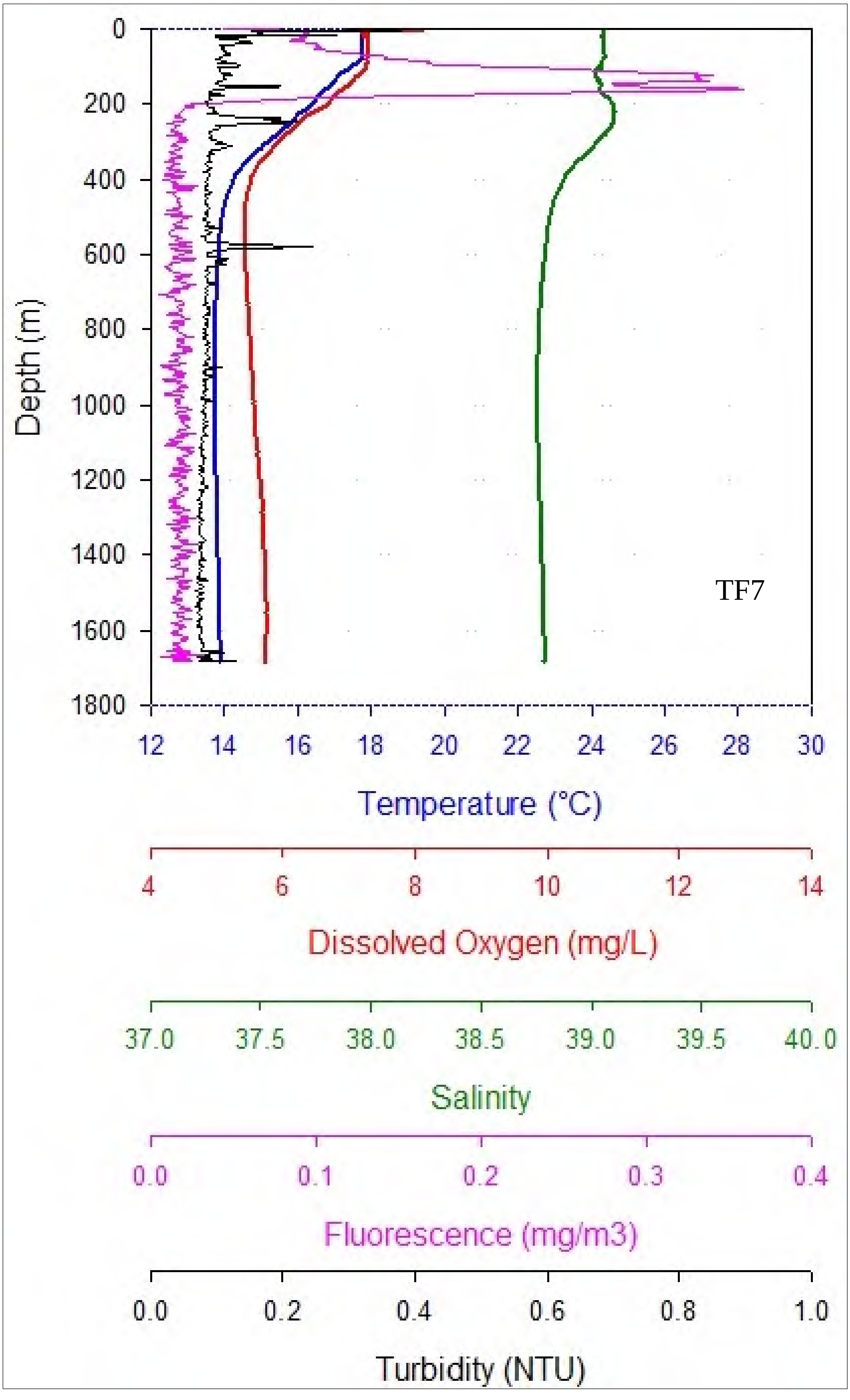


Figure 1-39. Hydrographic profile of the water column collected at 07:00 on 26 March 2013 at Station TF7 (From: CSA Ocean Sciences Inc., 2014).

Similarity in Hydrographic Profiles Between Surveys

Hydrographic water profiles recorded during the March 2013 Tamar Field and Pipeline Survey and the February 2014 Tamar Field Background Monitoring Survey are nearly identical. This finding is not surprising as both surveys were conducted during approximately the same season, although one year apart. The similarity indicates that the hydrographic conditions within the Tamar Field are uniform geographically as well as temporally.

The photosynthetic maximum at 100 to 175 m is typically due to an optimal combination of nutrient and light availability at those depths that promotes phytoplankton growth. Above this layer, nutrient availability for phytoplankton growth is generally limiting, while below this layer, a reduction in light penetration inhibits phytoplankton growth. Increased grazing by zooplankton and other faunal organisms may also reduce the phytoplankton community in the upper layers of the water column. The slight difference in the depth of the photosynthetic maximum between surveys is likely due to minor interannual variations in environmental conditions.

The near-surface depression of DO during both surveys may be attributed to photoinhibition (i.e., sunlight decreasing photosynthesis). The DO stabilization at water depths below 400 m is typical of the Levantine Basin because the amount of organic material sinking from the surface waters is low, which limits microbial respiration at depth (Krom, 1995).

1.2.3 Nature and Ecology

The following resource-specific discussions present summaries of pertinent, available information on both a regional (i.e., eastern Mediterranean Sea, Levantine Basin) and site-specific basis (i.e., Tamar study area). A series of site-specific surveys have been completed in the Tamar Field area, including infaunal sampling and remotely operated vehicle (ROV)-based observations to document benthic epifauna (i.e., benthic fauna present on the sediment surface) and evidence of biological activity (e.g., burrows, mounds). Regional data were derived from available literature and relevant data sources; site-specific information concerning benthic communities in the Tamar study area is available from the March 2013 and February 2014 surveys conducted in the Tamar Field and pipeline corridor to the Tamar Platform (CSA Ocean Sciences Inc., 2014).

1.2.3.1 Plankton

Marine plankton include organisms with limited swimming capabilities that drift with the prevailing currents. Plankton range in size from less than 0.2 µm (marine viruses) to greater than 600 mm (large jellyfish) and may derive energy from sunlight (i.e., plant plankton [phytoplankton]), from the consumption of organic material (i.e., animal plankton [zooplankton]) or, in several unique deepsea habitats, from chemosynthesis of inorganic molecules. In marine systems, phytoplankton form the base of the food web, while zooplankton link phytoplankton to higher trophic levels (e.g., fish). Zooplankton also mediate the transfer of organic material from the ocean surface to the deep sea and thus are indirectly responsible for maintaining benthic community production in most deepsea ecosystems.

Phytoplankton

Phytoplankton productivity in the Mediterranean Sea is nutrient-limited (Longhurst, 1998). In contrast to other marine systems, Mediterranean phytoplankton production is co-limited by phosphorus and nitrogen (Krom et al., 1991; Thingstad et al., 2005). A west-to-east decrease in nutrient concentrations in the Mediterranean Sea results in extremely nutrient-poor ("ultra-oligotrophic") surface waters in the eastern Levantine Basin compared to the western Mediterranean Sea. Severe nutrient depletion in the eastern Mediterranean Sea results in low phytoplankton biomass and productivity (Tanaka et al., 2007).

Phytoplankton dynamics in the eastern Levantine Basin, including the Tamar study area, vary on a seasonal basis. Phytoplankton blooms occur in the winter and early spring (November to March) because deep winter mixing brings nutrients to surface waters (Vidussi et al., 2001). Phytoplankton growth during this season rapidly depletes phosphorus, and nutrient levels remain low during the summer when the surface water stratifies. Thus, the summer phytoplankton biomass (i.e., pigment concentration [chlorophyll *a*]) is low in the surface mixed layer; up to 10 times lower than observed during the winter (Krom et al., 1991). Herut et al. (2000) reported distinct phytoplankton biomass peaks in surface water (upper 120 m) following autumn and winter storms.

The dominant phytoplankton in eastern Mediterranean assemblages is *Synechococcus* spp. (Pitta et al., 2005), a small (<2 µm) cyanobacterium (blue-green algae). Koppelmann et al. (2003) suggested that *Synechococcus* spp. is one of the primary mechanisms for nitrogen fixation in the Levantine Basin and is common (Li et al., 1993; Detmer, 1995) under oligotrophic conditions (Kress, 2000; Struck et al., 2001). Analysis of phytoplankton accessory pigments in the eastern Levantine Basin also indicates the importance of prymnesiophyte nanoplankton (2 to 20 µm) and the presence of coccolithophorids, diatoms, and dinoflagellates (Psarra et al., 2005). Diatom populations studied by Psarra et al. (2005) were found to be dominated by *Thalassionema frauenfeldii*.

Phytoplankton in the study area are found primarily in the surface waters (0 to 150 m) where light levels are sufficient for growth; the euphotic zone, with maximum phytoplankton productivity, occurs in the surface mixed layer at a depth of 0 to 50 m (Tanaka et al., 2007). However, phytoplankton pigments (chlorophyll *a*) have been found to 500 m in the deep mixed layer of a warm-core eddy to the south of Cyprus (Krom et al., 1991). On average, the vertical distribution of phytoplankton pigment concentrations (chlorophyll *a*) in the eastern Levantine Basin reaches a maximum at 90 to 110 m, just above the nutricline (Yacobi et al., 1995; Krom et al., 2005). This is corroborated by the fluorescence profile of the water column at the Tamar SW-1 study area during July 2012 (**Figure 1-37**).

<u>Zooplankton</u>

Zooplankton in the eastern Mediterranean Sea can be categorized by size into microzooplankton (20 to 200 µm), mesozooplankton (>200 µm), and macrozooplankton (>2 mm). Zooplankton in surface waters rely on a phytoplankton-based food web, whereas zooplankton in the deep sea rely on a food web based on organic particulate material sinking from the surface.

Microzooplankton in the study area is a diverse assemblage of small cells that consume bacteria and small phytoplankton. The microzooplankton community includes heterotrophic nanoflagellates (2 to 10 µm) and ciliates (10 to 350 µm), as well as autotrophic nanoflagellates that have chloroplasts and can derive energy from sunlight, and are thus “mixotrophic” (Pitta et al., 2005). Ciliate abundances are maximal in the surface mixed layer (0 to 50 m) where phytoplankton production is highest, while autotrophic nanoflagellate abundances are maximal just above the nutricline, at approximately 100-m depth (Tanaka et al., 2007). In contrast, no consistent pattern is found for heterotrophic nanoflagellates in surface and deep waters of the eastern Levantine Basin, although their abundance and bacterial abundances decrease with depth (Tanaka et al., 2007).

Mesozooplankton and macrozooplankton in the eastern Levantine Basin are extremely diverse. In surface waters between Sicily and Cyprus, for example, zooplankton communities are dominated by copepods (Mazzocchi et al., 1997), specifically the small copepods *Clausocalanus furcatus*, *C. paululus*, *Oithona plumifera*, and *Farranula rostrata* (Siokou-Frangou et al., 1997). In addition to copepods, at least 21 other zooplankton taxa are found in the eastern Levantine Basin, including medusae, siphonophores, ctenophores, heteropods, pteropods, molluscan larvae, polychaetes, cladocerans, ostracods, euphausiids, decapod larvae, isopods, amphipods, echinoderm larvae, chaetognaths, appendicularians, pyrosomes, doliolids, salps, and fish eggs and larvae (Mazzocchi et al., 1997).

Nearshore plankton in the eastern Mediterranean Sea, especially prominent macrozooplankton, is characterized by the presence of gelatinous swarms of scyphomedusan jellyfish and ctenophores. Each summer since the mid-1980s, huge swarms of the jellyfish *Rhopilema nomadica* have appeared along the Levant coast (Galil and Zenetos, 2002). Jellyfish swarms now appear year-round with an unwelcome addition of the comb jelly *Mnemiopsis leidyi* (Fuentes et al., 2009), which has invaded the Black Sea via ballast water and caused a massive commercial collapse of its pelagic fisheries. These massive swarms of voracious planktotrophs, some stretching 100 km long, draw nearer to shore, with the potential to adversely affect tourism, fisheries, and coastal installations. *R. nomadica*-dominated swarms are usually poly-specific and commonly include jellyfish of Atlanto-Mediterranean origin such as *Rhizostoma pulmo* and *Aurelia aurita* as well as the Lessepsian scyphomedusa *Phyllorhiza punctata* (Australian white-spotted jellyfish) (Edelist et al., 2011). These macrozooplankton swarms appear to be coastal-related events, and it is uncertain if the swarms would occur and affect the offshore habitat in the area of the Tamar Field.

1.2.3.2 Benthic Communities

The benthos refers to animals (benthic fauna) and plants (benthic flora) that are found on the seafloor (epifauna), in the seafloor (infauna), or near the seafloor. Benthic fauna are often sorted according to size into meiobenthos (less than 1 mm) and macrobenthos (greater than 1 mm). Information for this report was derived from regional study data from available literature and from three surveys conducted by Noble Energy. The surveys included a video documentation survey of the Tamar SW-1 site (CSA Ocean Sciences Inc., 2013b) and infauna surveys conducted in March 2013 and February 2014 (CSA Ocean Sciences Inc., 2014).

A video documentation survey recently conducted at the Tamar SW-1 study area (CSA Ocean Sciences Inc., 2013b) characterized the seafloor substrates and associated biological communities. The seafloor of the entire survey area was characterized by a smooth, relatively flat soft bottom. Soft bottom substrate was composed of mud and a fine silt veneer that was subject to resuspension from physical disturbance. Seafloor features included subtle variations in surficial topography and bioturbation in the form of mounds, burrows, and motile biota track lines. No consolidated substrates (i.e., hard bottom) or signatures of chemosynthetic communities were observed within the survey area, supporting the determinations presented in the site-specific geohazard survey (Gardline Surveys Inc., 2012).

Biological activity was a relatively common observance within the Tamar SW-1 study area and was predominantly motile biota and biologically maintained burrows and mounds (CSA Ocean Sciences Inc., 2013b). The most commonly observed organisms during the video survey were fish and shrimp. The most commonly observed fish was the tripod fish (*Bathypterois* sp.). Many of the fish observed during the video survey were unidentifiable by video analysis due to their awkward positioning relative to the camera or small body size. Frequency of occurrence for fish and shrimp averaged approximately two and three individuals per 100 m of survey transect, respectively. Bioturbation was frequently observed along video transects and included patterned burrows (i.e., small groupings) and small (approximately 15 to 30 cm), conical mounds likely formed by deposit-feeding worms (Polychaeta).

Within the Tamar Field, 667 individual organisms were collected during the 2013 and 2014 surveys. The taxonomic listing of infauna within the Tamar Field is provided in **Table 1-3**. Infaunal abundance within the Tamar Field was patchy and ranged from 25 to 125 individuals per m^2 (**Figure 1-40**). The dominant taxa within the field were annelid worms (**Figure 1-41**), primarily composed of *Notomastus* sp. (**Figure 1-42**) which accounted for 31% of the total organisms collected (**Table 1-3**). Crustaceans were abundant (25 to 50 individuals per m^2) within the northeastern portion of the field (**Figure 1-43**). Mollusks and other various phyla were not abundant within the field (**Figures 1-44** and **1-45**; **Table 1-3**).

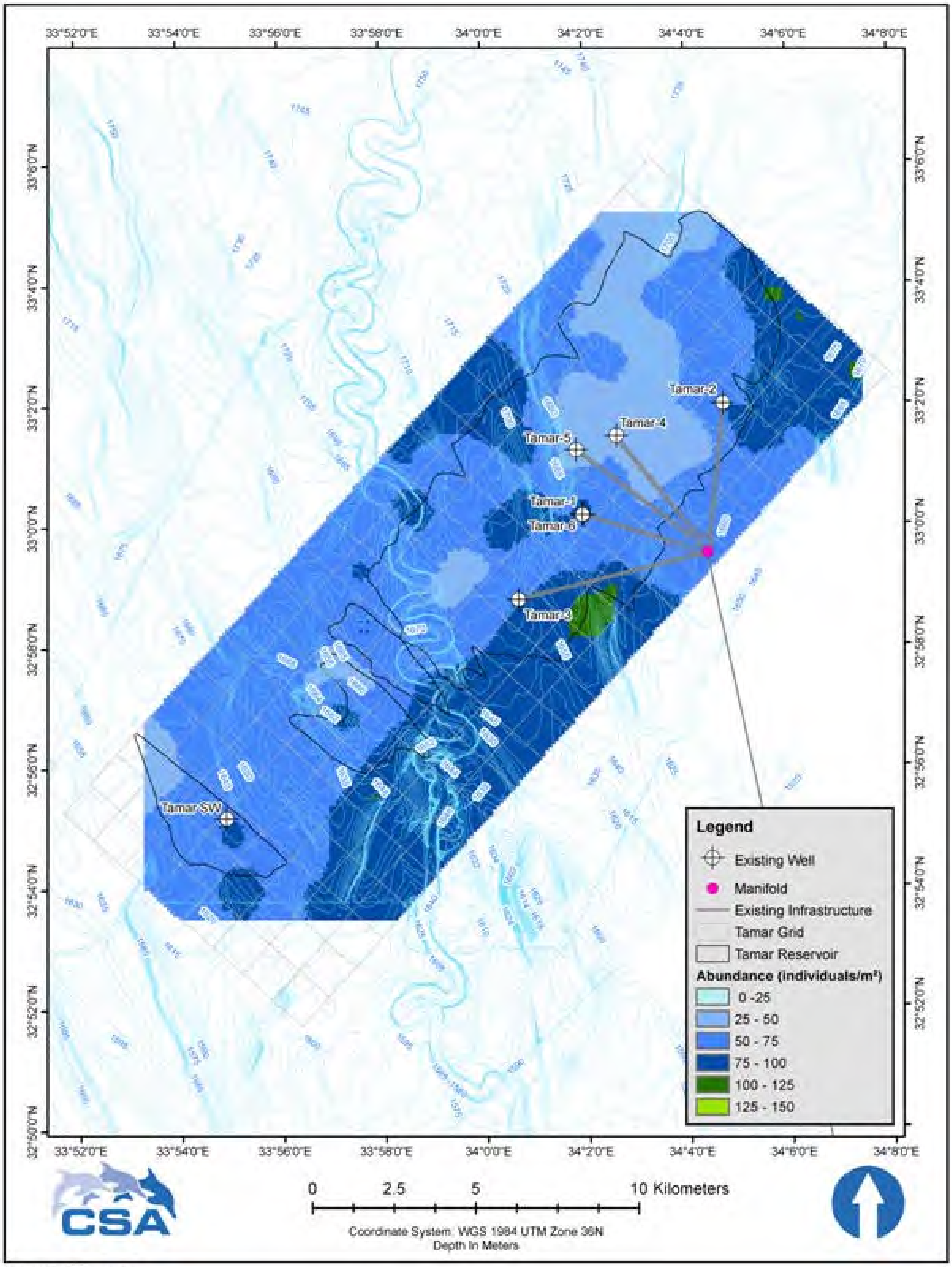


Figure 1-40. Abundance (individuals/m^2) of infauna organisms within the Tamar Field. Map color scales are standardized to show the possible range of values; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

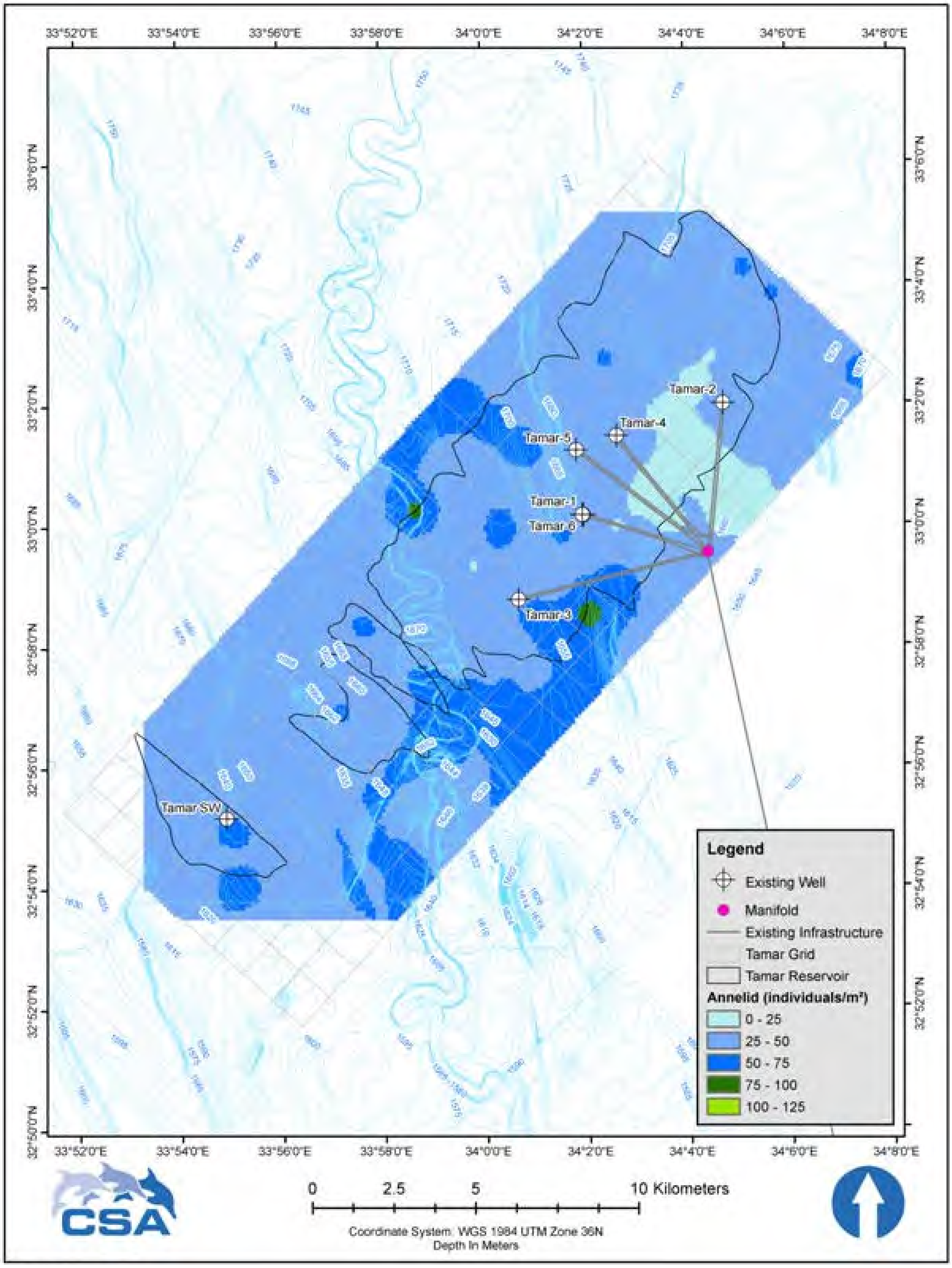


Figure 1-41. Abundance (individuals/m^2) of annelids within the Tamar Field. Map color scales are standardized to show the possible range of values; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

Figure 1-42. Specimen of the polychaetous annelid *Notomastus* sp. (From: CSA Ocean Sciences Inc., 2014).

Species richness throughout the field was low ranging from 1 to 10 species for most samples (**Figure 1-46**). Given the low species richness, it is not surprising that Pielou's evenness was high (**Figure 1-47**) and species diversity was moderate (**Figure 1-48**) throughout the region. There is no apparent pattern to organism abundance, composition, or diversity with existing infrastructure within the field.

Table 1-3. Taxonomic listing and total abundance distribution of major taxa and subgroups in infaunal samples collected from the Tamar Field (1,700 m water depth) (From: CSA Ocean Sciences Inc., 2014).

Phylum	Class	Lowest Practical Identification Level (Taxonomic Subgroups)	Abundance (# of specimens)	Abundance (individuals/m^2)	Total Fauna (%)
Annelida	Clitellata	Oligochaeta	7	0.86	1.05
	Polychaeta	Capitellidae	2	0.25	0.30
		Capitella capitata	2	0.25	0.30
		Notomastus sp.	204	24.99	30.58
		Pseudocapitella incerta	2	0.25	0.30
		Opheliidae	7	0.86	1.05
		Aphroditiformia	8	0.98	1.20
		Pettiboneia sp.	3	0.37	0.45
		Glycera lapidium	26	3.19	3.90
		Microphthalmus sp.	1	0.12	0.15
		Lumbrineridae	1	0.12	0.15
		Abyssoninoe sp. 1 EcoA	1	0.12	0.15
		Nephtys sp.	1	0.12	0.15
		Ancistrosyllis groenlandica	1	0.12	0.15

Table 1-3. (Continued).

Phylum	Class	Lowest Practical Identification Level (Taxonomic Subgroups)	Abundance (# of specimens)	Abundance (individuals/m^2)	Total Fauna (%)
Annelida (continued)	Polychaeta (continued)	*Exogone* sp.	5	0.61	0.75
		Acrocirridae	4	0.49	0.60
		Spiochaetopterus sp.	4	0.49	0.60
		Cirratulidae	4	0.49	0.60
		Aphelochaeta sp.	1	0.12	0.15
		Oweniidae	1	0.12	0.15
		Galathowenia sp.	4	0.49	0.60
		Poecilochaetus sp.	1	0.12	0.15
		Lygdamis sp.	12	1.47	1.80
		Pseudochitinopoma sp.	7	0.86	1.05
		Spionidae	58	7.11	8.70
		Spiophanes sp.	8	0.98	1.20
		Polycirrinae	23	2.82	3.45
		Terebellinae	12	1.47	1.80
		Terebellides stroemii	18	2.21	2.70
		Aricidea (Allia) antennata	13	1.59	1.95
Arthropoda	Malacostraca	Amphipoda	1	0.12	0.15
		Lysianassidae	2	0.25	0.30
		Harpinia sp.	2	0.25	0.30
		Pseudotiron bouvieri	5	0.61	0.75
		Cumacea	4	0.49	0.60
		Makrokylindrus sp.	3	0.37	0.45
		Lampropidae	1	0.12	0.15
		Nannastacidae	4	0.49	0.60
		Asellota	3	0.37	0.45
		Desmosomatidae	10	1.23	1.50
		Tanaidomorpha sp.	2	0.25	0.30
		Tanaidomorpha sp. 1 EcoA	25	3.06	3.757
		Tanaidomorpha sp. 2 EcoA	17	2.08	2.55
		Tanaidomorpha sp. 3 EcoA	46	5.64	6.90
		Tanaidomorpha sp. 4 EcoA	3	0.37	0.45
		Tanaidomorpha sp. 5 EcoA	1	0.12	0.15
		Tanaella unguicillata	1	0.12	0.15
Mollusca	Bivalvia	Cuspidariidae	2	0.25	0.30
		Cardiomya costellata	6	0.74	0.90
		Arcidae	19	2.33	2.85
		Microgloma sp.	39	4.78	5.85
		Galeommatoidea	1	0.12	0.15
		Kelliella sp.	4	0.49	0.60
	Gastropoda	Gastropoda	4	0.49	0.60
		Mangeliidae	1	0.12	0.15
	Solenogastres	Solenogastres	4	0.49	0.60
Nemertea	Anopla	Lineidae	2	0.25	0.30
		Palaeonemertea	3	0.37	0.45
	Palaeonemertea	Tubulanidae	1	0.12	0.15
Sipuncula	Phascolosomatidea	Sipuncula	8	0.98	1.20
		Apionsoma murinae bilobatae	1	0.12	0.15
Phoronida	N/A	*Phoronis* sp.	1	0.12	0.15
Total			**667**	**81.7075**	**100.00**

N/A = not available.

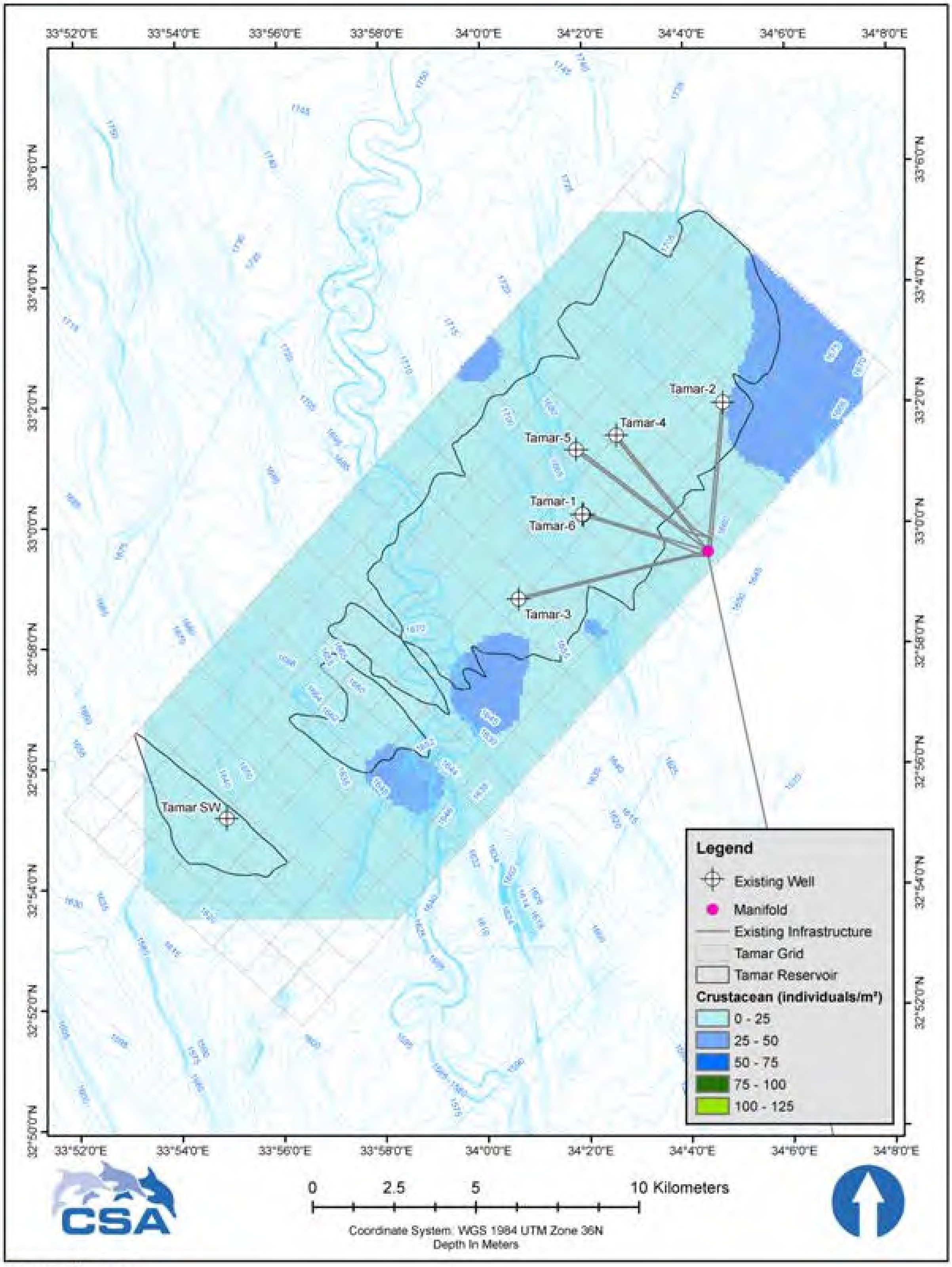


Figure 1-43. Abundance (individuals/m^2) of crustaceans (Arthropoda) within the Tamar Field. Map color scales are standardized to show the possible range of values; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

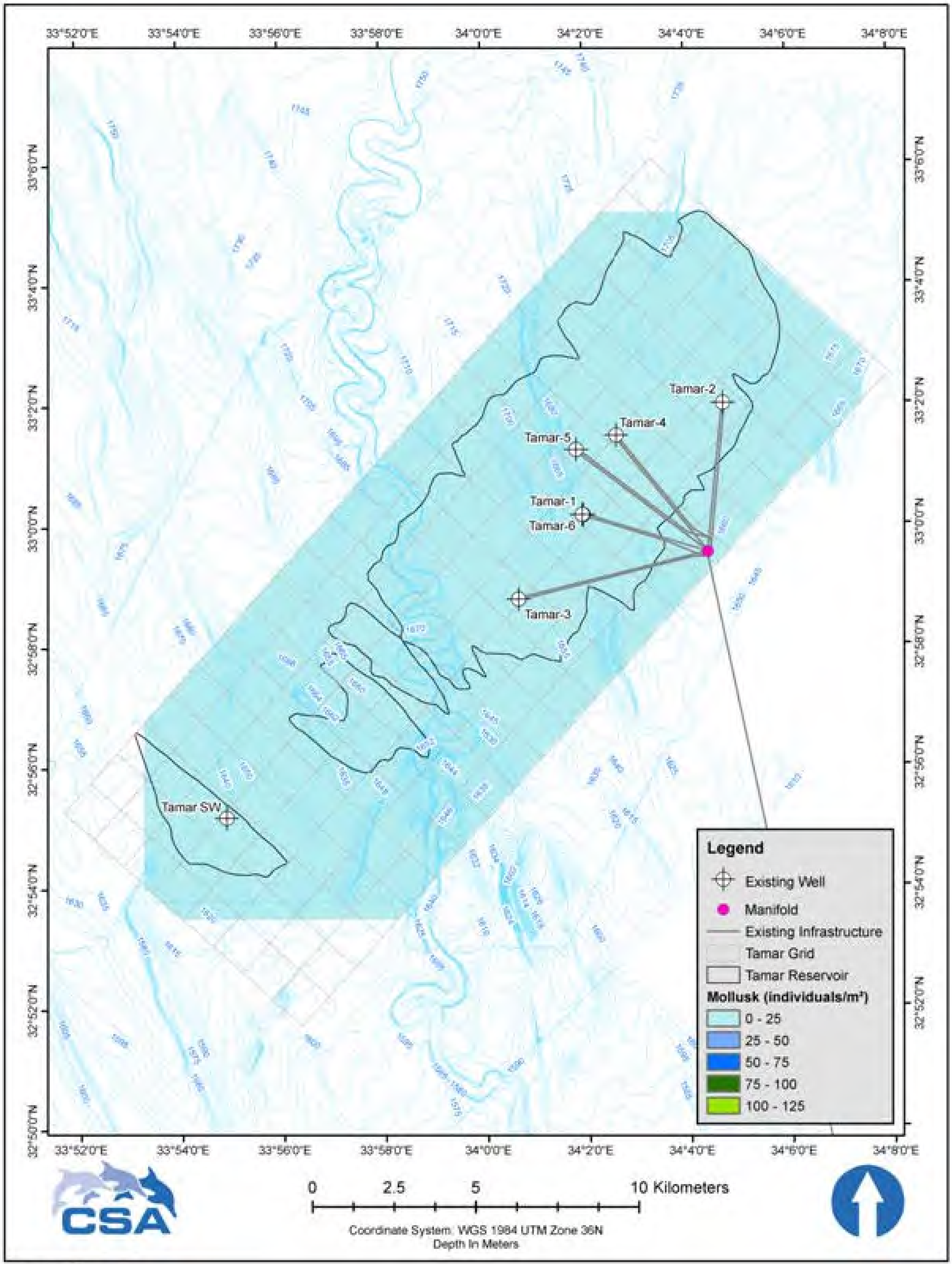


Figure 1-44. Abundance (individuals/m^2) of mollusks within the Tamar Field. Map color scales are standardized to show the possible range of values; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

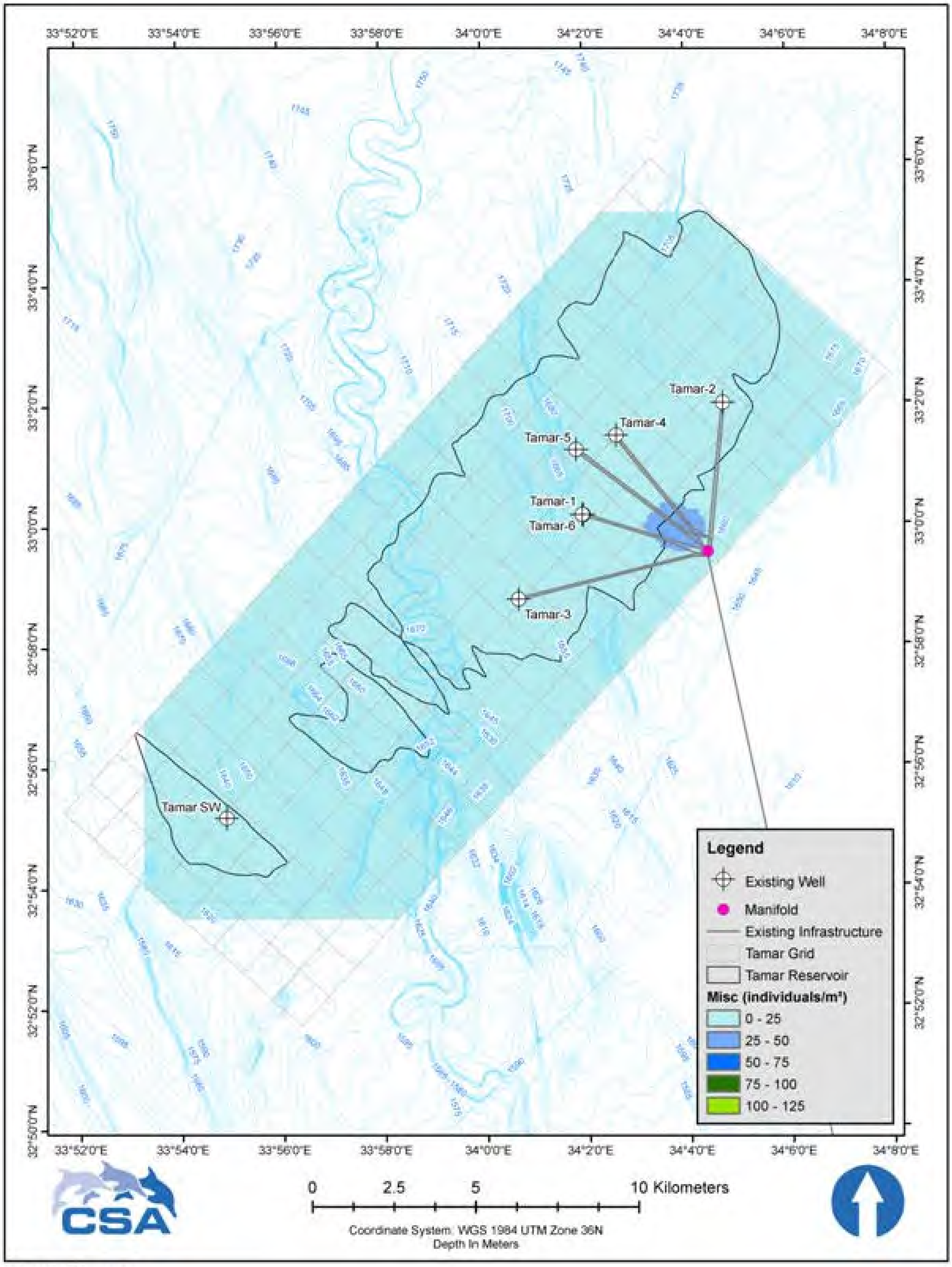


Figure 1-45. Abundance (individuals/m^2) of Nemertea, Sipuncula, and Phoronida within the Tamar Field. Map color scales are standardized to show the possible range of values; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

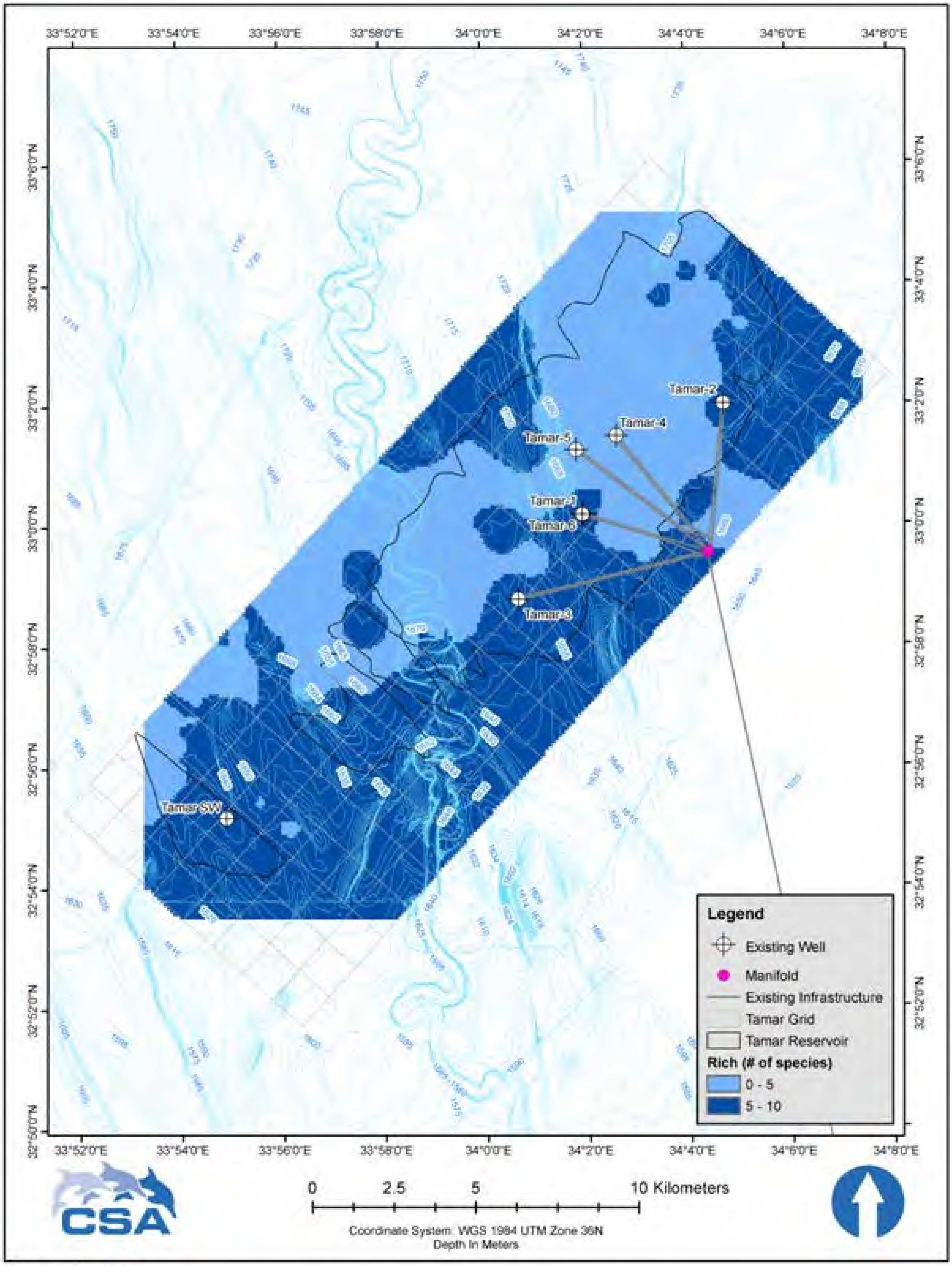


Figure 1-46. Species richness within the Tamar Field. Map color scales are standardized to show the possible range of values; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

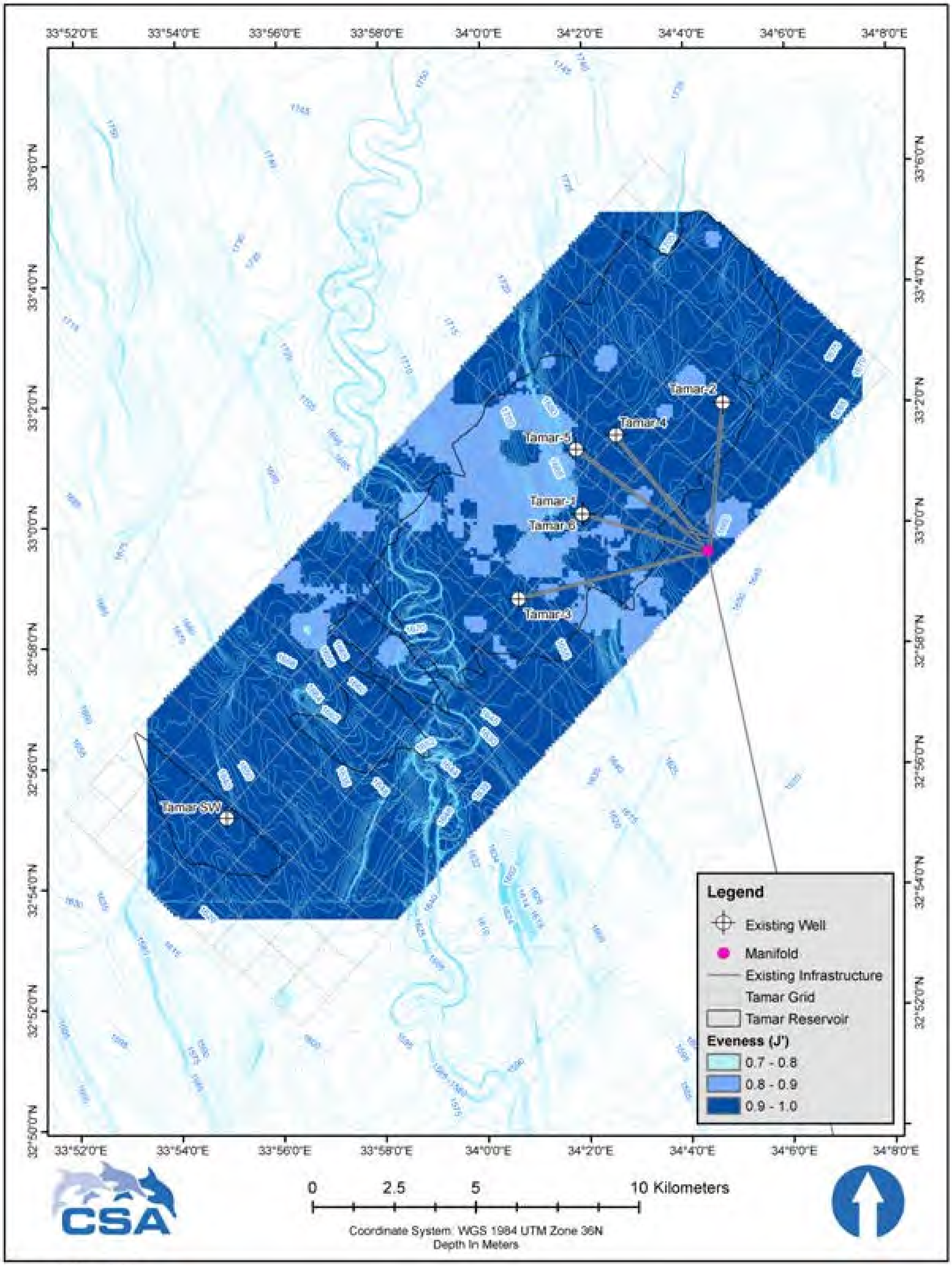


Figure 1-47. Pielou's evenness (J′) metrics from within the Tamar Field. Pielou's evenness is a value that ranges from 0 (low evenness) to 1 (high evenness). Map color scales are standardized to show the possible range of values; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

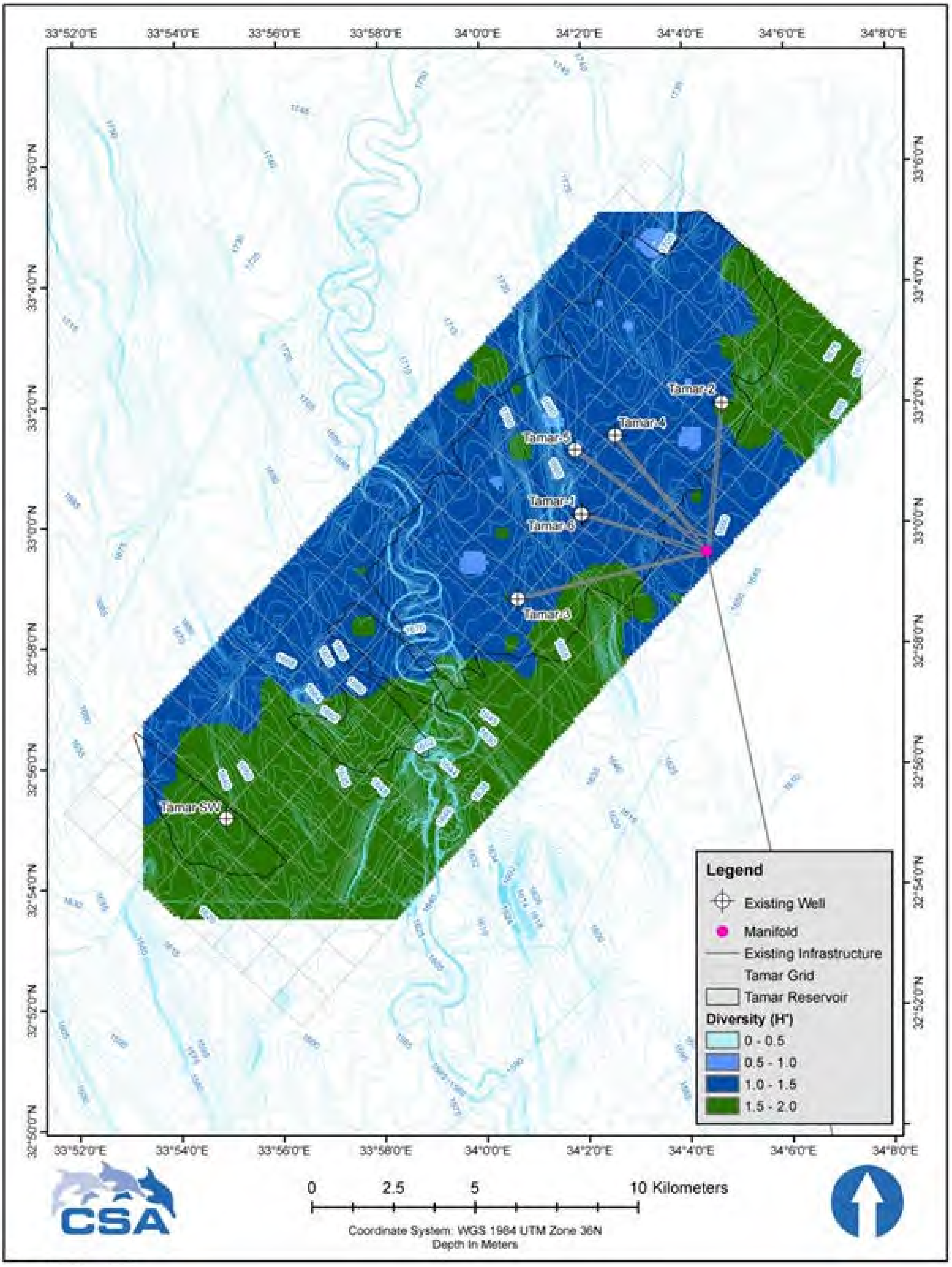


Figure 1-48. Shannon-Wiener Diversity Index (H′) values from within the Tamar Field. The Shannon-Weiner Diversity Index operates on a scale of 0 (lowest diversity) to 4 (highest diversity). Map color scales are standardized to show the possible range of values; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

Continental Slope and Deepsea Habitats

Continental slope and deepsea habitats in the Mediterranean Sea are characterized by eurybathic fauna (i.e., occupying a wide depth range), with very few true deepwater species (Cartes et al., 2004). Deepsea fauna found in the eastern Levantine Basin historically have been considered to be extremely impoverished in terms of species number, but recent observations from the R/V *Nautilus* survey conducted off the Israeli slope between 5 and 14 September 2010 (Bell and Fuller, 2011) may indicate that deepsea species diversity in the Levantine Basin is not as low as originally thought. The R/V *Nautilus* survey made observations of exposed rock outcrops in water depths exceeding 500 m along the Palmachim disturbance (a geological feature offshore of Tel Aviv). The rock outcrops provide habitat for relatively dense coverage of soft corals, shrimps, and crabs (Bell and Fuller, 2011).

The abyssal basins of the eastern Mediterranean Sea are extremely unusual deepsea systems. With water temperatures at 4,000 m in excess of 14°C (rather than less than 4°C for other deep oceanic basins), the entire benthic environment is as hot as the water around a hydrothermal vent system, but lacks the vents' rich chemical energy supply. The Mediterranean also differs from other deepsea ecosystems in terms of its species composition, notably the absence of the near-ubiquitous deepwater grenadier fish *Coryphaenoides armatus* and the amphipod *Eurythenes gryllus*. Instead, *Acanthephyra eximia*, a deepsea shrimp species, appears to have functionally replaced *E. gryllus*, the dominant deepsea scavenging crustacean throughout most of the world's oceans (Christiansen, 1989).

Danovaro et al. (2010) summarized all available information on benthic biodiversity (i.e., prokaryotes, foraminifera, meiofauna, macrofauna, and megafauna) in different deepsea ecosystems of the Mediterranean Sea (i.e., from 200 to >4,000 m water depths). Results indicated that the deepsea biodiversity is similarly high for both the eastern and the western basins of the Mediterranean Sea. In general, the biodiversity components decreased with increasing water depth. Quantitative analyses of macrofauna in deep water of the eastern Mediterranean are limited (Tyler, 2005).

Few studies have examined deepwater meiofauna off Israel; however, based on existing evidence, Galil (2004) characterized these communities as diverse but scarce, consisting of "autochthonous, self-sustaining populations of opportunistic, eurybathic species." Survey results from 1993 revealed a strong dependence of meiofaunal abundance on depth, distance from the coast, and food (labile organic carbon) availability (Tselepides and Lampadariou, 2004). The meiofaunal community was dominated by nematodes, harpacticoid copepods, and polychaetes.

Chemosynthetic Communities

The presence of chemosynthetic benthic communities, driven by the biological oxidation of sedimentary methane (CH_4), has been documented offshore Israel (Coleman and Ballard, 2001). Coleman and Ballard (2001), using side-scan sonar and ROV ground-truthing techniques, discovered gas seeps and associated calcium carbonate substrate in a water depth slightly greater than 700 m. The acoustic signature appears as small depressions or surficial pockmarks, which have been similarly described in various locations within the eastern Mediterranean (Dimitrov and Woodside, 2003; Bayon et al., 2009). The biological community associated with the pockmark formations was dominated by polychaetes and bivalves.

Mediterranean seeps appear to represent a rich habitat characterized by megafaunal species richness (e.g., gastropods) or the exceptional size of some taxa such as sponges (e.g., *Rhizaxinella pyrifera*) and crabs (e.g., *Chaceon mediterraneus*). This contrasts with the perceived non-seep characteristics of low macrofaunal and megafaunal abundance and diversity of the deep eastern Mediterranean Sea (Danovaro et al., 2010). Seep communities in the Mediterranean that include endemic chemosynthetic species and associated fauna differ from the other known seep communities in the world both at the species level and by the notable absence of the large bivalve genera *Calyptogena* or *Bathymodiolus*. The isolation of the Mediterranean seeps from the Atlantic Ocean after the Messinian crisis led to the development of unique communities that are likely to differ in composition and structure from those in the Atlantic.

1.2.3.3 Fish and Other Nekton

The distribution and abundance of nekton of the Levantine Basin are determined, to a large extent, by the mesoscale oceanographic features of the Mediterranean Sea. The Mediterranean gets most of its nutrient salts from surface layers of the Central Atlantic, where nutrient levels are moderate. The Atlantic Water that enters the Mediterranean through the Strait of Gibraltar follows the northern coast of Africa, with various branches from circulation eddies on the way to the eastern Mediterranean Sea. On its way through the Mediterranean, seawater becomes not only oligotrophic but also warmer and very salty, hence denser. In the area offshore Israel, this water (known as Mediterranean Surface Water) sinks in a downwelling pattern to the intermediate layer and moves west during the winter. Ultimately, these waters (i.e., Levantine Intermediate Water) flow out of the Mediterranean and into the Atlantic through the lower strata of the Strait of Gibraltar. With this general pattern, the productivity of the sea offshore of Israel is estimated to be even lower than productivity of the rest of the eastern Mediterranean and is termed ultra-oligotrophic.

The Mediterranean has its own specific fauna and flora as a result of its origins and peculiar hydrography. The marine fishes of the eastern Levantine Basin have been studied by several authors. A historical account of these studies was developed by Golani (1996). The first general study of the Israeli marine ichthyofauna was by Ben-Tuvia (1953), who later revised this list (Ben-Tuvia, 1971). Another comprehensive study of the ichthyofauna of this region (Golani, 1996) included species from adjacent countries, such as Cyprus, southern Turkey, and Egypt (Golani, 2005).

The Mediterranean Sea as whole supports more than 700 fish species (Froese and Pauly, 2014). These species are variously distributed in relation to hydrography, physiography, and environmental factors over multiple basins and ridges that shape the Mediterranean. A broad pattern within the Mediterranean proper is that the number of species decreases from west to east; in the easternmost Levantine Basin offshore Israel, only 350 indigenous species are reported (Golani, 2005). 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. Another suspected effect of low productivity is that individuals of some species tend to mature at smaller sizes in the eastern Mediterranean than they do in other parts of their range – a phenomenon known as nanism.

Overall, the ichthyofauna in the Mediterranean Sea is composed of species with Atlantic (75%) and cosmopolitan (20%) origins. Important additions to the ichthyofauna are the numerous Indo-Pacific species introduced through the Suez Canal. Approximately 60 fish species of Indo-Pacific origin have invaded the Levant region since the Suez Canal opened in 1869. When these invaders are included, the total list of fish species known from the coast of Israel is slightly more than 400, from 130 families. This invasion is significant for local ecosystems as well as fisheries because several invaders have become numerically dominant in some habitats.

Fishes found off the coast of Israel 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 particular species associate with. The following characterizations briefly describe the composition of pelagic and demersal fish assemblages found offshore of Israel.

Pelagic Fishes

Pelagic fishes are generally migratory species that usually form schools and traverse shelf waters. Movements may be onshore to offshore, but typically parallel the coastline. Pelagic species found off the Israeli coast are represented by sharks (Carcharhinidae), anchovies (*Engraulis* sp.), herrings

(*Sardinella aurita*), jacks (*Trachurus* spp. and *Seriola dumerili*), mackerels (*Scomber japonicus*), tunas (*Euthynnus* spp., *Auxis* spp.), mullets (Mugilidae), and barracudas (*Sphyraena* spp.). These species generally respond to vertical and horizontal changes in water temperature driven by seasonal weather patterns as well as prey availability. Smaller pelagic fishes such as anchovies, herrings, and some jacks (*Trachurus* spp.) are planktivores. Larger pelagic species including sharks, tunas, mackerels, jacks, and barracudas feed on smaller pelagic species.

Demersal Fishes

Demersal fishes associate with either soft or hard (structured) bottom types. On a spatial scale of kilometers, fishes on soft bottom segregate into recognizable assemblages along gradients of water depth (Edelist et al., 2011). Characteristics of the sediments also influence the distribution of soft bottom demersal fishes. Offshore of Israel, medium to coarse sand is found from nearshore to approximately 80 m depth where it changes to mud. In inner shelf water depths (15 to 38 m), the soft bottom assemblage is composed of porgies (*Boops boops*, *Pagellus erythrinus*, *Lithognathus mormyrus*), lizardfishes (*Saurida undosquamis*), and goatfishes (*Upeneus pori*). In water depths greater than 84 m, hake (*Merluccius merluccius*), sparids (*Dentex macrophthalmus*), snipefishes (*Macroramphosus scolopax*), and goatfishes (*Mullus barbatus*, *Mullus* spp.) are prevalent. Some demersal species such as dragonets (*Callionymus filamentosus*), gurnards (*Lepidotrigla cavillone*, *Trigla* spp.), and flatfishes (*Bothus podas*, *Citharichthys lingulata*) live in direct contact with the substrate, whereas others, including conger eels (*Ariosoma baelericum*), cusk-eels (*Ophidion barbatum*), weavers (*Trachinus draco*), and stargazers (*Uranoscopus scaber*), remain buried (or partially buried) in the sediment. These species feed on a variety of invertebrates and small fishes (Edelist et al., 2011).

Limited study reveals that the demersal fish assemblages of the basin, where water depths range from 1,000 to 4,264 m, are numerically dominated by a tripodfish (*Bathypterois mediterraneus*) and a grenadier (*Nezumia sclerorhynchus*) (Jones et al., 2003; Galil, 2004). Other fishes included an anglerfish (*Lophius piscatorius*), forkbeards (*Phycis phycis*, *Phycis blennioides*), ghost shark (*Chimera monstrous*), 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 six-gill shark (*Hexanchus griseus*), blackmouth catshark (*Galeus melanostomus*), several gulper shark species (*Centrophorus* spp.), Portuguese dogfish (*Centroscymnus coelolepis*), and velvet belly (*Etmopterus spinax*) were recorded also.

Results of site-specific surveys in the Tamar Field indicate the presence of several demersal fish species. For example, the most common fish species observed during the July 2012 Environmental Baseline Survey at the Tamar SW-1 drillsite were tripod fish (*Bathypterois* sp.) and halosaurs (*Halosaurus* sp.).

1.2.3.4 Marine Mammals

There are no 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. **Table 1-4** lists marine mammal species that may be present in the Application Area.

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*), Cuvier's beaked whale (*Ziphius cavirostris*), 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 also 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).

Six of the species in **Table 1-4** are listed by the International Union for Conservation of Nature (IUCN) as critically endangered (Mediterranean monk seal), endangered (fin whale, sei whale, and north Atlantic right whale), or vulnerable (sperm whale and common bottlenose dolphin) (International Union for Conservation of Nature, 2014). Of these, the common bottlenose dolphin is the most abundant in the region and the only species 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 have not been reported in Israeli waters.

Table 1-4. Marine mammal species potentially occurring in the Application Area based on Kerem et al. (2012), ACCOBAMS (2012), and Notarbartolo di Sciara and Birkun (2010), and their International Union for Conservation of Nature (IUCN) status.

Common Name	Scientific Name	IUCN Status[1]	Presence Confirmed in Israeli Waters
Regular Species (Levantine Basin)			
Short-beaked common dolphin	*Delphinus delphis*	LC	Yes
Risso's dolphin	*Grampus griseus*	LC	Yes
Striped dolphin	*Stenella coeruleoalba*	LC	Yes
Rough-toothed dolphin	*Steno bredanensis*	LC	Yes
Common bottlenose dolphin	*Tursiops truncatus*	VU[2]	Yes
Cuvier's beaked whale	*Ziphius cavirostris*	LC	Yes
Visitor Species (Levantine Basin)			
Fin whale	*Balaenoptera physalus*	EN	Yes
Minke whale	*Balaenoptera acutorostrata*	LC	Yes
Sperm whale	*Physeter macrocephalus*	VU	Yes
False killer whale	*Pseudorca crassidens*	DD	Yes
Vagrant Species (Levantine Basin)			
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*	CR	No

[1] IUCN status: CR = critically endangered; DD = data deficient; EN = endangered; LC = least concern; VU = vulnerable.
[2] The VU designation for bottlenose dolphins applies to the Mediterranean subpopulation.

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, 2014). It is very unlikely that monk seals will be present in the Application Area because they are extremely rare within waters offshore Israel. A single monk seal was spotted off the coast of Herzliya in January 2010, the first sighting in recent decades. The last sightings of Mediterranean monk seals off Israel's coast prior to this event were 50 to 60 years ago.

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 is the most abundant cetacean in Israeli waters, accounting for 85% of reported sightings and 60% of strandings. Although most of the sightings are in coastal waters, there have been sightings up to 30 km offshore, over water depths of approximately 1,300 m. As noted previously, the Mediterranean subpopulation has been listed by the IUCN (2014) as vulnerable. The justification for this status includes evidence of substantial incidental mortality in fishing gear, overfishing of dolphin prey, habitat loss and degradation, disturbance by marine traffic, and high levels of contamination by pollutants (Bearzi et al., 2012).

1.2.3.5 Sea Turtles

There are no 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: the green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), and loggerhead turtle (*Caretta caretta*) (**Table 1-5**). The IUCN (2014) lists loggerhead and green turtles as endangered, and the leatherback turtle as vulnerable. The hawksbill turtle (*Eretmochelys imbricata*), a critically endangered species, also occurs occasionally in the Mediterranean Sea (Camiñas, 2004) but would not be expected within the Levantine Basin (Kot et al., 2013).

Table 1-5. Sea turtle species potentially occurring in the Application Area.

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

[1] International Union for Conservation of Nature (IUCN) status: EN = endangered; VU = vulnerable.

Loggerhead turtles and green turtles nest along the Israeli coast, with the loggerhead turtle being the most 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 also 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 National Parks Authority, there were 98 loggerhead turtle nests in 2009, 132 in 2010, and 139 in 2011; and there were 17 green turtle nests in 2009, 10 in 2010, and 25 in 2011 (Levy, 2011).

1.2.3.6 Seabirds and Migratory Birds

There are no site-specific bird data 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.

At least 38 seabird species are native to Israeli waters (**Table 1-6**), including 36 seabird species listed by BirdLife International (2014a) and 2 other species based on additional information (International Union for Conservation of Nature, 2014; 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 Storm-Petrel (*Oceanodroma leucorhoa*), Sooty Shearwater (*Puffinus griseus*), and Levantine 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 coastal waters.

Two of the seabirds listed in **Table 1-6** are vulnerable according to the IUCN (2014) Red List. The Levantine 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 basin of the Mediterranean, from Corsica and Sardinia through the central Mediterranean, the Adriatic, and the Aegean (International Union for Conservation of Nature, 2014). 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 of the 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*), Dalmatian Pelican, Great White Pelican (*Pelecanus onocrotalus*), Pygmy Cormorant (*Phalacrocorax pygmeus*), Levantine 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, the Great White Pelican and Little Tern, breed in Israel; their IUCN status is "least concern."

Annex II also includes several shorebirds reported from Israel as listed in **Table 1-7**. The Slender-billed Curlew (*Numenius tenuirostris*), is listed by the IUCN as critically endangered but 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.

Israel is well known as one of two major bird 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 Great White Pelicans.

The Mediterranean lies along seasonal migratory pathways for several European and African bird species; several species that breed in Europe over-winter in the Mediterranean Basin. Autumn and spring are the most active 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 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 their southern hemisphere wintering grounds before crossing the thousands kilometers of Arabian desert. The areas also provide a respite for these flying migrants on their way back.

Table 1-6. Seabird species occurring in Israeli waters (Adapted from: BirdLife International, 2014a).

Common Name	Scientific Name	IUCN Red List 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	--	--
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	--	--
Levantine 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	*Sterna nilotica*	LC	Yes	--
White-cheeked Tern	*Sterna repressa*	LC	--	--
Sandwich Tern	*Sterna sandvicensis*	LC	Yes	--
Brown Booby	*Sula leucogaster*	LC	--	--

1 International Union for Conservation of Nature (IUCN) status: CR = critically endangered; EN = endangered; 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 (2014) and their individual species descriptions on the BirdLife International website.

Table 1-7. Shorebird species occurring in Israel that are on the Annex II list.

Common Name	Scientific Name	IUCN Red List 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 smyrnensis*	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) status: CR = critically endangered; EN = endangered; LC = least concern; NT = near-threatened; VU = vulnerable.
[2] Occurrence in Israel based on IUCN (2014).
[3] Breeding in Israel based on BirdLife International (2014a) map viewer showing range and breeding locations.

BirdLife International (2014b) lists 315 migratory bird species as occurring in Israel. Of these, species listed by the IUCN (2014) as endangered, critically endangered, or vulnerable are: 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 (*Puffinus yelkouan*), Syrian Serin (*Serinus syriacus*), and Sociable Lapwing (*Vanellus gregarius*).

1.2.4 Seawater and Sediment Quality

1.2.4.1 Seawater Quality

This section reviews the Tamar Field portion of the results from the February 2014 Tamar Field Background Monitoring Survey and the March 2013 Tamar Field and Pipeline Survey (CSA Ocean Sciences Inc., 2014). As for the water column profiles, results from the February 2014 Survey are presented first because they constitute a more complete picture of the environmental conditions within the Tamar Field.

Total Suspended Solids

February 2014 Tamar Field Background Monitoring Survey

Total suspended solids (TSS) concentrations averaged 6.7 ± 1.6 mg/L in the near-surface, 5.2 ± 0.6 mg/L at mid-depth, and 5.7 ± 0.8 mg/L at the near-bottom during the February 2014 Survey. Values generally were similar among the four water stations located on the perimeter of the field and the station located in the center of the field (**Table 1-8**).

Table 1-8. Station concentrations of total suspended solids (TSS) in seawater samples collected throughout the water column during the February 2014 Tamar Field Background Monitoring Survey (From: CSA Ocean Sciences Inc., 2014).

Location	Station	Depth	TSS (mg/L)
Perimeter of Tamar Field	B08	Near-Surface	5.8
		Mid-Depth	5.3
		Near-Bottom	6.0
	C01	Near-Surface	7.1
		Mid-Depth	4.1
		Near-Bottom	6.2
	D17	Near-Surface	5.7
		Mid-Depth	5.3
		Near-Bottom	4.7
	H09	Near-Surface	5.6
		Mid-Depth	5.4
		Near-Bottom	4.9
Center of Tamar Field	E11	Near-Surface	9.3
		Mid-Depth	5.7
		Near-Bottom	6.6

March 2013 Tamar Field and Pipeline Survey

TSS concentrations at the near-bottom averaged 13.4 ± 22.0 mg/L during the March 2013 Tamar Field and Pipeline Survey. The high TSS concentration at Station TF1 (72.0 mg/L) was likely due to the resuspension of sediments near the seafloor due to ROV operations (**Table 1-9**). The removal of this station decreases the near-bottom average to 6.1 ± 1.3 mg/L, which is within one standard deviation of the February 2014 Survey results.

Table 1-9. Station concentrations of total suspended solids (TSS) in seawater samples collected from near-bottom water during the March 2013 Tamar Field and Pipeline Survey (From: CSA Ocean Sciences Inc., 2014).

Station	TSS (mg/L)
TF1	72.0
TF2	7.8
TF3	7.2
TF4	7.4
TF5	5.6
TF6	4.3
TF7	4.9
TF8	6.1
TF9	5.6

Similarity in TSS Concentrations Between Surveys

TSS concentrations in the near-bottom samples generally were similar among stations and surveys (**Table 1-10**). Concentrations from within the Tamar Field were slightly higher (0.4 to 0.9 mg/L) than stations located at the perimeter of the field; however, all values were well below the Levantine Basin mean concentrations. This indicates that TSS concentrations within the Tamar Field are uniform geographically as well as temporally.

Similar to previous surveys, TSS levels recorded from the survey area were higher than those reported for northeastern Mediterranean surface waters, which have been reported to range from 0.6 to 1.7 mg/L (Yilmaz et al., 1998). The eastern Mediterranean Sea is known as a highly oligotrophic body of water with high water column transparency. Historically, the low TSS levels and high water transparency expected in the eastern Mediterranean Sea are attributed to low water column productivity and low terrestrial inputs from riverine discharges. Deepsea near-bottom water generally has few suspended solids due to few disturbances stirring up the sediment on the seafloor; small particles transported from the surface usually are entrained in subsurface currents or pycnoclines (i.e., density gradient).

Table 1-10. Mean concentrations (± standard deviation) of total suspended solids (TSS) in seawater samples collected during the March 2013 Tamar Field and Pipeline Survey and the February 2014 Tamar Field Background Monitoring Survey. Levantine Basin means are provided for comparison (From: CSA Ocean Sciences Inc., 2014).

<table>
<tr><th>Survey</th><th>Location</th><th>Depth</th><th>TSS (mg/L)</th></tr>
<tr><td>March 2013</td><td>Inside Tamar Field*</td><td>Near-Bottom</td><td>6.1 ± 1.3</td></tr>
<tr><td rowspan="6">February 2014</td><td rowspan="3">Perimeter of Tamar Field</td><td>Near-Surface</td><td>6.7 ± 1.6</td></tr>
<tr><td>Mid-Depth</td><td>5.2 ± 0.6</td></tr>
<tr><td>Near-Bottom</td><td>5.7 ± 0.8</td></tr>
<tr><td>Center of Tamar Field</td><td>Near-Surface</td><td>9.3</td></tr>
<tr><td rowspan="2">Center of Tamar Field (continued)</td><td>Mid-Depth</td><td>5.7</td></tr>
<tr><td>Near-Bottom</td><td>6.6</td></tr>
<tr><td rowspan="3" colspan="2">Levantine Basin Mean**</td><td>Near-Surface</td><td>9.8 ± 7.7</td></tr>
<tr><td>Mid-Depth</td><td>9.9 ± 7.1</td></tr>
<tr><td>Near-Bottom</td><td>9.6 ± 8.2</td></tr>
</table>

*The anomalous high TSS concentration for TF1 has been removed from the mean and standard deviation because the result was due to sampling error.
**Mean and standard deviation calculated from pre-drill and environmental baseline surveys conducted by CSA prior to September 2013.

Nutrients

Seawater nutrient analysis consisted of total organic carbon (TOC), total nitrogen (TN), total phosphorus (TP), nitrite, nitrate, ammonium, and phosphate during the February 2014 Tamar Field Background Monitoring Survey. Only TN and TP were analyzed during the March 2013 Tamar Field and Pipeline Survey.

February 2014 Tamar Field Background Monitoring Survey

Nutrient concentrations in seawater samples were low and nearly uniform throughout the water column and survey area (**Table 1-11**). TOC concentrations were slightly higher in the near-surface (0.70 ± 0.10 mg/L) than in the near-bottom (0.51 ± 0.08 mg/L). TN concentrations were slightly higher in the mid-depth (0.17 ± 0.01 mg/L) than in the near-surface (0.12 ± 0.01 mg/L) or in the near-bottom (0.15 ± 0.01 mg/L). Concentrations of nitrite, nitrate, TP, and phosphate were negligible throughout the survey region. There was no appreciable difference between stations located at the perimeter of the reservoir and the station located at the center of the field.

Table 1-11. Station concentrations of total organic carbon (TOC), total nitrogen (TN), nitrite (NO_2), nitrate (NO_3), ammonium (NH_4), total phosphorus (TP), and phosphate (PO_4) in seawater samples collected throughout the water column during the February 2014 Tamar Field Background Monitoring Survey (From: CSA Ocean Sciences Inc., 2014).

Location	Station	Depth	Concentration (mg/L)						
			TOC	TN	NO_2	NO_3	NH_4	TP	PO_4
Perimeter of Tamar Field	B08	Near-Surface	0.65	0.12	0.0007	0.035	0.001	0.010	0.003
		Mid-Depth	0.47	0.16	0.0007	0.081	0.001	0.015	0.008
		Near-Bottom	0.49	0.17	0.0007	0.075	0.001	0.011	0.007
	C01	Near-Surface	0.87	0.11	0.0007	0.039	0.001	0.007	0.004
		Mid-Depth	0.72	0.18	0.0007	0.080	0.001	0.016	0.007
		Near-Bottom	0.63	0.16	0.0007	0.072	0.001	0.012	0.007
	D17	Near-Surface	0.69	0.11	0.0007	0.065	0.001	0.007	0.006
		Mid-Depth	0.55	0.15	0.0007	0.074	0.001	0.011	0.007
		Near-Bottom	0.41	0.14	0.0007	0.023	0.001	0.012	0.003
	H09	Near-Surface	0.62	0.13	0.0008	0.040	0.001	0.010	0.004
		Mid-Depth	0.50	0.17	0.0007	0.070	0.003	0.019	0.007
		Near-Bottom	0.48	0.14	0.0008	0.063	0.001	0.013	0.007
Center of Tamar Field	E11	Near-Surface	0.68	0.14	0.0007	0.033	0.001	0.009	0.004
		Mid-Depth	0.48	0.17	0.0007	0.073	0.001	0.012	0.007
		Near-Bottom	0.54	0.15	0.0007	0.067	0.001	0.013	0.007

March 2013 Tamar Field and Pipeline Survey

Near-bottom nutrient concentrations during the March 2013 Tamar Field and Pipeline Survey were low and uniform throughout the survey area (**Table 1-12**). TN concentrations averaged 0.17 ± 0.04 mg/L, while TP concentrations averaged 0.01 ± 0.002 mg/L.

Table 1-12. Station concentrations of total nitrogen (TN) and total phosphorus (TP) in seawater samples collected near the seafloor during the March 2013 Tamar Field and Pipeline Survey (From: CSA Ocean Sciences Inc., 2014).

Station	TN (mg/L)	TP (mg/L)
TF1	0.20	0.009
TF2	0.13	0.012
TF3	0.14	0.013
TF4	0.14	0.013
TF5	0.26	0.009
TF6	0.14	0.009
TF7	0.16	0.009
TF8	0.17	0.011
TF9	0.20	0.011

Similarity in Nutrient Concentrations Between Surveys

Concentrations of TN and TP were similar between the two surveys (**Table 1-13**). TOC, nitrite, nitrate, ammonium, and phosphate were not analyzed during the March 2013 Tamar Field and Pipeline Survey; therefore no comparison can be made regarding these five nutrients. All nutrient concentrations generally were similar regardless of whether the sample was collected inside the field or the perimeter. This indicates that like other water column constituents discussed previously, TSS concentrations within the Tamar Field are uniform geographically as well as temporally. Concentrations of all nutrients were also well below the Levantine Basin mean and the proposed Mediterranean Sea water quality standards in Israel (MEQS).

The eastern Levantine Basin has extremely low levels of nutrients, and the region is considered "ultra-oligotrophic." Nitrate and phosphate concentrations in surface waters in the eastern Mediterranean are one-half their concentrations in the western basin (Bethoux et al., 1992). This severe nutrient deficit in the Mediterranean Sea is because the distant Atlantic Ocean inflow brings in nutrient-depleted surface waters and there is very little nutrient input from rivers in the eastern Levantine Basin (Krom, 1995).

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. Generally, TOC levels are the net result of mineralization of organic matter (i.e., transformation of organic material to inorganic forms), uptake and respiration (oxidation into carbon dioxide) by microorganisms, and releases from organisms in the water column.

Table 1-13. Mean concentrations (± standard deviation) of total organic carbon (TOC), total nitrogen (TN), nitrite (NO_2), nitrate (NO_3), total phosphorus (TP), and phosphate (PO_4) in seawater samples collected during the March 2013 Tamar Field and Pipeline Survey and the February 2014 Tamar Field Background Monitoring Survey. Mean (± standard deviation) Levantine Basin baseline survey data and the proposed Mediterranean Sea water quality standards (MEQS) in Israel are provided for comparison (Ministry of Environmental Protection, 2002). Levantine Basin mean and standard deviation is calculated from pre-drill and environmental baseline surveys conducted prior to September 2013 (From: CSA Ocean Sciences Inc., 2014).

Survey	Location	Depth	Concentration (mg/L)						
			TOC	TN	NO_2	NO_3	NH_4	TP	PO_4
March 2013	Inside Tamar Field	Near-Bottom	N/A	0.17 ± 0.01	N/A	N/A	N/A	0.011 ± 0.002	N/A
February 2014	Perimeter of Tamar Field	Near-Surface	0.71 ± 0.11	0.12 ± 0.01	0.001 ± 0.000	0.045 ± 0.013	0.001 ± 0.000	0.008 ± 0.002	0.004 ± 0.001
		Mid-Depth	0.56 ± 0.11	0.17 ± 0.01	0.001 ± 0.000	0.076 ± 0.005	0.002 ± 0.001	0.015 ± 0.003	0.007 ± 0.000
		Near-Bottom	0.50 ± 0.09	0.15 ± 0.01	0.001 ± 0.000	0.058 ± 0.024	0.001 ± 0.000	0.012 ± 0.001	0.006 ± 0.001
	Center of Tamar Field	Near-Surface	0.68	0.14	0.0007	0.033	0.001	0.009	0.004
		Mid-Depth	0.48	0.17	0.0007	0.073	0.001	0.012	0.007
		Near-Bottom	0.54	0.15	0.0007	0.067	0.001	0.013	0.007
Levantine Basin Mean		Near-Surface	1.72 ± 0.14	0.44 ± 0.49	N/A	N/A	N/A	0.008 ± 0.004	N/A
		Mid-Depth	0.89 ± 0.22	0.48 ± 0.47	N/A	N/A	N/A	0.014 ± 0.002	N/A
		Near-Bottom	0.84 ± 0.14	0.48 ± 0.48	N/A	N/A	N/A	0.011 ± 0.002	N/A
Proposed MEQS in Israel			N/A	1.0	N/A	N/A	0.5	0.1	N/A

N/A = data not available.

Ions

Cation and anion concentrations were analyzed only in seawater samples from the February 2014 Tamar Field Background Monitoring Survey. Ions were not included in the analysis of seawater samples collected during the March 2013 Tamar Field and Pipeline Survey.

Results of major ion composition analysis in seawater samples collected from several stations in the Tamar Field are presented in **Figure 1-49** and **Table 1-14**. The cation/anion balance for all water samples are within the acceptable ±5% analytical difference for seawater samples (**Table 1-14** and **Figure 1-50**). All ion concentrations were similar to worldwide and Mediterranean Sea means with the exception of sulfate, which was slightly elevated over Mediterranean Sea means at a few locations (**Table 1-14**). Sulfate is a major component of seawater, accounting for approximately 8% of its ionic composition; in the Tamar Field, it accounts for 7% to 10% of the ionic composition of seawater. The two stations with the highest sulfate concentrations occur in the near-surface or mid-depth, indicating that these slightly higher than average levels are unlikely to be due to drilling and/or production activities occurring in the field.

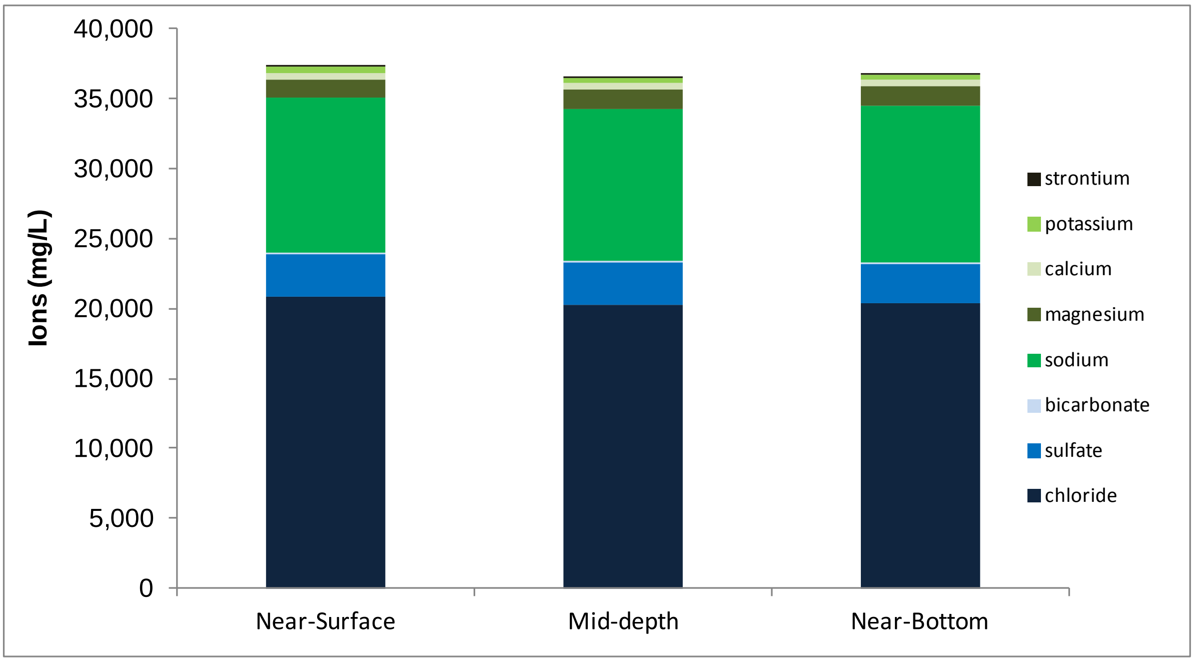


Figure 1-49. Ionic concentration and composition of seawater collected from near-surface, mid-depth, and near-bottom within the Tamar Field. Shades of blue represent anion concentrations (chloride, sulfate, bicarbonate); shades of green represent cation concentrations (sodium, magnesium, calcium, potassium, strontium) (From: CSA Ocean Sciences Inc., 2014).

Table 1-14. Major ion composition and ionic balance of seawater samples collected within the Tamar Field (From: CSA Ocean Sciences Inc., 2014).

Location	Station	Depth	Anions (mg/L)			Cations (mg/L)					Ionic Balance		
			Chloride	Sulfate	Bicarbonate	Sodium	Magnesium	Calcium	Potassium	Strontium	Anion (meq/L)	Cation (meq/L)	% Difference
Perimeter of Tamar Field	B08	Near-Surface	21,800	3,250	132	11,200	1,390	466	441	8.36	685.24	636.12	3.70
		Mid-Depth	20,100	2,580	127	10,900	1,350	443	427	7.98	623.23	618.27	0.40
		Near-Bottom	21,100	2,480	131	11,400	1,380	468	441	8.45	649.44	644.09	0.40
	C01	Near-Surface	21,300	2,570	129	11,000	1,350	455	432	8.24	656.92	623.35	2.60
		Mid-Depth	20,500	2,910	129	11,300	1,380	460	442	8.26	641.43	639.56	0.10
		Near-Bottom	21,100	2,710	128	11,500	1,410	463	451	8.32	654.17	651.11	0.20
	D17	Near-Surface	19,700	3,750	121	10,800	1,320	433	425	7.77	636.19	611.08	2.00
		Mid-Depth	19,300	2,700	120	10,200	1,250	422	399	7.49	603.03	578.00	2.10
		Near-Bottom	20,100	2,980	124	10,900	1,340	442	429	7.94	631.50	617.63	1.10
	H09	Near-Surface	19,900	2,790	128	11,100	1,360	454	434	8.17	621.98	628.71	0.50
		Mid-Depth	20,500	2,910	127	11,000	1,350	457	432	8.21	641.39	623.63	1.40
		Near-Bottom	18,100	2,530	126	10,800	1,320	449	423	8.11	565.75	611.83	3.90
Center of Tamar Field	E11	Near-Surface	21,300	3,130	128	10,900	1,340	457	429	8.26	668.56	618.39	3.90
		Mid-Depth	21,100	3,610	129	11,300	1,380	465	437	8.24	672.93	639.68	2.50
		Near-Bottom	21,400	3,110	131	11,600	1,410	459	454	8.23	671.02	655.33	1.20
Worldwide Mean[1]			19,000	2,649	140	10,556	1,272	400	380	13	N/A	N/A	N/A
Mediterranean Sea Mean[2]			21,200	2,950	120 – 161[3]	11,800	1,403	423	463	5 – 7.5[3]	N/A	N/A	N/A

N/A = not available.
[1] Libes, 2011.
[2] Al-Mutaz, 2000.
[3] Millero, 2005.

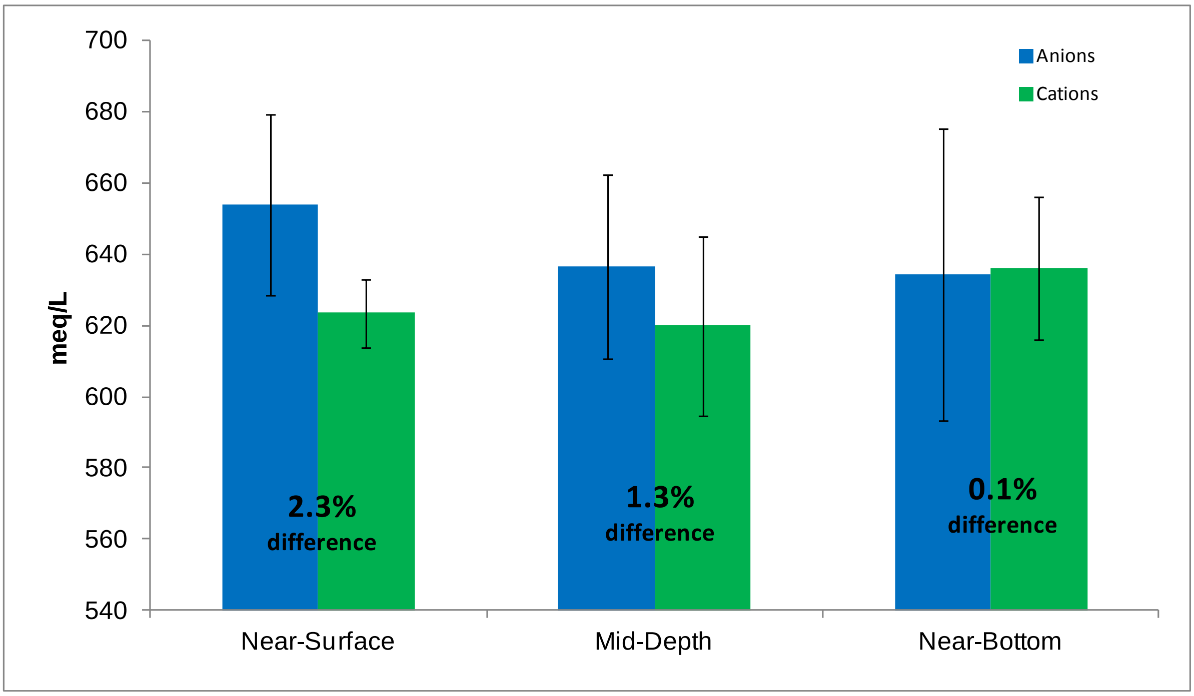


Figure 1-50. Means (± standard deviation) of the sum of anions and cations in seawater collected from the near-surface, mid-depth, and near-bottom within the Tamar Field. The percent difference between anions and cations in water samples are all below the ±5% threshold for analytical acceptability (From: CSA Ocean Sciences Inc., 2014).

Metals

Total and dissolved metals concentrations in seawater were analyzed by ALS Environmental in Kelso, Washington, U.S. for the February 2014 Tamar Field Background Monitoring Survey. Total metals concentrations in seawater were analyzed by Geological Survey of Israel in Jerusalem, Israel for the March 2013 Tamar Field and Pipeline Survey. Dissolved metals were not analyzed from the March 2013 Survey.

February 2014 Tamar Field Background Monitoring Survey

Total and dissolved metals concentrations in seawater were either below or just above the method reporting limit for the analytical laboratory (**Tables 1-15** and **1-16**). Values were similar among the four water stations located on the perimeter of the field and the station located in the center of the field. Concentrations generally were similar between total and dissolved metals fractions. This indicates that metals concentrations, when detectable, will be bio-available.

Dissolved zinc concentrations were higher than total zinc concentrations (**Tables 1-15** and **1-16**), which is contrary to what would be expected. The equipment and field blanks (composed of deionized water) for total zinc had concentrations of 1.0 and 7.6 µg/L, respectively. The equipment and field blanks for dissolved zinc concentrations were 2.5 and 8.3 µg/L, respectively. The zinc concentrations in the field blanks were relatively high for both the total and dissolved fraction. While this does not explain why the dissolved fraction was higher than the total fraction, it does suggest a potential source of zinc contamination that may have affected the results.

March 2013 Tamar Field and Pipeline Survey

Total metals concentrations in seawater were below the method reporting limit for the analytical laboratory, except for barium, which had a low concentration at each station (**Table 1-17**).

Similarity in Metals Concentrations Between Surveys

Mean (± standard deviation) metals concentrations for the March 2013 Tamar Field and Pipeline Survey and the February 2014 Tamar Field Background Monitoring Survey are reported in **Table 1-18**. **Table 1-18** also compares these values to Israel's MEQS (Ministry of Environmental Protection, 2002), European Union Commission on Environmental Quality Standards (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). Where the U.S. Environmental Protection Agency's (USEPA's) National Recommended Water Quality Criteria (Buchman, 2008) are not available for a metal, criteria from other countries (e.g., New Zealand) are provided for reference. All seawater total and dissolved metals concentrations were below Israel's MEQS, EUCEQS, and CCC reference values, indicating there are no seawater metals concentrations of concern within the region. Metals concentrations were also similar to concentrations reported elsewhere within the Levantine Basin (**Table 1-18**). Similarity among surveys and locations indicates that metals concentrations, when detected, are bio-available dissolved fractions and that concentrations are uniform geographically as well as temporally within the Tamar Field.

Table 1-15. Total metals concentrations (μg/L) in seawater collected during the February 2014 Tamar Field Background Monitoring Survey, with the analytical laboratory's (ALS Environmental) method detection limit (From: CSA Ocean Sciences Inc., 2014).

Location	Station	Depth	Ag	As	Ba	Be	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	V	Zn
Perimeter of Tamar Field	B08	Near-Surface	<0.03	1.5	8.6	<0.03	<0.03	<0.3	0.2	<0.001	0.3	<0.03	<1.0	<1.0	<0.03	<4.0	<0.7
		Mid-Depth	<0.03	1.4	7.5	<0.03	<0.03	<0.3	0.2	<0.001	0.3	<0.03	<1.0	<1.0	<0.03	<4.0	<0.7
		Near-Bottom	<0.03	1.5	11.1	<0.03	<0.03	0.3	0.2	0.015	0.3	0.06	<1.0	<1.0	<0.03	<4.0	0.9
	C01	Near-Surface	0.04	1.5	8.4	<0.03	<0.03	0.3	0.3	<0.001	0.3	0.07	<1.0	<1.0	0.04	<4.0	4.9
		Mid-Depth	<0.03	1.5	16.9	<0.03	<0.03	0.3	0.2	<0.001	0.3	0.03	<1.0	<1.0	<0.03	4.6	1.1
		Near-Bottom	<0.03	1.5	11.7	<0.03	<0.03	0.3	0.2	<0.001	0.3	0.04	<1.0	<1.0	<0.03	<4.0	<0.7
	D17	Near-Surface	<0.03	1.5	8.4	<0.03	<0.03	0.3	0.2	<0.001	0.3	0.03	<1.0	<1.0	<0.03	<4.0	<0.7
		Mid-Depth	<0.03	1.5	11.0	<0.03	<0.03	0.3	0.2	<0.001	0.3	<0.03	<1.0	<1.0	<0.03	4.0	<0.7
		Near-Bottom	<0.03	1.5	11.4	<0.03	<0.03	0.3	0.2	<0.001	0.3	0.04	<1.0	<1.0	<0.03	<4.0	1.0
	H09	Near-Surface	<0.03	1.5	8.2	<0.03	<0.03	<0.3	0.2	<0.001	0.3	<0.03	<1.0	<1.0	<0.03	<4.0	<0.7
		Mid-Depth	<0.03	1.5	12.7	<0.03	<0.03	0.3	0.1	<0.001	0.3	<0.03	<1.0	<1.0	<0.03	<4.0	0.9
		Near-Bottom	<0.03	1.5	11.6	<0.03	<0.03	0.3	0.2	<0.001	0.3	<0.03	<1.0	<1.0	<0.03	<4.0	0.7
Center of Tamar Field	E11	Near-Surface	<0.03	1.5	8.2	<0.03	<0.03	0.3	0.2	<0.001	0.3	0.03	<1.0	<1.0	<0.03	<4.0	<0.7
		Mid-Depth	<0.03	1.5	11.3	<0.03	<0.03	0.3	0.1	<0.001	0.3	0.03	<1.0	<1.0	<0.03	<4.0	<0.7
		Near-Bottom	<0.03	1.5	11.4	<0.03	<0.03	0.3	0.2	<0.001	0.3	0.04	<1.0	<1.0	<0.03	<4.0	0.8
Method reporting limit of laboratory			0.03	0.7	4.0	0.03	0.03	0.3	0.1	0.001	0.3	0.03	1.0	1.0	0.03	4.0	0.7

Ag = silver; As = arsenic; Ba = barium; Be = beryllium; Cd = cadmium; Cr = chromium; Cu = copper; Hg = mercury; Ni = nickel; Pb = lead; Sb = antimony; Se = selenium; Tl = thallium; V = vanadium; Zn = zinc.

Table 1-16. Dissolved metals concentrations (µg/L) in seawater collected during the February 2014 Tamar Field Background Monitoring Survey, with the analytical laboratory's (ALS Environmental) method reporting limit (From: CSA Ocean Sciences Inc., 2014).

Location	Station	Depth	Ag	As	Ba	Be	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	V	Zn
Perimeter of Tamar Field	B08	Near-Surface	<0.03	1.5	8.6	<0.03	<0.03	0.3	0.4	<0.001	0.3	0.05	<1.0	<1.0	<0.03	<4.0	4.9
		Mid-Depth	<0.03	1.5	12.7	<0.03	<0.03	0.3	0.3	<0.001	0.3	0.10	<1.0	<1.0	<0.03	<4.0	2.0
		Near-Bottom	<0.03	1.5	11.1	<0.03	<0.03	0.3	0.4	<0.001	0.3	0.07	<1.0	<1.0	<0.03	<4.0	1.9
	C01	Near-Surface	<0.03	1.5	9.2	0.06	<0.03	0.3	0.8	<0.001	0.3	0.14	<1.0	<1.0	<0.03	<4.0	3.0
		Mid-Depth	<0.03	1.6	11.5	<0.03	<0.03	0.3	0.4	<0.001	0.4	0.10	<1.0	<1.0	<0.03	<4.0	2.7
		Near-Bottom	<0.03	1.5	11.2	<0.03	<0.03	0.3	0.4	<0.001	0.3	0.10	<1.0	<1.0	<0.03	<4.0	3.9
	D17	Near-Surface	<0.03	1.5	9.5	<0.03	<0.03	0.3	0.3	<0.001	0.3	0.05	<1.0	<1.0	<0.03	<4.0	4.0
		Mid-Depth	<0.03	1.5	12.3	<0.03	<0.03	0.3	0.3	<0.001	0.3	0.05	<1.0	<1.0	<0.03	<4.0	3.1
		Near-Bottom	<0.03	1.5	12.0	<0.03	<0.03	0.3	0.3	<0.001	0.4	0.05	<1.0	<1.0	<0.03	4.1	2.2
	H09	Near-Surface	<0.03	1.5	9.9	<0.03	<0.03	0.3	0.3	<0.001	0.3	0.06	<1.0	<1.0	<0.03	<4.0	3.7
		Mid-Depth	<0.03	1.5	12.4	<0.03	<0.03	0.3	0.4	<0.001	0.3	0.03	<1.0	<1.0	<0.03	<4.0	2.0
		Near-Bottom	<0.03	1.5	12.8	<0.03	<0.03	0.3	0.3	<0.001	0.3	0.05	<1.0	<1.0	<0.03	4.1	2.4
Center of Tamar Field	E11	Near-Surface	<0.03	1.5	9.8	<0.03	<0.03	0.3	0.3	<0.001	0.4	0.07	<1.0	<1.0	<0.03	<4.0	1.9
		Mid-Depth	<0.03	1.4	12.1	<0.03	<0.03	<0.3	0.3	<0.001	0.4	0.05	<1.0	<1.0	<0.03	<4.0	1.6
		Near-Bottom	<0.03	1.5	11.8	<0.03	<0.03	0.3	0.3	<0.001	0.3	0.06	<1.0	<1.0	<0.03	<4.0	2.4
Method reporting limit of laboratory			0.03	0.7	4.0	0.03	0.03	0.3	0.1	0.001	0.3	0.03	1.0	1.0	0.03	4.0	0.7

Ag = silver; As = arsenic; Ba = barium; Be = beryllium; Cd = cadmium; Cr = chromium; Cu = copper; Hg = mercury; Ni = nickel; Pb = lead; Sb = antimony; Se = selenium; Tl = thallium; V = vanadium; Zn = zinc.

Table 1-17. Total metals concentrations (μg/L) in seawater collected during the March 2013 Tamar Field and Pipeline Survey, with the analytical laboratory's (Geological Survey of Israel) method reporting limit (From: CSA Ocean Sciences Inc., 2014).

Station	Ag	As	Ba	Be	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	V	Zn
TF1	<0.1	<7.0	10	<0.5	<0.1	<10	<1.0	<0.02	<1.0	<0.1	<0.2	<7.0	<0.1	<10	<2.0
TF2	<0.1	<7.0	10	<0.5	<0.1	<10	<1.0	<0.02	<1.0	<0.1	<0.2	<7.0	<0.1	<10	<2.0
TF3	<0.1	<7.0	10	<0.5	<0.1	<10	<1.0	<0.02	<1.0	<0.1	<0.2	<7.0	<0.1	<10	<2.0
TF4	<0.1	<7.0	9	<0.5	<0.1	<10	<1.0	<0.02	<1.0	<0.1	<0.2	<7.0	<0.1	<10	<2.0
TF5	<0.1	<7.0	9	<0.5	<0.1	<10	<1.0	<0.02	<1.0	<0.1	<0.2	<7.0	<0.1	<10	<2.0
TF6	<0.1	<7.0	9	<0.5	<0.1	<10	<1.0	<0.02	<1.0	<0.1	<0.2	<7.0	<0.1	<10	<2.0
TF7	<0.1	<7.0	9	<0.5	<0.1	<10	<1.0	<0.02	<1.0	<0.1	<0.2	<7.0	<0.1	<10	<2.0
TF8	<0.1	<7.0	9	<0.5	<0.1	<10	<1.0	<0.02	<1.0	<0.1	<0.2	<7.0	<0.1	<10	<2.0
TF9	<0.1	<7.0	9	<0.5	<0.1	<10	<1.0	<0.02	<1.0	<0.1	<0.2	<7.0	<0.1	<10	<2.0
Method reporting limit of laboratory	0.5	7	0.2	0.5	0.1	10	1	0.02	0.1	0.1	0.2	7	0.1	10	2

Ag = silver; As = arsenic; Ba = barium; Be = beryllium; Cd = cadmium; Cr = chromium; Cu = copper; Hg = mercury; Ni = nickel; Pb = lead; Sb = antimony; Se = selenium; Tl = thallium; V = vanadium; Zn = zinc.

Table 1-18. Mean (± standard deviation) metals concentrations (µg/L) in seawater from the March 2013 Tamar Field and Pipeline Survey and February 2014 Tamar Field Background Monitoring Survey (with comparisons to toxicity reference values, Criterion Continuous Concentrations [CCCs]) (Buchman, 2008), mean Levantine Basin baseline survey data, proposed Mediterranean Environmental Water Quality Standards (MEQS) in Israel (Ministry of Environmental Protection, 2002), and European Union Commission on Environmental Quality Standards (EUCEQS) for priority substances in the field of water policy (Directive 2008/105/EC and proposed amendment COM(2011)876). Beryllium, cadmium, silver, selenium, thallium, and vanadium are not included in this table because all means were less than the laboratories detection limit, and therefore less than established environmental characterization values (From: CSA Ocean Sciences Inc., 2014).

Analytical Fraction	Survey	Location	Depth	Concentration (µg/L)								
				As	Ba	Cr	Cu	Hg	Ni	Pb	Sb	Zn
Total Metals	March 2013	Inside Tamar Field	Near-Bottom	<7.0	9.3 ± 0.5	<10.0	<1.0	<0.02	<1.0	<0.1	<0.2	<2.0
	February 2014	Perimeter of Tamar Field	Near-Surface	1.5 ± 0.0	8.4 ± 0.2	0.3 ± 0.0	0.2 ± 0.1	0.004 ± 0.007	0.3 ± 0.0	0.05 ± 0.03	<1.0	1.5 ± 2.3
			Mid-Depth	1.5 ± 0.1	12.0 ± 3.9	0.3 ± 0.0	0.2 ± 0.1	<0.001	0.3 ± 0.0	0.03 ± 0.00	<1.0	0.7 ± 0.4
			Near-Bottom	1.5 ± 0.0	11.5 ± 0.3	0.3 ± 0.0	0.2 ± 0.0	<0.001	0.3 ± 0.0	0.05 ± 0.01	<1.0	0.7 ± 0.3
		Center of Tamar Field	Near-Surface	1.5	8.2	0.3	0.2	<0.001	0.3	0.03	<1.0	<0.7
			Mid-Depth	1.4	11.3	0.3	0.1	<0.001	0.3	0.03	<1.0	<0.7
			Near-Bottom	1.5	11.4	0.3	0.2	<0.001	0.3	0.04	<1.0	0.8
	Levantine Basin Mean		Near-Surface	1.31 ± 0.17	9.11 ± 1.59	0.34 ± 0.39	0.29 ± 0.11	0.5 ± 0	0.77 ± 1.02	0.07 ± 0.05	0.55 ± 0.15	7.19 ± 12.56
			Mid-Depth	1.35 ± 0.15	11.8 ± 0.43	0.2 ± 0.08	0.22 ± 0.04	0.5 ± 0	1.65 ± 1.9	0.04 ± 0.02	0.6 ± 0.24	1.03 ± 0.69
			Near-Bottom	1.32 ± 0.15	13.12 ± 2.27	0.18 ± 0.06	0.18 ± 0.04	0.5 ± 0	1.09 ± 0.76	0.04 ± 0.04	0.5 ± 0.0	0.98 ± 0.72

Table 1-18. (Continued).

Analytical Fraction	Survey	Location	Depth	Concentration (µg/L)								
				As	Ba	Cr	Cu	Hg	Ni	Pb	Sb	Zn
Dissolved Metals	February 2014	Perimeter of Tamar Field	Near-Surface	1.5 ± 0.0	9.3 ± 0.5	0.3 ± 0.0	0.5 ± 0.2	<0.001	0.3 ± 0.0	0.08 ± 0.04	<1.0	3.9 ± 0.8
			Mid-Depth	1.5 ± 0.1	12.2 ± 0.5	0.3 ± 0.0	0.4 ± 0.1	<0.001	0.3 ± 0.1	0.07 ± 0.04	<1.0	2.5 ± 0.5
			Near-Bottom	1.5 ± 0.0	11.8 ± 0.8	0.3 ± 0.0	0.4 ± 0.1	<0.001	0.3 ± 0.1	0.07 ± 0.02	<1.0	2.6 ± 0.9
		Center of Tamar Field	Near-Surface	1.5	9.8	0.3	0.3	<0.001	0.4	0.07	<1.0	1.9
			Mid-Depth	1.4	12.1	<0.3	0.3	<0.001	0.4	0.05	<1.0	1.6
			Near-Bottom	1.5	11.8	0.3	0.3	<0.001	0.3	0.06	<1.0	2.4
	Levantine Basin Mean		Near-Surface	1.27 ± 0.08	8.98 ± 0.43	0.25 ± 0.08	0.42 ± 0.15	0.6 ± 0.24	0.65 ± 0.35	0.08 ± 0.05	0.5 ± 0	5.1 ± 5.5
			Mid-Depth	1.33 ± 0.27	11.8 ± 0.28	0.28 ± 0.13	0.3 ± 0.09	0.5 ± 0	0.88 ± 0.66	0.05 ± 0.02	0.5 ± 0	14.63 ± 28.28
			Near-Bottom	1.35 ± 0.1	12.28 ± 0.92	0.25 ± 0.08	0.23 ± 0.05	0.5 ± 0	0.78 ± 0.7	0.05 ± 0.03	0.5 ± 0	2.18 ± 2.39
	Proposed MEQS in Israel		Mean	36	N/A	10	5	0.16	10	5	N/A	40
			Maximum	69	N/A	20	10	0.4	50	20	N/A	100
	EUCEQS (Directive 2008/105/EC and proposed amendment COM(2011)876)		MAC	N/A	N/A	N/A	N/A	0.07	34.0	14	N/A	N/A
			AAC	N/A	N/A	N/A	N/A	N/A	8.6	1.3	N/A	N/A
	CCC Value[3]			36	200 BC	50	3.1	0.94	8.2	8.1	500[p]	81

AAC = annual average concentration; As = arsenic; Ba = barium; Cr = chromium; Cu = copper; Hg = mercury; MAC = maximum allowable concentration; N/A = parameter not analyzed; Ni = nickel; Pb = lead; Sb = antimony; Zn = zinc.

[1]Concentrations lower than reported method detection limits may be due to slight variations in analyzed sample volumes.

[2]Levantine Basin baseline data mean calculated from pre-drill and environmental baseline surveys conducted by CSA prior to September 2013.

[3]Sources of CCC toxicity reference values: primary entry is the U.S. Ambient Water Quality Criteria; BC = British Columbia Water Quality Guidelines.

[p] = proposed.

-- = concentration not determined.

Hydrocarbons

February 2014 Tamar Field Background Monitoring Survey

Seawater total petroleum hydrocarbons (TPH) concentrations were low but detectable throughout the survey region (**Table 1-19**). Higher concentrations of TPH generally were found in near-surface water samples in comparison to mid-depth or near-bottom samples. Seawater polycyclic aromatic hydrocarbon (PAH) concentrations were also low, with many PAHs below the laboratory's method detection limit. PAHs were dominated by phenanthrene and naphthalene compounds.

March 2013 Tamar Field and Pipeline Survey

Seawater TPH concentrations were below the analytical laboratory's detection limit (**Table 1-20**). Seawater PAH concentrations were also low, with the majority of PAHs below the laboratory's detection limit. PAHs were dominated by phenanthrene and naphthalene compounds.

Relatively high concentrations of PAHs, compared to the rest of the survey area, were found in the near-bottom seawater sample at station TF6 (**Table 1-20**). The TPH concentration was not detected at this station. The location of station TF6 is approximately 1 km northwest from the nearest wellsite (Tamar-5) (**Appendix A**), indicating that it is likely far enough away and not in the downstream direction of bottom currents to be influenced by this wellsite; therefore, it is not possible to interpret the cause of elevated PAH concentrations at this location.

Similarity in Hydrocarbon Concentrations Between Surveys

Mean hydrocarbon concentrations for the March 2013 Tamar Field and Pipeline Survey and February 2014 Tamar Field Background Monitoring Survey are reported in **Table 1-21**. TPH concentrations during the February 2014 Survey were similar to and within one standard deviation of the Levantine Basin mean throughout the water column. TPH concentrations were higher during the February 2014 Survey than during the March 2013 Survey; however, the explanation for this is unknown. During the March 2013 Survey, water samples were collected in close proximity (within 1 km) to existing infrastructure, while water samples collected during the February 2014 Survey generally were collected more than 5 km away from the existing infrastructure and on the perimeter of the reservoir (with the exception of station E11). TPH analysis on equipment and field blanks for these sample produced concentrations of 25 and 30 μg/L, respectively. While concentrations within these blanks were higher than the March 2013 samples, and indicate that some contamination from the water column or ship may have taken place, these concentrations are not high enough to account for the difference between surveys. It must be noted that TPH concentrations reported for the February 2014 Survey are extremely low and do not indicate a level of environmental concern.

PAH concentrations were similar between surveys with the exception of the relatively high values reported for Station TF6 during the March 2013 Tamar Field and Pipeline Survey. All applicable values are below the CCC (Buchman, 2008) (**Table 1-21**). Naphthalene and fluoranthene means are below the maximum allowable concentration (MAC) and annual average concentration (AAC) of the EUCEQS (**Table 1-21**). The analytical laboratory's detection limit of benzo(b)fluoranthene, benzo(k,j)fluoranthene, benzo(a)pyrene, ideno(1,2,3-c,d)pyrene is above that of the MAC and benzo(g,h,i)perylene is above that of the MAC and AAC of EUCEQS. The laboratory only detected these samples at Station TF6 during the March 2013 Survey (**Table 1-20**). Mean PAH concentrations for both surveys were low and do not indicate any source of environmental concern.

Table 1-19. Hydrocarbon concentrations in seawater from the February 2014 Tamar Field Background Monitoring Survey. Total petroleum hydrocarbons (TPH) and the U.S. Environmental Protection Agency priority polycyclic aromatic hydrocarbons (PAHs) are represented (From: CSA Ocean Sciences Inc., 2014).

Location	Station	Depth	TPH (µg/L)	PAH (ng/L)															
				Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene/Triphenylene	Benzo(b)fluoranthene	Benzo(k,j)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-c,d)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,i)perylene
Perimeter of Tamar Field	B08	Near-Surface	41.1	6.60	<1.3	<1.5	1.25	<0.8	8.84	4.87	3.42	<0.8	<0.9	<2.6	<2.7	<2.1	<1.5	<1.2	<2.7
		Mid-Depth	77.7	6.61	<1.3	<1.5	1.16	0.42	7.29	3.06	2.30	0.70	0.27	<2.6	<2.7	<2.1	<1.5	<1.2	<2.7
		Near-Bottom	22.7	4.89	<1.3	<1.6	1.14	<0.8	5.86	2.47	2.16	<0.8	<0.9	<2.6	<2.7	<2.1	<1.5	<1.2	<2.7
	C01	Near-Surface	49.5	4.71	<1.2	<1.5	0.48	<0.8	2.74	0.86	1.54	<0.8	<0.8	<2.5	<2.6	<2	<1.5	<1.2	<2.6
		Mid-Depth	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Near-Bottom	9.6	3.83	<1.2	<1.5	0.75	<0.8	3.42	0.88	1.61	<0.8	<0.8	<2.5	<2.6	<2	<1.5	<1.2	<2.6
	D17	Near-Surface	89.1	5.87	0.80	2.01	1.25	<0.8	8.21	4.12	2.83	0.83	0.32	<2.5	<2.6	<2	<1.5	<1.2	<2.6
		Mid-Depth	33.5	6.29	0.77	2.30	1.19	<0.8	7.42	3.20	2.21	0.74	0.24	<2.6	<2.8	<2.1	<1.5	<1.2	<2.8
		Near-Bottom	41.2	6.56	<1.2	<1.5	1.34	<0.8	8.90	3.86	2.22	<0.8	<0.8	<2.5	<2.6	<2	<1.4	<1.2	<2.6
	H09	Near-Surface	66.5	7.19	<1.2	<1.5	1.54	<0.8	10.81	4.59	2.19	0.98	0.28	<2.5	<2.6	<2	<1.5	<1.2	<2.6
		Mid-Depth	45.2	5.59	<1.3	<1.6	0.93	<0.8	5.59	2.06	1.25	0.78	0.16	<2.6	<2.7	<2.1	<1.5	<1.2	<2.7
		Near-Bottom	19.5	5.68	<1.3	<1.6	1.17	<0.8	6.99	2.60	1.57	0.84	0.18	<2.6	<2.8	<2.1	<1.5	<1.2	<2.8
Center of Tamar Field	E11	Near-Surface	20.4	5.15	<1.2	<1.5	0.93	<0.8	5.12	2.40	2.81	<0.8	<0.8	<2.5	<2.6	<2	<1.5	<1.2	<2.6
		Mid-Depth	53.2	5.00	<1.2	<1.5	0.86	<0.8	5.84	2.15	1.58	<0.8	<0.8	<2.5	<2.6	<2	<1.5	<1.2	<2.6
		Near-Bottom	52.3	5.34	<1.3	<1.6	0.93	<0.8	6.76	2.89	2.25	0.75	0.24	<2.6	<2.8	<2.1	<1.5	<1.2	<2.8

N/A = data not available.

Table 1-20. Hydrocarbon concentrations in seawater from the March 2013 Tamar Field and Pipeline Survey. Total petroleum hydrocarbons (TPH) and the U.S. Environmental Protection Agency priority polycyclic aromatic hydrocarbons (PAHs) are represented (From: CSA Ocean Sciences Inc., 2014).

Station	TPH (µg/L)	PAH (ng/L)															
		Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene/Triphenylene	Benzo(b)fluoranthene	Benzo(k,j)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-c,d)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,i)perylene
TF1	<10.0	6.79	<1.2	<1.4	0.42	<0.8	1.45	<1.1	<1.4	<0.7	<0.8	<2.4	<2.5	<1.9	<1.4	<1.1	<2.5
TF2	<10.0	5.25	<1.2	<1.5	0.39	<0.8	1.57	<1.1	0.51	<0.8	<0.8	<2.5	<2.6	<2	<1.4	<1.2	<2.6
TF3	<10.0	5.01	<1.2	<1.4	0.37	<0.8	1.06	<1.1	0.25	<0.7	<0.8	<2.4	<2.5	<1.9	<1.4	<1.1	<2.5
TF4	<10.0	6.32	<1.2	<1.5	0.37	<0.8	1.15	<1.1	0.35	<0.8	<0.8	<2.5	<2.6	<2	<1.4	<1.2	<2.6
TF5	<10.0	7.49	<1.2	<1.5	0.42	<0.8	1.20	<1.1	0.34	<0.7	<0.8	<2.4	<2.5	<1.9	<1.4	<1.1	<2.5
TF6	<10.0	6.17	<1.2	<1.4	1.58	3.09	14.72	21.50	17.65	13.14	9.57	12.87	5.39	10.15	4.78	1.48	5.80
TF7	<10.0	5.45	<1.2	<1.5	0.41	<0.8	1.08	<1.1	0.20	<0.8	<0.8	<2.4	<2.6	<2	<1.4	<1.2	<2.6
TF8	<10.0	6.04	<1.2	<1.4	0.48	<0.8	1.37	<1.1	0.28	<0.7	<0.8	<2.4	<2.5	<1.9	<1.4	<1.1	<2.5
TF9	<10.0	5.60	<1.2	<1.5	<0.8	<0.8	1.01	<1.1	0.19	<0.8	<0.8	<2.5	<2.6	<2	<1.4	<1.2	<2.6

Table 1-21. Mean (± standard deviation) hydrocarbon concentrations in seawater from the March 2013 Tamar Field and Pipeline Survey and February 2014 Tamar Field Background Monitoring Survey area (with comparisons to toxicity reference values (Criterion Continuous Concentrations [CCC]), mean Levantine Basin baseline survey data, and European Union Commission on Environmental Quality Standards (EUCEQS) for priority substances in the field of water policy (Directive 2008/105/EC and proposed amendment COM(2011)876) (CSA Ocean Sciences Inc., 2014).

Survey	Location	Depth	TPH (µg/L)	PAH (ng/L)																
				Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene/Triphenylene	Benzo(b)fluoranthene	Benzo(k,j)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-c,d)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,i)perylene
March 2013	Inside Tamar Field	Near-Bottom	<10.0	6.0 ± 0.8	<1.2	<1.5	0.6 ± 0.4	<0.8	2.7 ± 4.5	<1.1	2.4 ± 6.1	<0.8	<0.8	<2.4	<2.0	<1.4	<1.4	<1.2	<2.5
February 2014	Perimeter of Tamar Field	Near-Surface	61.6 ± 21.2	6.1 ± 1.1	<1.3	<1.6	1.1 ± 0.5	<0.8	7.7 ± 3.5	3.6 ± 1.9	2.5 ± 0.8	0.9 ± 0.1	0.3 ± 0.0	<2.6	<2.8	<2.1	<1.5	<1.2	<2.8
		Mid-Depth	52.1 ± 22.9	6.2 ± 0.5	<1.3	<1.6	1.1 ± 0.1	<0.8	6.8 ± 1.0	2.8 ± 0.6	1.9 ± 0.6	0.7 ± 0.0	0.2 ± 0.1	<2.6	<2.8	<2.1	<1.5	<1.2	<2.8
		Near-Bottom	23.3 ± 13.2	5.2 ± 1.2	<1.3	<1.6	1.1 ± 0.3	<0.8	6.3 ± 2.3	2.5 ± 1.2	1.9 ± 0.4	<0.8	<0.9	<2.6	<2.8	<2.1	<1.5	<1.2	<2.8
	Center of Tamar Field	Near-Surface	20.4	5.15	<1.2	<1.5	0.93	<0.8	5.12	2.40	2.81	<0.8	<0.8	<2.5	<2.6	<2	<1.5	<1.2	<2.6
		Mid-Depth	53.2	5.00	<1.2	<1.5	0.86	<0.8	5.84	2.15	1.58	<0.8	<0.8	<2.5	<2.6	<2	<1.5	<1.2	<2.6
		Near-Bottom	52.3	5.34	<1.3	<1.6	0.93	<0.8	6.76	2.89	2.25	0.75	0.24	<2.6	<2.8	<2.1	<1.5	<1.2	<2.8
EUCEQS (Directive 2008/105/EC and proposed amendment COM(2011)876		MAC	N/A	130,000	N/A	N/A	N/A	N/A	N/A	120	N/A	N/A	N/A	0.17	0.17	0.17	0.17	N/A	0.17
		AAC	N/A	2,000	N/A	N/A	N/A	N/A	N/A	6.3	N/A	N/A	N/A	17.0	17.0	27.0	N/A	N/A	0.82
CCC[1]			N/A	1,400	N/A	N/A	N/A	40,000	4,600	11,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Levantine Basin Baseline Data[2]		Near-Surface	61.31 ± 144.49	9.43 ± 13.42	0.37 ± 0.29	0.56 ± 0.51	1.04 ± 2.19	0.26 ± 0.21	2.66 ± 2.92	0.76 ± 0.9	1.69 ± 2.87	0.25 ± 0.18	0.27 ± 0.2	0.8 ± 0.61	0.83 ± 0.64	1.13 ± 0.92	0.46 ± 0.38	0.36 ± 0.28	0.76 ± 0.65
		Mid-Depth	24.23 ± 31.94	7.08 ± 8.23	0.39 ± 0.27	0.51 ± 0.35	0.4 ± 0.36	0.27 ± 0.19	1.69 ± 2.01	0.65 ± 0.54	1.02 ± 1.36	0.27 ± 0.18	0.27 ± 0.18	0.85 ± 0.56	0.89 ± 0.59	1.24 ± 0.86	0.5 ± 0.32	0.4 ± 0.26	0.76 ± 0.57
		Near-Bottom	30.54 ± 32.07	6.85 ± 8.19	0.38 ± 0.28	0.5 ± 0.37	0.44 ± 0.52	0.23 ± 0.18	1.43 ± 1.41	0.58 ± 0.48	0.94 ± 1.31	0.24 ± 0.17	0.27 ± 0.19	0.81 ± 0.58	0.85 ± 0.61	1.18 ± 0.88	0.47 ± 0.34	0.36 ± 0.27	0.81 ± 0.61

AAC = annual average concentration; MAC = maximum allowable concentration; N/A = data not available.

[1] Proposed CCC in marine surface waters (Buchman, 2008).

[2] Mean calculated from pre-drill and environmental baseline surveys conducted by CSA prior to September 2013.

Radionuclides

February 2014 Tamar Field Background Monitoring Survey

Radionuclide concentrations were low or non-detectable throughout the survey region during the February 2014 Tamar Field Background Monitoring Survey (**Table 1-22**). Concentrations generally were similar between water stations located on the perimeter of the field and at the water station located at the center of the field.

Table 1-22. Radionuclide concentration for radium (Ra) 226, Ra 228, and combined concentrations in seawater samples collected during the February 2014 Tamar Field Background Monitoring Survey (From: CSA Ocean Sciences Inc., 2014).

Location	Station	Depth	Concentration (pCi/L)		
			Ra 226	Ra 228	Combined Ra 226 and Ra 228
Perimeter of Tamar Field	B08	Near-Surface	0.15	0.20	0.35
		Mid-Depth	0.30	0.00	0.30
		Near-Bottom	0.18	0.00	0.18
	C01	Near-Surface	0.23	0.14	0.37
		Mid-Depth	0.09	0.12	0.21
		Near-Bottom	0.21	0.00	0.21
	D17	Near-Surface	0.11	0.00	0.11
		Mid-Depth	0.11	0.46	0.57
		Near-Bottom	0.16	0.22	0.38
	H09	Near-Surface	0.11	0.01	0.12
		Mid-Depth	0.06	0.12	0.08
		Near-Bottom	0.12	0.00	0.12
Center of Tamar Field	E11	Near-Surface	0.23	0.09	0.32
		Mid-Depth	0.08	0.01	0.09
		Near-Bottom	0.03	0.00	0.03

March 2013 Tamar Field and Pipeline Survey

Radionuclide concentrations were low or non-detectable throughout the survey region during the March 2013 Tamar Field and Pipeline Survey (**Table 1-23**).

Table 1-23. Radionuclide concentration for radium (Ra) 226, Ra 228, and combined concentrations in seawater samples collected during the March 2013 Tamar Field and Pipeline Survey (From: CSA Ocean Sciences Inc., 2014).

Station	Concentration (pCi/L)		
	Ra 226	Ra 228	Combined Ra 226 and Ra 228
TF1	0.11	0.20	0.31
TF2	0.11	0.21	0.32
TF3	0.16	0.08	0.24
TF4	0.06	0.00	0.06
TF5	0.10	0.33	0.43
TF6	0.11	0.11	0.22
TF7	0.06	0.00	0.06
TF8	0.03	0.01	0.04
TF9	0.31	0.05	0.36

Similarity in Radionuclide Concentrations Between Surveys

Mean concentrations of seawater radionuclide concentrations (radium [Ra] 226 and Ra 228) were similar between the March 2013 Tamar Field and Pipeline Survey and February 2014 Tamar Field Background Survey and are provided in **Table 1-24**.

Table 1-24. Mean (± standard deviation) and combined mean concentrations of radionuclides (radium [Ra] 226 and Ra 228) in seawater from the Tamar Field. Levantine Basin baseline data are provided for comparison (From: CSA Ocean Sciences Inc., 2014).

Survey	Location	Concentration (pCi/L)			
		Depth	Ra 226	Ra 228	Combined Ra 226 and Ra 228
March 2013	Inside Tamar Field	Near-Bottom	0.12 ± 0.08	0.11 ± 0.12	0.23 ± 0.14
February 2014	Perimeter of Tamar Field	Near-Surface	0.15 ± 0.06	0.09 ± 0.10	0.24 ± 0.14
		Mid-Depth	0.14 ± 0.11	0.18 ± 0.20	0.29 ± 0.21
		Near-Bottom	0.17 ± 0.04	0.06 ± 0.11	0.22 ± 0.11
	Center of Tamar Field	Near-Surface	0.23	0.09	0.32
		Mid-Depth	0.08	0.01	0.09
		Near-Bottom	0.03	0.00	0.03
Levantine Basin Mean*		Near-Surface	0.13 ± 0.09	0.2 ± 0.13	N/A
		Mid-Depth	0.17 ± 0.1	0.16 ± 0.1	N/A
		Near-Bottom	0.13 ± 0.1	0.16 ± 0.13	N/A

N/A = data not available.
*Mean calculated from pre-drill and environmental baseline surveys conducted by CSA prior to September 2013.

Radium, naturally present in formation rock, co-precipitates with other alkaline earth elements, such as barium, and is associated with metal sulfates in drill cuttings (Veil and Smith, 1999). However, 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. The USEPA (1976) established a maximum contaminant level for combined Ra 226 and Ra 228 at 5 pCi/L. Combined Ra 226 and Ra 228 concentrations in seawater from the both surveys were well below this threshold. The maximum contaminant level is a maximum permissible level of a contaminant that ensures the safety of the water over a lifetime of consumption and also takes into consideration feasible treatment technologies and monitoring capabilities. The data indicate that radium levels in seawater throughout the Tamar Field are extremely low and well below levels of concern.

1.2.4.2 Sediment Analysis

The sediment analyses presented here are derived from the surveys completed by Noble Energy during 2013 and 2014. A figure of the sampling stations was presented in **Appendix A** and the full report is presented in CSA Ocean Sciences Inc. (2014). As stated previously, in addition to covering the Tamar Field, the surveys included sample stations along the pipeline corridor from the Tamar Field to the Tamar Platform. A review of this information is included in this section, even though the sampling stations are not in close proximity to the proposed activities, in order to provide information that may be of value in identifying potential project impacts on the environment.

Particle Size

Figures 1-51 and **1-52** summarize the particle size distribution and sediment types within the Tamar Field. All samples, including those in close proximity to existing development, were predominately composed of very fine silt and clay (approximately 80%, combined; **Figure 1-51**) and thus were classified as silty clay (**Figure 1-52**).

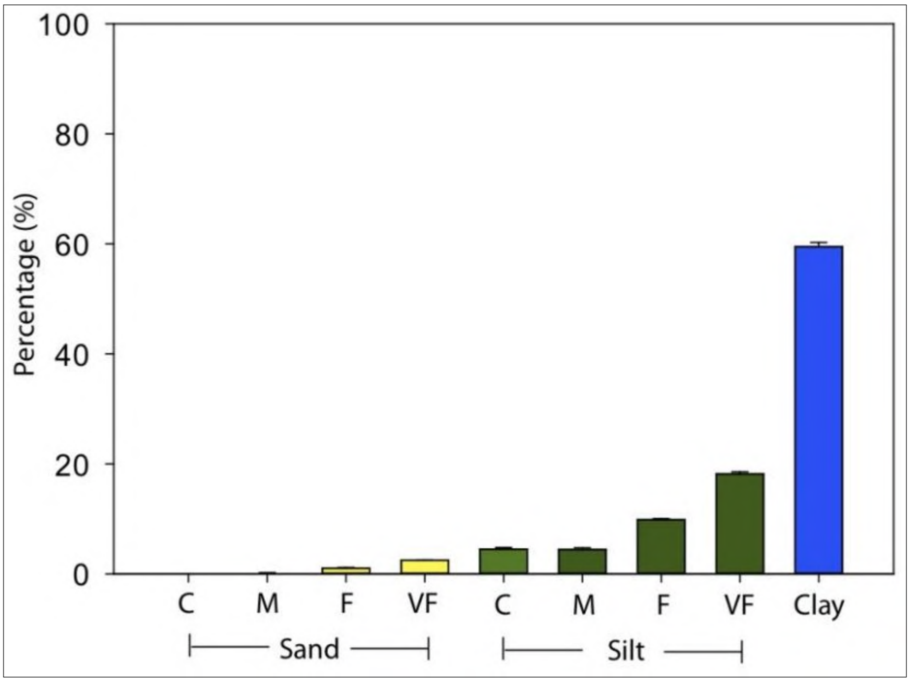


Figure 1-51. Particle size distribution (Wentworth scale; mean + standard deviation) within the Tamar Field. C = coarse; M = medium; F = fine; VF = very fine. Yellow = sand fractions; blue = silt fractions; green = clay fractions (From: CSA Ocean Sciences Inc., 2014).

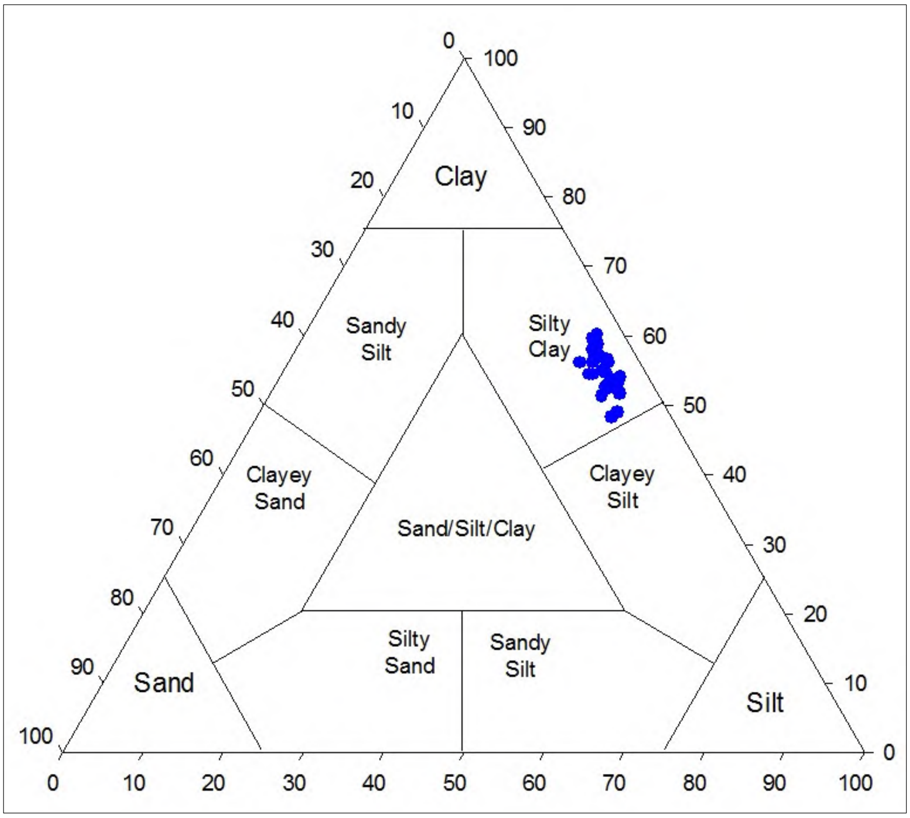


Figure 1-52. Individual grid cell and pipeline station particle size classifications (Shepard, 1954) for sediment samples collected within the Tamar Field (Adapted from: CSA Ocean Sciences Inc., 2014).

Total Organic Carbon

High-resolution sediment TOC concentrations within the Tamar Field are illustrated in **Figure 1-53**. Sediment TOC concentrations throughout the survey region were low (0.60% ± 0.07%) and were within the 99% confidence limit (CL) of the mean for the field. Sediment TOC concentrations within the Tamar Field were also within the 99% CL of the mean TOC concentration of the Levantine Basin (**Figure 1-54**).

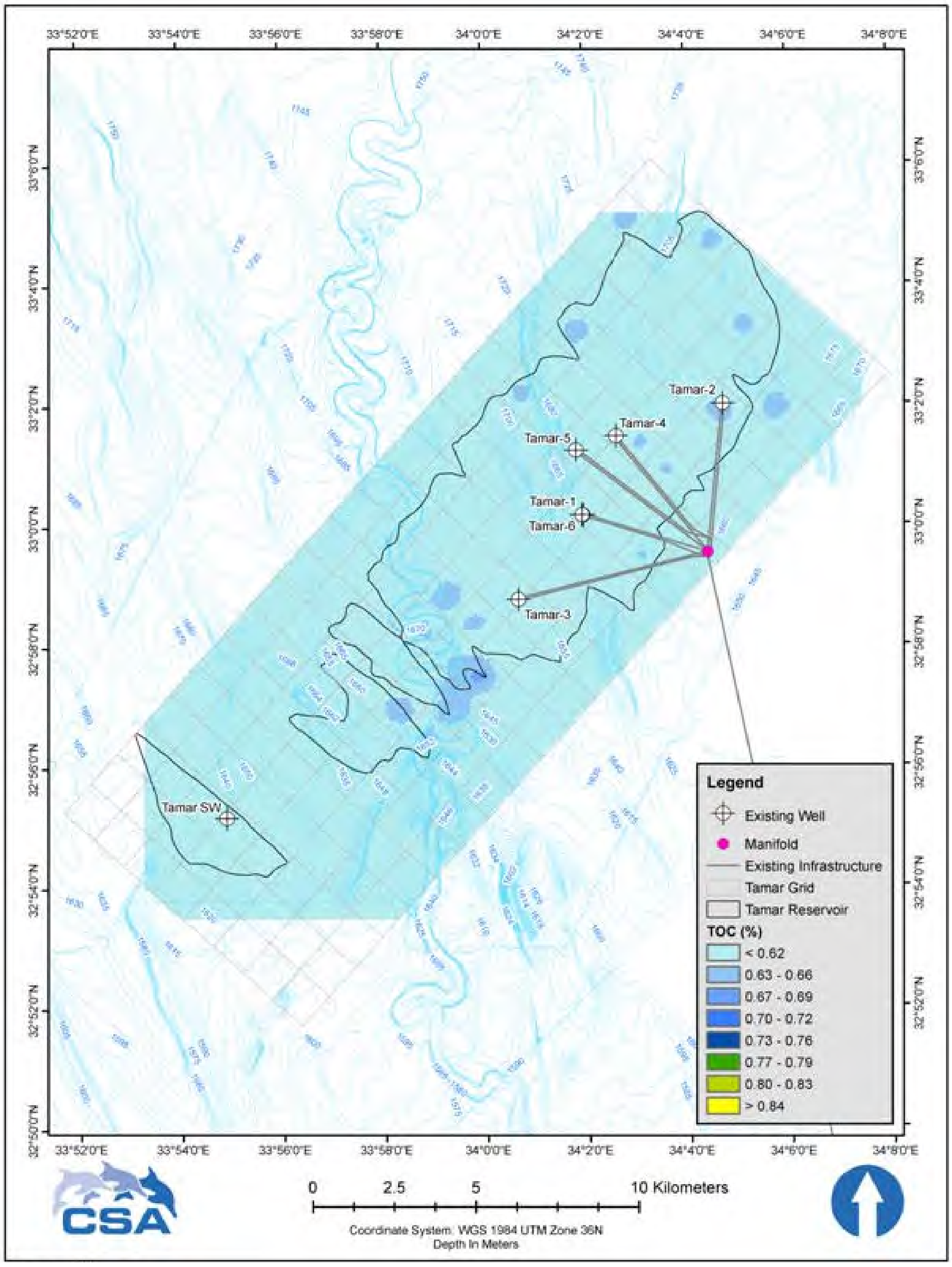


Figure 1-53. Kriged surface of sediment total organic carbon (TOC) concentrations within the Tamar Field. Concentrations represented by shades of blue were within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

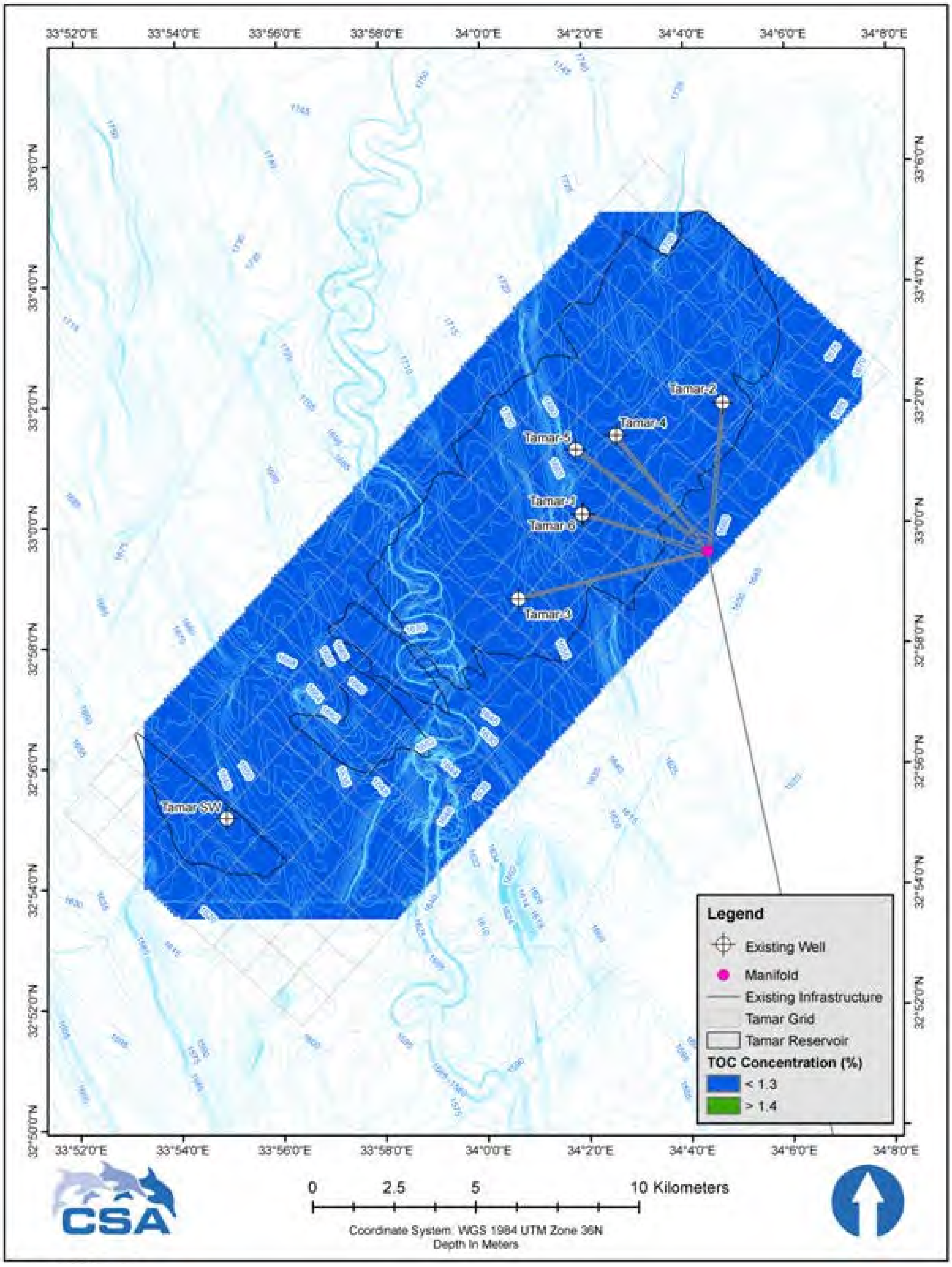


Figure 1-54. Sediment total organic carbon (TOC) concentrations within the Tamar in comparison to the Levantine Basin mean. Blue represents values that are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Levantine Basin mean. Dark green represents values that are greater than 2.5 SD from that mean. Levantine Basin means were calculated from pre-drill and environmental baseline surveys conducted by CSA prior to September 2013. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

Metals

Figures 1-55 to **1-69** are high-resolution sediment metals concentrations (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, mercury, nickel, thallium, vanadium, and zinc) within the Tamar Field. Selenium and silver concentrations generally were not detectable within the region (more than 75% were non-detects); therefore, figures are not provided for these metals. Most metals concentrations were within the 99% CL of the Tamar Field mean (**Figures 1-55** to **1-69**), with the exception of barium (**Figure 1-58**) and lead (**Figure 1-64**).

Barium concentrations throughout the Tamar Field were elevated, resulting in a situation where barium concentrations as high as 884 parts per million (ppm) were within the 99% CL of the region (**Figure 1-58**). Comparison of barium concentrations within the field to the Levantine Basin mean shows a clearer picture of the state of barium concentrations within the region (**Figure 1-70**). Elevated barium concentrations around Tamar-1/Tamar-6, Tamar-3, Tamar-4, Tamar-5, and Tamar SW-1 are not unexpected because barite is a compound normally added to drilling mud as a weighing material to add density in order to control and balance formation pressure and increase stability of the wellbore. However, the high levels of barium in the north section of the field and reservoir centered on grid cells B09 and C09 were unexpected. These cells are located more than 2.9 km from the nearest wellsite (**Appendix A**) and occurred in concentrations much higher than expected for this distance, especially as forecast concentrations were lower between this location and the nearest wellsites. Laboratory error has been ruled out through examination of the analytical laboratory's quality control procedures, as has sampling error because there were no sources of barium on board the vessel to potentially contaminate samples. It is impossible to know the source of the high barium concentration, although it is likely not directly related to drilling activities at the existing Tamar wellsites. Barium is not considered a toxic chemical; therefore, there are no established toxicity thresholds for this metal. High concentrations of barium within the region are not expected to negatively impact the environment within the region.

Concentrations of lead were elevated above the 99% CL of the Tamar Field mean in close proximity (approximately 1 km) to the manifold (**Figure 1-64**). Lead is a component of drilling mud (approximately 136 ppm) and barite (approximately 165 ppm) and has been found in cuttings (approximately 133 ppm), so its presence in the field and reservoir was not surprising. Interestingly, lead concentrations were also slightly elevated (but below the 99% CL) in the area of the inexplicitly high barium concentrations of grid cells B09 and C09. The slightly elevated lead signature in this region may indicate that the barium anomaly may have been derived from the surface, given that drilling muds and cuttings are relatively high in lead. Lead concentrations, while elevated in comparison to the Tamar Field, were not elevated in comparison to the Levantine Basin mean and are within the 99% CL threshold of this metal (**Figure 1-71**). Lead concentrations throughout the field and reservoir, even in areas with slightly elevated concentrations, were well below the effects range low (ERL) and effects range median (ERM) values for lead (46.7 and 218 ppm, respectively).
A concentration below an ERL represents a minimal effects range where biological effects are very rarely observed, while a concentration above an ERM represents a range where biological effects are likely to be observed (Long and Morgan, 1990).

Cadmium concentrations were within the 99% CL of the Tamar Field mean (**Figure 1-60**); however, slightly elevated cadmium concentrations, relative to the rest of the field mean, were clustered on the eastern portion of the field though not directly around the five wellsites in the region. Cadmium is a component of the drilling mud and barite used in drilling and plugging activities within the Tamar Field (less than 2 ppm). Studies have shown that cadmium in barite has very low solubility, leaches only slightly into the seawater, and has very limited availability to marine organisms (Trefry and Smith, 2003; Neff, 2007). Similarly, after deposition to the seafloor, cadmium remains bound in barite, does not leach into sediment pore water, and remains unavailable to marine organisms. It is impossible to determine the source of the cadmium, especially because the elevated barium signature (**Figure 1-58**) does not spatially overlap with the cadmium concentrations (**Figure 1-60**). Besides being within the 99% CL of the Tamar Field mean, cadmium concentrations in the eastern portion of the field and reservoir were well below the ERM value (9.6 ppm) and ERL value (1.2 ppm) for cadmium (Long and Morgan, 1990). Concentrations of cadmium were within the 99% CL of the Levantine Basin mean (**Figure 1-72**). Cadmium concentrations may reflect either extremely low-level anthropogenic enrichment or natural patchiness within seafloor sediments of the region. In either case, the findings indicate that cadmium concentrations within the field were not significantly different from Tamar Field means or Levantine Basin means, and were well under concentrations of environmental concern.

Concentrations of aluminum and other trace metals 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. However, sediments classified as silt or sand are composed primarily 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 and Smith, 2003; Trefry et al., 2013). All sediment metals concentrations (with the exception barium, as described previously) were within the 99% CL of the Levantine Basin mean (**Figure 1-73**). Additionally, normalization of metals concentrations with sediment grain size, achieved by performing a regression of each metal against aluminum, also showed that metals concentrations in the Tamar Field were generally within the 99% prediction interval of the Levantine Basin (**Figures 1-74** and **1-75**). Figures for selenium and silver are not shown because concentrations generally were below the laboratory's detection limit. A figure for thallium is not shown because regression values are similar to other metal regressions (i.e., vanadium).

Concentrations of all metals within the field and reservoir were below ERL and ERM values with the exception of arsenic, copper, and nickel (**Table 1-25**). However, these three metals are naturally found in high concentrations throughout the Levantine Basin. Concentrations above the ERL should be considered ambient for arsenic and copper, and concentrations above the ERM should be considered ambient for nickel (**Table 1-25**).

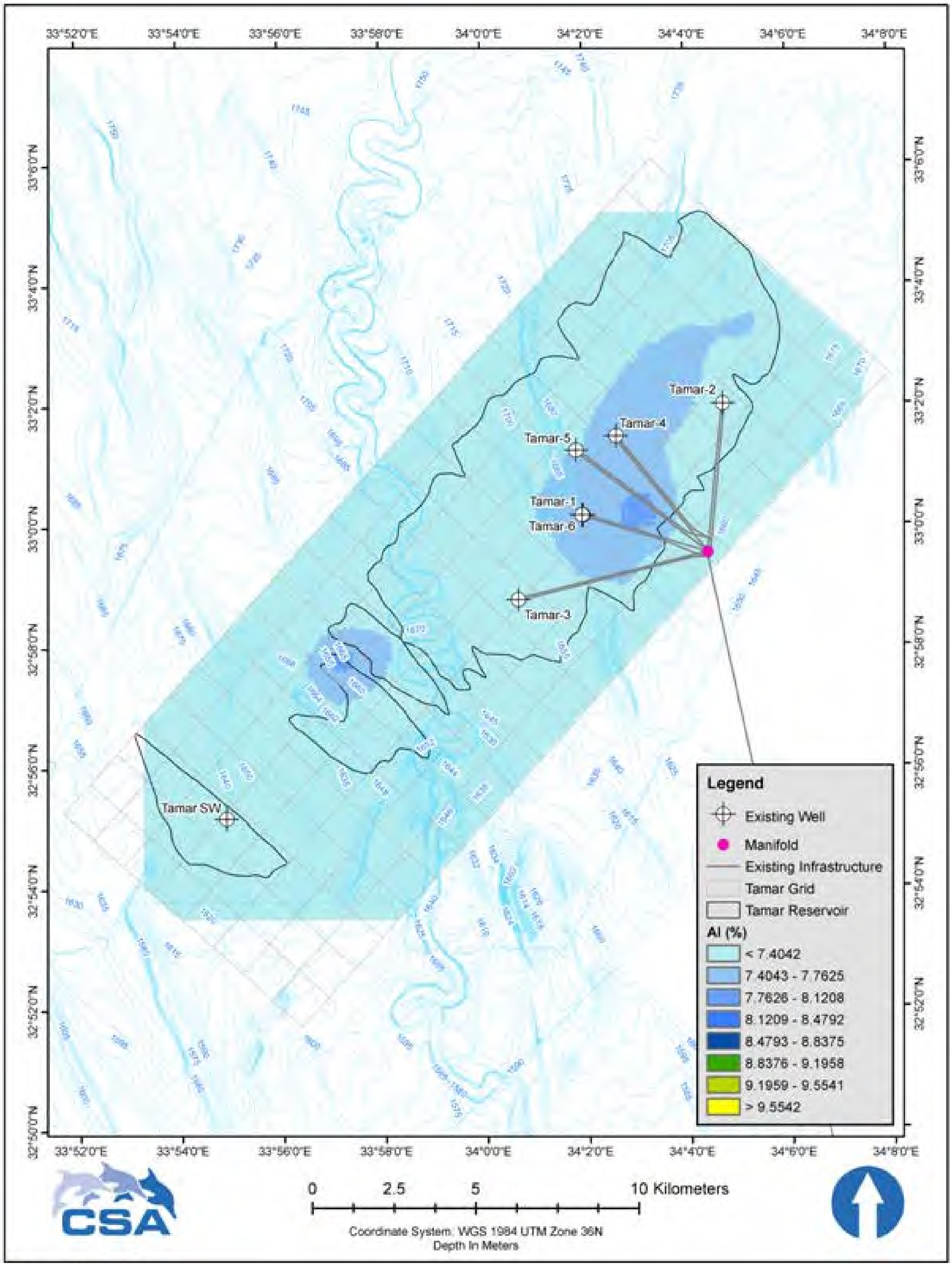


Figure 1-55. High-resolution sediment aluminum concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

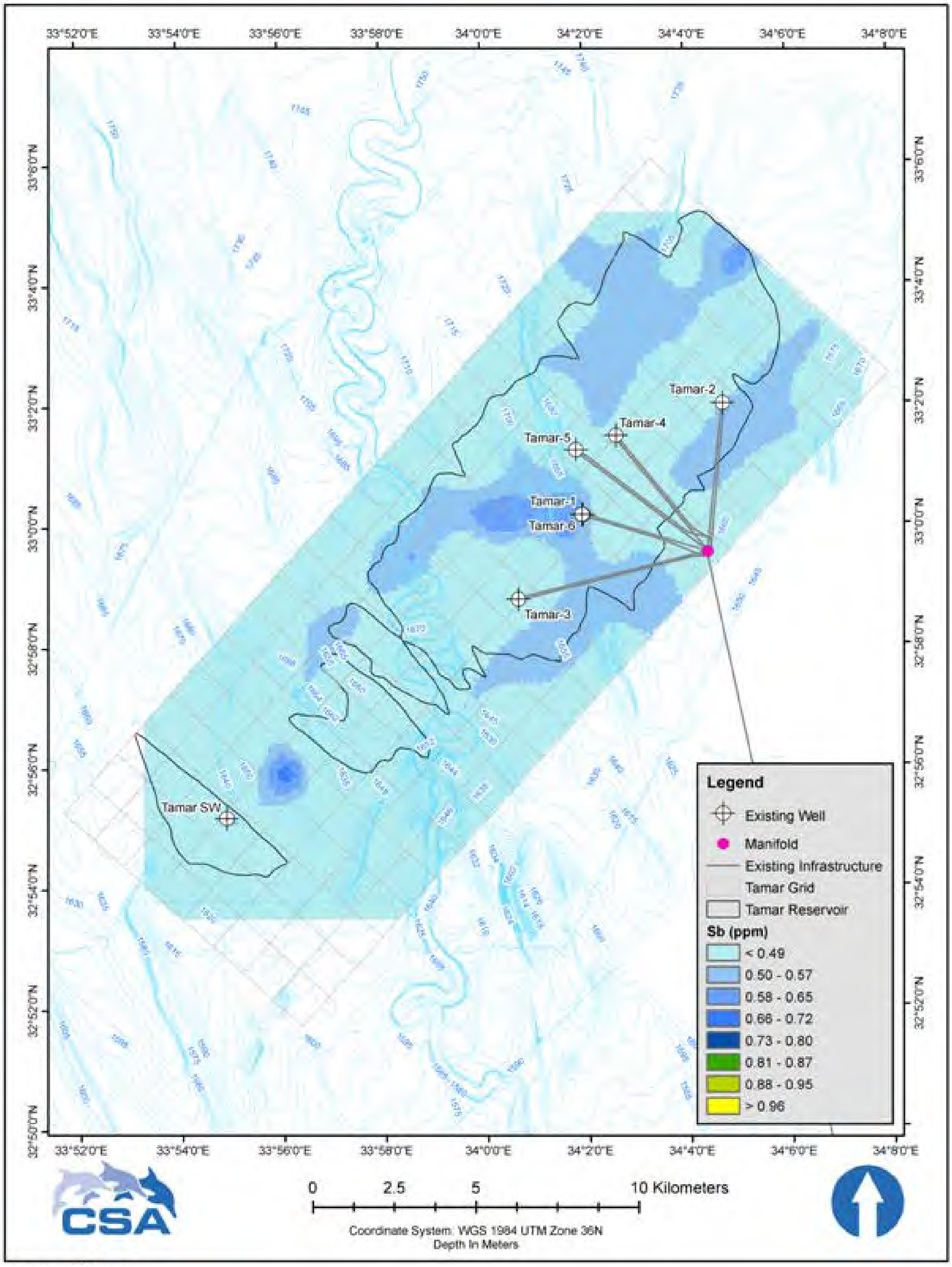


Figure 1-56. High-resolution sediment antimony concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

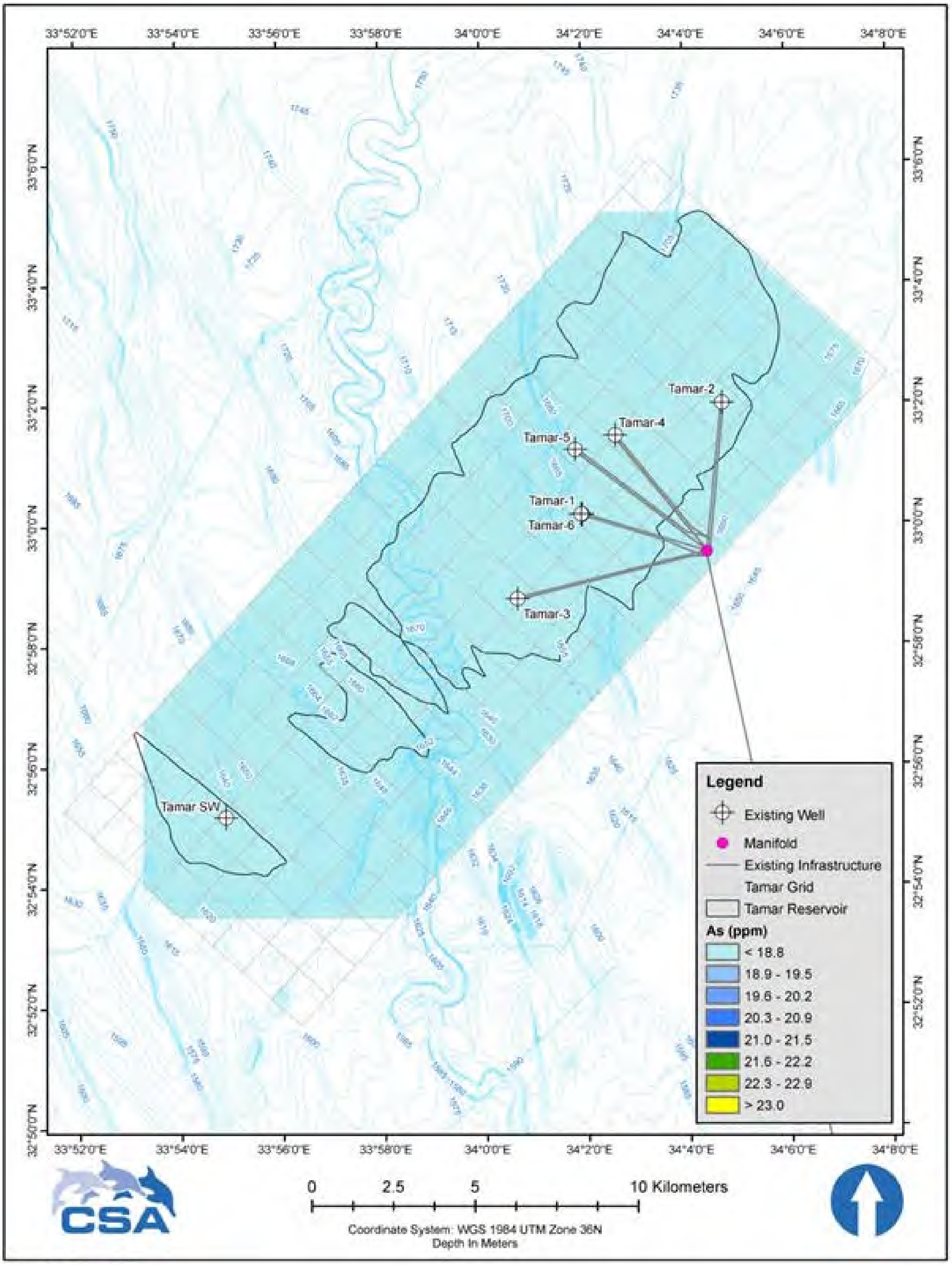


Figure 1-57. High-resolution sediment arsenic concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

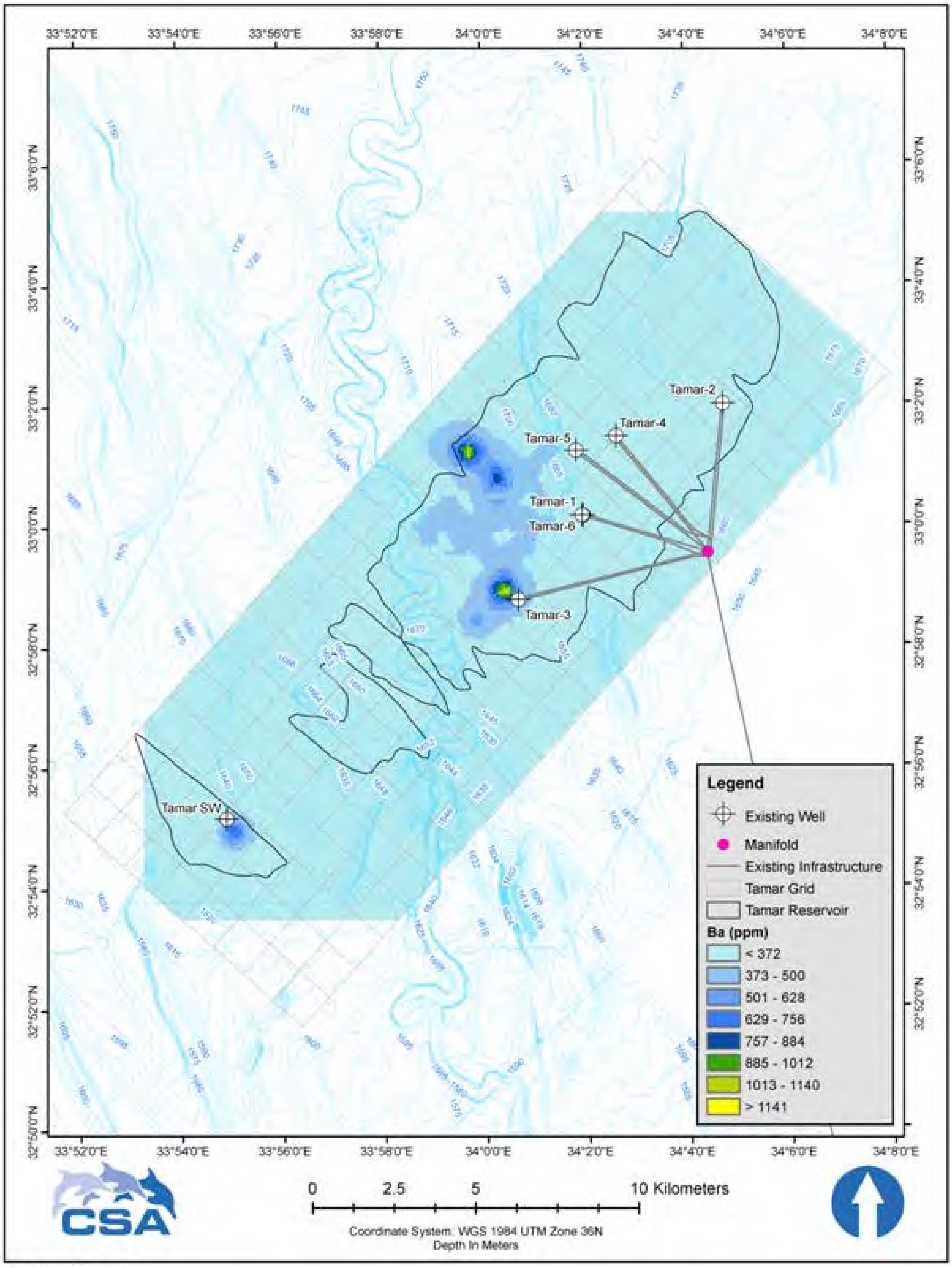


Figure 1-58. High-resolution sediment barium concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

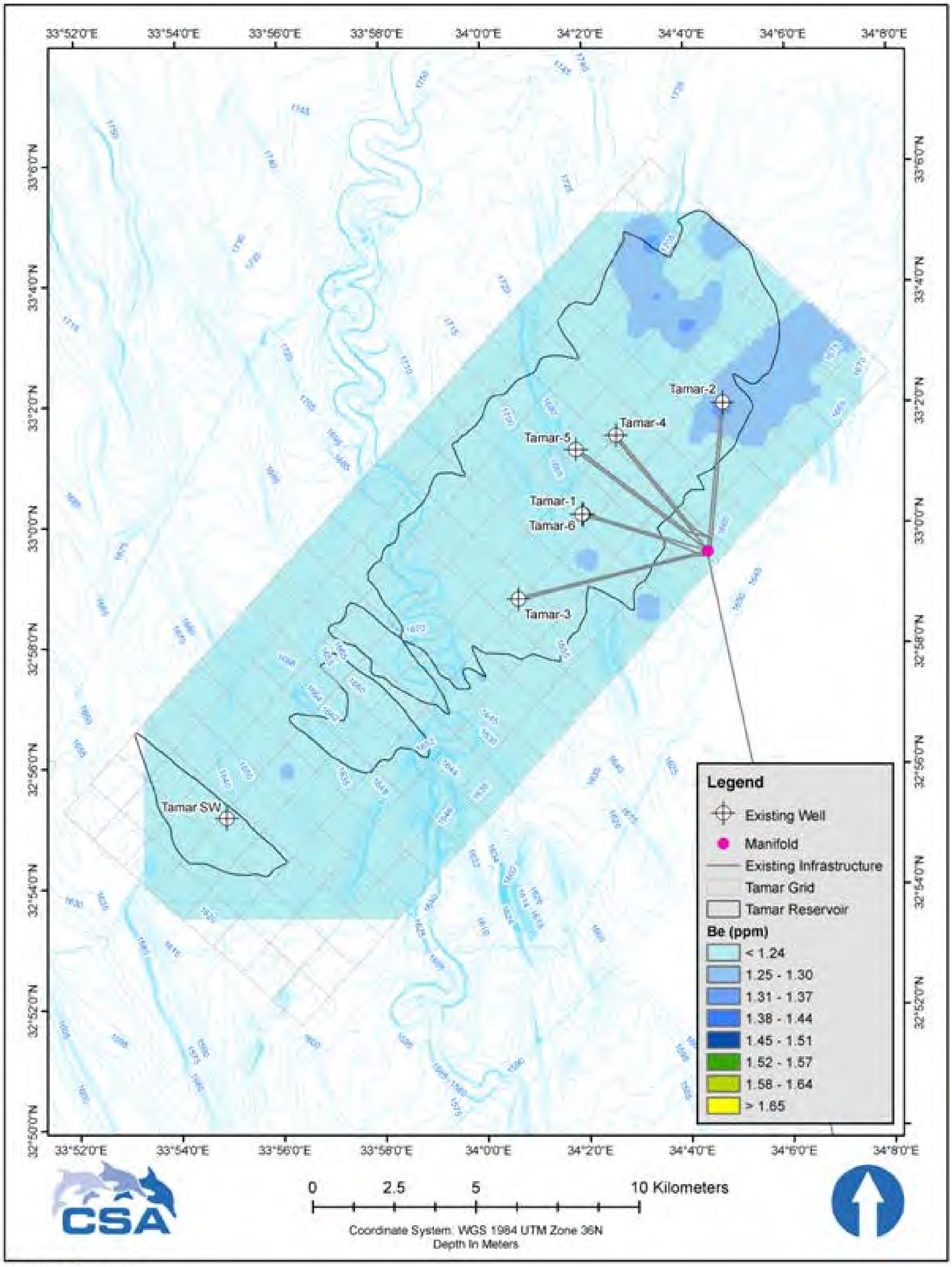


Figure 1-59. High-resolution sediment beryllium concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

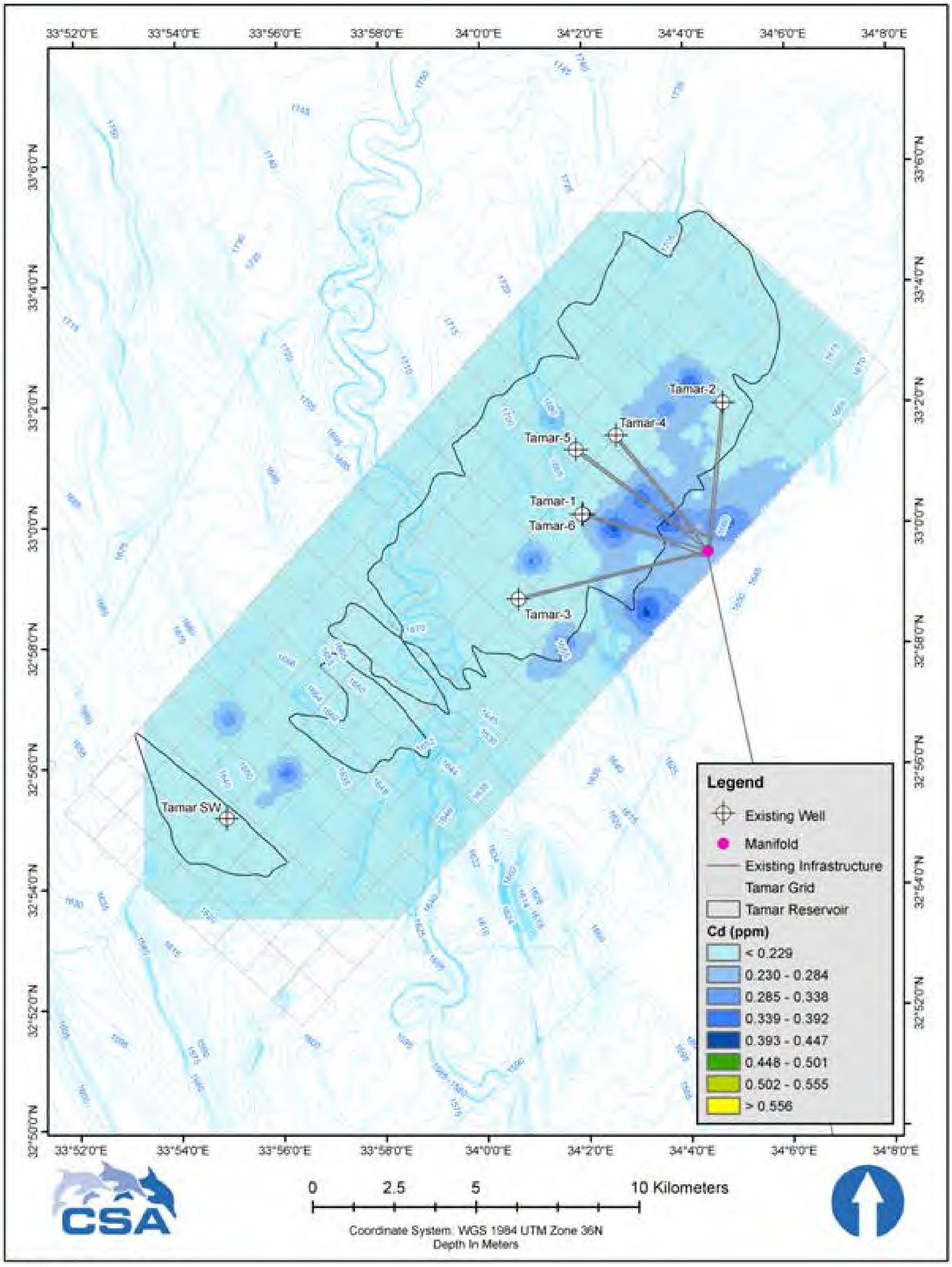


Figure 1-60. High-resolution sediment cadmium concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

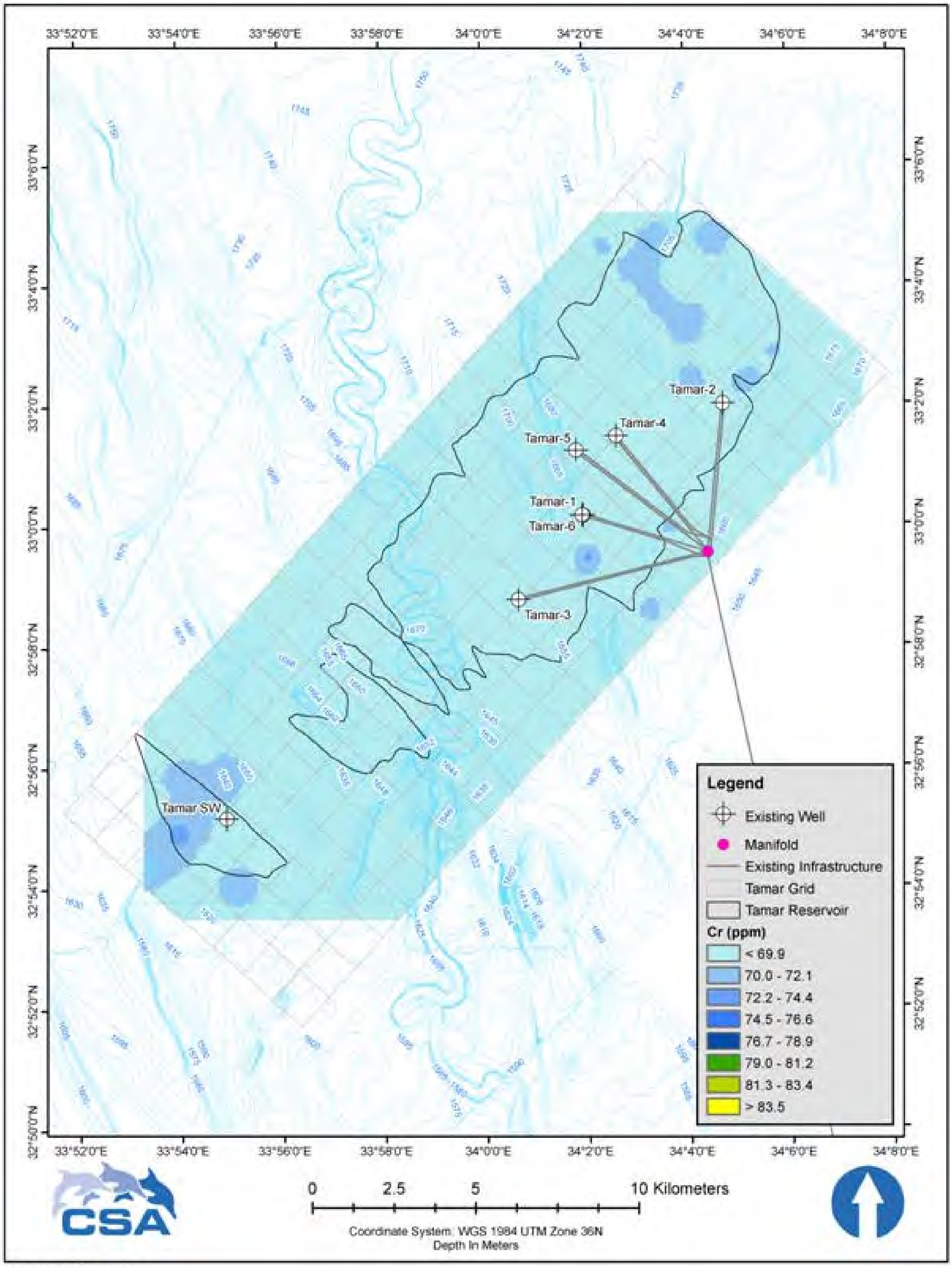


Figure 1-61. High-resolution sediment chromium concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

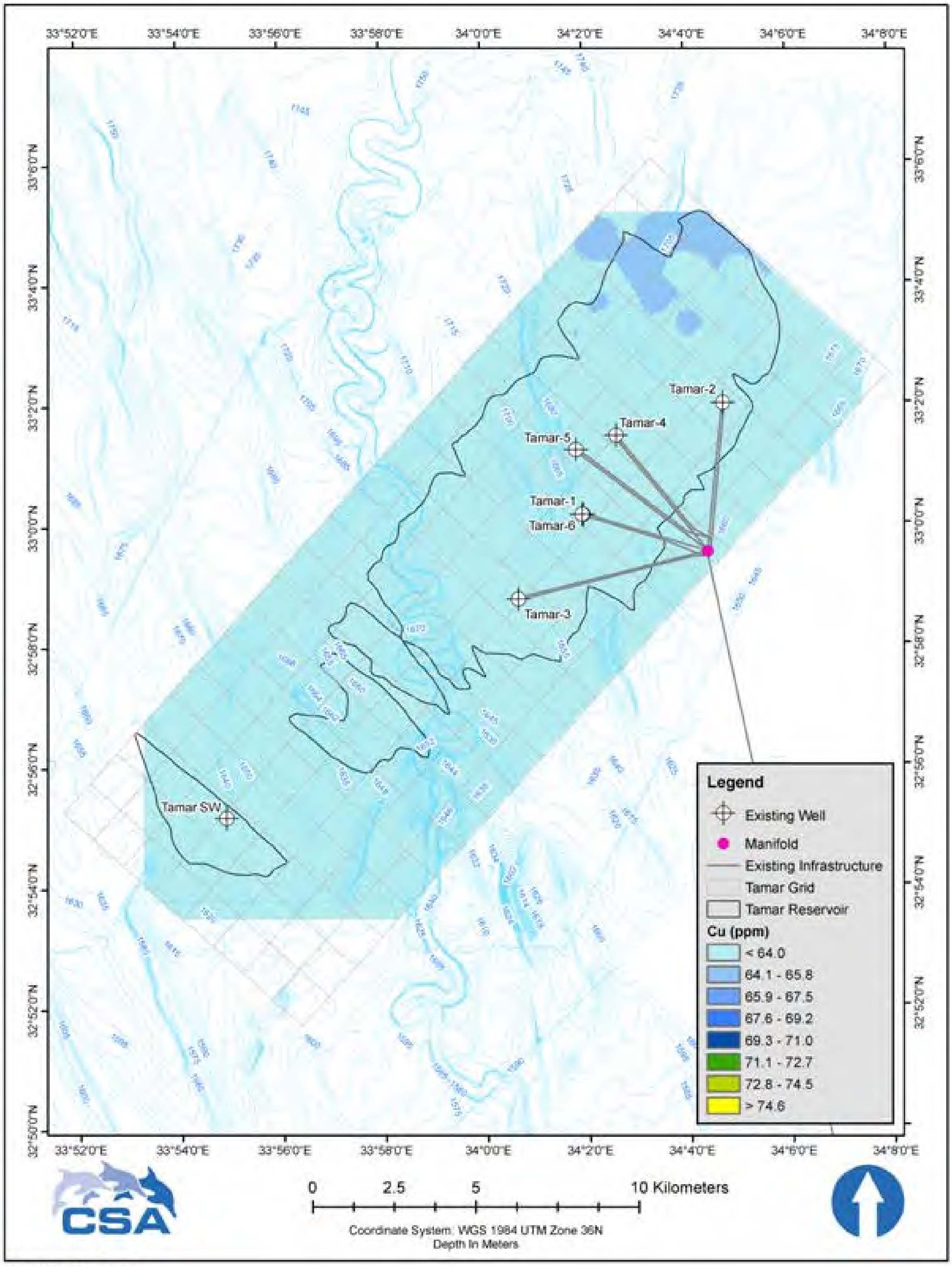


Figure 1-62. High-resolution sediment copper concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

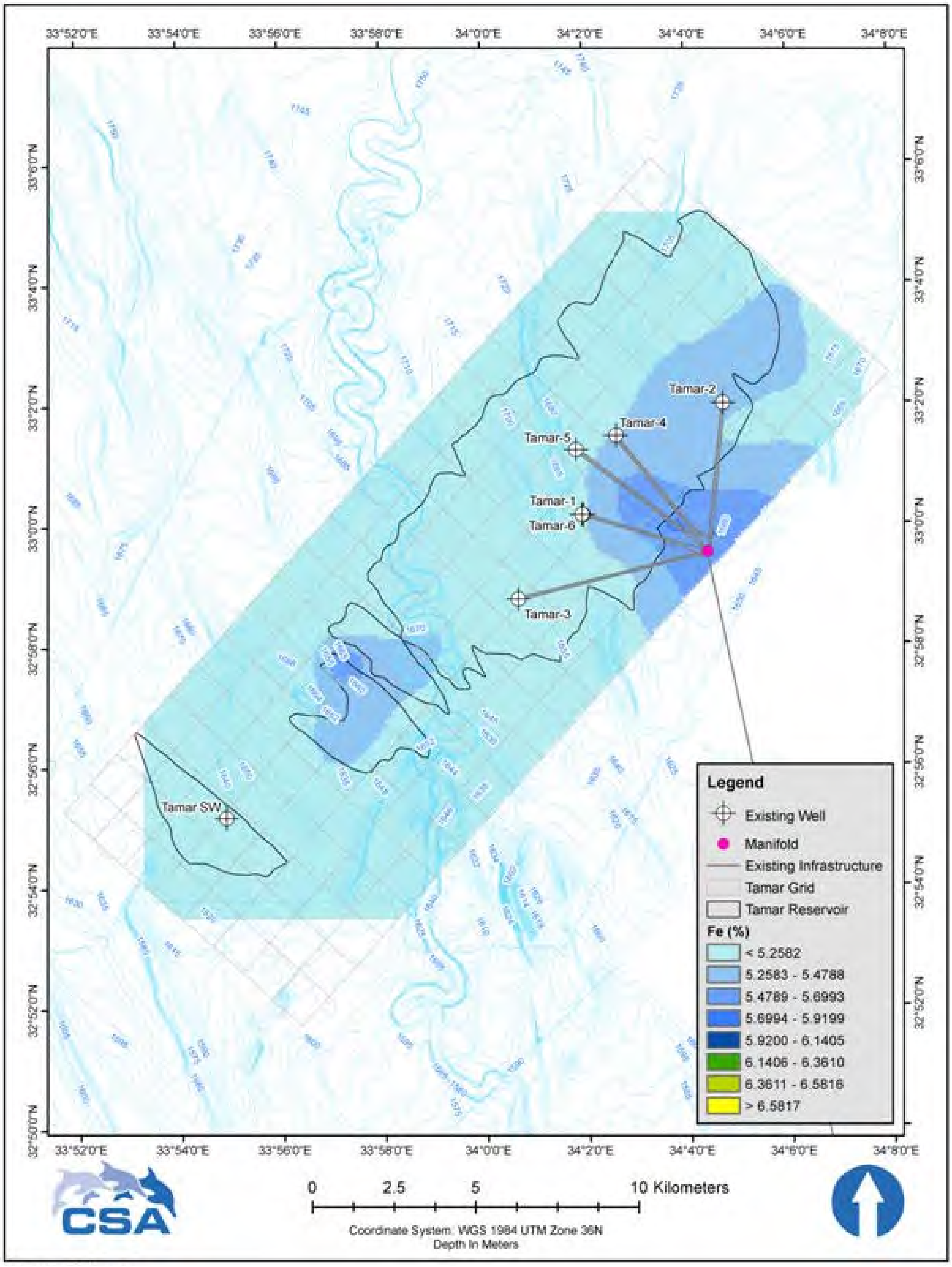


Figure 1-63. High-resolution sediment iron concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

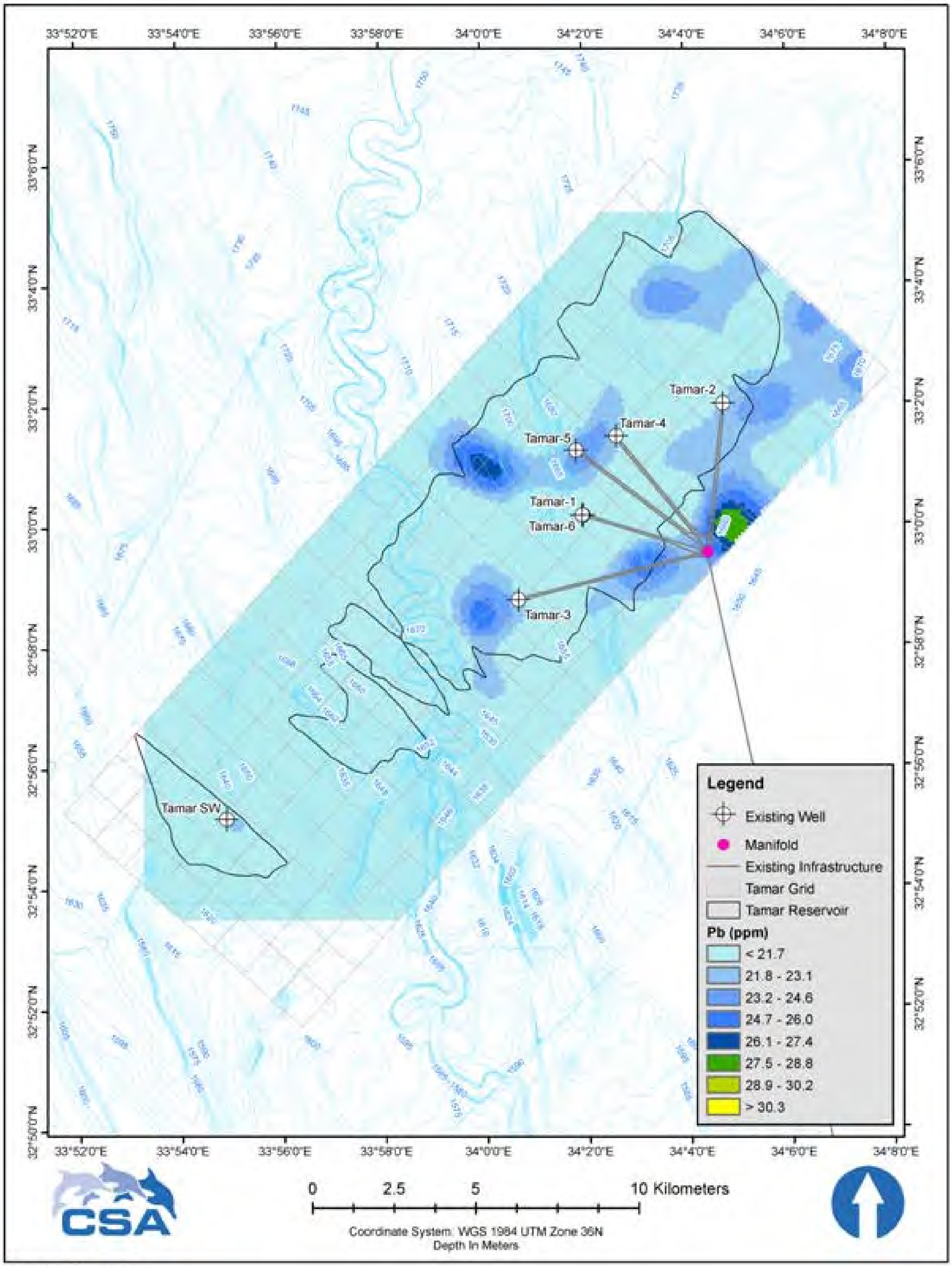


Figure 1-64. High-resolution sediment lead concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

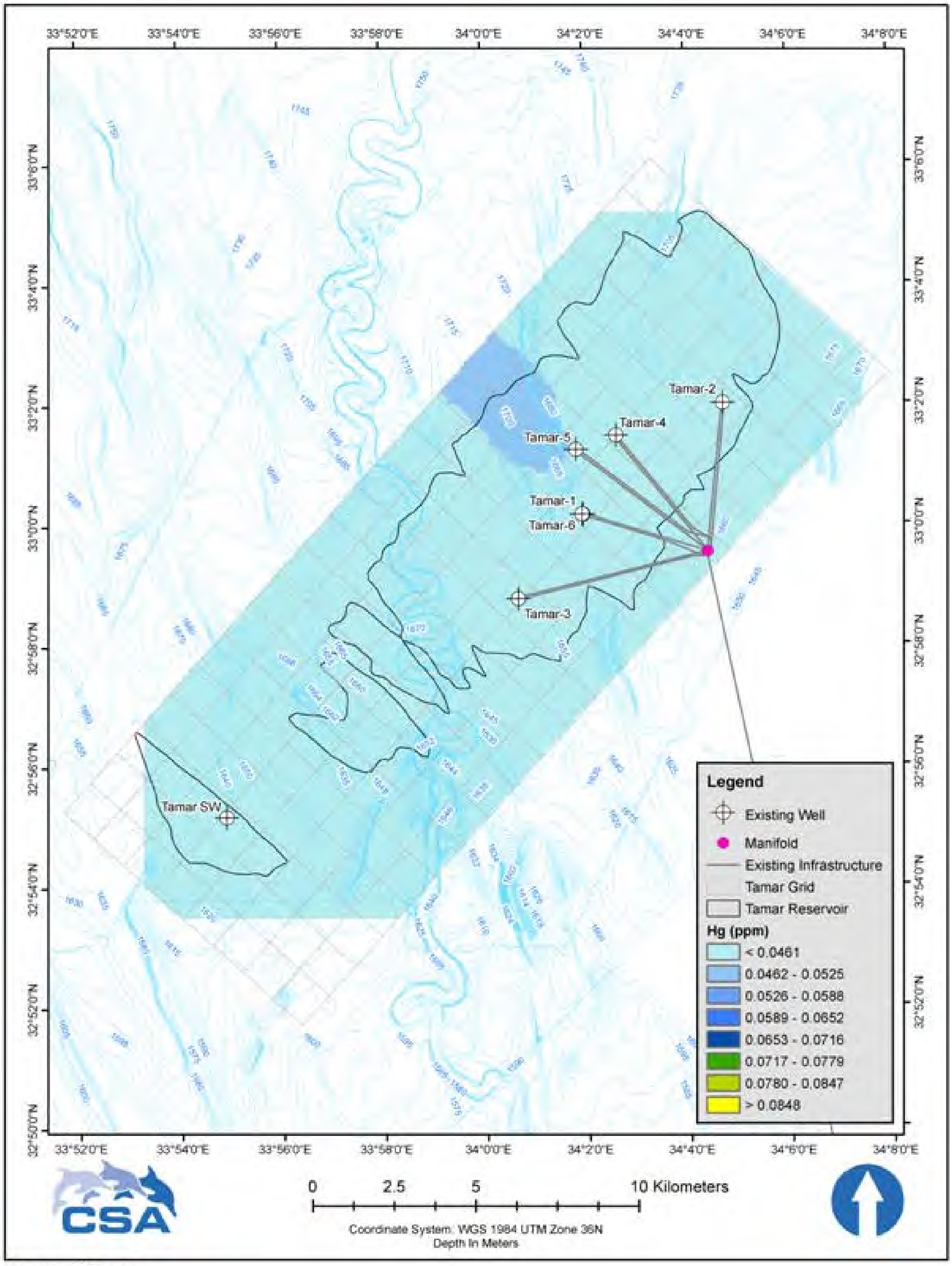


Figure 1-65. High-resolution sediment mercury concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

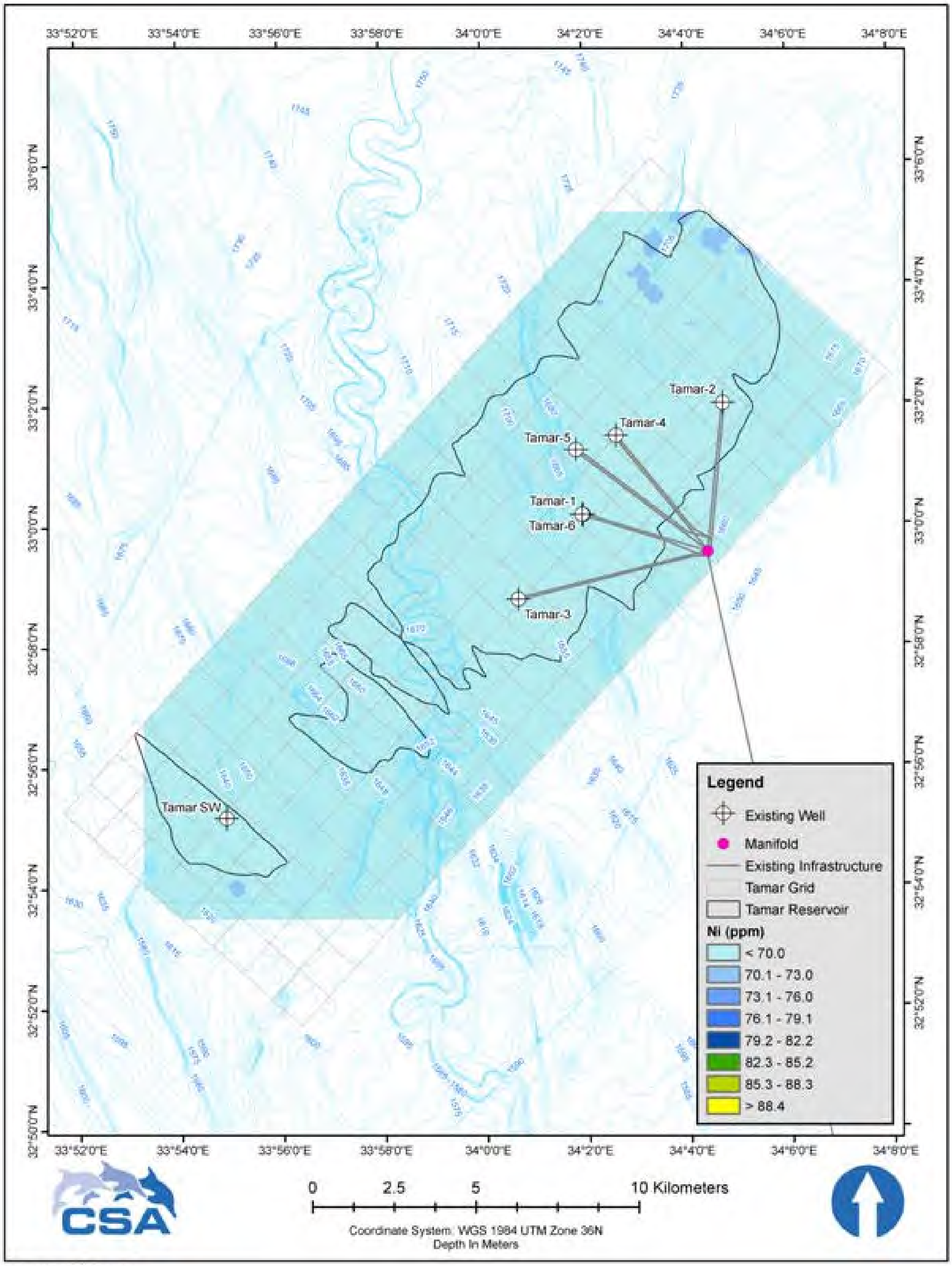


Figure 1-66. High-resolution sediment nickel concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

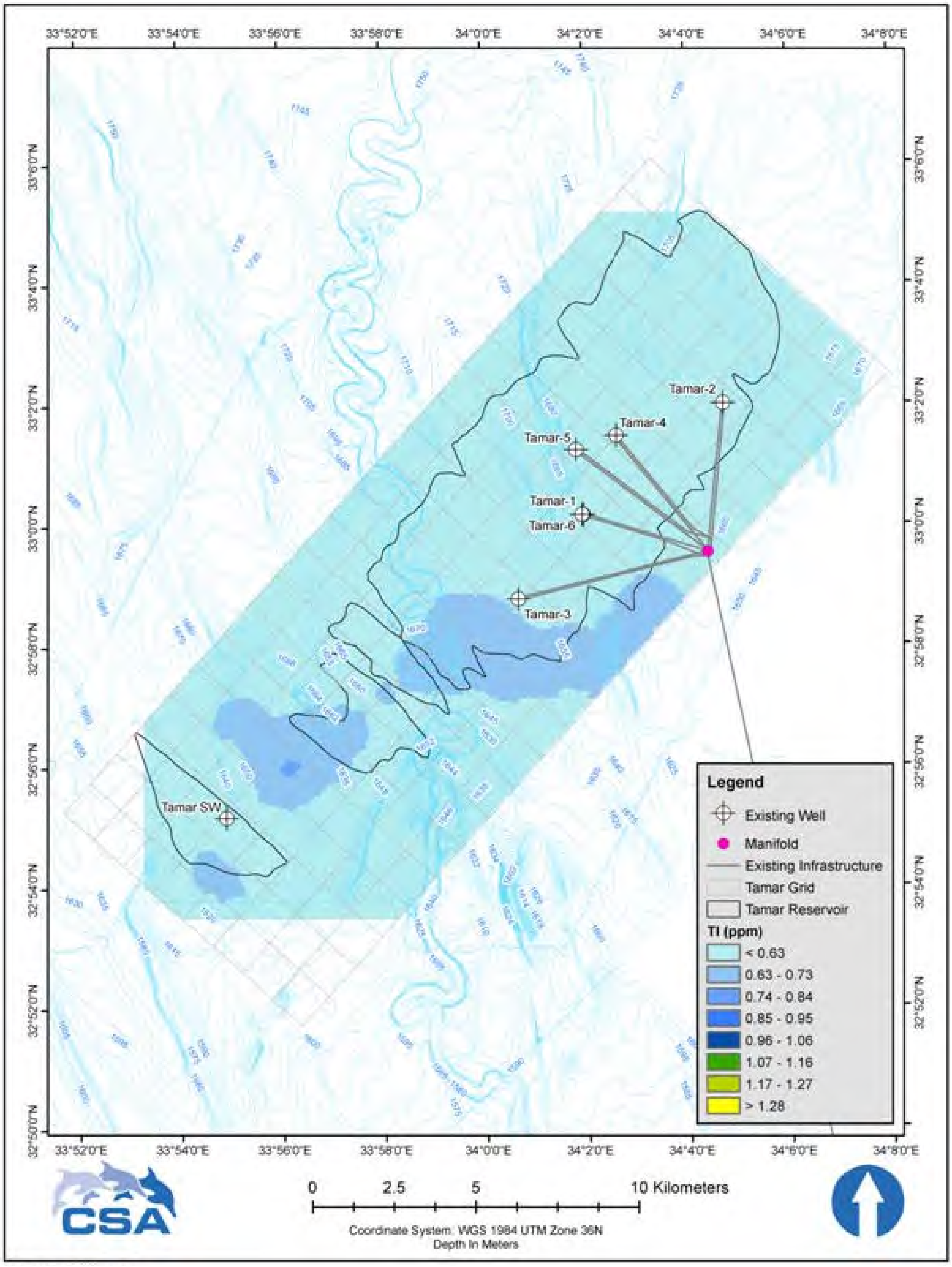


Figure 1-67. High-resolution sediment thallium concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

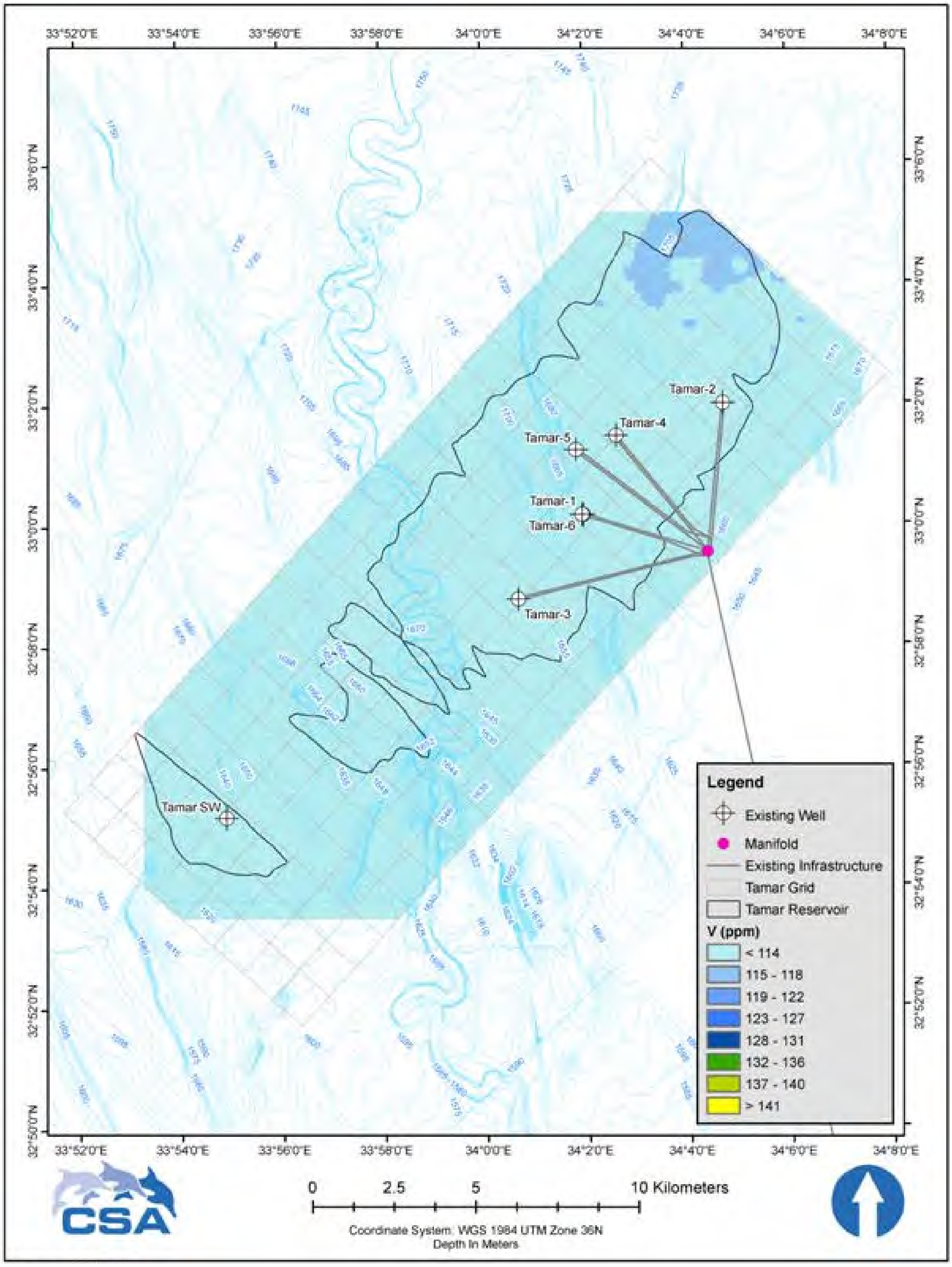


Figure 1-68. High-resolution sediment vanadium concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

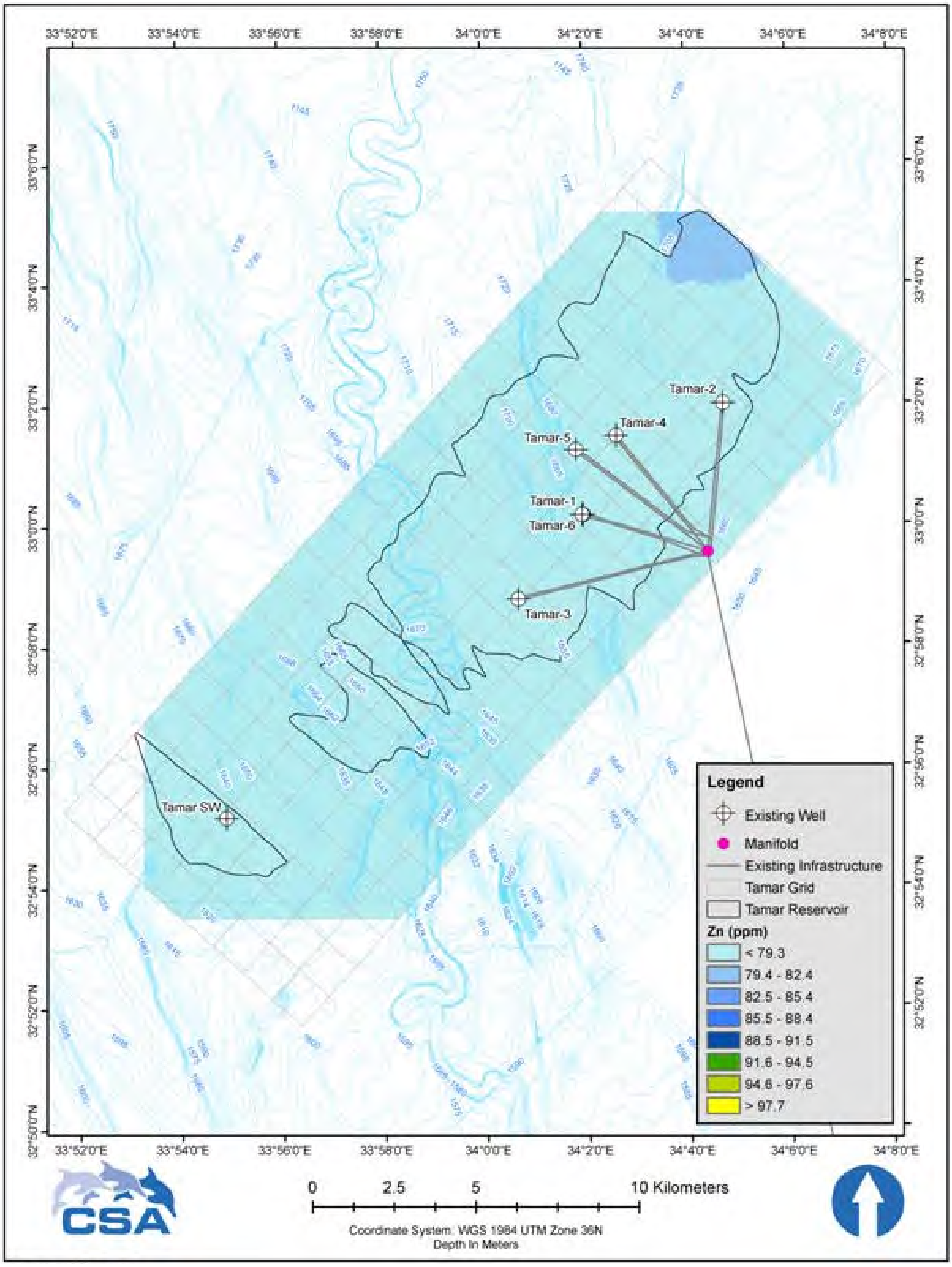


Figure 1-69. High-resolution sediment zinc concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

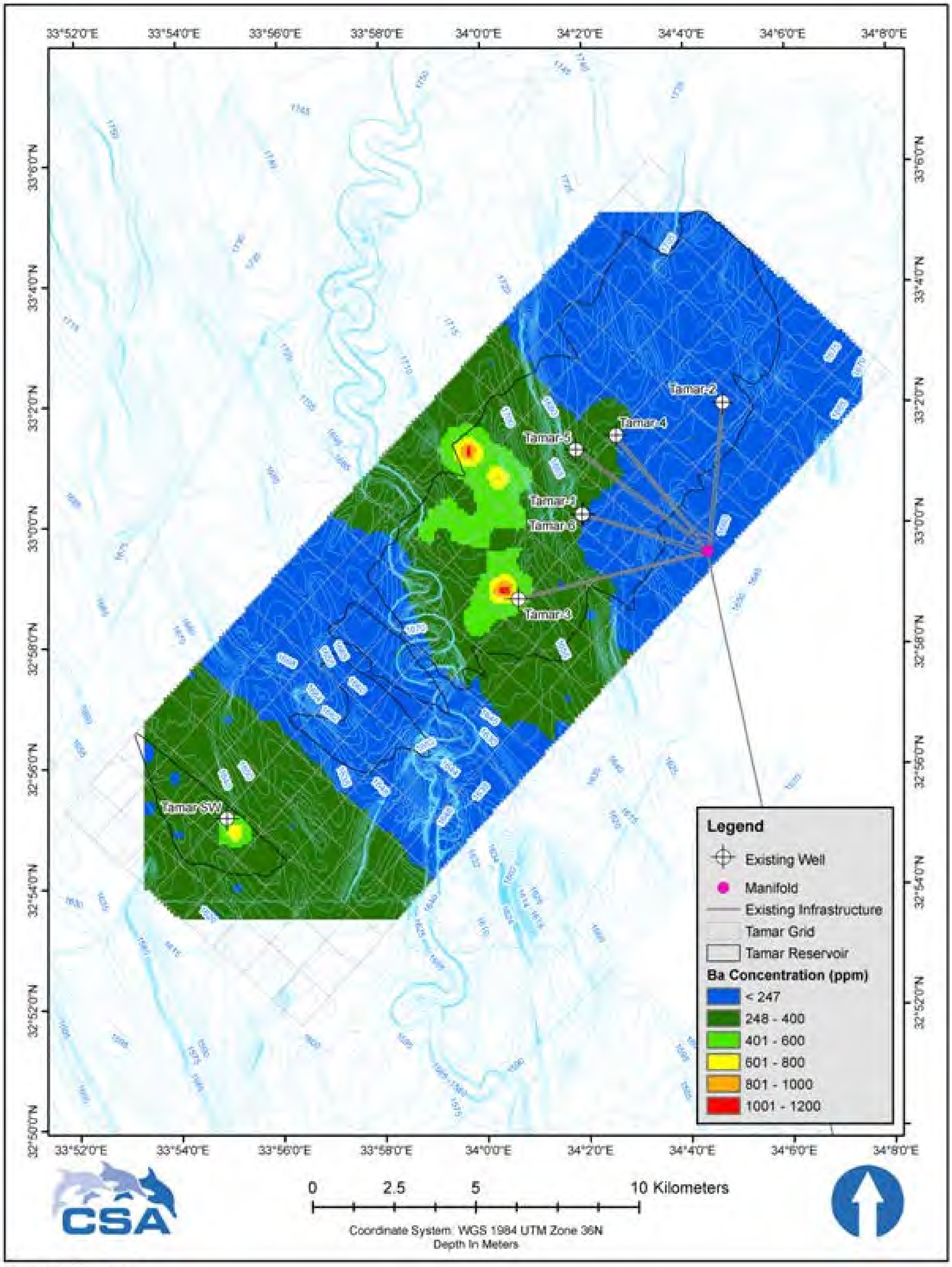


Figure 1-70. Sediment barium concentrations within the Tamar Field in comparison to the Levantine Basin mean. Blue represents values that are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Levantine Basin mean. Other colors represent elevated levels of barium in 200 ppm increments. Levantine Basin means are calculated from pre-drill and environmental baseline surveys conducted by CSA prior to September 2013 (From: CSA Ocean Sciences Inc., 2014).

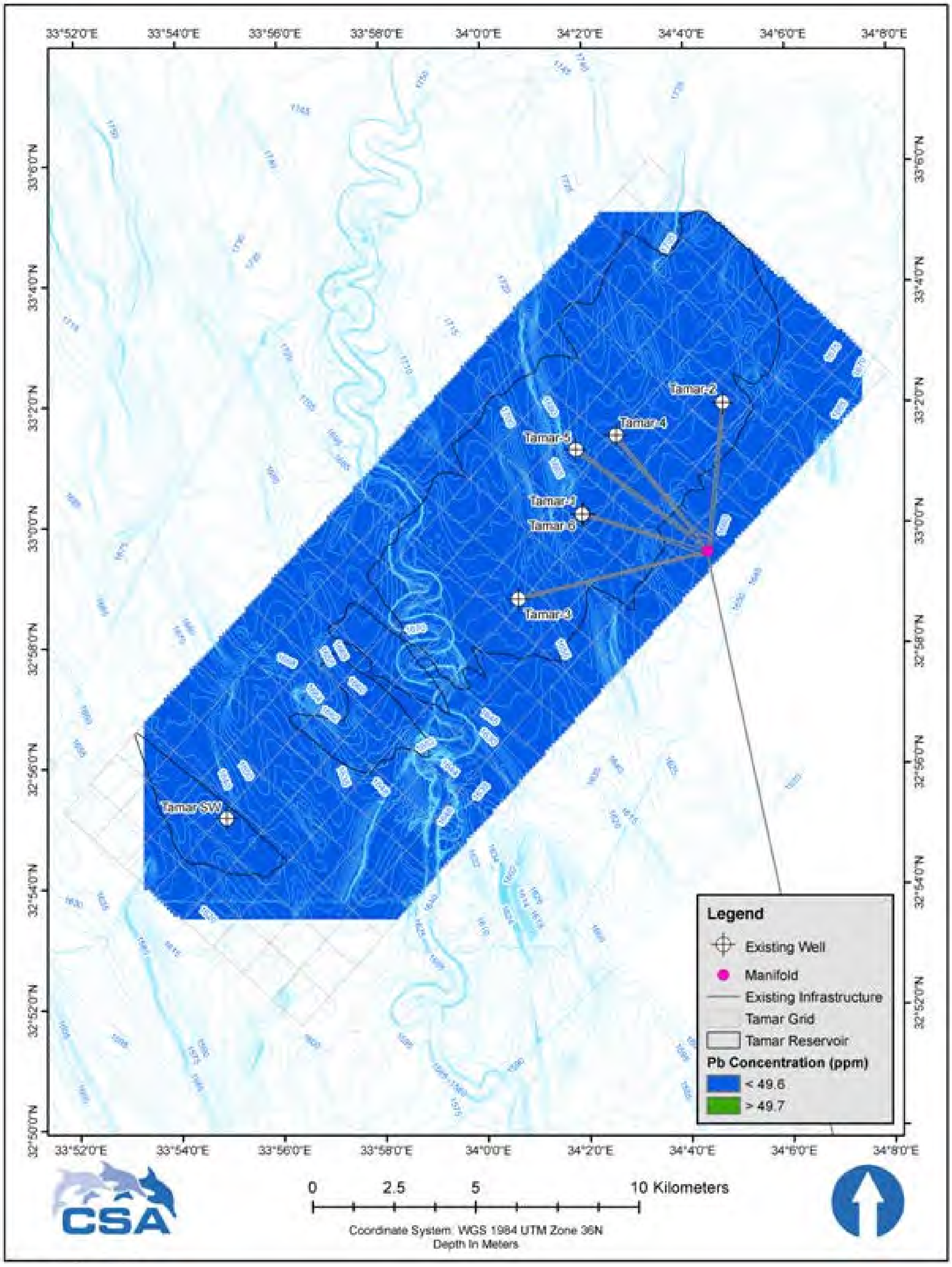


Figure 1-71. Sediment lead concentrations within the Tamar Field in comparison to the Levantine Basin mean. Blue represents values that are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Levantine Basin mean. Dark green represents values that are greater than 2.5 SD from that mean. Levantine Basin means are calculated from Pre-Drill and Environmental Baseline Surveys conducted by CSA prior to September 2013. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

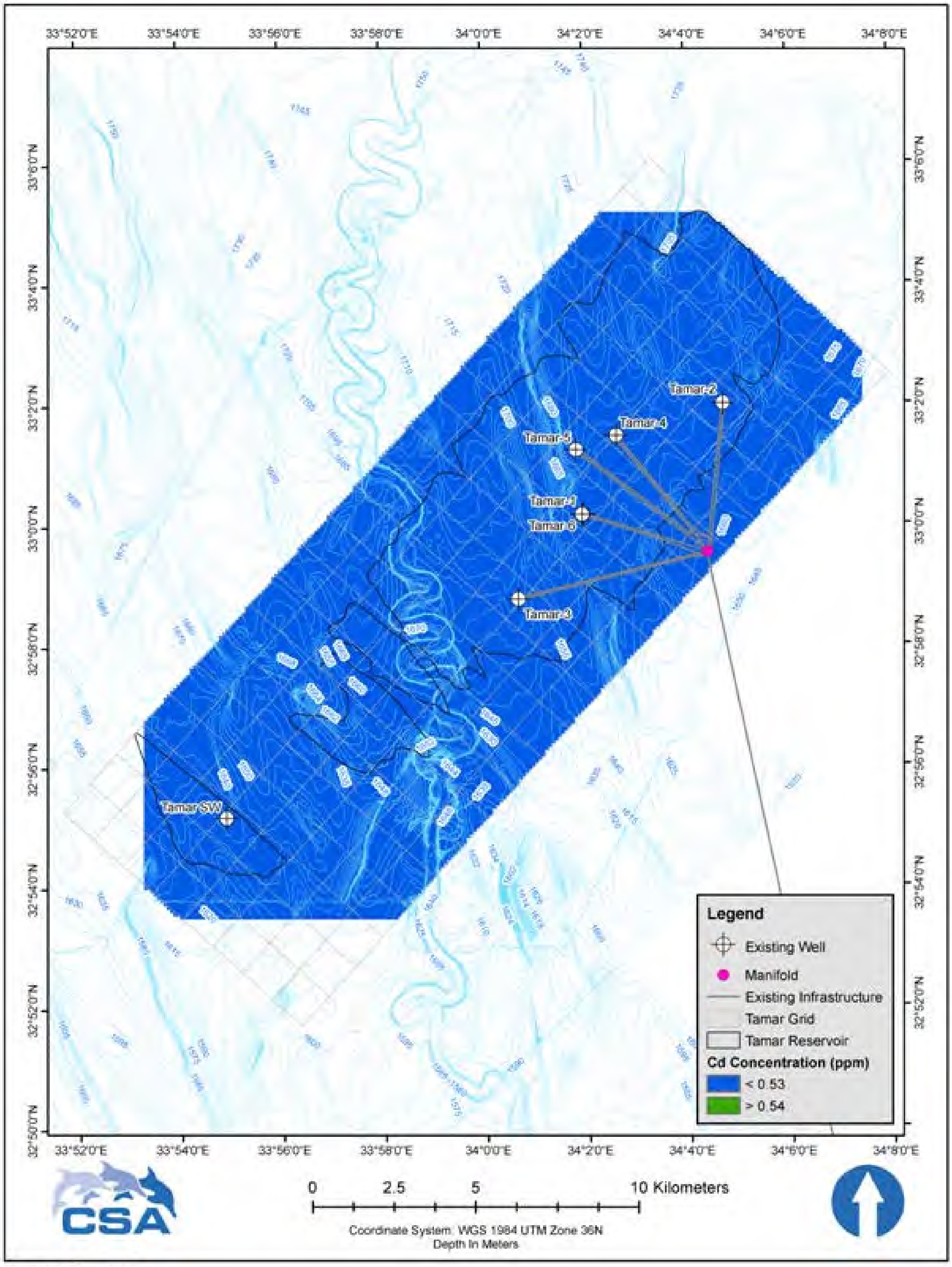


Figure 1-72. Sediment cadmium concentrations within the Tamar Field in comparison to the Levantine Basin mean. Blue represents values that are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Levantine Basin mean. Dark green represents values that are greater than 2.5 SD from that mean. Levantine Basin means are calculated from pre-drill and environmental baseline surveys conducted by CSA prior to September 2013. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

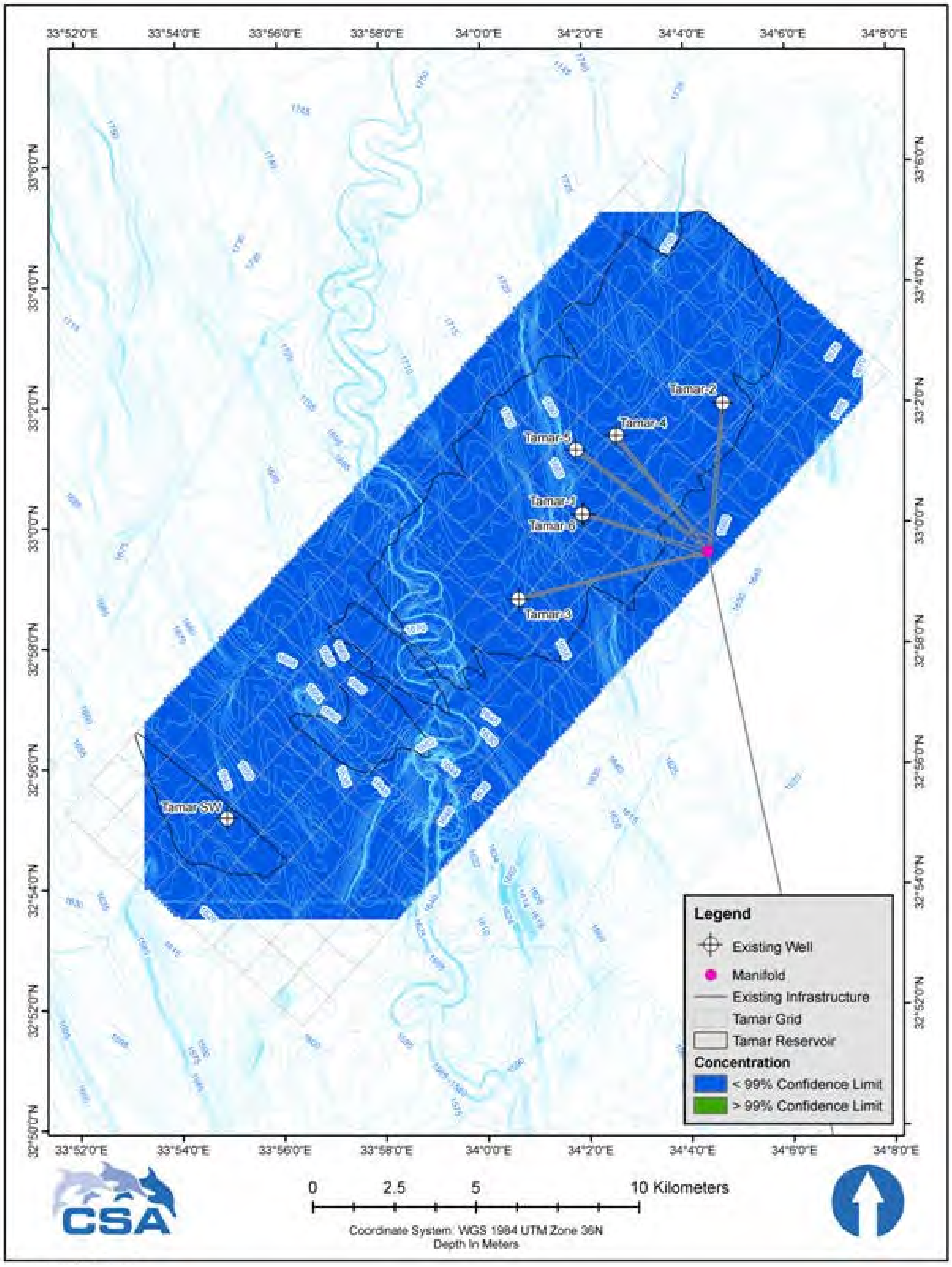


Figure 1-73. Representative map of sediment metals concentrations (ppm) for antimony, arsenic, beryllium, chromium, copper, iron, mercury, nickel, thallium, vanadium, and zinc within the Tamar Field in comparison to the Levantine Basin mean. Blue represents values that are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Levantine Basin mean. Dark green represents values that are greater than 2.5 SD from that mean. Actual Tamar Field and Reservoir means (± SD) for these metals are provided in **Table 1-25**. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

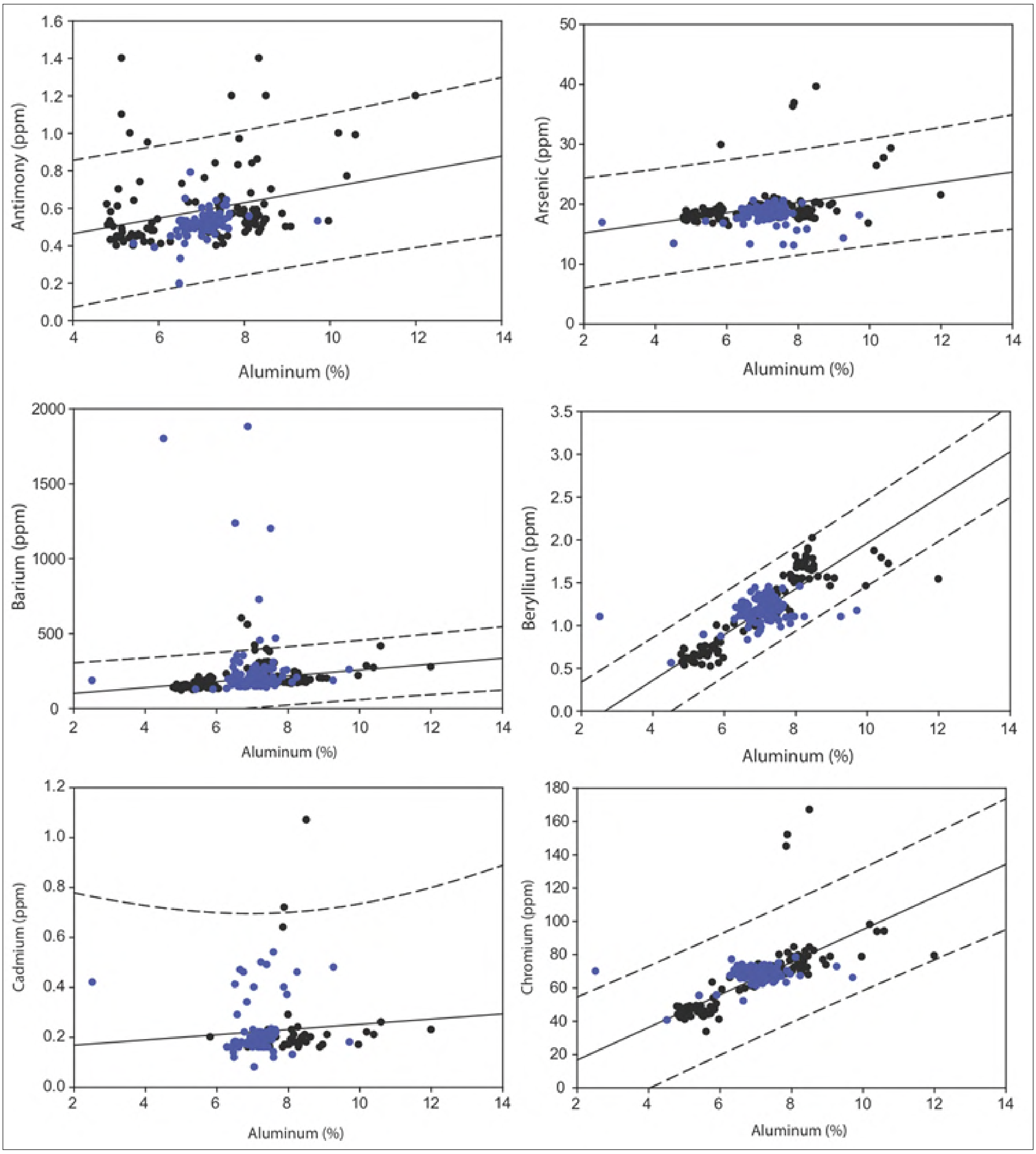


Figure 1-74. Plot of aluminum versus antimony, arsenic, barium, beryllium, cadmium, and chromium. Regression line (solid) and 99% prediction interval (dashed) based on Levantine Basin data collected during pre-drill and environmental baseline surveys conducted by CSA prior to September 2013 (black dots). Blue dots represent data from the Tamar Field (From: CSA Ocean Sciences Inc., 2014).

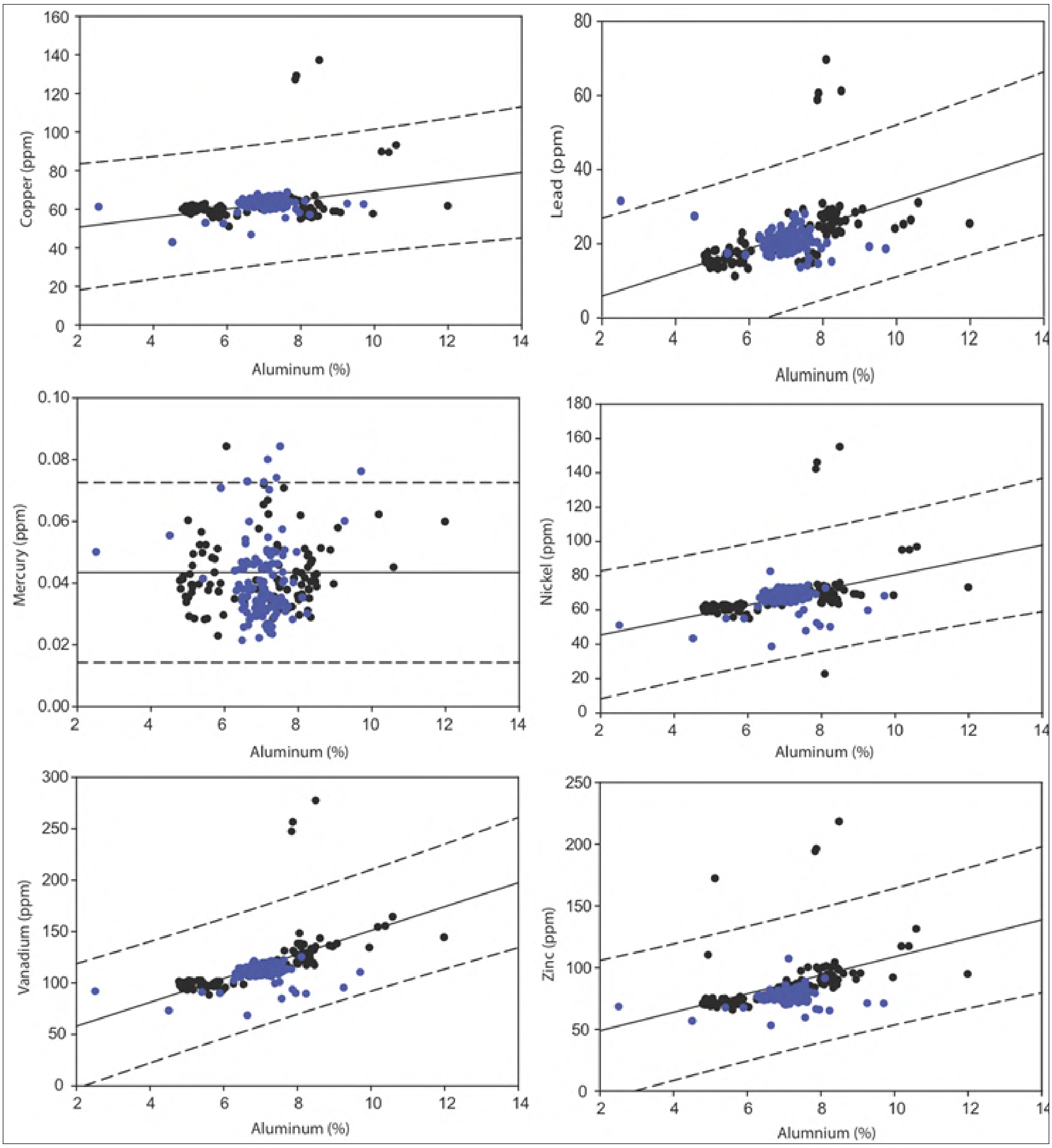


Figure 1-75. Plot of aluminum versus copper, lead, mercury, nickel, vanadium, and zinc. Regression line (solid) and 99% prediction interval (dashed) based on Levantine Basin data collected during pre-drill and environmental baseline surveys conducted by CSA prior to September 2013 (black dots). Blue dots represent data from the Tamar Field (From: CSA Ocean Sciences Inc., 2014).

Table 1-25. Mean (± standard deviation) total metals concentrations (ppm) in sediments collected from within the Tamar Field. Metals concentrations in seafloor sediments of the Levantine Basin (pre-drill and environmental baseline surveys conducted prior to September 2013), effects range low (ERL) and effects range median (ERM) values (Buchman, 2008), and metals concentrations found in drilling muds and barite used at Tamar SW-1 are provided for comparison. Antimony, selenium, and silver concentrations were generally below primary analytical laboratory detection limits and are not presented in the table (From: CSA Ocean Sciences Inc., 2014).

Location	As	Ba	Be	Cd	Cr	Cu	Hg	Ni	Pb	Tl	V	Zn
Tamar Field	18.3 ± 1.4	249.4 ± 263.2	1.2 ± 0.1	0.18 ± 0.11	67.7 ± 4.5	62.5 ± 3.4	0.04 ± 0.01	67.1 ± 6.2	20.5 ± 2.9	0.5 ± 0.2	110.4 ± 8.8	76.4 ± 6.2
Levantine Basin Mean	19.2 ± 3.4	172.0 ± 29.9	1.2 ± 0.5	0.15 ± 0.15	64.8 ± 23.8	62.1 ± 13.5	0.04 ± 0.01	67.3 ± 16.7	22.3 ± 10.6	0.4 ± 0.2	118.9 ± 31.9	88.2 ± 26.6
99% Confidence Limit of Levantine Basin Mean	29.2	249.2	2.5	N/A	126.1	97.0	0.06	110.4	49.6	0.9	201.2	156.8
ERL	8.2	N/A	N/A	1.2	81.0	34.0	0.2	20.9	46.7	N/A	N/A	150.0
ERM	70.0	N/A	N/A	9.6	370.0	270.0	0.7	51.6	218.0	N/A	N/A	410.0
Drilling Mud	4 ± 2.3	1,076.0 ± 396.3	1.0 ± 1.1	1.0 ± 1.1	4.0 ± 3.1	8.0 ± 2.1	0.001 ± 0.001	2.0 ± 1.9	162.0 ± 46.3	N/A	3.0 ± 2.5	15.0 ± 6.1
Barite	20.0	N/A	N/A	1.6 ± 0.6	8.0	121.0	N/A	7.0	165.0	N/A	N/A	109.0

As = arsenic; Ba = barium; Be = beryllium; Cd = cadmium; Cr = chromium; Cu = copper; Hg = mercury; N/A = data not available; Ni = nickel; Pb = lead; Tl = thallium; V = vanadium; Zn = zinc.

Hydrocarbons

TPH concentrations throughout the survey area were generally within the 99% CL of the Tamar Field mean (**Figure 1-76**) and the Levantine Basin mean (**Figure 1-77**), with the exception of grid cells surrounding the Tamar-1/Tamar-6 and Tamar SW-1 wellsites. The approximate distance from the center point of affected grid cells D09, F08, and G08 to the Tamar-6 wellsite is 1.55 km; while the approximate distance of affected grid cells D20 and E20 to the Tamar SW-1 wellsite is 1 km (**Appendix A**). Hydrocarbons were a minor component of the mud used to drill the Tamar wellsites, and slightly elevated levels of TPH at these locations may be indicative of minor impacts due to drilling and production activities. TPH concentrations throughout the field, even in the slightly elevated grid cells, are low 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. All individual PAH concentrations were below the Levantine Basin mean (**Figure 1-78**). Total PAH concentrations (less than 60 parts per billion [ppb]) were within the 99% CL of the Tamar Field mean (**Figure 1-79**), below the Levantine Basin mean (77.5 ± 19 ppb), and well below 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 enriched in three- to five-ringed PAH compounds while fossil fuels (petrogenic) are enriched in polynuclear organosulfur compounds (e.g., dibenzothiophene) and two- to three-ringed PAH assemblages (Steinhauer and Boehm, 1992). The FFPI is calculated by the following equation (Boehm and Farrington, 1984):

$$\frac{\left[\Sigma\, naphthalenes(C_o - C_4) + \Sigma\, dibenzothiophenes(C_o - C_3) + \frac{1}{2}\Sigma\, phenanthrenes(C_o - C_1) + +\Sigma\, phenanthrenes(C_2 - C_4)\right]}{\Sigma\, PAH}$$

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 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).

The FFPI ratio for sediments throughout the Tamar Field are classified as either having pyrogenic or pyrogenic/petrogenic sources (**Figure 1-80**). Most of the sediments classified as having a mixture of pyrogenic/petrogenic sources are far from the wellsites and none directly surround any wellsite.

Radionuclides

Ambient radium concentrations in most natural soils and rocks are approximately 0.5 to 5.0 pCi/g 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 (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 at the sediment surface as a threshold for the cleanup of the top 15 cm of soil from contaminated U.S. Superfund sites.

All radionuclide concentrations within the Tamar Field are considered natural ambient concentrations (Agency for Toxic Substances and Disease Registry, 1990; U.S. Geological Survey, 1999) and are below levels of concern as outlined by the USEPA (1998) protective health-based level recommendations. High-resolution variations of sediment Ra 226 and Ra 228 as well as Th 228 concentrations are shown in **Figures 1-81** to **1-83**. All values were within the 99% CL for radionuclide concentrations within the Levantine Basin.

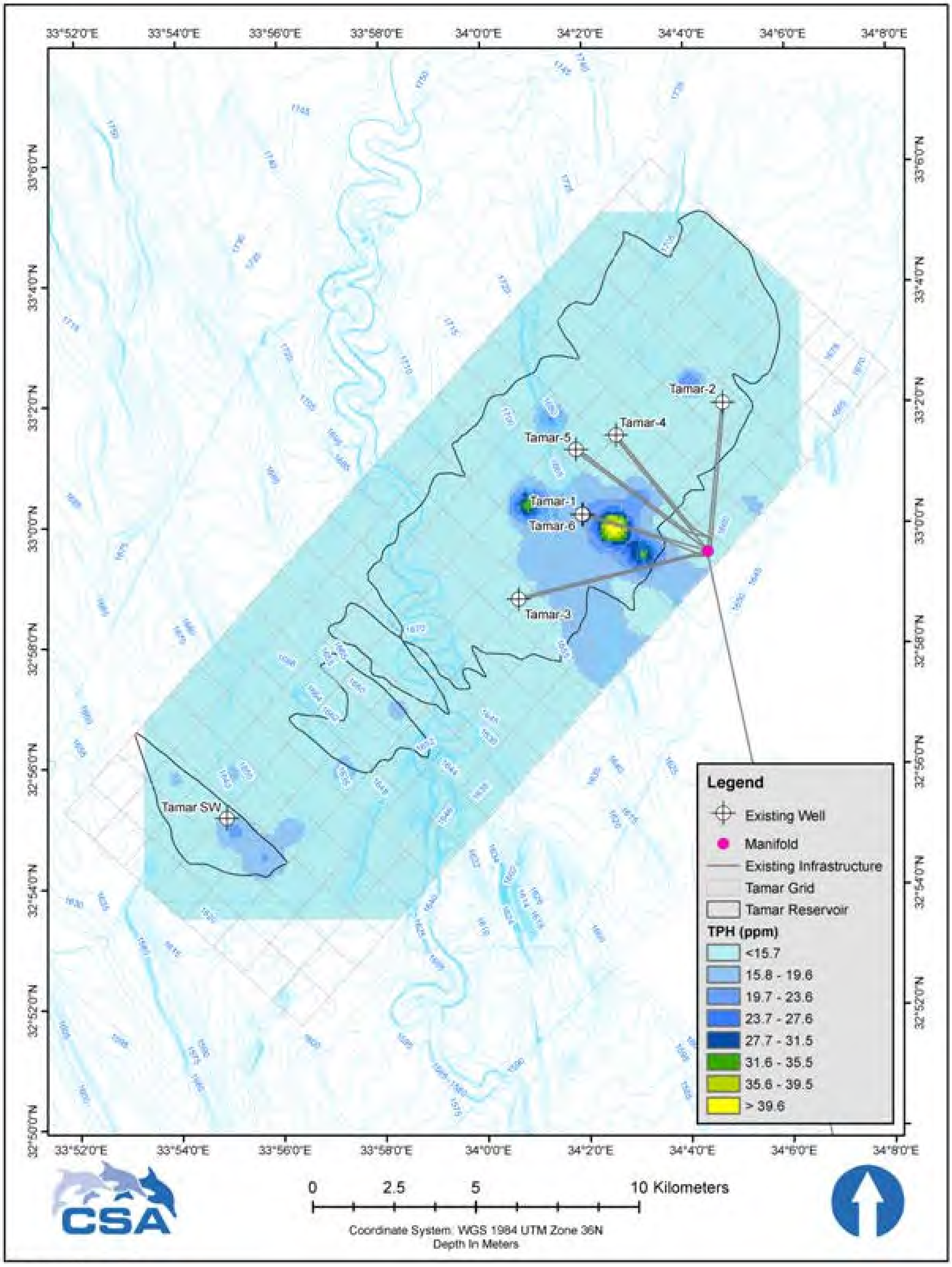


Figure 1-76. High-resolution sediment total petroleum hydrocarbons (TPH) concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean (From: CSA Ocean Sciences Inc., 2014).

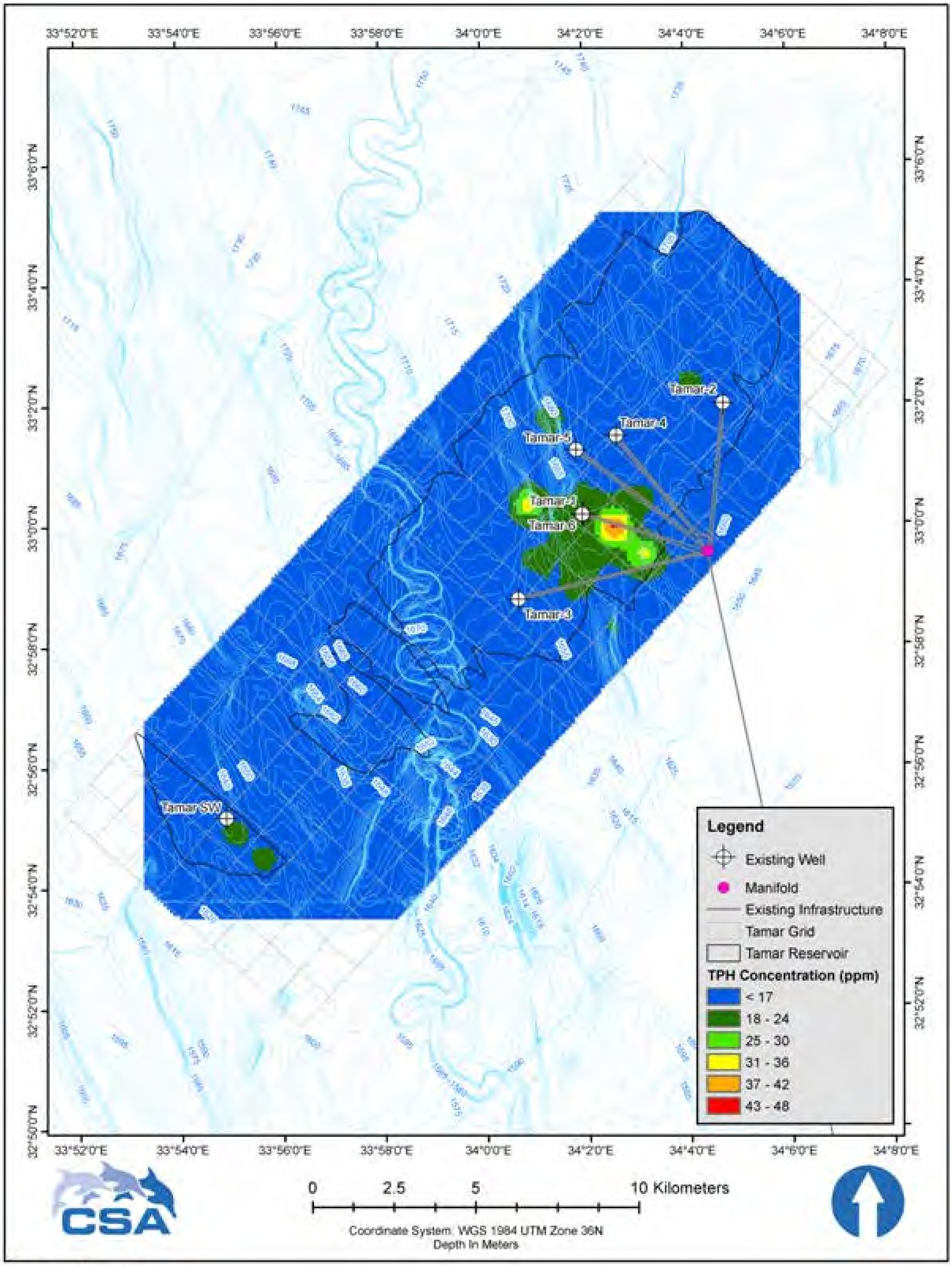


Figure 1-77. Sediment total petroleum hydrocarbons (TPH) concentrations within the Tamar Field in comparison to the Levantine Basin mean. Blue represents values that are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Levantine Basin mean. Other colors represent elevated levels of TPH in 6 ppm increments. Levantine Basin means are calculated from pre-drill and environmental baseline surveys conducted by CSA prior to September 2013 (From: CSA Ocean Sciences Inc., 2014).

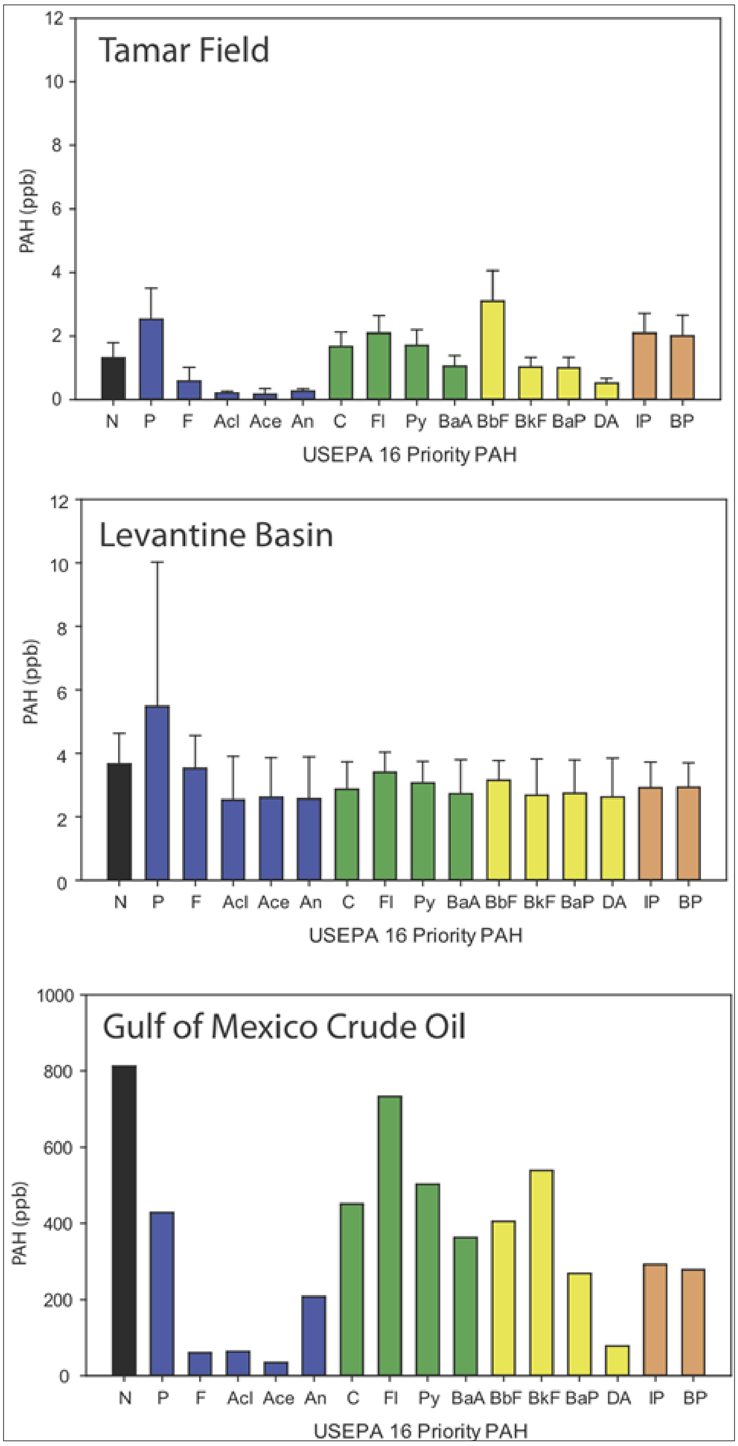


Figure 1-78. Mean (+ standard deviation) concentrations for the 16 U.S. Environmental Protection Agency (USEPA) priority polycyclic aromatic hydrocarbons (PAHs) for sediment samples collected in the Tamar Field (top). For comparative purposes, PAH signatures for the Levantine Basin Mean and Gulf of Mexico Crude Oil (SRM2779) are also shown (note scale change). Black = 2 rings (naphthalene); blue = 3 rings (phenanthrene, fluorene, acenaphthylene, acenaphthene, anthracene); green = 4 rings (chrysene, fluoranthracene, pyrene, benzo[a]anthracene); yellow = 5 rings (benzo[b]fluoranthene, benzo[k,j]fluoranthene, benzo[a]pyrene, and diben[a,h]anthracene); orange = 6 rings (ideno[1,2,3-cd]pyrene, benzo[g,h,i]perylene) (From: CSA Ocean Sciences Inc., 2014).

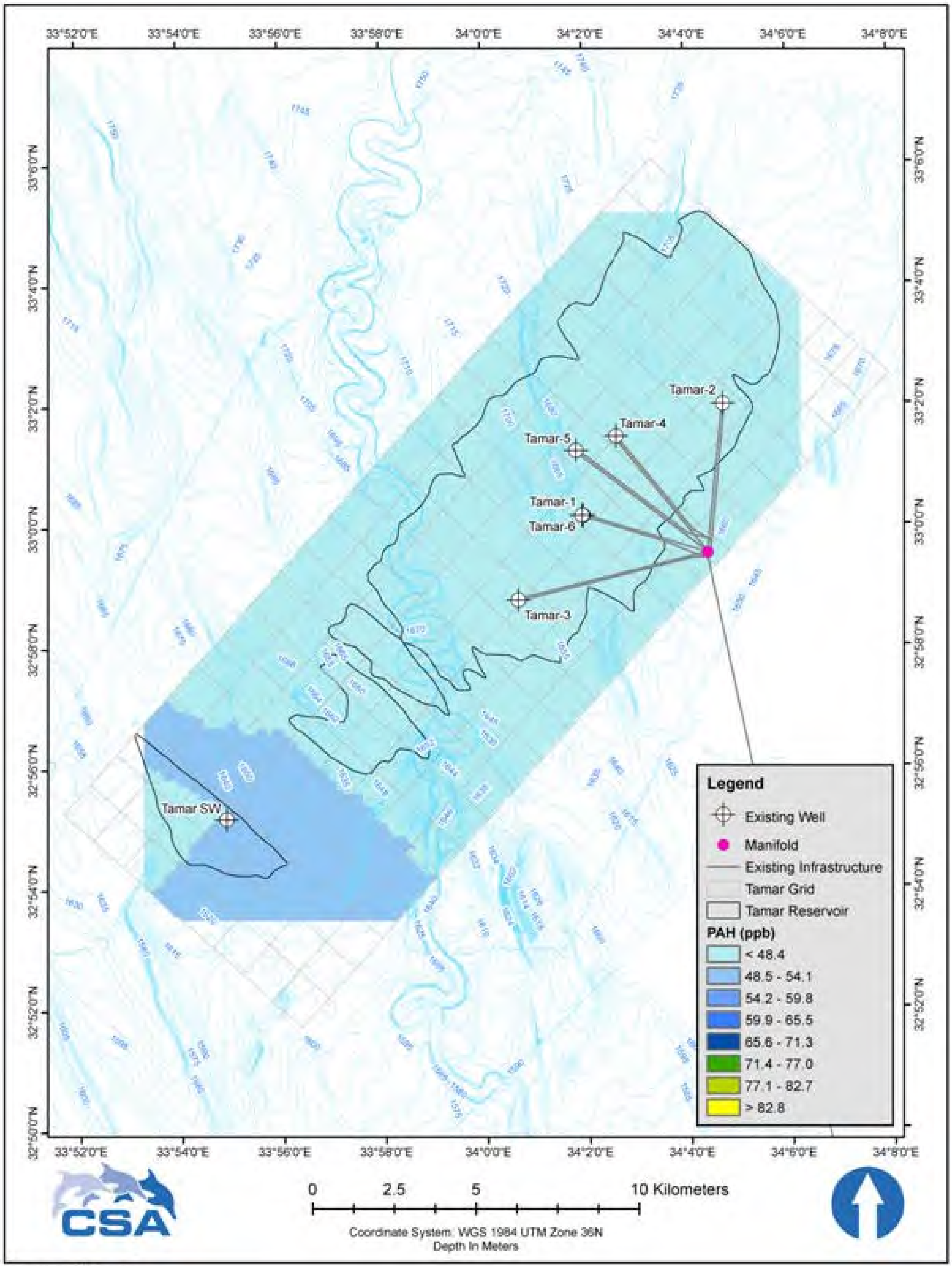


Figure 1-79. High-resolution sediment total polycyclic aromatic hydrocarbon (PAH) concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

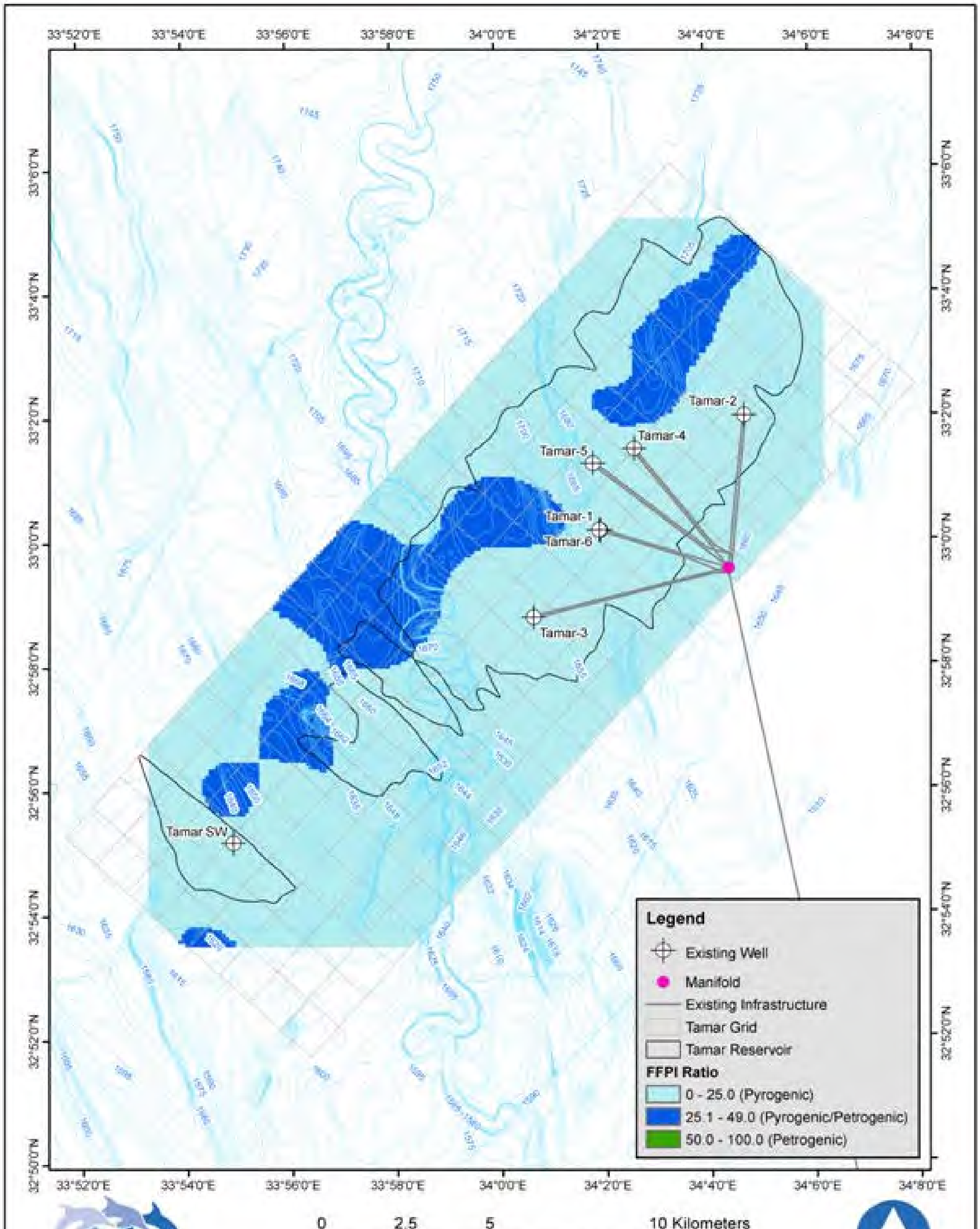


Figure 1-80. Calculated Fossil Fuel Pollution Index (FFPI) ratios within the Tamar Field. Light blue represents an FFPI ratio of 25%, which indicates a polycyclic aromatic hydrocarbon (PAH) assemblage dominated by pyrogenic sources. Dark blue represents an FFPI ratio between 25% and 40%, which is indicative of a mixture of pyrogenic and petrogenic sources. Green represents an FFPI ratio between 40% and 100% which indicates a PAH assemblage dominated by petrogenic sources. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

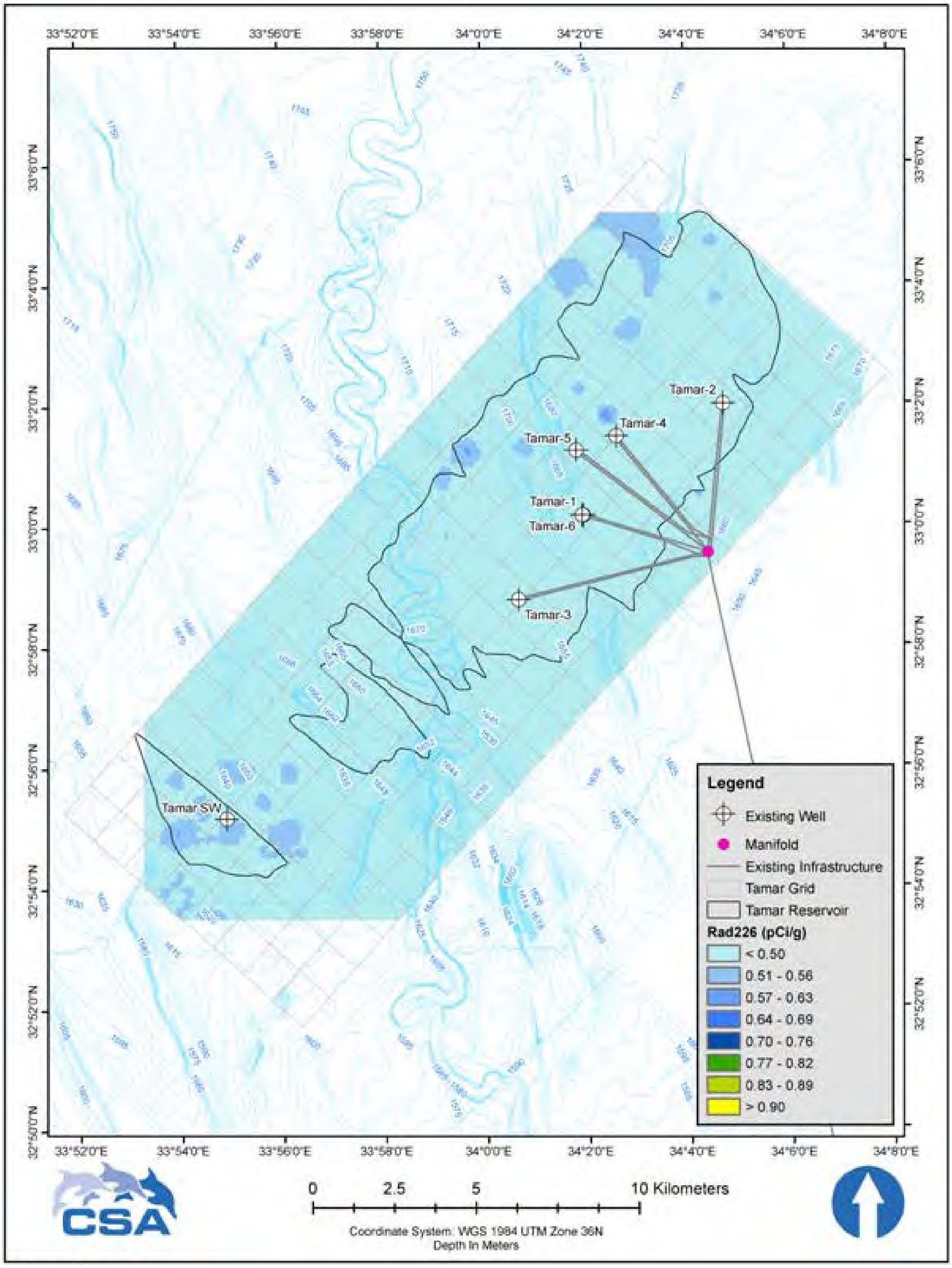


Figure 1-81. High-resolution sediment radium 226 concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

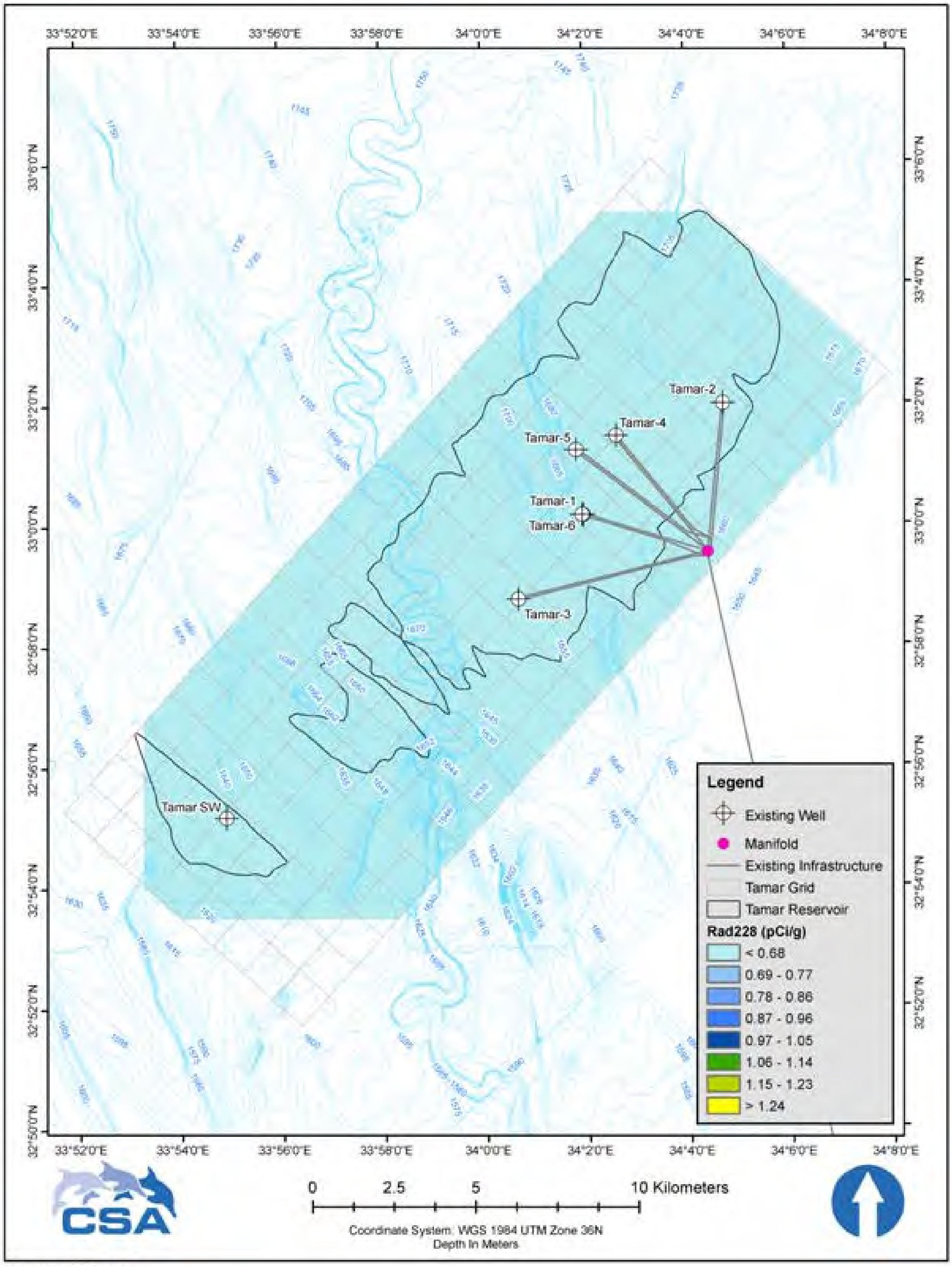


Figure 1-82. High-resolution sediment radium 228 concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

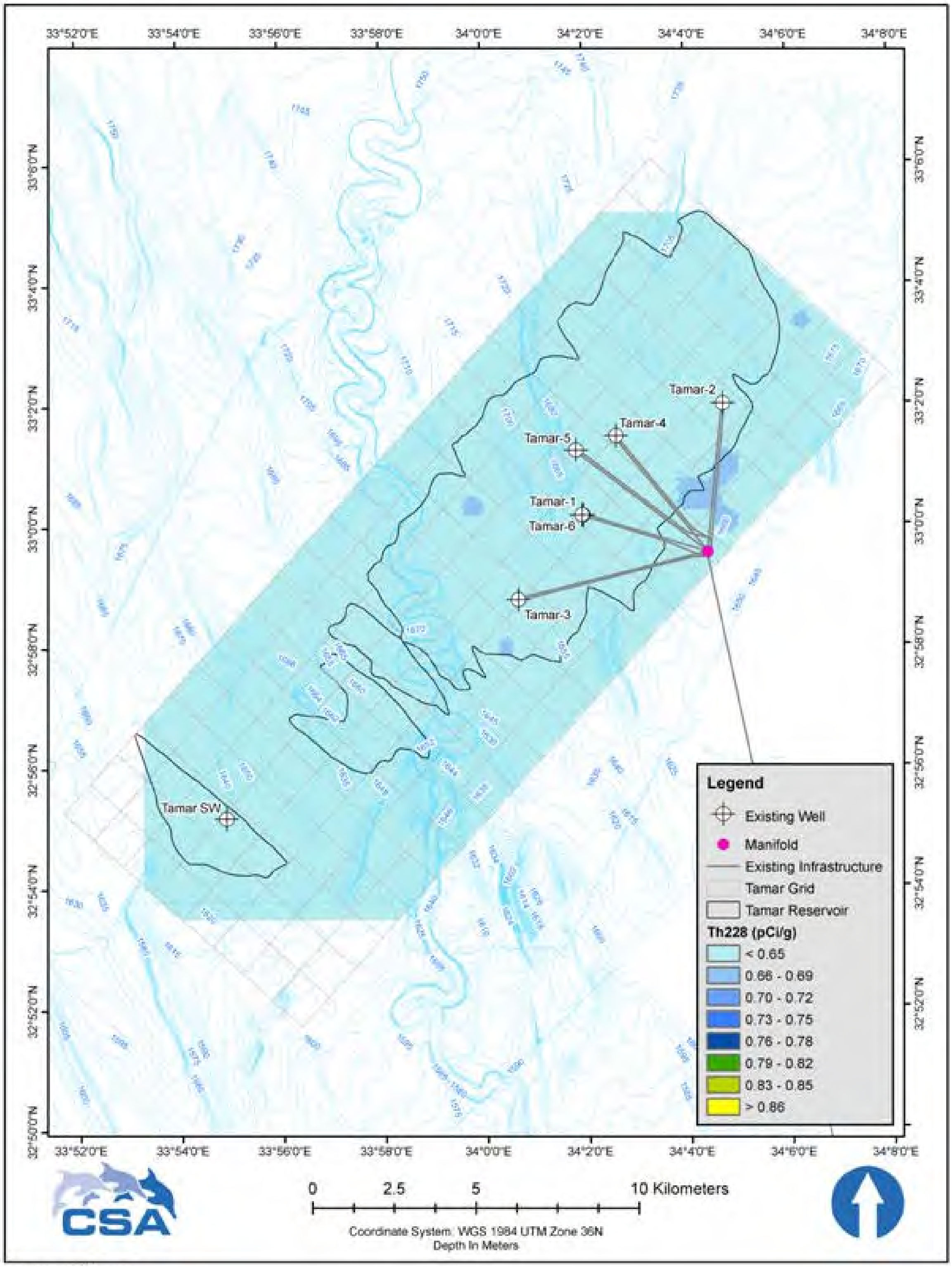


Figure 1-83. High-resolution sediment thorium 228 concentrations within the Tamar Field. Concentrations represented by shades of blue are within the 99% confidence limit (less than 2.5 standard deviations [SD]) of the Tamar Field mean. Dark green represents values that are 2.5 to 3.0 SD from the mean. Light green represents values that are 3.0 to 3.5 SD from the mean. Yellow represents values that are greater than 3.5 SD from the mean. Map color scales are standardized to show the possible range of concentrations over the established SD scale; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present (From: CSA Ocean Sciences Inc., 2014).

1.2.5 Culture and Heritage Sites

Noble Energy conducted a geophysical survey and shallow geotechnical investigation of the Tamar Development area and pipeline routes for potential cultural and heritage sites. A total of 95 side-scan sonar contacts were identified in the Tamar Field; 2 correspond to well locations and 15 indicate possible anchor locations (DOF Subsea UK, 2010a). The rest are classified as unidentified because they have not been visually inspected. The side-scan contact list is presented in **Appendix D**. One of the largest unidentified contacts (**Figure 1-84**) has dimensions 10.5-m × 0.9-m × 6.8-m and can be seen on the subbottom profile.

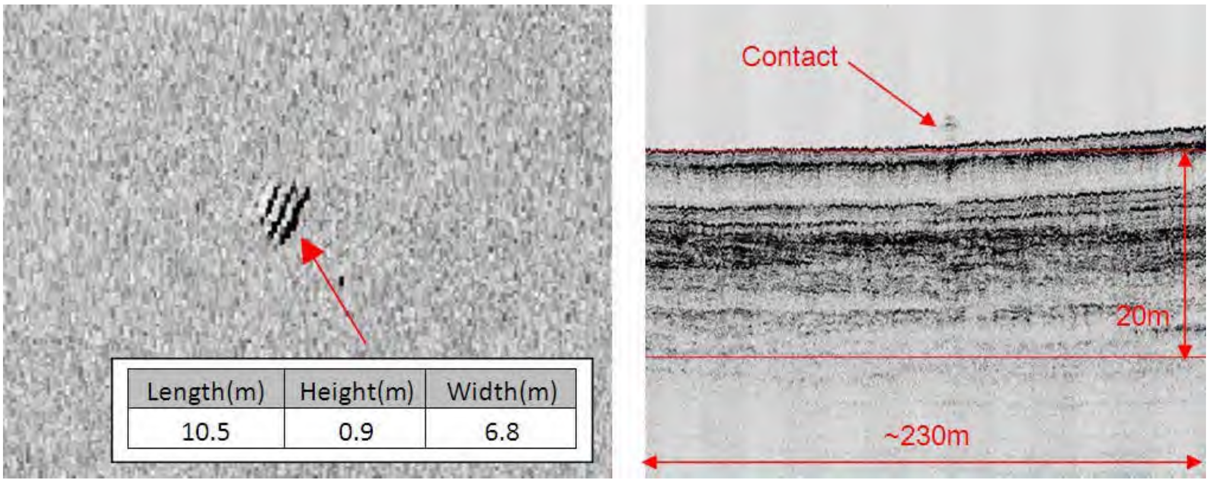


Figure 1-84. Side-scan sonar image (left) and subbottom image (right) showing contact number 20 (From: DOF Subsea UK, 2010a).

1.2.6 Meteorology and Air Quality

There are no publicly available air quality data for the offshore areas of Israel, nor are site-specific offshore air quality measurements available for the Tamar Field area. Given the relatively remote location of the offshore area of interest and prevailing wind patterns (i.e., predominant westerly winds January through October; variable November and December), air quality offshore likely reflects the long-range transport of natural and anthropogenic air pollutants, with contribution from regional sources. The air quality issues noted onshore have not affected offshore air quality in the Tamar Field. In the offshore environment of the eastern Mediterranean Sea where the Tamar Field is located, air quality is expected to be good.

The primary pollutants involved in the photochemical cycles that determine air quality are nitrogen oxides (NO_x), composed mainly of nitric oxide (NO) and nitrogen dioxide (NO_2), and volatile organic compounds (VOCs). Another important group of air pollutants are the oxidants (e.g., ozone [O_3] or peroxyacetal nitrate [PAN]), which are byproducts of the aforementioned primary compounds. Air quality measurements in coastal Israel have shown consistent decline in the last century, with recent improvements evident as a result of more stringent emissions regulations and the transition of major combustion sources from fuel oil to natural gas. During recent years, shipping and airport activities (i.e., vessel and aircraft emissions, support operations) have become significant regional sources of air pollution (Maritime Communication Services, Inc. et al., 2008).

Air quality offshore Israel is influenced by long-range transport of anthropogenic and natural air pollutants. Air pollutants of anthropogenic origin that reach Israeli waters originate mainly upstream of the main flow patterns. These pollutants are emitted from sources located in Eastern Europe, the Black Sea, and the Balkan area as well as the Western Mediterranean, Greece, and Turkey. Desert dust that arises from the Sahara is transported offshore into the Mediterranean mainly during the transient seasons of spring and autumn (Michaelidis et al., 1999). Dust transport offshore Israel is a rather episodic phenomenon. Dust is usually transported from the Sahara northward under anticyclonic conditions or ahead of a trough.

Because the Application Area is more than 10 km from the Israeli coast, onshore air quality is not reviewed in this report. No special meteorological conditions that might cause conditions of dispersal that will give rise to high air pollution concentrations in the environment are known for the Application Area.

1.2.7 Noise

Acoustic Environment

The underwater acoustic environment includes sound produced from a variety of natural and anthropogenic sources. Some natural sounds are biological (e.g., fishes, marine mammals, some invertebrates), while others are environmental (e.g., waves, earthquakes, rain). Among the anthropogenic sources, many produce noise as a byproduct of their normal operations (e.g., shipping, drilling, tidal turbines), whereas others (e.g., sonars, airguns) are produced for specific remote sensing purposes. These sounds combine to give the continuum of noise against which all acoustic receivers have to detect required signals. Ambient noise is generally made up of three constituent types – wideband continuous noise, tonals, and impulsive noise. Ambient noise covers the whole acoustic spectrum from below 1 Hz to well above 100 kHz (Urick, 1983). Above this frequency, the ambient noise level drops below thermal noise levels.

Although there is no specific measurement of ambient noise in the Tamar Field study area, the most likely dominant sources of ambient noise for a location in proximity to one of the busiest sea routes in the world will be industrial noise and distant shipping in the absence of wind and precipitation. In addition, the areas affected by different noise contributions likely will vary throughout the year, as acoustic propagation loss varies throughout the seasons.

Potter et al. (1997) measured ambient noise levels in shallow water (i.e., 4 to 5 m water depth) off Haifa, noting that measurements of ambient noise ranged between 100 and 10,000 Hz. It is clear that the Haifa site exhibited moderate shipping activity. Further, biological sound sources (i.e., snapping shrimp) dominated the spectrum above a few hundred hertz, exceeding anticipated levels by 20 dB or more above 10 kHz.

Galil (2006) broadly characterized the acoustic environment of the Mediterranean and noted that the Eastern Mediterranean region represents one of the busiest sea routes in the world with a number of 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. While shipping noise affects large segments of the world's oceans, noise levels are greatest near well-travelled shipping lanes, straits and canals, and busy ports. According to Galil (2006), the ambient noise in areas of heavy shipping could range between 85 and 95 dB. Supertankers, large bulk carriers, container ships, and cargo vessels produce sound with source levels of approximately 190 dB (Ross, 1976; Richardson et al., 1995; National Research Council, 2003a).

1.2.8 Marine Transportation System and Infrastructure

1.2.8.1 Shipping and Maritime Operations

Figures 1-85 through **1-88** are based on data available from the Ministry of Transport (Shipping and Ports Authority) and the Israel Port Authority website. These websites present a summary of information on ship visits and source and destination data for containers passing through both the Port of Haifa and Ashdod Port; data are available for both cargo shipping and passenger traffic. **Figure 1-85** presents the annual number of ship visits to the ports of Israel from 2000 to 2009. Source and destination data for ship visits are presented in **Figures 1-85** and **1-87**, respectively.

Figure 1-88 presents the total amount of cargo transported through the ports of Israel from 1995 to 2008.

In 2010, the movement of containers at the Port of Haifa, Ashdod Port, and Port of Eilat amounted to approximately 2.281 million containers, in thousand 20-ft equivalent units (TEU), compared to 2.032 million TEU in the same period in 2009, an increase of 12.3% in container traffic. During this period, container traffic increased by 11.5% through the Port of Haifa and 13.9% through the Port of Eilat. Total freight (in tons) at the Port of Haifa, Ashdod Port, Port of Eilat, and Israel Shipyards (Haifa) in 2010 amounted to approximately 43.3 million tons, compared to approximately 37 million tons in 2009, an increase of approximately 20.5% (Israel Ports Authority, 2011).

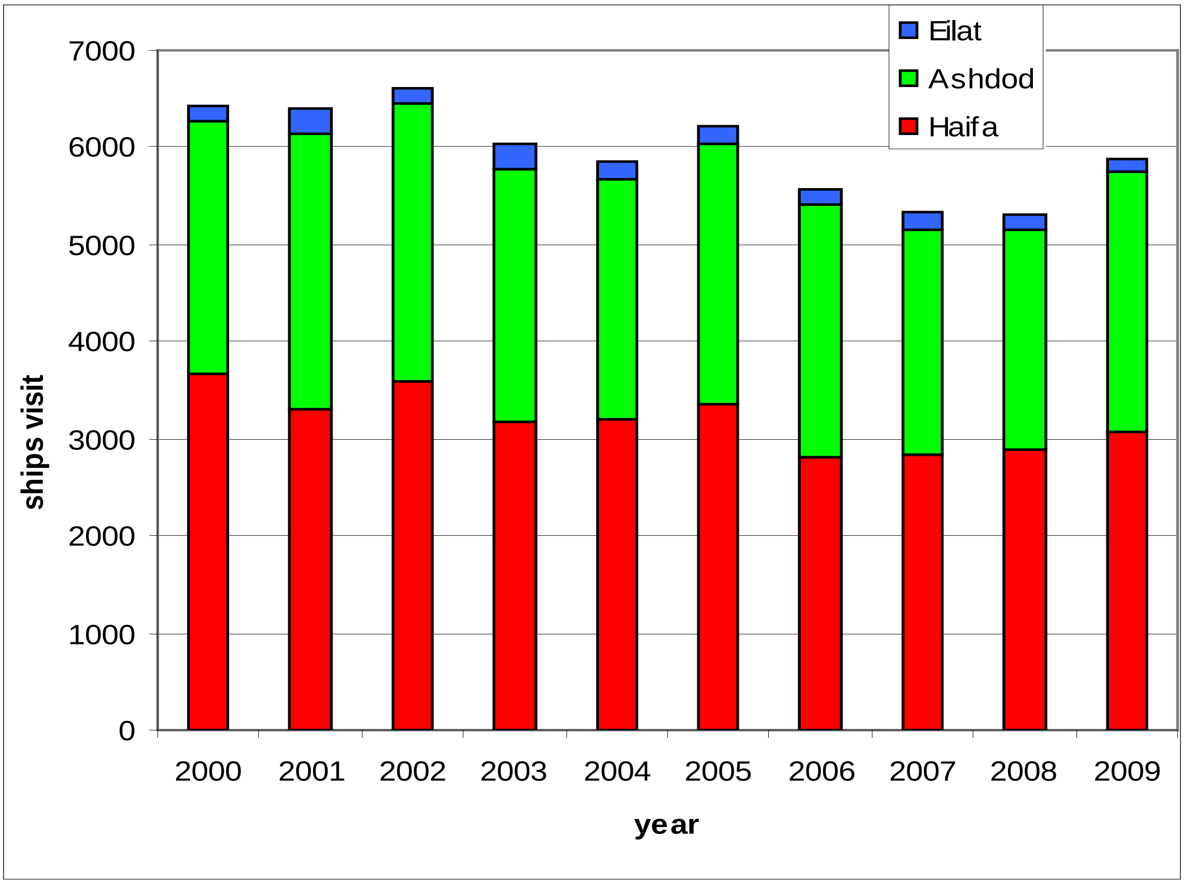


Figure 1-85. Ship docking at the ports of Israel, 2000 to 2009 (From: Ministry of Transport and Road Safety, Shipping and Ports Authority, 2009).

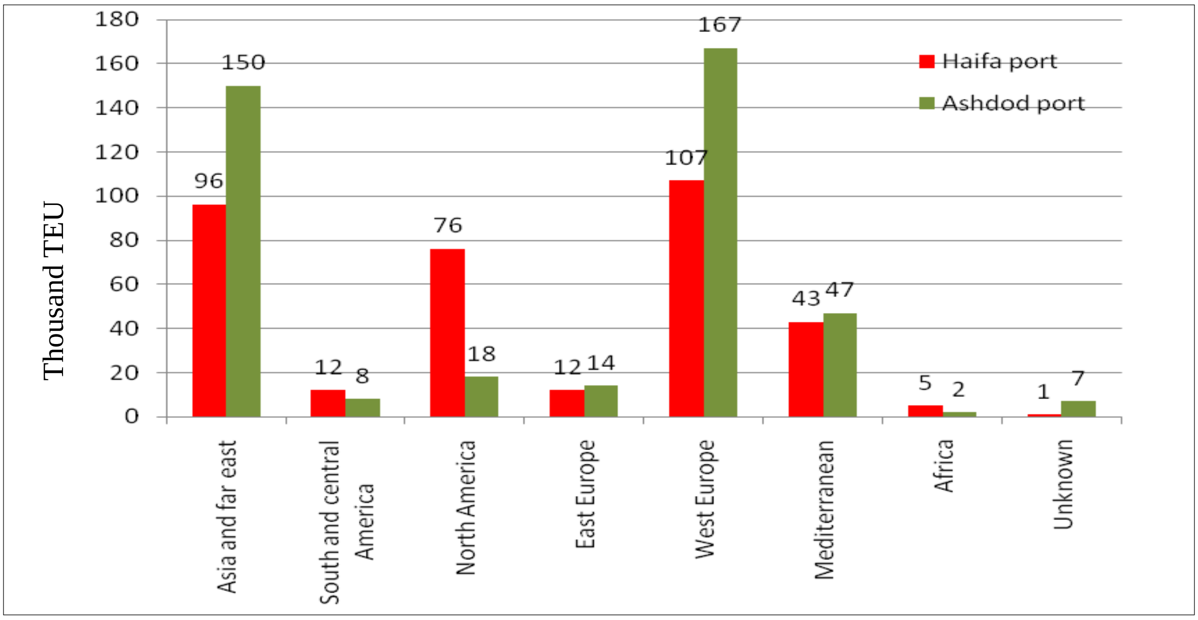


Figure 1-86. Sources of shipping containers arriving at the main ports of Israel (in thousand 20-ft equivalent units [TEU]) (From: Israel Ports Authority, 2011).

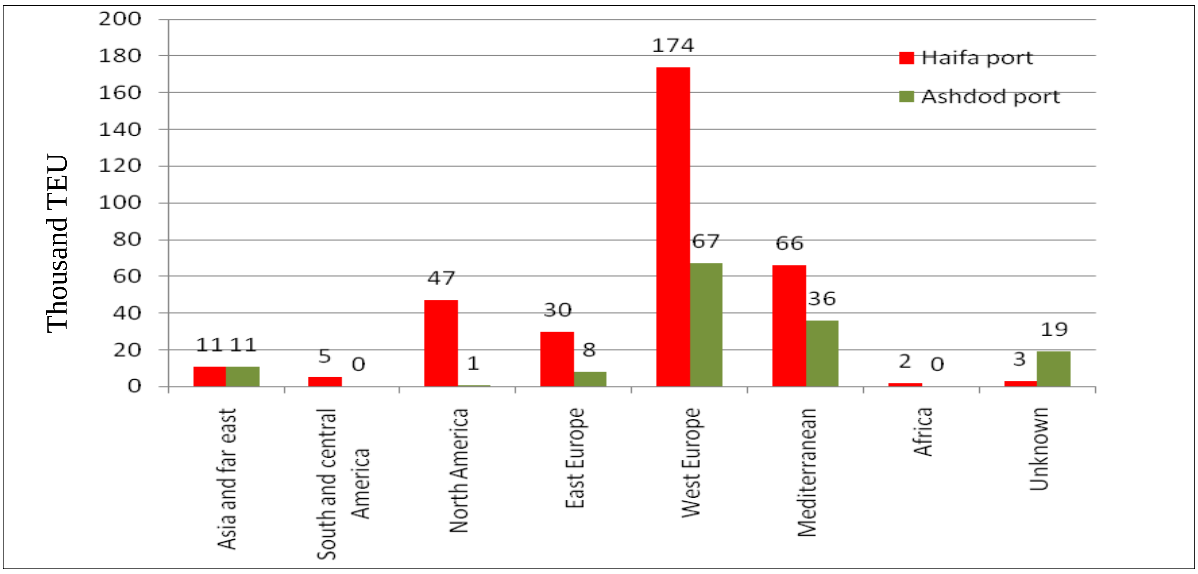


Figure 1-87. Destination of shipping containers from main ports of Israel (in thousand 20-ft equivalent units [TEU]) (From: Israel Ports Authority, 2011).

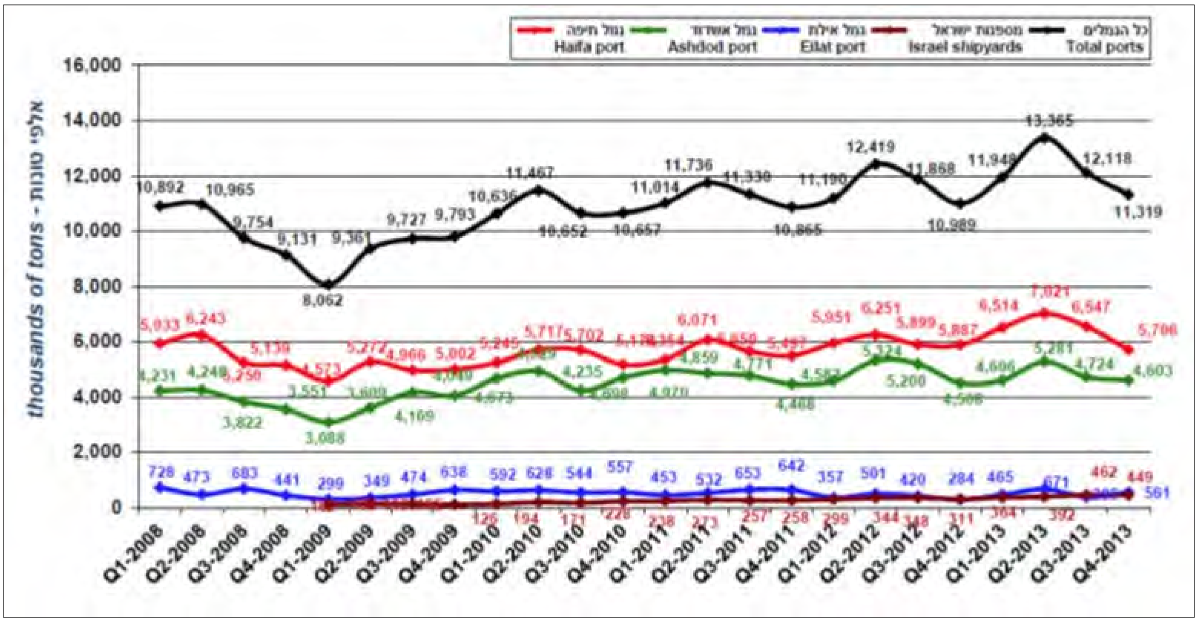


Figure 1-88. Cargo volumes passing through Israeli commercial ports, 1995 to 2008. Blue = Port of Eilat; green = Ashdod Port; red = Port of Haifa; and black = total (From: Ministry of Transport – Administration of Shipping & Ports, 2013).

1.2.8.2 Port of Haifa

The Port of Haifa is Israel's largest port. The port contains a broad variety of facilities that allow for the shipping and transportation of all types of cargo as well as docking facilities for large passenger liners; it is also the location for Noble Energy's onshore supply base, located at Israel Shipyards Ltd. The Port of Haifa handled a variety of cargo products in 2011, including local containers (8.19 million tons; 37%), transshipment containers (5.658 million tons; 26%), oil (2.815 million tons; 13%), bulk grain (2.680 million tons; 12%), bulk in grabs (1.412 million tons; 6%), and liquid chemicals (1.084 million tons; 5%) (Port of Haifa, 2012).

The port is operated by the Haifa Port Company, a government-owned company that is committed to the advancement of Israel's economy and growth. The Haifa Port Company reportedly handled approximately 16 million tons of cargo during 2011, including 1.24 million TEUs of container traffic.

Several smaller terminal operators in the port handled another 7 tons, including the Israel Shipyards Port and specialized bulk handlers Dagon Grain Terminal and the Petroleum and Energy Infrastructures oil terminal. From 2001 to 2011, ship traffic at the Port of Haifa ranged between 2,602 and 3,066 voyages per year; average annual ship traffic was 2,796 voyages (Port of Haifa, 2012).

1.2.8.3 Shipping Lanes

Numerous shipping lanes cross Israel's territorial waters, including shipping lanes 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. Shipping fairways relative to the Tamar Field were shown previously in **Figure 1-3**.

1.2.8.4 Telecommunications

The telecommunication system in Israel is the most developed system in the region. It is based mainly on two sea-based cables operated by Med Nautilus: MED1 and LEV. A Med Nautilus submarine telecommunications cable oriented perpendicular to the Israeli shore is located approximately 2 km north of the Tamar SW-1 wellsite, within the Tamar Field, as shown previously in **Figure 1-3**. The general locations of the Med Nautilus cables are shown in **Figure 1-89**. In addition, a number of Israeli firms (Bezeq International, Tamres) have installed two additional fiber optic cables.

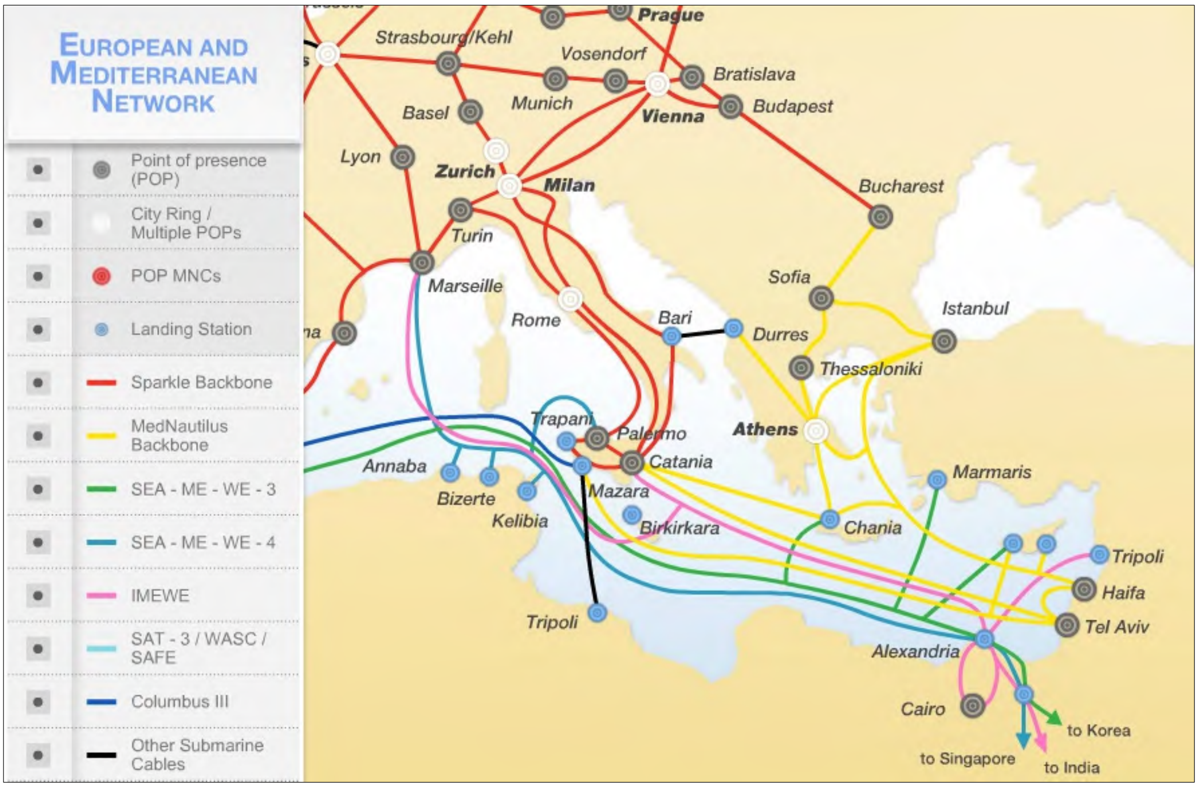


Figure 1-89. Map of telecommunication cables of the Mediterranean region (From: Lan Med Nautilus Limited, 2012).

1.2.9 Marine Farming

No fishing or marine farming operations are known within 30 km of the Application Area. The closest marine farming occurs close to the coast near Haifa.

CHAPTER 2: REASONS FOR PREFERENCE OF THE LOCATION OF THE PROPOSED PLAN AND POSSIBLE ALTERNATIVES

2.1 OVERVIEW AND APPLICATION RATIONALE

The Tamar Field Development Project includes the completion of the Tamar SW-1 well, an infield subsea tie-back for the Tamar SW-1 well into the existing Tamar subsea field architecture and the drilling and infrastructure construction for three additional wells: Tamar-7, Tamar-8, and Tamar-9. The Tamar SW Field is located within the southwest reservoir of the Tamar lease block, approximately 98 km west-northwest of Haifa, within the Levantine Basin. It was discovered based on the interpretation of seismic and geophysical survey data, and confirmed by the drilling of the Tamar SW-1 exploration well in 2013. Tamar SW-1 was drilled to a depth of 5,377 m measured depth and established the presence of 134 m gas column in three discrete sand units. The Tamar Field Development Project will complete this well for production.

Tamar-7, Tamar-8, and Tamar-9 will be drilled in the main Tamar Reservoir where five existing wells (Tamar-2, Tamar-3, Tamar-4, Tamar-5, and Tamar-6) are currently producing. The three new wells will increase production from the field based on the information gathered from the existing wells.

The rationale for the project is to increase the production from the Tamar Field by tying in the Tamar SW Reservoir and expanding the existing production from the main Tamar Reservoir. The Tamar SW Reservoir will have a production capacity of 250 million standard cubic feet per day (mmscfd).

2.2 LOCATION ALTERNATIVES

The Tamar Field Development Project will put in place the infrastructure necessary for production from the existing Tamar SW-1 well and add three additional wells to the existing Tamar Reservoir wells within the Tamar license area. The Tamar Field manifolds are in place. The pipeline route from the Tamar SW-1 well to the manifold in the Tamar Field was determined based on seafloor morphology and preliminary survey information. The pipeline routes have been selected to avoid obstacles and the routes have been reviewed to ensure that there are no significant biological communities or archaeological sites along the routes.

The Tamar-7 to Tamar-9 well locations have been selected based on the interpretation of seismic and geophysical survey data acquired in the Tamar Field, as well as results from previous wells completed in the Tamar Field and drilled into the geological formations. Other factors (e.g., environmental, planning, engineering, economics) were considered and helped to identify optimal project locations.

2.3 TECHNOLOGICAL ALTERNATIVES

Noble Energy does not plan to use new technology for the Tamar Field Development Project that would affect hydrocarbon recovery systems. Noble Energy will use existing, known and proven technology to limit risk for the Tamar Field Development Project. Selected alternatives for several mechanical systems include:

Drilling Technology: The wells are planned to be drilled vertically to the 13⅝-in. casing point. Below that, a directional pilot hole will be drilled to total depth, the reservoir will be evaluated, and the wellbore will be sidetracked back to vertical, offsetting the original wellbore, down to the top of reservoir as required. The wells are planned with a generous target tolerance. Control drilling or sliding to maintain the wellbore vertically is not a requirement; however, care will be taken to minimize dog legs. Rotary steerable technology will be utilized.

Rotary steerable systems (RSSs) are designed to drill vertically or directionally with continuous rotation from the surface, eliminating the need to slide a steerable motor. Penetration rates improve with an RSS because there are no stationary components to create friction, which reduces efficiency and anchors the bottom hole assembly in the hole. Flow of drilled cuttings past the bottom hole assembly is enhanced because annular bottlenecks are not created in the wellbore. State-of-the-art RSSs have minimal interaction with the borehole, thereby preserving borehole quality. The most advanced systems exert consistent side force, similar to traditional stabilizers that rotate with the drillstring, or orient the bit in the desired direction while continuously rotating at the same number of rotations per minute as the drillstring. RSSs offer precise steering control that maximizes reservoir contact for increased production. The technology reduces the uncertainty of drilling away from the target due to deviation prone sections (salt sections). The precision steering system can be combined with polycrystalline diamond compact bits, modular motors, near-bit sensors, and measurement while drilling (MWD) and logging while drilling (LWD) tools. Based on real-time formation evaluation, better reservoir navigation decisions can be made.

Polycrystalline diamond compact bits provide superior directional control, longer run life, improved rate of penetration, enhanced durability, and drilling efficiency. The synthetic diamond disks shear the rock with a continuous scraping motion. Polycrystalline diamond compact bits are effective at drilling shale formations, especially when used in combination with oil-based muds.

Modular motors are positive displacement drilling motors that use the hydraulic horsepower of the drilling fluid to drive the drill bit. Mud motors are used extensively in jetting in conductor casing and directional drilling operations.

Measurement while drilling (MWD) provides evaluation of physical properties, usually including pressure, temperature and wellbore trajectory in 3D space while extending a wellbore. MWD is standard practice in offshore directional wells. The measurements are made downhole, stored in solid-state memory for some time, and later transmitted to the surface. Data transmission methods vary from company to company but usually involve digitally encoding data and transmitting it to the surface as pressure pulses in the mud system. These pressures may be positive, negative, or continuous sine waves. Some MWD tools have the ability to store measurements for later retrieval with wireline or when the tool is tripped out of the hole, if the data transmission link fails. MWD tools that measure formation parameters (resistivity, porosity, sonic velocity, gamma ray) are referred to as logging while drilling (LWD) tools. LWD tools use similar data storage and transmission systems, with some having more solid-state memory to provide higher resolution logs after the tool is tripped out than is possible with the relatively low bandwidth, mud-pulse data transmission system.

Logging while drilling (LWD) provides measurements of formation properties during the excavation of the hole, or shortly thereafter, through the use of tools integrated into the bottom hole assembly. LWD has the advantage of measuring properties of a formation before drilling fluids invade deeply. Further, many wellbores prove to be difficult to measure with conventional wireline tools. Timely LWD data can be used to guide well placement so that the wellbore remains within the zone of interest or in the most productive portion of a reservoir.

Near-bit sensors placed below an RSS can accurately pick a casing point with the bit only 2.5 m below the RSS. The data are transmitted to the surface along with other LWD data farther up the bottom hole assembly without any signal detection issues. This helps steer the hole section to the best place in less time.

Noble Energy conducted a study (Brenner, 2014) of various options for the hydrotesting operation to be conducted during commissioning (see **Section 3.6.1.7**). Four options for the brine solution were evaluated, including two brine alternatives ($CaCl_2$ and NaCl), 100% monoethylene glycol (MEG), and a 50/50 MEG/water mix. The proposed alternatives included discharging the hydrotest fluids subsea. The fate of the discharge plume and the initial dilution were evaluated along with other operational considerations, including the shape and dimensions of the discharge port and the small-scale mixing and entrainment processes in the vicinity of the port. Noble Energy will model the dispersion of these possible releases to evaluate their potential impacts.

Section 3.2.2.3 of this report discusses the reasons for Noble Energy's preference of the proposed drilling fluid system over the water-based mud (WBM) system used previously in the Tamar Field.

2.4 INFRASTRUCTURE ALTERNATIVES

No infrastructure alternatives were considered for the Tamar Field Development Project as the work will tie into existing infrastructure that carries the product to the Tamar Platform and then to the Ashdod Onshore Terminal (AOT).

CHAPTER 3: PROJECT DESCRIPTION

3.1 GENERAL OVERVIEW

The Tamar and Tamar SW Reservoirs are located within the Levantine Basin in the Tamar License (#309) in the Matan Block, approximately 90 km west of Haifa (**Figure 1-1**). Noble Energy has been active in the license area since 2006 and has drilled six gas wells in the Tamar Reservoir (Tamar-1 through Tamar-6; Tamar-6 was a re-drill/completion of Tamar-1) and one in the Tamar SW Reservoir (Tamar SW-1). Tamar-2 through Tamar-6 were competed in 2012. In 2013, Noble Energy drilled the Tamar SW-1 well and installed the Tamar Platform close to the existing Mari-B Platform. At that time, flowlines and utility lines were laid to tie the Tamar Reservoir Production together through subsea infrastructure projects to send the production to the Tamar Platform. From the Tamar Platform, production is sent to the AOT via a 30-in. pipeline.

The sections that follow will present information on the proposed Tamar Field Development Project planned for 2015 to develop additional Tamar gas production. Activities that have occurred to date will be discussed as well. Presenting this information on the past activities as well as the proposed activities provides the necessary background for assessing potential cumulative impacts in the Tamar lease area.

3.1.1 Proposed Activities – Tamar Field Development Project

The proposed Tamar Field Development Project is expected to start in 2015, and will include the following activities:

- Completion of the Tamar SW-1 well;
- Drilling and completion of the Tamar-7, Tamar-8, and Tamar-9 wells;
- Infield flowline 12¾-in. from the Tamar SW-1 well to the Tamar-7 well location;
- Infield flowline 16-in. from the Tamar-7 well to Tamar production manifold;
- Infield flowlines from Tamar-8 and Tamar-9 to Tamar production manifold;
- Jumper from Tamar SW-1 to flowline end termination (FLET) on 12-in. west end flowline, 8⅝-in. outer diameter (OD);
- Jumper from FLET on 12-in. east end flowline to 16-in. FLET/flowline west end, 10¾-in. OD;
- Jumper from 16-in. FLET on east end 16-in. flowline to intermediate jumper starter (IJS), 10¾-in. OD;
- Jumper from IJS to manifold, 10¾-in. OD;
- Installation of electrical, hydraulic, flexible, and optical flying leads; and
- Post-installation testing and pre-commissioning.

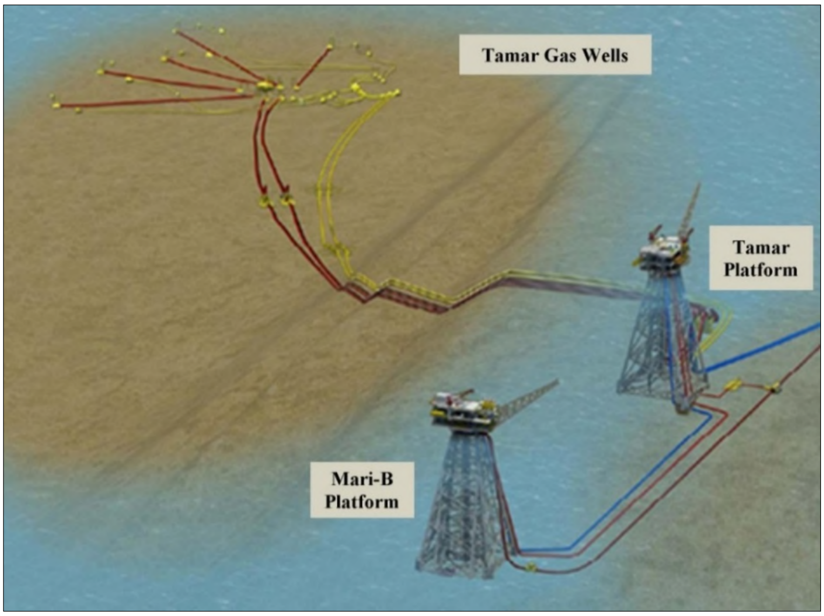
3.1.2 Existing Facilities

An overview of the activities which have been completed in the Tamar Field is provided in **Table 3-1**.

Table 3-1. Overview of activities and dates for the Tamar Field.

Activity	Project Date	Operational Start-Up Date
Drill Tamar-1	Nov. 2008-Feb. 2009	Re-drilled; now Tamar-6
Drill Tamar-2	April – July 2009	2013
Tamar Field Development Project – drill and completeTamar-3 through Tamar-6 (Tamar-6 is a re-drill/completion of Tamar-1)	2011-2013	2013
Drill Tamar SW-1	2013	--

The Tamar Reservoir has been developed as a subsea tie-back to the Tamar Platform, located within 2 km of the existing Mari-B Platform. The Tamar Platform is located approximately 25 km off the coast of Israel at a water depth of approximately 250 m. The Tamar Reservoir is approximately 90 km west of Haifa at a water depth of 1,600 to 1,700 m. A subsea view of the existing Tamar Field Development, except for the Tamar SW-1 well, is shown in **Figure 3-1**.



Legend:

Red lines: 4-in. monoethylene glycol/hydrate inhibitor/corrosion inhibitor lines and hydro-electrical umbilical lines (Tamar Platform to Tamar Field)

Yellow lines: 10-in. infield flowlines; subsea manifold; dual 16-in. natural gas pipelines (Tamar Field to Tamar Platform)

Dark red: natural gas line to Ashdod Onshore Terminal

Blue lines: utility lines

Figure 3-1. Subsea view of the Tamar Field Development. The Tamar SW-1 well is not included in the figure.

3.1.2.1 Wells

The first well (Tamar-1) was targeted at the crest of the Tamar Reservoir. It spudded on 18 November 2008 and reached total depth on 11 January 2009. The well was completed on 25 February 2009 and retained as a future producing well. It was subsequently re-drilled as Tamar-6.

This was followed by the drilling of Tamar-2. The Tamar-2 well was targeted on the northeast side of the Tamar Reservoir. It spudded on 26 April 2009 and reached total depth on 1 July 2009. The well was completed on 16 July 2009 and retained as a future producing well.

The Tamar Field Development Project included the drilling and completion of three locations (Tamar-3, Tamar-4, and Tamar-5), re-drill and completion of the Tamar-1 location (Tamar-6), and completion of Tamar-2. These locations and completions were designed to fully test continuity between sands and fault blocks. These wells were placed online 31 March 2013 and all have produced at rates up to 250 mmscfd.

Tamar SW-1 is a separate feature on the southwest plunging nose of the main Tamar anticline. The structure is a three-way fault closure. The well will be kept as a producing well from the Tamar “A” sand. Completion will occur in 2015 and the well will be an open hole gravel pack capable of flow rates as high as 250 mmscfd.

3.1.2.2 Tamar Platform

The Tamar Platform is a self-sustaining and independent facility, separate from the Mari-B Platform. Process capabilities were designed for full flow from the Tamar Reservoir up to the maximum design pressure of the incoming production flowlines. System design included the ability to direct full flow to the departing pipeline(s) or split flow to the dedicated injection wells via an injection header on the Mari-B Platform. Flow splitting is accomplished through a combination of in-line flow control and pressure control devices.

The Tamar Platform is equipped with all ancillary systems, including living quarters, power generation, emergency power generation, safety systems, heating and heat medium processes, potable water, sewage, and produced water equipment processing to make the new platform entirely self-sufficient. Water, instrumentation, utility air, diesel, and electricity are connected to the existing Mari-B Platform (via subsea cables, conduits, or lines) to allow sharing of these utilities as necessary. Both the platform structure and process facility have the capability for expansion to meet future field optimization requirements. The platform was discussed in detail in an EIA prepared for Noble Energy (CSA International, Inc., 2012).

3.1.2.3 Tamar Field Infrastructure

Gas production from the Tamar Reservoir occurs through the high flow rate subsea wells into a subsea gathering system, which consists of a 10-in. infield flowline from each well to a subsea manifold. From the subsea manifold within the Tamar Field, dual 16-in. subsea pipelines transport Tamar production approximately 149 km to the Tamar Platform, where the gas is processed.

The Tamar Field is controlled from the Tamar Platform via electrohydraulic umbilicals. The umbilicals terminate at a subsea distribution assembly located close to the subsea manifold. Electric power, communication, and chemicals are distributed from the subsea distribution assembly to the wells via individual infield umbilicals.

Corrosion inhibitor is mixed with MEG, a hydrate inhibitor, and delivered from the Tamar Platform to the subsea distribution assembly via dual 4-in. supply pipelines then distributed to the wells through infield umbilicals. The processed gas is delivered to the existing AOT via the existing 30-in. pipeline for gas sales into the Israel Natural Gas Line system. Tamar condensate is injected into a dedicated condensate pipeline running between the Tamar Platform and AOT receiving facility. The condensate line is one of three utility pipelines for production services installed from the Tamar Platform to AOT.

The pipelines and infrastructure connecting the platform to the Tamar wells was discussed in detail in an EIA prepared by Noble Energy (CSA International, Inc., 2012).

3.2 DESCRIPTION OF THE ACTIVITIES FOR THE EXISTING DEVELOPMENT AND FOR THE TAMAR FIELD DEVELOPMENT PROJECT

3.2.1 Well Locations

The surface locations of the existing and proposed Tamar wells are listed in **Table 3-2**.

3.2.2 Drilling Program

3.2.2.1 Tamar-1 Through Tamar-6 Wells

There are five producing wells in the Tamar Reservoir. The Tamar-6 well was drilled as a replacement (twin) for Tamar-1 to allow for an open hole gravel pack completion that could not be accomplished in Tamar-1 because of the existing casing. The wells were drilled from the Transocean *Sedco Express*, a dynamically positioned (DP) floating drilling unit. Information on the *Sedco Express* is presented in **Figure 3-3**. All wells were completed subsea and drilled with conventional WBMs similar to those used for Tamar SW-1.

Table 3-2. Tamar well surface locations for existing and proposed wells.

Well	Geographic Coordinates				Mud Line Depth (m)	Seafloor Gradient (degrees)	Notes
	Easting (m)	Northing (m)	Latitude (N)	Longitude (E)			
Tamar-1	596,477	3,652,061	33°00'09.76"	34°01'58.01"	-1,678	0.6	Will not be completed; see Tamar-6
Tamar-2	600,749	3,655,499	33°01'59.98"	34°04'43.97"	-1,685	0.4	Complete
Tamar-3	594,501	3,649,470	32°58'46.27"	34°00'40.91"	-1,669	<1.0	Complete
Tamar-4	597,487	3,654,491	33°01'28.33"	34°02'37.85"	-1,687	<1.0	Complete
Tamar-5	596,256	3,654,047	33°01'14.32"	34°01'50.24"	-1,704	1.0	Complete
Tamar-6	596,449	3,652,070	33°00'10.06"	34°01'56.94"	-1,678	<1.0	Complete. Tamar-1 twin. Required for an open hole gravel pack completion
Tamar-7*	595,919	3,651,335	32°59'46.37"	34°01'36.20”	-1,665	1.4	Proposed
Tamar-8*	593,227	3,649,741	32°58'55.45"	33°59'51.93"	-1,670	<0.4	Proposed
Tamar-9*	597,717	3,655,825	33°02'11.56"	34°02'47.23"	-1,690	<0.4	Proposed
Tamar SW-1	585,568	3,642,734	32°55'10.192"	33°54'54.517"	-1,645	<1.0	Drilled; completion proposed

* Proposed well to be drilled in the Tamar Field Development Project.

Rig Name: Sedco Express
Rig Manager: Transocean Ltd.
Rig Owner: Transocean Ltd.
Competitive Rig: Yes
Rig Type: Semisub
Semisub Generation: 5
Rig Design: Sedco Forex SFXpress 2000
Rated Water Depth: 7,500 ft
Drilling Depth: 25,000 ft

RIG CONSTRUCTION DETAILS

Classification: ABS
Rig Design: Sedco Forex SFXpress 2000
Shipyard: DCN Brest, France
Delivery Year: 2000
Flag: Liberia

RIG EQUIPMENT

Derrick: Joseph Paris 190'; Capacity: 2,057,000 lbs
Drawworks: Hitec / Dreco AHDD 6,800 HP
Mud Pumps: 3 x National Oilwell 14-P-220 triplex, 2200 HP
Top Drive: CanRig 1275E
Rotary Table: Varco 60.5 in. diameter

Figure 3-3. Information on the *Sedco Express* (From: Rigzone, 2014).

The drilling dates for the existing Tamar Reservoir wells were as follows:

- Tamar-1: 16 November 2008 to 25 February 2009 (101 days)
- Tamar-2: 24 April to 16 July 2009 (83 days); completion from 10 November to 7 December 2012 (60 days)
- Tamar-3: 24 April to 3 July 2011 (71 days); completion from 7 July to 8 November 2012 (35 days)
- Tamar-4: 17 to 23 April 2011, 22 to 25 August 2011, 18 January to 9 March 2012 (62 days); completion from 8 May to 6 July 2012 (60 days)
- Tamar-5: 14 to 17 April 2011, 3 July to 22 August 2011 (55 days); completion from 10 August to 10 September 2012 (32 days)

- Tamar-6: 9 to 14 April 2011, 4 September to 8 November 2011, 18 December 2011 to 18 January 2012 (74 days); completion 10 September to 9 October 2012 (29 days)

Key design parameters for the wells included:

- Well design life of +30 years;
- 7-in. tubing;
- 9⅝-in. production liner top setting the reservoir;
- Erosion/corrosion tolerant; and
- DP rig tolerant.

The wells were completed as single zone sand control completions with 7-in. tubing to enable high-rate gas production. Each well was completed with an open-hole gravel pack. Design parameters for the completions were as follows:

- Well design life of +30 years;
- 7-in. tubing;
- Sand control is a requirement;
- Open hole gravel packs to provide high deliverability;
- Erosion tolerant well design; and
- Real-time downhole surveillance.

Figures 3-4 through **3-9** present the wellbore schematics for the Tamar-1 through Tamar-6 wells.

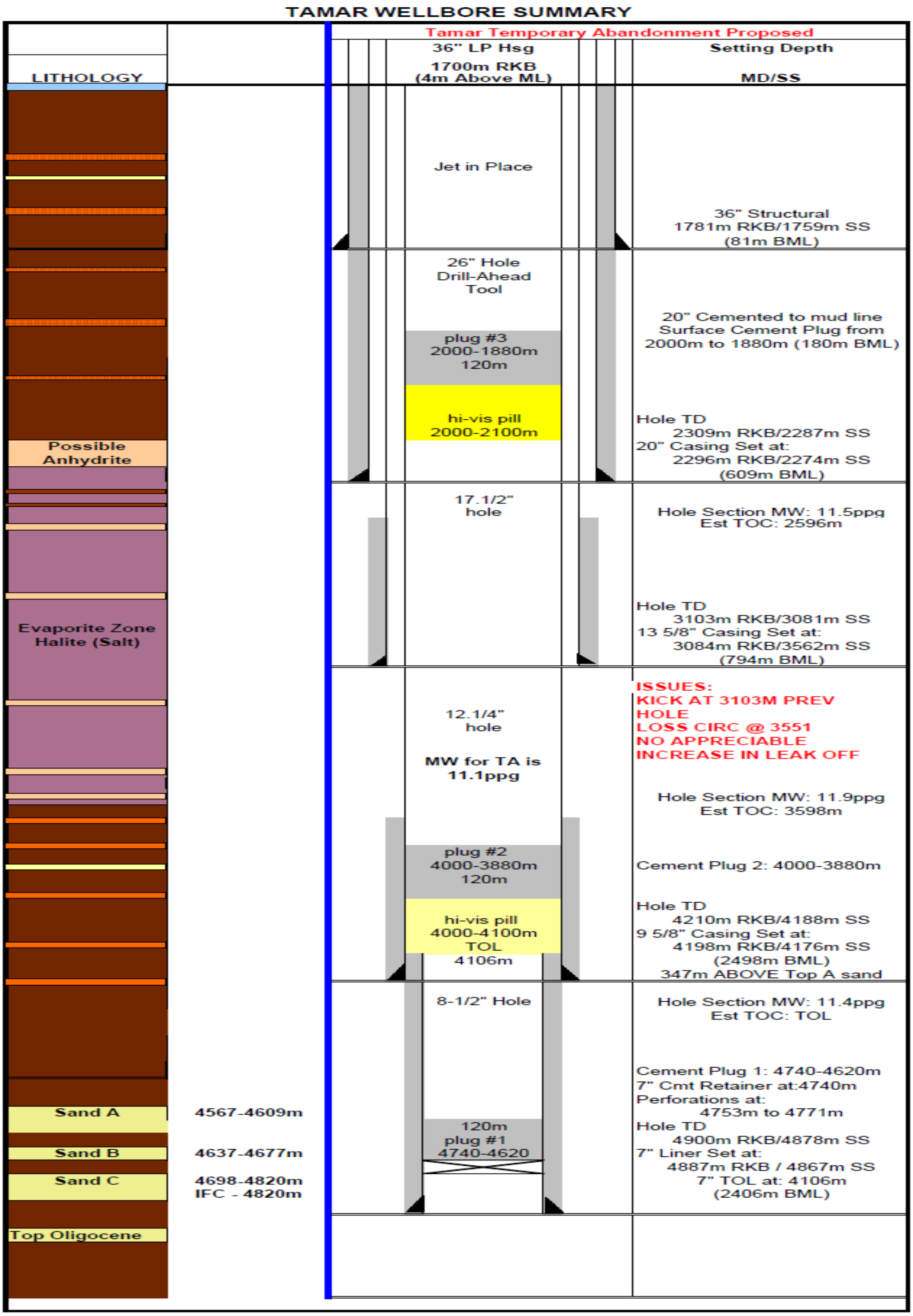


Figure 3-4. Tamar-1 drilling schematic – as built.

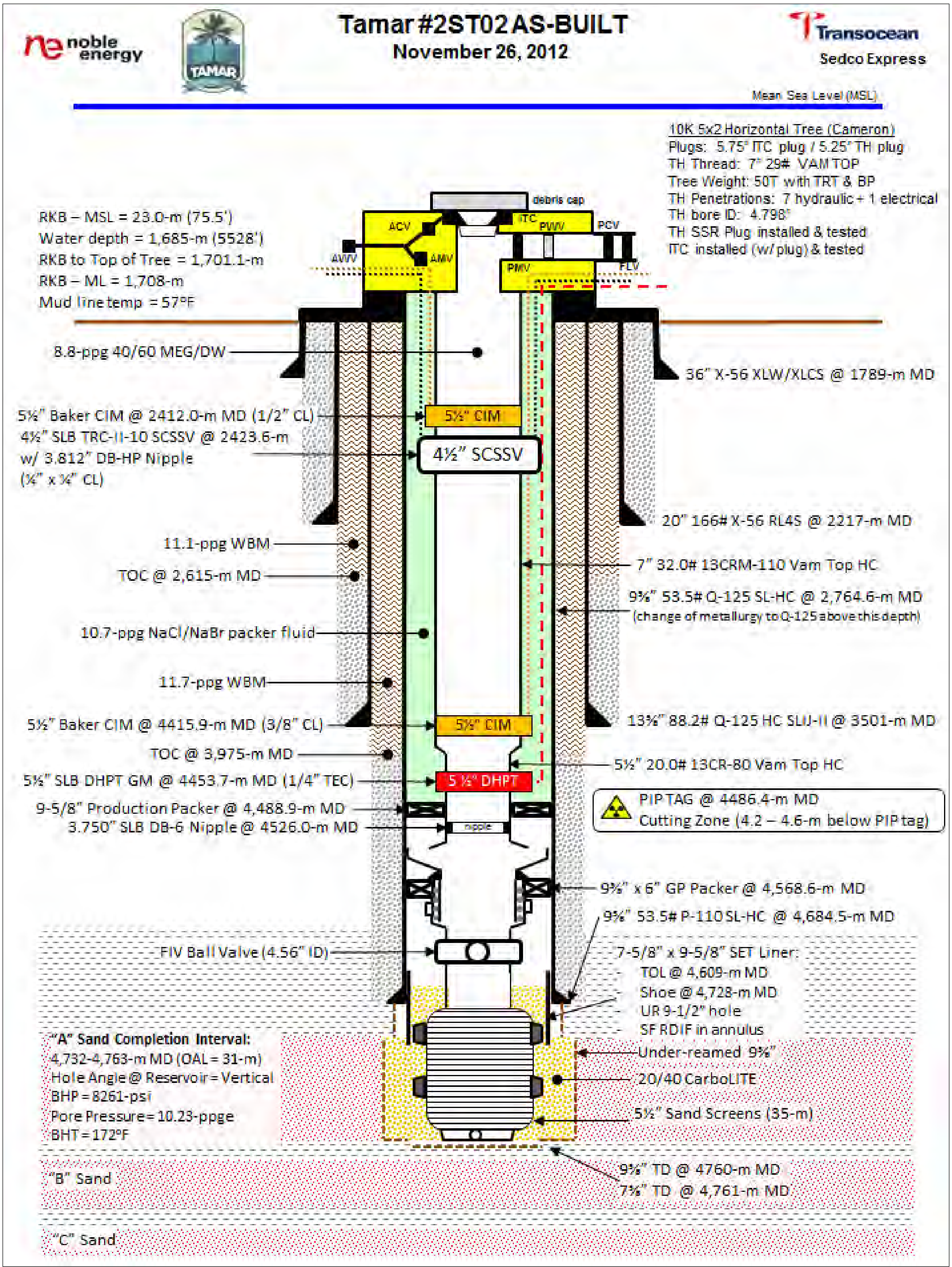


Figure 3-5. Tamar-2 drilling schematic – as built.

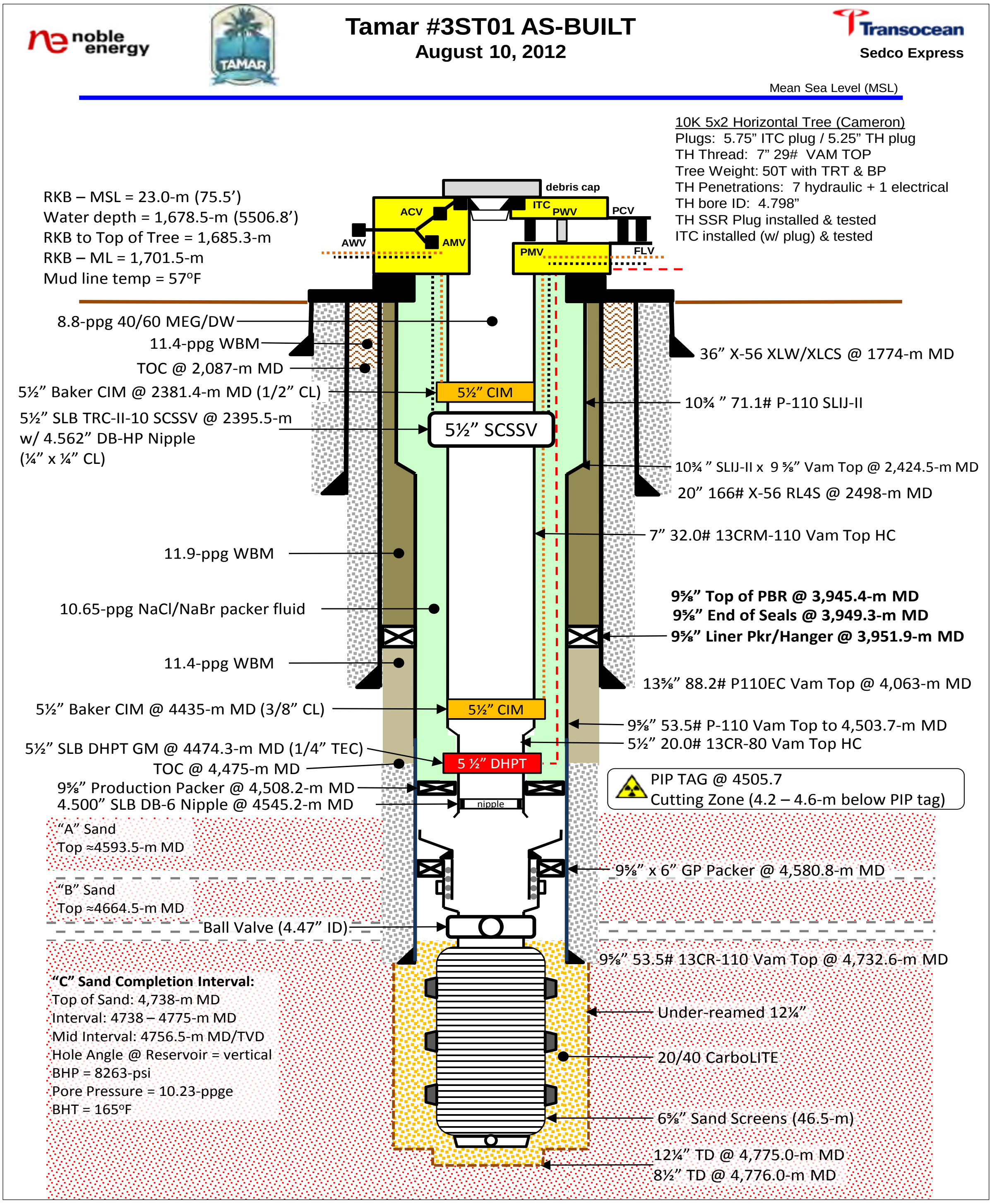


Figure 3-6. Tamar-3 drilling schematic – as built.

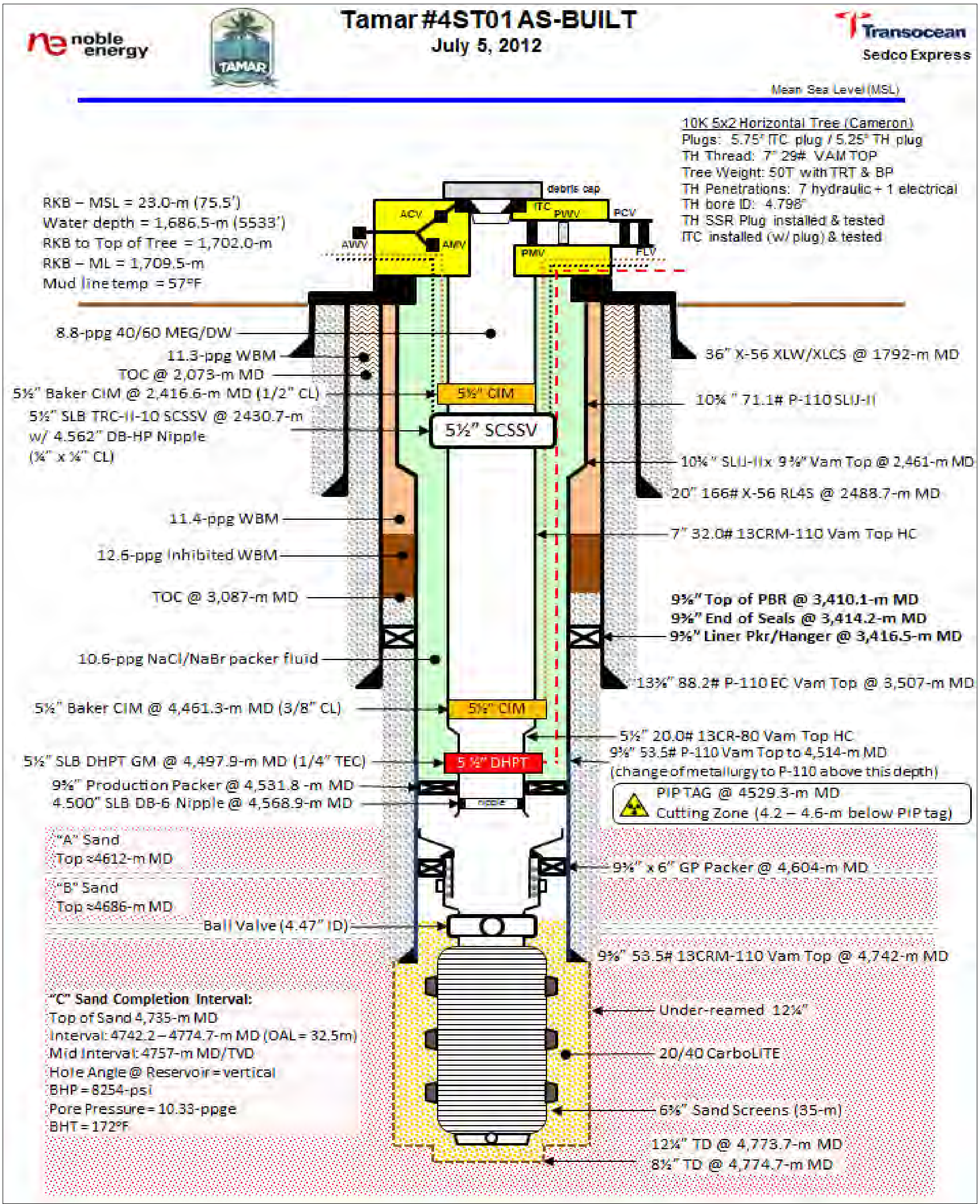


Figure 3-7. Tamar-4 drilling schematic – as built.

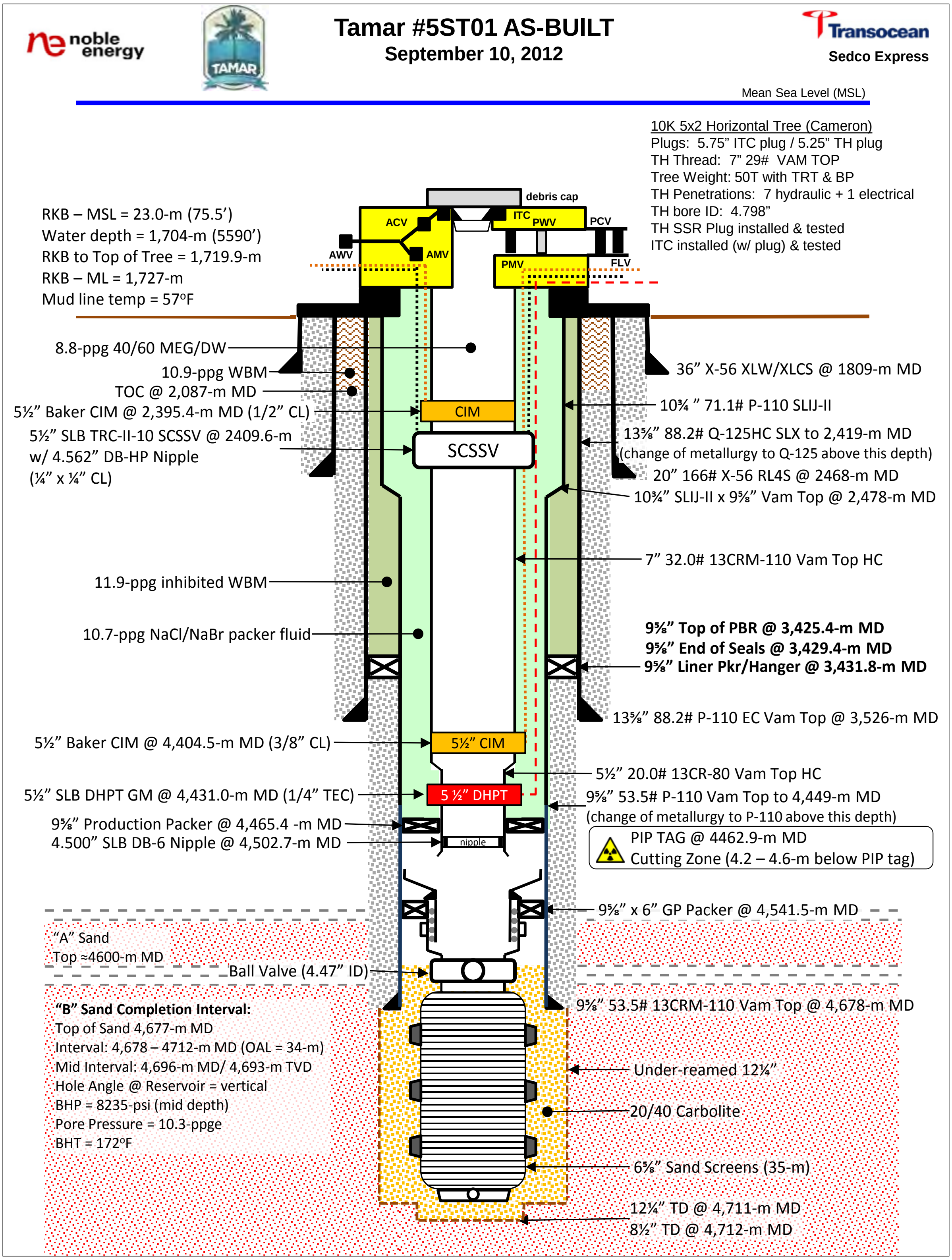


Figure 3-8. Tamar-5 drilling schematic – as built.

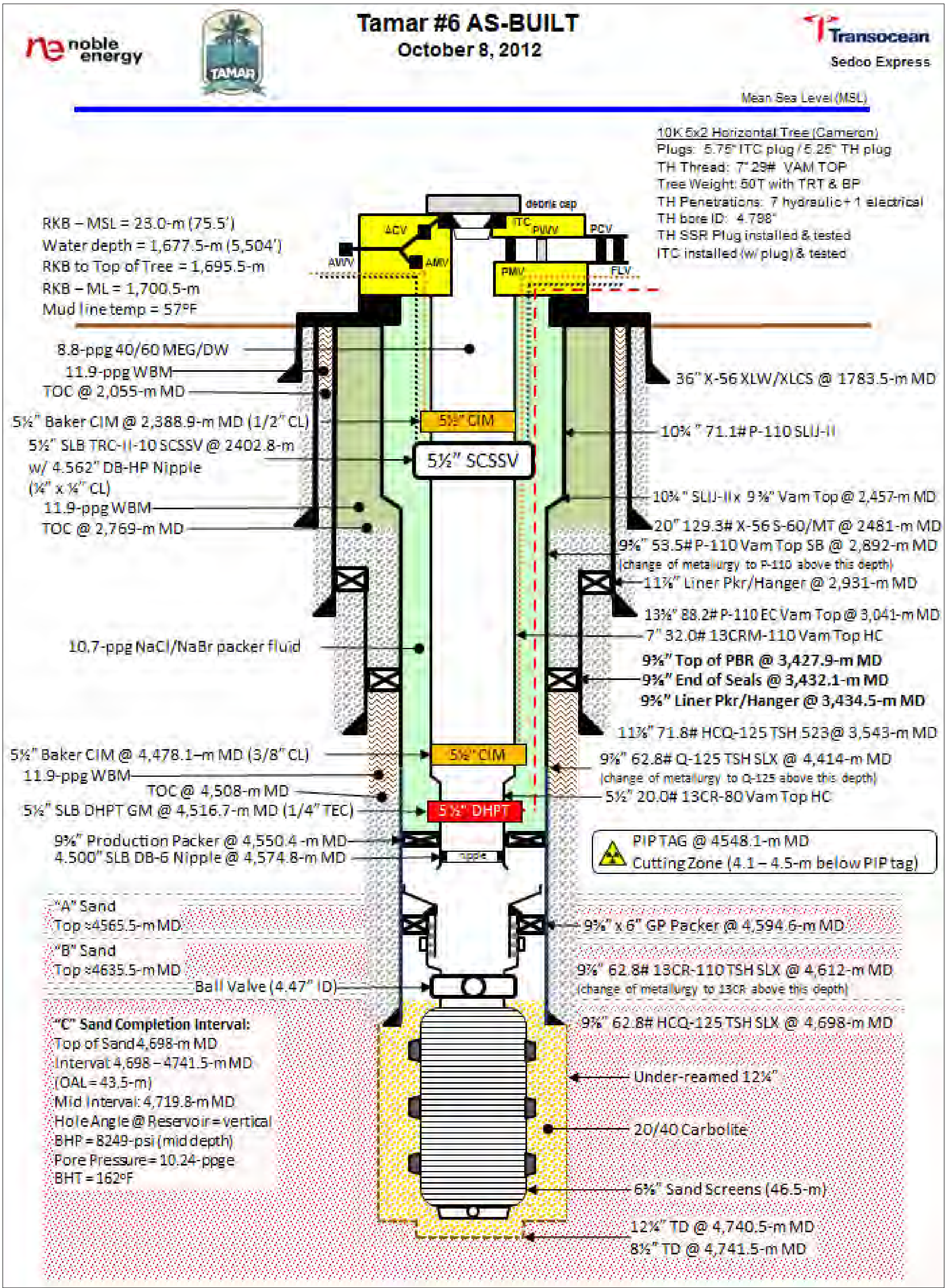


Figure 3-9. Tamar-6 drilling schematic – as built.

3.2.2.2 Tamar SW-1

<u>Drilling of Tamar SW-1</u>

The Tamar SW-1 well was drilled in 2013 by the *ENSCO 5006* (**Figure 3-10**). The well is in the Tamar SW Reservoir in the Matan Block located in the eastern Mediterranean Sea approximately 98 km west-northwest of Haifa, Israel in the southeastern portion of the Levantine Basin (**Figure 3-11**).

ENSCO

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ENSCO 5006

GENERAL INFORMATION
Flag Vanuatu
Previous Name(s) Pride North America
Year Built 1998/1999
Builder Friede & Goldman, Pascagoula, USA
Design Bingo 8000, modified by the addition of 22.96 ft pontoon extensions Fore & Aft.
Classification DNV, Maltese Cross 1A1 Column Stabilized Drilling Unit

MAIN DIMENSIONS
Deck Area 252.60 x 213.3 ft

MACHINERY
Main Power (4) Caterpillar 3608-TA diesel engines, 3,055HP; (1) Baylor AC generator, 600V 60Hz 3,571 kVA each.
Power Distribution 6 SCR's: M&I ; 2,200 amp 750V dc output each SCR units for drilling and mooring
Emergency Power (1) Caterpillar 3512-DITA diesel engine 1,281 HP, (1) Caterpillar SR-4 AC generator, 480 V 60 Hz 1,137 kVA

OPERATING PARAMETERS
Water Depth Maximum design value: 7,500 ft, Outfitted for 6,200 ft
Maximum Drilling Depth 25,000 ft
Transit Speed 5 knots
Survival Conditions Wind: 100 knots; Waves: 105 ft at 15 sec; Current: 1.5 knots

DRILLING EQUIPMENT
Derrick Loadmaster 172 x 44 x 40 ft, rated at 1,600,000 lb SHL capacity with 14 lines
Drawworks National 1625 UBDE, input 3,000hp;7838 Elmagco brake
Rotary National 60-1/2 in powered by GE 752 electric motor
Top Drive Varco TDS-4S, 2 speeds, rated 750 ton, 45,50 0ft.lb @ 130 rpm, 7,500psi WP
Mud Pumps (3) National 14P220, 2,200HP each, 7,500 psi WP

HOISTING EQUIPMENT
Cranage (1) AmClyde Kingpost crane, rated 80 mt at 31.5 m with 48.76 m boom
(1) Liebherr Kingpost crane MTC-1900-60D Litronic, rated 60 mt at 8.9 m with 45.72 m boom

CAPACITIES
Liquid Mud 5,100 bbls (Deck Box), 4,800 bbls Reserve Mud (Minor columns)
Bulk Mud/Cement 20,600 ft3
Sacks 6,000 sacks
Drillwater 12,320 bbls
Potable Water 4,620 bbls
Fuel Oil 16,650 bbls

WELL CONTROL SYSTEMS
BOP VetcoHD-H4 well head connector 18-3/4 in 15,000psi WP; 2 x Cameron 18-3/4 in type TL double 15,000psi WP H2S trimmed preventers; 1 x Hydril 18-3/4 in dual annuflex annular 10,000psi WP H2S trimmed; LMRP: Cameron connector model HC, 18-3/4 in 15,000psi WP; Oil State 5,000 psi flex joint.
BOP Handling (1) BOP carrier, 272 mt; (1) X-mas Tree Carrier, 272 mt; (2) 72.5 mt BOP overhead crane
Control System Cameron Multiplex system, 5,000psi
Diverter Hydril FS-21-500, 21-1/4 in for a 60 1/2 in rotary, 500psi WP, 2 x 14 in vent line and 1 x 18 in flow line outlets
Choke and Kill Cameron 15,000psi, 4 in, H2S service manifold

MOORING
Winches (4) Skagit double drum traction winches
Wire 10,600 ft x 3-3/4 in wire and 2,500 ft x 3-1/4 in R3S chain
Anchors (8) Vryhof Stevpris MK-5 anchors, 15 mt each

HELIDECK Sikorsky S-61N, 84 x 84 ft
ACCOMMODATION 120 persons

ADDITIONAL DATA
(4) Norsafe 60-man totally enclosed life boats; 5 x 25 man life rafts

Figure 3-10. Information on the *ENSCO 5006*, which was used to drill the Tamar SW-1 well.

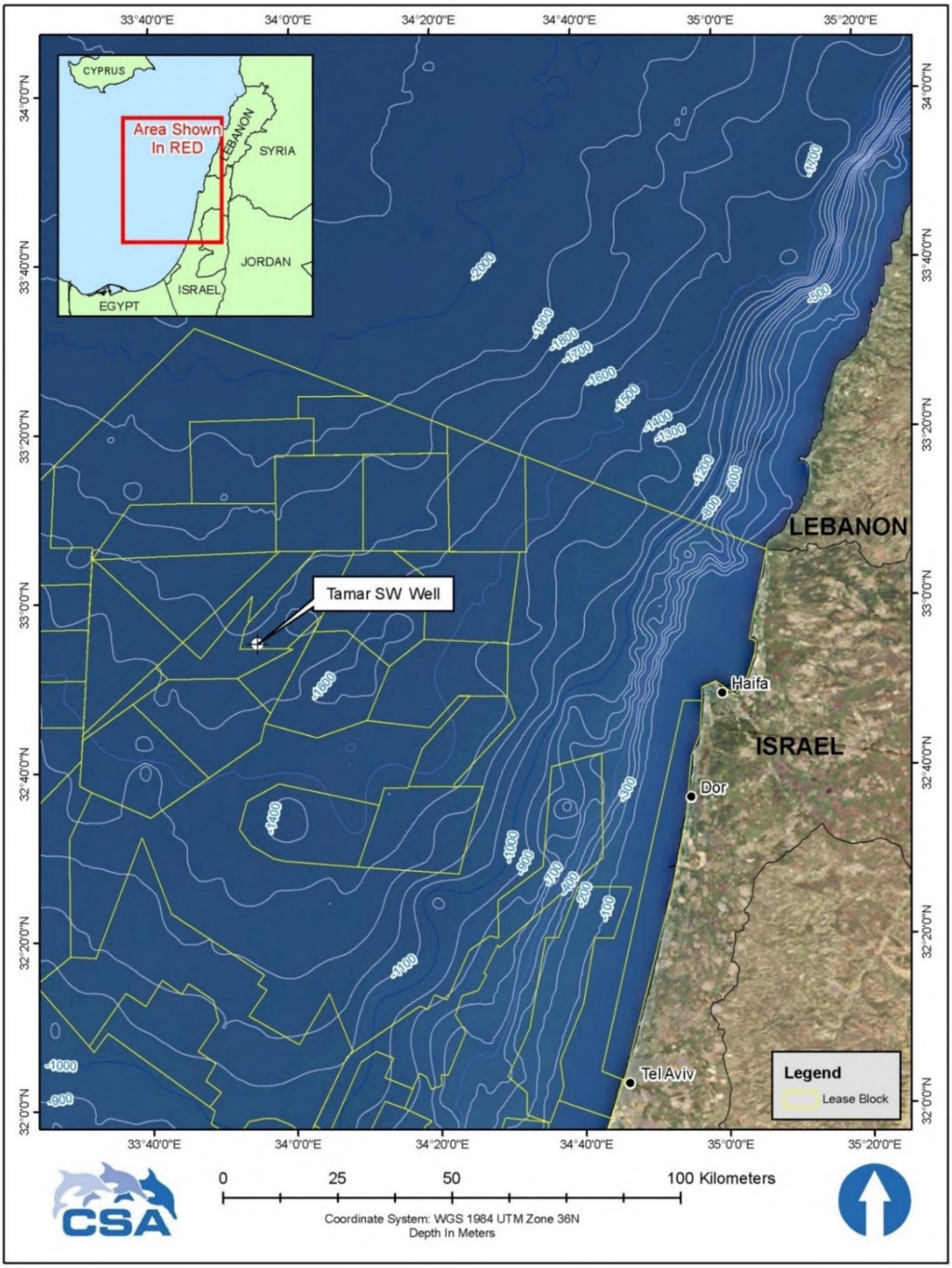


Figure 3-11. Location of the Tamar SW-1 drillsite relative to the Israeli coastline and regional bathymetric contours. The Tamar SW-1 well is located at 32°55'10.20" N latitude and 33°54'54.40" E longitude. X/Y coordinates for the drillsite are E 585,565 and N 3,642,734 (Geodesy: GCS WGS84; UTM 36 North; meters), or E 98,850 and N 759,025 (Geodesy: GCS Israel; Israeli Transverse Mercator; meters).

Tamar SW-1 was drilled to evaluate the Tamar SW prospect, which consists of a three-way structural closure along a fault. The location is within the Tamar lease block. The well penetrated and evaluated a section of stacked turbidite sands. The data showed these were the equivalent sands penetrated in both the Tamar Field (11.1 km northeast) and the Dolphin-1 well (17.8 km southwest). These equivalent sands also were drilled in the Tanin-1 and Leviathan wells. The final well total depth was 5,377 m measured depth (MD); 5,366 m total vertical depth (TVD); 100 m into the top of the "D" sand. The Tamar sands were fully evaluated with open hole wireline logs. The Tamar SW-1 well will be kept as a producing well in the Tamar "A" sand. Completion will be an open hole gravel pack capable of flow rates up to 250 mmscfd.

A 9⅞-in. × 10¾-in. production casing was set to 4,884.5 m MD (3 m into top of "A" sand at 4,881.5 m MD). The production string was cemented with 94 barrels (bbl) Elasticem mixed at 13.8 pounds per gallon (ppg). The cement was displaced with 11.9 ppg NaCl/NaBr brine. The wiper plug bumped with 2,000 pounds per square inch (psi) and the floats held. No mud was lost while running and cementing the casing string. The 10¾-in. seal assembly was set and energized with 3,000 psi. Then a 100 kilopounds force (kip) overpull was taken and the seal assembly was pressure tested to 6,700 psi.

A lead impression block run was performed, verifying the 10¾-in. casing hanger space out. Then a 10¾-in. lock-down hanger was run, set, and confirmed with 100 kips overpull.

A wireline was rigged up and a gauge ring/segmented bond tool run was made. Wireline ran a 9⅞-in. EZ-SV and set it at 4,773 m WL and it and the production casing were successfully pressure tested to 6,500 psi for 30 minutes.

A 125-m surface cement plug was set from 2,075 to 1,950 m with 37 bbl of Class G cement mixed at 15.8 ppg as a temporary well abandonment. The wellbore and casing hanger seal assembly was negative pressure tested (790 psi) with a seawater gradient to the mud line for 30 minutes. The blowout preventer (BOP) and riser were then disconnected and pulled, and a trash cap was installed on the MS 700 wellhead with the ROV. The anchors were then pulled and bolstered. The *ENSCO 5006* departed the Tamar SW-1 well location at 06:00 hours on 2 January 2013.

The wellbore schematic for the Tamar SW-1 well is shown in **Figure 3-12**, and the drilling timeline is shown in **Figure 3-13**.

Supply vessel support was provided by several vessels, including the M/V *EAS* and M/V *Leon*. The M/V *EAS* is a DP anchor handling towing supply (AHTS) vessel measuring 61.8 m in length, and the M/V *Leon is* a swift crew and supply boat measuring 51 m in length. Both vessels were operated by EDT Ship Management Ltd. out of the port of Haifa.

Helicopter support was provided by a Bell 412SP owned by PHI, Inc. and operated by LAHAK out of Haifa Airport.

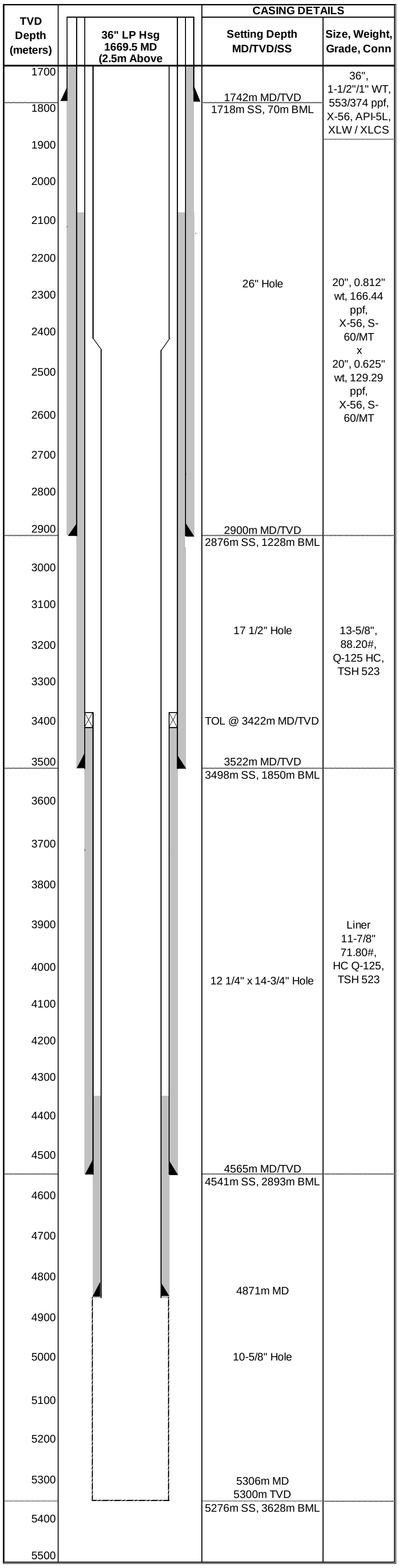


Figure 3-12. Tamar SW-1 wellbore schematic (From: Noble Energy, 2012).

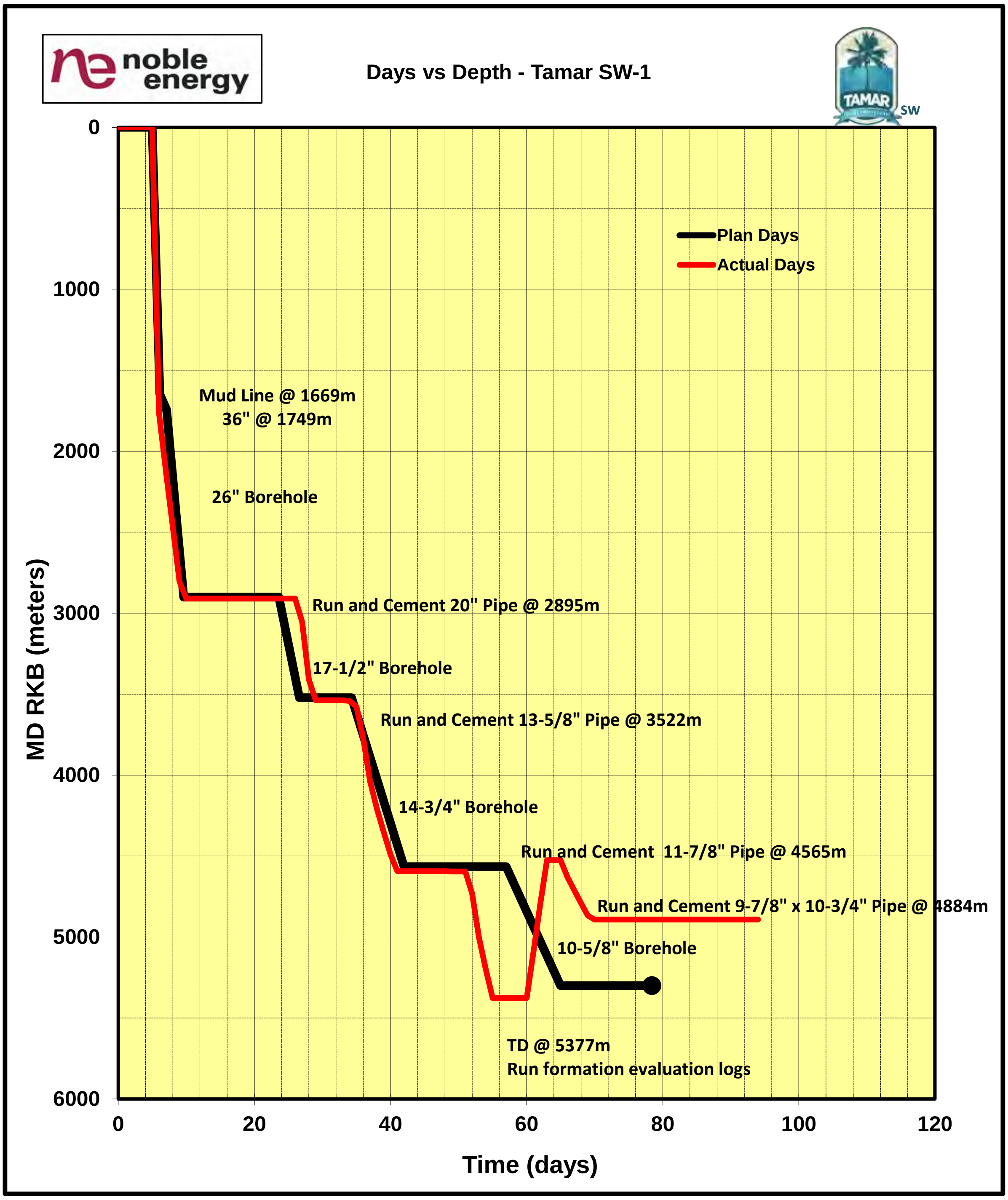


Figure 3-13. Tamar SW-1 plan and actual days versus depth timeline for drilling of the Tamar SW-1 well.

Table 3-3 lists the volume of WBM drilling materials used for the Tamar SW-1 well.

Table 3-3. Volumes of drilling materials used in drilling the Tamar SW-1 well.

Product	Function	36-in.	26-in.	17½-in.	12¼-in. × 14¾-in.	10⅝-in.	8½-in. × 12¼-in.	9⅞-in. Cased Hole	Metric Ton and Barrels	Packaging in Sacks or US Gallons	# of Packages Used
BARACARB 5 (FIBC 1 MT)	Bridging agent					7.00	3.00		10.00	# of Bulk Bag used avg. 1 MT	10.00
BARACARB 25 (FIBC 1 MT)	Bridging agent				20.00	2.00	3.00		25.00	# of Bulk Bag used avg. 1 MT	25.00
BARACARB 50 (FIBC 1 MT)	Bridging agent			48.00					48.00	# of Bulk Bag used avg. 1 MT	48.00
BARACARB-DF 150 (25 kg Sx)	Bridging agent			48.00					1.20	# of 25 kg Sacks used	48.00
BARACARB-DF 25 (25 kg Sx)	Bridging agent			48.00					1.20	# of 25 kg Sacks used	1.20
BaraFibre Course (40 lb Sx)	Fiber			4.00					0.07	# of 40 lb Sacks used	4.00
BaraFibre Superfine (11.3 kg Sx)	Fiber			70.00					0.79	# of 25 kg Sacks used	70.00
BARAZAN D (25 kg Sx)	Viscosifier	41.00	147.00	57.00	28.00	22.00	8.00		7.58	# of 25 kg Sacks used	303.00
BARAZAN (25 kg Sx)	Viscosifier			33.00					0.83	# of 25 kg Sacks used	33.00
BARAZAN LIQUID	Viscosifier			33.00					33.00	* Gallons	
Barite (Bulk)	Weighting agent	126.30	196.00	8.00	62.10	43.68	27.00	35.80	498.88	Bulk 1 MT	498.88
BDF-467/kg	Inhibition				69.00	13.00	3.00		85.00		85.00
Bentonite (FIBC 1 MT)	Viscosifier	18.00	35.50	6.80					60.30	# of Bulk Bag used avg. 1 MT	60.30
Brine 10.0 LPG 42 gal/bbl			12,505.00						12,505.00	US Gallons	525,210
C-250 55 gal Drum							4.00		4.00		
Caustic Soda (25 kg Sx)	pH Control								0.00	# of 25 kg Sacks used	0.00
Citric Acid (25 kg Sx)	Alkalinity control				16.00	110.00	72.00		4.95	# of 25 kg Sacks used	198.00
Clay Seal (275 bbl IBC)	Inhibition				23.00	3.00	3.00		182.40	275 bbl IBC	29.00
Defoamer (20 L/5 gal jug)	Defoamer		6.00	11.00			12.00		3.65	US Gallons	153.22
GEM CP (1000 IBC)	Inhibition				20.00				125.80	# of IBC 1 cubic	125.80
GEM GP @ 3% v/v (55 gal Drum)	Inhibition				64.00				402.55	# of IBC 1 cubic	
GEM SP (1000 IBC)	Inhibition				16.00	3.00	5.00		150.96	# of IBC 1 cubic	
Guar Gum (25 kg Sx)	Viscosifier	30.00	176.00	40.00					6.15	# of 25 kg Sacks used	246.00
KCl (Potassium Chloride)	Inhibition/Weight		84.00	74.00					158.00	# of Bulk Bag used avg. 1 MT	158.00
NaCl (Sodium Chloride)	Inhibition/Weight		688.60	324.00					1316.38	# of Bulk Bag used avg. 1.3 MT	1,012.60
OS-8 (5 kg CN)							10.00				

Table 3-3. (Continued).

Product	Function	36-in.	26-in.	17½-in.	12¼-in. × 14¾-in.	10⅝-in.	8½-in. × 12¼-in.	9⅞-in. Cased Hole	Metric Ton and Barrels	Packaging in Sacks or US Gallons	# of Packages Used
PAC L (25 kg Sx)	Filtration Control					40.00			1.00	# of 25 kg Sacks used	40.00
PAC LE (25 kg Sx)	Filtration Control			49.00		87.00	74.00		5.25	# of 25 kg Sacks used	210.00
PAC ULV (25 kg Sx)	Filtration Control		107.00	9.00	197.00	115.00	72.00		12.50	# of 25 kg Sacks used	500.00
Soda Ash (25 kg Sx)	Calcium Treatment	2.00	11.00	40.00	30.00				2.08	# of 25 kg Sacks used	83.00
Bicarbonate Sodium (25 kg Sx)	Calcium Treatment			68.00		80.00	67.00		5.38	# of 25 kg Sacks used	215.00
STARCIDE (20 L/5 gal jug)	Biocide		68.00	7.00					9.43	US Gallons	396.26
Steel Seal 400 (25 kg Sx)	Bridging agent			10.00					0.25	# of 25 kg Sacks used	10.00
Xanthan Gum (25 kg Sx)	Bridging agent			40.00					1.00	# of 25 kg Sacks used	40.00
Xan Plex (25 kg Sx)	Bridging agent			13.00					0.33	# of 25 kg Sacks used	13.00
Aquagel Gold Seal (25 kg Sx)	Viscosifier								0.00		
CA+ CARBONATE	Bridging agent								0.00		
ClaySeal 275 gal/IBC	Inhibition								0.00	275 gal	
DEXTRID E (Sx)	Filtration Control								0.00		
Nova Carb 26 (1 Ton Sacks)	Bridging agent					30.00			30.00		
QUIK-THIN (Sx)	Thinner								0.00		
Total		**217.30**	**14,024.10**	**1,040.80**	**545.10**	**548.68**	**360.00**	**35.80**	**15,688.89**		

Note: empty cells imply that nothing was discharged for that section.

Completion of Tamar SW-1

The proposed Tamar Field Development Project includes the completion of the Tamar SW-1 well. The Tamar SW-1 well was temporarily abandoned with the production casing set at the top of the reservoir sand. A summary of the planned completion process is described here.

A Cameron 10,000 psi working pressure (WP) horizontal subsea tree will be installed and pressure tested to 10,000 psi on the Tamar SW MS-700 high pressure wellhead. This may utilize an intervention vessel or the selected rig chosen for the completion operations depending on its capabilities.

The rig will run the BOP, riser, and latch onto the Cameron subsea tree. The BOP will be pressure tested. The riser will be displaced to 11.9 ppg NaCl/NaBr brine.

A drilling assembly will be run and the temporary shallow set cement plug at 1,950 to 2,075 m will be drilled out. The drilling assembly will be retrieved.

An 8½-in. drilling assembly with LWD will be run. The CIBP and 9⅞-in. cemented shoe track will be drilled out to 3 m above the shoe at 4,884.50 m MD. The 11.9 ppg NaCl/NaBr brine will be displaced with a Baker Hughes reservoir drill-in-fluid (RDIF).

The remainder of the shoe track will be cleaned out and approximately 30 m of 8½-in. hole will be drilled into the A sand formation. A log will be performed with the LWD. The drilling assembly will be retrieved.

An 8½-in. × 12¼-in. underreamer drilling assembly will be run and the 8½-in. open hole in the A sand will be opened up to a 12¼-in. hole. A solids-free RDIF (SFRDIF) spotted prior to pulling out into the 9⅞-in. liner approximately 150 m above the shoe. The RDIF will be displaced to a 10.65-ppg NaCl/NaBr filtered brine, and the well will be cleaned up prior to retrieving the underreamer assembly.

A gravel pack assembly will be run consisting of wash down shoe, 6⅝-in. wire mesh shrouded screens, fluid loss isolation valve, gravel pack packer assembly with gravel pack crossover tool to total depth. The SFRDIF will be displaced and the gravel pack packer set and tested. The SFRDIF will be reversed out with 10.65 ppg NaCl/NaBr.

An open hole gravel pack will be performed utilizing proppant. Once a screen out has occurred, the crossover tool will be pulled, closing the fluid loss isolation valve for well control, and the cross over tool will be retrieved.

A scoop head seal assembly will be run to isolate the gravel pack ports within the gravel pack assembly. The well will be displaced to a 10.65 ppg inhibited NaCl/NaBr brine.

The Cameron subsea tree bore protector will then be pulled.

The upper completion will be run consisting of a nipple, 9⅞-in. production packer, down hole pressure gauges, deep set chemical injection valve, 7-in. tubing, 5½-in. surface-controlled subsurface safety valve (SCSSV), shallow set chemical injection valve, and a Cameron tubing hanger. All equipment will be rated to 10,000 psi WP.

The upper completion will be run in hole, utilizing a Cameron tubing hanger running tool, Dual Ball Valve Subsea Test Tree with slick joint spaced out for BOP RAM and annular closure, a retainer valve, electrohydraulic operating pod, 7-in. landing string, lubricator valve, and 7-in. landing string to a surface flow head.

A launch and recovery system/installation workover control system (LARS/IWOCS) will be deployed to the seafloor to take control of the Cameron Subsea tree and to control the functions of the upper completion, utilizing the rig ROV for jumper installations and pressure testing.

A coil tubing lift frame will be installed prior to picking up the surface flow head. Once picked up, the upper completion would be landed and the Cameron tubing hanger set and tested.

The upper completion production packer would be set and tested.

Flow back testing will be performed as described in **Section 3.2.4**.

The well will be equipped with an SCSSV (a “fail-safe” downhole safety valve) below the mud line to prevent an uncontrolled release in the extremely unlikely event the subsea wellhead is compromised. In addition, the well will be equipped with two redundant downhole pressure and temperature gauges for real-time downhole surveillance as well as one chemical injection mandrel for mitigation against the potential risk of scale or hydrates. Also, the 10¾-in. casing will allow for the installation of a larger 5½-in. SCSSV. The proposed completion schematic is shown in **Figure 3-14**.

The completion fluid components to be used for the Tamar SW-1 completion are listed and described in **Table 3-4**, and the amounts expected to be used are presented in **Table 3-5**.

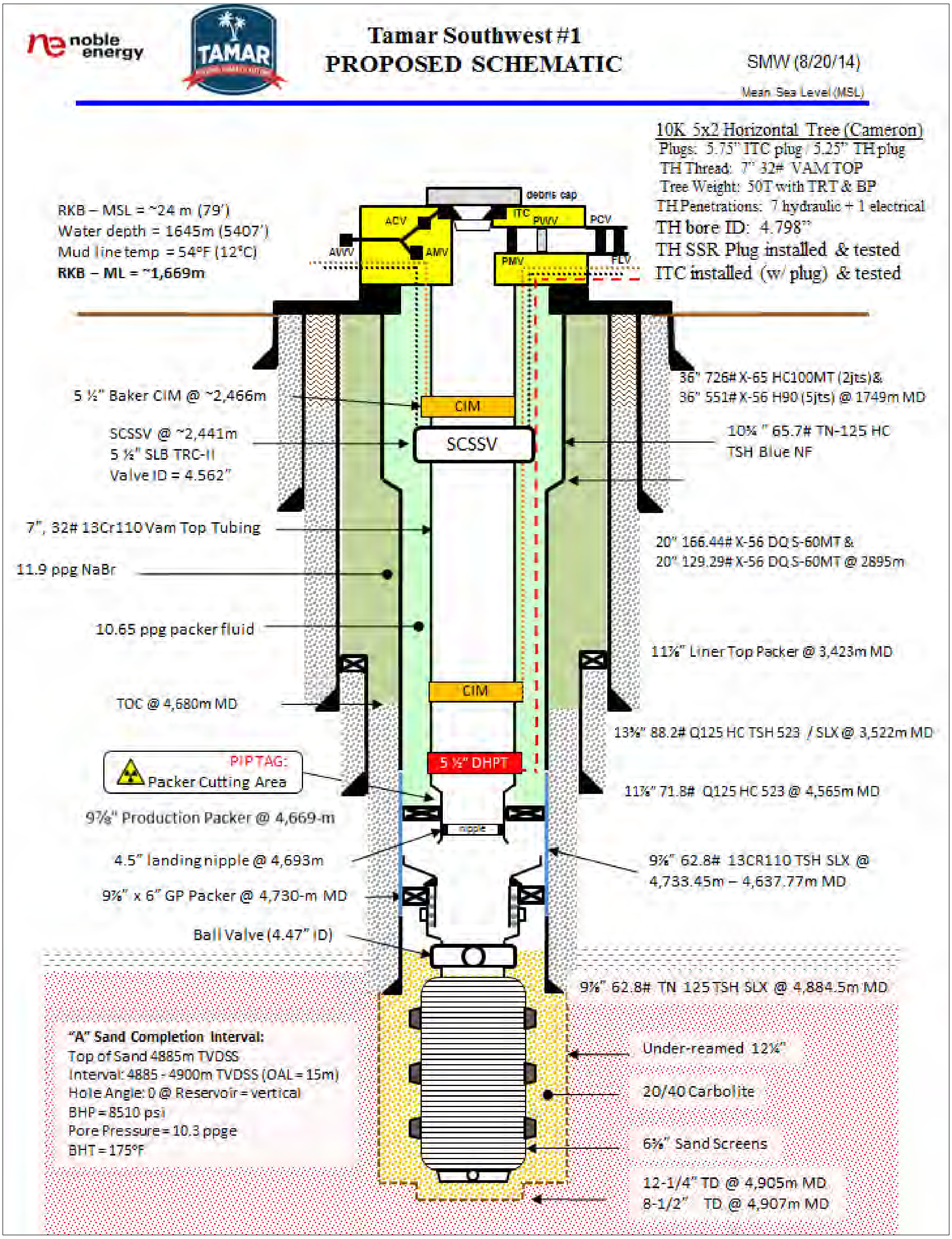


Figure 3-14. Proposed completion schematic (Tamar SW-1).

Table 3-4. The completion fluid product description for Tamar SW-1.

Name	Packaging	Information
Sodium Bromide	Bulk Fluid	Base brine is 12.5 ppg. Blended with limited volume of sodium chloride salt to adjust density and increase hydrate protection.
Sodium Chloride	Blended in Bulk Fluid	Utilized to provide better hydrate protection and lower brine cost.
Acetic Acid (Glacial)	200 L/drum	High strength organic acid used to lower pH in breaker fluids to dissolve residual calcium carbonate in filter cakes.
BioPaq	50 lb sx	Chemically modified corn starch. Used as a fluid loss reducer and co-viscosifier in PerfFlow CM systems.
Carbosan 135/TR	50 kg keg	A modified triazine-type biocide effective against many forms of bacteria encountered in oilfield water and drilling fluids.
Caustic Soda	50 lb/sx	Sodium hydroxide used in conjunction with well wash to effectively clean and displace wellbore.
CI 27	55 gal/drum	Amine-based corrosion inhibitor used in low pH breaker fluids carrying gravel.
KD-40	55 gal/drum	KD-40 is a water soluble corrosion inhibitor. It is an organophosphate formulation that forms a strong protective film on metal surfaces. It possesses a low aquatic toxicity and protects tubular goods approved for use in environmentally sensitive areas.
Defomex	55 gal/drum	Long chain alcohol-based compound to reduce and prevent air entrapment in drilling muds when circulating/mixing.
Magnesium Oxide	25 kg sx	Used as a pH buffer for PerfFlow CM mud systems.
MaxGuard	55 gal/drum	Complex polyamine formulation designed to inhibit clay swelling. Used in PerfFlow CM RDIF formulations to ensure no clay swelling/migration within pore areas that are in contact with fluid filtrate.
Mudzyme X GBW 14 C	50 gal/drum	Specific enzyme to break xanthan biopolymer. Used in cake breaker formulations.
Mudzyme S GBW 16 C	53 gal/drum	Specific enzyme to break starch-based polymers. Used in cake breaker formulations.
MulFree RS	200 l Dr	Special surfactant to ensure water wetting and avoid emulsion block. Used in RDIF systems to ensure filtrate does not cause water block inside pore throats.
Novocarb 60	1 MT BB and 25 kg sx	Ground-sized marble. (Calcium carbonate). Used to seal pores and increase density.
Novocarb 20	1 MT BB and 25 kg sx	Fine ground sized marble. (Calcium carbonate). Used to seal pores more effectively in conjunction with N60 for Tamar sands.
NOXYGEN	15 lb/pail	NOXYGEN XT is an organic salt, non-sulfur-based oxygen scavenger for use in calcium chloride, calcium bromide, and zinc bromide completion brine. Will not precipitate calcium sulfates such as sulfur-based scavengers do. Acts synergistically with corrosion inhibitors.
Sodium Acetate	25 kg sx	Used as a pH buffer regulator in specially designed RDIF cake breaker systems.
Soda Ash	50 lb and 25 kg sx	Sodium carbonate. Used as alkaline pH buffer for packer fluids.
Well Wash 150	55 gal/drum	Blend of special surfactants with the capability of being used in brine formulations up to 18.0 ppg weighted spacer system. Water-soluble surfactants formulated to remove water-based drilling mud and mud residues from casing, pipe, and formation, and restores tubular surface to a water wet state.
UltraVis	5 gal/pail	UltraVis is a highly concentrated liquid dispersion of a high quality, non-ionic, water soluble polymer (10.5 lb/5 gal) in an organic potassium salt solution. UltraVis is used in spacer trains where these cannot come into reservoir contact.
XanVis-L	5 gal/pail	High molecular weight prehydrated xanthan biopolymer for building viscosity, a highly refined product that provides clarified fluids with low polymer residues and exceptional suspension properties, preferably pH = 6 to 10.5, additional pH, shearing and temperature will increase hydration.

BB = base box; MT = metric ton; ppg = pounds per gallon; RDIF = reservoir drill-in-fluid; sx = sacks.

Table 3-5. Materials to be used for the Tamar SW-1 well completion program.

Product	Function	Total Weight (lb)	Excess (%)	Total Plus Excess (Tons)
NaBr (Dry Salt)	Weight	2,251,749.70	15	1174.915
NaCl (Dry Salt)	Weight	931,175.56	15	485.867
Fresh Water	Weight	1,057,796.91	15	551.936
Caustic Soda	Sodium Hydroxide	1,968.00	50	1.339
Xanvis L	Calcium Treatment	2,748.90	50	1.871
UltraVis	Viscosifier	13,494.60	50	9.184
Well Wash 150	Surfactant	14,060.62	50	9.569
Dope Free	Surfactant	880.00	100	0.799
MULFREE RS	Surfactant	7,742.62	50	5.269
BIO-PAQ	Fluid Loss	37,800.00	50	25.726
XAN-PLEX D	Viscosifier	4,762.80	50	3.241
MAGNESIUM OXIDE	pH Buffer	6,300.00	50	4.288
MAX-GUARD	Inhibition	74,934.76	50	50.999
X-CIDE 207	Microbiocide	24.00	50	0.016
NOVO-CARB 60	Weight	170,617.00	50	116.119
NOVO-CARB 20	Weight	67,240.30	50	45.762
MUDZYME X	Enzyme Breaker	5,918.76	50	4.028
MUDZYME S	Enzyme Breaker	1,189.39	50	0.809
Sodium Acetate	pH Buffer	3,350.00	50	2.280
Glacial Acetic	pH Control	5,084.04	50	3.460
CL-27 Corrosion Inhibitor	Corrosion Inhibitor	555.38	50	0.378
KD-40	Corrosion Inhibitor	1,399.44	50	0.952
NOXYGEN	Oxygen Scavenger	120.00	50	0.082
Soda Ash	pH Buffer	2,700.00	50	1.838

3.2.2.3 Proposed Wells

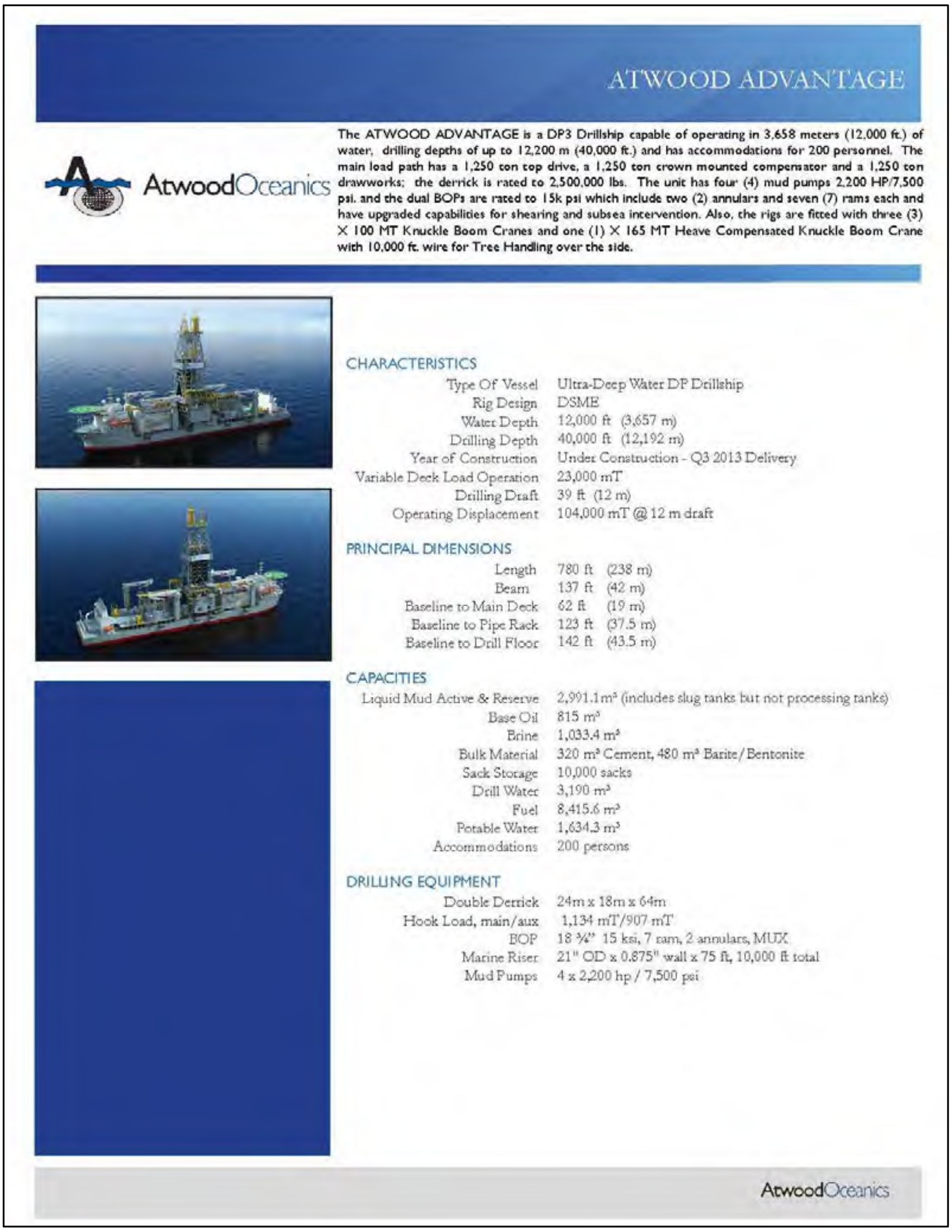
The proposed wells (Tamar-7, Tamar-8, and Tamar-9) will be drilled in the Tamar Reservoir to the same specifications as the Tamar SW-1 well, described in **Section 3.2.2.2**. Drilling is planned to occur during 2015. A drilling vessel has not been identified, but is expected to be similar to the *Atwood Advantage* (**Figure 3-15**). Support vessels and aircrafts to be used will be similar to those used for the drilling of Tamar SW-1 (see **Section 3.2.2.2**).

The components of the mud system for the *Atwood Advantage* include the following:

- Mud Pumps: Four NOV 14P-220 horsepower (hp) mud pumps, 2,200 hp, 7,500 psi;
- Riser Boost Pump: One NOV 10P-130 pump, 1,300 hp;
- Shale Shakers: Eight NOV VSM-300 shale shakers;
- Mud Cleaners: Two NOV VSM-300 Desilter Header (20 cone) over shakers;
- Degassers: Three NOV/Brandt DG-12 vacuum degassers, 1,200 gpm each;
- One Techdrill Mud Gas Separator (Poorboy degasser); and
- One Techdrill 15-k × 10-k choke and kill manifold with glycol injection.

The bulk mud and cement system includes:
- Six bulk storage tanks for barite/bentonite; 80 m^3 ea. complete with dust collector/cyclone;
- Four bulk storage tanks for cement; 80 m^3 ea. complete with dust collector/cyclone; and
- Two bulk mud surge tanks; 6 m^3 ea. complete with dust collector/cyclone.

The initial well intervals (before the marine riser is set) will be drilled using a water-based "spud mud," and the cuttings and "spud mud" will be released at the seafloor. For the intervals drilled after the riser is set, Noble Energy has selected INNOVERT CFMOB, a high-performance invert emulsion fluid system developed by Baroid (a product service line of Halliburton). ExxonMobil Chemical's ESCAID 110 would be the base fluid for the INNOVERT mud system. ESCAID 110 mineral base oil is derived from selected petroleum feed stocks that have been highly refined and reacted with hydrogen to convert aromatics to cycloparaffins. This deep hydrogenation results in products of controlled composition with low aromatics content, negligible relative impurities, and a faintly sweet odor. It is a complex mixture of hydrocracked and desulfurized hydrocarbons with a narrow distillation range (205°C to 237°C). ESCAID 110 has a low viscosity and can reduce the friction factor between the drill string and the sides of the borehole considerably. It offers high drilling performance and enhanced rates of penetration and shale inhibition. **Table 3-6** lists selected physical, chemical, and environmental characteristics of ESCAID 110 mineral oil-based mud (MOBM).



ATWOOD ADVANTAGE

AtwoodOceanics

The ATWOOD ADVANTAGE is a DP3 Drillship capable of operating in 3,658 meters (12,000 ft.) of water, drilling depths of up to 12,200 m (40,000 ft.) and has accommodations for 200 personnel. The main load path has a 1,250 ton top drive, a 1,250 ton crown mounted compensator and a 1,250 ton drawworks; the derrick is rated to 2,500,000 lbs. The unit has four (4) mud pumps 2,200 HP/7,500 psi. and the dual BOPs are rated to 15k psi which include two (2) annulars and seven (7) rams each and have upgraded capabilities for shearing and subsea intervention. Also, the rigs are fitted with three (3) X 100 MT Knuckle Boom Cranes and one (1) X 165 MT Heave Compensated Knuckle Boom Crane with 10,000 ft. wire for Tree Handling over the side.

CHARACTERISTICS

Type Of Vessel	Ultra-Deep Water DP Drillship
Rig Design	DSME
Water Depth	12,000 ft (3,657 m)
Drilling Depth	40,000 ft (12,192 m)
Year of Construction	Under Construction - Q3 2013 Delivery
Variable Deck Load Operation	23,000 mT
Drilling Draft	39 ft (12 m)
Operating Displacement	104,000 mT @ 12 m draft

PRINCIPAL DIMENSIONS

Length	780 ft (238 m)
Beam	137 ft (42 m)
Baseline to Main Deck	62 ft (19 m)
Baseline to Pipe Rack	123 ft (37.5 m)
Baseline to Drill Floor	142 ft (43.5 m)

CAPACITIES

Liquid Mud Active & Reserve	2,991.1 m^3 (includes slug tanks but not processing tanks)
Base Oil	815 m^3
Brine	1,033.4 m^3
Bulk Material	320 m^3 Cement, 480 m^3 Barite/Bentonite
Sack Storage	10,000 sacks
Drill Water	3,190 m^3
Fuel	8,415.6 m^3
Potable Water	1,634.3 m^3
Accommodations	200 persons

DRILLING EQUIPMENT

Double Derrick	24m x 18m x 64m
Hook Load, main/aux	1,134 mT/907 mT
BOP	18 ¾" 15 ksi, 7 ram, 2 annulars, MUX
Marine Riser	21" OD x 0.875" wall x 75 ft, 10,000 ft total
Mud Pumps	4 x 2,200 hp / 7,500 psi

AtwoodOceanics

Figure 3-15. Information on the *Atwood Advantage*.

Table 3-6. Selected physical, chemical, and environmental characteristics of ESCAID 110 mineral oil-based mud (MOBM) (From: Imperial Oil and ExxonMobil; see **Appendix E**).

Property or Test	Method	Specifications
Aniline Point (°C)	ASTM D 611	65.6 (minimum) – 76
Appearance	Visual	Pass
Aromatics Content (wt. %)	AM-S 140.31	0.5 (maximum)
PAH Content (wt. %)	--	<0.001
Color (Saybolt Units)	ASTM D 156 or ASTM D 6945	30 (minimum)
Distillation (Initial Boiling Point, °C)	ASTM D 86	192 (minimum) – 205
Distillation (DP, °C)	ASTM D 86	250 (minimum)
Flash Point (°C)	ASTM D 93	70 (minimum) – 80
Pour Point (°C)	ASTM D 97	-39 – -35 (minimum)
Specific Gravity (kg/dm^3 @ 15.6°C)	ASTM D 4052	0.790 – 0.810
Viscosity (@ 40°C, cSt)	ASTM D 445	1.50 – 1.75
Octonol/Water Partition Coefficient (Log K_{ow})	OECD TG 117	>6.5
Biodegradability (in seawater)	OECD 306 (OECD, 1992)	67%
Bioassays		
Corophium volutator (amphipod)	10-day LL_{50}	341 mg/kg
Acartia tonsa (copepod)	48-hr LL_{50}	9,229 mg/L
Skeletonema (alga)	72-hr NOEL	10,000 mg/L
Tilapia mossambica (fish)	96-hr LL_{50}	31,3000 mg/L
Mugil parsia (fish)	96-hr LL_{50}	306,000 mg/L
Cyprionodon variegatus (fish)	96-hr LL_{50}	8,958 mg/L

ASTM = American Society for Testing and Materials; LL_{50} = median lethal loading (equivalent to lethal concentration 50 [LC_{50}]); NOEL = no observable effects level; OECD = Organisation for Economic Co-operation and Development.

INNOVERT is classified as a "Group III NADF" based on its aromatic content of less than 0.5% and PAH content of less than 0.001% (International Association of Oil & Gas Producers, 2003). Key components of the INNOVERT mud system include: (1) ESCAID 110 – the mineral oil base fluid; (2) LE SUPERMUL – a polyaminated fatty acid that can be used to emulsify water into the fluid (helps improve wetting characteristics and is designed for use in high-performance fluids); (3) lime – that can be used to increase the alkalinity level of the water phase; (4) calcium chloride – used as a brine salt in invert emulsion fluids; (4) BAROID – barite, added as needed as a weighting agent; (5) RHEMOD L – a unique, modified fatty acid for providing suspension and viscosity; (6) ADAPTA – a co-polymer for providing high-pressure/high-temperature filtration control; (7) EZ Mul NT – an invert emulsifier and oil-wetting agent; and (8) TAU MOD – a viscosifier used to improve suspension and hole cleaning capabilities in high-performance fluids.

The advantages of this formulation are as follows:

- Stable mud properties over a wide temperature and density range; suitable for high-temperature/high-pressure applications;
- A better seal than conventional technologies;
- Reduced downhole losses of drilling mud;
- Unique rheological properties that eliminate the need for fine-ground weighting agents while providing excellent hole cleaning;
- Increased tolerance to contaminants such as solids and water influxes;
- Significantly lower solids content to help increase penetration rates;
- Fewer products than for conventional synthetics, improving logistics and rig space usage;
- Real-time response to chemical treatments; and
- Enhanced electrical formation evaluation.

Cuttings will be separated from the MOBM prior to discharge (if approved) or transport for shore disposal. If the cuttings will be discharged, they will be treated using a thermomechanical cuttings cleaner (or equivalent system) cuttings handling process unit to process the cuttings to less than 1% oil on cuttings. **Figure 3-16** shows a flow diagram for processing the drilling mud and cuttings on the drilling rig. Drilling mud is circulated down the drill pipe continuously during drilling and returns to the surface through the annular space between the drill pipe and casing, carrying drill cuttings in suspension. On the drilling rig, the mud and cuttings are passed through solids control equipment designed to separate the drill cuttings so that the mud can be pumped back down the hole. The cuttings are initially separated using mesh screens on shale shakers and then transferred to a process plant that uses mechanical action applied directly to the drill cuttings creating temperatures (260°C to 280°C) that rise above the boiling points of water and oil. Reaching these temperatures removes the hydrocarbons from the solids to less than 1% oil on cuttings. The remaining water and oil vapor is condensed into the relevant streams and recovered separately. The recovered oil is pumped back into the mud system and the water is disposed overboard if it meets offshore disposal guidelines. Water that does not meet the discharge limits is transferred to a holding tank and disposed of onshore. Typical oil in water (OIW) content of the recovered water is less than 30 ppm.

The process mill's main function is to generate friction heat to force the evaporation of water and oils present in the feed material. The rotor operates with a rotational speed of 600 to 700 rpm, which creates a ring-shaped bed of material along the stator wall. Due to the intense agitation of the rotor, motor energy is transferred as heat to the material bed, allowing water and oil in the material to be efficiently flash evaporated. The condenser module is broken into four stages with the oil scrubber being the primary vessel that removes the final solids from the recovered vapor. From there, the vapor travels through an oil condenser, water condenser, and oil-water separator.

Key advantages of the system are as follows:

- Direct heating of the waste stream resulting in maximum energy efficiency;
- Recovered base oil which can be directly recycled;
- Dried solids which are clean and can be disposed of on site;
- An easily relocated unit that is ideal for offshore use; and
- Rapid start-up and shutdown, which facilitates simple maintenance tasks.

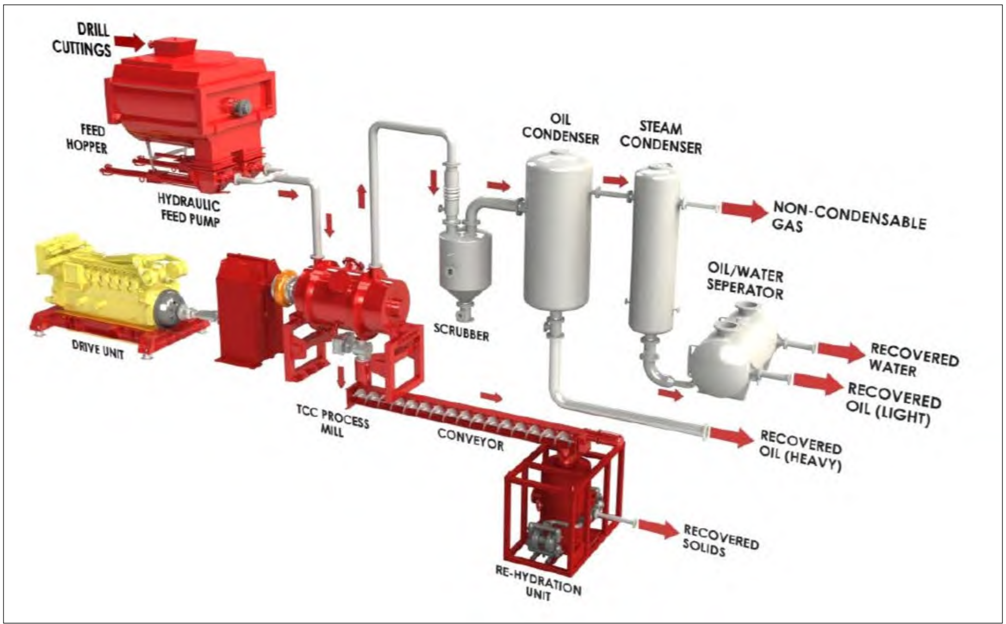


Figure 3-16. Process flow diagram for separating mineral oil-based mud (MOBM) cuttings for on-site discharge.

3.2.3 Pipelines

Pipelines planned for the Tamar Field Development Project include the following:

- Infield flowline 12¾-in. from the Tamar SW-1 well to the Tamar-7 well location;
- Infield flowline 16-in. from the Tamar-7 well to Tamar production manifold;
- Infield flowlines from Tamar-8 and Tamar-9 to Tamar production manifold;

The material grade chosen for the line pipe from the Tamar SW-1 well to the Tamar-7 well is DNV grade 450 (API Grade X-65). The tieback pipelines are manufactured as seamless pipe, as are the MEG lines and infield flowlines. The infield flowlines, tieback pipelines, and MEG lines are coated with a three-layer polypropylene (3LPP) corrosion coating. These are the same type of pipelines utilized for previous projects in the Tamar lease area (CSA International, Inc., 2012). The 16-in. flowline will carry only Tamar SW product until T-7 is brought online, at which point the 16-in. flowline will carry combined T-7 and Tamar SW-1 production to the Tamar production manifold.

3.2.4 Safe Drilling Practices

Noble Energy followed safe drilling practices during its drilling activities, and best industry practice was employed during all drilling phases (e.g., setting of BOP; cementing of concrete between bore and protective pipe).

3.2.4.1 BOP Specifications

Typical BOP specifications include the following (from the *ENSCO 5006* specifications as used on the Tamar SW-1 well):

- BOP: VetcoHD-H4 well head connector 18¾ in. 15,000 psi WP; 2 × Cameron 18¾-in. type TL double 15,000 psi WP hydrogen sulfide (H_2S) trimmed preventers; 1× Hydril 18¾ in. dual annuflex annular 10,000 psi WP H_2S trimmed; lower marine riser package: Cameron connector model HC, 18¾ in. 15,000 psi WP; Oil State 5,000 psi flex joint.
- BOP Handling: one BOP carrier, 272 MT; one x-mas tree carrier, 272 MT; two 72.5 MT BOP overhead crane.
- Control System: Cameron Multiplex system, 5,000 psi.
- Diverter: Hydril FS-21-500, 21¼ in. for a 60½ in rotary, 500 psi WP, 2 × 14-in. vent line and 1 × 18-in. flowline outlets.
- Choke and Kill: Cameron 15,000 psi, 4 in., H_2S service manifold.

3.2.4.2 Well Locations

The location and trajectory of the wells was designed to minimize the risk of encountering the following shallow hazards:

- Sensitive Communities: The wells are at least 500 m from any sensitive sessile benthic communities or other seafloor features that could affect well emplacement;
- Anomalous Seafloor Amplitudes: There are no high seafloor amplitudes in the records that indicate any fluid seepage within 500 m of the well locations;
- Seafloor Instability: The wells are in relatively flat locations that are at least 600 m from any seafloor channel or fault scarp;
- Shallow Faulting: The location of the wells avoids all areas of supra-salt thrust faulting and vertical faulting; and
- Anomalies Within Salt: The wells intersect clastic interbeds where there is minimal deformation.

3.2.4.3 Well Testing

The following is a description of the well testing activities. Any well-specific information refers to the Tamar SW-1 well; all well completions are planned to follow this procedure. Well drilling activities are discussed in **Section 3.2.2**.

The surface well testing equipment final installation and all safety shut-in tests will be performed and seawater deluge system tested prior to flowing the well. Six emergency shutdown stations will be installed: one at the drillers BOP console, one at the living quarters BOP console, one at the life boats, and three within the well test equipment. Independent deep well pumps will be installed to supply seawater to the surface booster pump deluge system for the burner booms and hand rail spray nozzles.

The surface well test equipment will consist of the following:

- Surface flow head;
- Coflexip hose production flow line;
- Kill line to flow head;
- Inline surface safety valve;
- Cyclonic desander;
- Iso-split sampler;
- Double block choke manifold;
- Data header;
- Chemical injection pumps upstream and downstream of choke manifold;
- Three heat exchangers;
- 2,000 barrels of water per day (bowpd) separator;
- Dual compartment surge tank;
- Triple compartment gauge tank;
- Four 4-mbtu steam exchangers;
- Oil manifold;
- Gas manifold;
- Two burner booms and burners with ignition systems;
- Two air compressors;
- Surface well flow and monitoring system;
- Sampling and fluid and gas testing equipment; and
- A dual pot filtration unit.

Once all surface safety systems have been tested, the landing string will be displaced to a lighter fluid to underbalance the well at approximately 500 psi.

The overall strategy to the flow back is to bring the well online as quickly as necessary to unload liquids and steadily ramp production to the maximum flow rate of 120 mmscfd with a maximum condensate gas ratio rate of 1.2 barrels per minute. Once at maximum rate, the well will be monitored to determine when it can be considered "cleaned up." After determining the well is clean, flow will continue until condensate yield is determined and samples are taken. The well will be stepped down in four steps as shown in **Table 3-7**. After shutting in at surface for the pressure build up, the bottom hole pressure will be monitored and recorded for a minimum of 3 hours at a high-frequency scan rate (1 second intervals). Methanol will be injected at the subsea test tree, upstream and downstream of the choke manifold for hydrate inhibition. All produced gas, condensate, and injected methanol will be sent to a flare.

Any NaCl/NaBr, formation water, or condensate flowed back will be collected, filtered, tested, and discharged overboard as per Noble Energy standards. Any fluid that does not meet applicable discharge standards will be collected and sent to shore for proper disposal.

Well build up will be monitored and recorded under a closed SCSSV via the IWOCS for at least 3 hours until rig activities force the cessation of monitoring and recording bottom hole pressure data. **Table 3-8** presents the well production parameters expected for the wells. **Table 3-7** and **Figure 3-17** show the estimated gas and oil flow for the flow test period of 49.5 hours.

Table 3-7. Estimated gas flow and carbon dioxide (CO_2) emissions from the Tamar SW-1 flow test.

Test Period	Duration (hours)	Gas Rate (mmscfd)	Total Gas Flowed (mmscf)	Total Oil Flowed (bbl)
Initial ramp-up	9	120,000,000.00	45,000,000.00	54.00
Extended clean up	36	120,000,000.00	180,000,000.00	216.00
First step down to 110	0.1	110,000,000.00	458,333.33	0.55
Flow for 0.25 hr at 110	0.25	110,000,000.00	1,145,833.33	1.38
Second step down to 100	0.1	100,000,000.00	416,666.67	0.50
Flow for 0.25 hr at 100	0.25	100,000,000.00	1,041,666.67	1.25
Third step down to 90	0.1	90,000,000.00	375,000.00	0.45
Flow for 0.25 hr at 90	0.25	90,000,000.00	937,500.00	1.13
Fourth step down to 80	0.1	80,000,000.00	333,333.33	0.40
Flow for 0.25 hr at 80	0.25	80,000,000.00	833,333.33	1.00
Fast shut-in for PBU	0.1	80,000,000.00	333,333.33	0.40
Shut-in end of test	3	0.00	0.00	0.00
Methanol injected				100.00
Total	**49.5**		**230,875,000.00**	**377.05**

bbl = barrel; mmscf = million standard cubic feet; mmscfd = million standard cubic feet per day; PBU = pressure build up.

Table 3-8. Well production parameters for well completions used for estimating emissions.

Parameter	Units	Tamar SW-1
Target Gas Rate	mmscfd	250
Maximum Gas Rate	mmscfd	300
Condensate Gas Ratio	bbl/mmscf	1.20
Gas Gravity	SG	0.57
Condensate Gravity	API	30
H_2S	ppm	0.00
CO_2	MOL%	0.10

API = American Petroleum Institute; bbl = barrel; CO_2 = carbon dioxide; H_2S = hydrogen sulfide; mmscf = million standard cubic feet; mmscfd = million standard cubic feet per day; MOL% = mole percent; ppm = parts per million; SG = specific gravity.

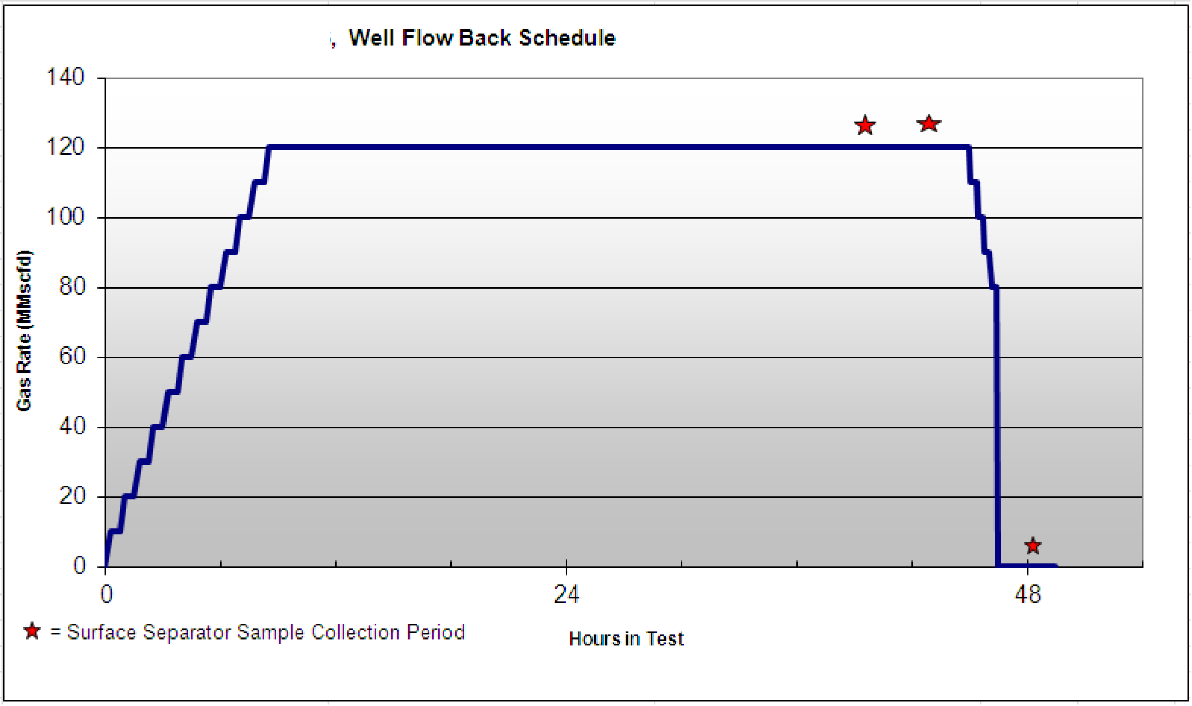


Figure 3-17. Well flow back schedule.

The well flow back sampling matrix is presented in **Table 3-9**, and the hydrate curve is presented in **Figure 3-18**.

Table 3-9. Well flow back sampling matrix.

Sample Type	End of Well Clean-up	After Flow
Iso-Split	1 × 20L Gas	
	2 × 200 cc Condensate	
Separator	1 × 20L Gas	4 × 25 L Dead Condensate
	2 × 600 cc Condensate	
SGS Volatiles	3 × 500 cc Gas	
	3 × 500 cc Condensate (Separator)	
	3 × Radon	
	4 × Mercury	
Total Per Period	2 × 20 L Gas	4 × 25 L Dead Condensate
	2 × 200 cc Condensate	
	2 × 600 cc Condensate	
	3 × 500 cc Gas	
	3 × 500 cc Condensate	
	3 × Radon	
	4 × Mercury	

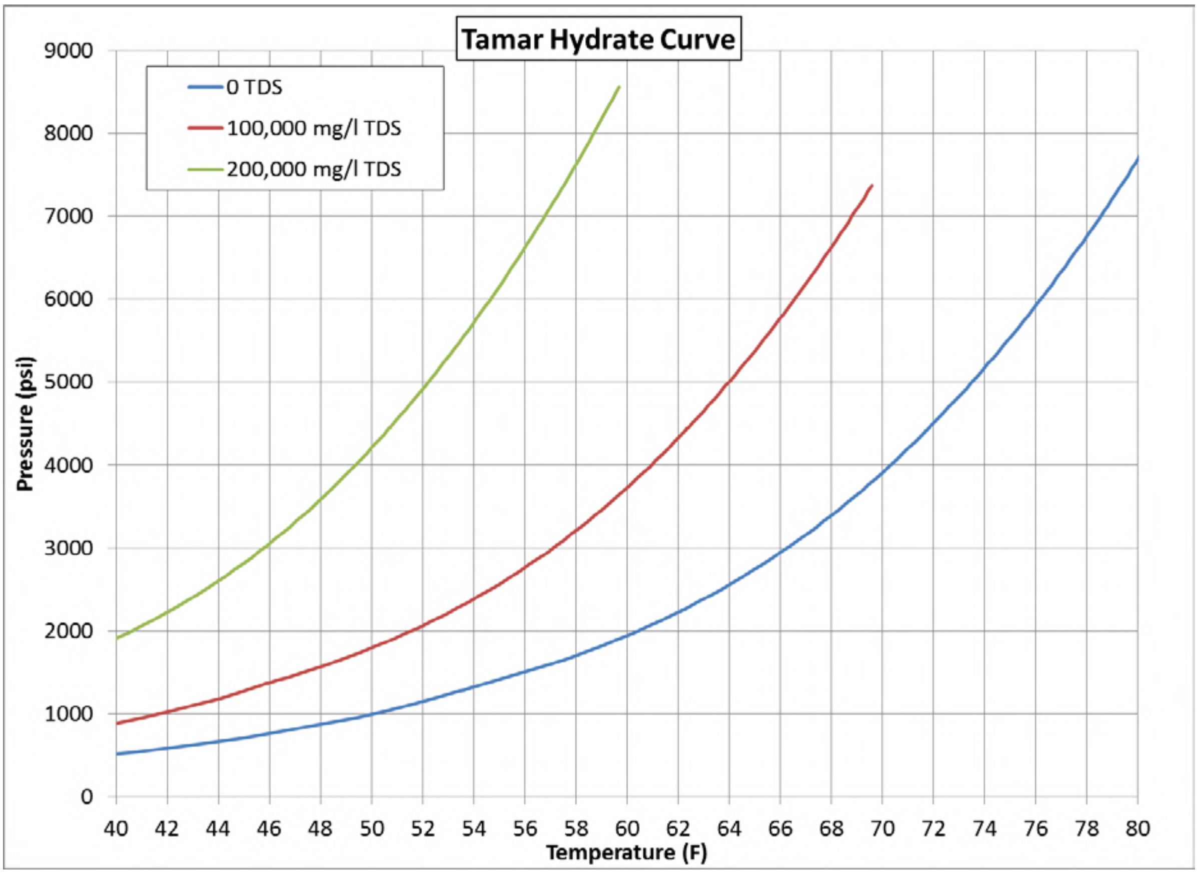


Figure 3-18. Well completion hydrate curve.

Once the final build up period has finished, the SCSSV will remain closed and the tubing pressure will be bled off. A 60/40 MEG/seawater mix will be lubricated above the SCSSV to the subsea tree.

Slickline will be rigged up and the nipple bore protector will be retrieved from the tubing hanger. A 5¼-in. tubing hanger plug will be run and tested to make the well secure.

The landing string with the subsea test tree and tubing hanger running tool will be retrieved. The riser will be displaced to seawater, and the BOP and riser will be unlatched from the Cameron subsea tree.

The internal tree cap with 5¾-in. plug installed will be run, open water set, and tested for final well safety. A light weight debris cap will be installed.

The Cameron subsea tree would be made safe and the IWOCS will be retrieved

Drilling Integrity Tests and Maximum Anticipated Surface Pressure

The purpose of drilling integrity tests is to determine the competence of the BOPs, casing, and primary cement job and the competence of the formation below the casing shoe. Integrity tests will be performed after running and cementing each casing string.

The maximum required casing and blind shear ram surface test pressure will be equivalent to the maximum anticipated surface pressure (MASP) plus 500 psi or 70% of the minimum internal yield pressure ($MIYP_{70\%}$) of the casing being tested less mud weight versus pore pressure at the previous shoe difference at the wellhead, casing top, or shoe, whichever is less. For production casing strings, the casing test pressure will be determined by the completion requirements.

The MASP calculations and results accepted by the U.S. Bureau of Safety and Environmental Enforcement are reported as the lesser of the pressures calculated using the following two methods:

1. Pore Pressure Method ($MASP_{pore}$): This calculation assumes the well is partially unloaded to gas and equals the maximum expected pore pressure at the bottom of the open hole less the hydrostatic head of the gas column and the mud column from the bottom of the hole to the "surface."
2. Fracture Gradient Method ($MASP_{frac}$): This calculation assumes the well is completely unloaded to gas and equals the fracture pressure at the deepest exposed casing or liner shoe less the hydrostatic head of the gas from that shoe to the "surface."

The corresponding maximum anticipated wellhead pressure (MAWP) is equivalent to MASP plus gas hydrostatic from surface to the wellhead.

The maximum required surface BOP pressure test will be equivalent to the MASP plus 500 psi less mud weight versus seawater hydrostatic difference at the mud line. Test pressures are not to exceed 70% of the annular rating or 100% of the ram rating at seafloor conditions.

A formation integrity test will be performed after running and cementing each casing string, cleaning out the rathole section, and drilling 3 m (10 ft) of new formation below the casing shoes. If a leak-off pressure that is lower than anticipated is obtained and the equivalent mud weight is less than that required to safely drill to the next casing depth, consideration will be given to squeezing the casing shoe with cement. Subsequent re-testing should verify if the primary cement job was ineffective or if the formation fracture gradient was lower than anticipated.

3.3 NOISE HAZARDS

The noise characteristics of a typical drilling unit conducting routine drilling activities and various support operations (e.g., support vessels, helicopters) are available and outlined in **Table 3-10**, as derived from Richardson et al. (1995). These values may be used as estimates for the noise generated during the drilling of the Tamar wells.

Table 3-10. Summary of representative noise source levels for oil and gas exploration-associated drilling operations, vessels, and aircraft (Adapted from: Richardson et al., 1995).

Sound Source	Source Levels (dB re 1 µPa at 1 m)							Highest 1/3-Octave Band	Level Band Level
	Broadband (45-7,070 Hz)	1/3-Octave Band Center Frequency (Hz)							
		50	100	200	500	1,000	2,000		
Continuous Sound Sources									
Drilling									
Kulluk (45-1780 Hz)	185	174	172	176	176	168	--	400	177
C. Explorer II	174	162	162	161	162	156	148	63	167
Semi-submersible	154	--	--	--	--	--	--	--	--
Transient Sound Sources									
Vessels Underway									
Supply Ship	181	162	174	170	166	164	159	100	174
Supply Vessel	128-158	--	--	--	--	--	--	--	--
Crew Boat	156	--	--	--	--	--	--	--	--
Aircraft									
Bell 212 Helicopter	162	154	155	151	145	142	142	16	159

Note: Richardson et al. (1995) computed aircraft flyover source levels, as initially provided by Malme et al. (1989) for a standard altitude of 305 m; values were changed to a reference range of 1 m by adding 50 dB.

Salient characteristics of these representative noise sources as they apply to proposed operations include the following:

- Most man-made noise associated with offshore oil and gas drilling operations or support activities are in the low frequency bands (<500 to 1,000 Hz).

- Propeller cavitation, propeller singing, and propulsion machinery are primary noise sources for vessels (regardless of size), which is not an issue with a DP drillship, but would be associated with AHTS and support vessel operations.

- Semi-submersible drilling units produce sound levels which are generally lower than other drilling vessels or bottom-founded drilling units (e.g., drillships, jack-up rigs) because the rig machinery is mounted on raised decks, which benefit from portions of the noise spectrum reflecting off the ocean surface.

- Sound source levels for a semi-submersible are in the range of 154 dB re 1 µPa at 1 m.

- Supply and crew boats produce sound source levels in the range of 128 to 158 dB re 1 µPa at 1 m; these sound sources are considered transient as they move between shore base and the drilling rig; sound from the standby vessel will be at a lower source level while idling on station.

- Underwater sounds from helicopters, as with all aircrafts, reach their highest levels just below the surface and directly under the aircraft. When the aircraft is overhead, sound levels decrease with increasing aircraft altitude or increasing receiver depth. The highest energy of helicopter rotor sound is at frequencies <500 Hz, while helicopter turbines contribute to higher sound levels at frequencies >500 Hz.

- Transmission of airborne sound into the water is a function of source altitude, orientation (e.g., <26° maximizes sound penetration into the water column), receiver water depth and orientation, and sea surface conditions.

Sound emanating from the drillship can be expected to be continuous, at a level of approximately 154 dB re 1 µPa at 1 m while drilling, with most energy in the low frequency bands. During non-drilling periods, sound source levels from the drillship will originate only from diesel generators, cranes, and crew activity aboard the rig.

Supply vessels in transit to and from the rig will produce transient sounds in the 128 to 158 dB (re 1 µPa at 1 m) range, with predominant low frequency components. If a supply vessel remains on standby at the rig, it will produce lower but continuous sound levels. In similar fashion, transient helicopter visits to the rig will produce predominantly low frequency sound source levels of 162 dB (re 1 µPa at 1 m), with highest sound levels to be experienced directly below the aircraft.

Noise associated with installation operations for the pipeline and infrastructure is relatively weak in intensity, and any animals that are affected are exposed to these sounds for a relatively short time. Some of the noise (from vessel engines and propellers) is similar to the existing noise associated with shipping traffic in the region. Very little noise will be generated by the operation of the flowlines and utility lines.

3.4 AIR QUALITY

Activities associated with drilling, including rig positioning, drilling, cementing, and logging operations, along with associated support operations, produced emissions from internal combustion engines, including greenhouse gases and varying amounts of other pollutants such as carbon monoxide (CO), NO_x, sulfur oxides (SO_x), VOCs, and particulate matter (PM). The location and duration of these operations were variable. For example, while the drilling rig maintained station at the drillsite, support vessels and helicopters traveled between the shore base or airport and offshore. On a weekly basis, there was approximately one supply vessel round trip and one helicopter round trip during drilling.

The recent Tamar SW-1 well information is representative of past Tamar wells. The Tamar SW-1 well utilized the *ENSCO 5006* which is equipped with four Caterpillar 3608-TA diesel engines, each rated at 3,055 hp, driving one Baylor AC generator (600 V; 60 Hz; 3,571 kilovolt amp [kVA]). Power distribution was via six silicon-controlled rectifiers, the latter of which were M&I 2,200 amp 750 volt direct current units, used for drilling and mooring. Emergency power was provided by a single Caterpillar 3512-DITA diesel engine rated at 1,281 hp, driving a single Caterpillar SR-4 AC generator (480 V; 60 Hz; 1,137 kVA).

Anchor handling and tow capabilities were provided by two support vessels. A representative vessel for these capabilities is the AHTS vessel *Richard M. Currence*. The *Richard M. Currence* and *John P Laborde* are each equipped with four EMD 16-265-H7 engines, each rated at 6,300 hp. The M/V *EAS* is equipped with two MaK 12 M453 AK engines, capable of producing a total 7,760 brake horsepower (bhp). The M/V *Leon* is equipped four Caterpillar 3512B TA engines, capable of producing a total of 6,000 bhp. Helicopter support is the same or similar to that provided by a Bell 412SP aircraft, equipped with two Pratt and Whitney Canada PT6T-3BE Twin-Pac turbo shafts, each producing 900 shaft horsepower (shp) (671 kW).

Emissions included pollutants that are similar to other ocean-going vessels and included carbon dioxide (CO_2), NO_x, SO_x, PM, and unburned hydrocarbons (VOCs). Project air emissions were also associated with the operation of supply boats and AHTS vessels. A summary of air modeled using emissions from project-related sources for the representative Tamar SW-1 well is provided in **Table 3-11**.

Table 3-11. Summary of maximum daily air emission estimates, by source, for the representative Tamar SW-1 well.

Source	Emissions (tons/day)							
	CO_2	CO	NO_x	SO_x	VOCs	PM	CH_4	CO_2 e
Semisubmersible Drilling Vessel (Drilling)								
ENSCO 5006	157.62	0.72	3.30	0.44	0.10	0.10	0.01	157.81
Supply Vessel (Drilling Support)								
EAS	170.06	0.78	3.56	0.47	0.11	0.10	0.01	170.27
Leon	253.83	1.16	5.31	0.71	0.16	0.15	0.01	254.13
AHTS Vessel (Rig Emplacement and Demobilization)								
Richard M. Currence	834.50	3.81	17.44	2.33	0.52	0.51	0.05	835.50
John P Laborde	834.50	3.81	17.44	2.33	0.52	0.51	0.05	835.50

AHTS = anchor handling towing supply; CO = carbon monoxide; CO_2 = carbon dioxide; CO_2 e = carbon dioxide equivalent; CH_4 = methane; NO_x = nitrogen oxides; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound. Greenhouse gas emissions include both CO_2 and CH_4; the latter was assumed to have a CO_2 equivalence of 21 (Wilson et al., 2007).
ENSCO 5006 emissions based on three generators operating 24 hr/day, plus a fourth primary generator running 12 hr/day and the fifth (emergency) generator operating 12 hr/day.
EAS emissions based on two primary engines operating 18 hr/day, an auxiliary engine operating 18 hr/day, and two tunnel thrusters operating 6 hr/day.
Leon emissions based on four engines operating 18 hr/day.
Richard M. Currence and *John P Laborde* based on two engines operating 18 hr/day and two engines operating 12 hr/day.
Emissions calculations derived using the U.S. Gulf of Mexico Air Emissions Calculations Instructions and accompanying worksheet (EP_AQ.XLS) developed by the U.S. Department of the Interior, Bureau of Ocean Energy Management and the American Petroleum Industry/Offshore Operators Committee Air Quality Task Force employing USEPA AP-42 emission factors. Vessel engine characteristics derived from owner/operator specifications.

The flow testing to be conducted during the completion of the Tamar SW-1 well will result in emissions. **Section 3.2.4** presented the well production parameters for the completion, and **Table 3-12** presents the test duration and CO_2 to be flared. As indicated, the test period is expected to last for 49.5 hours.

Table 3-12. Estimated carbon dioxide (CO_2) emissions from the Tamar SW-1 flow test.

Test Period	Duration Hours	CO_2 Flared Tons
Initial ramp-up	9	2966
Extended clean up	36	11863
First step down to 110	0.1	30
Flow for 0.25 hr at 110	0.25	76
Second step down to 100	0.1	28
Flow for 0.25 hr at 100	0.25	69
Third step down to 90	0.1	25
Flow for 0.25 hr at 90	0.25	62
Fourth step down to 80	0.1	22
Flow for 0.25 hr at 80	0.25	55
Fast shut-in for PBU	0.1	22
Shut-in end of test	3	0
Methanol injected		45
Total	**49.5**	**15,263.00**

PBU = pressure build up.

Future well air emissions have been estimated for the *Atwood Advantage,* and expected maximum daily air emissions for the planned wells are presented in **Table 3-13**.

Table 3-13. Summary of maximum daily air emission estimates, by source, for the planned Tamar-7 to Tamar-9 wells.

Source	Emissions (tons/day)							
	CO_2	CO	NO_x	SO_x	VOCs	PM	CH_4/CO_2 e	GHGs
Semisubmersible Drilling Vessel (Drilling)								
Atwood Advantage	459.83	2.54	11.63	1.55	0.35	0.34	0.01/0.21	460.04
Supply Vessel (Drilling Support)								
EAS	54.92	0.30	1.39	0.19	0.04	0.04	0.01/0.21	55.13
EDT Leon	23.52	0.14	0.63	0.08	0.02	0.02	0.01/0.21	23.73

CO = carbon monoxide; CO_2 = carbon dioxide; CO_2 e = carbon dioxide equivalent; CH_4 = methane; GHG = greenhouse gases; NO_x = nitrogen oxides; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.
Greenhouse gas emissions include both CO_2 and CH_4; the latter was assumed to have a CO_2 equivalence of 21 (Wilson et al., 2007). CO_2 values determined using IMO (2010) conversion factors for marine diesel, based on fuel consumption.
Atwood Advantage emissions based on three generators operating 24 hr/day, plus three additional generators running 8 hr/day and the fifth (emergency) generator operating 8 hr/day.
EAS emissions based on two primary engines operating 12 hr/day, three auxiliary engines operating 4 hr/day, and two tunnel thrusters operating 8 hr/day.
EDT Leon emissions based on two primary engines operating 12 hr/day, two auxiliary engines operating 4 hr/day, and three generators operating 8 hr/day.
Emissions calculations derived using the U.S. Gulf of Mexico Air Emissions Calculations Instructions and accompanying worksheet (EP_AQ.XLS) developed by the U.S. Department of the Interior, Bureau of Ocean Energy Management and the American Petroleum Industry/Offshore Operators Committee Air Quality Task Force employing USEPA AP-42 emission factors. Vessel engine characteristics derived from owner/operator specifications.

3.5 HAZARDOUS MATERIALS

Safety data sheets (SDSs) have been obtained for the chemicals, including hazardous materials, to be used during the project (**Appendix F**). The sheets provide information on the measures to be followed for reducing risks, treatment and handling, and response methods in case of incidents. Hazardous chemicals are handled in accordance with their SDS-specified guidelines, as integrated into the operator's guidelines for handling hazardous materials.

To date, the only H_2S that has been recorded within Israel was at Pinnacles 1, where the wellhead gas has H_2S concentration readings in excess of 20 ppm.

3.6 DISCHARGES

The discharges of drilling muds, cuttings, cement, and other discharges are discussed in the following subsections. Representative data are presented to indicate the approximate volumes of each discharge, and typical treatment methodology is discussed. Separate sections present information on non-drilling discharges (e.g., domestic waste, cooling water) and drilling discharges (e.g., drilling mud, drill cuttings, cement). Some overlap between the discussion on routine discharges and drilling discharges occurs due to the nature of the waste handling equipment.

3.6.1 Non-Drilling Discharges

Non-drilling discharges are summarized in **Table 3-14**, using the Tamar SW-1 well as representative for previously drilled Tamar wells. The highest volumes of non-drilling discharges were cooling water and brine from the reverse osmosis (RO)/water maker units.

Table 3-14. Summary of non-drilling discharges from the *ENSCO 5006* during drilling of the Tamar SW-1 exploratory well.

Source	Estimated Volume (m^3/day)	Pipe Diameter (in.)	Discharge Depth (m)
Sanitary waste (black water effluent)	8-10	8	-14
Domestic waste (gray water)	20-24	8	-14
Water maker brine*	160-320	8	-14
Cooling water	6,000-7,000	14, 16, and 18	-14
Organic waste	100-120 kg/day	8	-14

* There are two production units installed on the rig which each produce 30 cubic meters per day (m^3/day). Usually only one unit operates at once – no additives are added to the process.

Table 3-15 presents the same information for the *Atwood Advantage*, which is expected to be representative of the Tamar-7 through Tamar-9 wells.

Table 3-15. Summary of non-drilling discharges expected for the *Atwood Advantage*.

Source	Estimated Volume (m^3/day)	Pipe Diameter (in.)	Discharge Depth (m)
Sanitary Waste (black water effluent)	14 (est.)	4	-7
Domestic Waste (gray water)	35 (est.)	6	-8
Water Maker Brine*	318	4	-8
Cooling Water	105,360	12	-8
Organic Waste	200 kg/day	6	-8

* There are three production units installed on the drillship which are capable of producing 156 m^3/day. Water production will be based on expected demand; no additives are added to the process.

3.6.1.1 Non-Drilling Discharge Flow (Comingling)

For the completed wells that were drilled using the *ENSCO 5006*, comingling occurred between sanitary and domestic waste streams (i.e., sewage and gray water), food scraps discharge, and potable water maker (brine) discharge. These discharges were released 14 m below the sea surface through an 8-in. diameter pipe. Note that there were no discharges from the oil-water separator while the drillship was moored at the drillsite; any liquids normally processed by the oil-water separator were captured while the drilling rig was moored and shipped to shore by means of shipping tanks.

Cooling water discharge was separate from other waste streams, but was mingled with the discharge of drilling muds and cuttings; these discharges were released 14 m below the sea surface through 14-in., 16-in., and 18-in. discharge lines. Note that the discharge of muds and cuttings from the drilling rig only occurred in the lower sections of the well; when discharging, cuttings were released nearly continuously, while drilling muds were released at the end of the well (i.e., cooling water was discharged continuously; cuttings discharged continuously only during drilling of the lower hole sections; drilling muds discharged only at the end of the well). A diagram showing the flow of various discharge streams from the *ENSCO 5006* is provided in **Figure 3-19** and is representative of completed Tamar lease area drilling activities.

The overboard flow system for the proposed wells in the Tamar Field Development Project are expected to be similar to those represented in **Figure 3-20**, which is the system used on the *Atwood Advantage*.

3.6.1.2 Non-Drilling Discharge Treatment

Completed Wells

Sanitary waste (i.e., black water or sewage) consists of wastes from toilets and urinals. For the drilling of the Tamar lease area wells, all sanitary waste was treated using a marine sanitation device, producing an effluent with low residual chlorine concentrations and no visible floating solids. On board the drillship, sanitary waste was treated to oxidize and disinfect raw sewage by means of electrochemical reaction. Waste was transferred from a holding tank to a second tank for maceration, then moved via salt water over electrically charged plates. In this process, chloride salts in seawater are decomposed by electrolysis to form hypochlorite, which kills coliform bacteria and oxidizes organic compounds. Treated sanitary wastes left the electrolytic cell through a “down-comer” pipe, which acted as a flow stabilizer, into a final processed tank; sanitary wastes were then gravity-fed overboard below sea level.

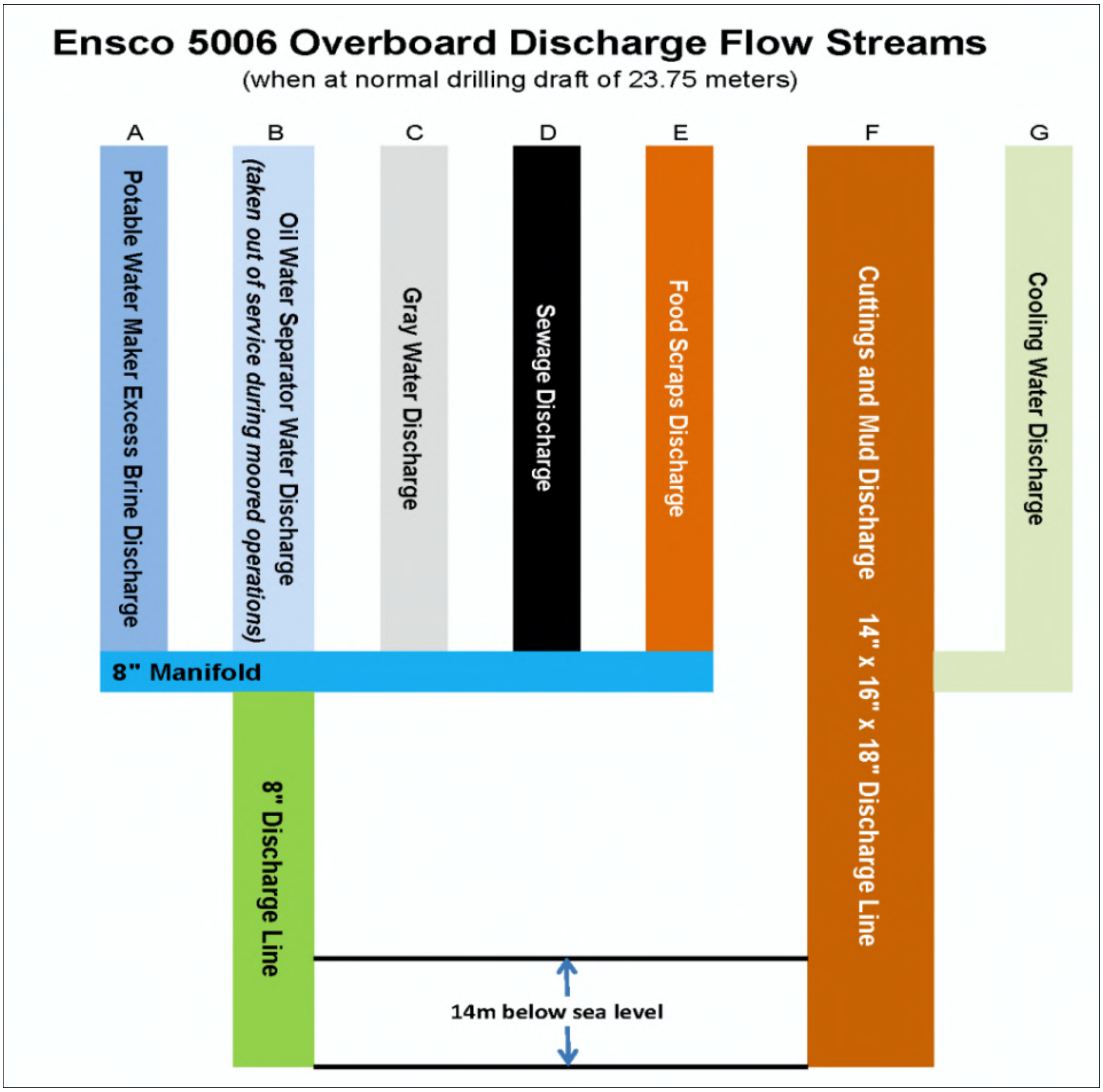


Figure 3-19. Discharge streams for the *ENSCO 5006*.

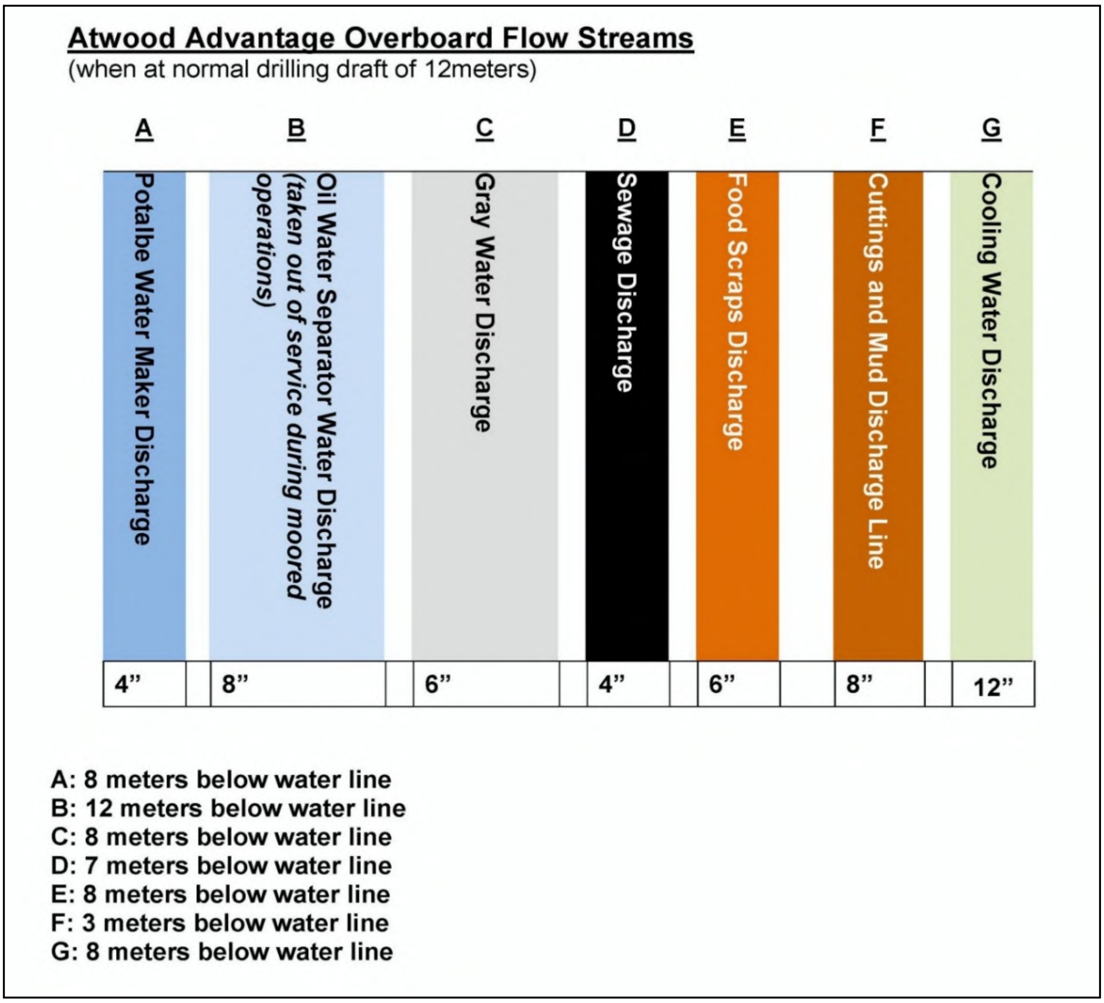


Figure 3-20. Discharge streams for the *Atwood Advantage*.

Domestic waste (i.e., gray water) consists of the water generated from showers, sinks, laundries, galleys, safety showers, and eyewash stations. Domestic wastewater is typically screened to remove any floating solids, then discharged below sea level.

Cooling water is used to control and maintain proper temperatures on internal combustion engines on board the drilling rig and project vessels. Cooling water was comingled with muds and cuttings discharges; comingled discharges occurred below sea level.

Organic or food wastes are generated from galley and food service operations. On the *ENSCO 5006*, food waste was ground prior to discharge (i.e., comminuted), in accordance with Annex V of International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) requirements (i.e., for vessels 400 gross tonnage and above). Food scraps were ground up in a Gulf Gulp garbage disposal unit. Food waste was typically ground to less than 25 mm diameter. Aside from grinding, no other treatment of organic wastes was conducted. Following grinding, food wastes were discharged 14 m below sea level through an 8-in. line.

Freshwater was generated on board the *ENSCO 5006* via RO water makers, generating brine (i.e., concentrated seawater) as a byproduct. At maximum rated capacity, each unit could generate 30 m^3/day of freshwater, or a total of 60 m^3/day. Under normal operating conditions, only one RO unit operated at a time. Maximum feed water flow rate through the unit was 380 m^3/day; maximum brine discharge flow rate was 320 m^3/day. The excess seawater which was discharged did not contain any added chemicals. The discharge was below sea level.

Proposed Wells

A description of the non-drilling discharge treatment aboard the *Atwood Advantage* is presented as representative of the process likely to be used for the proposed wells. The proposed wells will utilize the same discharge treatment process, or equivalent.

Sanitary waste will be treated by one of two wastewater treatment units. The sewage treatment system meets the most recent International Maritime Organization (IMO) effluent standards and performance tests for treatment efficiency, IMO Resolution MEPC.159(55). Due to the length of the rig, the system is composed of two separate sewage treatment plants or units, one serving the forward end of the rig and the other serving the aft end of the rig. These units have received IMO Type Approval as meeting the geometric mean limits prescribed in the MEPC Resolution for the following effluent standards: thermotolerant coliform standard, TSS standard, biochemical oxygen demand and chemical oxygen demand standards, residual chlorine, and pH.

The forward sewage treatment plant is designed for a total service of 200 persons (black water only capacity). The sewage holding tank has a volume total of 39.5 m^3. The sewage water is collected by a vacuum toilet system. In order to maintain the vacuum in the piping system, a vacuum unit is installed as a part of the sewage treatment plant.

Collected sewage is transferred to the sewage treatment plant or a sewage holding tank. The sewage holding tank is equipped with an alarm system for high (85%) and low (20%) levels, and a high alarm system (i.e., when the holding tank is at 90% capacity) to avoid overflow. Treated sewage is discharged overboard through the sewage treatment plant or can be directly held in the sewage holding tank.

The aft sewage treatment plant is designed for a total service of 15 persons (black water only capacity). The sewage is drained by a gravity toilet system. Treated sewage is discharged overboard through the sewage treatment plant. Treated sewage will be discharged through 4-in. diameter lines located 7 m below the sea surface.

Domestic waste (also known as gray water) consists of the water generated from showers, sinks, laundries, galleys, safety showers, and eyewash stations. Domestic wastewater typically is screened to remove any floating solids, then discharged; domestic waste does not require treatment before discharge. The gray water discharge system is arranged by gravity directly overboard and could be led to the sewage treatment plant by manual valve (this valve is normally closed). A grease trap (1,000 L) is fitted on the drain lines from galley, scullery, and mess service areas except for the drain from the waste disposer. Discharge of domestic waste occurs through a 6-in. diameter line 8 m below the sea surface.

Cooling water is used to control and maintain proper temperatures on internal combustion engines aboard the drillship and project vessels. Cooling water discharge effluent should result in a temperature increase of no more than 3°C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, the dilution zone typically is considered to be 100 m from the point of discharge. Thermal discharges must meet MARPOL and Barcelona Convention requirements. No treatment of cooling water is expected. Cooling water discharges occur through a 12-in. diameter line 8 m below the sea surface.

Organic or food wastes are generated from galley and food service operations. Food waste, a type of domestic waste, will be ground prior to discharge (i.e., comminuted), in accordance with Annex V of MARPOL 73/78 requirements (i.e., for vessels 400 gross tonnage and above). Food scraps are ground up in a garbage disposal unit. Food waste is typically ground to less than 25 mm diameter to meet discharge requirements. Food waste discharges are allowed, when ground, if the vessel is 12 nmi or more from land when within special areas (including the Mediterranean Sea). Aside from grinding, no other treatment of organic wastes is expected. Following grinding, food wastes are discharged through a 6-in. diameter line 8 m below the sea surface.

Freshwater is generated aboard the drillship via two RO water makers, generating brine (i.e., concentrated seawater) as a byproduct. At maximum rated capacity, each unit can generate 6.5 m^3/hr, or 156 m^3/day, of freshwater. Total freshwater generation capacity is 312 m^3/day. Maximum feed water flow rate through the freshwater generating system is approximately 380 m^3/day; maximum brine discharge flow rate is estimated at 318 m^3/day. The excess seawater being discharged does not contain any added chemicals. The discharge is through a 4-in. diameter line 8 m below the sea surface.

The processing of drilling mud, designed to prolong the life of the drilling fluid, typically includes flow through various pieces of equipment to remove cuttings and large particles (i.e., scalper shakers, shale shakers). Once the drilling mud has passed through the shakers, it is pumped into a settling/processing pit (i.e., sand traps). Once in the sand traps, the drilling mud can be circulated and processed by other equipment (e.g., degasser, mud cleaner, desander, desilter, and centrifuge) to further remove unwanted particles. Chemicals may be added to change the rheological properties of the mud or to address a specific downhole need. Details of drilling mud treatment and processing, including schematics of the mud processing system, are provided in **Appendix G**.

3.6.1.3 Non-Drilling Discharge Timing and Flow Characteristics

The timing (i.e., frequency) and flow characteristics of discharges for the *ENSCO 5006* during drilling activities on the Tamar SW-1 well are summarized in **Table 3-16** and are representative of Tamar wells for the completed wells. Discharge volumes are presented in **Table 3-14**.

For the Tamar SW-1 well, sanitary and domestic waste streams (i.e., sewage and gray water) were discharged periodically at rates of 10 to 14 m^3/day and 20 to 24 m^3/day, respectively. Organic waste (i.e., food scraps) were discharged periodically at 100 to 150 kg/day. Potable water maker discharge (brine) was discharged continuously at a rate of 160 to 320 m^3/day. There were no discharges from the oil-water separator while the *ENSCO 5006* was moored at the Tamar SW-1 drillsite.

Cooling water discharge occurred continuously at a rate of 5,000 to 10,000 m^3/day. The discharge of muds and cuttings from the drilling rig only occurred while drilling in the lower sections of the well; when discharging, cuttings were released nearly continuously, while drilling muds were released at the end of the well. It is estimated that the continuous cuttings discharges (i.e., during drilling of the lower hole sections) occurred continuously at a rate of 21 m^3/day; note that there are periods where work in the lower hole sections did not involve drilling, therefore, and cuttings discharges did not occur during these periods. Drilling muds were discharged from the rig only at the end of the well; the bulk discharge of mud was done at a rate of 1,749 m^3/day.

Table 3-16. Discharge timing and flow characteristics of non-drilling discharges for the *ENSCO 5006* during drilling of the Tamar SW-1 exploratory well.

Source	Estimated Volume (m^3/day)	Pipe Diameter (in.)	Discharge Depth* (m)	Frequency and Treatment
Sanitary waste (black water)	10-14	8	-14	Periodic; chlorinated
Domestic waste (gray water)	20-24	8	-14	Periodic; no treatment
Water maker brine	160-320	8	-14	Continuous; no treatment
Cooling water	5,000-10,000	14, 16, and 18	-14	Continuous; no treatment
Organic waste	100-150 kg/day	8	-14	Periodic; macerated

* Negative entries indicate water depth below the sea surface.

The wells proposed to be drilled for the Tamar Field Development Project are expected to be drilled with a drilling unit similar to the DP drillship *Atwood Advantage*. **Table 3-17** shows the expected discharge timing and flow charachteristics. Discharge volumes are presented in **Table 3-15**.

Table 3-17. Summary of non-drilling discharge timing and flow charachteristics for the *Atwood Advantage*.

Source	Estimated Volume (m^3/day)	Pipe Diameter (in.)	Discharge Depth* (m)	Frequency and Treatment
Sanitary waste (black water)	10-14 (est.)	4	-7	Periodic; chlorinated
Domestic waste (gray water)	20-24 (est.)	6	-8	Continuous; no treatment
Water maker brine	318	4	-8	Continuous; no treatment
Cooling water	105,360	12	-8	Continuous; no treatment
Organic waste	100-150 kg/day	6	-8	Periodic; macerated

Negative entries indicate water depth below the sea surface.

3.6.1.4 Non-Drilling Discharge Method and Orientation

The *ENSCO 5006* was used to drill the Tamar SW-1 well, and its discharge method and orientation is representative of the other wells that have been drilled. Processed and unprocessed discharges on the *ENSCO 5006* occurred through a series of 8-in., 14-in., 16-in., and 18-in. pipes located 14 m below the ocean surface. Discharges were either gravity fed or pumped, with pipe orientation in a vertical, downward direction.

Discharges from the *ENSCO 5006* included drilling muds and cuttings, sanitary and domestic wastes, cooling water, water maker brine, and organic waste, as detailed previously in **Table 3-16**. There were two primary waste streams (i.e., waste streams are comingled) – one through an 8-in. pipe located 14 m below the sea surface, the other through 14-in., 16-in., and 18-in. pipes also located at 14 m below the sea surface.

Characteristics of discharges through the 8-in. pipe:

- Sanitary and domestic wastes: periodic; 10 to 14 m^3/day and 20 to 24 m^3/day, respectively.
- Organic waste (i.e., food scraps): periodic; 100 to 150 kg/day.
- Potable water maker (brine): continuous; 160 to 320 m^3/day.

Characteristics of discharges through the 14-in., 16-in., and 18-in. pipes:

- Cooling water: continuously; 5,000 to 10,000 m^3/day.

3.6.1.5 Non-Drilling Discharge Quantity

Total quantities of non-drilling discharges from the *ENSCO 5006* during the drilling of the Tamar SW-1 well are summarized in **Table 3-18**. These values are representative of the wells which have been drilled.

Discharge volumes will be less than the above values for the proposed wells because the new wells are expected to take approximately 3.5 days less to drill per well since MOBM will be used. This will result in estimated decreases in the discharge volumes as shown in **Table 3-19**.

Table 3-18. Discharge volumes of non-drilling discharges from the Tamar SW-1 well.

Discharge Type	Total Volume (m^3)
Runoff	11,444
Waste Water (Oil-Water Separator)	0
Sanitary Treated Water	779
Gray Water	2,050
Brine Concentrate	10,013
Cooling System Water	603,180
Shredded Organic Kitchen Waste	10,241 kg

Table 3-19. Rig process discharge reductions per well assuming 3.5-day reduction in estimated drilling time based on the use of the *Atwood Advantage*.

Source	Estimated Volume (m^3/day)	Quantity (m^3) 3.5 days/well
Sanitary waste (black water)	14	49
Domestic waste (gray water)	35	122
Water maker brine	318	1,113
Cooling water	105,360	368,760
Organic waste	200 kg/day	700

3.6.1.6 Alternatives to On-Site Discharge of Non-Drilling Discharges

Alternatives to the on-site discharge of non-drilling related effluents either are not practical or are limited. There are no practical, viable alternatives to cooling water discharges. Alternative disposal methods for brine, organic (food) wastes, and sanitary and domestic wastes include containerization and shipment to shore. The location of the drilling activity in deep water, well offshore in an open ocean environment indicates that only limited, localized impacts from these discharges are expected. Containerization and shipment will produce their own set of impacts (e.g., air quality, onshore processing, treatment, and disposal impacts), in addition to increasing safety and hygienic concerns with loading and offloading additional waste containers. For these reasons, on-site discharge was selected for the past and proposed projects.

3.6.1.7 Hydrotest Discharge

Hydrotest water, also known as hydrostatic test water, is used following installation and prior to commencement of operations to test the integrity of a pipeline, flowline, or chemical transport line.

For the 2013 Tamar Field Development Project, hydrotesting of pipelines, chemical lines, and utility lines was conducted prior to start-up. Noble Energy utilized seawater for hydrotesting. The hydrotest water was filtered to 50 µm and chemically treated with 600 ppm Weatherford Pipetreat 2001 for pipeline preservation, plus Fluordye 649 to aid in leak detection. Hydrotest water was discharged back to the ocean upon completion of testing.

For the proposed Tamar Field Development Project, hydrotesting of the flowlines will be required. A $NaCl_2$ brine with a density of 1,270 kg/m^3 will be used and discharged subsea. The brine will contain 600 ppm pipeline preservation chemicals just as in the Phase 1 project. Multiple pigs separated by slugs of MEG will be used for de-brining the pipelines. The procedure will be as follows:

- After a successful pressure test, the pressure will be reduced to ambient and the pig train will be launched. The pig train design will consist of three to five foam pigs separated by slugs of MEG.
- Produced gas from the manifold end will be used to push the de-brining pig train. Approximately 10 bbl of methanol will be injected at the manifold end ahead of the gas to prevent any seawater that may be in the jumper from forming a hydrate. The pig speed will be controlled by throttling at the discharge point. The optimal pig speed is assumed to be approximately 0.6 m/s.
- When the first pig arrives in the pig launcher/receiver, the discharge color will change due to the dye. Upon arrival of the first pig, the ROV will temporarily stop de-brining activities and connect coiled tubing from the vessel.
- De-brining will then resume taking the MEG discharge up to the vessel until the last pig is received. The MEG will be captured on deck and any entrained gas will be separated and vented to the atmosphere in a controlled manner. Captured MEG will be returned to shore for proper disposal or recycling.

Chemically treated seawater or brine used in filling, pigging, and pressure testing is to be discharged to sea during pre-commissioning and testing activities.

As many as 15 to 40 bbl of MEG, plus 10 bbl of methanol, may be released to the environment during de-brining of each flowline. There will be trace amounts of MEG discharge during each subsea hot stab connection cycle, pig launcher/receiver installation/removal, and incidental draining of hoses.

In total, up to 10,000 bbl of brine will be discharged near the seafloor from four locations spread across a distance of approximately 17.9 km. The discharge port specifications and discharge rates are shown in **Table 3-20**.

Table 3-20. Discharge port specifications and discharge rates.

Diameter	5.08 cm	
Height above seafloor	10 m	
Brine discharge rate	T7: 3,204 bbl/2.49 hr (0.0491 m^3/s)	SW: 6,534 bbl/9.7 hr (0.0297 m^3/s)

The dilution of the plumes for T7 and SW represent the worst case scenario and are shown in **Figure 3-21** (Brenner, 2014).

After reaching the end of the initial mixing and dilution stage (plume hitting the bottom in the cases considered), the effluent will continue to mix with ambient water and the dilution will continue to increase. However, the mixing is now accomplished through processes that depend upon the ambient turbulent flow (eddy diffusion) rather than the plume dynamics.

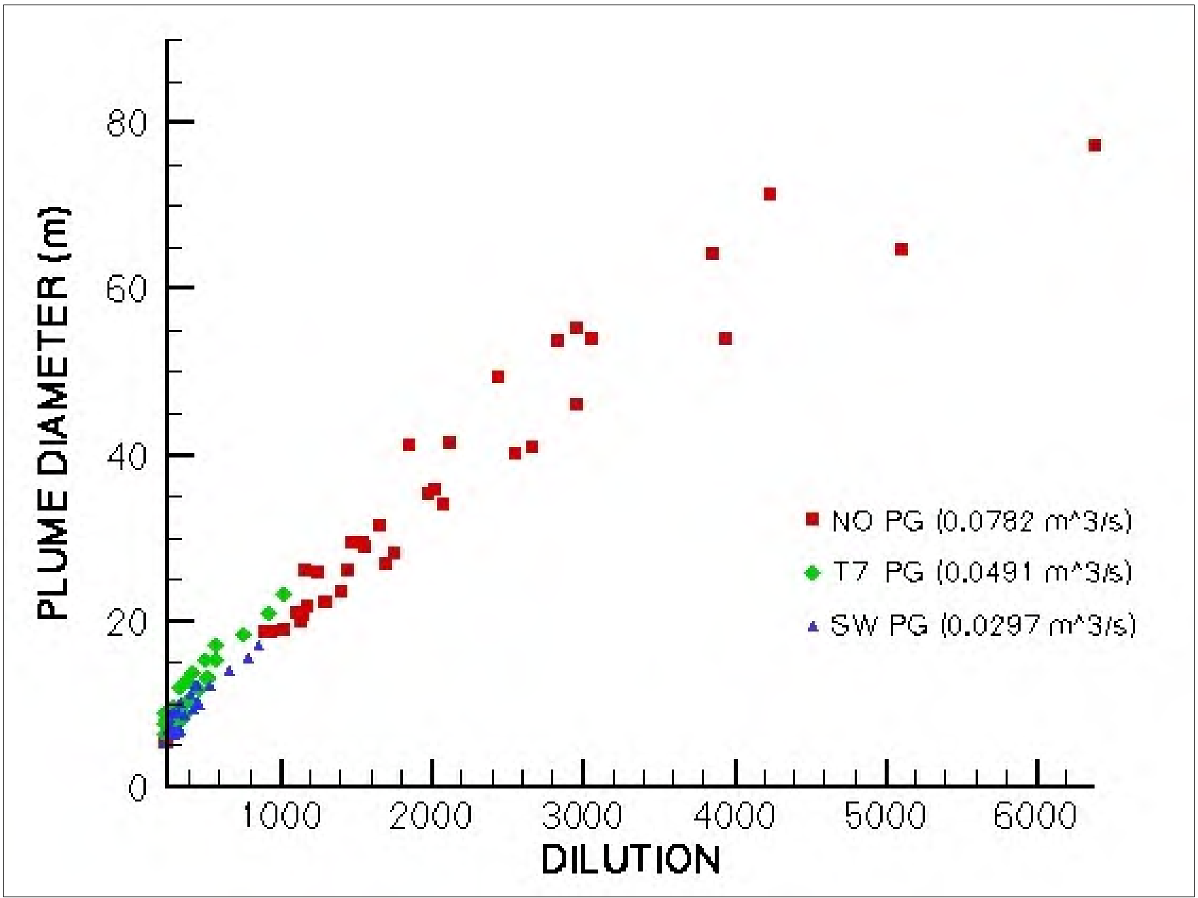


Figure 3-21. Plume diameter versus dilution for all 135 simulations (red squares for the no pigging cases; green diamonds and blue triangles for the pigging T7 and SW outlets, respectively).

3.6.2 Drilling Mud, Drill Cuttings, and Concrete Discharge

Drilling discharges include both used drilling muds and drill cuttings, as well as cement.

For the wells that have been drilled in the Tamar lease area, Noble Energy used a WBM and several additives to facilitate drilling and maintain well control. During the initial well sections (36-in. and 26-in.), there were no surface returns; muds and cuttings exited at the borehole, settling near the drillsite and dispersing in the lower portions of the water column. Similarly, with the completion of each hole section, cementing was performed. Excess cement exited at the borehole between the casing and the formation.

Once the riser was set, surface returns commenced (i.e., with drilling of the 17½-in. section), which allowed for processing of used muds on board the drilling rig and, as necessary, the discharge of used muds and cuttings from the drilling rig. With surface returns, WBM was processed on board the drilling rig, passing through screens and shakers to remove cuttings. WBM quality was monitored and additives used, as needed. The type and volume of mud additives was determined primarily by the current state of the drilling mud and existing or anticipated downhole conditions.

Cuttings, once removed from the muds and cuttings stream, were discharged overboard. Drill cuttings are composed of formation solids (i.e., bits of rock from the formation). Clay-sized cuttings are more difficult than larger cuttings to separate from drilling mud. A typical cuttings discharge during drilling with WBM usually contains 5% to 25% drilling fluid solids after passage through the solids control equipment on the drilling rig (Neff, 2005).

All wells drilled to date have used WBM, which was discharged at the wellsite. For the proposed wells (Tamar-7, Tamar-8, and Tamar-9), Noble Energy plans to use a MOBM for all sections following spudding of the well. The MOBM will not be discharged unless Noble Energy receives MoEP approval to discharge the MOBM-associated cuttings. The following sections review the WBM-drilled wells from previous projects as well as the changes that would occur in the drilling discharges from the use of MOBM.

3.6.2.1 Materials Used During Drilling

Drilling materials are described in **Section 3.2.2.2** for the Tamar SW-1 well, representing the wells drilled to date. **Section 3.2.2.3** discusses the drilling materials to be used for the Tamar-7 through Tamar-9 wells.

3.6.2.2 Drilling Discharge Treatment

The wells previously drilled have utilized WBM, which was discharged at the wellsite. Tamar-7 through Tamar-9 will be drilled using MOBM, which will not be discharged. Cuttings from drilling Tamar-7 through Tamar-9 may be discharged if approval is received. Cuttings treatment was discussed in **Section 3.2.2.3**.

3.6.2.3 Discharge Timing and Flow Characteristics for Drilling Discharges

The discharge timing and flow characteristics for drilling discharges for the Tamar SW-1 well are listed in **Table 3-21**. The other completed wells have used a similar WBM formula, and the data may be considered representative for drilling activities to date.

For the wells proposed to be drilled during the Tamar Field Development Project, MOBM will be used, and there will be no discharge of drilling muds other than from the initial section drilled with WBM and discharged at the seafloor. The MOBM will be retained and brought to shore at the end of the project for reuse or recycling. Noble Energy has applied to MoEP for approval to discharge the cuttings from the proposed wells. If approved, the cuttings will be treated to remove the majority of the MOBM and then discharged. If approval is not received, the cuttings will be transported to shore for disposal.

Table 3-21. Discharge timing and flow characteristics for drilling discharges for the *ENSCO 5006* during drilling of the Tamar SW-1 well.

Source	Total Volume (m^3)	Duration (days)	Capacity (m^3/day)	Pipe Diameter (in.)	Discharge Depth (m)	Frequency and Treatment
Drilling muds and cuttings – 36-in. and 26-in. sections; no surface returns (muds and cuttings released at the wellbore)	Muds: 2,861.8 Cuttings: 550	3	Muds: 953.9 Cuttings: 183.3	36 (wellbore)	-1,700	Continuous during drilling; no treatment
Drilling muds and cuttings – 17½-in., 14¾-in., 12¼-in., and 10⅝-in. sections; surface returns (muds and cuttings discharged at the surface)	Muds: 1,176.5 Cuttings: 321	19	Muds: 1,176.5 Cuttings: 16.9	14, 16, or 18	-14	Continuous for cuttings while drilling; minor amounts of WBM with cuttings; cuttings separated from muds WBM bulk discharge at end of well
Cement (at the wellbore)	206.7	1 to 2 (total)	~60	36, maximum (wellbore)	-1,700	No treatment

Notes:

- Drilling of 36-in. and 26-in. sections estimated to require 3 days total; muds and cuttings to be released from the wellbore continuously during this period;
- Drilling of 17½-in., 14¾-in., 12¼-in., and 10⅝-in. sections estimated to require 19 days total (drilling only); cuttings are discharged continuously while drilling; muds recirculated and discharged as an end of well discharge (at completion of drilling). End of well discharges of WBM will occur at <1,000 bbl/hr; 1 bbl = 0.159 m^3; <159 m^3/hr; total muds: 1,176.5 m^3 discharged in approximately 7.4 hours, minimum;
- Cementing occurs periodically throughout drilling, at the completion of the drilling of each section, when setting pipe; total estimate of cement to be used: 6,900 bbl (1,097 m^3); cement discharge estimated to be 1,300 bbl (206.7 m^3); and
- Negative entries in the Discharge Depth column indicate water depth below the sea surface.

3.6.2.4 Drilling Discharge Method and Orientation

The discharge of WBM drill cuttings and drilling muds from the *ENSCO 5006* occurred through 14-in., 16-in., and 18-in. pipes located 14 m below the ocean surface. Discharges were either gravity fed or pumped, with the pipe oriented in a vertical, downward direction. As indicated previously, Noble Energy will not discharge the MOBM that is being proposed for use for the proposed wells and will discharge MOBM-associated cuttings only if approved by MoEP.

3.6.2.5 Bottom Discharge During Well Spudding

The weights of the individual products used during the initial stages of drilling the Tamar SW-1 well (i.e., with no surface returns) and subsequently discharged at the wellbore are summarized in **Table 3-22**. The total amount of drilling-related material discharged prior to riser installation is estimated to include 18,000 bbl (2,861.8 m^3) of drilling mud and 25,600 bbl of brine. This information is representative for the completed wells in the Tamar lease area, as well as the process which will be used for spudding the proposed wells. WBM will be used during this process for the wells to be drilled in the proposed Tamar Field Development Project.

Table 3-22. Estimated weights of drilling mud additives used for well spudding (From: Tamar SW-1 well; Noble Energy, 2012).

Product	Function	Total Weight (lb)	Total Weight (tons)
NaCl	Salinity control	2,816,000	1,277.7
Soda ash	Calcium reducer	12,595	5.7
Caustic soda	Alkalinity/pH control	3,795	1.7
Bentonite	Viscosifier	328,396	149.0
Guar gum	Stabilizing agent	9,900	4.5
BARAZAN D	Fluid loss control	11,770	5.3
PAC RE	Fluid loss control	1,025	0.5
PAC LE	Fluid loss control	3,818	1.7
Barite	Weighting agent	2,207,400	1,001.5
BARA-DEFOAM W300	Defoamer	596	0.3
DEXTRID E	Filtration control	7,636	3.5
STARCIDE	Biocide	764	0.3

3.6.2.6 Surface Discharge of Drilling Muds

The concentrations and amounts of WBM discharges, including various mud additives, discharged at the end of drilling the Tamar SW-1 well are detailed in **Table 3-23** and are similar to the surface discharges from the previous wells. These discharges occurred below the water line at a rate of less than 1,000 bbl per hour. The total amount of drilling mud discharged from the rig at the completion of drilling was estimated to be 7,400 bbl (1,176.5 m^3).

Table 3-23. Water-based mud discharges from the drilling rig (From: Tamar SW-1 well; Noble Energy, 2012).

Product	Composition and Function	Concentration (lb/bbl)	Total Weight	
			(lb)	(tons)
NaCl	NaCl (sodium salt); Inhibition/Weight	75.0	555,000	251.8
KCl	KCl (potassium salt); Inhibition/Weight	35.0	259,000	117.5
Soda ash	Na_2CO_3; Calcium Treatment	0.5	3,700	1.7
Sodium bicarbonate	$NaHCO_3$; Calcium Treatment	0.3	2,220	1.0
Caustic soda	NaOH; pH Control	0.3	2,220	1.0
Citric acid	$C_6H_8O_7$; Alkalinity Control	0.3	1,850	0.8
Barite	Barium Sulfate $BaSO_4$; Weighting Agent	140.0	1,036,000	470.1
BARAZAN D	Xanthan gum; Viscosifier	2.0	14,800	6.7
PAC LE	Polysaccharide; Filtration Control	3.0	22,200	10.1
PAC RE	Polysaccharide; Filtration Control	0.4	2,960	1.3
PAC ULV	Polysaccharide; Filtration Control	3.0	22,200	10.1
BARA-DEFOAM W300	Petroleum distillate, Soybean oil; Defoamer	0.2	1,480	0.7
STARCIDE	N, N' -Methylene bis (5-methyl oxazolidine); Biocide	0.2	1,480	0.7
GEM GP @ 4.5% v/v	Polyalkylene glycol; Inhibition	10.5	77,700	35.3
CLAYSEAL PLUS	Ethoxylated polyamine; Inhibition	7.0	51,800	23.5
BARACARB 5	Calcium Carbonate; Bridging Agent	7.5	55,500	25.2
BARACARB 25	Calcium Carbonate; Bridging Agent	66.2	489,880	222.3
BDF-467	Anionic Polymer; Flocculent	1.0	7,400	3.4

The completion of the Tamar SW-1 well will result in drilling discharges as presented in **Table 3-24**.

Table 3-24. Total estimated discharges from the Tamar SW-1 completion activities.

Product	Function	Total Weight (tons)
NaBr (Dry Salt)	Weight	1162.013
NaCl (Dry Salt)	Weight	479.481
Fresh Water	Weight	542.729
Caustic Soda	Sodium Hydroxide	1.339
Xanvis L	Calcium Treatment	1.871
UltraVis	Viscosifier	9.184
Well Wash 150	Surfactant	9.569
Dope Free	Surfactant	0.799
MULFREE RS	Surfactant	5.269
BIO-PAQ	Fluid Loss	25.726
XAN-PLEX D	Viscosifier	3.241
MAGNESIUM OXIDE	pH Buffer	4.288
MAX-GUARD	Inhibition	50.999
X-CIDE 207	Microbiocide	0.016
NOVO-CARB 60	Weight	116.119
NOVO-CARB 20	Weight	45.762
MUDZYME X	Enzyme Breaker	4.028
MUDZYME S	Enzyme Breaker	0.809
Sodium Acetate	pH Buffer	2.280
Glacial Acetic	pH Control	3.460
CL-27 Corrosion Inhibitor	Corrosion Inhibitor	0.378
KD-40	Corrosion Inhibitor	0.710
NOXYGEN	Oxygen Scavenger	0.061
Soda Ash	pH Buffer	1.370

Noble Energy will use MOBM for the proposed Tamar Field Development Project wells; only the mud from the initial well sections drilled using WBM will be discharged.

3.6.2.7 Cuttings Discharges

Estimated cuttings discharge volumes, by hole section, for the Tamar SW-1 well are outlined in **Table 3-25** and are representative of those for previously drilled wells. A total of 5,454 bbl of cuttings weighing 2,180 tons were released during drilling; including volumes added due to the wash out factors which varied by hole section. Cuttings from the 36-in. and 26-in. sections were released from the borehole, while cuttings from the remaining sections were released from the drilling rig on a continuous basis while drilling. Cuttings and drilling fluids released from the drilling rig were discharged 14 m below sea level.

Table 3-25. Cuttings volumes and weights, by section (From: Tamar SW-1 well; Noble Energy, 2012).

Hole Size	Interval (MD)	Cuttings Volume with Wash Out Factor (bbl)	Wash Out Factor (%)	Cuttings Volume (m^3)	Cuttings Weight (tons)
36 in. (Drive Pipe)	1,672-1,742 m (70 m)	290	0	47	124.6
26 in.	1,742-2,915 m (1,173 m) (with 15-m rathole)	3,160	25	503	1,257.5
17½ in.	2,915-3,537 m (622 m) (with 15-m rathole)	730	20	117	257.4
14¾ in.	3,537-4,565 m (1,028 m)	820	15	131	347.2
10⅝ in.	4,565-5,306 m (741 m)	293	10	47	124.6
12¼ in.	4,565-4,871 m (306 m)	161	10	26	68.9
Total		**5,454**	**--**	**871**	**2,180**

bbl = barrel; MD = measured depth.

The completion of the Tamar SW-1 well will result in a smaller amount of cuttings being discharged from the drilling unit, as shown in **Table 3-26.**

Table 3-26. Cuttings volumes to be discharged during the Tamar SW-1 completion.

	ID (in.)	Interval Top (m MD)	Interval Bottom (m MD)	Length (m)	Volume (bbl)	Cuttings Volume (m^3)
10¾-in. Shallow Cement Plug	9.56	1950	2075	125	36.41	5.79
9⅞-in. Shoe Track	8.625	4680	4884.5	204.5	48.48	7.71
12¼-in. Open Hole + 10%	12.25	4884.5	4914.5	30	15.78	2.51

bbl = barrel; ID = inner diameter; MD = measured depth.

The estimated quantities of MOBM cuttings to be generated during drilling of the wells proposed for the Tamar Field Development Project wells using MOBM are provided in **Table 3-27**. The cuttings volumes are based on the volume of the hole intervals that would be drilled, plus an additional "wash out factor." MOBM amounts are based on a worst case assumption of 1% retention of base fluid on cuttings. The actual retention on cuttings after treatment is expected to be less.

Table 3-27. Estimated cuttings volumes using the mineral oil-based mud (MOBM) system.

Discharge	Example Well Values*	
	Volume (bbl)	Mass (MT)
Total amount of cuttings	2,841	1,059
MOBM base fluid adhering to cuttings (assuming an OOC of 1%)	28.4	3.6

bbl = barrel; MT = metric ton; OOC = oil on cuttings.
*Totals do not include the riserless section (initial well intervals where water-based muds [WBM] and cuttings will be released at the seafloor).

Total cuttings volumes are estimated to be 2,841 bbl (1,059 MT), including 28.4 bbl (3.6 MT) of MOBM base fluid adhering to cuttings. These totals do not include the initial riserless well intervals where WBM and associated cuttings will be released at the seafloor. These cuttings will be discharged only if Noble Energy receives approval from MoEP.

3.6.2.8 Alternatives to On-Site Drilling Discharges

Available alternatives to the on-site discharge of drilling muds (and cuttings) include injection or discharge into wellbores or subsurface formations, and transport of waste to shore for treatment and disposal. These practices are characterized by their own set of environmental effects, costs, and inherent limitations (e.g., practical and technical considerations). For example, the use of onshore disposal methods requires that the material be transported onshore, with increased risks to the environment and personnel safety and hygiene through handling, shipping, and transport. These issues are discussed further in **Section 3.7**.

3.6.2.9 Cementing

Cementing is the process of placing a cement slurry in a well by mixing powdered cement, additives, and water at the surface and pumping it by hydraulic displacement to the desired location. Actual discharge amounts of chemicals used during the cementing activities for the Tamar SW-1 well are presented in **Table 3-28** and are similar to those used for the other completed and proposed Tamar Field wells. Upon completion of each hole section, cementing is performed. Excess cement exits at the borehole between the casing and the formation.

Table 3-28. Actual discharge amounts (kg) of chemicals used during the cementing for the Tamar SW-1 well.

Product	36-in.	26-in.	17½-in.	12¼-in. × 14¾-in.	10⅝-in.	8½-in. × 12¼-in.	Total Weight (tons)
Barite			9,920.18	16,575.51	11,791.38	17,785	**56.07**
Calcium Chloride		3,066.67					**3.07**
Cement Class G		608,000.00	94,300.00	76,550.00	75,410		**854.26**
D-Air 3000L		63.49	13.61	9.07	1.36		**0.088**
Econolite L		26,179.11	2,422.67				**28.60**
ElastiCem							
FluorodyeUC		14.00					**0.01**
Halad-322			544.22		748.3		**1.29**
Halad-344							
Halad-413						876.9	**0.88**
HR-4		3,563.27	45.35	362.81			**3.97**
HR-4L		8,961.45					**8.96**
HR-5					317.46	876.5	**1.19**
KCL		3,900.93	4,015.67	2195.01			**10.11**
Latex 3000						1746.4	**1.75**
Microblock			9,598.78		5,603.27	2101.6	**17.30**
Musol			173.70	208.44	291.81	140.6	**0.81**
NF-6		736.19	17.53	17.53	10.52	48.1	**0.83**
Silicalite Liquid							
Tuned Spacer			952.38	1,020.41	907.03	1,170	**4.05**
WellLife-734							
Total Metric Tons	**0.00**	**654.49**	**122.00**	**96.94**	**95.08**	**24.75**	**993.25**

3.6.3 Infrastructure Installation Discharges

Discharge volumes of sanitary and domestic wastes are expected to be 20 gal/person/day (0.075 m^3) and 30 gal/person/day (0.113 m^3), respectively, from the installation vessel during pipelaying operations. The estimated number of persons on board the DP pipelay vessel is 270. Assuming a maximum number of persons on board, daily discharges of treated black and gray water from the

DP pipelay vessel would be 5,400 gal (20 m^3) and 8,100 gal (31 m^3), respectively; similar to that experienced during the 2013 Tamar Field Development Project.

Vessels operating during installation of pipelines, MEG lines, utility lines, and control lines will be equipped with approved marine sanitation devices. Sanitary and domestic wastes will be collected and treated prior to discharge (e.g., chlorination for sewage, removal of floating solids for domestic wastes) according to the requirements of MARPOL.

3.6.4 Quality of Discharges

3.6.4.1 Non-Drilling Discharge Quality

The results of the analyses of sanitary waste samples for the Tamar SW-1 well are presented in **Table 3-29**.

Table 3-29. Results of analyses of Tamar SW-1 sanitary waste.

Sampling Date	Sample Reception Date	Time	Report No.	Flow [m^3/mo]	Flow [m^3/yr]	pH Field Test	BOD	TOC	TSS 105°C	Turbidity Field Test [NTU]	Chlorine Field Test		Oil & Grease (FTIR)	Mineral Oil (FTIR)	DOX	NO_3-N + NO_2-N	NH_4-N	TKN-N	Total N	Total P	Enterococcus	Fecal coliforms	TDS	Cl^-
											Free	Total									μ/100 mL			
10/10/2013	10/10/2013	9:30	Starboard - C11857, FWC-09663.13			7.7	33	28	59	46	0.66	2.5	1.2	0.2		71.1	15	40	111	3	2.40E+05	1.70E+05	43,405	22,078
10/12/2013			Port			7				37.4	0.3	1.9												
10/16/2013			Port			7				49.84	0.79	1.1												
10/17/2013			Starboard			7				32.4	2.9	6.4												
10/23/2013			Port	250	250	7				32.4	0.85	1.9												
10/24/2013	10/24/2013	8:00-14:00	Starboard - C12580, FWC-10210.13			7.6	44	49	90	56.3	1	1.45	5.3	0.3		1.2	32	46	47.2	4	79	540	39,570	704
10/24/2013	10/24/2013	8:00-14:00	Port - C12581, FWC-10198.13			6.9	28	36	48	45.7	3.5	6	5.6	0.3		1.8	13	24.4	26.1	3	1.1	5.1	39,520	4,305
10/27/2013			Starboard			8				29.96	2.44	3.5												
11/4/2013	11/4/2013		Starboard			7.5				56	2.8	1.92												
11/5/2013	11/5/2013		Port			8				60	1.13	3.62												
11/9/2013	11/9/2013		Starboard			7.5				59	2.33	2.53												
11/10/2013	11/10/2013		Port			6.5				61	0.29	2.7												
11/17/2013	11/17/2013		Port			8.4				41	0.8	0.15												
11/18/2013	11/18/2013		Starboard	265	515	7.3				20	1.6	2.89												
11/20/2013	11/20/2013	10:30	Starboard - C14099, FWC-11408.13			7.2	32	55	15	45.4	1.3	2.3	1.4	0.2	3.4	1.8	20	114	115.8	3	49	9.20E+05	41,173	22,025
11/20/2013	11/20/2013	10:10	Port - C14100, FWC-11406.13			7.1	23	31	161	22.5	5.1	6	2	0.2	5.6	2.1	8.8	63	65	3	23	1.1	40,395	22,338
11/24/2013	11/24/2013		Starboard			7.3				50	2.6	1.8												
11/25/2013	11/25/2013		Port			7.9				49	1.4	2.65												
12/4/2013	12/4/2013	10:20	Starboard - C14731, FWC-11975.13			7.7	66	54	108	70.2	1.1	1.6	6	3		2.8	24	125	127.8	5	540	1.60E+03	40,415	21,905
12/4/2013	12/4/2013	10:00	Port - C14732, FWC-11875.13			7.2	15	47	18	46	5.2	6	2.4	0.1		2.1	13.5	23	25	3	1.1	1.1	38,910	21,345
12/7/2013			Starboard	264	779	7.2				50	0.3	0.95												
12/8/2013			Port			7.8				48	0.29	3.11												
12/16/2013			Starboard			8				36	1.02													
12/16/2013			Port			8				46	0.82													
12/23/2013			Starboard			8				35.5	1.3													
12/23/2013			Port			8				21.8	1.3													

BOD = biochemical oxygen demand; Cl^- = chloride; DOX = dissolved organic halides; FTIR = Fourier Transform Infrared; N = nitrogen; NH_4 = ammonium; NO_2 = nitrite; NO_3 = nitrate; NTU = nephelometric turbidity units; P = phosphorus; TDS = total dissolved solids; TKN = total Kjeldahl nitrogen; TOC = total organic carbon; TSS = total suspended solids.

Note: units are mg/L unless noted otherwise. Yellow cells present values within the threshold defined in the discharge permit. Red cells present values above the threshold defined in the discharge permit.

Gray water samples were collected and analyzed. The analytical results for the testing of the gray water from the Tamar SW-1 well are presented in **Table 3-30**.

Table 3-30. Results of testing of the gray water from the Tamar SW-1 well.

Sampling Date	Sample Reception Date/Time	Report No.	Flow [m^3/mo]	Flow (Annual) [m^3/yr]	TSS 105°C	Oil and Grease (FTIR)	TDS	MBAS – Anionic Detergent
10/24/2013	10/24/2013 8:00-14:00	C12592	659	659	188	748	441	0.9
11/20/2013	11/20/2013 10:00	C14128	697	1,356	8	96	192	1.9
12/4/2013	12/4/2013 10:30	C14755	694	2,050	102	40	422	6

FTIR = Fourier Transform Infrared; MBAS = methylene blue active substances (assay method); TDS = total dissolved solids; TSS = total suspended solids.
Note: units are mg/L unless noted otherwise.

The organic waste test results for the Tamar SW-1 well are presented in **Table 3-31**.

Table 3-31. Results of organic waste discharge analyses for the Tamar SW-1 well.

Sampling Date	Sample Reception Date/Time	Report No.	Flow [kg/mo]	Flow (Annual) [kg/yr]	BOD	TOC	TSS 105°C	Oil and Grease (FTIR)	Total N	Total P
10/13/2013	10/14/2013	C12014	3,293	3,293	43,875	28,157	--	4,488	4,242	227
10/24/2013	10/24/2013 8:00-14:00	C12593			6,300	5,900	14,914	2,771	500.2	66
11/20/2013	11/20/2013 9:20	C14120	3,485	6,778	21,400	22,835	--	12,075	11,682	133
12/4/2013	12/4/2013 10:40	C14756	3,463	10,241	3030	6214	--	197	368	16

BOD = biochemical oxygen demand; FTIR = Fourier Transform Infrared; N = nitrogen; P = phosphorus; TOC = total organic carbon; TSS = total suspended solids.
Note: units are mg/kg unless noted otherwise.
-- data not available.

3.6.4.2 Drilling Discharge Quality

Results of the analysis of the drilling mud from the Tamar SW-1 well are presented in **Tables 3-32** (organics and other parameters) and **3-33** (metals). As for the other Tamar SW-1 data, these results are considered to be representative for Tamar Field wells.

Table 3-32. Analytical results for organics and other parameters for the Tamar SW-1 drilling mud.

Sampling Date	Sample Reception Date/Time	Report No.	Flow [m^3/mo]	Flow (Annual) [m^3/yr]	pH	BOD	TOC	TSS (105°C)	Mineral Oil (FTIR)	Total Oil (FTIR)	PAHs	Phenol	Cresol	DOX	Toxicity	NH_4-N	TKN-N	NO_3-N	NO_2-N	Total N	TDS	Cl^-	Total GC-MS (AS O-xylene)	Total VOCs
36-in. and 26-in. Sweeps																								
10/10/2013	10/10/2013 9:20	C11878	2,688.6	2,688.6	5.6	1,896	11,440	68,340	140	197	--	<0.2	<0.2	--		92	197	2	<1	199	301,896	193,750	93.5	--
17½-in. Sweeps																								
10/24/2013	10/24/2013 8:00-14:00	C12587	151.5	2,840	7.8	1,640	10,000	--	111	188	--	<0.2	<0.2	--	--	85	302	3	<1	305	266,200	153,400	33	--
14½-in. Sweeps																								
11/11/2013	11/12/2013	C13601	525.7	3,365.7	9.1	7,750	23,000	--	8	364	--	<0.2	<0.2	--	--	631	809	<1	<1	809	227,830	117,300	3,488.2	--
10⅝-in. Sweeps																								
11/20/2013	11/20/2013 9:40	C14119	86.4	3,452	9.3	6,900	19,920	--	15.5	283	--	<0.2	<0.2	--	--	33	740	22	<1	762	189,750	98,830	4,075.7	--

BOD = biochemical oxygen demand; Cl^- = chloride; DOX = dissolved organic halides; FTIR = Fourier Transform Infrared; GC-MS = gas chromatography-mass spectrometry; N = nitrogen; NH_4 = ammonium; NO_2 = nitrite; NO_3 = nitrate; PAH = polycyclic aromatic hydrocarbon; TDS = total dissolved solids; TKN = total Kjeldahl nitrogen; TOC = total organic carbon; TSS = total suspended solids; VOC = volatile organic compound.
Note: units are mg/L unless noted otherwise.
-- data not available.

Table 3-33. Metal analysis results for the Tamar SW-1 drilling mud.

Sampling Date	Sample Reception Date/Time	Report No.	Flow [m^3/mo]	Flow (Annual) [m^3/yr]	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg - ICP	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr	Ti	V	Zn
36-in. and 26-in. Sweeps																																			
10/10/2013	10/10/2013 9:20	C11878	2,688.6	2,688.6	0.1	105	1	2	1,579	<0.05	16,829	<0.05	0.3	0.2	4	805	<0.05	2,296	0.2	198	36	<0.1	175,714	0.2	58	8	671	0.3	<0.05	216	<0.1	92	1	0.2	6
17½-in. Sweeps																																			
10/24/2013	10/24/2013 8:00-14:00	C12587	151.5	2,840	0.1	111	1	0.3	1,529	<0.05	3,263	0.1	0.3	0.2	6	1,048	<0.05	64,731	0.1	219	47	0.05	104,005	0.3	15	213	500		<0.05		<0.1	75	1	0.2	8
14½-in. Sweeps																																			
11/11/2013	11/12/2013	C13601	525.7	3,365.7	<5	3,370	<5	5	903	<2	17,040	<2	2	6	9	4,039	<2	32,301	<5	1,095	123	<2	70,781	4	60	149	1,712	<5	<5	41	<5	140	68	5	16
10⅝-in. Sweeps																																			
11/20/2013	11/20/2013 9:40	C14119	86.4	3,452	<5	1,632	<5	5	795	<2	21,918	<2	2	5	10	3,309	<2	32,680	<5	878	91	<2	65,051	3	57	123	1,183	<5	<5	18	<5	85	28	4	20

Ag = silver; Al = aluminum; As = arsenic; B = boron; Ba = barium; Be = beryllium; Ca = calcium; Cd = cadmium; Co = cobalt; Cr = chromium; Cu = copper; Fe = iron; Hg = mercury; ICP = inductively coupled plasma; K = potassium; Li = lithium; Mg = magnesium; Mn = manganese; Mo = molybdenum; Na = sodium; Ni = nickel; P = phosphorus; Pb = lead; S = sulfur; Sb = antimony; Se = selenium; Si = silica; Sn = tin; Sr = strontium; Ti = titanium; V = vanadium; Zn = zinc.
Note: units are mg/L unless noted otherwise.

The barite analysis for the Tamar SW-1 well is presented in **Table 3-34**.

Table 3-34. Analytical results for barite samples used for Tamar SW-1.

Date of Shipment	Analysis Report Date/Time	Report No.	Hg - Cold Vapor	Ag	As	Cd	Cr	Cu	Ni	Pb	Zn
10/10/2013	10/10/2013 9:20	C-64124.13	2	<5	20	<2	8	121	7	165	109
11/3/2013	11/4/2013 17:00	C13127	1.5			1					
12/4/2013	12/4/2013	C14760	0.7			<2					

Ag = silver; As = arsenic; Cd = cadmium; Cr = chromium; Cu = copper; Hg = mercury; Ni = nickel; Pb = lead; Zn = zinc.
Note: units are mg/kg unless noted otherwise.

An analysis of samples of the cuttings was performed also; the results are presented in **Table 3-35**.

Table 3-35. Cuttings analyses for the Tamar SW-1 well.

Sampling Date	Sample Reception Date/Time	Report No.	TOC	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
10/29/2013	11/3/2013 20:30	C13130	32,700	<5	<5	<2	9	13	<5	5	98	14
10/30/2013	11/3/2013 22:00	C13130	45,900	<5	<5	<2	2	4	<5	<2	96	7
10/31/2013	11/3/2013 10:40	C13130	34,800	<5	<5	<2	2	4	<5	<2	94	6
11/6/2013	11/12/2013 22:00	C13602	14,000	<5	<5	<2	2	4	<2	<2	83	7
11/8/2013	11/12/2013 22:10	C13602	34,200	<5	<5	<2	46	63	<2	35	207	80
11/11/2013	11/12/2013 5:55	C13602	23,600	<5	<5	<2	34	41	<2	23	127	55
11/12/2013	11/20/2013 16:20	C14135	27,400	<5	5	3	43	56	<2	38	161	89
11/23/2013	12/4/2013 11:00	C14759	31,800	<5	5	<2	40	58	<2	26	249	83
11/24/2013	12/4/2013 21:34	C14759	32,700	<5	<5	<2	56	65	<2	50	116	100
11/27/2013	12/4/2013 0:40	C14759	33,000	<5	<5	<2	48	50	<2	26	118	72
12/7/2013	12/23/2013 15:52	C15700	36,000	<5	8	<2	17	44	<2	9	206	79
12/9/2013	12/23/2013 11:40	C15700	53,000	<5	<5	<2	38	71	<2	41	98	67
12/11/2013	12/23/2013 8:50	C15700	33,800	<5	<5	<2	36	58	<2	25	84	66

Ag = silver; As = arsenic; Cd = cadmium; Cr = chromium; Cu = copper; Hg = mercury; Ni = nickel; Pb = lead; TOC = total organic carbon; Zn = zinc.
Note: units are mg/L unless noted otherwise.

Samples of drilling muds and cuttings were tested for radioactive substances. The results of the analysis of samples from the Tamar SW-1 well are presented in **Table 3-36**.

Table 3-36. Results of analyses for radioactive substances in drilling muds and cuttings from the Tamar SW-1 well.

Sampling Date	Time	Sample ID	Ra 226	Ra 228	Ra 226/228	Th 228	Pb 210
10/29/2013	20:30	70831.13-C	0.02	0.18	0.111	0.06	0.23
10/30/2013	22:00	70832.13-C	0.02	-0.17	-0.118	0.036	-0.04
10/31/2013	10:40	70833.13-C	0	-0.26	0.000	0.006	0.09
11/6/2013	22:00	73311.13-C	0.05	-0.01	-5.000	0.028	0.12
11/8/2013	22:10	73312.13-C	0.02	0.25	0.080	0.44	0.49
11/11/2013	5:50	73313.12-C	0.02	0.14	0.143	0.38	0.46
11/12/2013	16:20	75340.13-C	0.14	0.7	0.200	0.44	0.74
11/23/2013	11:00	79078.13-C	0.09	0.43	0.209	0.53	0.43
11/24/2013	21:34	79079.13-C	0.13	0.61	0.213	0.37	0.37
11/27/2013	0:40	79080.13-C	0.15	0.39	0.385	0.36	0.52
12/7/2013	12:52	Tamar SW-1 ST01 7/12/13; 12:52PM CUTTINGS	0.052	0.44	0.118	0.179	0.61
12/9/2013	11:40	Tamar SW-1 ST01 9/12/13; 11:40AM CUTTINGS	0.21	0.44	0.477	0.404	1.04
12/11/2013	8:50	Tamar SW-1 ST01 11/12/13; 08:50AM CUTTINGS	0.21	0.79	0.266	0.57	0.85

Pb = lead; Ra = radium; Th = thorium.

Discharges from the proposed wells will differ in that MOBM will not be discharged. Noble Energy has requested approval to discharge MOBM-associated cuttings, and the cuttings handling will differ due to the different mud system and treatment system. **Table 3-37** presents data on the cuttings discharges from the proposed solids control system obtained from a well in the United Kingdom North Sea.

Table 3-37. Hammermill treatment data from actual sections in United Kingdom North Sea, December 2012 to January 2013 (Data from: Noble Energy, 2014).

Date	Hole Section	MT Processed	M3 Processed	Feed Stock						Discharge	
				Oil		Water		Solids		Oil on Cuttings	Oil in Water
				%	M3	%	M3	%	M3	%	mg/L
Dec 24, 25	17.5	36.7	20.39	33	6.7	22	4.3	47	9.6	0.031	8.0
Dec 25, 26	17.5	100	55.56	34	18.9	22	12.2	45	25.0	0.044	12.0
Dec 26, 27	17.5	68	42.50	36	15.3	22	9.4	43	18.3	0.042	39.0
Dec 27, 28	17.5	95	59.38	39	23.2	21	12.5	41	24.3	0.056	6.5
Dec 29, 30	17.5	10.2	6.38	40	2.6	18	1.2	42	2.7	0.029	43.0
Jan 3, 4	12.25	99	55.00	25	13.8	32	17.6	44	24.2	0.093	53.2
Jan 4, 5	12.25	104	54.74	28	15.3	27	14.8	46	25.2	0.024	19.7
Jan 5, 6	12.25	103	54.21	23	12.5	20	10.8	58	31.4	0.034	21.5
Jan 6, 7	12.25	113	56.50	29	16.4	18	10.2	54	30.5	0.104	21.7
Jan 22, 23	8.5	130	65.00	31	20.2	13	5.5	56	36.4	0.058	8.6
Mean										0.051	26.3

Table 3-38 lists the Chemical Hazard and Risk Management (CHARM) data for the MOBM system to be used for the proposed wells (http://www.cefas.defra.gov.uk/industry-information/offshore-chemical-notification-scheme.aspx).

Table 3-38. Summary of the Offshore Chemical Notification Scheme (OCNS) Chemical Hazard and Risk Management (CHARM) data for the proposed drilling mud system.

Product	OSPAR-Derived Data			Toxicity Data		Comments
	OCNS (UK) Registered	OCNS Rating	Substitution Warning	Toxicity (worse case)	Toxicity Sediment Reworker	
LE Supermul	No					Likely to pass pre-screening and the final rating would depend upon the *Corophium* toxicity. Expected to be an OCNS C or D rating.
ESCAID 110	Yes (non-CHARM)	C	No	1,000 mg/L (96-hr LL_0) (*Onchorhyncus mykiss*)		Readily biodegradable, does not bioaccumulate (69% in 28 days)
Lime	PLONOR	E	No	N/A	N/A	
Calcium Chloride	PLONOR	E	No	N/A	N/A	
Barite	PLONOR	E	No	N/A	N/A	
Rhemod L	Yes (non-CHARM)	B	Yes	237.1 mg/L EC_{50} 72-hr (*Skeletonema costatum*)	8,872 mg/kg (LC_{50} *Corophium volutator*)	
Adapta	Yes (non-CHARM)	E	Yes	>1,000 (mg/L limit test) (*Scophtalmus maximus*)	105,000 mg/L (LC_{50} *Corophium volutator*)	
EZ Mul NT	Yes (non-CHARM)	D	No	23 mg/L EC_{50} 72-hr (*Skeletonema costatum*)	10,000 mg/kg (LC_{50} *Corophium volutator*)	SPP in generic at 15.0 lb/bbl; 64,600 ppm SPP
TAU MOD	Yes (non-CHARM)	E	No	5,600 (mg/L limit test) (*Scophtalmus maximus*)	13,662 mg/kg (LC_{50} *Corophium volutator*)	SPP in INNOVERT at 5.0 lb/bbl; 68,100 ppm SPP

bbl = barrel; EC_{50} = median effective concentration; LC_{50} = lethal concentration 50; LL_0 = loading concentration at which no mortality or effects exist; PLONOR = pose little or no risk to the environment; ppm = parts per million; SPP = suspended particulate phase.

3.7 WASTE

Wastes generated by drilling vessel operations and processes will be identified and classified. Each identified waste will be classified and handled as scheduled waste or non-scheduled waste.

The waste classification determination will be conducted by using one or more of the following methods:

- Process knowledge – Applying knowledge of the hazardous characteristic(s) of the waste in light of the materials or the processes used; and
- Regulatory listing review – Determining if the waste is listed by waste management regulations or authorities as being considered a hazardous, scheduled, or other type of waste.

Different waste streams will be segregated by type and will not be mixed together or managed in the same container. Under no circumstances will non-hazardous wastes be allowed to be mixed in the same container with hazardous or scheduled wastes.

Waste storage areas are designated on the drilling vessel in areas isolated from other operations. Waste containers will be stored in these areas prior to processing or shipment to the contract waste management vendor. All waste materials will be stored properly in containers that are non-leaking and compatible with the waste being stored. All containers will have their lids, rings, covers, bungs, and other means of closure properly installed at all times except when waste is being added or removed, and will be stored in secondary containment.

Volumes of non-drilling liquid wastes were presented in **Section 3.6.1**, and drilling wastes volumes were presented in **Section 3.6.2**.

Well-specific estimates of solid wastes to be generated during the drilling program are unavailable. However, based on operator data provided in filed plans, the U.S. Minerals Management Service estimated that each exploration well drilled in U.S. waters generates an average of 2,000 ft^3 (56.6 m^3) of trash and debris (Dismukes et al., 2007). Cantin et al. (1990) employed a different approach to estimate the amount of trash and debris, basing their evaluation on the number of personnel aboard a drilling rig and daily generation rates. They estimated that approximately 2 kg/person/day of trash and debris are generated during offshore oil and gas exploratory drilling operations. For a 90-day drilling program and 150 personnel, total trash and debris generated would be approximately 27,000 kg (27 MT).

Wastes are handled and disposed of according to MARPOL and permit requirements. Wastes that cannot be discharged overboard are shipped to authorized onshore waste disposal sites in accordance with regulations.

If MOBM cuttings discharge after treatment is approved, the waste disposal requirements for the planned drilling program are expected to be negligible relative to the available services and landfill capacity, and could provide a short-term beneficial impact for waste transporters and management facilities.

If the discharge of cuttings from the wells proposed for the Tamar Field Development Project is not approved, Noble Energy plans to use a completely enclosed system to avoid exposure of personnel to contaminated wastes. The amount of mud retained on cuttings under this option would be 12% to 14% because the cuttings need enough fluid to maintain a slurry composition for transport. Total cuttings for each well is estimated to be approximately 2,600 MT. The cuttings would be transported to Haifa by supply vessel and then by truck to the Ramat Hovav landfill. It is estimated that approximately 27 vessel trips (between wells and Haifa) and 80 truck trips (Haifa to the Ramat Hovav landfill) would be required for onshore cuttings disposal (CSA Ocean Sciences Inc., 2013c).

3.8 ABANDONMENT/CLOSURE

The wells will be abandoned in accordance with United States Code of Federal Regulations, Title 30 Mineral Resources, Chapter II – Bureau of Safety and Environmental Enforcement, Department of the Interior, Subchapter B – Offshore, Part 250, Section 1721, Temporary Abandoned Wells, revised 1 July 2012. Specific details of temporary well abandonment are outlined below.

After the well has reached total depth and wireline evaluation logs have been run, the wellbore will be temporarily abandoned and secured with multiple barriers. A 9⅞-in. × 10¾-in. casing string will be run to total depth and cemented in place. The cement will be displaced with sufficient mud weight to provide a hydrostatic pressure equal to or greater than the pore pressure plus 300 psi with a seawater column above the mud line. A retrievable mechanical plug will be set at the bottom of the casing string and pressure tested. A retrievable mechanical plug will be set approximately 300 m below the mud line and pressure tested. The wellbore will then be negative pressure tested with a seawater column to the mud line prior to disconnecting the BOP stack and riser.

The design life of the pipelines, MEG lines, utility lines, and control lines is comparable to the 30-year life expectancy of the Tamar Platform. Prior to abandonment, Noble Energy will evaluate the Israel regulations in place regarding subsea pipelines, flowlines, utility lines, and control lines. Noble Energy expects that abandonment plans will be developed that comply with existing regulations. Possible abandonment approaches include abandonment in place, or complete to partial removal of the lines.

For final closure, the wells will be plugged and abandoned and the sites cleared in accordance with the Tamar lease requirements and applicable regulations.

CHAPTER 4: EVALUATION OF ENVIRONMENTAL IMPACTS

4.1 INTRODUCTION

4.1.1 Impact Assessment Methodology

Two factors are used to determine the significance of an impact: impact consequence and impact likelihood. Impact consequence refers to an impact's characteristics on a specific resource (e.g., air quality, water quality, benthic communities, etc.). Such determinations take into account resource-specific sensitivity to an impact, recovery capability, and spatial and temporal occurrence. Impact consequence also includes whether an impact is:

- direct or indirect;
- reversible or irreversible; and
- short term (generally reflecting the duration of a project, which typically is in the range of several weeks to several months) or long term (longer than project duration, which is typically on the order of years to decades).

Impact consequence classifications include *beneficial*, *negligible*, *low*, *medium*, and *high* as described in **Table 4-1**.

Table 4-1. Definitions of impact consequence.

Consequence	Physical/Chemical Environment	Biological Environment	Socioeconomic and Cultural Environment
High	One or more of the following impacts: • Widespread, persistent contamination of air, water, or sediment • Frequent, severe violations of air or water quality standards or guidelines	One or more of the following impacts: • Extensive, irreversible damage to sensitive habitats such as sensitive deepwater communities, hard/live bottom communities, seagrass beds, marshes, and/or coral reefs, and other sites identified as MPAs, marine protected habitats, or areas of special concern • Death or injury of large numbers of a species listed by the IUCN as endangered, critically endangered, or vulnerable, or irreversible damage to their critical habitat	One or more of the following impacts: • Extensive, irreversible damage to recreational resources such as beaches, boating areas, and/or tourism • Impacts posing a significant threat to public health or public safety • Impacts of a magnitude sufficient to alter the nation's social, economic, or cultural characteristics, or result in social unrest
Medium	One or more of the following impacts: • Occasional and/or localized violation of air or water quality standards or guidelines • Persistent sediment toxicity or anoxia in a small area	One or more of the following impacts: • Localized, reversible damage to sensitive habitats such as sensitive deepwater communities, hard/live bottom communities, seagrass beds, marshes, and/or coral reefs, and other sites identified as MPAs, marine protected habitats, or areas of special concern • Extensive damage to non-sensitive habitats to the degree that ecosystem function and ecological relationships could be altered • Death, injury, disruption of critical activities (e.g., breeding, nesting, nursing), or damage to critical habitat of individuals of a species listed by the IUCN as endangered, critically endangered, or vulnerable	One or more of the following impacts: • Disruption of fishing activities at any location for more than 30 days or exclusion from more than 10% of the fishable area at a given time • Impacts leading to greater than a 10% change in fishery harvest • Localized, reversible impacts on recreational resources such as beaches, boating areas, and/or tourist area
Low	• Changes that can be monitored and/or noticed but are within the scope of existing variability, and do not meet any of the High or Medium definitions (above)		
Negligible	• Changes unlikely to be noticed or measurable against background activities		
Beneficial	• Likely to cause some enhancement to the environment or the social/economic system		

IUCN = International Union for Conservation of Nature; MPA = Marine Protected Area.

Impact likelihood is rated according to its estimated potential for occurrence:

- likely (>50% to 100%);
- occasional (>10% to 50%);
- rare (1% to 10%); or
- remote (<1%).

The impact analysis completed for the Tamar Field projects considered both factors – impact consequence and impact likelihood – to determine overall impact significance. The matrix integrating impact consequence with impact likelihood (**Table 4-2**) provides the basis for determining ***overall impact significance.*** Like the impact table, the overall impact significance rating includes beneficial and negative impact levels that range from Negligible to High. Impacts rated as High or Medium in significance are priorities for mitigation. Mitigation is also considered for less significant impacts to further reduce the likelihood or consequence of impacts.

Table 4-2. Matrix combining impact consequence and likelihood to determine overall impact significance.

Likelihood vs. Consequence		Decreasing Impact Consequence ←				
		Beneficial	Negligible	Low	Medium	High
Decreasing Impact Likelihood ↓	Likely	Beneficial	Negligible	Low	Medium	High
	Occasional	Beneficial	Negligible	Low	Medium	High
	Rare	Beneficial	Negligible	Negligible	Low	High
	Remote	Beneficial	Negligible	Negligible	Low	Medium

4.1.2 Impact-Producing Factors

Based on the description of the proposed exploratory drilling program outlined previously in **Chapter 3** a series of impact-producing factors (IPFs) have been identified. In the left column, **Table 4-3** identifies the sources of impacts associated with the Tamar Field projects and, across the top, identifies the environmental resources that *may* be affected. **Table 4-3** has been developed, *a priori*, to focus the impact analysis on those environmental resources that may be impacted as a result of one or more IPFs. The tabular matrix indicates which of the routine activities and accidental events could affect specific resources. The potential project impacts identified in the matrix are discussed in this chapter of the EIA in the sections listed in **Table 4-3**. As much as possible, the discussions are presented in the order presented in the "Framework Guidelines for Preparation of Environmental Document Accompanying License for Exploration Purposes" (**Appendix B**).

Table 4-3. Matrix of potential impacts (*a priori*). A "●" indicates a potential impact to a resource, and numbers refer to the EIA section in which the potential impact is discussed.

Project Activity/ Impact-Producing Factor	Environmental Resource											
	Physical/Chemical			Biological				Socioeconomic and Cultural				
	Air Quality	Sediments/Sediment Quality	Water Quality	Plankton, Fish, and Fishery Resources	Benthic Communities	Marine Mammals and Sea Turtles	Marine and Coastal Birds	Protected Marine Species and Habitats, Marine Habitats of Interest, and Areas of Special Concern	Fishing and Marine Farming	Shipping and Maritime Industry	Recreation and Aesthetics/ Tourism	Archaeological Resources
NON-ROUTINE (ACCIDENTAL) EVENTS (4.3)												
Drilling Worst Case Gas Discharge	● (4.3.1)		● (4.3.1)	● (4.3.1)	● (4.3.1)	● (4.3.1)	● (4.3.1)	● (4.3.1)	● (4.3.1; 4.12)	● (4.3.1)	● (4.3.1)	● (4.3.1)
Large Diesel Fuel Spill	● (4.3.2)	● (4.3.2)	● (4.3.2)	● (4.3.2)	● (4.3.2)	● (4.3.2)	● (4.3.2)	● (4.3.2)	● (4.3.2; 4.13)	● (4.3.2)	● (4.3.2)	● (4.3.2)
Solid Waste (Accidental Loss)		● (4.3.4)	● (4.3.4)		● (4.3.4)	● (4.3.4)	● (4.3.4)	● (4.3.4)			● (4.3.4)	
ROUTINE PROJECT-RELATED ACTIVITIES												
Drilling Activities												
Drillship Arrival, Departure, and Stationkeeping			● (4.6.2)			● (4.6.5)			● (4.12)	● (4.7.1)		● (4.7.3)
Drilling (including release/discharge of drill muds and cuttings, flaring, and other well operations	● (4.8)	● (4.6.1)	● (4.6.2)	● (4.6.3)	● (4.6.4)				● (4.12)			● (4.7.3)
Physical Presence				● (4.6.3)			● (4.6.6)			● (4.7.1)	● (4.5.3; 4.7.2)	
Lights							● (4.6.6; 4.4)					
Noise (including support vessels and aircrafts)						● (4.6.5; 4.5)						
Routine (non-drilling related) Discharges			● (4.6.2)	● (4.6.3)								
Solid Waste					● (4.6.4; 4.9)							
Infrastructure Installation and Operation (platform, pipelines, umbilicals)												
Installation Vessel Arrival, Operation, and Departure			● (4.6.2)			● (4.6.5)			● (4.12)	● (4.7.1)		
Installation Activities		● (4.6.1)	● (4.6.2)	● (4.6.3)	● (4.6.4)		● (4.6.6)		● (4.12)			● (4.7.3)
Physical Presence		● (4.6.1)			● (4.6.4)				● (4.12)			
Combustion Emissions	● (4.8)											
Noise						● (4.6.5; 4.5)						
Solid Waste					● (4.6.4; 4.9)							
Support Vessel and Helicopter Traffic												
Support Vessel Traffic	● (4.8)					● (4.6.5)		● (4.6.7)	● (4.12)	● (4.7.1)		
Helicopter Traffic	● (4.8)					● (4.6.5)	● (4.6.6)	● (4.6.7)				

"(#)" refers to the section number of this Environmental Impact Assessment in which the potential impact is reviewed.

4.2 FLOW BACK TESTS

Flow back and integrity testing is discussed in **Section 3.2.4**, which presents the steps to be taken to ensure that no loss of hydrocarbons is occurring from the well. **Section 3.2.2** describes the drilling process, which also is designed to prevent any loss of well integrity.

4.3 ENVIRONMENTAL IMPACTS OF NON-ROUTINE EVENTS

Three different non-routine events were evaluated for the Tamar Field activities: 1) a continuous 30-day discharge of condensate with API 35 at a rate of 3,369 bbl/day from the Tamar SW-1 exploration well occurring at a depth of approximately 1,650 m; 2) an instantaneous discharge of 16,500 bbl of diesel fuel from the drilling rig; and 3) the accidental loss of solid waste. These events will be reviewed in this section.

The two accidental hydrocarbon release scenarios have been analyzed for the Tamar SW-1 location and are discussed in a report prepared by CSA Ocean Sciences Inc. for Noble Energy entitled "Condensate and Diesel Spill Analysis for the Tamar SW-1 Exploration Well" (CSA Ocean Sciences Inc., 2013d). Trajectory modeling for the study was conducted for Noble Energy by Dr. Steve Brenner of Bar-Ilan University. The scope of the report included the following topics:

- Impact of WCDs on the ecosystem, in general, and on species at risk;
- Impact on the uses of various facilities and infrastructures at sea and on shore, using Israel's Mediterranean coastline sensitivity atlas as a basis for reference; and
- Measures and time required to remedy the damages and restore the situation to its previous state, including an assessment of the costs for taking the necessary steps in accordance with published documents and international experience in similar incidents.

The oil spill model used for these simulations was the MEDSLIK Version 5.3.6. MEDSLIK was developed by the Cyprus Oceanographic Center and currently is the model of choice used by the Mediterranean Forecasting System (MFS) community. An oil spill is treated as a collection of tens of thousands of particles dispersed using a Lagrangian particle tracking scheme and a random walk diffusion scheme. It also includes processes of physicochemical weathering such as evaporation and emulsification.

The currents used to drive MEDSLIK were generated using an expanded domain version of the model developed for the southeastern Levantine Basin within the framework of the MFS. The model is based on the Princeton Ocean Model (POM), which is a time dependent, 3D primitive equations ocean model. For the scenarios considered here, the model domain covers the entire Levantine Basin east of 30° E. The horizontal resolution is 1' (approximately 1.7 km) and the water column is divided into 30 unevenly spaced sigma layers. The bathymetry was extracted from the GEBCO (2014) global 1' data set. The model is nested in the daily MFS reanalysis fields (1/16°, approximately 6.5 km horizontal resolution) for the relevant period following the methodology of Brenner (2003) and Brenner et al. (2007). The models and nesting methodology have been extensively tested and validated for this region within the framework of MFS.

The hydrodynamic model requires initial conditions as well as time-dependent lateral boundary conditions at the open (western) boundary and surface forcing. The initial and lateral boundary conditions were extracted from the daily reanalysis fields produced by hindcasts and retrospective analyses within the framework of the operational MFS. Daily averaged fields of temperature, salinity, currents, and sea level are available beginning from 1999. The spatial resolution was 1/16° (approximately 6.5 km) horizontal and 72 fixed-depth levels in the vertical. For surface forcing, the 10-m winds were extracted from the NCEP reanalysis data sets. The data are available with a frequency of 6 hours. Surface heat and fresh water fluxes were approximated by relaxing the model's surface temperature and salinity to the MFS reanalysis fields with a relaxation time scale of 2 days. All data were spatially and temporally interpolated to the model grid and time step as necessary. In order to eliminate the initial mismatch between the original reanalysis fields and the interpolated values, each simulation was started 3 days before the desired data to allow for model spin up.

As required my MoEP, four time periods representative of various climatic conditions over the eastern Mediterranean were considered. For each period, two types of simulations were conducted:

1. a continuous 30-day discharge of oil at a rate of 3,369 bbl/day with API 35; and
2. an instantaneous discharge of 16,500 bbl of diesel fuel from the platform.

The four time periods considered were:

1. 9 December 2010 to 8 January 2011: a period that included an extreme winter storm;
2. 26 January to 25 February 2008: typical winter conditions;
3. 17 July to 16 August 2008: typical summer conditions with persistent northwesterly winds and swell; and
4. 25 September to 25 October 2007: autumn conditions typical of the transition seasons and including at least one episode of strong easterly to northeasterly wind.

The model analyzed the potential for spill weathering to estimate how much condensate and diesel fuel would remain on the sea surface at various times following a spill. Portions of the study are presented in the following sections along with a discussion of the potential impacts of the two non-routine events.

The modeling results have been used by Noble Energy in the development of their Oil Spill Response Plan, and a plan has been developed for the monitoring of a potential condensate spill (CSA Ocean Sciences Inc., 2013e). Numerous assumptions were made for the modeling effort, which by definition does not represent an actual release but predicts what could happen using the scenario's assumptions.

4.3.1 Drilling Worst Case Well Discharge (Gas)

4.3.1.1 Model Results

The results of the modeling for a continuous 30-day discharge of condensate with API 35 at a rate of 3,369 bbl/day from the Tamar SW-1 Exploration Well occurring at a depth of approximately 1,650 m are presented in **Table 4-4.** The tabular data include percent evaporated, percent of oil on the sea surface, percent dispersed, and percent deposited on the coast. The table also provides estimates of the time required to initially reach the shoreline, the length of shoreline affected, impact hotspots, and relative oiling concentration.

Table 4-4. Trajectory and weathering model results for a continuous 30-day discharge of condensate at a rate of 3,369 bbl/day for the four environmental scenarios at the end of 30 days.

Scenario	Percent Evaporated	Percent Oil on Sea Surface	Percent Dispersed	Percent Deposited on Coast	Days Until Initial Shoreline Impact	Length of Coastline Affected (km)	Coastline Affected	Impact Hotspot	Oiling Concentration (bbl/km)
Continuous 30-Day Discharge of Condensate (3,369 bbl/day)									
1	45.4	43.3	11	0.1	25	16.5	Cyprus and Israel	Paphos, Cyprus	86
2	45.4	26.1	9	18.6	16	223	Israel and Lebanon	Zichron Yaakov, Israel	>500
3	45.4	24.9	12	17.3	11	95	Israel and Lebanon	Jieh, Lebanon	500 to 1,100
4	45.4	39.9	10	4.2	14	133	Israel and Lebanon	Haifa Bay, Israel	100 to 195

The model predicts that condensate would evaporate and disperse rapidly, with approximately 43% of the spill evaporating in the first 72 hours in all scenarios. **Figure 4-1** shows the percentages of condensate: 1) on the sea surface; 2) evaporated; 3) dispersed (into the water column); 4) deposited on the coast; and 5) deposited on the coast but potentially releasable. Shoreline impacts may occur as early as 11 days after the discharge begins. At the end of 30 days, all four scenarios show 45.4% evaporation, from approximately 25% to approximately 43% oil remaining on the sea surface, and up to 12% dispersed. The percent of condensate deposited on the coastline ranges from 0.1% to 18.6% with impacts to the coastline of Israel, Cyprus, and Lebanon. Total length of impacted shoreline ranges from 16.5 to 223 km. Impact hotspots in Israel are Zichron Yaakov and Haifa Bay, depending on the weather conditions. In all but one scenario (Scenario 1), the Israel coastline is impacted from the border of Lebanon to an area just north of Haifa. Two of the scenarios impact areas farther south of Haifa (Scenarios 2 and 4), with one scenario impacting the coastline to the south of Tel Aviv (Scenario 2). **Figure 4-2** shows the extent and concentration of condensate deposited on the coast for the four scenarios.

Scenario 1 resulted in the lowest percentage of condensate deposited on the coastline (0.1% over 16.5 km), with the majority occurring outside of Israel's waters. The worst case scenario is Scenario 2 (typical winter conditions), which resulted in 18.6% of the condensate being deposited on the coastline starting within 16 days; however, condensate reached the shoreline in 11 days for Scenario 3. Scenario 2 resulted in impacts to 223 km of coastline extending from Tel Aviv to north of the border of Lebanon, with the most adversely affected area being a 15- to 20-km section of coast near Zichron Yaakov that was expected to receive condensate concentrations greater than 500 bbl/km. Scenario 3 resulted in 17.3% of condensate being deposited on 95 km of coastline; however, the majority occurs outside of Israel. Scenario 4 resulted in 4.2% of condensate deposited on the 133 km of the coast, with the area most adversely affected being Haifa Bay, where concentrations were projected to reach 195 bbl/km.

The results for the worst case condensate spill scenario indicate that a condensate spill from the Tamar SW-1 Exploration Well would affect both offshore and coastal resources to varying extents depending on the environmental conditions. Overall, coastal impacts to Israel are expected for approximately 117 km from just south of Tel Aviv to the Lebanon border.

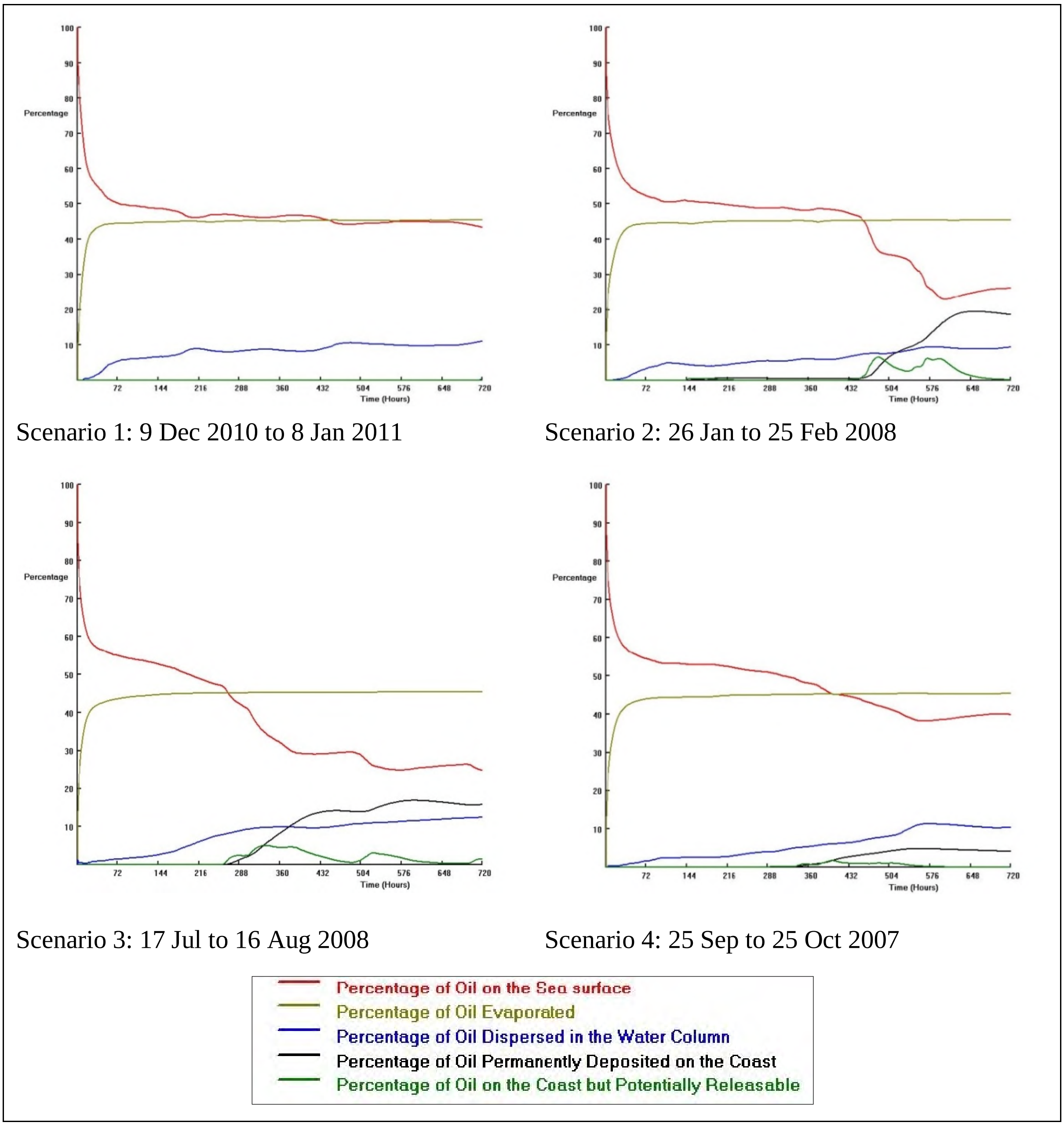
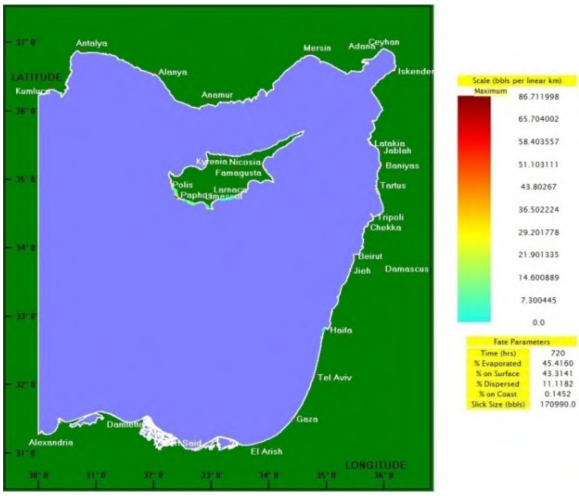
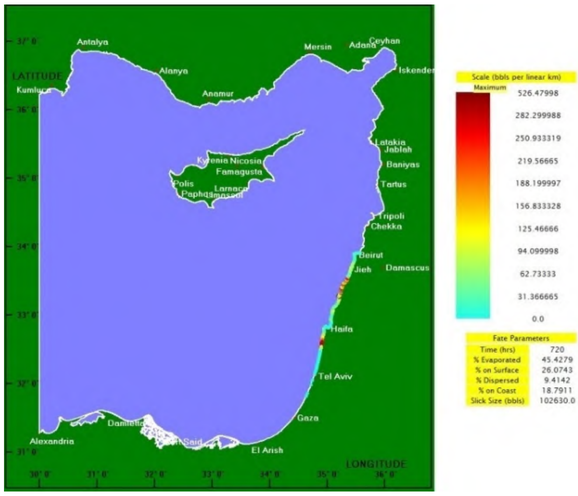


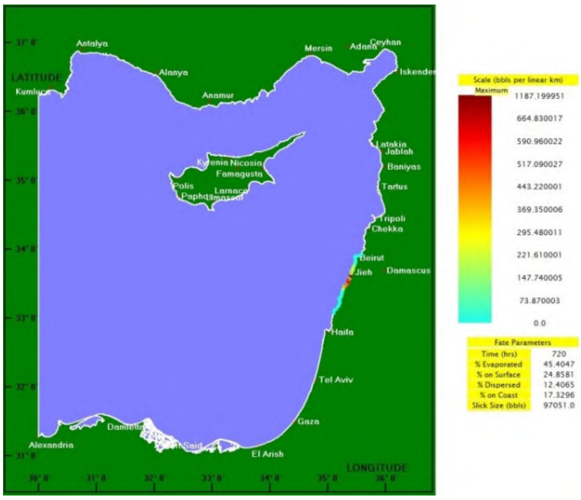
Figure 4-1. Condensate fate parameters for a 30-day continuous discharge of condensate at Tamar SW-1 exploration well for four different time periods representing various climatic conditions.

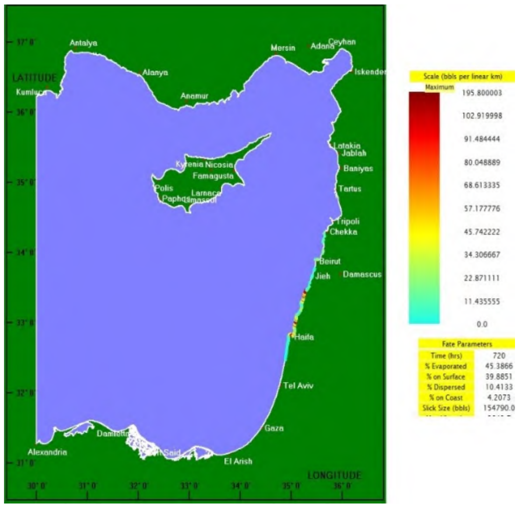




Scenario 1: 9 Dec 2010 to 8 Jan 2011

Scenario 2: 26 Jan to 25 Feb 2008





Scenario 3: 17 Jul to 16 Aug 2008

Scenario 4: 25 Sep to 25 Oct 2007

Figure 4-2. Total amounts of condensate deposited on the coast at the end of 30 days of continuous discharge at Tamar SW-1 exploration well for four different time periods representing various climatic conditions.

4.3.1.2 Discharge Plume

In a catastrophic release (i.e., blowout or pipeline failure) at depth, gas released from the seafloor is driven into the water column where it initially forms a momentum jet. The jet region is confined to the immediate vicinity and is relatively short in length (i.e., on the order of meters). The density difference between the discharge plume and the receiving water results in a buoyant force that drives the plume upward. As the plume rises, it entrains ambient seawater due to the velocity difference between the rising plume and the receiving water. This entrainment reduces the plume’s velocity and buoyancy and increases its radius. If the buoyant driving force for the plume is dissipated by 1) entrainment; 2) dissolution of gas bubbles; or 3) formation of gas hydrates before it reaches the surface, the plume will terminate.

At the upper end of the plume, oil droplets will leave and ascend to the surface solely by their own buoyancy. Rise velocities of oil droplets are much slower than the velocity of a buoyant gas-liquid plume. Compared to situations in which the plume retains its original buoyancy and remains intact all the way to the surface, oil particles released when a plume terminates will take considerably longer to reach the surface and may be transported farther (horizontally) from the release site by ambient currents. The terminal height of the plume (i.e., when a plume terminates midway up the water column or hits the water surface) depends on total blowout discharge rate, gas oil ratio, ambient temperature (hydrate formation), and density field (entrainment).

Figure 4-3 shows a perspective view of a plume for a case with no horizontal currents.

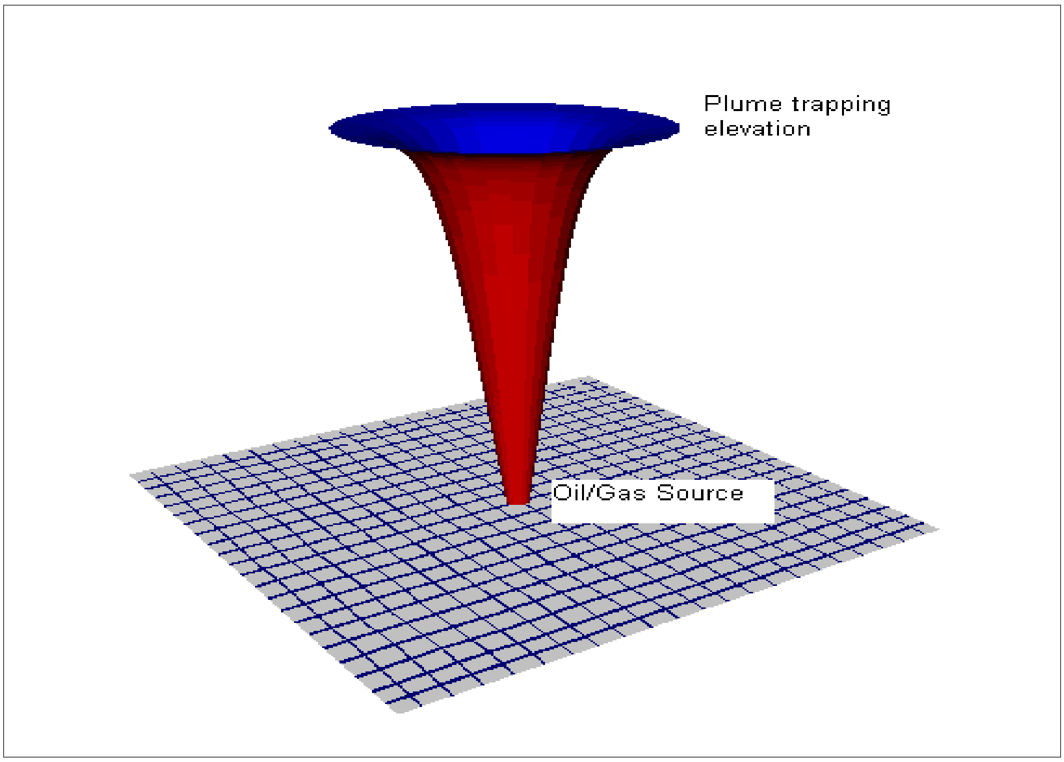


Figure 4-3. Perspective view of example oil/gas plume.

In a catastrophic release (or well blowout), discharged materials – whether oil, gas, condensate, or a mixture of gaseous and liquid hydrocarbons – go through three phases (**Figure 4-4**):

1. Momentum jet: The immediate pressure difference between inside the well and the ambient water drives the discharge. Due to the relatively high density of deep ocean water, the jet momentum dissipates relatively quickly and is confined to the vicinity of the seafloor (i.e., on the order of meters).
2. Buoyant density plume: As the discharge moves upward, the density difference between the expanding gas bubbles in the plume and the receiving water results in a buoyant force that drives the plume. As the plume rises, it continues to entrain sea water, reducing the plume's velocity and buoyancy while increasing its radius. Any oil present in the gas release will be rapidly mixed by the turbulence in the plume, causing it to break up into small droplets. These droplets (typically a few micrometers to millimeters in diameter) are rapidly transported upward by the rising plume, their individual rise velocities contributing little to their upward motion.
3. Free rise and advection-diffusion: As the plume reaches the sea surface or its termination height (when all momentum is lost), it can be deflected in a radial pattern within a horizontal/surface flow zone without appreciable loss of momentum. This radial jet carries the oil particles rapidly away from the center of the plume. The velocity and oil concentrations in this surface flow zone decrease while the depth of the zone increases. In the far field, where the plume buoyancy has been dissipated, ambient currents and wind-generated waves determine the subsequent transport and dispersion of the oil.

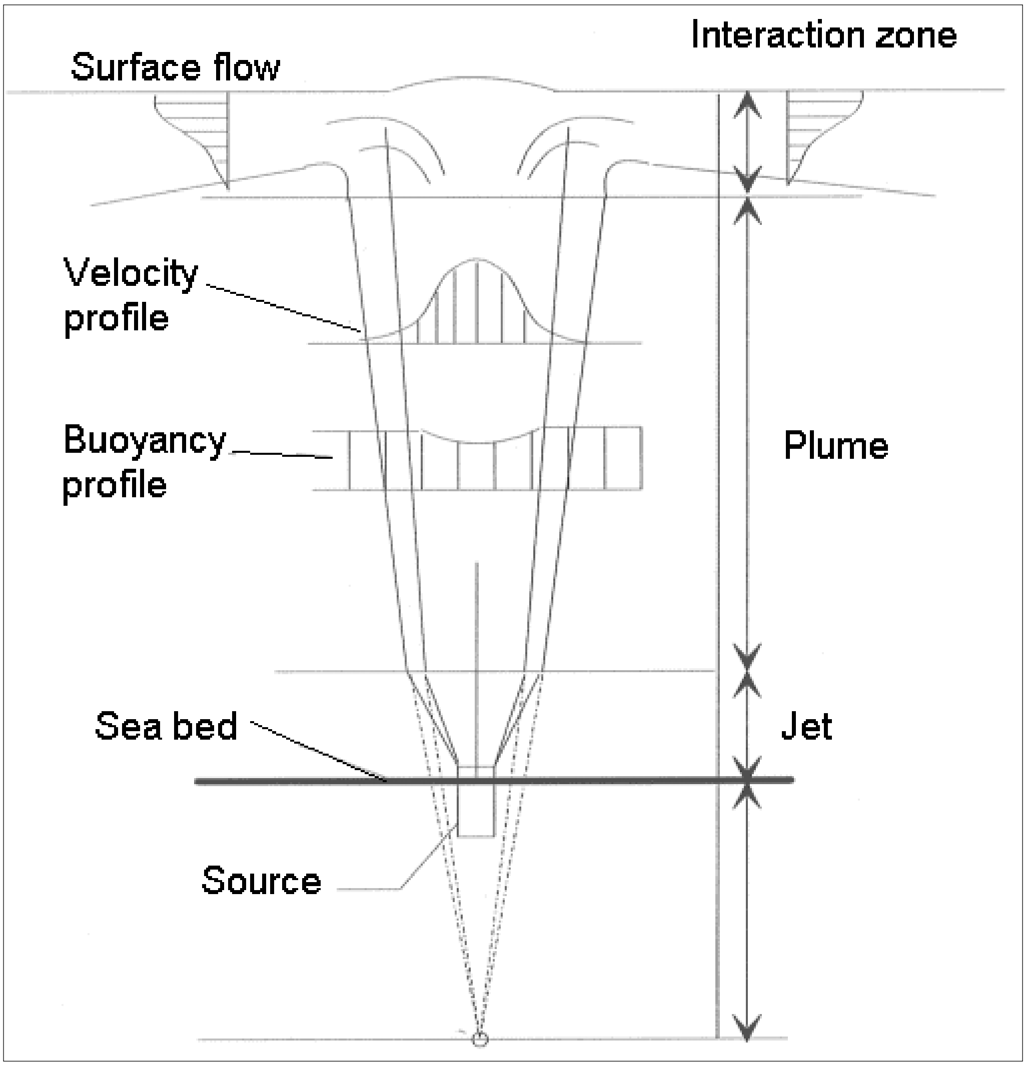


Figure 4-4. Three phases (momentum jet, buoyant density plume, and free rise) exhibited by a gas release at depth.

4.3.1.3 Air Quality

The modeled condensate release would affect air quality in the vicinity of the oil slick by introducing VOCs through evaporation. Emissions would not last long due to rapid volatilization of hydrocarbons. Evaporation is greatest within the first few hours. The modeling results indicated that approximately 43% of the condensate will evaporate within 54 hours after release based on environmental conditions (**Figure 3-21**). Evaporated hydrocarbons are degraded rapidly by sunlight. Biodegradation of condensate on the water surface and in the water column by marine bacteria and fungi initially removes the n-alkanes and subsequently the light aromatics. Other components are biodegraded more slowly. Photo-oxidation attacks mainly the medium and high molecular weight PAHs of a condensate release.

The extent and persistence of air quality impacts would depend on meteorological and oceanographic conditions at the time. Impacts to air quality in the offshore environment will be concentrated in the vicinity of the spill location. Minor impacts to air quality are expected for impacted coastal areas as concentrations deposited on the coast will be low (20 bbl/km) for most of the impacted area; however, impacts are expected to be more significant in the vicinity of Zichron Yaakov where concentrations will be greater than 500 bbl/km. Overall impact significance to air quality from a condensate spill is low.

4.3.1.4 Water Quality

A condensate release would affect marine water quality by increasing hydrocarbon concentrations due to dissolved components and small oil droplets. A condensate discharge at depth would be expected to undergo dissolution (i.e., dissolution of water soluble fractions, including monocyclic aromatic hydrocarbons and PAHs), dispersion, and dilution (i.e., for water soluble fractions only). While in the water column, spilled condensate rising to the surface during buoyant ascent will be subject to adsorption to suspended particulate matter. Suspended particular matter and any adsorbed condensate may undergo settling or continuing suspension/resuspension in the water column. Natural weathering processes are expected to help remove the condensate from the water column and dilute the constituents. Based on the model results (**Figure 3-21**), approximately 43% of the condensate will evaporate or disperse naturally within 54 hours.

The constituents of condensate are light to intermediate in molecular weight and moderately volatile. The constituents can be readily degraded by aerobic microbial oxidation. Condensate is expected to float on the sea surface. Condensate dispersed in the water column can adhere to suspended sediments, but this generally occurs in coastal areas with high suspended solid loads (National Research Council, 2003b) and would not be expected to occur to any appreciable degree in Israeli offshore waters.

The extent and persistence of water quality impacts would depend on meteorological and oceanographic conditions at the time. Impacts to water quality in the offshore environment will be concentrated in the vicinity of the spill location as the volatile components evaporate. Minor to significant impacts on water quality in coastal areas would be expected for the worst case scenario. Overall impact significance to water quality from a condensate spill is medium.

4.3.1.5 Plankton, Fish, and Fishery Resources

A condensate release could affect phytoplankton and zooplankton because they do not have the ability to avoid contact with the condensate. Plankton, including fish eggs and larvae, exposed to condensate hydrocarbons could be killed or stressed. The hydrocarbons may stimulate the growth of some species and prove toxic to others (Abbriano et al., 2011). The exposure of plankton to elevated hydrocarbon concentrations would be relatively brief (generally a few days before most of the condensate evaporates or disperses and moves away from the spill site). Planktonic communities typically recover quickly due to their short generation times and high fecundity (Abbriano et al., 2011).

For exposure to methane or natural gas, fishes are expected to quickly respond to exposure, with rapid absorption of the gas into the body via the gills and adverse effects on respiratory and nervous systems; in addition, blood formation and enzyme activities will be affected. Behavioral responses to toxic gas exposure include excitement, increased activity, and a flight response. Continued exposure, although unlikely in a pipeline rupture situation, would lead to chronic poisoning. Once fishes are exposed to methane in seawater, they will move out of the area. Once fish have moved out of the area, their physiological conditions are expected to return to normal in a short period of time. Field and experimental studies cited by Patin (1999) support the general pattern of fish exposure and response to methane and its homologues in the environment.

Patin (1999) indicated that environmental factors must be considered when assessing the toxicological effects of gas exposure, including methane and its derivatives. Temperature and ambient oxygen levels can alter symptoms of gas exposure. For example, toxicant levels that do not cause an effect under low temperature can become more serious, even lethal, with increasing water temperature. Numerous studies have shown that oxygen deficits directly control the rate of fish metabolism and decrease their resistance to many organic and inorganic toxins (Patin, 1999).

Data pertinent to the effects of methane on fish are very limited. As reported by Patin (1999), gas exposure experiments by Patin (1993) showed 1) initial signs of excitement and increased motor activity by young carp; 2) scattering behavior; 3) cessation of air gulping, attributed to the filling of the gas bladder; 4) reduced motor activity after continued exposure; and 5) severe reductions in stimulus response after 1 to 2 hours of exposure. In gas concentrations of 1 mg/L and higher, lethal effects were seen after 1 to 2 days of exposure.

Patin (1999) also summarized studies of behavioral responses to gas exposure, noting high olfactory sensitivity of bream and perch fry as well as avoidance effects at dissolved gas concentrations of 0.1 to 0.5 mg/L. After repeated exposure, avoidance effects were observed at 0.02 to 0.05 mg/L. Gas concentrations resulting in mortality (48-hr LC_{50}) were 1 to 3 mg/L (Umorin et al., 1991). Other studies cited by Patin (1999) give similar values of LC_{50} (96-hr) for marine fish fry of 0.6 to 1.8 mg/L (Borisov et al., 1994; Kosheleva et al., 1997).

Patin (1999) summarized the effects on indigenous fishes of accidental gas releases in the Sea of Azov. Fishes from the area around the gas releases developed significant pathologies, including impaired movement, loss of coordination, weakened muscle tone, pathologies of organs and tissues, damaged cell membranes, disturbed blood formation, modifications of protein synthesis, and radically increased total peroxidase activity. Similar anomalies were observed in flounder and sturgeon kept for 4 to 5 days in net cages within the gas plume. Fishes caught on the control stations and fishes kept in the control cages did not show any physiological deviations from one another.

Impacts to plankton, fish, and fishery resources from a pipeline gas release are expected within the gas plume and in adjacent waters where dissolution of the plume has occurred. The impact consequence to plankton, fish, and fishery resources is expected to range from minor to moderate.

In summary, the significance of impacts to plankton, fish, and fishery resources associated with a gas release is expected to range from low to medium.

4.3.1.6 Benthic Communities

A condensate release would be expected to have little or no impact on benthic communities offshore. For this analysis, CSA Ocean Sciences Inc. assumed that a release would occur from the BOP located on the seafloor and form a buoyant plume that would rise towards the sea surface. Depending on the orientation and location of the release point relative to the surrounding benthos (e.g., vertical or horizontal, at or below the sediment surface), the benthic community in the immediate vicinity of the discharge may be exposed to the plume. Any toxicity to the benthos at the initial release point will be localized to within several meters of the wellhead. Because condensate is expected to float on the sea surface, there is limited potential for any extensive contact with sediments or benthic organisms. Some portion of the condensate could adhere to particulates and eventually sink to the seafloor.

As the condensate within surface waters enters shallow water, it may come into contact with nearshore sediments, resulting in increased hydrocarbon concentrations and potential effects to nearshore benthic organisms along 117 km of coastline. Overall impact significance to benthic communities from a condensate spill is low (offshore) to medium (nearshore).

4.3.1.7 Marine Mammals and Sea Turtles

Condensate may affect marine mammals through various pathways: direct contact, inhalation of volatile components, ingestion (directly or indirectly through the consumption of fouled prey species), and (for mysticetes) impairment of feeding by fouling of baleen (Geraci and St. Aubin, 1990; Loughlin et al., 1996). Cetacean skin is highly impermeable and not seriously irritated by brief exposure to condensate; direct contact is not likely to produce a significant impact. Whales and dolphins apparently can detect slicks on the sea surface but do not always avoid them; therefore, they may be vulnerable to inhalation of hydrocarbon vapors, particularly those components of condensate that readily evaporate. Ingestion of the lighter hydrocarbon fractions found in condensate can be toxic to marine mammals. Ingested condensate can remain within the gastrointestinal tract and be absorbed into the bloodstream, where it can irritate and/or destroy epithelial cells in the stomach and intestines. Certain constituents of condensate (i.e., aromatic hydrocarbons, PAHs) include some well-known carcinogens. These substances, however, do not show significant biomagnification in food chains and are readily metabolized by many organisms.

The impacts of a condensate release on marine mammals are expected to be moderate because the exposure to elevated hydrocarbon concentrations would be relatively brief. In general, most of the condensate will evaporate or disperse within a matter of days, effectively reducing the potential for direct impacts to marine mammals. Due to the physical/chemical properties of the condensate, toxicity would be the main concern rather than fouling. It is unlikely that large numbers of marine mammals would be exposed to the condensate, and therefore population-level impacts are unlikely to occur.

Condensate in the marine environment may affect sea turtles through various pathways: direct contact, inhalation of condensate and its volatile components, ingestion of condensate (directly or indirectly through the consumption of fouled prey species), and ingestion of floating emulsions (Geraci and St. Aubin, 1990). Several aspects of sea turtle biology and behavior place them at risk, including lack of avoidance behavior, indiscriminate feeding in convergence zones, and inhalation of large volumes of air before dives (Milton et al., 2003). Studies have shown that direct exposure of sensitive tissues (e.g., eyes, nares, other mucous membranes) to condensate or volatile hydrocarbons may cause irritation and inflammation. Condensate can adhere to sea turtle skin or shells. Sea turtles surfacing within or near a condensate release would be expected to inhale petroleum vapors. Ingested condensate, particularly the lighter fractions, can be toxic to sea turtles. Hatchling and juvenile sea turtles feed opportunistically at or near the surface in oceanic waters and are especially sensitive to released hydrocarbons (including condensate).

The impacts of a condensate release on sea turtles are expected to be moderate because the area affected would be relatively large and the exposure to elevated hydrocarbon concentrations would last more than a few days. Due to the physical/chemical properties of the condensate, toxicity would be the main concern rather than fouling. It is unlikely that large numbers of sea turtles would be exposed to the condensate offshore, and therefore population-level impacts are unlikely to occur.

Impacts on sea turtle nesting beaches would be significant during the nesting season (May through August), but is not expected to be significant during the non-nesting season. Nesting is known to occur along the beaches near Rishon Le-Zion, which may be in the impact area for a worst case scenario.

Given the remote probability of a spill and the medium consequence, the overall significance of a condensate spill on marine mammals and sea turtles is low.

4.3.1.8 Marine and Coastal Birds

Marine birds may be at risk from accidental events such as a condensate release, and the magnitude of that risk depends on factors such as the amount of time a species spends on the sea surface and the number of individuals present. It is likely that impacts would occur only once the condensate release reached the shoreline. Direct contact of marine birds with condensate may result in the fouling or matting of feathers with subsequent limitation or loss of flight, insulating, or water-repellent capabilities; irritation or inflammation of skin or sensitive tissues, such as eyes and other mucous membranes; or toxic effects from ingested condensate or the inhalation of condensate and its volatile components. Although individual birds may be oiled during an accidental release offshore, such impacts will be unlikely to affect marine and coastal birds at the population level.

The impacts of a condensate release on marine and coastal birds present along the coast are expected to be greater because the area affected would cover 117 km of shoreline, potentially impacting feeding and nesting sites. Due to the physical/chemical properties of the condensate, toxicity would be the main concern rather than fouling. It is unlikely that large numbers of birds would be exposed to the condensate offshore; however, significant impacts could occur along the coastline. Depending on the season (e.g., during high migratory periods or following fledgling of young birds), impacts at the population level are possible. Of greatest concern are bird species whose populations are currently at risk. Considering the likelihood and consequence of a condensate spell on marine and coastal birds, the overall impact significance is low to medium.

4.3.1.9 Protected Marine Species and Habitats, Marine Habitats of Interest, and Areas of Special Concern

Israel has established several different types of conservation areas, including those located along Israel's coastal zone. Conservation areas found within Israel include the following:

- National Parks: National parks are defined as areas meant for "the public enjoyment of nature or for the preservation of areas of historic, archaeological, or architectural importance."
- Nature Reserves: A nature reserve is "an area in which animals, plants, inanimate objects, soil, caves, water, and landscape are protected from changes in their appearance, biological makeup, and natural development."
- Protected Natural Resources: A protected natural resource is defined as "anything or class of things in nature, whether animal, vegetable or mineral, whose preservation, in the opinion of the Minister of Agriculture, is of value."

Designated protected marine or marine-terrestrial habitats along the Mediterranean coast of Israel, including those listed by the IUCN are summarized in **Table 4-5**.

Table 4-5. Summary of designated protected marine or marine-terrestrial habitats along the Mediterranean coast of Israel, including those listed by the International Union for Conservation of Nature (IUCN).

Site Name	Designation	IUCN or National Category	Marine or Terrestrial	Total Area (ha)	Total Marine Area (ha)
Hof Hasharon (Sharon Beach)	National Park; MPA	V	Both	ND	ND
Hof Palmachim	National Park	National	Both	ND	ND
Hof Dor HaBonim	Marine Nature Reserve; MPA	IV	Marine	ND	ND
Iyye Hof Rosh Ha-niqra	Nature Reserve	IV	Marine	31.0	31.0
Iyye Hof Dor U-Ma'agan Mikha'el	Nature Reserve	IV	Marine	ND	ND
Nahal Alexander	National Park, MPA	V	Marine	374.0	374.0
Nahal Poleg	Nature Reserve	IV	Both	ND	ND
Rosh HaNigra	Nature Reserve	IV	Both	440.0	--
Rosh Hanikra Sea and Shore	Nature Reserve; MPA	National	Marine	960.0	960.0
Sidney Ali	National Park	National	Both	ND	ND
Yam Dor HaBonim	Marine Nature Reserve; MPA	IV	Both	574.0	532.0
Yam Evtah	Marine Nature Reserve; MPA	National	Marine	137.0	137.0
Yam Gador	Marine Nature Reserve; MPA	National	Marine	138.0	65.0
Yam Maa'gan Mikeael	Nature Reserve	National	Both	450.0	--
Yam Shiqma	Nature Reserve; MPA	National	Marine	1,030.0	1,030.0

IV and V = IUCN marine habitat categories (see text); MPA = Marine Protected Area; ND = not determined.

Table 4-5 lists two IUCN categories, which are defined as follows:

- **Category IV** protected areas usually help to protect or restore: 1) floral species of international, national, or local importance; 2) faunal species of international, national, or local importance, including resident or migratory fauna; and/or 3) habitats. The size of the area varies but can often be relatively small; this is not a distinguishing feature however. Management will differ depending on need. Protection may be sufficient to maintain particular habitats and/or species. However, as Category IV protected areas often include fragments of an ecosystem, these areas may not be self-sustaining and will require regular and active management interventions to ensure the survival of specific habitats and/or to meet the requirements of particular species.
- **Category V** protected areas result from biotic, abiotic, and human interaction and should have the following essential characteristics: 1) landscape or coastal and island seascape of high or distinct scenic quality with significant associated habitats, flora, fauna, and associated cultural features; 2) a balanced interaction between people and nature that has endured over time and still has integrity, or where there is reasonable hope of restoring that integrity; and 3) unique or traditional land-use patterns, such as evidenced in sustainable agricultural and forestry systems as well as human settlements that have evolved in balance with their landscape. The following are desirable characteristics: 1) opportunities for recreation and tourism consistent with lifestyle and economic activities; 2) unique or traditional social organizations as evidenced in local customs, livelihoods, and beliefs; 3) recognition by artists of all kinds and in cultural traditions (now and in the past); and 4) potential for ecological and/or landscape restoration.

Abdulla et al. (2008) described 17.97 km^2 or 0.56% of Israel's coast as managed or protected areas. The small declared nature reserves of Achziv in the north and Dor-Habonim midway along the coast make up the bulk of the protected and managed areas, holding a unique status as the only sites along the entire Levantine coast that conserve the coastal rocky and sandy ecosystem and their fishery resources in a near pristine state. The 0.56% of managed coast makes Israel the least advanced of the 16 Mediterranean countries surveyed by Abdulla et al. (2008).

In recent years, plans were implemented to enhance and develop at least three larger Marine Protected Areas (MPAs) along the coast in the north, south, and center of the country. These are expected to be an expansion of existing MPAs. Plans called for the establishment of four large nature reserves, stretching from the 12-nmi territorial water boundary; this will comprise approximately 600 km^2, or 20% of Israel's territorial sea. The Israel Nature and Parks Authority (INNPA) is currently negotiating this plan with the Department of Fisheries and other stakeholders, legislators, and relevant bodies. The plan is to implement several large-scale MPAs in order to protect the environment and conserve biodiversity (Yahel, 2010).

The worst case scenario for this analysis impacts a coastal area approximately 117 km in length, exposing the shoreline to concentrations of condensate ranging from 20 to more than 500 bbl/km. Most of the shoreline consists of long, sandy beaches with changing landscapes (sandstone, dunes, low shrub land). There are extensive swimming beaches used for recreation, and sea turtle nesting has been recorded also.

While there is extensive literature about impacts of crude oil spills on coastal habitats, relatively little has been published about condensate spill impacts. Lucas and Freeman (1989) sprayed condensate onto beach grasses in Nova Scotia, Canada, and observed a temporary herbicidal effect. However, the roots were unaffected, and the plants recovered substantially by the next growing season.

Sammarco (1997) reviewed information on oil spill impacts on wetlands in an attempt to infer potential impacts of a condensate spill in Louisiana wetlands, noting that the responses of the fauna and flora will vary depending on a variety of factors. Factors that influence the extent and duration of impact include the specific compounds in the condensate, its solubility in seawater, concentration, sorptive characteristics, the organics in the sediment, season, water temperature, salinity, wind velocity, community composition, degree of wind and wave exposure, and history of the site with respect to exposure to petroleum hydrocarbons. Initial concentrations are important to predictions of spill effects, but long-term effects depend on final chemical composition and concentrations in the sediment and water (Sammarco, 1997).

Persistent contamination and severe ecological impacts are not expected along the shoreline.

Overall impact significance to coastal habitats from a condensate spill is low based on a remote likelihood and medium impact.

4.3.1.10 Fishing and Marine Farming

Impacts on fishing or marine farming would be limited to the low probability that a safety and response zone would be established near the release site that would exclude commercial fishing vessels. This would have a limited impact due to the low levels of fishing in the project area. Negligible impacts on marine farming are anticipated due to their distance from the project site.

4.3.1.11 Shipping and Maritime Industry

A non-routine release of gas or condensate would not be expected to impact shipping or the maritime industry other than the possible establishment of a safety and response zone that would exclude non-project vessels for a short time. Overall impact significance is negligible.

4.3.1.12 Recreation and Aesthetics/Tourism

A 117-km stretch of coastline from south of Tel Aviv to the Israel/Lebanon border could be affected under the worst case scenario condensate spill. The shoreline segment adjacent to the city of Zichron Yaakov would realize the highest levels of condensate deposition. Other coastal cities affected under the worst case scenario include Haifa, Rishon LeZion, and Netanya. There also are several coastal villages in between the listed cities. These areas serve coastal and marine-related tourism with lodging, restaurants, and other facilities. Lodging in the cities is mainly based on large hotels approved by the Ministry of Tourism. The main tourist attractions along the coast of Israel are bathing beaches, heritage sites, archaeological sites, nature reserves, and national parks. Tourism and recreation in the nearshore waters and on the coast of Israel are spread all along the coast from north to south. In nearshore waters, tourism is mainly based on marine sporting activities and recreation. Water sports include diving, surfing, and sailing.

Impacts on recreational activities and resources are expected, resulting in temporary exclusion from these areas due to oil spill response and cleanup activities. Beaches may be contaminated where concentrations are great enough to require clean up to restore the affected areas. Overall impact significance to recreation and aesthetics/tourism from a condensate spill is low due to the remote likelihood and medium consequence.

4.3.1.13 Archaeological Resources

For the worst case scenario condensate spill, nearshore waters and the 117 km of coastline will be affected via deposition of weathered condensate. There is a potential for contamination of unknown or undiscovered archaeological features; much less likely is the potential for direct damage to such features during spill response and cleanup activities. If condensate should come into contact with wooden shipwrecks on the seafloor, it could adversely affect their condition or preservation (U.S. Bureau of Ocean Energy Management, 2012). Overall impact significance to archaeological resources from a condensate spill is low.

4.3.2 Large Diesel Fuel Spill

4.3.2.1 Model Results

The second non-routine event examined is for an instantaneous discharge of 16,500 bbl of diesel fuel from the drilling rig from the Tamar SW-1 exploration well. The results of the modeling for this event are presented in **Table 4-6.** The tabular data include percent evaporated, percent of oil on the sea surface, percent dispersed, and percent deposited on the coast. The table also provides estimates of the time required to initially reach the shoreline, the length of shoreline affected, impact hotspots, and relative oiling concentration.

Table 4-6. Trajectory and weathering model results for an instantaneous discharge of 16,500 bbl of diesel fuel from the drilling rig from the Tamar SW-1 Exploration Well for the four environmental scenarios at the end of 30 days.

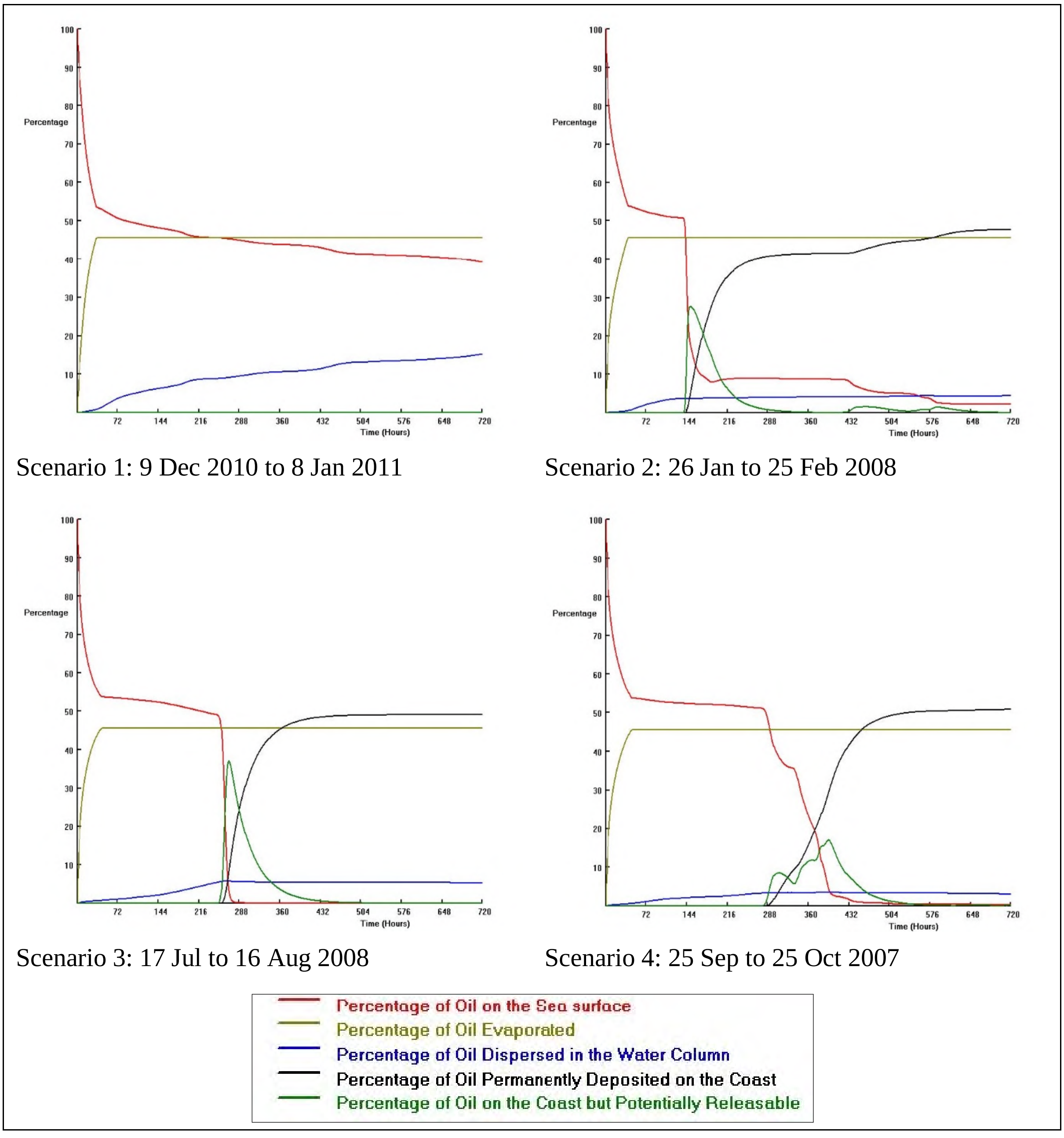
Scenario	Percent Evaporated	Percent Oil on Sea Surface	Percent Dispersed	Percent Deposited on Coast	Days Until Initial Shoreline Impact	Length of Coastline Affected (km)	Coastline Affected	Impact Hotspot	Oiling Concentration (bbl/km)
1	45.6	39.1	15	0.014	N/A	2.9	Lebanon	Sidoh, Lebanon	2.3 bbl total
2	45.6	2.2	4.4	47.7	6	234	Israel and Lebanon	Sidoh, Lebanon	100 to 1,200
3	45.6	0	5.3	49.1	11	56.4	Israel and Lebanon	Jieh, Lebanon	200 to 1,800
4	45.6	0.34	3	50.9	12	148	Israel and Lebanon	Haifa Bay, Israel	200 to 900

N/A = not applicable.

For the instantaneous discharge of diesel fuel, the model predicts that diesel fuel would evaporate and disperse rapidly, with approximately 45% of the spill evaporating in the first 46 hours (or less) in the four scenarios. **Figure 4-5** show the percentages of oil: 1) on the sea surface; 2) evaporated; 3) dispersed (into the water column); 4) deposited on the coast; and 5) deposited on the coast but potentially releasable for the four scenarios. Shoreline impacts occur as early as 6 days after discharge. At the end of 30 days, all four scenarios show 45.6% evaporation, from 0.0% to approximately 39% oil remaining on the sea surface, and up to 15% dispersed. The percent of diesel fuel deposited on the coastline ranges from 0.014% to 50.9% with impacts to the coastline of Israel and Lebanon. Total length of impacted shoreline ranges from 2.9 to 234 km. Impact hotspots in Israel are Haifa Bay, Jieh, and Sidoh. In all but one scenario (Scenario 1), the Israel coastline is impacted from the border of Lebanon to an area just north of Haifa. Two of the scenarios impact areas farther south of Haifa (Scenarios 2 and 4), with a single scenario impacting the coastline south of Tel Aviv (Scenario 2). **Figure 4-6** shows the extent and concentration of condensate deposited on the coast for the four scenarios.

Scenario 1 resulted in the lowest percent of diesel fuel deposited on the coastline (0.014% over 2.9 km), with the majority occurring outside of Israel's waters. Scenario 2 resulted in 47.7% of diesel fuel being deposited on 234 km of coastline from Tel Aviv to north of the border with Lebanon; however, most of the Israel coastline will see concentrations less than 10 bbl/km. Scenario 3 resulted in 49.1% of diesel fuel being deposited on 56.4 km of coastline; however, again, the majority occurs outside of Israel. The worst case scenario is Scenario 4, which resulted in 50.9% of the diesel fuel being deposited on the coastline starting within 12 days of release; by comparison, condensate reached the shoreline most quickly (i.e., in 6 days) under Scenario 2. Scenario 4 resulted in impacts to 148 km of coastline extending from Zichron Yaakov to north of the border with Lebanon. The most adversely affected area of the Israel coastline was projected to be Haifa Bay and the northern coast of Israel, where concentrations could exceed 900 bbl/km.

The results for the worst case diesel fuel spill scenario indicate that diesel fuel release from the Tamar SW-1 exploration well would affect both offshore and coastal resources to varying extents depending on the environmental conditions. Overall, coastal impacts to Israel could occur over approximately 60 km, from Zichron Yaakov northward to the Lebanon border.



Scenario 1: 9 Dec 2010 to 8 Jan 2011

Scenario 2: 26 Jan to 25 Feb 2008

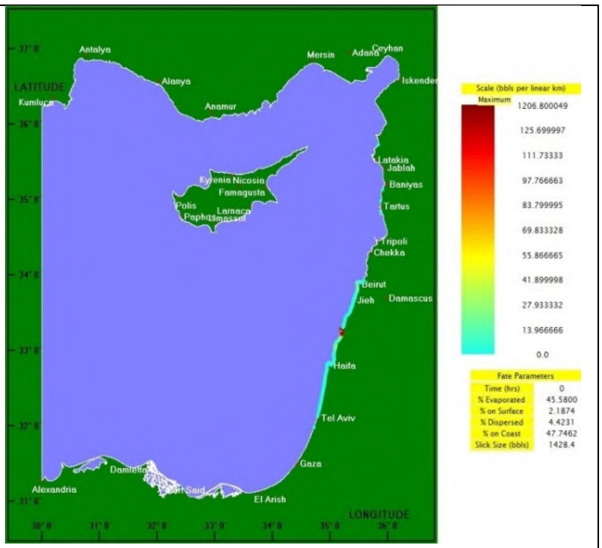
Scenario 3: 17 Jul to 16 Aug 2008

Scenario 4: 25 Sep to 25 Oct 2007

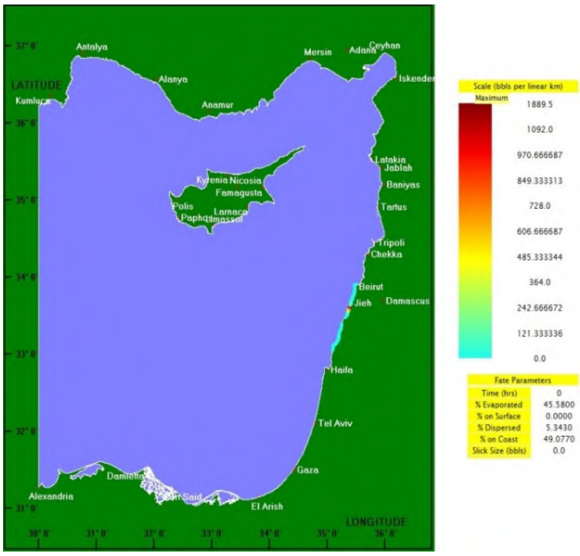
Figure 4-5. Oil fate parameters for the instantaneous diesel fuel spill at Tamar SW-1 exploration well for four different time periods representing various climatic conditions.

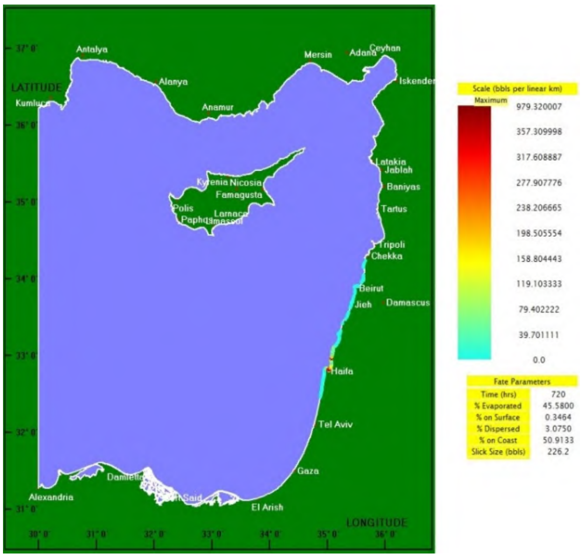
No figure provided in modeling report.

Scenario1: 9 Dec 2010 to 8 Jan 2011



Scenario 2: 26 Jan to 25 Feb 2008





Scenario 3: 17 Jul to 16 Aug 2008

Scenario 4: 25 Sep to 25 Oct 2007

Figure 4-6. Total amounts of diesel fuel deposited on the coast at the end of 30 days after an instantaneous discharge at Tamar SW-1 exploration well for four different time periods representing various climatic conditions.

4.3.2.2 Air Quality

A diesel fuel release would affect air quality in the vicinity of the oil slick by introducing VOCs through evaporation. Emissions would not last long due to rapid volatilization of hydrocarbons. Evaporation is greatest within the first 24 hours. The more toxic, light aromatic and aliphatic hydrocarbons are lost rapidly by evaporation and dissolution (National Research Council, 1985; Payne et al., 1987). Evaporated hydrocarbons are degraded rapidly by sunlight. Biodegradation of diesel fuel on the water surface and in the water column by marine bacteria and fungi initially removes the n-alkanes and subsequently the light aromatics. Other components are biodegraded more slowly. Photo-oxidation attacks mainly the medium and high molecular weight PAHs of a diesel release.

The extent and persistence of impacts would depend on meteorological and oceanographic conditions at the time. Little or no impact on air quality in coastal areas would be expected due to the distance of the Tamar Field from shore and the degree of weathering expected. Impact consequence to offshore air quality would be short term (due to rapid evaporation) but moderate. Overall impact significance would range from negligible to low.

4.3.2.3 Sediment/Sediment Quality; Water Quality

A diesel fuel release would affect marine water quality by increasing hydrocarbon concentrations due to dissolved components and small oil droplets. Natural weathering processes are expected to rapidly remove the diesel fuel from the water column and dilute the constituents to background levels. Diesel releases are unlikely to affect sediment quality offshore, but may be expected to be carried into shallow water under certain meteorological and oceanographic conditions. Impact consequences are variable, ranging from negligible to moderate. Overall impact significance ranges from negligible to low.

4.3.2.4 Plankton, Fish, and Fishery Resources

A diesel fuel release could affect phytoplankton and zooplankton because they do not have the ability to avoid contact with oil. Planktonic communities drift with water currents and recolonize from adjacent areas. Because of these attributes and their short life cycles, plankton usually recover relatively rapidly to normal population levels following disturbances.

While adult and juvenile fishes may actively avoid a large diesel release, planktonic fish eggs and larvae would be unable to avoid contact. Eggs and larvae of fishes will die if exposed to certain toxic fractions of diesel fuel. Most fishes inhabiting oceanic waters have planktonic eggs and larvae. However, due to the wide dispersal of early life history stages of fishes, a diesel release would not be expected to have significant impacts at the population level. In the event of a large diesel release, fishing activities near the project area could be disrupted temporarily. The area affected would be moderate in size, and the duration presumably would extend beyond 30 days. Impact consequence ranges from minor to moderate. Overall impact significance ranges from negligible to low.

4.3.2.5 Benthic Communities

A diesel fuel release in surface waters would have no impact on benthic communities. Diesel is unlikely to reach the seafloor, especially at the water depth of the Tamar Field wells. A diesel fuel release transported into nearshore waters will have undergone evaporation, leaving heavier, less volatile hydrocarbon components. Weathered diesel fuel reaching shore will affect beach and subtidal sediments as well as associated benthic communities. As the diesel fuel release moves toward land, it will contact nearshore sediments, resulting in increased hydrocarbon concentrations in nearshore waters and possible adhesion to suspended sediments with subsequent sinking, with the potential to affect benthic organisms. Impact consequence is moderate. Overall impact significance is low.

4.3.2.6 Marine Mammals and Sea Turtles

Diesel fuel may affect marine mammals through various pathways: direct contact, inhalation of volatile components, ingestion (directly or indirectly through the consumption of fouled prey species), and (for mysticetes) impairment of feeding by fouling of baleen (Geraci and St. Aubin, 1987, 1988, 1990; Loughlin et al., 1996). Cetacean skin is highly impermeable and is not seriously irritated by brief exposure to diesel fuel; direct contact is not likely to produce a significant impact. Whales and dolphins apparently can detect slicks on the sea surface but do not always avoid them; therefore, they may be vulnerable to inhalation of hydrocarbon vapors, particularly those components of diesel fuel that are readily evaporated.

Ingestion of the lighter hydrocarbon fractions found in diesel fuel can be toxic to marine mammals. Ingested diesel fuel can remain within the gastrointestinal tract and be absorbed into the bloodstream, irritating and/or destroying epithelial cells in the stomach and intestines. Certain constituents of diesel fuel (i.e., aromatic hydrocarbons, PAHs) include some well-known carcinogens. These substances, however, do not show significant biomagnification in food chains and are readily metabolized by many organisms. Additionally, released diesel fuel may foul the baleen fibers of mysticetes, thereby impairing food-gathering efficiency or result in the ingestion of diesel fuel or diesel fuel-contaminated prey.

Diesel fuel in the marine environment may affect sea turtles through various pathways: direct contact, inhalation of diesel fuel and its volatile components, ingestion of diesel fuel (directly or indirectly through the consumption of fouled prey species), and ingestion of floating tar (Geraci and St. Aubin, 1987). Several aspects of sea turtle biology and behavior place them at risk, including lack of avoidance behavior, indiscriminate feeding in convergence zones, and inhalation of large volumes of air before dives (Milton et al., 2003). Studies have shown that direct exposure of sensitive tissues (e.g., eyes, nares, other mucous membranes) to diesel fuel or volatile hydrocarbons may produce irritation and inflammation. Diesel fuel can adhere to sea turtle skin or shells. Sea turtles surfacing within or near a diesel release would be expected to inhale petroleum vapors. Ingested diesel fuel, particularly the lighter fractions, can be toxic to sea turtles. Hatchling and juvenile sea turtles feed opportunistically at or near the surface in oceanic waters and are especially sensitive to released hydrocarbons (including diesel fuel).

Overall impact significance of a diesel fuel spill on marine mammals and sea turtles is negligible to low, based on the low probability of the impact occurring and the low to medium consequence of the impact.

4.3.2.7 Marine and Coastal Birds

Direct contact of marine birds with diesel fuel may result in the fouling or matting of feathers with subsequent limitation or loss of flight capability or insulating or water-repellent capabilities; irritation or inflammation of skin or sensitive tissues, such as eyes and other mucous membranes; or toxic effects from ingested diesel fuel or the inhalation of diesel and its volatile components. Although individual birds may be oiled during an accidental release offshore, such impacts are unlikely to affect marine and coastal birds at a population level.

The impacts of a diesel fuel release on marine and coastal birds present along the coast are expected to be medium because the area affected would be cover 60 km of shoreline, potentially impacting feeding and nesting sites. Due to the physical/chemical properties of the diesel fuel, toxicity would be the main concern rather than fouling of these animals. It is unlikely that large numbers of birds would be exposed to the diesel fuel offshore; however, significant impacts could occur along the coastline. Depending upon the season (e.g., during high migratory periods; following fledgling of young birds), impacts at the population level are possible. Of greatest concern are bird species whose populations are currently at risk. Overall impact significance to marine and coastal birds from a diesel spill is low due to the medium consequence and remote probability.

4.3.2.8 Protected Marine Species and Habitats, Marine Habitats of Interest, and Areas of Special Concern

The worst case scenario for this analysis impacts a coastal area greater than 60 km in length, exposing the shoreline to concentrations of condensate ranging from 20 to more than 900 bbl/km (**Figure 4-6**). Most of the shoreline consists of long, sandy beaches with changing landscapes (sandstone, dunes, low shrub land). There are extensive swimming beaches used for recreation, and sea turtle nesting has been recorded also. Designated protected marine or marine-terrestrial habitats along the Mediterranean coast of Israel, including those listed by the IUCN are summarized in **Table 4-5**.

While there is extensive literature about impacts of crude oil spills on coastal habitats, relatively little has been published about diesel fuel spill impacts. Results of diesel fuel exposure are considered to be similar to condensate exposure. As noted previously, Lucas and Freeman (1989) observed a temporary herbicidal effect following the spraying of condensate onto beach grasses; roots were unaffected and the plants recovered substantially by the next growing season.

Because most of the Israeli shoreline consists of beaches, persistent contamination and severe ecological impacts found within estuarine environments following an oil spill are not expected. Light oils such as diesel are expected to leave a film on intertidal resources and have the potential to cause persistent contamination. Oil can be directly toxic to marine invertebrates or may affect them through physical smothering, altering metabolic and feeding rates, and altering shell formation. These toxic effects can be acute (lethal) or chronic (sublethal). While intertidal benthic invertebrates may be especially vulnerable if oil becomes highly concentrated along the shoreline, concentrated diesel fuel accumulations are not expected.

Sediments may become reservoirs for spilled diesel, depending upon substrate type and how far into the sediments diesel may penetrate. While some benthic invertebrates can survive oil exposure, they may accumulate high body burdens of oil-based contaminants. Marine algae exhibit variable responses to oiling. Algae may die or become more abundant in response to oil exposure. Although oil can prevent the germination and growth of marine plants, most vegetation appears to recover after clean up. Under the worst case scenario where significant amounts of spilled diesel may accumulate and remain, shifts in population structure, species abundance and diversity, and distribution may result. Habitat loss and the loss of prey items also have the potential to affect fish and wildlife populations.

Given the likelihood of a diesel spill, the time required for it to reach the coast, the relative amounts of diesel that may be expected to reach the shoreline, and the nature of each coastal segment, the overall impact significance to coastal habitats from a diesel fuel spill is low.

4.3.2.9 Fishing and Marine Farming; Shipping and Maritime Industry

A diesel spill would temporarily disrupt fishing, shipping, and maritime industry activities because of the hydrocarbon slick and oil spill response activities. While the spill response area (based on surface waters affected) would be relatively large, the expected duration of spill response activities would be relatively brief. The volume of the spill remaining will be reduced significantly through evaporation (i.e., approximately 50% of the diesel fuel will evaporate within 3 days). Impacts to fishing activities would occur initially within offshore waters near the release site, then along 60 km of the coastline approximately 12 days after release. Resulting impacts would require exclusion from the area while the spill was offshore. Shoreline impacts would include exclusion from the area and oiling of fish ponds and cages, resulting in moderate impacts. Overall impact significance to fishing, shipping, and maritime industry activities from a diesel fuel spill is low due to the small amount of such activity in the project area.

4.3.2.10 Recreation and Aesthetics/Tourism

A 60-km stretch of coastline from south of Zichron Yaakov to the Israel/Lebanon border could be affected under the worst case scenario diesel fuel spill (**Figure 4-6**). Shoreline segments around Haifa Bay could realize the highest levels of diesel fuel deposition. There also are several coastal villages located between Haifa and the Israel/Lebanon border. These areas serve coastal and marine-related tourism with lodging, restaurants, and other facilities. Lodging in the cities is mainly based on large hotels approved by the Ministry of Tourism. The main tourist attractions along the coast of Israel are bathing beaches, heritage sites, archaeological sites, nature reserves, and national parks. Tourism and recreation in the nearshore waters and on the coast of Israel are spread along the coast from north to south. In nearshore waters, tourism is based mainly on marine sporting activities and recreation. Water sports include diving, surfing, and sailing.

Impacts on recreational activities and resources are expected, given that 60 km of coastline will realize some level of diesel fuel deposition, resulting in temporary exclusion from these areas due to oil spill response and cleanup activities. Beaches may be contaminated where concentrations are great enough to require clean up to restore the affected areas.

Impact consequence ranges from low to medium, depending on season and predicted landfall. Overall impact significance to recreation and aesthetics/tourism ranges from negligible to low.

4.3.2.11 Archaeological Resources

Archaeological resources such as historic, prehistoric, and cultural sites occur onshore and buried in the seafloor offshore. Underwater archaeological remains can include submerged prehistoric settlements, coastal settlements, shipwrecks, ports and anchorages, and rock-cut installations on the coastline.

For the worst case scenario diesel fuel spill, nearshore waters and 60 km of coastline will be affected. There is potential for contamination of unknown or undiscovered archaeological features, and archeological resources could be damaged during spill response and cleanup activities. If diesel fuel should come into contact with wooden shipwrecks on the seafloor, it could adversely affect their condition or preservation (U.S. Bureau of Ocean Energy Management, 2012). Protective measures would take priority at significant coastal heritage and historic sites in the event of a spill near these sites. Overall impact significance to archaeological resources from a diesel fuel spill is low.

4.3.3 Response Costs Associated with Potential Non-Routine Events

The costs associated with oil spills were estimated by Dr. Steve Brenner of Bar-Ilan University (CSA Ocean Sciences Inc., 2013d). The estimated costs are strongly influenced by multiple factors such as the type and quantity of product spilled; response methodology and effectiveness; location and timing of the spill; affected habitat types, including sensitive areas; wildlife affected; liability limits in place; local and national laws; and cleanup strategy (Grigalunas et al., 1986; Etkin, 1998a,b, 1999, 2000, 2001a,b, 2003a,b, 2004a,b; White and Molloy, 2003; Kontovas and Psaraftis, 2008; International Tanker Owners Pollution Federation, 2013). No two spills are identical, and impacts are more diverse than the spills themselves.

The following calculations based on Etkin (2000, 2001a) are presented as an initial approximation. Etkin (2000, 2001a) did not specifically analyze a condensate spill, but data for No. 2 diesel fuel and light crude oil are used as an approximations. Etkin (2000, 2001a) proposed the following equation for estimating the cost of spill response:

- $C_{ui} = C_{li}\ t_i\ o_i\ m_i\ s_i$
- and $C_{li} = r_i\ l_i\ C_n$
- and $C_{ei} = C_{ui}\ A_i$

Where:

- C_{ui} = response cost per unit for scenario i;
- C_{li} = cost per unit spilled for scenario i;
- C_n = general cost per unit spilled in nation n;
- C_{ei} = estimated total response cost for scenario i;
- t_i = oil type modifier factor for scenario i;
- o_i = shoreline oiling modifier factor for scenario i;
- m_i = cleanup methodology modifier factor for scenario i;
- s_i = spill size modifier factor for scenario i;
- r_i = regional location modifier factor for scenario i;
- l_i = local location modifier for scenario i; and
- A_i = specified spill amount for scenario i.

For this calculation:

- C_n for Israel = $2,313.60/MT (in 1999 U.S. dollars) (Etkin, 2000);
- l_i = 1.46 for a nearshore spill;
- r_i = 1.00 for regional factor;
- t_i = 0.18 for diesel fuel; 0.32 for light crude oil (as a proxy for condensate)
- o_i = 0.61 for 20 to 90 km of shoreline oiling (a conservative estimate for impacts to the Israel coastline);
- m_i = 0.46 for dispersants as the primary response method;
- m_i = 0.92 for mechanical clean up as the primary response method;
- s_i = 0.27 for spill size 340 to 1,700 MT (actual size for diesel fuel is 1,117 MT); and
- s_i = 0.15 for spill size 1,700 to 3,400 MT (actual size for condensate is 2,557 MT).

Based on these figures, the response cost per unit spilled (C_{ui}) is approximately: 1) $46/MT for dispersants as the primary response method for condensate; 2) $91/MT for mechanical clean up as the primary response method for condensate; 3) $646/MT for dispersants as the primary response method for diesel fuel; and 4) $92/MT for mechanical clean up as the primary response method for diesel fuel. Multiplying by the amounts specified in the two worst case spill scenarios yields the cost estimates listed in **Table 4-7**.

Table 4-7. Spill response cost estimates in 1999 U.S. dollars for two worst case discharge scenarios. Calculations are based on equations presented by Etkin (2000, 2001a).

Worst Case Scenario	Amount		Primary Response Method (Cost)	
	Barrels	Metric Tons	Dispersants	Mechanical Recovery
Condensate	18,799	2,557	$116,317	$232,635
Diesel Fuel	8,398	1,117	$51,454	$102,908

The estimated costs range from $51,454 to $232,635 in 1999 U.S. dollars. Dividing by a factor of 0.726 to account for inflation (Oregon State University, 2013), these costs convert to $70,873 to $320,434 in 2012 U.S. dollars. Finally, these figures can be converted to approximately 250,890 to 1,134,336 Israeli New Shekels (ILS).

These estimates are considered to be reasonable based on the quantities and physical/chemical characteristics of the condensate/diesel fuel. In both worst case scenarios as discussed in **Sections 4.3.1** and **4.3.2**, the impacts would occur to resources in offshore waters, nearshore waters, and to the coastline. However, in each scenario, coastline impacts tend to be concentrated outside of Israel. It is expected that impacts would occur within 1 to 2 weeks of initial release. Most areas affected, and several specific resources at risk (e.g., oiled birds, oiled heritage sites), would require clean up and restoration in order to recover, particularly on the shoreline.

4.3.4 Solid Waste (Accidental Loss)

The disposal of solid waste from any vessel into the sea is prohibited under MARPOL regulations. Solid waste will be containerized and/or palletized and shipped to shore for proper disposal. However, the accidental loss of solid waste from the drillship or support vessels has the potential to adversely affect several marine resources. Ingestion of, or entanglement with, floating debris accidentally discarded into the marine environment can have a negative impact on marine mammals, sea turtles, and marine and coastal birds, or may be transported to shore where it could affect coastal habitats. Debris sinking to the seafloor can affect benthic communities. Each of these resources is evaluated in the following subsections.

4.3.4.1 Sediments/Sediment Quality

Heavy items such as welding rods, buckets, pieces of pipe, etc. may accidentally fall overboard from a drilling unit and accumulate on the seafloor. These may have a minor, localized impact on sediment quality beneath the rig location by creating small areas of hard substrate on the soft bottom seafloor (Shinn et al., 1993; Gallaway et al., 2008). The area affected would be negligible in relation to the seafloor area in the Tamar Field.

4.3.4.2 Water Quality

Lighter pieces of debris may float on the sea surface and adversely affect water quality and marine biota (National Research Council, 2008; National Oceanic and Atmospheric Administration, National Ocean Service, 2013). The potential impacts on water quality from marine debris are expected to be negligible and similar to those from the existing shipping and fishing industries.

4.3.4.3 Benthic Communities

The occasional and accidental loss of debris (e.g., welding rods, buckets, pieces of pipe, etc.) will result in an accumulation on the seafloor. Pieces of debris reaching the seafloor may be colonized by epibiota and attract fishes (due to their physical structure on the otherwise flat seafloor), with a corresponding minor and localized impact to the benthic community (Shinn et al., 1993). Depending on the nature of solid waste, leaching of organics or trace metals may occur, resulting in localized changes in sediment quality. Due to the restrictions on dumping and expected adherence to applicable MARPOL provisions, this impact is anticipated to be minor. Given the likely nature of this impact, overall impact significance is anticipated to be negligible.

4.3.4.4 Marine Mammals and Sea Turtles; Marine and Coastal Birds

Materials accidentally lost overboard during offshore oil and gas operations could 1) entangle marine fauna or 2) cause injury through the ingestion of trash and debris (Laist, 1996). Marine debris is among the threats affecting the population status of both humpback and sperm whales (National Marine Fisheries Service, 1991, 2006). Similarly, ingestion of or entanglement with accidentally discarded debris can kill or injure sea turtles (Laist, 1996; Lutcavage et al., 1997). Marine debris is among the threats affecting the endangered population status of several sea turtle species (National Research Council, 1990). Leatherback turtles are especially attracted to floating debris, particularly plastic bags because they resemble their preferred food: jellyfish. Ingestion of plastic and Styrofoam can result in drowning, lacerations, digestive disorders or blockage, and reduced mobility. Marine debris can also have a negative impact on birds that ingest or become entangled in it.

Impacts on these resources are expected to be low to medium, with a rare to occasional likelihood. As a result, overall impact significance ranges from negligible to medium and is considered low from an overall standpoint.

4.3.4.5 Protected Marine Species and Habitats, Marine Habitats of Interest, and Areas of Special Concern

Surface currents to shore may carry floating debris accidentally lost overboard. Debris accidentally lost overboard, should it reach shore, will produce minor impacts on coastal habitats, including areas where protected marine species and habitats/marine habitats of interest and areas of special concern. Given the occasional nature of this impact, overall impact significance is low.

4.3.4.6 Recreation and Aesthetics/Tourism

Floating marine debris may be carried by surface currents to shore. Debris accidentally lost overboard, should it reach shore, would produce aesthetic impacts and require cleanup. Waste from the offshore oil and gas industry has historically contributed to marine debris on beaches and other shorelines (National Research Council, 2008; U.S. Bureau of Ocean Energy Management, 2012). Due to the distance from shore, it is highly unlikely that floating debris would contact any shorelines in sufficient quantities to affect recreation and tourism and overall impact significance is negligible.

4.4 LIGHT HAZARDS

Potential impacts from lighting on the vessels and drillship associated with the Tamar Expansion Project may affect the resources identified in **Table 4-3**, which included:

- Sea turtles; and
- Marine and coastal birds.

The potential impacts of light from the proposed project are discussed in the following sections. Due to the period of time between projects in the Tamar Field and the minor footprint of the platform, cumulative impacts are anticipated to be negligible.

4.4.1 Sea Turtles

Some sea turtles may be attracted to offshore structures (Rosman et al., 1987; Lohoefener et al., 1990). It has been suggested that sea turtle hatchlings could be attracted to brightly lighted offshore structures, including drillships and platforms, where they may be subject to increased predation by birds and fishes (National Marine Fisheries Service, 2001).

The presence of the drillship lights will be a new light source in the study area; however, the drillship will only be on site for a relatively short period of time (i.e., several months). Impacts on sea turtle populations are likely to be limited, if they occur, to only a few individuals; no population-level impacts are expected. In the Gulf of Mexico, where thousands of offshore structures are present, platform lighting is considered unlikely to appreciably reduce the reproduction, numbers, or distribution of sea turtles (National Marine Fisheries Service, 2001).

Due to the duration of exploratory drilling operations, this impact is anticipated to be minor. Overall impact significance of lighting on sea turtles is low.

4.4.2 Marine and Coastal Birds

The potential causes for the well-documented attraction of seabirds to structures at sea include attraction to lights and the structure itself (Wolfson et al., 1979; Tasker et al., 1986; Baird, 1990; Wiese et al., 2001), as well as to the increased concentration of food sources around the structure (Baird, 1990; Montevecchi et al., 1999). Seabirds use mostly optical cues for migrating between breeding and wintering areas; navigation aids include internal maps, sunlight and sunrise/sunset cues, starlight and celestial navigation, topography, and an internal magnetic compass (Greer et al., 2010). Birds migrating through an environment which is otherwise flat and very dark at night find offshore structures an attractive visual cue. It should be noted that visibility is important in itself, to prevent collisions.

The presence of offshore structures has both a positive and negative impact on birds. The presence of offshore structures, whether permanent (e.g., platforms) or temporary (e.g., drillships, support vessels) may have an effect on bird life both as an attractant as well as a harmful agent (Baird, 1990; Montevecchi et al., 1999; Fraser et al., 2006). Some birds may be attracted to offshore structures because of the lights, as well as the fish populations that aggregate around these structures.

Particularly sensitive species would be petrels and other procellariforms that forage on vertically migrating bioluminescent prey.

Birds may use offshore structures for resting, feeding, or as temporary shelter from inclement weather (Russell, 2005). However, birds migrating over water at night have been known to strike offshore structures, resulting in death or injury (Wiese et al., 2001; Russell, 2005).

While the bulk of the bird migration over Israel occurs inland, the edge of the migration routes passes over the nearshore portions of the eastern Mediterranean Sea. The radius of the bird monitoring radar located in Latrun, Israel, reaches to approximately 30 km off the shoreline and regularly detects activity up to its margin (Birding Israel, 2013). The bird migration period extends from March to the end of May and from August to the end of November.

Because of the distance between the Tamar Field and shore, it is expected that the project vessels will not be visible to migrating birds that routinely migrate along or near the coast. Consequently, the presence of the project vessels is expected to have a negligible impact on marine (seabirds or migratory) birds. Given the likely nature of this impact, overall impact significance is negligible.

4.5 NOISE IMPACTS

Potential impacts from the Tamar Expansion Project and their associated noise, as identified in **Table 4-3**, may affect:

- marine mammals;
- sea turtles; and
- recreation and aesthetics/tourism.

Expected noise levels from various project sources were identified in **Chapter 3**. Salient characteristics of representative noise sources as they apply to proposed operations include the following:

- Most man-made noise associated with offshore oil and gas drilling operations or support activities are in the low frequency bands (<500 to 1,000 Hz).
- Propeller cavitation, propeller singing, and propulsion machinery are primary noise sources for vessels (regardless of size).
- Drillships (and jack-up drilling rigs) produce sound levels that generally are higher than other drilling vessels (e.g., semi-submersibles) due to the sounds generated through the vessel’s hull or cantilever legs. Noise from a DP drillship would originate primarily from DP thrusters use (for stationkeeping) and machinery (e.g., generators).
- Sound source levels for a drillship are in the range of 184 to 190 dB re 1 µPa at 1 m, depending on activity.
- Supply and crew boats produce sound source levels in the range of 128 to 158 dB re 1 µPa at 1 m; these sound sources are considered transient as they move between the shore base and the drillship; sound from the standby vessel will be at a lower source level while idling on station.
- Underwater sounds from helicopters, as with all aircrafts, reach their highest levels just below the surface and directly under the aircraft. When the aircraft is overhead, sound levels decrease with increasing aircraft altitude or increasing receiver depth. The highest energy of helicopter rotor sound is at frequencies <500 Hz, while helicopter turbines contribute to higher sound levels at frequencies >500 Hz.
- Transmission of airborne sound into the water is a function of source altitude, orientation (e.g., <26° maximizes sound penetration into the water column), receiver water depth and orientation, and sea surface conditions.

Sound emanating from the drillship can be expected to be continuous and variable, with source level fluctuations depending upon activity level. During drilling, source levels are expected to be approximately 184 dB re 1 µPa at 1 m, while during maintenance, source levels are expected to be approximately 190 dB re 1 µPa at 1 m. Maintenance activities include maintaining station, setting of casing, and cementing. Most sound energy will occur in the low frequency bands. Kyhn et al. (2011) measured drillship noise ranging from 20 Hz to >10 kHz, with clearly discernible peaks below 500 Hz noted during drilling. During maintenance, levels were elevated from 20 Hz to well above 10 kHz, with clearly detectable measurements also evident between 20 and 35 kHz at close range to the drillship. The higher frequency sound components were generated as part of the dynamic positioning of the *Stena Forth* and attributed to transponder use. As noise from the vessel thrusters used during dynamic positioning represents the major source of noise from the drillship, there are differences in sound levels emanating from the vessel between drilling and non-drilling periods. In addition to the thrusters, sound sources include diesel generators, cranes, and crew activity aboard the drillship.

Supply vessels in transit to and from the drillship will produce transient sounds in the 128 to 158 dB re 1 µPa at 1 m range, with predominant low frequency components. If a supply vessel remains on standby (idles) at the drillship, it will produce lower, but continuous sound levels. In similar fashion, transient helicopter visits to the drillship will produce predominantly low-frequency sound source levels of 162 dB re 1 µPa at 1 m, with highest sound levels to be experienced directly below the aircraft.

The Tamar projects have been separated by periods of months to years, making the potential for cumulative impacts very low.

4.5.1 Marine Mammals

Some marine mammals may avoid the project area due to noise associated with drilling operations. Others might be attracted to fish populations around the drillship. The most likely impacts would be short-term behavioral changes such as diving and evasive swimming, disruption of activities, or departure from the area. As resident marine mammals become accustomed to the operation noise, they will return to their routine behavior patterns.

Richardson et al. (1995) defined four zones of potential noise effects on marine mammals. In order of increasing severity, they are 1) audibility; 2) responsiveness (behavioral effects); 3) masking; and 4) hearing loss, discomfort, or injury (physical effects). The levels of sound produced during operations aboard the drillship are sufficient to be audible and to produce behavioral responses, but much lower than those known to cause hearing loss, discomfort, or injury.

Low-frequency noise from engines and equipment, including the drilling rotary table, aboard the *Atwood Advantage* can be detected by marine mammals (Richardson et al., 1995). Mysticetes (baleen whales such as the humpback, minke, and Bryde’s whales) are more likely to detect low-frequency sounds than are most odontocetes (toothed whales and dolphins), which have their best hearing in high frequencies. Because of recent, ongoing drilling and installation (i.e., subsea completions, pipelines) operations in the region, marine mammals in the area may have become acclimated to oil and gas operations, vessel transits, and related noise.

Drillship noise will be continuous and of moderate intensity, estimated to be in the range of 184 to 190 dB re 1 µPa. Some of the noise (from support vessel engines and propellers) will be similar to the existing noise associated with shipping traffic in the region, in the range of 128 to 158 dB re 1 µPa.

No absolute sound exposure thresholds exist for marine mammals on a worldwide basis, and few countries have established exposure criteria. Since 1997, the U.S. National Marine Fisheries Service has used generic sound exposure thresholds, based on sound pressure levels (SPLs) expressed in root mean square (rms) metrics, to determine when an activity in the ocean that produces sound might result in impacts to a marine mammal such that a take by harassment might occur. Take, as defined under the U.S. Marine Mammal Protection Act, means “to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill" any marine mammal. Harassment, as defined under the Marine Mammal Protection Act, includes two levels: Level A and Level B harassment. Level A harassment is any act which has the potential to injure a marine mammal or marine mammal stock in the wild. Level B harassment is any act, which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, but does not have the potential to injure a marine mammal or marine mammal stock in the wild. To date, few studies have been conducted that examine impacts to marine mammals from continuous sound (e.g., from drilling) from which empirical sound thresholds have been established.

National Marine Fisheries Service (2013) practice regarding exposure of marine mammals to sound has been based on cetaceans. Cetaceans and pinnipeds exposed to sound pressure levels of 180 and 190 dB re 1 µPa rms or above, respectively, are considered to have been taken by Level A (i.e., injurious) harassment. Thresholds for behavioral response from impulse sounds are 160 dB rms (received level) for all marine mammals, based on behavioral response data for marine mammals exposed to seismic airgun operations (Malme et al., 1983, 1984; Richardson et al., 1986); this threshold is not applicable in the current context.

Behavioral harassment (Level B) is considered to have occurred when marine mammals are exposed to sounds at or above 120 dB rms for continuous sound, but below injurious thresholds; thresholds for behavioral response for "continuous" (non-impulsive) sounds, considered within an SPL context, have been set at 120 dB rms (for some but not all sound sources) based on the results of Malme et al. (1984) and Richardson et al. (1990). Different exposure levels have been established for pinnipeds exposed to airborne sound (i.e., 100 dB [unweighted] for pinnipeds in general; 90 dB [unweighted] for harbor seals), specifically as they pertain to pinniped disturbance (e.g., from haul-outs); these latter exposure criteria are not applicable in this context, as no pinniped or pinniped haul-outs occur near the Tamar Field. Under previous criteria, the applicable exposure threshold for drilling operations is 180 dB re 1 µPa (rms) for injury and 120 dB re 1 µPa (rms) for behavioral disturbance, using the SPL metric.

NOAA recently (December 2013) issued new acoustic exposure guidelines (National Marine Fisheries Service, 2013). While currently in the review and comment stage and not yet finalized, new acoustic exposure criteria, in general, consider two metrics upon which to assess potential for impact – peak SPL and cumulative sound exposure level (SEL_{cum}). However, sound exposure containing transient components (e.g., short duration and high amplitude; impulsive sounds) can create a greater risk of causing direct mechanical fatigue (as opposed to strictly metabolic) to the inner ear compared to sounds that are strictly non-impulsive (Henderson and Hamernik, 1986; Levine et al., 1998; Henderson et al., 2008). NOAA noted that the risk of damage from these transients often does not depend on the duration of exposure (e.g., concept of "critical level," where damage switches from being primarily metabolic to more mechanical; short duration of impulse can be less than the ear's integration time, leading to the potential to damage beyond the level the ear can perceive). Thus, the cumulative sound exposure level is not an appropriate metric to capture these effects.

Support vessel sound sources are below the threshold for injury (i.e., only the potential for behavioral response exists). Only DP thruster noise from a DP drillship exceeds the 180 dB threshold for injury. All project sound sources have the potential to produce behavioral response. The calculated distances from each source to the thresholds for injury and behavioral response are provided in **Table 4-8**.

The degree to which underwater sound propagates away from a sound source is dependent on a variety of factors, the most important of which are bathymetry and presence or absence of reflective or absorptive conditions (e.g., in-water structures, sediments). Spherical spreading occurs in a perfectly unobstructed (i.e., free-field) environment not limited by depth or water surface, resulting in a 6 dB reduction in sound level for each doubling of distance from the source (20log[range]). Because the drillship used for the Tamar projects will be operating in open ocean conditions, spherical spreading criteria are most appropriate to calculate distances to threshold.

Table 4-8. Sound sources associated with the drilling program and calculated distances to the applicable exposure threshold for injury and behavioral response.

Sound Source	Source Levels (dB re 1 µPa at 1 m)	Applicable Sound Exposure Threshold (dB re 1 µPa rms) – Injury	Applicable Sound Exposure Threshold (dB re 1 µPa rms) – Behavioral Response	Distance from Source to Threshold (m)	
				Injury	Behavior
Continuous Sound Sources					
Drilling and Maintenance					
Drillship	184-190	180	120	1.6-3.2	1,585-3,162
Transient Sound Sources					
Vessels Underway					
Supply Vessel	128-158	180	120	0	2.5-74.9
Crew Boat	156	180	120	0	63.1
Aircraft					
Bell 212 Helicopter	162	180	120	0	125.9

The potential for injury from sound exposure is extremely low. Sound sources sufficiently high to cause injury are only associated with the drillship. Calculated distances noted in **Table 4-8** indicate that marine mammals would have to be within 1.6 to 3.2 m of the DP thrusters to experience injury. It is extremely unlikely that marine mammals will approach this close to an operational thruster.

Based on calculations presented in **Table 4-8**, marine mammals (i.e., mysticetes) within 1,585 to 3,162 m of the drillship may experience behavioral disturbance from drilling- or maintenance-related noise. Similarly, marine mammals (i.e., mysticetes) within 2.5 to 74.9 m of transiting vessels may experience behavioral disturbance. In either case, marine mammals will hear the sound source prior to any exposure to these source levels; they may respond by changing course or diving, thus avoiding or minimizing any further exposure.

Due to the duration of exploratory drilling operations, the nature of the project-related sound sources, and the calculated radial distances from source to threshold levels, this impact is anticipated to be minor. Given the likely nature of this impact, overall impact significance is low.

4.5.2 Sea Turtles

Some sea turtles may be attracted to offshore structures (Rosman et al., 1987; Lohoefener et al., 1990). It has been suggested that sea turtle hatchlings could be attracted to brightly lighted offshore structures, including drillships and platforms, where they may be subject to increased predation by birds and fishes (National Marine Fisheries Service, 2001) and may be subject to noise exposure from the drillship.

Sound exposure criteria for marine mammals historically have been applied to sea turtles. Based on calculations presented in **Table 4-8**, sea turtles within 1.6 to 3.2 m and 1,585 to 3,163 m of the drillship may experience injury or behavioral disturbance, respectively, from drilling-related noise. Similarly, sea turtles within 2.5 to 74.9 m of transiting vessels may experience behavioral disturbance. Sea turtles within 126 m of transiting helicopters may experience behavioral disturbance when helicopters are directly overhead. As was the case with marine mammals, sea turtles will hear the sound source prior to any exposure to these source levels; they may respond by changing course or diving, thus avoiding or minimizing any further exposure.

The drillship will only be on site for a relatively short period of time (i.e., several months), limiting the potential for noise exposure. Due to the duration of exploratory drilling operations, when coupled with the nature of the project-related sound sources and the calculated radial distances from source to threshold levels, this impact is anticipated to be minor. Noise from approaching vessels and aircrafts are expected to elicit an avoidance response. Given the likely nature of this impact, overall impact significance is low.

4.5.3 Recreation and Aesthetics/Tourism

Offshore structures (e.g., platforms, drillships) typically are visible 5 to 16 km from shore, with small structures barely visible at 5 km. On a clear night, lights on top of offshore structures may be visible to a distance of approximately 32 km (U.S. Minerals Management Service, 2007a,b). Because the Tamar Field is located approximately 90 km west of Haifa, the drillship will not be visible from shore.

Supply vessels and helicopters will periodically transit between Haifa and the Tamar Field projects. During those periods when vessels and aircraft are close to shore, they will be visible to coastal visitors involved in recreation and tourism. The Port of Haifa is one of Israel's busiest ports. Tourists and those involved in coastal recreation will experience a variety of vessel traffic, including tankers, cargo vessels, cruise ships, and a diverse assortment of smaller watercrafts. The periodic transit of supply vessels and aircrafts does not represent a unique or unexpected event. Impacts on nearshore recreational activities, aesthetics, and tourism are expected to be negligible. With the possible exceptions of fishing and deepwater yachting, it is expected that no recreational activities will be conducted in the vicinity of or near the Tamar Field. Given the likely nature of this impact, overall impact significance is negligible.

4.6 NATURE AND ECOLOGY IMPACTS

Nature and ecology impacts are discussed in this section, which includes the following resources as identified in **Table 4-3**:

- Sediments and sediment quality;
- Water quality;
- Plankton, fish, and fishery resources;
- Benthic communities;
- Marine mammals and sea turtles;
- Marine and coastal birds; and
- Protected species/habitats.

These potential impacts are discussed under the relevant sections below, including potential cumulative impacts as applicable. Impacts from WBM mud and cuttings discharges are discussed to support the evaluation of potential cumulative impacts; no discharges of mud or cuttings are proposed for the Tamar Field Development Project.

4.6.1 Sediments and Sediment Quality

Activities at the Tamar Field may impact sediments and sediment quality, as identified in **Table 4-3**, by the following:

- Drilling (including the release/discharge of drill muds and cuttings);
- Installation activities; and
- Physical presence.

4.6.1.1 Drilling (including the release/discharge of drill muds and cuttings)

<u>WBM Discharge Impacts on Sediment and Sediment Quality</u>

WBM mud and cuttings were discharged for the previous Tamar wells. The impacts of these discharges are discussed here, using literature and the results of the Tamar surveys to predict impacts.

Seafloor releases of WBM and associated drill cuttings will create a mound with a diameter of several meters to tens of meters around the wellbore. Also, during setting of the casing, cement slurry will be pumped into the well to bond the casing to the walls of the hole. Excess cement slurry will emerge from the hole and accumulate on the seafloor, typically within 10 to 15 m of the wellbore (Shinn et al., 1989). Cement slurry components include cement mix and some of the same chemicals used in WBM (Boehm et al., 2001). These releases will alter the sediment quality near the well location. Eventually, sediments will return to baseline conditions due to normal sediment movement, remixing of sediments by benthic organisms, and sediment deposition from the water column.

WBM and associated drill cuttings discharged from the drilling unit will accumulate on the seafloor, possibly resulting in changes in bottom contours, grain size, barium concentrations, and concentrations of other metals (National Research Council, 1983; Boothe and Presley, 1989; Neff, 1987, 2005, 2010). Because of the water depth, only a thin layer of deposition is expected and detectable changes may be limited to within a few hundred meters around each well.

Barite (barium sulfate) is a major insoluble component of drilling fluid discharges, and barium concentrations will increase in bottom sediments around the well. Concentrations of other metals in drilling fluids are similar to those in marine sediments, but some metals such as cadmium, copper, lead, mercury, and zinc may be elevated within a few hundred meters of the well (Boothe and Presley, 1989).

Predictive modeling of the WBM discharge was performed for a site offshore Cyprus (MUDMAP; RPS-ASA, 2013) to estimate the accumulation of mud and associated drill cuttings on the seafloor as well as their dispersion in the water column. The site is similar to sites in the Tamar Field and the results are indicative of impacts expected to have occurred during the drilling of previous wells in the Tamar Field. Two discharge scenarios were modeled: October to January and July to September. **Table 4-9** summarizes the areal extent of deposition for each scenario.

Table 4-9. Areal extent and distance of water-based muds and cuttings seafloor deposition from a surface location for two scenarios (October to January and July to September) (From: RPS-ASA, 2013).

Deposition Thickness (mm)	October to January		July to September	
	Cumulative Area Exceeding this Thickness (ha)	Maximum Distance (m)	Cumulative Area Exceeding this Thickness (ha)	Maximum Distance (m)
0.1	57.651	618	57.788	634
1	1.368	82	1.648	85
6.3	0.439	42	0.479	42
10	0.409	38	0.399	39
54	0.19	28	0.20	27
100	0.15	23	0.14	22
200	0.07	17	0.07	17

Beyond 600 m from a potential well location, modeling predicts a depositional accumulation of 0.1 mm or less from a WBM discharge, which may not be detectable and may have little or no impact on benthic communities. A deposition thickness of 1 mm may extend for approximately 85 m around the wellsite, covering an area of approximately 2.3 ha. The total area potentially covered by 1 mm of deposition for the seven wells that have been drilled to date would equate to approximately 16 ha.

The effects of WBM and associated drill cuttings discharges on benthic communities have been reviewed extensively (National Research Council, 1983; Neff, 1987, 2005, 2010; Ellis et al., 2012). Due to the low toxicity of WBM, the main impact mechanism is increased sedimentation, possibly resulting in burial or smothering of benthic communities. Monitoring programs have shown that benthic impacts of WBM discharges are minor and localized within a few hundred meters of the well (National Research Council, 1983; Neff, 1987, 2005, 2010). The water depth is expected to facilitate the dispersion of drilling mud and associated drill cuttings, minimizing benthic impacts.

While there are low levels of metals in the WBM and associated drill cuttings accumulations, the metals in drilling fluids show very low bioavailability to marine animals and do not pose a risk to benthic organisms or their predators (Neff et al., 1989a,b).

Smit et al. (2008) reviewed studies of burial impacts and estimated that a thickness of 54 mm is hazardous to 50% of benthic organisms studied. Therefore, a value of 54 mm can be used as a general impact threshold for burial of soft bottom benthic organisms. The MUDMAP model predicts that deposition having a thickness of 54 mm or more would affect an area of approximately 0.2 ha under either scenario and would extend less than 28 m from the well (**Table 4-9**).

A lower threshold may be appropriate for sensitive species such as deepwater corals. Smit et al. (2008) estimated that a burial thickness of 6.3 mm would be hazardous to 5% of benthic species studied; therefore, a value of 6.3 mm is used here as a threshold for species sensitive to sediment deposition. The MUDMAP model predicts that deposition having a thickness of 6.3 mm or more would affect approximately 0.5 ha and extend less than 42 m from the well (**Table 4-9**).

A survey of the Tamar lease area conducted in 2013 and 2014 (CSA Ocean Sciences Inc., 2014) found that the seafloor within the survey area was relatively flat and generally undisturbed, except for some highly localized (within 10 m) visual evidence of seafloor disturbance near existing infrastructure. The survey did identify some possible residual petrogenic hydrocarbon contamination in the area of the platforms; however, the concentrations were well below concentrations of concern – individual PAH concentrations were between 1 and 12 ppb. Barium concentrations also were elevated in seafloor sediments at a few locations. While barium is an indicator of development activity, it is not toxic to marine organisms; therefore, its potential for environmental impact is insignificant.

Due to the limited and minor impacts of the depositional thickness, the size of the Tamar lease area, and the limited benthic infauna, the current and cumulative impact of the discharge of WBM mud and cuttings is considered to be of low to negligible impact.

<u>WBM and MOBM Discharge Impacts on Sediment and Sediment Quality</u>

While the proposed Tamar Field Development Project will not discharge MOBM drilling fluids, Noble Energy has requested approval to discharge MOBM-associated cuttings. The WBM from the initial well sections will be discharged also. To support their request to discharge MOBM-associated cuttings from drilling in the Leviathan Field, Noble Energy contracted RPS-ASA (2014) to model the discharges from proposed wells in the Leviathan Field (Leviathan-9 and 9 ST01) based on the use of WBM for the initial well sections and MOBM for the deeper well sections. The site of the modeled well is approximately 9 to 19 km from the proposed Tamar wellsites. Because the proposed Leviathan and Tamar wells are similar enough in design, depth, drilling fluid system, solids control procedures, physical oceanography, and location the Leviathan modeling results may be considered representative of Tamar cuttings discharges. The RPS-ASA MUDMAP model was used to predict the transport of solid releases in the marine environment and the resulting seafloor deposition. Discharge simulations were run to examine the dispersion of mud and drill cuttings during two different seasonal periods: Scenario 1 (December to February) and Scenario 2 (July to September). The later period is characterized by substantially stronger currents in the upper water column. For each period, the MUDMAP model was applied to predict the deposition associated with each phase of drilling and the cumulative seafloor impact of all drilling discharges. This discussion is based on preliminary results for the report and should be verified when the final report becomes available. A description of the MUDMAP model is provided in **Appendix H**.

Time-stamped current measurements from a mooring in the Leviathan Field (mooring site LV1-1) located 13 to 18 km from the proposed Tamar wellsites were used for modeling. The data were binned to 13 vertical layers through the water column. Vertically and time varied currents for two potential drilling periods (beginning in December and July, respectively) were subset from the full dataset and used as forcing for the MUDMAP simulations. Following a qualitative review, data from deployments in 2013 and 2014 were selected for use in the dispersion model due to more frequent instrument malfunction and/or missing data during earlier periods. A series of processing steps were used to resample currents to a common (1-hour) time step; flagged or missing data for periods less than 10 hours were interpolated.

Figure 4-7 shows the current profile of the modeled site along with the annual current distribution by depth, and **Figure 4-8** shows the average current speeds used in the modeling efforts. **Table 4-10** shows the composition of the discharged fluids used for the modeling.

Table 4-10. Composition of drilling discharges used for modeling (WBM formulations based on Leviathan-5; data provided by Noble Energy).

Discharged Material	Bulk Density (ppg)	Bulk Density (kg/m^3)	Percent Solid by Weight	Average SG of Solid Fraction
WBM cuttings (section 1-2)	22.1	2,650	100	2.65
WBM (section1)	8.6	1,030	22	4.48
WBM (section2)	12.5	1,500	22	4.48
MOBM cuttings (section 3-6)	20.9	2,500	100	2.5

MOBM = mineral oil-based mud; ppg = pounds per gallon; SG = specific gravity; WBM = water-based mud.

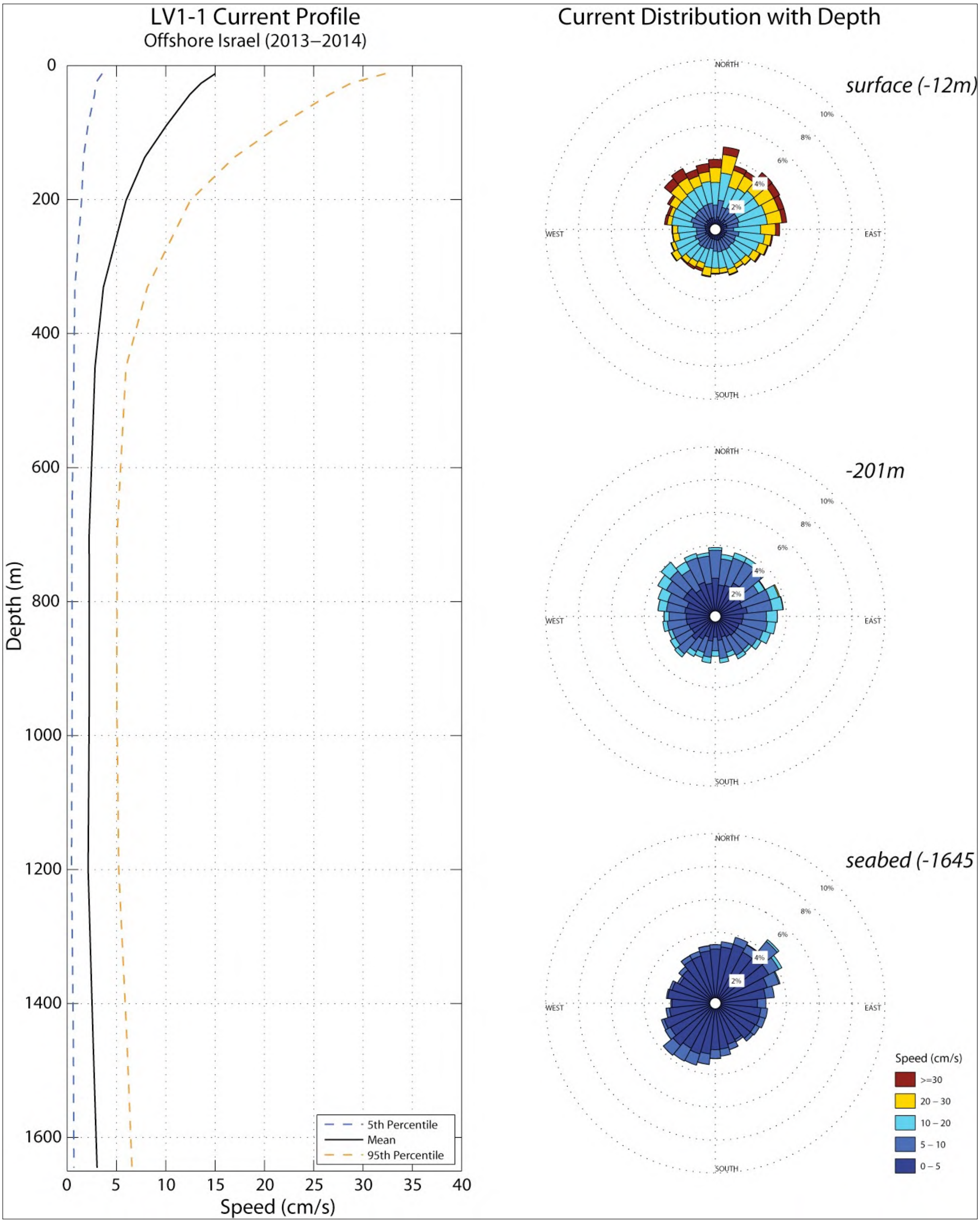


Figure 4-7. Vertical profile (left) and current roses showing annual distribution of current speeds (right) at the LV1-1 mooring between 2013 and 2014.

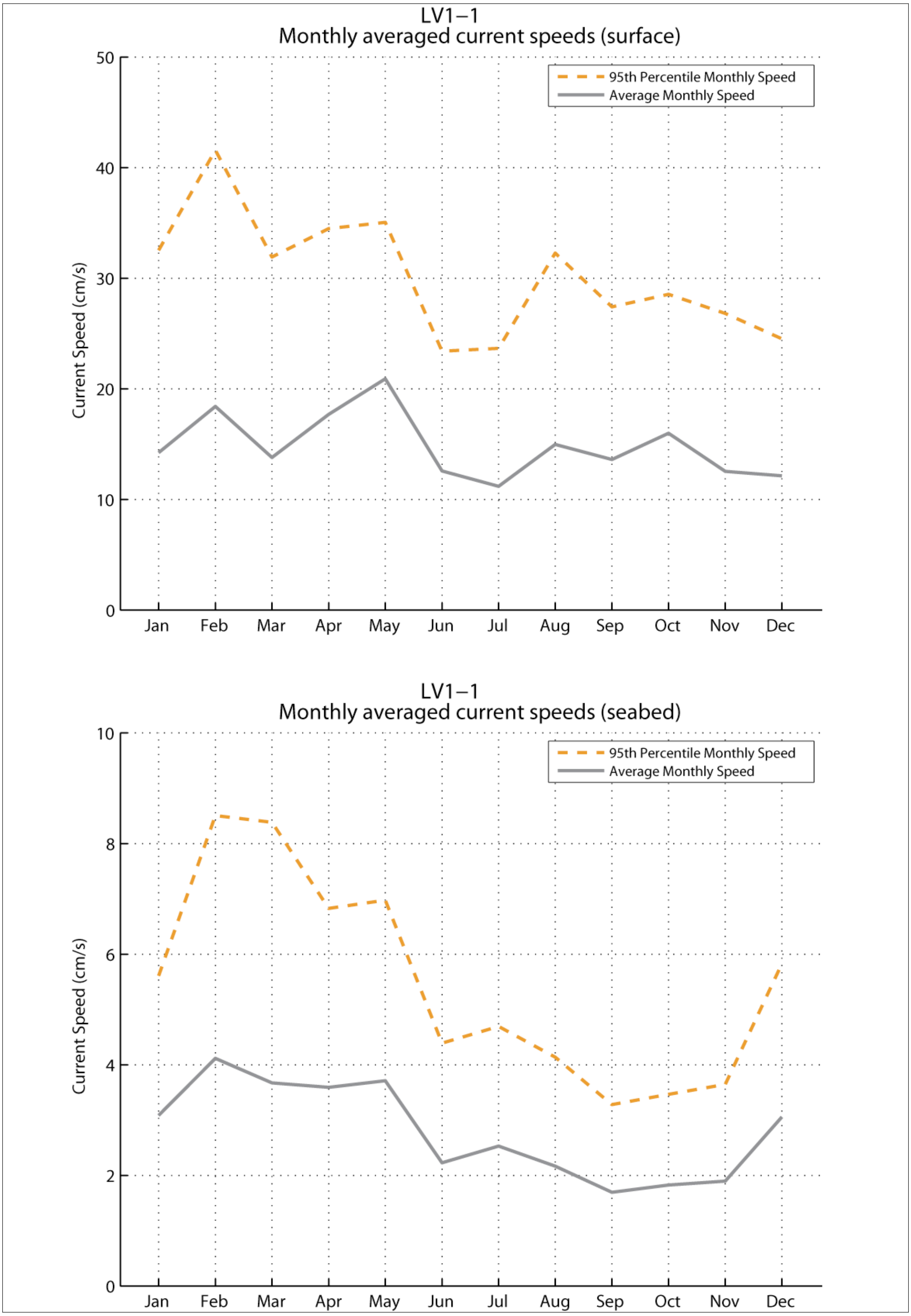


Figure 4-8. Monthly averaged current speeds at LV1-1 derived from measurements between 2013 and 2014 at the sea surface (top) and seafloor (bottom).

Tables 4-11, **4-12**, and **4-13** present the settling velocities of WBM cuttings, WBM and MOBM cuttings used for the 2 simulations.

Table 4-11. Water-based mud (WBM) cuttings settling velocities used for simulations (Brandsma and Smith, 1999).

Size Class	Percent Volume	Settling Velocity	
		(cm/s)	(m/day)
1	8.00	1.350E-04	0.12
2	6.00	1.686E-03	1.46
3	7.00	2.182E-02	18.86
4	3.00	2.328E-01	201.14
5	2.00	1.447E+00	1,250.37
6	18.00	4.011E+00	3,465.65
7	16.00	9.796E+00	8,463.98
8	15.00	1.352E+01	11,679.45
9	25.00	2.598E+01	22,442.45

Table 4-12. Water-based mud (WBM) settling velocities used for simulations.

Mud Particle Size (microns)	Percent Volume	Settling Velocity	
		(cm/s)	(m/day)
1	26.8	0.000108	0.093312
2	6.8	0.000431	0.372384
3	5	0.00097	0.83808
4	5.6	0.001724	1.489536
6	6	0.003878	3.350592
8	6.6	0.006894	5.956416
11	7.2	0.013	11.232
16	7.8	0.0276	23.8464
22	4	0.0521	45.0144
26	3.92	0.0728	62.8992
31	3.72	0.1035	89.424
37	3.39	0.1475	127.44
44	2.94	0.2086	180.2304
53	2.41	0.3026	261.4464
63	1.86	0.4276	369.4464
74	1.36	0.5899	509.6736
88	0.97	0.8342	720.7488
105	0.72	1.188	1,026.432
125	0.59	1.683	1,454.112
149	0.55	2.392	2,066.688
177	0.55	2.997	2,589.408
210	0.52	3.617	3,125.088
250	0.43	4.381	3,785.184
297	0.28	5.296	4,575.744

Table 4-13. Thermomechanical cuttings cleaner-treated mineral oil-based mud (MOBM) cuttings settling velocities used in the modeling.

Size Class	Percent Volume	Settling Velocity	
		(cm/s)	(m/day)
0.399	0.560	0.00001	0.00637
0.502	1.900	0.00001	0.01009
0.632	2.920	0.00002	0.01599
0.796	3.630	0.00003	0.02537
1.002	4.010	0.00005	0.04020
1.262	4.200	0.00007	0.06377
1.589	4.390	0.00012	0.10109
2.000	4.600	0.00019	0.16015
2.518	4.690	0.00029	0.25385
3.170	4.520	0.00047	0.40233
3.991	4.080	0.00074	0.63772
5.024	3.480	0.00117	1.01056
6.325	2.870	0.00185	1.60172
7.962	2.410	0.00294	2.53810
10.024	2.190	0.00466	4.02297
12.619	2.150	0.00738	6.37550
15.887	2.240	0.01170	10.10528
20.000	2.410	0.01854	16.01490
25.179	2.640	0.02938	25.38290
31.698	2.950	0.04656	40.22797
39.905	3.320	0.07379	63.75569
50.238	3.700	0.11700	101.04830
63.246	3.970	0.18540	160.15130
79.621	4.050	0.29380	253.81630
100.237	3.890	0.46560	402.27260
126.191	3.570	0.73790	637.56010
158.866	3.220	1.17000	1010.47700
200.000	2.940	1.85400	1601.49000
251.785	2.770	2.44700	2113.80600
316.979	2.570	3.15200	2723.11400
399.052	2.090	4.06000	3508.04200
502.377	1.060	5.23100	4519.23600
563.677	0.010	5.93700	5129.39000

Results from the two MUDMAP simulations representing different seasons are presented in **Figures 4-9** and **4-10**. For each, a continuous discharge rate was specified for each drilling section. Following the simulated release of each drilling section in MUDMAP, the model continued to track the far-field dispersion for a minimum of 72 hours, to account for settling of very fine material from the water column. For each simulation, thickness was calculated based on mass accumulation on the seafloor and assuming a deposit bulk density of 2,500 kg/m^3 and no void ratio (zero porosity).

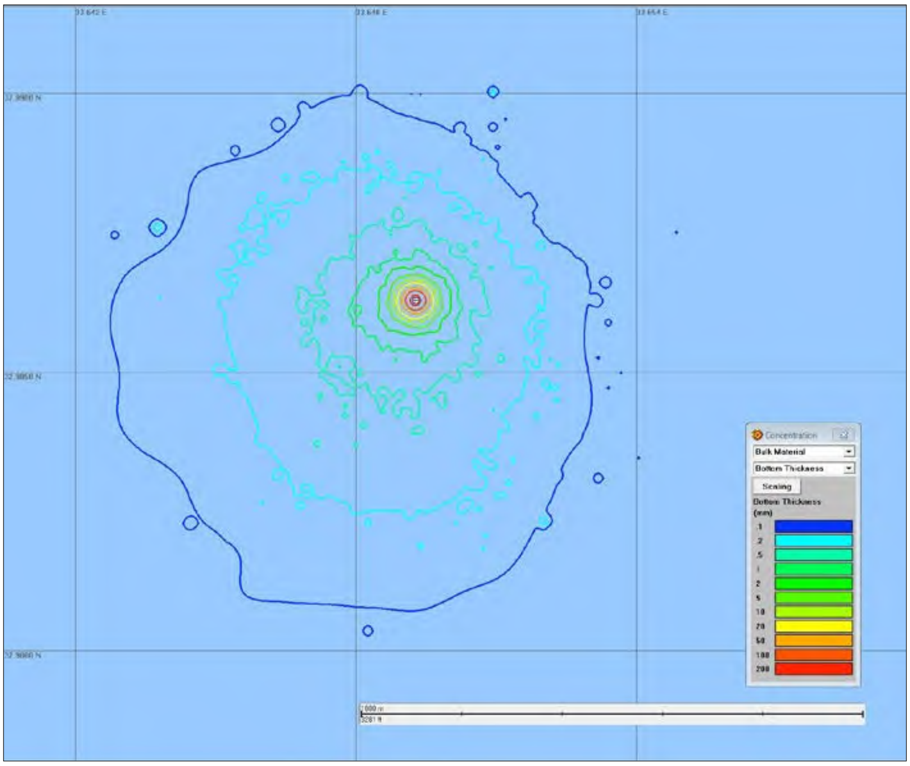


Figure 4-9. Cumulative deposition thickness (cuttings and mud) from modeled drilling discharges at Leviathan-9 and 9 ST01 (Scenario 1: December to February).

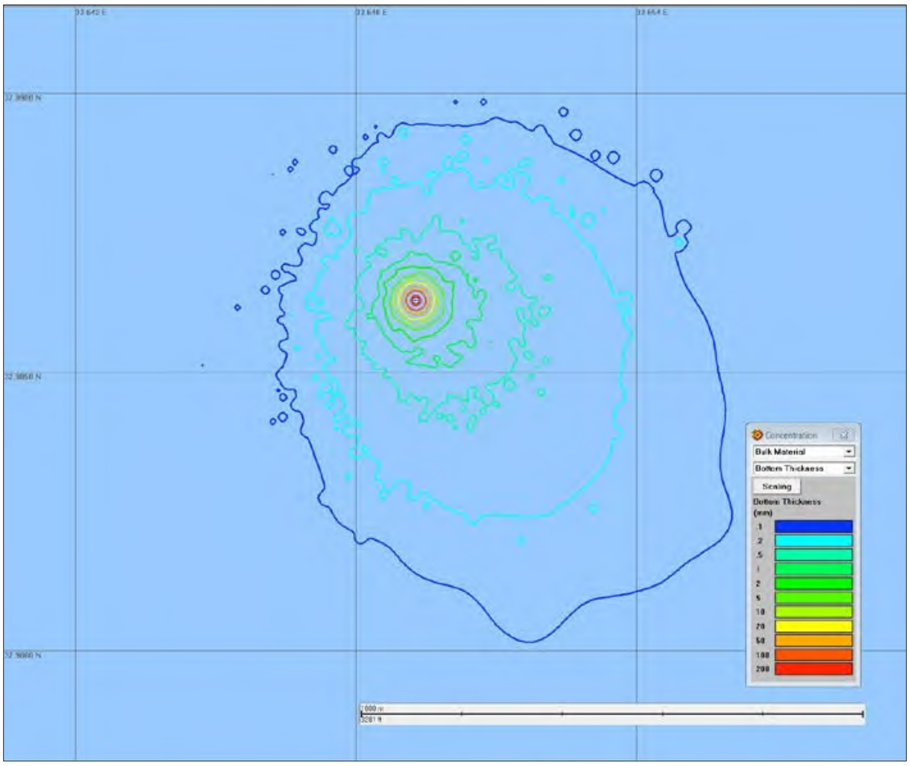


Figure 4-10. Cumulative deposition thickness (cuttings and mud) from modeled drilling discharges at Leviathan-9 and 9 ST01 (Scenario 2: July to September).

Table 4-14 shows the distance from the discharge point impacted by different depositional thicknesses, and **Table 4-15** lists the area of seafloor impacted by various depositional thicknesses.

Table 4-14. Maximum extent of thickness contours (by distance from release site) for each model scenario for the Leviathan-9 and 9 ST01 wells. Burial thresholds from Smit et al. (2008) are shown in bold.

Deposition Thickness (mm)	Maximum Extent From Discharge Point (m)	
	Scenario 1*	Scenario 2**
0.1	676	775
1	136	149
6.3	**54**	**55**
10	45	47
54	**27**	**27**
100	20	21
200	11	11

*Scenario 1: December to February.
**Scenario 2: July to September.

Table 4-15. Areal extent of seafloor deposition (by thickness interval) for each model scenario for the Leviathan-9 and 9 ST01 wells. Burial thresholds from Smit et al. (2008) are shown in bold.

Deposition Thickness (mm)	Cumulative Area Exceeding (km^2)	
	Scenario 1*	Scenario 2**
0.1	0.7309	0.6913
0.2	0.3316	0.3365
0.5	0.0951	0.0958
1	0.0327	0.0348
2	0.0159	0.0158
5	0.0090	0.0092
6.3	**0.0079**	**0.0080**
10	0.0060	0.0061
20	0.0041	0.0041
50	0.0023	0.0023
54	**0.0021**	**0.0021**
100	0.0012	0.0012
200	0.0003	0.0003

*Scenario 1: December to February.
**Scenario 2: July to September.

As discussed previously, Smit et al. (2008) reviewed studies of burial impacts and estimated that a thickness of 54 mm is hazardous to 50% of benthic organisms studied. Therefore, a value of 54 mm can be used as a general impact threshold for burial of soft bottom benthic organisms. The MUDMAP model predicts that deposition having a thickness of 54 mm or more would affect an area of approximately 0.002 ha under either scenario and would extend approximately 27 m from the wellsite (**Tables 4-14** and **4-15**).

Smit et al. (2008) estimated that a burial thickness of 6.3 mm would be hazardous to 5% of benthic species studied, therefore, a value of 6.3 mm is used here as a threshold for species sensitive to sediment deposition. The MUDMAP model predicts that deposition having a thickness of 6.3 mm or more would affect approximately 0.008 ha and extend approximately 54 to 55 m from the wellsite (**Tables 4-14** and **4-15**).

Approximately 69% of the ESCAID 110 is expected to biodegrade in 28 days (Noble Energy, 2014). Due to this and the small area of significant depositional thicknesses, the discharge of WBM and MOBM-associated cuttings will have a limited impact on the sediments and sediment quality in the vicinity of the drillsites. Recovery of the relatively small areas that are impacted could take several years. Overall impact significance is medium based on the likely occurrence of the discharge and the medium impact consequence.

4.6.1.2 Installation Activities

Emplacement of the pipelines, MEG lines, control lines, and utility lines will disturb surficial sediments, causing increased localized turbidity, possible mobilization, transport of sediment-associated contaminants, and crushing and/or burial of benthic communities near the pipeline corridor. Impacts on water quality, sediment quality, and benthic communities are expected to be minor. Given the short duration of this activity, overall impact significance is low.

4.6.1.3 Physical Presence

Either a moored semisubmersible drilling unit or a DP drillship will be utilized for the Tamar Field projects. If a DP drillship is used, no anchors will be required and no impacts to the seafloor will occur. Moored semisubmersible drilling units typically are held in place by eight anchors with steel chains and cables. Each anchor is estimated to disturb an area of approximately 35.5 m^2, for an approximate total of 284 m^2 (0.03 ha). When the anchor is initially deployed and then tensioned, approximately 1,200 m of the total length of anchor chain is estimated to be in contact with the seafloor, and the chain is assumed to "sweep" a width of 5 m along that length, for an approximate total area of 0.6 ha for each chain or 4.8 ha for eight chains. The total area disturbed by anchors and chains would be dependent on the mooring pattern needed to secure the semisubmersible drilling unit. The anchors, chains, and cables will affect only a portion of the anchoring radii, even when laid on the seafloor. Cables and chains will be resting on the seafloor during the installation; once the rig is on location, cables are pulled taut towards the rig. The cables and chains will sweep the soft sediments of the seafloor, but will not cross any sensitive features, as there will be exclusion zones if any such features are identified in the high-resolution side-scan sonar survey.

If a moored drilling unit is utilized, anchor or cable scars created during the drilling program will likely remain on the seafloor for months to years (Shinn et al., 1993). In a study of wellsites on the U.S. Gulf of Mexico continental slope, Continental Shelf Associates, Inc. (2006) detected anchor scars up to 14 years after drilling was completed. However, these features will disappear eventually as sediments are redistributed by currents and reworked by benthic organisms.

Pipelines, MEG lines, control lines, and utility lines will be installed by a DP pipelaying or similar vessel. Lines will be placed on the seafloor along the pipeline and utility line routes. Emplacement of the pipelines, MEG lines, control lines, and utility lines will disturb surficial sediments, causing increased localized turbidity, possible mobilization, transport of sediment-associated contaminants, and crushing and/or burial of benthic communities near the pipeline corridor. Given the short duration and limited area of this impact, overall impact significance is low.

4.6.2 Water Quality

Activities at the Tamar Field may have an impact on water quality due to the following as identified in **Table 4-3**:

- Drillship arrival, departure and stationkeeping;
- Drilling (including the release/discharge of drill muds and cuttings);
- Routine (non-drilling related) discharges;
- Installation vessel arrival, operation, and departure; or
- Installation activities.

These potential impacts are discussed in the following sections.

4.6.2.1 Drillship Arrival, Departure, and Stationkeeping

During transit to and from the project area, the drilling unit and support vessels will discharge treated sewage, domestic waste, and deck drainage. Sewage will pass through a sewage treatment plant prior to discharge. Domestic wastes (gray water) will be discharged without treatment, except for food waste, which will be macerated to pass through a 25-mm mesh. Deck drainage from machinery areas will pass through an oil-water separator prior to discharge or retained on board to be disposed of onshore. These discharges would be similar to those from other ships in the region. It is expected that the discharges would dilute rapidly in the water and not be detectable beyond the immediate vicinity of the vessel(s). As a result, the overall impact significance is negligible.

4.6.2.2 Drilling (including the release/discharge of drill muds and cuttings)

Release of drilling muds and cuttings from the wellbore during the initial stages of drilling will produce increased turbidity within the lower portions of the water column around the drillsite. This localized and short-term reduction in water quality will end shortly after completion of the upper well sections and installation of the BOP and riser.

When WBM and cuttings are discharged to the ocean (e.g., from a drilling rig or drillship), the larger particles and flocculated solids, representing approximately 90% of the mass of mud solids, form a plume that settles quickly to the bottom. The remaining 10% of the mass of the mud solids consisting of fine-grained unflocculated clay-sized particles and a portion of the soluble components of the mud from another plume in the upper water column that drifts with prevailing currents away from the discharge point and dilutes rapidly in the receiving waters (Neff, 2005).

Muds and cuttings will be expelled continuously from the wellbore during drilling of the 36-in. and 26-in. sections. Due to their size and weight, cuttings are expected to fall quickly to the seafloor as deposits near the wellbore, while drilling muds will remain suspended for a longer period. Because the drilling fluids have a density greater than that of ambient seawater, suspended muds will tend to collapse into the benthic boundary layer, the latter of which may be 1 m or more in thickness (Wimbush and Munk, 1970; Richards, 1990). Due to current shear and turbulence in the boundary layer, suspended muds will tend to stay in suspension above the seafloor. Dimensions of the mud plume will be dictated by the degree of initial dilution in surrounding seawater and ambient currents at depth. As the mud plume is advected away from the wellbore by benthic currents, its diameter will continue to grow and mud concentrations will decrease due to dispersion and mixing. Estimates of seafloor release of muds and cuttings presented by AMEC (2011) indicate that the turbidity plume generated from the release will be visible as small clouds of fine particles in the benthic boundary layer, and may extend several hundred to several thousand meters from the wellbore.

Drilling fluid and cuttings releases at the wellbore will produce a visible plume that will move with the currents as these materials are diluted and settle to the seafloor. Turbid water may extend between a few hundred meters and several kilometers down current from the discharge point. Given the continuous nature of this release, the turbidity plume from the wellbore will be present during jetting and drilling; the plume will persist for several hours after completion of the 26-in. section.

While few studies have been conducted regarding releases of drilling muds and cuttings at the wellbore, studies of surface discharges have demonstrated reductions in water clarity within a few hundred meters to approximately 2 km of drilling rigs (Ayers et al., 1980a,b; Ray and Meek, 1980). Neff (2010) reported that field studies of WBM and cuttings discharges in temperate and cold water environments exhibit up to a 30-fold dilution in the discharge pipe; within 30 m of the discharge, the muds and cuttings discharge can be expected to dilute an additional 1,000- to 3,000-fold. Dispersion to background levels typically requires several minutes to several hours (Neff, 1987). Depending upon near-bottom currents (i.e., velocity), releases of muds and cuttings at the wellbore may be expected to produce a turbidity plume which will extend several hundred meters from the drillsite.

The results of the Tamar Field Background Monitoring Survey (CSA Ocean Sciences Inc., 2014) indicate that water quality within the survey area has not been persistently impacted by drilling activities or infrastructure development.

Water quality impacts of MOBM cuttings discharges are expected to be less than those of WBM because 1) MOBM cuttings are treated using additional equipment (thermomechanical cuttings cleaner) to recover and recycle as much mud as practicable, and therefore the amount of mud (fine particles) discharged with cuttings is reduced; and 2) MOBM tends to adhere tightly to the cuttings particles, and they would not be expected to produce much turbidity as the cuttings sink through the water column (Neff et al., 2000). Discharges of treated MOBM cuttings may produce temporary, localized increases in suspended solids in the water column around the drilling rig.

Turbidity effects will be localized; the total area affected by increases in water column turbidity will be limited to several hundred meters around the drillsite. The impact consequence of changes to water quality is minor. Given the localized nature of this impact and its likely occurrence, overall impact significance is anticipated to be low. Due to the time periods between drilling the wells and the transient nature of the potential impacts of drilling discharges on water quality, cumulative impacts are unlikely and not expected.

4.6.2.3 Routine (Non-Drilling Related) Discharges

Routine discharges will include treated sanitary and domestic wastes, water-maker brine, cooling water, and organic waste originating from the drillship and support vessels. Support vessels, including the AHTS vessels, may discharge sanitary and domestic wastes and small amounts of runoff water (i.e., deck drainage).

Sanitary waste consists of human body wastes from toilets and urinals. Sanitary wastes will be treated by means of marine sanitation devices that produce an effluent with a minimum residual chlorine concentration of 1.0 mg/L and no visible floating solids or oil and grease. Sanitary waste will be discharged periodically at an estimated rate of 10 to 14 m^3/day. Additional details regarding sanitary waste processing are provided previously in **Chapter 3**.

Domestic waste, or “gray water,” includes water from showers, sinks, laundries, galleys, safety showers, and eye-wash stations. Aside from screening to remove solids, domestic waste does not require treatment before discharge. Domestic waste will be discharged periodically at an estimated rate of 20 to 24 m^3/day.

Freshwater on a drillship may be generated using RO water makers. Under normal operating conditions, the number of RO units operating depends on demand. On the *Atwood Advantage*, the maximum feed water flow rate through the units is 380 m^3/day, with a maximum brine discharge flow rate of 318 m^3/day. The excess seawater being discharged does not contain any added chemicals.

Cooling water is used to control and maintain proper temperatures on internal combustion engines aboard the drillship and project vessels. Cooling water discharge effluent should result in a temperature increase of no more than 3°C at the edge of the zone where initial mixing and dilution take place, typically within 100 m of the discharge source.

Organic waste (i.e., food waste) will be ground prior to discharge in accordance with Annex V of MARPOL 73/78 requirements. Aside from grinding to <25 mm particle size, no other treatment of organic wastes is expected. Organic waste will be discharged periodically at an estimated rate of 100 to 150 kg/day.

Sanitary, domestic, and organic waste from the drillship and support vessels may affect concentrations of suspended solids, nutrients, and chlorine in the water column as well as generate increases in biological oxygen demand. Brine and cooling water discharges will produce localized increases in salinity and water temperature, respectively. However, these discharges are expected to dilute rapidly in the open ocean (U.S. Environmental Protection Agency, 1993; U.S. Minerals Management Service, 2007a). Impacts likely would be undetectable beyond tens of meters from the source. Due to the nature of routine discharges and their dilution in the receiving environment, impacts to water quality are expected to be minor. Given the likely nature of this impact, overall impact significance is low.

Deck drainage consists of all waste resulting from rainfall, equipment and deck washings, tank-cleaning operations, and runoff from curbs and gutters, including drip pans and work areas. Vessels are designed to contain runoff and prevent oily drainage from being discharged. The flow is diverted to separation systems depending on the area collected. Measures will be taken to prevent any discharge of free oil in deck drainage that would cause a film, sheen, or discoloration of the surface of the water or a sludge or emulsion to be deposited beneath the surface of the water. Only non-oily water (no visual sheen) will be discharged overboard. If the deck becomes contaminated, oily deck drainage will be contained by absorbents or collected with a pollution pan for recycling and/or disposal. Because of the separation and treatment of water from oily areas prior to discharge, deck drainage is not expected to produce a visible sheen or any other detectable impacts on water quality.

Additional miscellaneous discharges typically occur from numerous sources on project vessels. Examples include uncontaminated freshwater and seawater used for cooling water, ballast water, fire test water, desalination unit discharges, and boiler blowdown discharges (U.S. Environmental Protection Agency, 1993). These discharges must meet MARPOL and Barcelona Convention requirements and are expected to dilute rapidly in the open ocean. Impacts on water quality would likely be undetectable beyond tens of meters from the source. Pipeline, MEG line, and utility line testing may result in the discharge of varying quantities of untreated seawater, with no impacts to near-surface water quality.

Due to the nature of routine discharges and their dilution in the receiving environment, impacts to water quality are expected to be minor. Given the likely nature of this impact, overall impact significance is low.

As for drilling discharges, the time periods between drilling the wells and the transient nature of the potential impacts of these routine discharges on water quality, cumulative impacts are unlikely and not expected.

4.6.2.4 Installation Vessel Arrival, Operation, and Departure

The DP pipelaying vessel and its support vessels will discharge treated sewage, domestic waste, and deck drainage. Sewage will pass through a sewage treatment plant prior to discharge. Domestic wastes (gray water) will be discharged without treatment, except for food waste, which will be macerated to pass through a 25-mm mesh. Deck drainage from machinery areas will pass through an oil-water separator prior to discharge or retained on board to be disposed of onshore. These discharges would have a negligible impact and would be similar to those from other ships in the region. It is expected that the discharges would dilute rapidly in the water and not be detectable beyond the immediate vicinity of the vessel(s).

4.6.2.5 Installation Activities

Emplacement of the pipelines, MEG lines, control lines, and utility lines will disturb surficial sediments, causing increased localized turbidity, possible mobilization, transport of sediment-associated contaminants, and crushing and/or burial of benthic communities near the pipeline corridor. Impacts on water quality are expected to be minor. Given the short duration of this impact, overall impact significance is low.

4.6.3 Plankton, Fish, and Fishery Resources

The following activities at the Tamar Field could impact plankton, fish, and fishery resources as identified in **Table 4-3**:

- Drilling (including the release/discharge of drill muds and cuttings);
- Physical presence;
- Routine discharges; and
- Installation activities.

4.6.3.1 Drilling (including the release/discharge of drill muds and cuttings)

In the upper portions of the water column, the turbidity plume created by routine discharges will reduce light penetration for a short period of time in close proximity to the discharge, with minimal impacts to phytoplankton. Discharges from the drillship will occur 7 to 8 m below the surface, further reducing the potential for impact to plankton in the upper portions of the water column. Within the water column, potential exposure to routine discharges will be very limited. Due to rapid dilution and the location of the discharge plume, this impact is anticipated to be negligible. Given the likely nature of this impact, overall impact significance is negligible.

Discharges of drilling fluids and cuttings are likely to have little or no impact to plankton or fish due to the low toxicity and rapid dispersion of these discharges (National Research Council, 1983; Neff, 1987; Hinwood et al., 1994). Further, the only discharge or release of drilling muds and cuttings will occur at the wellbore. Plankton in the upper water column will not be affected. Demersal zooplankton within the benthic boundary layer, near the sediment-water interface, may be affected by muds and cuttings released from the wellbore (e.g., fouling of respiratory structures). Given the localized nature of this impact, the rapid dispersion of the discharges, and the low toxicity of the discharges in the water column, overall impact significance of drilling from previous and planned Tamar lease area projects is anticipated to be negligible.

No cumulative impacts are expected on plankton, fish, and fishery resources due to drilling as the drilling periods have been spaced out over a period of months to years as well as being spaced out geographically.

4.6.3.2 Physical Presence

The presence of the drillship will attract fishes, providing shelter and food in the form of attached fouling biota (Gallaway and Lewbel, 1982). Offshore structures typically attract epipelagic fishes such as tunas, dolphin, billfishes, and jacks (Holland et al., 1990; Higashi, 1994). This "artificial reef effect" generally is considered a beneficial impact. While the impact, either positive or negative, is likely to occur, overall impact significance is negligible.

4.6.3.3 Routine Discharges

Routine discharges are unlikely to affect most marine resources (e.g., marine mammals, sea turtles, birds), but may affect plankton and fish that actively or passively pass through the discharge plume.

In the upper portions of the water column, the turbidity plume created by routine discharges will reduce light penetration for a short period of time in close proximity to the discharge, with minimal impacts to phytoplankton. Discharges from the drilling rig occur below the surface, further reducing the potential for impact to plankton in the upper portions of the water column. Within the water column, potential exposure of plankton to routine discharges will be very limited.

While increased turbidity is not expected to physically affect fishes (e.g., via interference with gill function), turbidity increases may alter the foraging success of some fishes when they are present within a plume (De Robertis et al., 2003). Given that the total area affected by these discharges is very small, foraging fish are expected to either avoid or move out of the discharge plume. Turbidity effects will be very localized.

Due to rapid dilution and the location of the discharge plume, the impact of routine discharges on plankton and fish is anticipated to be negligible. Given the likely, but localized nature of this impact, overall impact significance is anticipated to be low for the proposed drilling operations as well as for the cumulative impacts of Tamar Field activities.

4.6.3.4 Installation Activities

Routine and miscellaneous discharges typically occur from numerous sources on project vessels. Examples include sanitary waste, deck drainage, uncontaminated freshwater and seawater used for cooling water, ballast water, fire test water, desalination unit discharges, and boiler blowdown discharges (U.S. Environmental Protection Agency, 1993). These discharges must meet MARPOL and Barcelona Convention requirements and are expected to dilute rapidly in the open ocean. Impacts on water quality likely would be undetectable beyond tens of meters from the source. The potential for impacts on plankton, fish, and fishery resources is negligible.

Pipeline, MEG line, and utility line testing may result in the discharge of varying quantities of untreated seawater, with no impacts to near-surface water quality. The potential for impacts on plankton, fish, and fishery resources is negligible.

Due to the nature of routine discharges and their dilution in the receiving environment, impacts to plankton, fish, and fishery resources are expected to be minor. Given the likely nature of this impact, overall impact significance is low.

4.6.4 Benthic Communities

The following activities at the Tamar Field may impact benthic communities as identified in **Table 4-3**:

- Drilling (including the release/discharge of drill muds and cuttings);
- Solid waste (drilling and infrastructure activities);
- Installation activities; and
- Infrastructure physical presence.

4.6.4.1 Drilling (including the release/discharge of drill muds and cuttings)

Drilling and WBM Discharge Impacts on Benthic Communities

Benthic community effects of drilling discharges have been reviewed extensively by the National Research Council (1983), Neff (1987), and Hinwood et al. (1994), among others. Due to the low toxicity of most drilling fluids, the main mechanism of impact to benthic communities is increased sedimentation, possibly resulting in burial or smothering. Most benthic fauna live in the upper few centimeters of offshore, fine-grained sediments, with benthic communities composed of varying feeding guilds – filter feeders, surface deposit feeders, subsurface deposit feeders, and carnivores. Deposit feeders, in particular, are recognized for their ability to process/ingest or move sediment during tube-building and feeding (i.e., bioturbation). The maximum depth of bioturbation is 4 to 5 cm for most infauna, although larger infaunal burrowers are known to extend 20 cm or more into the sediment. Infaunal feeding guilds are important in determining impacts from sediment deposition (i.e., filter feeding species are highly susceptible to increased sedimentation compared to deposit feeders).

Monitoring programs have shown that benthic impacts of drilling are minor and localized within a few hundred meters of the drillsite (EG&G Environmental Consultants, 1982; National Research Council, 1983; Neff, 1987; Continental Shelf Associates, Inc., 2006).

Impacts to the benthos due to seafloor releases are expected to be of minor consequence. During the first well interval, when the hole is being jetted into the seafloor, cuttings and "spud mud" will be released at the seafloor, creating a mound several meters to tens of meters around the wellbore.

Also, during setting of the casing, cement slurry will be pumped into the well to bond the casing to the walls of the hole. Excess cement slurry will emerge from the hole and accumulate on the seafloor, generally within 10 to 15 m around the wellbore (Shinn et al., 1989). Cement slurry components typically include cement mix and some of the same chemicals used in water-based drilling fluids (Boehm et al., 2001).

The impacts resulting from the release of these materials will be burial and smothering of benthic organisms within several meters to tens of meters around the wellbore. WBM typically contain an organic phase that can increase the potential for oxygen depletion in near-surface sediments (when deposited in sufficient amounts), with an increase in possible mortality of the benthic community (Schaanning et al., 2008a,b). While field measurements of this phenomenon are very limited, Trannum et al. (2006) observed lowered redox potentials 75 m from a well drilled with WBM. In addition, the deposition of muds and cuttings particles appears to prompt tube-building and burrowing activity of indigenous fauna in response to this short-term disturbance of the sediment surface. New tube-building and burrowing increases irrigation and solute exchange across the newly deposited muds and cuttings layer (Trannum et al., 2010).

Soft bottom sediments and their associated benthic community disturbed by cuttings, drilling muds, and cement slurry eventually will be recolonized through larval settlement and migration from adjacent areas. Recovery may require several years and is dependent on the nature of the indigenous fauna, their tolerance to burial, their life history characteristics (e.g., spawning and settlement characteristics), and their relative abundance in the deposition areas.

During Noble Energy surveys of the Tamar lease area in 2013 and 2014 (CSA Ocean Sciences Inc., 2014), no hard bottom substrate or chemosynthetic communities were observed. There was visible biological activity observed on video at most of the locations surveyed by ROV, and observations included fauna and bioturbation (i.e., biologically maintained burrows and mounds). As may be expected for a soft bottom deepwater environment where food availability is presumably low, fauna observed on the seafloor were sparse. The organisms most commonly observed were tripod fish and unidentifiable shrimp. Small groupings of patterned burrows and small conical mounds likely created by polychaetes were observed in the soft sediments.

Cumulative impacts can be determined by calculating the area around drilling operations that has a negative impact on the benthic communities due to smothering. For concrete and other discharges around the wellbore, this is approximately 0.7 ha (using an impact area of 15 m around the wellbore and adding the impacted area for the seven completed wells and the three proposed wells, which will have a seafloor discharge from the initial well sections). If benthic communities are impacted for a radius of 75 m around the wellbore, the total impacted bottom area is approximately 1.8 ha per well. Due to the low density of benthic infauna, the distance between wells, and the relatively small size of the impacted area relative to the Tamar lease area, the cumulative impact significance of drilling discharges on benthic communities is considered to be low.

<u>MOBM Discharge Impacts on Benthic Communities</u>

The benthic impacts of SBM (a category including MOBM) cuttings have been reviewed by Neff et al. (2000), and two major monitoring studies have been conducted in the Gulf of Mexico by Continental Shelf Associates Inc. (2004, 2006). A key factor is the residual SBM on the cuttings, for the following three reasons:

- The residual SBM may cause cuttings to adhere or form clumps that settle relatively rapidly to the seafloor, resulting in thicker deposits. (However, the use of a cuttings dryer is expected to reduce the potential for this clumping to occur.)
- The residual SBM is organic matter, and when the cuttings are deposited on the seafloor, decomposition of this organic matter by sediment microbes can cause anoxic conditions.
- The residual SBM has greater potential for toxicity than WBM. However, the ESCAID 110 base fluid proposed by Noble Energy is a low-toxicity fluid which has a CHARM rating of "C" (sediment toxicity of 100 to 1,000 ppm for *Corphium volutator* LC_{50} tests).

Monitoring studies have shown that when SBM cuttings are discharged, areas within approximately 500 m of the wellsite may develop elevated organic carbon concentrations and anoxic conditions (Continental Shelf Associates, Inc., 2004, 2006; Neff et al., 2005; Santos et al., 2010). Benthic infaunal communities may be adversely affected because of organic enrichment (with resulting anoxia) (Neff et al., 2000). Infauna numbers may increase and diversity may decrease as opportunistic species that tolerate low oxygen and high H_2S concentrations predominate (Continental Shelf Associates, Inc., 2006). As the base synthetic fluid is decomposed by microbes, the area will gradually return to pre-drilling conditions. Disturbed sediments will be recolonized through larval settlement and migration from adjacent areas.

Continental Shelf Associates Inc. (2006) studied drilling discharge impacts at several sites on the Gulf of Mexico continental slope in water depths of 1,033 to 1,125 m where both SBM and WBM were used. At all sites, areas of SBM cuttings deposition were associated with elevated organic carbon concentrations and anoxic conditions. Areas within approximately 500 m of drillsites had patchy zones of disturbed benthic communities, including microbial mats, areas lacking visible benthic macroinfauna, zones dominated by pioneering stage assemblages, and areas devoid of surface-dwelling species. Infaunal and meiofaunal densities generally were higher near drilling, although some faunal groups were less abundant near drillsites. Some stations near drilling had lower diversity, lower evenness, and lower richness indices compared with stations farther away from drilling. Some stations affected by drilling were dominated by high abundances of one or a few deposit-feeding species, including known pollution indicators. The severity of these impacts was greatest at two post-development sites that had multiple wells at the same location. Less extensive and less severe impacts were observed at a site where only one exploration well was drilled.

In addition to the Gulf of Mexico monitoring studies conducted by Continental Shelf Associates Inc. (2004, 2006), studies in other areas have shown generally similar results (Hurley and Ellis, 2004; Santos et al., 2010; Husky Energy, 2010; Canada-Nova Scotia Offshore Petroleum Board, 2011; Ellis et al., 2012). Biological effects of SBM cuttings generally have been detected at distances within approximately 500 m from wellsites. In some cases, subtle impacts have been detected at greater distances. However, most of these studies were in shallow water (less than 300 m). Because of the water depth of Noble Energy's wellsites (greater than 1,600 m), the cuttings accumulation on the seafloor is expected to be thinner, and the biological impacts less significant.

To evaluate the significance of depositional thickness, it is helpful to consider the review of benthic impact studies conducted by Smit et al. (2008). They estimated median (50%) and low (5%) effects levels of 54 mm and 6.3 mm, respectively. That is, 54 mm is the thickness estimated to adversely affect 50% of the benthic species studied, and a thickness of 6.3 mm affected 5% of the species studied. **Table 4-15** indicates that approximately 0.002 ha will be covered to a depth of 54 mm, and approximately 0.008 ha will be covered by 6.3 mm of discharged drilling mud and cuttings.

Based on the modeling, the benthic impacts of MOBM cuttings discharges are expected to be less than those observed in the Gulf of Mexico studies of SBM cuttings discharges conducted by Continental Shelf Associates Inc. (2004, 2006). The water depth of the wellsite (1,650 m) is a contributing factor because the Gulf of Mexico studies were in shallower water depths (37 to 556 m for Continental Shelf Associates, Inc., 2004; 1,034 to 1,125 m for Continental Shelf Associates, Inc., 2006). In deeper water, the cuttings will disperse more widely while settling to the seafloor. The impacts also are expected to be lower than the referenced studies due to the low amount of residual MOBM on the cuttings (<1%).

Based on CSA Ocean Sciences Inc.'s surveys in the area, the soft bottom community is dominated by surface and subsurface deposit-feeding annelids, which are less sensitive than filter feeders to sedimentation and which have a high potential for reworking of sediments (which aids in community recovery). Soft bottom sediments affected by drilling discharges eventually will be recolonized through larval settlement and migration from adjacent areas.

Metals in drilling fluids show very low bioavailability to marine animals and do not pose a risk to benthic organisms or their predators (Neff et al., 1989a,b).

The discharge of WBM from the initial wells sections and the cuttings with associated MOBM is expected to have a medium impact significance; while the impacts are greater for MOBM, the overall discharge volumes are reduced and the most heavily impacted area is very limited in size. Recovery may require several years (Continental Shelf Associates, Inc., 2006).

4.6.4.2 Solid Waste (Drilling and Infrastructure Activities)

The occasional and accidental loss of debris (e.g., welding rods, buckets, pieces of pipe) may result in accumulation on the seafloor. Pieces of debris reaching the seafloor may be colonized by epibiota and attract fishes (due to their physical structure on the otherwise flat seafloor), with a corresponding minor and localized impact to the benthic community (Shinn et al., 1993). Depending upon the nature of solid waste, leaching of organics or trace metals may occur, resulting in localized changes in sediment quality. Due to restrictions on dumping and expected adherence to applicable MARPOL provisions, this impact is anticipated to be minor. Given the nature of this impact, overall impact significance for individual wells as well as cumulatively is anticipated to be low.

4.6.4.3 Installation Activities

Emplacement of the pipelines, MEG lines, control lines, and utility lines will disturb surficial sediments, causing increased localized turbidity, possible mobilization, transport of sediment-associated contaminants, and crushing and/or burial of benthic communities near the pipeline corridor. Impacts on benthic communities are expected to be minor. Given the occasional nature of this impact, overall impact significance is low.

The discharge of the hydrotest fluids will be short term but will result in high levels of salts and MEG. In terms of the salt compounds, it can be expected that any organisms that are entrapped in the brine plumes at the point of release could suffer acute exposure (Brenner, 2014). No chronic exposures are expected given that the plume is shown to quickly dissipate to ambient salt levels. Based on the modeling results, the acute toxicity levels will dissipate quickly. While it is expected that any organisms trapped in the immediate vicinity of the plume release will suffer mortality, the depauperate nature of the deepsea biota should cause only a negligible impact.

MEG has a low toxicity although entrapment in the immediate vicinity of the hydrotest discharge could cause acute effects. The bigger risk from MEG in the environment comes from possible anoxia due to bacterial degradation of the product. However, a very small amount of MEG is expected to be lost to the environment, and this material will disperse rapidly (e.g., hours) to low to non-detect levels which will minimize any impacts. Therefore, it is not expected that an MEG release will result in significant impacts on the biota. As a result, the overall impact significance of installation activities on benthic communities is negligible.

4.6.4.4 Infrastructure Physical Presence

The pipelines, umbilicals, and potentially the matting used to support them will cover benthic organisms and smother them. The presence of these hard substances (pipe) on the seafloor will serve as a substrate for additional benthic community development. Due to the limited area to be occupied by the benthic infrastructure, overall impact significance is low.

4.6.5 Marine Mammals and Sea Turtles

The following activities at the Tamar Field may impact marine mammals and sea turtles as identified in **Table 4-3**:

- Drillship arrival, departure, and stationkeeping;
- Noise (drilling and installation);
- Installation vessel arrival, operation, and departure;
- Support vessel traffic; and
- Helicopter traffic.

4.6.5.1 Drillship Arrival, Departure, and Stationkeeping

There is the potential for disturbance of marine mammals and sea turtles during transit of the drilling unit. The disturbance impacts would be similar to those associated with existing vessel traffic in the region. The risk of a vessel strike is considered low because of the limited amount of vessel movement and the slow speed at which the vessels will be moving, resulting in a negligible overall impact significance.

4.6.5.2 Noise (Drilling and Installation)

The drilling unit and support vessels will create noise from their operations that could have impacts on marine mammals and sea turtles. Some marine mammals may avoid the drilling unit area due to noise. The most likely impacts would be short-term behavioral changes such as diving and evasive swimming, disruption of activities, or departure from the area.

Richardson et al. (1995) defined four zones of potential noise effects on marine mammals. In order of increasing severity, they are 1) audibility; 2) responsiveness (behavioral effects); 3) masking; and 4) hearing loss, discomfort, or injury (physical effects). The levels of sound produced during drilling are sufficient to be audible and to produce behavioral responses, but much lower than those known to cause hearing loss, discomfort, or injury.

Low-frequency noise from offshore drilling activities can be detected by marine mammals (Richardson et al., 1995). Mysticetes are more likely to detect low-frequency sounds than are most odontocetes, which have their best hearing in high frequencies. However, noise associated with drilling is relatively weak in intensity, and the mammals' exposure to these sounds will be transient. The noise will be similar to the existing noise associated with shipping traffic in the region.

Sound exposure criteria for marine mammals have been historically applied to sea turtles. Sea turtles may experience injury or behavioral disturbance from drilling-related noise. As is the case with marine mammals, sea turtles will hear the sound source prior to any exposure to these source levels; they may respond by changing course or diving, thus avoiding or minimizing any further exposure.

The drilling unit will only be on site for a relatively short period of time (i.e., several months), limiting the potential for noise exposure. Due to the duration of drilling operations, when coupled with the nature of the drilling program-related sound sources, the impact significance of noise on marine mammals and sea turtles is anticipated to be low.

Tamar drilling operations are not performed simultaneously. As a result, cumulative impacts are not considered to be different than impacts from a single drilling operation. While drilling could be occurring in neighboring lease areas, the distance between lease areas and the limited noise generated would not alter the minimal impacts on marine mammals and sea turtles from noise associated with drilling (see **Section 4.5**).

4.6.5.3 Installation Vessel Arrival, Operation, and Departure

There is potential for disturbance of marine mammals and sea turtles during transit of the installation vessel. The disturbance impacts would be similar to those associated with existing vessel traffic in the region. The risk of a vessel strike is considered to be low because of the limited amount of vessel movement and the slow speed at which the vessels will be moving, resulting in negligible impact significance.

4.6.5.4 Support Vessel Traffic

There is a small possibility of a support vessel striking a marine mammal during routine operations. The risk is similar to that associated with existing vessel traffic in the region. Collisions with dolphins or whales are considered highly unlikely. Most dolphins are agile swimmers and are unlikely to collide with vessels. Of the 11 marine mammal species known to have been hit by vessels in the eastern Mediterranean Sea, fin whales have been struck most frequently, sperm whales have been hit commonly, and collisions with Bryde's whales have been rare (Laist et al., 2001). Although all sizes and types of vessels can collide with whales, most lethal or severe injuries are caused by ships 80 m or longer and traveling 14 knots or faster (Laist et al., 2001).

Vessel strikes are among the threats affecting the population status of both humpback and sperm whales (National Marine Fisheries Service, 1991, 2010). Sperm whales are vulnerable to ship strikes because they typically spend up to 10 minutes "rafting" at the surface between deep dives (Jacquet et al., 1998). There have been many reports of sperm whales of different age classes being struck by vessels, including passenger ships and tug boats. There were also instances in which sperm whales approached vessels too closely and were injured by propellers (National Marine Fisheries Service, 2010).

Due to the short duration of the drilling program, the low levels of support vessel traffic, and the low abundance of marine mammals in the area, the likelihood of vessels significantly disturbing marine mammals is considered negligible.

There is a remote possibility of a support vessel striking a sea turtle during routine operations. Vessel strikes are among the threats affecting the endangered population status of several sea turtle species (National Research Council, 1990). The risk of striking a sea turtle during this drilling program is similar to that associated with existing vessel traffic in the region. Studies indicate that sea turtles are at the surface approximately 10% of the time and readily sound (dive) to avoid approaching vessels (Byles, 1989; Lohoefener et al., 1990; Keinath and Musick, 1993; Keinath et al., 1996).

Due to the short duration of the drilling program and the frequency of the support vessel traffic, the impact significance of support vessel impacts on sea turtles is considered negligible.

4.6.5.5 Helicopter Traffic

Helicopter traffic has the potential to disturb marine mammals (Richardson et al., 1995). Reported behavioral responses of marine mammals are highly variable, ranging from no observable reaction to diving or rapid changes in swimming speed or direction (Efroymson et al., 2000; Smultea et al., 2008). Similarly, sea turtles may experience behavioral disturbance from helicopter noise. Sea turtles will hear the sound source prior to any exposure to these source levels; they may respond by changing course, diving, or avoiding further exposure. Smultea et al. (2008) concluded that behavioral responses to brief overflights by aircrafts are short term and probably of no long-term biological significance. The impact significance of helicopter traffic on marine mammals and turtles is negligible.

4.6.6 Marine and Coastal Birds

The following activities at the Tamar Field may impact marine and coastal birds as identified in **Table 4-3**:

- Physical presence;
- Lights;
- Installation activities; and
- Helicopter traffic.

4.6.6.1 Physical Presence

The presence of offshore structures can have a positive and/or negative impact on birds. Some birds may be attracted to offshore drilling units and platforms because of the lights and the fish populations that aggregate around these structures. Birds may use offshore structures for resting, feeding, or as temporary shelter from inclement weather (Russell, 2005). However, birds migrating over water at night have been known to strike offshore structures, resulting in death or injury (Wiese et al., 2001; Russell, 2005). Because of the limited scope and short duration of drilling activities proposed in this program, adverse effects on marine birds from rig presence are unlikely and the overall impact significance is negligible (see **Section 4.4**).

4.6.6.2 Lights

A study in the North Sea indicated that platform lighting causes circling behavior in various birds, especially on cloudy nights. van de Laar (2007) and Poot et al. (2008) suggested that the birds' geomagnetic compasses are upset by the red part of the spectrum from the type of lights currently in use. The numbers varied greatly, from none at all to some tens of thousands of birds per night per platform, with an apparent effect radius of up to 5 km. A study in the Gulf of Mexico also noted the circling phenomenon (Russell, 2005). Because of the limited scope and short duration of drilling activities proposed in this program, adverse effects from lighting on marine birds are considered unlikely and the overall impact significance is negligible.

4.6.6.3 Installation Activities

The support vessels will be transiting to and from the shore base, using the most direct route between the shore base and the drilling unit, weather permitting. Vessel traffic could disturb individuals or groups of coastal birds. It is likely that individual birds would experience, at most, a short-term behavioral disruption, resulting in a negligible overall impact significance.

4.6.6.4 Helicopter Traffic

Helicopter traffic and noise can disturb birds. Responses are highly dependent on bird species, activities that animals were previously engaged in, and previous exposures to overflights (Efroymson et al., 2000). It is likely that individual birds would experience, at most, only short-term behavioral disruption from helicopter traffic and noise. The impact significance is considered to be negligible.

4.6.7 Protected Species/Habitats

The following activities at the Tamar Field may impact protected species/habitats as identified in **Table 4-3**:

- Support vessel traffic; and
- Helicopter traffic.

4.6.7.1 Support Vessel Traffic

Support vessel traffic along the route between shore base port and the drilling unit is not expected to cross or affect any protected areas. No impacts to protected areas or sensitive habitats are expected from support vessel traffic.

4.6.7.2 Helicopter Traffic

If helicopters cross protected areas or sensitive coastal habitats, the noise could disturb nesting birds or other wildlife. It is likely that individual wildlife would experience, at most, only short-term behavioral disruption from helicopter traffic and noise. Helicopters normally will follow the most direct route between the shore and the drilling unit (weather permitting), and under normal conditions are not expected to cross any protected areas.

4.7 SHIPPING, MARITIME INDUSTRY, RECREATION, AESTHETICS/TOURISM, AND ARCHAEOLOGICAL RESOURCES

Culture and heritage sites are addressed by the project's review of potential impacts to: the shipping and maritime industry, recreation and aesthetics/tourism, and archaeological resources as presented in **Table 4-3**.

4.7.1 Shipping and Maritime Industry

The shipping and maritime industry may be impacted by activities at the Tamar Field due to the following as identified in **Table 4-3**:

- Drillship and installation vessel arrival, departure, and stationkeeping;
- Physical presence; and
- Support vessel traffic.

4.7.1.1 Drillship Arrival, Departure, and Stationkeeping

There will be limited operating access around the drilling unit for the duration of 1) drilling unit arrival from a mobilization port outside of the region and transiting through Cypriot waters; 2) positioning of the drilling unit (installation); and 3) drilling unit departure from project location. Due to the distance from shore and the fact that there are no identified shipping lanes through Block 12, very few vessels are expected to be present in the project area and impacts to the fishing industry are expected to be minimal. Although the location from which the drilling unit will be mobilized is not currently known and the drilling unit could possibly use or transit through shipping lanes, little or no impact to shipping and the maritime industry is expected. The overall impact significance is expected to be negligible.

4.7.1.2 Physical Presence

The physical presence of the drilling unit is not expected to have any impacts on shipping and maritime industry. The impacts of the 500-m safety zone are discussed separately in **Chapter 3**.

4.7.1.3 Support Vessel Traffic

As support vessels use the shore base, a minor increase in vessel traffic will occur, and support vessel transit routes may cross normal shipping routes. These impacts are anticipated to be of minor importance due to the transit period. Support vessels will follow the most direct route between the drilling unit and the shore base, weather permitting. It is expected that support vessels would avoid traveling close to the coast, except at the approach to the shore base, and that they would minimize traversing coastal waters at night when traps or nets left overnight could be damaged. Accordingly, significant impacts from support vessel traffic on shipping or other maritime activities are expected to be avoided, with negligible impact significance.

4.7.2 Recreation and Aesthetics/Tourism

Activities at the Tamar Field may impact recreation, aesthetics, and tourism due to the physical presence of the drilling units and vessels. Offshore structures such as drilling units and platforms typically are visible 5 to 16 km from shore, with small structures (e.g., a single offshore drilling unit) barely visible at distances greater than 5 km. On a clear night, lights on top of offshore structures may be visible to a distance of approximately 32 km (U.S. Bureau of Ocean Energy Management, 2012). Since any drilling unit in the Tamar Field will be more than this distance offshore, it will not be visible from shore and will have no aesthetic impact on coastal or nearshore recreation and tourism. The Tamar Platform may be visible from shore, but is far enough offshore to be unobtrusive and have minimal impacts on aesthetics. With the possible exceptions of deepsea fishing and yachting, which could be temporarily impacted due to the presence of the project vessels, recreational activities are not expected to occur near the potential well locations.

4.7.3 Archaeological Resources

The following activities at the Tamar Field may impact archaeological resources as identified in **Table 4-3**:

- Drilling unit arrival, departure, and stationkeeping;
- Drilling (including release/discharge of drill muds and cuttings and other well operations); and
- Installation activities.

4.7.3.1 Drillship Arrival, Departure, and Stationkeeping

A high-resolution side-scan sonar survey or an ROV survey (depending on the type of rig utilized) will be conducted to evaluate the presence of cultural and archaeological resources when a well location or pipeline route has been selected. If any resources are detected during the survey, avoidance zones will be established to prevent any potential impacts from project activities, and the resultant impact significance is negligible.

4.7.3.2 Drilling (including release/discharge of drill muds and cuttings and other well operations)

Cultural/archaeological resources could be impacted by the seafloor release of mud and cuttings. Surface discharges of WBM and associated drill cuttings are not expected to reach archaeological resources on the seafloor per the results of the pre-drill surveys conducted to ensure that there are no such resources at or near the well locations. The impact significance is negligible because all impacts of drilling mud and cuttings discharges on archaeological resources are expected to be avoided.

4.7.3.3 Installation Activities

The installation of pipelines and other bottom structures has the potential to impact archaeological resources. Two surveys were conducted during 2010; one of nearshore areas out to 12 miles from shore (Oceana Marine Research Ltd., 2010), and one of areas from 12 miles offshore to the Tamar Field (DOF Subsea UK, 2010a,b). The surveys included the Tamar Field and potential pipeline routes to shore. One potential shipwreck was identified along one of the potential pipeline routes to shore, and a total of 95 side-scan contacts were identified in the Tamar Field. Two of these corresponded to well locations and 15 were possible anchor locations (DOF Subsea UK, 2010a). The rest were classified as unidentified because they have not been visually inspected. The results of the surveys will be used to ensure that such potential archaeological resources are not impacted. The overall impact significance is negligible.

4.8 AIR QUALITY

Air quality could be impacted by the Tamar Expansion Project through the following as identified in **Table 4-3**:

- Drilling (including release/discharge of drill muds and cuttings, flaring, and other well operations);
- Combustion emissions;
- Support vessel traffic; and
- Helicopter traffic.

Air modeling was not performed for this EIA because the project location is more than 10 km from the Israeli coast.

4.8.1 Drilling (including release/discharge of drill muds and cuttings, flaring and other well operations) and Combustion Emissions

As discussed in **Section 3.4**, engines on the drilling will emit emissions containing air pollutants, including CO, NO_x, SO_x, VOCs, and PM as well as greenhouse gases such as CO_2 and CH_4. Support vessels and helicopters will also emit air pollutants from the combustion of diesel fuel (vessels) and aviation fuel (helicopters).

Under certain atmospheric conditions, some of these gases are known to react or degrade to form different secondary compounds. These degradation products and transformation processes are important in the context of problems such as global climate change, ozone formation, and acidification.

Air pollutant emissions from the drilling unit and support vessels are expected to rapidly dilute and disperse in the offshore atmosphere. There may be intermittent impacts on air quality within several hundred meters of the wellsite during drilling. However, no detectable impacts on air quality are expected onshore based on the relatively small quantities of pollutants emitted and the distance of the Tamar Field from shore.

Gas from well testing is either flared or vented directly to the atmosphere. Combustion from flaring will result in emissions to the atmosphere. Flaring would occur only during the period of a well test, at most over a period of 2 to 3 days. If undertaken, the emissions from a well test will depend on the flow rate and gas/liquid hydrocarbon/water ratio for each well tested.

As indicated in **Section 3.5**, to date the only H_2S that has been recorded within Israel was at Pinnacles 1, where the wellhead gas had H_2S concentrations in excess of 20 ppm; H_2S concentrations of concern are not expected for this project, although potential H_2S emissions will be monitored.

Air pollutant emissions from a well test are expected to rapidly dilute and disperse in the offshore atmosphere. There will likely be some decrease in ambient air quality within several hundred meters of the drilling unit during the test. However, no detectable impacts on air quality onshore are expected based on the relatively small quantities of pollutants emitted and the distance of the Tamar Field from shore.

The impact significance of drilling on air quality negligible; as for water quality impacts, the time and distance between drilling operations for each well result in a negligible cumulative impact on air quality.

4.8.2 Support Vessel Traffic

The emissions from support vessels were discussed in **Chapter 3**. Air pollutant emissions from support vessels are expected to rapidly dilute and disperse in the atmosphere. There may be intermittent impacts on air quality within several hundred meters around a support vessel during transit. The impacts would be similar to those from other vessel traffic in the region. Little or no detectable impact on air quality is expected onshore based on the relatively small quantities of pollutants emitted and the fact that most of the vessel transit will occur in offshore areas. The overall impact significance is expected to be negligible.

4.8.3 Helicopter Traffic

Air pollutant emissions from helicopters are expected to rapidly dilute and disperse in the atmosphere. There may be intermittent impacts on air quality within several hundred meters around a helicopter during transit. The impacts would be similar to those from other aircraft traffic in the region. Negligible or no detectable impact on air quality is expected onshore based on the small quantities of pollutants emitted and the fact that most of the helicopter transit will occur in offshore areas.

4.9 WASTE

4.9.1 General Waste

Waste (other than drilling discharges discussed in **Chapter 3**) has been and will be transported onshore for disposal at a licensed disposal facility.

Debris accidently lost overboard could have impacts on water and sediment quality and benthic communities (National Research Council, 2008; U.S. Bureau of Ocean Energy Management, 2012). Heavy items such as welding rods, buckets, pieces of pipe, etc. may have a minor, localized impact on sediment quality beneath the rig location by creating small areas of hard substrate on the soft bottom seafloor (Shinn et al., 1993; Gallaway et al., 2008). The size of the area affected would be negligible. Lighter pieces of debris may float on the sea surface and adversely affect water quality and marine biota (National Research Council, 2008; National Oceanic and Atmospheric Administration, National Ocean Service, 2013). The potential impacts on water quality from marine debris are expected to be similar to those from the existing shipping and fishing industries.

Materials accidentally lost overboard during offshore oil and gas operations could entangle marine fauna or cause injury through the ingestion of the debris (Laist, 1996). Marine debris is among the threats affecting the population status of both humpback and sperm whales (National Marine Fisheries Service, 1991, 2010). Ingestion of or entanglement with accidentally discarded trash and debris can kill or injure sea turtles (Laist, 1996; Lutcavage et al., 1997). Marine debris is among the threats affecting the endangered population status of several sea turtle species (National Research Council, 1990). Leatherback turtles are especially attracted to floating debris, particularly plastic bags because they resemble their preferred food: jellyfish. Ingestion of plastic and Styrofoam can result in drowning, lacerations, digestive disorders or blockage, and reduced mobility. The types of impacts on marine mammals and sea turtles from program-related marine trash and debris would be similar to those from existing shipping and fishing industries.

Marine trash and debris could injure or kill birds that ingest or become entangled in it. The ingestion of plastic by marine and coastal birds can cause obstruction of the gastrointestinal tract, which can result in mortality (Laist, 1996). The types of impacts on marine birds from program-related marine trash and debris would be similar to those from the existing shipping and fishing industries.

The overall impact significance of waste generation is expected to be low to negligible (see **Section 4.6.4**).

4.9.2 MOBM Cuttings

If the discharge of MOBM cuttings from the proposed wells is not approved, the cuttings from these sections will be transported to shore for disposal. As described in **Section 3.7**, it is estimated that approximately 27 vessel trips (between the wells and Haifa) and 80 truck trips (Haifa to the Ramat Hovav landfill) would be required for onshore cuttings disposal (CSA Ocean Sciences Inc., 2013c). The vessels and trucks will produce emissions from internal combustion engines, including greenhouse gases and other pollutants such as CO, NO_x, SO_x, VOCs, and PM. The estimated air pollutant emissions from this activity for a well offshore Israel are presented in **Tables 4-16** and **4-17**.

Table 4-16. Estimated air pollutant emissions from vessels transporting mineral oil-based mud (MOBM) cuttings from an offshore wellsite to the Port of Haifa. The data represent 27 vessel trips.

Emissions (MT)	Air Pollutant					
	CO_2	CO	NO_x	SO_x	VOCs	PM
Per ton of diesel	3.200	0.016	0.059	0.004	0.002	0.002
Per trip (12 MT of diesel)	38.4	0.188	0.713	0.048	0.024	0.023
Per 27 vessel trips	1,037	5.076	19.251	1.296	0.648	0.621

CO = carbon monoxide; CO_2 = carbon dioxide; MT = metric ton; NO_x = nitrogen oxides; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.

Table 4-17. Estimated air pollutant emissions from trucks transporting mineral oil-based mud (MOBM) cuttings from the Port of Haifa to the Ramat Hovav landfill. The data represent 80 truck trips.

Emissions	Air Pollutant				
	CO_2	CO	VOCs	NO_x	$PM_{2.5}$
Per km for one truck (g)	643	0.91	0.21	5.57	0.15
Per 220 km trip to Ramat Hovav (g)	141,460	200	46	1,225	33
Per 80 truck trips to Ramat Hovav (kg)	11,316	16	3.70	98	2.64

CO = carbon monoxide; CO_2 = carbon dioxide; NO_x = nitrogen oxides; PM = particulate matter; VOC = volatile organic compound.

The increased air pollutant emissions generally are consistent with the USEPA (2000) findings for a "zero discharge" option in the U.S. Gulf of Mexico. While this level of emissions is not unusual for vessel or vehicle traffic, the cumulative effects add to air quality concerns. The impacts would be mostly to onshore air quality rather than offshore where the distance from shore and prevailing winds would reduce the chance of impacting onshore air quality.

Drill cuttings from each well would represent almost 2.5% of the total amount disposed in the Ramat Hovav landfill in 2010. The individual and cumulative impacts of the disposal of MOBM-associated cuttings would decrease the ability of the Ramat Hovav landfill to accept wastes from other sources. The increased landfill requirements and negative environmental implications were noted by the USEPA (2000) in their evaluation of a "zero discharge" option in the U.S. Gulf of Mexico.

The additional vessel traffic due to onshore cuttings disposal is not expected to cause any disruptions to vessel traffic; however, there is a small chance for potential interactions with fishing boats or other vessels and a small risk of a vessel striking a marine mammal or sea turtle.

There is a small risk of accidents during crane transfer of cuttings tanks from vessels to trucks at the shore base. However, the Port of Haifa is equipped with state-of-the-art cargo-handling cranes, and the risk would be similar to that for any cargo handling at the port. There is a small risk of accidents (e.g., collisions) during vessel trips between the rig and shore base, or vehicle accidents during truck trips between Haifa and the Ramat Hovav landfill. The risks are assumed to be similar to those for any routine vessel or vehicle traffic in the region.

4.10 HAZARDOUS MATERIALS

The accidental loss of a battery overboard is considered in this section as an example of the potential impacts of hazardous items.

Accidental loss of a battery or similar hazardous item would have a minor, localized impact on sediment quality and benthic communities. The benthic community could be affected by the physical presence of the battery (which may attract fishes and epibiota) and by any toxic chemicals leaking from it that may accumulate in seafloor sediments. The size of the area affected would be negligible.

Accidental loss of a battery or similar hazardous item would not be expected to affect water quality upon release, as it would sink to the seafloor. However, there could be minor water quality impacts over time due to the release of chemicals from the battery as it deteriorates.

4.11 SUMMARY OF POTENTIAL IMPACTS

Table 4-18 presents a summary of the potential impacts from the project. Most of the evaluated impacts have an expected impact significance of negligible to low. Six of the potential impacts were ranked as medium impact significance. Four of these were expected to result from a worst case discharge, and two were from drilling activities. The potential worst case discharge impacts included impacts on water quality; plankton, fish, and fishery resources; benthic communities; and marine and coastal birds. The medium impact of a worst case discharge on benthic communities would only occur if the released material reached coastal waters; the impact would be expected to be low if the material remained in deep water. The two medium rated potential impacts resulting from drilling included impacts on sediments/sediment quality and on benthic communities. The medium impact of drilling on benthic communities would only occur if MOBM cuttings are discharged. No impacts were expected to be of high significance.

4.12 PREPARATION FOR EARTHQUAKES – EMERGENCY PROCEDURES

The project is located offshore, and Noble Energy has considered the impact of potential earthquakes (see **Chapter 1** for a review of seismic activity in the area). If damage from an earthquake results in the loss of hydrocarbons from a well or pipeline, Noble Energy's emergency response plan, which describes the procedures to be followed, will be implemented.

4.13 FISHING AND MARINE FARMING

All vessels (including fishing boats) will be excluded from a 500-m radius around the *ENSCO 5006* for safety reasons. Support vessels will monitor this buffer zone and help minimize the potential for other vessels to enter the area. Any inconveniences associated with the buffer zone are expected to be minimal.

Although no conclusive studies have been conducted to quantify catch losses resulting from the temporary emplacement of an exploratory drilling rig, only a limited number of fishing vessels traditionally use the area where the drilling rig will be located. The impacts to commercial fishing activities are expected to be negligible.

The nearest marine farming activity is close to shore near Ashdod (see **Figure 1-3**). The project is not expected to impact fishing or marine farming due to its distance from shore and from established fishing grounds.

Table 4-18. Summary matrix of overall impact significance. If a potential impact ranges between two categories, the higher category is presented.

Project Activity/ Impact-Producing Factor	Environmental Resource											
	Physical/Chemical			Biological				Socioeconomic and Cultural				
	Air Quality	Sediments/Sediment Quality	Water Quality	Plankton, Fish, and Fishery Resources	Benthic Communities	Marine Mammals and Sea Turtles	Marine and Coastal Birds	Protected Marine Species and Habitats, Marine Habitats of Interest, and Areas of Special Concern	Fishing and Marine Farming	Shipping and Maritime Industry	Recreation and Aesthetics/ Tourism	Archaeological Resources
NON-ROUTINE (ACCIDENTAL) EVENTS (4.3)												
Drilling Worst Case Gas Discharge	Low		Medium	Medium	Medium *	Low	Medium	Low	Negligible	Negligible	Low	Low
Large Diesel Fuel Spill	Low	Negligible	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Solid Waste (Accidental Loss)		Negligible	Negligible		Negligible	Low	Low	Low			Negligible	
ROUTINE PROJECT-RELATED ACTIVITIES												
Drilling Activities												
Drillship Arrival, Departure, and Stationkeeping			Negligible			Negligible			Negligible	Negligible		Negligible
Drilling (including release/discharge of drill muds and cuttings, flaring, and other well operations	Negligible	Medium	Low	Negligible	Medium **				Negligible			Negligible
Physical Presence				Negligible			Negligible			Negligible	Negligible	
Lights						Low	Negligible					
Noise (including support vessels and aircrafts)						Low					Negligible	
Routine (non-drilling related) Discharges			Low	Low								
Solid Waste					Low							
Infrastructure Installation and Operation (platform, pipelines, umbilicals)												
Installation Vessel Arrival, Operation, and Departure			Negligible			Negligible			Negligible	Negligible		
Installation Activities		Low	Low	Low	Low		Negligible		Negligible			Negligible
Physical Presence		Low			Low				Negligible			
Combustion Emissions	Negligible											
Noise						Low						
Solid Waste					Low							
Support Vessel and Helicopter Traffic												
Support Vessel Traffic	Negligible					Negligible		Negligible	Negligible	Negligible		
Helicopter Traffic	Negligible					Negligible	Negligible	Negligible				

* The impact of a worst case discharge is expected to be low for offshore areas, and medium if the discharge reaches the shoreline.

** The impact of drilling cuttings discharges is expected to be low if the MOBM cuttings are not discharged.

Key:

Negligible Impact
Low Impact
Medium Impact

4.14 SAFETY AND PROTECTION – SAFETY ZONE

Consistent with international industry practice, Noble Energy will establish a 500-m radius safety zone around the drilling unit, which will be kept clear of all unauthorized vessels. A continuous bridge watch on the drilling unit will be maintained to ensure compliance with the safety zone. A standby vessel (e.g., a supply vessel) supporting the drilling will keep watch also and will be used to enforce the safety zone, intervening if any vessel makes a close approach.

4.15 MONITORING AND CONTROL PROGRAM

4.15.1 Drilling and Installation Activity Monitoring

Monitoring procedures are an integral element of Noble Energy's operations and help to ensure that the mitigation measures identified for the project are implemented. Some monitoring is prescribed in various regulations and plans; other monitoring is directed by Noble Energy's Environmental, Health and Safety (EHS) procedures.

Monitoring will be performed at all levels and phases of the work, including during drilling and installation activities and during ongoing operations. Discharges to be tested, the frequency of testing, and analyses will comply with all applicable permits and regulations, Noble Energy policy, and best industry practice. Permit-required monitoring limits, frequency, and analyses for drilling discharges is expected to be similar to that required for the drilling of the Tamar SW-1 well (**Appendix I**), as shown in **Tables 4-19** and **4-20**. The permit for the Tamar SW-1 well noted that there might be other parameters for the criteria, such as TOC in the drilling mud or the composition of oils and organic material in kitchen waste.

Table 4-19. Monitoring criteria for the Tamar SW-1 well (from the Tamar SW-1 discharge permit).

Index	Units	Maximum Value
Drilling Mud		
pH		9.5>pH>6.0
Sanitary Waste		
Free Chlorine (after neutralization, for discharging in the water)	mg/L	0.3
Floating Solids (TSS 105°C)	mg/L	50
General BOD_5	mg/L	50
Turbidity	NTU	50
All Sources		
pH		9.5>pH>6.0

BOD_5 = 5-day biochemical oxygen demand; TSS = tot*al suspended solids.

Table 4-20. Frequency of discharge testing and analyses performed for the Tamar SW-1 well (from the Tamar SW-1 discharge permit).

<table>
<tr><th colspan="3">Discharge Testing Frequency</th></tr>
<tr><td colspan="3">1. Drilling Mud(1)</td></tr>
<tr><td rowspan="10">The sampling frequency below has been determined based on the stages of drilling and based on the drilling plan.
Grab sampling, in each drilling segment, 26-in. + 36-in., 17½-in., 12¼-in., 8½-in.
Total of at least 4 samples</td><td>* General BOD_5</td><td>* Toxicity tests(2)</td></tr>
<tr><td>* TOC</td><td>* Nitrate as N</td></tr>
<tr><td>* Floating solids (TSS) 105°C</td><td>* Nitrite as N</td></tr>
<tr><td>* Mineral oil (FTIR)</td><td>* Ammoniacal nitrogen as N</td></tr>
<tr><td>* General oils and lipids (FTIR)</td><td>* Kjeldahl nitrogen as N</td></tr>
<tr><td>* PAH</td><td>* General nitrogen (calculated)</td></tr>
<tr><td>* Phenol</td><td>* pH</td></tr>
<tr><td>* Carzol</td><td>* Total dissolved solids (TDS)</td></tr>
<tr><td>* DOX (GC)</td><td>* Chlorides</td></tr>
<tr><td colspan="2">• Extended metal scan (ICP), including P.
• GC-MS, probability percentages, half-quantity concentrations, and total concentrations.
• VOCs, probability percentages, half-quantity concentrations, and total concentrations.
• Metal content in barite(3)</td></tr>
</table>

Table 4-20. (Continued).

Discharge Testing Frequency		
2. Cutting Discharge		
Grab sampling, every 500 m or in the event of any significant change in the underground fraction of the drilling cross section[4]	* Content of metals: Ag, As, Cd, Cu, Cr, Hg, Ni, Pb, Zn	
	* Content of organic material is expressed as TOC.	
	* Radioactive materials: Ra 226, Ra 228, Th 228, Pb 210[5]	
3. Sanitary Waste		
Representative sampling, once a month, unless otherwise required.	* General BOD_5	* Ammoniacal nitrogen as N
	* TOC	* Kjeldahl nitrogen as N
	* Floating solids (TSS) 105°C	* General nitrogen
	* Turbidity	* General phosphorus
	* Turbidity - field test – once a week.	* Fecal coli per 100 mL
	* Free chlorine – field test, once a week	* Enterococci per 100 mL
	* AOX	* pH
	* Oils and lipids (FTIR)	* Total dissolved solids (TDS)
	* Mineral oil (FTIR)	* Chlorides
	* Nitrate as N + Nitrite as N	
4. Gray Water		
Representative sampling, once a month	* Floating solids (TSS) 105°C	* Oils and lipids (FTIR)
	* Detergents (MBAS)	* Total dissolved solids (TDS)
5. Ground Organic Waste (Food)		
Representative sampling, once a month	* General BOD	* General oils and lipids (FTIR)
	* TOC	* General nitrogen
	* Floating solids (TSS) 105°C	* General phosphorus
6. Quantities		
Quantity, Recording and Reporting Reports shall include details of the basis for the information – quantity meter, discharging hours, etc. (including an explanation).	* Daily quantity (for each day of the month), monthly and total cumulative from the beginning of discharge for each of the sources, and total discharge into the sea, according to the details set out in section 3B above and as follows. * Drilling mud – volume quantity (cubic meters) and mass quantity (dry tons) * Cutting discharge, cement residue – mass quantity (dry tons). * Maximum number of persons on the rig each day (POB).	

[1] The results of the tests are to be submitted in units of mass per volume (mg/L) except in tests of barite and cutting discharge. The results of the tests for drilling mud will be submitted in units of mass per volume (mg/L) and in units of dry mass (mg/kg dry material). The results of the tests will be submitted noting the depth of the drilling beneath the seafloor and beneath the surface of the sea, the diameter of the drilling segment, at the time of sampling.

[2] A toxicity test is to be conducted in a test lasting 96 hours in accordance with the general permissions of the National Pollutant Discharge Elimination System (NPDES) for existing and new sources in the sea, under the subcategory of extraction and removal of oil and gas for the western portion of the coastal threshold of the Gulf of Mexico (29000GMG), or any other pre-approved and relevant protocol. The test will be conducted in an authorized laboratory overseas, subject to the presentation of approval of the authorization of the laboratory, and in accordance with the instructions of the Marine and Coastal Division.

[3] The recipient of the Permit shall conduct metal content tests on the barite, taking a representative sample from the raw material as follows:

- Cadmium and mercury content (AA, at a sensitivity of at least 0.1 mg/kg at least) – once a month (at least three tests: 1. at the start of the drilling; 2. in the middle of the drilling and at the end of the drilling; and 3. using the method and sensitivity set out above).
- Metal content: Ag, As, Cd, Cu, Cr, Hg, Ni, Pb, and Zn – once every three months.

[4] The tests shall be performed on the cutting discharge, following normalization (where possible) of the sticky drilling mud for the cutting discharge.

[5] Performance assessments will be conducted to address requirements identified under the Environmental Approval and Exploration Authorization and to review the implementation of the EHS management plans required per the Environmental Approval.

Other monitoring activities include the following:

- Noble Energy will conduct a performance assessment to confirm that a Notice to Mariners was issued and support vessels were instructed to monitor and enforce the safety zone.
- Noble Energy will conduct a performance assessment immediately prior to spudding the well to determine the status of the EHS processes and resources in place.
- Noble Energy will conduct a performance assessment at least once during the drilling of each well to confirm that the discharge monitoring requirements on the drilling unit(s) have been complied with. These include barite certificates, Safety Data Sheets for all chemicals listed in the Chemical Use Plan, and the chemicals inventory, among others.
- Monitoring of drilling discharges will be conducted as part of daily monitoring activities on the drilling rig(s). This includes the testing of drilling muds and associated chemicals, and periodic toxicity testing of drilling muds during drilling. The well-specific monitoring will be identified in a drilling fluid monitoring program. The Tamar SW-1 well discharge monitoring requirements and permit limits were included in the well's discharge permit which is attached as an example (**Appendix I**).
- Documentation of discharges and related monitoring activities will be conducted as part of daily monitoring activities on the drilling unit(s) and per the Offshore Discharge Program that will be prepared.
- Discharge requirements and documentation will be evaluated during a performance assessment on the drilling unit at least once during the drilling program.
- Waste management on the drilling unit will be evaluated during a performance assessment on the drilling unit at least once during the drilling program. Waste tracking documentation and related monitoring activities will be conducted per the Waste Management Program that will be prepared.
- Fuel use will be monitored and estimated air pollutant emissions will be calculated at the termination of drilling activities.
- Noble Energy will conduct performance assessments to confirm instructions were provided to vessel masters and helicopter pilots regarding avoidance of fishing vessels, aquaculture structures, and protected species.
- Waters in the vicinity of the drilling unit will be monitored for oil sheen on a daily basis. If an oil sheen is observed, the source will be identified and steps taken to reduce, minimize, or eliminate (if possible) the discharge if the source is the drilling unit or support vessels.
- Noble Energy will conduct performance assessments at least once during each drilling program to confirm that spill response resources are in place, trained personnel are available on site, and third-party contractors are familiar with spill prevention and response procedures, including notification requirements.

4.15.2 Environmental Surveys

Noble Energy has conducted numerous monitoring surveys of the Tamar lease area (CSA International, Inc., 2010; CSA Ocean Sciences Inc., 2013f,g,h,i,j,k), including a recent survey (CSA Ocean Sciences Inc., 2014), that assessed the environmental conditions throughout the Tamar and Tamar SW Reservoir areas, the pipeline corridor to the Tamar Platform and the Tamar Platform area. The latest report was prepared to meet a requirement of the MoEP and MNIEWR to develop and implement an environmental monitoring program.

The purpose of the Tamar Field Background Monitoring Survey (CSA Ocean Sciences Inc., 2014) was to provide a characterization of the environmental conditions within the boundaries of the field, natural gas reservoir, and pipeline corridor to establish an environmental baseline for the field after its partial development. The sampling was intended to establish the predictability of values from place to place in the study area and preclude the need for any additional pre-activity sampling within the field or pipeline corridor. A survey of the Tamar Field was conducted in two stages. The first stage was conducted from 22 to 26 March 2013 and consisted of video, hydrographic profiling data, near-bottom water samples, and sediment and infauna samples collected within close proximity (approximately 2 km) of the Tamar wellsites. The second stage was conducted from 9 to 13 February 2014 and consisted of hydrographic profiling data, water column samples, and sediment and infauna samples collected throughout the Tamar Field. Additionally, a survey of the Tamar pipeline corridor was conducted from 26 to 31 March 2013 and consisted of sediment samples collected in close proximity (within 50 m) of the pipeline.

The Tamar Field Background Monitoring Survey design consisted of a uniform grid, superimposed over the natural gas reservoir, in which the center point of each grid cell was sampled. Grid cells containing previously sampled locations were not re-sampled. Data from previously sampled locations within a grid cell were averaged and assigned to the center point of that cell. The physical, chemical, geological, and biological environmental conditions were inspected for spatial variation within the study area by using geostatistical techniques based on the computation of semivariance and interpolation by kriging. The kriged data were used to assess existing effects from drilling discharges and infrastructure development through the comparison of deviations from regional ambient background values typical of the eastern Levantine Basin and internationally and locally accepted environmental standards. Additionally, the data will be used to provide information on further deviations from ambient conditions and environmental standards due to the potential effects of future development within the field. The survey design along the pipeline corridor consisted of a stratified random sampling design in which samples were randomly divided among strata that were defined by water depth. As this report is establishing the current baseline for the survey region, interpretation of data from along the pipeline is primarily descriptive; however, statistical comparisons with Levantine Basin means are provided.

Collectively, the monitoring surveys provide the necessary baseline information to support future monitoring of the environment to evaluate potential impacts from Noble Energy's activities in the Tamar lease area. Previously prepared EIAs for the Tamar lease area also contribute information to facilitate the evaluation of spatial and temporal changes in the potentially impacted environment (CSA International, Inc., 2012; CSA Ocean Sciences Inc., 2013l). Noble Energy will continue to perform periodic surveys at specific sites and in the entire lease area. The sampling design used to date within the Tamar Field has been developed to ensure the environment within the reservoir footprint is characterized sufficiently by geostatistical methods so that no additional pre-activity survey (i.e., pre-drill surveys) will be required.

Additionally, surveys specific to post-drill analysis of each new wellsite will be conducted as per regulations. Area-wide monitoring surveys of the Tamar Field will be conducted periodically. Seawater and sediment parameters specific to the post-drill analysis and area-wide monitoring surveys are found in **Tables 4-21** and **4-22**.

Table 4-21. Analytical parameters, primary laboratory, analysis methods, reporting units, and reporting limits of quantification for seawater samples to be collected during post-drill and area-wide monitoring surveys. Laboratories to be used may vary from those listed.

Parameter/ Analyte	Primary Analytical Laboratory	Digestion/ Extraction Method	Analytical/Detection/ Quantification Method	Quantification Limit [1]	CCC[2]	Units
Arsenic	ALS Environmental – Kelso	Red. Ppt	ICP-MS	0.5	36	µg/L
Antimony		20× dilution	ICP-MS	1	500[p]	µg/L
Barium		N/A	ICP-MS	4	200	µg/L
Beryllium		Red. Ppt	ICP-MS	0.02	--	µg/L
Cadmium		Red. Ppt	ICP-MS	0.02	8.8	µg/L
Chromium		Red. Ppt	ICP-MS	0.2	--[4]	µg/L
Copper		Red. Ppt	ICP-MS	0.1	3.1	µg/L
Lead		Red. Ppt	ICP-MS	0.02	8.1	µg/L
Mercury		N/A	Based on USEPA 1631E	0.001	0.94	µg/L
Nickel		Red. Ppt	ICP-MS	0.2	8.2	µg/L
Selenium		N/A	BRAAS	1.0	71	µg/L
Silver		Red. Ppt	ICP-MS	0.02	--	µg/L
Thallium		Red. Ppt	ICP-MS	0.02	--	µg/L
Vanadium		N/A	ICP-OES	4.0	50	µg/L
Zinc		Red. Ppt	ICP-MS	0.5	81	µg/L
Ions		N/A	ICP-AES/Ion Chromatography	4.5 to 60,000	--	µg/L
TPH	TDI-Brooks	Methylene chloride	USEPA/SW-846 Modified 8100/8015C	13	--	µg/L
PAHs[3]		Methylene chloride	USEPA SW-846/ 8260/GC-MS	0.74 to 2.91	--	ng/L
Total nitrogen	Chesapeake Biological Laboratory	Persulfate digestion	Diazo colorimetric method	0.01	--	mg/L
Ammonium		N/A	USEPA Method 350.2	0.01	--	mg/L
Nitrite		N/A	Diazo colorimetric method	0.0175/0.0035	--	mg/L
Nitrate		Enzyme or Cd reduction	Diazo colorimetric method	0.0175/0.0035	--	mg/L
Phosphate		N/A	USEPA Method 365.1	0.0025	--	mg/L
Total phosphorous		Persulfate digestion	Ascorbic acid colorimetric method	0.0013	--	mg/L
TOC/DOC		N/A	High-temperature combustion	0.24	--	mg/L
Total suspended solids		N/A	Analytical balance	0.01	--	mg/L
Radium 226[4]	ALS Environmental – Ft. Collins	N/A	USEPA Method 903.1	1	--	pCi/L
Radium 228[4]		N/A	USEPA Method 904.0 and SW-846 9320	1	--	pCi/L

Cd = cadmium; DOC = dissolved organic carbon; GC-MS = gas chromatography-mass spectrometry; ICP-AES = inductively coupled plasma-atomic emission spectrometry; ICP-MS = inductively coupled plasma-mass spectrometry; ICP-OES = inductively coupled plasma-optical emission spectrometry; N/A = not applicable; PAH = polycyclic aromatic hydrocarbon; Red. Ppt. = reduction precipitation; TOC = total organic carbon; TPH = total petroleum hydrocarbons; USEPA = U.S. Environmental Protection Agency.

[1] Limits of quantification are the detection limits for metals, and ions, and reporting limit for TPH and PAHs.

[2] CCC = Criterion Continuous Concentration (Buchman, 2008); CCC is an estimate of the highest concentration of a material in ambient.

[3] Polycyclic aromatic hydrocarbons will be analyzed for only if total petroleum hydrocarbon samples are greater than the Levantine Basin baseline as determined from pre-drill and environmental baseline surveys.

[4] Only 10% of water samples will be analyzed for radium 226/228.

[p] = proposed.

Table 4-22. Analytical parameters, analytical laboratory, analysis methods, reporting units, reporting/limits of quantification, and sediment quality guidelines (effects range low [ERL] and effects range median [ERM]; Buchman, 2008) for sediment samples to be collected during post-drill and area-wide monitoring surveys. Laboratories to be used may vary from those listed.

Parameter/ Analyte	Analytical Laboratory	Digestion/ Extraction Method	Analytical/Detection/ Quantification Method	Quantification Limit	ERL	ERM	Units
Particle size distribution	Weatherford	N/A	Laser diffraction particle size analysis	0.1	--	--	µm
TOC		N/A	Based on European Standard Norm 1484	5	--	--	ppm
Aluminum	ALS Environmental – Kelso	HF[1]	ICP-OES	25	--	--	ppm
Antimony		HF[1]	ICP-MS	0.4	--	--	ppm
Arsenic		HF[1]	ICP-MS	4.0	8.2	70	ppm
Barium		HF[1]	ICP-OES	10.0	--	--	ppm
Beryllium		HF[1]	ICP-MS	0.16	--	--	ppm
Cadmium		HF[1]	ICP-MS	0.16	1.2	9.6	ppm
Chromium		HF[1]	ICP-MS	11.6	81	370	ppm
Copper		HF[1]	ICP-MS	0.8	34	270	ppm
Iron		HF[1]	ICP-OES	50	--	--	ppm
Lead		HF[1]	ICP-MS	0.4	46.7	218	ppm
Mercury		HNO_3/H_2SO_4	Based on USEPA 1631E	0.001	0.15	0.71	ppm
Nickel		HF[1]	ICP-MS	1.6	20.9	51.6	ppm
Selenium		HF[1]	ICP-MS	8	--	--	ppm
Silver		HF[1]	ICP-MS	0.16	1	3.7	ppm
Thallium		HF[1]	ICP-MS	0.16	--	--	ppm
Vanadium		HF[1]	ICP-MS	1.6	--	--	ppm
Zinc		HF[1]	ICP-MS	4	150	410	ppm
TPH	TDI-Brooks	Methylene chloride	USEPA/SW-846 Modified 8100/8015C	1.4	--	--	µg/g
PAHs[2]		Methylene chloride	USEPA SW-846/8260/ GC-MS	0.342 – 0.041	552[3] 4,002[4]	3,160[3] 44,792[4]	ng/g
Radium 226[5]	ALS Environmental – Ft. Collins	N/A	USEPA Method 901.1	1	--	--	pCi/g
Radium 228[5]		N/A	USEPA Method 901.1	1	--	--	pCi/g
Thorium 228[5]		N/A	USEPA, EMSL/LV	0.2	--	--	pCi/g

EMSL/LV = Environmental Monitoring Systems Laboratory, Las Vegas; GC-MS = gas chromatography-mass spectrometry; HF = hydrofluoric acid; HNO_3 = nitric acid; H_2SO_4 = sulfuric acid; ICP-MS = inductively coupled plasma-mass spectrometry; ICP-OES = inductively coupled plasma-optical emission spectrometry; ISO = International Organization for Standardization; N/A = not applicable; TOC = total organic carbon; TPH = total petroleum hydrocarbons; USEPA = U.S. Environmental Protection Agency.

[1] This digestion procedure results in the release of nearly all the metal content of a sample and it is believed to be a more accurately estimate of the metal concentrations in all sample matrices.

[2] PAHs = polycyclic aromatic hydrocarbons; PAHs will be analyzed for only if TPH concentrations are greater than the Levantine Basin baseline as determined from pre-drill and environmental baseline surveys.

[3] Low molecular weight polycyclic aromatic hydrocarbons.

[4] Total polycyclic aromatic hydrocarbons.

[5] Only 10% of sediment samples will be analyzed for radium 226, radium 228, and thorium 228.

4.16 CLOSURE AND ABANDONMENT

The design life of the Tamar Platform is 30 years. Near the end of its life, Noble Energy will evaluate the Israeli regulations in place pertinent to offshore structures and will propose abandonment plans that comply with existing regulations. Possible abandonment approaches include complete removal of the facility, cutting of the upper portions of the structure to eliminate navigational hazards, or toppling of the structure in place.

The design life of the pipelines, MEG lines, utility lines, and control lines is comparable to the life expectancy of the Tamar Platform – 30 years. As field production in the Tamar Field nears, Noble Energy will evaluate the Israeli regulations in place regarding subsea pipelines, flowlines, utility lines, and control lines. Noble Energy expects that abandonment plans will be developed that comply with existing regulations. Possible abandonment approaches include abandonment in place or partial to complete removal of the lines.

CHAPTER 5: PROPOSAL FOR APPLICATION GUIDELINES (MITIGATION)

5.1 OVERVIEW

This section outlines the environmental, health, and safety management practices of Noble Energy, followed by a review of the mitigation and abatement actions and procedures to be implemented and followed to protect the environment throughout the Tamar Expansion Project.

5.1.1 Noble Environmental, Health, and Safety Management

Environmental management of Noble Energy activities is implemented through a hierarchy of policies, plans, and procedures that cascade from the corporate level to the business units and their individual operations. To ensure that Noble Energy's corporate environmental, health, and safety policies are systematically applied and that industry best practices are adopted within all of its operations, Noble Energy has developed its Environmental, Health, and Safety Global Management System (GMS) that integrates health, safety, and environmental considerations into all elements of the management process. The hierarchy of this system is illustrated in **Figure 5-1**.

The EHS policies are at the top of the EHS management hierarchy and demonstrate the commitment and intentions of the company. At the next level are the Corporate EHS Standards and Guidelines, documented in the Noble Energy GMS, which support the policies. At the base of the structure are the project-specific Operational Plans, Programs, and Procedures that provide the specifics of how things are done within each project.

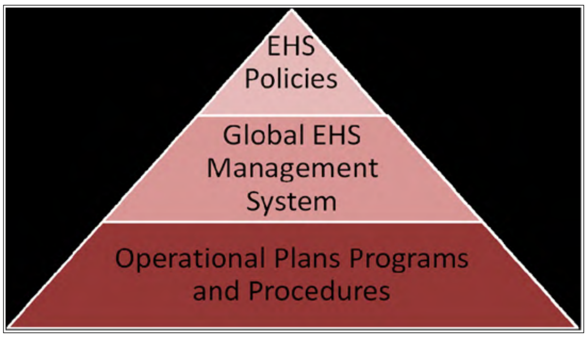


Figure 5-1. Environmental, Health and Safety (EHS) management hierarchy.

The GMS provides a framework for establishing performance goals and incorporates Noble Energy's legal requirements and best practices into an umbrella framework within a model that integrates elements from the Safety and Health Management System and Environmental Management System.

Specific to Israel, Noble Energy is implementing a Safety and Environmental Management System (SEMS) that builds upon the elements that make up its GMS system. The SEMS provides the framework to make offshore gas development safe for workers and protective of the environment.

The SEMS is implemented across Noble Energy's offshore operations and is applied to third-party contractors involved in drilling and other support activities. This ensures that all levels of operations are performed in a consistent manner and that safety and environmental protection are consistently achieved. The integration between the Noble Energy SEMS and contractor operations is implemented through interface documents that identify common processes and approaches to address any differences in procedures between Noble Energy and the contractor as well as any site-specific hazards of the Tamar Field Development Project. Noble Energy will conduct an extensive comparison and review of vessel plans, processes, and procedures relative to the Noble Energy SEMS to ensure that the contractor's plans are acceptable for use as the primary system during the Tamar Field Development Project.

5.1.2 Environmental Policy

Noble Energy is implementing an Environmental Management System based on an environmental policy that stresses development of energy resources in a responsible manner and works diligently to reduce risks to the environment and human health. Noble Energy is committed to ensuring compliance with applicable EHS legislation, to implementing best practice standards where laws do not exist, and to mitigating risk while protecting the environment and the communities where the company operates. Elements of the Environmental Management System that facilitate achieving the objectives of the environmental policy include the following key philosophies:

- **Continuous Improvement** – Noble Energy has numerous initiatives in place to analyze, monitor, and continuously improve its environmental performance. Noble Energy actively evaluates the availability and performance of green technologies (e.g., drilling fluids), and is actively involved in adopting technologies and practices that improve operational efficiency while reducing methane emissions.
- **Internal Responsibility** – In addition to enforcing stringent policies and adopting best practices for environmentally responsible operations, Noble Energy has created forums dedicated to improving performance. For example, the Noble Environmental Council meets quarterly to share experiences, issues, and concerns and to advise management on fostering a culture of environmental excellence.
- **Preservation of Wildlife** – Noble Energy's commitment to the environment extends to the preservation of wildlife and natural areas.

Noble Energy also has implemented an environmental protection policy that includes the following key components:

- **Environmental Training** – Noble Energy provides environmental education for various personnel that includes hands-on training and may incorporate third-party trainers and computer-based training.
- **Spill Prevention** – In addition to meeting all regulations regarding the timely reporting of hydrocarbon and produced water discharges, Noble Energy has a procedure to report and track spills and unintentional discharges. Noble Energy periodically reviews and updates its storm water, spill prevention, and countermeasure plans to ensure compliance and the best possible performance.
- **Waste Management** – Waste management plans developed by Noble Energy for its North American operations and many of its international locations are based on a strategy of reduce, reuse and recycle. Noble Energy perpetually seeks ways to reduce the amount of operational wastes and strives to reuse materials when feasible. Noble Energy has implemented a series of recycling programs and encourages its employees to participate.
- **Environmental Regulatory Compliance** – Recognizing the potential environmental risks associated with exploratory activities and production operations, Noble Energy has developed both an internal and external environmental audit program.

5.1.3 Health and Safety Policies

One of Noble Energy's primary EHS policies is that safety is central to the job of every employee and contractor. To attain this goal, Noble Energy fosters a culture based on genuine care and compassion that encourages individual responsibility for protecting people and the environment. This culture is developed and implemented through the SEMS. The SEMS focuses on how facilities and equipment are designed and operated to ensure safety in the operations. Additionally, Noble Energy has prepared a Safety Plan in accordance with the Labor Inspection (Organization) Regulations (Safety Management Plan), 5773-2013. This plan, mandated through the Ministry of Economy, focuses on standards to be implemented by companies to ensure safety in the workplace.

Noble Energy provides a solid foundation for responsible operations with safety and environmental training. Training requirements are elements common to the SEMS and the Safety Management Plan. Noble Energy promotes individual vigilance and responsibility by assigning every person working at a Noble Energy facility the authority – and duty – to stop work when necessary to protect health, safety, or the environment. Noble Energy strives for continuous improvement through teamwork and collaboration.

Some of the key components that compose Noble Energy's health and safety policies are as follows:

- **Safe Work and Operating Practices** – Designed to provide a framework for effective health, safety, environmental, and sustainability practices, these guidelines include detailed plans, procedures, and strategies to protect people and the environment. In addition to procedures that govern day-to-day operations, Noble Energy practices include job analyses to proactively identify and address potential health and safety hazards. Noble Energy requires third-party contractors to follow their own Safe Work and Operating Practices, which must meet the same general requirements.
- **Emergency Preparedness and Community Awareness** – Noble Energy develops and implements incident management plans at each of its operations and also at the corporate level in order to coordinate emergency response at all of its facilities. The plans contain provisions for dealing with potential emergencies and clearly assign authority and duties to ensure timely and effective response.
- **Safety and Environmental Training** – All personnel at Noble Energy-operated facilities are trained to perform their functions in a manner that protects people, the environment, and equipment. Noble Energy requires its contractors to provide comparable training to their employees before they start work at Noble Energy facilities and to submit documentation or verification of adequate training.
- **Contractor Safety Management** – Noble Energy is committed to a safe, healthful, and environmentally responsible work environment. Recognizing the role of its contractors in achieving EHS excellence, it is required that contractors work under conditions and rules that are at least as protective as those governing Noble Energy's own employees. Noble Energy does not take control of a contractor's safety program or relieve any contractor of its safety responsibility. However, Noble Energy has a Contractor Safety Management Plan that provides guidelines to contractors to meet to achieve the standards outlined in Noble Energy's SEMS, EMS, and Safety Management Plan with this element of the GMS. Noble Energy's plan includes the evaluation of contractor safety performance prior to contract award through the ISNetworld Contractor Database. Dedicated to effective EHS communication with its contractor workforce, Noble Energy has worked with various business units to host several contractor symposiums in strategic areas. These symposiums communicate the value that Noble Energy places on each individual, the environment, and the communities in which it works, and underscores Noble Energy's expectations for superior EHS performance from its contract workforce. The symposiums also introduce resources designed to help small contractors develop effective EHS programs within their own organizations. Through these symposiums, Noble Energy partners with its contractor workforce to improve EHS performance throughout its operations.

5.2 DRILLING AND PRODUCTION TEST PERFORMANCE

- Drilling and completion operations will be conducted using industry best practice. The installation, maintenance, and testing of the BOP will follow prescribed safety protocols.
- Drilling operations will comply with applicable well control standards, including adherence to safe drilling practices. All drill string sections will be properly set in concrete to assure well integrity. Upon the completion of drilling, the well will be properly closed and abandoned per current industry best practice.

- All drilling operations will be conducted in compliance with a series of operational procedures and instructions, including prescribed drilling procedures, well control procedures, and work instructions. Primary responsibilities and relevant reference documents, which cover operational procedures, including drilling, will be clearly identified.

5.2.1 Handling of Hazardous Materials

- Hazardous chemicals will be handled in accordance with their SDS-specified guidelines, as integrated into the operator's guidelines for handling hazardous materials. All hazardous materials will be properly identified, stored, and handled, per SDS requirements and in such a manner that secures no spill/discharge to sea. In addition, hazardous materials will be handled with SDS-based exposure limits.
- Hazardous wastes will be handled in compliance with applicable regulations and permit requirements, and guidelines and will be detailed in the environmental management procedures.
- Hazardous materials that should be kept away from each other (e.g., oxidizers and flammables) will be separated.
- SDS information will be on hand for each hazardous material in store.
- Firefighting equipment will be available on board.
- Hazardous materials will be stored in a proper container.

5.2.2 Reduction and Prevention of Harm – Land, Seawater, and Coastline, Including Marine Ecology

- All seafloor activities will be conducted considering the location of communication cables.
- All discharges to the sea will be according to the discharge permit provisos.
- Oil spill response, both aboard the project vessels and overboard, will adhere to the vessel's Shipboard Oil Pollution Emergency Plan and Noble Energy's Oil Spill Response Plan for Offshore Operations and its Emergency Preparedness and Community Preparedness protocols.
- All solid waste processing, storage, and transport will comply with waste management priorities and procedures (e.g., Israel Regulation, MARPOL Annex V). No solid waste discharge will be allowed.
- The operator will maintain the solids control equipment in optimal operating condition.
- The operator will maintain its Marine Sanitary Devices in operating conditions.
- Conduct a detailed survey along the alignment of the planned utility lines to determine the possible existence and extent any archaeological sites.

5.2.3 Preservation of Fauna and Flora

- Use shallow geohazards data to verify the absence of hard bottom or chemosynthetic communities within the pipeline and control line corridor;
- Ensure support vessels follow the most direct route possible (weather conditions permitting) between the project location and the marine transportation hub (Haifa);
- Plan flight paths to avoid populated areas, wildlife areas, and bird colonies, and set minimum cruise altitudes when crossing the coast or offshore islands to minimize physical presence and noise-related effects; and
- Conduct routine flights during daylight hours only.

5.2.4 Monitoring Procedures

Discharge monitoring is discussed in **Section 4.15**. Additional monitoring will be performed as discussed in **Appendix J**.

- Monitoring program will be conducted following completion of drilling. The post-drilling survey will be conducted, including sampling of seawater, sediments, and infauna. Reporting of results will include comparison of pre-drill and post-drill survey results.
- The specific seawater and sediment chemistry analytes are outlined in **Tables 4-21** and **4-22**.
- Mud samples will be taken for every drilling section, including those drilled using MOBM.
- Testing of drilling muds and associated chemicals will be conducted in compliance with discharge permit requirements, including the periodic toxicity testing of drilling muds during drilling. The nature and frequency of testing are outlined in **Table 4-20**.
- Monitoring is performed at all levels and phases of the work, including during drilling and installation activities, and for ongoing operations. Area-/well-specific environmental monitoring is performed, as are periodic area-wide monitoring surveys. As discussed in **Section 4.15**, monitoring procedures have been and will be instituted to comply with all applicable permits and regulations, Noble Energy policy, and best industry practice.

5.2.5 Preventing/Reducing Light Hazards

- Lights should be shielded (i.e., oriented downwards) to maximize work areas and minimize lighting of the sea surface, when feasible and when vessel navigational safety is not compromised. This minimizes the potential for light to be visible to marine organisms.

5.2.6 Measures for Reducing Air Emissions

- Conduct routine maintenance procedures.
- When practical, utilize low-sulfur fuels to limit SO_x production.
- During the drilling of the well, every attempt will be made to ensure that no H_2S gas is released into the atmosphere. This will be done by keeping the wellbore full of drilling mud that is of sufficient density to exert a hydrostatic pressure greater than formation pressure, which will ensure that no influx into the wellbore will occur.
- Mud logging personnel will install and maintain H_2S detection equipment at strategic locations on the rig. The Control Room Operator and supervisory personnel will be alerted should H_2S be detected.
- An H_2S detection system will be installed to warn of the presence of H_2S. The sensors will be located at the possum belly, moon pool area, pit room, and rig floor. Audible alarms will sound if H_2S is detected.
- An H_2S sensor will be installed in the separator area. Test personnel will be equipped with Draeger tube detectors to sample produced gas to determine if H_2S is present in the flow stream.

If H_2S is encountered, operations will be discontinued until safety appliances are in place.

5.2.7 Measures for Preventing/Reducing Noise

- Internal combustion engines and electrical equipment (e.g., draw works) will undergo routine maintenance and monitoring.

5.2.8 Accidental Spills and Emergency Procedures

- Develop and implement an Oil Spill Contingency Plan/Emergency Response Plan, which outlines Tier II and III equipment and resource requirements;
- Routinely check equipment stockpiles onshore and aboard supply vessels;
- Conduct spill drills to familiarize personnel with emergency response procedures;
- Comply with Noble Energy's EHS GMS, including its Environmental Policy and Health and Safety Policies;
- Conduct oil spill dispersion modeling to determine likely trajectories and resources at risk;
- Accidental spills will be reported to the relevant authorities; and
- Noble Energy will maintain appropriate oil spill response and cleanup equipment and supplies to efficiently address spill incidents.

5.2.9 Measures for Reducing the Impacts of Discharges and Wastes

- Conduct routine maintenance procedures and verify that all equipment associated with discharge sources (e.g., oil-water separators, solids control equipment, sanitary wastes, gray water, food wastes) is working within stated discharge specifications, in compliance with permitted discharge limitations or acceptable standards;
- Comply with Noble Energy's Waste Management Plan and adhere to MARPOL restrictions on overboard dumping of waste; and
- Conduct a site clearance survey at the Tamar Field and along the pipeline corridor to verify the absence of marine debris.

5.2.10 Measures to Manage the Safety of Vessels and Infrastructure

- Enforce a buffer zone around the DP pipelay vessel;
- Ensure that Noble Energy consults with Haifa port authorities and provides notices to mariners that a DP pipelay vessel and other support vessels will be operating offshore;
- Position the DP pipelay vessel away from major shipping lanes to the maximum extent feasible;
- Mark the DP pipelay vessel with appropriate navigational markers;
- Ensure support vessels follow the most direct route possible (weather conditions permitting);
- Avoid traveling close to the coast, except for when approaching the shore base;
- Ensure support vessels do not transverse coastal waters at night; and
- Vessel operators are to follow applicable maritime navigation rules.

5.2.11 Wellsite Abandonment and Rehabilitation

At the time of abandonment, Noble Energy will comply with applicable regulations and best industry practice, which are designed to achieve the following:

- Isolate and protect all freshwater zones.
- Isolate all potential future commercial zones.
- Prevent in perpetuity leaks from or into the well.
- Cut pipe to an agreed level below the seafloor and remove all surface equipment, if required.

In practice, operators remove the completion hardware, set plugs and squeeze cement into the annuli at specified depths across producing and water-bearing zones to act as permanent barriers to pressure from above and below in addition to protecting the formation against which the cement is set. The wellhead is removed last, if required.

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