Chapter 2: Description of Construction Activities

2.1 Introduction

This chapter gives a detailed technical description of all major offshore facilities and activities during the construction phase of the project. The descriptions include programme locations (Piltun-Astokhskoye Licence Area, Lunskoye Licence Area, and Aniva Bay); principal construction activities (platforms, cables and pipelines, beach landing facility, tanker-loading unit, and jetty); construction schedule; and sources of potential impacts (effluents, solid wastes, air emissions, noise, and disturbance). The operations phase of the project is described in the following chapter.

2.2 Project Locations

2.2.1 Piltun-Astokhskoye License Area

The Piltun-Astokhskoye (PA) License Area is located 15-20 km east of the southern end of Piltun Bay and approximately 150 km north of the Lunskoye License Area. It is predominantly an oil field, but contains both associated and non-associated gas. It was discovered in 1986 and has been delineated with three exploration and 14 appraisal wells.

The Piltun-Astokhskoye field structure is well defined through dense 2-D seismic coverage, 3-D seismic data, and the development wells drilled in the area. The PA-A platform is located at 52º42’59”N and 143º33’59”E. It was set in place during the weather window of 1998, and drilling of development wells commenced in late 1998.

The first oil was produced in July 1999, representing the first production under a Production Sharing Agreement (PSA) in Russia and from an offshore platform in Russia. Thirteen oil production wells and one east flank development/appraisal well have been drilled to date. The appraisal well was brought on stream in 2001. A further three in-fill production wells are planned. The PA field features complex geology, including changes to shale and poor continuity of reservoir rocks in terms of quality and thickness. It includes several reservoirs and hydrocarbon accumulations that have been identified or inferred in 15 layers.

2.2.2 Lunskoye License Area

The Lunskoye License Area is a gas condensate field containing the bulk of the gas reserves, which will be dedicated to liquefied natural gas (LNG) production. Lunskoye was discovered in 1984, and has been delineated with seven test wells. The Lunskoye License Area is 27.5 km long by 12.5 km wide, and the structure is divided by faults into six major blocks. The productive horizons are the Daghinsky sandstones and siltstones that were deposited as deltaic and shallow, marine inner to middle shelf deposits. Sixteen productive sandstone and sandy siltstone layers have been drilled and evaluated.

During the period 1998 to 2000, revised structure and reservoir property maps were generated with data from the 1997 3-D survey. The 21,000-km line 3-D survey covered the entire field. However, because of the presence of a gas chimney, an additional 3-D seismic survey is planned for 2003. That survey will be subject to its own EIA. A full field reservoir simulation has been constructed with the revised maps.

Model studies have indicated that the Lunskoye field has the production capacity to meet the average annual offtake of 41-44 million scm/day required to deliver the gas volumes necessary for the LNG plant plus domestic sales and fuel. Approximately 0.35 Tscm is required to meet the needs of a 20-year LNG contract totaling 9.6 mtpa, domestic sales, and fuel.

2.2.3 Aniva Bay

The construction of the LNG plant and the Oil Export Terminal (OET) is going to take place in the Korsakov District of the Sakhalin Oblast on Aniva Bay. These sites will be located between the Mereya River and the Goluboi Creek, in the vicinity of the hamlet of Prigorodnoye, 13 km east of the city of Korsakov, and 53 km to the south of Yuzhno-Sakhalinsk. The Tanker-Loading Unit (TLU) will be located on the continental shelf of Sakhalin Island in Aniva Bay, offshore from Prigorodnoye. The TLU will be connected to the OET by a 5.5-km pipeline. Loading of oil tankers will take place year-round. During operations, there will be regular tanker traffic from a mooring jetty associated with the LNG plant and the TLU to areas outside of Aniva Bay.

2.3 Principal Construction Activities

2.3.1 Platforms

The planned PA-B platform will be located at 52°55'59"N and 143°29'54"E in the Piltun-Astokhskoye field. It will be situated about 20-25 km north of the existing PA-A platform, in a water depth of 30 m. It is anticipated that the platform will start production in the 4th quarter of 2006.

The PA-B platform will be a drilling and oil production platform with accommodation facilities for the operating personnel. The platform is designed for operation throughout the year under extreme weather conditions. The PA-B platform has been designed to meet the following criteria:

- transportation operations and other aspects;
- production of 11,129 m^3 of crude oil per day (70,000 barrels per day);
- gas export rate of $2.6 \cdot 10^6$ Sm^3/d ($92 \cdot 10^6$ scf/d);
- production of 3,975 m^3/day of produced water;
- injection of 19,078 m^3/day of water; and
- transportation of oil and gas.

The maximum annual output will be 3.2-3.4 million t/year of crude oil and about 0.9 billion m^3 of associated gas. Oil and gas produced at the PA-B platform will be processed and then transported southwards to the existing PA-A platform via two underwater pipelines of 14" diameter, and then to shore (Table 2-1).

The planned LUN-A platform will be located at 51°24'55" N and 143°39'44" E in the Lunskoye License Area, where water depth is about 48 m. The LUN-A platform will be a habitable operation and drilling platform designed for year-round operation in ice conditions, low temperatures, winds, waves, and seismic activity. It will be the primary supplier of gas for the LNG plant. Condensate/oil and gas from LUN-A will be sent to an onshore processing facility (OPF).

TABLE 2-1. Main Technical Parameters of the Sakhalin II Project Offshore Pipelines.

Pipelines		Diameter	Length
Gas	Main pipeline from the PA-B platform via PA-A platform to the shore	14"	41 km
Oil	Main pipeline from the PA-B platform via the PA-A platform to the shore	14"	41 km
	Pipeline from the OET to the TLU in Aniva Bay	30"	5.5 km
Multiphase	2 Pipeline from the LUN-A platform to the shore	30"	13.5 km
Regenerated glycol	From the OPF to the LUN-A platform	4.5"	13.5 km

The platform has been designed to meet the following functions:

- production of about 7,949 m^3 of condensate per day, at the OPF outlet;
- production of at least 51.1 million Sm^3 of gas per day;
- production of 2,544 m^3 of oil per day;
- production of 3,180 m^3/day of produced water; and
- transportation of gas and condensate/oil.

The maximum annual output will be ~19 billion m^3 of gas and ~2.9 million m^3 of condensate and oil. The gas condensate and gas produced at the LUN-A platform will be transported to onshore processing facilities via two 30"diameter multiphase pipelines (Table 2-1). A 4.5" diameter offshore pipeline will be used for recycling of regenerated monoethylene glycol (MEG) from the OPF to the LUN-A platform.

Construction and installation of the PA-B and LUN-A platforms will be similar. The platforms would be manufactured outside of Sakhalin, probably in the Russian Far East or Southeast Asia. The GBS (gravity base structure) and the upper structure of the platforms will be towed to their final locations and then connected together. Ground and sand mixture (dredged material) will be used as ballast in an amount of ~150,000 m^3.

The installation of the platforms is planned in stages. First, the GBSs will be towed at a slow pace (a few knots) from a location on the Russian Far Eastern mainland coast or Southeast Asia via the south of Sakhalin Island, and will be positioned at the designated sites (PA-B and LUN-A) on the Northeast Sakhalin shelf. They will be ballasted down on location. The platforms' topsides will then be towed at a slow pace from locations in the Russian Far East or Southeast Asia via the south of Sakhalin Island to the designated sites. The topsides final towing route in the south is partly dependent upon the location of the shipyard, but off north-eastern Sakhalin, the towing route will remain well offshore (probably >20 km) to maintain an adequate bottom clearance. The topsides will be positioned and placed onto the GBSs using float-over techniques. It is anticipated that the installation of each GBS and topside will take ~60 days. The exact timing of the installations has not yet been finalised, but they will occur during the open-water season.

Prior to platform installation, the sites will be leveled, loose sediments will be removed, and a sand and gravel bed provided. The site might be in the form of a circle with a maximum diameter of ~100 m. The maximum volume of excavated material is estimated at 160,000 m^3. High-quality sand and gravel from offshore quarries will be used as fill material for the site preparation. That material will be unloaded through the bottom of barges. In order to protect the ground base against washout and to prevent erosion of the seabed at the base of the jacket, rock scour protection will be placed around the skirt of the jacket itself after the platform is lowered to the seabed. The total volume of material required for the scour protection protective layer is estimated at 15,000 m^3 (~5,000 m^3 of crushed stone and gravel and 10,000 m^3 of rock). The requirement of individual materials will be determined once suitable quarries have been identified. In case of favorable conditions, the amounts of materials to be handled in the process of the site preparation will be much less than the above estimates. The ballast filling of the GBSs will be accomplished by the same dredge via a slurry pipeline system. The operation will take ~6 days for each platform.

2.3.2 Cables and Pipelines

Hydrocarbons will be transported from the three offshore production platforms (PA-B, PA-A, and LUN-A) via offshore pipelines, which include pipelines for oil and gas from the PA-A and PA-B platforms, multiphase pipelines from the LUN-A platform (and a line for transportation of MEG from the OPF to the LUN-A platform), and a pipeline from the OET to the TLU in Aniva Bay (Table 2-1). Pipelines will be constructed from the PA-A and LUN-A platforms westward to the shore.

SEIC anticipates installing the Piltun pipelines during the open-water season in 2004 and the Lunskoye and Aniva Bay pipelines/cables in 2005. The activities will take place primarily from June to September. Table 2-2 summarises the tentative schedule for pipeline/cable installation. Construction activities will be quite intense (estimated at 24 hours per day, seven days a week), involving many vessels and stages.

Trenches 10-190 m wide (at the shoreline) and up to 7 m deep will be excavated along the pipeline routes with a cutter suction dredge (CSD) in shallow waters (< 8-10 m) and a trailing hopper suction dredge (THSD) equipped with jetting nozzles in waters > 10 m. The TSHD has a dredging speed of 1-3 knots, and excavated material is dumped approximately 500 m from the pipeline route. The CSD also works at a slow speed, and the dredged soil is pumped and stockpiled about 450 m from the pipeline route. It is anticipated that at least six vessels will be involved in dredging for approximately 43, 23, and 7 days at Piltun, Lunskoye, and Aniva Bay, respectively (Table 2-2). The operations will be aided by numerous support vessels, which will make periodic visits to the dredging site. Dredging alone will produce strong sources of continuous noise, especially at low frequencies. In the Beaufort Sea, broadband received sound levels from dredges diminished to 115 dB some 4-20 km away. It is uncertain how propagation losses in the Sakhalin area would compare to the Beaufort Sea findings. Another major contributor to the overall noise level associated with dredging is the use of bow thrusters on the Multi-Cat and TSHD vessels.

TABLE 2-2. Summary of the proposed pipeline laying schedule and number of vessels required for installation.

Site	Activity	Year and Month of Occurrence (No. of Days)	Total No. of Days	No. of Vessels Involved[a]
Piltun	Dredging	2004 - Jun (30), Jul (13)	43	6
	Pipeline Laying	2004 - Jul (17), Aug (31), Sept (7) 2005 - May (1), Jun (30), Jul (2)	2004 - 55 2005 - 33	11
	Sand Backfilling	2004 - Aug (15), Sep (21), Oct (8)	44	4
	Rock Backfilling	2004 - Aug (15)	15	3
	Post-trenching	2005 - Aug (15)	15	3
Lunskoye	Dredging	2005 - June (23)	23	6
	Pipeline Laying	2005 - Jul (29), Aug (2)	31	11
	Cable Lay Vessel	2005 - Aug (20)	20	1
	Sand Backfilling	2005 - Aug (17), Sep (10)	27	4
	Rock Backfilling	2005 - Aug (17)	17	3
Aniva Bay	Dredging	2005 - Apr (7)	7	6
	Pipeline Laying	2005 - May (13)	13	11
	Rock Backfilling	2005 - Jun (2)	2	3

[a] These numbers do not include crew transfer vessels, fuel bunkering vessels (2), water bunkering vessel (1), and wastewater bunkering vessels (2).

The next stage is the actual laying of the pipe (and cable in the case of the LUN-A to shore route) in the trench. It is estimated that ~12 vessels will be involved in pipe laying for ~88, 31, and 13 days at Piltun, Lunskoye, and Aniva Bay, respectively (Table 2-3). The lay barge will move forward using winches and heavy anchors; tugboats will place the anchors. Other sources of noise will be diesel-driven cranes, compressors, and generators. It is uncertain whether any of the vessels involved in pipe laying will use thrusters. No radiated noise data apparently exist for pipe-laying operations in shallow water such as off the northeast Sakhalin shelf. The pipe-laying vessels will probably use anchor systems. However, the use of a much noisier dynamic positioning (DP) thruster system has not been completely ruled out. If the marine pipe-laying vessels do use thruster systems to maintain position, then very loud noises will be produced that will be audible to marine mammals for several kilometres Other types of noise associated with handling large pipes and with the vessel's gas turbine generators are not specifically known and are difficult to estimate. When the pipe-laying vessel is re-supplied with pipe by another supply vessel (presumably with bow thrusters), near-field cumulative sound levels (i.e., overall received levels at some places within the near field) could be as high as 177 dB re 1 μ Pa rms. Continuous broad-band sounds will be transmitted through the

vessel's hull from the gas turbines used to produce power for pipe welding station(s), movement of pipe sections and the welded pipe string, and other shipboard sounds.

TABLE 2-3. Summary of the types of vessels and sources of noise involved in pipeline/cable laying at the Piltun, Lunskoye, and Aniva Bay sites.

Activity/Vessel Type	No. of Vessels [c]	Estimated Duration of Construction (No. of Days)			Sources of Noise
		Piltun	Luns-koye	Aniva Bay	
Dredging					
Cutter suction dredge [a]	1	43	23	7	2 main engines, 2 aux. engines, 1 inboard dredge pump, 1 submerged dredge pump
Trailer hopper suction dredge [b]	1	43	23	7	2 bow thrusters, 2 main engines, 2 aux. engines, 2 inboard dredge pumps, 2 shore delivery pumps, 2 jet pumps
Tug	1	43	23	7	2 main engines, 1 pump, 2 generators
Multi-cat vessel	2	43	23	7	2 bow thrusters, 2 main engines, 4 generators
Survey vessel	1	43	23	7	?
Pipeline Laying					
Lay barge	1	88	31	13	3 cranes, 1 generator, 5 compressors, 3 pumps, 5 welding groups, 4 GE 700 KVA, 2 GE 1600 KVA
Anchor handling tug	2	88	31	13	?
1500 T Carry. Capicity Vessel	3	88	31	13	?
DSV vessel	2	61	24	10	?
Support tug	2	88	31	13	?
Survey vessel	1	88	31	13	?
Cable lay vessel	1	0	20	0	?
Post Trenching					
Jetting support vessel	1	15	0	0	?
Jetting sledge	1	15	0	0	?
Survey vessel	1	15	0	0	?
Sand Backfilling					
Anchor handling tug	1	44	27	0	?
Cutter suction dredge	1	44	27	0	See above
Backfilling vessel	1	44	27	0	2 bow thrusters, 1 main engine, 1 aux. engine, 4 pumps
Survey vessel	1	44	27	0	?
Rock Backfilling					
Positioning pontoon (crane)	1	15	17	2	1 crane, 4 generators
Anchor handling tug	1	15	17	2	?
Tug	1	15	17	2	2 main engines, 1 pump, 2 generators

[a] This dredge will operate in waters < 8-10 m.

[b] This dredge will operate in waters > 10 m.

[c] These numbers do not include crew transfer vessels (??), fuel bunkering vessels (2), water bunkering vessel (1), and waste water bunkering vessels (2) that will periodically service the other vessels.

Pipeline post-trenching will be performed at the Piltun sites during a period of ~15 days. That will be accomplished with a jetting sledge pulled at the surface by a dedicated vessel. No acoustic recordings are available for such a procedure, to the best of our knowledge. The trenches will be backfilled with sand and rock at the Piltun and Lunskoye sites, and with rock only at the Aniva Bay site. That will involve the use of a dredge and vessels that use bow thrusters.

2.3.3 Beach Landing Facility

Even though the main technical facilities of the OPF will be assembled at the site, some elements will be delivered in the pre-assembled form. The largest of the pre-assembled elements could have a weight of 600 t. The existing land transportation routes on the island are inadequate to handle such cargoes. Furthermore, there is no port facility at the OPF location, and the nearest port (Kaigon), some 35 km to the north, cannot be used because it cannot handle such cargo, and transport routes are inadequate.

Therefore, a temporary landing facility is required to facilitate the construction of the OPF. Engineering details are still being finalised. One option is that two parallel sheet pile walls will be built from the coastline into the sea and filled with dredged material from outside the structure. The OPF structural elements will arrive via sea freight, barge, or vessel, and offloaded at the landing facility. Upon completion of the transport operations, the beach-landing facility will be dismantled, and the site will be restored.

The beach landing facility at Lunskoye will be at least 500 m from the pipeline landfall. Construction will begin in 2003, but marine-based works will not begin until 2004. Dredging will be required to install a temporary beach landing pier and approach channel to the Lunskoye beach landing facility. At this time, it is uncertain what type of dredge vessel will be used. The construction of the channel will take two to three weeks during the ice-free season. Sheet walls along the channel and for the pier will be installed by pile driving.

Pile driving is likely to be the construction activity that produces the loudest noises that may effect marine mammals. Dredging also produces strong sounds, especially at low frequencies.

2.3.4 Tanker-loading Unit

The TLU will be a small, steel gravity-based, fixed loading structure. It will be located in Aniva Bay, ~5.5 km offshore from the town of Prigorodnoye, in which vicinity the LNG plant and the onshore facilities of the OET will be constructed. The port of Korsakov is located ~18 km to the east. To allow for full loading of tankers with a maximum loading capacity of 150,000 t, the design water depth at the TLU is ~30 m (at lowest astronomical tide). The TLU location was selected based on navigational criteria and current knowledge of the seabed conditions. The TLU will be connected by a 5.5-km subsea pipeline to the OET. The TLU will be designed to handle conventional crude oil tankers of opportunity without specialised vessel-loading equipment during the ice-free season. During the ice season, specialised tankers equipped for bow loading will be required. The terminal will be designed to allow the complete loading operations, including mooring, loading, and leaving the mooring within 24 hours, in line with other loading terminals.

Preliminary investigations for the TLU resulted in the determination that a gravity-based fixed tower to resist ice loading and to protect the loading hoses would be the most suitable design for this location; however, piled alternatives were also considered. The tower will support a rotating head containing the tanker mooring equipment, crude oil swivel, and transfer hose string configurations. The TLU will be capable of handling two hose string configurations, one for use during the ice-free season (connection to central manifolds) and one for use during the ice season (connection for bow loading).

The TLU will be towed by tugboats to the site during July and August 2005, and the gravity-based fixed tower will be installed in August and September 2005. After positioning of the TLU, it will be lowered to the seabed by flooding the tanks of its base and tower. Installation of the TLU will require dredging to remove unsuitable material from the seabed and perhaps to deepen the seabed. It is uncertain what type of dredge vessel will be used and how many support vessels will be involved in the TLU installation. Then the tanks will be filled with solid ballast using a ballasting vessel (equipped with a slurry pipeline), which may take ~18 days.

The rotating head will then be hoisted by means of the floating crane and installed on the tower. The central support section of the rotating head will be welded to the tower. The final stage will be provision of a protective riprap, preventing washout of the material at the base of the structure and investigation of the seabed to confirm the completion of the TLU installation. Electric power supply and technical maintenance of the TLU, including preventive maintenance and repair, will be provided from the onshore facilities of the OET. Electric power will be supplied via a seafloor cable line laid along the oil pipeline.

2.3.5 Jetty

In Aniva Bay, a jetty 850 m long will be constructed to facilitate LNG plant operations. Dredging will be necessary to create an approach channel and turning basin (600-m diameter) for LNG carriers. Dredging will also be required to install the caissons that support the jetty. The exact schedule for the jetty construction (most likely during the open-water season) and the number and types of vessels required are presently unknown.

2.4 Sources of Potential Impacts

2.4.1 Air Emissions

Mobile air emission sources (vessels, dredges, aircraft) used during towing of the PA-B and LUN-A platforms, and for construction and installation work, will be potential sources of impact, because they emit exhaust gas from engines. The duration of the potential impact during towing and construction is approximately 35 days and 2 months, respectively. The total amount and the intensity of emissions during construction will be much lower than during the platform operation stage.

The following air-polluting substances are expected to comprise emissions:

- CO;
- CO_2;
- Nox;
- SO_2;
- Hydrocarbons; and
- Particulates.

The engineering measures intended to reduce the volume of air emissions and the concentrations of air pollutants potentially including the following:

- use of low-emitting turbines;

- minimisation of flaring;
- use of seals on pumping equipment;
- installation of relief valves protecting the platform equipment from pressure surges; and
- automatic and remote shut down of pumping units in case of accident, fire, or excessive air pollution.

2.4.2 Wastewater

Wastewater will be generated during various phases of construction. Wastewater from vessels will consist of components typical of all marine vessel operations, including engine cooling water and greywater. Other anticipated sources of effluent from the construction phase are:

- domestic sewage and greywater from construction camps and construction sites;
- vehicle and machinery washdown water;
- hydraulic testing of pipelines and tanks; and
- excavation dewatering.

The first three sources of effluent (sewage, vehicle wash, and hydrotest water) normally contain substances with the potential to contaminate groundwater and impact watercourse biology. Although most of the aforementioned effluents will be generated onshore, there is the potential that they might drain into the sea and affect the western gray whale feeding area.

2.4.3 Noise and Disturbance During Construction

All of the underwater construction activities of the Sakhalin II project will introduce noise into the environment and have the potential to disturb western gray whales. Noise will be introduced into the marine environment from the following construction activities:

- pipeline/cable installation;
- GBS and topsides installation;
- construction of a landing pier and approach channel;
- construction of a jetty;
- TLU installation;
- numerous supply vessels used to support the above construction; and
- helicopters and fixed-wing aircraft.

Noises from those sources may be water-borne, air-borne, or *via* subsurface vibrations, and may be transmitted directly through water or indirectly through the ground or air and then through water. Noise measurements do not exist for many of the proposed construction activities, and there is very limited information on propagation loss in the waters around Sakhalin Island. Also, it is uncertain how the presence of numerous construction activities in a small area will contribute to overall noise levels. Table 2-4 lists some of the noise sources often associated with offshore oil/gas development projects

(from Lawson et al. 2001). Most data in Table 2-4 are taken from the 1/3rd-octave band level summaries of Malme et al. (1989), summarised in Table 6.9 of Richardson et al. (1995).

TABLE 2-4. Summary and comparison of source levels for a variety of sources of man-made under-water noise (adapted from Lawson et al. 2001).

	Source levels, dB re 1 µPa at 1 m							Highest Level		
		1/3rd octave Band Centre Frequencies (kHz)						1/3rd octave band		
Sound Source	**Broad band (45-7070 Hz)**	**0.05**	**0.1**	**0.2**	**0.5**	**1**	**2**	**Freq.**	**Level**	**Strong infra-sonics?**
Transient Sources										
Super Puma helicopter takeoff[a]	-	112	96	94	90	90	86	16	122	Yes
Super Puma flyover at 305 m[a]	-	98	96	85	88	88	85	20	109	Yes
Sik-61 helicopter flyover at 305 m[b]	108	97	94	97	97	91	88	25	98	Yes
Bell 212 helicopter flyover	162	154	155	151	145	142	142	22	159	Yes
Seismic airgun array (32 guns)	216	210	209	199	184	191	178	50	210	Yes
Pile driving on Scotian Shelf[c]	165	134	145	158	154	141	136	250	159	Yes
Supplier III vessel thruster (900 HP)	190	176	182	173	169	168	164	50	184	Yes
Military search sonar	230+ pk-pk	0	0	0	0	0	0	2-5000	230+	No
Continuous Sources										
Tug and barge, 18 km/h	171	143	157	157	161	156	157	630	162	Yes
5-m Zodiac	156	128	124	148	132	132	138	6300	152	No
Supply ship (*Kigoriak*)	181	162	174	170	166	164	159	100	174	Yes
Large tanker underway	186	174	177	176	172	169	166	100+ 125	177	Yes
Kulluk Drillship (45-1780 Hz)	185	174	172	176	176	168	-	400	177	No?
Canmar Explorer II Drillship	174	162	162	161	162	156	148	63	167	No?
Sedco J jackup rig during drilling[d]	59	55.9	54	55.6	46.9	-	-	16	62.5	-
Sedco J during highlevel tripping[d]	68	61.2	65.2	68	56.4	-	-	200	68	-

Note that some sources also emit strong sounds at frequencies below 45 Hz, not considered here.

[a] Brueggeman et al. 1990 (note that these data are *received levels*).

[b] These data are *received levels*.

[c] Scotian Shelf pile driving recording by Greene and Davis (1999) and RAM model verification by Malme et al. (1998). The hammer impacts occurred in air. Values are for received levels at 1.5 km.

[d] Buerkle (1975). The *Sedco J* jackup rig operated in 63 m of water; it may have had a rotary drill table; "tripping" occurs when the drill string is pulled from the hole, the bit changed, then the string is lowered back in the hole; the drill bit was operating at 2440 m.

The main noise sources associated with construction/installation activities of the Sakhalin II project are discussed below. Because underwater noise propagates for long distances, the potential zone of influence around a particular activity can be many tens of kilometres in

radius. The zone of influence of underwater noise at the construction areas includes zones around the development area, shipping routes between the supply base and offshore sites, and the helicopter flight routes between mainland and the platforms and vessels.

2.4.3.1 Dredging

Dredging will produce strong sources of continuous noise, especially at low frequencies. In the Beaufort Sea, broadband received sound levels from dredges diminished to 115 dB some 4-20 km away. It is uncertain how propagation losses in the Sakhalin area would compare to the Beaufort Sea findings. Another major contributor to the overall noise level associated with dredging is the use of bow thrusters on the TSHD vessels.

2.4.3.2 Pipe and Cable Laying

It is estimated that approximately twelve vessels will be involved in pipe and cable laying; that may take approximately 88, 31, and 13 days at Piltun, Lunskoye, and Aniva Bay, respectively (Table 2-3). Should a marine pipe-laying vessel be used that has a thruster system to maintain position, high sound energy may be produced that could cause reactions by whales as much as several kilometres away (Greene 1987; Brueggeman et al. 1990). Estimates of the levels of noise produced by dynamic-positioning (DP) thrusters, based on their physical characteristics, have been made for some specific situations (Lawson et al. 2001). Other types of noise associated with handling large pipes and the vessels' turbine generators are not specifically known and are difficult to estimate. When the pipe-laying vessel is re-supplied with pipe by another supply vessel (presumably with bow thrusters), near-field cumulative sound levels (i.e., overall received levels at some places within the near field) could be as high as 177 dB re 1 μPa rms. Continuous broadband sounds will be transmitted through the vessel's hull from the gas turbines used to produce power for pipe welding station(s), movement of pipe sections and the welded pipe string, and other shipboard sounds. High sound energy will also be produced by dumping gravel/rockfill as erosion protection around the pipelines.

Pipeline post-trenching may be performed at the Piltun sites during a 15-day period. That will be accomplished with a jetting sledge pulled at the surface by a dedicated vessel. To the best of our knowledge, no acoustic recordings are available for that procedure.

2.4.4.3 Tug-tow of offshore facilities from the Fabrication Yard

The platforms' GBSs and topsides will be towed by four tugboats at a slow pace (a few knots) from a location on the Russian Far Eastern mainland coast or Southeast Asia via the south of Sakhalin Island to the designated sites (PA-B and LUN-A) on the Northeast Sakhalin shelf. The TLU will be towed by tugboats to a site 5.5 km offshore in Aniva Bay during July and August 2005. Most of the noise associated with these activities will arise from tugboats (discussed in a later section).

2.4.4.4 Installation of Offshore Platforms

Installation of the GBSs at the platform sites will generate noise. The most significant source of underwater sound produced during platform installation likely will arise during dredging, which may be necessary for site preparation. Metal riveting and crane operations would emit intermittent sounds during installation of the topside modules and other structures, with in-air source sounds from a riveting machine likely equal to or less

than 110 dB re 20 μPa-m (from Fig. 3 in Solar Turbines Incorporated [1998]; not reported if this was a peak level). Given the height of the platform above the water and the sound-dampening nature of concrete, there will be significant loss of sound strength during propagation to the sea surface, and below. SEIC plans to construct most of the topside structures at shore locations, and then transport these almost-complete components to the PA-B and LUN-A sites to be installed on top of the support structures. That will reduce the amount and duration of construction sound to which marine mammals would be exposed to.

2.4.4.5 Pile driving

During installation of a temporary beach landing pier and approach channel to the Lunskoye beach landing facility, dredging and pile driving will occur. The construction of the channel will take between two to three weeks during the ice-free season. Sheet walls along the channel and for the pier will be pile driven into place. Pile driving will also be required for installation of the jetty at Aniva Bay. Pile driving is likely to be the construction activity that produces the loudest noises that may affect whales.

2.4.4.6 Vessels and Aircraft

Numerous vessels (tugboats, barges, supply vessels, etc.) will be used to support the construction activities. Vessel traffic will be a frequent, and at times, a continuous source of sound. Supply and service vessels (tugboats, barges, etc.) of various sizes will operate near the platforms, along the pipeline route, and at landing sites, and many will possess thrusters used to assist manoeuvring. Thrusters are propellers located below the water line, that may be mounted in tunnels running crosswise through the vessel's hull, or hung below the vessel's hull. Many of the vessels will occur in a relatively small area at the same time, which will increase overall noise levels.

Vessel noise also includes strong tonal sounds at low frequencies, with the specific frequencies being determined by propeller rotation rate and the number of propeller blades (Ross 1976). Propulsion and auxiliary machinery can also radiate significant noise. Overall, the sounds are often strong enough to be detected tens (and occasionally hundreds) of kilometres away. Radiated noise is roughly related to vessel size, speed, and mode of operation. Large vessels (e.g., supertankers) tend to be noisier[2] than small ones, and vessels underway with a full load (or towing or pushing a load) produce more noise than unladen vessels (Greene and Moore 1995). Noise also increases with vessel speed. Propeller cavitation produces most of the broadband noise, with dominant tones arising from the propeller blade rate. Propellers create more noise if damaged, operating asynchronously, or operating without nozzles. Propulsion and auxiliary machinery can also radiate significant noise.

Most helicopter use will occur during operations to transfer crew and supply to the offshore platforms. Noise from helicopters is discussed in the next section.

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[2] Broadband source levels of supertanker noise can exceed 205 dB re 1 μPa-m if infrasonic components down to ~2 Hz are included. Low-frequency noise levels from large container ships can also be high (Greene and Moore 1995).