Chapter 2 Oil Spill Response

2.1 INTRODUCTION

The risk of oil spills and potential consequential environmental damage is a major public and Government agency concern and this concern is shared by Sakhalin Energy Investment Company (SEIC), Shareholders and other stakeholders of the Project. The management of potential hydrocarbon spills is, and will be, an integral part of the detailed design of all facilities. This incorporates measures to minimise the likelihood, size and effects of a spill. Whilst the risk of spills is low, high performance in oil spill response (OSR) is essential for SEIC to maintain an efficient project and company reputation. To this end, SEIC is preparing, developing, researching and implementing a comprehensive OSR strategy as part of the overall management of oil spill issues in the Sakhalin II Project.

2.1.1 Background

Sakhalin Energy has a general philosophy on its approach to oil spill response, which includes:

- The protection of human safety and the minimisation of adverse impact on the environment;
- The adoption of international best practice in Sakhalin Energy controlled OSR operations and the use of the best local and international resources;
- Compliance with relevant national and regional legislation and international conventions and guidelines;
- Efficient and effective emergency response procedures and response equipment maintenance;
- Environmental monitoring in the event of a spill; and
- Investigation of incidents that result in safety, health and environmental consequences.

SEIC maintains a Phase 1 OSR Plan that is regularly updated to address any changes in regulatory requirements or operations or to incorporate recommendations/improvements from emergency response training exercises or drills. It has established a programme for the training of employees, contractors and third parties in oil spill response and holds regular desktop and field-based exercises. These are undertaken in cooperation with Oblast and Russian Federal authorities, oil spill response operators and other relevant parties.

To date, SEIC has operated its oil spill response resources in northeast Sakhalin on a shared basis with Exxon Neftegas Ltd (ENL), the operator of the Sakhalin-I development. It also maintains offshore response equipment on the OSR vessel “Irbis”, which is located at the Molikpaq Platform on a standby basis during the production season. The equipment is annually checked and exercised. The Phase 1 operations have a Memorandum of Understanding (MOU) with the Japanese Maritime Disaster Prevention Centre (MDPC) regarding collaborative arrangements in the event of an oil spill that has the potential to enter Japanese waters. This is currently being updated for Phase 2 operations.

2.1.2 Objectives of the Chapter

A large number of documents have been prepared during the development of the OSR strategies and initiatives mentioned above. Publicly available documents have included the international-style Environmental Impact Assessment (EIA), this EIA-Addendum (EIA-A), and documents provided as part of the Russian Technical and Economic Substantiation for Construction (TEO-C) process.

Since the international-style EIA was prepared in 2003, the OSR planning process has been significantly progressed. In addition to providing supplementary information to the original international-style EIA, this chapter sets out the context of Phase 2 OSR planning and provides an update of progress in a number of areas. It also describes future plans and studies and provides a summary of the various key work initiatives.

It should be noted that this Section has been prepared in response to specific concerns or requests for clarifications raised by stakeholders and interested parties during the review process. Specifically, the chapter provides information relating to the following issues:

- Transboundary oil spill issues (Section 2.2) including:
    - The risk of oils spills passing from Russian into Japanese waters. This has been investigated thoroughly using computer-based oil spill trajectory modelling. Year-round risks were also investigated, including the potential transboundary transport of oil in the ice season;
    - OSR strategies for oil spills passing into Japanese waters or on the shorelines of Hokkaido, northern Japan.
- Onshore and offshore oil spill response planning (Section 2.3) including:
    - Oil spill trajectory modelling;
    - The identification of sensitive areas;
    - The planned level of resources for oil spill response;
    - Field surveys;
    - Future oil spill response related work programme.
- Risks of spills from tankers moving to and from the Aniva Bay facilities, including risks associated with tanker traffic during ice conditions (see Sections 2.5 and 2.6);

- Leak detection in both onshore and offshore pipelines (Section 2.7).

Each of these issues is set out in detail below. The chapter provides a summary and update on SEIC's OSR Department initiatives, based around the topics raised during the review process. The following sections need to be read in conjunction with Appendix 1 at the end of this chapter, which contains all the figures referred to in the text.

2.1.3 Development of the SEIC OSR Planning Strategy

The additional infrastructure associated with Phase 2 together with year-round production carries with it a greater degree of complexity for OSR planning, in terms of equipment needs, type and availability; the requirements for additional trained personnel; river as well as coastal and marine oil spill recovery tactics, response in ice conditions and increased coordination with Russian Federation (e.g. Russian Federation Ministry of Emergency Situations; Emercom), Ministry of Transport), Japanese (e.g. Maritime Disaster Protection Centre; MDPC) and international response organisations.

In mid-2002, SEIC developed an OSR Concept Paper for its proposed Phase 2 operations, which was submitted to the Russian Federation and Oblast authorities for consideration and approval. The Concept Paper was endorsed by the relevant authorities, which enabled the development of the principles and approach for the Phase 2 OSR plans. In October 2002, as part of the Russian approvals' process, SEIC submitted several detailed asset-specific OSR plans to the Federal and Oblast authorities, which were based on the principles set out in the Concept Paper. Each plan was tailored to each new major asset, namely for PA-B and Lun-A platforms; the Onshore Processing Facility (OPF); the onshore and offshore pipeline network; the Oil Export Terminal (OET); and the Tanker Loading Unit (TLU).

The plans were prepared by Russian and US oil spill response consultants and provided information on trajectory modelling with reference to prevailing and extreme hydro-meteorological conditions and known oil characteristics; spill response tactics specific to their surroundings and the fate and effects of oil; notification procedures; equipment inventories and locations; coastal sensitivity maps; Health, Safety and Environment (HSE) emergency considerations; training and drills; agreements with national and international response organisations; and wildlife rescue.

Following a review by the State Ecological Expertiza, the OSR plans submitted for TEO-C were accepted in principle by the relevant authorities, on the premise that they would be updated at least six months prior to first production, taking into account the recommendations of the TEO-C Conclusion.

The focus of OSR planning is now to update those TEO-C plans to fully comprehensive and tested documents. Each plan will comply with relevant RF regulations and international best practice, drawing on the guidelines produced by international organisations such as the International Petroleum Industry Environmental Conservation Association (IPIECA). They will be prepared in accordance with the International Finance Corporation (IFC) and World Bank 1998 Onshore and Offshore Guidelines pertaining to oil spill response.

Due to the proximity of some of the Phase 2 assets to Hokkaido, considerable effort is underway to develop collaborative approaches with Japanese oil spill response authorities (see Section 2.2.3). The Company is developing a programme for a series of workshops and seminars with Japanese stakeholders on technologies and response strategies. Sakhalin Energy will participate in a joint oil spill drill with Russian and Japanese Authorities in May 2006 in Aniva Bay.

2.2 TRANSBOUNDARY OIL SPILLS

This subsection provides information on oil spill trajectory modelling, in particular the risks of oil spills passing from the Russian Federation (RF) into Japanese waters. It provides an update on the studies undertaken, the response implications and a description of SEIC initiatives to engage with Japanese organisations.

2.2.1 Transboundary Oil Spill Response Initiatives

Oil spills have the potential to cross national boundaries and thus have implications for both oil spill response planning and the development of effective response strategies across their borders (Wardrop *et al.,* 2004). The north coast of Japan lies almost 40km from the southern tip of Sakhalin Island, and consequently SEIC has identified a number of initiatives to assist cross border response and cooperation:

- To assist in the development of cooperative agreements between the Russian Federation and Japan in order to facilitate the movement of oil spill response vessels across territorial sea boundaries;
- To encourage the development of agreements and procedures for enabling the efficient and rapid movement of personnel and equipment between countries within the region and more widely. This includes the protocols for overcoming delays in immigration, customs and flight clearance during emergencies;
- To encourage the compatibility of procedures, equipment and communications' channels used by the countries of the region;
- Cross-border reporting and notification. Where feasible, this should include the routine sharing of shipping movement data or reporting procedures for oil spills and other maritime emergencies.

Considerable and continued inter-governmental discussions will be required to ensure that these objectives are agreed and implemented.

Russian Federal agencies and their Japanese counterparts are responsible for progressing these developments. For example, a joint Japan Coast Guard / Russian Ministry of Transport oil spill response exercise is being planned for 2006. SEIC is actively facilitating and participating in co-operative events such as this, as well as in regional workshops and forums, and is committed to continuing to do so.

2.2.2 Assessment of Transboundary Issues

There is an existing level of risk to the coastline of Japan from crude oil spills. Crude oil imports to Japan over the period August 2001 to August 2003 varied between approximately 540,500m^3 (3,400,000 barrels) and 779,000m^3 (4,900,000 barrels) per day and peak in winter periods (IEA 2003). The Sakhalin II Phase 2 will produce approximately 31,800m^3 (200,000 barrels) of oil per day and this will represent approximately 5% of the total crude oil movement into and through Japanese waters.

Full Phase 2 production is anticipated to require one oil tanker every four days (approximately 90 per annum) and an LNG tanker every two days (to the TLU and LNG in Aniva Bay), a combined total of approximately 239 per year (i.e. five per week). Currently, 16 to 17 tankers per year sail along the south and east coast of Sakhalin Island to the Sakhalin II Phase 1 facility at Piltun-Astokh (Vityaz Complex, which contains the PA-A, or Molikpaq, platform). Tanker movements to the Vityaz Complex along the Sakhalin Island east coast will cease once Phase 2 production commences.

A number of reports and papers have speculated that a spill from tankers entering or leaving the existing Piltun-Astokh (PA) facilities, or a spill from the planned Phase 2 facilities could enter Japanese waters and possibly impact the coast of Hokkaido (e.g. Kanaami *et al*. 2003). The potential for oil spills to impact the Japanese coastal area would depend on a number of factors:

- The probability of particular incidents (e.g. vessel grounding, collision, pipeline rupture);
- Volume of oil that could be spilled;
- Location of the oil release;
- Oil spill trajectory, which in turn depends on meteorological parameters (*e.g*. prevailing winds) and currents (also dependant on season and location of spill);
- Oil persistence at sea, which depends on the type of oil spilled and air temperature, sea temperature and sea state.

SEIC has undertaken a number of spill risk studies for both the Phase 1 and Phase 2 Projects. These have comprised spill volume and frequency calculations and spill trajectory studies. The latter includes a number of studies designed to address transboundary risks. The work undertaken as part of these studies has involved the following:

- Phase 1 Spill Trajectory Studies: PA-A Platform (Molikpaq) and tanker routes; and
- Phase 2 Spill Trajectory Studies: In particular spills from Aniva Bay facilities and various locations along the shipping routes.

More detail on trajectory modelling is presented in Section 2.3.1, where the work undertaken for each phase of the project is described in more detail.

The earliest trajectory studies undertaken for the Piltun-Astokh field (PTC 1996) suggested that a predominantly long-shore drift of spills would occur from the production complex Vityaz, and that this would be in a northwards direction in summer but predominantly southwards in autumn.

DVNIGMI (2000) specifically investigated the potential for oil from the Vityaz complex to impact upon the Hokkaido coast. The results confirmed that summer (northward) spill trajectories posed little or no risk to Japan whereas autumn trajectories had a low probability of reaching Hokkaido within 30 days of spillage. However, as noted below (see subsection on Oil Characterisation Studies in Section 2.4.1), slicks of Vityaz crude oil are unlikely to persist for this period of time at sea (see also Section 2.3.1 on trajectory modelling).

The most recent Aniva Bay modelling studies confirmed that there is some risk of transboundary shoreline impact on Hokkaido from oil spills during tanker transit and also a risk, albeit much smaller, from large spills should they occur at the Tanker Loading Unit (TLU). Trajectories vary according to season with smaller oil excursion envelopes in summer. Season will also influence oil slick behaviour and persistence (see Figures 2.11 to 2.13 and the accompanying Table entitled "Shoreline Impact Probability by Shore Zones in Winter" in Appendix 1); high-energy seas (winter and autumn) increase dispersion and therefore slick break-up.

2.2.3 Memorandum of Understanding with Japan

Under its Phase I Project, SEIC has an existing Memorandum of Understanding (MOU) with the Japanese Maritime Disaster Prevention Centre (MDPC). This MOU establishes co-operation and assistance in developing practical contingency plans and sets out actions to be taken in case of the occurrence of a major oil spill from SEIC's Vityaz Complex that may threaten the surrounding sea areas of Japan. The MOU states that SEIC will inform the Japanese agencies of any spill from SEIC facilities that may enter Japanese waters, notify MDPC about the quantity, time and estimated trajectory of a spill and provide daily updates of its position and trajectory

Furthermore, in the case of any spill which does not threaten the seas or coastline of Japan, MDPC shall, as far as possible, assist SEIC in combating the spill. According to the MOU, this shall be consistent with best international oil spill response practice and be subject to approval by both parties.

This MOU is currently being updated to cover Phase 2.

2.2.4 Public Engagement with Japan

In addition to the MOU, and since Phase I began, SEIC has engaged regularly with stakeholders in Japan, particularly in Hokkaido. Key engagement events and activities that have taken place in this regard include:

- Participation of SEIC representatives at Japan Bank for International Cooperation (JBIC) environmental forums (e.g. in May 2005);
- Public meetings in Sapporo and Tokyo during Q4 2005 / Q1 2006;

- Regular technical expert meetings on key transboundary issues such as oil spill response planning, fisheries ands migratory bird species and other relevant topics of interest and importance to Japan;
- Shoreline Response Courses. The first of these were presented in Sapporo, Hokkaido, in October 2004. An equivalent course was held in Yuzhno, 14-16 June 2005.
- Town hall meetings (e.g. in Rumoi, Wakkanai, Abashiri and Monbetsu) along the Okhotsk shoreline of Hokkaido on key issues of relevance;
- Public announcements (e.g. on website, in Japanese media);
- Stakeholders' visits (e.g. Hokkaido fishery);
- Ongoing informal meetings with communities and organisations.

The public meetings planned in Sapporo and Tokyo in Q4 2005 / Q1 2006 will take an open-format style but will include short presentations and a question and answer session. The key topics will include an update on the progress of the development and transboundary issues of which OSR is an important component. Invitations will be advertised in Japanese newspapers three weeks in advance of the public meetings.

Additional information on the programme of Japanese engagement can be found in the Public Consultation and Disclosure Plan (PCDP) on the Sakhalin Energy website: www.sakhalinenery.com (English) or www.sakhalinenergy.ru (Russian). A Japanese version of the Company's commitments to engagement in Japan is provided in Annex 4 of the PCDP.

A review of the 2005 consultation programme will be undertaken at the end of the fourth quarter of 2005 to determine the programme for 2006.

2.3 DEVELOPMENT OF OIL SPILL RESPONSE PLANS

Successful oil spill response initiatives typically require the following key inputs:

- A significant planning effort, based on the acquisition of relevant information. This includes determination of spill frequencies, volumes, trajectory modelling and environmental assessment to identify resources at risk;
- Development of effective and efficient response strategies;
- A firm commitment to the acquisition, storage, deployment and maintenance of suitable equipment;
- Maintenance of a team of trained personnel;
- Development of an efficient response organisation, integrated into local, regional and international agencies.

SEIC is committed to developing a sound oil spill response system based on the above requirements. In the current Phase 1 Oil Spill Response Plan (OSRP) for the Vityaz Complex (Piltun-Astokh), SEIC response procedures and the emergency response organisation illustrate this commitment and these have been reviewed and approved by Russian Federal, Regional and Oblast agencies.

Phase 2 OSRPs must be assessed and ultimately approved by several Oblast agencies and Russian Federal agencies. Before activation, the plans will be tested through both desktop and field exercises. (See also “Training” in Section 2.3.4).

2.3.1 Spill Trajectory Studies

The Sakhalin II Project began production at the Piltun-Astokh field in 1999. Since the early stages of planning, a large number of assessments of oil spill risk have been undertaken and these have focused on production and transfer operations, appraisal drilling operations and tanker movements. For the most part these studies have been undertaken for OSR planning purposes and have provided vital information on spill trajectories and the identification of shorelines at risk from Piltun-Astokh offshore activities.

Spills from each of the existing Phase 1 and Phase 2 facilities and pipelines have been modelled. The volumes modelled have been based on either quantitative risk assessments (maximum credible spill) or nominal volumes based on RF legislation (TAU 2002a to g; Risktec 2004, Risktec 2005).

A number of different spill scenarios have been modelled at each facility and these are indicated in the Tables in the sections below.

For each scenario the following output was typically generated:

- Probability distribution of slick (stochastic). These use multiple-wind scenarios to model trajectories and form an area enclosing locations within which a slick can be expected to be present in a given time period. The time intervals from the start of the spill are 6-hrs, 12-hrs, 24-hrs, 2 days, 3 days, 5 days and then 5-day intervals until the oil slick dissipates, crosses the shoreline, or goes beyond the modelled area. Models are not run for longer than 30 days for oil spill volumes below 2,000m^3, 60 days for oil spill volumes of 2,000–10,000m^3, and 90 days for oil spill volumes over 10,000m^3;
- Oil slick distribution charts by direction;
- Single slick trajectories, undertaken to show minimum times from spill to coastal impact or to identify conditions under which key resources could be impacted;
- Shoreline impact probability maps:
  - impact probability by different shoreline areas;
  - probability of shoreline impact at a certain time;
- Maximum excursion envelope maps (location and days).

All initial studies have been based on Vityaz crude oil irrespective of the facility being studied. Vityaz is a heavier crude oil than both the condensate-crude blends produced at Lunskoye and the blended crudes moved by the pipeline from the OPF facility and exported via the TLU at Aniva Bay. Consequently, the modelling outcomes are conservative i.e., the oil persistence at sea is longer and final excursion envelopes are larger than would likely be the case in a real situation. Oil from PA-B has the same characteristics as Vityaz crude from PA-A. SEIC is currently modelling condensate at Lunskoye.

It is important to remember that the “Excursion Envelopes” obtained by this modelling do not illustrate the extent of individual slicks but rather the perimeter within which a slick is likely to be located over a wide variety of scenarios and conditions. The proportion of the Excursion Envelope occupied by a slick (i.e. the slick area) will depend largely on the volume of the spillage and the degree of weathering of the oil (see Figure 2.1 in Appendix 1).

It is useful to summarise the wide variety of computer modelling that has been commissioned to date by SEIC (see following subsections).

(i) Piltun-Astokh

As noted above, the earliest trajectory studies (PTC 1996) indicated a predominant longshore drift for spills at or near the Piltun-Astokh (PA) production complex (Vityaz). Under the average summer winds (July), the drift was northward and southward in autumn (October). By simulating an onshore (easterly) wind, shoreline impact occurred in 37-hours.

Similar results were obtained by subsequent (more detailed) modelling carried out for the preparation of the first Vityaz OSR Plan (FERHRII 1997). Four spill scenarios were run under summer and autumn conditions and fifteen wind regimes were modelled for each spill and seasonal scenario. Probabilities of shoreline impact were calculated at 15% in summer and 30% under autumn conditions over a ten day time period. These probabilities were calculated as being slightly higher by additional modelling undertaken in 1998 (DVNIGMI 1998), which indicated that coastline pollution with oil after ten days is estimated at 45% in summer and 50% in autumn (by total number of markers that reached the coastline). These studies confirmed the general direction and rate of movement reported in the earlier studies.

Additional modelling was undertaken for appraisal drilling (DVNIGMI 2000) and this study specifically investigated risks to Hokkaido from Piltun-Astokh. The summer (northward) trajectories posed little or no risk and autumn trajectories were considered to have little chance of reaching Hokkaido within 30-days of spillage. In contrast to the earlier study, shoreline impacts were estimated at 36% in summer and 16% in winter.

Single slick trajectories were also obtained under specific wind conditions (DVNIGMI 2002).

Additional modelling was undertaken for the Phase 2 developments.

The spill scenarios comprised a variety of ruptures, leaks and collisions. All pipeline rupture scenarios are based on both pipelines being ruptured in either an anchor-type incident (summer) or an ice-scour incident (winter).

Table 2.1 Potential Oil Spill Scenarios Modelled at Piltun-Astokh

No.		Facility	Initial Release		Secondary Release	
			Volume, m^3	Duration (minutes)	Volume, m^3	Duration (hrs)
1.		**Sakhalin-2 Phase 2 Facilities**				
1.1		Piltun A-A Platform (Molikpaq)	96	12	76	51
1.2		Piltun A-B Platform	97	12	92	51
1.3	a	Base case pipeline, 1 km from the shore	97	12.	210	115
	b		44	43	–	–
1.4	a	Base case pipeline, 10 km from the shore	97	12	34	18
	b		45	30	–	–
1.5		Pipeline alternative 1, 1 km from the shore	97	12	151	83
1.6		Pipeline alternative 1, 10 km from the shore	97	12	50	28
1.7		Pipeline alternative 2, 1 km from the shore	97	12	244	133
1.8		Pipeline alternative 2, 10 km from the shore	97	12	42	23
2.		**Operating Facilities (Sakhalin-2 Phase 1)**				
2.1	a	Floating, storage and offloading (FSO)	1,763 (1,500 t)	10	–	–
	b		14,846	54	–	–
2.2		Single anchor leg mooring (SALM)	99	12.3	149	92
2.3		Tanker	10,475	33	–	–

Note: The flow out of a pipe (secondary release) is restricted by pressure, bathymetry and limited by water ingress into the pipe.

Recent modelling of potential spills at Piltun-Astokh (PA-A and PA-B) (REA 2004) has again shown a predominant north-south longshore trajectory with the southernmost excursions occurring in autumn (see Figure 2.2 in Appendix 1). In this latest modelling exercise for PA-A, slicks were modelled for 30-days, well beyond the expected persistence of most spills. Potential slick areas were calculated, as were key changes in oil characteristics due to weathering, such as viscosity. Probabilities of shoreline impact were calculated and generally confirmed the results of the earlier studies (refer to Figures 2.3 and 2.4 showing modelling output for PA-A). The outputs of the modelling at PA-A and PA-B are very similar. Outputs from PA-A are shown in Appendix 1.

(ii) Lunskoye

Similar trajectories were calculated for Lunskoye (TAU 2002f) but, as noted above, these were based on Vityaz crude oil rather than the oil and condensate blends likely to be in the pipeline or produced from drilling operations. Spills from two locations were modelled for the period May to December:

- Lunskoye Platform (spill volumes modelled: 23t, 140t and 1,200t);
- Offshore pipeline from Lunskoye to OPF (7.5t, 48.4t and 258.5t).

The scenarios of metocean conditions, based on global data and oil weathering processes (e.g. evaporation, natural dispersion), were taken into account in the course of modelling. 14,390 oil trajectories were modelled for a ten years period. Figures 2.5 and 2.6 in Appendix 1 show the oil trajectories that would result in contact with the shoreline and Lunskyi Bay inlet within the first four days. The calculations show that the probability of shoreline impact during the first four days following a major blowout is 25% of all cases analysed. Shoreline impact, if it does occur, is likely to occur 18 to 36-hours after a spill. Figure 2.7 shows the risk zones for the marine areas where an oil spill can theoretically be present within specified time periods following the spill (assuming that no spill containment and response measures are taken). Modelling results show that more than 90% of the original oil will disappear from the sea surface in four days (see Figure 2.8 in Appendix 1).

Modelling using Vityaz crude oil, as explained above, means that the results are conservative i.e., oil distributions and persistence differ and are greater than those expected from the light oils and condensates produced at Lunskoye. The modelling outcomes overstate the potential for shoreline impact. This study will be updated in 2005 (see item viii in Table 2.11, Section 2.4.5). Variations in the composition of the hydrocarbons in the pipeline (e.g. different oil-condensate-gas ratios) have resulted in the assessment of a number of scenarios.

(iii) Aniva Bay

The proposed development of Phase 2 facilities at Aniva Bay initiated two modelling programmes for spill scenarios from the Tanker Loading Utility (TLU). The first of these (DVNIGMI 2002) modelled a large spill volume (6,500 cubic metres) from the TLU in autumn, and also from a hypothetical tanker spill in La Perouse Strait. On the basis of earlier work, autumn conditions were found to result in the maximum southward excursion of the oil. Oil from the TLU site drifted eastward under the modelled conditions and reached Aniva Cape after 72-hours (three days).

The modelling undertaken by TAU (2002a and 2002b) used a probability-based approach rather than tracked individual trajectories and produced an oil spill risk or “Excursion” map. Figure 2.9 (in Appendix 1) shows the possible distances that a slick could travel in any direction under sampled historical wind and current conditions. Similarly to the DVNIGMI modelling output, transboundary impacts from facility-sourced spills was found to be very low.

This is due to the predominantly east–west movement of potential trajectories, the time taken (over 72-hours) for shoreline impact on Hokkaido to occur and the likely short time of crude oil persistence (see the Table following Figure 2.13 in Appendix 1).

Extensive modelling has recently been carried out under all-year conditions, including an evaluation of the presence of ice (ROSHYDROMET and FEHRI 2004). These trajectories were run for both Vityaz crude oil and Heavy Fuel Oil (HFO) and were again continued for a 30-days period, longer than the calculated persistence time of anticipated crude oil slicks at sea. Vityaz crude was again modelled rather than the lighter Phase 2 blend that will be exported and so results are considered to be conservative (i.e. likely to be worse than will be the case).

There are common outcomes revealed for each season:

- In summer, oil (including HFO) is mainly transported northward, including north-westward, northward, and north-eastward. The probability of oil transport in any of the above directions is approximately the same. The probability of oil transport southwards (i.e. southwest, south and south-east) is low and amounts to 10–20% depending on the oil spill location;

- In autumn, south-eastward oil transport is very prominent. However, oil may also be transported north-eastward;

- In winter, oil is mainly transported southward, south-westward or south-eastward towards Japan shoreline;

- In spring, oil is mainly transported north-eastward or eastward.

The scenarios modelled included both spills from the TLU facility and tanker accidents along the tanker route. Figure 2.10 in Appendix 1 shows the points modelled (and referred to below) whilst Figures 2.11 and 2.12 illustrate the spill envelopes for two scenarios. Figure 2.13 shows the distribution of potential shoreline impact.

According to the specification of potential oil spill sources, leakage of oil or oil products is short (i.e. hours), hence the initial oil slick is round in shape. As it moves, the oil slick stretches downwind and becomes elliptical in shape. When the oil slick contacts the shoreline, it can break into several slicks or stretch and form a strip parallel to the shore. Calculated average oil pollution areas show oil slick areas to be expected near the TLU and in the centre of Aniva Bay. The change of average oil slick area is dependent on the oil spill location relative to the shore, prevailing oil transport direction and spill volumes.

According to calculations, shoreline impact within 40-days post-spill is possible over an extended area, including the Aniva Bay coast, northern and western coasts of Hokkaido Island, southwestern and southeastern coasts of Sakhalin Island, south Kuril Islands, and coast of northern Primorsky region. It should be noted that this is the zone of risk and not the extent of a shoreline impact.

The fastest shoreline impact is expected in the case of a summer oil spill at the TLU. In this case, oil may reach the coast of Aniva Bay within three hours of the spill. In winter and spring, the fastest shoreline impact from a TLU-based spill is calculated as within 64 and 93-hours, respectively. A vessel-based spill in the centre of Aniva Bay is calculated to possibly have a shoreline impact at the Japanese coast within 34–40 hours after the spill (under worst-case conditions).

In case of the oil spill in La Perouse/Soya Strait (point no. 3 on Figure 10 in Appendix 1) oil may reach the Japanese shore near Soya Cape within 7–13 hour after the spill (see Figure 2.13) and the Russian shoreline near Krillion Cape within 16–21 hours after the spill.

Calculations and analysis of physical and chemical processes occurring in the spilled crude oil “Vityaz” and HFO MF-380 show that::

- About 50% of Vityaz crude oil and only 5% of HFO are estimated to evaporate within three days;
- Oil dispersion may amount to 10–20% in summer and autumn, less than 1% in winter (due to very small waves and low water temperature) and about 2% in spring (due to low water temperature); dispersion of HFO into water is very low and amounts to a few fractions of a percent due to high viscosity of HFO;
- Oil slick volumes may increase due to emulsification and the extent of this will depend on temperature and mixing energies. See also Section 2.4.5, which describes the future studies being undertaken by SEIC, including oil behaviour.

(iv) Onshore Pipeline

The primary risk and hazards associated with the pipeline operation have been identified as part of an oil spill risk assessment undertaken during the design phase of the Project. The primary causes of spill events from onshore pipelines are identified as:

- Failures of process equipment, including failures due to factory defects in pipelines and equipment, equipment corrosion, physical wear and tear, mechanical damage;
- Human error, including mistakes relating to equipment clean up, repair and dismantling;
- Natural impacts such as earthquakes, landslides, and other natural events;
- Mechanical damage due to accidents;
- Acts of sabotage.

Other factors identified as influencing the likelihood of these events include:

- The quality of construction and installation work and the operational lifetime;
- The level of human activity;

- Structural and technological factors;
- The quality of equipment used, defects in equipment materials and welded joints;
- Operational factors;
- Rates of corrosion;

Potential spills from the onshore pipeline have been modelled (TAU 2002c) for the purpose of:

- Identifying oil spill scenarios, including volumes that could be released;
- Identifying the potential "zones of impact";
- Determining times from release to impact on areas of special value;
- Determining required OSR resources and response methods.

Modelling took into account: pipeline parameters; oil properties; relief features; soil properties; streams and rivers and their hydrology patterns; and the region's seasonal climatic conditions. The pipeline modelling process was undertaken in two phases. For the first, the type and locations of potential oil spill spread on land were defined. For the second phase, oil spread by rivers and streams was investigated.

The potential spill volumes were calculated assuming that in any of the above types of incident, the impact on the pipeline could range from small, difficult to detect pinholes through to complete rupture and failure of the pipeline. On this basis, three scenarios were developed to assess the likely spill volumes:

i) A small pinhole rupture that may be difficult to detect through pipeline leak detection systems and as a result may have a long leak time. This scenario may be caused by poor construction or unexpected corrosion of the pipe resulting in small leaks;

ii) A moderately sized rupture or hole that may be caused by an accident or third party intervention and could result in a spill up to 500t;

iii) A catastrophic rupture that might be caused by a large natural event such as an earthquake, significant third party intervention or major accidental damage. This scenario is likely to result in spills of more than 500t.

To identify zones of risk, oil spills were simulated along the entire pipeline route at 50m intervals (approximately 16,000 runs), as were oil spill spreads in various types of watercourses (over 200 runs). The volume of the spill depends on the characteristics of the hole in the trunk pipeline.

Oil spill simulation results were provided for maximum or worst-case. The following results were generated in the course of modelling:

- Definition of onshore contaminated areas and the volume of skimmed oil;

- Definition of oil volume potentially reaching watercourses;
- Definition of the time limits for oil to reach special value areas and the water in protected bays;
- A catalogue of typical scenarios related to the contamination of the special value areas;
- A list of areas potentially subject to contamination from oil spills;
- A set of location maps reflecting the special value areas and the areas' contamination dynamics;
- A set of maps containing results of the pipeline route and the adjacent area zoning from a contamination danger perspective.

Based on established scenarios, potential spill volumes along the various sections of the pipe where calculated on the following assumptions:

- The location and the area of the defective hole;
- The duration of the oil leak from the time of the accident until the pumps are shut down. For small holes this is assumed to be 15 minutes; for other rupture types this is five minutes;
- The duration of the oil leak from the time when the pumps are shut down until the valves close. For small holes this is assumed to be one hour; for other rupture types it is five minutes;
- The time of arrival of the response team(s) (30 minutes to two hours) and the time necessary for the response measures to stop the hydrocarbon release.

On this basis, the spill volume will be determined by the following:

- Oil release from the time of the rupture until the pumps are shutdown;
- Release of oil from the pipeline during the period between the shut down of the pumps and the closure of the valves;
- Release of oil from the pipeline during the period between closure of the valves and the end of the leak, assuming a worst case whereby no response measures are established before complete releases of spill potential.

Having completed these calculations, additional spill volumes were calculated on the basis of RF requirements which are:

- Puncture: 2% of 14-day throughput;
- Rupture: 25% of 6-hour throughput and the volume of oil between the valves of the defective section.

The results generated by the modelling were shown in table format whilst the strategic results are shown graphically in Figure 2.14 in Appendix 1. Table

2.2 provides a summary of the maximum calculated spill volumes under each of these scenarios by segment.

Having established spill volumes it was important to assess the potential consequence of any spill on key receptors such as rivers and Areas of Special Value (ASV). This was undertaken by calculating the potential migration times to these receptors. This involved the analysis of the following set of scenarios:

- Oil spill to rivers: With respect to river spill fate, transport and impact, Sakhalin rivers are generally medium/high energy and consequently have high flow velocities (in summer). The majority of pipeline river crossings are within 20km of the sea and many are within 5km. Accordingly, transport and dispersion of an intermediate to large spill to a river or stream is expected to be rapid and may reach the mouths of rivers and coastlines in a matter of hours. An indication of the time taken for a spill to reach bays and coastlines was given in the report (e.g. typically under two hours) (see example Figure 2.14 in Appendix 1);

- Oil spill to land: Pipeline burial depths are low (90cm), soil water content is generally high and water table levels are generally high along the pipeline route. Therefore, in such conditions, vertical (deep) penetration of spilled oil into the subsurface is expected to be limited and the general trend is expected to be surface breakthrough and lateral spreading, particularly in waterlogged areas. Spill impacts on land are expected to be local in scale. The significance of any spill to land will largely depend upon its proximity to water bodies. Detailed mapping of the information was provided and an example is shown in Figure 2.14 in Appendix 1.

- Oil spills that may impact ASVs: Impacts are as a result of either river or land spills where oil is transported into the ASV. Such scenarios were assessed and represented graphically (see Figure 2.14).

Table 2.2 Pipeline Spill Magnitude – Examples

Valve Location		**Spill Location, km of Pipeline**	**Potential Spill Magnitude, based on Response Time (6-hrs), tonnes**			**Spill Magnitude According to RF Govt Decree No. 613**	
Km of Pipeline	**Description**		**Puncture**	**Hole**	**Rupture**	**2%**	**25%**
Piltun-Astokhskoye Section							
Segment 1							
1.8	Tie-in with offshore pipeline	1.8	6.64	76.16	412.13	4,959.36	1,194.15
Segment 8							
142.4	Upstream of Imchin River	142.4	6.70	38.63	192.04	4,959.36	1,176.72
Lunsky Section							
Segment 6							

Valve Location		Spill Location, km of Pipeline	Potential Spill Magnitude, based on Response Time (6-hrs), tonnes			Spill Magnitude According to RF Govt Decree No. 613	
Km of Pipeline	**Description**		**Puncture**	**Hole**	**Rupture**	**2%**	**25%**
19	Downstream of River Vazy, upstream of River Nyshnyi	27	14.19	157.20	911.16	7,305.98	1,668.50
27.15	Downstream of Stream Sredniy	27.15	16.28	157.12	910.55	7,305.98	1,718.77
Main Pipeline							
Segment 2							
18.3	Downstream of River Chkharnia, upstream of Argy-Pagy	20.483	16.05	138.67	820.69	7,305.98	1,685.34
39.5	Downstream of Vosiy	39.5	11.81	137.28	812.15	7,305.98	1,752.19
Segment 3							
283.7	Downstream 282.4 km break, River Kissa	296.483	15.52	159.43	923.22	7,305.98	1,635.07
296.5	River Gorianka	296.5	14.60	159.32	922.29	7,305.98	1,752.19
Segment 4							
324.1	Upstream of 326.1 km break	324.1	18.52	156.47	907.71	7,305.98	1,727.06
Segment 5							
435.3	Pig receiver / launcher	437.483	14.61	142.92	832.87	7,305.98	1,660.21
519.5	Upstream of Aprelovskiy km 520.6 break	519.5	15.56	125.74	729.23	7,305.98	1,752.19
Segment 7							
597.2	Upstream of River Mereya	597.2	10.03	116.24	641.05	7,305.98	1,701.93

Note: These calculations are indicative only and are being reassessed. Pipeline route changes have occurred since these figures were calculated.

All modelling results have been used in the decision-making process to best determine the approach to oil response and equipment inventories. As a result, SEIC has reviewed potential staging areas throughout Sakhalin for the pre-placement of equipment at critical locations, for example, near lagoons and river mouths.

Equipment requirements and location of equipment is being reassessed as a result of the Alternative 1 pipeline reroute. SEIC is currently rewriting the Onshore Pipeline OSRP (expected at the end of 2005).

Trajectory Modelling: Summary Conclusion

Marine trajectory modelling studies, using three models over a six-year study period, have produced relatively consistent results. The risk of transboundary impacts from facility sources is very low due to predominant metocean conditions and oil persistence. Spills from tankers can be expected to pose some risk depending on wind conditions and variability of locations. However, the character of exported crude oil will be much lighter with the Phase 2 development due to blending of condensates into the Vityaz crude oil. Additional oil characterisation and trajectory studies will be undertaken (see Section 2.4.5) to refine this information once samples of the blended oil are obtained.

2.3.2 Mapping

Having identified areas or resources at risk from oil spills through the trajectory modelling, each of these areas will be assessed in relation to its sensitivity to the impact of oil and potential cleanup strategies. This information will also be used to refine the distribution and character of the response requirements, including equipment, personnel and training.

The primary purposes of the environmental sensitivity maps are to determine the coastline protection priorities in the case of oil spills and for the development of deployment and cleanup strategies.

(i) Initial Mapping

The shorelines and bays of north-east Sakhalin Island from Cape Elizaveta to Cape Terpenya have been surveyed and sensitivity maps were prepared as part of the Phase 1 oil spill response planning programme.

Sensitivity maps were prepared for the offshore and onshore pipeline route, facility sites and for Aniva Bay, for the initial Phase I EIA and for the conceptual Oil Spill Response Plans (OSRPs). These were based on existing information and site surveys (by experienced environmental scientists and in consultation with relevant government agencies) and concentrated on identifying Areas of Special Value (ASV) and other resources at risk from spills from each facility. Some key ASVs are listed in Table 2.3 below. There are other notable areas (that are not formal ASVs) requiring protection for example, the whole of Nabilski Bay. It should be noted that these sensitivity maps are being progressively updated as results of the SEIC ground surveys, then analysed and integrated into the GIS system.

These maps have recently been revised and will be further upgraded in 2005 on the basis of the 2004 and 2005 ground survey programme.

Table 2.3 Examples of Identified Areas of Importance including Areas of Special Value (ASV)

ID	Name	Description	Facility
1	Vrangelya Island	Protected natural area of particular importance to nesting birds. Located in Piltun Bay.	PA-A, PA-B & Lun-A
2	Lyarvo Island	Protected natural area of particular importance to nesting birds. Located in northern part of Nyiskyi Bay.	PA-A, PA-B & Lun-A; Onshore Pipeline
3	Chayka Island	Protected natural area of particular importance to nesting birds. Located in northern Nabilskyi Bay.	PA-A, PA-B & Lun-A; Onshore Pipeline
4	Lunskyi Bay Nature Preserve	Protected natural area of particular importance to nesting and migrating birds. Located on the northeast coast of Sakhalin Island.	PA-A, PA-B & Lun-A; Onshore Pipeline
5	Daginskie thermal spas	Social and economic significance. Located in north-east Sakhalin Island near Dagi Bay western coast.	Onshore Pipeline
6	Makarovsky Reserve	Protected natural area designated as a biological reserve. Pipeline passes along the far eastern, downstream edge of the preserve.	Onshore Pipeline
7	Izubrovyi Preserve	Hunting reserve located between the rivers Ai and Firsovo.	Onshore Pipeline
8	Pugachevo Mud Volcano	Mud volcano located in the southern part of Makarovskii District, near Pugachvo village.	Onshore Pipeline
9	Korsakov Fir Grove	Grove of Glen Spruce trees located in Mereya river valley, 2km to the north of Prigorodnoye.	Onshore Pipeline
10	Mass recreation sites (beaches)	Social and economic significance.	OET/TLU; Onshore Pipeline
11	Korsakovskoye farm	Social and economic significance.	OET/TLU; Onshore Pipeline
12	Busse Lagoon Preserve	Protected area located in north-eastern part of Tonino-Aniva Peninsula.	OET/TLU
13	Krillion Peninsula Hunting Area	Located in south-western part of Krillion Peninsula.	OET/TLU

(ii) Ongoing Mapping

Extensive photographic material, shoreline morphology data and environmental sensitivity information for the Aniva Bay area was obtained in 2004 to supplement the existing portfolio of information. The surveys covered the shoreline from Cape Kuznetsova on the west coast of the Krillion Peninsula to Cape Aniva at the southern most tip of the Tonino-Anivskii

Peninsula. This material is being incorporated into the OSR Geographical Information System (GIS) database and will provide the basis for updated sensitivity maps of the area (see example of Aniva Bay – Figure 2.18).

Ground surveys of river systems along the pipeline route were carried out during 2004 and further surveys are planned for 2005. These will include additional river sites and shoreline areas of the Sakhalin coast.

Field surveys are being undertaken to obtain OSR-related information for rivers and streams, lagoons and wetlands, and shorelines and will be further expanded on extensive information already collected for EIA purposes. The types of information collected from each area include:

- Logistics information (e.g. roads, access, suitable staging areas);
- Biological character (i.e. sensitivity to oil and cleanup);
- Shoreline and riverbank character (e.g. substrate and form);
- Water depths, flow rates and widths of rivers and streams;
- Height and slope of river banks, cliffs etc.

Opportunities for SEIC and stakeholders to discuss, contribute and identify sensitive sites and areas have been taken during the extensive project-wide consultation exercise, which is ongoing. Further information on the results from these studies is outlined in the following sections.

The sensitivity mapping will also take into account particularly sensitive species such as the Steller's Sea-eagle (see also EIA-Addendum Chapter 4), non-western gray whale marine mammal species (see EIA-Addendum Chapter 5 for details) and Red Data Book and migratory birds (see EIA-Addendum Chapter 15). The GIS identifies the distribution of the eagles and other endangered wildlife and the tool is being used to develop response priorities. See the following subsection entitled "Wildlife" (part (iii) under Section 2.3.3) for more details.

(iii) Hokkaido Mapping

Sensitivity receptors along the northern coastline of Hokkaido will also be considered in SEIC oil spill planning. SEIC will utilise the maps that are currently in development, being prepared by the Geological Survey of Hokkaido (GSH) in association with the Japanese Coast Guard (JCG).

The Hokkaido Environmental Sensitivity Index (ESI) maps are based on the ESI mapping system used by the USA's National Oceanic and Atmospheric Administration (NOAA), and consist of three key parts (Hamada, *pers. comm.* 2004):

- *Geological Information:* describing geographical conditions, for example, locations of sandy shorelines, rocky shores etc.;
- *Biological Information:* describing flora and fauna;

- *Social Information:* location of recreational beaches, commercial operations such as fish-farming etc.

Extracted examples are shown in Figure 2.19. The maps comprise five example sections of the northern Hokkaido coastline, namely (west to east): Rumoi, Wakkanai, Soya, Monbetsu and Abashiri. The focus of the maps is the coastline with adjacent coastal area and immediate hinterland. A wide range of symbols are shown (see key for the maps), ranging from both natural and physical features. These include natural and biological habitats (e.g. sea turtle egg laying habitats, shellfish gathering locations, algae etc) and formally designated areas (e.g. Ramsar Convention registered wetlands, National Park) as well as other demarcated areas (e.g. fishery areas). Recreational features and areas of human usage such as seaside resorts are clearly identified. Other sensitive features and important focal points (e.g. schools, Marine Traffic Centre, historic sites) are also represented. Importantly, OSR facilities and equipment locations (e.g. equipment storage facilities, dredger, oil recovery vessel, high viscosity oil collection net, oil collecting vessel, waste oil disposal facility) are also included in the maps.

From 1999 to 2000, GSH surveyed and geologically classified the 3,000km shoreline of the Hokkaido region (Hamada 2004). Some information on Hokkaido's shoreline types became available to the public in Japanese in pdf-form in May 2004 (see Figure 2.19 in Appendix 1). The GSH is currently collecting further information about human-use resources and biological resources for input into its GIS database; these results are expected to be available to the public in May 2006 on their website in pdf-format.

The system adopted by GSH is compatible with that being developed by SEIC and will form an effective basis for the development of shoreline response strategies in Hokkaido.

As noted in earlier sections, risks of oil impact from spills related to SEIC activities have been identified and consequently the company will acquire any available Hokkaido shoreline data for response planning purposes. SEIC will ensure that shoreline response documents produced by SEIC are suitable for application to Hokkaido shorelines.

A variety of other data sources are being utilised and this ongoing work effort is expected to be complete by mid-2006 and before first oil. These maps form part of SEIC's ongoing development to operations preparedness and will be finalised and incorporated into oil spill response planning documents prior to commissioning and their subsequent approval by the Russian Federation.

The Hokkaido coastline is divided into three regional areas: Northern, Okhotsk and Kushiro/Nemuro.

The Okhotsk Sea coast can be divided into two regions separated by the Shiretoko Peninsula. The northern region is characterised by flat sandy beaches. The southern region is characterised by a big embayment formed between the Shiretoko Peninsula and the Nemuro Peninsula.

In addition, some of the Kuril Islands are located in the entrance of this embayment.

The channel lying between Hokkaido and Kunashiri Island is called the Nemuro Strait. This region is characterised by many large and small brackish lakes along the coast. The warm Soya Current (a branch of the Tsushima Current) flows southward along the Okhotsk Sea coast and a cold East Sakhalin Current runs along the outside and parallel with the Soya Current. Considerable freezing of seawater, especially in lakes and inlets, and drifting ice occur from December to April. These icy conditions greatly restrict fishing activities and mariculture during this period.

2.3.3 Oil Spill Response Plans

The types of risks associated with construction and operation are defined in SEIC's Central Oil Spill Response Plans (in Draft). Examples of potential spill scenarios are shown in Table 2.4.

Table 2.4 Examples of Potential Spill Scenarios

Scenario	Oil Type	Comments
Scenarios for Offshore Operations and Drilling Activities		
Small spill from general maintenance or other operations, for example wire line logging.	Diesel, lubrication oil, hydraulic oil or drilling muds.	Possible during any oil handling or use of equipment. Spills unlikely to be greater than 1 tonne and are unlikely to reach the water.
Damage to utility or storage tanks.	Diesel, hydraulic oil, lube oil.	Amount likely to be spilled depends on whether bunding is damaged during the incident. If bunding is not damaged, the full inventory of the tank should be held. Bunding should be designed to 110% tank capacity in line with international standards.
Loss of oil during loading operations.	Diesel.	Any spills are most likely to result from drips and leaks from hoses during (e.g. hose connection or disconnection). Over filling of storage tanks may result in oil being lost.
Vessel or helicopter colliding with drilling infrastructure, not resulting in a blow out.	Diesel, lube oil, hydraulic oil, aviation fuel.	Tier 3 would be unlikely (see Table 2.5). Worst-case is a total loss of drilling infrastructure inventory; loss of vessel fuel may occur. Chemicals associated with drilling activities may also be lost.
Burner failure during well testing and flaring operations, leading to spill of unburned oil from flares.	Crude.	Most likely during well testing.
Temporary loss of well control during drilling or well testing.	Crude.	Such incidents likely to be caused by either human error or equipment failure / malfunction.
Blowout during drilling as a result of human error, independent accidents, tectonic activity or primary equipment failure.	Crude.	May occur subsea (e.g. collapse of geological formation or, failure of tubing, casing, down hole safety valves or conductor) or from failure of, or damage to, the well control equipment (e.g. Christmas tree, blow out preventer, wellhead, risers, etc). Blowouts can also occur during wireline / coiled tubing operations. (May result from vessel colliding with drilling infrastructure.)

Scenario	Oil Type	Comments
Accidental discharge from drilling operations.	Crude, diesel, hydraulic oil and lube oil.	Such incidents likely to be caused by either human error or equipment failure / malfunction.
Loss of oil based drilling muds.	Drilling muds.	Most likely to occur during transfer operations.
Helicopter crash with no impact with drilling infrastructure.	Aviation fuel.	A spill of any significance would be unlikely. Potential loss of life / search and rescue procedures would take precedence in an emergency.
Scenarios for Vessels		
Small spill resulting from discharge of contaminated ballast or engine room bilges.	Diesel.	Small spills only.
Loss of diesel during ship-to-ship transfer.	Diesel.	Any spills are most likely to result from drips and leaks from hoses during (e.g. for example hose connection or disconnection).
Greater loss of diesel during ship-to-ship transfer operations.	Diesel.	Spill resulting from a full bore hose burst or rupture during fuel transfer.
Major collision between supply tanker and other vessel.	Diesel and fuel oil.	Major collision where full inventory of supply tanker is lost along with its fuel oil. Depending on the other type of vessel involved different oils types, or even chemicals, may also be lost.
Vessel collision, not involving a tanker.	Diesel and / or fuel oil.	Collisions could occur between any SEIC or contractors' operating vessels, or collisions could occur with external vessels (e.g. fishing boats, passing merchant vessels).
Loss of fuel storage barge.	Diesel.	Numerous potential causes including, collision, grounding, hull failure or fire / explosion. May be related to a large incident (e.g. collision with other vessel or drill infrastructure).
Incident involving one vessel (not a tanker) or fuel storage barge.	Diesel, fuel oil, other.	Volume and oil type depends on vessel involved. Numerous potential causes including, collision, grounding, hull failure or fire / explosion.
Scenarios for Pipelines		
Small to large hole in a pipe or flow line.	Crude, condensate and mix.	Current risk is related to the pipelines and piping currently being constructed and used in the existing drilling operations. In the longer term, spill risks are discussed in site facilities OSRP.
Scenarios for Onshore Construction Activities		
Small spill from general maintenance or other operations.	Diesel, lubrication oil, hydraulic oil	Possible during any oil handling or use of equipment. Spills unlikely to be greater than 1 tonne.
Loss of stored oils.	Diesel,	Storage of oils maybe inadequate and not in

Scenario	Oil Type	Comments
	lubrication oil, hydraulic oil	compliance with international best practice, thus heightening risk. Oils are required to be stored in adequately bunded areas in line with SEIC standards.
Road tanker truck roll over.	Diesel.	Likely to result from inferior roads, ageing vehicles and less than adequate driving conditions and behaviour.

(i) Construction Phase

During construction activities, spill risks are covered by Contractors' OSR Plans (OSRP). All SEIC contractors and sub-contractors are required to comply with SEIC standards and procedures. All plans are reviewed and when adequate, approved by SEIC prior to activities commencing. As part of this assessment, SEIC undertakes an analysis of equipment requirements against the risk from the activities.

Following this review, contractors are required to have sufficient capability and capacity to respond to their risk either through a contractual arrangement with a spill response company, or by using their own personnel and equipment. However, in the event of an incident that is beyond a contractor's resources, SEIC will assist and support any spill response, as they would to any third party spill. All contractors can access SEIC emergency and response procedures via the Duty Emergency Coordinator (EC). SEIC project staff undertake site inspections to ensure that systems and equipment are maintained.

Having contacted the Emergency Coordinator (EC), the EC will evaluate the requirements of the incident and release equipment and resources accordingly. As necessary, SEIC will activate their spill response structure and Emergency Coordination Team (ECT) to manage and assist with a spill from contractors. SEIC and their Contractors have a number of resources available to support a response. These resources are located at various points on the island (see Figure 2.16 and subsection (i) of Section 2.4.6).

SEIC also provides OSR support to Contractors and will respond to spills if requested through the RF Unified Command System. Such a case occurred in September 2004 when the dredging vessel "Cristoforo Colombo" ran aground during a cyclone off Kholmsk, Sakhalin Island. Despite this being a third party spill, SEIC assisted Emercom in coordinating the spill response at the request of the ship owner and the Oblast Emergency Committee. SEIC and contractor equipment and human resources were used together with personnel from community groups, local, Oblast and Sakhalin Island-based RF Government agencies.

As a result of this incident, SEIC is increasing its stockpile of OSR equipment in the south of Sakhalin Island and is commissioning a number of mobile OSR units. As a goodwill gesture, SEIC has pledged its support to local authorities to increase their capacity in OSR and has also provided for substantial aesthetic improvements to the shorefront promenade of the town of Kholmsk.

(ii) Operations Phase

SEIC will develop functional operational OSRPs for each of the Phase 2 facilities. These OSRPs will be maintained, reviewed and revised, as required, for the duration of the operational phase for each facility. Furthermore, RF law demands that each OSRP will be approved by Oblast and Federal Government agencies before the commencement of operations. It is planned that all OSRPs will be finalised at least six months prior to Sakhalin II Phase 2 first oil.

An approved OSRP is currently in place for the Sakhalin II Phase 1 facility at Piltun-Astokh A (the "Vityaz" complex). This will be revised to address the changes to PA operations resulting from the Phase 2 developments. The existing PA OSRP has been approved by Sakhalin Oblast and RF agencies and the SEIC response organisation and equipment resources have been assessed by relevant authorities as being sufficient for the facility. This assessment is based, in part, on two government response exercises held in 2003.

The first of these was held by Emercom in June 2003. The second was a joint Ministry of Defence / Ministry of Transport exercise held in August 2003. Both exercises required the activation of both the SEIC Emergency Coordination Centre in Yuzhno and site control teams. The Ministry of Defence / Ministry of Transport exercise also involved a field deployment of SEIC marine response resources, shoreline protection equipment and response teams and also a significant deployment of personnel.

For Phase 2 planning, Sakhalin Energy developed a Draft SEIC Corporate OSRP, a Draft SEIC OSR Concept Paper and conceptual OSRPs for each facility. These documents set out the broad approach to oil spill planning and response as well as proposed equipment acquisitions and distribution. These documents are currently undergoing a detailed revision and will be finalised at least six months prior to the start of Phase 2 operations. PA-A and PA-B will be covered under one Piltun-Astokh field OSRP, in accordance with RF Government requirements.

Tankers and other vessels will operate under their own Shipboard Oil Pollution and Emergency Plans in accordance with MARPOL and Port-State control arrangements. Regulation 26 of Annex I of MARPOL 73/78 requires that oil tankers of 150t (gross tonnage) or more and all ships of 400t (gross tonnage) or more, carry an approved Shipboard Oil Pollution Emergency Plan (SOPEP). Regulation 16 of Annex II of MARPOL 73/78 makes similar stipulations for all ships of 150t (gross tonnage and above) carrying noxious liquid substances in bulk: they are required to carry on board an approved marine pollution emergency plan (MPE Plan) for noxious liquid substances. The latter should be combined with a SOPEP, since most of their contents are the same and the combined plan is more practical than two separate ones in case of an emergency. The International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990, also requires such a plan for certain ships.

The SOPEP contains information from the owners to the Master of a particular ship and advises how to react in case of oil spill to prevent, or at least mitigate, negative effects on the environment. The Plan contains operational aspects for various oil spill scenarios and lists communication information to be used in case of incidents. Based on the minimum requirements in the MARPOL document “Guidelines for the Development of a Shipboard Oil Pollution Emergency Plan”[1]. Typical chapter contents are:

- Ship identification data;
- Table of contents;
- Record of changes;
- Preamble (compulsory chapter 1);
- Reporting requirements (compulsory chapter 2);
- Steps to control discharges (compulsory chapter 3);
- National and local coordination (compulsory chapter 4);
- Minimum appendices:
  - List of coastal state contacts (as published annually by the International Maritime Organisation ;IMO);
  - List of Port contacts (to be kept up-to-date by the Master);
  - List of ship interest contacts (communication data including 24-hrs contact telephone number for owners/managers, any information on charterer, insurance, Protection and Indemnity etc.);
- Ship’s drawings:
  - General arrangement plan;
  - Tank plan;
  - Fuel oil piping diagram;
- Further appendices on owner’s decision, for example:
  - Training and drill procedures;
  - Plan review procedures;
  - Record-keeping procedures
  - Public affairs policy.

(Germanischer Lloyd 2005).

SEIC has the right to audit these.

SEIC also commits to maintaining adequate levels of trained staff. Training will include joint training with Government and other oil industry personnel and

(1) Published by IMO under MEPC.54 (32) 1992 as amended by MEPC.86(44) 2000.

continued participation in Tier 2 and Tier 3 response exercises (see Section 2.3.6).

The SEIC Phase 2 OSRPs will be fully compliant with RF laws and will be consistent with the Russian Tier system (explained in Table 2.5) and Emergency Response system (Figure 2.20). The latter is based on a hierarchy of Emergency Committees, which coordinate a Unified Command System. The description of the tiers in the RF column is consistent with International Petroleum Industry Environmental Conservation Association (IPIECA) working definitions.

Response Tier	Description of Tier (Significance of Spill and Level of Response)	Indicative Spill Volume	
		RF(1)	Sakh. Oblast(2)
Tier 1	Emergency of local importance (1). The oil spill should be contained and effectively responded to by resources of the organisation/company that owns facility where the spill has occurred (Asset Resources). In this case, a Tier 1 response is managed by SEIC using SEIC resources and existing OSR Contractors.	From the Ministry of Natural Resources (MNR) defined lower limit up to 500t	Up to 20t
Tier 2	Emergency of regional importance (1). The resources of the Sakhalin subsystem of RSChS, the RF Ministry of Transport (SakhBASU) and other local specialised organisation holding appropriate licenses for performance of OSR activities may be engaged in addition to the asset resources (Tier 1 Resources).	500t to 5,000t	Up to 5,000t
Tier 3	Emergency of federal importance (1). The response resources of Russian RSChS, Ministry for Emergencies, Russian State Marine Rescue Service and foreign companies and OSR Contractors may be engaged in addition to the Tier 1 and Tier 2 Resources.	Exceeding 5,000t	Exceeding 5,000t

Table 2.5 Summary Definitions of Offshore Emergency Oil Spill Response Tiers in the RF

(1) From Government Executive Order No. 240 of 15 April 2002;

2) From Sakhalin Oblast Governor Decree No. 193 of 8 May 2001.

The current Oblast and Federal definitions of Tier 1 are different with respect to indicative volumes although both regulations are currently being revised. In this way, the volumes are an RF upper limit trigger value to ensure higher activation levels and thus is not specifically related to SEIC equipment or RF equipment requirements for facilities. However, the overriding practical application of the tiered response system is independent of volume (i.e. if those responsible for the spill can manage the response, it is a Tier 1 response). If the spiller requests assistance, or if Emercom (or the Oblast Emergency Committee) decides that they are not managing the response well, then they may take over (i.e. implement the “Unified Command”) and it becomes a Tier 2 response. The Cristoforo Colombo (28t of oil spilled) was identified by Emercom as a Tier 2 response, despite the relatively low volume of the spill). The incident resulted in SEIC managing the spill response on behalf of (and at the request of) the Oblast Emergency Committee.

The draft Phase 2 OSRPs that were prepared for the approvals TEO-C process are currently being extensively revised. The new OSRPs will be both comprehensive and practical. They will clearly demonstrate the environmental risks associated with oil spills to Sakhalin Island and the northern part of Japan as well as the methods to be implemented in managing them.

OSRPs will be developed in close consultation with relevant local and RF authorities, and will take account of any relevant views raised by stakeholders. The structure and contents of the OSRPs will encompass the contents and requirements of the IFC Guidelines on Oil and Gas Development (Offshore) (IFC December 2000), IPIECA Guidelines (IPIECA 2000) and be compliant with Russian Federal and Sakhalin Oblast Government requirements.

Each plan will include, as a minimum, the following:

- A description of the operations, site conditions, and weather patterns;
- Potential spill scenarios to identify worst-case potential accidents, taking into account local conditions such as seasonal climatic variations, hydrometeorology, catchments and river gradients;
- A definition of Tier 1, 2 and 3 levels in accordance with Russian Federation regulations and a clear demarcation of Company responsibilities and obligations with reference to each tier (contractual arrangements with third party oil spill response contractors will be described within the plans);
- Environmental sensitivity mapping of habitats and other areas of special value (the information will include detail on sensitive areas, facilities, equipment inventory and equipment locations);
- Organisational structures for oil spill response, including roles and responsibilities, notification and communications procedures, and contact details. The emergency response and crisis management systems are currently being upgraded;
- A list and description of onsite and offsite response equipment and instructions on usage;
- The contributions of Government personnel, as appropriate;
- Strategies for the deployment of equipment and personnel, according to the potential location of the spill and environmental sensitivity, to ensure protection of the environment. These strategies will take into account local and climatic conditions, such as the presence of ice and key habitats such as coastal lagoons;
- Procedures for the protection of oil spill response personnel and potentially affected populations;
- Guidelines for wildlife hazing, rescue and management (see paragraphs below);

- Plans for the treatment and disposal of waste materials (see below, following Wildlife subsection);
- Programmes for the training of relevant SEIC staff and Contractors.

(iii) Wildlife

Oil spills may result in oiled wildlife and wherever practical, these must be cleaned and rehabilitated. The existing Piltun-Astokhskoye OSR Plan contains "Wildlife Response Guidelines" as the region's wildlife includes marine mammals (e.g. pinnipeds, such as seals and sea lions; cetaceans such as whales and dolphins; and sea otters) and marine and coastal birds. The document outlines priority areas for wildlife protection including:

- Coastal bays and lagoons, due to the presence of salt marshes that sustain a high level of fauna and attract migrating birds, wildlife etc;
- Large concentrations of shorebirds and/or seabirds (e.g. migration stopovers and wintering areas of migratory birds; seabird colonies; and major seabird feeding areas);
- Concentrations of marine mammals (e.g. seal haulouts; upping and moulting seasons; entrances to bays, particularly in the Spring);
- Ice leads used by whales as migration pathways.

The document also provides guidelines for the safe handling and treatment of oiled wildlife (e.g. that participants in wildlife response and recovery operations must have received adequate training, adherence to all industrial hygiene safety precautions stated in the Health and Safety Plan, PPE, not working alone etc). Furthermore, responsibilities are outlined in the document including:

- Appointing a Wildlife Operations Coordinator (WOC);
- Continued dialogue on wildlife issues through consultation with regional agencies, e.g. Sakhalin Oblast Ministry of Natural resources, Sakhrybvod Department (fishery authority) and Sakhalin Oblast Sanitary and Epidemic Supervision Centre;
- Management guidelines, for example, the development of a Wildlife Response Plan, transport, documentation and reporting.

Methods will be used, where feasible, to move birds and marine mammals from locations that are in the projected pathway of the oil, or are oiled, or to exclude them from these areas via hazing methods, exclusion or pre-emptive capture/removal of animals.

SEIC has commissioned a report from the International Fund for Animal Welfare (IFAW), which will set out the background on existing capabilities for wildlife response on the Island. The study will investigate options for what is required to develop and enhance wildlife response capability for future operations. SEIC will invest in wildlife response equipment and this is likely to include: rescue trailers and clean-up/rescue equipment kits; temporary heated enclosures for short-term holding; and equipment for hazing (i.e. nets and mesh for delineating and protecting wildlife areas). Wildlife response guidelines will be developed for the Phase 2 OSR plans.

(iv) Waste Management

Storage and transfer systems will be required to enable the offloading, treatment, and ultimate disposal of recovered oil. In order to address immediate (portable) waste storage, the following items will be considered: transfer lines; vacuum truck capability; external pump loading capability to storage tanks; and oil reception capabilities.

In terms of ultimate disposal, the draft SEIC Solid Waste Management Strategy states that the design, permitting and construction of secure storage, bioremediation, contingency holding areas and ultimate disposal for oil spill wastes at strategically located asset sites (e.g. LNG, OPF) such that they are in place at, or during, commissioning (for more information see EIA-Addendum Chapter 10 on Solid Waste Management for information on this topic).

2.3.4 Training

All OSR instruction, whether in the classroom or in the field, theoretical or practical, and including response exercises (desktop and deployment) is considered to be “training”. A crucial part of the OSR strategy is a comprehensive training programme to ensure that all personnel who are, or may be, assigned tasks during a response are suitably trained and are capable of performing their designated roles efficiently and effectively, including contractors.

Spill training programmes are intended to ensure the safety of SEIC and contracted personnel, to mitigate or prevent discharges, and to effectively reduce the effect of a spill on property and the environment. Safety and environmental training cover all aspects of safety and environmental protection, both onshore and offshore. The SEIC HSE Department ensures that spill response and related training is given to all employees that handle oil or hazardous liquids or that operate in the vicinity of these products. The training programme explains in detail how to implement the Project’s prevention and OSR plans by describing response actions to be carried out under the plans.

SEIC has prepared a Guideline Oil Spill Response Training document (SEIC June 2005), which defines the preferred levels of training required of personnel nominated to various OSR roles. These roles may be in the Crisis Management team (CMT), Emergency Coordination Team (ECT), Site Teams or as first responders in the event of a spill. The training recommended is designed to ensure that all personnel can operate safely, effectively, and efficiently during a response. It does not replace any OSR training required under RF Regulations, Acts or Decrees. The Guideline for Oil Spill Response Training is consistent with, and is a supplement to, the SEIC HSE Training Standard.

The types of training required to fulfil good responses to different tiers of spill are included in SEIC’s training programme.

Examples of general and tailor-made training courses are listed below:

- Oil spill introductory course (awareness): three to five days;
- Oil spill senior management course: two days;
- Shoreline response two to three days;
- Wildlife response: cleanup and rehabilitation: two days;
- Environmental awareness for OSR course: two days;
- Inland spills course: two days.

Employees trained in OSR will receive refresher training of sufficient content and duration to maintain their competencies. Certification records are kept, including for training courses outside of SEIC.

Conduct of Regular Oil Spill Response Exercises and Drills

Running small scale and large-scale OSR exercises enables the effectiveness of OSRPs and response teams to be tested. These may be facility-based, SEIC-wide or undertaken in cooperation with relevant RF and Sakhalin Oblast authorities, and participation in regional exercises. Exercises may involve any combination of the following:

- Desktop exercises;
- Field deployment exercises;
- Combined exercises (desktop and field).

(i) Desktop Exercises

- **OSR Plan orientation** – an exercise conducted as an informal workshop focusing on familiarising the management team with roles, procedures and responsibilities. The aim is to review each section of the plan and by utilising local knowledge and expertise make useful and practical improvements to the plan;
- **Desktop Scenarios** – uses a simulated oil spill incident to test teamwork, decision-making and procedures. The exercise needs to be properly planned with a realistic scenario, clearly defined objectives for participants and a well-briefed team in control of the running and debriefing exercise. A desktop exercise typically lasts from two to eight hours;
- **Notification Procedures and Callouts** – A notification exercise practises the procedures to alert and call out the OSR teams. These are normally conducted over the telephone or radio, depending on the source of initial oil spill report. They test communications systems, the availability of personnel, travel options and the ability to transmit information quickly and accurately. This type of exercise will typically last one to two hours and can be held at any time of the day or night.

(ii) Field Deployment Exercises

- **Equipment Deployment** – Deployment exercises may be designed to give personnel a chance to become familiar with equipment or part of a detailed and specific emergency response scenario, where maps, messages, real-time weather and other factors can be included. The exercise is designed to test or evaluate the capability of equipment, personnel, or functional teams within the wider OSR. Teams could be located at different places in the field with each team practising different skills. In deployment exercises, the level of difficulty can be varied by increasing the pace of the simulation or by increasing the complexity of the decision-making and coordination needs. A deployment exercise would typically last from four to eight hours.

(iii) Combined Exercises

- **Full-scale Combined Emergency Management Exercises** – Such exercises provide a realistic simulation by combining all of the elements of the desktop exercise (e.g. use of maps, communications etc) as well as the actual mobilisation and deployment of related personnel and equipment. This complex and very intense learning environment tests cooperation communications, decision-making, resource allocation and documentation. Organising a realistic full-scale exercise could take many months and a large support team to run the exercise. They generally last at least one day and often carry on overnight into a second or third day.

The structure, authorisation and management of exercises are detailed in Table 2.6. It should be noted that exercise levels within this table do not correlate with Tier levels as all types of incidents can be exercised in all levels (Tier 1 through Tier 3). Level I and II exercises are carried out annually and major exercises (i.e. Level III) are undertaken every 2-3 years.

Table 2.6 Description of Oil Spill Response Exercises

Level	Type	Description	Authorisation	Participants
I	D	Small-scale desktop exercise involving SEIC personnel and Contractors. Some Government observation or limited participation if required or requested.	Nominated Asset Emergency Coordinator in consultation with Asset Manager	SEIC Asset and corporate personnel; Contractors; External agencies; Some Government Agency participants/observers.
	F	Small-scale field deployment. Usually involving only one activity (e.g. boom deployment at sea, shoreline deployment.		
	C	Combined. As above.		

Level	Type	Description	Authorisation	Participants
II	D	Medium-scale desktop exercise involving SEIC personnel. Includes Contractors and Government personnel.	Asset Manager in consultation with SEIC Chief Executive Officer (CEO)	SEIC Asset and corporate personnel; Contractors; Shell/STASCO; External agencies; Government Agency participants and resources.
	F	Medium-scale field deployment. May involve a number of activities (e.g. boom deployment at sea, shoreline deployment, aerial surveillance or response).		
	C	Combined, as above		
III	D	Major exercise with substantial field deployment.	SEIC CEO	As for II above
	F			
	C			

D – Desktop exercises; F – Field deployment exercises; C – Combined exercises (desktop and field).

These major exercises include the participation of Government representatives (e.g. Emercom and Dept of Defence- Ministry of Transport exercises in 2003). The next exercise of this type, planned by RF Ministry of Transport (SakhBASU) and involving the Japanese Coast Guard, will take place in May 2006. This is a high level cooperative exercise and will involve the joint participation of the RF Government, RF Navy and Japanese Coastguard resources being deployed in or near Aniva Bay. The exercise will include a potential transboundary spill scenario (e.g. oil moving into Japanese waters). The “Irbis” will take part.

External consultants with expertise in emergency response and crisis management are often commissioned to set up the exercises and practice drills. These organisations are able to monitor the success of the exercise and give useful feedback. Some exercises are monitored by external organisations or Government representatives in an auditing capacity. For example, in July 2004, Emercom auditors were present at SEIC desktop exercises and took part in equipment audits at Nogliki.

2.3.5 Third Party Response

SEIC has a “Passing Ship Policy” in place stipulating the Company’s commitment to provide assistance to third party spills as far as is reasonable and practicable to do so. This Policy will be upgraded to reflect the broader nature of the Phase 2 development. That commitment is also supported by the purchase of a range of OSR equipment to address spills from a variety of oil types crude, HFO vessels, marine diesels etc which in some cases are not directly used in SEIC operations. SEIC’s response capabilities are also integrated into Sakhalin Island, Russian national and international response arrangements through the Russian and Oblast Unified Command system.

For example, equipment (e.g. booms, skimmers and storage tanks) has been placed in Kholmsk and Korsakov.

It should be noted that, as per international liability and compensation conventions, liabilities for spills from laden tankers lies with the vessel owner and not with SEIC. However, although OSRPs will focus on spills from facilities and tankers within SEIC facility perimeters, SEIC resources will respond to spills outside of these areas in cooperation with relevant regional authorities, as required.

2.3.6 Oil Behaviour in Ice

The precise spreading rate and extent of spreading of oil under ice is often difficult to determine due to the high variability in ice character and the ice-water interface. However, in general terms oil spreads relatively slowly either above or underneath ice cover compared to an uncovered water surface due to the colder temperatures and additional barriers to spread provided by ice formations (broken ice, pack ice and fast ice). Whilst the final "area" of an oil slick under ice may be smaller than that on a water surface, recovery techniques are constrained by additional cold weather safety constraints, difficulties in locating the oil and physical difficulties in gaining access to the oil.

Studies undertaken by the US Coastguard have shown that in the presence of ice the process of crude oil spreading on the water surface stops with oil films less than 5mm in thickness (Derzhavets 1981 in Hydrotex 2004).

During freeze-up, oil will drift to the ice edge from the windward side where it will accumulate together with slush and sludge ice (Buist *et al*. 1987 in Hydrotex 2004). A small amount of oil may get mixed with the ice and slush/sludge; this is particularly characteristic for heavy viscous oil (Wilson and Mackay 1987).

When the concentration of ice cover decreases during April and May, the spreading rate of oil will gradually increase until the ice condition reaches a level where spread is similar to open water conditions.

Spilt oil can become trapped under ice or spilled on an ice surface with the following potential results:

- *Oil under ice* – influenced by currents, and the degree of the lower ice edge roughness, and the possibility of ice capturing (accumulating) oil from water. The average depth of an oil layer under ice may vary from several centimetres for oil spills at the beginning of winter to several dozens of centimetres for under-ice oil spills in April;

- *On ice surface* – A spill on ice is comparable to an onshore spill with the spreading rate determined by oil density and viscosity and being greatly reduced when compared to spreading rates in open water. The eventual contamination area depends on roughness, slope of the ice surface and infiltration rates. Spills on the surface ice can be covered with a layer of snow that absorbs the spilt oil, preventing its further spreading. Oil spilt on snow will penetrate to reach ice, where it will spread along the interface between ice and snow. (S.L. Ross and D.F. Dickins 1988, Bech and Sveum 1991 – all in Hydrotex 2004).

The following factors also play an important role:

- *Evaporation*: Evaporation is one of the main factors affecting the physical condition of an oil patch. The presence of snow cover, cold conditions and ice will slow evaporation rates;

- *Dissolution:* The dissolution of water-soluble components will take place as oil contacts water; however, the process only removes approximately 1% of spilled oil (Buist and Dickins 2000 in Hydrotex 2004);

- *Dispersion*: Dispersion is the separation process of tiny oil drops scattering in water. Dispersion rates depend on the condition of the sea, oil viscosity, the inter-phase strength and the emulsifying property of oil;

- *Emulsification*: Emulsification of oil spilled in ice seas should be much lower due to lower or no sea roughness (S.L. Ross and D.F. Dickins 1987, Singaas *et al.* 1994 – both in Hydrotex 2004);

- *Encapsulation:* This involves the capture and retention of oil in the inter-crystalline space of ice. Where oil is spilled under solid ice, the growing ice fully encapsulates the oil layer within 18-72 hours, depending on the season (Dickins and Buist 1981 in Hydrotex 2004), which in turn stops atmospheric processes acting upon it. The effects of encapsulation are reduced in early May or in sub-arctic conditions post-April due to the insufficient growth of new ice before the thawing season;

- *Vertical migration:* If oil is trapped in ice during freeze up the process of vertical migration of oil begins as the ice cover becomes warmer. This is a function of ice temperature, thickness of the trapped oil layer and oil viscosity. In the period from the beginning of freezing till the middle of winter, when fast cooling takes place and the ice cover grows, oil has very few ways to penetrate it. At this time, vertical migration of oil is limited to several centimetres (Hydrotex 2004). The rate of oil migration sharply increases as soon as the day air temperature begins to exceed the freezing point on a regular basis;

- *Oil Biodegradation*: In the case of ice seas the breakdown of oil through bacteria and fungi occur much slower than in warm seas. For example, as the air temperature decreases by 10°C, the rate of oil spill disintegration is reduced by two to four (Zubakina and Simonov 1978; Ryabinin and Afanasyev 1977 – In Hydrotex 2004). In field studies conducted between 1988 and 1990, G.N. Moiseyevsky made an investigation of the processes of bacterial destruction of oil spills in the conditions of north-eastern shelf areas of Sakhalin Island. By looking at the potential for bacterial hydrocarbon oxidation, the results show that in these conditions, the potential of self-purification from oil pollution is extremely low.

SEIC has studied the options for dealing with spills, accidents and incidents relating to oil in or under ice. The strategic response to these scenarios starts with the presence of standby ice-breaking vessels, based at the north-east of Sakhalin. Skimmers (with recovery of oil in ice capability) will be used in broken ice conditions. A rope-mop system can recover oil in ice effectively. They can also be deployed into narrow spaces. The procedure takes in large volumes of ice and the mop slowly shreds. In-situ burning will be developed as an option, in particular times and conditions over which the oil will remain combustible. As the oil is light, with minimal residual oil after burning, SEIC will carry out an analysis before employing this option.

Dispersants are unlikely to be used but will be retained as an option, subject to further investigation. Furthermore, SEIC is investigating ways of aerial surveillance of oil under ice (e.g. infrared technology for tracking). SEIC is also looking at OSR trajectory modelling (real-time) perhaps with a plume modelling option. Compatibility with the existing SEIC GIS would also be developed. The combined product would allow the input of a given spill and help predict its direction and the potential receiving areas.

Heavy Fuel Oils (HFO) could be spilled from tankers using the export facilities in Aniva Bay. HFO will behave differently to the SEIC crude blends and OSR equipment will be purchased, and strategies developed, to deal with spills of this oil. HFO will be more viscous than the crude oils and will spread much more slowly. Evaporation rates in winter conditions will be minimal and the tendency for the oil to emulsify will be lower in ice conditions due to the reduced mixing energy in the sea. Mechanical recovery devices such as brush skimmer systems, toothed disc skimmers, grab systems and weir skimmer systems would be used rather than rope mops.

2.3.7 Spill Response Strategies

The primary differences between response in ice-free waters and during any of the ice periods are based on operational limitations imposed on marine equipment by the presence of ice. Strategies include mechanical recovery both from vessels and from the ice, assuming it is safe to do so, in-situ burning and tracking and monitoring.

The likely effectiveness will vary according to the specific ice conditions (e.g. ice roughness, ice thickness, floe size and coverage) and the configuration of the oil (e.g. between floes, trapped within solid ice, or mixed with snow on the surface).

(i) Freeze-up and Winter

Shoreline and coastal sensitivity to offshore spills in the winter is sharply reduced by the presence of a protective barrier of land-fast ice. For much of the winter there is no credible pathway whereby oil spilled offshore can directly impact the shoreline. Even a narrow fringe of fast ice (hundreds of metres), which often occurs along the north-east Sakhalin shore, is enough to prevent direct oiling of the beach. This same fast ice could, however, hold oil for significant periods if oil became part of the freeze-up process in the nearshore area.

The selection of the most appropriate strategy for spills in ice will consider both Health and Safety issues and the net environmental benefit of a chosen response strategy. In some cases, safety concerns will necessitate the "monitor and wait" approach rather than alternative approaches. The choice of this response strategy for safety reasons also occurs during the summer due to severe weather conditions or explosive risk and is not unique to ice operations.

Ice conditions do, however, necessitate a need for specialised logistics' support, such as:

- Icebreaking vessels with onboard equipment to support mechanical, dispersant or in-situ burning operations (high degree of manoeuvrability with azimuthing drive[2] and ability to maintain station in moving pack ice preferred);
- Specialised winter Personal Protective Equipment (PPE).

Ice conditions start in early December to early January (50-100% chance of any ice) on the north-east coast and mid January (50-100% chance of any ice) to early April in Aniva Bay. Possible strategies for dealing with offshore oil spills in ice include the following:

- *Containment and Recovery*: Booms and skimmers may be used in very light to light ice (1/10-6/10)[3] during the initial stages of freeze-up and at the end of the ice season (see below). Boom deployment becomes more difficult as the ice concentration increases and the risk of mechanical damage to booms also increases. This is, of course also related to ice thickness, with booming being possible if ice thickness is thin ("new ice"). Over-the-side skimmers may be used in most ice conditions although the type of skimmer is important. Conventional and well-proven solid-ice recovery techniques (e.g. trenches, slots, pits and skimmers) may also be effective in rivers, river mouths, lagoons and inshore where the ice is sufficiently stable for personnel and light equipment. (Dickins and Buist, 1999; Allen 1983, Alaska Clean Seas 1999 – in Dickins and Associates 2004). These conditions are not likely to be stable in north-east Sakhalin or Aniva Bay's offshore areas;
- *Use of Dispersants*: Removal of oil from the water surface through the application of dispersants can be accomplished with a variety of aerial or ship-borne systems. High ice concentrations may inhibit the use of fixed wing aircraft due to safe altitude limitations and the low ability of such aircraft to target small areas for dispersants application. Helicopter based systems and vessel based systems do not have these constraints. Helicopter application may be limited by fog and vessels may be inhibited by high ice cover and thickness. Tests have been conducted (Owens and Belore, 2004; Belore, 2003; Brown and Goodman, 1996 – all in Dickins and Associates 2004) with dispersants in broken ice and brash ice that indicate that interactions between ice floes can enhance the dispersion process in high ice concentrations,

[2] Where the propeller can be rotated 360 degrees around the vertical axis, providing omni-directional thrust

[3] Using the nomenclature for sea ice established by the World Meteorological Organization (WMO, 1970 – in Dickens and Associates 2004) 1-6/10 is defined as <u>open drift ice</u> with many leads and polynyas where the floes are generally not in contact with one another; 7-8/10 is defined as <u>close pack ice</u> where the floes are mostly in contact. The condition of 6/10 to 7/10 represents a transition period between these two states of pack ice.

despite the fact that mixing energy (wind, waves and background swell) are dampened by the ice pack (January – March in north-east Sakhalin). In any case, dispersants will only be used with the approval of RF authorities as in the case of open water applications;

- *In-situ Burning*: Controlled burns of oil, thickened and contained in broken ice or on ice may be feasible. Such burns may also be conducted effectively with oil that has been exposed following the deliberate break-up of ice at sea, or following the exposure of oil from within or below land-fast ice. SEIC oils are light and likely to be initially combustible, but will become less so after weathering. Tests are to be undertaken to determine the precise "windows of opportunity" for in-situ burning. Volume losses that may result from weathering also need to be considered. If losses are high, burning may not be required. *In-situ* burning is subject to Government approval and net environmental benefit assessment (NEBA).

(ii) Ice Break-up Response Options

During ice break-up (April to early June), the openings in the ice cover or areas between individual floes will consist of either open water or, at times, a mix of melting brash ice chunks (wreckage of decaying thicker floes) and open water. Under these conditions there will be many more opportunities to employ a derivation of familiar open-water strategies than in earlier months and this will steadily improve as ice dissipates. The major constraints on conventional recovery in April and May are associated with manoeuvring support vessels through the remaining pack ice and keeping drift ice out of the booms as this can result in significantly reduced efficiency of mechanical techniques.

The lessening ice severity combined with increasing air temperatures and daylight allows OSR teams greater flexibility, including the consideration of dispersants and additional booming operations. Conversely, the use of in-situ burning is more difficult as the contaminant and subsequently thickness is reduced.

Coastal sensitivity becomes an important issue in relation to response options again during break-up around May and into June as the last remnants of shore ice disintegrate and expose the coast to potential oiling from offshore spills and releases of oil that had become trapped in ice structures during the winter months.

Starting in late April to early June (50-100% absence of any ice) on the northeast coast or mid to late April (50-100% absence of any ice) in Aniva Bay. The reducing ice cover combined with increasing air/water temperatures and daylight allows responders greater flexibility to use a wider range of response options. At the same time, the lower ice concentrations will result in fewer opportunities to use natural ice containment for burning or recovery. Issues associated with implementing different response strategies during break-up are summarised below:

- *Mechanical recovery:* The moderate temperatures and lack of frazil and grease/slush ice in the water will allow more effective skimmer operations approaching open water effectiveness as the ice decays. Normal skimmers could be used for slicks concentrated with booms, and suspended rope mop skimmers could be used from a barge or recovery vessel to recover pockets of oil among rotting ice floes;

- *Chemical dispersion:* In the break-up period, many of the factors reducing dispersant effectiveness are diminished. For example, concentrations are reduced and mixing energy (wind and waves) increase. Potential issues, which need to be accounted for when considering the use of dispersants during break-up, include:

  - Mixing energy may still be locally reduced (aerial application alone may not be sufficient);

  - For heavier oil, (lubricating oils, fuel oils) cold-water temperatures will continue to be a factor in influencing oil properties (pour point and viscosity) that may limit dispersant efficiency;

  - When waves and natural (or man-induced) agitation of the surface occurs with broken ice, the ice may actually enhance the mixing of treated oil, resulting in a more efficient dispersion of that oil.

- *In-situ burning*: The application of in-situ burning during the break-up period may include:

  - In-situ burning of oil pools naturally contained between ice floes and on the ices surface may be possible but will depend upon the volume of oil spilled and the nature of its release and will only be possible were containment and thickness are sufficient;

  - Strategies could involve a mix of aerial ignition techniques on naturally contained pools in close pack ice and the deployment of fire boom during periods of open drift ice;

  - Ongoing surveillance and monitoring can identify and focus in-situ burning operations.

  An assessment by SEIC would need to be made in advance of employing this option.

In all spill events, SEIC will assess the situation in detail and select the best option appropriate to the location, meteorological conditions and context of the spill. A table summary of these options and ongoing assessment work on oil spill response in ice is provided in Table 2.7.

Table 2.7 Summary of Potential Marine Response Strategies

Response Method	General Comment	Freeze-up and Winter Ice Conditions	Break-up Ice Conditions	Development/Research Needs
Surveillance and Monitoring	Remote sensing: Numerous methods have been reviewed particularly focussed on the location and tracking of oil beneath ice, which is difficult.	Visual aerial observation is effective when oil is on ice or amongst broken ice.	Visual aerial observation is effective when oil is on ice or amongst broken ice.	Formal review and evaluation of remote sensing methods.
				Investigate adaptation of existing SEIC aerial Global Positioning System (GPS)-Digital video system (e.g. infrared or ultraviolet enhancement).
				Preparation of handbook for aerial surveillance in ice conditions and training materials to be developed.
Containment	Not overly limited by ice cover of less than 30%, depending on the size of ice floes. Not required above 60-70%. Ice cover of between 30 and 60% is likely to restrict effectiveness and pose a threat to boom integrity, however, this will depend on ice type.	Could be used during initial stages of freeze-up in low ice cover.	Could be used in later stages of break-up in low ice cover.	Develop a matrix of ice cover and ice type/s to provide better guidelines for potential boom use.
				Develop guidelines and matrix relating oil character to boom length, towing speed and or current, and boom type so that responders can better avoid stress on booms (as part of OSRP development).
				Evaluation of robust booming systems.

Response Method	General Comment	Freeze-up and Winter Ice Conditions	Break-up Ice Conditions	Development/Research Needs
Recovery	Skimmers can operate in ice conditions of up to 70% and some systems may be able to operate above this coverage. Problems may still occur and additional skimmers and spare parts may be required to offset possible mechanical failure in the field.	Some skimmers' ability to deal with oil/slush mixtures are limited. Over-side skimmer system can be used to collect concentrated spots of oil between ice. When (at river/ lagoon) the nearshore ice becomes stable, trenches and pits can be cut to collect/trap oil under ice for recovery.	No formation of new ice and reduced amounts of slush opens up for successful use of booms/skimmers (up to 3/10 of ice).	Evaluation required of available oil in ice skimmers.
In-Situ Burning	In-situ burning is a viable response tool especially for light oils such as Vityaz crude. Oil still needs to be contained either by ice or by booms. In the latter case fireproof booms are needed and the deployment of these is as constrained as the deployment of conventional booms (see above). Herders, gelling and wicking agents may also aid burning.	Fireproof booms could be used with success in low ice conditions but newly frozen ice will compete with oil for surface area.	Priority will be given to burning oil in-situ when it is trapped in relatively high ice cover or forming melt pools before it is released to areas with large open areas were fireproof booms can be used.	
		Difficult since natural containment by ice requires thicker/solid ice. Wind/current could concentrate/contain oil towards an ice edge giving	Efficiency of burning could be very high when oil is available and concentrated between ice floes or in concentrated melt pools.	Investigate use of herders and wicking agents to facilitate burning.
				Field and laboratory programme to investigate burning efficiencies and amount and character of residues.

Response Method	General Comment	Freeze-up and Winter Ice Conditions	Break-up Ice Conditions	Development/Research Needs
		sufficient thickness for in-situ burning. When the nearshore ice becomes stable, oil in open areas can be burned with higher efficiency. Aerial release of igniters by Heli-Torch is flexible and gives large coverage combined with good overview.	Use of aerial igniters gives large coverage and good overview. However, successful ignition is dependant on oil weathering state (evaporation/ emulsification).	Undertake net environmental benefit analysis (NEBA) scenario assessments to better define conditions that favour in-situ burning. Recovery systems for residues may need to be assessed.
Dispersants	Viable response option for crude oil (not for heavy fuel oil) but effectiveness depends on mixing energy applied to the sea surface. This may require some modification to standard practices for dispersant spraying from vessels.	Low application success on oil trapped in newly frozen ice. Reduced wave energy due to wave dampening from ice. Very low efficiency with existing equipment (helicopter/boat or manual spraying).	Dispersants can be used with success in areas with open water (less than 3/10 of ice). However, dispersant effectiveness is dependant on oil weathering state (evaporation/ emulsification).	Requires net environmental benefit analysis (NEBA) in order to better define guidelines for their use.

2.4 CURRENT WORK PROGRAMME AND FUTURE STUDIES

An extensive OSR work programme is currently underway to develop well-organised and resourced OSRPs and response capability for the new Phase 2 facilities. The work programme also encompasses over 50 further background studies, preparation of specific plans or guidelines (e.g. shoreline plans, health and safety guidelines), acquisition of equipment and the further development of cooperative arrangements with Government agencies and other companies.

Many of these programmes are described in this section. Details of the key OSR Projects are provided in Table 2.11 (see Section 2.4.5). Information about the programme for the key study items is included in the table.

2.4.1 Oil Characterisation Studies

A laboratory characterisation of the weathering behaviour of Vityaz crude oil has been undertaken. The study indicated that during calm conditions (*e.g.* winds of $2ms^{-1}$ or lower), crude oil slicks will maintain a steady rate of evaporation and natural dispersion and that a steady reduction in the volume of surface oil will occur over time. The report concluded that this rate of decrease in surface oil will be slightly faster under summer conditions than in winter. The latter conclusion was based solely on temperature considerations and not wind or sea states although wind speeds can significantly influence evaporation rates.

In rougher conditions (e.g. wind speeds of 10-20 ms^{-1}) an initial increase in slick volume was predicted as a result of emulsification followed by a steady decrease through evaporation and natural dispersion factors. Vityaz crude was predicted to form unstable emulsions but no indication of the influence of temperature or mixing energy influences on this was provided. Even in autumn (i.e. in relatively strong wind conditions and potentially rough sea conditions), the surface slick from a 1,000-tonnes spill was predicted to persist for less than three days.

An additional assessment of Vityaz crude oil is being commissioned (see item vii in Table 2.11 on future studies, below). This includes additional studies of emulsification rates at various temperatures and various (realistic) mixing energies. Once representative samples of the Phase 2 oil blend have been obtained, a similar range of laboratory analyses will be undertaken on these oils and oil-condensate blends.

The dispersal behaviour of Vityaz crude oil, Marine Diesel Oil and Heavy Fuel Oil at different sea states over time is summarised in Table 2.8. Table 2.9 provides a description of the general behaviour and properties of each of these hydrocarbons at sea.

2.4.2 Oil Behaviour Studies

Oil characterisations undertaken for routine operations do not entirely reflect OSR needs and consequently, additional studies are required, for example:

Project 35.1– Oil at Sea (Non-ice): Including analysis of oil properties and behaviours in spring, summer and autumn conditions; weathering and persistence; spreading coefficient; and dispersants' effectiveness at realistic energies (wave/wind conditions) and at various temperatures;

Project 31.2 – Oil in Ice: As above, but requiring identification of sea-ice interface conditions (particularly energy). Dispersant aspects link to work being undertaken on effectiveness of dispersants at low temperatures.

The effects that spilt oil can have on marine and coastal life depends on a number of factors including weather and sea conditions, oil characteristics and behaviour and the distribution of biological resources. These factors also determine the oil spill response strategies that are required during an oil spill emergency (see preceding Section 2.3.7).

Earlier laboratory studies of Vityaz crude oil behaviour will be extended to encompass behaviour under a wide range of sea states and seasonal temperatures. These will focus on oil behaviour and weathering (emulsification, evaporation and dissolution) with a view to better predicting oil persistence at sea and hence the potential characteristics, such as spreading rate and viscosity. Weathering rates will be determined over a range of realistic temperatures and sea states.

When details are obtained regarding the ratio of the blending of condensate into the crude and consequent changes in oil character, the need for further studies will be assessed.

Oil character and behaviour data will eventually be input into oil spill trajectory models. This process will be ongoing as the character of oil within oil fields varies as production progresses.

Oil behaviour in freshwater will also be studied, in particular dissolution and evaporation rates. Studies will again be undertaken at a range of temperatures and mixing energies to simulate seasonal effects, including oil under ice conditions.

Table 2.8 Relative Fates of Various Hydrocarbons under Varying Wind Speeds Over Time (assuming a spill of 100m^3, at sea temperatures of 15°C)

Time	Fate	Wind Speeds		
		5 Knots	**15 Knots**	**25 Knots**
Vityaz Crude Oil *				**Units in m^3**
12-hours	Evaporated	50	52	46
	Physically dispersed	0	48	54
	Remaining on sea surface	50	0	0
24-hours	Evaporated	55	-	-
	Physically dispersed	0	-	-
	Remaining on sea surface	45	-	
48-hours	Evaporated	60	-	-
	Physically dispersed	0	-	-
	Remaining on sea surface	40	-	-
Marine Diesel				
12-hours	Evaporated	4	9	<5
	Physically dispersed	0	59	85
	Remaining on sea surface	96	32	<10
24-hours	Evaporated	18	10	<3
	Physically dispersed	0	83	97
	Remaining on sea surface	82	7	0
48-hours	Evaporated	36	11	3
	Physically dispersed	0	89	97
	Remaining on sea surface	64	0	0
HFO				
24-hours	Evaporated	5	6	6
	Physically dispersed	0	6	28
	Remaining on sea surface	95	88	66
48-hours	Evaporated	6	7	7
	Physically dispersed	0	12	45
	Remaining on sea surface	94	81	48
96-hours	Evaporated	7	8	7
	Physically dispersed	0	20	63
	Remaining on sea surface	93	72	30

*NB. * Emulsification at realistic wind and wave energies will be addressed in the future Oil Characterisation Study.*

A summary of future studies, of which there are over fifty in total, is provided in Table 2.11.

Table 2.9 Properties and Behaviour of Oils at Sea

Oil Type	Vityaz Crude	Marine Diesel	Heavy Fuel Oil
Specific Gravity [4]	0.86	0.84 – 0.87	High. Usually > 0.9
Viscosity (cSt, centistokes)	4 @ 15°C	4.2 @ 40°C	High (Variable)
Persistence at Sea	Very Short	Short	High
General Comments	• Vityaz crude has a low pour point and low viscosity and is liquid at all sea temperatures. • Vityaz crude does form emulsions and the maximum water content is about 62% water by weight. • Vityaz crude oil slicks tend to disperse readily into the water column and have a relatively high potential for vertical mixing.	• Diesels have a low pour point and low viscosity and are liquid at sea temperatures. • Do not tend to form emulsions. • Relatively rapidly spreading oils. • Diesel slicks tend to disperse readily into the water column and have a relatively high potential for vertical mixing. • Diesels have a relatively low soluble fraction and this reduces the potential levels of dissolved hydrocarbons in seawater. • Diesels are usually non-sticky oils and removal from consolidated surfaces is possible using washing methods. • They may lose 45% or more of their volume through evaporation within 24-hours at sea. • Due to high spreading and relatively high evaporation rates slicks of diesel rapidly break up at sea. • The constituents of these oils are light to intermediate in molecular weight and can be readily degraded by aerobic microbial oxidation.	• HFOs are solid or semi-solid at temperate sea temperatures. • Most HFOs are sticky and tend to attach firmly to consolidated surfaces such as rock. • They are relatively slow spreading oils. • HFOs are persistent with a low level of volatiles. They do not lose much volume through evaporation. • Due to low spreading and low evaporation rates they are persistent oils at sea. • Heavy fuel oils tend to be less toxic than crude oils and some other refined products but they may form thick coatings and have a significant effect due to physical covering of fauna and flora. • Due to the high specific gravity and potential for the formation of water-in-oil emulsions, HFO may be mixed into the water column by wave action. • HFO may take up sediments and may sink although this is rare.

[4] Specific gravity is the density of a substance divided by the density of water. Since water has a density of 1 gram/cm^3, and since all of the units cancel, specific gravity is the same number as density but without any units

2.4.3 Studies of the Characteristics of Offshore Ice in Sakhalin Island

The key factors that constrain or influence spill response in icy conditions include:

- Ice season duration;
- Age of the ice (i.e. thickness);
- Floe size (horizontal character);
- Roughness (e.g. hummocking);
- Concentration or sea surface coverage (measured in tenths);
- Ice movement (drift);
- Safety constraints.

SEIC is undertaking a range of studies with the aim of providing the best possible oil spill response capability. These studies are outlined below.

SEIC has been studying ice conditions offshore Sakhalin for a number of years. Examples of the ice season in the area of SEIC operations are shown in Figures 2.23, 2.24 and 2.25 and are summarised in Table 2.10. Ice thickness can vary from 5cm up to 2000cm (without roughness) on the northeast shelf of Sakhalin Island and from 5cm up to 80cm flat ice (without roughness) in Aniva Bay. Generally ice drifts along the shelf from the north to the south and southeast at a rate of six to eight kilometres per day (0-200cm/sec). The predominant ice movements in Aniva Bay are towards the south and southwest, at speeds of between 1 and 15cm/sec. Direction may vary with diurnal and semi-diurnal tides. Giant floes on the northeast shelf can be differentiated from large floes in Aniva Bay (1m pancake ice up to 1-2km in length). Floe size, as illustrated in Figure 2.26, can vary from pancake ice to giant floes (up to 30km).

SEIC has an Ice Management Team (IMT) that has a wide-range of experience working in ice conditions and for providing operations support.

The IMT group consists of staff who are located and work at the Molikpaq during the start and finish of the ice season. These people are responsible for collecting data and performing an analysis and estimation of ice conditions from a wide range of collected information (e.g. meteorological and satellite data, direct observations, including regular ice reconnaissance from helicopter or fixed wings plane, and ice forecasts). These experts typically have at least 15-20 years' extensive experience of working in ice conditions and have particular expertise in observing ice conditions, satellite data performance and interpretation, data collection, analysis and interpretation. The group consists of Russians and Canadians, working on a round-the-clock (i.e. 24-hrs) shift pattern.

Table 2.10 Summary of Ice Conditions in North-east Sakhalin and Aniva Bay

Ice Character	Northeast Sakhalin	Aniva Bay
Ice season	125 to 195 days	42 to 119 days.
Ice thickness It should be noted, that rafting of ice may significantly increase its thickness (more accurately height).	Between 5-200 cm thick with a 100-year return of 250-300cm. Ice drifting from other areas may have greater thickness. Usually highly variable.	Typical seen ice thicknesses were less than 0.2 m. However, the 100 year return period value is considered to be 0.85 m
Ice concentration Ice concentration measured in tenths, or coverage in percentage) describes the amount of the water surface covered by ice as a fraction of the observed area. 10/10 will mean that 100 % of observed area is covered by ice.	At the end of freeze-up period (generally 15 - 30 days), maximum ice concentrations range from 9/10 to 10/10. The concentration of any ice in the area may vary from 0 to 10/10. When all ice types (thin to thick) are included, typical concentrations are generally in 9/10 or more. However, the level of coverage does not describe ice conditions and level of operability completely.	In the Aniva Bay average drifting ice concentration is estimated to be 6 – 9/10 but sometimes may exceed this.
Flaw lead Flaw leads (or polynya) are bands of open water or very thin ice running parallel to the coast between the narrow landfast ice zone and the heavier pack ice areas towards the east. These are transient but can persist for periods of days to several weeks during winter.	Thin flaw leads are quite common at Piltun and Lunskoye, and over the pipeline routes, particularly during the early January to mid March. When the flaw lead occurs, it can result in open water and/or thin drifting ice conditions (less then 30 cm thick) at the platform sites and over the subsea pipeline to the coast (or the land-fast ice edge if exists).	Flaw leads also occur. Frequent winds from the north tend to continually push any ice that is forming nearshore into the offshore areas, toward the mouth of Aniva Bay. In some years, only open water or thin ice types are seen in the northeast part of the bay
Ice floes size	Floes may be of different size, particularly mid ice season. There are reports of ice floes more than 30-35 km across. Typically, floe sizes are smaller during the freeze-up, early winter and break-up periods, with most floes having dimensions of tens of metres to several hundred metres. In mid-winter, ice floes are characteristically larger, in the range of hundreds of metres to a kilometre or more in extent.	Floe sizes are normally small, in the order of tens of metres to several hundred metres
Ice drift speed	Ice drift speed on the northeast of Sakhalin Island is quite variable and depends on winds and tidal currents. It may achieve 170 cm/sec (more than 2 knots). However, on average this speed is about 20-30 cm/sec.	Ice drift in the top part of the Aniva Bay depends on the local winds blowing mainly from north to south. The maximum ice drift velocity is estimated to reach 100 cm/sec.
Landfast Ice parameters	A narrow strip of landfast ice is typically found along the shallow waters adjacent the coast. This strip of landfast ice is very unstable and can appear and disappear a few times per season. Maximum estimated level ice thicknesses are in range of 1.6 to 1.7 m. Based on field measurements, rafted (or layered) ice areas in the fast ice have been reported to have an average thickness of 1.9 to 2.2 m, with maximum values of 3.5 m having been recorded in some drill holes.	Fast ice in the area of Prigorodnoye does not form every year, it is extremely unstable and gets broken by strong winds. Fast ice formation is most probable in severe winters. And persistent landfast ice is uncommon. The width of the landfast ice, when it occurs, is quite narrow; typically no more than 0.1 km to 0.2 km from the shoreline.

Team members also have good experience from other oil and gas companies based in the Canadian Arctic in Russian Hydromet services (i.e. AARI, FERHRI, SakhHydromet) and other organisations where the working conditions require an advanced knowledge of ice conditions research and observations. Other persons in the IMT are located on MSV's or ice class vessels. This group is responsible for escorting vessels in ice, making direct observations, etc. These team members, who have experience in field studies and navigation in ice conditions are mostly professional mariners (e.g. Ice Captains or professional observers) and are recognised as professionals worldwide. Many of the staff have published papers and books on the subject of ice conditions.

These two groups are led by the Ice Management Director, who has extensive experience in icy conditions in different areas of the Arctic, Caspian Sea and Russian Far East.

In terms of managing work in ice conditions, the IMT:

- Makes direct ice conditions measurements from Molikpaq and MSVs;
- Conducts aerial surveillance;
- Conducts ice reconnaissance from ice-breakers;
- Collects and process satellite information (see examples in Figure 2.27);
- Performs ice conditions' analysis in comparison with historical data to predict potential development of ice structures;
- Assist Operations in decision-making processes.
- Adapts operations to ice and weather conditions;
- Collects ice and weather information for analysis and forecasts;
- Develops new tools and techniques for operational support;
- Undertakes operational risk assessment and ice alert zones mapping.

2.4.4 Development of Safety Procedures for Working in Ice

The safety of workers working in ice conditions is a priority and safety guidelines are being developed as part of a Health & Safety Operational Handbook, which will include ice issues.

2.4.5 Further Development of OSR Methods

Response to oil spills in ice conditions requires different strategies in different ice conditions in order to optimise recovery or treatment. SEIC is investigating ways of improving its oil spill response in ice capabilities through a four-phased study programme, which encompasses:

i. A review of oil behaviour in ice and spill response strategies with particular emphasis on Sakhalin's ice conditions. This literature review is now complete (Hydrotex 2004, Dickens and Associates 2004) see subsections below;

ii. An assessment of oil spill response equipment designed for ice conditions. This focuses mostly on detecting the oil, and applicable and available recovery devices in different ice conditions and the separation of oil and ice at sea. Specific equipment is being assessed by SEIC and a report will be prepared based on an on-site inspection of this and industry testing (e.g. by a relevant organisation). SEIC's commitment is for two ice class vessels. These will be on standby in the north of Sakhalin. At least two vessels are being fitted for Oil Spill Response (OSR) capabilities. SEIC is committed to oil spill recovery and purchase of equipment necessary to achieve the aims in the OSR strategy. SEIC is currently assessing the suitability and availability of this equipment;

iii. Investigation of other response methods for oil in ice. To date this has involved SEIC participation in joint oil industry studies of the use of chemical herders (chemical herders are applied around the slick to push it together and thickening the slick for the initiation of treatment, for example, burning) in ice conditions to improve recovery, and a study of the effects of temperature on dispersant efficiency; The use of chemical agents requires RF approval and the outcome of both studies will be reviewed in respect to applicability to Sakhalin ice conditions and "net environmental benefit analysis (NEBA)";

iv. Laboratory investigation of the behaviour of SEIC oils and condensates in ice conditions.

This programme will require the establishment of close communication with both the Russian federation and international scientific institutes as well as spill response organisations.

The studies will ultimately increase knowledge about oil behaviours in ice conditions and allow SEIC to select correct equipment/tools; develop appropriate techniques in OSR; and further refine oil spill modelling (i.e. trajectory, oil distribution and persistence).

Associated studies include:

- A review of in-situ burning in ice conditions. This included a review of recent research in burning in slush and brash ice conditions, consideration of dispersants in broken ice, examples of previous accidental spills in ice, and a number of milestone experimental spills to illustrate the key points surrounding the use of burning in a variety of ice environments. Laboratory studies will also be undertaken to determine the physical and chemical character and quantity of residual oil post-burning under realistic conditions;

- Review and acquisition of aerial surveillance and tracking technology.

Table 2.11 Summary of Main Study Projects for OSRP Development and Related Activities

Item No.	Project Title (Estimated end date)	Project Outline
i.	Dispersant Strategy and Assessment of Net Environmental Benefit (February 2006)	(Stage 1: Review of effects of dispersants, dispersed oil and oil on the marine environment – completed); (Stage 2: Joint industry/Government workshop held. RF experts were invited and made presentations). Stage 3: • A range of scenarios will be assessed to determine the following: - Likely success of dispersant operations considering: time for deployment; size of spill versus volume of dispersants; capacity to apply dispersants; - Environmental effects and costs of: a fully successful dispersion; partial dispersion; non-use of dispersants (i.e. effects of oil impact alone); - Scenarios or locations when the benefits or disadvantages of dispersant use is clearly not favoured or clearly favoured will be developed. • Refined dispersant use guidelines will then be developed in consultation with RF authorities and experts; • This programme will be undertaken for offshore locations, commencing with Piltun-Astkh.
ii.	Oil Spill Response Training (Ongoing)	• Numerous training programmes are being, and will be, undertaken for SEIC. Most of these will also involve personnel from Government agencies and other oil companies on Sakhalin Island. Anticipated training courses include: - Familiarisation training (OSR Introductory Course); - Shoreline response; - Inland spills; - Wildlife response; - Equipment operators course and exercises; - Field exercises and drills; - Senior management; - ICS (Emergency Control/Command Systems).
iii.	Preparation of Oil Spill Response Handbooks and Manuals (Ongoing)	• A number of Operational Handbooks will be prepared including: - Shoreline response (for Sakhalin and also for Hokkaido and available in Japanese);

Item No.	Project Title (Estimated end date)	Project Outline
		- OSR in ice; - Sakhalin Island Environmental Handbook; - OSR Health and Safety; - Dispersants; - Aerial surveillance and assessment. • Computer Modelling for OSR (GNOME/OSTM and ADIOS); • Development of an English-Russian OSR Technical Glossary. This is designed primarily as an aid to OSR translation but will eventually be a more technical reference document.
iv.	Transboundary Issues (November 2005)	• Transboundary risks have been identified through oil spill modelling studies. Additional deterministic modelling may be undertaken to determine potential impacts, including “worst-case” impacts to Hokkaido and the resources required to respond to such impacts. This will consider both oil trajectory and also oil persistence; • Additional transboundary oil spill response issues will be addressed as part of the process of developing OSRPs, particularly for Aniva Bay facilities (see below); • SEIC is currently participating in, and supports, bilateral OSR discussions between RF and Japanese agencies. Most recently, SEIC took part in the planning for the joint JCG-RF Ministry of Transport Exercise (Aniva Bay May 2006). SEIC has an OSR MOU with the Maritime Disaster Prevention Centre (MDPC). Section 2.2 contains more information on transboundary issues.
v.	OSR Equipment and Response Capability Review (November 2005)	• The equipment held for Phase 1 and anticipated for Phase 2 facilities is currently being reassessed. This assessment covers: – Location, types and quantities of equipment; – Logistics (transport, storage); – Specifications of equipment (related to oil character and environmental conditions); • The review will be regularly updated in consideration of the findings of other studies; • The review will encompass SEIC, ENL, Government and regional equipment and OSR capabilities. Section 2.3.3 deals with oil response planning issues in more detail.

Item No.	Project Title (Estimated end date)	Project Outline
vi.	Oil Spill Response in Ice Conditions (May 2006)	This series of studies is currently being undertaken in part in association with Exxon Mobil (to date, this has included the use of herders, and dispersants, in ice). It is anticipated that the studies will encompass oil behaviour and persistence, trajectory studies, and assessment and development of technologies for tracking, recovering, or treatment of oil in ice and spill response equipment. The results of some of these studies will be published, as appropriate. See also Sections 2.3.6 sand 2.3.7 for more detailed descriptions on this item.
vii.	Oil Behaviour Studies (February 2006)	• The behaviour of Vityaz crude in summer, autumn/spring and winter conditions will be further investigated through laboratory testing. Studies will emphasise oil persistence at sea and characteristics such as spreading rate and viscosity; • Lunskoye condensate; • When details are obtained regarding the blending of condensate into the crude and consequent changes in oil character, the need for further studies will be assessed; • Oil behaviour findings will be input into oil spill trajectory models; • Oil behaviour in freshwater will also be studied, in particular dissolution and evaporation rates. Refer also to subsection in Section 2.4.2 for a description of this study.
viii.	Trajectory Studies (December 2005)	• Numerous trajectory modelling studies have been undertaken and future exercises are intended. Those undertaken to date have encompassed spills along tanker routes (involving crude oil, HFO), spills at Aniva Bay facilities (crude, HFO and diesel), supply vessel spills (diesel) and Piltun (crude, diesel). Additional modelling of oil, condensate and gas spills at Lunskoye will also be undertaken; • Modelling will include a range of volumes and weather conditions (including ice conditions). See also Section 2.3.1 and the Figures in Appendix 1 for more details on trajectory studies.
ix.	Shoreline and Land Surveys and Sensitivity Mapping (March 2006)	• Coastal sensitivity mapping of north-east Sakhalin has already been undertaken as part of the Phase 1 development. These extend south from the Piltun-Astokh field and cover the shorelines adjacent to the Lunskoye field; • Additional field surveys have been undertaken in 2004 and continue in 2005 to obtain additional information on the pipeline routes, adjacent wetlands and outflow rivers, and also the coastlines along Aniva Bay; • For coastlines of Hokkaido identified as being at risk from spills from SEIC activities, detailed sensitivity maps will be acquired, when available, and reviewed with respect to suitability for shoreline response. Section 2.3.2 presents more detail on mapping issues.
x.	Preparation of Oil Spill Response Plans	• OSRPs will be prepared for each facility; • The following plans will be prepared:

Item No.	Project Title (Estimated end date)	Project Outline
	(March 2006)	- Piltun-Astokh OSRP; - Lunskoye OSRP; - Aniva Bay (Tanker Loading Utility and LNG Terminal) Offshore OSRPs; - Oil Export Terminal-LNG Facility Onshore OSRP; - OPF Onshore OSRP; - Onshore Pipeline OSRP including Booster Station 2 Onshore OSRP. • OSRPs will be of similar format and integrated within the SEIC Corporate OSR Plan and Emergency Response Plans. See also Sections 2.3.3 for information on OSRPs.
xi.	OSR Equipment Purchases (January 2006)	• Review of equipment needs (ongoing) for marine, onshore (land), rivers, lakes, lagoons and other wetlands; • Special equipment or modifications for oil recovery in ice conditions; • Includes rapid-deployment equipment (based on shore-based vehicles, road trailers and helicopter – transferable packs).
xii.	Wildlife Rescue and Treatment Plan	• SEIC has commissioned a report from the International Fund for Animal Welfare (IFAW), which will set out the background on existing capabilities for wildlife response on the Island. The study will investigate options for what is required to develop and enhance wildlife response capability for future operations. SEIC will invest in wildlife response equipment and this is likely to include: rescue trailers and clean-up/rescue equipment kits; temporary heated enclosures for short-term holding; and equipment for hazing (i.e. nets and mesh for delineating and protecting wildlife areas). Wildlife response guidelines will be developed for the Phase 2 OSR plans.

2.4.6 Development of OSR Resources, Organisation and Arrangements

In addition to the above, SEIC is committed to a number of actions aimed at developing and maintaining a high level of oil spill response capability. These initiatives are outlined below.

(i) Establishment of Equipment Stockpiles

OSR equipment for construction and operation needs to be fit for purpose. This means that it must be robust, suitable for use in cold temperatures and rapidly changing temperatures (e.g. steam may be used to free-up frozen gear) and be compatible with SEIC existing equipment and that of other oil companies in the region. SEIC is responsible for determining the type and amount of equipment to be acquired in order to ensure cross-asset and operations compatibility. A list of indicative SEIC OSR equipment is provided in Table 2.12 below. Following purchase, OSR equipment is to be stored at a number of locations:

- Along the onshore pipeline route;
- Port facilities;
- Offshore on support vessels.

Planned emergency response depots are listed below and shown in Figure 2.16 (in Appendix 1). The actual distribution of equipment will be determined on the basis of assessment of risk and environmental sensitivities relative to the operations at any time. This may be varied seasonally to cover changes in environmental risk and as a result Mobile OSR packs are being sourced for this purpose (see below).

Emergency Response Depots (ERDs) – There are main depots containing OSR and ER equipment, support equipment (e.g. PPE, communications etc) and transport (e.g. small boats, dedicated vehicles). They are manned, although staff may have other functions other than OSR/Emergency Response (ER). ERDs are planned to be located at:

- Nogliki (Marine and Onshore);
- OPF (Onshore);
- Yasnoye·(Onshore);
- BS2 (Onshore);
- Sovetskoye (Onshore);
- OET/LNG (Marine and Onshore);
- Kholmsk (minor Marine).

Rapid Deployment Packs (RDPs) – These consist of light equipment contained in a helicopter sling, Ural (possibly with trailer), road trailer or other container. This equipment is designed to be located in areas that are difficult to access from an ERD, either because of distance, road condition or other factor or at areas of seasonal sensitivity. They may also provide support to construction, maintenance or other temporary activities. They may also be located at ERDs.

Vessels – Emergency standby vessels will be equipped for oil spill response and an indicative list of equipment is provided in Table 2.12. In the event of an emergency, other SEIC operational vessels may be directed from any facility to assist cleanup actions in another.

Table 2.12 Indicative Equipment List

Nogliki – Summary of Existing Stockpile	**Quantity**
Water Boom - Fast Water and shallow water boom varying size	3,840
Sorbent Boom - Varying types of sorbent boom including, pom-Pom, turf and synthetic	5,010m
Skimmer - Varying types for range of oil viscosities and conditions	11
Sorbent -Rolls, pads and turf sorbents	260 units
Anchor system - Several varieties	174
Pump - Positive Displacement type pump and gear type pump	6
Generator - 5 kW, 120v / 220v	4
Incinerator	2
Storage - Collapsible portable storage tanks	40
HDPE liners - Varying sizes	6,600 m^2
Vessels - airboat, inflatable keels varying sizes	9
Dispersant	12.5 m^3
Helitorch	1
Typical Rapid Deployment Packs	**Approximate Quantity**
River booms and deployment system	400m
Sorbent boom	360m
Sorbent pads	200
Anchor sets, stakes and ropes	5
PPE kits (10 per pack, TBA)	1
Pump- spate	1
Skimmer	1
Collapsible storage container	1
Rake/Shovel packages	10
Flushing system	1
Buckets	10
Chainsaw	1
Container/helicopter sling	1

Nogliki – Summary of Existing Stockpile	Quantity
Indicative Emergency Response Depot	
River boom and deployment system	2,000m
Shore-seal boom	400m
Sorbent (snare, pom-pom, sweep)	300m
Sorbent pads	200
Anchor systems - danforth 1 anchor/chain/buoys/rope	10
Skimmers various types (Disc, Drum, rope, vacuum)	4
20 cubic m storage tanks (liquid) (ISO Container)	2
Power generation/lighting plants 10m trailer diesel	2
Portable Oil storage tanks	5
Decontamination packs	1
Water pumps	
Portable incinerator	1
Communications/radio gear	10 Sets
Rake and shovel packages	50
Flushing systems	1
Personal Protective Equipment -sets (10 persons)	10
Pressure washers/steamer	5
Chain saw	5
Shallow draft work boats (inflatable)	3
Indicative Shore Base	
Ocean boom	300m
Fence boom	200m
Shore sealing boom	400m
Shoreline protection boom	200m
River booms and deployment system	140m
Sorbent boom (Snare, Sweep, etc.)	300m
Sorbent pads/ mats (200 pack)	200
Anchor systems	10
Skimmer (disc/drum/brush weir vacuum rope mop)	4
Dispersant	Under review
Marine storage containers/barges	2
Collapsible shore storage containers	5
Portable Power generation/lighting plants	2
Decontamination stations/packs	2
Water pumps	1

Nogliki – Summary of Existing Stockpile	Quantity
Portable incinerator	1
Communications/radio gear	10 sets
Rake and shovel packages (50 per package)	50
Flushing systems (pumps and hoses)	1
Personal Protective Equipment (PPE) sets (10)	
Pressure washers/steamer	1
Chain saws	1
Indicative Vessel Equipment	
Ocean boom and associated system for deployment	200m
Ocean skimmer system	1
Dispersant spray system vessel based 6m arms	1
Dispersant	$1m^3$
Transfer pump	1
On deck vessel-work skiff	1

(ii) Development and Cooperation with Regional Response Arrangements

Given the proximity of Sakhalin Island to the Japanese island of Hokkaido, SEIC will cooperate with Japanese and Russian authorities, to the extent that this is reasonably practicable, to ensure effective transboundary contingency planning. It is SEIC's understanding that issues relating to cooperation and coordination between regional Governments are being addressed at the bilateral Government level as part of the development of the Northwest Pacific Action Programme (NOWPAP) Regional Oil Spill Contingency Plan. SEIC will continue to monitor the progress of this and facilitate the process as possible and appropriate.

(iii) Improvement of Cross Border Response Coordination

This is currently being addressed through a number of initiatives including:

- Development of customs clearance, flight clearance and immigration procedures through Government exercise (*e.g.* Ministry of Transport/ Ministry of Defence exercise in August 2003) and ongoing negotiations concerning aircraft clearances;
- Extension of the SEIC-MDPC MOU;
- Northwest Pacific Action Programme (NOWPAP) Regional Oil Spill Contingency Plan (see above);
- Review of international response services and agencies to further expand options.

(iv) Maintenance of Adequate Insurance Cover

Throughout the construction and operation of the Project, SEIC will maintain a level of insurance sufficient to cover costs in the event of a spill occurring for which SEIC incurs legal liability. Costs may include claims by affected parties and cleanup costs. SEIC will also require Contractors to be adequately covered by insurance.

(v) Development and Participation in Tier 2 or Tier 3 Response Arrangements

SEIC already has mutual assistance agreements (e.g. MOUs) for oil spill response for Phase 1 activities in place with ExxonMobil Neftegas Ltd (ENL) and the other Sakhalin Island-based oil companies.

Currently SEIC and ENL utilise equipment from a jointly owned stockpile and make available their OSR equipment to the party responding to the spill. A trained operator from the assigning party is also provided, as necessary.

SEIC, in conjunction with other Sakhalin Island based oil companies, is developing a Tier 2/3 regional OSR capability in consultation with the Sakhalin Oblast. This will ensure a greater and more flexible OSR capability within the region.

2.4.7 Conclusions

SEIC has a current OSRP that addresses the oil spill risks for the existing Phase 1 development. This OSRP has been approved by the Russian authorities and tested in joint exercises with those authorities. This OSRP provides a firm foundation for the development of OSRPs for the Phase 2 activities that will also be based on further and ongoing environmental risk assessment (i.e. oil characterisation, modelling and coastal sensitivities analysis).

2.5 RISK DUE TO INCREASES IN TANKER TRAFFIC

2.5.1 Introduction

Public and stakeholder concerns regarding oil spill risks focuses on the transport of oil by sea. Statistically, the likelihood of an accident involving a crude oil tanker or LNG carrier is small and this risk is further reduced by measures described in the following sections. Firstly, all vessels will be required to comply with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), which sets out procedures for preventing chemical and biological pollution from vessels. All crude oil tankers and LNG carriers chartered by SEIC or scheduled to load at Sakhalin Energy's facilities will be vetted using Shell Tanker Vetting Procedures and only those that qualify will be accepted. For safety at sea and around offshore installations during the ice season, SEIC will require tankers to comply with the RF's "ice passport" requirements. In addition, tugs will be provided to assist tankers on their approach into Aniva Bay.

All tankers visiting SEIC facilities will be required to adhere to approved recommended tanker shipping routes. The Prigorodnoye terminal will have port limits marked by navigation aids and an exclusion zone will be established around SEIC's marine facilities to ensure navigational safety.

2.5.2 Outline of the Issues

The volume of tanker traffic around Sakhalin Island and through La Perouse Strait predominantly consists of shuttle tankers supplying Sakhalin Island, north-eastern Russian areas and the tankers offloading product from the Floating Storage and Offloading Vessel (FSO).

The Western part of La Perouse Strait is the narrowest part and is approximately 37km wide. This is the passage from the Sea of Japan into Aniva Bay, as well as into the Sea of Okhotsk. There is one small but prominent rock in the Strait approximately 13km south-east of Point Krillion and this is well marked and forms the central section of the Separation Zone. The recommended route for the crude oil tankers and LNG carriers is to the South of the Separation Zone, thus avoiding the main traffic routes and inshore fishing vessels. The vessels may meet crossing traffic proceeding to/from Wakkanai, Japan, but there is sufficient sea room to allow the vessels to pass.

The major port in the region is Korsakov, which accommodates vessels of length approximately 130m and draft of 8m. These tend to be the largest size of vessels presently trading in the area, other than the tankers trading to the Vityaz terminal during the summer months. There are inshore fishing vessels working in the area close to Point Krillion and the separation zone.

Multipurpose Supply Vessels (MSVs) will travel between the Port of Kholmsk and from the PA-A and PA-B offshore platforms at Piltun-Astokh and the LUN-A platform at the Lunskoye field. Currently MSVs supply the Vityaz complex at PA from Kholmsk.

The Sakhalin II Phase 2 Project will result in new tanker vessel movements to and from the offshore facilities in Aniva Bay and the cessation of tanker movements along the east coast to PA.

The principal source of potential adverse environmental effects associated with tanker movements is oil spills (crude oil or bunker fuel oils). These could result from:

- Spillage during transfer of crude oil to tankers;
- Collision between tanker and another vessel or object at sea;
- Groundings.

Potential sources of spills of diesel associated with MSV activities include:

- Spillage during loading of fuel into MSV;
- Spillage during vessel to platform transfer of fuel;
- Collision between MSV and another vessel, or object at sea;
- Groundings.

Historically, in operations of this type, the most frequent spills involve a small discharge during connections and disconnections of hoses although larger spills (<10 m^3) may occur, with lower probability of occurrence, due to hose leaks or breakages (assuming pumping rates of <100 m^3/ hour).

Vessel collisions may cause financial or other adverse effects such as loss of life, injury or requirements for salvage operations.

At peak production in 2009, the frequency of visit of LNG carriers to the export facility is expected to be approximately 190 per annum (i.e. almost one every two days). For crude oil tankers, the frequency of visit is expected to be one tanker every four days.

Anatec UK was commissioned to assess the change in shipping risk resulting from the increased tanker traffic to and from the LNG/OET. The purpose of this study was to highlight and inform SEIC of any unexpected risks in order to better plan their shipping activities.

Section 2.1 of the Health, Safety, Environment and Social Action Plan (HSESAP) table on hydrocarbons refers to shipping issues and the commitment to mitigation measures designed to reduce the risks of accidents and collisions.

2.5.3 Assessment of Changes in Tanker Shipping Risk

SEIC has adopted a range of measures aimed at minimising the risk of a spill incident, including:

- A tanker vetting procedure to ensure that tankers are in good condition and are operated safely by competent managers;
- A marine operations system to ensure the safe operation of tankers.

Before discussing these, information is provided on vessel movements in Aniva Bay.

(i) Vessel Movements at Aniva Bay Facilities

The basis of the design for the LNG Jetty is for large vessels of 125,000m^3 up to 145,000m^3 as well as small vessels. For guidance, the main particulars of the LNG carriers which use the facility are as follows:

Table 2.13 Specifications of Typical LNG Carriers

Parameter	Dimensions
Typical size:	125,000 to 145,000m^3
Length overall:	290m
Breadth:	46m
Depth:	26m
Max draft:	12m
Ballast draft:	9m
Lateral area above waterline:	7,707m^2 (load) 8258m^2 (ballast)
Lateral area below waterline:	3,078m^2 (load) 2527m^2 (ballast)
Frontal area above waterline:	1,596m^2 (load) 1688m^2 (ballast)
Frontal area below waterline:	488m^2 (load) 396m^2 (ballast)

Vessels will be berthed stern to the shore on the LNG jetty within a 600m-radius turning circle and with a minimum under keel clearance of 1.5m during the lowest astronomic tide (LAT). Four LNG berths and two guard vessel berths will be provided for mooring and anchoring the LNG vessels.

During periods of maximum LNG production, it is planned to load one vessel (approximately) every two days (see earlier). Loading is anticipated to be of 16-hours duration (for 145,000t tankers).

Monitoring equipment will be installed in the mooring area to monitor mooring speeds, waves and tidal flows. During LNG tanker manoeuvring onto and off the LNG Jetty, the tanker will be assisted by three tug vessels. Support vessels will be based in the port of Korsakov.

Oil will be exported via the TLU, which will be connected to the OET via a subsea pipeline. The OET facility will provide oil storage to ensure continuous pipeline operations and ready volumes for tanker loading year round. It will be supplied with crude oil from PA-A and PA-B and condensate from the LUN-A platform and the LNG plant. Condensate from the LNG plant will be transferred to the OET via above ground pipeline.

The proposed TLU will be located at a distance of 4.3 km offshore and approximately 4.8 km south of the OET in a depth of approximately 28m of water (LAT). The Port of Korsakov is approximately 18km to the west.

It is anticipated that the number of vessels will peak at 95 crude oil tanker movements per year. Tankers will be accompanied by icebreaking harbour tugs during winter.

Full Phase 2 production is anticipated to require one oil tanker every four days and an LNG tanker every two days deploying to the TLU and LNG facilities in Aniva Bay, a total of approximately 239 per year *i.e.*, five per week. Tanker traffic will therefore be relatively limited although movements are unlikely to be uniform throughout the year and periodically traffic frequency might be higher. Present commercial cargo vessel traffic to and from the Port of Korsakov is around two vessels a day.

Currently, approximately 16 to 17 tankers per year sail along the south and east coast of Sakhalin Island to the Phase 1 facility at PA. Because the current number of tanker movements is small, the proportional increase in tanker traffic though the La Perouse Straits and into Aniva Bay, as a result of the Phase 2 development, is likely to be large. It should be noted, however, that tanker movements to PA (Vityaz) along the Sakhalin Island east coast will cease once Phase 2 is operational.

(ii) Tanker Vetting Procedure

The underlying principles of the SEIC tanker vetting procedure are as follows:

- Every tanker using SEIC facilities must have been positively vetted i.e., SEIC must have positive information that the ship is of acceptable quality. Mere absence of negative information is insufficient. This means that even if SEIC has not heard anything bad about the vessel, it is not necessarily accepted. On the contrary, SEIC specialists will go and look at all the databases and inspection reports to see first hand if it is has bad or weak features etc., by using experienced judgement;

- All vessels, of any type, on charter to SEIC or visiting an SEIC facility will be vetted. All crude oil tankers and LNG carriers chartered by SEIC or scheduled to load at the SEIC Aniva Bay facilities will be vetted before acceptance to load at the terminal. Where a tanker is leased by a third party (i.e. the oil or LNG purchaser), SEIC will ensure that the vetting procedures are applied once SEIC is informed which tanker is to be used;

- At present, SEIC requires that all tankers operating during the ice season must be double-hulled. This is specifically checked during the tanker vetting procedure. All SEIC chartered tankers will be double-hulled regardless of the time of year in which it is operating. Currently, SEIC charters one vessel, and this will increase to three or four vessels for Phase 2, representing about half of the future exports. In order to contribute to minimising the risk of any oil spill, from commencement of the 2005 production season, SEIC will adopt a policy that all crude oil shipments, both under the control of Sakhalin Energy and Free on Board (FOB) customers, be normally undertaken using double hull tankers. Access to single hull tankers would only be approved by the Company in very special circumstances, such as in the case of an "environmental emergency", where, for example, ship-to-ship transfer from a damaged double hull tanker, where lack of timely available double hull tankers might compound the incident. If in such extreme circumstances a dispensation of the policy is required, then such dispensation with appropriate mitigation measures must be authorised by the Chief Executive Officer (CEO) and any such dispensation is to be reported to the Board of Directors.

The tanker vetting procedure is based on Shell procedures and will be undertaken through accessing a wide range of sources that contain information on the condition, safety and incident records of every tanker in operation. These sources include:

- Inspections carried out by Shell (SEIC operator);

- Inspections carried out by other oil companies and entered into the Oil Companies International Marine Forum (OCIMF) Ship Inspection Report (SIRE) database (these are factual records of inspection rather than assessments of suitability);

- Port State Control inspections carried out by government authorities;

- Structural review on the ship carried out by Shell naval architects;

- Terminal reports from Shell terminals worldwide.

Tables 2.14 and 2.15 summarise the tanker requirements that must be satisfied prior to operation at SEIC installations during both the summer and the ice season (i.e. January to April).

Table 2.14 Tanker Requirements for Summer – May to October

Tanker Criteria	SEIC Requirement
Maximum Deadweight	150,000t
Minimum Deadweight	40,000t

Tanker Criteria	SEIC Requirement
Maximum Draft	18.5m
Midship Manifold	Midship manifold to comply with OCIMF manifold for connecting 2 x 16 inch hoses.
Bow Mooring	Bow arrangement to comply with OCIMF for connection of 1 x 76mm chafe chain.
Aft Towing Point	Tanker to have a strong point aft for connecting the towing line of the "pull back tug".
Ballast	Vessel to have segregated Ballast tanks.
Helicopter	Tanker to have a Helicopter Deck Winching Area complying with the International Chamber of Shipping (ICS).
Double Hull	Vessel to be double hull construction.

Table 2.15 Tanker Requirements for Ice Season – January to April

Tanker Criteria	SEIC Requirement
Maximum deadweight	150,000t
Minimum deadweight	40,000t
Maximum draft	18.5m
Bow loading arrangement	Tanker to be fitted with a forward loading arrangement sited as far forward as possible and to the port side of the hawser connection. The arrangement is to be fitted with a 16" valve compatible with the hose end valve, and fitted with a dry break emergency release quick disconnect coupler.
Bow mooring	Bow arrangement to comply with OCIMF for connection of 1 x 76mm chafe chain.
Aft towing point	Tanker to have a strong point aft for connecting the towing line of the "pull back tug".
Ballast	Vessel will have sufficient ballast capacity to submerge the propeller by 70cm, and to have the bow submerged so as to provide maximum visibility when operating with the icebreaker.
Helicopter	Tanker to have a helicopter deck winching area complying with the ICS guide to Helicopter / Ship Operations.
Double hull	Vessel to be double hull construction.
Winterisation – see below	Vessel to be able to operate in sub-zero temperatures to –23°C.
Searchlights for ice navigation	Xenon type focused lights – Two on bow, one on each bridgewing.
Radar scanner	3cm scanner sited forward.
Ice passport	Vessel to be in possession of an "Ice Passport".

Tanker Criteria	**SEIC Requirement**
Power certificate	Certificate of main engine power; Vessel to be able to maintain a minimum speed of four knots in ice up 70cm thick following two icebreakers.
Cooling water systems	Tankers will have two cooling water suctions for the main and auxiliary machinery located on opposite sides of the hull. At least one of these suctions will be located at or near the bottom of the vessel to minimise the probability of ice clogging.

Another component of the tanker vetting system will be imposed by SEIC when a tanker arrives at Aniva Bay with the intention of loading at either terminal. Before any tanker is permitted to enter the SEIC controlled marine area the following actions will take place:

- The vessel's name will be checked to make sure it has no recent inspection failures or incidents of concern;
- The SEIC Marine Coordinator will require a report of any factor or condition that may adversely affect the working of the vessel or pose any risk to the proposed operation;
- The Marine Coordinator must be made aware of any defects in relation to, but not limited to, the following:
  - main engines;
  - thrusters;
  - steering gear;
  - communications' equipment;
  - navigation equipment;
  - mooring equipment;
  - bulk pumps;
  - cargo stowage;
  - lifting gear.
- Any defects occurring after the vessel has reported its arrival must be reported to the Marine Coordinator, who will decide whether or not operations may continue. Depending on the nature of the defect, berthing could be delayed until the problem is fixed. It is anticipated that most repairs would be complete within three days. In the event of a serious defect such as a structural fault with the hull requiring the vessel to go to a shipyard for repair, production would be shutdown if a substitute vessel could not be chartered in time. If a shutdown becomes necessary this would be for a short period of time, as vessels will be scheduled to arrive every three or four days;
- The cause and rectification of such defects must be similarly reported;

- The SEIC tanker vetting procedures ensure that all tankers comply with all applicable international conventions, regulations, standards and laws, including, but not limited to the following:
  - International Convention for the Prevention of Pollution from Ships (MARPOL 73/78 and Annexes) including International Oil Pollution Prevention (IOPP) Certificate;
  - The International Convention for the Safety of Life at Sea (SOLAS) 1974 and its Protocols;
  - Oil Company International Marine Forum (OCIMF) Guidelines;
  - Applicable International Maritime Organisation (IMO) requirements.

(iii) Marine Operations System

The marine operations system comprises a number of strategies as listed below:

- Provision of a designated tanker shipping lane for passage to and from the LNG jetty and TLU in Aniva Bay. A preferred approach to TLU, LNG terminal and MOF has been agreed with Korsakov Port Control. This approach is intended to minimise interference with other vessel traffic. All tankers will be required to lodge Passage Plans with SEIC before heading to, or leaving, Aniva Bay. These are standard maritime safety measures and draft Passage Plans are shown in Figure 2.28. This has also been agreed and approved by the Sakhrybvod (an agency for the Federal Fishery Committee "Goskomrybolovstvo"). The designated tanker lane (in Figure 2.28) maintains a safe route for vessels as far as possible from the coast and outside of any existing shipping lanes for marine traffic using the Port of Korsakov to minimise the risk of any interference between tankers and other marine traffic;
- For the Phase 2 developments, SEIC will align navigational control with existing authorities (*e.g*. Port Control at Korsakov) to ensure comprehensive coverage of SEIC and third party vessels. SEIC is already initiating capacity building initiatives in the Port of Korsakov;
- A safety zone will be established and enforced around all of the marine project components offshore of Sakhalin, as follows:
  - A 64 km^2 area around the LNG jetty and TLU will be established and will remain a restricted area throughout the operation phase; anchoring and bottom fishing will be prohibited and vessel movements will be strongly restricted;
  - More specifically, the PA-A, PA-B and LUN-A platforms and the LNG Jetty and TLU will have a 500m exclusion zone within which no non-project related vessels or people will be permitted to enter;
  - The current exclusion zone around the Vityaz complex will be maintained. At present, all SEIC tankers operating around the north-east coast of Sakhalin Island are overseen by an on-site Marine Coordinator during the production season. The

coordinator provides 24-hour coverage. Support vessels are used to enforce the Vityaz complex exclusion zone;

- At Aniva Bay, tugs and support vessels will be on permanent standby and will enforce the exclusion zone;

- The Offshore Installation Manager (OIM) will be responsible for each of the sites of activity during offshore operations. The OIM will monitor shipping activities in the areas and ensure that safety zones established for each of the areas are enforced.

- In Aniva Bay, the Marine Coordinator will work closely with the Korsakov Port Authority, which is the statutory harbour authority with the appropriate powers, to control marine traffic in the area;

- A voyage risk assessment for all tanker traffic (both LNG and Oil Tankers) transiting Aniva Bay and La Pérouse Strait will be undertaken by SEIC. This will ensure that all risks associated with tanker movements are understood and steps are taken to ensure any potentially significant risks are minimised. The STASCO 'STAR' (Systematic Tool for the Assessment of voyage Risk) system will be used;

- All tankers will be required to use a qualified pilot when approaching the tanker route in Aniva Bay. No Pilotage Exemption Certificates (PECs) will be issued to tankers;

- It is intended that three tug vessels will be on permanent standby to assist tankers with the approach to the LNG jetty and TLU and with mooring. Tugs will also be capable of providing emergency assistance in the event of a marine incident involving a tanker. Note that the three tugs retained in Prigorodnoye at all times will also be able to provide emergency cover. The fourth tug may be in Korsakov for bunkers, stores, repairs and crew change.

Diesel fuel supply to the PA-A and PA-B platforms at PA will be via Multi-purpose Supply Vessels (MSVs). The LUN-A platform at the Lunskoye field will not have a high demand for diesel as they will use electricity from the OPF power station. The MSVs are designed to hold approximately 1,200m^3 of diesel, of which 800m^3 is for the platforms and on-site standby vessels. The remainder is fuel for the MSV (15-day supply).

The principal source of diesel consumption is by standby vessels. When undertaking voyages on full power the vessels utilise 40 tonnes per day (tpd). The two standby boats will only be using about five tpd. For the initial period when using the three boats to supply drilling, consumption will be approximately 120tpd then will reduce to 50tpd when drilling is completed in summer and approximately 80tpd in winter when the standby boats have to operate in ice.

2.5.4 Assessment

In considering the potential effects of a large oil spill in Aniva Bay, it is concluded that the residual risk from tanker loading operations and movements is reduced to As Low as Reasonably Practicable (ALARP) levels by the measures proposed (i.e. the extensive mitigation measures proposed in the SEIC tanker vetting system and the marine operations system). This will ensure that all practical steps have been taken to reduce the risk of a hydrocarbon spills.

2.5.5 Future Studies and Work Programme

As noted above, an individual voyage risk assessment will be undertaken by SEIC for all tanker traffic (both LNG and oil tankers) to ensure that all risks associated with tanker movements are understood and that steps are taken to ensure any potentially significant risks are minimised as follows:

- Identification of navigation hazards (e.g. rocks, fog and currents);
- Frequency and routing of SEIC tanker traffic;
- Frequency and routing of third party vessels, in particular fishing vessels;
- Specification of vessels used for transporting oil and any seasonal requirements.

2.6 RISKS ASSOCIATED WITH TANKER TRAFFIC DURING ICE CONDITIONS

2.6.1 Background and Potential Impacts

The extensive sea ice coverage around the waters of Sakhalin during the winter months presents an increased risk to the safe operation of tanker (and other vessel) traffic due to the potential of ice damage and the increased complications of operating a tanker of significant size in sea ice conditions. Both these factors increase the risk of an incident involving a tanker that could result in a spill.

Concerns have been expressed in relation to two areas of interest; both are described below.

(i) Offshore Platforms

Ice volumes on the north-eastern Sakhalin Shelf, where the PA and Lunskoye fields are located, are generally high during the winter period. Ice formation off the north coast of Sakhalin Island begins at the end of November in the PA field and in Lunskoye. Peak ice cover is in March and ice may persist until early June. The average duration of ice cover in the vicinity of the PA field is 187 days and at the Lunskoye field 150 days. Average level ice thickness increases from 0.4m in January to 1.2m in May although deformation usually occurs in this area, increasing the volume of ice in some locations up to, on average, 1.5m thickness during the winter period. Maximum level ice thickness recorded at the PA and Lunskoye fields is 2.1m.

The pack ice in the region of north-eastern Sakhalin is dynamic, and is in near continual motion because of winds, currents and tides. Maximum drift speeds – generally experienced during January to February (*TEO-C Volume 2A Book 8, EPB: Chapter 6,* 2002) – observed at the PA field are 0.2m/s and at the Lunskoye field 0.1m/s).

The movement of drift ice begins from Sakhalin Bay in December to the shelf region on the north-east coast and through both the PA and Lunskoye fields. Movement is generally south-easterly in direction, coinciding with the East

Sakhalin current with occasional movements to the north, east and west. Cyclical tidal drift may be observed on shorter timescales.

(ii) Aniva Bay

The ice season in Aniva Bay is the later winter period from January to March. The extent of the ice depends on the severity of winter. For example, at mid-January in a severe winter, ice occurs within 20 miles of the coast in the upper Aniva Bay. During moderate and mild winters, the extent of ice is limited to approximately five nautical miles (9km). Generally, by February the majority of Aniva Bay is filled with ice up to 60 nautical miles (110km) from shore.

The ice season is deemed to start in Aniva Bay when early types of ice are observed in the Bay and the La Pérouse Strait in concentrations greater than 6/10. The ice season continues until ice in Aniva Bay and in the La Pérouse Strait has broken up and cleared out. The *Guides for Crude Oil tankers and LNG Carriers transiting Aniva Bay & La Pérouse Strait*, developed by the Central Marine Research and Design Institute (CNIIMF) and Arctic and Antarctic Research Institute (AARI) – both in St Petersburg – have been approved by Roshydromet and the Ministry of Transport. The present ice season, as defined by Korsakov Port Authority, commences on the 15 January and ceases on the 31 March.

2.6.2 Mitigation Measures

(i) General Mitigation Measures

In order to ensure that all tankers operating at the SEIC offshore installations during the ice season are in a good condition and are adequately equipped to cope with operating safely in sea ice conditions, SEIC will impose an ”ice-passport” system in accordance with RF requirements. The system is designed to ensure that each tanker holds a valid “ice passport” that sets out the documented vessel operating limits when working in ice conditions. Tanker ice passports will be developed by a competent body approved by the Russian Administration and will be obligatory for ship operators of all large tankers calling at Prigorodnoye transiting the La Pérouse Strait and the Aniva Bay during the ice season.

The Russian Maritime Register of Shipping (RMRS) has notations for Ice Classification and the Northern Sea Route and publishes a table of equivalence with other major classification societies. The ice passport only applies to vessels that have an ice class equivalent less or lower than RMRS notation ”LU4”. The RMRS ice classification of LU4 approximately corresponds to ice classes of the following Classification Societies. LU4 is comparable with the following industry standards:

- Finnish-Swedish Ice Class Rules – IA;
- American Bureau of Shipping – IA;
- China Classification Society – Ice Class B1;
- Det Norske Veritas – ICE-1A;
- Korean Register of Shipping – IS1;
- Lloyd’s Register of Shipping – 1A.

These classifications refer specifically to vessels that are ice strengthened and have the required engine output for navigation in ice. The above classifications further refer to “Baltic Ice Classes” in agreement with the Finnish-Swedish Ice Class Rules.

The detailed requirements of the ice passport that each tanker must satisfy include:

- Tanker safe speeds;
- Distance between icebreakers and tankers in the convoy;
- Other parameters influencing the safety of tanker operations in ice.

The ship operating limits contained in the ice passport may be presented as a printed manual or computer-based software. The relevant tanker owner will be required to submit to the competent body sufficient and appropriate drawings and other documentation needed for the development of the ice passport. The ice passport will be valid for ten years from the date of its issue or, if within this period of time the oil tanker or LNG carrier is refitted and this refit could exert influence on the ship’s capabilities to operate in ice, until the date of such a refit.

(ii) Ice Condition Marine Operations

Operation of tankers in the ice of Aniva Bay and the La Pérouse Strait without ice class (*i.e*. those tankers that are not designated Ice Class LU4 or better) will only be allowed with icebreaker support providing the following provisions are met:

- Type, power and breadth of icebreakers are to be determined depending on the ice cover conditions and sizes of the tankers to be escorted. During the ice season two linear icebreakers will be available for the escort of tankers transiting between the ice edge and Prigorodnoye. These icebreakers together are capable of providing a broken ice channel being at least 25–30% wider than the breadth of a tanker. The number of icebreakers needed for the escort of each particular tanker will be determined by the captain of the leading icebreaker depending on the ice situation. The requirement is for the icebreaker to produce a lead that is 25% wider than the beam of the vessel. Two icebreakers may do this; the required lead is approximately 60m wide, the beam of the icebreakers is more than 20m and travelling at a separation distance of 20m they will make the 60m. There are techniques that a single icebreaker can use to achieve it;
- In order to ensure choice of a safe distance and the solution of operative problems in the course of escorting, icebreaker captains will be provided with necessary information on the characteristics of the escorted tanker, its propulsive performance, stopping ability and manoeuvring characteristics;
- A joint SEIC and AARI initiative is being developed so that AARI and Sakhydromet can develop an Ice Forecast and Routing System for Sakhalin Island. A Centre will be established in the area of Aniva Bay or Yuzhno. Roshydromet is the central body responsible for both AARI

and Sakhydromet. The Information Centre located in the area of the Aniva Bay and reported to Roshydromet will arrange monitoring and forecasting of ice conditions and dissemination of information to be used by pilots and masters of icebreakers and tankers in planning and undertaking safe navigation in the La Pérouse Strait and Aniva Bay. During the ice season, the optimal route will be communicated to the tankers. The monitoring and forecasting of ice conditions and dissemination of information to the vessels which will be transiting La Perouse Strait will be carried out using all available technology including: satellite imagery, aerial surveillance, radar and vessel reports. The information will be transmitted to vessels through company Owners as well as to the vessels directly via satellite, radio and computer services;

- In transportation during the ice season, preference will be given to tankers not older than ten years. Tankers over ten years old will be subject to a special classification survey;
- Tankers must have double hull for the cargo section in accordance with the requirements of Annex 1, Regulation 13F of MARPOL including all current amendments;
- All tankers regardless of size will be capable of withstanding flooding of any two adjacent compartments if the side should be damaged by ice. For survivability calculations, provision will be made for a damage penetration of 760mm;
- Tankers will have sufficient segregated ballast tank capacity to ensure that the propeller and seawater intakes are fully submerged under all conditions and the sufficient draft is maintained at the bow to allow the vessel to be operated within any limitations required by paragraph 3.1 of the *Confirmation of Capability to Operate in Ice*;
- The vessel will also have adequate forward visibility in the ballast condition to allow safe operation behind escorting icebreakers;
- Steel plates in the main deck and upper side will be confirmed to have adequate toughness for operation at an ambient air temperature of -25°C. Side plates above the waterline and the tanker deck plates will preferably have a steel grade of AH or higher. Mild steel (Grade A) is permitted in the vessel provided it is to the satisfaction of the ship's Classification Society for operation in ambient air temperature of -25°C.

The SEIC ice passport requirements will ensure that all tankers are of a suitable quality and operating standard to travel safely in sea ice conditions. In addition, the marine operating system that will apply during the ice season will ensure that all the practical mitigation measures that can be applied to tanker movements are put in place and enforceable. This will ensure that risks to tankers due to ice conditions are managed as far as is reasonably practical.

2.7 RISKS ASSOCIATED WITH SMALL SCALE LEAKS IN THE PIPELINE

2.7.1 Introduction

Oil spill prevention and response is particularly relevant to the onshore and offshore pipeline system, which will convey oil and gas for approximately

850km along the length of Sakhalin Island. The pipelines have been designed to high standards of integrity, conforming to RF regulations, drawing on international practice and assured by a team of highly competent international renowned pipeline engineers.

The onshore pipelines will be built to withstand, without rupturing, the most serious earthquake that can be expected in a 1,000 year return period; for the offshore pipeline, this is a 2,000 year return period (as set out in SEIC Project Specific Technical Specifications). There are some differences at the platforms for the offshore pipelines where parts are designed for 3,000 years to match the platform return periods[5].

At particularly sensitive locations, such as rivers, roads and railways, and in the vicinity of settlements, the thickness of the pipeline wall has been increased and approximately 150 block valves have been installed along the length of the pipelines to optimise the control over the transport of hydrocarbons.

The pipeline system will also be equipped with a state-of-the-art highly sensitive leak detection system and maintenance programme, which will detect losses of less than 1% of the inventory of the pipeline. All of these integrity systems will be backed up by a regular internal and external pipeline maintenance and inspection regime, which will employ a number of techniques ranging from the use of electronic pigging devices to visual site inspections.

In accordance with good international practice, the pipelines will be buried to protect them from physical damage or third-party interference, though it may be necessary to go above ground for short stretches to accommodate a few active seismic fault lines where realignment is not possible.

2.7.2 Volumes of Potential Spill

The pipeline leak detection system is designed to monitor small changes in flows and pressures to detect leaks using a statistical model of the pipeline. The current design of this system can detect a leak as small as 400 Barrels from the crude oil system. The time required to detect this volume will vary depending on the how fast the oil is flowing from the pipeline. A small leak might take 16-hours to detect the 400 Barrel leak. Using the same 400 Barrel leak scenario, a larger leak that is 5% of the pipeline flow rate can be detected in approximately 50 minutes.

The current design for the oil and gas pipelines includes over 160 automated block valves. The block valves are located to minimise the volume of hydrocarbon release along the pipeline. The valves placed at river crossings will limit the volume spilled to the volume of the pipe crossing the river after the pipeline is shutdown.

[5] The seismic design philosophy followed by SEIC, in this case, satisfies two levels of earthquake intensity: an extreme event referred to as strength level earthquake (SLE) with a return period of 200 years; and a rare intensity earthquake with a return period of 3000 years, known as a ductility level earthquake (DLE).

The potential worst-case scenarios or concerns for an oil pipeline spill are listed below with comments on how these factors were considered by SEIC alongside:

- *Seismic event* – block valves have been planned on either side of the fault zone; a full seismic study to determine zones of seismicity, the movement of soil in zones and the design of pipelines in such zones has been undertaken (see EIA-Addendum Chapter 8 on Geohazards for more information on crossings of active faults, pipeline strain criteria, welding inspection, ground-shaking effects etc);

- *Third party intervention* (e.g. illegal tap, sabotage, terrorism) – where possible, SEIC limits access to roads that are used to get to the pipeline and these areas are patrolled by security guards; the pipeline is often in remote or relatively remote locations and potential saboteurs are likely to be spotted quickly; with an average depth of 1.5m below the surface, the pipeline is difficult to access;

- *Leak from flange* (e.g. at block valve station) – there are no flanges as the pipeline is completely welded; the pipeline is submerged for most of its length except where it above ground at pig traps at the OPF, LNG and BS2. These areas are fully monitored by cameras and the leak detection system;

- *Subterranean leak from corrosion* – use of corrosion inhibitors and application of pigging programme (see also below);

- *External damage* – for example, a third party construction contractor digging and breaching the pipeline; in order to reduce such a risk, there are a number of initiatives such as: a Contractor awareness programme; community awareness (via the Community Liaison Officers for each of the five operating camps); the right-of-way is well-marked through signage; and air and foot patrols.

It is extremely difficult to predict the volume of spilled oil that could emanate from a breach or leak following detection. There are many contributing factors and each section of the Right of Way (RoW) is unique in terms of pipeline shape, terrain and other topographical and geological features. The volume of oil in the pipe at any point in time is dictated by the flow rate and distance between block valves (e.g. 20 to 23km), however, it is unlikely to be the case that all that oil would leave the pipeline.

A hole caused by corrosion is unlikely (because of the measures described in this section) but in such an event it is typically on the side or top of the pipe. The worst-case would be a hole on the underside of the pipeline towards the bottom of an incline. In the low probability event of a leak occurring, operators of pipelines would typically expect between 10 and 20% of the content to escape, although this depends on the factors mentioned above.

2.7.3 Shutdown Procedures

The leak detection system will alarm the pipeline controller to shutdown and close the block valves on the system to isolate the leak and limit the drainage at the leak site using the following procedures:

Accidental Release Shutdown Procedures

The main concern when responding to a release is the protection of persons, property, and the environment.

***Type 1*:** The Type 1 shutdown procedure is used in cases where the potential or actual release location is not specific. The Pipeline Controller must take immediate action to:

- Shut down the pipeline by shutting down the originating stations continuing downstream until all pumps are off line (immediate);
- Allow the pressure wave to subside (approximately two minutes);
- Isolate all pipeline segments by closing remotely controlled mainline block valves (one to 1.5 minutes closure time).

The entire line is controlled from one place and completely closed in approximately three to five minutes. Furthermore, the controller and team have comprehensive knowledge about local and regional conditions and characteristics. It might be the case that specific valves in a certain location or pipeline profile line are left open if it is known that oil will draw away in a safe direction because of topography.

***Type 2*:** The Type 2 shutdown procedure may be used in cases where the potential or actual release location is known. The Pipeline Controller must take immediate action to:

- Shut down the pipeline by shutting down the upstream pump stations of the segment of pipeline the release is suspected to be in;
- Proceed upstream shutting down each running station, until the originating station of the pipeline is shutdown;
- Shutdown the remaining downstream stations, as applicable;
- Isolate the pipeline segment that the pipeline release is suspected to be in, and the upstream and downstream segments surrounding it, by closing all remotely controlled mainline block valves on those segments.

Regardless of which shutdown procedure is used (Type 1 or 2 above), the Pipeline Controller must also:

- Notify Field Personnel that a release is suspected so that the exact site can be determined and release can be contained;
- Notify the Operations' Supervisor;
- Support Field as requested.

The Supervisor must:

- Assure that the pipeline or pipeline segment suspected of releasing a commodity is isolated;
- Communicate with Field Personnel about air surveillance if needed;
- Notify the Operations Manager.

The Supervisor must also:

- Ensure that the Control Centre has copies of the repair “scope of work” and or Work Authorisation Permit. The Control Centre role in repair activity must be understood;
- Authorise the restart of the pipeline when repairs are completed. The decision-making process of re-starting a pipeline, in which a release has occurred, will be a shared decision in all cases. The following people will be utilised:
    1. Operations Manager;
    2. Asset Manager;
    3. Federal Agencies.
- Conduct a review of response to an abnormal operating condition or emergency.

Pipelines operations utilise a full training simulator, which assists in certifying the competence of the operator. Supervisors are able to set up scenarios and model a wide variety of situations. Regular courses will enable engineers and operators to effectively create pipeline models, run interactive simulations and analyse the results. Such training provides operators with the ability to respond to system logic failures, communication failures, leaks and ruptures, loss of compression, mechanical failures, exercise all emergency response procedures, and perform normal but infrequent operations.

2.7.4 Assessment of the Issue

Pipeline design has been undertaken with a view to minimising the risk of leaks or ruptures. Such measures include:

- Selection of steel specification – high quality materials are being used;
- Selection of high quality pipe coating materials;
- Pipeline sizing and wall thickness;
- Location of block valves;
- Burial of pipeline;
- Corrosion management system, including corrosion inhibitor and cathodic protection;
- Leak detection system.

An inspection system is also in place to ensure that prior to pipeline laying, for example, there are no pinholes in the coatings and that the pipeline is bedded properly.

2.7.5 Leak Detection Systems

Leak detection for SEIC pipelines will utilise a variety of strategies as part of the leak detection systems. These reflect operational and environmental conditions and include the following:

- **Manual line-balance calculations**: Comparing volumes delivered into a pipeline system with volumes passing out are nearly as sensitive as visual detection and may be faster to indicate problems (NAS 1994). These techniques are not applicable to gas pipelines owing to the pressure and temperature variations of natural gas;

- **Line-balance calculations**: These are made automatically by supervisory control and data acquisition (SCADA) systems, which remotely monitor and/or control key operating parameters. The system will detect leaks in liquid and gas lines, provided they have simple operations with minimal variations in pressure. This method requires the use of the input and output meters and the pressure and temperature monitoring points along the pipeline. The change in the pipeline inventory are used in the line balance calculation to provide faster and more sensitive leak detection the oil and gas movements;

- **Statistical Pipeline Model:** The statistical model monitors pipeline throughput and pressure changes depending on the supply and demand variations. The model incorporates advanced pattern recognition functions using statistical techniques to analyse the flow and pressure measurements of a pipeline. Variations generated by operational changes are registered, ensuring that a leak alarm is generated only when a unique pattern of changes in flow and pressure exist. This model provides for improved leak detection under all operating conditions.

Leak detection thus involves a number of coordinated and complementary techniques. No one system or combination is sufficient for every pipeline. Timely notification is as important as timely detection. The discoverer of a leak may find it difficult to identify and establish the precise location of the leaking pipeline and notify the operator or operators likely to be affected (it is commonly necessary to shut down in an orderly way the pipelines and platforms injecting into the leaking pipeline).

The leak detection system shall meet the internally recognised Alaskan standard for leak sensitivity (Alaskan Administrative Code Title 18 Chapter 75 - Regulation of pipeline leak detection systems).

2.7.6 Small Leak Detection Methods

The operations of the pipeline system include plans to minimise the risk of small leaks by the following:

- Routine air and ground patrol;

- Routine pigging for cleaning;

- Intelligent pigging programme;
- Corrosion inhibitors;
- Oil spill response plan;
- Regular monitoring, inspections and maintenance of the pipeline equipment, corrosion control systems and condition monitoring;
- Groundwater well monitoring.

For the onshore pipeline, high-risk areas have already been identified and considered in the pipeline design (see *Volume 4, Chapter 2* of the EIA). These risks relate primarily to geological hazards (see separate Chapter of the EIA-Addendum) and sensitive locations, such as water body crossings and settlements.

Internal cleaning of the oil pipelines by means of pigging will be undertaken on a routine basis to ensure that flow remains unimpeded and to prevent the build-up of corrosion-forming products. Corrosion inhibitors will be used to prevent internal corrosion of the pipeline system.

Intelligent pigging (i.e. internal pipeline integrity inspections) for crude oil will be undertaken at five-year intervals. The intelligent pigging will identify any defects or corrosion in the pipelines. This data will be used to make repairs before the defects or corrosion can cause leaks in the pipelines. For multi-phase, pigging will be every two years, particularly as a check for corrosion spots.

In addition, groundwater-monitoring wells will be installed at pre-selected locations along the pipeline route. The locations of these have been selected based on environmental sensitivity and include water-crossings of high environmental value as well as a number of wetland locations. The selection included for the protection of groundwater resources used for drinking water. The current plan is that 107 monitoring wells will be installed. To date, 92 of these wells have been installed and the remainder will be installed when access along the pipeline has been constructed. They will be cased and capped in order that they can be accessed throughout the operational life of the pipeline. Parameters monitored at each well will include depth, pH, and total petroleum hydrocarbons (TPH) as a minimum. The testing for the latter is one way of identifying subsurface leakage of hydrocarbons that does not surface. Surfacing hydrocarbons will be identified by aerial survey (see below).

Regular ground and aerial observations along the length of the pipeline right-of-way will be carried out at weekly intervals to assess pipeline integrity, including any third-party interference, security, right-of-way erosion or the presence of oil. Pilots are trained to observe the signs of leakage and spill. In the case of offshore lines, SEIC will endeavour to conduct aerial observations at least every two days, depending on meteorological conditions. The visual observations will detect gas bubbles or oil sheens (e.g. on the surface of the sea) that may be observed during such overflights. This can detect small or large leaks but may take several days depending on the timing of overflights. The pilots and observers are trained to look for the signs of leakage and thus detect that there is a problem.

2.8 SUMMARY

Sakhalin Energy will continue its programme of regular oil spill response exercises with local authorities, dedicated oil spill response contractors, and other oil and gas companies, and lessons learned through these will inform the development of the Phase 2 plans.

SEIC is committed to undertake a number of future programmes for oil spill prevention, preparedness and response as follows:

- Re-examine the existing environmental risks, particularly those associated with navigation and transboundary spills, demonstrate these are ALARP and input the results into the developing OSRP;
- Undertake studies to assess the fate of SEIC oil in ice conditions;
- Continue to assess and map the sensitivity of shorelines and rivers;
- Undertake voyage risk assessments;
- Ongoing development of GIS as an oil spill planning and response tool;
- Acquire an improved oil spill trajectory model for Phase 2 operations;
- Develop detailed maintenance and/or inspection procedures to supplement pipeline design;
- Develop detailed integrity management to detect and prevent small leaks;
- Develop detailed maintenance and/or inspection procedures to supplement pipeline design;
- Refine the design of small leak detection systems and programmes;
- Develop Oil Spill Response Plans;
- Identify equipment and personnel needs, procure these and implement training and maintenance programmes;
- Continue and extend training programmes and participation in exercises;
- Wildlife rescue and treatment plan.

These will build upon the current level of preparedness and response capability that is currently in place for Phase 1.

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EIA Addendum Chapter 2 – Oil Spill Response

Appendix 1 – Figures

(To accompany main text in Chapter)

Contents

Figure 2.1 Change of Average Vityaz Oil Slick area (km^2) at Sea Surface 97m^3 Spill
(Source REA 2004)

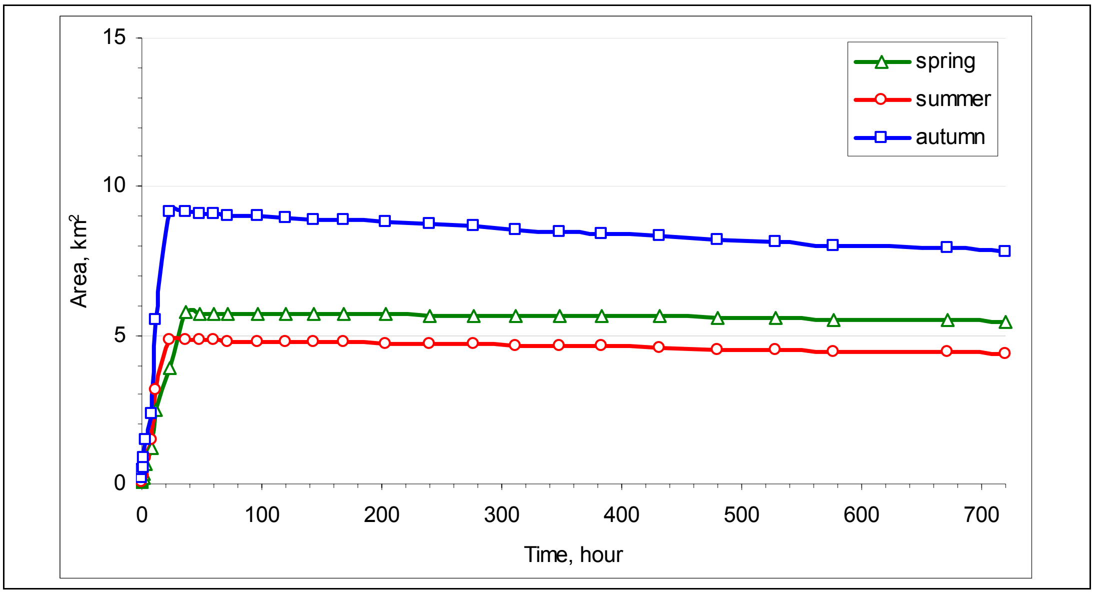


Figure 2.2 Excursion Envelopes (Risk Zones) for Oil Spills from Piltun-A Platform (Molikpaq): Autumn *(Scenario: Volume: 96m³; Cause: Pipeline rupture, REA 2004)*

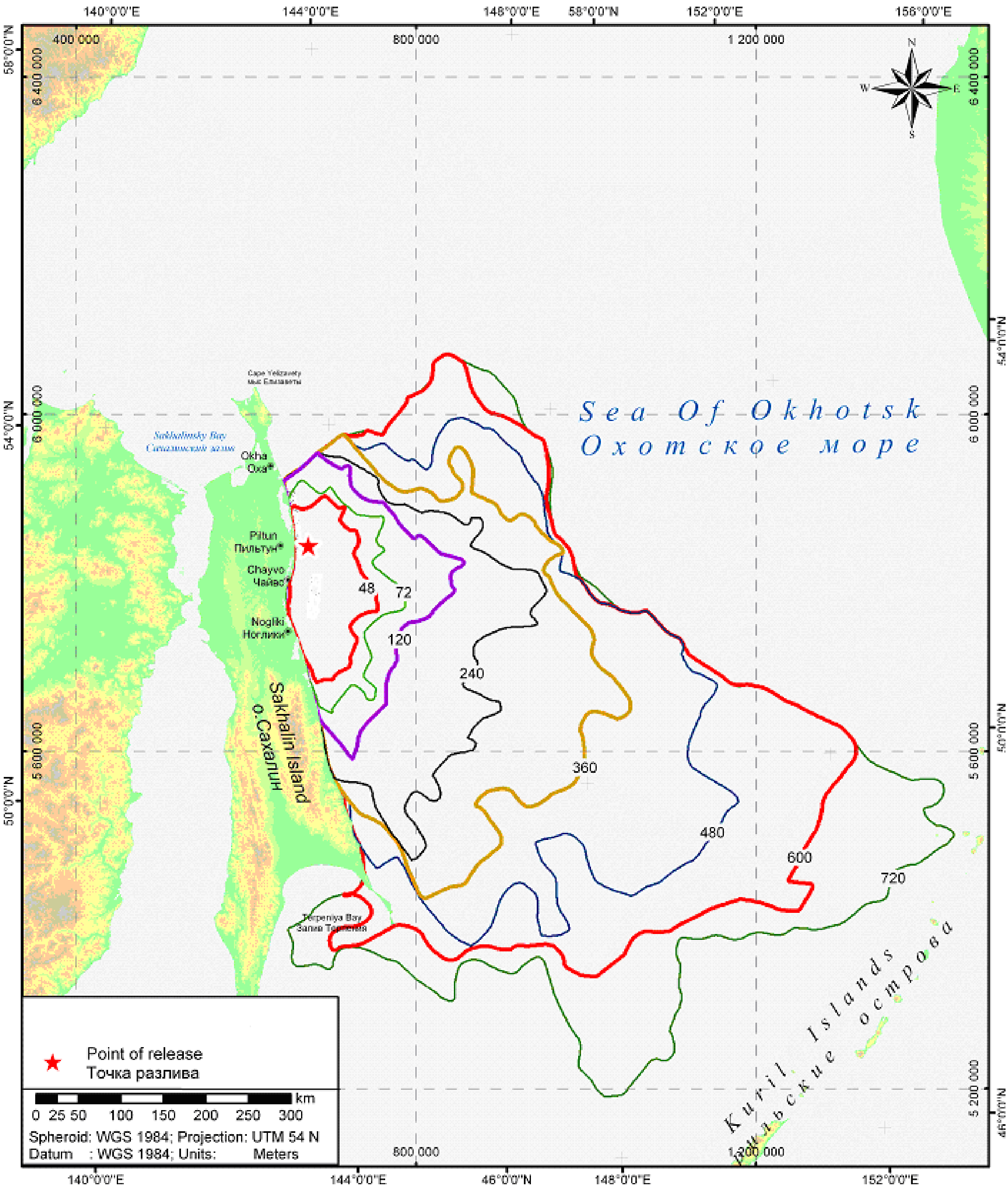


Figure 2.3 Potential Shoreline Impact for Oil Spills from Piltun-A Platform (Molikpaq): Autumn
(Scenario: Volume: 96m^3; Cause: Pipeline rupture, REA 2004)

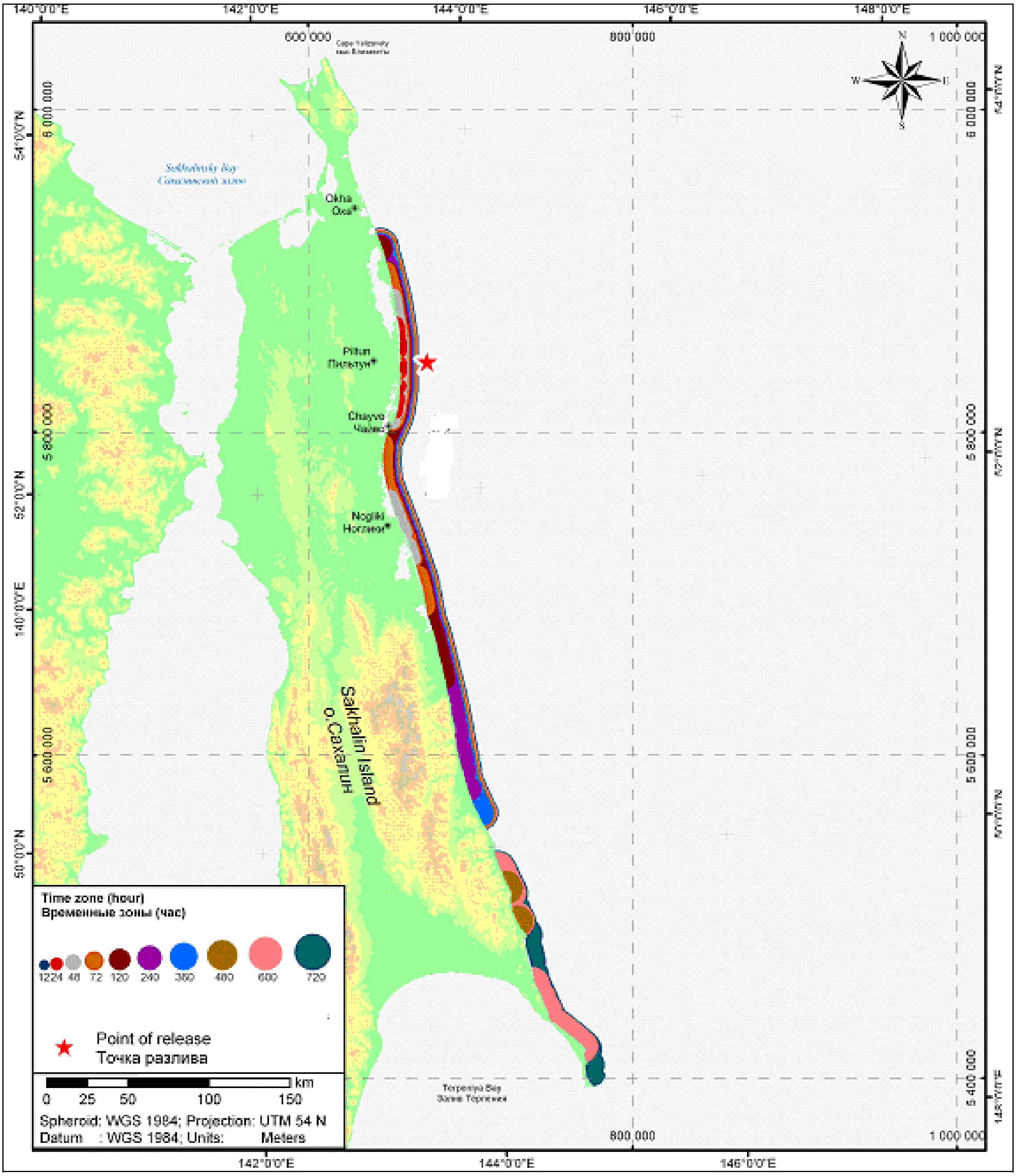


Figure 2.4 Probability of Shoreline Impact from Piltun-A Platform (Molikpaq): Autumn *(Scenario: Volume: 96m^3; Cause: Pipeline rupture, REA 2004)*

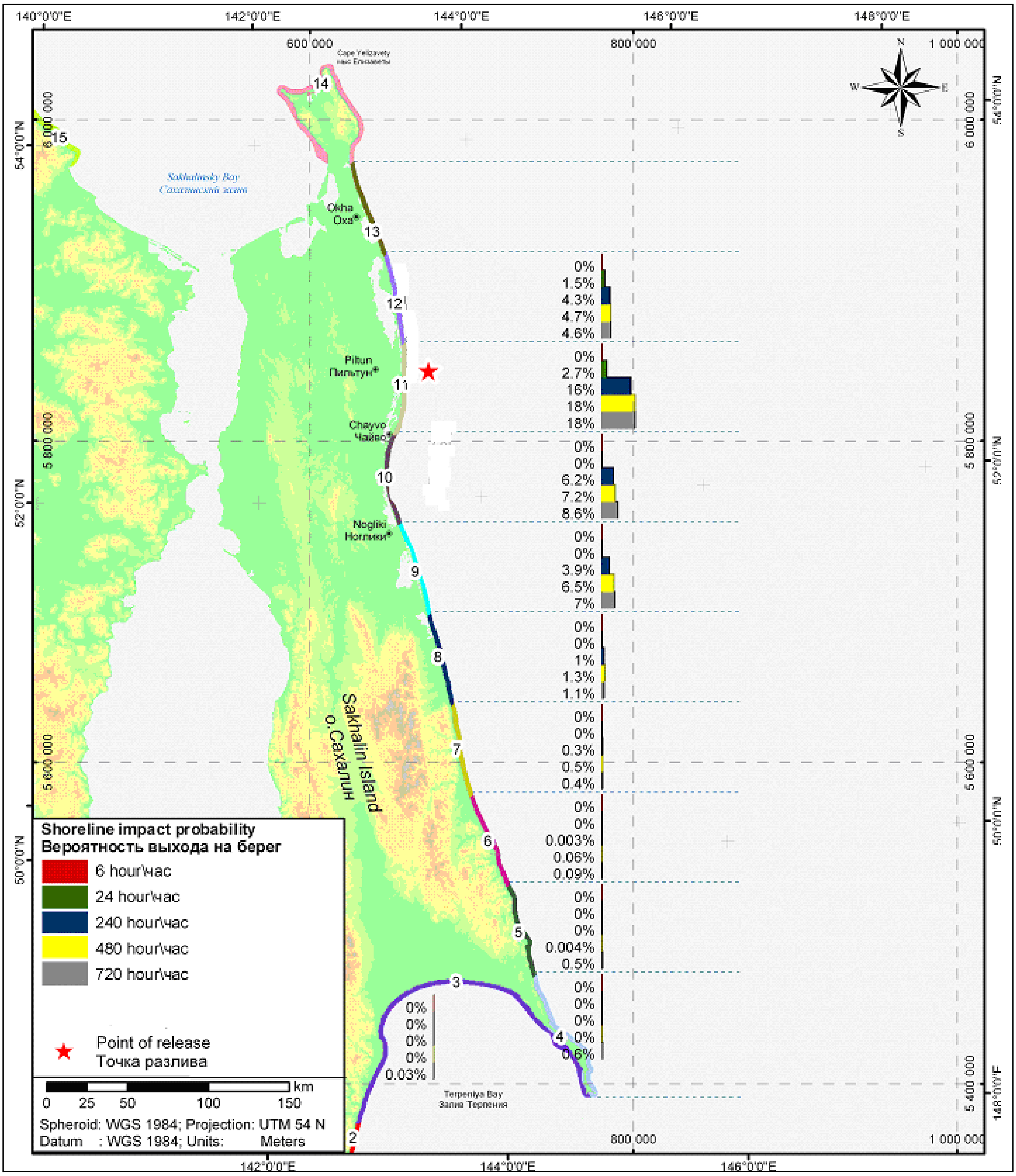


Figure 2.5 Typical Risk Scenarios of Oil Trajectories during the Ice-free Period Resulting in Coastal Contact following Incidents at LUN-A

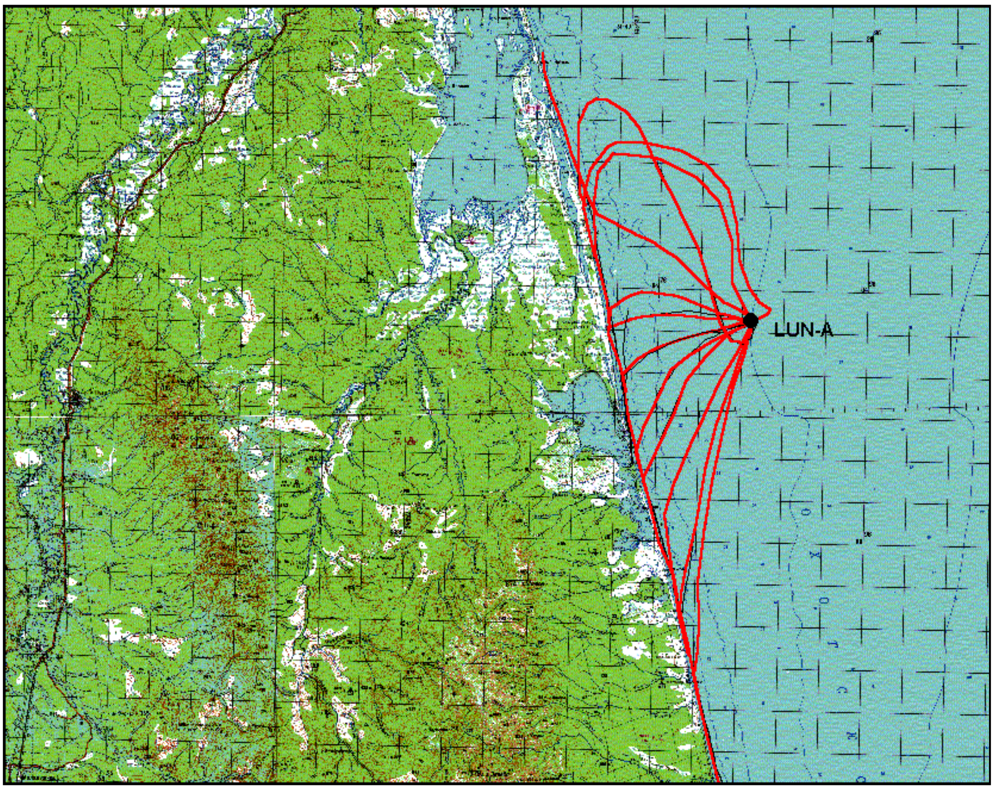


Figure 2.6 Oil Slick Trajectories that Penetrate in Lunskyi Bay

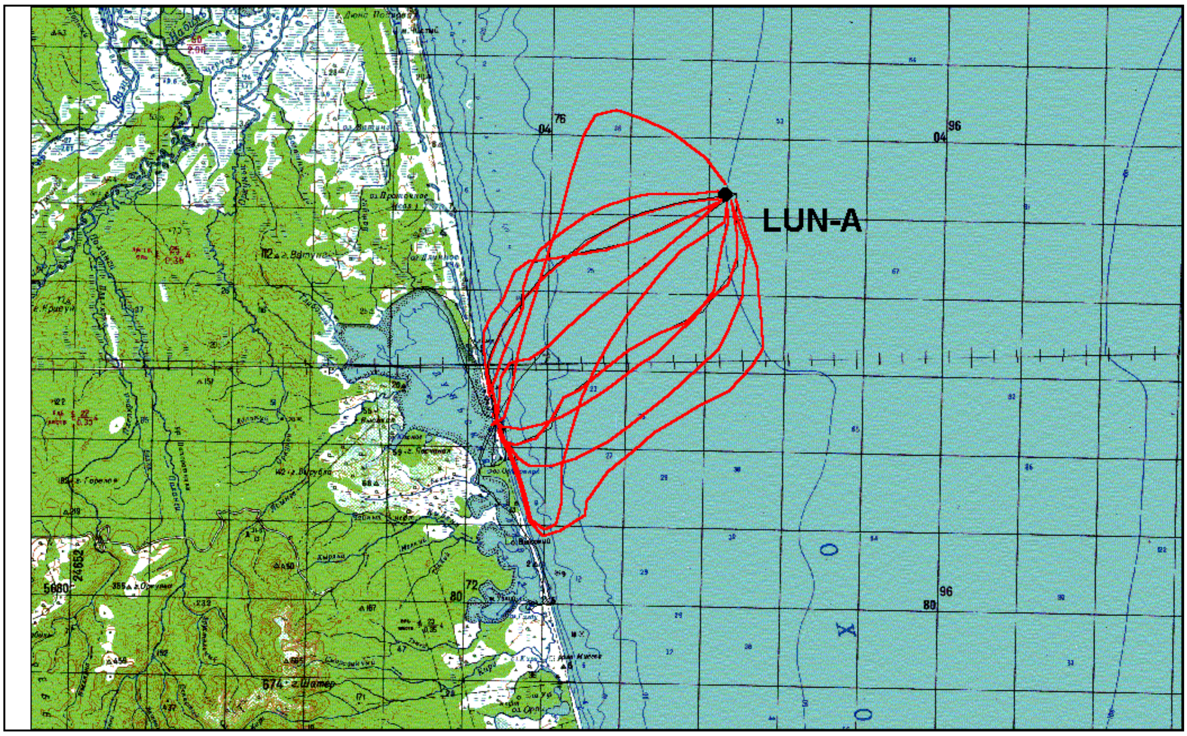


Figure 2.7 Risk Zones based on Oil Trajectories from an Accident Oil Spill at LUN-A

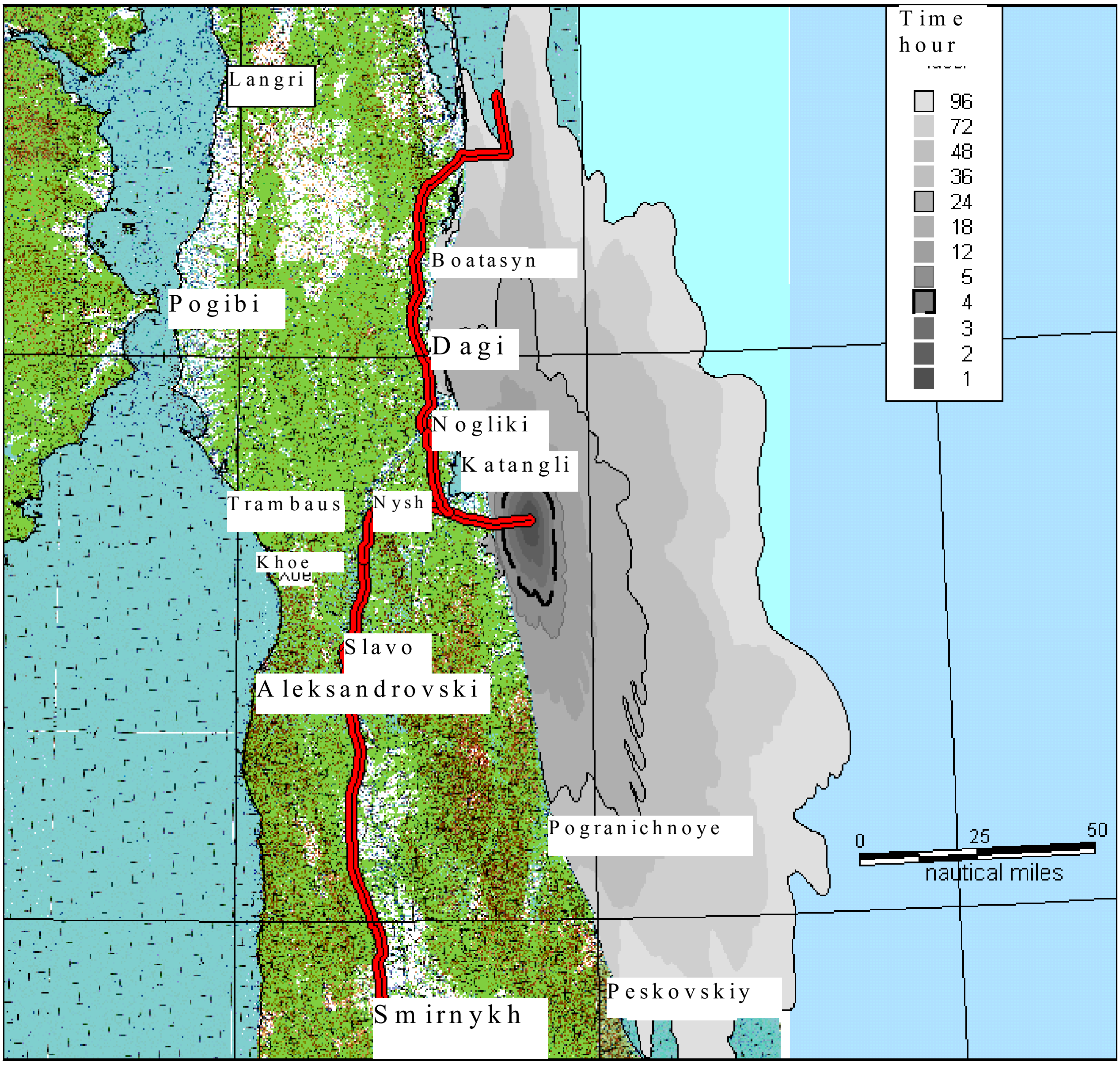


Figure 2.8 Minimal and Maximal Mass of Condensate on Sea Surface

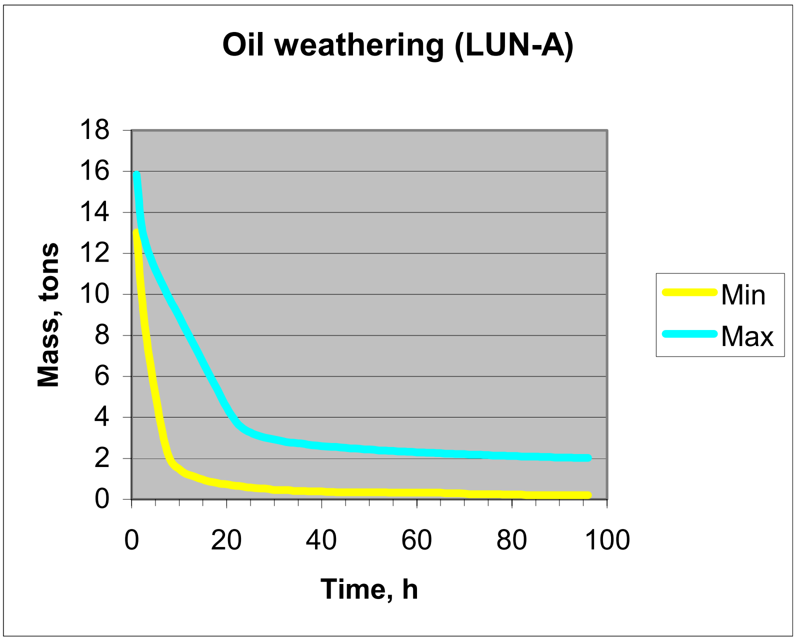


Figure 2.9 Risk Zones for Oil Spill from the Tanker Loading Utility, Aniva Bay (TAU 2002)

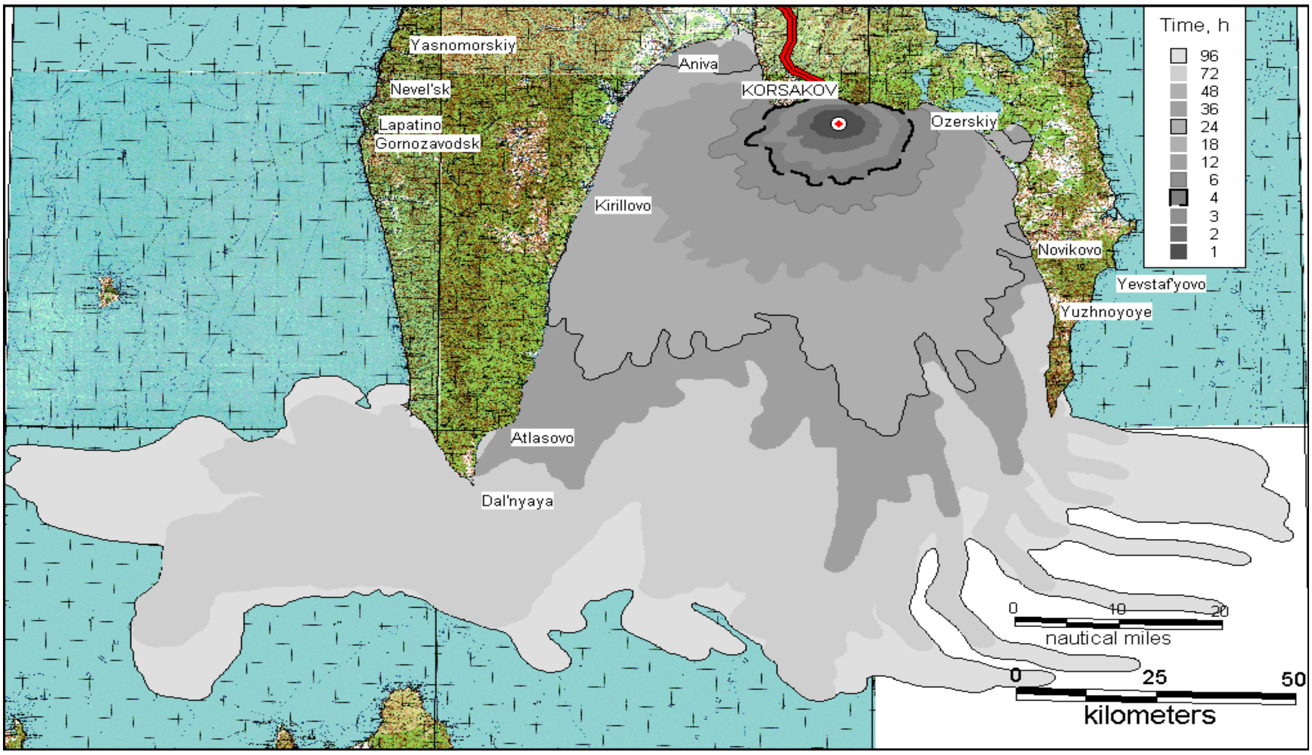


Figure 2.10 Aniva Bay: Tanker Route and Modelled Spill Locations

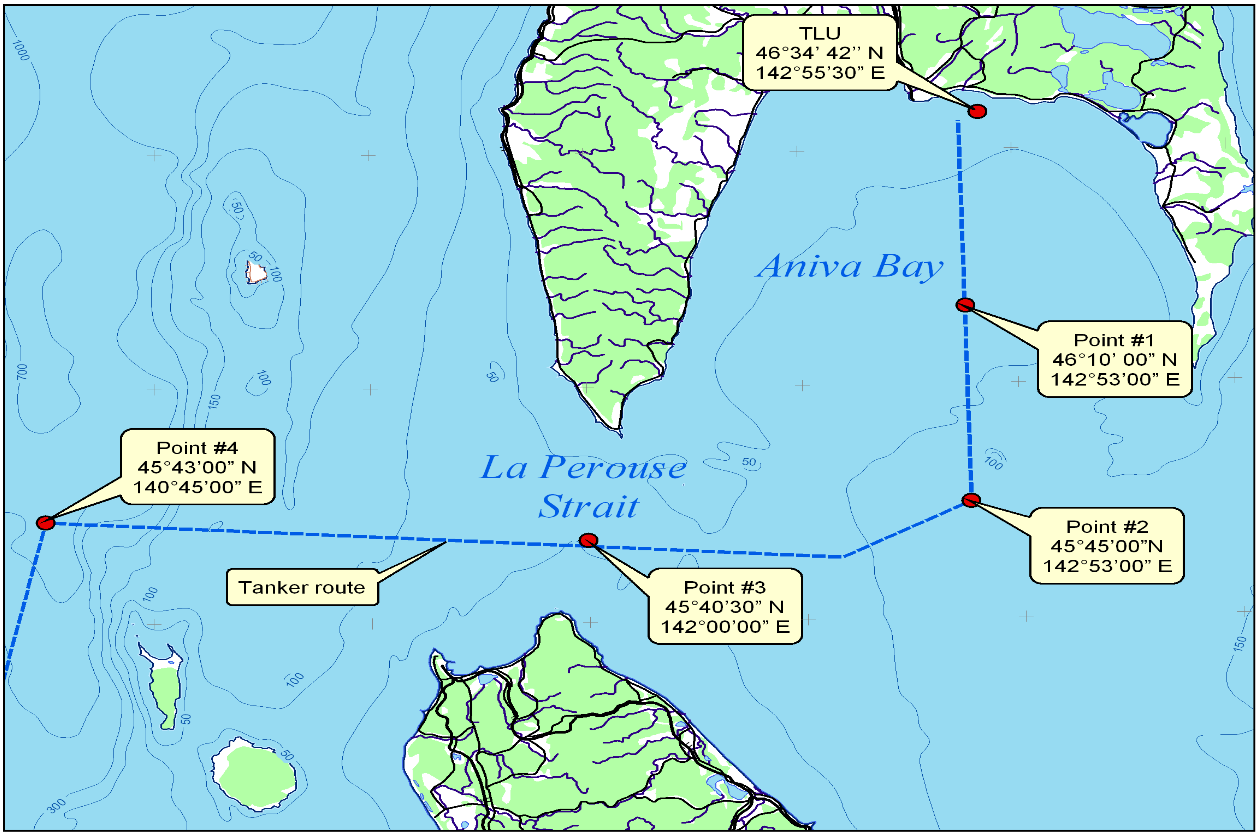


Figure 2.11 Trajectory Envelopes for Modelled Crude Oil Spill (fromTanker) Mid-Aniva Bay in Summer

(Volume modelled was 21,000 tonnes; numbers indicate hours after incident)

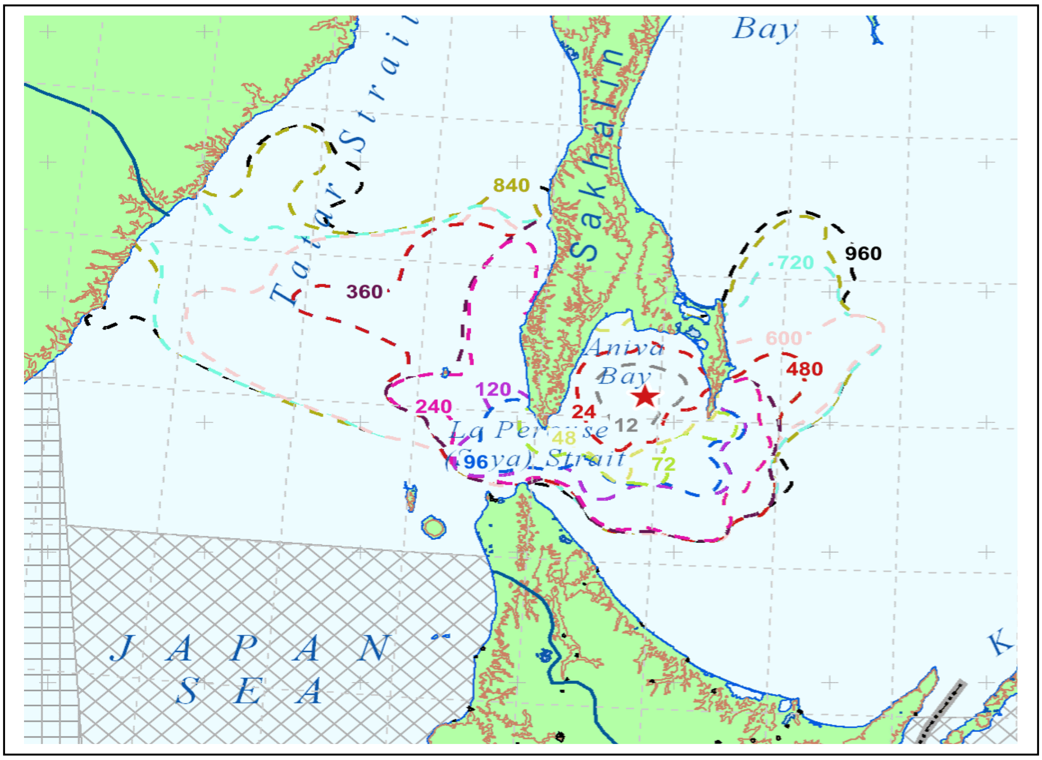


Figure 2.12 Trajectory Envelopes for Modelled Crude Oil Spill (from Tanker) Mid-Aniva Bay in Winter

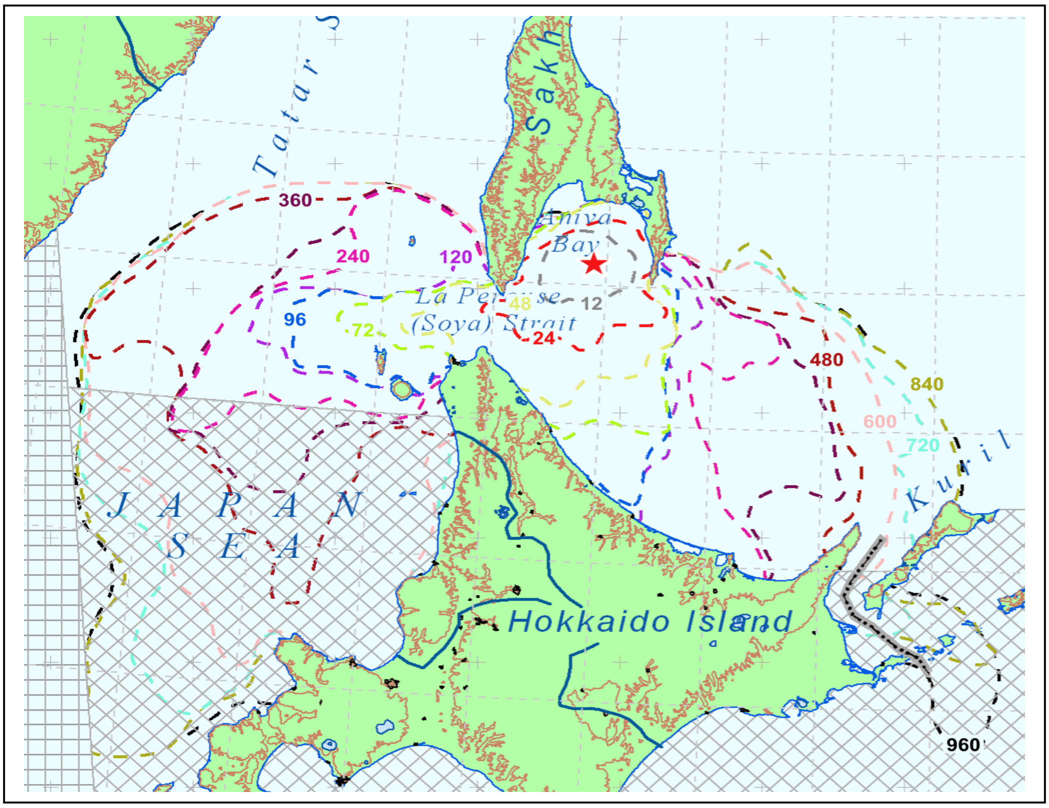


Figure 2.13 Modelled Probabilities for Shoreline Impact to Hokkaido from a 21,000 tonnes Tanker Spill in Aniva Bay in Winter (See also Table below)

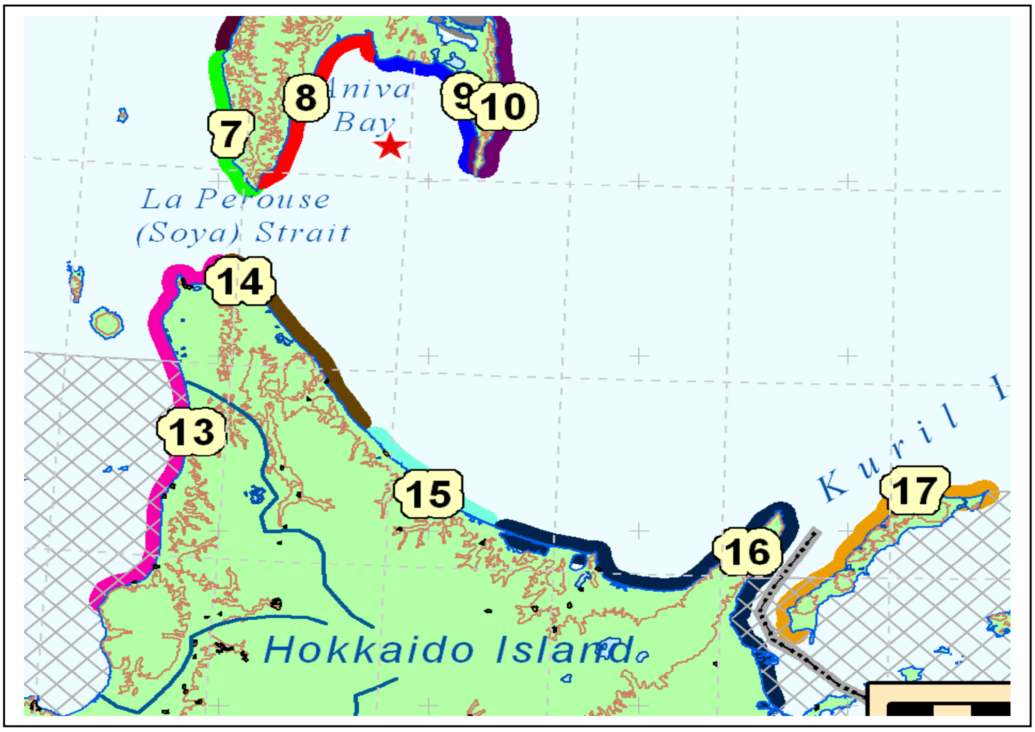


Table Shoreline Impact Probability (%) by Shore Zones in Winter (see Figure 2.13 above)

Zone	Time after oil release in days												
	0.5	1	2	3	4	5	10	15	20	25	30	35	40
7	–	–	0.206	0.226	0.237	0.262	0.329	0.382	0.368	0.359	0.360	0.357	0.347
8	–	–	1.4	2.2	3.2	3.6	5.2	5.1	4.9	4.7	4.8	4.7	4.6
9	–	0.310	5.4	10	14	15	18	17	18	18	18	18	17
10	–	–	–	0.001	0.001	0.257	0.355	0.367	0.346	0.338	0.340	0.338	0.329
13	–	–	0.104	0.385	0.516	1.2	2.4	4.1	4.6	4.7	4.7	4.7	5.2
14	–	–	0.295	1.5	2.8	5.1	17	25	29	33	35	36	35
15	–	–	–	–	–	0.589	7.5	9.3	11	11	13	13	13
16	–	–	–	–	–	–	1.1	1.9	1.9	3.3	4.9	6.5	7.3
17	–	–	–	–	–	–	–	–	–	–	0.002	0.659	1.9
Total	–	0.310	7.4	15	20	26	51	63	71	76	81	85	86

Figure 2.14 Example of Pipeline Oil Spill Distribution (see Figure 2.15 for key)

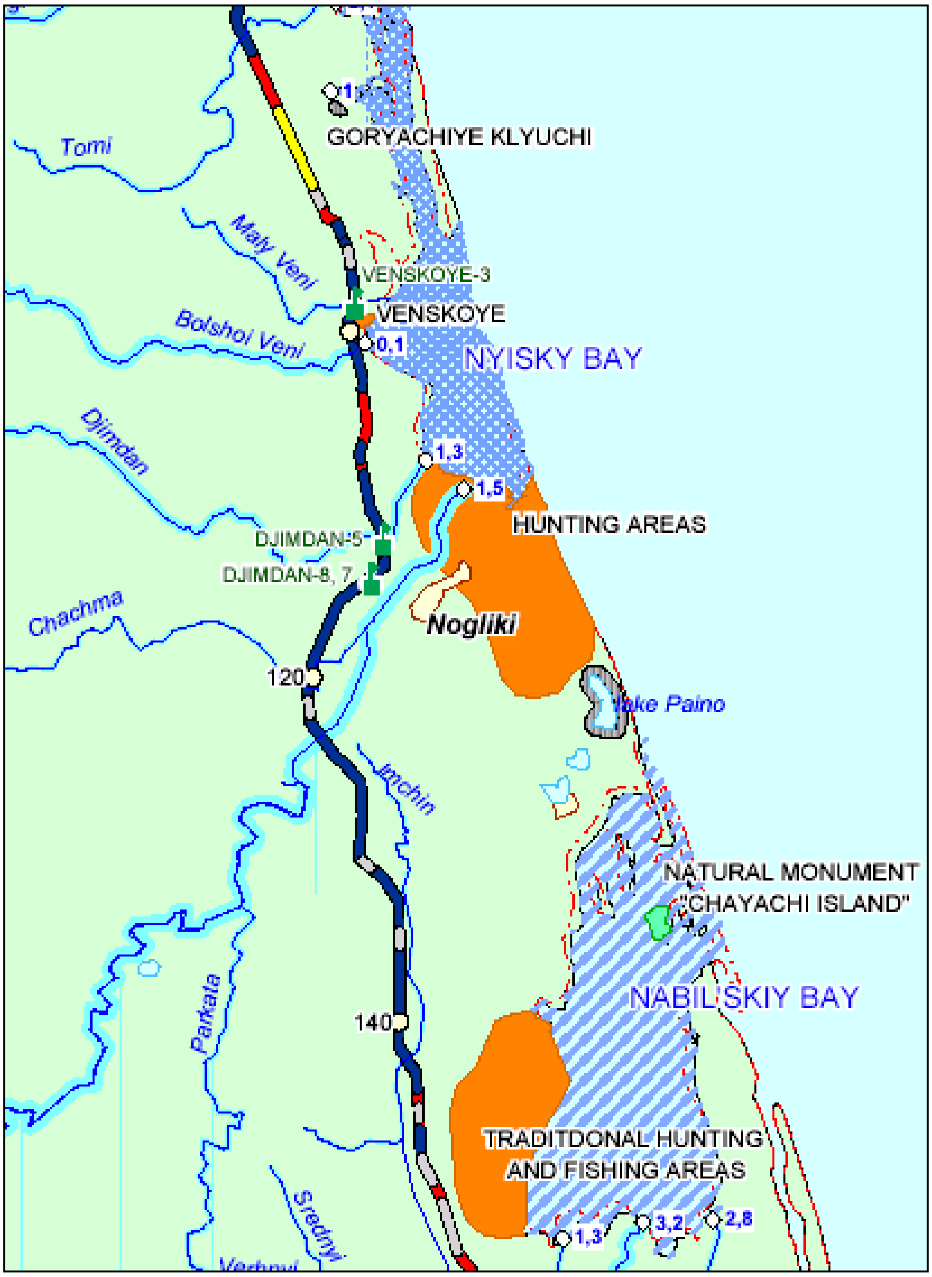


Figure 2.15 Key to Map Shown in Figure 2.14

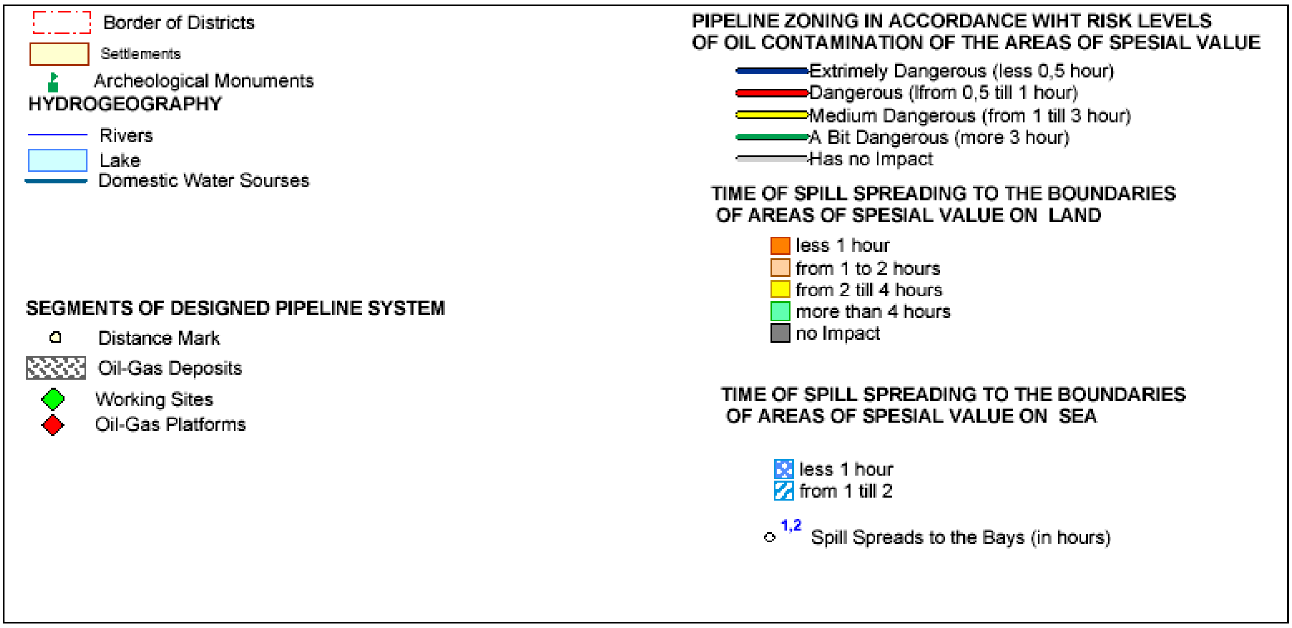


Figure 2.16 SEIC's Construction Emergency Response Capabilities

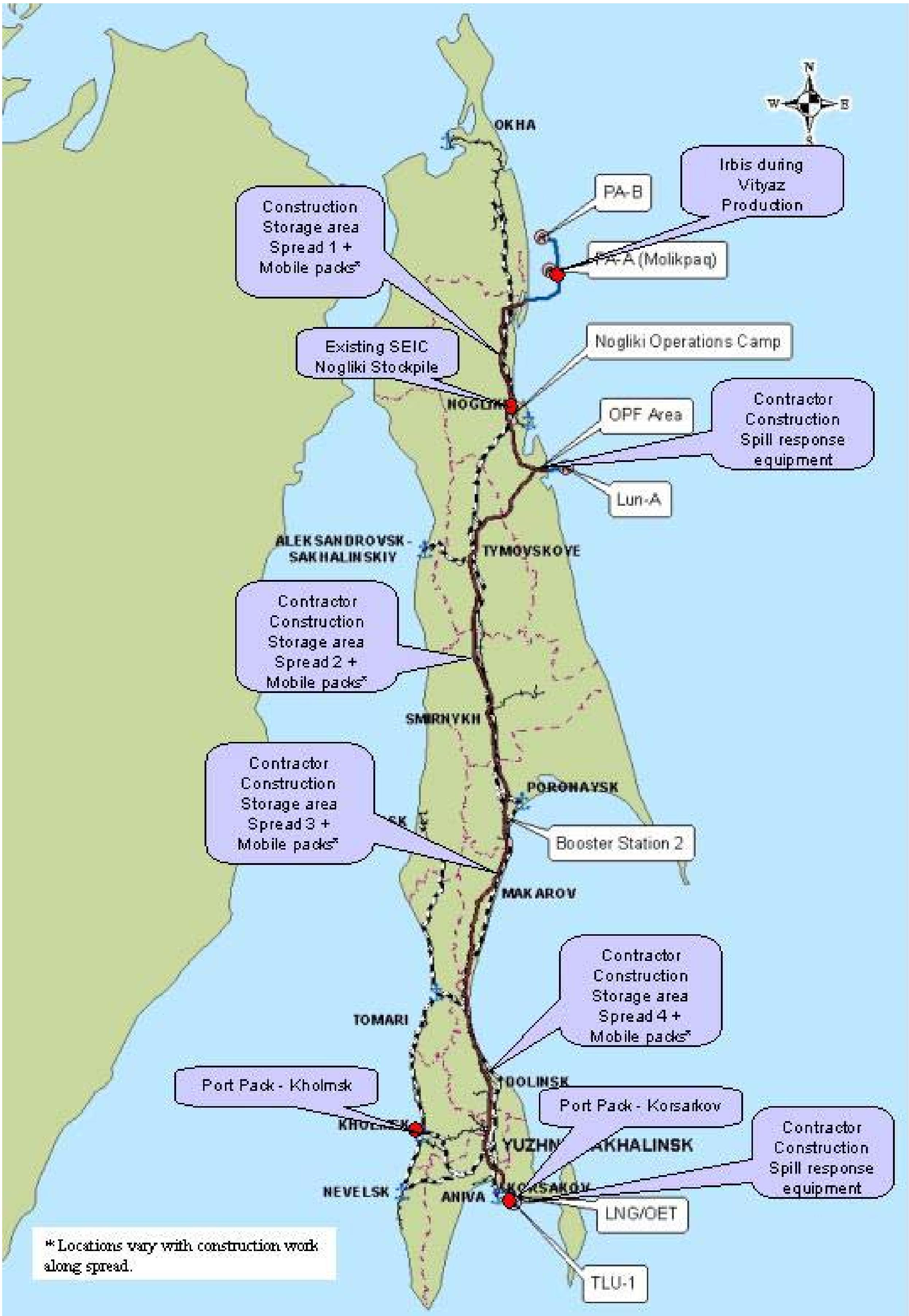


Figure 2.17 Current Initial (and Proposed) GIS-Based Sensitivity Map Coverage

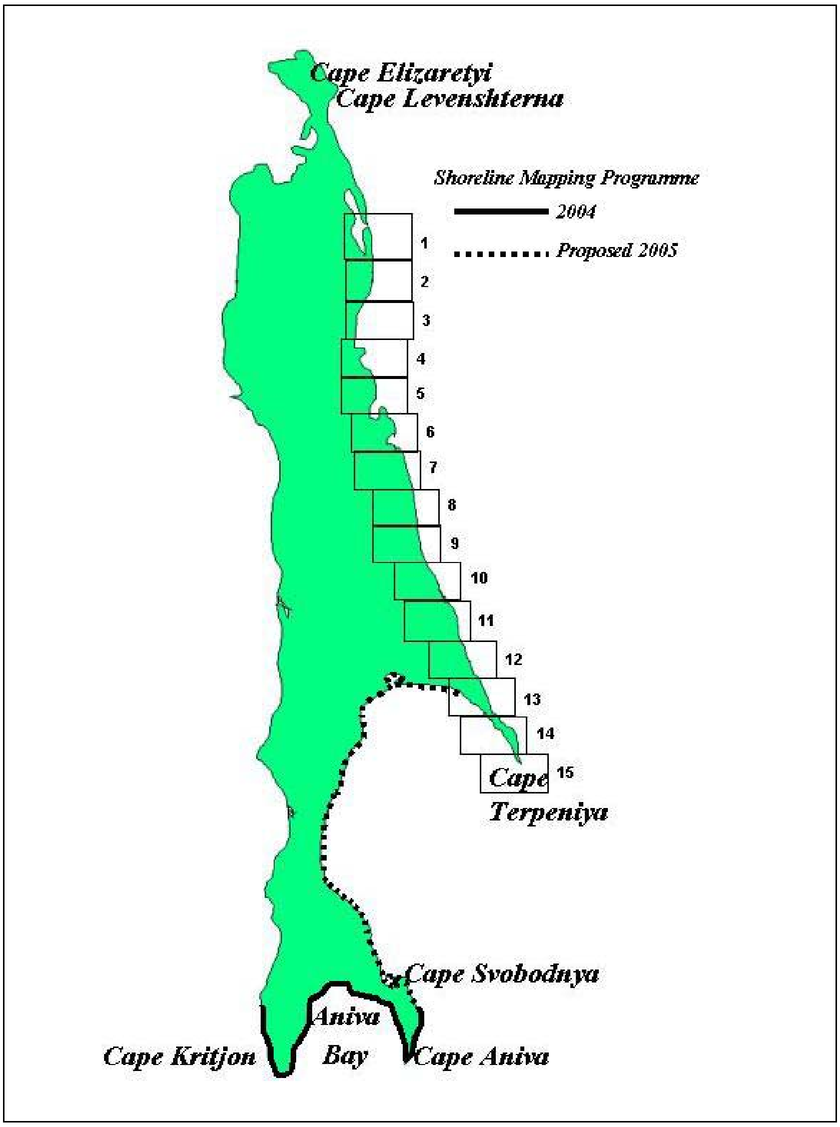


Figure 2.18 Preliminary Sensitivity Map of Aniva Bay

Note: This Map Is To Be Supplemented By Field Survey Data In 2004 And 2005

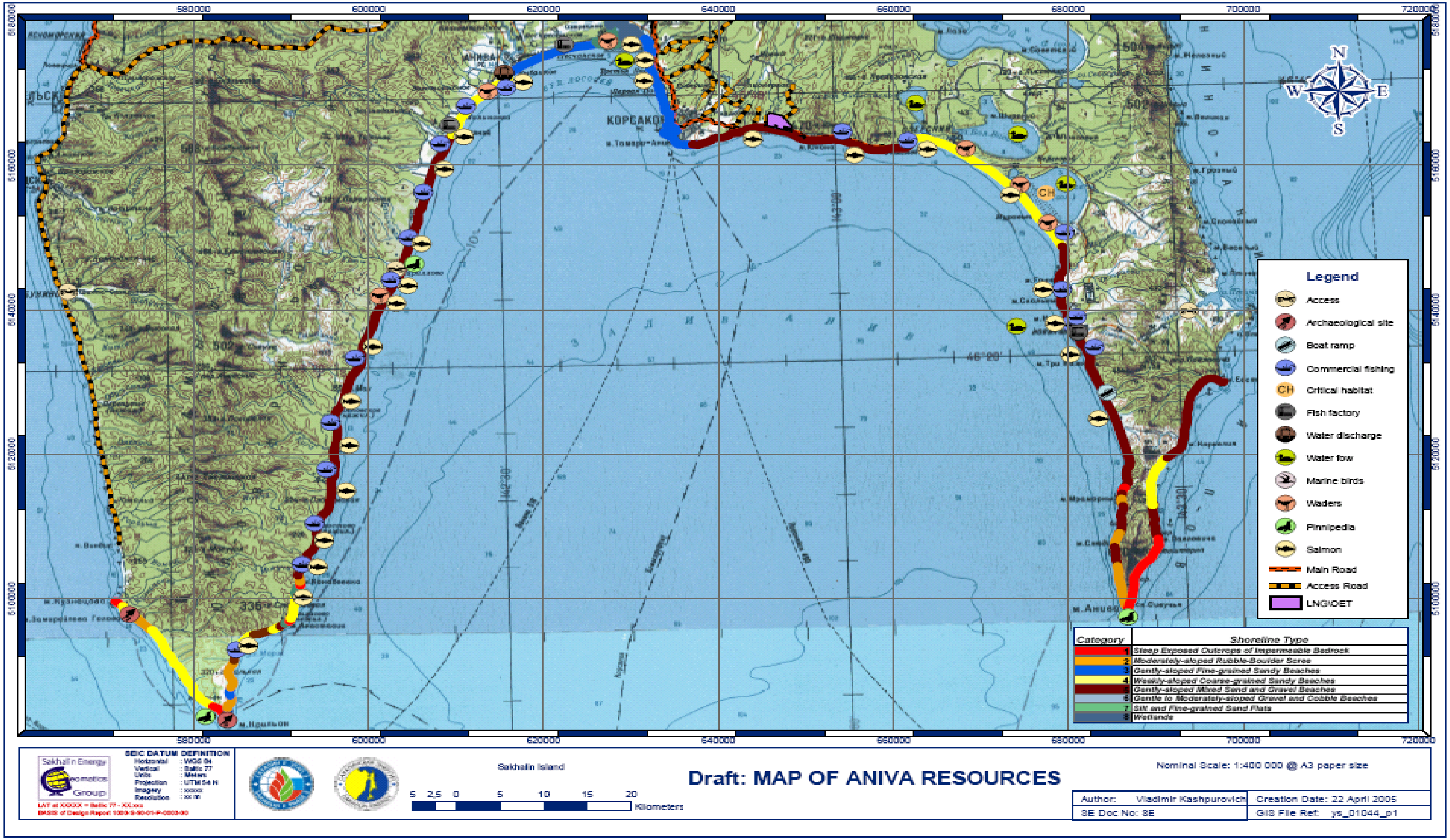
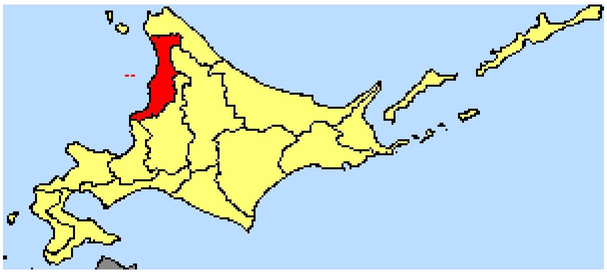


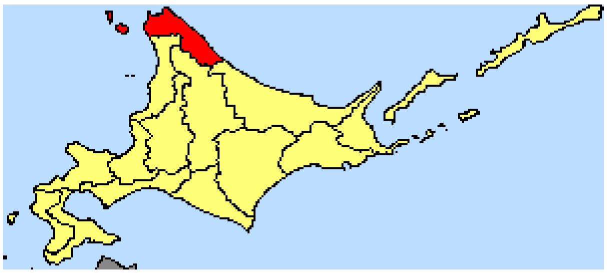
Figure 2.19 Series of Example Maps Showing Sensitivities along the North Hokkaido Coastline

Six Coastal Regions of Northern Hokkaido (West to East)

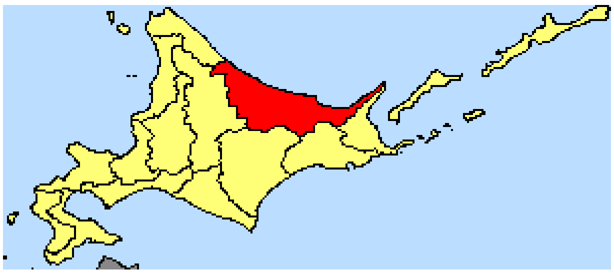
Rumoi Region



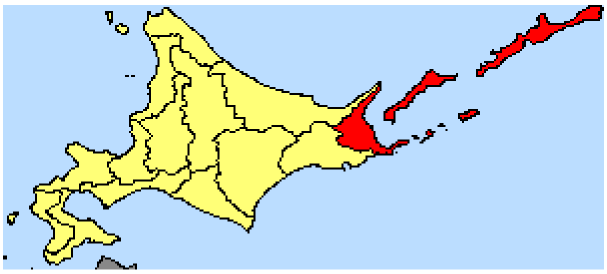
Soya Region



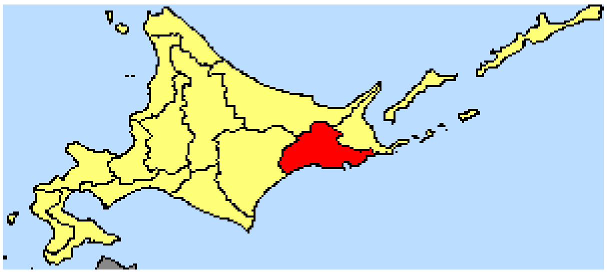
Abushiri Region



Nemuro Region



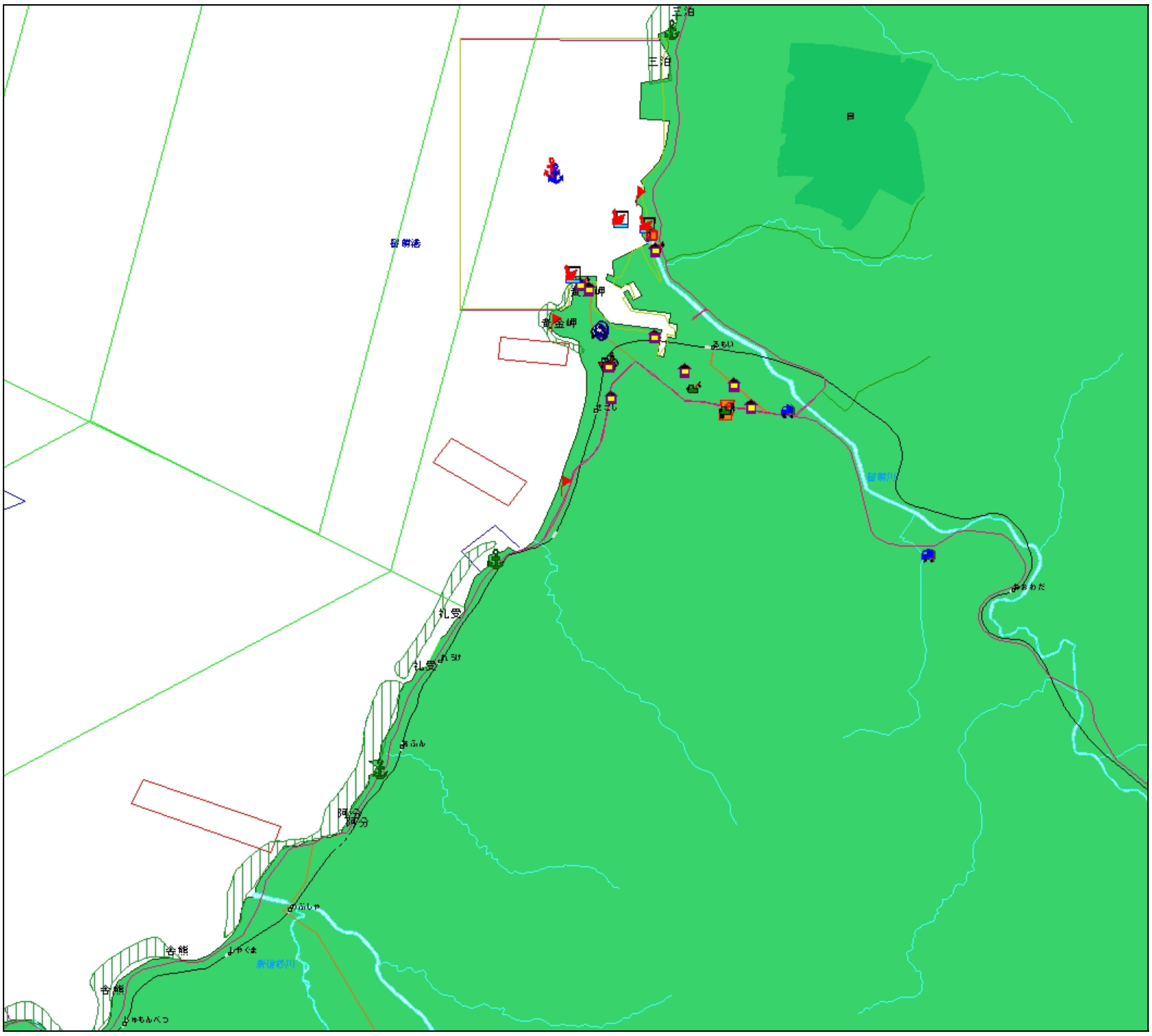
Kushiro Region



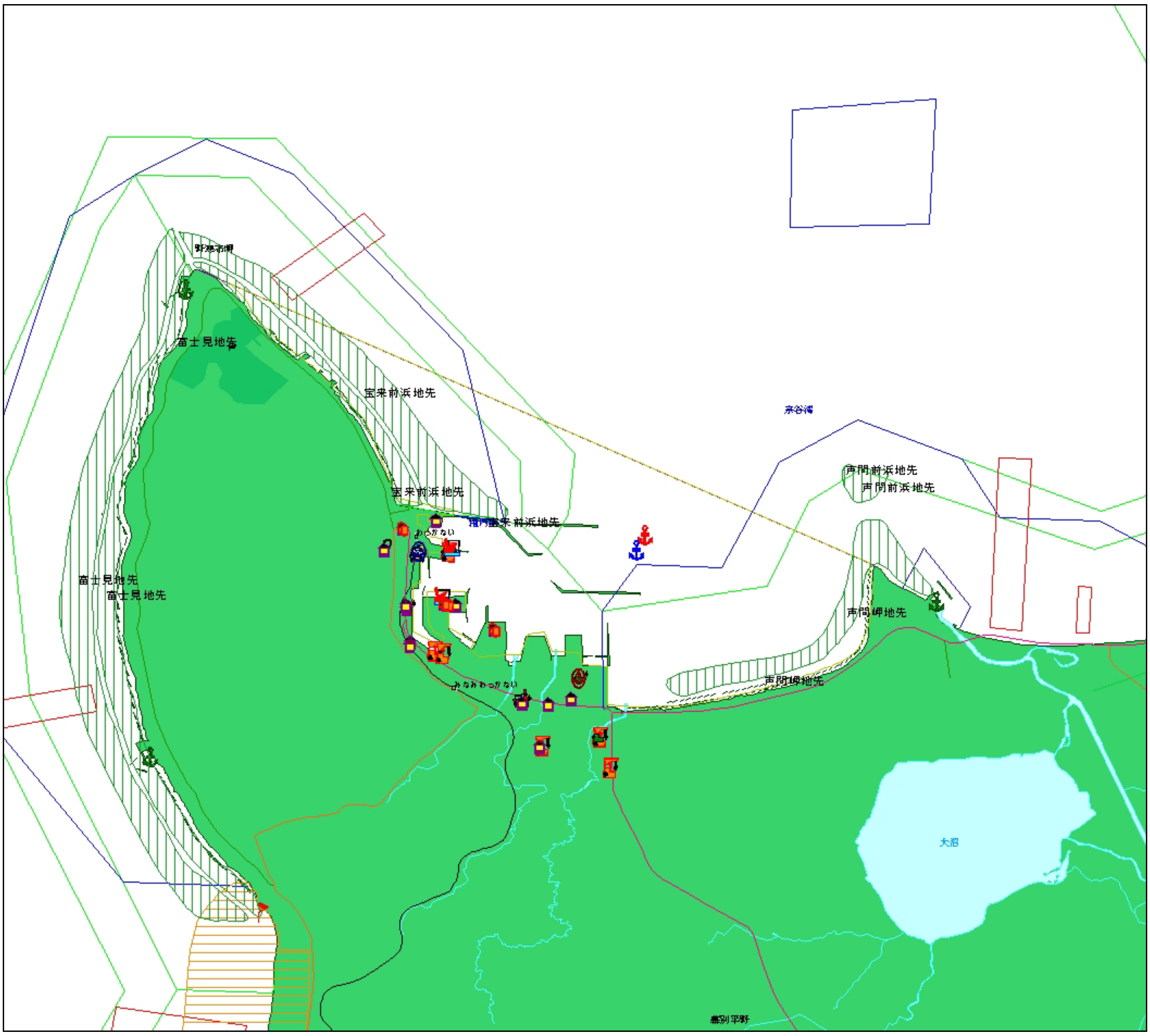
Key to Location of Example Maps (following)

Key to Features on Example Maps (following)

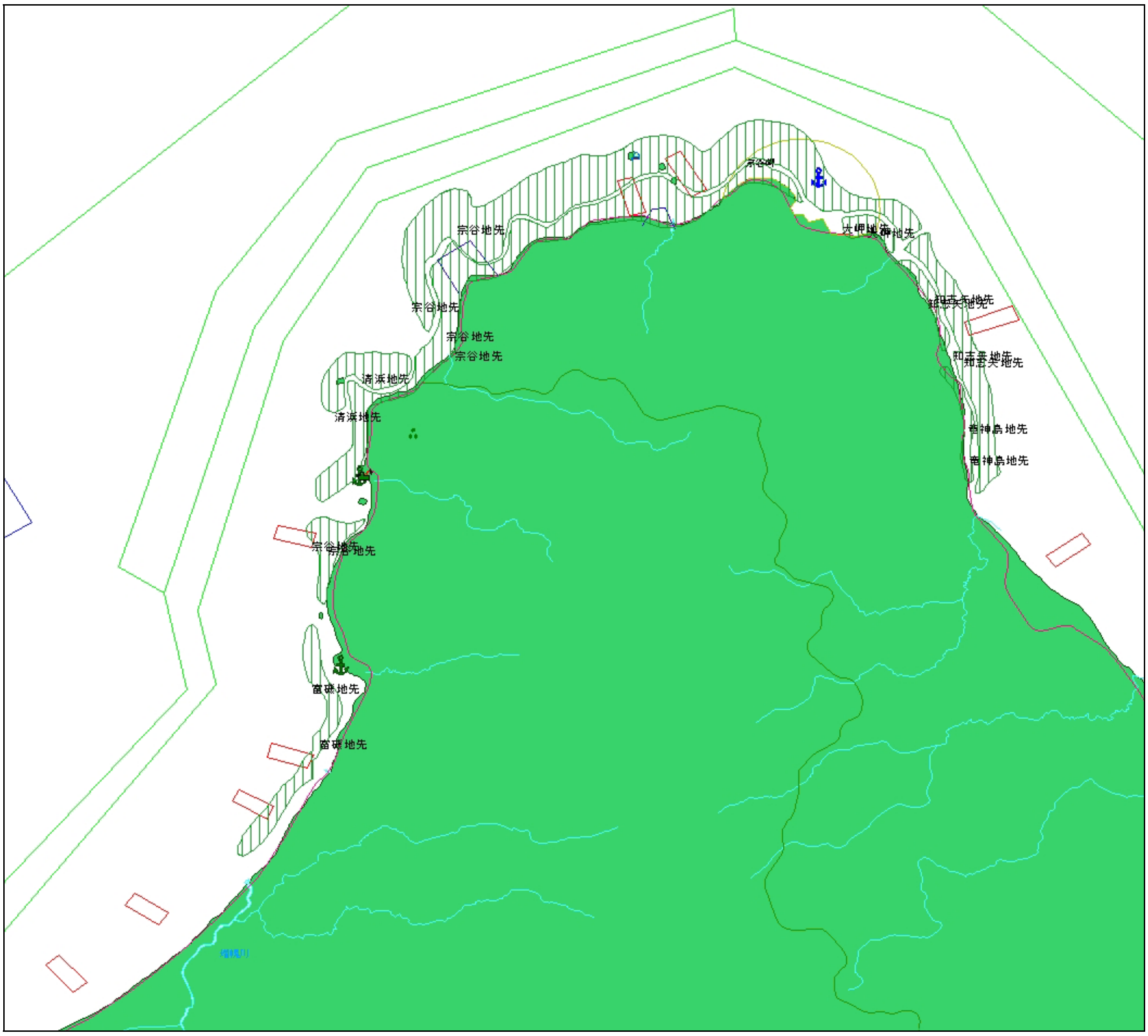
Natural and Physical Features		OSR Facilities and Equipment		Buildings, Sensitive Receptors and Important Features		Demarcated Areas (includes sensitive, administrative, protected areas etc)	
	Sea turtle egg-laying ground		Equipments storage facility		Agency headquarters etc.		Wetland
	Sea animal habitat		Oil fencing boat		Secure department etc.		Algae
	Harbors		Dredger		Aviation station		Ramsar convention registered wetland
	Port rule applied port		Working boat		Communication office etc.		Tidal flat
	Fishing port		Tugboat		Waterway observation point		Quasi-national park
	Power plant		Tank lorry car		Beacon office etc.		National park
	Water i ntake		Oil recovery vessel		Marine traffic center		Coral reef
	Marina		Oil collection device		School		Mangrove
	Seaside resort		High viscosity oil collection net		Industry facilities on coast		Common fishery
	Gathering shellfish place		Oil absorbing car		Natural monument		Demarcated fishery area
	Marine park		Oil collecting vessel		Place of scenic beauty		Drift-net fishing area
	Birds		Waste oil disposal facility		Historic site		Harbor district, port rule applied district, fishing port district port rule applied sea route, U.S. military maneuver district, etc



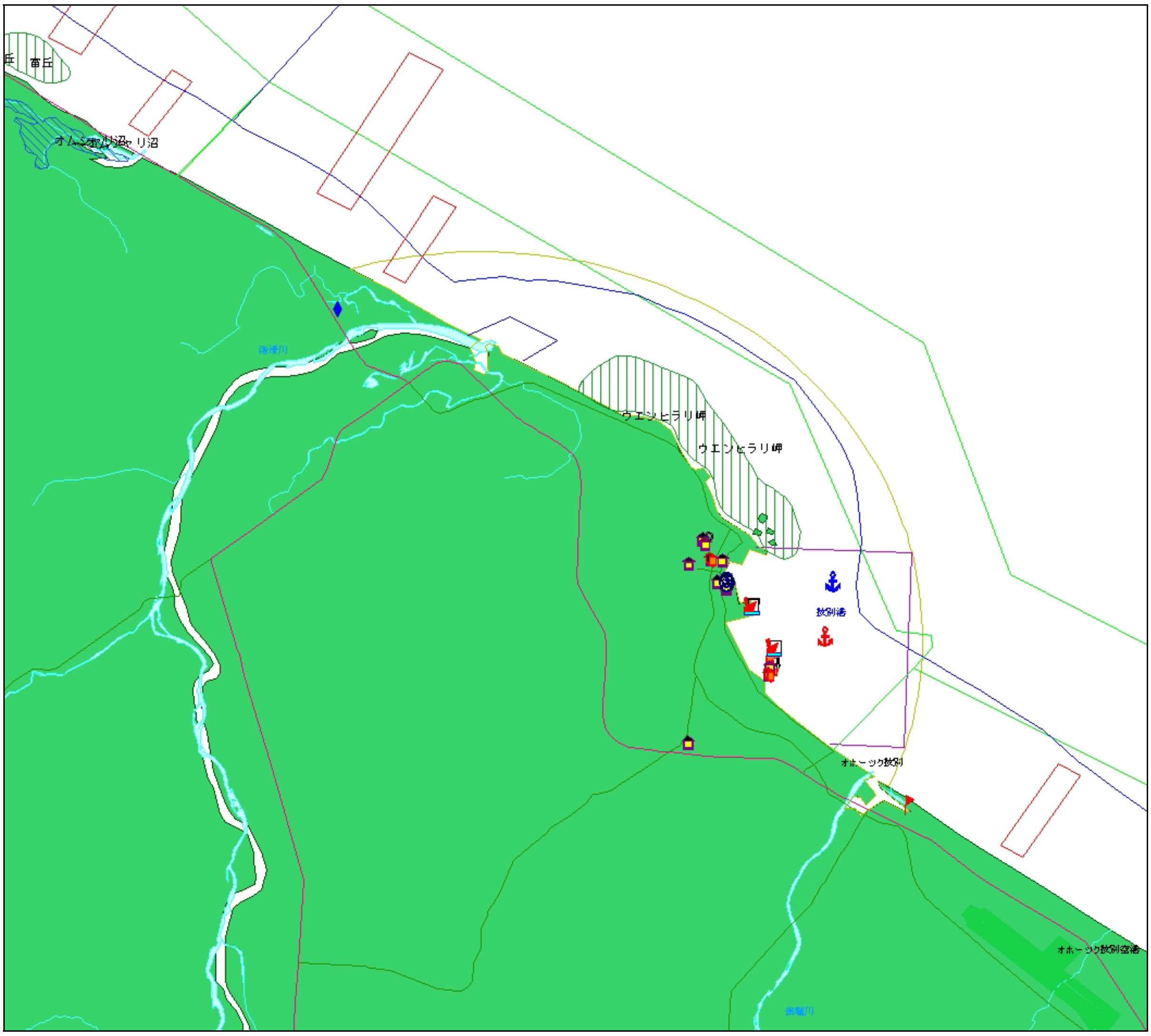
1 – Extract from Rumoi Sensitivity Map



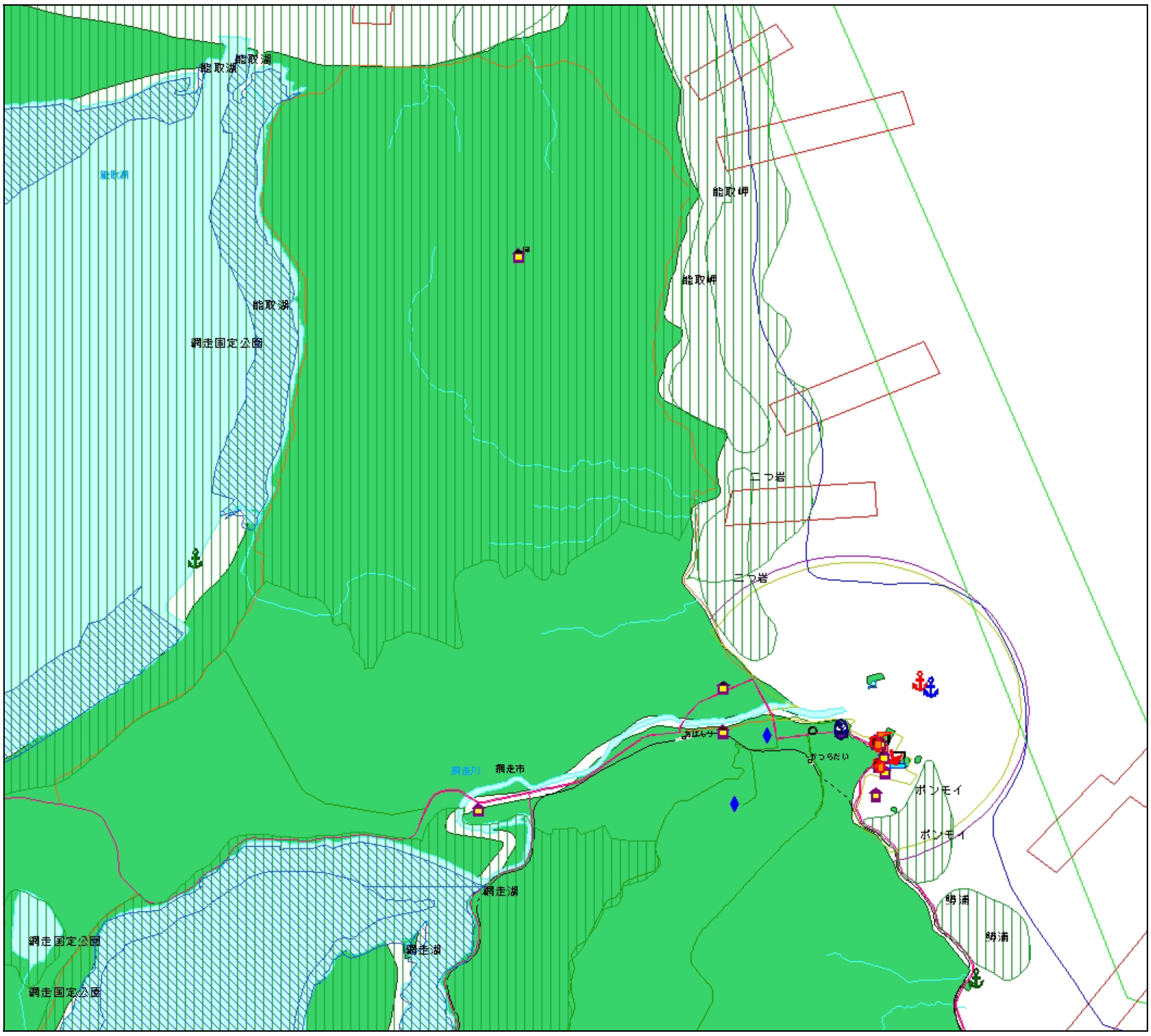
2 – Extract from Wakkanai Sensitivity Map



3 – Extract from Soya Sensitivity Map



4 – Extract from Monbetsu Sensitivity Map



5 – Extract from Abashiri Sensitivity Map

Figure 2.20 Organisation of the RF Emergency Coordination System
(RSChS: Russian Unified Emergency Prevention, Preparedness and Response System)

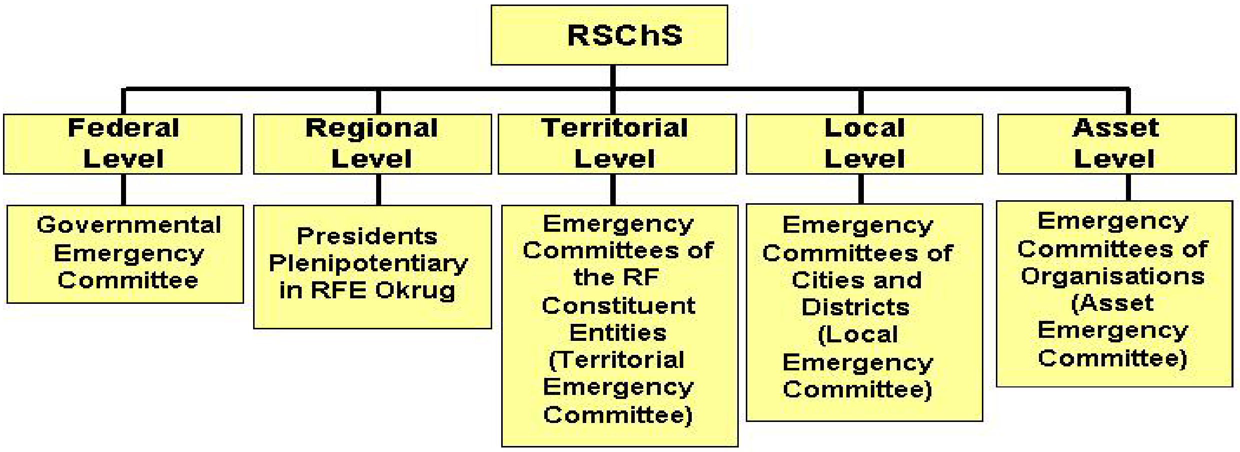


Figure 2.21 SEIC OSRP Organisation (2004)

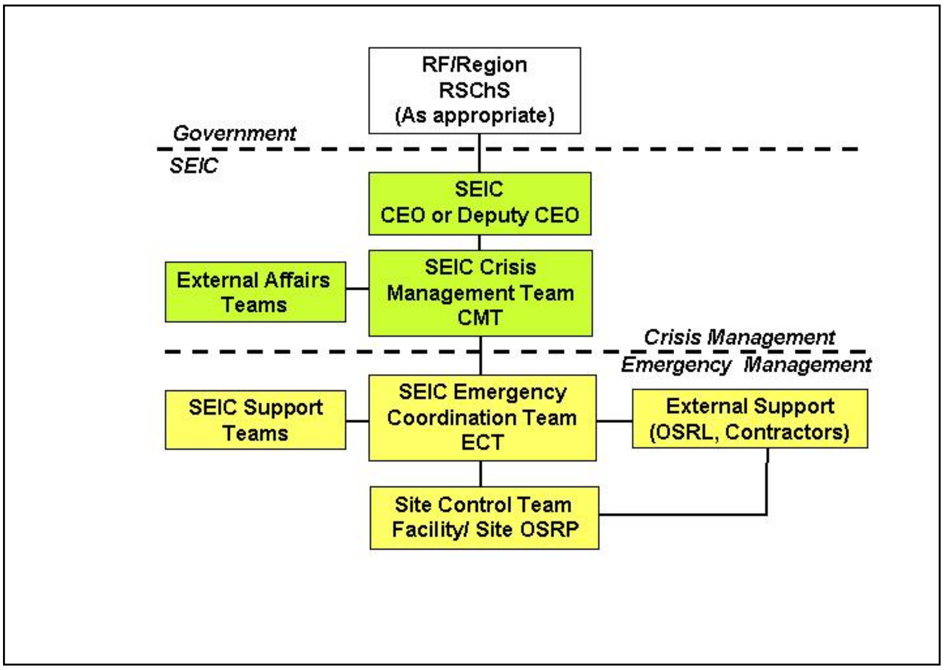


Figure 2.22 Simplified Emergency Coordination Team Structure for Oil Spills

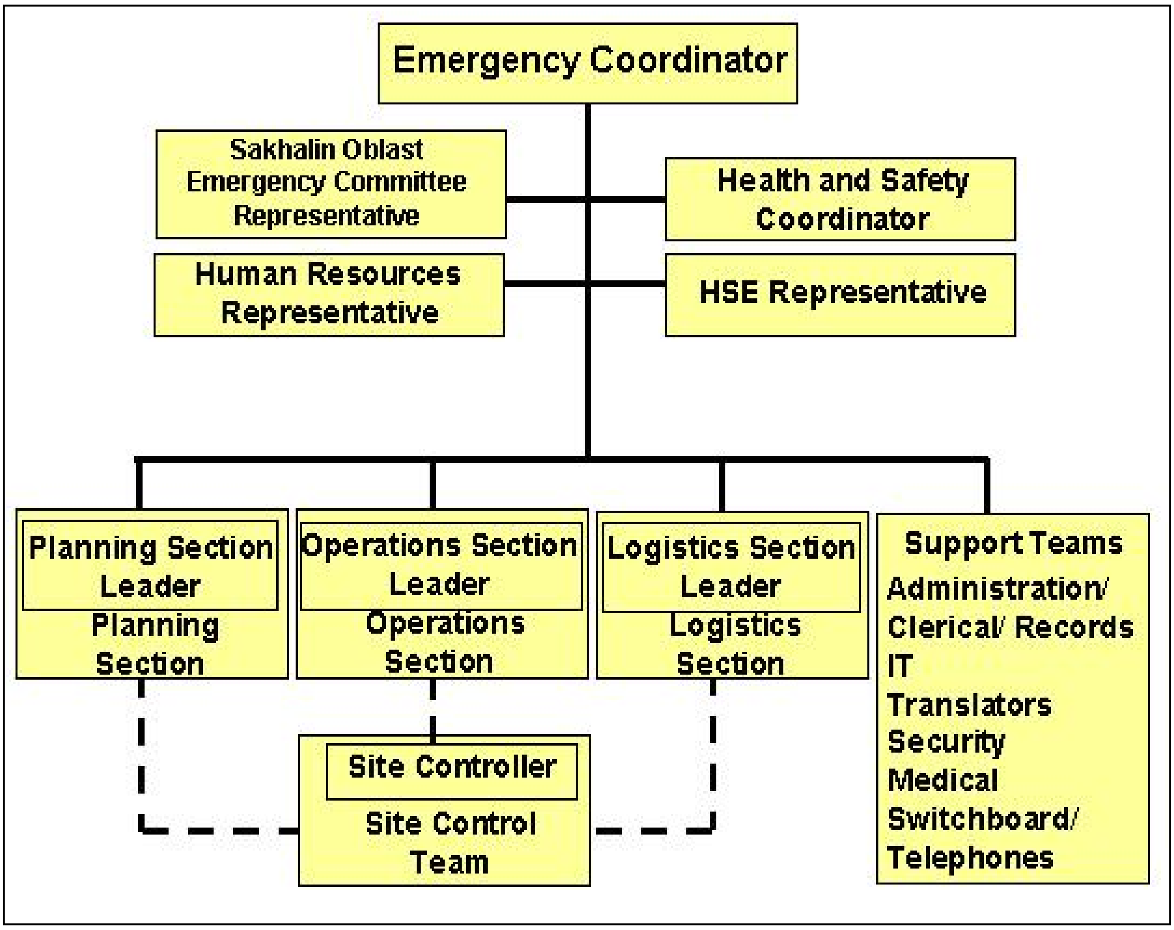


Figure 2.23 Typical Ice Season – Pilton-Astokh

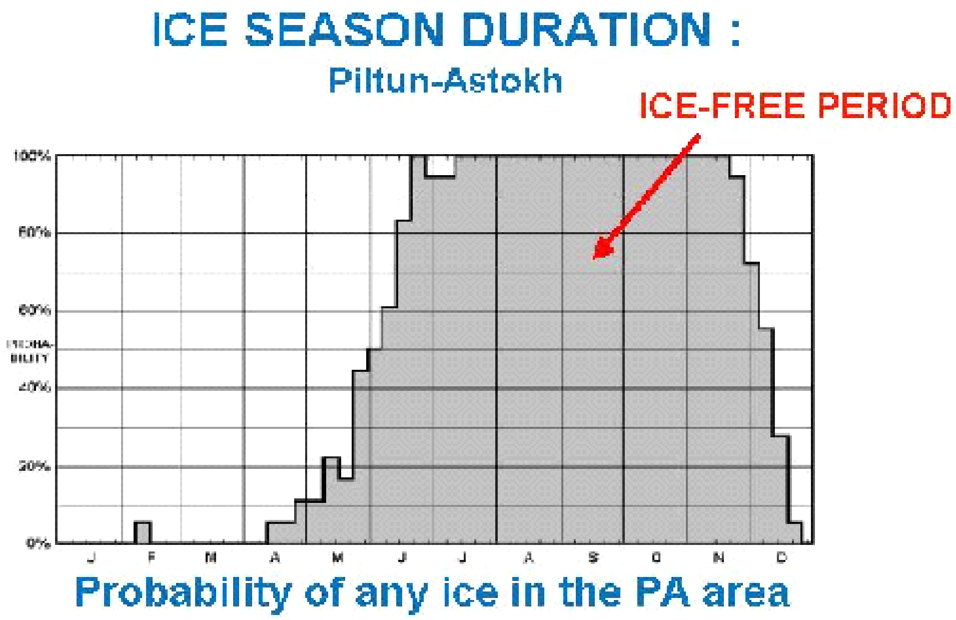


Figure 2.24 Typical Ice Season – Lunskoye

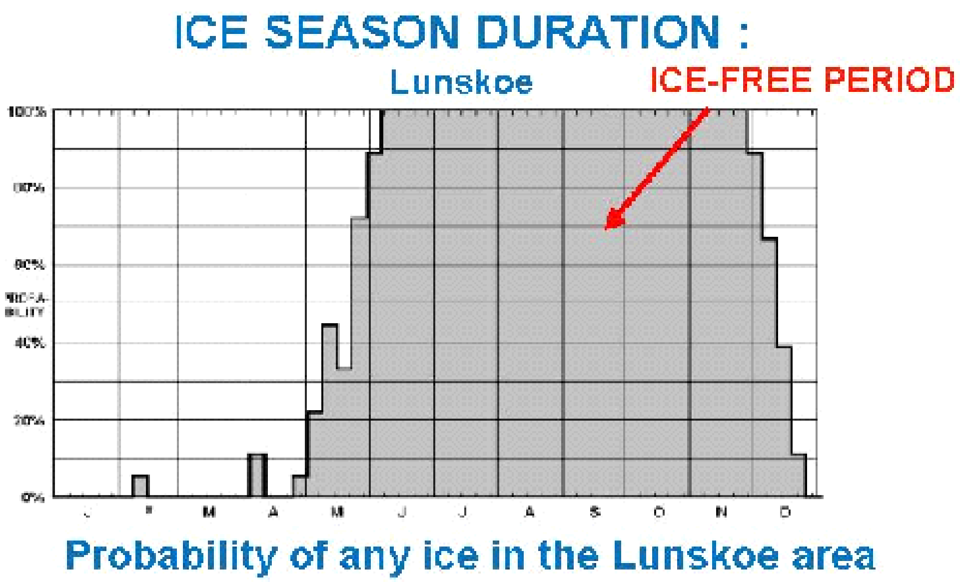


Figure 2.25 Typical Ice Season – Aniva Bay

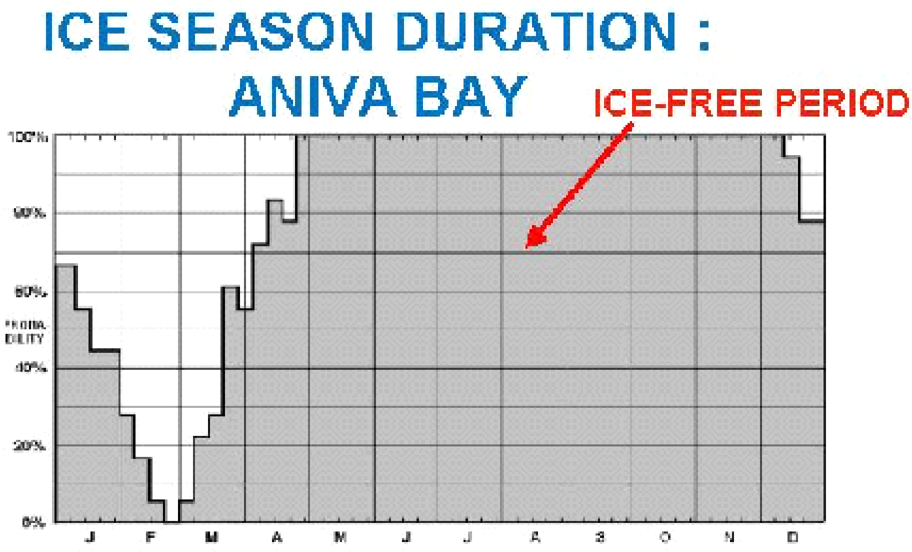


Figure 2.26 Example of Ice Floe Size

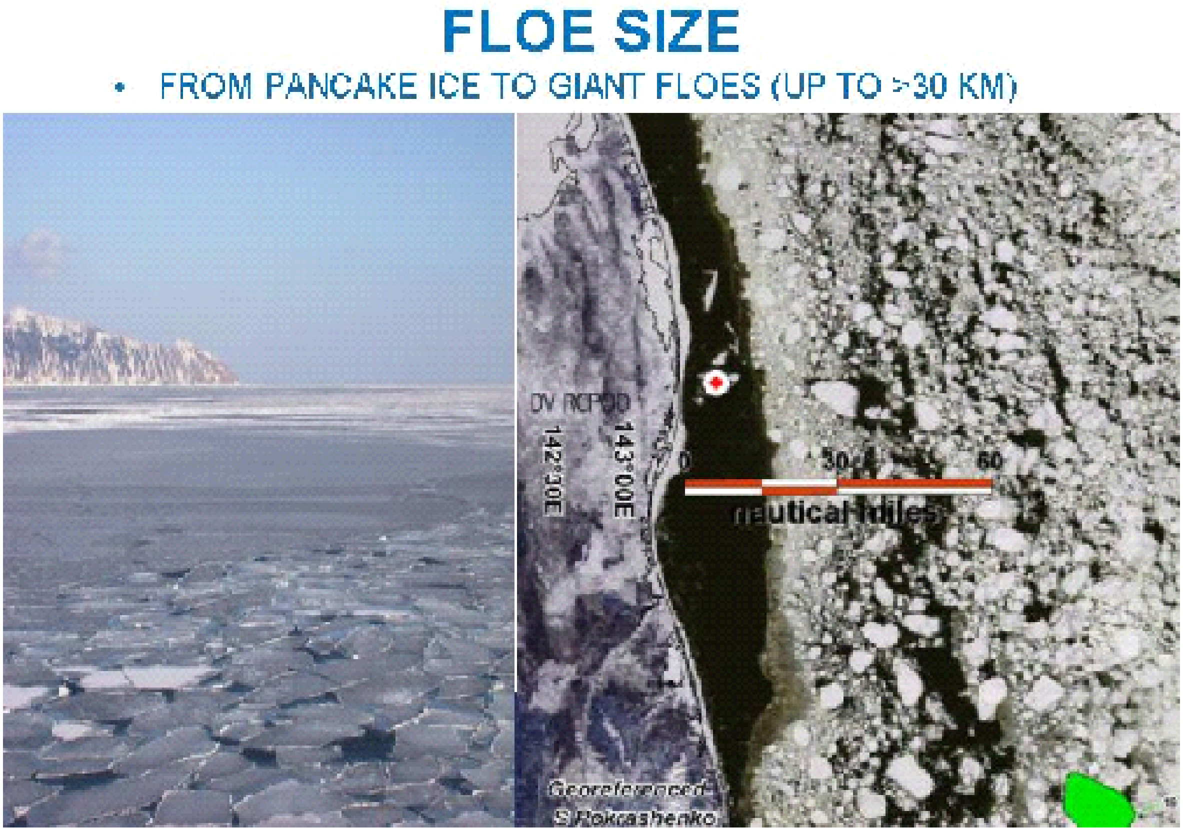


Figure 2.27 Examples of Radarsat Satellite Images

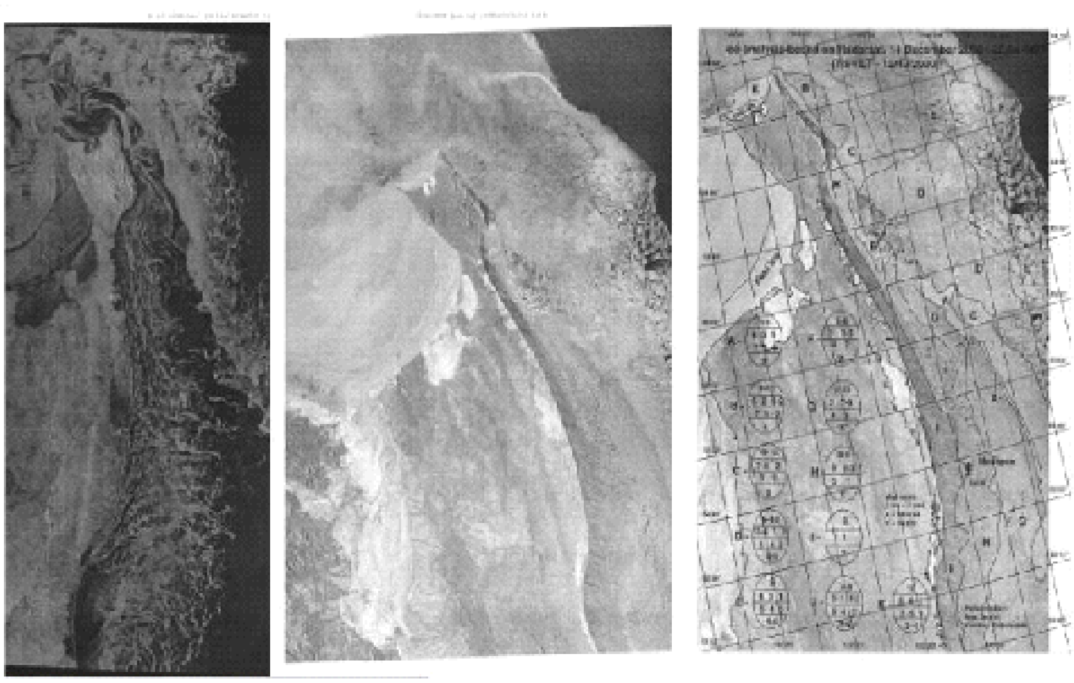


Figure 2.28 Designated Tanker Lane