by a 120 m container ship passing within 100 m in spite of the fact that they were apparently able to hear it (Nowacek et al. 2004).

Fin Whale

The fin whale was recently confirmed as a species of Special Concern in May 2005 and is listed as such on Schedule 1 of *SARA*. This species is commonly found on the Grand Banks and in coastal waters of Newfoundland's south coast during summer months (Piatt et al. 1989) and is often associated with the presence of capelin. Historical whaling records show that the fin whale was by far the most hunted whale species with over 10,000 whales taken in the first half of the 20th century (Sergeant 1966 in Lawson 2006). There is no reliable population estimate for fin whales that occur in Newfoundland waters. Recent genetic studies indicate that fin whale populations that summer in Nova Scotia, Newfoundland, and Iceland may be genetically distinct from each other (Arnason 1995). For the area between Georges Bank and the mouth of the Gulf of St. Lawrence the best available population estimate is 2,814 individuals (CV = 0.21) and for the Gulf of St. Lawrence about 380 individuals (COSEWIC 2005). For Newfoundland waters, the best available information is based upon recent aerial surveys conducted by DFO. Aerial surveys were conducted in mid September to October 2002 and 2003 in the coastal waters of Newfoundland. Most survey transects extended from shore to at least 172 km. Total survey effort was approximately 11,000 km (Lawson 2006). There were 12 confirmed sightings of fin whales (29 individuals); two occurred along the south coast of Newfoundland but not within the Study Area. For coastal areas of Newfoundland, preliminary analyses yielded a density estimate of 0.006 fin whales per km^2 and an uncorrected point estimate (for September/October) of 1,103 fin whales (95 per cent CI: 459-2654). It is expected that density estimates would be higher during July and August. A fin whale density of 0.007 individuals per km^2 was observed during an aerial survey conducted in Placentia Bay on 6 August 1980 (Hay 1982). It is acknowledged that more reliable and wide-ranging surveys are required for better estimates of fin whale numbers in Newfoundland waters (J. Lawson, DFO, pers. comm.) and in the northwest Atlantic as a whole (Waring et al. 2004).

One fin whale was identified during recent boat-based surveys in Placentia Bay. The sighting occurred on 3 August 2006 east of Placentia (Table 3.32; Figure 3.82; Abgrall and Moulton 2007). It is expected that fin whales would be more numerous in June and July.

It is generally assumed that fin whales, like other baleen whales that occur in Atlantic Canada, migrate between foraging habitat in the north and calving/breeding grounds in the south. However, year-round observations of fin whales in areas like eastern Nova Scotia suggest that not all individuals within a population complete a full migration route each year (COSEWIC 2005). Fin whales have been reported in the Study Area from March to August (DFO, unpubl. data). Like other balaenopterids, migration is segregated and in the case of fin whales, pregnant females typically initiate seasonal movement, followed by adult males, resting females and lactating females. Juveniles are the last to migrate (Aguilar 2002).

Little is known about the distribution and movements of fin whales off Newfoundland during the fall, winter and spring after they leave inshore foraging areas (Hay 1982). During summer they are known to occur in coastal areas of Placentia Bay where they forage (Marques 1996; see Figure 3.81). Boat-based surveys conducted in June and July of 1993 and 1994 off the southeastern coast of Placentia Bay, found that fin whales accounted for 25.8 per cent of the 349 baleen whale sightings. Fin whales were sighted in shallower waters (and closer to shore) than humpback and minke whales and fin whale abundance appeared to peak later in the season. Relatively few sightings have been reported for the central and western portions of Placentia Bay (Figure 3.81) but this is likely related to observation effort. Marques (1996) suggests that fin whale inshore abundance in Newfoundland has increased, based on sighting rates in 1993-94 vs. the early 1980s. Fin whale abundance in Placentia Bay (mean: 0.53 fin whales/hour) was much higher than that reported in 1982-85 (mean: 0.11 fin whales/hour; Piatt et al. 1989). Based upon DFO's sighting database, fin whales were most commonly reported in June (41.9 per cent of 93 fin whale sightings), followed by July (31.2 per cent) and August (14.0 per cent; DFO, unpubl. data).

Breeding and calving are thought to occur during winter at lower latitudes. Gestation is 11-12 months and calves nurse for about six months. The generation time is estimated at 20-30 years (COSEWIC 2005).

The predominant prey item of fin whales in waters off Newfoundland is capelin (Whitehead and Carscadden 1985; Piatt et al. 1989). In Placentia Bay, fin whales are also known to feed on euphausiids and mackerel (Marques 1996). Fin whales sometimes travel in groups of 2-7 individuals (Aguilar and Lockyer 1987 in COSEWIC 2005) and larger aggregations can occur in feeding aggregations; these larger groups last for only a short period of time. Fin whales are known for their fast swimming speeds; their normal traveling speed is 5-8 knots and they can sustain speeds of 15 knots for short periods of time. Dives typically last 3-10 minutes and usually are limited to depths of 100-200 m (Aguilar 2002).

Harbour Porpoise

The harbour porpoise is found in shelf waters throughout the northern hemisphere, usually in waters colder than 17°C (Read 1999). The northernmost limit of their range is 70°N, but they are present in northern coastal waters only during the summer months (IWC 1996).

Harbour porpoises can be divided into genetically different subpopulations within the western North Atlantic. These include: the Bay of Fundy/Gulf of Maine, Gulf of St. Lawrence and eastern Newfoundland (Wang et al. 1996; Westgate and Tolley 1999). Population estimates for the Newfoundland subpopulation do not exist. The Northwest Atlantic harbour porpoise population has no schedule or status under *SARA* and is considered of Special Concern by COSEWIC (2007). It is currently under consideration for listing under Schedule 1 of *SARA*. Sightings of harbour porpoises in the Gulf of St. Lawrence occurred in shallow waters out to about a depth of 285 m (Kingsley and Reeves 1998). A density of 0.0545 (CV = 0.26) harbour porpoises per km^2 for the entire Gulf of St. Lawrence was found in that study. The best estimate of abundance for the Gulf of Maine/Bay of Fundy subpopulation of harbour porpoises is 89,700 (CV = 0.22) (Waring et al. 2006).

Very little is known about the distribution, abundance and movements of harbour porpoises in Newfoundland. Based on DFO's database (DFO, unpubl. data), there have been 23 sightings of harbour porpoises scattered throughout nearshore waters of the Study Area (Figure 3.81). Based upon DFO data, this species appears to be most abundant in the Study Area from June to September; one harbour porpoise was observed in each of November and December. Based on bycatch events involving harbour porpoise in the fixed-gear fishery for Atlantic cod in 2002 in Newfoundland, the highest bycatch rates were recorded in Placentia Bay during April to June (Lawson et al. 2004). Relative to other coastal areas of Newfoundland, bycatch data suggest that Placentia Bay (and St. Mary's Bay) may be harbour porpoise "hotspots" (Lawson et al. 2004). The density[6] of harbour porpoises based upon recent boat-based surveys in the Study Area during August 2006-April 2007 was 0.065 harbour porpoise per km^2 (Abgrall and Moulton in prep.). Harbour porpoise were sighted in all survey months with the exception of September and October (Table 3.32) and along all survey routes (Figure 3.82) including areas near the Project Area. Based on the available information, the occurrence of harbour porpoises within the Study Area is likely common, at least in small numbers throughout the year.

Harbour porpoises are usually seen in small groups of one to three animals, often including at least one calf; occasionally they form much larger groups (Bjørge and Tolley 2002). Harbour porpoises feed independently on small schooling fishes (Read 1999). In Newfoundland, harbour porpoise diet consists primarily of capelin, Atlantic herring, sand lance and horned lantern fish; this assessment was based on the stomach contents of by-caught individuals (COSEWIC 2006). Breeding occurs in late spring or early summer and gestation lasts for 10-11 months and lactation lasts for at least 8 months (COSEWIC 2006).

Marine-associated Birds

In the Project Area, there is potential habitat for several marine-associated species of birds considered at risk. The species listed as at risk (Table 3.32) for the island of Newfoundland are Harlequin Duck, Barrow's Goldeneye, Ivory Gull, Piping Plover and Red Knot.

[6] This estimate was derived using the DISTANCE program from 21 sightings of harbour porpoise; it is corrected for detection and availability biases (Forney and Barlow 1998).

Harlequin Duck

The eastern population of Harlequin Ducks is considered of Special Concern and is listed as such on Schedule 1 of *SARA*. A Management Plan has recently become available (Environment Canada 2007) which outlines research and conservation priorities designed to increase the population of Harlequin Ducks in eastern Canada. In 1990, this species was designated as 'Endangered' by COSEWIC and during the 1990s, an increased effort in research and monitoring of the eastern Harlequin Duck was undertaken on breeding grounds, moulting sites and wintering sites which resulted in improved knowledge of the species. An increase in numbers at four key wintering sites in North America, and the discovery that some eastern North American Harlequin Ducks winter in southwest Greenland, was instrumental in COSEWIC down-listing Harlequin Duck to a species of 'Special Concern' in 2001 (Environment Canada 2007).

The eastern Harlequin Duck breeds on rivers in northern Quebec (rivers draining in to the eastern side of Hudson Bay and Ungava Bay), Labrador (Nachvak Fiord to Hopedale), western coast of Great Northern Peninsula, Newfoundland, Gaspé Peninsula, Quebec and northern New Brunswick (Robertson and Goudie 1999). It winters on the coast, mainly from Newfoundland to Massachusetts with more than half the population wintering in coastal Maine (Robertson and Goudie 1999).

Cape St. Mary's has the largest known wintering population in Newfoundland. Survey results in late winter 2005 and 2006 showed 200+ individuals between Point Lance and Cape St. Mary's (P. Thomas, CWS, pers. comm.). Cape St. Mary's Christmas bird count totals for the period from 1997-2006 range from 51-200 individuals with an average of 120.

Virtually all information on population status of Harlequin Ducks wintering in coastal Newfoundland is based on the single (one day per year) annual Audubon Christmas Bird Count at Cape St. Mary's. Winter site fidelity is close to absolute in adults. Therefore, monitoring these small groups along the coast provides a measure of population status. However, there is a need to identify areas in coastal Newfoundland suitable for long-term monitoring of Harlequin Ducks in addition to Cape St. Mary's, as small numbers of Harlequin Ducks probably occur during migration and winter (October to April) in other areas of Placentia Bay, particularly areas around small islands and rocky islets in zones of high wave energy in Placentia Bay. This data gap was recognized by the Proponent and Harlequin Duck surveys were undertaken in an attempt to address the gap. It is noteworthy that suitable Harlequin Duck habitat does not occur in or near the proposed site for the oil refinery. However, there is slight possibility that this species may occur in the Project Area.

Surveys for Harlequin Ducks were completed in the Placentia Bay area in winter-spring 2007 using low-level helicopter searches of marine archipelago and headland areas in western Placentia Bay and southern Burin Peninsula of Newfoundland (Goudie 2007). A number of concentrations of sea ducks and considerable habitat were documented, and many of these areas appeared like suitable habitat for Harlequin Ducks. The confirmation of only one isolated group of twelve Harlequin Ducks near Lamaline (Allens Island), Burin Peninsula, highlighted the continued scarcity of this species, and the importance of concerted efforts to locate and protect remnant numbers resident to this area in winter-spring (Figure 3.85).

In addition to helicopter searches, shore-based surveys for Harlequin Ducks were conducted in January to April 2007 (Goudie 2007). Survey areas (see Figure 3.85) included sites representative of:

- the Cape St. Mary's area where Christmas Bird Counts have been conducted (Golden Bay, Cat's Cove, Redland Point);
- the Cape Shore area (Cahoon's Cliff, Little Half Way Gully and Sunkers Point); and
- the periphery of the traditional wintering area at Cape St. Mary's (Paint Point, Lily's Point).

Significant numbers of Harlequin Ducks (n > 100) were noted at the sites representative of the Cape St. Mary's area whereas small but consistent numbers (~12 individuals per survey date) were detected at all other sites. Relative to counts of Harlequin Ducks conducted at the same areas in the early 2000's, data collected in 2007 indicate that modest increases in Harlequin Duck numbers may have occurred along the southeast coast of Placentia Bay (Goudie 2007).

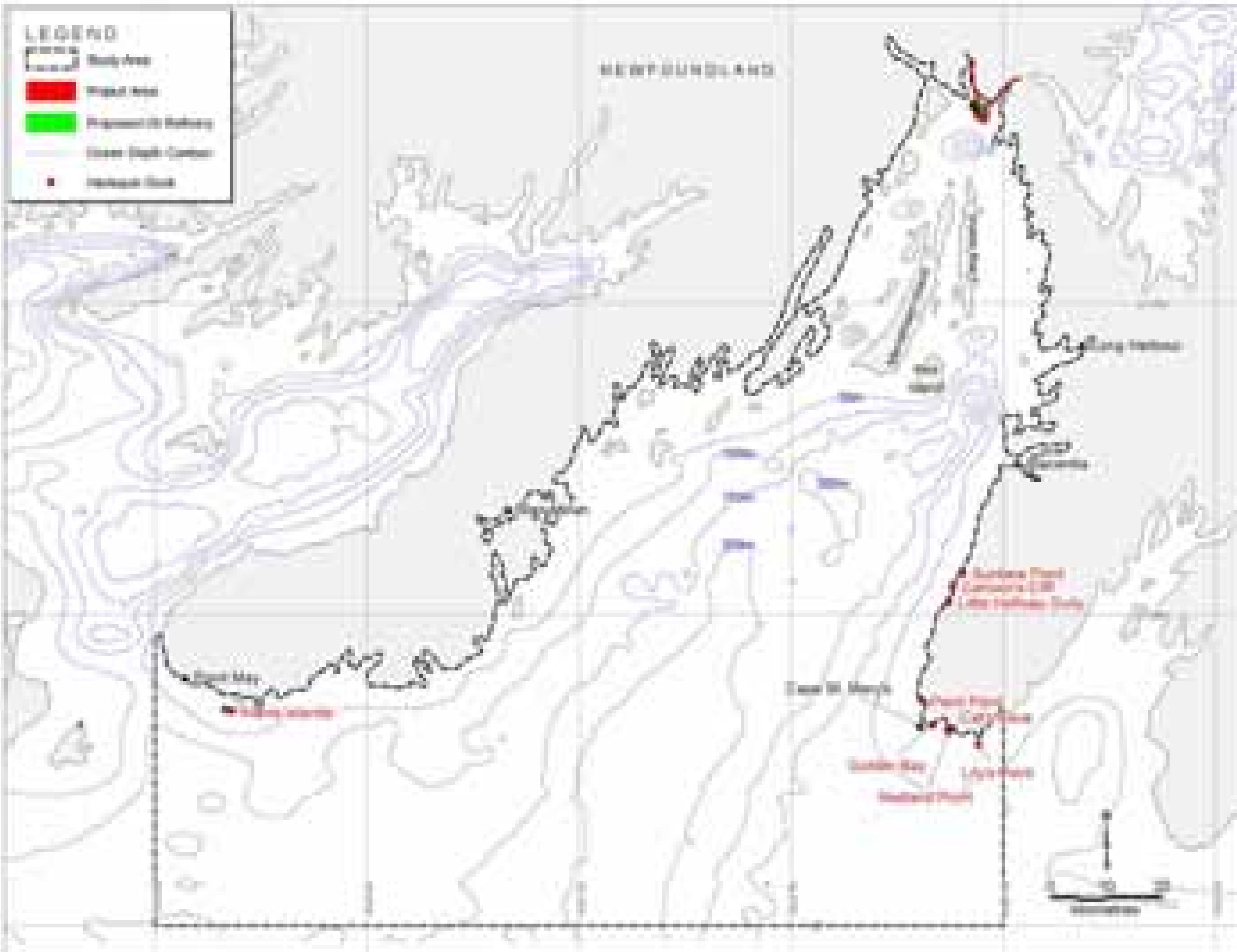

Figure 3.85 Locations of sites where Harlequin Ducks were observed during aerial and shore-based surveys.

Barrow's Goldeneye

Barrow's Goldeneye is designated as Vulnerable under the Newfoundland and Labrador Endangered Species Act a species of Special Concern by COSEWIC and *SARA*. The total population of eastern Barrow's Goldeneyes is about 4,500 birds. The core breeding area of eastern Barrow's Goldeneye is currently believed to be small lakes at high elevation in drainage systems draining into the north shore of the Gulf of St. Lawrence. Indications of breeding in northern Labrador remain unsubstantiated but should be further investigated. Summer moulting sites have been identified on the northeastern side of Hudson Bay, Ungava, Frobisher Bay and the coast of Labrador from Nain northward (Schmelzer 2006).

At least 90 per cent of the eastern Barrow's Goldeneye winter in St. Lawrence estuary. Approximately 400 individuals winter in coastal Atlantic Canada and Maine. In Newfoundland, small numbers have been documented wintering at the mouth of the Humber River near Corner Brook, and at Traytown, Port Blandford, Spaniard's Bay and St. Mary's Bay. In addition there have been sightings from St. Paul's Inlet, Inner Newman Sound. There is at least one sighting of Barrow's Goldeneye in Placentia Bay, an adult male and female at Arnold's Cove estuary 30 November 1993 (B Mactavish, pers. obs.).

The eastern population of Barrow's Goldeneye is most threatened during the winter season because 90 per cent of the population winter within an important shipping corridor to the Great Lakes. There is the risk of serious losses of the population in the event of an oil spill.

Barrow's Goldeneye is rare in the Study Area. Judging from the regular occurrence of a few wintering individuals in eastern Newfoundland, including the Avalon Peninsula (Spaniard's Bay and St. Mary's Bay), it is possible a few are wintering undetected among Common Goldeneyes in parts of Placentia Bay. The 1993 sighting from Arnold's Cove shows the species can occur in Placentia Bay, at least during the non-breeding season.

Ivory Gull

COSEWIC designated the Ivory Gull a species of Special Concern in April 1979. This status was re-examined and confirmed in April 1996 and in November 2001. However, the status was re-examined and designated Endangered in April 2006. It is presently under consideration for addition to Schedule 1 under *SARA*. Surveys of breeding sites known from the 1980s were conducted in 2002 and 2003 (Gilchrist and Mallory 2005). An 80 per cent decline of breeding pairs at these sites triggered a worldwide concern over the global population of the Ivory Gull. The global population of the Ivory Gull is thought to be <12,800 pairs, but population estimates from Russia may be overestimates (Stenhouse 2004).

The Ivory Gull inhabits the Arctic Ocean and is usually associated with pack ice. The breeding range includes the high Arctic in Canada, northern Greenland and Spitsbergen to Novaya Zemlya (Godfrey 1986). The diet of the Ivory Gull consists of various small fish including lanternfish and Arctic cod, crustaceans and carrion (Haney and MacDonald 1995). Ivory Gulls traditionally winter as far south as the pack ice off northeast Newfoundland (Godfrey 1986; B. Mactavish, LGL, pers. obs.). Recent warm winters have lead to a reduction in the overall area of pack ice off Newfoundland and a corresponding reduction of Ivory Gull sightings. There are very few records of Ivory Gulls for the south coast of Newfoundland and none for Placentia Bay (P. Linegar, pers. comm.). However, there are three records of Ivory Gulls for St. Pierre et Miquelon (February 1979, January 1988 and January 2002) (P. Linegar, pers. comm.). Ivory Gulls could occur as a very rare visitor to the Study Area from November to April.

Piping Plover

Piping Plover is listed as Endangered on Schedule 1 of *SARA*. In 2001, the total global population (all North America) of Piping Plover was estimated at 5,945 individuals, with a breakdown of 1,454 in Canada, and 481 in Atlantic Canada (Haig et al. 2004). The 61 adults counted during the 2006 census of Newfoundland is a slight increase over recent years, probably as a result of continued protection of breeding sites (Paul Harris CWS, pers.comm.). The Newfoundland breeding range is essentially the southwest corner of the island from Flat Bay Island in St. Georges Bay to Grand Barasway near Burgeo. An isolated two pairs have recently been found (2006) breeding at Seal Cove, Fortune Bay (P. Harris, CWS, pers. com.). One or two pairs nesting at Miquelon, St. Pierre et Miquleon are the closest breeding birds to Placentia Bay. There are no records of Piping Plover for Placentia Bay; however a sighting from Bellevue Beach, Trinity Bay indicates the possibility of rare occurrences of Piping Plover in the Study Area during migration. The extensive sandy beaches required by Piping Plover for breeding sites do not exist in Placentia Bay.

Red Knot

The Red Knot was listed as Endangered by COSEWIC in April 2007. It is not currently listed on *SARA* and it is not listed as at risk by the Government of Newfoundland and Labrador. The Red Knot breeds in the Arctic of both the Old and New Worlds. In the New World it winters along the coasts from California and Massachusetts south to South America. A significant decrease in numbers at migration staging and wintering sites in North America have given cause for concern in the North American population. The Red Knot is an uncommon southbound migrant in coastal Newfoundland, as its main migration corridor occurs west of Newfoundland. It prefers open sandy beaches often with rotting kelp piles and extensive mud flats for feeding. Such habitats occur sparingly in Placentia Bay. During shore-based surveys conducted during August to December 2006 at Arnold’s Cove, Come By Chance, North Harbour and Southern Harbour, four and two Red Knot individuals were observed at Come By Chance lagoon and Southern Harbour estuary, respectively. Sightings were made in late August (at Southern Harbour) and late September (Come By Chance). Little suitable habitat exists in the area of Southern Head. Red Knot may occasionally occur in small numbers at various locations at the head of Placentia Bay during fall migration in August to October.

Sea Turtles

Three species of sea turtles may occur in the Study Area: leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), and Kemp’s ridley (*Lepidochelys kempi*) turtles (Ernst et al. 1994); however, only the leatherback has been identified in the Study Area. Loggerhead and Kemp’s ridley turtles are considered rare in the Study Area and are not listed under *SARA*.

Leatherback Sea Turtle

The leatherback sea turtle is considered Endangered on Schedule 1 of *SARA*. A recovery strategy is in place for this species (ALTRT 2006). The leatherback is the largest living turtle and it also may be the most widely distributed reptile, as it ranges throughout the Atlantic, Pacific, and Indian oceans and into the Mediterranean Sea (Ernst et al. 1994). Because of its primarily pelagic distribution, it is difficult to obtain a total population estimate. A study conducted in 1995 based on data from 28 nesting beaches throughout the world yielded an estimate of 34,500 females (Spotila et al. 1996). There are no reliable population estimates for this species in Atlantic Canada and the Study Area as the scattered nature of the data (primarily incidental sightings) makes estimating the number of turtles in the Canadian Atlantic difficult. However, more leatherbacks visit waters of the Study Area than was once believed.

Adults engage in routine migrations between temperate and tropical waters, presumably to optimize both foraging (temperate waters) and nesting (tropical waters) opportunities. Female leatherbacks tagged at nesting beaches in French Guiana, Suriname and the Caribbean coast of Costa Rica have been observed in Atlantic Canadian waters (James 2004). Canadian waters are thought to support one of the highest summer and fall densities of leatherbacks in the North Atlantic and it has been suggested that waters in Atlantic Canada should be considered critical foraging habitat (James et al. 2006a). Adult leatherbacks are regularly sighted in the waters off Newfoundland from June to October (with peak abundance in August and September), where they likely come to feed on jellyfish, their primary prey (Bleakney 1965; Cook 1981, 1984; ALTRT 2006). Leatherbacks can remain active in water as cold as 0.4°C (James et al. 2006b). Leatherbacks, both adults and juveniles, undergo annual migrations that include areas off southern Newfoundland (James et al. 2005). The analysis of satellite telemetry, morphometric and fishing entanglement data identified areas of high-use habitat of leatherbacks in Northwest Atlantic waters. It was shown that leatherbacks do not migrate along specific routes but that they utilize broad areas of the Atlantic. Leatherback sea turtles did exhibit foraging site fidelity to shelf and slope waters off Canada and the northeastern United States (James et al. 2005).

Little is known about the distribution and abundance of leatherback turtles in the Study Area. As with marine mammals, the primary source of information on the distribution and occurrence of sea turtles is a DFO database maintained by Dr. Jack Lawson. This database primarily contains records of incidental sightings and as such interpretation of the data must be made cautiously. Nonetheless, the database does offer valuable information about species occurrence in Placentia Bay. Overall, there have been 54 sightings of leatherbacks reported in the Study Area based upon incidental sightings, surveys, entanglements and stranding data (DFO, unpubl. data; see Figure 3.86). Most of these sightings have occurred in the southern half of the Study Area. Based upon sightings data with month recorded, sightings were relatively more frequent in September (46.5 per cent of 43 sightings) and August (32.6 per cent) vs. July (20.9 per cent) in the Study Area. One leatherback was reported in January near Fox Harbour. Most sightings have been made in coastal areas (Figure 3.86) but this may be related to observation effort. Two leatherback turtles were observed between Bar Haven and Merasheen Island on 3 September 1999 (DFO, unpubl. data; Figure 3.86). No sea turtles have been observed during boat-based surveys in 2006 and 2007.

The diving behaviour of leatherbacks differs during transit vs. foraging periods. Turtles typically spend more time at greater depths and dive durations are longer when transiting vs. foraging

(Jonsen et al. in press). It has been suggested that leatherbacks make deeper scouting dives for prey while transiting and shallower dives associated with extended foraging may reduce the energetic demands of foraging at depth (Jonsen et al. in press).

The diving behaviour of leatherbacks in continental shelf and slope waters of the northeastern United States and eastern Canada suggests they spend 43-50 per cent of their time at the water surface (<3 m; James et al. 2006c). The primary prey of leatherbacks is jellyfish (Lutcavage and Lutz 1986) and in eastern Canada, the movements of leatherbacks are thought to be closely linked with the seasonally abundant *Cyanea sp*., their principal jellyfish prey (James and Herman 2001). Large flotillas of these jellyfish are evident at the surface during summer and fall, but they may also be abundant lower in the water column (James and Herman 2001). Leatherbacks have been observed consuming large *Cyanea capillata* at the water surface in Atlantic Canada, and James et al. (2006c) suggest (based on diving profile data) leatherbacks do not have to undertake deep dives to locate jellyfish prey in shelf waters within their northern foraging areas (i.e., offshore Nova Scotia and Newfoundland). Based on satellite tag data collected from leatherbacks after they nested in the Caribbean, sea turtles spent most of their time in the epipelagic zone (near-surface) and over 99 per cent of dives were <250 m (Hays et al. 2004). More than half of an individual's time was spent diving to depths below 10 m.

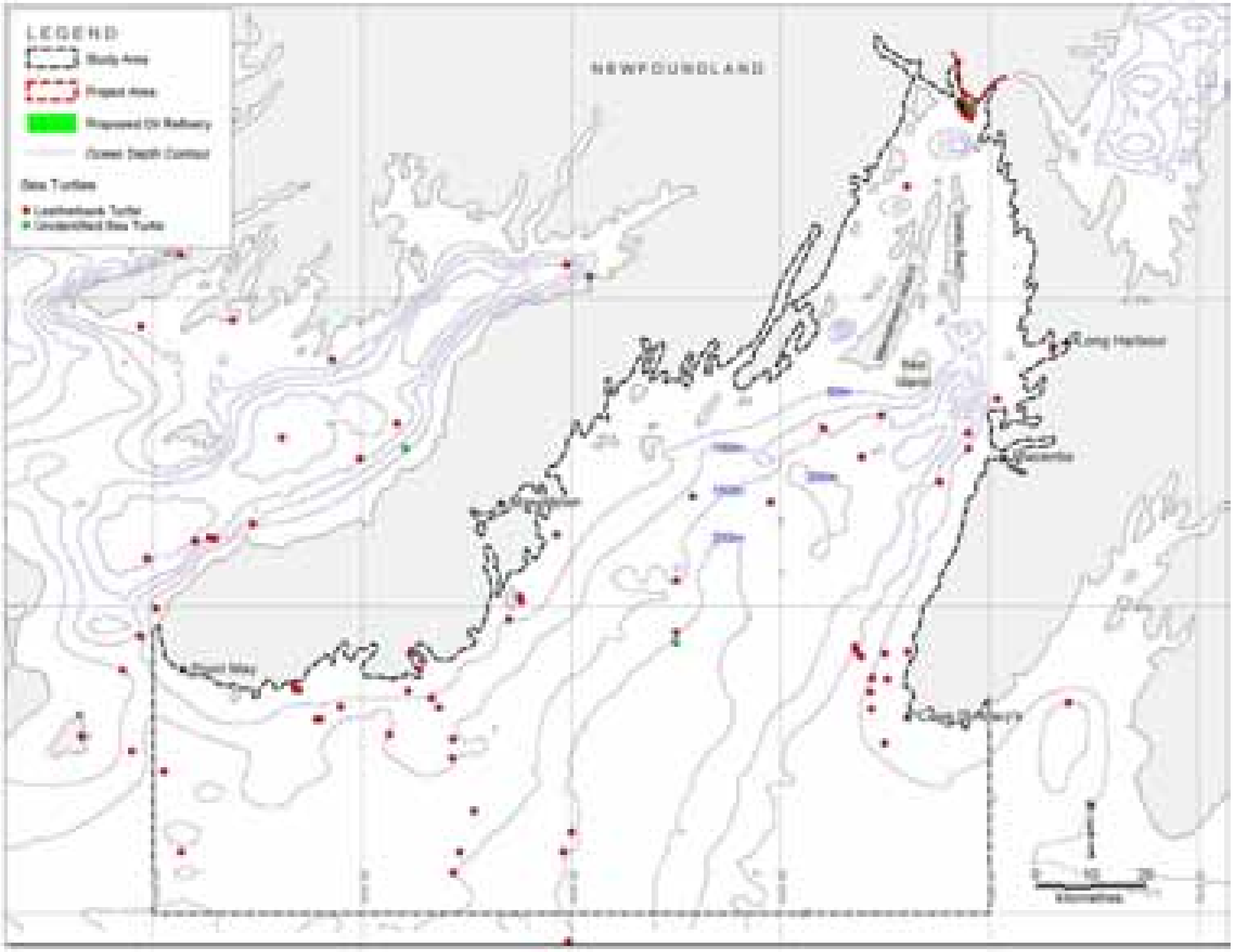

Figure 3.86 **Sightings of sea turtles in and near the Study Area obtained from the DFO sightings database.**

3.8 Protected Areas

3.8.1 Parks and Resorts

Serveral parks and resorts can be found throughout Placentia Bay. One Provincial Park, Gooseberry Cove Provincial Park, is located within the Bay. This park is a sandy day-use beach with a grassy back shore (Parks and Natural Areas, 2007) located on the Cape Shore of the Avalon Peninsula. There are also a number of private parks throughout the Bay, including Jack's Pond, Fitzgerald's Pond Park, Piper's Hole River and Freshwater Park.

There are two well-known resorts in Placentia Bay: Woody Island Resort based on Woody Island, and Kilmory Resort in Swift Current. Winter recreation resorts include the White Hills ski resort located outside Clarenville.

3.8.2 Protected Areas

Cape St. Mary's Seabird Ecological Reserve is a major seabird colony located at the eastern entrance to Placentia Bay (Figure 3.87). Approximately 200 km southwest of St. John's, this reserve supports 24,000 Northern gannet, 20,000 black-legged kittiwake, 20,000 common murre and 2,000 thick-billed murre. Razorbills, black guillemots, double-crested and great cormorants, as well as Northern fulmars, can also be found within this ecological reserve (Parks and Natural Area, 2007).

In 1995 a Wetland Stewardship Area was introduced in Come By Chance. This management area covers 290 ha, while the total stewardship zone protects over 4000 ha. A Habitat Management Plan has been developed for the area to protect wetland habitat, and the various flora and fauna species that it supports. The Wildlife Division has prepared a Habitat Management Plan for the stewardship zone (Eastern Habitat Joint Venture (EHJV), 1995) that provides recommendations for best management practices of these wetlands.

A Bird Sanctuary has also been developed within the town of Arnold's Cove, which allows for the protection of various species of birds, ranging from Canada geese, ducks, bald eagles, etc. The hunting, trapping, or snaring of birds within these limits is strictly prohibited.

Several historic sites can be found throughout Placentia Bay, most notably Castle Hill National Historic Site and The Atlantic Charter Site Monument Historic Site. Castle Hill National Historic Site protects the remains of fortifications built by the French and English in 17th and 18th century. North of the community of Placentia is Ship Harbour where the Atlantic Charter Monument is located, that commemorates the drafting of the Atlantic Charter in 1941 by then British Prime Minster, Sir Winston Churchill and United States President, Franklin Roosevelt. The Charter, which was signed just offshore of Ship Harbour, is a joint declaration on the purposes of the war against fascism.

Figure 3.87 Map Showing Location of Placentia Bay Shipping Lanes in Relation to Cape St. Mary's Seabird Ecological Reserve.

3.9 Effects of the Environment on the Refinery

The physical environment will provide the dominant set of design criteria for the project and will govern the design of many aspects of the proposed facility. The area is subject to high winds, large amounts of precipitation, both in the form of rain and snow, fog seasonally and cold temperatures seasonally. Seasonally, the head of Placentia Bay can experience high winds that generate heavy seas with large waves. All structures either located on land or in the marine environment will be designed to withstand the maximum expected environmental loads with the appropriate safety factors to provide a robust design.

Measures will be taken to minimize the effect of the environment during the construction and operation stages of the project. The physical design of temporary structures for the aid of construction, will take into account winter conditions, maximum wind and wave action and extreme sea state. Construction activities will be scheduled to avoid environmental impacts if there is a safety concern. A local weather office and wind monitoring station will be established for major heavy lifts and for marine construction. The SmartBay project will also play a role in this process, by providing real-time water quality and oceanographic/meteorological information.

3.10 Future Environment

The Future Environment section describes the proposed project area's future environmental conditions over the expected lifespan of the project (25 years), if the project was not approved. The purpose of forecasting the future environment is vitally important in distinguishing possible project-related environmental effects from environmental change due to natural processes. In forecasting future environmental conditions the following is assumed:

1. The proposed project area will not undergo any major development for the duration of 25 years.
2. The proposed project area will not be significantly altered or impacted as a result of current or future industrial activity in the vicinity.

The southern region (Southern Head) of the peninsula between North Harbour and Come-by-Chance Bay is an isolated greenfield site, accessible only by boat. Available information indicates that anthropogenic uses are limited to recreational fishing and hunting. Based on present conditions and the noted assumptions, future environmental conditions within the proposed project area are predicted to remain consistent with current environmental conditions detailed in Section 3.0. Minor environmental/ecological changes may result from natural processes such as ecological succession, which is the natural progression or change in environmental conditions over time (e.g. tree stand maturation, river/stream meandering patterns, changes in wetlands, coastal geomorphology). Over a short ecological timeframe of 25 years, natural changes to the proposed project site would be slight unless accelerated by natural disastrous events. Significant changes to the current environment, may they occur, could be attributed to natural phenomena such as fires, infestation, disease, storms and/or storm surges.

Based on this information, conclusions concerning the following environmental characteristics can be implied:

- Environmental and ecological interactions and processes will remain consistent with current baseline information and data.
- Habitat fragmentation occurs when an intact habitat is broken into pieces by natural or anthropogenic forces. In the absence of development, any increase in terrestrial or marine habitat fragmentation will be the result of natural events (e.g. fire).
- Air quality and greenhouse gas levels will remain consistent with current baseline information and data. Local short-term changes in air quality and greenhouse gas levels may be triggered in the event of fire.
- The physical landscape including geology, topology, and soils will remain unchanged.
- Local hydrology and associated habitats would remain consistent with current baseline information and data.
- Coastal/marine geomorphology processes, water quality, and habitats would remain consistent with current baseline information and data.

4.0 EFFECTS ON VALUED ECOSYSTEM COMPONENTS

4.1 Introduction

4.1.1 Schedule

Pre-construction activities will commence immediately upon receipt of the environmental approvals and necessary permits. Clearing and grubbing of the access road and site would begin as soon as possible. Other early site preparation activities include leveling/in-filling and installation of temporary offices with associated services (power, potable water cooler/storage systems, temporary sanitary facilities) and will commence as soon as the access road is completed sufficiently for equipment and personnel to access the site.

Construction of the refinery and associated utilities and support systems is proposed to begin in January 2008 and is expected to be complete within three and a half years. Construction of the marine terminal will also occur during this time frame. Commissioning will take place unit by unit as the facility is completed and will take approximately six months. It is anticipated that the first shipments of crude will be loaded before the end of 2011 (Figure 4.1).

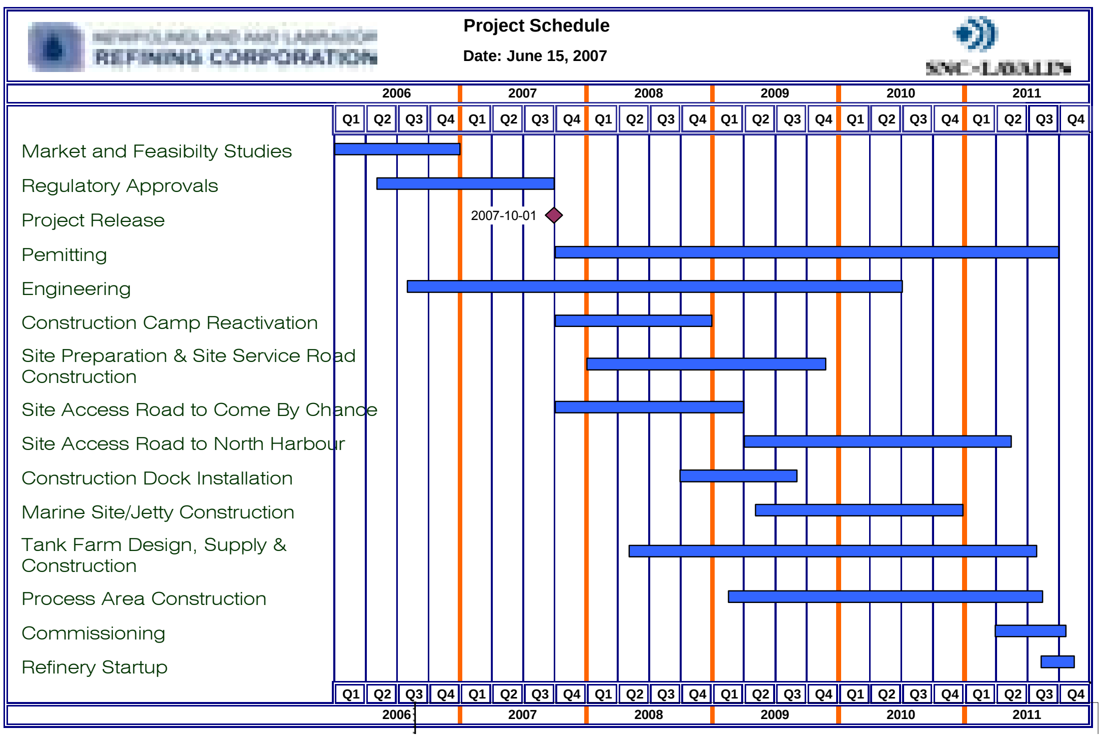

Figure 4.1 Project Schedule

4.1.2 Construction Phase Activities

Land-based Construction

Access

The project site is currently accessible only by boat, helicopter or all-terrain vehicle, and a new access road is required to connect the site into the provincial highway network. The proposed principal access point will be from the Trans-Canada Highway (TCH) near the Town of Come By Chance. A new interchange will be constructed approximately 1 km north of the existing intersection to provide a connection point for the main access road. The access road from the TCH to the main project site will be 9.2 km long.

In order to expedite work on the refinery site while the access road is being constructed, a temporary access will be built consisting of a tote road located at or near the permanent road location. Where practical, the tote road will be designed to be incorporated into the permanent road structure. A temporary modular bridge will also be used for the Come By Chance River crossing during construction and removed upon completion of the permanent bridge.

The permanent bridge over the Come By Chance River will be a concrete structure with a clear span of 30 m and dry abutments (will not interfere with fish habitat). Once permanent access has been established from the Come By Chance area, an alternate access road will be extended to the North Harbour area to connect into provincial Route 210. This extension will provide an alternate route for employee access from the Burin Peninsula, as well as second access for emergency purposes.

This portion of the access road will require two additional river crossings, one at Watson's Brook and one at North Harbour River. Both bridges will be of concrete construction with clear spans and dry abutments. The Watson's Brook crossing will have a clear span of 10 m and the North Harbour River Crossing will have a larger clear span of 30 m. The length of this alternate access road is 12.1 km.

Site Utilities

The initial supply of power for construction purposes will be obtained from Newfoundland Power from the provincial grid using a temporary power line to be constructed adjacent to the main site access road. Temporary power generation (diesel generators) may be required at early stages od construction, which will be used later as an emergency/standby power source.

Power for facility operations will be obtained from Newfoundland and Labrador Hydro (NLH) and will be on a new, dedicated power transmission line to the project site. Where possible, the transmission line will run adjacent to the access road; however, the final alignment location will be determined during design and will depend upon the connection point into the NLH system.

Site Preparation

The project footprint occupies an area that has a grade variation of approximately 52 m from the lowest valley to the highest peak. The site will require excavation to balance out the low and high areas to make a surface suitable for construction and operations.

Standard earthmoving procedures will be employed (in accordance with the EPP for construction), including drilling and blasting, mechanical busting and mechanical excavation. A large portion of the material to be moved on the site consists of rock. The rock is typically hard, sound sandstone that will require blasting and mechanical impact to free it for excavation. Till and unusable material (USM) can be excavated using conventional mechanical means including excavators, loaders and dozers.

All surficial root mat, topsoil, grubbing, peat, and weathered glacial till will be removed prior to cut/fill operations. Unusable material will be placed on the south east edge of the project site to provide a berm to act as a visual screen of the project area from the shoreline. Organic material will be stockpiled in the same area. This stockpile will be used for surface preparation of the berm and other areas to be revegetated.

Blasting operations are only required during the site work phase of the project and will not be required for any operational phase after construction is complete. Blasting will not be undertaken in marine areas.

In order to minimize the seismic impact, blasting patterns and procedures will be used to reduce the shock wave and noise. Overblasting will not be permitted. Blasting activities will be co-ordinated and scheduled to minimize the number of blasts required per week. Time-delay blasting may be used as necessary to control debris scatter. Prior to any blast, the site will be surveyed to identify the presence of any sensitive animals (black bear, caribou, etc.). Presence of such animals will result in delay or cancellation of the blast until such time that they are no longer present.

Waterbodies

Water bodies within the immediate footprint will be effectively removed from site and will not exist in the project area upon completion of construction. Those water bodies with fish habitat will be electrofished to remove any fish, which will be relocated to an area of similar habitat that will remain unaltered. The water body will then be dewatered in a manner to prevent siltation, incorporating silt control measures. Unusable material from the drained water body will be excavated and removed to the USM waste site.

Water bodies outside the project footprint will have a minimum 15 m buffer zone as required by the regulatory agencies to preserve the shoreline.

Crossing of streams will be required for the construction of site roads and project infrastructure. Culverts will be installed at stream crossing locations on the site access roads. Bridge structures will be required for more substantial rivers (fish habitat) including Come By Chance River, Watson's Brook and North Harbour River.

All stream crossings will be constructed in accordance with the procedures outlined in the NLRC Environmental Protection Plan and will meet or exceed the requirements of the Department of Environment and Conservation, the Department of Fisheries and Oceans and Transport Canada pursuant to the Navigable Waters Protection Act. Consultations with local conservation and stewardship interests will also be undertaken prior to this work.

Ongoing Rehabilitation

Temporary erosion and sedimentation control measures will be installed and maintained throughout the construction phase. Following completion of construction, there will be a site-wide review and implementation of stabilization and reclamation.

Marine Construction

The Marine Wharf facilities include the tug berth and construction dock, a dry product berth for loading petroleum coke and sulphur products, a small boat basin, central control building and emergency response warehouse. The marine wharf area will be constructed by infilling the existing marine area with rock fill from on-site excavations. The east side will be protected and supported with concrete caissons, sheet pile cells or sheet pile bulkhead walls. Armour stone similar to that used in the existing causeway at North Atlantic Refinery will be used as wave protection to the South.

The heavy lift construction dock will be incorporated into the tug berth/small boat basin and will be designed to accept large pre-fabricated modules and construction supplies for the construction phase. Large deck, low draft barges will be used to transport construction supplies and large construction modules ranging in size from 100 to 5,000 tonnes. Most heavy packages (greater then 100 tonnes) will be transported with roll-on/roll-off barges via multi-wheeled transporters.

These facilities will be constructed in a 30-month period, with most marine components installed in the first 20 months of construction.

It is anticipated that marine wharf construction, including the tug and dry products berths, will require 18 months to complete the primary structures and an additional 12 months to install equipment and piping.

The current design involves the use of bulkhead walls consisting of caissons filled with rock and affixed to rock mattresses. Rock mattresses will be put in place with a barge with suitable handling equipment. Caissons will be floated into place using small tugs for positioning. Once in position, the caissons will be sunk to the rock mattress and filled with rock offloaded from a barge.

It is anticipated that within 8-10 months of the start of marine wharf construction, construction will begin (concurrently) on the jetties, which are located 300-400 m from shore.

Jetty construction is anticipated to take 12 months for the installation of marine components and eight months for the installation of topside mechanical equipment. Each jetty will consist of jackets that sit on the seabed with piles driven through them. Some portions of the jackets will require drilling for placement of tension anchors.

Drilling is expected to occur via a self-elevating platform or jack-up barge (that typically has four legs) placed on the seafloor with the platform above sea level. Drilling will be completed after all the jackets are in place and would carry on for two months.

Vessel traffic during jetty construction will consist of tugs for positioning jackets and shuttling personnel, barges equipped with cranes for placement of heavy components, barges equipped with rock placing equipment, and a self-elevating platform. At any one time, no more than six vessels will be operating during this phase of construction.

During the construction phase of the Project, vessel noise will be concentrated in the area of the marine terminal and jetty. Specific sound levels or estimates are not available for the specific vessels or the cumulative noise levels from vessels, but it is expected that the greatest and most continuous noise source during construction of the marine terminal will be tugs and barges.

Construction Safety Zones

Before the start of marine construction activities, NLRC will establish a Construction Safety Zone (CSZ) of approximately 500m x 1000m in the Come By Chance Point nearshore area. This exclusion zone will encompass the marine area in which the construction dock/tug berth, and later the jetty, will be built. For safety and security purposes, and also to allow marine construction activities to take place in an efficient and timely manner, the CSZ will be closed to all fishing activities and fishing vessel transits, at least until the Construction Dock is operational, expected to be September 2009.

In addition, two other CSZs will be established for the installation of the seawater intake at Holletts Cove and for the outfall pipe off Southern Head. Both of these components will be installed at the same time. The safety zone for the intake pipe will be approximately 100m x 1000m, and the zone for the outfall will be approximately 100 m x 250 m. Fishers will have to avoid both of these marine construction areas during the three months or so they will take to install.

At any given time, there would likely be no more than six vessels operating concurrently on the marine wharf. The noises from ships associated with construction are not expected to be different from those usually associated with other vessels in the bay, such as fishing boats and other marine industries.

4.1.3 Operations Phase Project Activities

Land-based Operations

Specific activities within the refinery complex of interest to the biophysical assessment include emissions control and effluent management as well as the overall Environmental Protection Plan. The environmental management policies and procedures for the proposed Refinery are discussed in Section 9.0 Environmental Management of this Volume as well as in Section 11.0 of Volume 2, Environmental Management. Emergency Response planning and procedures are discussed in both Volume 2, Section 12.0 and this Volume in Section 8.0.

Marine Operations

During the operational phase, permanent marine facilities (wharf, tug basin and jetty) will occupy an area 400 m wide along the shoreline and extending out a distance of about 800 m from the Come By Chance Point. This area is deemed to be the operations phase Marine Terminal.

Other marine facilities include the intake and outfall pipes. When installed, the seawater intake pipe will extend out 985 m from the shoreline at Holletts Cove and the intake end will be at a depth of 18 m. The outfall will extend approximately 400 m from the shoreline at Southern Head to a depth of about 15 m. These facilities will be partially trenched and buried in the tidal zone, but will lie on the seabed along most of their route.

It is expected that there will be an average of 17 vessel movements a week associated with refinery operations. This includes inbound and outbound bulk crude oil and refined product tankers; there will be many additional movements by tug, pilot and support vessels.

A typical time needed for offloading a cargo of crude oil is 18 hours, with 24 hours a maximum. A typical loading time for a dry bulk carrier (for sulphur or coke) or for a cargo of refined product is 18 to 24 hours.

When circumstances require, some tankers may need to hold at anchorages within the bay. However, these vessels will use existing anchorages and no new grounds will be required for this project. The primary sites would be AA, BB, CC, DD (CHS Marine Chart 4839).

As a result of early consultation with area fishers, the marine facilities have been re-aligned from the original design in order to accommodate requests that efforts be taken to allow continues access to an important cod fishing grounds. NLRC meetings with local fishers indicate that the area that will be occupied by the Marine Terminal is fished primarily for lobster by seven or eight fishing enterprises. FFAW research indicates that quantities of other species – capelin, scallop, blackback flounder, lumpfish, herring and mackerel – are also occasionally harvested in the vicinity.

Consultation with one of the very few sea urchin harvesters in the bay indicates that the Marine Terminal is not a desirable location for this species due to the siltation flowing into the nearshore area from several rivers. Established sea urchin harvesting activities (from November to March) in seabed areas close to shore in Holletts Cove would not be affected by the intake and outfall installations. These urchins are taken relatively close to shore in this cove in water depths of 10 m and less.

Placentia Bay is within the Placentia Bay Vessel Traffic Services (VTS) Zone, and vessels 20 metres (24 m for fishing boats) or more in length are managed under Vessel Traffic Services Zones Regulations under the *Canadian Shipping Act*, as administered in the area by the Canadian Coast Guard (CCG). CCG maintains a Marine Communications and Traffic Services facility in Argentia, Placentia Bay. Participation in the Placentia Bay VTS system will be mandatory for all tankers arriving or departing from the Marine Terminal.

Consultations with Transport Canada and the Canadian Coast Guard indicate that the vessel traffic management system in Placentia Bay has sufficient capacity to accommodate refinery-related traffic as well as that associated with other proposed projects.

4.1.4 Interaction Matrices

At an early stage of the environmental impact assessment process, issues scoping, though public and government consultations, and based on the knowledge of the study team and knowledge of the study area bio-physical environment and environmental sensitivities, the assessment team has compiles a list of all potential receptors or species (both marine and terrestrial) that might have an interaction with the expected project activities during all phases of the project.

From that, a long list of species has been prepared to include all potentially affected species or ecosystem components that might have an interaction with a project activity.

Further iterations of the long list had produced a preliminary "Master List" of valued ecosystem components that would have had an interaction (pathway) with an activity that requires further assessment. The interaction matrices liking project activities to the VECs were prepared for the following areas/activities:

- Construction – Terrestrial,
- Construction – Marine,

- Operations – Terrestrial, and
- Operations – Marine.

Accidents or malfunctions during construction and operations were also identified in these matrices.

The “Master Interaction Matrices” are provided in the following tables.

Table 4.1 Interaction Matrix for Effects on VECs During Terrestrial Construction

Project Activities	Environmental Considerations	Valued Ecosystem Components - Terrestrial																						
Key to Interaction Rating: **0 No interaction** **Y Interaction but effect undetermined**		Fresh-water Fish & Fish Habitat			Birds & Bird Habitat				Wildlife			Vege-tation			Lichens				Special Areas			Human Health		
		Atlantic Salmon	**Brook Trout**	***SARA* Species**	**Raptors**	**C. Heathland**	**Inter-tidal Flats**	***SARA* Species**	**River Otter**	**Black Bear**	***SARA* Species**	**Wetlands (fens)**	**Herb-rich Balsam Fir**	***SARA* Species**	**Lung-lichen**	**Green Beard**	***A. Sammentosa***	***SARA* Species**	**Wetlands Stew.**	**Salmon Rivers**		**Air quality**	**Water Quality**	**Aesthetics**
CONSTRUCTION																								
Site preparation	Air emissions	y	y		y			y	y	y	y	y	y		y	y	0	y	y	y		y	y	0
	Noise	y	y		y			y	y	y	y	0	0		0	0	0	0	0	0		0	0	y
Clearing, leveling, grubbing, blasting, drilling	Lights	0	0		y			y	y	y	0	0	0		0	0	0	0	0	0		0	0	y
	Run-off, siltation	y	y		y			0	y	0	0	y	y		0	0	0	0	y	y		0	y	y
	Vehicular traffic	0	0		0			y	y	y	y	y	y		0	0	0	0	0	0		y	0	y
	Loss of habitat	y	y		y			y	y	y	y	y	y		y	y	y	y	y	0		0	y	y
Site access road, transmission lines, bridge/culvert	Air emissions	0	0		y			y	y	y	y	y	y		y	y	0	y	y	0		y	y	0
	Noise	0	0		y			y	y	y	y	0	0		0	0	0	0	0	0		0	0	y
	Lights	0	0		y			y	0	y	0	0	0		0	0	0	0	0	0		0	0	y
	Run-off, siltation	y	y		y			0	0	0	0	y	y		0	0	0	0	y	y		0	y	y

Project Activities	Environmental Considerations	Valued Ecosystem Components - Terrestrial																						
Key to Interaction Rating: **0 No interaction** **Y Interaction but effect undetermined**		Fresh-water Fish & Fish Habitat			Birds & Bird Habitat				Wildlife			Vege-tation			Lichens				Special Areas			Human Health		
		Atlantic Salmon	**Brook Trout**	***SARA* Species**	**Raptors**	**C. Heathland**	**Inter-tidal Flats**	***SARA* Species**	**River Otter**	**Black Bear**	***SARA* Species**	**Wetlands (fens)**	**Herb-rich Balsam Fir**	***SARA* Species**	**Lung-lichen**	**Green Beard**	**A. *Sammentosa***	***SARA* Species**	**Wetlands Stew.**	**Salmon Rivers**		**Air quality**	**Water Quality**	**Aesthetics**
Grading, paving, excavating, in-filling, clearing of right of way, concrete production	Vehicular traffic	0	0		0			y	y	y	y	y	y		0	0	0	0	0	0		y	0	y
	Stream crossings	y	y		0			0	0	0	0	y	y		0	0	0	0	y	y		0	y	y
Intakes/outfalls - desalination plant, oily water/process water system, fire water system, sewage treatment, storm water system (sedimentation ponds)	Air emissions	0	0		y			y	y	y	y	y	y		y	y	0	y	0	0		y	0	0
	Noise	0	0		y			y	y	y	y	0	0		0	0	0	0	0	0		0	0	y
	Lights	0	0		y			y	y	y	0	0	0		0	0	0	0	0	0		0	0	y
	Run-off, siltation,	y	y		y			0	0	0	0	y	y		0	0	0	0	y	y		0	y	y
	Vessel traffic	0	0					0	y	0	0	0	0		0	0	0	0	0	0		y	y	y
Quarry development	Air emissions	0	0		y			y	y	y	y	y	y		y	y	0	y	0	0		y	0	0
	Noise	y	y		y			y	y	y	y	0	0		0	0	0	0	0	0		0	0	y
	Lights	0	0		y			y	0	y	0	0	0		0	0	0	0	0	0		0	0	y
	Storage and disposal of wastes, debris	0	0		y			0	0	y	0	0	0		0	0	0	0	0	0		0	0	y

Project Activities	ENVIRONMENTAL CONSIDERATIONS	VALUED ECOSYSTEM COMPONENTS - TERRESTRIAL																						
Key to Interaction Rating: **0 No interaction** **Y Interaction but effect undetermined**		FRESH-WATER FISH & FISH HABITAT			BIRDS & BIRD HABITAT				WILDLIFE			VEGE-TATION			LICHENS				SPECIAL AREAS			HUMAN HEALTH		
		Atlantic Salmon	**Brook Trout**	***SARA* Species**	**Raptors**	**C. Heathland**	**Inter-tidal Flats**	***SARA* Species**	**River Otter**	**Black Bear**	***SARA* Species**	**Wetlands (fens)**	**Herb-rich Balsam Fir**	***SARA* Species**	**Lung-lichen**	**Green Beard**	***A. Sammentosa***	***SARA* Species**	**Wetlands Stew.**	**Salmon Rivers**		**Air quality**	**Water Quality**	**Aesthetics**
	Run-off, siltation	y	y		y			0	0	0	0	y	y		0	0	0	0	y	y		0	y	y
	Vehicular traffic	0	0		0			y	y	y	y	y	y		0	0	0	0	0	0		y	0	y
Buildings - main power generation building, substations, support buildings	Air emissions	y	y		y			y	y	y	y	y	y		y	y	0	y	0	0		y	0	0
	Noise	0	0		y			y	y	y	y	0	0		0	0	0	0	0	0		0	0	y
	Lights	0	0		y			y	0	y	0	0	0		0	0	0	0	0	0		0	0	y
	Storage and disposal of wastes, debris	0	0		y			0	0	y	0	0	0		0	0	0	0	0	0		0	0	y
	Run-off, siltation	y	y		y			0	0	0	0	y	y		0	0	0	0	y	y		0	y	y
	Vehicular traffic	0	0		0			y	y	y	y	y	y		0	0	0	0	0	0		y	0	y
	Presence of new structures	0	0		y			y	0	0	y	0	0		0	0	0	0	0	0		0	0	y
Process plant, storage tanks and pipelines - tank farm, coke and sulphur storage yards, pipelines	Air emissions	0	0		y			y	y	y	y	y	y		y	y	0	y	0	0		y	0	0
	Noise and lights	0	0		y			y	y	y	y	0	0		0	0	0	0	0	0		0	0	y
	Storage and disposal of wastes, debris	0	0		y			0	0	y	0	0	0		0	0	0	0	0	0		0	0	y
	Run-off, siltation	y	y		y			0	0	0	0	y	y		0	0	0	0	y	y		0	y	y
	Vehicular traffic	0	0		0			y	y	y	y	y	y		0	0	0	0	0	0		y	0	y
	Presence of new structures	0	0		y			y	0	0	y	0	0		0	0	0	0	0	0		0	0	y
Waste management –	Air emissions	0	0		0			y	y	y	y	y	y		y	y	0	y	0	0		y	0	0

Project Activities	ENVIRONMENTAL CONSIDERATIONS	VALUED ECOSYSTEM COMPONENTS - TERRESTRIAL																						
Key to Interaction Rating: **0 No interaction** **Y Interaction but effect undetermined**		FRESH-WATER FISH & FISH HABITAT			BIRDS & BIRD HABITAT				WILDLIFE			VEGE-TATION			LICHENS				SPECIAL AREAS			HUMAN HEALTH		
		Atlantic Salmon	**Brook Trout**	***SARA* Species**	**Raptors**	**C. Heathland**	**Inter-tidal Flats**	***SARA* Species**	**River Otter**	**Black Bear**	***SARA* Species**	**Wetlands (fens)**	**Herb-rich Balsam Fir**	***SARA* Species**	**Lung-lichen**	**Green Beard**	***A. Sammentosa***	***SARA* Species**	**Wetlands Stew.**	**Salmon Rivers**		**Air quality**	**Water Quality**	**Aesthetics**
solid waste, liquid waste, sewage, hazardous waste	Noise	0	0		y			y	y	y	y	0	0		0	0	0	0	0	0		0	0	y
	Lights	0	0		y			y	0	y	0	0	0		0	0	0	0	0	0		0	0	y
	Storage and disposal of wastes, debris	0	0		y			0	0	y	0	0	0		0	0	0	0	0	0		0	0	y
	Run-off, siltation	y	y		y			0	0	0	0	y	y		0	0	0	0	y	y		0	y	y
	Vehicular traffic	0	0		0			y	y	y	y	y	y		0	0	0	0	0	0		y	0	y
	Wildlife attraction	0	0		y			0	0	y	0	0	0		0	0	0	0	0	0		0	0	y
	Location of wastewater outfall	y	y		y			0	y	0	0	0	0		0	0	0	0	0	0		0	y	y
Accidents or malfunctions		y	y		y			y	y	y	y	y	y		y	y	y	y	y	y		y	y	y

Table 4.2 Interaction Matrix for Effects on VECs During Marine Construction

Key to Interaction Rating:

0 No interaction

Y Interaction but effect undetermined

Project Activities	ENVIRONMENTAL CONSIDERATIONS	VALUED ECOSYSTEM COMPONENTS - MARINE																				
		FISH & FISH HABITAT						MARINE MAMMALS & SEA TURTLES						SEABIRDS			SPECIAL AREAS					
		Commercial	**Recreational**	***SARA* Species**	**Aquaculture**	**Marine Plants**		**Toothed Whales**	**Baleen Whales**	**Seals**	**Sea Turtles**	***SARA* Species**		**Pelagic**	**Coastal**	***SARA* Species**	**.**					
CONSTRUCTION																						
Site Preparation	Air emissions	0	0	0	0	0		0	0	0	0	0		0	y	0						
	Noise	y	y	0	0	0		y	y	y	y	y		0	0	0						
Clearing, grubbing, blasting, drilling, leveling	Lights	0	0	0	0	0		0	0	0	0	0		y	y	0						
	Run-off, siltation	0	y	0	0	0		0	0	y	0	0		0	y	0						
	Vehicular traffic	0	0	0	0	0		0	0	0	0	0		0	y	0						
	Loss of habitat	0	y	0	0	0		0	0	0	0	0		0	y	0						
Site access road, jetty road, transmission lines, bridge/culvert	Air emissions	0	0	0	0	0		0	0	0	0	0		0	y	0						
	Noise	y	y	0	0	0		0	0	0	0	0		0	y	0						
	Lights	0	0	0	0	0		0	0	0	0	0		y	y	0						
Grading, paving, excavating, clearing of right of way, concrete production	Run-off, siltation	y	y	0	0	0		0	0	y	0	0		0	y	0						
	Vehicular traffic	0	0	0	0	0		0	0	0	0	0		0	y	0						
	Presence of new structures	0	0	0	0	0		0	0	0	0	0		0	y	0						
	Proximity to fish harvesting sites	y	y	0	0	0		0	0	0	0	0		0	0	0						

Project Activities	ENVIRONMENTAL CONSIDERATIONS	VALUED ECOSYSTEM COMPONENTS - MARINE																				
Key to Interaction Rating: **0 No interaction** **Y Interaction but effect undetermined**		FISH & FISH HABITAT						MARINE MAMMALS & SEA TURTLES						SEABIRDS			SPECIAL AREAS					
		Commercial	**Recreational**	***SARA* Species**	**Aquaculture**	**Marine Plants**		**Toothed Whales**	**Baleen Whales**	**Seals**	**Sea Turtles**	***SARA* Species**		**Pelagic**	**Coastal**	***SARA* Species**	.					
	Proximity to aquaculture sites	0	0	0	y	0		0	0	0	0	0		0	0	0						
Inshore wharf structures and new causeway - Construction dock, tug berth, jetty control building	Air emissions	y	y	0	0	y		0	0	y	0	0		0	y	0						
	Noise	y	y	y	0	0		y	y	y	y	y		0	y	0						
	Lights	0	0	0	0	0		0	0	0	0	0		y	y	0						
	Run-off, siltation	y	y	y	0	y		y	y	y	y	y		0	y	0						
	Vessel traffic	y	y	y	y	y		y	y	y	y	y		y	y	0						
Underwater drilling, pile driving	Vehicular traffic	0	0	0	0	0		0	0	y	0	0		0	y	0						
	Presence of new structures	y	y	y	y	y		y	y	y	y	y		y	y	0						
	Proximity to fish harvesting sites	y	y	0	0	0		0	0	0	0	0		0	0	0						
	Proximity to aquaculture sites	0	0	0	Y	0		0	0	0	0	0		0	0	0						
Offshore berthing facilities Mooring dolphins, breasting dolphins, loading platform, trestle structures,																						
	Noise	y	y	y	y	y		y	y	y	y	y		0	y	0						
	Lights	0	0	0	0	0		0	0	0	0	0		y	y	0						
	Run-off, siltation	y	y	y	0	y		y	y	y	y	y		0	y	0						
	Vessel traffic	y	y	y	y	y		y	y	y	y	y		y	y	0						
	Vehicular traffic	0	0	0	0	0		0	0	y	0	0		0	0	0						

Project Activities	ENVIRONMENTAL CONSIDERATIONS	VALUED ECOSYSTEM COMPONENTS - MARINE																				
Key to Interaction Rating: **0 No interaction** **Y Interaction but effect undetermined**		FISH & FISH HABITAT						MARINE MAMMALS & SEA TURTLES						SEABIRDS			SPECIAL AREAS					
		Commercial	**Recreational**	***SARA* Species**	**Aquaculture**	**Marine Plants**		**Toothed Whales**	**Baleen Whales**	**Seals**	**Sea Turtles**	***SARA* Species**		**Pelagic**	**Coastal**	***SARA* Species**	**.**					
underwater and sub-sea structures (piles or jackets), ship loader	Presence of new structures	y	y	y	0	y		y	y	y	y	y		0	0	0						
	Proximity to fish harvesting sites	y	y	y	0	y		0	0	0	0	0		0	0	0						
Underwater drilling, pile driving	Proximity to aquaculture sites	0	0	0	y	0		0	0	0	0	0		0	0	0						
Intakes/outfalls - desalination plant, oily water/process water system, fire water system, sewage treatment, storm water system (sedimentation ponds)	Location	y	y	y	y	y		0	0	0	0	0		y	y	0						
	Noise	y	y	0	0	0		y	y	y	y	y		0	y	0						
	Lights	0	0	0	0	0		0	0	0	0	0		y	y	0						
	Run-off, siltation	y	y	y	0	y		y	y	y	y	y		0	y	0						
	Vehicular traffic	0	0	0	0	0		0	0	y	0	0		0	0	0						
	Presence of new structures	y	y	y	0	y		0	0	y	0	0		0	y	0						
	Proximity to fish harvesting sites	y	y	y	0	y		0	0	0	0	0		0	0	0						
	Proximity to aquaculture sites	0	0	0	y	0		0	0	0	0	0		0	0	0						
Accidents or malfunctions		y	y	y	y	y		y	y	y	y	y		y	y	y						

Key to Interaction Rating:

0 No interaction

Y Interaction but effect undetermined

Project Activities	ENVIRONMENTAL CONSIDERATIONS	VALUED ECOSYSTEM COMPONENTS - MARINE																				
		FISH & FISH HABITAT						MARINE MAMMALS & SEA TURTLES						SEABIRDS			SPECIAL AREAS					
		Commercial	**Recreational**	***SARA* Species**	**Aquaculture**	**Marine Plants**		**Toothed Whales**	**Baleen Whales**	**Seals**	**Sea Turtles**	***SARA* Species**		**Pelagic**	**Coastal**	***SARA* Species**	**.**					
Waste management – solid waste, liquid waste, sewage, hazardous waste	Air emissions	0	0	0	0	0		0	0	0	0	0		0	0	0						
	Noise	0	0	0	0	0		0	0	0	0	0		0	0	0						
	Lights	0	0	0	0	0		0	0	0	0	0		0	0	0						
	Storage and disposal of wastes, debris	0	0	0	0	0		0	0	0	0	0		y	y	0						
	Run-off, siltation	y	y	y	0	y		y	y	y	y	y		0	y	0						
	Vehicular traffic	0	0	0	0	0		0	0	0	0	0		0	0	0						
	Wildlife attraction	0	0	0	0	0		0	0	0	0	0		y	y	0						
	Location of wastewater outfall	y	y	y	y	y		y	y	y	y	y		y	y	0						

Table 4.3 Interaction Matrix for Effects on VECs During Terrestrial Operations

Project Activities	ENVIRONMENTAL CONSIDERATIONS	VALUED ECOSYSTEM COMPONENTS - TERRESTRIAL																						
Key to Interaction Rating: **0 No interaction** **Y Interaction but effect undetermined**		FRESH-WATER FISH & FISH HABITAT			BIRDS & BIRD HABITAT				WILDLIFE			VEGE-TATION			LICHENS				SPECIAL AREAS			HUMAN HEALTH		
		Atlantic salmon	**Brook trout**	***SARA* Species**	**Raptors**	**C. Heathland**	**Inter-tidal Flats**	***SARA* Species**	**River Otter**	**Black Bear**	***SARA* Species**	**Wetlands (fens)**	**Herb-rich Balsam Fir**	***SARA* Species**	**Lung-lichen**	**Green Beard**	***A. Sammentosa***	***SARA* Species**	**Wetlands Stew.**	**Salmon Rivers**		**Air Quality**	**Water Quality**	**Aesthetics**
OPERATIONS																								
Crude oil processing	Air emissions	y	y		y			y	y	y	y	y	y		y	y	0	y	y	y		y	y	0
	Effluent discharges	y	y		y			0	y	0	0	0	0		0	0	0	0	0	y		0	y	0
	Noise	0	0		y			0	0	y	y	0	0		0	0	0	0	0	0		0	0	y
	Lights	0	0		y			y	0	y	y	0	0		0	0	0	0	0	0		0	0	y
	Storage and disposal of wastes, debris	0	0		y			0	0	y	0	0	0		0	0	0	0	0	0		y	y	y
	Equipment, materials storage	0	0		0			0	0	0	0	0	0		0	0	0	0	0	0		0	0	0
	Vehicular traffic	0	0		y			y	0	y	y	0	0		0	0	0	0	0	0		y	0	y
Water management – potable water, process water																								
	Water usage, availability (streams)	y	y		y			0	y	0	0	y	0		0	0	0	0	y	y		0	y	y
Waste management – solid waste, sewage,	Air emissions	0	0		y			y	y	y	y	0	0		y	y	0	y	0	0		y	0	y
	Effluent discharges	y	y		y			0	y	0	0	0	0		0	0	0	0	0	0		y	y	y

Project Activities	ENVIRONMENTAL CONSIDERATIONS	VALUED ECOSYSTEM COMPONENTS - TERRESTRIAL																						
Key to Interaction Rating: **0 No interaction** **Y Interaction but effect undetermined**		FRESH-WATER FISH & FISH HABITAT			BIRDS & BIRD HABITAT				WILDLIFE			VEGE-TATION			LICHENS				SPECIAL AREAS			HUMAN HEALTH		
		Atlantic salmon	**Brook trout**	***SARA* Species**	**Raptors**	**C. Heathland**	**Inter-tidal Flats**	***SARA* Species**	**River Otter**	**Black Bear**	***SARA* Species**	**Wetlands (fens)**	**Herb-rich Balsam Fir**	***SARA* Species**	**Lung-lichen**	**Green Beard**	***A. Sammentosa***	***SARA* Species**	**Wetlands Stew.**	**Salmon Rivers**		**Air Quality**	**Water Quality**	**Aesthetics**
liquid waste, hazardous waste	Noise	0	0		0			0	0	0	0	0	0		0	0	0	0	0	0		0	0	y
	Lights	0	0		0			0	0	0	0	0	0		0	0	0	0	0	0		0	0	y
	Vehicular traffic	0	0		y			0	0	y	y	0	0		0	0	0	0	0	0		y	0	y
	Wildlife attraction	0	0		y			0	0	y	0	0	0		0	0	0	0	0	0		0	0	0
	Location of outfalls	y	y		y			0	y	0	0	0	0		0	0	0	0	0	0		0	y	y
Maintenance and repairs - site access road, bridge/culvert, power lines; right-of-way maintenance	Air emissions	0	0		0			0	0	0	0	0	0		0	0	0	0	0	0		y	0	0
	Noise	0	0		y			y	y	y	y	0	0		0	0	0	0	0	0		0	0	y
	Lights	0	0		y			y	0	y	0	0	0		0	0	0	0	0	0		0	0	y
	Run-off, siltation	y	y		y			0	0	0	0	0	0		0	0	0	0	y	y		0	y	y
	Storage and disposal of wastes, debris	0	0		y			0	0	y	0	0	0		0	0	0	0	0	0		0	0	y
	Vehicular traffic	0	0		y			y	y	y	y	0	0		0	0	0	0	0	0		y	0	y
Maintenance and repairs - process plant, storage tanks, storage yards, loading and unloading pipelines	Air emissions	0	0		y			y	y	y	y	y	y		y	y	0	y	y	0		y	0	0
	Noise	0	0		y			y	0	y	y	0	0		0	0	0	0	0	0		0	0	y
	Lights	0	0		y			y	0	y	0	0	0		0	0	0	0	0	0		0	0	y
	Run-off, siltation	y	y		y			0	0	0	0	y	0		0	0	0	0	0	0		0	y	y
	Storage and disposal of wastes, debris	0	0		y			0	0	y	0	0	0		0	0	0	0	0	0		y	y	y

Project Activities	ENVIRONMENTAL CONSIDERATIONS	VALUED ECOSYSTEM COMPONENTS - TERRESTRIAL																						
Key to Interaction Rating: **0 No interaction** **Y Interaction but effect undetermined**		FRESH-WATER FISH & FISH HABITAT			BIRDS & BIRD HABITAT				WILDLIFE			VEGE-TATION			LICHENS				SPECIAL AREAS			HUMAN HEALTH		
		Atlantic salmon	**Brook trout**	***SARA* Species**	**Raptors**	**C. Heathland**	**Inter-tidal Flats**	***SARA* Species**	**River Otter**	**Black Bear**	***SARA* Species**	**Wetlands (fens)**	**Herb-rich Balsam Fir**	***SARA* Species**	**Lung-lichen**	**Green Beard**	***A. Sammentosa***	***SARA* Species**	**Wetlands Stew.**	**Salmon Rivers**		**Air Quality**	**Water Quality**	**Aesthetics**
	Vehicular traffic	0	0		y			y	0	y	y	0	0		0	0	0	0	0	0		y	0	y
Accidents or Malfunctions		y	y		y			y	y	y	y	y	y		y	y	y	y	y	y		y	y	y

Table 4.4 Interaction Matrix for Effects on VECs During Marine Operations

Project Activities	ENVIRONMENTAL CONSIDERATIONS	VALUED ECOSYSTEM COMPONENTS - MARINE													
Key to Interaction Rating: **0 No interaction** **Y Interaction but effect undetermined**		FISH & FISH HABITAT					MARINE MAMMALS & SEA TURTLES					SEABIRDS			SPECIAL AREAS
		Commercial	**Recreational**	***SARA* Species**	**Aquaculture**	**Marine Plants**	**Toothed Whales**	**Baleen Whales**	**Seals**	**Sea Turtles**	***SARA* Species**	**Pelagic**	**Coastal**	***SARA* Species**	.
OPERATIONS															
Vessel loading and off-loading - at tug berth and Jetty Site	Air emissions	0	0	0	0	0	0	0	y	0	0	0	y	0	
	Noise	y	y	y	0	0	0	0	y	0	0	0	0	0	
	Lights	0	0	0	0	0	0	0	0	0	0	y	y	0	
	Storage and disposal of wastes, debris	0	0	0	0	0	0	0	0	0	0	0	y	0	
	Vessel traffic	y	y	y	0	y	y	y	y	y	y	y	y	0	
Shipping	Air emissions	0	0	0	0	0	y	y	y	y	y	0	0	0	
	Noise	y	y	y	y	0	y	y	y	y	y	0	0	0	
	Lights	0	0	0	0	0	0	0	0	0	0	y	y	0	
	Storage and disposal of wastes, debris	0	0	0	0	0	0	0	0	y	0	y	y	0	
	Vessel traffic	y	y	y	y	0	y	y	y	y	y	y	y	y	
Seawater intakes	Noise	0	0	0	0	0	0	0	0	0	0	0	0	0	

Project Activities	ENVIRONMENTAL CONSIDERATIONS	VALUED ECOSYSTEM COMPONENTS - MARINE																				
Key to Interaction Rating: **0 No interaction** **Y Interaction but effect undetermined**		FISH & FISH HABITAT						MARINE MAMMALS & SEA TURTLES						SEABIRDS			SPECIAL AREAS					
		Commercial	**Recreational**	***SARA* Species**	**Aquaculture**	**Marine Plants**		**Toothed Whales**	**Baleen Whales**	**Seals**	**Sea Turtles**	***SARA* Species**		**Pelagic**	**Coastal**	***SARA* Species**	**.**					
	Lights	0	0	0	0	0		0	0	0	0	0		0	y	0						
	Vessel traffic	0	0	0	0	0		0	0	0	0	0		0	y	0						
	Location of pipes	y	y	y	0	y		0	0	0	0	0		0	0	0						
	Maintenance	y	y	y	0	y		y	y	y	y	y		0	y	0						
	Entrainment	y	0	y	0	0		0	0	0	0	0		0	0	0						

4.2 Air Emissions Modeling

4.2.1 Introduction

Baseline description of the air quality is provided in Section 3.2. In addition, a number of studies on air quality including the Air Quality Component Study (submitted with this EIS); Human Health and Ecological Effects Assessment for the Proposed New Refinery at the Southern Head of Placentia Bay, NL (SENES Consultants Limited, July 2007); the report by the Health Research Unit of Faculty of Medicine of the Memorial University of Newfoundland (June 2007) entitled A Review of the Health Status of the Come By Chance Area, Newfoundland and Labrador; and other studies by the various environmental consultants involved in the EA as it relates to specific VEC.

Air quality in a region is determined by the concentration of pollutants in the atmosphere as well as the size and topography of the air shed basin and its meteorological conditions. The Placentia Bay region has high turbulent winds, which are not conductive to local high accumulation of air pollutants for extended periods. Although there is the possibility for quick dispersal of air pollutants, NLRC has committed to the reduction of air emissions to as low as possible with the use of BATEA. NLRC has established an Air Quality Advisory Group consisting of local community leaders, local industry and government agencies to advise and provide feedback on NLRC's efforts to reduce air emissions.

The construction and operation of the refinery will result in atmospheric emissions as described in Volume 2 of the EIS. An inventory of all significant emissions has been prepared for the Project. Atmospheric emissions from the refinery operations are estimated using the best available data, industry standards (US EPA, CPPI Code of Practice) and government regulations (NL DOEC and CCME).

Construction Emissions

Emissions associated with the construction activities will include dust from site development and road construction, excavation, vehicular traffic, mobile equipment, temporary power generators and heaters, fuel storage tanks, and vessels loading and unloading. These activities are of relatively short duration and can be controlled by application of good construction practices, application of EPP, environmental control and mitigation measures considered in each activity as detailed in Volume 2 (Chapters 5 and 8).

Prior to the construction phase, and as part of construction permits, the Proponent will prepare a general program to control atmospheric emissions of major construction heavy equipments, generators and other sources. The program will include among other items:

- a dust control program;

- heavy equipment specifications to have recent equipments in good conditions (to minimize criteria air contaminants emissions);
- heavy equipment maintenance program; and
- fuel oil specifications.

An environmental monitoring station will be used at the property limit to verify the compliance to ambient air quality criteria

Operation Emissions

During the operations, emission sources include:

- storage tanks (the tank farm);
- process unit emissions (stacks, vents, and fugitive emissions);
- waste water treatment and potential cooling water system;
- ship loading/unloading;
- vessel operations; and
- flares.

The methodology of estimating the air emission quantities from these sources and the estimated values used in the air dispersion model are described in details in Volume 2 (Section 8.3) and the Air Emissions Component Study Appendix A.

4.2.2 Air Emission Dispersion Model Selection

Air dispersion modeling was carried out for normal operations of proposed refinery to evaluate the impacts of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), suspended particulates (PM_{10} and $PM_{2.5}$) and benzene on ambient air quality. The predicted results were then compared with Newfoundland and Labrador ambient air quality standards as well as the World Health Organization (WHO) standards as related to impact on human health.

The CALMET/CALPUFF version 6 air dispersion modeling system was used to estimate ground level concentrations of contaminants in ambient air. CALPUFF is an advanced non-steady-state meteorological and air quality modeling system. When provided with hourly three-dimensional meteorological fields, it can simulate the effects of time and space-varying meteorological conditions on pollution transport, transformation, and removal.

This model was chosen over other models used worldwide because of its ability to estimate changes in wind flow in complex terrain and its ability to consider changes in boundary layer parameters over the model domain, especially at the land-sea interface in a coastal region. The choice of the selected model was also a requirement from the Department of Environment and Conservation for this project.

Methodology

Several types of data and treatment are required to perform air dispersion modeling., including land use, topography, meteorology, emissions characteristics. From the start of the project, the Newfoundland Department of Environment and Conservation was consulted regularly to discuss model options, data sources and model results.

CALMET is the meteorological processor for the CALPUFF air dispersion model. CALMET produces the 3-D wind and temperature fields and calculates the 2-D atmospheric boundary layer parameters needed by CALPUFF.

Model Domain and Meteorological Grid

The study area is presented in Figure 4.2. The meteorological domain covers a 35 x 35 km area, extending 15 km south and west and 20 km north and east from the proposed refinery. The grid resolution is set to 500 meters and 9 vertical levels, extending up to 2000 meters. Model results are presented on a high-resolution grid of 50 m.

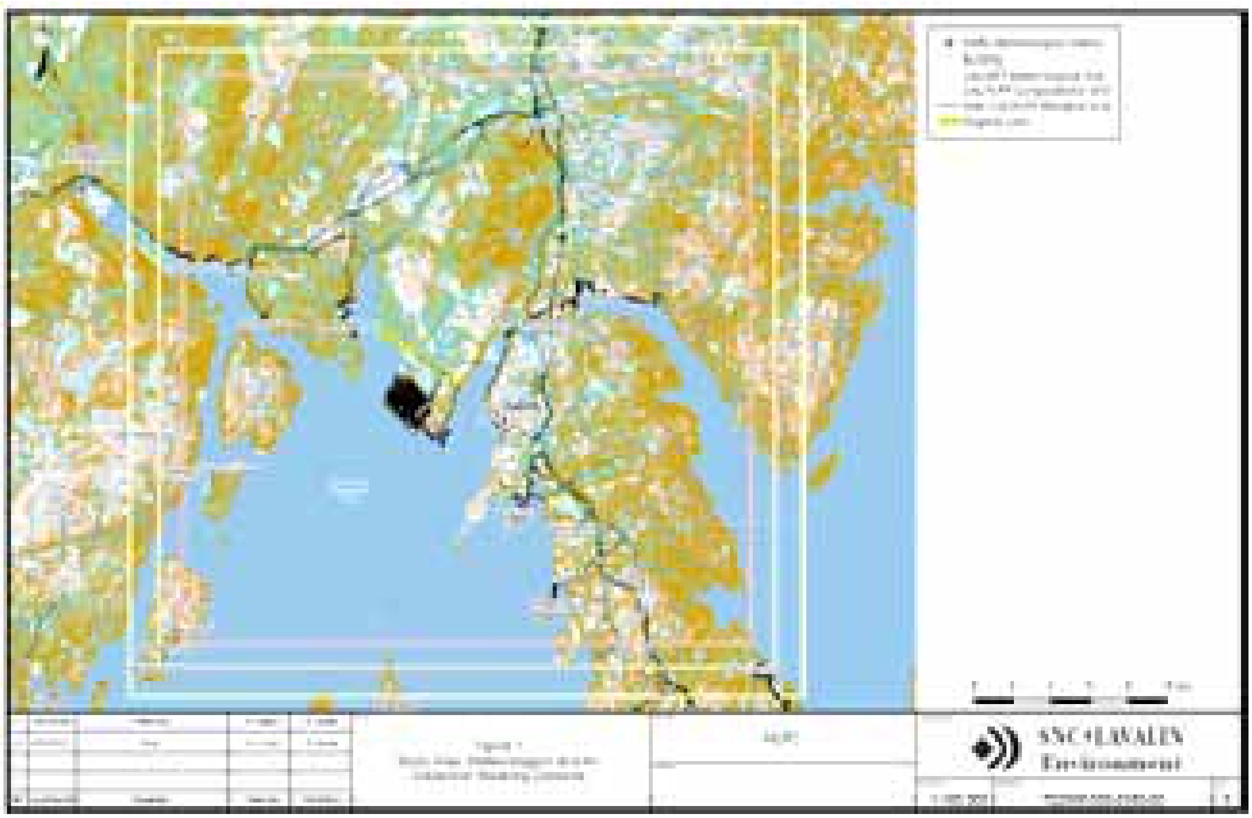

Figure 4.2 Study Area, Meteorological and air dispersion modeling domains

Topography, Land Use and Surface Parameters

Topography and land use are important features needed to describe the atmospheric boundary layer (e.g., elevation, land use, surface roughness, albedo, etc. are estimated for each grid cell).

Topographic data were extracted from the 1:50,000 Canadian Digital Elevation Data files using the TERREL tool included in the CALMET/CALPUFF system. Land use was obtained for the Natural Resource Canada 1:50,000 topographic maps using GIS software tools for these categories: water (large and small body), wetland, built-up areas, and wooden areas. Non-classified areas were designated as barren scrubland. For each land use type, surface characteristics per season were estimated from literature and discussions with the Department of Environment and Conservation.

Topographic information from TERREL and high-resolution land use data were merged to produce the girded geophysical data file needed by CALMET. presents the dominant land use for each cell in the modeling domain. It also shows the topography of the region, as seen by the model.

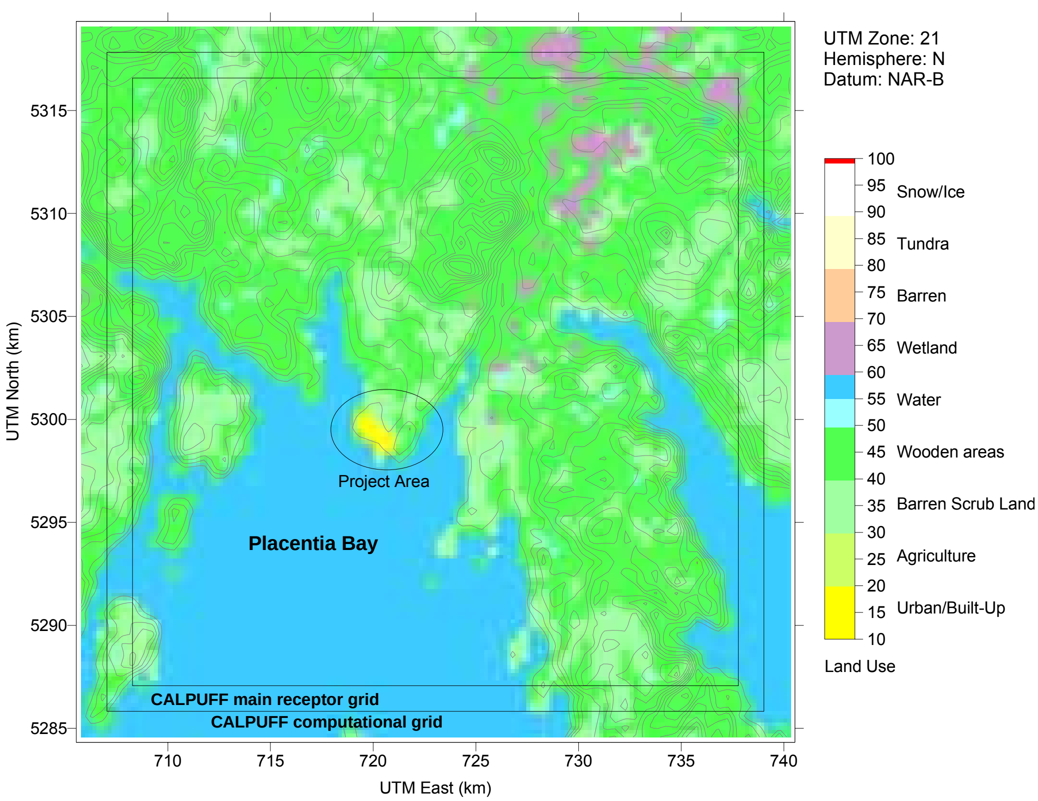

Figure 4.3 CALMET domain, dominant land use and topography (every 20 m)

Meteorological data

CALMET requires hourly wind speed and direction, temperature, relative humidity, cloud cover and twice daily, upper air sounding data. The North Atlantic Refinery Limited (NARL) in Come By Chance has been operating a surface station for many years. Hourly observations from 2002 to 2006 were obtained from NARL. To complete the meteorological database, hourly surface observations and twice daily upper air for the same period were obtained from Environment Canada for St. John's. Stephenville upper air station was also used to replace missing soundings in St. John's. Hourly air-sea temperature difference observations (to drive its over-water boundary layer sub-model) were obtained from the Nickerson Bank buoy for the same period.

Wind Roses

Figure 4.4 presents wind roses for the plant site, North Harbour, Sunnyside and Arnold's Cove. These wind roses were generated from the CALMET generated wind fields. As expected, all wind roses are very similar, with dominant winds from the south and east-south-east. Very slight differences can be observed.

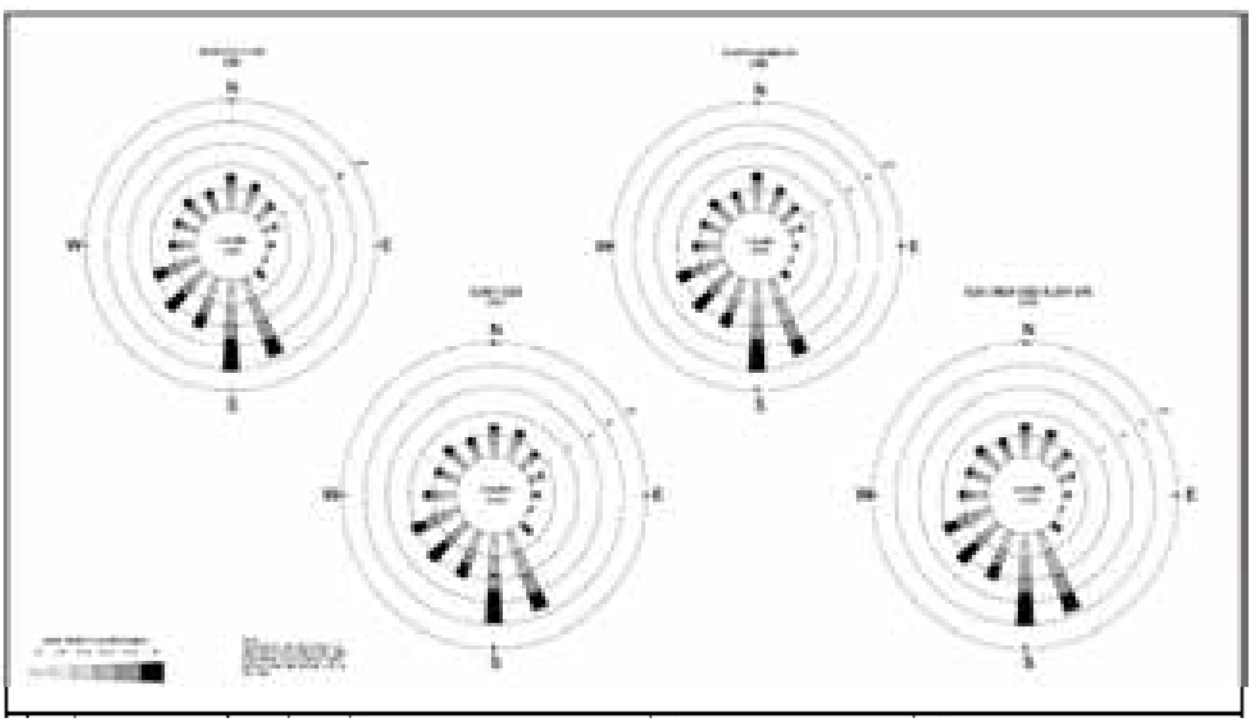

Figure 4.4 Wind rose in communities and the NLRC site (CALMET modeling for 2002)

Computational Grid, Receptors, and CALPUFF Setup

The computational grid or the CALPUFF model domain was set to a subset of the CALMET meteorological grid. The computational grid, in which CALPUFF tracks puffs until they exit the domain, covers a 32 x 32 km domain. The main receptor grid was set to a subset of the computational grid and covers a 30 x 30 km domain. Each of these grids has a 500 m resolution. Discrete receptors were added to get high-resolution results at the property line (every 50 m).

Nitrogen Oxides (Conversion of NO to NO_2)

The NO_x emissions due to the combustion of fossil fuels usually consist of 90 per cent of NO and 10 per cent of NO_2. In the atmosphere, NO reacts quicker with the ozone (O_3) in air than it does with the oxygen (O_2) and to form NO_2 in both cases. The presence of VOCs accelerates the process by which NO is transformed into NO_2. Furthermore, an inverse reaction occurs because NO_2 breaks up under the effect of sunrays to form NO and ozone. Several other reactions involving NO_x, free radicals and VOCs occur in the atmosphere, particularly in urban areas.

Air modeling for NO_2 was performed assuming a total conversion of NO into NO_2 at the top of the stack. This assumption implies an overestimation of predicted ground level concentrations of NO_2, especially close to the sources. However, the NL DOEC air quality standard for NO_2 applies to both NO_x (NO and NO_2) when expressed as NO_2. The total conversion assumption of NO to NO_2 is therefore a regulatory requirement for comparison of NO_x predicted concentrations with NL DOEC air quality standards.

4.2.3 Background Concentrations

The air quality modeling for this project includes other sources in the area, with the closest ones being the North Atlantic Refinery in Come By Chance and NTL near Arnolds Cove. In order to take into account these other sources, the DOEC provided maximum background concentration values in nearby communities for SO_2, NO_x, PM_{10} and $PM_{2.5}$. These values were determined from previous monitoring and air quality modeling studies in the region and are presented in Table 4.5. All background concentrations are below air quality standards.

Table 4.5 Maximum background concentrations in communities

Pollutant	Time Frame	NL DOEC Standard	Communities				
			Arnold's Cove	Come By Chance	North Harbour	Southern Harbour	Sunnyside
SO_2	1-hour	900	348	279	200	175	235
	3-hour	600	220	169	125	125	149
	24-hour	300	79	74	20	30	70
	Annual	60	2	5	1	1	6
NOx	1-hour	400	100	75	60	30	45
	24-hour	200	12	10	6	5	10
	Annual	100	1	1	1	1	1
PM_{10}	24-hour	50	14	14	13	12	15
	Annual	N.A.	7	7	7	7	7
$PM_{2.5}$	24-hour	25	10	10	9	8	11
	Annual	N.A.	5	5	5	5	5

Note:

* Background concentrations estimated by the Department of Environment and Conservation.

Potential Cumulative effects

The NL DOEC provided background concentration of pollutants in communities in order to take account for existing sources of pollutants and in particular the North Atlantic refinery and NTL.

Future projects were also analyzed on a qualitative basis. Projects such as the future LNG Transshipment facility and the VBNC Long Harbour Nickel-processing plant are either not a significant emitter of criteria air pollutant or too far away (> 10 km) to have a significant impact in the study zone.

4.2.4 Emissions Scenarios and Parameters

Air quality modeling was performed for process point sources at the refinery and for point source emissions from ships at the dock for SO_2, NO_x, CO, PM_{10} and $PM_{2.5}$. Fugitive benzene emission for storage tanks, processes leaks, cooling tower and ship cargo (loading/unloading) were also considered. Tables 4.6 and 4.7 present the emission parameters used as input to the CALPUFF air dispersion model.

Figure 4.5 shows the proposed plant layout, tank farm, jetty and source locations and major structure on the plant site.

Figure 4.5 Plant layout and source locations

Stack Height and Building Wake Effects

At this stage of the project, only the height of the tanks (14-18 m), boiler house (18 m) and coke silos (91 m) were identified as potential structures that may affect stack plumes at the refinery. For ships, the craft itself and especially the bridge (20-30 m above water level) may also affect the ship's stack plume.

Based on these results, all stack heights at the refinery were set to 45 m, except the ones affected by building wake effects. The 45 m height is the maximum height allowed by the NL *Air Pollution Control Regulations (2004)* for estimating ground level concentration. For the crude units, boiler units and coker units, several model runs were performed increasing stack heights until there was no more evidence of building wake effects. The selected heights for these stacks were set to 75 m, still much lower than the maximum Good Engineering Practice (GEP) stack height of over 200 m.

For ships (VLCC and Handymax), approximate dimensions and stack heights taken from typical layouts of those ships were used as input for the building wake program.

Estimation of Emission Parameters

Emissions from the refinery point sources are related to fuel combustion with the exception of the incinerator of the sulphur recovery units. From the estimated hourly fuel consumptions, flue gas flow rates were estimated assuming 3 per cent O_2 in flue gas. Temperature was set to 200 ºC. However, this is a relatively low temperature for these types of equipment, thus minimizing plume rise and maximizing the increase in predicted ground level concentrations.

Typical exhaust velocities in similar installations are around 8 m/s and approximate stack diameters were calculated based on estimated flue gas volumetric flow rates and selected temperatures to maintain an 8 m/s exhaust velocity. This emission scenario considers that 61 per cent of the thermal energy needs of the plant come from refinery generated gas and 39 per cent from purchased heavy fuel oil containing a maximum sulphur content of 0.7 per cent by weight. Additionally, NOx emissions were set to the maximum permitted levels allowed in Schedule G of the Air Pollution Control Regulations, 2004, Newfoundland and Labrador Regulation 39/04. For other emissions, US-EPA AP-42 emission factors from heavy fuel oil and gas fuels were used. Therefore, the emissions considered in this analysis represent the maximum expected emissions from the refinery.

Emissions from the process vents and flares will be treated later on, at the detailed engineering phase of the project. At this stage, it is not possible to set realistic emission parameters for these sources. Flaring will not be a major source of SO_2 with an estimated total of about 6 t/y.

For ships, the scenario considers the unloading of a Very Large Crude Carrier (VLCC) and the presence of a smaller ship loading at the dock. During unloading, the VLCC must produce energy (steam, electricity) for its internal systems and the unloading pumps. The emission scenario presented in Table 4.6 considers the concurrent use of a 4 MW diesel auxiliary generator and a 42 MW (heat input) steam generator (boiler) during unloading of a VLCC. Approximately one third of the flue gases generated by the boiler(s) will be used as an inert blanket gas for the unloading cargo compartments. For the other ship present at the dock, emissions from a 1 MW diesel generator were considered.

As for the refinery stacks, flue gas flow rates from ships were estimated based on fuel consumption and considering 3 per cent O_2 in the flue gas for the boilers and 15 per cent O_2 for the auxiliary diesel generator. Temperature was fixed at 200°C, and stack diameter set to a reasonable exhaust velocity. The fuel considered in the scenario is Marine Diesel Oil with a 1.5 per cent sulphur content for all ships.

VLCC tankers take about 20 hours to unload and smaller Suzemax tankers take about 16 hours. A total of 66 crude oil deliveries per year (39 for VLCCs and 27 for Suzemax tankers) is expected. When estimating maximum daily and annual concentrations, the hourly emissions for the VLCC tankers in Table 4.6 were scaled by 0.85 on a daily basis (20 hours per day) and by

0.15 on an annual basis (66 days per year and 20 hours per day). These scaling factors neglect that Suzemax tankers would take 16 hours instead of 20 hours for VLCC tankers.

Table 4.6 Point Sources Emissions Parameters Used for Air Dispersion Modeling for the Proposed Petroeum Refinery

Item N°	Unit	Service	Stack number	Base elev.	Stack Height	Temp.	Velocity	Stack Diameter	Building wake	Contaminant emission rates (g/s)				
				(m)	(m)	(°C)	(m/s)	(m)	(Yes/No)	SO_2	NOx	CO	PM_{10}	$PM_{2.5}$
1	Hydro cracker	Recycle Gas Htr 1	STCK1	30	45	200	8	1.60	No	0.038	1.320	0.942	0.085	0.085
2	**Hydro cracker**	**Product Frac Fd Htr 1**	**STCK2**	**30**	**45**	**200**	**8**	**1.96**	**No**	**15.147**	**4.226**	**0.689**	**1.351**	**0.952**
3	Hydro cracker	Recycle Gas Htr 2	STCK3	30	45	200	8	1.60	No	0.038	1.320	0.942	0.085	0.085
4	**Hydro cracker**	**Product Frac Fd Htr 2**	**STCK4**	**30**	**45**	**200**	**8**	**1.96**	**No**	**15.147**	**4.226**	**0.689**	**1.351**	**0.952**
5	Diesel HTU	Combined Feed Htr	STCK5	30	45	200	8	1.16	No	0.020	0.448	0.496	0.045	0.045
6	Kero HTU	Rx Charge Htr	STCK6	30	45	200	8	0.78	No	0.009	0.203	0.225	0.020	0.020
7	Kero HTU	Stripper Reboiler	STCK7	30	45	200	8	1.47	No	0.032	0.714	0.790	0.071	0.071
8	Naphtha HTU	Charge Htr	STCK8	30	45	200	8	1.14	No	0.019	0.430	0.475	0.043	0.043
9	Naphtha HTU	Stripper Reboiler	STCK9	30	45	200	8	1.53	No	0.035	1.208	0.862	0.078	0.078
10	Naphtha HTU	Splitter Reboiler	STCK10	30	45	200	8	2.12	No	0.067	2.298	1.641	0.148	0.148
11	Coker Naphtha HTU	Rx 2 Charge Htr	STCK11	30	45	200	8	0.89	No	0.012	0.262	0.290	0.026	0.026
12	**Crude**	**Crude Heater**	**GRP3**	**30**	**75**	**200**	**8**	**3.44**	**Yes**	**51.180**	**17.639**	**4.743**	**4.775**	**3.429**
13	**Crude**	**Vac Heater**												
14	**Utility**	**Steam Boiler 1**	**GRP2**	**30**	**75**	**200**	**8**	**4.52**	**Yes**	**80.906**	**22.571**	**3.681**	**7.216**	**5.084**
15	**Utility**	**Steam Boiler 2**												
16	**Utility**	**Steam Boiler 3**												
17	H2 Plant	Reformer	STCK17	30	45	200	8	2.47	No	0.091	3.135	2.238	0.202	0.202
18	H2 Plant	Reformer	STCK18	30	45	200	8	2.47	No	0.091	3.135	2.238	0.202	0.202
19	CCR	Charge Htrs 3	STCK19	30	45	200	8	3.62	No	0.196	6.730	4.805	0.435	0.435
20	CCR	Vent Stack	STCK20	30	45			0.00	No					
21	TGT/TO	Incinerator	STCK21	30	45	650	8	4.01	No	2.992				
22	Delayed Coker	Coker Htr 1	GRP1	30	75	200	8	4.42	Yes	0.177	6.080	4.341	0.393	0.393
23	Delayed Coker	Coker Htr 2												

Item N°	Unit	Service	Stack number	Base elev.	Stack Height	Temp.	Velocity	Stack Diameter	Building wake	Contaminant emission rates (g/s)				
				(m)	(m)	(°C)	(m/s)	(m)	(Yes/No)	SO_2	NOx	CO	PM_{10}	$PM_{2.5}$
24	Delayed Coker	Coker Htr 3												
25	Acid Gas Flare	Acid Gas Flare	FLACID	30	80									
26	High Pressure Flare	High Pressure Flare	FLHP	30	80									
27	Low Pressure Flare	Low Pressure Flare	FLLP	30	80									
28	**VLCC unloading**	**Ship**	**VLCC**	**0**	**45**	**200**	**15**	**1.49**	**Yes**	**26.992**	**17.586**	**4.102**	**1.185**	**0.941**
29	**Handymax loading**	**Ship**	**HANDY**	**0**	**30**	**200**	**10**	**0.54**	**Yes**	**1.509**	**2.500**	**0.697**	**0.076**	**0.074**

Sources in bold use heavy fuel oil, others use refinery gas.

Table 4.7 Area Source Emission Parameters for Fugitive Benzene Emissions

Source	Surface Area (m^2)	Base Elevation (m)	Height (m)	Benzene Emissions (t/y)	Benzene Emissions ($g/s/m^2$)
Storage Tanks	704,000	25	15	0.71	3.20×10^{-8}
Process Area	617,500	30	5	3.73	1.92×10^{-7}
Ship (loading)	7,264	0	10	0.34	1.48×10^{-6}

4.2.5 Model Results

Results of maximum and average predicted concentrations are presented on Figures 4.6 to Figure 4.14. These results are produced from predicted concentrations on the main receptor grid used in the CALPUFF air dispersion model. For criteria air contaminants (CAC), results are presented for each regulated time frame in the NL regulations. For benzene, only the long-term concentration is presented, since potential health effects related with this contaminant are for a very long-term exposure.

As shown on Figures 4.6 to 4.14, all maximum predicted concentrations occur within the plant site boundary. Secondary maxima also occur over water near the jetty and on elevated terrain several kilometers from the proposed refinery. In all cases, the predicted maximum concentrations of all substances and for all time frames (short term and long term), are below the NL regulatory limits at the project boundary line and within nearby communities.

Criteria Air Contaminants Results in Communities

Table 4.8 to Table 4.12 present maximum predicted concentrations in the communities of Arnold's Cove, Come By Chance, North Harbour, Southern Harbour and Sunnyside. Maximum background concentrations are also added to maximum Project predicted concentration to give total result concentration, even if maximum predicted and maximum background concentrations are unlikely to occur at the same moment and at the same receptor. All results are also expressed in term of percentage of the NL DOEC air quality standards. All results for all contaminants and time frames remain well below the NL DOEC air quality standards. These results are also compared to the WHO air quality standards for human health risk assessment.

Table 4.8 Summary of Results for Criteria Air Contaminants in Arnolds Cove

Pollutant	Time Frame	Standard	WHO	Background	NLRC (Maximum)		Total	
		(µg/m³)	Guidelines	(µg/m³)	(µg/m³)	%Standard	(µg/m³)	%Standard
SO_2	1-hour	900	350	348	136	15 %	484	54 %
	3-hour	600	20	220	76	13 %	296	49 %
	24-hour	300	20	79	32	11 %	111	37 %
	Annual	60	20	2	1.5	3 %	3.5	6 %
NO_2	1-hour	400	200	100	58	15 %	158	40 %
	24-hour	200	20	12	15	8 %	27	14 %
	Annual	100	20	1	0.9	1 %	1.9	2 %
CO	1-hour	35,000	35,000	2,200	23	0.1 %	2,223	6 %
	8-hour	15,000	15,000	1,400	9	0.1 %	1,409	9 %
PM_{10}	24-hour	50	50	14	3.1	6 %	17	34 %
	Annual	N.A.	20	7	0.12	N.A.	7.1	N.A.
$PM_{2.5}$	24-hour	25	25	10	2.3	9 %	12	49 %
	Annual	N.A.	10	5	0.08	N.A.	5.1	N.A.

Notes: NO2 results consider a total conversion of NO to NO2.
Maximum results for NLRC are added to maximum background concentrations without considering that maximums would most probably not occur simultaneously.

Table 4.9 Summary of Results for Criteria Air Contaminants in Come By Chance

Pollutant	Time Frame	Standard	Background	NLRC (Maximum)		Total	
		(µg/m³)	(µg/m³)	(µg/m³)	(%Standard)	(µg/m³)	(%Standard)
SO_2	1-hour	900	279	120	13 %	399	44 %
	3-hour	600	169	75	13 %	244	41 %
	24-hour	300	74	40	13 %	114	38 %
	Annual	60	5	2.3	4 %	7.3	12 %
NO_2	1-hour	400	75	60	15 %	135	34 %
	24-hour	200	40	20	10 %	60	30 %
	Annual	100	1	1.4	1 %	2.4	2 %
CO	1-hour	35,000	2,200	25	0.1 %	2,225	6 %
	8-hour	15,000	1,400	11	0.1 %	1,411	9 %
PM_{10}	24-hour	50	14	4.1	8 %	18	36 %
	Annual	N.A.	7	0.21	N.A.	7.2	N.A.
$PM_{2.5}$	24-hour	25	10	3	12 %	13	52 %
	Annual	N.A.	5	0.16	N.A.	5.2	N.A.

Notes:

NO_2 results consider a total conversion of NO to NO_2.
Maximum results for NLRC are added to maximum background concentrations without considering that maximums would most probably not occur simultaneously.

Table 4.10 Summary of Results for Criteria Air Contaminants in North Harbour

Pollutant	Time Frame	Standard	Background	NLRC (Maximum)		Total	
		(µg/m³)	(µg/m³)	(µg/m³)	(%Standard)	(µg/m³)	(%Standard)
SO_2	1-hour	900	200	169	19 %	369	41 %
	3-hour	600	125	121	20 %	246	41 %
	24-hour	300	20	54	18 %	74	25 %
	Annual	60	1	4	7 %	5.0	8 %
NO_2	1-hour	400	60	69	17 %	129	32 %
	24-hour	200	6	23	12 %	29	15 %
	Annual	100	1	2.2	2 %	3.2	3 %
CO	1-hour	35,000	2,200	28	0.1 %	2228	6 %
	8-hour	15,000	1,400	15	0.1 %	1415	9 %
PM_{10}	24-hour	50	13	4.1	8 %	17	34 %
	Annual	N.A.	7	0..35	N.A.	N.A.	N.A.
$PM_{2.5}$	24-hour	25	9	3.0	12 %	12	48 %
	Annual	N.A.	5	0.26	N.A.	5.3	N.A.

Notes:

NO2 results consider a total conversion of NO to NO2.
Maximum results for NLRC are added to maximum background concentrations without considering that maximums would most probably not occur simultaneously.

Table 4.11 Summary of Results for Criteria Air Contaminants in Little Southern Harbour

Pollutant	Time Frame	Standard	Background	NLRC (Maximum)		Total	
		(µg/m³)	(µg/m³)	(µg/m³)	(%Standard)	(µg/m³)	(%Standard)
SO_2	1-hour	900	175	78	9 %	253	28 %
	3-hour	600	125	58	10 %	183	31 %
	24-hour	300	30	21	7.0 %	51	17 %
	Annual	60	1	0.7	1.2 %	1.7	3 %
NO_2	1-hour	400	30	41	10 %	71	18 %
	24-hour	200	5	11	6 %	16	8 %
	Annual	100	1	0.36	0.4 %	1.4	1 %
CO	1-hour	35,000	2,200	20	0.1 %	2,220	6 %
	8-hour	15,000	1,400	6	0.0 %	1,406	9 %
PM_{10}	24-hour	50	12	2	4.0 %	14	28 %
	Annual	N.A.	7	0.05	N.A.	7.1	N.A.
$PM_{2.5}$	24-hour	25	8	1.5	6 %	10	38 %
	Annual	N.A.	5	0.04	N.A.	5.0	N.A.

Notes:

NO2 results consider a total conversion of NO to NO2.
Maximum results for NLRC are added to maximum background concentrations without considering that maximums would most probably not occur simultaneously.

Table 4.12 Summary of Results for Criteria Air Contaminants in Sunnyside

Pollutant	Time Frame	Standard	Background	NLRC (Maximum)		Total	
		(µg/m³)	(µg/m³)	(µg/m³)	(%Standard)	(µg/m³)	(%Standard)
SO_2	1-hour	900	235	122	14 %	357	40 %
	3-hour	600	149	91	15 %	240	40 %
	24-hour	300	70	27	9.0 %	97	32 %
	Annual	60	6	1.4	2.3 %	7.4	12 %
NO_2	1-hour	400	45	43	11 %	88	22 %
	24-hour	200	10	14	7 %	24	12 %
	Annual	100	1	0.8	0.8 %	1.8	2 %
CO	1-hour	35,000	2,200	14	0.0 %	2,214	6 %
	8-hour	15,000	1,400	10	0.1 %	1,410	9 %
PM_{10}	24-hour	50	15	2.8	5.6 %	18	36 %
	Annual	N.A.	7	0.13	N.A.	7.1	N.A.
$PM_{2.5}$	24-hour	25	11	2.1	8 %	13	52 %
	Annual	N.A.	5	0.1	N.A.	5.1	N.A.

Notes:

NO2 results consider a total conversion of NO to NO2.
Maximum results for NLRC are added to maximum background concentrations without considering that maximums would most probably not occur simultaneously.

Maximum Results Near the Property Line

Table 4.13 presents the maximum predicted concentrations at the Project property line, considered to extend from line to the north of the refinery (along the access road) to the coastline of the Southern Head. All these maxima occur at the property line, or more precisely at the coastline, to the south and south-east of the refinery. Maximum one hour (734 µg/m³) and daily (251 µg/m³) SO_2 concentrations predicted at the property line represent approximately 82 per cent of the DOEC standards of 900 µg/m³ and 300 µg/m³, respectively. For NO_x (expressed as NO_2), the maximum hourly-predicted concentration (297 µg/m³) reaches 74 per cent of the air quality standard (400 µg/m³) and the maximum daily average predicted NO_2 concentration (163 µg/m³) reaches 82 per cent of the air quality standard (200 µg/m³). For hourly and daily SO_2 and NO_2 concentrations, the second highest maximum overall property line receptors are also shown in Table 4.13, which shows the second largest concentration in the model domain outside the property line is reduced significantly.

Table 4.13 Summary of Results for Criteria Air Contaminants at the Property Line

Pollutant	Time Frame	Standard	NLRC - Highest First (Second) Maximum	
		(µg/m³)	(µg/m³)	(%Standard)
SO_2	1-hour	900	734 (539)	82 % (60 %)
	3-hour	600	335	56 %
	24-hour	300	251 (207)	84 % (69 %)
	Annual	60	21	35 %
NO_2	1-hour	400	297 (267)	74 % (67 %)
	24-hour	200	163 (135)	82 % (68 %)
	Annual	100	16	16 %
CO	1-hour	35,000	123	0.4 %
	8-hour	15,000	38	0.3 %
PM_{10}	24-hour	50	11	22 %
	Annual	N.A.	1.1	N.A.
$PM_{2.5}$	24-hour	25	8.7	35 %
	Annual	N.A.	0.9	N.A.

Notes:

NO_2 results consider a total conversion of NO to NO_2.

Table 4.14 presents the maximum contribution of the refinery source and the unloading ship at the property line. These results show that the refinery emissions produce the hourly maximum predicted concentrations of SO_2 and NO_2 at the property line and that the unloading VLCC produced the maximum daily average concentrations of SO_2 and NO_2 at the property line. From the refinery, the boilers stack (GRP2) and the crude units (GRP3) are the major contributors to the predicted maxima from the refinery. Since the property line is in between both sources (ship and refinery), it is unlikely that both sources contribute significantly to the same short maximum concentration.

Table 4.14 Maximum Short-term Predicted Concentration Outside the Property Line from the Refinery and the Unloading Ships

Pollutant	Time Frame	Standard (µg/m³)	NLRC Refinery (µg/m³)	Ships (µg/m³)	Both (µg/m³)
SO_2	1-hour	900	734 Coast line South of refinery	414 Coast line West of jetty	734 Coast line South of refinery
	24-hour	300	64 Local summit 10 km north north-west of refinery	251 Coast line South of refinery	251 Coast line South of refinery
NO_2	1-hour	400	297 Coast line South of refinery	270 Coast line West of jetty	297 Coast line South of refinery
	24-hour	200	31 Local summit 10 km north north-west of refinery	163 Coast line West of jetty	163 Coast line West of jetty

Notes:

NO2 results consider a total conversion of NO to NO2.
Ships: one VLCC unloading and one Handymax in standby

Benzene

Annual average predicted concentrations of benzene in ambient air are presented in Figure 4.14 and are summarized for communities and at the property line in Table 4.15. There is no local air quality standard for benzene in ambient air. These results will be used in the health impact assessment since benzene is a known carcinogenic substance. The highest concentrations are predicted at the property line (at 0.42 µg/m³). In communities, the highest concentrations are predicted in Comeby-Chance (0.026 µg/m³) and North Harbour (0.0173 µg/m³).

Table 4.15 Summary of Results for Benzene

Receptor area	Maximum annual average concentration in the area (µg/m³)
Arnold's Cove	0.0086
Come By Chance	0.0126
North Harbour	0.0173
Little Southern Harbour	0.0026
Sunny Side	0.0062
Property line	0.42 (on the coastline, near the jetty)

Conclusion

The air quality modeling prediction and air quality impact assessment was made with the best information available to estimate the overall atmospheric emissions using a conservative approach. These estimates are realistic (on the conservative side) and allow NLRC to proceed with the atmospheric dispersion study. The precautionary principle was applied in this situation.

With regards to predicted concentrations in the nearby communities, all results remain well below NL DOEC air quality regulations, even when adding maximum estimated background concentrations other sources. It is also near or below WHO guidelines.

At the property line and the coastline (which is considered as the property line to the south and south-east of the proposed refinery), the predicted short-term (1-hour to 24-hour) average concentrations of NO_2 and SO_2, could reach levels about 80-85% of the NL DOEC air quality standards. However, if these maximum concentrations were effectively observed, their frequency of occurrence would be very low. These results are based on a cautious or worst-case emission scenario during normal operation of the proposed refinery, which considers maximum permitted NOx levels and the maximum sulfur content of the fuel oil specification.

Figure 4.6 Maximum 1-hour average predicted SO_2 concentration ($\mu g/m^3$) in ambient air

Figure 4.7 Maximum 24-hour average predicted SO_2 concentration (µg/m³) in ambient air

Figure 4.8 Maximum annual average predicted SO_2 concentration (µg/m³) in ambient air

Figure 4.9 Maximum 1-hour average predicted NOx (as NO_2) concentration (µg/m³) in ambient air

Figure 4.10 Maximum 24-hour average predicted NOx (as NO_2) concentration (μg/m³) in ambient air

Figure 4.11 Annual average predicted NOx (as NO_2) concentration (μg/m³) in ambient air

Figure 4.12 Maximum 24-hour average predicted PM_{10} concentration (μg/m³) in ambient air

Figure 4.13 Maximum 24-hour average predicted $PM_{2.5}$ concentration (µg/m³) in ambient air

Figure 4.14 Annual average predicted benzene concentration (µg/m³) in ambient air

4.3 Effluents Discharge Modeling

4.3.1 Introduction

To support the impact assessment at the proposed refinery site of southern head, Come By Chance, this section details the results of wastewater effluent simulation. In the simulation, both the average and worst-case scenarios were considered. To accompany delivery of the wastewater effluent modeling results, a description of the model theory, outfall configuration, and conclusions based on the modeling activity are presented.

There will be one outfall pipe approximately 400m with a 100m diffuser at its end, located west of the Southern Head point. It should be noted that the actual concentration of various substances in the treated effluent is not known at present and will be determined as detailed engineering progresses. However, all discharges will be in compliance with the Newfoundland & Labrador "*Environmental Control Water and Sewage Control Regulations and Associated Guidelines*." (Government of Newfoundland and Labrador, 2003). Where specific substances are not addressed in these regulations, permissible levels have been supplement with those listed in the CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life.

Treated wastewater from the wastewater treatment plant will be combined with other discharges from the site: cooling water from the main closed loop cooling system, cooling water from the thermal desalination process, and desalination brine from the thermal desalination process. The principal components of concern in the combined discharge are high salinity and temperature. Site-specific models will be prepared to ensure these parameters fall within acceptable ranges for marine discharge.

4.3.2 Description of the Model

Overview

There are two major types of models usually used for effluent analysis. They are the steady-state mixing zone models and the non-steady-state ocean circulation models. Although non-steady-state models are more advanced, they are not applicable for near field analysis and should only be used for areas far from the discharge due to the inherent model limitations. For the purpose of outfall design and near field analysis, steady-state models have been used.

There are three steady-state models available, which may be used for near field analysis. They are: Cornell Mixing Zone Expert System (CORMIX); Visual Plumes model (U.S. Environmental Protection Agency); and the VISJET model (University of Hong Kong). Among these three models, the CORMIX is the most comprehensive model and was used in the simulation.

CORMIX

CORMIX is a USEPA-supported mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones resulting from continuous point-source discharges. The system emphasizes the role of boundary interaction to predict steady-state mixing behavior and plume geometry.

The current version of CORMIX includes three sub-models - CORMIX1 for submerged single-port discharges, CORMIX2 for submerged multi-port discharges, and CORMIX3 for surface discharges. The latest version of CORMIX also included a D-CORMIX sub-model, which extends the CORMIX expert system to water quality prediction from continuous dredge disposal sources.

Use of CORMIX1 requires the specification of a rectangular grid system. Flow rate and discharge velocity, the density of the discharged water, and the contaminant concentration in the discharged water is specified. For non-conservative contaminants, a first-order decay rate can be specified. From 35 possible flow classes, the decision support system implemented in CORMIX1 selects the solution class most representative of the specified situation and provides the user with graphical and tabular summaries of the solution results that are used to define the mixing zone.

The CORMIX2 sub-model idealizes a multi-port diffuser as a finite-length, buoyant slot jet with the slot width and orientation chosen to give volume, momentum, and buoyancy fluxes equivalent to the vector sums of the corresponding port fluxes. The ambient flow environment is specified by an idealized rectangular cross section, a steady and uniform ambient flow, and a piece-wise linear vertical density structure, consistent with CORMIX1. The discharge is specified by its position and orientation (angles with respect to the horizontal and vertical), the slot equivalent volume flow rate and discharge velocity, the density of the discharged water and its contaminant concentration. From 24 possible classes, the decision support system implemented in CORMIX2 can select the solution class most representative of the specified situation and provide graphical and tabular summaries of the solution results for dilution and near-field the mixing zone definition.

The CORMIX3 sub-model simulates a surface discharge from a pipe into a semi-infinite ambient environment. The ambient flow environment is represented by a constant shoreline depth and bottom sloping downward away from the shoreline. The spatially and temporally constant ambient current is aligned parallel to the shoreline. The discharge is specified by its orientation (angle with respect to the shoreline), pipe diameter, volume flow rate and discharge velocity, density of the discharged water and its contaminant concentration. CORMIX3 is particularly suited for the analysis of thermal discharges and includes a wind speed-dependent atmospheric heat exchange formulation. From nine possible classes the decision support system implemented in CORMIX3 can select the solution class most representative of the specified situation and provide graphical and tabular summaries of the solution results for dilution and near-field mixing zone definition.

4.3.3 Model Input

The dispersion of the effluent is affected by several factors such as discharge characteristics (flow-rate and density), ambient characteristics (water column density profile, currents speeds, and wind speeds etc.), and outfall configuration (length of diffuser, size and space of discharge ports, orientation of ports etc.).

Discharge Characteristics

The effluent considered has four components: 1) cooling water at a rate of 13,300 GPM; 2) desalination (cooling) reject water at a rate of 20,000 GPM; 3) brine at a rate of 7,000 GPM at 1.5 times ambient seawater salinity; and 4) treated wastewater at a rate of 2,218 GPM. The total discharge rate of combined discharge is 42,518 GPM. The detailed water system is illustrated in Figure 4.15.

The temperature of the combined discharge is 32 ºC. This temperature is about 26.6 ºC (May) and 15 ºC (August) higher than the temperature of ambient seawater. The salinity of the combined discharge is about 33.18 psu, which is only about 1~2 psu above the salinity of ambient seawater. The discharge may also contain various pollutants, such as heavy metals and PAHs.

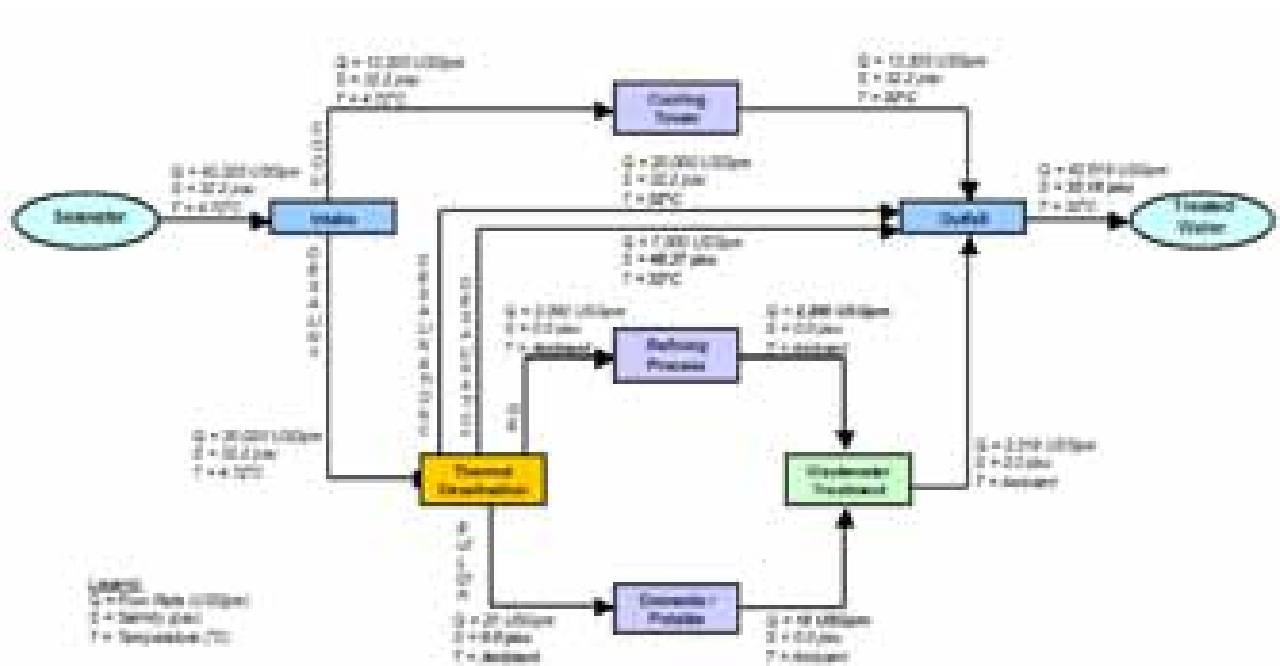

Figure 4.15 Schematic of the Water System

Ambient Characteristics

The ambient seawater characteristics for the modeling were based on field measurements conducted in June 2007 near the proposed refinery site, and additional ambient profiles for summer case derived from literature.

For the June case, the CTD casts give the temperature and salinity for various depths up to 21.5 m (Figure 4.16). The CORMIX cannot take arbitrary density profiles and can only take three different approximations. In this simulation, a linear stratification approximation (Type A profile) was used.

For the summer case, the surface layers up to 18 meters are well mixed and a similar linear profile was used.

The currents at the discharge point are relatively weak. A recent measurements conducted in June 2007 indicated the mean current is 0.2 m/s, while the minimum current is 0.002 m/s (almost stagnant). For the worst-case scenario, the minimum current was used.

Although surface wind may enhance `mixing, zero wind speed was used in the simulation to ensure adequate mixing and dilution can be maintained in calm conditions as well.

The water depth at the discharge point ranges from 10 m to 20 m. An average depth of 15 m was adopted.

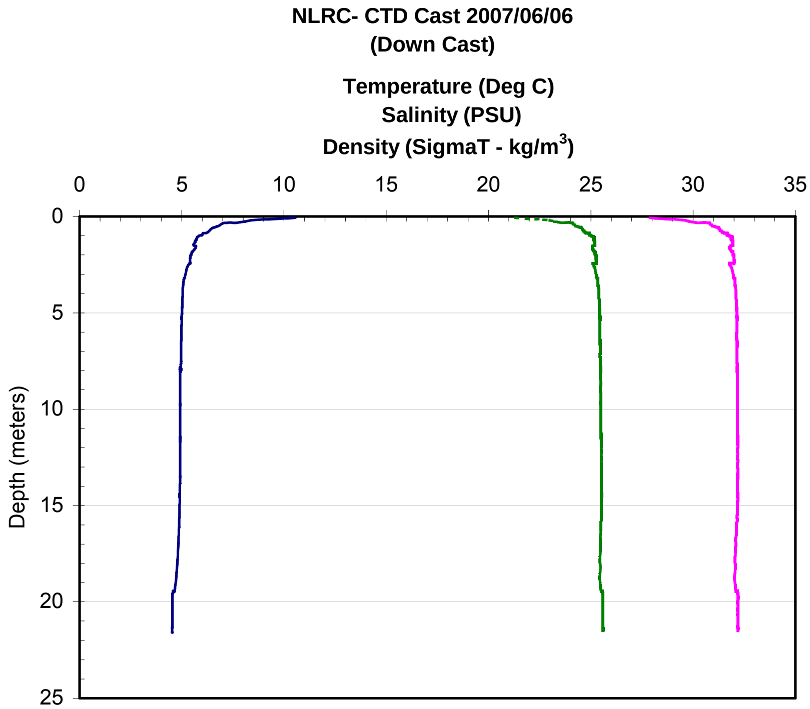

Figure 4.16 Ambient Sea Water Profile

Outfall Configuration

In this study, a submerged multi-port diffuser was used to maximize dilution. The 100 m diffuser is located at the end of the outfall pipe, about 300 m away from shore and is positioned perpendicular to the mean current direction. The internal diameter of the diffuser pipe is 1.2 m with 100 ports, each oriented 45 degrees upward. The spacing of the ports is 1 m and the size of the ports is 0.1 m in diameter. The outfall pipe could be a steel pipe coated with concrete, high-density polyethylene or fiberglass. The average water depth at the discharge is about 15 m.

The configuration of the outfall is illustrated in Figure 4.17.

4.3.4 Model Output

The model results are shown in Figures 4.18, 4.19 and 4.20. The shape of the plume up to a downstream distance of 50 m is illustrated in Figure 4.18. Once discharged, the effluents from each port first spread as individual plumes and then merged together. While the plume thickness continues to increase until fully mixed vertically, there is a decrease in plume width before the increasing due to buoyancy effects.

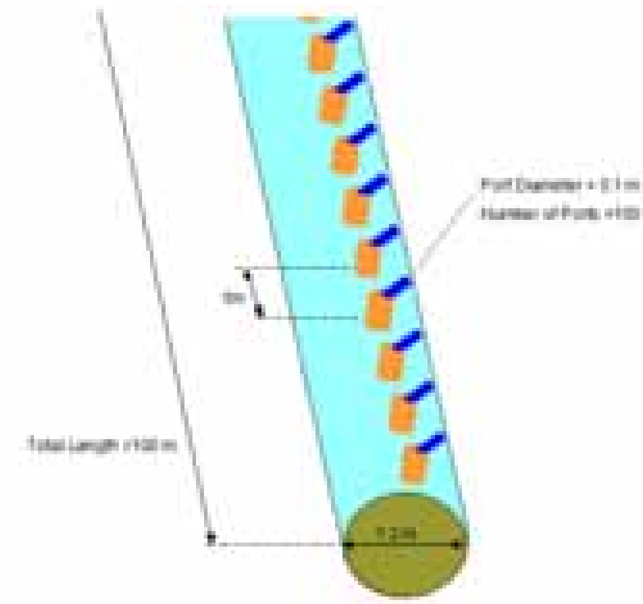

Figure 4.17 Outfall Configuration

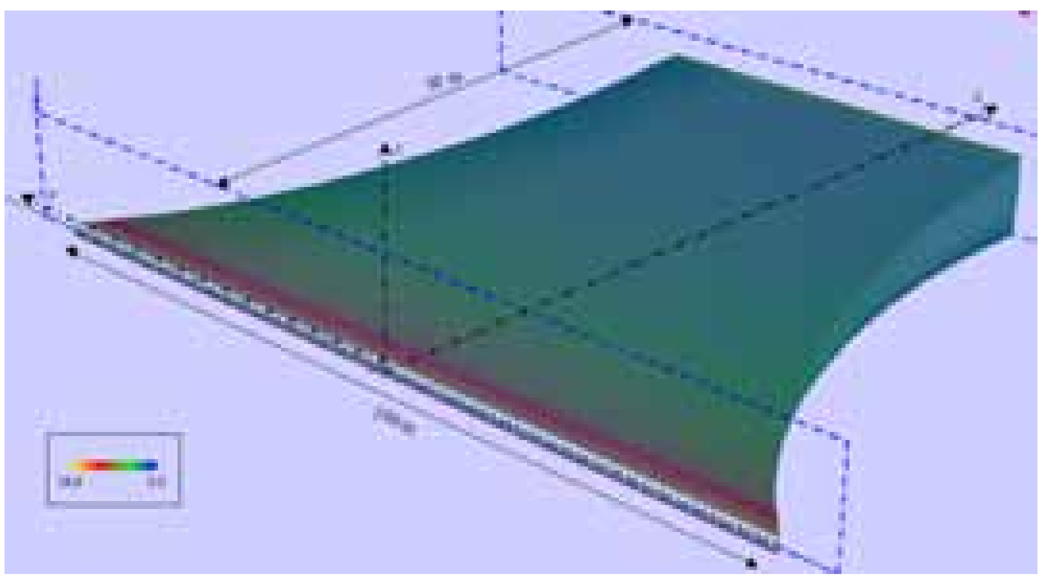

Figure 4.18 Plume Profile

The results based on the June ambient profile are shown in Figure 4.19. The dashed line is the predicted downstream excess temperature under mean currents speed and the solid line is the predicted temperature under minimum current speed. For an initial excess temperature of 26.6 ºC, the excess temperature decreased to 0.25 ºC under mean current speed at 50 m downstream. Under the minimum current speed, the excess temperature decreased to about 1 ºC at 50 m downstream.

Additional modeling was conducted to study the impacts during summer. In summer, due to the higher ambient seawater temperature, the increase of temperature may be more critical. Site-specific ambient data for summer temperature is unavailable therefore measured data from another site in Placentia Bay was used. The measured seawater temperature in August is about 16.5 ºC; this yields an initial excess temperature of 15.5 ºC.

Although a different ambient profile was used, the CORMIX predicted same order of dilution. This implies that the model is not sensitive to the small variation of ambient density based on the current outfall design. However, although the predicted dilutions for the two cases are same, the predicted excess temperatures are different due to the different initial values. The results for the summer case are shown in Figure 4.19. The solid line represents the results under minimum currents while the dashed line represents the results under mean currents. It can be seen from Figure 4.20 that the excess temperature can reach 1 ºC at a distance of 15 m under minimum current. At 50 m downstream, the excess temperature is only 0.57 ºC. If mean currents are used, the predicted excess temperature at 50 m down stream is only about 0.14 ºC.

It should be noted that wind was not considered in the simulation to produce a conservative analysis. With the presence of wind, additional mixing will be introduced and lower excess temperature will result, producing a smaller zone of influence.

The above model results are good indications of the mixing behaviours of other substances (pollutants).

4.3.5 Conclusions

As shown, the predicted zone of influence for the cooling/effluent discharge is within less than 100 m radius for the outfall diffuser and the impact on receiving water is localized (limited to the diffuser length). Therefore its effect on receiving water is insignificant.

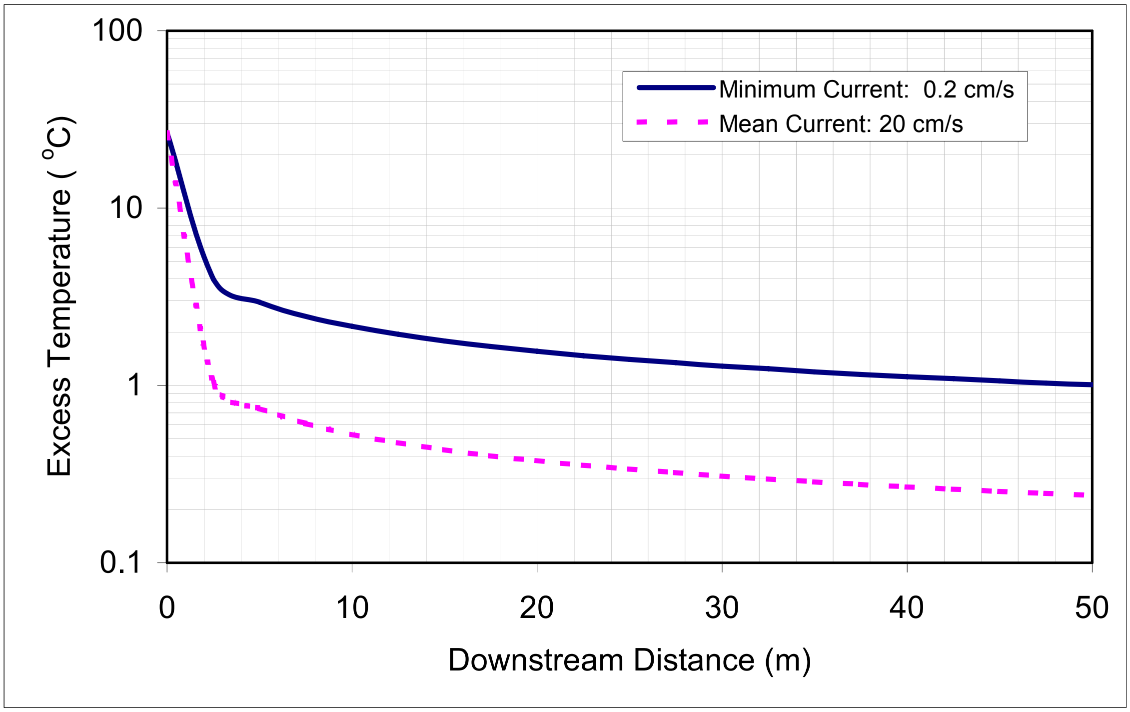

Figure 4.19 Model Results - Excess Temperature versus downstream distance (May Ambient Density Profile)

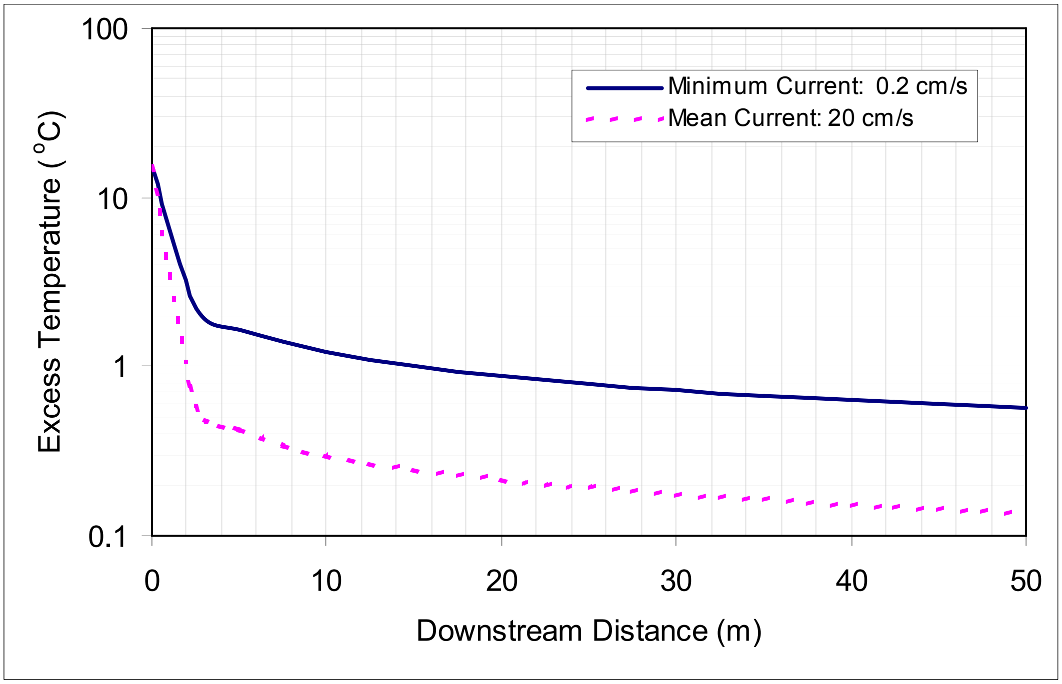

Figure 4.20 Model Results - Excess Temperature versus downstream distance (August Ambient Density Profile)

4.4 Air Quality Effects Assessment

4.4.1 Introduction

Baseline description of the air quality is provided in Section 3.2. In addition, a number of studies on air quality has been consulted, including the Air Quality Component Study (SNC-Lavalin Environment, July 2007); Human Health and Ecological Effects Assessment for the Proposed New Refinery at the Southern Head of Placentia Bay, NL (SENES Consultants Limited, July 2007); the report by the Health Research Unit of Faculty of Medicine of the Memorial University of Newfoundland (June 2007) entitled A review of the Health Status of the Come by Chance Area, Newfoundland and Labrador; and other studies by the various environmental consultants involved in the EA as it relates to specific VEC.

The report on ‘Health Implications of Petroleum Refinery Air Emissions” prepared for, Health Prioritization Sub-Group of National Framework for Petroleum Refinery Emissions Reduction (NFPRER) of the Canadian Council of Ministers of the Environment (CCME) by WBK and Associates Inc. (March 2003), reviewed recent public health risk assessments conducted in the areas of impact of petroleum refineries and epidemiological or community health studies of populations residing in the vicinity of petroleum refineries.

NLRC, in consultation with the Department of Environment and Conservation, has modelled the dispersion of air emissions from the proposed new crude oil refinery at Southern Head. The results of this investigation are provided in Section 4.2 of this volume. The air dispersion modeling was carried out for the proposed refinery operations, to evaluate the impacts of the refinery emissions (particularly sulphur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), suspended particulates (PM10 and PM2.5) and benzene) on ambient air quality. The predicted results were then compared with Newfoundland and Labrador ambient air quality standards as well as the World Health Organization (WHO) standards as related to impact on human health.

Air quality issues such as smog and acid rain result from the presence of, and interaction between, a group of pollutants known as Criteria Air Contaminant (CAC) and some related pollutants include:

- Sulphur Oxides (SOx ,particularly Sulphur Dioxide SO2)
- Nitrogen Oxides (NOx, particularly NO2)
- Particulate Matter (PM10, PM2.5)
- Volatile Organic Compound (VOC)
- Carbon monoxides (CO)
- Ammonia (NH3)

In addition, Ground level Ozone (O3) and Secondary Particulate Matter (PM) and are also referenced among CAC because both ozone and secondary PM are by-products of chemical reactions between CACs. CAC are produced from number of sources including burning of fossil fuel, refinery process, power generators, etc.

4.4.2 Project Effects During Construction

Various air emissions will be associated with the construction activities, which mainly include dust from site development and road construction, excavation and vehicular traffic, also emissions from mobile equipment, temporary power generators and heaters, fuel storage tanks, and vessels loading and unloading of construction materials and supplies. These activities are of relatively short duration and can be controlled by application of good construction practices, application of EPP, environmental control and mitigation measures considered in each activity as detailed in Volume 2 (Chapters 5 and 8).

Prior to the construction phase, and as part of construction permits, the Proponent will prepare a general program to control atmospheric emissions of major construction heavy equipments, generators and other sources. The program will include among other items:

- a dust control program;
- heavy equipment specifications to have recent equipments in good conditions (to minimize criteria air contaminants emissions);
- heavy equipment maintenance program;
- fuel oil specifications.

An environmental monitoring program will be implemented including the installation of air monitoring station at the property limit to verify the compliance to ambient air quality criteria.

The effects on various Valued Ecosystem Components are presented and assessed for each VEC in the relevant sub-sections of this Chapter (Sections 4.4 to 4.10).

Dust emissions and runoff will be created at the Project site from crushing operations, aggregate and overburden stockpiles, unpaved roadways and cleared areas.

Dust generated during construction will be controlled using one or more conventional measures, as applicable to the particular location, including water spraying, wind breaks, spray-on adhesives and vegetative coverings. Chemical-based solutions will not be used or applied near water bodies.

All surficial root mat, topsoil, grubbing, peat, and weathered glacial till will be removed prior to the cut/fill operation. Unsuitable material (USM) will be placed on the south-east edge of the project site to provide a berm to act as a visual screen of the project area from the shoreline. Organic material will be stockpiled in the same area. This stockpile will be used for surface preparation of the berm and other areas to be re-vegetated. A perimeter ditch will be installed to intercept any surface runoff.

The movement of bulk sulphur and coke from production to the storage area and to the ship will be via rubber belt conveyors. The conveyors will be covered to minimize the escape of dust to the environment. To minimize the amount of dust formed, the free fall height from one conveyor or hopper to another, the number of drops in the conveying system will be minimized. Covered hoppers and flaps on the discharge and receiving belts will reduce air currents and the amount of dust that is picked up.

Water runoff from the sulphur and coke stockpiles will be collected in a contained drainage system and directed to the treatment plant for processing.

All concrete required for the Project will be brought in from existing batch plants in the surrounding area.

In general, environmental effects of the construction activities on air quality are mitigatable, and the residual effects of such activities is assessed to be negligible to moderate (insignificant).

4.4.3 Monitoring and Follow-up

NLRC will install air quality monitors in the project area. The proposed monitoring network will be complementary to the existing network (Sunnyside, Come By Chance, etc.). A monitoring station will be installed at the property limit (and other locations in the nearby communities as determined in consultation with communities and regulatory agencies). Additional locations may be needed, as a result of a specific study related to the analysis of the air monitoring network, which will be carried out at the detailed engineering phase.

Air monitoring stations will be installed early in the construction phase to provide baseline data and will be used to supply continuous monitoring of local air pollutants and determine compliance with operating permits and validate the results of air quality modeling.

NLRC is also required to report on all emissions from its operation (including those during construction activities) to the National Pollutant Release Inventory (NPRI), Environment Canada. These include Criteria Air Contaminants or Chemicals of Concerns (COC).

4.4.4 Project Effects During Operations

During the operations, emission sources include:

- storage tanks (the tank farm);
- process unit emissions (stacks, vents, and fugitive emissions);
- waste water treatment and potential cooling water system;
- ship loading/unloading

- vessel operations
- flares.

The methodology of estimating the air emission quantities from the above sources and the estimated values used in the air dispersion model are described in details in Volume 2 (Section 8.3). Air quality dispersion model results are shown in Section 4.2 of this Volume (3).

Potential Cumulative Effects on Air Quality

The NL DOEC provided background concentration of pollutants in communities in order to take account for existing sources of pollutants and in particular the North Atlantic refinery and NTL.

Future projects were also analyzed on a qualitative basis. Projects such as the future LNG Transshipment facility and the VBNC Long Harbor Nickel processing plant are either not a significant emitter of criteria air pollutant or too far away (> 10 km) to have a significant impact in the study air-shed, therefore not considered in the modeling simulations.

Summary of Model Results

The air quality modeling prediction and air quality impact assessment was made using the best information available to estimate the overall atmospheric emissions using a conservative approach. These estimates are realistic and are on the conservative side, where the precautionary principle was applied in this situation.

With regards to predicted concentrations in the nearby communities, all results remain well below NL DOEC air quality regulations, even when adding maximum estimated background concentrations due to other sources (cumulative effects). These concentrations in most part are near or below WHO guidelines at these communities.

At the property line and the coastline (which is considered as the property line to the south and south-east of the proposed refinery), the maximum predicted short-term (1 hour to 24-hour) concentrations of NO_2 and SO_2, could reach levels about 80-85% of the NL DOEC air quality standards. However, if these maximum concentrations were effectively observed, their frequency of occurrence would be very low. These results are based on a cautious or worst-case emission scenario during normal operation of the proposed refinery, which considers maximum permitted NO_x levels and the maximum sulfur content of the fuel oil specification.

Table 4.16 provides a summary of the air quality model results at the refinery property lines and the nearby communities. It also compares the contributions from the refinery (NLRC) alone and in combination (cumulative) with other sources (background concentrations).

Table 4.16 Summary of Air Quality Model Results at Project Boundary and Nearby Communities in Comparison with NL and WHO Guidelines

Pollutant	Time Frame	NL DOEC Standard (µg/m³)	WHO Guidelines (µg/m³)	NLRC Property Line (µg/m³)	Communities									
					Arnold's Cove (µg/m³)		Come By Chance (µg/m³)		North Harbour (µg/m³)		Southern Harbour (µg/m³)		Sunnyside (µg/m³)	
					NLRC	Total	NLRC	Total	NLRC	Total	NLRC	Total	NLRC	Total
SO_2	1-hour	900	350	734	136	484	120	399	169	369	78	253	122	357
	24-hour	300	20	251	32	111	40	114	54	74	21	51	27	97
	Annual	60	20	21	1.5	3.5	2.3	7.3	4	5.0	0.7	1.7	1.4	7.4
NO_2	1-hour	400	200	297	58	158	60	135	69	129	41	71	43	88
	24-hour	200	20	163	15	27	20	60	23	29	11	16	14	24
	Annual	100	20	16	0.9	1.9	1.4	2.4	2.2	3.2	0.36	1.4	0.8	1.8
CO	1-hour	35,000	35,000	123	23	2,223	25	2,225	28	2228	20	2,220	14	2,214
	8-hour	15,000	15,000	38	9	1,409	11	1,411	15	1415	6	1,406	10	1,410
PM_{10}	24-hour	50	50	11	3.1	17	4.1	18	4.1	17	2	14	2.8	18
	Annual	N.A.	20	1.1	0.12	7.1	0.21	7.2	0.35	N.A.	0.05	7.1	0.13	7.1
$PM_{2.5}$	24-hour	25	25	8.7	2.3	12	3	13	3.0	12	1.5	10	2.1	13
	Annual	N.A.	10	0.9	0.08	5.1	0.16	5.2	0.26	5.3	0.04	5.0	0.1	5.1

NLRC: NLRC refinery emissions only

Total: cumulative concentrations from NLRC and other sources

4.4.5 Ecological Risk Assessment

The ecological risk assessment is an assessment to determine if plant and animal species in the vicinity of the proposed refinery would experience adverse effects from emissions of chemicals of concern (COC). Once the refinery is erected, there is no potential for pathway of exposure for ecological receptors on the site. As such, the ecological risk assessment only examines potential off-site effects (i.e., at and beyond the Project property limits).

The evaluation is based on the fact that Southern Head is a greenfield site, although there is considerable industrial infrastructure nearby in this area of Placentia Bay. The proposed refinery will consist of process facilities, a marine terminal, storage tanks and an access road and utilities. The primary product of the proposed refinery will be gasoline, kerosene / jet fuel, ultra-low sulphur diesel and refining by-products.

Methodology

The methodology used in the ecological risk assessment follows general guidance concerning the views of the Canadian Council of Ministers of the Environment (CCEM) on what constitutes as ecological risk assessment. The framework provided is similar to that proposed by Environment Canada. The CCME proposes three levels of investigation:

3. Screening level assessment (SLA): essentially a qualitative assessment of potential risks to important ecological receptors.
4. Preliminary quantitative risk assessment (PQRA): focuses on filling gaps identified at the screening level.
5. Detailed quantitative risk assessment (DQRA): includes more detailed data and modelling.

A screening level ecological risk assessment was appropriate for evaluating off-site emissions from the proposed refinery to determine if any risks exist to ecological receptors in the vicinity of the facility as well as in the near-by communities and whether a more detailed analysis is warranted. The screening level assessment was carried out using the following four basic elements:

- Receptor characterization - at this phase of the assessment the potential receptors are identified and the pathways of exposure defined.
- Exposure assessment - the purpose of this stage is to quantify the contact between the receptor and the chemical of concern.
- Hazard assessment - this phase of the ERA examines the potential effects of a chemical to a receptor using toxicity reference values (TRVs).
- Risk characterization - the risk characterization stage combines the information collected in the exposure assessment and the hazard assessment and the potential for adverse ecological effects is estimated.

Assessing the potential risks of unacceptable mortality, decreased growth, or reproductive impairment for populations exposed to chemicals was carried out by the accurate integration of estimates or measures of exposure and dose with benchmark concentrations known to produce toxic responses.

The screening level ecological risk assessment was performed for representative ecological receptors (e.g., vegetation, as well as wildlife) to cover a range of possible exposure scenarios following the guidance set out by the CCME. The assessment considered terrestrial vegetation, earthworms, mice, shrews, hare, waterthrush, woodpeckers and owls. These receptors covered a wide range of exposure. Predatory mammals were not considered in the assessment as the waterthrush, woodpecker, and owl exposure would encompass the exposure of mammalian predators and the chemicals considered in the assessment do not have the ability to bio-accumulate.

Since the maximum predicted soil concentrations after 30 years of deposition of VOCs, PAHs and PHCs are very low, the predicted concentrations in a waterbody in the area would be much lower as not to be measured. Therefore, aquatic receptors, including seabirds, were not considered in the assessment.

The chemicals of concern identified were gaseous air pollutants (sulphur dioxide, nitrogen oxides and carbon monoxide,), volatile organic compounds (VOCs), petroleum hydrocarbon (PHC), polycyclic aromatic hydrocarbons (PAHs), and particulate matter (PMs). (A description of these chemicals is provided in Volume 3 Biophysical Assessment, Section 3.2 Air Quality.)

The exposure pathways that were evaluated included soil uptake by plants and direct soil contact exposure to soil invertebrates, uptake of gases (SO_2, NO_x) by vegetative species, direct contact with soil, and ingestion of vegetation, earthworms and prey by terrestrial animals and birds.

The pathways are discussed below:

- Soil uptake by plants and direct soil contact exposure to soil invertebrates: Terrestrial vegetation comprise one of the most potentially exposed populations since these receptors reside in the soil and are therefore continuously exposed. Because these receptors are not mobile they would be exposed to the contamination over a lifetime.
- Uptake of gases (SO2, NOx) by vegetative species: Sulphur dioxide penetrates the stomata of plants. High concentrations of sulphur dioxide over a short duration of exposure are known to cause acute injury in the form of foliar necrosis. However, longer term effects of SO2 exposure are more important since they occur at much lower concentrations and are cumulative in nature resulting in adverse effects such as reduced growth and yield and increased aging which may not be visible or manifested as chlorosis. Nitrogen containing air pollutants can affect vegetation indirectly, via chemical reactions in the atmosphere or directly by deposition on vegetation soil or water. NO and NO2 are precursors to trophospheric ozone which is also known to be phytotoxic. Uptake of NOx (NO and NO2) in the leaves from wet

deposition is generally via the cuticle. External factors such as humidity, temperature, and light intensity affect the phototoxicity and influence the rate of uptake of SO2 and NOx and thus the degree of injury.

- Direct contact with soil, soil ingestion and inhalation exposure to terrestrial animals and birds: The predicted air concentrations are so low that the inhalation pathways are considered to be insignificant. Terrestrial mammal and birds are potential exposed through direct contact and ingestion of soil through ingestion of soil dwelling invertebrates and vegetation. Terrestrial invertebrates or soil dwelling organisms also comprise a potentially highly exposed population since these receptors reside in the soil and are therefore continually exposed to contaminated soil. The earthworm acts as a surrogate for effects on all soil dwelling organisms due to the fact that the most comprehensive toxicity data is available for the earthworm.
- Ingestion of vegetation, earthworms and prey by terrestrial animals and birds: Birds and small mammals such as mice, shrews and various birds will most likely inhabit the area around the proposed refinery as well as the various communities. In general, these small mammals are potentially exposed by consuming vegetation and/or earthworms from the study area as well as through direct contact with the soil. These animals are considered to be the most exposed; therefore if the results indicate that no adverse effects are predicted in smaller animals then larger animals are also protected.

As discussed previously, the maximum predicted soil concentrations after 30 years of deposition of VOCs, PAHs and PHCs at the property boundary as well as at the various communities are so low that they will not be measurable and as such will not impact groundwater in the area or any surface water bodies. Therefore, drinking water pathways are not considered in the assessment.

Effects Assessment

A screening index value was used to determine whether there will be potential for adverse impacts in any ecological species. The screening index is defined as the ratio of the estimated exposure or soil/feed concentration to the ecological benchmark.

Potential Adverse Effects due to Gaseous Air Pollutants

A review of the maximum 24 hour and annual average isopleths as provided in the air dispersion modelling results (Section 4.2), indicates that the location for the maximum 24 hour and annual average for SO2 and NO_x are located offshore near Doughboy Cove (at or near the marine terminal), although below the NL DOEC regulatory maximum limits, they are above the WHO Guidelines limit. The nearest location on land is to the north of the site and the 24 hour and annual concentrations for both gaseous COC's are below the World Health Organization (WHO) phytotoxicity guideline value. Since terrestrial plants are the target receptor, use of the onland maximum values is considered applicable. As a result, terrestrial plants are not considered at risk due to levels near the proposed refinery.

Potential Adverse Effects on Terrestrial Mammals and Birds

As the assessment only focused on incremental soil and vegetation concentrations associated with the NLRC refinery, a screening index (SI) value of less than or equal to 0.1 indicates that there is no potential for an ecological effect and a more detailed assessment is not necessary.

The results of the assessment indicated that the screening index values are well below 0.1. Even though, an assessment of the direct comparison to ecological benchmarks could not be made for the plant and earthworm species, these effects are captured within the food chain effects for the terrestrial mammals, such as the mouse and rabbit. Thus, ecological receptors in the vicinity of the proposed refinery will likely not experience adverse effects from emissions arising from its operation and a more detailed ecological risk assessment is not warranted.

Conclusions

In summary, exposure to contaminants such as PAH's and VOC's that would be released from the proposed refinery are not expected to have any adverse ecological effects on off-site vegetative, terrestrial mammal or bird populations.

The maximum predicted incremental soil concentrations (in the order of 10-2 to 10-11 mg/kg) arising from emissions from the proposed refinery were so low that they are not discernable from natural background. However, a comparison of the incremental soil concentration against available CCME Soil Quality Guidelines (Parkland) was carried out. No potential issues were identified. A quantitative assessment of the exposure to contaminants to the selected receptors was also conducted and indicated that there are no adverse effects on ecological receptors are expected.

Potential adverse effects of gaseous air pollutants (NOx, and SO2) on vegetation were also considered in the assessment. The maximum 24 hour and annual concentrations of SO2 and NO2 were below phytotoxicity levels in vegetation indicating that no potential adverse effects will occur in vegetation

Due to maximum predicted soil concentrations of COC's at the site boundary as well as at the various communities being so low that they will not be measurable, surface water bodies and groundwater are not expected to be affected.

4.4.6 Human Health Risk Assessment

The human Health risk assessment is addressed in detail in Volume 4 Socio-Economic assessment.

The Health Research Unit (HRU), Division of Community Health and Humanities, Faculty of Medicine, Memorial University of Newfoundland, prepared a report on the health status of the residents of an area within approximately 50 km radius from the proposed oil refinery location at

Southern Head, situated between North Harbour and Come By Chance Bay, Placentia Bay. This baseline data on the health status of the local population is of value in determining the potential impact from future operations on human health in the study area. The results of this report are discussed in more detail in Volume 4 – Socio-Economic Assessment. The following is an excerpt from the health risk report as related to air emission effects (epidemiological/community health effects, i.e., respiratory diseases) and Table 4.17 is from the health risk assessment report.

"Certain diseases of the respiratory system are more likely to be aggravated by emissions from refineries. Those of particular concern are Chronic Obstructive Pulmonary Disease (COPD) and asthma. Table 4.17 shows that over the years 1999 to 2004 the Study Area had lower rates of hospitalization for COPD and asthma than Eastern Regional Integrated Health Authority (Eastern RIHA), the province or Canada. Rates for bronchitis and emphysema (a subgroup within COPD) in the Study Area show similar values for males, but lower for females, when compared to Eastern RIHA, the province, or Canada. "

Table 4.17 Acute Care Hospital Separation for Diseases of the Respiratory System

Acute Care Hospital Separations for Diseases of the Respiratory System[1], 1999/00 - 2003/04								
Separations/100,000 Population (5-year average)								
Area of Residence	**Study Area**		**Eastern RIHA**		**Province**		**Canada[2]**	
Sex	M	F	M	F	M	F	M	F
All Respiratory Diseases	584.9	522.5	1074.3	928.9	1215.9	1049.4	884	780
Chronic Obstructive Pulmonary Disease (COPD)	160.8	129.4	295.1	233.7	336.9	237.6	288	275
Bronchitis and Emphysema	21.9	5.0	20.3	19.4	26.7	25.3	111	102
Asthma	43.9	77.1	84.9	110.7	98.3	110.2	98	103
Other respiratory	404.5	350.8	728.7	634.3	823.2	747.9	595	505

Source: Clinical Database Management System 1999/00 to 2003/04; Canadian rates are from the Canadian Institute for Health Information online report "Hospital Morbidity Tabular Reports 2000-2001" available at http://secure.cihi.ca/cihiweb/products/HospitalMorbidityTabularReports2000-2001.pdf

1 Based on the most responsible diagnosis

2 Rates are for fiscal year 2000/1

For this assessment, potential adverse effects and risks are calculated using deterministic (point estimate) risk estimates. Hazard quotient values for short-term (1-h, 8-h or 24-h) or long-term (annual) exposure to gaseous air pollutants were calculated. A hazard quotient value for gaseous air pollutants below 1 implies that the health effects associated with the gaseous air pollutant are not significant.

Based on the results of the human health risk assessment by SENES, it is expected that the potential for a human health effect from short-term exposure is considered to be low. However, the short-term maximum concentration off-site for NO_2 and SO2 is above the health based criteria specified by the WHO at specific sites over water near the marine terminal as a result of ship emissions.

The long term exposure to NO_2, CO and $PM_{2.5}$ are well below health-based guidelines and therefore not expected to be a concern. SO_2 concentrations are expected to remain below the WHO interim guideline and be similar to those recently experienced in this area. The cancer risk values for long-term exposure to carcinogenic chemicals, VOCs and PAHs are all below the negligible risk level. Hazard quotients for non-carcinogenic chemicals associated with the non-carcinogenic chemicals, VOCs, PHCs and PAHs are all well below 0.2.

It was concluded that no measurable adverse health effects would be expected to occur in the vicinity of the proposed refinery.

4.4.7 Air Quality Monitoring and Follow-Up

NLRC has committed to install air quality monitors in the study Area. The proposed monitoring network will be complementary to the existing NARL network (Sunnyside, Come By Chance, etc.). NLRC committed during public meetings to install monitoring stations at the following locations: Goobies, North Harbour and the property limit. Additional locations may be needed. Also, a specific study related to the analysis of the air monitoring network will be made at the detailed engineering phase.

Air monitoring stations will be installed early in the construction phase to provide a project baseline and will be used to supply continuous monitoring of local air pollutants and determine compliance with operating permits and the results of air quality modeling.

The air quality monitoring plan will be developed in consultation with regulators and the Community Liaison group.

Water quality monitoring in the nearby streams, particularly Watson's Brook, has already started by NLRC to provide baseline information (to study if acid rain impact is measurable in these streams). The results of site-specific water quality measurements did not show any unusually high acidity (low pH) levels in streams surveyed. Historical data from the Come By Chance River did not show any noticeable low pH (a direct indicator of acid rain impact). However, water quality monitoring in both Come By Chance River and Watson's Brook will continue (along with the stream flow measurement program)

Emissions Rate Validation

During the detailed engineering phase, the estimated emission rates will be validated through engineering calculations and manufacturers data and the atmospheric dispersion study revised as needed.

These emission rates will also be validated at the plant start-up through a detailed stack testing program.

4.4.8 Conclusions

The air quality modeling prediction and air quality impact assessment were made using the best information available about the project and a 'worst case scenario' in order to err on the side of caution to estimate the overall atmospheric emissions. The precautionary principle was applied in this situation.

With regards to predicted concentrations in the nearby communities, all results remain well below NL DEC air quality regulations, even when adding a maximum estimated background concentration due to other existing sources or air emissions (industries, traffic, etc.). It is also near or below World Health Organization guidelines, which are very stringent.

At the Refinery property line and the coastline (which is considered as the property line to the south and south-east of the proposed refinery), the predicted short-term (1 hour to 24-hour) average concentrations of NO_2 and SO_2, could reach levels about 80-85% of the NL DOEC air quality standards: however, the frequency of occurrence would be very low. These results are based on a cautious or worst-case emission scenario during normal operation of the proposed refinery.

Based on these results, we conclude that the proposed refinery will comply with all applicable regulations and the effect of refinery operation on air quality within the study area is of negligible to moderate significance.

4.5 Water Resources Effects Assessment

4.5.1 Project Effects During Construction

Stream Crossings

The installation of watercourse structures (culverts and bridges) will be required for the construction of site roads and infrastructure. Culverts will be installed at stream crossing locations on the site access roads. Bridge structures will be required for more substantial rivers including Come By Chance River, Watson's Brook, and North Harbour River. The installation of dams will not be required for the Project.

All stream crossings will be constructed in accordance with the procedures outlined in the Environmental Protection Plan and will meet or exceed the requirements of the Department of Environment and Conservation and the Department of Fisheries and Oceans. The Department of Environment and Conservation's Environmental Guidelines for Water Investigations will be used as a guide to working in and around water bodies, as well as the Department of Fisheries and Oceans Fact Sheets.

A total of 38 potential stream crossings have been identified. Table 4.18 presents a summary of the habitat type present within the immediate vicinity of each stream crossing.

Table 4.18 Summary of road access stream crossings, Southern Head, Placentia Bay

Crossing Number	Location (MTM NAD 83)		Habitat Classification	Description
	Northing	Easting		
1	5302212.826	231319.160	Riffle	Come By Chance River
2	5302260.100	231125.100	Intermittent	
3	5302016.410	230807.139	Cascade	
4	5301277.463	230331.246	Cascade	
5	5300930.766	230023.473	Intermittent	
6	5300851.077	229940.639	Intermittent	
7	5300665.022	229751.553	Intermittent	
8	5300285.200	229475.400	Intermittent	
9	5299958.470	229243.595	Intermittent	
10	5299668.453	229038.200	Intermittent	
11	5299355.817	228718.193	Intermittent	
12	5299272.877	228632.623	Intermittent	
13	5299090.347	228462.076	Intermittent	
14	5298961.642	228341.763	Intermittent	
15	5298772.520	227586.137	Intermittent	
16	5298877.490	227203.123	Intermittent	Eastern Access Road

Crossing Number	Location (MTM NAD 83)		Habitat Classification	Description
	Northing	Easting		
17	5298481.415	227017.460	Intermittent	Eastern Access Road
18	5298397.425	226979.171	Intermittent	Eastern Access Road
19	5297813.629	226713.980	Intermittent	Eastern Access Road
20	5297745.661	226683.096	Intermittent	Eastern Access Road
21	5299221.373	226940.399	Intermittent	
22	5299429.729	226640.681	Riffle	
23	5299470.735	226581.658	Riffle	
24	5299846.207	226041.410	Intermittent	
25	5299706.400	225513.300	Intermittent	Western Access Road
26	5299576.900	225499.900	Intermittent	Western Access Road
27	5299532.400	225487.800	Intermittent	Western Access Road
28	5299396.442	225427.749	Riffle	Watson’s Brook
29	5300338.257	225359.411	Intermittent	
30	5300406.154	225283.127	Intermittent	
31	5301788.926	224613.332	Intermittent	
32	5303150.294	224574.042	Intermittent	
33	5303219.225	224561.622	Intermittent	
34	5303305.156	224545.093	Intermittent	
35	5303772.605	224458.366	Intermittent	
36	5305649.053	224786.086	Cascade	
37	5305769.927	224730.903	Riffle	North Harbour River
38	5306956.159	223735.342	Intermittent	

Dewatering

Only water bodies that are in the immediate project footprint will be disturbed. Water bodies outside the project footprint will have a minimum 15 m buffer as required by the regulatory agencies to preserve the shoreline.

Figure 4.21 Stream Crossing Locations Along Proposed Access Roads

4.5.2 Project Effects During Operations

During refinery operations, the required freshwater will not be extracted from streams or ponds, therefore water resources will not be affected. All water for the operational phase, including all processes and domestic consumption, will be obtained from marine seawater that will be desalinated prior to use. Surface runoff from this site will be collected in sedimentation ponds for use as make-up, processing and firefighting. Discharge of all water from the site, including treated wastewater and storm water, will be via marine outfall. No discharge will occur into freshwater sources.

The NLRC Refinery will operate under a Certificate of Approval (CoA) from the Department of Environment and Conservation, Pollution Prevention Division, Industrial Compliance Section. This CoA is required by industries with air emissions and/or effluent discharge. The Project will also follow applicable regulatory legislation including the Petroleum Refinery Liquid Effluent Regulations under the Fisheries Act and the Environmental Control Water and Sewage Regulations under the Environmental Protection Act.

The Petroleum Refinery Liquid Effluent Regulations state that "liquid effluent" means wastewater and includes process water, cooling tower blow-down, tank draining, ballast water, storm water, wastes from water treatment facilities and run-off from land used for the disposition of waste water and sludges associated with the operation of a refinery.

The Project components will include a storm water drainage system, oily water/process water drainage system, sanitary sewerage system, wastewater treatment plant and containment ponds and a wastewater outfall. All effluent and sewage will be treated to meet provincial and federal guidelines before it is released into the environment.

4.5.3 Mitigation

Stream Crossings

The following mitigation measures will be used to control siltation, erosion and run-off and storm drainage management procedures during the installation of culverts and bridges:

- Alignment of culverts will be such that the original direction of stream flow is not significantly altered;
- Where possible, crossing infrastructure will be installed at right angles to the stream to minimize the crossing length;
- The use of heavy equipment in waterbodies will be avoided; they will operate in dry stable areas;
- In-stream work will be avoided; if excavation is required all flow will be temporarily diverted or confined to a section to allow work to be carried out in the dry;

- Silt screening will be used to prevent silt resulting from precipitation runoff from progressing to the surrounding area;
- Approaches to all stream crossings will be constructed with erosion resistant materials such as rock or clean gravel;
- Any materials placed in the stream to improve the crossing will be clean, non-erodable, and non-toxic to aquatic life; and
- Where streams are deemed to be fish habitat, culvert installations will be designed to allow the passage of fish and to preserve habitat.

All culverts and bridges will be designed to accommodate maximum peak flow volumes, typically fall and spring, and they are installed during low flow, typically summer. Installations will be scheduled according to forecasts to try to avoid increased flows from sudden storms.

Electrical power lines for the project site will be accessed for construction, wherever possible, from access roads and service roads. Where this is not practical, watercourses may be forded for temporary access only for pole and cable installation.

The following mitigation measures will be used when fording of a water body must occur:

- The immediate area will be stabilized by the use of brush mats, corduroy, or coarse clean gravel fill; and
- The Environmental Guidelines for Fording as published by the Newfoundland and Labrador Department of Environment and Conservation, Water Resources Division, will be applied.

Dewatering

Dewatering of the site will be undertaken in accordance with approved practices and with the objective of preventing drainage related issues in the area surrounding the site. The following mitigation measures will be followed:

- Protective measures such as silt screening will be used to prevent silt from precipitation runoff from progressing to the surrounding area;
- Pumps may be used to assist with dewatering and will be used in such a manner to prevent the passage of silted water into the surrounding area;
- Where pumps are used, backups will be available in the event of a failure to provide secure control of the water flow;
- Surface water will be inhibited from entering the work site by using perimeter ditching to redirect the flow;
- Velocity controls such as check dams will be used to assist in the removal of sediment that may be in the drainage water in perimeter ditches;
- Surface water from the site will be directed to one or more settling ponds that will be constructed to remove silt and turbidity prior to discharge back into the surrounding environment; and

- The water will be evaluated for compliance with the provincial Environmental Control Water and Sewage Regulations prior to discharge.

Desalination

Some of the freshwater consumption for the refinery will come from an on-site desalination plant. There will be no use of natural fresh water sources in the Southern Head Area. To reduce the potential effects of water desalination technology on the local marine environment, the following mitigation measures will be taken:

- The saltwater intake pipe will be buried at the shoreline and weighted with concrete anchor bocks over the entire length to prevent floating;
- A wedge-wire or V-wire screen (Johnson ScreenTM) will be used at the end of the intake pipe to reduce the inlet velocity below 0.15 m/s, which will protect the surrounding aquatic species and prevent debris from clogging the screen;
- The screen will be equipped with an air cleaning system, which will produce a periodic blast of compressed air through the screen to remove accumulated debris; and
- The screen material will be selected specifically for the application to prevent corrosion and biofouling.

4.5.4 Residual Effects

The overall residual effect on water resources in the project area is that 4.2 per cent of the Watson's Brook watershed will be removed.

4.5.5 Accidents and Malfunctions

The site will be developed in such a way that will minimize the discharge of contaminants into streams or ponds. Oil spills or chemical spills and other accidents or malfunctions will be contained within the site. Cleanup will be carried out immediately after such spill. The EPP for construction and operations will cover such incidents.

4.6 Migratory Birds Effects Assessment

4.6.1 Project Effects During Construction

During construction of the oil refinery and the marine terminal, there are six main types of activities that may impact birds and bird habitats:

- Habitat Destruction;
- Noise and Disturbance (including traffic);
- Presence of Structures;
- Artificial Lighting;
- Run-off and Siltation; and
- Air Emissions (see Section, 4.6.2, Project Effects During Operations).

Of these construction activities, habitat destruction and noise/disturbance have the greatest potential to impact birds and bird habitat. Noise is defined as a sound of human origin that might significantly disturb animals (Bowles et al. 1991), that is, it may have deleterious effects on wildlife. Noise is associated with almost every aspect of the construction phases of the Project and this VEC is known to be sensitive to noise. Data exist for response of some species of birds to noise.

Terrestrial

Habitat Destruction

Habitat Loss

Species such as waterfowl are thought to saturate the habitats, in this case wetlands, of a given landscape. Loss of habitat is directly linked to loss of carrying capacity of the local or regional landscape hence 'no net loss' of wetlands is premised on the negative effects of habitat loss on waterbird populations.

Habitat Avoidance

Disturbance is equated to habitat loss that is reversible. Owen (1973) calculated that due to disturbance, only half the potential usage by the geese of the Wildfowl Trust refuge at Slimbridge, England was being realized. Animals may distribute themselves more widely in the absence of disturbance (Gerdes and Reepmayer 1983 in Bell and Owen 1990; Mayhew 1985). Disturbance can be equated to lessening of carrying capacity, at least temporarily. Some animals may distribute themselves around the landscape in relation to disturbances, implying that birds are being prevented from exploiting areas they would otherwise favour (Bell and Owen 1990). Notwithstanding that disturbance may impact species differentially, it is clear that certain types of disturbance can impact biological communities. For example, Reijnen et al.

(1995) determined that twenty-six of forty-three species of songbirds showed reduced densities adjacent to noisy highways.

Change in Distribution

A change in distribution has a number of possible consequences, including restriction in feeding opportunities (time and space), increased energetic costs of moving, and increased concentration of individuals, which increases intraspecific competition and/or risk of disease. Such consequences could affect the condition of individual animals (e.g. Dzubin 1984; Temple et al. 1996). In Denmark, staging Pink-footed Geese (*Anser brachyrhynchus)* in undisturbed fields increased their body condition (as measured by Abdominal Profile Indices) whereas birds using disturbed fields did not. Of marked individuals resighted in the subsequent autumn, birds from the undisturbed sites were more successfully at breeding (Madsen 1994). Wildlife densities will rise as habitat is lost. Whether or not this affects the local or global population will depend on whether rates of emigration, mortality and reproduction are already or will become density dependent (Goss-Custard et al. 1994, 1995).

Animals may avoid sites when disturbance events are frequent, but subsequently use such sites when less disturbed sites have been depleted of food (e.g. Owens 1977). Some animals may compensate for daytime disturbances by feeding at night (Owen and Williams 1976). Compensatory feeding maybe constrained by the morphology of feeding apparatus or time-activity budgets (Goudie and Ankney 1986). Some animals are able to increase their feeding rate (e.g. Swennen et al. 1989), while other animals do not (e.g. Belanger and Bedard 1989).

Habitat Loss and Carrying Capacity

Disturbance may cause redistribution of wildlife. If animals are displaced from a site, their survival depends on the availability of alternate feeding sites. Displaced individual animals, such as shorebirds and songbirds, may suffer from mutual interference when forced to feed elsewhere under increased densities, thereby affecting food intake rate which, repeated, would affect carrying capacity leading to metapopulation effects and subsequently population effects (Sutherland and Anderson 1993; Goss-Custard et al. 1995). Hill et al. (1997) presented a schematic model of the relationship between disturbance and habitat loss, food supply, intake rate, carrying capacity and importance to metapopulations.

Effects of Noise and Disturbance

Effects of noise and disturbance on wildlife is a very broad subject ranging from impacts on physiology and/or behaviour of the individual animal, through to consequences of noise to populations, to alterations of the communities, landscapes and ecoregions. Disturbance is one of the most important stressors that humans and their devices have impinged upon the natural world (Nisbet 1977, 2000). Effects of disturbance are any consequence of this anthropogenic influence, and are not necessarily biologically significant or even negative (Bowles et al. 1991).

Noise disturbance may cause stress in animals and this has physiological implications that have received attention in humans (Kryter 1970) and wildlife (Selye 1950, 1976; Welch and Welch 1970, Siegel 1980, Westman and Walters 1981, Wasser et al. 1997,). Noise disturbance stimulates the auditory senses of wildlife, and effects originate from acoustical stimulation of the neuro-physiological system in animals (Welch and Welch 1970). Behavioural responses range from mild annoyance to panic and escape behaviour, and such responses are manifestations of stress. Excessive stimulation of the nervous system can amount to chronic stress, and this has implications to health, growth and reproductive fitness of animals (Fletcher and Bushel 1978, Fletcher 1980).

The concept of disturbance (especially noise) as a stressor is basic to understanding its physiological effects on animals. Altered reproductive behaviour resulting from noise disturbance (e.g. Holthuijzen et al. 1986, Anderson et al. 1989) is a major area of concern due to possible effects on survival of populations or species (Informatics 1980). Ultimately, all response to disturbance is affected by physiological changes in individual animals.

While stress responses seem maladaptive, they actually perform important functions, such as reducing inflammation and speeding acclimation to environmental stressors (Bowles 1994). When an animal’s capacity to adapt is exceeded, it experiences distress (pathological), evidenced by clinical systems of ill health, including such things as neurotic behaviour, reproductive failure, inhibition of growth, and/or disease. Depending on type and intensity of noise disturbance, the same adverse stimulus may affect either the whole body or mainly one part (Selye 1976) because stress involves a number of complex neuro-endocrine interactions.

Noise can be broadly classified into three categories: (1) continuous noise (2) impulse noise and (3) impact noise. Continuous noise is seldom encountered by wildlife except when adjacent to human activities. Some animals, such as Harlequin Ducks, live in environments with high-background sound levels. The rapid onset of intense noise, i.e., sudden onset may cause noise of high amplitude to sound less loud than is indicated by its power spectrum, and to act as if it has effects at high frequencies disproportionate to their representation in its spectrum (Larkin 1996). Therefore rapid-onset impulse noise may be potentially more damaging than would be predicted strictly from its physical characteristics. Impulse noise and continuous noise differ both in their potential physical effects, namely hearing damage, and in their sensory-mediated physiological and behavioural effects (Roberto et al. 1985). Animals habituate poorly to high amplitude noise with rapid onset (Korn and Moyer 1966).

Hearing damage from loud noise is a result of physiological change to the auditory system, notably loss or damage to hair cells in the cochlea. Hearing loss or damage can be produced by brief exposure to very loud sound or by prolonged exposure to moderate levels of sound. Animals vary greatly in their sensitivities and susceptibilities to hearing loss. The frequency content of sound is very important because sounds of different spectra affect the auditory system differently; for example, high frequency tones tend to produce localized changes in the inner ear, whereas low frequency tones tend to produce changes throughout the length of the cochleae (Fletcher and Busnel 1978).

Noises of high amplitude are expected for construction of a mega-project, such as the proposed oil refinery. To assess the potential effects of noise and disturbance from construction activities on birds and bird habitat in the Study Area, this section provides: (A) a background on the types of disturbance effects on birds and bird habitat; (B) information on the hearing abilities of birds, and (C) a consideration of non-auditory physiological effects.

Categories of Disturbance Effects

Effects on Individuals

Effect is any consequence of an anthropogenic disturbance. When confronted with disturbance, an animal may respond in three ways: (1) choose a behavioural response, and/or it may evoke the (2) autonomic and/or (3) neuroendocrine systems. The responses of the latter systems result in changes in biological function, i.e., diverting the animals own resources from ongoing biological activities to new biological activities that may assist the animal in coping with the stressor (Moberg 1985, 1987). Reflexes may be weakened and learning responses decreased through chronic exposure to harmful noise levels. There is close correspondence between behavioural responses and physiological measures (Thiessan and Shaw 1957; Bowles et al. 1991).

The behavioural effects of disturbance on birds are highly variable, and can be categorized as follows:

- Avoidance - Animals can avoid disturbances (especially noise), and this can involve abandonment of preferred habitat, change in home ranges, and/or altered migration patterns, and may confer a decrease in survival.
- Adaptive Habituation - In some cases wildlife may demonstrate no response or may habituate or adapt to human disturbance.
- Attraction - In certain cases, wildlife maybe attracted to the disturbances such as vehicles and traffic, lights (e.g., raptors and small mammals attracted to area of airport runways possibly because of availability of food; Informatics 1980).

Behavioural Responses to Disturbance

Birds may react to disturbances by ceasing all activity ("freezing"), reducing feeding rates (e.g. Cramp and Simmons 1977), reducing food intake (e.g. Stockwell et al. 1991), ceasing feeding (e.g. Belanger and Bedard 1989) and/or diverting their attention to the source of disturbance (e.g. Brown 1980, 2001a,b) or by moving to another area (Bell and Owen 1990, Anderson et al. 1996, Colescott and Gillingham 1998). Individuals affected by disturbance may demonstrate short-term responses yet exhibit protracted residual effects also, such as: (i) becoming more aggressive, and (ii) decreasing courtship (Goudie and Jones 2004), increasing self-comforting behaviours (e.g. preening), and increasing vigilance and/or becoming inactive (Goudie 2006). Time/activity budgets could be affected by disturbance (Salter 1979; Murphy and Curatolo 1987; Maier et al. 2001). The lack of behavioural responses to disturbances do not necessarily mean that animals are not stressed by stimuli because physiological changes may still occur even when no outward behavioural change is apparent (e.g. Jungius and Hirsch 1979; Conomy et al. 1998 versus Temple et al. 1996; Gill and Sutherland 2000; Goudie 2006).

Lowering of Breeding Success

Many studies of the effects of human disturbance on breeding success of individuals show biologically significant results (Hockin et al. 1992). Disturbance from vehicular traffic noise can lower reproductive performance of a population or segment of a population of songbirds utilizing forested habitats adjacent to roads (Reijnen and Foppen 1994). In areas of bird concentrations, such as seabird colonies, human disturbance can cause mass loss of eggs and/or young affecting the reproductive output of the entire colony (Manuwal 1978).

Sometimes real effects on the study animals are compounded by effects attributable to the presence of researchers (e.g. Gotmark 1992; Rodway and Montevecchi 1996). However, few studies have quantified reactions of animals or their young to disturbance, and few quantified the mechanisms by which reproductive success was affected (but see Anderson and Keith 1980, Flemming et al. 1988).

Many studies rely on the perception of the observer of the potential disturbing effect, rather than a measure of the effects on the individuals (Trimper et al. 1998, Bell and Owen 1990). Such short-comings can be improved when demonstrating the relationship between response in animals and to a measurable dose of disturbance (Goudie and Jones 2004, Bowles et al. 1991).

The main reasons postulated for lower breeding success in birds subjected to human disturbances are:

- nest abandonment (Anderson and Keith 1980; Anderson 1980);
- increased predation of eggs and young (Titus and van Druff 1981);
- direct destruction of nests (Burger 1991);
- Deferment of breeding (Tremblay and Ellison 1979; Hobson and Hallinan 1981);
- Exposure of eggs (Hunt 1972);
- Inhibiting effects on female maternal behaviour (broodiness) (Jeannoutot and Adams 1961);
- Reduced feeding and brooding of young and increased mortality (Flemming et al. 1988); and
- Accidental collisions (Safina and Burger 1983; see also Blokpoel and Hatch 1976).

Predator Avoidance

Birds can lose eggs and young to predators after being startled into flight (Rodway and Montevecchi 1996). Harrington and Veitch (1991, 1992) reported that caribou exposed to low-altitude over-flights by military jets in Labrador lost more calves (to wolves) than unexposed caribou.

Implications to Energy Budgets

Disturbance generally reduces feeding time and increases energetically costly behaviours, notably flying (Owens 1977; Belanger and Bedard 1989, 1990), and overall daily energy expenditure can increase significantly (e.g. 31per cent in White-Robinson 1982; 20per cent in Watmough 1983). For example, energetic costs of flight are 10 to 12 times Basal Metabolic Rate (BMR), swimming four times BMR, comfort behaviour two times BMR, brooding 1.5 times BMR, and walking, hopping and running three to five times BMR (Paynter 1974). Such stress is thought to confer a survival cost to individuals, and increased mortality within populations.

Impacts on Body Condition

The effects of disturbance on behaviour could make certain feeding sites unprofitable. Disturbance may affect body condition, subsequent reproductive output, and/or parental care (Fernandez and Azkona 1992). For example, Geese are known to rely heavily on nutrient reserves accumulated before nesting (Ankney and MacInnes 1978, Ankney 1984; Ebbinge 1989, 1992; Madsen 1994), therefore disturbance at this time could be very detrimental to acquiring optimal body condition.

<u>Effects on Populations</u>

Effects on Demographics

Effects in survival rates, emigration rates and/or breeding success of individuals will affect populations. If disturbance has an effect on population size, there should also be consequential change in the local survival and/or fecundity of individuals (Cayford 1993). Disturbances can reduce populations of birds in certain geographic areas or zones of disturbance (Reijnen and Foppen 1994). The sizes of animal populations are determined by the availability of a limiting resource, usually food (Lack 1965), but carrying capacity over extensive areas is difficult to measure.

Effects on Density

Disturbance may lower carrying capacity of habitat for waterfowl and/or songbirds leading to lower densities in zones affected by disturbances (Madsen 1994; Reijnen and Foppen 1994). Alternatively, disturbance may result in wildlife such as shorebirds feeding in poorer quality habitats, and feeding below the threshold rate required for survival rates sufficient to maintain populations over the longer term. This leads to rises in the proportion of birds dying or emigrating as population size increases, i.e., a density dependent effect (Goss-Custard et al. 1995; Gill et al. 1996).

Disturbance and Carrying Capacity

Disturbance may cause redistribution of wildlife. If animals are displaced from a site, their survival depends on the availability of alternate feeding sites. Displaced individual animals, such as shorebirds and songbirds, may suffer from mutual interference when forced to feed elsewhere under increase densities thereby affecting food intake rate which repeated would affect carrying capacity leading to metapopulation effects and subsequently population effects (Sutherland and Anderson 1993; Goss-Custard et al. 1995). Hill et al. (1997) presented a schematic model of the relationship between disturbance and habitat loss, food supply, intake rate, carrying capacity and importance to metapopulations.

Timing of Disturbance

Disturbance is most likely to have an impact during the periods of the annual life cycle when food resources are depleted and birds have difficulty in meeting daily energy requirements (e.g. winter in waterfowl Madsen 1994 or fall migration in shorebirds in Goss-Custard et al. 1995). Such periods probably occur when individuals need to build up nutrient reserves in advance of periods of high energetic demand. In migratory bird species, energy reserves are accumulated in the late summer-fall and/or early winter to “fuel” migration or in spring to ‘fuel” breeding. Such reserves may be depleted but subsequently replenished (Owen and Cook 1977; Pienkowski et al. 1984; Ebbinge 1992; Fox et al. 1992; Owen et al. 1992). Strong intraspecific competition can limit nutrient acquisition when resources are space limited (Teunissen et al. 1985; Ebbinge 1992).

Mitigative actions

Approaches such as determining thresholds of response and discrimination of important explanatory variables are used to develop management recommendations that, if applied, can minimize human impacts, as for example with Bald Eagle (Grubb and King 1991; Grubb and Bowerman 1997). Managers seek to minimize human disturbance on wildlife. Management actions may be based on empirical data, especially where dose and response are known (e.g. Goudie and Jones 2004) or, in many cases, may be based on subjective judgments. Bowles (1994) proposed a number of general approaches to help limit important behavioural and physiological responses of wildlife to disturbance.

Hearing Abilities in Birds

Similar to humans, birds are most sensitive to sounds ranging from is approximately 1 kHz to 4 kHz with sensitivity decreasing at lower and higher frequencies. For this reason, birds are more