Appendix 19.2: Maritime Risk Assessment and Oil Spill Modelling

URS-EIA-REP-204635

1 Maritime Risk Assessment and Oil Spill Modelling

1.1 Maritime Risk Assessment

The Project vessels involved in the Construction and Pre-Commissioning Phase of the Project will include shallow-water and deep-water pipe-laying vessels, pipe-carrying vessels and support vessels. Where practical, Project vessels deployed in the Project Area will use MGO or MDO, commonly referred to as 'marine diesel' and conforming to ISO-8217:2010 Marine Distillate Fuel Grades DMA, DMB or DMZ.

Accidental spillages of oil could be a consequence of:

- An unplanned incident during a planned operational event, such as a leak of fuel oil while bunkering at sea; or
- An unplanned event or accident involving a Project vessel at sea.

Unplanned events that could occur involving Project vessels at sea include:

- Sinking;
- Grounding;
- Collision; and
- Fire and explosions.

An oil spill is not an inevitable consequence of an unplanned event involving Project vessels at sea. The damage to an affected vessel would have to be severe for an oil spill to occur. In many circumstances, such as after grounding, salvage actions would be undertaken on the damaged vessel and this would include removing the fuel oil to prevent any oil being spilled during salvage operations.

The approach of the maritime risk assessment as detailed below has been to:

- Estimate the probability of an oil spill occurring, based on available historical information, and rank these probabilities into categories;
- Estimate the severity of the potential consequences of any oil spill that could occur and rank these severities into categories;
- Construct a risk matrix of probability and consequence severity; and
- Assess various oil spill scenarios and determine their overall risk rating.

Conclusions have then been drawn from the oil spill risk screening discussed below, with some scenarios being selected for oil spill hydrodynamic modelling.

1.2 Estimation of the Probability of an Oil Spill Occurring

Specific information about the historical occurrence of oil spills resulting from unplanned events during the construction of sub-sea natural gas pipelines is not available. Most information about oil spills relates to the oil and gas exploration and production activities or to the operations of oil tankers.

Water transport accident statistics are available from the OGP (International Association of Oil and Gas Producers) Risk Assessment Data Directory Report No. 434-10, dated 10 March 2010 (Ref. 19.3) and the EMSA (European Maritime Safety Agency) Marine Accident Review 2010 (Ref. 19.4). The unplanned events resulting in the total loss and serious casualty to all types of merchant ships with gross tonnages above 100[1] tons taken from this reference are given in Table A19.2.1.

Table A19.2.1 Statistical Frequency of Unplanned Events Occurring to Ships

Unplanned Event	Global Probability (All Merchant Ships > 100 GT)	
	Total Loss	Serious Casualty
Sinking	1.4×10^{-3}	-
Grounding	5.4×10^{-4}	3.2×10^{-3}
In collision	3.6×10^{-4}	2.1×10^{-3}
Fire or explosions	4.2×10^{-4}	2.5×10^{-3}
Other	2.4×10^{-4}	1.4×10^{-3}
TOTALS	**3.0×10^{-3}**	**9.3×10^{-3}**

It should be noted that the statistical frequencies in Table A19.2.1 are derived from all types of merchant shipping on a global basis. Information about ship collisions with offshore oil and gas installations is available the OGP Risk Assessment Data Directory Report No. 434-16, dated 16 March 2010 (Ref. 19.5). This reference was consulted because the supply of pipe sections by vessels to the pipe-laying vessels at sea during the construction of the sub-sea pipeline has similarities to supply ship operations during oil production.

One significant omission from the above data sources, and others such as the European Marine Safety Agency (EMSA) (Ref. 19.4) was the frequency of oil spills resulting from vessel casualties. As noted earlier, an oil spill is far from an inevitable consequence of a ship casualty. A vessel running aground would have to suffer very severe damage for an oil spill to occur and in some

[1] The Project vessels gross tonnage weight ranges from 50 tonnes to 172,000 tonnes

circumstances, such as running aground on a soft sediment seabed an oil spill is inherently unlikely. However, the risk of an oil spill would be higher if the same vessel ran aground on jagged rocks.

The statistical frequencies of different unplanned events as described in Table A19.2.1 were used as the 'raw' risk inputs and the circumstances of the Project vessels were used to adjust the numerical estimated probability of:

a. An unplanned event occurring to a Project vessel; and

b. An oil spill resulting from the unplanned event.

1.2.1 Likelihood of an Unplanned Event Occurring to a Project Vessel

The risk profile of Project vessels involved in the construction of the sub-sea pipeline is somewhat different to that of merchant vessels operating at sea anywhere in the world and changes depending on which phase of the construction is occurring.

There will be two pipe-laying vessels, one for shallow water and another for offshore operations. These pipe-laying vessels will need to be replenished with pipeline sections at sea as the pipeline is laid. This will require the pipe supply vessels to manoeuvre close to the pipe-laying vessels to deliver the pipeline sections. Manoeuvring close together at sea increases the risk of collision, even though the vessels' crew are competent at such activities. The construction of the near-shore sections of the pipeline in Russia will require the Project vessels to operate in shallow water and close to shore during dredging and pipe-laying operations. The risks of grounding of such vessels are inherently higher than general shipping on the open ocean.

1.2.2 An Oil Spill Resulting From an Unplanned Event

The offshore pipe-laying vessel will be a very large vessel. For instance, the *Saipem 7000* carries a maximum fuel load of 8,000 m^3. A shallow water pipe-laying vessel, such as the *Castoro Sei* carries a maximum fuel load of just over 3,000 m^3. The class of vessel that will be used as pipe supply vessels - typically has a maximum fuel load of 1,000 to 1,500 m^3. The potential for an oil spill therefore clearly exists should these Project vessels suffer serious damage.

From the limited data available, oil spills are a rare consequence of most unplanned events at sea. As noted earlier, the probability of an oil spill resulting from an unplanned event to a vessel depends on the circumstances of the event. A vessel grounding on a relatively soft seabed, such as could occur during pipe-laying works near the Russian shore, is much less likely to result in an oil spill than the same vessel grounding on a rocky shoreline.

The numerical, statistical risk of a collision is most likely to be between a Project vessel and another Project vessel. This is because the Project vessels will be acting in concert in close proximity with each other. A collision between a pipe supply vessel and the very large offshore pipe-laying vessel would most probably result in minimal damage to the pipe-laying vessel, but the pipe supply vessel could suffer some damage. In most cases, any collision would be a low relative velocity and damage would be light.

Collision of Project vessels with third-party vessels has been considered during this evaluation. A scenario involving a fully laden oil tanker that is unrelated to the Project colliding with an offshore pipe-laying vessel could conceivably result in a large spill of crude oil. This would require a set of circumstances where the exclusion zone to be imposed around the pipeline route was violated. The likelihood of such an unplanned event occurring is considered to be too remote to require detailed consideration.

1.3 Ranking of the Probability of an Oil Spill Occurring

In order that information can be used to construct a risk matrix, the statistical probability of events have been categorised into seven categories as shown in Table A19.2.2. A ranking of 0 represents an "extremely remote" rating with a statistical frequency of less than 1 x 10^{-6} per year, whilst a ranking of 7 represents a "very likely" event with a statistical frequency of between 1 per year and 1 x 10^{-1} per year.

Table A19.2.2 Ranking of Statistical Frequency of Events

No.	Rating	Description	Statistical Probability
1	Extremely remote	A similar event has not occurred during any previous pipeline project, and is considered extremely remote	<1 x 10^{-6} per year
2	Remote	A similar event has not occurred during any previous pipeline project, but is considered a possibility	1 x 10^{-5} - 1 x 10^{-6} per year
3	Very unlikely	A similar event has occurred during a previous pipeline project, i.e. within the industry	1 x 10^{-4} - 1x10^{-5} per year
4	Unlikely	A similar event has occurred during a previous pipeline project within the organisation	1 x 10^{-3} - 1x10^{-4} per year
5	Possible	Potential that the event may occur during the lifetime of the project	1 x 10^{-2} - 1x 10^{-3} per year
6	Probable	Event likely to occur during the lifetime of the project	1 x 10^{-1} - 1 x10^{-2} per year
7	Very likely	Event likely to occur several times during the lifetime of the project	1 - 1 x 10^{-1} per year

1.4 Estimating the Severity of the Consequences of an Oil Spill

The severity of the consequences caused by an oil spill depends on many factors and cannot be related to a single parameter such as the spilled oil volume. The amount and severity of potential damage caused by the spilled oil depends on several factors, including:

- Area affected by an spilled oil;
- Sensitivity of the affected environment; and
- Time that it will take the affected area or resources to recover (recovery period).

1.4.1 Area Affected by an Spilled Oil

The area affected by spilled oil is related to the oil spill volume because most spilled oils rapidly spread out to cover a large area of sea surface. A commonly-used generalisation is that oil slicks have an average oil thickness of 0.1 mm and 1 m^3 of oil would rapidly spread to cover 10,000 m^2 of sea if it was 0.1 mm thick. However, spilled oils do not spread uniformly and form oil layers ranging from sheens of less than 0.1 micron (0.0001 mm) thick to layers many millimetres thick, if the oil emulsifies. A 1 m^3 oil spillage spreading to sheen that is only 0.1 micron thick could be spread over an area of 10 km^2 of the sea surface.

For the purposes of estimating the severity of the consequences of an oil spill, the extent of area affected by an oil spill has been ranked as 4 levels of severity from 1 - "immediate area" (the least severe consequence), up to 4 - "widespread" (Table A19.2.3).

Table A19.2.3 Severity Ranking by Extent of Area Affected by Oil

Severity Rating	Extent of Area Affected by Oil
4	Widespread
3	Extensive
2	Localised
1	Immediate area

The area affected by an oil spill can be expressed as that relative to the surface area of sea or the length of coastline being considered. A spill of a relatively small volume of oil in a small, semi-enclosed body of water will affect a higher proportion of the sea surface or coastline than the same amount of oil spilled in a much larger body of water, far from the shore.

1.4.2 Sensitivity of the Affected Environment

The sensitivity of the affected environment or socio-economic resources therein will influence the severity of the consequences of an oil spill. Oil spills have the potential to negatively impact several ecological habitats and organisms. The effects of spilled oil include:

- Spilled oil on the sea surface can contaminate plumage of seabirds or can affect marine mammals that swim on or dive into the sea;
- Naturally dispersed oil and some partially water-soluble chemical compounds in the oil can be transferred into the water column. With oil floating in deep water, the dispersed oil and soluble chemical compounds are rapidly diluted to below harmful concentrations. Fish swim away from oil after detecting it in the water column;
- Some marine organisms in more shallow or semi-enclosed waters can be negatively affected if the concentration of the dispersed oil and soluble compounds is present at a high concentration for prolonged periods; and
- Shoreline and coastal habitats and their residents are often the most severely impacted ecological resources at oil spills. Oil drifting ashore can accumulate in locally high concentrations. Emulsified oil can smother small coastal creatures and oil becoming trapped in the shoreline substrate can pose a chronic toxic hazard to a wide variety of organisms. Particularly oil-sensitive sites include mud-flats and salt-marshes. These attract a wide variety of birds (waders) because of the feeding opportunities they provide on the benthos in the intertidal zone.

For the purposes of estimating the severity of the consequences of an oil spill, the sensitivity of the area that could be affected has been ranked as three categories; from 1 - "Insensitive" to 3 - "Very sensitive" (Table A19.2.4).

Table A19.2.4 Severity Ranking by Sensitivity of Affected Environment

Severity rating	Sensitivity of Affected Environment
3	Very sensitive
2	Sensitive
1	Insensitive

1.4.3 Recovery Period

One of the indicators of the severity of consequences of an oil spill is the time that it will take the affected area or the affected organisms to recover. This depends on several different factors.

One aspect concerns the physical persistence of the oil. The effects of oil spill on organisms in the water column, if any, tend to be very short-lived. Dispersed oil, or water-soluble oil components, will be rapidly diluted to very low concentrations into the surrounding water column in most cases. Oil that strands on shorelines is most often much more persistent. One characteristic determining the persistence will be the shoreline type. Exposed, rocky shores will be cleaned of oil by wave action fairly rapidly, but oil will remain in low-energy shoreline environments, such as mud-flats, for a long time.

Another factor is the life-time of the organisms affected. Large seabirds have long life-times. If a significant proportion of the local population of large seabirds were killed by the oil spill, it would take many years for the local population to recover. On the other hand, many marine organisms breed in vast excess to overcome very high levels of predation to their larvae.

Zooplankton at sea could be locally affected by an oil spill, but would be very rapidly replaced by plankton from nearby.

For the purposes of estimating the severity of the consequences of an oil spill, the recovery or restoration period has been ranked as five categories, from 1 - "Days or weeks" up to 5 - "More than 5 years" (Table A19.2.5).

Table A19.2.5 Severity Ranking by Recovery Period

Severity Rating	Recovery or Restoration Period
5	More than 5 years
4	1 to 5 years
3	About 1 year
2	Months
1	Days or weeks

1.5 Combining Consequence Severity Rankings to Produce Overall Rankings

The severity ranking scopes for (i) extent of area affected by oil, (ii) affected area sensitivity, and (iii) affected area recovery period can be combined to produce five levels of overall event severity (Table A19.2.6).

Table A19.2.6 Overall Severity of Consequence Ranking

Overall Severity Rating	Extent of Area Affected by Oil	Sensitivity of Affected Environment	Recovery or Restoration Period	Score
5 - Very severe	Widespread (4)	Very sensitive (3)	More than 5 years (5)	12
	Extensive (3)	Very sensitive (3)	More than 5 years (5)	11
	Widespread (4)	Sensitive (2)	1 to 5 years (4)	10
4 - Major	Extensive (3)	Sensitive (2)	1 to 5 years (4)	9
	Localised (2)	Very sensitive (3)	1 to 5 years (4)	9
	Widespread (4)	Insensitive (1)	About 1 year (3)	8
	Immediate area (1)	Very sensitive (3)	1 to 5 years (4)	8

Overall Severity Rating	Extent of Area Affected by Oil	Sensitivity of Affected Environment	Recovery or Restoration Period	Score
3 - Serious	Extensive (3)	Insensitive (1)	About 1 year (3)	7
	Localised (2)	Sensitive (2)	About 1 year (3)	7
2 - Moderate	Localised (2)	Insensitive (1)	Months (2)	5
	Immediate area (1)	Sensitive (2)	Months (2)	5
1 - Minor	Immediate area (1)	Insensitive (1)	Days or weeks (1)	3

The combination of consequences leads to a combined severity score of:

- 10 or greater classified as "Very severe" and given an overall severity rating of 5;
- 8 or 9 were classified as "Major" and given an overall severity rating of 4;
- 6 or 7 were classified as "Serious" and given an overall severity rating of 3;
- 4 or 5 were classified as "Moderate" and given an overall severity rating of 2; and
- 1 to 3 were classified as "Minor" and given an overall severity rating of 1.

1.6 Preparation of a Risk Matrix

A risk matrix consisting of the statistical likelihood (or probability) versus the overall consequence severity ranking was then prepared as shown in Table A19.2.7.

The level of acceptability of the defined risk is calculated by multiplying the overall consequence severity ranking by the statistical probability ranking. The results were then colour coded as follows:

- Risk result of 1 to 9: acceptable (coloured green in matrix);
- Risk result of 10 to 16: undesirable (coloured yellow in matrix); and
- Risk result of 18 and above: unacceptable (coloured red in matrix).

1.7 Screening Results and Outcomes

Conceivable oil spill scenarios for the Russian sector of the Project have been considered for the different geographical areas as follows:

- Offshore Black Sea; and
- Russia Nearshore.

Table A19.2.7 Oil Spill Risk Matrix

Overall Consequence Severity Rating	Statistical Likelihood or Probability						
	Extremely Remote 1	Remote 2	Very Unlikely 3	Unlikely 4	Possible 5	Probable 6	Very Likely 7
5 Very Severe	5	10	15	20	25	30	35
4 Major	4	8	12	16	20	24	28
3 Serious	3	6	9	12	15	18	21
2 Moderate	2	4	6	8	10	12	14
1 Minor	1	2	3	4	5	6	7

The construction activities considered were restricted to:

- Pipeline section delivery;
- Dredging; and
- Pipe-laying operations.

The unplanned events considered were:

- Sinking;
- Grounding;
- Collision with third-party vessel;
- Collision with another project vessel; and
- Bunkering.

The assumptions, such as the amount of oil spilled, during these events are detailed in Table A19.2.8 together with the calculated overall risk rating.

Table A19.2.8 Event Description and Assumptions and Overall Event Risk Rating

Location	Activities	Event Description	Assumption	Overall Frequency	Consequence / Severity	Overall Risk Rating
Black Sea Nearshore	Dredging and Delivery	Grounding	MDO spillage @750 m3 (loss of fuel over four hours), grounding on rocky shore.	Unlikely 6.4*10-4	Extent = Extensive (3) Sensitivity = Sensitive (2) Recovery = Months (2) = SERIOUS	12
		Collision with third party	MDO spillage of 1,200 m3 (loss of fuel over six hours).	Very Unlikely 1.25*10-5	Extent = Extensive (3) Sensitivity = Sensitive (2) Recovery = Days / weeks (1) = SERIOUS / MODERATE	9
		Collision with project vessel	MDO spillage of 1,200 m3 (loss of fuel over six hours).	Very Unlikely 4.2*10-5	Extent = Extensive (3) Sensitivity = Sensitive (2) Recovery = Days / weeks (1) = SERIOUS / MODERATE	9
		Sinking	MDO spillage of 1,200 m3 (loss of fuel over six hours).	Unlikely 1.5*10-4	Extent = Extensive (3) Sensitivity = Sensitive (2) Recovery = Days / weeks (1) = SERIOUS / MODERATE	12
Black Sea Nearshore	Pipe-lay	Bunkering at sea	MDO spillage of 10 m^3.	Possible 1*10-2	Extent = Immediate area (1) Sensitivity = Insensitive (1) Recovery = Days / weeks (1) = MINOR	5

Continued...

Location	Activities	Event Description	Assumption	Overall Frequency	Consequence / Severity	Overall Risk Rating
Black Sea Nearshore	Pipe-lay	Refuelling at port facilities	MDO spillage of 10 m^3.	Possible 1*10-2	Extent = Immediate area (1) Sensitivity = Insensitive (1) Recovery = Days / weeks (1) = MINOR	6
		Grounding	MDO spillage of 1,500 m^3 (loss of fuel over six hours). Grounding on rocky shore.	Unlikely 6.4*10-4	Extent = Extensive (3) Sensitivity = Sensitive (2) Recovery = Months (2) = SERIOUS	12
		Collision with third party	Collision with fully laden oil tanker, MDO spillage of 10,000 m^3, released from 2 wing tanks of tanker vessel (loss of fuel over six hours).	Extremely Remote 6.25*10-6	Extent = Widespread (4) Sensitivity = Sensitive (2) Recovery = 1 to 5 years (4) = Very Severe	5
		Collision with project vessel	MDO spillage of 1,500 m^3 (loss of fuel over six hours).	Remote 2.1*10-5	Extent = Extensive (3) Sensitivity = Sensitive (2) Recovery = Days / weeks (1) = SERIOUS / MODERATE	6
		Sinking	MDO spillage of 1,500 m^3 (loss of fuel over six hours).	Unlikely 1.5*10-4	Extent = Extensive (3) Sensitivity = Sensitive (2) Recovery = Days / weeks (1) = SERIOUS / MODERATE	12

Continued…

Location	Activities	Event Description	Assumption	Overall Frequency	Consequence / Severity	Overall Risk Rating
Black Sea Nearshore	Pipe-lay	Bunkering	MDO spillage of 10 m^{3}.	Possible 1*10-2	Extent = Immediate area (1) Sensitivity = Insensitive (1) Recovery = Days / weeks (1) = MINOR	5
Black Sea Offshore	Delivery	Grounding	Not possible.	-	-	-
		Collision with third party	MDO spillage of 2,000 m^3 (loss of fuel over six hours).	Extremely Remote 1.25*10-6	Extent = Extensive (3) Sensitivity = Insensitive (1) Recovery = Days / weeks (1) = MODERATE	2
		Collision with project vessel	MDO spillage of @750 m^3 (loss of fuel over six hours).	Remote 8.4*10-6	Extent = Extensive (3) Sensitivity = Insensitive (1) Recovery = Days / weeks (1) = MODERATE	4
		Bunkering	MDO spillage of 10 m^{3}.	Possible 1*10-2	Extent = Immediate area (1) Sensitivity = Insensitive (1) Recovery = Days / weeks (1) = MINOR	5
		Sinking	MDO spillage of 2,000 m^3 (loss of fuel over six hours).	Unlikely 1.5*10-4	Extent = Extensive (3) Sensitivity = Insensitive (1) Recovery = Days / weeks (1) = MODERATE	8

Complete.

The influencing factors of the operations being undertaken, such as shallow water or close manoeuvring, were considered and the oil spill probability (derived from the general shipping statistics) was multiplied by a factor of 2 or 3 in light of this consideration. Similarly, the oil spill probability was multiplied by a factor of 0.5 to reflect the existing control measures in force, such as exclusion zones, in reducing the probability of an oil spill occurring.

The severity of the consequences, relevant to the spill site, for each scenario was then considered.

An important factor was the inherent sensitivity of the potential oil spill site. While the open, offshore Black Sea would be relatively insensitive to spills of MDO, areas within or close to the Russian coast would be more sensitive.

Table A19.2.8 indicates that the construction of the sub-sea natural gas pipelines across the Black Sea does not present a major risk of oil spills.

Oil Spill Modelling

Oil spill modelling has been undertaken and is reported in *Black Sea Diesel and Fuel Release Modelling Technical Note August 2013* (Ref. 19.2) which provides details of the modelling techniques employed, including input data, modelling parameters and modelling scenarios and associated results.

The oil spill modelling was undertaken using the Oil Spill Contingency and Response (OSCAR) model as developed by SINTEF in Norway. OSCAR consists of a dispersion model based on wind and 3D current data and a component-specific fate model whereby the physical-chemical, toxicity and biodegradation properties of the components of a discharge are modelled. Spill scenarios were stochastically analysed with time series weather and current data, demonstrating how the behaviour of the hydrocarbons change in variable metocean conditions. Stochastic outputs examined shoreline, surface and water column statistics. For the worst case stochastic simulation in terms of hydrocarbons reaching the shore, a deterministic model run was carried out to predict the behaviour and fate of the spill over time in terms of surface sheen development, water column concentrations and oil reaching the shore.

Modelling was undertaken for oil spillages at locations as illustrated in Figure 19.2 (Russian nearshore and offshore locations). Results obtained from the modelling scenarios are detailed in the sections below.

Modelling a Nearshore Oil Spill

Possible oil spill scenarios in the nearshore section would occur relatively close to the shore in relatively shallow water. Project vessels could run aground in shallow water. An oil spill resulting from the collision of a Project vessel with a 'third party' vessel would occur further out to sea, but the effects and consequences would be similar.

A spill of 1,200 m^3 of MDO was modelled close to the Russian shoreline. The spill site selected (Figure 19.2.1) was located within 1 km of the shore in a water depth of 5 m.

This would be representative of a location where a Project vessel, such as a pipe-carrier vessel, could run aground. The volume of 1,200 m^3 is close to the maximum amount of fuel that such a vessel could carry.

The model outputs are summarised in Figure A19.2.1. It is predicted a moderate area of the Black Sea would be affected with a surface slick of thicknesses > 1 µm visible for up to 58 km from the release location. Surface hydrocarbons are not predicted to drift into other national waters.

Risk of shoreline beaching is predicted to be medium (up to 50%) due to the proximity to shore and transport by coastal currents. The minimum coastal arrival time is predicted to be around 1 hour and in the worst case weather conditions a maximum oil mass of up to 705 tonnes is predicted along a moderate stretch of Russian shoreline. However, only a fraction of this mass would remain onshore as the light diesel does not emulsify and can be washed back into sea. Dissolved water column concentrations of greater than 50 ppb are predicted a maximum of 50 km away from the release site, with concentrations taking up to 4 days to fall below this threshold in localised areas).

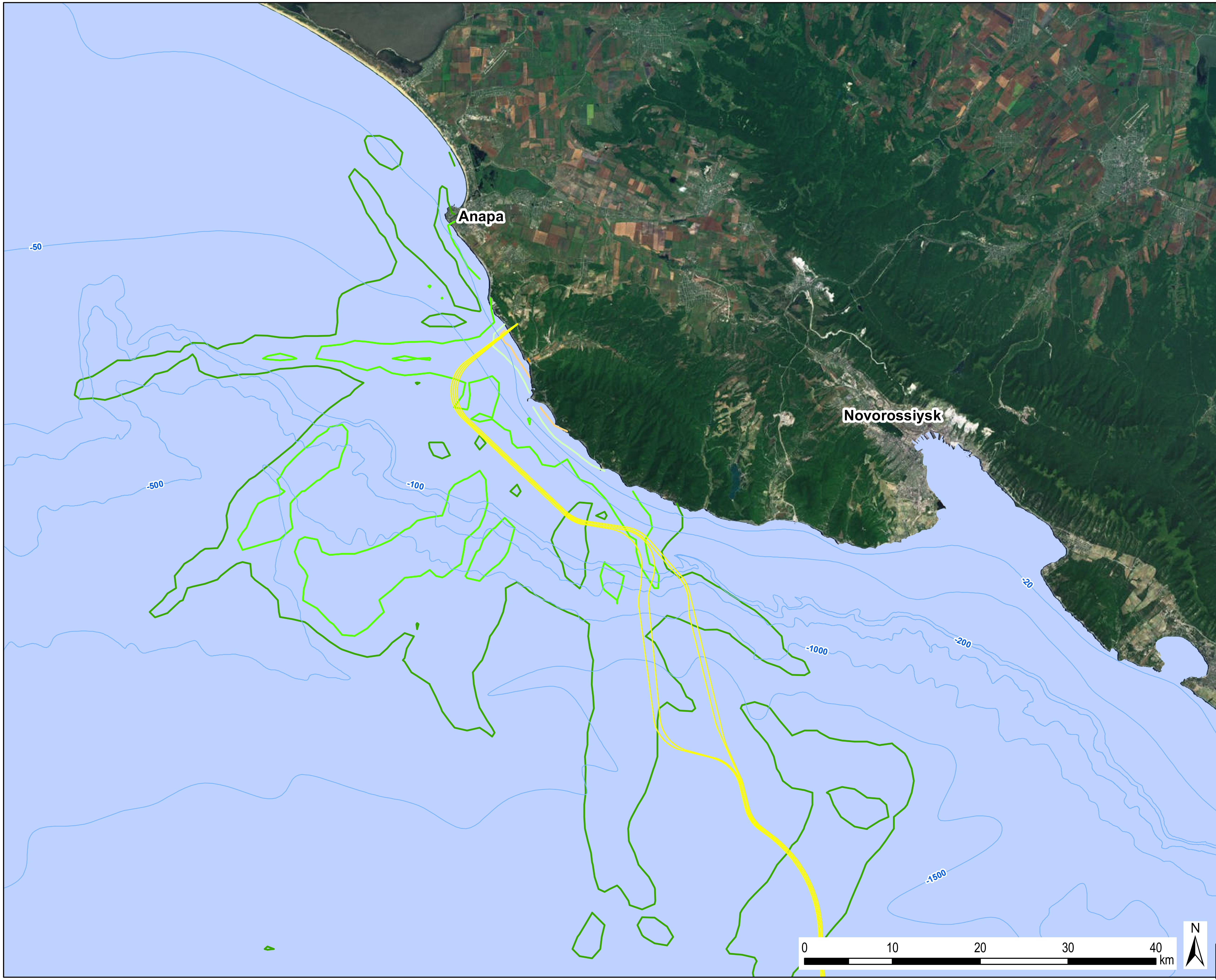
For the worst scenarios of oil reaching the shoreline, deterministic modelling was undertaken to predict the mass balance fate of the oil as it disperses over time, typical development and appearance of the surface slick. Because of the proximity of the release to the coast, combined with worst case onshore currents and winds, a high proportion of the diesel would initially be washed onshore before the mass begins to decline through evaporation and biodegradation, although some oil is expected to remain in sediments and onshore 30 days after the event.

Modelling an Oil Spill in the Offshore Section

An oil spill in the offshore section of the pipeline route could conceivably occur at any location as a result of the collision of a Project vessel with another Project vessel, although the probability of such a collision occurring is considered to be very low. The probability that such an incident would result in an oil spill is even lower, as a high-energy collision would be required to damage a vessel to such an extent that marine diesel was spilled into the sea.

Despite the inherently low probability of an offshore oil spill occurring, modelling was conducted to estimate the area of sea surface that might be affected and the time for which oil would persist on the sea surface. The location for oil spill modelling was selected to be along the pipeline route, in the Turkish EEZ, but very close to the border with the Russian EEZ (Figure 19.2). Oil spill modelling was undertaken for a representative spill of 2,000 m^3 of MDO.

The model outputs are illustrated in Figure A19.2.2. It is predicted that a moderate area of the Black Sea would be affected with a surface slick of thicknesses > 1 µm visible for up to 96 km from the release location. There is a 33 % probability of visible surface hydrocarbons reaching Russian waters and a 10 % probability of visible surface hydrocarbons reaching Ukraine waters. Hydrocarbons may enter Russian waters within 1 hour of the spillage



LEGEND
Russian Sector of South Stream Offshore Pipeline

- Proposed offshore pipelines

Probability (%)

- 5
- 10
- 20
- 30
- 40
- Isobaths

Projection: Lambert Conformal Conic

Purpose of Issue
For Information

Client
South Stream Offshore Pipeline ENERGISING EUROPE

Project Title
SOUTH STREAM OFFSHORE PIPELINE

Drawing Title
PROBABILITY OF VISIBLE SHEEN (THICKNESS > 1 MM) FOLLOWING A 1,200 M^3 MDO NEARSHORE SPILLAGE

Drawn	Checked	Approved	Date
AH	RW	MW	26/02/2014

URS Internal Project No.	Scale @ A3
46369082	1:400,000

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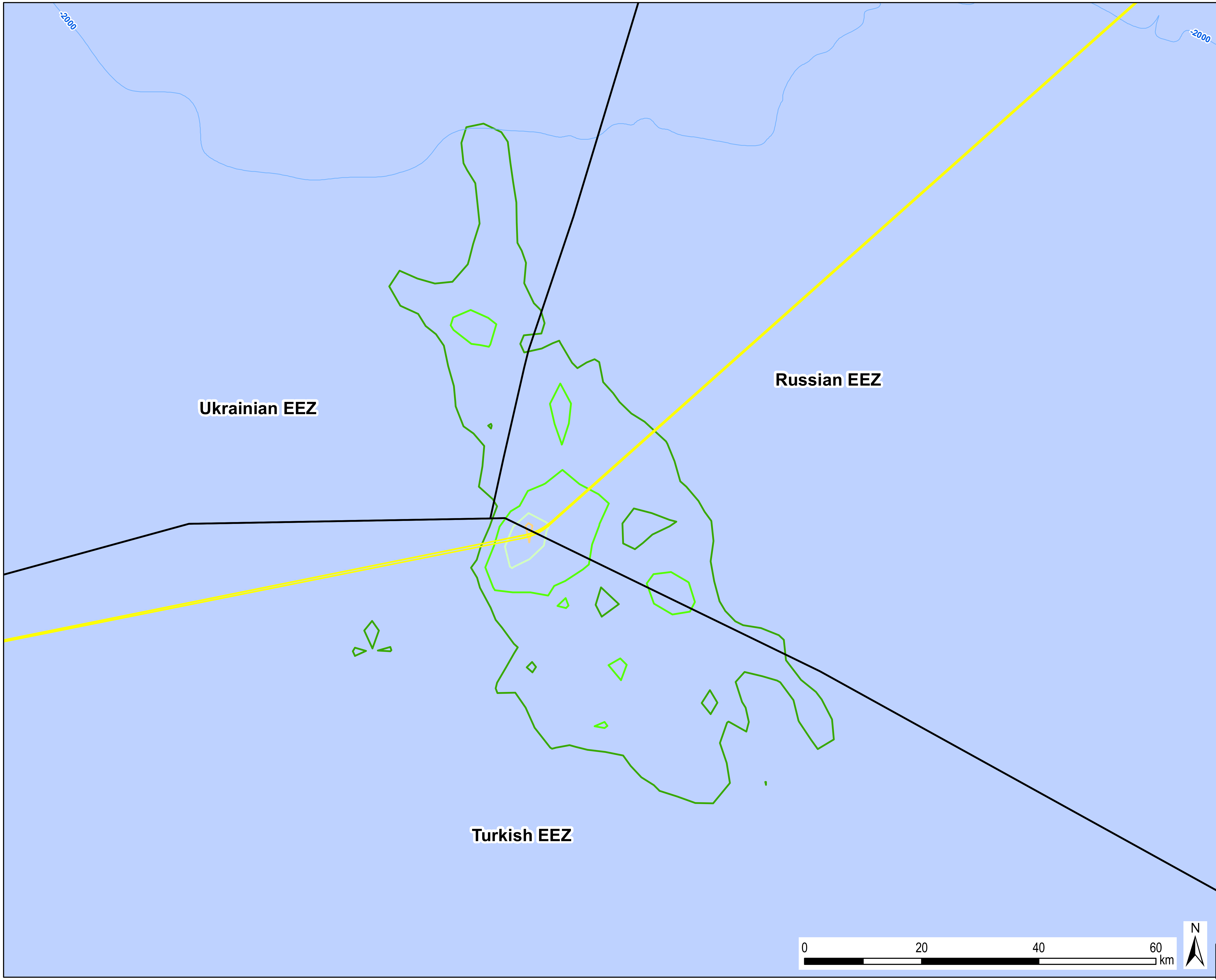
Drawing Number
Figure A19.2.1

Rev

Plot Date: 26 Feb 2014
File Name: I:\5004 - Information Systems\46369082_South_Stream\MXDs\Report Maps - Russia\Russian ESIA v2\Chapter 19 Unplanned Events\Figure A19.2.1 Probability of Visible Sheen (thickness 1 um) Following a 1,200 m3 MDO Nearshore Spill.mxd



LEGEND

Russian Sector of South Stream Offshore Pipeline

Proposed offshore pipelines

Probability (%)

- 5
- 10
- 20
- 30

Exclusive Economic Zone boundary

Isobaths

Projection: Lambert Conformal Conic

Purpose of Issue
For Information

Client
South Stream Offshore Pipeline
Stream ENERGISING EUROPE

Project Title
SOUTH STREAM OFFSHORE PIPELINE

Drawing Title
PROBABILITY OF VISIBLE SHEEN (THICKNESS > 1 MM) FOLLOWING A 2,000 M³ MDO OFFSHORE SPILLAGE

Drawn	Checked	Approved	Date
AH	RW	MW	26/02/2014

URS Internal Project No.	Scale @ A3
46369082	1:600,000

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Figure A19.2.2

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Plot Date: 26 Feb 2014
File Name:I:\5004 - Information Systems\46369082_South_Stream\MXDs\Report Maps - Russia\Russian ESIA v2\Chapter 19 Unplanned Events\Figure A19.2.2 Probability of Visible Sheen (thickness 1 µm) Following a 2000 m3 MDO Offshore Spillage.mxd

The risk of shoreline beaching is predicted to be low (up to 13 %) due to the central Black Sea location of the release and limited shore-ward transport by prevailing currents. The minimum coastal arrival time for dissolved oil is predicted to be around 3 days with a total mass onshore of approximately 85 tonnes. This quantity would be spread across a large coastal area such that concentrations would be likely to be very low - the majority of oil would arrive as fine droplets which are not expected to be visible.

Dissolved water column concentrations of greater than 50 ppb are predicted a maximum of 68 km away from the release site, with concentrations taking up to 1.5 days to fall below this threshold in localised areas.